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NEOGENE FLORAL CHANGE IN JAPAN

By

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I. Introduction

Palaeobotany is first, of course, aimed at usefulness in deciding the relative age of sediments, their correlation and historical interpretation. Accordingly, palaeobatanists have desire to solve some problems: they search for a key to the evolution of the plant kingdom; they desire information on the relation of plants that are extinct to plants which still exist, and on the relation of the vegetation of one period to that of another. The present vegetation in Japan includes very abundant and various components, which are also very complicated in their modern distribution. Furthermore, there are not rarely endemic living plants in Japan, while many characteristic genera or species are common with China, partly even with North America as already described by various botanists and palaeobotanists. In order reasonably to explain such modern vegetation and distribution in Japan, it is necessary to investigate the Late Cenozoic flora of Japan which is the past flora immediately preceding the present.

Since the first record of Tertiary plants reported at the end of the previous century in Japan, a great number of palaeobotanical contributions have been presented. Thus, concerning the Cenozoic floral change of Japan, Pliocene and Pleistocene floras have been comparatively clarified in the composition and components, however, the knowledge on pre-Pliocene flora has been very fragmentary up to the present. Since 1945, the writer has employed himself mainly in research on the Tertiary palaeobotany of Japan. Some years ago, he published a general outline of Middle Miocene flora of Japan, and very lately discussed several Neogene floras. Thus, on the basis of many observations made himself, he intends to present mainly a general outline of Neogene flora, especially of the stratigraphic sequence of Neogene floras over Japan, though the details are not entirely satisfactory. In addition, more than 200 Neogene species used by the writer for the present work are described in the last chapter; however species already described by previous authors are simply noted, unless there is necessity to revise or discuss them.

It is, of course, necessary for palaeobotanical research that the plant-bearing sediments are accurately known in respect to their stratigraphic sequence. However, these sediments were frequently uncertain in several areas of Japan, so that the writer sometimes spent many months in stratigraphic research rather than in palaeobotany. Thus, his investigation occasionally wandered from the principal purpose of palaeobotany. However, in connection with the palaeobotanical research, the writer has intended also to present some ideas in respect of the stratigraphic value of Neogene flora. More definitely the chief object of the present study is to determine the resemblances or differences among many Neogene floras of Japan in regard to the general facies of vegetation and to trace the Neogene floral changes, rather than strictly to determine the specific evolution of Neogene plants.

On the one hand, the fossil pollens and woods also occupy an important place in Neogene floral research. Although many contributions published on the basis of these materials by various authorities should be referred to, they are mostly not cited in the present work, because, they are not directly necessary for establishing the stratigraphic sequence of Japanese Neogene flora.

II. Acknowledgements

The writer takes this opportunity to express his deep gratitude to the late Dr. Yanosuke OTUKA, formerly Professor of the Geological Institute, Tokyo University who first introduced the writer to the study of Cenozoic palaeobotany, and who gave his sincere guidance and encouragement in the early course of the writer's investigation. It is the writer's pleasure to express his most warm thanks to Professor Teiichi KOBAYASHI and Professor Fuyuji TAKAI of the Geological Institute, Tokyo University who gave their continuous guidance and encouragement during the present study. Deep appreciation is due to Dr. Katsu KANEKO, the Director of the Geological Survey of Japan who gave valuable advice and kind encouragement during the present work. He is also indebted to Professor Yasuo SASA of the Department of Geology and Mineralogy, Hokkaido University for his valuable guidance concerning Neogene sediments of Hokkaidô and kind encouragements in the completion of the work.

During the course of this work, the writer has received valuable support and guidance from the following persons to whom he takes this opportunity to express his deep gratitude: to Professor Kazuo HUZIOKA of the Department of Mining, Akita University, and Professor Shigeru MIKI of the Botanical Institute, Osaka City University for their valuable guidance and suggestions in the identification of several plant fossils; to Professor Ralph W. CHANEY of the Department of Paleontology, University of California who gave many valuable references on American Tertiary floras and arranged financial support in 1959 offered to the writer from the National Academy of Science, U.S.A.; to Mr. Shirô ISHIDA of the Institute of Geology and Mineralogy, Kyoto University for his kind permission to study some of his collections; to Mr. Tôru ONOE of the

Geological Survey of Japan for his kind and untiring assistance in the collection and identification of many fossil materials used for the present study; to Mr. Nobuo SUZUKI of the Department of Geology and Mineralogy, Hokkaidô University who has assisted the writer to collect and arrange many specimens from southwestern Hokkaidô, which specimens add materially to palaeobotanical knowledge of this little-known region; to Miss Akiko YAMADA of Hokkaidô University for her kind assistance in the preparation of figures and this manuscript.

During the course of the present work, the writer has made partial use of the collections of the Department of Geology and Mineralogy, Hokkaidô University, of the Geological Survey of Japan and of the Geological Institute, Tokyo University. The comparisons of fossil species with modern leaves, seeds, etc., were made at the herbaria of the Botanical Institute, Tokyo University and the faculty of Agriculture, Hokkaidô University and sometimes at the Botanical Garden of Kyoto University. The writer is indebted to these Institutions and to members of their staffs for the opportunities they have afforded for making use of the materials.

Lastly, the writer wishes to express his cordial thanks to the following institutions or office for their financial support during the present work.

The present study has been partly aided by a Grant for Fundamental Scientific Research from the Ministry of Education during the years from 1949 to 1951 and from 1957 to 1959.

During the years 1952 to 1956, the Geological Survey of Japan provided the research funds for a study of Miocene floras from the Jôban and Okitama coal fields of Honshû, the Sasebo coal field of northern Kyûshû, and the Ishikari coal field of Hokkaidô. These investigations were made on the theme of "Studies of the Original Plant Materials of Japanese Coal." The Geological Survey also provided a grant to collect plant fossils from the Tempoku coal field of Hokkaidô in the autumn of 1958.

The National Academy of Science, U.S.A., provided funds for study of six Miocene floras in southwestern Hokkaidô in 1959.

III. Previous Works on Neogene Flora

Nearly 80 years have passed since the first fossil plants of Tertiary age were described from Japan. In those early times, Tertiary palaeobotanical research was mainly done by foreign palaeobotanists such as NATHORST, KRYSHTOFOVICH and FLORIN, and then since the beginning of the present century Japanese palaeontologists have gradually taken interest in research of Cenozoic palaeobotany. Thus, up to the present, abundant contributions have been made to the knowledge of Tertiary palaeobotany in Japan. These many researches were mainly made on the basis of megafossils such as leaves, seeds, cones, nuts, silicified woods, etc. Whereas, there have been recently many contributions to Cenozoic palaeobotany on the basis of pollen analysis which were mainly made on materials from later Cenozoic bituminous deposits.

Among these contributions made by various authors, the papers on Neogene flora or plants of Japan number more than 200. An abridged historical review of previous main works concerning such flora follows, which works were made on the basis of plant remains excluding specimens of wood and pollen.

At first, GEYLER, H. (1880, 1883) and ETTINGSHAUSEN, C. (1883) described some plant fossils from Neogene sediments of Japan. However, NATHORST, A. G. (1883) was the first to describe systematically a Neogene flora from Japan on the basis of the abundant materials which were collected by NORDENSKIOLD from Mogi, near Nagasaki City, North Kyûshû. Many years later, about 70 Pliocene species identified by him, were somewhat revised by FLORIN (1920) and YABE & ENDO (1930), but his contribution has been one of the authoritative guide to late Cenozoic flora. In 1888, NATHORST also described a number of Neogene species including several Palaeogene and Pleistocene species from various localities in Honshû, Shikoku and Kyûshû. These two works have been frequently referred to ever since for the identification of Tertiary plants of Japan, and are quoted by many Japanese geologist and palaeobotanists at present. For instance, "*Comptoniphyllum Naumanni*" was established in the later work. This species has been once considered one of the Middle Miocene index fossils, familiar to Japanese geologists.

KRYSHTOFOVICH, A. (1920) described several specimens collected from Miocene flora in the vicinity of Sendai City, Miyagi Prefecture. In 1926, he described many Miocene species from Middle Miocene sediments near Kwannonzawa, Niigata Prefecture, and then in 1930 from Nagano and Hyôgo Prefectures.

FLORIN, R. (1920) re-investigated the Pliocene Mogi and Amakusa floras already described by NATHORST, and discussed their geological age and palaeoecology.

Until about 1930, Neogene flora had been mainly investigated by the above-noted foreign palaeobotanists, though a few contributions by Japanese authors were published on the basis of fossil woods, nuts, etc. Since 1930, many contributions by Japanese palaeobotanists have been gradually presented.

MORITA, H. (1931) reported Middle Miocene Oguni flora from northern Yamagata Prefecture, and described 2 new species of *Cinnamomum* and *Smilax* respectively. Then, he (1933 a, b) described a new species of *Aralia* from Miocene Kôbe flora, and a new species of *Terminalia* from the Oguni flora.

ENDO, S. (1931, 1933) summarized the Cenozoic flora of Japan, and described several Neogene floras and some Neogene species. Since then, he has been mainly employed in descriptive works on representative Cenozoic species; especially from 1933 to 1936, he reported the occurrence of many exotic elements such as *Juglans cinerea* (1933), *Liriodendron* (1934), *Sassafras* (1936), *Sequoia* (1936), *Glyptostrobus* (ENDO et OKUTSU, 1936), etc. from Neogene sediments in various localities of Honshû. ENDO and MORITA (1932) collected many specimens of *Comptoniphyllum* and *Liquidambar* from Neogene sediments in Honshû and Hokkaidô, and re-investigated them. ENDO's investigation was made mainly on the basis of the leaf-impressions, occasionally cones, nuts, fruits, etc.

Late Pliocene Akashi flora was described by MIKI, S. (1937) from Hyôgo Prefecture on the basis of abundant fossil seeds, nuts, fruits, spines, leaves, etc., collected by him. Since then, his investigation extended to Late Cenozoic flora over the whole area of Japan excluding Hokkaidô, and many noteworthy studies have been reported one by one up to the present.

SHIKAMA, T. (1936) reported the precise composition of the Miocene Shirakawa flora near Kôbe City, and discussed its geologic age and palaeoecology. However, there are no description of fossil species except some figures in his report.

HUZIOKA, K. (1938) reported a Pliocene flora from Heigun Island, Yamaguchi Prefecture, and described a new species each of *Sassafras* and *Carpinus*.

OKUTSU, H. (1939) described Neogene *Trapa* including 2 new species from Hokkaidô and Saghalien, but these *Trapa* were lately revised to the new genus *Hemitrapa* by MIKI (1952). OKUTSU (1940 a, b) reported the floristic composition of Late Miocene flora near Sendai City, and described many new interesting species.

YABE and ENDO (1940) summarized the representative Cenozoic floras, and presented a general outline of Cenozoic floral change. In their paper, the components of several Neogene floras were listed, though figures were not given.

MIKI (1939) discussed the oral change since the Pliocene age in Japan on the basis of 3 Pliocene and 8 Pleistocene floras investigated in detail by him and others. In the same year, he described cones of a characteristic pine, *Pinus trifolia,* from central Honshû. In 1941, he reported, furthermore, the precise floristic composition and components of the "*Pinus-trifolia*-bearing flora" from Late Tertiary lacustrine sediments in Gifu and Aichi Prefectures. His investigation making use of various plant remains, added information on many genera and species which had not been found before that time in Japan, and contributed considerably to the knowledge of Late Cenozoic flora. For instance, among the newly-found genera the new genus *Metasequoia* was established on the basis of many fossil cones and leafy twigs. However, in 1948 living trees belonging to this genus were found in Central China (HU, H. 1948), which new genus was evidently confirmed its modern existence. MIKI's report did not only clarify partly the Pliocene flora of Japan, but it has been one of the useful references for the identification of Late Tertiary plants in Japan.

Since 1941, OISHI, S. who had investigated mainly Mesozoic flora of East Asia, studied Tertiary plants from Hokkaidô and Saghalien with the assistance of HUZIOKA, and described several genera one after one. Among them, they described many Neogene species from Hokkaidô: *Salvinia* (OISHI & HUZIOKA, 1941), *Comptoniphyllum* (1941), *Tilia* (1943), *Acer* (1943), *Platanus* (1943), *Marlea* (1941), *Ulmus, Zelkova* and *Celtis* (1954). Beside them, they (OISHI and HUZIOKA, 1942) reported the new discovery of *Pteroceltis* and *Ailanthus* from Miocene flora of southwestern Hokkaidô. In 1943, HUZIKA also described 2 new Miocene species of *Carpinus* and *Ostrya* on the basis of fossil bracts collected from southwestern Hokkaidô, while OKUTSU (1943) discussed the fossil *Liriodendron* found in Japan. Thus, many Neogene plants by the contributions of OISHI and HUZIOKA, were reported from Hokkaidô where Neogene flora had been scarcely known till that time. However, the floristic composition of Hokkaidô Neogene has not been yet reported.

In 1948, MIKI discussed Cenozoic floral change since Pliocene age on the basis of many plant remains collected from 101 localities in Kinki district. He subdivided the Later Cenozoic flora into 7 zones on the basis of the percentage of extinct plants and topography of fossil-bearing beds: *Pinus trifolia* zone, *Metasequoia* zone, *Paliurus* zone, *Cryptomeria* zone, *Larix* zone, *Sapium* zone and *Aphananthe* zone in ascending order. Among these 7 zones, the lower two are Pliocene in age. Since then, by the addition of data obtained from other areas of Honshû he (MIKI 1950) also discussed Later Cenozoic floral changes in Japan.

ENDO (1949, 1952) summarized the floras from the lignite-bearing formations in northeastern Honshû, and divided them into 4 floral zones on the basis of floristic components: *Comptoniphyllum* zone, *Betula*-bearing zone, *Juglans cinerea* zone and *Menyanthes* zone in ascending order. Among them, the uppermost zone was considered by him to be Pleistocene in age. However, this zoning seems to be somewhat confused in stratigraphic sequence.

HUZIOKA (1949, 1950) investigated many fossil floras of Middle Miocene age in northern Japan, and discriminated two distinctly different flora in the floristic composition: they are the Daijima- and Aniai-type floras, though these two are nearly of the same age. However, no precise description has been reported by him up the present.

OISHI (1950) compiled the "Illustrated Catalogue of East-Asiatic Fossil Plants," in which catalogue many Neogene plants are systematically arranged with short explanations respectively.

The writer (TANAI, 1952 a) reported a Middle Miocene flora from the Nishitagawa coal field, Yamagata Prefecture, and described its floristic composition and many components. In the same year, he (TANAI, 1952 b) presented an outline of Cenozoic flora in Japan on the basis of his and various other authors' investigations, and discussed floral change in the Cenozoic Era of Japan.

Since 1950, MIKI and ENDO have re-examined Cenozoic plants on abundant specimens from various localities of Japan and her adjacent regions. ENDO described many new species of *Acer* (1950, 1951), *Carpinus* (1950), *Sequoia, Comptonia, Liquidambar,* etc. (1954). Then, he compiled the "Icones of Japanese Fossil Plants," in which there are recorded many interesting or important species of Neogene plants. MIKI has re-investigated many Late Cenozoic plants including Quaternary species, and sometimes discussed the evolutional change of some plants in many contributions presented up to the present: Taxodiaceae (1950), *Trapa* (1952), *Hemitrapa* (1953), *Taiwania* and *Palaeotsuga* (1954), Juglandaceae (1955), Alangiaceae, Cornaceae and Nyssaceae (1956), Vitceae (1956), Pinaceae (1957), Cupressaceae, Taxaceae, etc. (1958).

TAKAHASHI, K. (1954) reported a Late Pliocene flora from Nagasaki Prefecture, described in detail the floristic composition and components.

The writer (TANAI, 1955) investigated Early and Middle Miocene flora from the coal-bearing sediments in all Japan, and described in detail the floristic composition and components with many figures of representative plants. In this contribution, he also observed the two different floras of the Daijima- and Aniai-types, and discussed their stratigraphic relationships and palaeoecology. Then, he investigated a Miocene flora in the Sasebo coal field, northern Kyûshû with the assistance of ONOE, T., and preliminarily reported its floristic composition (TANAI & ONOE, 1956). In this paper, they proposed the Ainoura-type flora as the Earliest Miocene flora, considering its foristic composition and stratigraphical position.

OKUTSU (1955) described Neogene flora in the area surrounding Sendai City, and clarified in detail the floristic change during Neogene time in this area. In this paper, some interesting species such as *Fagus palaeocrenata* were described by him.

SUZUKI, K. has investigated in detail the Late Tertiary flora in the Aizu basin, Fukushima Prefecture and, he and HUZIOKA reported Late Miocene flora with the description of several species (HUZIOKA and SUZUKI, 1954). Then, he described some several new species of *Cercis* (1958 a) and *Platanus* (1958 b). Recently, SUZUKI (1959 a) reported a Late Miocene Tennôji flora from Fukushima basin, Fukushima Prefecture, and discussed its floral composition, components and palaeoecology.

IMAMURA, S. (1957) reported a Miocene flora containing a new species of *Sassafras* from Shimane Prefecture, while MATSUO, H. (1953, 1959) described some new species of *Osmunda* and *Plenasium* from Miocene sediments in Ishikawa Prefecture. Furthermore, MURAI, S. (1957) described a Late Miocene flora near Morioka City, Iwate Prefecture, and discussed its geologic age and palaeoecology. Then, he (MURAI, 1957, 1958) described several interesting species.

Lately, the writer investigated a Miocene flora from the Jôban coal field, Fukushima Prefecture with the assistance of ONOE, and described the floristic composition and palaeoecology (TANAI & ONOE, 1959). He also presented discussion on the formation of the coal-bearing deposits in northeastern Honshû, and described in outline of Tertiary floral changes in that region (TANAI, 1959). In the same year, SUZUKI (1959) summarized Neogene floral changes in the southern part of northeastern Honshû; he subdivided the Neogene flora of this region into 7 floral zones. However, these 7 zones seem to be rather based on the divisions of marine fauna which were described by KITAMURA, S. (1958).

Thus, from the above-noted many works, a general outline of Neogene flora in Japan has by now become comparatively clear.

IV. Notes on Neogene Plant-bearing Deposits

1. Distribution of Neogene plant-bearing deposits

Palaeogene sediments in Japan are mainly distributed in Hokkaidô and Kyûshû, with scarcely any in Honshû. These sediments are mainly terrestrial in origin, and partly marine. On the other hand, Neogene sediments are widely distributed all over the Japanese Islands; they offer nearly 25 per cent of the total extent of all sedimentary rocks* distributed in Japan. Most of these Neogene sediments are mainly of marine origin; they contain abundant marine molluscs and foraminiferas. The plant-bearing deposits are terrestrial in origin. However, some plant fossils are sometimes contained in marine sediments; they are considered probably to be mostly drift materials.

The Neogene plant-bearing sediments are, in general, comparatively well developed in coal or lignite fields; excellently-preserved plant fossils have been frequently found from the coal-bearing formations in those fields. The distribution of Neogene coal or lignite fields in Japan is shown in Figure 1. This distribution is, of course, differentiated from the distribution of Neogene sediments. However, there are also non-coal-bearing sediments: though the Neogene widely and thickly develops, nearly all of which are of marine origin in several regions such as southern Kwantô, southern Shizuoka, etc. On the one hand, in the marginal area of marine depositional basins the lacustrine or littoral sediments having no coal seams, frequently develop; they occasionally contain many plant fossils. For instance, such plant-bearing formations are frequently found in Late Miocene sediments in northeastern Honshû, Hokkaidô, etc.

Northeastern Honshû provides a comparatively complete Neogene sequence of terrestrial sediments, compared to other regions of Japan. These sediments were widely accumulated in this region during most of the Neogene time. The plant-bearing deposits, however, are not always arranged in complete sequence in one depositional basin; they show a somewhat scattered occurrence. As already discussed by the writer (TANAI, 1959), most of the plant-bearing formations in the adjacent basins are reasonably explicable from the palaeogeographic viewpoint in northeastern Honshû, although they are isolated in present occurrence. Accordingly, most of the typical floras in each stage of Neogene time are found in northeastern Honshû, as described in the following chapter.

Earliest Miocene sediments are not widely distributed in Japan, being known only from northern Kyûshû, westernmost Honshû, southern Shizuoka area, etc. The plant-bearing deposits of this stage are found in the Sasebo coal field of northern Kyûshû, the Yuya-wan area of Yamaguchi Prefecture.

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* The distribution of all sedimentary rocks occupies about 61 per cent of the whole area of Japan. Among them, the Quaternary has the most wide distribution, nearly 21 per cent, followed by the Tertiary of nearly 19 per cent.

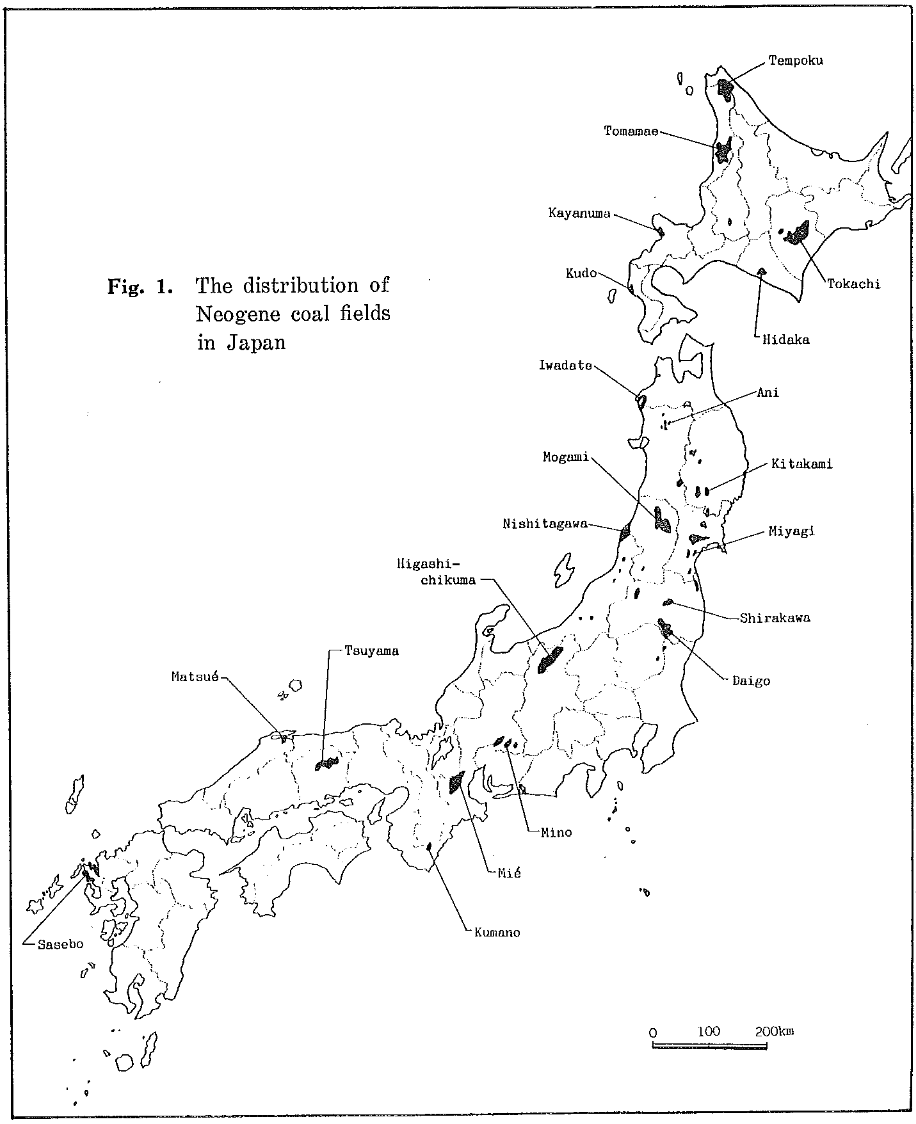

Fig. 1. The distribution of Neogene coal fields in Japan

Miocene deposition generally commenced with considerable volcanism in the most part of Japan, excluding certain regions such as the outer zone of Honshû, North Kyûshû, northeastern Hokkaidô. In the so-called "green-tuff region" such as the inner zone of Honshû, southwestern Hokkaidô, pyroclastic sediments which are called "green-tuff" are thickly distributed;

they occasionally contain coal-bearing formations in their upper part. In other regions Early-Middle Miocene sediments are sometimes accompanied by coal-bearing formations in the basal or lower part. These coal-bearing formations are scattered in many localities, especially abundant in the inner zone of northeastern Honshû and Hokkaidô, and they frequently contain numerous plant fossils.

Succeeding the previous stage, a very extensive transgression of Middle Miocene age took place in most of the lowland area of Japan, and brought about the wide distribution of marine sediments in Japan. The terrestrial or littoral deposits frequently occupy the basal part of them, and contain abundant well-preserved plant fossils. These plant-bearing formations are frequently found in various localities in Honshû and Hokkaidô, but scarcely in Kyûshû and Shikoku.

Miocene sea begun gradually to differentiate subsequent to its later stage; in some regions consequently the marine sediments were thickly deposited, while non-marine sediments were formed in isolated basins or marginal areas of marine basins in other regions. The terrestrial sediments frequently contain coal or lignite seams, and also many plant fossils. These plant-bearing formations are widely scattered in western and northeastern Honshû, a few in central Honshû and Hokkaidô, scarcely any in Shikoku and Kyûshû.

Following Late Miocene time, the regional differentiation of depositional sites became more and more considerable in Pliocene age. Pliocene terrestrial sediments were successively formed on Late Miocene non-marine sediments in various areas of northeastern and western Honshû. The Pliocene sea covered other regions, gradually regressed with the approach of the close of its age, and consequently terrestrial or brackish sediments were formed at various areas. Thus, the plant-bearing terrestrial deposits of Late Pliocene are widely scattered in nearly the whole of Japan excluding some regions such as southern Kwantô region, southern Kyûshû and southern Shizuoka district.

Table 1 shows each typical sequence and their correlation into the representative sedimentary basins of Japan; the marine and terrestrial sediments in each sequence are marked respectively.

2. Condition of preservation of Neogene plants

The materials forming the basis of the present study are mostly impressions of leaves, additionally of cones, fruits, seeds, samaras, etc. Fossil woods suitable for anatomical study of plants and fossil pollens fit for statistical analysis of flora, are not included in the materials for the

TABLE 1. Typical Sequence of Stratigraphy in Representative Neogene Sedimentary Basins of Japan.

Age \ Area		Hakkaidô			Northeastern Honshû			Kwantô and Shizuoka			Central & western Honshû			Kyushû	
		eastern	central	south-western	inner zone	interior region	outer zone	Jôban	Southern Kwantô	Shizuoka	Seto Depression	Hokuriku	San'in	North-western	South-eastern
Pliocene	Late	Hombetsu g. ✤ ⓑ	Fukagawa g. ⓑ	Setana f. ⓑ	Shibikawa ⓑ f. ▥	Oriwatari f. ✤	ⓑ Sendai g. ✤		Narita f. ▥	Soga g.	✤ Akashi g. ▥			Hirata f. ▥	
	Early			▥	Wakimoto f. ⓑ	Waraguchi ✤ f.		Hatsuzaki f. ⓑ Hitachi f.	Miura g. ⓑ	▥ Kakegawa g.	Seto g. ✤	Himi g.	Matsue g.	Minamitabira f. ✤	
Miocene	Late	ⓑ Atsunai g.	Shintotsugawa g. ⓑ	Kuromatsunai g. ⓑ	Kitaura f. ⓑ Funakawa ⓑ	✤ Obayashi f. ⓑ ⓑ Furukuchi f.	Akyu g. ✤	Taga g. ⓑ ⓑ Takaku g.	Awa g. ⓑ	Sagara g. ▥	▥	Otokawa g.	Furue f.	▥	Miyazaki g.
	Middle	ⓑ Chûrui f.	ⓑ Kawabata f. Takinoue f. ⓑ	Yakumo ⓑ f. Kunnui ⓑ f. Yoshioka f. ⓑ ✤	Onnagawa f. ⓑ Nishikurosawa f. ⓑ Daijima f. ✤	Kusanagi f. ⓑ Kanayama f.	Natori g. ✤ ⓑ	ⓑ Shirado g. ⓑ Yunagaya g. ✤	▥	Saigo g. Kurami f.	Mizunami g. "Hiramaki" f. ✤	Yatsuo g. Iwaine g.	Koura f. ✤ Hata f.	Nojima g. ✤ ▥ Kase f. ✤ ▥	▥
	Early		Asahi f. ✤ ⓑ	Fukuyama f. ✤	Monzen f. ✤ Akashima f.				Hota g. ⓑ		"Nakamura" f. ✤	Futomiyama g.		Sasebo g. ✤ ✤ Ainoura g.	Osuzuyama g.

: marine ✤ : terrestrial g. : group f. : formation present study, because the writer is unskillful in the investigation of them.

The remains of Neogene plants in Japan are mainly found with good preservation from the siltstone immediately above coal or lignite seams, or frequently tuffaceous siltstone or tuff of lacustrine sediments. The fossil plants from Miocene coal-bearing formations are generally preserved in the banded shales, which rocks were suited to preserve them without destruction owing to their calm deposition as indicated by fine stratification, etc.; these plants are represented mostly by leaf-impressions, among which the leaves have sometimes a few carbonized remains. Pliocene lignite-bearing formations frequently contain carbonized plant remains; hard materials such as seeds, nuts, cones, etc. are usually better-preserved than leaf remains. Generally speaking, the older the plant remains in age, the more leaf impressions abundantly occur than the other remains of plants.

Also tuff and tuffaceous rocks frequently preserve many leaf-impressions, or a few cones, seeds, etc., in Neogene lacustrine sediments. Considerable volcanism during Neogene time provided the wide distribution and accumulation of pyroclastic sediments throughout Japan. Ash and tuff seem to be suited by texture and mode of deposition to preserve the remains of plants.

V. Geologic Occurrence and Floristic Composition of Japanese Neogene Flora

1. General review

The Cenozoic floral change was once briefly reviewed by YABE and ENDO (1940) and also by the writer (TANAI, 1952). However, their descriptions contained some confusion or inconsistency, because these plant-bearing formations were not sufficiently examined by stratigraphical investigation. Lately, Neogene flora has been described from various localities in Japan by many authors, and consequently the floristic composition of each flora is comparatively well known at present.

The writer has collected many plant fossils from Tertiary sediments in Japan, from Hokkaidô in the north to Kyûshû in the south, and investigated the composition and components of representative floras in each stage of Tertiary time. On the basis of these investigations, the writer divided Neogene flora of Japan into six types, considering the floristic composition and components, along with the geological ages indicated by them. In ascending order, those types are: the Ainoura, Aniai, Daijima, Mitoku, Shinjô and Akashi types. The six type floras have, though different in age, several or occasionally many common components respectively, and corresponding with change of physical condition they show a gradual change in floristic composition, especially in the later stages of Neogene time.

Among the above-noted six type floras, the change from the Aniai type to the next succeeding Daijima type is most considerable, and these two types show a striking contrast in floristic composition: the Aniai type flora comprises mainly temperature or cool-temperate deciduous trees, on the contrary the Daijima-type consists mainly of warm-temperate trees, accompanying frequently by covering marine formations, which generally include examples of warm-sea fauna. The marine formations occasionally contain also plant fossils, most of which plants are Daijima-type species. The Mitoku-type flora found from Late Miocene lacustrine sediments, is characterized by mixed floristic composition of cool-temperate and warm-temperate elements, though the former elements are far more numerous than the latter. Namely, the Mitoku-type flora may be said in respect to composition to combine the character of the previous two types. However, the individual components of the Mitoku-type are mostly modernized, making this type entirely different from the previous two types in components. Since Late Miocene time, the older elements have gradually disappeared from the vegetable world of Japan, and changed to the Shinjô- and Akashi-types. These two types of Pliocene floras have many common components, and they are occasionally difficult of distinguishment from each other. However, the Shinjô-type flora contains more relics from the previous Mitoku-type than the Akashi-type.

Lately, the writer (TANAI, 1959) published an outline of Neogene floristic change in northeastern Honshû, Japan. This tendency of floral change rather coincides with the general history of floral change throughout the Japanese Islands. However, in the Japanese Archipelago lengthly extended from north to south, from Hokkaidô to Kyûshû, some regional difference of floristic composition is observed among the distantly separated of the same age. Such difference probably indicates the differential distribution of the forest, caused by the existence of climatic zones at that time. These difference shall be described in detail below.

2. Ainoura-type flora

The Sasebo coal field located in the northwestern part of North Kyûshû, is one of the productive fields of strong-coking coal in Japan. From the Sasebo group which includes the coal-bearing deposits in this field, well-preserved plant fossils abundantly occur as preliminarily reported by the writer (TANAI et ONOE, 1956). The Ainoura formation, the lowermost of the Sasebo group, has a characteristic flora which is mixedly composed of warm and temperate elements, and furthermore includes some Palaeogene elements. These fossil plants from the Ainoura formation are listed in Table 2, and their localities and stratigraphic horizons are shown in Figure 2.

As shown in Table 2, the fossil flora from the lower and middle parts of the Ainoura formation consists mainly of temperate or warm-temperate dicotyledons belonging to Betulaceae, Ulmaceae, Rosaceae, Leguminoceae, Tiliaceae, Alangiaceae, Styraceae, etc., accompanied by abundant conifers. Most of these temperate elements such as *Betula, Ulmus, Tilia, Alangium,*

TABLE 2. Component Species of the Ainoura-type Flora and their Main Localities in Japan

Localities Fossil Species	1	2	3
Metasequoia occidentalis	×	×	×
Glyptostrobus europeaus	×	×	×
Taxodium dubium	×		
Sequoia affinis	×		×
Salix varians	×	×	×
Juglans shanwangensis	×		×
Pterocarya asymmetrosa		×	
Alnus prenepalensis		×	
Alnus kefersteinii	×		×
Alnus sp.		×	
Betula miolumminifera	×		×
Betula uzenensis			×
Carpinus subcordata	×	×	×
Carpinus miofangiana		×	
Corylus macquarrii		×	
Corylus miochinensis		×	
Fagus antipofi	×		×
Ulmus pseudolongifolia		×	
Ulmus appendiculata		×	
Zelkova ungeri	×	×	×
Celtis sp.			×
Nelumbo nipponica	×	×	×
Cercidiphyllum crenatum		×	
Cocculus heteromorpha		×	
Berberis saseboensis	×	×	
Hydrangea lanceolimba	×		
Liquidambar mioformosana		×	
Hamamelis miomollis		×	
Rosa usyuensis	×	×	×
Sophora miojaponica	×	×	×
Cercis miochinensis	×	×	
Euonymus protobungeana	×		
Acer articum		×	
Acer ezoanum			×
Acer palaeodiabolicum		×	×
Tilia distans		×	×
Tilia subnobilis			×
Alangium aequalifolium	×	×	×
Alangium basiobliquum	×		
Cornus megaphylla	×		
Cornus saseboensis	×		
Styrax saseboense	×		×
Viburnum sp.			×

1. Kida coal mine (the basal part of the Ainoura formation)
2. Shinminato and Hino coal mines (the middle part of Ainoura formation)
3. Emukae coal mine (the uppermost of the Ainoura formation)

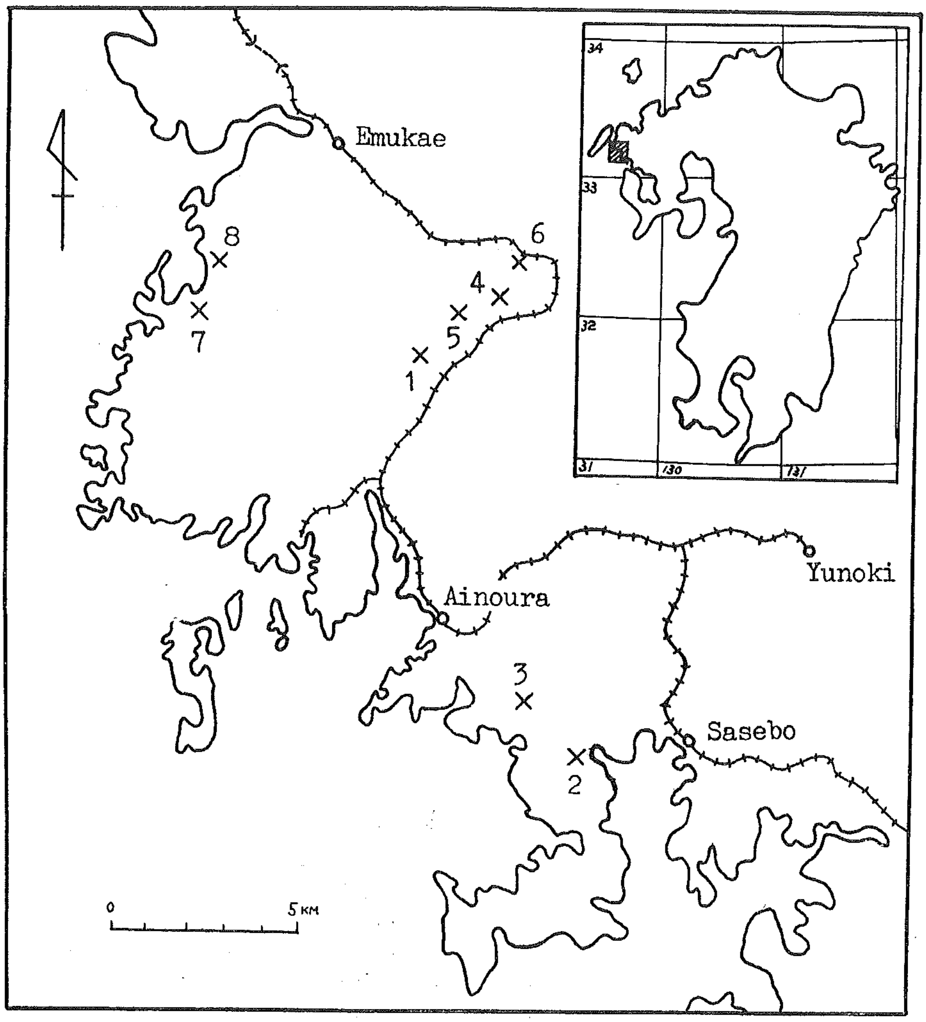

Fig. 2. Localities of Fossil Plants in the Sasebo Coal Field, Kyûshû, Japan.

1. Kida coal mine (the lower part of the Ainoura formation) 2. Shin-minato coal mine (the middle part of the Ainoura formation) 3. Hino coal mine (Do.) 4. Nakatoba old pit (Do.) 5. Nicchitsu-Eri pit (the uppermost part of the Ainoura formation) 6. Nicchitsu-Emukae pit (Do.) 7. Nittetsu-Shikamachi pit (the Yunoki formation) 8. Nittetsu-Hongaura pit (the upper part of the Fukui formation)

Metasequoia, are similar to the flora has commonly several warm or warm-temperate elements such as *Rosa*, *Berberis*, *Liquidambar*, *Sophora*, *Cercis*, which are not nearly included in the Aniai-type flora. It is also one of the characteristics of the Ainoura flora to have some Palaeogene species such as *Nelumbo nipponica, Acer arcticum* and *Alangium basiobliquum*. Considering from the number of specimens, the dominant genera occur in the following order—*Metasequoia, Alangium, Nelumbo, Styrax, Sophora, Berberis*, etc., while, the temperate genera such as *Betula, Alnus, Fagus, Ulmus, Zelkova* being common in Neogene flora of Japan on the whole are not so common in the Ainoura flora. Thus, the fossil flora having such floristic composition and components, was named the Ainoura-type flora by the writer, and considered by him to be one of the characteristic Early Miocene floras in Japan.

The fossil flora from the uppermost part of the Ainoura formation, consists mainly of materials from deciduous broad-leaved trees such as grow in temperate regions, and rather close to the Aniai-type flora in floristic composition and components. However, it has also several elements existing in the middle or lower Ainoura flora such as *Nelumbo, Rosa, Sophora*. Accordingly, the upper Ainoura flora seems to show a transitional composition from the Ainoura-type to the Aniai-type flora.

In the area along Yuya Bay, northwestern Yamaguchi Prefecture, the Hitomaru formation of brackish origin is distributed on the Palaeogene Ashiya group, and underlies the Middle Miocene Igami formation of marine origin with unconformity. The Hitomaru formation possesses many plant fossils as reported by IMAMURA (1951, 1959) ; this flora was named the Daibô flora by him. It comprises temperate elements such as *Ulmus, Zelkova, Acer, Carpinus* and warm elements such as *Liquidambar* and *Cinnamomum*. Furthermore, this flora contains some Palaeogene species such as *Platanus* cfr. *aceroides, Alangium* cfr. *basiobliquum*. Accordingly, the Daibô flora is closely similar to the Ainoura type flora in respect to floristic composition and components. However, this flora as known at present is poor in number of species, so that it should be investigated more precisely in future.

The Kita-aigi flora from central Shinano, Nagano Prefecture, was investigated by NATHORST (1888), KRYSHTOFOVICH (in YAGI, 1921) and ENDO (in FUJIMOTO, 1930), and has been considered to be probably Eocene-Oligocene in age. According to their floral lists, the Kita-aigi flora consists mainly of temperate elements such as *Juglans, Betula, Alnus, Fagus, Acer, Zelkova*, etc., and it is rather similar to the Aniai-type flora. However, there are some warm elements such as *Platanus, Cinnamomum, Castanea ungeri, Salvinia formosa*, etc. Accordingly, this flora is somewhat similar to the Ainoura-type in floristic composition, though not similar in floristic components.

The Ainoura-type flora has not yet been found in Japan except the

Sasebo coal field, but it may be expected to be found from the basal part of the so-called "green-tuff formation," which is widely distributed from southwestern Hokkaidô to the inner zone of Honshû.

3. Aniai-type flora

As already described by the writer (TANAI, 1959), many small coal fields are scattered in the inner zone of northeastern Honshû and southwestern Hokkaidô, some of which fields have workable bituminous coals. Excellently preserved plant fossils abundantly occur from these coal-bearing formations, which are generally contained in the upper part of the so-called green-tuff formation distributed in these regions. The fossil flora from these formations are to a considerable degree common in floristic composition and components, as already described by HUZIOKA (1949) and the writer (TANAI, 1955).

The Aniai-type flora consisted mainly of deciduous broad-leaved trees as grown in temperate regions and also commonly includes many coniferous trees. Among the broad-leaved trees, those belonging to Betulaceae, Ulmaceae and Aceraceae are plentiful in number of species and specimens. Especially, the family Betulaceae is most dominant, represented by temperate genera such as *Betula, Carpinus, Alnus, Corylus,* and *Ostrya.* The family Ulmaceae is represented by such genera as *Ulmus* and *Zelkova*; the fossil leaves of *Zelkova* are very abundant in number. Beside them, the temperate genera such as *Juglans, Pterocarya, Populus, Cercidiphyllum, Alangium* and *Tilia,* are also commonly found in this type flora. It is one of the striking characters that fossil leaves belonging to the genera *Quercus* and *Castanea* are nearly absent in the Aniai-type flora, though the remains of beech are very abundant. Among the conifers the family Taxodiaceae is dominant in number of specimens; in particular, the foliar shoots and cones of *Metasequoia* and *Glyptostrobus* are abundant, while those of *Taxodium* and *Sequoia* are rather rare. Though the fossil remains of Pinaceae are not so common in this type flora, fossil cone-scales or seeds of *Abies* and *Picea* are found. Furthermore, this type flora frequently includes some aquatic plants such as *Nelumbo, Hemitrapa* and *Salvinia.*

In short, the Aniai-type flora is represented by a floristic composition characterized by temperate or cool-temperate elements such as deciduous broad-leaved trees and conifers. Nearly all of the dicotyledons are deciduous trees in this type flora, while most floras belonging to this type scarcely contain the ever-green trees excepting coniferous trees. Namely, it is one of the characters of this type flora that southern warm elements are nearly absent.

Miocene floras having the above-described floristic composition, are found from various localities over Japan except Shikoku; in particular, they are abundantly scattered in northeastern Honshû and western Hokkaidô. The distribution of these floras is shown in Figure 3, and respective components of each flora are listed in Table 3. In the Aniai-type flora little regional difference of floristic composition and components is observed at each locality with some exception, though there is some difference in the relative abundance of specimens found. However, the Aniai-type flora in Kyûshû and Hokkaidô contains some Palaeogene elements such as *Platanus aceroides, Nelumbo nipponica, Alangium basiobliquum,* but they are nearly not found in Honshû.

Honshû

Miocene floras belonging to the Aniai type are widely distributed in Honshû. However, they are commonly found in northeastern and central Honshû, while they have been nearly not found in western Honshû up to the present. Such maldistribution of them is not due to insufficient investigation, but rather probably to the actual maldistribution of Middle Miocene sediments in Honshû.

In the inner zone of northeastern Honshû the so-called "green-tuff formation" is widely distributed as the basal of Neogene sediments. As already stated by the writer (TANAI, 1959), coal-bearing formations frequently develop in various limited areas of this region, occupying the middle part of the "green-tuff formation", namely the uppermost part of the Monzen stage. These coal-bearing formations have generally well-preserved plant fossils. For instance, in the Iwadate and Ani coal fields of Akita Prefecture and the Nishitagawa coal field in Yamagata Prefecture many excellently preserved plant fossils occur from the platy shale being immediately above the coal seams.

The Iwadate coal-bearing area is situated near the boundary between Aomori and Akita Prefectures, and has a few thin coal seams which were once mined. The Iwadate flora, as already reported by TAKAYASU (1950), apparently belongs to the Aniai-type in floristic composition and components, though it is rather poor in number of species. This flora consists mainly of several conifers such as *Picea, Metasequoia, Glyptostrobus,* etc. and many dicotyledons, among which plants Betulaceae, Ulmaceae and Acerceae are dominant. Furthermore, it has some aquatic plants such as *Nelumbo* and *Hemitrapa.*

In the Ani coal field situated in the northern part of Akita Prefecture, the Aniai coal-bearing formation is distributed in shred condition owing to

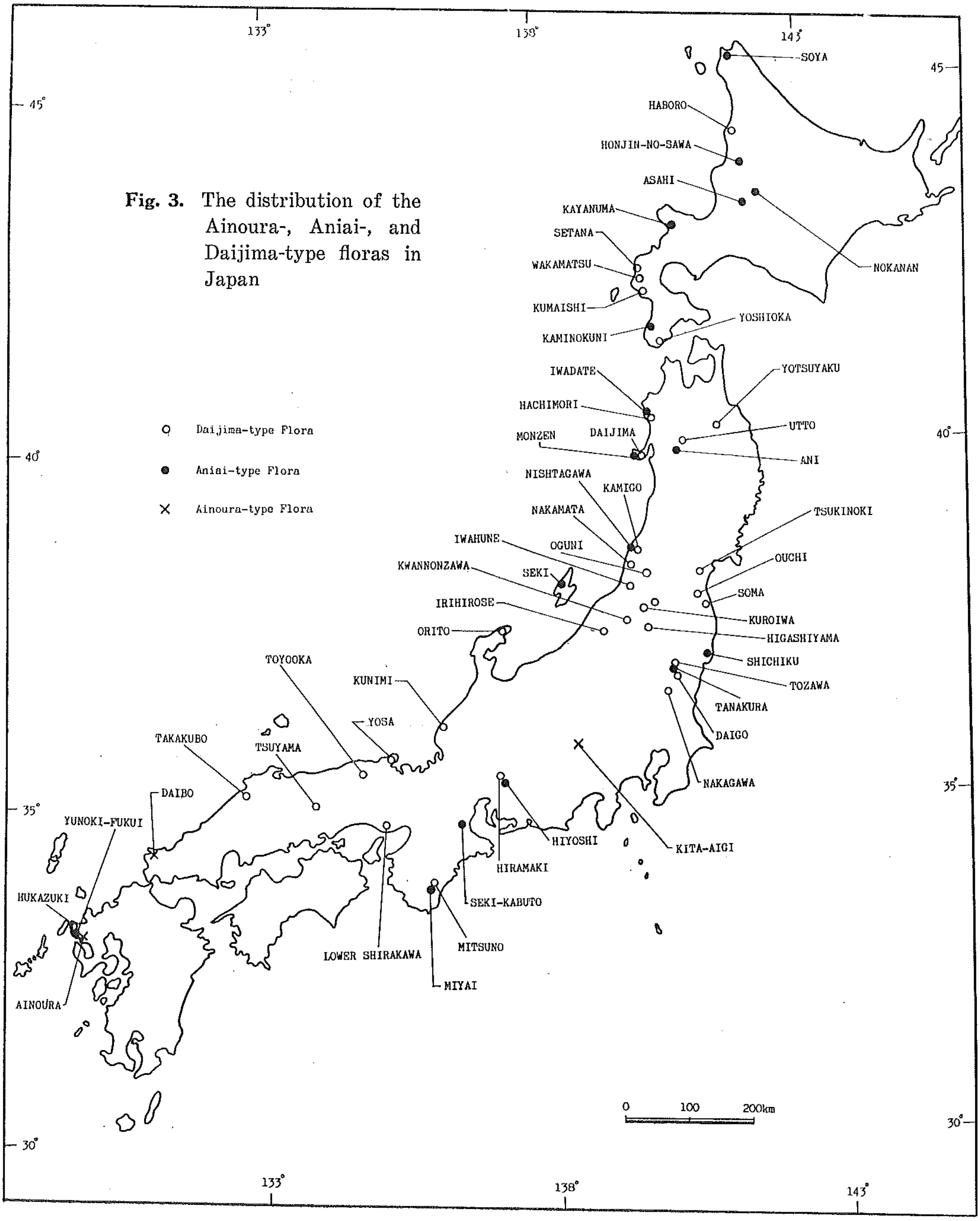

Fig. 3. The distribution of the Ainoura-, Aniai-, and Daijima-type floras in Japan

TABLE 3. Component Species of the Aniai-type Flora and their Main Localities in Japan

Fossil Flora / Fossil Species	Hokkaidô						Honshû					Kyûshû	
	1	2	3	4	5	6	7	8	9	10	11	12	13
Equisetum sp.	×												
Osmunda japonica	×												
Salvinia formosa			×c								×		
Abies honshuensis									×				
Keteleeria ezoana											×		
Picea miocenica											×		
Picea sugaii									×	×			
Picea kanoi						×		×			×		
Picea ugoana						×							
Picea magna						×			×		×		
Pseudolarix japonica											×		
Glyptostrobus europaeus	×a		×c	×	×	×	×	×a	×a		×	×	×
Metasequoia occidentalis	×a	×c	×a	×a	×		×	×a	×a	×c	×	×	×
Metasequoia miocenica									×	×			
Sequoia affinis													
Taxodium dubium								×	×				
Populus balsamoides	×c					×							
Populus latior						×		×					
Salix varians		×c	×		×			×					×
Myrica (Comptonia) naumanni			×										
Carya miocathayensis	×												
Juglans japonica	×										×		
Juglans miocathayensis	×								×				
Juglans shanwangensis										×			×
Platycarya miocenica											×		
Pterocarya asymmetrosa	×		×c			×	×	×	×	×		×	
Alnus kefersteinii	×										×	×	
Alnus arasensis								×	×				
Alnus prenepalensis												×	
Alnus usyuensis	×c					×c	×	×	×				
Betula mioluminifera	×		×	×		×c			×c	×a		×	
Betula uzenensis		×				×		×	×c				
Carpinus ishikiensis										×			
Carpinus kodairae-bracteata											×		
Carpinus miocenica											×		
Carpinus miofangiana	×					×		×		×c			×
Carpinus miofargesiana										×			

TABLE 3. (*Continued 1*)

Fossil Flora / Fossil Species	Hokkaidô						Honshû					Kyûshû	
	1	2	3	4	5	6	7	8	9	10	11	12	13
Carpinus shimizuii											×		
Carpinus simplicibracteata										×			
Carpinus s-satoi										×c			
Carpinus stenophylla											×		
Carpinus subcordata	×c	×	×c		×	×a		×	×c	×c		×	
Carpinus subyedoensis						×	×	×			×		
Corylus macquarii						×			×	×			×
Corylus miochinensis						×							
Ostrya huziokai	×					×				×	×		
Ostrya subvirginiana						×		×		×			
Castanea ungeri											×		
Fagus antipofi			×	×a	×	×	×	×	×a	×	×c		
Ulmus appendiculata	×		×a			×				×			
Ulmus carpinoides													
Ulmus longifolia			×			×c		×	×			×	
Ulmus shiragica			×	×c		×c	×	×c	×c	×			
Zelkova ungeri			×a			×	×	×a	×a	×a	×	×	×
Nelumbo endoana			×				×	×	×				
Nelumbo nipponica			×										
Cocculus heteromorpha				×						×			
Cercidiphyllum crenatum	×	×		×		×		×	×				
Magnolia nipponica											×		
Platanus aceroides			×	×	×	×							
Platanus guillelmae													
Sassafras subtriloba									×		×		
Hydrangea lanceolimba		×								×		×	
Hydrangea miobretschneideri												×	
Sorbus nipponica			×						×				
Prunus miobrachypoda	×												
Sophora miojaponica										×			
Wistaria fallax										×			
Acer ezoanum	×		×c			×		×	×c	×c	×		
Acer fatisiaefolia											×		
Acer nordenskiöldi									×				×
Acer palaeodiabolicum							×	×	×	×	×		
Acer palaeoplatanoides										×			
Acer palaeorufinerve						×							
Acer protonegundo										×			

TABLE 3. (*Continued 2*)

Fossil Flora / Fossil Species	Hokkaidô						Honshû					Kyûshû	
	1	2	3	4	5	6	7	8	9	10	11	12	13
Acer prototrifidium										×			
Acer protojaponicum						×				×c	×		
Acer pseudoginnala										×			
Acer subpictum	×		×a			×		×	×	×c	×	×	×
Aesculus majus	×	×		×	×		×	×	×c	×		×	
Aesculus miochinensis	×												
Tilia distans	×					×			×	×			×
Tilia miohenryana	×c												
Tilia subnobilis						×				×		×	×
Tilia protojaponica						×							
Alanguim aequalifolium	×	×		×				×	×c	×	×	×	×
Aralia celtisfolia										×			
Kalopanax acerifolium				×						×			
Hemitrapa borealis					×			×	×	×			
Hemitrapa yokoyamae							×	×					
Hemitrapa hokkaidoensis			×			×					×		
Cornus megaphylla	×												
Viburnum otukai									×			×	
Viburnum protoparvifolium									×	×			

Fossil Flora

1. Sôya 2. Honjin-no-sawa 3. Nokanan 4. Asahi 5. Kayanuma
6. Kaminokuni 7. Iwadate (HUZIOKA, MS) 8. Aniai 9. Nishitagawa
10. Shichiku 11. Hiyoshi 12. Yunoki 13. Fukui

faulting and igneous intrusion. This coal-bearing formation contains abundant well-preserved plant fossils at various localities of this field. These plant fossils were investigated by HUZIOKA (1949) and the writer. They represent mainly temperate genera. The Aniai flora, as listed in Table 3, consists of 27 species, representing 20 genera and 14 families. Twenty-one of the plants are dicotyledons, 4 are conifers. The largest family is the Betulaceae with 9 species representing 5 genera of *Alnus, Betula, Carpinus, Corylus* and *Ostrya*. The following genera are dominant in number of species: *Acer, Carpinus* and *Ulmus* with 3 species each, *Alnus* and *Betula* with 2 species each. All the remaining genera are represented by only one species. Conifers are *Picea, Glyptostrobus, Metasequoia* and *Taxodium*. Nearly all of the components of the Aniai flora, excluding some conifers and *Hemitrapa,* are familiar genera found now in Japan. In respect of relative abundance of specimens in this flora, *Metasequoia, Alnus, Betula, Carpinus, Ulmus, Zelkova, Fagus* and *Acer* are more abundant than other genera, and they occupy more than a half of the total specimens of this flora. The Aniai flora was originally considered as the typical flora of the so-called Aniai-type by HUZIOKA (1949), and it is, as already stated, characterized by a floristic composition comprising many temperate elements and their association.

The Nishitagawa coal field is situated in the western part of Yamagata Prefecture, along the coast of the Japan Sea. This field was one of the productive fields of strong-coking coal which is rarely found in Japan, however, at present that coal is nearly not mined because of complicated geologic structure. The Aburato and Iragawa coal-bearing formations, which are of the same horizon, contain abundant excellently preserved plant fossils. Though most of these plants have been already reported by the writer (1952), further investigation has been conducted with collection of more specimens. The Nishitagawa flora consists of 29 species, representing 7 conifers, 20 broad-leaved trees and 2 aquatic plants. In this flora conifers and dicotyledons such as Betulaceae, Ulmaceae and Aceraceae are abundant in number of species and specimens. The genus *Fagus* is comparatively abundant in number of specimens, and fossil leaves, bracts and bud-scales of beech (*Fagus antipofi* HEER) are commonly found. The abundant occurrence of this beech is one of the characteristics of the Aniai-type flora in the inner zone of northeastern Honshû. However, this beech species is not always confined in occurrence to the Aniai-type flora, and occasionally survives to the higher horizoned flora in several localities of southwestern Hokkaidô and northeastern Honshû as precisely described below. Thus, the Nishitagawa flora is, as listed in Table 3, quite similar to the Aniai-type flora in floristic composition and components. It is, however, somewhat peculiar as to the floristic composition that this flora has such southern element as *Sassafras.* This flora, along with the above-noted Iwadate and Aniai floras, contains some aquatic plants such as *Hemitrapa* and *Nelumbo,* which fact is probably related to the formation of coal. From these three floras Palaeogene survivals such as *Platanus* have not been found up to the present, though they are found from the Aniai-type flora of Hokkaidô.

The Jôban coal field lies along the Pacific coast, and it is one of the most productive fields in Honshû. Though the main coal-bearing formation in this field is of Oligocene age, thin Miocene lignite-bearing deposits (the Taki formation) are distributed in places on the base of Neogene sediments which unconformably overlie Palaeogene sediments or older rocks. From the lignite-bearing formation in northwestern part of the Iwaki district of this field, Miocene plants abundantly occur as lately reported by the writer (TANAI et ONOE, 1959). The Shichiku flora comprises 47 species, representing 26 genera and 19 families. As already described in detail, this flora apparently belongs to the Aniai-type in floristic composition and components. However, up to the present, some conifers *Glyptostrobus, Taxodium,* etc. and northern dicotyledons such as *Cercidiphyllum* have been not yet found from this field. On the other hand, these plants are commonly found in the above-described many floras belonging to the Aniai-type. The Shichiku flora has very abundant remains of Betulaceae, Ulmaceae and Aceraceae in number of species and specimens, and especially Betulaceae is most dominant, whereas fossils belonging to Fagaceae are very rare in this flora, and merely a few leaves of *Fagus antipofi* have been found. This flora contains almost not warm elements, though southern elements such as *Wistaria, Sophora* and *Aralia* are contained in it. In respect to habitat, mixed-slope elements occupy nearly 60 per cent of the Shichiku species, plants from the mixed-slope to stream-side about 26 per cent, upland plants about 8 per cent, and the remaining are reparian or marshy plants. Such habitat percentages of the components of this flora are generally similar to the other Aniai-type floras of northeastern Honshû and southwestern Hokkaidô.

A Miocene lignite-bearing formation which has been called the "Nakamura formation," is distributed in the southern part of Gifu Prefecture. It lies unconformably upon and irregular relief of granite or Palaeozoic rocks. It has been known that well-preserved plant fossils occur abundantly in this lignite-bearing formation. The writer has studied the plant fossils lately collected by T. ONOE from Hiyoshi district* of the Gifu lignite field. The Hiyoshi flora is composed of 30 species, representing by 8 conifers, 21 dicotyledons and only one aquatic fern. The largest family is Betulaceae with 7 species representing 3 genera of *Alnus, Carpinus* and *Ostrya*. The following genera are dominant in number of species: *Carpinus* and *Acer* 5 species each, *Picea* 2 species. All of the remaining genera are represented by only one species each respectively. Thus, the fossil remains of *Acer* and *Carpinus* are most dominant in number of species and specimens, followed by remains of conifers. It is very characteristic for this flora that rather northern elements such as *Betula, Ulmus,* etc. are almost never found, whilst some conifers such as *Pseudolarix* and *Ketele-*

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[*] This field is subdivided into several small basins such as the Hiyoshi, Mizunami, Mitake and Iwamura. These coal-bearing basins are isolated respectively.

eria are to be found. Furthermore, this flora has *Sassafras subtriloba* and *Castanea ungeri*, though specimens are very rare. The latter species is one of the representatives of the Daijima-type flora described in the next paragraph; it is abundantly found in that flora. The genus *Quercus* of the Fagaceae is, however, never found in the Hiyoshi flora, while it is very dominant in number of species and specimens in the Daijima-type flora as described in detail below. On the other hand, *Fagus antipofi* is very abundantly found in the Hiyoshi flora, which species is identified by many fossil leaves, bracts and bud-scales. In short, the Hiyoshi flora consists mainly of temperate genera being accompanied by several southern and warm-temperate elements, but never does it contain warm or subtropical elements such as are found in the Daijima-type flora. Thus, this flora is, on the whole, rather similar to the Aniai-type flora in respect to their floristic composition and components as seen in Table 3, though somewhat different from the typical flora of northeastern Honshû. Such difference of floristic composition is probably due to the ecological circumstance owing to geographical position that this flora is situated more southwards than the typical flora.

Besides the above-described floras, Miocene floras probably belonging to the Aniai-type are known from several localties of Honshû: for instance, the Monzen formation in Akita Prefecture, the Asakawa lignite-bearing formation in Fukushima Prefecture, the Suginoura formation in Sado Island of Niigata Prefecture and Seki-Kabuto coal-bearing formations in Mié Prefecture. These floras, however, have not yet been precisely studied or reported.

Kyûshû

In Kyûshû, Miocene floras have nearly not been known up to the present, except the flora from the Sasebo coal field lately found by the writer (TANAI et ONOE, 1956). This may be due to the fact that the most of the lower half of Miocene sediments are generally of marine origin. For instance, Middle Miocene sediments are comparatively widely distributed in southeastern Kyûshû. However, in nearly all of these areas lacustrine deposits bearing plant fossils have not yet been found.

As already stated above in paragraph 2, the uppermost part of the Ainoura formation in the Sasebo coal field, has a flora similar to the Aniai-type. The upper Ainoura flora consists mainly of Betulaceae, Ulmaceae, Aceraceae, Tiliaceae, conifers, etc., accompanied by some southern elements such as *Rosa, Sophora,* etc. It contains many leaves and roots of *Nelumbo nipponica* which is one of the relics from Palaeogene time. However, this flora does not contain so many southern exotic genera as the above-described Hiyoshi flora of Honshû, though the latter flora is in a more southern latitude than the former. Furthermore, the Aniai-type flora was found by the writer some time ago from the Yunoki formation conformably covering the Ainoura formation and also even from the Fukui formation which is younger than the Yunoki. The Yunoki-Fukui flora consists mainly of temperate genera of Betulaceae, Ulmaceae, Aceraceae and Tiliaceae, accompanied by conifers such as *Metasequoia* and *Glyptostrobus*. It is nearly lacking in southern or warm elements, and is nearly similar to the typical flora of the Aniai-type in regard to floristic composition and components. Why did such typical temperate flora grow in the same age in this district, which is located most southward among many localities possessing Aniai-type flora. It may be due to topographic environments or other physical conditions under which this flora was growing.

Hokkaidô

Miocene flora has previously hardly known in Hokkaidô, however, the writer found many plant fossils from Middle Miocene formations in various localities. The fossil floras belonging to the Aniai-type are mainly distributed in central and southwestern Hokkaidô, but nearly none in eastern Hokkaidô. Most of these plant-bearing formations contain several coal seams which are mined at present.

The Tempoku coal field in the northernmost part of Hokkaidô, has a great amount of Miocene brown coals: it is one of the great coal fields in Japan. The Sôya coal-bearing formation having several workable coal seams in this area, occupies the lower part of Neogene deposits, and yields abundant plant fossils, though not in very good preservation. The writer collected many plant fossils from the coal-bearing formation in the Horonobe, Koishi and Sôya coal mines (Fig. 4): their fossils are listed in Table 4. The fossil flora from the Sôya formation consists mainly of Juglandaceae, Betulaceae, Ulmaceae and Taxodiaceae, even though the components differ somewhat in the three localities. The temperate genera of their above-noted families are abundant in number of species and specimens, and most of them are similar to the components of the Aniai-type flora. The Sôya flora does not often include the specimens of Pinaceae and Aceraceae, and it is generally simpler in floristic composition than the Aniai-type flora in northeastern Honshû. Thus, the Sôya flora is almost lacking in warm elements, so that it seems to belong to the Aniai-type in floristic composition and components.

In the northeastern area of the Ishikari coal field, Miocene Nokanan

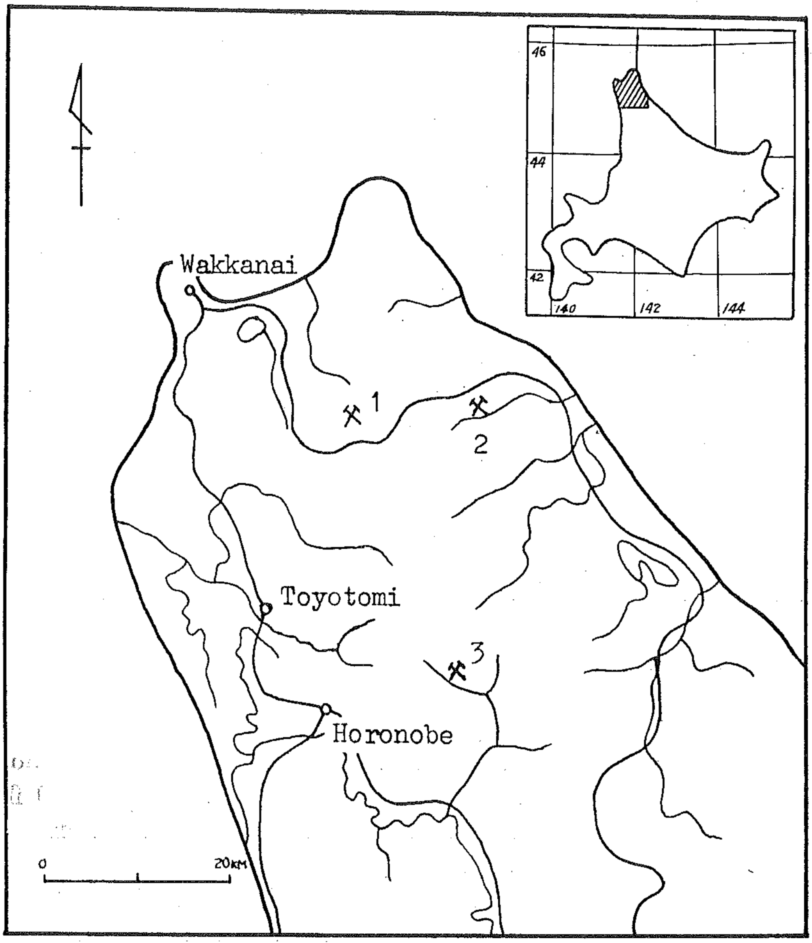

Fig. 4. Localities of Fossil Plants in the Tempoku Coal Field, Hokkaido.
1. Soya-Magaribuchi coal mine 2. Hokutaku-koishi coal mine
3. Horonobe coal mine

coal-bearing formation is distributed on a small scale on the Palaeogene Ishikari group, which is one of the most important coal-bearing deposits in Japan. The Miocene coal-bearing formation contains comparatively abundant plant fossils from black shale near coal seams. The Sakipempetsu flora, as shown in Table 3, entirely coincides with the Aniai-type in floristic composition and components. This flora consists mainly of *Metasequoia, Ulmus, Zelkova, Acer* and *Nelumbo.* It is, however, one of the characteristics of the floristic composition to include *Nelumbo nipponica*

TABLE 4. Fossil Flora of the Tempoku Coal Field, Hokkaido

Locality Fossil Species	1	2	3	Locality Fossil Species	1	2	3
Osmunda sp.	×	×		*Ostrya huziokai*	×		
Equistetum sp.		×		*Ulmus appendiculata*		×	×
Glyptostrobus europaeus	×c	×	×	*Cercidiphyllum crenatum*		×	
Metasequoia occidentalis	×a	×a	×	*Prunus miobrachypoda*		×	
Populus balsamoides		×c	×	*Acer ezoanum*			×
Juglans miocathayensis		×		*Acer subpictum*		×	×
Juglans japonica		×	×	*Aesculus majus*	×		
Carya miocathayensis		×c	×	*Aesculus miochinensis*	×	×	
Pterocarya asymmetrosa		×		*Tilia distans*		×	
Alnus kefersteinii	×	×		*Tilia miohenryana*		×	
Alnus usyuensis	×	×c	×	*Alangium aequalifolium*		×	
Betula mioluminifera		×c		*Cornus megaphylla*			×
Carpinus miofangiana		×		*Buxus protojaponica*		×	
Carpinus subcordata	×	×	×				

Locality

1. Sôya-Magaribuchi. 2. Hokutaku-koishi. 3. Horonobe.

and *Platanus aceroides*, which usually occur from the coal-bearing formations of the Palaeogene Ishikari group. *N. nipponica* is, as already stated, known from the Ainoura flora of Early Miocene age, and this species from the Miocene Sakipempetsu flora seems to have been a relique from Palaeogene flora.

In the northern part of the Yûbari district of the Ishikari coal field, Miocene Asahi coal-bearing formaiton is distributed in certain localities upon the Palaeogene formation with unconformity. This Asahi coal-bearing formation occupying the basal part of Neogene sediments in this area, commonly yields plant fossils. It is underlain by marine sediments having Miocene marine molluscs such as *Yoldia biremis* UOZUMI, *Spisula onnechuria* (OTATSUME), *Thracia asahiensis* UOZUMI, etc. The Asahi flora, though not so abundant in number of species, consists mainly of conifers such as *Metasequoia* and *Glyptostrobus*, and temperate dicotyledonous genera such as *Carpinus*, *Ulmus*, *Cercidiphyllum*, *Aesculus* and *Alangium* shown in Table 3; it shows apparently typical characteristics of the Aniai-type flora in floristic composition and components. Furthermore, this flora rarely contains *Platanus aceroides* also which is a relic of Palaeogene elements.

The Kayanuma coal field is situated in the northern part of southwestern Hokkaidô, and is one of the productive fields of strong-coking coal in Japan. This field has a complicated structure resultant from folding, faulting and igneous intrusion. The Kayanuma coal-bearing formation occupies the middle part of the so-called "green-tuff formation" which is widely distributed in southwestern Hokkaido; it probably occupies the uppermost part of the Fukuyama formation of Middle Miocene age. From this coal-bearing formation, some plant fossils are occasionally found, however, they are poor in number of specimens and preservation. The Kayanuma flora, though poor in number of species as far as known at present, probably belongs to the Aniai-type flora: it consists mainly of temperate dicotyledons such as *Betula, Carpinus, Fagus* and *Acer,* containing some coniferous trees. This flora contains also *Platanus aceroides* GEOP. and *P. guillelmae* GOEP. as relics of Palaeogene elements.

The Kaminokuni coal-bearing area is situated in the southwestern part of southwestern Hokkaidô. The coal-bearing sediments occupy the uppermost part of the Fukuyama formation, which is widely distributed overlying on Palaeozoic rocks in this region. From the coal-bearing formation in this area, plant fossils frequently occur; they are comparatively well-preserved and abundant in number of specimens. The Kaminokuni flora, as listed in Table 3, comprises 41 species, representing 23 genera and 15 families. Thirty-five of the plants are dicotyledons, five are conifers, and the remaining one is *Equisetum.* The largest family is the Betulaceae with 13 species representing 5 genera of *Alnus, Betula, Carpinus, Corylus* and *Ostrya.* The following genera are dominant in number of species: *Acer* with 5 species, *Tilia* with 4, *Carpinus* and *Ulmus* with 3 each. All the remaining genera are represented by one or two species. In the Kaminokuni-flora, the temperate genera of Betulacae, Ulmaceae, Aceraceae and Tiliaceae are dominant in number of species and specimens. Nearly all of the remaining genera, excluding only one extinct genus of *Hemitrapa,* are commonly living at present in Japan ad China. There are nearly no warm or warm-temperate genera in this flora. Accordingly, the Kaminokuni flora apparently has the typical floristic composition of the Aniai-type flora, and consists of characteristic components of that type flora. However, the Kaminokuni flora has also *Platanus aceroides* which must have survived from Palaeogene flora.

Beside the above-described floras, some Miocene floras belonging to the Aniai-type have been found in Hokkaidô by the writer, though they are very poor in number of specimens and species. For instance, the Honjin-no-sawa coal-ebaring formation in the southern part of the Rumoé coal field and Niikappu coal-bearing formation in the eastern part of the Hidaka coal-bearing area, frequently yield ill-preserved plant fossils. These two floras, as listed in Table 3, are composed mainly of Aniai-type components, though they are poor in number of species. However, these flora should be further investigated in future after obtainment of more specimens.

In short, the Aniai-type flora in Hokkaidô is nearly uniform in its floristic composition, and from the various localities is composed mainly of same components. However, the Sôya flora located in northernmost Hokkaidô is more or less simpler in floristic composition and components than the others. This type flora of Hokkaidô entirely lacks warm or southern elements which are rarely contained in the Aniai-type flora of Honshû, while there are some Palaeogene relics in Hokkaidô.

4. Daijima-type flora

In the Middle Miocene, the marine transgression extended over the Japanese islands with some exception, and consequently the deposition at this tim occurred with wide extension. Most of the sediments known to have been laid down since this age are generally marine origin, while small scale lacustrine or littoral sediments are frequently found from various localities of Japan. These lacustrine sediments are lenticularly developed, or partially intercalated in marine sediments. That is to say, most of these non-marine sediments seem, in general, to have been earlier products in the considerable transgression of Middle Miocene age. From such lacustrine sediments have been frequently found a characteristic floras in various localities of Japan, which is called the Daijima-type flora.

The Daijima-type flora is generally characterized by the facts that the coniferous tree were comparatively rare whilst the ever-green trees were abundant in number of species and specimens, though local differences in floristic composition are more or less found. This flora, of course, includes many deciduous trees, but the ever-green trees commonly occupy more than 40 per cent of the total species of this flora, occasionally attaining about 80 per cent. As shown in Table 5, among the broad-leaved trees the remains of Fagaceae, Juglandaceae, Hamamelidaceae, Lauraceae, Leguminoceae, Aceraceae are very abundant in number of species and specimens, especilly the family Fagaceae is most dominant. It is one of the most common characters in the Daijima-type flora that *Quercus, Castanea* and others of the Fagaceae are very abundant in number of species and specimens. The remains of Betulaceae and Ulmaceae such as *Alnus, Carpinus, Ulmus, Zelkova,* etc. are also commonly found; however, most

TABLE 5. Component Species of the Daijima-type Flora and their Main Localities in Japan.

Fossil Flora / Fossil Species	Hokkaidô				Northeastern Honshû												Western Honshû						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Salvinia formosa							×													×			
Salvinia pseudoformosa									×														
Abies aburaensis	×	×																					
Abies n-suzukii	×																						
Keteleeria ezoana		×		×a																			
Picea miocenica	×																						
Picea kanoi	×																						
Picea magna	×	×																					
Picea ugoana	×c	×																					
Pinus palaeopentaphylla				×													×						
Pinus miocenica	×	×	×	×		×				×							×	×			×		
Pinus fujiii																	×						
Pseudolarix japonica				×																			
Pseudotsuga ezoana		×																					
Tsuga aburaensis	×																						
Tsuga miocenica	×	×		×																			
Cunninghamia protokonishii									×														
Glyptostrobus europaeus	×c				×	×														×		×	×
Metaseuoia occidentalis	×c	×		×	×	×			×	×						×	×	×	×	×	×	×	×
Taiwania japonica	×			×													×						
Populus balsamoides		×					×						×							×			
Populus latior	×						×																
Myrica (Comptonia) naumanni	×	×	×a	×	×	×a			×a	×a	×	×	×			×a	×		×	×		×	×
Carya miocathayensis	×	×	×	×					×	×							×						
Juglans japonica		×														×							

Juglans shanwangensis						×											×						
Platycarya miocenica	×																×				×		
Pterocarya asymmetrosa	×	×					×	×	×c	×		×		×	×	×			×		×		
Alnus kefersteinii	×																×			×			
Alnus miojaponica	×	×							×														
Alnus protomaximowiczii		×		×																			
Betula kamigoensis						×			×														
Betula mioluminifera	×																×						
Betula nipponica				×																	×		
Carpinus miocenica									×		×		×			×	×		×		×		
Carpinus miofangiana	×	×		×		×																	
Carpinus miofargesiana																	×						
Carpinus shimizui									×					×			×						
Carpinus subcordata	×	×		×c	×							×		×				×					
Carpinus subyedoensis	×	×												×	×		×						
Ostrya huziokai	×														×		×						
Castanea ungeri	×	×		×a	×	×	×	×	×a	×a	×c	×	×	×a	×	×c	×	×	×	×	×a		×
Fagus antipofi	×a	×			×	×			×									×			×		
Quercus koraica								×			×			×									
Quercus mandraliscae					×	×a	×	×	×c	×	×	×	×	×c		×	×	×			×		
Quercus miocrispula		×																					
Quercus nathorsti						×					×		×	×c									
Quercus sinomiocenicum		×a		×		×								×							×		
Quercus subvariabilis		×a		×a		×a			×c	×		×		×a			×			×			
Celtis miobungeana									×					×									
Pteroceltis ezoana	×																						
Ulmus carpinoides										×											×		
Ulmus longifolia	×									×			×	×			×	×		×			×
Ulmus subparvifolia						×			×						×								
Zelkova ungeri	×	×	×	×	×	×c	×		×a	×	×		×	×	×	×c	×	×			×c	×	×

TABLE 5. *(Continued)*

Fossil Flora / Fossil Species	Hokkaidô				Northeastern Honshû												Western Honshû						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Fothergilla viburnifolia			×	×c						×				×c		×	×	×			×		
Liquidambar mioformosana	×			×c		×c	×	×	×	×c	×		×	×		×	×	×	×	×			×
Eucommia japonica									×														
Magnolia nipponica		×		×																			
Actitodaphne nipponica						×								×									
Cinnamomum miocenum										×			×				×						×
Cinnamomum oguniense								×	×	×			×	×				×					
Lindera gaudini														×									
Machilus ugoana							×			×	×			×									
Neolitsea japonica						×								×									
Parabenzoin protopraecox				×					×					×c									
Sassafras subtriloba	×			×																			
Rosa usyuensis				×					×			×		×									
Entada mioformosana									×						×		×						
Sorbus nipponica				×																			
Sophora miojaponica						×			×						×						×		
Robinia nipponica		×							×														
Pistacia miochinensis									×														
Rhus ezoense				×																			
Rhus miosuccedanea						×			×	×					×	×	×						
Rhus protoambigua				×																			
Dilodendron sp.									×						×								
Dodonaea japonica									×	×					×								
Sapindus kaneharai									×							×	×						
Buxus protojaponica																		×					
Acer ezoanum	×	×		×a													×						

Acer fatisiaefolia	×			×																			
Acer megasamarum	×																						
Acer nordenskiöldi									×											×			
Acer palaeodiabolicum	×	×		×c					×								×				×		
Acer palaeoplatanoides				×																			
Acer palaeorufinerve				×																			
Acer protodistylum				×																			
Acer prototataricum	×			×																			
Acer prototrifidium																	×			×			
Acer protonegundo	×			×																			
Acer protojaponicum	×	×		×													×						
Acer pseudoginnala		×		×					×														
Acer subpictum	×	×		×					×								×	×		×			×
Tilia distans	×	×													×		×						
Alangium aequalifolium						×	×			×	×		×	×a	×	×c			×	×	×		×
Aralia miobippinata									×														
Aralia yabei							×																×
Diospyros miokaki						×								×			×						×
Fraxinus sp.		×													×								
Hemitrapa borealis		×					×										×						
Hemitrapa yokoyamae		×					×																
Smilax trinervis							×			×		×											

Fossil Flora

1. Setana 2. Wakamatsu 3. Kumaishi 4. Yoshioka 5. Hachimori 6. Uttô 7. Daijima (HUZIOKA, 1949) 8. Kuroiwa (SUZUKI, 1959) 9. Kamigô 10. Oguni 11. Kannonzawa (KRYSHTOFOVICH, 1926) 12. Irihirose 13. Tsukinoki (OKUTSU, 1955) 14. Ouchi 15. Higashiyama (SUZUKI, 1959) 16. Daigo 17. Orito 18. Hiramaki 19. Kunimi (HUZIOKA, 1955) 20. Toyooka (ISHIDA, MS) 21. Yosa 22. Takakubo (OKAMOTO, 1959)

of the nearest living equivalent species of their fossils are rather southern elements or widely-distributed species. Abundant occurrence of Lauraceae is also one of the characters of this flora; southern genera such as *Actinodaphne, Cinnamomum, Lindera, Machilus, Neolitsea, Parabenzoin* and *Sassafras* are commonly found, although some of them are locally not found. Beside these genera of Lauraceae, many southern genera of warm or subtropical region are frequently contained in this type flora: for instance, *Liquidambar* and *Fothergilla* of Hamamelidaceae, *Dodonaea* and *Sapindus* of Sapindaceae, *Entada* and *Robinia* of Leguminoceae, *Pistacia* of Anacardiaceae, *Reevesia* of Sterculiaceae, etc. Conifers are, in general, not so common in this type flora of Honshû, but rather commonly found in Hokkaidô. *Metasequoia, Glyptostrobus, Cunninghamia, Taiwania* of Taxodiaceae and *Pinus* of Pinaceae of frequently found from various localities of Honshû and Hokkaidô. In particular, southern genera such as *Cunninghamia* and *Taiwania,* have never been found in the above-described Aniai-type flora up to the present. Furthermore, it is interesting that *Pseudolarix* and *Keteleeria* are found from the Daijima-type flora in several localities.

In short, the Daijima-type flora shows a mixed floristic composition of ever-green and deciduous broad-leaved trees and conifers; it consists mainly of warm-temperate or subtropical trees, accompanied by temperate decidous broad-leaved trees and conifers. Accordingly, it exhibits a striking difference of floristic composition in contrast with the Aniai-type flora which consists mainly of temperate or cool-temperate trees. As already stated (TANAI, 1955), considering the nearest equivalent living species of the Daijima-type species, this flora is closely related to the present flora of Formosa, or of central to southern China.

The Daijima-type flora is very widely distributed in Hokkaidô and Honshû as shown in Fig. 3, however nearly not in Shikoku and Kyûshû, because, Miocene sediments are nearly non-existent in Shikoku, while they are generally of marine origin in Kyûshû.

Northern Honshû

The Daijima-type flora is commonly distributed in Honshû, in particular it is abundantly found in northeastern Honshû. The plant-bearing formations are not only widely distributed in that region, but also palaeobotanical research of Miocene sediments there is comparatively more advanced than in the other regions of Honshû.

In the eastern and southern part of the Nishitagawa coal field, Yamagata Prefecture, the plant-bearing sediments called the Kamigô formation by the writer (TANAI, 1952), are distributed upon the coal-bearing formation. The various plant fossils occurred from tuffaceous siltstone, are excellently preserved, and abundant in number of specimens. The Kamigô flora, as listed in Table 5, comprises 35 species, represented by 26 genera and 15 families. Only one is an aquatic fern, *Salvinia,* 2 conifers are *Metasequoia* and *Cunninghamia*, and the remaining 31 species are dicotyledons. Among these latter, *Castanea* and *Quercus* are most abundant in number of specimens, with *Myrica* (*Comptonia*), and *Parabenzoin* of Lauraceae are commonly found in this flora; furthermore several warm-temperate or subtropical genera such as *Dodonaea, Entada, Pistacia, Dilodendron,* etc. are found, though they are rare in number of specimens. It is interesting that *Eucommia* was found from this flora. The only one living species of this genus is constricted in distribution to southern China at present. The Kamigô specimen is the first occurrence of *Eucommia* from Middle Miocene flora of Japan. The ever-green broad-leaved trees of the Kamigô flora supply more than 30 per cent of the total number of dicotyledon species. However, fossil remains of many indetermined plants having coriaceous leaves have been obtained up to the present by the writer, so that the actual percentage of ever-green trees is probably larger than that of dicotyledons. On the other hand, among the 26 genera, about 70 per cent consist of southern genera which are luxuriantly growing at present from warm-temperate to subtropical region. Thus, the Kaimgô flora is quite similar to the typical Daijima-type flora in floristic composition and components.

In the Oga peninsula of Akita Prefecture, the lacustrine Daijima formation overlies the "green-tuff formation" of Monzen stage with an unconformity, and underlies the marine Nishikurosawa formation. The Nishikurosawa formation contains warm-current marine fossils such as *Miogypsina* and *Operculina,* and is one of the typical Middle Miocene sediments in Japan along with the Daijima formation. The stratigraphic sequence in the Oga peninsula is accepted as one of the standard sections in northeastern Honshû. It has been known from many years ago that plant fossils such as *Myrica*(*Comptonia*) and *Liquidambar,* occur from the Daijima formation, however no precise description of this flora has yet been given. Though the Daijima flora was lately studied in detail by HUZIOKA (1949), its whole floristic components have not yet been published. According to the preliminary note of HUZIOKA (1950), this flora comprises 35 species, representing 29 genera and 21 families. Thirty plant species are dicotyledons, 2 are monocotyledons, another 2 are conifers, and remaining one is an aquatic fern. In this flora *Castanea, Quercus, Litho-*

carpus of Fagaceae, *Cinnamomum* and *Machilus* of Lauraceae are abundant in number of species and specimens. Beside them, southern genera such as *Pittosporum, Liquidambar, Ilex, Camellia, Ternstroemia, Kadsura, Smilax,* are found. Thus, this flora comprises mainly warm elements such as the above-noted ever-green trees, with some temperate trees accompanying such as *Ulmus, Carpinus* and *Acer.* In brief the Daijima flora was originally considered as a typical flora of this type by HUZIOKA (1949), and it is represented by a characteristic floristic composition and components, as already described by the writer (TANAI, 1955).

In the Ani coal field of Akita Prefecture, the Uttô formation is distributed on the Aniai coal-bearing formation with conformity. The Uttô formation is mostly of marine origin, but partially intercalated by lacustrine sediments which contain excellently-preserved plant fossils. The writer investigated many such fossils collected by OSAWA from various localities of this district. The Uttô flora contains abundant leaves of the characteristic Daijima species such as *Castanea ungeri, Quercus subvariablis, Q. mandraliscae* and *Myrica (Comptonia) naumanni* as listed in Table 5. It is also characteristic that *Actinodaphne* and *Neolitsea* of Lauraceae are included, while temperate genera are rare. Accordingly, the Uttô flora is, though somewhat poor in number of species, closely similar to the Daijima-type in floristic composition and components.

In the environs of Oguni-machi, southwestern Yamagata Prefecture, the Oguni plant-bearing formation overlies the green-tuffs with conformity. The Oguni flora was once investigated by MORITA (1932, 1933), who described several species. Then, the present writer collected more specimens in order to re-examine this flora. It consists of 20 species representing 18 genera and 12 families. The Oguni flora has abundant specimens of *Castanea, Quercus, Cinnamomum, Machilus* and *Smilax* as many as the above-described three floras. Furthermore, it contains fossil capsules of *Dodonaea,* which is now living in the subtropical region. Considering the floristic composition and components, the Oguni flora quite evidently belongs to the Daijima-type as already pointed out by HUZIOKA (1949) and the writer (1955).

The Tsugawa formation unconformably everlies older granitic rocks in the neighbourhood of Tsugawa-machi, eastern Niigata Prefecture. This formation has lacustrine plant-bearing beds in the basal part of it, which beds are conformably covered by marine sediments containing marine fossils such as *Miogypsina* and *Operculina.* This flora which has been called the Kwannonzawa flora, was once investigated by KRYSHTOFOVICH (1926). The Kwannonzawa flora is also quite similar to the Daijima-type owing to the abundant occurrence of *Quercus, Castanea, Liquidambar* and *Myrica (Comptonia)*.

Beside these above-described floras, Miocene floras probably belonging to the Daijima-type are scattered in the inner zone of northeastern Honshû: for instance, in the Hachimori oil field of Akita Prefecture, Iwafune, Irihirose and Nakamata of Niigata Prefecture. In these districts, the plant-bearing terrestrial sediments lie on the so-called green-tuff with conformity or slight unconformity, and they are occasionally accompanied by some thin coal seams. All of these fossil floras found from these various localities by the writer, consist mainly of *Myrica (Comptonia) naumanni, Castanea ungeri, Quercus subvariabilis, Q. mandraliscae, Liquidambar mioformosana* and *Cinnamomum miocenum,* most of which species are representative components of the Daijima-type flora. These floras frequently contain some conifers such as *Metasequoia* and *Glyptostrobus.*

The Daijima-type flora is also commonly distributed in the outer zone of northeastern Honshû, especially in the areas surrounding the Abukuma Plateau as shown in Fig. 3.

In the neighbourhood of Ôuchi-mura, southernmost part of Miyagi Prefecture, the terrestrial sediments lie on granitic rocks of the Abukuma Plateau with unconformity. In these sediments composed of tuffaceous siltstone, tuff and sandstone, well-preserved plant fossils occur abundantly. The writer had a chance to investigate these plant fossils lately collected by ONOE. This flora called the Ôuchi flora, comprises 28 species, representing 23 genera and 13 families. As listed in Table 4, the Ôuchi flora consists mainly of Fagaceae, Lauraceae, Hamamelidaceae, Ulmaceae, Alangiaceae and Myricaceae, which are abundant in the order given. Their specimens occupy more than 80 per cent of the totals number of specimens of this flora. The family Lauraceae is represented by 6 genera such as *Cinnamomum, Actinodaphne, Machilus, Neolitsea, Lindera* and *Parabenzoin,* though they are not so abundant in number of specimens. On the other hand, Fagaceae represented by 2 genera of *Castanea* and *Quercus,* is most abundant in number of species and specimen. Hamamelidaceae is represented by 2 exotic genera of *Fothergilla* and *Liquidambar,* specimens of which are also commonly found from this flora. Ulmaceae represented by *Celtis, Ulmus* and *Zelkova,* is rather rare except the last genus. It is one of the characters of the Daijima-type flora that *Myrica* (*Comptonia*) is commonly found. Thus, it is characteristic that temperate genera are comparatively rare in this flora, whereas, on the contrary, southern elements, warm or subtropical trees, are abundant. Thus, the Ôuchi flora may be said to be entirely similar to the Daijima-type in its floristic composition and components.

In the area surrounding Tsukinoki-machi, southern part of Sendai City, the Miocene Tsukinoki formation composed of tuffaceous rocks, is widely distributed. This formation has been known from old times to contain abundant plant fossils. It has been considered as a terrestrial equivalent of the marine Moniwa formation which is distributed near Sendai. The Tsukinoki flora has been studied by various authors; lately OKUTSU (1955) reported the details of its floristic composition. According to OKUTSU's research, the Tsukinoki flora comprises 48 species, representing 38 genera and 23 families. Among these plants, Fagaceae and Lauraceae are dominant in number of species over the other families. This flora also displays such Daijima-type species as *Liquidambar mioformosana* and *Myrica naumanni,* though temperate elements such as *Populus, Salix, Carpinus* and *Ulmus* are commonly contained. Namely, the Tsukinoki flora probably belongs to the Daijima-type, on the basis of the floristic composition.

In the Daigo coal-bearing area situated between the Abukuma and Yamizo mountains of northernmost Kwantô region, Miocene sediments are thickly developed unconformably on the older rocks. The Asakawa formation frequently with intercalating thin coal seams, occupies the basal part of these Miocene sediments; it is covered by marine sediments containing *Miogypsina* and *Operculina.* The Asakawa formation being of terrestrial origin, frequently furnishes well-preserved plant fossils. Some of these plants have already been described by NATHORST (1888). The present writer collected many specimens from several localities in western and northern areas of Daigo-machi. The Asakawa flora has abundant leaves of *Myrica (Comptonia) naumanni, Castanea ungeri, Quercus mandraliscae, Q. subvariabilis, Liquidambar mioformosana, Alangium aequalifolium, Zelkova ungeri* and *Carpinus miocenica,* though it is somewhat poor in number of individual species. The leaves of Lauraceae are comparatively rare, but this flora is generally similar to the typical Daijima-type in floristic composition and components. Beside these three floras, Miocene sediments including the Daijima-type flora, are scattered in the area surrounding the Abukuma Plateau: for instance, the Tozawa coal-bearing formation in the Shirakawa coal field, the Nakagawa group in the environs of Karasuyama-machi, western part of the Yamizo mountains, the Yanagawa formation in the northeastern part of Fukushima City, the Miocene coal-bearing formation in the Sôma coal field. The fossil floras from these terrestrial or lacustrine formations include many remains of Fagaceae, Lauraceae, *Myrica* and *Liquidambar,* so that they are considered probably to belong to the Daijima-type.

Neogene flora in Fukushima Prefecture has been investigated by SUZUKI, and a part of his research was lately reported (SUZUKI, 1959). On the basis of the floristic composition listed by him, it seems that Higashiyama, Kuroiwa, Higashidate and Oodaira floras probably belong to the Daijima-type. The former two floras consist mainly of warm or subtropical and temperate elements; they are closely similar to the typical flora of the Daijima-type. On the other hand, the latter two, the Kuroiwa and Oodaira floras, include a larger number of temperate elements than of warm elements, as pointed out by SUZUKI. However, the latter two are composed mostly of typical the Daijima-type species, so that such observed difference of floristic composition may be due to insufficient collection.

In the environs of Fukuoka-machi, northern Iwate Prefecture, Miocene sediments are distributed on Palaeozoic rocks with unconformity. The Yotsuyaku formation underlies the Kadonosawa marine formation containing the Kadonosawa marine fauna which has been regarded as a typical Middle Miocene fauna. Many plant fossils were reported from the Yotsuyaku formation being of terrestrial origin by OTUKA (1934). This Yotsuyaku flora consists mainly of warm and temperate trees, and probably belongs to the Daijima-type.

Central and Western Honshû

In comparison to those from northeastern Honshû, Miocene floras belonging to the Daijima-type have been not so abundantly found up to the present in central and western Honshû. That is not due to the fact that plant-bearing sediments of this stage are poor in distribution in these districts, but rather due to the fact that the investigation of Miocene flora in these districts has not yet sufficiently progressed. In actual fact, lacustrine sediments containing some Miocene plants such as *Myrica (Comptonia) naumanni* and *Liquidambar*, have been frequently reported from various areas of these districts by many geologists; however, the floristic composition has been little touched upon up to the present.

In the Noto peninsula, Miocene sediments are widely distributed, accompanying by pyroclastic materials. The Orito member of the Higashi-innai formation which occupies the middle part of these Miocene sediments, abundantly offers excellently-preserved plant fossils as reported by ISHIDA and MASUDA (1956). The lacustrine Orito member is nearly equivalent to or slightly lower than the marine Fujio member which contains a Miocene warm-sea fauna represented by *Miogypsina, Operculina* and *Vicarya.* According to ISHIDA, the Orito flora comprises more than 40 species, most of which are warm or warm-temperate trees, but including several subtropical trees. Lately, the writer was able to investigate hastily ISHIDA's collections stored in Kyôto University through his kindnes. The larger families in this flora are Juglandaceae, Betulaceae, Fagaceae, Lauraceae, and Aceraceae in view of number of species, whilst Fagaceae and Lauraceae are most dominant in number of specimens. In more detail, *Quercus, Castanea, Lithocarpus* of Fagaceae and, *Cinnamomum* and *Machilus* to Lauraceae are abundant in number of species or specimens. Conifers are also commonly found, however, most of them are rather southern elements such as *Taiwania, Cunninghamia, Pinus, Keteleeria* and *Libocedrus*. Beside these trees, there are many other southern genera such as *Cercis, Entada, Sapindus, Dodonaea, Liquidambar* and *Fothergilla* which are commonly found in the typical flora of the Daijima-type in northeastern Honshû. On the other hand, this Orito flora has several temperate genera such as *Alnus, Betula, Carpinus, Acer, Ulmus* and *Zelkova*. However, the living equivalents are mostly distributed in southern temperate region of East Asia, and scarcely in only northern temperate region. Thus, the Orito flora is, in general, closely similar to the Daijima-type in floristic composition, furthermore it consists mainly of the Daijima-type species.

In the area surrounding Fukui City, Fukui Prefecture, a Miocene flora belonging to the Daijima-type was reported from the basal part of the Kunimi formation by HUZIOKA (1955). The Kunimi formation is of terrestrial origin in basal part, while it is brackish or marine in the middle and upper part. The Kunimi flora consists of 27 species, representing 21 genera and 14 families. Most of them are characteristic components of the Daijima-type flora; this Kunimi flora contains many southern warm elements such as *Machilus, Cinnamomum, Liquidambar, Fothergilla* and *Camellia*.

In the Gifu lignite field, the terrestrial or lacustrine sediments overlie the "Nakamura coal-bearing formation" which contains Aniai-type flora. These sediments are called the Hiramaki formation in the northern part of this field, and the Hongô formation in the southern part. The writer considers that these formations are nearly equivalent to or slightly lower than the marine formation* containing *Miogypsina, Operculina* and other warm-sea molluscan fossils, though this stratigraphic relationship has been variously discussed by many geologists and palaeontologists. The Hiramaki formation in the Gifu lignite field contains abundant mammalian fossils as already reported by TAKAI (1939), and also plant fossils collected

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* This has been called the Shukubora sandstone member or the Hiyoshi formation.

from the Hiramaki and Hongô formations in various localities of this field by the writer and ONOE. The Hiramaki flora consists of only 15 species, on the basis of the writer's investigation. However, this flora contains abundant the Daijima-type species such as *Pinus miocenica, Castanea ungeri, Fothergilla viburnifolia, Liquidambar mioformosana, Quercus subvariabilis, Q. mandraliscae,* etc. ENDO (1934) reported the occurrence of *Liriodendron* from this flora in the Mikasa area of this field. Accordingly, this flora seems to belong to the Daijima-type in floristic composition and components, though it is somewhat poor in number of species.

In the Yosa peninsula of northwestern Kyôto Prefecture, the Miocene Yosa group is distributed on granite with unconformity. The Yosa group is generally terrestrial or lacustrine in origin, and frequently includes plant fossils in the middle part. These plants were incompletely reported from Miyatsu City by MATSUMOTO, Y. (1937), but the details have not been published up to the present. Lately, the writer investigated many well-preserved plant fossils collected by her and HUZIOKA which are stored in Hokkaidô University. The Yosa flora comprises 22 species, representing 16 genera and 11 families as listed in Table 5. The largest family in this flora is Fagaceae, represented the genera *Castanea, Quercus* and *Fagus; Castanea* and *Quercus* are most abundant in number of specimens. However, temperate elements such as *Betula, Carpinus, Ulmus, Zelkova,* etc. are commonly contained in this flora, while Lauraceae and other southern elements are scarcely found. Accordingly, this flora may be stated to be somewhat different from the typical flora of the Daijima-type, though it contains many Daijima-type species. It is doubtful whether such difference is due to the environmental factors at the time of deposition, or to insufficient collection of specimens.

In northern Tazima district of Tottori Prefecture, Miocene sediments, accompanied by considerable pyroclastic materials are distributed on granite and other pre-Tertiary rocks. This district occupies one part of the "San'in green tuff region," and was lately investigated in detail by MATSUMOTO and WADATSUMI (1958). The Toyooka formation of the Hokutan group frequently supplies plant fossils from various localities; several species have been already reported by some authors (NATHORST, 1888; UEJI, 1938). MATSUMOTO and WADATSUMI also listed many plant fossils on the basis of ISHIDA's identification. The Toyooka flora consists mainly of warm or warm-temperate elements, most of which are typical Daijima-type species: *Catanea ungeri, Quercus subvariabilis, Liquidambar mioformosana* and *Myrica (Comopntia) naumanni.* Accordingly, this flora probably belongs to the Daijima-type, but attention should be paid to the fact that this flora has also many temperate trees as largely as the above-described Yosa flora.

In the northwestern part of the city of Kôbe, Hyôgo Prefecture, the Kôbe group is distributed on granite or Palaeozoic rocks. It is partly lacustrine, and partly brackish or littoral in origin. The middle part of this group, the Shirakawa formation, possesses abundant well-preserved plant fossils as already reported by SHIKAMA (1938). He collected and listed many plant fossils from 9 zones of this formation. According to his floral list, the lower and middle part of the Shirakawa flora (zone 1-6) is containing *Myrica* (*Comptonia*), *Liquidambar* and *M'clintockia,* and is closely similar to the Daijima-type in floristic composition and components.

In the neghbourhood of Hamada City, southwestern Shimane Prefecture, the Kokubu group is distributed on Palaeozoic rocks, and covered with unconformity by the Middle Miocene marine Togane formation. This group contains plant fossils as lately reported by IMAMURA (1957) ; the Fukui flora from the Kokubu volcanics, is from the upper part of this group. According to IMAMURA's investigation, the Fukui flora consists mainly of *Metasequoia, Fagus, Castanea, Quercus, Cinnamomum* and *Sassafras,* while the Yayadani flora contains *Liquidambar, Myrica* (*Comptonia*), *Castanea,* etc. Accordingly, these two floras probably belong to the Daijima-type on the basis of their floristic composition or components.

Besides these above-described floras, several Miocene floras have been found from various areas of western Honshû, though they are very poor in number of species. For instance, they were found from the Tsuyama coal-bearing formation of the Tsuyama basin in northeastern Okayama Prefecture, the Takakubo shale member of the Nabeyama formation in the southeastern part of Izumo City, Shimane Prefecture (OKAMOTO, 1959), the Koura formation near Matsué City, Shimane Prefecture (TAI, 1952), the Mitsuno formation of the Kumano coal field in southeastern Kii peninsula (TANAI, 1952), etc. The Miocene floras from these formations frequently contain some warm or subtropical trees, and seem to be similar to the Daijima-type flora in their floristic components. However, their floristic composition should be more precisely investigated in future.

Kyûshû

In Kyûshû, Miocene floras definitely belonging to the Daijima-type have been very rarely found up to the present. The Fukazuki formation of the Nojima group in the Sasebo coal field, contains some plant fossils, most of which are warm and subtropical elements as already reported by the writer (TANAI et ONOE, 1956). However, this flora is too poor in number of species to be compared with the Daijima-type flora in floristic composition. It seems at least to be a flora grown in a warm region, though it should be further investigated in future. Beside this flora, no Miocene flora comparable to the Daijima-type is known to date.

Hokkaidô

In Hokkaidô, Miocene floras belonging to the Daijima-type are mainly found from the southwestern region, having been nearly not found from other regions up to the present. This is mainly due to the fact that Cenozoic palaeobotanical research in Hokkaidô is not advanced comparatively speaking though Miocene plant-bearing sediments are known to be distributed in various areas. These Miocene floras are generally similar to the Daijima-type flora of Honshû, however, there are some differences in their floristic composition as described below in detail.

In the southernmost part of southwestern Hokkaidô, the Yoshioka shale member which forms the basal part of the Kunnui formation, is lenticularly distributed near Fukushima-machi. This member consisting mainly of shale, fire-clay and oil-shale, holds abundantly well-preserved plant fossils and in parts contains some marine molluscs such as *Yoldia, Pecten, Macoma, Thyasira,* etc. The Yoshioka flora comprises 76 species which are determinable at present, representing 48 genera and 25 families as listed in Table 5. Sixty-five of the plants are dicotyledons, while the remaining 11 are conifers. Most of these dicotyledons are represented by leaf-impressions, some of them by samara, cone-scales, seeds and bracts. On the other hand, most of the conifers are represented mainly by seeds or cone-scales, partly by leaves or leafy twigs. In the Yoshioka flora, the dominant families are Pinnaceae, Juglandaceae, Betulaceae, Fagaceae, Leguminoceae, and Aceraceae. The following genera are dominant in numbr of species: *Acer* with 12 species, *Quercus* with 6, *Carpinus* with 5, *Pinus* and *Rhus* with 3 each. All of the remaining genera are represented by only two or single species respectively. However, in respect to relative abundance of the species, *Zelkova ungeri* and *Castanea ungeri* are most abundant, followed by *Keteleeria ezoana, Quercus subvariabilis, Acer ezoanum, Carpinus subcordata, Metasequoia occidentalis, Quercus sinomiocenicum, Acer subpictum, Pinus miocenica, Liquidambar mioformosana, Cedrela bienensis* and *Fothergilla viburnifolia.* Thus, the Yoshioka flora consists mainly of deciduous broad-leaved trees such as *Carpinus, Quercus, Castanea, Zelkova, Magnolia, Acer* and *Cedrela,* accompanied by some conifers such as *Metasequoia, Keteleeria, Pinus* and *Pseudolarix.* However, this flora contains several warm elements such as *Cinnamomum,* *Parabenzoin* and *Sassafras* of Lauraceae, *Cercis* and *Robinia* of Leguminoceae, *Fothergilla* and *Liquidambar* of Hamamelidaceae, *Taiwania* of the conifers, though they are not very abundant in number of specimens. Accordingly, this flora is generally similar to the Daijima-type flora of Honshû in floristic composition and components, although abundant temperate elements are mixed in.

The Kudô coal-bearing area is situated about 30 km south of Setana-machi in the middle part of southwestern Hokkaidô. In this district, the Kunnui formation is distributed with unconformity on the Fukuyama formation, or in parts directly overlies Palaeozoic rocks. The coal-bearing member occupying the basal part of the Kunnui formation, has one or two workable coal seams now mined in the Wakamatsu coal mine. Plant fossils are occasionally contained in this coal-bearing members, and in particular, abundantly occur from the tuffaceous shale immediately above the coal seams in the Wakamatsu coal mine. The Wakamatsu flora comprising 45 species, 29 genera and 16 families. These plants consist of 13 conifers and 32 dicotyledons. The largest family is Pinaceae with 11 species representing 5 genera of *Abies, Keteleeria, Picea, Pinus, Pseudotsuga* and *Tsuga;* the next is Betulaceae with 4 genera. The following genera are most numerous in number of species: *Carpinus* with 5 species, *Picea* and *Acer* with 4 species each. All of the remaining genera are represented by one or two species. On the other hand, in respect to the relative abundance of specimens, *Quercus sinomiocenicum* is the most abundant species, followed by *Castanea ungeri, Fagus antipofi, Zelkova ungeri, Quercus subvariabilis, Carpinus miofangiana, C. subcordata, Acer ezoanum* and *Pinus miocenica.* This flora is dominant in Fagaceae, Aceraceae and Pinaceae etc., so that it is closely similar to the above-described Yoshioka flora in the floristic composition and components. However, the former possesses less number of exotic genera and warm elements than the latter. The Wakamatsu flora seems not contain Lauraceae, nor ever-green oaks, though that may be due to insufficient collection by the writer. On the contrary, this flora has slightly less number of coniferous trees than the Yoshioka flora; also the former has many leaves of beech which are never found in the latter flora.

Along the coast of the northern part of Setana-machi is distributed the Kunnui formation, which consists mainly of agglomeratic conglomerate, tuff-breccia, lava, etc. In the conglomerate beds, diatomaceous shale beds are lenticularly intercalated in shred condition. This shale frequently contains many well-preserved plant fossils, and also contains some amount of fresh-water diatoms. These plant-bearing rocks occupy the lower part of the Kunnui formation, and is probably situated in a slightly higher horizon than the rocks having Yoshioka and Wakamatsu flora. The Setana flora comprises 53 species, representing 34 genera and 19 families. These plants consist of one fern, 15 conifers and 37 dicotyledons. The following genera lead in number of species: *Acer* with 7 species, *Carpinus* and *Picea* with 4, *Tsuga* and *Abies* with 3, and *Populus, Pterocarya, Alnus* and *Ulmus* with 2 each. All the remaining genera are represented each by a single species. On the other hand, *Fagus antipofi* is most abundant in respect to the relative abundance of the specimens derived from all localities of this area; they are sufficiently common to account for more than 60 per cent of the flora. The next are *Matasequoia occidentalis, Picea ugoana, Glyptostrobus europaeus, Acer ezoanum, Abies aburaensis, Castanea ungeri, Carpinus subcordata, Carya miocathayensis*, etc. As listed in Table 5, the Setana flora consists mainly of temperate trees, accompanied by several northern elements such as *Abies, Picea, Ulmus, Cercidiphyllum,* while it contains some southern elements such as *Liquidambar, Sassafras, Taiwania,* etc. Accordingly, this flora shows a somewhat curious floristic composition of mixed southern and northern elements. The Setana flora is, in general, similar in floristic components to the above-described Yoshioka and Wakamatsu floras. However, comparing it with the latter two floras, the occurrence of beech is very considerable in this flora, and also conifers are more or less larger in number of species and specimens in proportion to the latter two. This is a striking contrast in floristic composition compared to the other two floras. Such difference of floristic composition is, of course, due to ecological or climatic change, but it may signify a slight difference of geologic age.

In the neighbourhood of Kumaishi-mura situated about 20 km southeast of the Kudô coal-bearing area, the Kunnui formation occasionally intercalates some thin coal seams or coaly shale beds in the basal part. Many fragments of plant fossils frequently occur from black shale of this coal-bearing member. The writer collected many fragmentary plant fossils, but most of them are generally ill-preserved. The Kumaishi flora is very poor in number of species and specimens. *Myrica* (*Comptonia*) *naumanni* appears to supply most of the components of this flora; such specimens supply more than 90 per cent of the total 129 collected by the writer. However, all the components of this flora are Daijima-type species.

The above-noted 4 floras, Yoshioka, Wakamatsu, Setana and Kumaishi, are, as a whole, similar to the Daijima-type flora of northern Honshû in respect to floristic composition and components. These 4 floras, however, are distinctly different from the Daijima-type flora of Honshû in the following three points. 1) They present distinctly less number of warm genera or species than the latter. For instance, the latter flora has generally more abundant warm elements such as ever-green trees of Lauraceae, Sapindaceae, Fagaceae, etc. 2) Compared with the Daijima-type flora of Honshû, these 4 floras contain a larger number of species and genera of conifers, although their conifer remains were transported into the depositional site from high back-ground. In particular, the relative abundance of the specimens of spruce, fir, and hemlock in these four floras must be given attention in palaeoecologic consideration of that time, though most of these specimens are represented by fruits or cone-scales. In the Daijima-type flora of Honshû, the remains of Taxodiaceae such as *Metasequoia* and *Glyptostrobus* are commonly found, but the remains of Pinaceae except pine are scarcely found. 3) Among the 4 floras, the leaves or bracts of beech, *Fagus antipofi,* are commonly contained in Setana and Wakamatsu floras. In the Daijima-type flora of Honshû, leaves of *Fagus antipofi*-type are scarcely or absolutely not found, though some leaves of the living Formosan beech-type, *Fagus hayatae* PALIB., are frequently found in various localities of Honshû. In these 4 floras, the northern two floras have been beech, and number of fossil beech leaves is most abundant in northernmost flora, the Setana. This fact must be carefully investigated in future, but it may be due either to the difference of physical condition or to the existence of floral zones at that time when these floras grew.

Beside the above-described 4 floras, there are nearly no fossil flora being comparable to the Daijima-type in Hokkaidô discovered up to the present. From the Haboro coal-bearing formation in the Tomamae coal field, northern Hokkaidô, the writer collected some plant fossils such as *Metasequoia occidentalis, Pterocarya asymetrosa, Carya miocathayensis, Carpinus subcordata, Cocculus heteromorpha, Acer* sp., *Populus latior, Zelkova ungeri,* etc., though the number of specimens is poor. However, many fossil pollens were lately found from the coals of this formation by SATO, S. (1960) ; they are mostly identified to the temperate genera such as *Abies, Pinus, Alnus, Corylus, Fagus, Quercus, Carya, Juglans,* etc., and also contain some southern genera such as *Liquidambar, Myrica,* etc. Accordingly, the Haboro flora may belong to the Daijima-type in floristic composition.

5. Middle Miocene flora from marine sediments

The above-described Daijima-type flora is known from the terrestrial or lacutrine sediments, which were produced a considerable transgression widely prevailing in Japan subsequent to Middle Miocene age as already described. These terrestrial or lacustrine sediments generally occupy the basal or lower part of thickly-developed marine formations, and with unconformity of slight unconformity are covered by marine sediments. In these marine sediments of Middle Miocene age frequently occur well-preserved plant fossils from various localities in Honshû and Hokkaidô, accompanied by shallow-sea molluscan fossils. The plant fossils are frequently southern warm elements, and most of them are members of the Daijima-type flora. For instance, there may be named the Kamenoo, Honya and Nakayama formations of the Jôban coal field, the Chiganoura formation near Sendai City, the Bessho formation in Nagano Prefecture, the Tsukiyoshi and Togari formations of the Gifu lignite field, the middle part of the Ayugawa group of southeastern Shiga Prefecture, the Okuyamada formation of southeastern Kyôto Prefecture, the Yûdoro formation of Rumoé district in Hokkaidô, etc. From these formation, well-preserved plant fossils occasionally occur with marine molluscs or foraminiferas.

In the Jôban coal field, the Kamenoo formation frequently contains plant fossils from various localities, though it is marine in origin, having molluscan fossils such as *Lucinoma kamenooensis* (OTUKA), *Yoldia tokunagai* YOKOYAMA, etc. The plant fossils found by the writer are as follows: *Carpinus subcordata, Quercus subvariabilis, Q. mandraliscae, Zelkova ungeri, Phoebe* sp., *Liquidambar mioformosana.* Besides them, Cfr. *Fagus antipofi, Q. protosalicina,* Cfr. *Castanea crenata* and Cfr. *Fraxinus japonica,* were lately reported by SUZUKI (1959). From the Honya and Nakayama formations, the writer found the following fossil plants in several localities: *Carpinus miocenica, Carya miocathayensis, Myrica (Comptonia) naumanni, Quercus subvariabilis, Q. mandraliscae, Zelkova ungeri, Liquidambar mioformosana, Cinnamomum* sp. and others. Especially, the Nakayama formation frequently has well-preserved plant fossils, while it contains also warm- and shallow-sea molluscus such as *Vicarya, Cerithidea* and *Chicoreus.* Thus, most of these plants from these 3 formations of the Jôban field are warm or warm-temperate elements, and also nearly all of them are Daijima-type species.

In central and western Honshû, Miocene shallow-sea sediments are scattered; they contain warm-current molluscan fossils such as *Vicarya, Vicaryella, Cerithidea* and *Katelysia.* From these sediments well-preserved plant fossils are frequently discovered: for instance, from the above-noted Ayugawa, Okuyamada, Tsukiyoshi and Togari formations. From the marine Tsukiyoshi and Togari formations, the writer secured the following fossil plants: *Myrica (Comptonia) naumanni, Quercus mandraliscae, Q.*

subvariabilis, Carpinus subcordata, Zelkova ungeri, Acer subpictum, Cinnamomum oguniense, Pinus fujii and others. From the Ayugawa formation the writer was able to identify the following several species on the basis of the specimens collected by OKUBO, M.: *Pinus fujii, Myrica naumanni, Quercus mandraliscae, Zelkova ungeri,* etc. *Myrica naumanni* was also found from the basal part of the Okuyamada formation by IKEBE (1948).

The Shiogama flora near Sendai City and Bessho flora in Nagano Prefecture are found from predominantly marine formations. The former flora consists mainly of warm and temperate elements as already described by KRYSHTOFOVICH (1920), OKUTSU (1955) and others, and is closely similar to the typical Daijima-type in the floristic composition and components. According to OKUTSU's research, it is characteristic that this flora contains southern genera such as *Trachycarpus, Myrica (Comptonia), Castanea, Liquidambar, Cinnamomum, Lindera* and others. The Bessho flora is found from marine black shales containing many molluscs such as *Palliolum peckami, Patinopecten kimurai* and *Lucinoma actulineata.* As already described in detail by KONNO (1930), this flora consists mainly of southern warm elements; it contains abundant leaves of the ever-green oaks and Lauraceae. Though this flora does not contain *Myrica naumanni* and *Liquidambar,* it is closely similar to the Daijima-type in floristic composition.

The Hibara flora was lately reported by SUZUKI* (1959) from the marine Hibara formation which is distributed in the eastern marginal area of Aizu basin, Fukushima Prefecture. This flora is very poor in number of species, but it contains *Myrica (Comptonia) naumanni, Alangium aequalifolium, Pterocarya asymetrosa,* etc.

The Yûdoro and Horoshin formations of Uryû district and the Naidabu formation of northern Sorachi district in Hokkaidô are generally marin in origin; they contain abundant marine molluscs and foraminiferas. However, these marine formations frequently yield some plant fossils such as *Myrica (Comptonia) naumanni, Carya miocathayensis, Castanea ungeri, Zelkova ungeri* and *Rhus miosuccedanea,* accompanying the marine fossils.

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* Lately, SUZUKI (1959) summarized Neogene flora in the southern part of northeastern Honshû, and divided it into 7 floral zones. The above-described floras from marine Miocene sediments partly correspond to his third zone, which was considered to be typically represented by the Hibara flora. However, the several floras of the third zone designated by him are confused in their stratigraphical position; they contain two horizoned floras. Furthermore, the floras of his third zone are too poor in floristic components to be treated as characteristic floral zones.

These above-described floras found from Middle Miocene marine sediments in various areas of Honshû and Hokkaidô, consist mainly of Daijima-type species, though the floras generally are represented by small number of species and specimens. Some of their components are frequently warm or even subtropical elements. These plant-bearing rocks are generally marine in origin, so that plant materials probably entered into the depositional site with considerable selection, as compared with the terrestrial sediments. That is to say, the specimens are largely firm materials such as coriaceous leaves, cones, nuts, seeds, etc., which were able to endure longly-distance transportation. Furthermore, the low-land plants grown near the depositional site seem to have supplied the sediments more remains than the high-land plants. Thus, such floras from marine sediments are considerably restricted in the number of species and specimens, and they do not always represent the original flora grown at that time. Accordingly, the above descriptions of many floras should be somewhat cautiously accepted when one is entering into stratigraphical and palaeoecological consideration.

6. The Mitoku-type flora

As already discussed by the writer (TANAI, 1959), regional emergence at the close of Middle Miocene time took place over the whole of the Japanese archipelago, and consequently the sea which reached its climax of transgression in Middle Miocene time gradually differentiated into various depositional basins. In consequence, lacustrine or littoral deposits are locally distributed in various districts of Japan, though most of the Late Miocene deposits are generally dominant in marine argillaceous facies. Such lacustrine or littoral deposits of this time frequently contain coal seams in various areas of Honshû and Hokkaidô, and also there occur abundantly well-preserved plant fossils.

Many fossil floras of this stage have been found in various areas of Japan, in particular abundantly from northeastern Honshû, however, most of such floras have not yet been sufficiently investigated. The writer gives the name of the Mitoku-type to them, considering the Mitoku flora as its type, which was lately studied in detail by the writer (TANAI et ONOE, 1961).

The Mitoku-type flora consists mainly of temperate deciduous broad-leaved trees, accompanied by several ever-green trees; it also commonly contains conifers. As shown in Table 6, the broad-leaved trees of this type include a large number of Juglandaceae, Betulaceae, Fagaceae, Ulmaceae and Aceraceae; especially, *Castanea, Quercus* (deciduous oaks), *Fagus,*

TABLE 6. Component Species of the Mitoku-type Flora and their Main Localities in Japan

Localities / Fossil Species	Hokkaidô				Northeastern Honshû										Cent. and West. Honshû					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
O. japonica subsp.	×										×				×					
Abies protofirma																			×	
Larix onbaraensis																			×	
Picea kaneharai																				
Picea cfr. *jessoensis*			×																	
Picea koribai																				
Pinus palaeopentaphylla																			×	
Pinus trifolia															×					
Pseudolarix japonica															×				×	
Juniperus honshuensis																		×		
Thuja nipponica				×	×		×												×	
Cunninghamia protokonishii															×				×	
Glyptostrobus europaeus				×	×	×			×a		×	×	×		×	×	×			
Metasequoia occidentalis	×			×	×	×			×		×		×		×	×	×			
Sequoia affinis				×	×	×	×	×	×						×					
Taiwania japonica																		×		
Taxodium dubium							×	×	×											
Populus aizuana										×	×							×	×	
Populus sambonsugii										×	×	×								
Populus balsamoides			×			×	×	×	×		×					×	×			
Salix k-suzukii	×		×						×	×	×			×						
Myrica(Comptonia) kidoi																				
Carya miocathayensis						×									×			×		
Juglans megacinerea															×					
Juglans japonica			×	×	×		×		×				×					×	×	×
Pterocarya nipponica				×	×				×									×		×

Pterocarya asymetrosa									×			×				×	×			
Pterocarya protostenoptera									×											
Alnus miojaponica	×		×				×		×	×	×	×	×		×	×	×		×	
Alnus protohirsuta				×			×		×	×	×								×	
Alnus protomaximowiczii							×													
Betula miomaximowicziana		×	×a			×	×		×				×	×			×			
Betula onbaraensis		×		×			×				×		×						×	
Betula protoermanni	×		×	×	×	×	×		×	×	×		×	×				×	×	
Betula protoglobispica				×	×		×											×	×	
Betula protojaponica			×				×													
Carpinus miocenica				×	×			×						×		×		×	×	
Carpinus nipponica							×											×	×	
Carpinus stenophylla				×		×	×	×	×						×	×			×	
Carpinus subcordata	×	×	×	×	×	×	×	×	×	×	×					×	×		×	
Carpinus subyedoensis	×			×			×	×	×		×	×	×		×	×	×	×	×	×
Ostrya huziokai							×		×		×									
Castanea miocrenata				×	×		×	×	×		×		×	×		×		×	×	
Fagus palaeocrenata	×	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	
Fagus protojaponica				×	×	×		×	×		×	×	×		×				×	
Quercus miocrispula						×	×	×	×		×		×	×a			×	×	×	
Quercus protodentata						×	×	×			×			×		×	×	×	×	
Quercus protosalcina													×						×	
Quercus protoserrata						×	×	×	×		×							×	×	
Celtis nathorsti				×		×										×	×		×	
Celtis nordenskioldii				×														×		
Ulmus carpinoides																				
Ulmus protojaponica		×	×c			×		×	×							×		×		
Ulmus protolaciniata			×				×		×									×	×	
Ulmus subparvifolia																×				
Zelkova ungeri	×					×	×	×	×	×	×	×	×		×			×	×	

TABLE 6. (*Continued*)

Localities / Fossil Species	Hokkaidô				Northeastern Honshû										Cent. and West. Honshû					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Cercidiphyllum crenatum	×			×			×		×					×						
Liquidambar protoformosana						×					×	×	×		×	×	×	×		
Eucommia japonica															×					
Liriodendron honshuensis				×	×		×	×										×		
Magnolia elliptica																		×		
Magnolia nipponica						×					×					×				
Cinnamomum miocenum								×	×								×			
Parabenzoin protopraecox								×												×
Sassafras subtriloba							×				×	×	×			×	×	×	×	×
Sassafras yabei				×	×		×				×			×				×		
Schizophragma mitokuensis																				
Sorbus nipponica				×	×													×		
Prunus protossiori			×	×	×		×		×							×	×			
Cercis endoi									×			×							×	
Sophora miojaponica	×								×							×				
Wistaria fallax	×									×					×			×	×	×
Rhus miosuccedanea																				
Rhus protoambigua													×							
Euonymus palaeosieboldiana												×							×	
Buxus protojaponica																			×	
Acer nordenskioldi					×	×	×		×[a]		×				×			×		×
Acer palaeodiabolicum				×	×	×	×	×	×		×		×					×	×	
Acer palaeorufinerve				×	×		×											×		
Acer protojaponicum				×			×													
Acer protosieboldianum																				
Acer prototrifidium						×														

Acer pseudocarpinifolium				×	×		×											×		
Acer submayri																		×		
Acer subpictum	×	×	×a	×			×	×	×				×			×		×	×	×
Tilia distans			×				×													
Tilia miohenryana																		×		
Tilia protojaponica			×	×	×	×			×	×	×			×	×					
Paliurus nipponicus				×							×				×				×	
Alangium koyamai																×	×			
Ilex cornuta									×		×	×								
Stewartia submonadelpha				×	×				×			×			×	×	×	×		
Stewartia okutsui			×				×								×	×	×			
Kalopanux acerifolium				×																
Cornus megaphylla																		×		
Cornus subkousa						×												×		
Clethra cfr. *barbinervis*				×		×							×			×		×		
Rhododendron protodilaratatum													×					×		
Tripetaleia pseudopaniculata									×										×	
Diospyros miokaki	×																			
Fraxinus honshuensis			×												×					
Styrax protoobassia	×					×	×				×				×					
Catalpa ovata			×		×		×		×c											
Lonicera protojaponica																			×	
Viburnum protofurcatum			×						×		×			×						
Smilax trinervis						×			×		×					×	×			

Fossil Flora

1. Utanobori 2. Ogawa 3. Nukabira 4. Shanabuchi 5. Gosho (MURAI, 1957) 6. Obayashi 7. Lower Nenoshiroishi (OKUTSU, 1955) 8. Upper Nenoshiroishi (OKUTSU, 1955) 9. Takamine 10. Shiotsubo (HUZIOKA & SUZUKI, 1954) 11. Shiroko (SUZUKI, 1959) 12. Sudani (SUZUKI, 1959) 13. Tennoji (SUZUKI, 1959) 14. Funaishi 15. "Pinus trifolia" (MIKI, 1940) 16. Chausuyama 17. Omi (KONNO, 1931) 18. Mitoku 19. Onbara 20. Heigun (HUZIOKA, 1938)

Alnus, Betula, Carpinus, Ulmus, Zelkova, Acer, etc. are most abundant in number of species or specimens. Compared to the previous-staged Aniai- and Daijima-type floras the broad-leaved species are considerably modernized, and their living equivalents are mostly distributed in Japan proper. Some of them are, however, now growing only in China or North America. *Fagus palaeocrenata, Betula protoermanni, B. miomaximowicziana, Alnus protohirsuta, Carpinus nipponica* and *Ulmus protojaponica,* are some of the representatives of the Mitoku-type flora, and they have first appeared since that time (Late Miocene). Most of the modern equivalents of these species are now luxuriantly growing in northern Japan. Mixed with many temperate zone trees, there are frequently found several warm or warm-temperate broad-leaved trees such as *Liquidambar, Ilex, Cinnamomum, Buxus,* ever-green oaks, *Smilax* and others in this type flora includes several exotic broad-leaved trees such as *Carya, Liriodendron, Sassafras, Liquidambar* and *Catalpa,* which are relics from the Daijima-type flora of the previous stage, but some of them were still flourishing in this type flora.

The Mitoku-type flora commonly contains coniferous trees; especially, *Glyptostrobus, Metasequoia* and *Sequoia* of Taxodiaceae were abundantly found, continuing from the previous stage. Besides them, *Thuja, Juniperus, Picea, Pinus* and *Abies* are occasionally contained; furthermore some southern conifers such as *Taiwania, Cunninghamia, Pseudolarix* are found though rarely from several localities. However, these conifers are far less in number of specimens than the broad-leaved trees in this type flora.

Thus, the Mitoku-type flora is characterized by mixed floristic composition of temperate and warm elements, though the former elements are far dominant in number of species and specimens over the latter. From the viewpoint of floristic composition, this flora is similar to the above-noted Aniai-type in abundant occurrence of temperate deciduous trees, while somewhat similar to the Daijima-type in having several warm or exotic elements. However, most of the component of the Mitoku-type are considerably modernized, and they are entirely different from those of the previous two types excepting several relics species.

Furthermore, the Mitoku-type flora has somewhat local or regional differences in floristic composition; especially the difference between Hokkaidô and Honshû seem to be conspicuous as described below in detail.

Northeastern Honshû

The floras belonging to the Mitoku-type are abundantly found from various localities in northeastern Honshû, especially in the interior basins

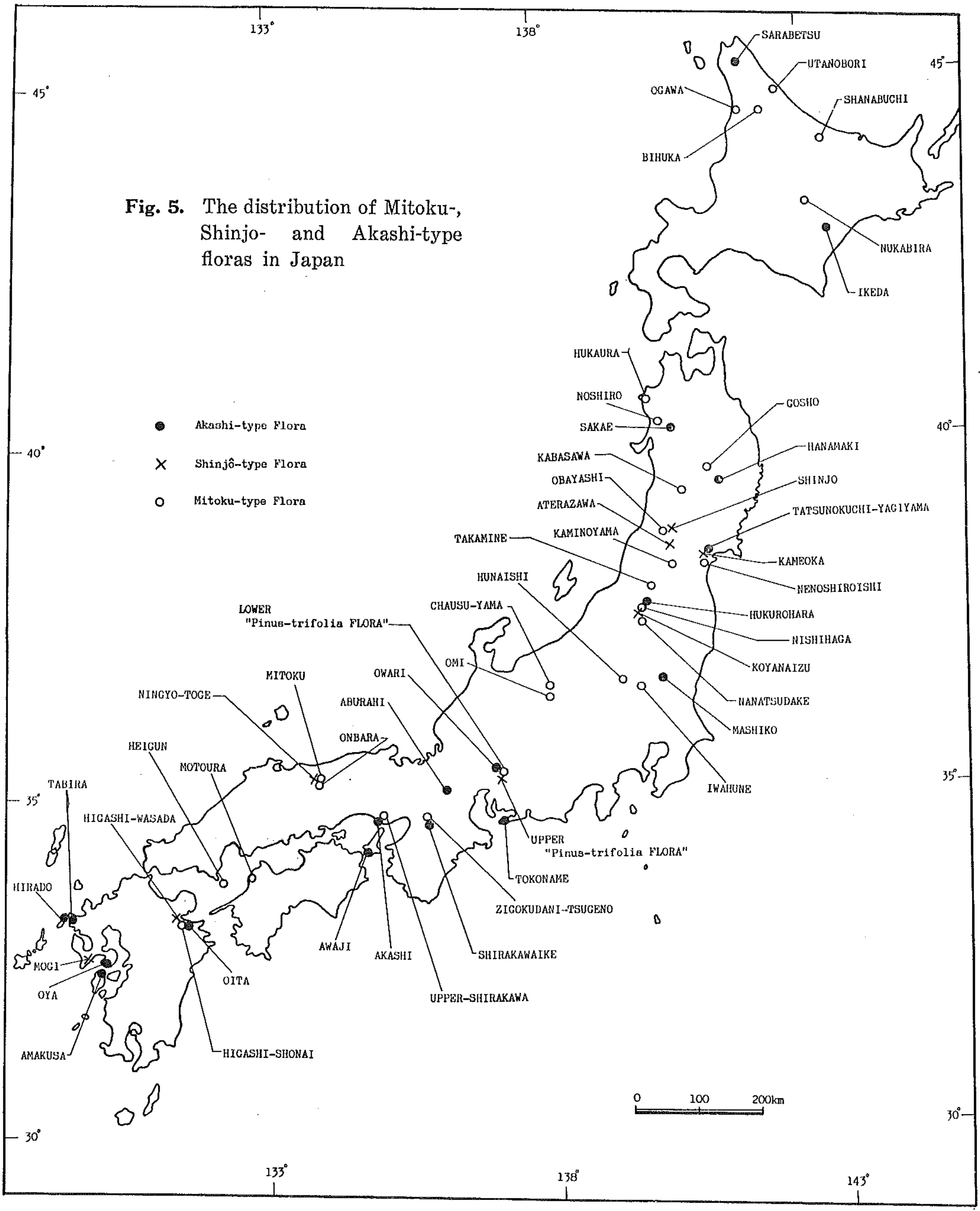

Fig. 5. The distribution of Mitoku-, Shinjo- and Akashi-type floras in Japan

existing between the central and Dewa mountain ranges, the area surrounding Sendai, the Noshiro district. Late Miocene non-marine sediments bearing plant fossils are distributed in these districts, frequently accompanied by several lignite seams. As already stated by the writer (TANAI, 1959), these liginites are one of the productive coal resources in northeastern Honshû, and are being mined in various areas.

Non-marine sediments containing the Mitoku-type flora in northeastern Honshû are more widely distributed than in other regions. It can be evidently explained by Neogene palaeogeography.

In the Okitama lignite field of southern Yamagata Prefecture, the Takamine coal-bearing formation abundantly yields well-preserved plant fossils from several localities, as already preliminarily reported by the writer (TOKUNAGA & TANAI, 1954). The Takamine flora comprises 40 species, representing 30 genera and 19 families. These plants are 4 conifers, one monotcotyledon and 35 dicotyledon. The largest family is Betulaceae of *Alnus, Betula, Carpinus* and *Ostrya* with 10 species, followed by Fagaceae of *Castanea, Fagus* and *Quercus* and Ulmaceae of *Ulmus* and *Zelkova.* Besides them, the remaining dicotyledons consist largely of temperate genera, and rarely include some southern warm elements such as *Cinnamomum* and *Ilex.* It is one of the characters of this flora that *Quercus, Betula, Fagus, Ulmus,* and *Carpinus* are abundant in number of species or specimens. Especially, this flora contains *Betula miomaximowicziana, Betula protoermanni, Fagus palaeocrenata, Ulmus protolaciniata* and *U. protojaponica,* which are some of the typical representatives of the Mitoku-type flora. Among the nearest modern equivalents of the Takamine species, most of them are dominantly distributed from central to northern Japan, and in northern China. In this flora exotic genera are comparatively rare except conifers; only *Catalpa* and *Cercis* have been found. However, some species of this flora are closely similar to the chinese living species; for instance, *Pterocarya protostenoptera,* Cfr. *Ilex cornuta, Smilax trinervis* and Cfr. *Catalpa ovata.* Conifers are commonly found as fossil cones or foliar shoots of *Metasequoia, Sequoia, Glyptostrobus, Taxodium.* Especially, the latter two are abundantly found from all localities of the Okitama field. In short, this flora consists mainly of cool-temperate and deciduous broad-leaved trees, with some coniferous trees mixed in such as Taxodiaceae. Furthermore, several warm or warm-temperate elements accompany with them. Accordingly, the Takamine flora evidently belongs to the Mitoku-type in floristic composition and components, with exotic genera somewhat less in number than the typical flora.

In the Mogami coal field of Yamagata Prefecture, the Obayashi formation (the lower coal-bearing formation) possesses abundant plant fossils, though the specimens are somewhat ill-preserved. The writer once investigated many plant fossils collected from this formation by TOKUNAGA and YONEBAYASHI. The Ôbayashi flora is composed of 29 species, representing 22 genera and 16 families. These plants consist mainly of temperate genera belonging to Taxodiaceae, Betulaceae, Fagaceae, Ulmaceae, Aceraceae, etc. However, there are some southern or warm elements such as *Platanus, Liquidambar, Clethra, Smilax,* etc. Accordingly, the Ôbayashi flora is closely similar to the Mitoku-type in floristic composition and components. This flora appears, however, to have somewhat less number of exotic elements than the typical flora. That is probably due not to the regional difference of floristic composition, but rather to the insufficient collection of specimens.

In the Shizukuishi basin, west of Morioka City, Iwate Prefecture, the plant-bearing Masuzawa formation is distributed on Middle Miocene pyroclastic sediments with conformity as described by HAYAKAWA, KITAMURA and others (1954). This formation abundantly presents well-preserved plants fossils; also it frequently intercalates thin lignite seams. The fossil flora found from this formation, has been lately investigated in detail by MURAI (1957, 1958) ; it was named the Gosho flora by him. According to his floristic list, the Gosho flora comprises 62 species, representing 37 genera and 23 families, though descriptions of the species have not yet been given. This flora consists mainly of cool-temperate elements such as Juglandaceae, Salicaceae, Fagaceae, Aceraceae, etc. However, several exotic genera such as *Catalpa, Liriodendron, Sassafras, Glyptostrobus, Metasequoia, Sequoia* are contained there in. Furthemore, besides them the flora includes some warm or warm-temperate elements such as *Benzoin, Sapium, Stewartia, Mallotus,* etc. Accordingly, the Gosho flora may be said to be quite similar to the Mitoku-type in its floristic composition and components.

In the Aizu lignite fields, western Fukushima Prefecture, the lignite-bearing Fujitôge formation overlies with conformity the marine Shiotsubo formation having so-called "Yama fauna" of Late Miocene. The Fujitôge formation has abundant plant fossils as already reported by SUZUKI (1951). According to his list (SUZUKI, 1959), the Nishihaga flora lately named by him, comprises 80 species, representing 50 genera and 33 families. This flora includes abundant cool-temperate and deciduous broad-leaved trees such as *Populus, Salix, Betula, Carpinus, Fagus, Quercus, Ulmus, Acer* and *Styrax*; especially, among these trees, *Fagus palaeocrenata* and *Betula protoermanni* are characteristic species. Further, mixed with these many temperate trees, there are several warm or subtropical elements such as *Cinnamomum*, *Neolitsea*, *Lindera*, *Paliurus*, *Ficus* and *Smilax*. Also there are some southern exotic genera of *Liquidambar*, *Sassafras*, *Cercis* and *Platanus*. The Nishihaga flora is, as a whole, similar to the Mitoku-type in floristic composition and components. This flora stratigraphically divided into 2 florules by SUZUKI (1959) : the lower is the Shiroko and the upper is the Sudani. The Sudani florule possesses less number of warm or subtropical elements than the Shiroko.

Beside the Nishihaga flora, there were found several floras probably belonging to the Mitoku-type by SUZUKI (1959) in Fukushima Prefecture: the Nanatsudake flora from the western marginal area of the Tajima basin, the Akogashima flora from the western part of the Kôriyama basin and others. However, these floras have not yet been reported in respect to their detailed floristic composition.

In the southern environs of the City of Sendai, Miyagi Prefecture, Late Miocene Akyu group being of lacustrine origin is distributed on Middle Miocene marine sediments with unconformity. The Shirasawa formation which is the upper part of this group, has been known from old time to yield abundantly well-preserved plant fossils. This Nenoshiroishi flora has already been preliminarily reported by ENDO (1938) and OKUTSU (1940), and lately also studied anew by OKUTSU (1955) on the basis of many specimens collected from various localities. This flora consists largely of Juglandaceae, Betulaceae, Fagaceae, Ulmaceae and Aceraceae. However, it contains several warm or subtropical elements such as *Parabenzoin*, *Cinnamomum*, *Litsea* and *Ilex*, and some exotic genera such as *Liriodendron*, *Sassafras* and *Firmiana*, *Catalpa*. Considering the floristic composition and component, the Nenoshiroishi flora is closely similar to the above-described Nishihaga flora, and evidently belongs to the Mitoku-type. Furthermore, the upper Nenoshiroishi flora seems to have somewhat less number of warm and exotic genera than the lower Nenoshiroishi flora, as already pointed out by SUZUKI (1959).

Besides the above-described floras, several floras probably belonging to the Mitoku-type are found from the northern part of northeastern Honshû: for instance, the Noshiro district of northern Akita Prefecture, Yokote basin of southeastern Akita Prefecture (Kabazawa formation), eastern part of Kaminoyama City in Yamagata Prefecture (Deita formation), and in the Fukaura-Iwasaki area of southern Aomori Prefecture (Fukaura formation). These four formations in these districts are lacustrine or littoral sediments which were formed in the marginal areas of Late Miocene depositional basins. These floras consist dominantly of

Betulaceae, Ulmaceae, Fagaceae, Aceraceae, Tiliaceae, etc., and most of these plants are typical Mitoku-type species.

In Kwantô region there are nearly no fossil floras which are evidently comparable to the Mitoku-type. That is due to the fact that Late Miocene sediments are mostly of marine origin in this region. Especially, marine condition seems to have considerably prevailed in southern Kwantô region, while in northern Kwantô some lacustrine sediments are scattered to a small extent.

In the neighbourhood of the Ashio copper mine situated in northern Tochigi Prefecture, northernmost Kwantô, the lacustrine Funaishi formation is distributed on Middle Miocene rhyolite with unconformity. This formation consisting of andesitic tuff and agglomerate, abundantly yields well-preserved plant fossils, and is considered a lake deposit. The writer investigated the plant fossils collected near the Ashio mine by G. ASANO. The Funaishi flora includes mainly temperate genera such as *Fagus, Qurcus, Castanea, Betula, Carpinus, Magnolia* and *Tilia,* as listed in Table 6. In particular, *Betula* and *Quercus* are dominant in number of specimens, while warm elements such as *Sassafras* are contained. That is to say, this flora is more or less similar to the Mitoku-type in floristic composition and components, though there is available only a small number of species. Accordingly, the Funaishi formation is probably Late Miocene in age, though it has been considered to be Pliocene or Pleistocene by many geologists.

In the southern area of Tochigi City, Tochigi Prefecture, the small lacustrine Iwafune formation is found; in it occur many plant fossils as already listed by UCHIO (1950). The Iwafune flora consists mainly of temperate deciduous broad-leaved trees such as *Populus, Carpinus, Quercus, Prunus, Sorbus* and *Tilia.* This flora seems not to contain warm elements, which opinion is probably due to the insufficient collection of specimens. Taking into consideration also the stratigraphic position of this plant-bearing formation, one may say that this flora is probably similar to some of the Mitoku-type floras; for instance, the above-noted Upper Nenoshiroishi and Shirako floras of northeastern Honshû. Accordingly, the Iwafune flora is not of Middle Miocene age as was once considered by UCHIO, but rather is of Late Miocene age.

Central and Western Honshû

In central and western Honshû, there are scattered Late Miocene lacustrine sediments, which are occasionally intercalated with coal or lignite seams. These lacustrine sediments frequently contain plant fossils, but their fossil floras have been not investigated in detail with some exceptions up to the present.

In the northern part of Nagano Prefecture, the so-called "Ogawa" formation is widely distributed on the "Aoki" formation with conformity. The "Ogawa" formation frequently shows several intercalated coal or lignite seams, and also abundantly contains plant fossils. The Omi flora from this formation was precisely investigated by KONNO (1931) on the basis of many plant fossils collected from various localities. According to the writer's re-study of KONNO's work, the Kangawa-Yamazaki florule which occurs from the lower and middle parts of the "Ogawa" formation, consists of 68 species, representing 45 genera and 28 families. Most of these plants are broad-leaved trees, in particular such temperate trees as Betulaceae, Fagaceae, Aceraceae are most dominant in number of species and specimens. There are representatives of some warm or exotic elements such as *Liquidambar, Cinnamomum, Sassafras, Ilex, Fagara, Bambusium,* etc. Accordingly, this florule is quite similar to the Mitoku-type in floristic composition and components. On the contrary, the Bôdaira flora from the upper part of the "Ogawa" formation, consists mainly of warm or warm-temperate elements. However, this florule is composed of only 11 species, and it is too poor in components to be discussed with respect to the floristic composition.

On the southeastern slopes of Chausu-yama situated near Shinonoi-machi, northern Nagano Prefecture, lignite-bearing deposits are distributed on rhyolite or rhyolitic tuff with conformity. The tuffaceous siltstone or tuff of these lacustrine deposits abundantly contains well-preserved plant fossils. The Chausu-yama flora was once preliminarily reported by ENDO (1948), but detailed description of the floristic composition has not yet been given. The writer also investigated the plant-bearing formation in this area, and collected many specimens. This plant-bearing formation is probably correlated to the middle part of the "Ogawa" formation. The Chausu-yama flora consists of 18 species, representing 16 genera and 11 families. Nearly all of these species are the same as the above-noted Omi flora species. This flora is closely similar to the above-noted Kangawa-Yamazaki florule in floristic components. However, in this flora the warm or warm-temperate elements such as *Cinnamomum, Alangium, Stewartia, Liquidambar, Meliosma, Bambusium,* etc. are larger in number of specimens than the temperate elements such as *Betula, Fagus, Quercus* and *Pterocarya.* Accordingly, this flora is also similar to the Bôdaira florule in floristic composition. Thus, the Chausu-yama flora probably belongs to the Mitoku-type.

In Seto area of Aichi Prefecture and Tajimi area of Gifu Prefecture, lignite and kaoline clay-bearing deposits are widely distributed on the pre-Tertiary rocks or Middle Miocene marine sediments. These lignite and clay have been often worked at various localities. From 12 localities of this district where *Pinus trifolia* occurred, abundant plant remains such as cones, seeds, fruits, nuts and leaves, were collected by MIKI (1940). He investigated these specimens in detail, and named the flora the "*Pinus trifolia* flora." It consists of 83 species belonging to 62 genera and 37 families. These plant are 11 conifers, 70 dicotyledons, 1 monocotyledon and 1 fern. Among the dicotyledons, there are many temperate deciduous trees, and especially Juglandaceae, Betulaceae and Fagaceae are most dominant in number of species, whereas, there are some southern conifers such as *Pseudolarix, Keteleeria, Cunninghamia* and several southern dicotyledons such as *Liquidambar, Benzoin, Stephania* and *Symplocos, Dalbergia.* Among the living equivalents of these 93 species of this flora, 28 species are now distributed only in Japan proper, whilst 33 species are found in both Japan and China. However, it is characteristic for the floristic composition of this flora to contain many endemic genera or species in China and North America. This flora contains *Glyptostrobus, Metasequoia, Pseudolarix, Cunninghamia, Keteleeria, Eucommia, Stephania, Meliodendron* and *Spondias* now living in central and southern China, and *Sequoia, Nyssa sylvatica, Juglans cinerea* now living only in North America. Accordingly, the "*Pinus trifolia* flora" is closely similar to the Mitoku-type in the floristic composition and components, and rather one of the typical flora of this type. However, this flora includes a more or less larger number of southern warm elements than the Mitoku-type flora of northern Honshû.

Very lately, the present writer reported in detail the Miocene-Pliocene Hôki flora from the Ningyô-togé area in the border of Tottori and Okayama Prefectures. This flora is divided into 3 florules: the Mitoku, Onbara and Ningyô-togé florules. The lowermost Mitoku florule is the type of the Mitoku-type flora described in this paragraph. The Mitoku florule comprises 40 species, representing 28 genera and 20 families. Among these plants, the following genera are dominant in number of species: *Acer* with 6 species, *Quercus* with 3, and *Betula, Carpinus, Ulmus,* and *Cornus* with 2 each. Considering the number of specimens, this florule is made up mainly of such temperate and deciduous broad-leaved trees as Betulaceae, Fagaceae, Ulmaceae, Aceraceae, Ericaceae and Leguminoceae. Also, several exotic genera such as *Taiwania, Carya, Liriodendron, Sassafras, Liquidambar* and *Cercis,* are contained in this florule, but they are scant in number of specimens.

As already discussed by the writer (TANAI et ONOE, 1960), the middle horizon Onbara florule of the Hôki flora, is closely similar to the Mitoku florule in floristic composition and components. However, the Onbara florule has slightly less number of exotic genera than the Mitoku, and on the contrary a larger number of conifers and cool-temperate elements. Accordingly, the Onbara florule probably belongs to the Mitoku-type in a wide sense, however, it tends to show a transitional floristic character between the Mitoku-type flora and higher horizoned flora.

In Heigun island situated in the western part of the Seto Inland Sea, lacustrine deposits consisting of pyroclastic materials are distributed on granitic gneiss with unconformity; they contain plant fossils as already reported by HUZIOKA (1938). The Heigun flora consists mainly of Juglandaceae, Betulaceae, Ulmaceae and Aceraceae and includes several southern elements such as *Lindera, Rosa, Sassafras, Wistaria,* etc. Accordingly, this flora may be said probably to belong to the Mitoku-type in floristic composition and components, though it is poor in number of species.

In the western or southwestern portion of Nara City, Nara Prefecture, the lacustrine Jigokudani and Tsugeno formations are distributed on Middle Miocene marine sediments, and they frequently yield many plant remains as already reported by KOKAWA (1954). The Jigokudani and Tsugeno floras consist of temperate elements such as *Pinus, Alnus, Quercus, Magnolia, Tilia* and *Styrax,* frequently accompanied by several southern or exotic elements such as *Liquidambar, Canarium, Machilus, Fortunearia,* etc. Accordingly, these two floras may belong to the Mitoku-type in floristic composition, though they are poor in number of species.

Beside the above-noted many floras, some fossil floras probably comparable to the Mitoku-type were found in western Honshû: for instance, the Hatabu flora near Shimonoseki City, Yamaguchi Prefecture (TAKAHASHI, 1959), the Upper Shirakawa flora near Kôbe City, Hyôgo Prefecture (SHIKAMA, 1938), etc. As already stated above in paragraph 4, the lower and Middle part of the Shirakawa flora are closely similar to the Daijima-type in floristic composition and components. However, the part of this flora (SHIKAMA's 7-9th zones) consists mainly of Salicaceae Betulaceae, Fagaceae, Ulmaceae, Aceraceae, etc., in company with several warm or exotic elements such as *Liquidambar, Cinnamomum* and *Sassafras.* That is to say, the upper Shirakawa flora is closely similar to the Mitoku-type in floristic composition and components.

Shikoku and Kyûshû

In Shikoku and Kyûshû, Late Miocene flora has been almost never found up to the present. However, some Late Miocene lacustrine sediments are scattered in the western part of the so-called "Palaeo-Seto inland region," and from these sediments several plant fossils have been reportd: for instanc, the Motoura formation near Matsuyama City, Ehime Prefecture (NAGAI, 1959), the Higashi-shônai formation near Oita City, Oita Prefecture (SHUTO, 1953). These two floras are probably correlated with the Mitoku-type, though they are very poor in number of components.

Hokkaidô

In Hokkaidô, Late Miocene flora evidently belonging to the Mitoku-type have been scarcely found up to the present. That is due to the fact that nearly all of Late Miocene sedidments in Hokkaidô are of marine origin. However, some lacustrine or littoral sediments were recently found in the marginal areas of Miocene depositional basins: for instance, Nayoro and Enbetsu areas of Teshio province, Utanobori and Engaru area of Kitami province, Nukabira area of Tokachi province, etc. From the lacustrine or littoral deposits of these districts, several fossil floras being probably of Late Miocene age, were lately found. These floras are, as described in detail below, somewhat different from the Mitoku-type of Honshû in floristic composition: they contain nearly no southern warm elements.

In the Nukabira lake side area, northwestern part of Tokachi province, the lacustrine Taushibetsu formation is distributed on the "green-tuff formation" with unconformity. These lacustrine deposits consist mainly of fine alternations of tuffaceous sandstone and silstone, which abundantly contain well-preserved plant fossils. The writer collected many plant fossils from several localities. The Nukabira flora consists of only 19 species, though the number of specimens is very abundant. Most of them belong to Betulaceae, Ulmaceae, Salicaceae, Aceraceae and Tiliaceae; this flora consists mostly of temperate deciduous broad-leaved trees. In particular, nearly all of the living equivalents of the fossil species are now distributed in northern Japan. It is characteristic to the floristic composition of this flora that northern elements such as *Betula miomaximowicziana**, *B. protoermanni*, *B. protojaponica*, *Ulmus protojaponica* and *Tilia distans*, are very abundantly included. These northern elements are also some of the representatives of the Mitoku-type flora in northeastern

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* There are many leaves of this species, and also cone-scales and seeds belonging to this species abundantly found from this fossil flora in various localities.

Honshû. This flora has almost no southern or exotic elements, and contains only one southern genus, *Stewartia*.

In the area eastward from the Kônomai mine, Kitami province, the lacustrine Shanabuchi formation is distributed on the so-called "green-tuff" of the Kônomai group with unconformity. This formation consisting of tuffaceous sandstone, siltstone and tuff, contains many well-preserved plant fossils. As listed in Table 6, the Shanabuchi flora consists of Mitoku-type components such as *Betula miomaxmowicziana, B. protoermanni, Ulmus protojaponica* and *Populus balsamoides,* which are mostly cool-temperate elements. This flora is somewhat poor in number of species, but it is closely similar to the above-described Nukabira flora in floristic composition and components. The Shanabuchi flora also contains nearly no southern elements except *Meliosma* and *Liquidambar.*

In the neighbourhood of Utanobori, northernmost part of Kitami region, the littoral Tachikarabetsu formation is distributed on pre-Tertiary rocks with unconformity. This formation includes several intercalated thin coal seams, and frequently plant fossils occurs. So far as investigated by the writer up to the present, the Utanobori flora consists of only 11 species, which are mostly temperate trees such as *Salix, Alnus, Betula, Fagus, Cercidiphyllum* and *Carpinus,* mixed with which there are some southern elements such as *Sophora miojaponica, Rhus miosuccedanea.* However, no exotic genus is found in this flora, excepting *Metasequoia.*

Besides the above-described floras, specimens of Late Miocene flora were lately found from the Ogawa coal-bearing formation in Tomamae area and the lower Bifuka group near Nayoro City. Though these floras are very poor in number of species and specimens as far as known up to the present, they are closely similar to the above-noted floras in floristic components.

Thus, Late Miocene flora of Hokkaidô shows a different floristic composition, from the Mitoku-type flora of Honshû: the former consists mainly of northern deciduous trees, with very few southern warm of exotic elements. The Mitoku-type flora generally contains several exotic genera such as *Liriodendron, Sassafras, Liquidambar* and *Pseudolarix,* on the other hand these exotic genera are nearly not contained in the above-described floras of Hokkaidô. Such a difference of floristic composition between Honshû and Hokkaidô may be due to the regional distribution of forest and the existence of climatic zones in Late Miocene time, if the inference is justifiable on the basis of the poor data collected up to the present.

7. The Shinjô-type flora

Subsequent to Late Miocene time, regional emergence or submergence were more considerably active, and such regional difference of epeirogenic movements caused the differentiation of Pliocene deposition sites in Japan. Though marine sediments are dominant at this stage in most areas of Japan, in northeastern Honshû, western Honshû, etc., there are localities where lacustrine or brackish sediments can be found, accompanied by marine sediments. The Early Pliocene non-marine sediments frequently contain plant fossils, and also occasionally intercalated thin coal seams.

Many fossil floras of this time have been found from various areas of Japan, especially in the interior basin region of northeastern Honshû and the Palaeo-Seto inland region. However, most of these floras have not yet been sufficiently clarified in respect to their floristic composition. Furthermore, fossil floras since Late Miocene time show occasionally somewhat regional difference in floristic composition and components, so that the floristic character of this time is occasionally difficult to be designated. The writer gives the name of Shinjô-type to the fossil flora of this stage, considering the Shinjô flora as its type, which flora is found in the lower and middle part of the Oriwatari formation located in the Shinjô basin, Yamagata Prefecture.

The Shinjô-type flora consists mainly of temperate broad-leaved trees, accompanied by several warm-temperate or warm elements and coniferous trees. Among the broad-leaved trees, Betulacea, Fagaceae, Ulmaceae and Aceraceae, are abundant in number of species or specimens. Accordingly, this type flora is not so considerably different from the Mitoku-type of the previous stage in floristic composition. Furthermore, in regard to the temperate broad-leaved trees there are many common species between these two type floras. However, the Shinjô-type flora contains very few exotic dicotyledonous genera such as *Liriodendron, Sassafras* and *Catalpa* with some exception, which are commonly found in the Mitoku-type flora. Furthermore, in this type flora northern temperate species such as *Populus balsamiodes, Betula miomaximowicziana, B. protoermanni* and *Ulmus protolaciniata,* are nearly absent, though these species are commonly or abundantly contained in the Mitoku-type. At the same time, some of the southern elements such as *Taiwania, Cunninghamia, Keteleeria,* have disappeared in the Shinjô flora. However, *Liquidambar, Smilax, Cinnamomum, Stewartia* and *Paliurus,* are very small in number of specimens. It is characteristic that some floras belonging to this type contain *Myrica* (*Comptonia*) *kidoi* (ENDO), which is closely similar to the modern M. (*C.*) *asplenifolia* BANK. living in North America.

TABLE 7. Main Component Species of the Shinjô-type Flora and their Main Distribution in East Asia.

Locality Fossil Species	1	2	3	4	5	Locality Fossil Species	1	2	3	4	5
Picea koribai	×	×	×			*Celtis nordenskioldii*				×	×
Picea kaneharai				×		*Ulmus protojaponica*	×				×
Picea maximowiczii						*Zelkova ungeri*	×	×	×	×	×
Pseudolarix japonica		×				*Liquidambar mioformosana*	×				×
Pinus palaeopentaphylla				×		*Magnolia elliptica*				×	
Thuja nipponica	×			×	×	*Magnolia nipponica*		×			
Glyptostrobus europaeus	×	×	×		×	*Cinnamomum miocenum*	×		×		
Metasequoia occidentalis	×	×	×		×	*Sophora sp.*		×			
Sequoia affinis	×		×			*Wistaria fallax*				×	×
Myrica (Comptonia) kidoi	×	×				*Prunus protossiori*				×	
Juglans megacinera						*Buxus protojaponica*		×	×		
Juglans japonica		×	×	×	×	*Acer nordenskiöldi*	×	×			×
Pterocarya nipponica				×		*Acer palaeosieboldianum*	×			×	
Alnus miojaponica		×	×			*Acer protojaponicum*				×	
Carpinus nipponica	×	×		×		*Acer subpictum*	×		×	×	×
Carpinus subyedoensis	×	×				*Tilia protojaponica*					
Carpinus stenophylla	×			×	×	*Paliurus nipponicus*		×			
Carpinus subcordata					×	*Euonymus palaeosieboldianus*					
Carpinus laxiflora		×	×			*Ilex cornuta*	×	×			
Ostrya huziokai		×			×	*Stewartia submonadelpha*	×	×			×
Castanea miocrenata		×		×	×	*Cornus subkousa*	×			×	
Fagus palaeocrenata	×	×	×	×	×	*Tripetaleia pseudopaniculata*					
Fagus protojaponica		×		×		*Fraxinus honshuensis*				×	
Quercus miocrispula	×	×	×	×		*Styrax protoobassis*					×
Quercus protodentata	×	×		×		*Styrax japonica*		×	×		×
Quercus protoserrata	×	×		×		*Smilax trinervis*	×	×			
Celtis nathorsti				×	×						

1. Shinjô 2. Koyanaizu (SUZUKI, 1959) 3. Kameoka (OKUTSU, 1959)
4. Ningyô-tôgé 5. Mogi

The Shinjô-type flora commonly includes coniferous trees: *Metasequoia, Sequoia, Glyptostrobus* are commonly found, continuing from the previous-staged flora. Besides them, *Picea, Pinus* and *Thuja* are frequently contained, however southern warm conifers such as *Taiwania, Cunninghamia,* are not found.

Thus, the Shinjô-type flora is also characterized by mixed floristic composition of temperate and warm elements to as great an extent the previous-staged Mitoku flora. However, particularly northern or southern elements are not contained in the Shinjô-type. In respect to the floristic composition, it is somewhat similar to the above-described Daijima-type flora at a glance, but the former contains few tropical elements, which are commonly contained in the latter.

Northeastern Honshû

In northeastern Honshû, the fossil floras belonging to this type are to be found from the upper coal-bearing formations in the interior basin region, the lower Sendai group in the environs of Sendai City, etc. as previously stated by the writer (TANAI, 1959).

In the Mogami coal field, Yamagata Prefecture, the upper coal-bearing formation, the middle and lower part of the Oriwatari formation, has abundantly yielded plant fossils from tuffaceous siltstone in various localities. The writer investigated many plant fossils collected by TOKUNAGA and YONEBAYASHI. As shown in Table 7, the Shinjô flora consists of 31 species, representing 24 genera and 18 families. These plants are 5 conifers, 25 dicotyledons and 1 monocotyledon. Among the broad-leaved trees, the temperate elements belonging to Betulaceae, Fagaceae, Ulmaceae and Aceraceae, are most abundant in number of species and specimens, but northern species of *Betula* and *Ulmus* are not found. Among the remains of Fagaceae, *Quercus* is not very abundant in number of specimens, while the characteristic beech, *Fagus palaeocrenata,* is commonly contained. At the same time, there are contained several warm elements such as *Liquidambar, Cinnamomum, Stewartia, Clethra* and *Smilax,* though they are not common. Thus, the Shinjô flora is composed mainly of temperate broad-leaved trees, accompanied by several warm elements; it commonly includes coniferous trees. From the middle part of the Oriwatari formation, *Myrica(Comptonia) kidoi* is abundantly found in the Kitomo coal mine.

In the Aizu lignite field, western Fukushima Prefecture, many plant fossils are found in the upper Fujitôge formation and the lower Izumi formation, which are the upper coal-bearing formation in this field. The Koyanaizu flora has been investigated in detail by SUZUKI (1951, 1959). This flora consists of 58 species, representing 45 genera and 28 families. It contains temperate genera of Betulaceae, Fagaceae, Ulmaceae, etc., but cool-temperate species such as *Betula miomaximowicziana, B. protoermanni, Populus aizuana, Acer palaeodiabolicum,* are not to be found as already stated by SUZUKI. There are several warm elements such as *Nyssa, Vaccinium, Stewartia, Buxus* and *Ilex,* though subtropical or warm elements such as *Cinnamomum, Liquidambar,* are not found. In this flora, conifers are commonly contained, among them being *Metasequoia, Glyptostrobus, Pseudolarix, Picea* are abundant. Accordingly, the Koyanaizu flora is nearly similar to the Shinjô-type in floristic composition and components.

In the vicinity of the City of Sendai, the plant-bearing Sendai group is distributed on the lacustrine Shirasawa formation with unconformity. This group is generally lacustrine in origin, and frequently intercalated with lignite seams which are mined. However, the marine Tatsunokuchi formation is intercalated in the middle part of this group. The plant fossils from the Sendai group have already been investigated by ENDO (1938), OKUTSU (1955), while the fossil pollen grains from these lignite seams have been discussed by SHIMADA (1951), SOHMA (1956, 1957) and others. According to their researches, the fossil flora from the Kameoka formation, the lowest part of the Sendai group, is closely similar to the Shinjô-type in floristic composition and components. The Kameoka flora consists mainly of temperate broad-leaved trees and conifers, accompanied with some warm elements such as *Cinnamomum* and *Ilex.*

Besides the above-noted 3 floras, no other fossil floras belonging to this type have yet been found in northeastern Honshû. From the upper lignite-bearing formations in the Okitama and Aterasawa lignite fields, several plant fossils are occasionally found, though they are poor in number of species up to the present. These floras may belong to the Shinjô-type.

Central and Western Honshû

In central and western Honshû, many Early Pliocene floras were reported from various localities by MIKI (1940, 1950, etc.), however regarding all of them there is doubt as to whether they belong to the Shinjô-type. It may be found that these plant-bearing formations are stratigraphically confused. At least, a part of MIKI's "*Pinus trifolia* flora" as already described in the previous section, is considered to be closely similar to the Mitoku-type flora. That is to say, the remaining part of the "*Pinus trifolia* flora" seems to belong to the Shinjô-type, for instance, the fossil flora from the upper half of the Seto group probably belongs to this type. However, the "*Pinus trifolia* flora" should be in future re-investigated from the viewpoint of stratigraphical relationships among the various localities.

Lately, the writer reported a characteristic flora from the uranium-bearing Ningyô-togé formation distributed in the Ningyô-togé florule comprises 25 species, representing 18 genera and 13 families. Among the dicotyledons, Fagaceae and Betulaceae are most abundant in number of species and specimens, followed by Ulmaceae and Juglandaceae. It is characteristic to the floristic composition of this flora that *Fagus palaeocrenata* is very abundantly contained, furnishing more than 70 per cent of the total specimens. Most of the dicotyledonous trees are temperate elements, but boreal temperate species are almost absent except the above-noted beech. On the other hand, no southern elements are contained, and there are only a few warm-temperate elements such as *Symplocos, Wistaria,* etc. There are, however, no exotic genera in this flora. Conifers are not so common; *Thuja, Picea* are found. Thus, the Ningyô-tôgé florule is closely similar to the Shinjô-type in floristic composition and components, though there is somewhat of difference or lack of characteristic components such as *Metasequoia, Glyptostrobus,* etc. As already stated by the write (TANAI & ONOE, 1960) the Ningyô-tôgé florule probably represents one of the montane forests of Early Pliocene time, while most of the Shinjô-type floras of northeastern Honshû may represent the mountain-slope or riparian forests of the same age.

Other than this florule, there is no fossil flora evidently belonging to the Shinjô-type in central and western Honshû as far as known up to the present, except the above-noted Pliocene floras reported by MIKI.

Kyûshû

There are scarcely any Early Pliocene floras in Kyûshû which are comparable to the Shinjô-type flora. This is mainly due to the fact that the lacustrine deposits of this stage are not widely distributed in Kyûshû. However, some floras in the "Palaeo-Seto inland region" are considered by the writer to be similar to the Shinjô-type.

In the area surrounding Ôita City, central Ôita Prefecture, the nonmarine Sekinan group is distributed; it is dominant in pyroclastic sediments. The Higashi-Wasada and Handa formations, the middle and upper parts of this group, frequently contain plant fossils as reported by SHUTO (1953). The fossil flora from these two formations, though poor in number of species, are composed mainly of temperate elements such as *Fagus, Quercus, Carpinus* and *Zelkova, Styrax,* accompanied by several southern elements such as *Smilax, Wistaria, Ilex,* etc. These floras seem to belong to the Shinjô-type in view of their floristic composition and also of the stratigraphic position of the fossil-bearing formations. However, these floras should be investigated in more detail in the future.

Along the coastal area of Mogi-Kitaura situated southeast of Nagasaki City, Nagasaki Prefecture, the Mogi plant-bearing beds are intercalated in andesitic agglomerate, and yield abundant well-preserved plant fossils.

The Mogi flora was investigated by NATHORST (1883), FLORIN (1920), YABE & ENDO (1930) many years ago. These are known 58 species representing 44 genera and 29 families. The writer lately collected many plant fossils from this area, and studied the Mogi flora. It consists mainly of temperate species such as Juglandaceae, Betulaceae, Ulmaceae, Fagaceae, Aceraceae and Tiliaceae, among which species *Fagus palaeocrenata* is most abundant in number of specimens. Whilst the particular boreal temperate species are scarcely found in the Mogi flora, it does include several southern elements such as *Liquidambar, Aphananthe, Wistaria* and *Ilex.* This flora represents a montane forest as already pointed out by YABE and ENDO (1930), and it is closely similar to the above-noted Ningyô-tôgé florule of western Honshû in floristic composition and components.

Hokkaidô

In central-northern and eastern Hokkaidô, Early Pliocene lignite-bearing formations are distributed in various areas. However, nearly no fossil plants have been found from these lacustrine sediments up to the present.

8. The Akashi-type flora

With the approach of the close of Pliocene time, the littoral or lacustrine environment was dominant over nearly all Japan, except some regions such as the southern Kwantô-Shizuoka region, the inner zone of north-eastern Honshû, southern Kyûshû, etc. Accordingly, the Late Pliocene lacustrine or littoral sediments are widely scattered in various areas of Japan; they occasionally intercalate lignite seams, and frequently contain abundant plant fossils. Late Pliocene flora in Japan, especially in western Honshû, has been investigated in detail by MIKI (1937, 1938, 1948, 1950, etc.). Many fossil floras of this stage have been found from various localities throughout Japan. The writer gives the name of "Akashi-type" to their floras, considering the Akashi flora as the type. That flora was once investigated in detail by MIKI (1937).

The Akashi-type flora probably corresponds to the so-called "*Metasequoia*-bearing flora" as designated by MIKI* (1948). This flora has been more precisely investigated than the other types of Japanese Neogene flora. It consists of very abundant components. MIKI and others have already

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* On the basis of the enormous quantity of plant remains collected in Japan, the Cenozoic plant-bearing beds since Pliocene time are classified into the following 7 horizons by MIKI (1948, 1953, etc.): "*Pinus trifolia* bed," "*Metasequoia* bed," "*Paliurus* bed," "*Cryptmeria* bed," "*Sapiun* bed," "*Aphananthe* bed" in ascending order.

presented detailed descriptions of the characters of its floristic composition and components. The writer has scarce additional data about this type flora, so in the present paper this type flora is very simply treated.

The Akashi-type flora consists mainly of temperate plants belonging to Salicaceae, Juglandaceae, Betulaceae, Fagaceae, Rosaceae, Leguminoceae and Styraceae, which are abundant in number of species. However, most living equivalents of these temperate fossil plants are now distributed in southern Japan and China. Furthermore, this type flora frequently contains southern elements such as *Parabenzoin, Ilex* and *Stewartia,* and also occasionally southern exotic elements such as *Liquidambar, Nyssa, Cunninghamia, Keteleeria, Pseudolarix,* which are relics from previous-staged floras. At the same time, the remains of fresh-water or marshy plants such as *Trapa, Euryale, Nuphur, Potamegoton* and *Menyanthes,* are comparatively abundantly found in various localities. Coniferous trees are commonly contained in this flora; they are mainly *Picea, Abies, Metasequoia, Glyptostrobus, Pinus* and *Thuja.* Briefly, the characteristic components of this type flora are mainly as follows: *Metasequoia occidentalis, Picea koribai, Juglans megacinerea, Euryale akashiensis, Nuphar akashiensis, Paliurus nipponicus, Rosa akashiensis, Menyanthes trifoliata, Sapium sebiferum* var. *pleistoceaca, Trapa octotuberculata* and others. Subsequent to this stage, many new elements appeared and then flourished in Pleistocene age, while in the close of this stage, several characteristic plants disappeared from the Japanese Archipelago.

Northeastern Honshû

In northeastern Honshû, the Late Pliocene lignite-bearing formations are scattered in various areas; they frequently yield plant fossils. The fossil floras from these areas have not been sufficiently investigated up to the present with some exception.

The lignite-bearing Tamazasa formation is widely distributed in the Kitakami lignite field, Iwate Prefecture. Plant remains occur abundantly in the area surrounding Hanamaki City. The Hanamaki flora has already been investigated by MIKI (1938) in detail. The present writer once re-investigated this flora on the basis of many specimens collected. This flora consists of 13 species, representing 13 genera and 11 families. Among these plants, the following species are characteristic and also abundant in number of species: *Juglans megacinerea, Prunus haussknechtii, Alnus japonica, Metasequoia occidentalis, Acer nordenskiöldi, Styrax obassioides, Menyanthes trifoliata, Euryale akashiensis, Paliurus nipponicus, Gleditchia japonica, Tsuga rotandata,* etc. Accordingly, the

Hanamaki flora is closely similar to the Akashi-type in floristic composition and components, though it is somewhat poor in number of species.

In the Aizu basin, Fukushima Prefecture, many plant fossils occur from the middle and lower parts of the Izumi formation as already reported by SUZUKI (1951). Lately, he (SUZUKI, 1959) listed 29 species from this formation, and named it the "Fukurohara flora." Among these species of this flora, the following species are numerically abundant: *Metasequoia occidentalis, Menyanthes trifoliata, Fagus crenata, Juglans megacinerea, Alnus japonica, Paliurus nipponicus* in the order given. The Fukurohara flora is closely similar to the Akashi-type in the floral characters.

In the area surrounding Sendai City, plant fossils are frequently found from the Tatsunokuchi and Yagiyama formations which occupy the middle part of the Sendai group. The fossil floras from these two formations contain *Metasequoia, Glyptostrobus, Juglans megacinerea, Fagus crenata, Acer,* etc., and probably belong to the Akashi-type in floristic components and composition.

Besides these floras, several fossil floras probably belonging to the Akashi-type were reported from Akita, Fukushima, Iwate and Tochigi Prefectures by MIKI (1940, 1950) : for instance, from the lignite bearing formation(probably the Madaki formation) in southern Kitakami lignite field, Iwate Prefecture; from the clay bed in Mashiko-mura, Kita-akita-gun, Akita Prefecture. Furthermore, terrestrial sediments containing *Juglans megacinerea,* were known from several localities in southern Kwantô region (ONISHI, 1940), and from the northernmost part of the Jôban coal field (Tomioka formation, collected by the writer), etc.

Central and Western Honshû

Fossil floras belonging to the Akashi-type have been very abundantly found in central and western Honshû, especially in the Kinki district the so-called "*Metasequoia*-bearing flora" were reported MIKI (1940, 1948, 1950, etc.) from lignite-bearing or clay beds in more than 40 localities. The "*Metasequoai*-bearing bed" in central Kinki district was stratigraphically re-examined by HUZITA, K. (1954), and ascertained to be Late Pliocene in age. These many floras are in detail described with respect to their floristic composition and components by MIKI, HUZITA and others. Accordingly, among them several representative floras are simply noted in the present paper.

The lacustrine Akashi group is distributed along the sea coast, forming the sea-cliff, in Akashi City, Hyôgo Prefecture. This group yields abundant plant fossils represented by seeds, nuts, fruits, cones, leaves, spines, etc., being accompanied by mammalian fossils such as of *Parastegodon akashiensis* TAKAI. The Akashi flora, as already in detail reported by MIKI (1937), consists of 58 species, representing 48 genera and 33 families. Among these plants, the broad-leaved trees are most abundant, and commonly contain the following characteristic species: *Juglans megacinerea, Fagus crenata, Berberis longispinus, Rosa akashiensis, Sapium sebiferum* var., *Ilex cornuta, Paliurus nipponicus, Styrax obassioides,* etc. There are abundantly contained such aquatic plants as *Euryale akashiensis, Nuphar akashiensis,* etc. The nearest modern equivalents of the Akashi species are commonly found in southern Japan, China and Manchuria; there are 16 species including *Thuja japonica, Picea polita, Parabenzoin trilobum, Fagus crenata,* etc., which grow in the southern half of Japan at altitude of about 500~1,000 meters above sea level.

In the hills surrounding the Osaka basin, the lacustrine Osaka group is widely distributed, and provides abundant plant fossils from various localities. These plants were mainly investigated by MIKI; lately their stratigraphical relationships were ascertained by HUZITA (1954). According to HUZITA's investigation, the occurrence of *Metasequoia* is confined to the Kôyôen formation, which is the lower part of the Osaka group. The fossil flora from this formation is evidently one of the "*Metasequoia*-bearing flora," and is closely similar to the Akashi flora in floristic composition and components, as listed by HUZITA.

On the southeastern part from Biwa Lake, Shiga Prefecture, the lacustrine Palaeo-Biwa group is distributed, and abundantly yields plant fossils. The fossil flora from the Aburahi formation, the lower part of this group, was ascertained by MIKI and HUZITA to belong to the "*Metasequoia*-bearing flora." As listed by HUZITA (1954), the Aburahi flora is common in floristic composition and components with the above-noted Akashi and Kôyôen floras. The upper part of this group, the Sayama formation, also includes many plant remains, accompanying some fossil elephants such as *Stegodon orientalis* OWEN and *Elephus namadicus naumanni* MAK. (IKEBE, 1954). The Sayama floras never includes *Metasequoia* remains, and is considered to be Early Pleistocene in age.

In the northern and eastern hilly area of the Nara basin, Nara Prefecture, the lignite-bearing Shirakawaike and Saho formations of lacustrine origin are distributed. They provide abundantly various plant fossils as reported in detail by KOKAWA (1954). According to his investigation, the Shirakawaike and Saho floras consists of 120 species, representing 76 genera and 53 families. Among these plants, fossils belonging to Pinaceae, Taxodiaceae, Fagaceae, Juglandaceae, Betulaceae, Magnoliaceae, Rosaceae, Styraceae, Cornaceae, Hydrocaryaceae, Cyperaceae, etc. are dominant in number of species or specimens. The lower florules of these floras contain many montane elements, and also include such characteristic components as *Metasequoia, Picea koribai, Juglans megacinerea, Rosa akashiensis, Paliurus nipponicus, Nuphar akashiensis,* etc. They are entirely similar to the Akashi and Kôyôen flora in floristic composition and components. The upper florules contain abundant marshy plants, and are somewhat different from the lower florules in floristic composition, although both florules have many common species. Thus, the upper florules may be correlated to the fossil floras of the Upper Osaka group, the Upper Palaeo-Biwa group, and are Pleistocene in age, though there are some exotic genera such as *Cunninghamia* and others.

Kyûshû

In the so-called "western Palaeo-Seto inland region" of northern and central Kyûshû, lacustrine sediments containing examples of the Akashi-type flora are scattered; they occasionally are found to contain some fossil elephants. These fossil floras have been not yet been sufficiently investigated with some exception.

In the most southeastern part of the Shimabara peninsula, Nagasaki Prefecture, the lacustrine Ôya formation is distributed; it bears abundant plant fossils as already reported in detail by TAKAHASHI, K. (1954). The Ôya flora consists of 43 species, representing 31 genera and 24 families. These plants comprises mainly temperate trees belonging to Taxodiaceae, Salicaceae, Betulaceae, Fagaceae, Aceraceae and also include several warm elements such as *Cinnamomum, Liquidambar, Buxus, Smilax* and *Entada.* This flora contains many characteristic components such as it is closely similar to the Akashi-type floras of Kinki district in floristic composition and components.

Besides this flora, fossil floras probably belonging to the Akashi-type, were known from the following formations: the Tabira formation in the northern part of the Sasebo coal field, the Hirado formation in Hirado island, the Iki formation in Iki island, the lacustrine sediments in northeastern Shimo-jima of Amakusa island, the lower part of the Ôita group in the southern part of Ôita City, etc. The fossil floras from these formations are generally poor in number of species; they should be investigated in detail.

Shikoku

Neogene sediments have only a small distribution in Shikoku, and Neogene flora has been very poorly known up to the present. Some fossil flora including *Metasequoia, Glyptostrobus, Styrax, Trapa* and *Euryale* were found by MIKI (1948, 1950) from Late Pliocene lignite-bearing sediments in the southwestern part of Kagawa Prefecture and the northeastern part of Tokushima Prefecture. They are poor in number of species, but may belong to the Akashi-type. Many fossil pollens such as those of *Metasequoia, Glyptostrobus, Cunninghamia, Piceae, Quercus,* etc. were found by NAKAMURA (1951, 1952) from Pliocene lignite seams in several localities of the southern part of Kôchi Prefecture. However, these pollen floras cannot with certainty be correlated to the Akashi-type flora.

Hokkaidô

In central, northern and southeastern regions of Hokkaidô, Pliocene littoral or lacustrine sediments are widely distributed, and they are frequently intercalated with several lignite seams. However, most of these sediments have been not yet sufficiently investigated, and there are some questions in stratigraphy. Furthermore, Pliocene floras from these sediments have practically not been investigated up to the present, excluding the pollen analysis of Pliocene lignite done by OKAZAKI (1958).

In the Tokachi lignite field situated in the area surrounding Obihiro City, eastern Hokkaidô, the littoral or lacustrine Ikeda formation is widely distributed; it is intercalated with many lignite seams which are mined at several localities. These lignites have been reported by many geologists to contain abundant fossil seeds of *Menyanthes trifoliata.* The writer and MIKI lately collected many plant remains from the basal part of the Ikeda formation to the west of Obihiro City. According to MIKI's identification, they are mainly *Picea* cfr. *gmelin, Larix* sp., *Euryale akashiensis, Ceratophyllum denersum, Trapa octotuberculata, Trapa Maximowiczii, Menyanthes trifoliata, Scirpus* sp., etc. From the lignite of the same locality, OKAZAKI found the following pollen grains: *Abies, Picea, Pinus, Taxodium, Betula, Fagus, Alnus,* etc. Though the Ikeda flora is very poor in number of species and specimens, it possesses some characteristic components of the Akashi-type flora: for instance, *Euryale akashiensis, Trapa octotuberculata,* etc.

Beside this flora, several floras are known from the Sarabetsu formation in the Tempoku coal field, the upper Takikawa formation near Takikawa-machi, etc., but they are very poor in number of species.

VI. Palaeoecological Consideration

In employing the fossil flora as indicators of the climatic evironments of the past, some reliable methods have been frequently employed by many authors. The writer uses the following three methods for palaeoecological consideration indicated by the flora.

1) The analysis of leaf characters. The method of analyzing leaf characters is frequently useful for determination of their relation to the environment.

2) A generic and specific comparison of fossil species with nearest living equivalents. It is customary to interpret the environment of a fossil flora on the basis of the climate in regions where the modern equivalents now live. This method is, of course, based on the assumption that past conditions were analogous to those under which the majority of the closely related living species are now growing.

3) The mode of occurrence of the fossils, and nature or texture of fossil plants. The various components of a fossil flora do not always have equal significance for physical considerations indicated by the floristic composition. Though the relative abundance and nature of fossil materials were controlled by local physiographic and edaphic condition, they also represent a floristic composition.

1. Climatic indication supplied by leaf characters.

The leaf characters of dicotyledonous trees have been generally observed to be related to the climatic environments. The method of analyzing leaf characters according to size, nervation, margin, organization, etc. in their relation to environment, was developed by BAILEY and SINNOT (1916) ; also CHANEY and his students (CHANEY et SANBORN, 1933; DORF, 1938; MACGINITIE, 1941; etc.) frequently used this method for climatic analysis of fossil flora. Lately, the writer also made use of this method as one means of climatic analysis in the research on the Hôki flora, and reported that this results generally agreed well with the climatic indications deduced by other method (TANAI et ONOE, 1961). Especially, among the leaf characters the marginal nature of the broad-leaved seems to depend more intimately on climatic environments than other nature. ENDO (1934) once investigated the marginal character of the main broad-leaved trees making up the Japanese modern forest, and he obtained the

Leaf serration / Climate forest zone of Japan	Non-entire %	Entire %
Warm-temperate	41	56
Temperate	81	19
Frigid	92	8

following data by respective computations on the frigid, temperate and warm-temperate forests.

The above-noted zoning Japanese forest was actually done by HONDA (1911). The warm-temperate zone covers central and southern Honshû, northern Kyûshû and northern Shikoku. The temperate zone is from southern Hokkaidô to northern Honshû, and the frigid zone includes northern Hokkaidô and southern Saghalien.

Briefly re-stated, some of the original conclusions of BAILEY and SINNOT may be summarized as follows: (1) The characters of large size, entire margin, pinnate venation and compound organization occur most frequently in the tropics, and decrease proportionally to the temperate region. (2) Palmate leaves are more primitive than pinnate. The relationship between leaf margin and climate appears to be most direct, and thus the percentage of dicotyledons with entire leaves may be a reliable indication of the climatic environments.

Thus, the writer undertook the analysis of the three leaf characters, organization, nervation and margin, of some representative floras among many Neogene floras described in the previous chapter. However, the computation of the leaf character analysis shall be apt to contain errors, if the fossil flora has only a small number of components. Accordingly, the fossil floras used for the computation consist of more than 20 species definitely determined by the writer or others. These computations on these floras are shown in Table 8.

In the Ainoura-type flora, the trees with entire-margined leaves occupy about 24 per cent of the total number of species, though this computation is based on only one fossil flora. The Aniai-type flora generally has 10~20 per cent of entire-marginal-leaved trees, while the Daijima-type contains generally 25~30 per cent with some exceptions. In respect of the marginal character of the broad leaves, a contrast between the Aniai- and Daijima-type floras is distinctly found among most fossil floras belonging to these two types. With respect to the characteristic organization and venation characters of leaves, the difference between these two types is generally observed: the trees with compound-leaves in the Daijima-type generally occur in higher percentage than in the Aniai-type, on the contrary the trees with plamate-leaves in the Aniai-type are generally larger in percentage than in the Daijima-type. The percentage figures of the Aniai-type flora are generally situated between those of the modern temperate and frigid forest zones in Japan, and rather close to those of the temperate forest. From the viewpoint of leaf characters, the Daijima-type flora seems to have existed under a

TABLE 8. Leaf Characters of Dicotyledons, showing Relative Percentages in each Category.

		Fossil Flora	Margin		Organization		Venation	
			Non-entire	Entire	Simple	Compound	Pinnate	Palmate
			%	%	%	%	%	%
Ainoura-type	Kyûshû	low. Ainoura	76	24	86	14	72	28
		up. Ainoura	90	10	85	15	67	33
Aniai-type	Hokkaidô	Kaminokuni	96	4	92	8	61	39
		Nokanan	81	19	87	13	67	33
		Sôya	80	20	75	25	65	35
	Honshû	Aniai	85	15	89	11	67	33
		Iwadate	93	7	72	28	86	14
		Nishitagawa	87	13	83	17	75	25
		Shichiku	83	17	83	17	66	34
		Hiyoshi	80	20	90	10	65	35
	Kyûshû	Fukui	89	11	84	16	74	26
		Yunoki						
Daijima-type	Hokkaidô	Yoshioka	71	29	76	24	77	23
		Setana	91	9	82	18	76	24
		Wakamatsu	86	14	83	17	86	14
	Honshû	Uttô	68	32	84	16	90	10
		Daijima	56	44	81	19	84	16
		Kamigô	65	25	69	21	83	17
		Oguni	55	41	83	17	67	33
		Ouchi	60	40	84	16	90	10
		Orito	70	30	80	20	67	33
Mitoku-type	Hokkaidô	Nukabira	94	6	89	11	78	22
	Honshû	Gosho	73	27	82	18	76	24
		Obayashi	77	23	92	8	62	38
		Takamine	81	19	87	13	72	28
		Tennôji	75	25	91	9	75	25
		Shiroko	73	27	95	5	68	32
		Sudani	82	18	91	9	77	23
		Mitoku	73	27	86	14	73	27
		Onbara	81	19	94	6	90	10
Shinjô-type	Honshû	Shinjô	85	15	92	8	85	15
		Koyanaizu	80	20	84	16	84	16
		Ningyô-tôge	86	14	82	19	92	8

warmer climatic environment than the Aniai-type. However, in respect to the leaf characters the Daijima-type flora of Hokkaidô are somewhat different from those of Honshû. For instance, in three floras in southwestern Hokkaidô, Yoshioka, Setana and Wakamatsu, the percentage figures of entire margined-leaved trees are somewhat less than the average in Honshû. Considering the leaf character analysis, the Daijima-type flora in Hokkaidô seems not to have lived in so warm in climatic conditions as that of Honshû.

The Mitoku-type flora shows intermediate percentages of leaf character between those of the Aniai- and Daijima-type floras with some exception. It is, however, somewhat close to the Daijima-type: the trees with entire-margined leaves count 20~25 per cent in average for the total species. On the contrary, the percentage figures of the trees with compound-leaves or palmate-nerved leaves are rather close to those of the Aniai-type. That is to say, the Mitoku-type flora exhibits mingled temperate and warm elements in floristic composition as already described in the previous part of this work, so that the leaf characters of it are somewhat complicated by various factors. However, in respect of leaf character analysis, the Mitoku-type flora is related to the temperate or somewhat warm-temperate forest in central and southern Japan, and it seems to have grown under a warm-temperate climatic environment. As far as known up to the present, the Mitoku-type flora in Hokkaidô seems to have grown in an environment considerably different from the abovementioned. For instance, the percentage figures of marginal character in the Nukabira flora are nearly similar to those of the modern frigid forest zone of Japan, and in respect of leaf character the Nukabira flora seems to have been similar to the forest living now in Hokkaidô.

Considering the regional difference of percentage of leaf characters in the respective type flora, the Mitoku-type flora seems to have existed in more variable localities than the two types of the previous stage. That deduction may probably be due to the fact that these computations were made on the basis of incomplete data, but also that the regional difference of plant distribution had gradually become more considerable than in the previous stage.

The Shinjô- and Akashi-type floras abundantly contain fossil dicotyledonous species determined only by non-foliar materials such as seeds, fruits, nuts, etc. Furthermore, the writer actually investigated a small number of the fossil floras belonging to these two types up to the present. Accordingly, it may be nearly insignificant that these two type floras are compared with others in the climatic condition indicated by leaf character analysis of the two types. However, the writer availed himself of this method for several floras of the Shinjô-type which were investigated mainly by the use of foliar materials. The percentage of entire-leaved species in these Shinjô-type floras is 15 to 20, and generally less than the percentages of the Mitoku-type of the previous stage.

As already stated earlier in this works, the Sudani and Onbara florules belonging to the Mitoku-type are somewhat higher horizoned in stratigraphic sequence than other typical floras of this type. These two florules are nearly similar to the Shinjô-type in the percentage ratio of entire to non-entire-leaves species. This percentage ratio of the Shinjô-type is close to that of modern temperate forest of Japan. Accordingly, from the Mitoku-type towards the Shinjô-type flora, the environments may have become gradually temperate from warm-temperate in climate.

It is not very significant for climatic consideration that the method of leaf character analysis is applied to Later Tertiary floras. This is true because Pliocene species are, in general, very close to the modern species living in Japan and its adjacent regions, and the fossil flora of later stages is comparatively easy to be compared with the modern forest in respect of floristic composition and climatic environment.

2. Distribution of the modern equivalent species.

Comparison between fossil species 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 the accurate information. However, certain difficulties arise in applying this method to Palaeogene flora, because it is frequently difficult to find similar living equivalents of Palaeogene species in the modern forest. The lapse of geologic time and change of physical conditions, seem to cause floristic associations and their component species to alter into new types. Accordingly, it is impossible to find an exact replica of a fossil flora in a modern forest. However, the Neogene species are, in general, comparatively modernized in morphological features, so it is not difficult to compare them with living equivalents with some exceptions.

The genera comprising Neogene flora in Japan are mostly distributed now in East Asia, and especially nearly all of the temperate dicotyledonous genera in fossil flora are luxuriantly growing in Japan. However, exotic genera are sometimes commonly contained in some type flora as already stated in the previous part. The exotic coniferous genera belonging to Pinaceae and Taxodiaceae, such as *Metasequoia*, *Glyptostrobus*, *Sequoia, Pseudolarix, Keteleeria,* etc., are found throughout the Neogene flora of Japan; they are mostly living now in China, some of them in North America. Neogene flora of Japan consists mainly of temperate genera throughout all stages, being accompanied by warm or subtropical genera frequently in some stages, or rarely in other stages. Most of these subtropical or warm genera are also now found in the modern forest of southern or central China, Formosa, and other southern regions of East Asia. Table 9 shows stratigraphic distribution of Neogene genera of Japan and their modern distribution in East Asia. In respect of generic association, Neogene floras of Japan are not considerably different from each other in the respective stages, and generally similar to the modern vegetation of Japan and adjacent regions.

In respect of specific consideration, the Neogene flora of Japan is considerably different from the modern flora of Japan proper. In general, the modern equivalents of later Neogene species are largely growing in Japan proper, but they gradually decrease in number of species and specimens towards the earlier stages of Neogene time. In order to reconstruct the environments during Neogene time, it is necessary first to compare the fossil flora of each stage with the living vegetation. The floristic lists of Neogene six type floras with the nearest modern equivalents and the geographical distribution of their modern species are presented in Tables 10~14.

As already reported by the writer (TANAI, 1959), the Aniai-type flora is most closely similar to the present flora growing in central and northern China, and northern Japan. The living equivalent species of temperate genera such as *Alnus, Betula, Carpinus, Ulmus, Cercidiphyllum, Acer, Tilia,* etc., are mostly distributed in the cool-temperate region of East Asia, for instance the regions from central to northern China, or from northeastern Honshû to Hokkaidô. In the Aniai-type flora the exotic genera are comparatively few in number; specimens very rarely occurred excepting the relict genera of Taxodiaceae such as *Metasequoia, Sequoia, Glyptostrobus, Taxodium.* Of the dicotyledonous trees there are found only 6 exotic or extinct genera from several floras of this type: they are *Carya, Myrica (Comptonia), Nelumbo, Platanus, Sassafras, Hemitrapa.* Most of these genera are warm or warm temperate elements, considering on the basis of modern vegetation. They, however, flourished rather well in pre-Neogene time, and some of them are abundantly found in the Palaeogene flora of Japan. As shown in Table 11, among the living equivalents of the Aniai-type species, the plants growing in central China are most abundant, followed by those in Honshû and Kyûshû,

TABLE 9. Stratigraphic Distribution of Neogene Main Genera in Japan and their Modern Distribution in East Asia

	Palaeo-gene	Miocene				Pliocene		Present	
		Aino-ura	Aniai	Dai-jima	Mito-ku	Shin-jô	Aka-shi	Japan	China
Osmunda	×		×		×			×	
Salvinia	×		×	×				×	
Abies			×	×	×	×	×	×	×
Keteleeria			×	×	?	?	(×)		×
Larix						×		×	×
Picea			×	×	×	×	×	×	×
Pinus				×	×	?	×	×	×
Pseudolarix			×	×	×	×			×
Pseudotsuga				×			×	×	×
Tsuga				×	(×)	(×)	×	×	×
Cryptomeria							(×)	×	×
Cunninghamia				×	×		×		×
Glyptostrobus	×	×	×	×	×	×	×		×
Metasequoia	×	×	×	×	×	×	×		×
Sequoia	×	×	×	?	×	×	×		
Taxodium	×	×	×	?					
Taiwania				×	×				
Juniperus					×			×	(×)
Thuja				?	×	×	×	×	×
Populus	×		×	×	×	?		×	×
Salix	×		×	×	×	×	×	×	×
Myrica (*Comptonia*)	×		×	×		×			
Carya	×		×	×	×		×		×
Juglans	×	×	×	×	×	×	×	×	×
Platycarya			×	×					×
Pterocarya		×	×	×	×	×	×	×	×
Alnus	×	×	×	×	×	×	×	×	×
Betula	×	×	×	×	×	×	×	×	×
Carpinus	×	×	×	×	×	×	×	×	×
Corylus	×	×	×				×	×	×
Ostrya			×	×	×	?		×	×
Castanea	×		×	×	×	×	×	×	×
Fagus		×	×	×	×	×	×	×	×
Quercus	×			×	×	×	×	×	×
Lithocarpus	?			×	×	(×)	(×)		×
Celtis				×	×	×		×	×
Pteroceltis				×					×

TABLE 9. (*Continued 1*)

	Palaeo-gene	Miocene				Pliocene		Present	
		Aino-ura	Aniai	Dai-jima	Mito-ku	Shin-jô	Aka-shi	Japan	China
Ulmus	×	×	×	×	×	×	×	×	×
Zelkova	×	×	×	×	×	×	×	×	×
Brasenia							×	×	×
Euryale							×	×	×
Nelumbo	×	×	×						×
Nuphar							×	×	×
Cercidiphyllum	×		×		×	?		×	×
Berberis		×			×		×	×	×
Cocculus		×	×	×	?			×	×
Sinomenium					(×)			×	×
Stephania							×	×	×
Liriodendron				?	×				×
Magnolia	×		×	×	×	×	×	×	×
Schizandra							×		
Actinodaphne				×				×	×
Cinnamomum	×			×	×	×	(×)	×	×
Lindera				×	×	(×)	(×)	×	×
Machilus				×				×	×
Neolitsea				×	×	?	(×)	×	×
Parabenzoin				×	×			×	×
Sassafras	×	?	×	×	×				×
Hydrangea			×	×	?			×	×
Shizophragma					×			×	
Fothergilla	×			×	?				
Fortunearia							×		×
Hamamelis	×	×		?	×	×	×	×	×
Liquidambar	×	×		×	×	×	(×)	(×)	×
Eucommia	×			×	(×)				×
Platanus	×	?	×		×				
Spiraea			×						
Sorbus	×		×	×	×	(×)		×	×
Rosa		×	(×)	×				×	×
Prunus	×				×		×	×	×
Entada				×			×		×
Cercis	?	×		×	×				×
Gleditsia				?			×	×	×
Robinia				×					
Sophora		×	×	×	×				×

TABLE 9. (*Continued 2*)

	Palaeo-gene	Miocene				Pliocene		Present	
		Aino-ura	Aniai	Dai-jima	Mito-ku	Shin-jô	Aka-shi	Japan	China
Wistaria			×	?	×		×	×	×
Fagara							×	×	×
Phelloderdron					×	(×)	×	×	×
Ailanthus				×	?				×
Canarium					(×)				×
Melia	×								
Mallotus				(×)	(×)				
Sapium				(×)	×	×	×	×	×
Buxus			(×)	×	×	(×)	×	×	×
Pistacia				×					×
Rhus				×	×	×		×	×
Spondias					(×)	?	×		×
Ilex				×	×	×	×	×	×
Euonymus		×		?	×	×		×	×
Acer	×	×	×	×	×	×	×	×	×
Dodonaea				×					
Sapindus	×			×				×	×
Dilodendron				×					
Reevesia				×					×
Melisma	?			?	×	×	×	×	×
Berchemia	?			?	(×)	(×)	×	×	×
Paliurus	?				×	×	×		×
Vitis	(×)			×	×	×	×	×	×
Tilia	×	×	×	×	×	×	×	×	×
Camellia				×	×		×	×	×
Stewartia					×	×	×	×	×
Alangium									
Menyanthes						×	×	×	
Hemitrapa			×	×					
Trapa							×	×	×
Aralia			×	×	?		×	×	×
Kalopanax	×		×					×	×
Cornus		×	×	?	×	×	×	×	×
Clethra					×	×		×	×
Rhododendron				?	×	×		×	×
Tripetaleia					×			×	×
Diospyros			(×)	×	×	×		×	×
Symplocos	×				×		×	×	×

TABLE 9. (*Continued 3*)

	Palaeo-gene	Miocene				Pliocene		Present	
		Aino-ura	Aniai	Dai-jima	Mito-ku	Shin-jô	Aka-shi	Japan	China
Meliodendron					(×)				×
Styrax		×			×	×	×	×	×
Fraxinus	×			×	×	×	×	×	×
Lonicera					×			×	×
Viburnum	×		×	?	×	×	×	×	×
Smilax	×			×	×	×		×	×
Phyllostachys							×	×	×
Bambusium					×				

North China, and Hokkaidô and Saghalien in the order given. In respect to each flora belonging to the Aniai-type, there are nearly no difference respectively in the modern distribution of the living equivalents excluding the Hiyoshi flora.

On the other hand, the Daijima-type flora contains many warm or subtropical genera, along with many temperate ones. There are many exotic genera which are not now living in Japan proper. They count more than 20 genera: the dicotyledonous genera, *Myrica*(*Comptonia*), *Carya, Pteroceltis, Liquidambar, Entada, Robinia, Cercis, Ailanthus, Pistacia, Dodonaea, Reevesia, Dilodendron, Eucommia, Sassafras,* and the coniferous genera, *Keteleeria, Pseudolarix, Cunninghamia, Taiwania, Metasequoia, Glyptostrobus,* etc. Some of them are commonly or abundantly found in all floras belonging to this type. The living equivalent species of these exotic genera are confined in distribution mostly to central and southern China, and Formosa, partly to North or South America. Besides them, there are many warm genera such as *Lithocarpus, Neolitsea, Parabenzoin, Cinnamomum, Actinodaphne* and *Rosa,* which are luxuriantly growing now in southern parts of East Asia. Furthermore, the Daijima-type flora contains temperate genera such as *Alnus, Carpinus, Ulmus, Zelkova, Fagus, Castanea, Quercus, Acer* and others. However, the modern equivalents of their species are widely distributed in East Asia as well as in Japan, or generally in rather southern regions.

As shown in Table 12, the living equivalents of the Daijima-type species show a contrasting difference in their distribution, compared with those of the Aniai-type. They are largely living in central and southern China, and Formosa. The plants distributed in Japan are also comparatively common, but they are mostly in southern Honshû and Kyûshû,

TABLE 10. The nearest living Equivalents of the Ainoura-type Species and their modern Distribution in the East Asia

Fossil Species	Nearest equivalents		Japan							China						habi-tat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Metasequoia occidentalis	*M. glyptostroboides*										×					M
Glyptostrobus europeaus	*G. pensilis*											×				S
Taxodium dubium	*T. distichum*														×	S
Sequoia affinis	*S. sempervirens*														×	M
Salix varians	*S. wilisonii*										×		×			S
Juglans shanwangensis	*J. regia*												×			S
Pterocarya asymetrosa	*P. paliurus*										×	×	×			S
Alnus prenepalensis	*A. nepalensis*										×	×	×			
Alnus kefersteinii	*A. sitchensis*														×	M
Betula mioluminifera	*B. luminifera*											×				M
Betula uzenensis	*B. schmidti*	×	×	×	×				×							M
Carpinus subcordata	*C. cordata*			×	×	×	×		×	×						S-M
Carpinus miofangiana	*C. fangiana*										×		×			M-U
Corylus macquarrii	*C. heterophylla*	×	×	×	×	×	×		×					×		S-M
Corylus miochinensis	*C. chinensis*									×	×					M
Fagus antipofi	*F. americana*														×	M
Ulmus pseudolongifolia	*U. lanceaefolia*												×			M
Ulmus appendiculata	*U. davidiana*	×	×						×	×				×		M
Zelkova ungeri	*Z. serrata*			×	×	×	×									M
Nelumbo nipponica	*N. nucifera*											×				L
Cercidiphyllum crenatum	*C. japonicum*		×	×	×	×	×									M
Cocculus heteromorpha	*C. trilobus*									×	×	×	×			S-M
Berberis saseboensis	*B. morrisonensis*							×								U
Hydrangea lanceolimba	*H. umbellata*	×	×	×	×	×	×									S-M

Liquidambar mioformosana	*L. formosana*							×								S
Hamamelis miomollis	*H. mollis*										×	×				M
Rosa usyuensis	*R. multiflora*		×	×	×	×	×									M
Sophora miojaponica	*S. japonica*								×	×	×	×	×			S
Cercis miochinensis	*C. canadensis*														×	S-M
Euonymus protobungeana	*E. bungeana*									×						M
Acer ezoanum	*A. miyabei*		×													M
Acer palaeodiabolicum	*A. diabolicum*			×	×	×	×									M
Tilia distans	*T. amurensis*	×								×						M
Tilia subnobilis	*T. nobilis*									×				×		U
Alangium aequalifolium	*A. chinense*										×	×	×			M
Alangium basiobliquum	*A. chinense*										×	×	×	×		M
Cornus megaphylla	*C. macrophylla*			×	×	×	×				×	×	×			S-M
Cornus saseboense	*C. kousa*									×	×					M-S
Styrax saseboense	*S. matsumurae*							×								M

Modern Distribution

1. Saghalien and Kurile Isl. 2. Hokkaidô 3. Northern Honshû 4. Central Honshû 5. South-western Honshû 6. Kyûshû and Shikoku 7. Formosa and Loochoo Isl. 8. Korea 9. North China 10. Central China 11. Southeast China 12. Southwest China 13. Manchuria and Primorskaya Prov. 14. North America, or other region.

Habitat

L: Lake and Marshy S: Stream-side and riparian M: Mixed-slope U: Upland

(The abbreviations concerning the modern distribution and habitat are common in Table 10–14.)

TABLE 11. The Nearest Equivalents of the Aniai-type Species and their Modern Distribution in East Asia

Fossil Species	Nearest equivalents		Japan							China					habi-tat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Osmunda japonica fossilis	*O. japonica*		×	×	×	×	×	×	×	×	×	×	×			S
Salvinia formosa	*S. natans*			×	×	×	×									L
Abies honshuensis	*A. homolepis*			×	×	×	×									M-U
Picea miocenica	*P. polita*				×	×	×									U
Picea sugaii	*P. jessoensis*	×	×						×							M
Picea kanoi	*P. koyamai*				×											U-M
Picea ugoana	*P. bicolor*				×											M
Picea magna	*P. neoveitichii*										×		×			U
Pseudolarix japonica	*P. kaempferi*										×	×				M
Glyptostrobus europaeus	*G. pensilis*											×				S
Metasequoia occidentalis	*M. glyptostroboides*										×					M
Metasequoia miocenica	*M. glyptostroboides*										×					M
Sequoia affinis	*S. sempervirens*														×	M
Taxodium dubium	*T. distichum*														×	S
Populus balsamoides	*P. candicans*														×	S
Populus latior	*P. tremuloides*														×	S
Salix varians	*S. wilsonii*										×		×			S
Carya miocathayensis	*C. cathayensis*											×				S
Juglans japonica	*J. ailathifolia*		×	×	×	×	×									S
Juglans miocathayensis	*J. cathayensis*										×		×			M
Juglans shanwangensis	*J. regia*												×			S
Platycarya miocenica	*P. strobilaceae*			×	×	×	×		×		×	×	×			S
Pterocarya asymmetrosa	*P. paliurus*										×	×	×			S
Alnus kefersteinii	*A. sitchensis*														×	M
Alnus arasensis	*A. serrulata*														×	M

Alnus prenepalensis	*A. nepalensis*										×	×	×			U-M
Alnus usyuensis	*A. sitchensis*														×	M
Betula mioluminifera	*B. luminifera*										×					M
Betula uzenensis	*B. schmidti*	×	×	×	×				×							M
Carpinus ishikiensis	*C. orientalis*														×	M
Carpinus kodairae-bracteata	*C. laxiflora*		×	×	×	×	×		×							S-M
Carpinus miocenica	*C. laxiflora*		×	×	×	×	×		×							S-M
Carpinus miofangiana	*C. fangiana*										×		×			M-U
Carpinus miofargesiana	*C. fargesiana*										×	×	×			M
Carpinus simplicibracteata	*C. cordata*			×	×	×	×									S-M
Carpinus s-satoi	*C. henryana*										×					M
Carpinus stenophylla	*C. carpinoides*			×	×	×	×									S-M
Carpinus subcordata	*C. cordata*			×	×	×	×									S-M
Carpinus subyedoensis	*C. tchonoskii*			×	×	×	×		×		×					S-M
Corylus macquarrii	*C. heterophylla*	×	×	×	×	×	×		×							S-M
Corylus miochinensis	*C. chinensis*									×	×					M
Ostrya huziokai	*O. japonica*		×	×	×	×	×		×	×	×					M
Ostrya subvirginiana	*O. virginiana*														×	M
Fagus antipofi	*F. americana*														×	M
Ulmus appendiculata	*U. davidiana*	×	×						×	×				×		M
Ulmus longifolia	*U. lanceaefolia*												×			M
Ulmus shiragica	*U. davidiana*													×		M
Zelkova ungeri	*Z. serrata*			×	×	×	×									M
Nelumbo endoana	*N. nucifera*											×				L
Nelumbo nipponica	*N. nucifera*											×				L
Cocculus heteromorpha	*C. trilobus*									×	×	×	×			S-M
Cercidiphyllum crenatum	*C. japonicum*		×	×	×	×	×									M
Magnolia nipponica	*M. kobus*			×	×	×	×		×							S-M
Platanus aceroides	*P. occidentalis*														×	M
Platanus guillelmae	*P. occidentalis*														×	M

TABLE 11. *(Continued)*

Fossil Species	Nearest equivalents		Japan						China					habitat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Hydrangea lanceolimba	*H. umbellata*	×	×	×	×	×	×					×	×			S-M
Hydrangea miobretschneideri	*H. bretschneideri*									×				×		M
Sorbus nipponica	*S. comixta*		×	×	×	×	×									S-M
Sophora miojaponica	*S. japonica*								×	×	×	×				S
Wisatria fallax	*W. floribunda*			×	×	×	×									M-S
Acer ezoanum	*A. miyabei*		×													M
Acer fatisiaefolia	*A. diabolicum*			×	×	×	×									M
Acer nordenskiöldi	*A. palmatum*			×	×	×	×				×	×				M
Acer palaeodiabolicum	*A. diabolicum*			×	×	×	×									M
Acer palaeoplatanoides	*A. platanoides*														×	M
Acer palaeorufinerve	*A. rufinerve*			×	×	×	×									M
Acer protojaponicum	*A. japonicum*		×	×	×	×	×		×							M
Acer pseudoginnala	*A. ginnala*	×	×	×	×	×	×									M
Acer subpictum	*A. mono*	×	×	×	×	×	×		×	×						M
Aesculus majus	*A. turbinata*		×	×	×	×	×									M
Aesculus miochinensis	*A. chinensis*									×	×					M
Tilia distans	*T. amuraensis*								×	×				×		M
Tilia miohenryana	*T. henryana*										×	×				M
Tilia subnobilis	*T. nobilis*	×												×		U
Tilia protojaponica	*T. japonica*		×	×	×	×	×							×		M
Alangium aequalifolium	*A. chinense*									×	×	×				M
Aralia celtisfolia	*A. californica*														×	M
Kalopanax acerifolium	*K. septemlobus*									×	×	×	×			S-M
Cornus megaphylla	*C. macrophylla*			×	×	×	×			×	×	×				S-M
Viburnum otukai	*V. betulifolium*										×					M-S
Viburnum protoparvifolium	*V. parvifolium*							×								U

whereas there are very rare cool- or boreal-temperate species which are luxuriantly growing in Hokkaidô and Saghalien, northern China, Manchuria, and other boreal regions of East Asia.

As already stated in the first part, the Daijima-type floras in Hokkaidô are somewhat different in floristic composition from those of Honshû. The modern equivalents of their component species shift somewhat further northwards in their distribution than those of Honshû. This fact evidently coincides with the result of leaf character analysis described in the previous section. Furthermore, it may indicate that the past vegetation in Japan has gradually segregated since this stage.

The Mitoku-type flora consists mainly of temperate genera, with warm elements commonly accompanying. The dominant genera among the temperate ones, are *Populus, Pterocarya, Alnus, Betula, Carpinus, Fagus, Castanea, Quercus, Ulmus, Zelkova, Acer, Tilia, Styrax, Viburnum,* etc. The modern equivalent species of them are mostly distributed in Japan proper, especially from central Honshû to Kyûshû. However, some of them such as *Betula maximowicziana, B. ermanni, Fagus crenata, Styrax obassia,* etc. are rather luxuriantly distributed in northern Honshû and Hokkaidô. Further, the Mitoku-type flora sometimes contains many exotic genera such as *Pseudolarix, Cunninghamia, Taiwania, Metasequoia, Glyptostrobus* of the conifers and *Carya, Liriodendron, Sassafras, Liquidambar, Platanus* and *Cercis* of the dicotyledons, though they are not abundant in number of specimens. Nearly all of their species were rather relicts which survived from the previous age. Accordingly, although the climatic environments in this stage were fitted for the luxuriant growth of abundant temperate trees including some boreal-temperate elements, they did not change so considerably or abruptly with the result that the above-noted exotic species were able to survive continuously. Such presumption regarding climatic environments is supported by the fact that the Mitoku-type flora frequently contains such warm elements as *Cinnamomum, Ilex, Lindera, Stewartia, Smilax, Clethra,* etc.

As shown in Table 13, the modern equivalent species of the Mitoku-type, are most abundantly distributed in southern Japan, and next in central and southern China. Most of the Mitoku-type species, excluding the exotic elements, are generally modernized in morphological features, and there are very abundant fossil species being closly similar or nearly identical to the modern species of Japanese forest. Furthermore, the Mitoku-type flora frequently shows some varieties in floristic composition, compared with the previous-staged three type floras: for instance, it contains dominantly warm elements, commonly aquatic plants, or some-

TABLE 12. The Nearest Living Equivalents of the Daijima-type Species and their Modern Distribution in East Asia

Fossil Species	Nearest equivalents		Japan							China						habi-tat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Salvinia formosa	*S. natans*			×	×	×	×									L
Abies aburaensis	*A. homolepis*			×	×	×	×									U
Abies n-suzukii	*A. lasicarpa*														×	M
Keteleeria ezoana	*K. davidiana*							×			×	×	×			M
Picea miocenica	*P. polita*				×	×	×									U
Picea kanoi	*P. koyamai*				×											U
Picea magna	*P. neoveitchii*										×		×			U
Picea ugoana	*P. bicolor*				×											M
Pinus palaeopentaphylla	*P. parviflora*		×	×	×	×	×									M-U
Pinus miocenica	*P. densiflora*			×	×	×	×		×							S-M
Pinus fujii	*P. thunbergii*			×	×	×	×		×							S
Pseudolarix japonica	*P. kaempferi*										×	×				M
Pseudotsuga ezoana	*P. japonica*					×	×									U
Tsuga aburaensis	*T. diversifolia*			×	×	×	×									U
Tsuga miocenica	*T. longibracteata*												×			M
Cunninghamia protokonishii	*C. konishii*							×								U
Glyptostrobus europaeus	*G. pensilis*											×				S
Metasequoia occidentalis	*M. glyptostroboides*										×					M
Taiwania japonica	*T. cryptomeroides*							×				×	×			U
Populus balsamoides	*P. candicans*														×	S
Populus latior	*P. tremuloides*														×	S
Myrica(Comptonia) naumanni	*M. asplenifolia*														×	S
Carya miocathayensis	*C. cathayensis*											×				S
Juglans japonica	*J. ailathifolia*		×	×	×	×	×	×								S

Juglans shanwangensis	*J. regia*												×			S
Platycarya miocenica	*P. strobilaceae*			×	×	×	×		×		×	×	×			S
Pterocarya asymmetrosa	*P. paliurus*										×	×	×			S
Alnus kefersteinii	*A. sitchensis*														×	M
Alnus miojaponica	*A. japonica*		×	×	×	×	×					×		×		S
Alnus protomaximowiczii	*A. maximowiczii*	×	×	×	×				×					×		M
Betula kamigoensis	*B. ermanni*	×	×	×	×				×							M-U
Betula mioluminifera	*B. luminifera*										×					M
Betula nipponica	*B. nigra*														×	M
Carpinus miocenica	*C. laxiflora*		×	×	×	×	×		×							S-M
Carpinus miofangiana	*C. fangiana*										×		×			M-U
Carpinus miofargesiana	*C. fargesiana*										×	×	×			M
Carpinus shimizui	*C. orientalis*														×	M
Carpinus subcordata	*C. cordata*		×	×	×	×	×		×	×	×			×		S-M
Carpinus subyedoensis	*C. tchonoskii*			×	×	×	×		×		×					S-M
Ostrya huziokai	*O. japonica*		×	×	×	×	×		×	×	×					M
Castanea ungeri	*C. mollissima*									×	×	×				S-M
Fagus antipofi	*F. americana*														×	M
Quercus koraica	*Q. tarokoensis*							×								S-M
Quercus mandraliscae	*Q. longinux*							×								M
Quercus miocrispula	*Q. crispula*	×	×	×	×	×	×			×	×			×		S-M
Quercus nathorsti	*Q. glauca*			×	×	×	×	×								S-M
Quercus sinomiocenicum	*Q. accutissima*			×	×	×	×		×	×	×		×			M
Quercus subvariabilis	*Q. variabilis*									×	×	×	×			M
Celtis miobungeana	*C. bungeana*								×		×			×		S
Pteroceltis ezoana	*P. tartarinowii*										×		×			S-M
Ulmus longifolia	*U. lanceaefolia*												×			M
Ulmus subparvifolia	*U. parvifolia*						×	×			×	×				S
Zelkova ungeri	*Z. serrata*			×	×	×	×		×		×	×				M
Fothergilla viburnifolia	*F. gardeni*														×	S-M

TABLE 12. *(Continued)*

Fossil Species	Nearest equivalents		Japan							China					habi-tat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Liquidambar mioformosana	*L. formosana*							×			×	×	×			S
Eucommia japonica	*E. ulmoides*										×		×			M
Magnolia nipponica	*M. kobus*		×	×	×	×	×		×							S-M
Actinodaphne nipponica	*A. longifolia*				×	×	×	×								S-M
Cinnamomum miocenum	*C. camphora*				×	×	×	×			×	×				S-M
Cinnamomum oguniense	*C. reticulata*							×								S
Lindera gaudini	*L. glauca*				×	×	×	×	×		×					S-M
Machilus ugoana	*M. japonica*				×	×	×	×	×		×	×				S-M
Neolitsea japonica	*N. sericea*			×	×	×	×	×	×							S-M
Parabenzoin protopraecox	*P. praecox*			×	×	×	×	×								S-M
Sassafras subtriloba	*S. tsumu*										(×)	(×)				S-M
Rosa usyuensis	*R. multiflora*		×	×	×	×	×									M
Entada mioformosana	*E. formosana*							×								M
Sorbus nipponica	*S. comixta*			×	×	×	×									S-M
Sophora miojaponica	*S. japonica*								×	×	×	×	×			S
Robinia nipponica	*R. viscosa*														×	S-M
Pistasia miochinensis	*P. chinensis*							×		×	×	×	×			S
Rhus ezoense	*R. typhina*														×	M
Rhus miosuccedanea	*R. succedanea*			×	×	×	×	×			×	×	×			M
Rhus protoambigua	*R. ambigua*	×	×	×	×	×	×			×	×					M
Dilodendron sp.	*D. bipinnatum*														×	?
Dodonaea japonica	*D. viscosa*							×				×	×			S
Sapindus kaneharai	*S. mukurossi*			×	×	×	×	×	×		×					S-M
Buxus protojaponica	*B. japonica*				×	×	×									M
Acer ezoanum	*A. miyabei*	×	×													M
Acer fatisiaefolia	*A. diabolicum*			×	×	×	×									M

Acer nordenskiöldi	*A. palmatum*			×	×	×	×				×	×				M
Acer palaeodiabolicum	*A. diabolicum*			×	×	×	×									M
Acer palaeoplatanoides	*A. platanoides*														×	M
Acer palaeorufinerve	*A. rufinerve*			×	×	×	×									M
Acer protodistylum	*A. distylum*			×	×	×										M
Acer prototataricum	*A. tataricum*										×	×	×			M
Acer prototrifidium	*A. trifidium*										×	×				M
Acer protonegundo	*A. negundo*														×	M
Acer protojaponicum	*A. japonicum*		×	×	×	×	×									M
Acer pseudoginnala	*A. ginnala*	×	×	×	×	×	×		×					×		M
Acer subpictum	*A. mono*	×	×	×	×	×	×		×	×			×	×		M
Tilia distans	*T. amuraensis*								×	×				×		M
Alangium aequalifolium	*A. chinense*									×	×	×				M
Aralia miobippinata	*A. bippinata*							×								S
Diospyros miokaki	*D. kaki*															S-M
Smilax trinervis	*S. china*		×	×	×	×	×		×	×	×					S

TABLE 13. The Nearest Equivalents of the Mitoku-type Species and their Modern Distribution in East Asia.

Fossil Species	Nearest equivalents		Japan							China						habitat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Osmunda japonica subsp.	*O. japonica*															S
Abies protofirma	*A. firma*			×	×	×	×									M
Larix onbaraensis	*L. kaempferi*				×		×									M
Picea kaneharai	*P. polita*				×	×	×									U
Picea cfr. *jessoensis*	*P. jessoensis*	×	×						×					×		M
Picea koribai	*P. excelsa*														×	M
Pinus palaeopentaphylla	*P. parviflora*		×	×	×											U
Pseudolarix japonica	*P. kaempferi*										×	×				M
Juniperus honshuensis	*J. chinensis*			×	×	×	×									S
Thuja nipponica	*T. standishii*			×	×				×							U
Cunninghamia protokonishii	*C. konishii*							×								U
Glyptostrobus europaeus	*G. pensilis*											×				S
Metasequoia occidentalis	*M. glyptostroboides*										×					M
Sequoia affinis	*S. sempervirens*														×	M
Taiwania japonica	*T. cryptomeroides*							×				×	×			U
Taxodium dubium	*T. distichum*														×	S
Populus aizuana	*P. alba*														×	S
Populus sambonsugii	*P. trichocarpa*														×	S
Populus balsamoides	*P. candicans*														×	S
Salix k-suzukii	*S. jessoensis*		×	×	×											S
Myrica(Comptonia) kidoi	*M. asplenifolia*														×	S
Carya miocathayensis	*C. cathayensis*										×	×				M
Juglans nipponica	*J. ailanthifolia*	×	×	×	×	×	×									S
Pterocarya nipponica	*P. rhoifolia*		×	×	×	×	×			×						M-S
Pterocarya asymmetrosa	*P. paliurus*										×	×	×			S

Pterocarya protostenoptera	*P. stenoptera*								×	×	×	×	×			S
Alnus miojaponica	*A. japonica*	×	×	×	×	×						×		×		S
Alnus protohirsuta	*A. hirsuta*	×	×	×	×	×								×		M-S
Alnus protomaximowiczii	*A. maximowiczii*	×	×	×				×						×		U
Betula miomaximowicziana	*B. maximowicziana*	×	×	×												M-U
Betula onbaraensis	*B. grossa*		×	×	×	×										M
Betula protoermanni	*B. ermanni*	×	×	×				×								M-U
Betula protoglobispica	*B. globispica*		×	×												M
Betula protojaponica	*B. japonica*	×	×	×												M
Carpinus miocenica	*C. laxiflora*	×	×	×	×	×		×								M
Carpinus nipponica	*C. lanceolata*										×	×				M
Carpinus stenophylla	*C. carpinoides*		×	×	×	×										M
Carpinus subcordata	*C. cordata*	×	×	×	×	×		×	×	×	×			×		M-S
Carpinus subyedoensis	*C. tchonoskii*		×	×	×	×		×			×					M-S
Ostrya huziokai	*O. japonica*	×	×	×	×	×		×	×	×	×					M
Castanea miocrenata	*C. crenata*	×	×	×	×	×										M
Fagus palaeocrenata	*F. crenata*	×	×	×	×	×										M-U
Fagus protojaponica	*F. japonica*		×	×	×	×										M
Quercus miocrispula	*Q. crispula*	×	×	×	×	×			×	×	×			×		M
Quercus protodentata	*Q. dentata*	×	×	×	×	×		×	×	×	×		×	×		M
Quercus protosalicina	*Q. sailcina*		×	×	×	×		×								M
Quercus protoserrata	*Q. serrata*	×	×	×	×	×			×	×	×	×	×			M-S
Celtis nathorsti	*C. jessoensis*	×	×	×	×	×		×								M
Celtis nordenskioldii	*C. occidentalis*														×	M
Ulmus protojaponica	*U. japonica*	×	×	×	×			×	×	×				×		S
Ulmus protolaciniata	*U. laciniata*	×	×	×	×			×	×	×						M
Ulmus subparvifolia	*U. parvifolia*					×	×				×	×				M
Zelkova ungeri	*Z. serrata*		×	×	×	×		×			×	×				M
Cercidiphyllum crenatum	*C. japonicum*	×	×	×	×	×										M
Liquidambar mioformosana	*L. formosana*						×				×	×	×			S

TABLE 13. (*Continued*)

Fossil Species	Nearest equiualents		Japan							China						habi-tat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Liriodendron honshuensis	*L. tulipifera*														×	S
Magnolia elliptica	*M. kobus*		×	×	×	×	×		×							M-S
Magnolia nipponica	*M. kobus*		×	×	×	×	×		×							M-S
Cinnamomum miocenum	*C. camphora*				×	×	×	×			×	×				S-M
Sassafras subtriloba	*S. tsumu*										×	×				M
Sassafras yabei	*S. tsumu*										×	×				M
Schizophragma mitokuensis	*S. hydrangeoides*		×	×	×	×	×		×		×					M
Sorbus nipponica	*S. comixta*			×	×	×	×									S-M
Prunus protossiori	*P. ssiori*	×	×	×	×									×		M
Cercis endoi	*C. canadaensis*														×	S-M
Sophora miojaponica	*S. japonica*								×	×	×	×	×			S
Wistaria fallax	*W. floribunda*			×	×	×	×									M-S
Rhus miosuccedanea	*R. succedanea*			×	×	×	×	×			×	×	×			M
Rhus protoambigua	*R. ambigua*	×	×	×	×	×	×			×	×					M
Euonymus palaeosieboldianus	*E. sieboldianus*		×	×	×	×	×									M-S
Buxus protojaponica	*B. japonica*				×	×	×									M
Acer nordenskiöldi	*A. palmatum*			×	×	×	×				×	×				M
Acer palaeodiabolicum	*A. diabolicum*			×	×	×	×									M
Acer palaeorufinerve	*A. rufinerve*			×	×	×	×									M
Acer protojaponicum	*A. japonicum*		×	×	×	×	×									M
Acer protosieboldianum	*A. sieboldianum*		×	×	×	×	×									M
Acer prototrifidium	*A. trifidium*										×	×				M
Acer pseudocarpinifolium	*A. carpinifolium*			×	×	×	×									M
Acer submayri	*A. mono*		×	×	×	×	×		×	×			×	×		M
Acer subpictum	*A. mono*	×	×	×	×	×	×		×	×			×	×		M

Tilia distans	*T. amuraensis*								×	×	×					M
Tilia miohenryana	*T. henryana*										×	×				M
Tilia protojaponica	*T. japonica*		×	×	×	×	×							×		M
Paliurus nipponicus	*P. spina-christii*														×	S
Alangium koyamae	*A. chinense*									×	×	×				M
Ilex cornuta	*I. cornuta*										×	×				M-S
Stewartia submonadelpha	*S. monadelpha*				×	×	×									M-S
Stewartia okutsui	*S. pseudo-camellia*				×	×	×									U-M
Kalopanux acerifolium	*K. septemlobus*									×	×	×	×			S-M
Cornus megaphylla	*C. macrophylla*			×	×	×	×			×	×	×				S-M
Cornus subkousa	*C. kousa*			×	×	×	×		×		×		×			M-S
Clethra cfr. *barbinervis*	*C. barbinervis*		×	×	×	×	×		×							M-S
Rhododendron protodilatatum	*R. dilatatum*			×	×	×										M
Tripetaleia pseudopaniculata	*T. paniculata*		×	×	×	×										M
Diospyros miokaki	*D. kaki*															S-M
Fraxinus honshuensis	*F. japonica*			×	×											M
Styrax protoobassia	*S. obassia*		×	×	×	×	×		×	×				×		M
Catalpa ovata	*C. ovata*											×				M
Lonicera protojaponica	*L. japonica*		×	×	×	×	×		×	×	×	×	×	×		M-S
Viburnum protofurcatum	*V. furcatum*	×	×	×	×	×	×									M
Smilax trinervis	*S. china*		×	×	×	×	×		×	×	×					S

TABLE 14. The Nearest Living Equivalents of the Shinjô-type Species and their Modern Distribution in the East Asia

Fossil Species	Nearest evuivalents		Japan							China					habi-tat
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Picea koribai	*P. exelsa*														×	M
Picea kaneharai	*P. polita*			×	×	×										U
Picea maximowiczii	*P. maximowiczii*															M
Pseudolarix japonica	*P. kaempferi*										×	×				M
Pinus palaeopentaphylla	*P. parviflora*		×	×	×											M-U
Thuja nipponica	*T. standishii*			×	×				×							U
Glyptostrobus europaeus	*G. pensilis*											×				S
Metasequoia occidentalis	*M. glyptostroboides*										×					M
Sequoia affinis	*S. sempervirens*														×	M
Myrica(Comptonia) kidoi	*M. asplenifolia*														×	S
Juglans megacinerea	*J. cinerea*														×	S
Juglans japonica	*J. ailanthifolia*	×	×	×	×	×	×									S
Pterocarya nipponica	*P. rhoifolia*		×	×	×	×	×			×						M-S
Alnus miojaponica	*A. japonica*										×	×	×			S
Carpinus nipponica	*C. lanceolata*										×	×				M
Carpinus subyedoensis	*C. tchonoskii*			×	×	×	×		×		×					S-M
Carpinus stenophylla	*C. carpinoides*			×	×	×	×									M
Carpinus subcordata	*C. cordata*		×	×	×	×	×		×	×	×					S-M
Carpinus laxiflora	*C. laxiflora*		×	×	×	×	×		×					×		S-M
Ostrya huziokai	*O. japonica*		×	×	×	×	×		×	×	×					M
Castanea miocrenata	*C. crenata*		×	×	×	×	×									M
Fagus palaeocrenata	*F. crenata*		×	×	×	×	×									M-U
Fagus protojaponica	*F. japonica*			×	×	×	×									M
Quercus miocrispula	*Q. crispula*	×	×	×	×	×	×			×	×			×		S-M

Quercus protodentata	*Q. dentata*	×	×	×	×	×	×		×	×	×		×	×		M
Quercus protoserrata	*Q. serrata*		×	×	×	×	×			×	×	×	×			M-S
Celtis nathorsti	*C. jessoensis*		×	×	×	×	×		×							M
Celtis nordenskiöldii	*C. occidentalis*														×	M
Ulmus protojaponica	*U. japonica*	×	×	×	×	×			×	×				×		S
Zelkova ungeri	*Z. serrata*			×	×	×	×		×		×					M
Liquidambar mioformosana	*L. formosana*							×			×	×	×			S
Magnolia elliptica	*M. kobus*		×	×	×	×	×		×							S-M
Magnolia nipponica	*M. kobus*		×	×	×	×	×		×							S-M
Cinnamomum miocenum	*C. camphora*				×	×	×	×			×	×				S-M
Sophora sp.	*S. japonica*								×	×	×	×	×			S
Wistaria fallax	*W. floribunda*			×	×	×	×									M-S
Prunus protossiori	*P. ssiori*	×	×	×												M
Buxus protojaponica	*B. japonica*				×	×	×									M
Acer nordenskiöldi	*A. palmatum*			×	×	×	×				×	×				M
Acer palaeosieboldianum	*A. sieboldianum*		×	×	×	×	×									M
Acer protojaponicum	*A. japonicum*		×	×	×	×	×									M
Acer subpictum	*A. mono*	×	×	×	×	×	×		×	×			×	×		M
Tilia protojaponica	*T. japonica*		×	×	×	×	×							×		M
Paliurus nipponicus	*P. spina-christii*														×	S
Euonymus palaeosieboldianus	*E. sieboldianus*		×	×	×	×	×									M-S
Ilex cornuta	*I. cornuta*										×	×				M-S
Stewartia submonadelpha	*S. monadelpha*				×	×	×									M-S
Cornus subkousa	*C. kousa*			×	×	×	×		×		×		×			M-S
Tripetaleia pseudopaniculata	*T. paniculata*		×	×	×	×										M
Fraxinus honshuensis	*F. japonica*			×	×											M
Styrax protoobassia	*S. obassia*		×	×	×	×	×		×	×				×		M
Styrax japonica	*S. japonica*															M
Smilax trinervis	*S. china*		×	×	×	×	×		×	×	×					S

times dominantly montane and northern elements. These facts may indicate that the physical or physiographic conditions at that time were more various and complicated than during the previous stage. As far as known, several floras of Hokkaidô corresponding to the Mitoku-type scarcely contain the above-noted exotic elements, and consist mainly of northern species, whereas the exotic or southern elements are contained more commonly in southwestern Honshû than in northern Honshû. Such a variable composition of the Mitoku-type flora suggests the probability that the segregation or regional differentiation of the forest distribution were advanced in this stage.

The Shinjô-type flora consists mainly of the same temperate genera which are dominantly found in the Mitoku-type. Among the modern equivalents of their fossil species, the charcteristic and dominant species are as follows: *Pinus parviflora, Pterocarya rhoifolia, Carpinus cordata, Fagus crenata, Quercus mongolica* var. *grosseserrata, Q. dentata, Castanea crenata, Zelkova serrata, Acer mono*, etc., most of which species are present main components of the beech forests in central and northern Honshû. However, this type flora sometimes contains several warm elements such as *Buxus, Ilex, Lindera, Wistaria, Vaccinium* and others. These warm associates are more commonly found in the fossil floras in western Honshû and Kyûshû than in those of northeastern Honshû. The exotic genera in the Shinjô-type flora are generally reduced in number below those found in the previous age. Furthermore, there are several modern equivalent species not distributed in Japan, although their genera are now represented in Japan. For instance, they are *Carpinus nipponica, Paliurus nipponicus, Myrica (Comptonia) kidoi* and *Celtis nathorsti.*

Thus, most of the Shinjô-type floras, in general, closely resemble the beech-bearing forest growing in central or northern Honshû. Some floras such as the Ningyô-tôgé and Mogi, are closely similar to the present montane vegetation of the beech forest in Central Honshû. Accordingly, the regional and altitudinal differentiation of forest distribution seem to be more distinctly presented in the time of the growth of the Shinjô-type flora.

In the Akashi-type flora, most of the modern equivalent species of the components are, as already stated by MIKI (1937, 1948), living in the southern half of Japan, and some of them are found at an altitude of 500 to 1000 meters above sea level. On the other hand, this type flora contains several exotic elements such as *Juglans megacinerea, Sapium sebiferum, Paliurus nipponicus, Nuphar akashiensis, Ilex cornuta, Metasequoia* and *Glyptostrobus,* which elements are more commonly contained in the

Akashi-type floras of western Honshû than in those of northern Honshû. Most of these exotic elements are intimately related to living species of central China and Manchuria, and a few to those of Mediterranean and Caucasus regions and of North America. However, most of them do not seem to have sufficiently adapted themselves to the climatic conditions of that time, but rather seem to have barely survived as relicts from the previous age.

Thus, the climatic indications by leaf character analysis coincide, as a whole, with the results based on consideration of geographic distribution of the modern equivalents of the fossil species.

3. General outline of habitats in each type flora.

In other to facilitate considerations on the probable ecologic conditions under which those ancient plants lived, the modern equivalents of the fossil species are grouped according to their habitats—four types of upland, mixed-slope, stream-side or riparian, and lake or marshy elements. These habitats of the component species in the five type floras: Ainoura, Aniai, Daijima, Mitoku and Shinjô, are indicated partly in Tables 10~14.

The Ainoura-type flora consists mainly of plants growing on mixed-slope to stream-side site, but contains upland and marshy plants. The Aniai-type flora consists largely of mixed-slope plants, followed by the plant growing from mixed-slope to stream-side, while upland and riparian elements are generally few in number. For instance, in the Shichiku flora of Honshû, mixed-slope plants make up nearly 10 per cent, plants from mixed-slope to stream-side about 26 per cent, upland plants about 8 per cent of the total species respectively, while the remaining about 6 per cent are riparian and marshy plants. In the Kaminokuni flora of Hokkaidô, mixed-slope elements make up nearly 67 per cent, upland plants about 8 per cent, plants from the mixed-slope to stream-side about 18 per cent, and the remaining 7 per cent riparian elements.

On the other hand, the Daijima-type flora consists largely of riparian plants and those which grew from hilly to riparian areas, followed by mixed-slope plants, and a few upland plants. That is to say, most of the Aniai-type floras are composed principally of elements from mountain-slope, on the contrary most of the Daijima-type flora are most abundant in lowland plants grown near coastal areas with several exceptions. For instance, in the Kamigô flora of Honshû the riparian plants make up about 35 per cent, the plants grown on mixed-slope to riparian sites nearly 15 per cent of the totals. However, in the Ouchi flora of Honshû the riparian plants occupy more than 45 per cent of the total species, followed by mixed-slope riparian plants of about 30 per cent. The Daijima-type flora in Honshû contains abundant lowland plants; in Hokkaidô the montane plants number more species and specimens than the riparian plants. In the Yoshioka and Wakamatsu floras of southwestern Hokkaidô, the mixed-slope plants make up about 52 per cent, riparian plants nearly 20 per cent, mixed-slope—riparian plants about 22 per cent of the totals respectively, whilst the remaining ones are upland or marshy plants. That the Daijima-type flora consists mainly of lowland plants is evidently related to the circumstances of the deposition of the plant-bearing rocks. As already stated in respect to the geologic occurrence of this type flora, the most of the lacustrine or littoral sediments containing the Daijima-type flora were formed in stratigraphical sequence very near to marine formations.

The Mitoku-type flora is, in general, composed mainly of mixed-slope or mixed-slope—riparian plants in number of species and specimens, and also abundantly contains upland—mixed-slope plants in respect to number of species. Namely, this type flora seems to represent a mixed-slope to riparian forest. For instance, in the Mitoku and Onbara floras of western Honshû the mixed-slope plants are 21 to 23 per cent, riparian plants 10 to 13 per cent of the total species respectively, while the remaining are upland or mixed-slope—upland plants. In the Obayashi flora of north-eastern Honshû, mixed-slope plants occupy nearly 50 per cent, riparian plants about 26 per cent of the total species, and the remainder are upland —mixed-slope ones.

The Shinjô-type flora consists mostly of mixed-slope plants which generally occupy more than 60 per cent of the total species and specimens, though there are a few exceptions. For instance, in the Ningyô-tôgé flora of western Honshû and the Mogi flora of Kyûshû, mixed-slope—upland plants occupy about 70 per cent of the total specimens collected by the writer. These two floras commonly contain riparian plants, but their number of specimens is smaller than that of montane plants. Generally, the Shinjô-type flora abundantly contains beech leaves; it probably represents a montane vegetation which grew from mixed-slope to upland.

Thus, from the "Daijima stage" to the "Shinjô stage," the Neogene flora of Japan seems to have gradually changed from lowland-elements-rich vegetation to montane-elements-rich vegetation without any considerable change of generic association. That is probably due not to the elevation of depositional sits, but rather to increased cooling and aridity in the climatic environment. In consequence of lowering temperature following the "Mitoku-stage," the warm or subtropical plants have trans-located to lowland region of East Asia at present, having gradually migrated towards southern regions, whereas, on the other hand, the montane cool-temperate elements seem to have become dominant in Later Neogene time.

4. Summary of climatic conditions indicated by the flora.

In the discussion of leaf character analysis and modern relationships of fossils flora, the general nature of ecological conditions indicated by respective 6 type floras has been briefly considered. Of course, the ecological conditions of fossil floras must be further analyzed by consideration of association of their dominant species. Actually, in view of the relative abundance of fossil species, the writer has investigated the Daijima-type flora of Middle Miocene by associate grouping of dominant species; this investigation will be further reported in another paper. On the basis of discussion offered in the previous paragraphs, the climatic conditions indicated by the flora are briefly summarized as follows.

It is presupposed that the present climatic conditions afford an approximation of the past time. The climatic data of present-day East Asia are provided in Fig. 6.

The Ainoura-type flora is close to the mixed-slope—lowland vegetation of southern to central China, which consists mainly of temperate and warm elements. The climatic conditions of the "Ainoura stage" seem to have been warm-temperate and somewhat humid. The Aniai-type flora consists mainly of deciduous broad-leaved trees grown in temperate region, and is closely similar to the present moutain-slope vegetation distributed from central to northern China, or in the northern half of Japan. The climatic conditions in these regions are temperate or rather cool-temperate, and moderate in precipitation; in summer the climate is somewhat wet, while in winter slightly dry and frequently snowy. However, the Aniai-type flora contains generally abundant *Metasequoia* and *Glyptostrobus*. The latter tree is now confined in distribution to southern China, while the former is to central China. In Szechuan province, central China where *Metasequoia* is living now, some of the moisture may have been in frozen form, but it is not snowy. Accordingly, although frost or snow was present in that time when the Aniai-type flora flourished in Japan, they were probably not heavy nor long-lasting. Thus, the climate of the "Aniai stage" was probably mild, though somewhat in cool-temperate condition.

On the other hand, the Daijima-type flora contains a large number

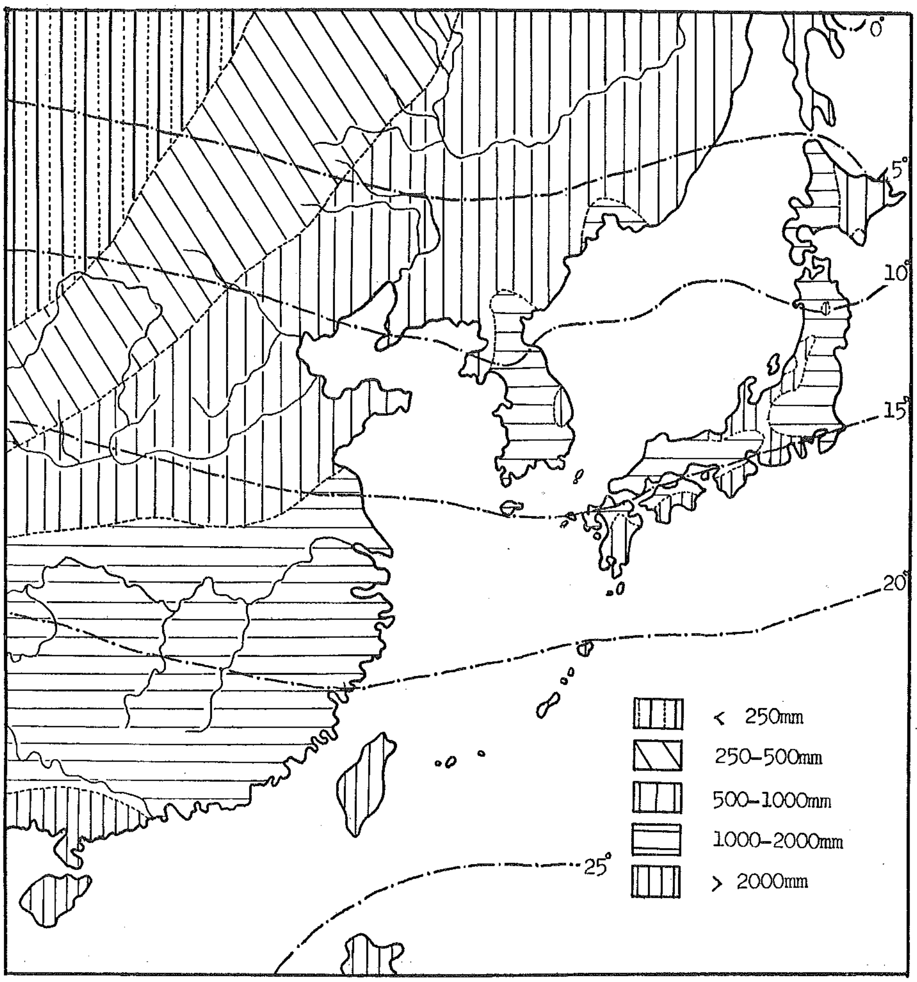

Fig. 6. Normals of Annual Mean Temperature and Annual Total Precipitation in East Asia.

of ever-green broad-leaved trees, frequently accompanied with subtropical plants. That flora is closely similar to the present lowland vegetation growing from central to southern China, or in Formosa. The climate in these regions is warm-temperate or subtropical, with well distributed precipitation: annual mean temperature and precipitation are in excess of 20°C and 1500 mm respectively. However, the common occurrence of temperate deciduous broad-leaved trees in the Daijima-type flora, indicates that such rather subtropical climatic conditions may not always be needed. Thus, the climate of the "Daijima stage" was evidently far warmer in temperature and somewhat heavier in precipitation than that of the previous stage: it was warm or warm-temperate with well-distributed precipitation, and effected by sea influence.

The Mitoku-type flora is similar to the present flora of central to southern Japan, where the climate is temperate with moderate precipitation. The predominance of deciduous conifers and hardwoods in the Mitoku-type flora has provided a basis for concluding that the climate in Japan during the "Mitoku stage" was temperate, with comparatively well distributed precipitation. However, the reduction of warm or subtropical plants of this flora evidently indicates that the temperature had lowered in comparison with that of the previous "Daijima stage."

The Shinjô-type flora is, as already stated, somewhat close to the beech-bearing forest now living in central or northern Japan. The floristic composition is variable by the localities of the fossil flora, so that the climate of that time shows a regional difference. The predominance of beech, deciduous oak, elm, birch in this flora, has provided a basis for concluding that the climate during the "Shinjô stage" was generally temperate or rather cool-temperate in most regions of Japan. Furthermore, the Shinjô-type flora has comparatively abundant coniferous trees, which fact probably indicates that the climatic conditions were rather humid and not so high in temperature in the summer season. On the one hand, several warm elements such as *Liquidambar, Cinnamomum* and *Stewartia,* were able to overwinter in the lowland area.

The Akashi-type floras of western Honshû and Kyûshû are closely similar to the present vegetation of southern Japan, and also nearly similar to the lowland flora of the previous "Shinjô stage." Furthermore, many aquatic plants and some sea-side plants are included therein, so that these floras seems to have been affected by sea influence. Thus, Late Pliocene climate in western Japan was probably not so different from that of previous stage. However, in northern Japan the Akashi-type flora is somewhat simpler in composition, and also the warmer elements are scantier. Therefore, it follows that northern Japan was probably under somewhat lower temperature than western Japan in Late Pliocene age.

VII. Discussion on Geologic Age of the Flora

1. Neogene stratigraphic sequence in Japan indicated by marine or mammalian faunas.

As already described above in chapter IV, Neogene sediments in Japan are dominant in marine facies, including many marine molluscs, foraminiferas, etc. Accordingly, Neogene stratigraphic sequence has been established mainly by marine fauna. However, these marine sediments do not always succeed in lateral or vertical distribution; they are frequently intermittent in succession, or separated in distribution. Furthermore, due to the differences of depositional conditions or sedimentary province, the fossil faunas contained in marine formations of the same age are frequently different in composition and components. Thus, there is, at present, no standard faunal sequence which is definitely applicable for the all of the Neogene sediments in Japan, though regional sequences have been precisely described by many stratigraphers and palaeontologists.

OTUKA, Y. (1939) subdivided the Tertiary of Japan into 6 stages on the basis of faunal characters, and discussed the correlation of Tertiary sediments and Tertiary palaeogeography in Japan. Lately, for the purpose of classifying and correlating Cenozoic strata of separately located sedimentary basins in Japan, IKEBE, N. (1954) designated 16 biochronologic units denominated A_0 to K on the basis mainly of faunal characters. Furthermore, he (IKEBE, 1957) described and figured the subdivisions of the Japanese Neogene, and subdivided it into 11 Neogene sedimentary basins. KOTAKA, T. (1957, 1958) described the Neogene megafaunal character in northeastern Honshû, and discussed the lateral and vertical changes of the faunas. On the basis of these many researches made by various authors, the Neogene marine faunal sequence of Japan generally accepted at present is as follows:

Lower Miocene fauna is characterized by several larger faraminiferas such as *Lipidocyclina* (*Nephrolepidina*) *nipponica*, *L.* (*N.*) *ferreoi*, *L.* (*N.*) *angylosa*, *Miogypsina kotoi*, *Operculina complanata japonica*, etc., whereas, there are nearly no characteristic molluscan fauna in this stage. However, there are sometimes mingled fauna composed of two type faunas components, the Ashiya-Poronai fauna of Oligocene age and the Yatsuo-Kadonosawa fauna of Middle Miocene age.

Middle Miocene sediments are widely distributed in Japan; the marine faunas of this stage are variable in associations and components. In the marginal area of sedimentary basins the faunas are represented by characteristic genera of tropical, shallow and brackish water environments, for instance, *Vicarya callosa*, *V. yokoyamai*, *Vicaryella ishiiana*, *Batillaria tateiwai*, *Katelysia nakamurai* and *Sanguinolaria minoensis*. Such elements are frequently accompanied with several larger foraminiferas such as *Lepidocylina* (*Naphrolepidina*) *japonica*, *L.* (*N.*) *makiyamai*, *Miogypsina kotoi* and *Operculina complanata japonica*. On the other hand, the fauna in other areas is characterized by a rich Pectinid assemblage of somewhat open-sea environment which contains *Chlamys kaneharai, Pecten kanbaraensis, Dosinia kaneharai, Anadara abita, Turritella kadonosawaensis* and others. Thus, this age is represented by the so-called "Yatsuo-Kadonosawa fauna", and the tropical and brackish fauna of this stage is closely akin to the Middle Miocene fauna in the Indo-Pacific region of East Asia.

The lower half of Late Miocene sediments are generally composed dominantly of argillaceous facies in most areas of Japan, and rather poor in megafauna though abundant in the smaller foraminiferas. In such argillaceous facies the *Conchocele-Lucinoma* fauna occurs, accompanying with some deep water Pectinids such as *Hyalopecten, "Propeamussium"*, etc. It is characterized by *Conchocele nipponica, Lucinoma otukai, Solemya tokunagai, Nuculana confusa* and others. However, in the marginal area of sedimentary basins the Buccinidae-Cardiidae fauna (the so-called Yama-Togeshita fauna) occurs, which is represented by *Buccinum leucostoma, Serripes yokoyamai, Thracia hitosaoensis, Trachycardium shiobarense, Neptunea modesta, Clinocardium shinjiense* and others.

The uppermost of Late Miocene sediments rarely contains, in general, megafossils except in some regions. In northeastern Honshû and Hokkaidô, the Buccinidae-Cardiidae fauna sometimes occurs, as a relic from earlier time. In the outer zone of Honshû, for instance, in the southern Kwantô-Shizuoka region and southern Kyûshû, the Lower Kakegawa fauna are contained. This molluscan fauna is the so-called Dainichi fauna which is characterized by *Turritella perterebra, Umbonium suchiense, U. obsoletum, Chlamys miurensis, Amussiopecten praesignis, Venericardia panda, Siphonalia declivis*, etc. These faunas were once considered to be Early Pliocene in age by may geologists and palaeontologists. However, they are lately accepted to be of Latest Miocene or Mio-Pliocene age, owing to a considerable difference from the adjacent fauna.

The Lower Pliocene fauna is regionally different in molluscan associations and components: for instance, it is represented by the Omma-Manganzi fauna in the inner zone of Honshû, and the upper Kakegawa (so-called Ketienji fauna) in southern Kwantô-Shizuoka region. This fauna is characterized by *Umbonium subsuchiense, U. akitanum, Turritella saishuensis, Pecten takahashii*, etc. The Upper Pliocene sediments are, as already stated above in chapter V, rather dominant in lacustrine facies, and there are nearly no fossil marine fauna characteristic to this stage.

Neogene mammalian fossils have been frequently found from terrestrial sediments, and sometimes in marine or brackish sediments. Although they are poor in number of species in Japan, they frequently become good indicators of geologic age. Especially, mammalian fossils from terrestrial deposits are frequently useful for age determination of the plant-bearing formation. TAKAI, F. (1938, 1939) subdivided Cenozoic mammalian fauna of Japan into 7 faunas and 4 faunules, and described their respective characters and component species. Furthermore, he (TAKAI, 1952) lately re-investigated many mammalian fossils from East Asia, and discussed the mode of their development and distribution. Besides them, many Neogene mammal-bearing formations of Japan have been investigated stratigraphically or discussed as to their correlation by various stratigraphers and palaeontologists. On the basis of these many contributions, in particular and minly of TAKAI's research, the Neogene sequence of mammalian fauna in Japan is generally accepted as follows:

Early Miocene age: Non

Middle Miocene age: *Bunolophodon annectens* (MATSUMOTO), *Anchitherium hypohippoides* MATSUMOTO, *Palaetapirus yagii* MATSUMOTO, *Rhinoceros* (*Chilotherium*) *pugnator* (MATSUMOTO), *Brachyodus japonicus* MATSUMOTO, *Amphitragulus minoensis* MATSUMOTO,

Latest Miocene age: *Dicrocerus hirabayashii* (TOKUNAGA)

Early Pliocene age: *Stegolophodon latidens* (CLIFT), *Eurhinodelphis pacificus* MATSUMOTO, *Pliohippus* sp.

Middle Pliocene age: *Stegodon elephantoides* (CLIFT), *Paralephas proximus* (MATSUMOTO), etc.

Late and Latest Pliocene age: *Parastegodon akashiensis* TAKAI, *Parastegodon aurorae* (MAKIYAMA), *Stegodon orientalis* OWEN, etc.

2. Geologic age of the flora.

In Japan, the correlation and age determination of Tertiary flora have been frequently maded by the use of several characteristic fossils such as *Nelumbo*, *"Comptoniphyllum,"* *Juglans megacinerea*, *Liquidambar*, etc. However, as already described in chapter V above, these characteristic species are sometimes not found in the same-aged floras, or sometimes are found in different-aged floras, due to the difference of climatic environments or differentiated distribution of the forest in the area where the fossil floras grew. Such a tendency of floristic differentiation seems to increase towards Later Neogene time. Thus, age determination of Late Tertiary floras must be based on lines of evidence other than upon the strictly stratigraphic ranges of individual species. Namely, the investigator must be concerned with the evolution of floras in time and space. Accordingly, the dates for age evaluation must be provided by an analysis of the floristic composition, geographic relation and climatic implications. Especially, in the case of the fossil flora which are found from isolated lacustrine basins, this method must be employed for age determination or correlation.

In the previous chapters, the writer described six types of Neogene flora, and discussed the similarity or simultaneity of the floristic composition and climatic implications of the respective types. Accordingly, in the present chapter the writer will discuss further in detail the geologic age of the respective flora.

The Ainoura formation including the Ainoura flora, contains mingled molluscan fossils of the Oligocene Ashiya and Middle Miocene Kadonosawa faunas. As alreay discussed by the writer (TANAI & ONOE, 1956), the Ainoura-type flora is probably Early or Earliest Miocene age. This evaluation is supported by the fact that the Ainoura flora contains several Palaeogene relict species. This flora contains traces of Palaeogene warm or tropical flora, which have not been completely replaced by Neogene elements.

The lacustrine formations bearing the Daijima-type flora are, as already described above in chapter V, slightly lower than or nearly contemporaneous in stratigraphic position to the Middle Miocene formations which contain Yatsuo-Kadonosawa molluscan fauna or larger foraminifera assemblages including *Miogypsina, Operculina,* etc. The Daijima-type flora indicates warm or warm-temperate climatic environments, so that it is closely related to the warm current condition of the the Dajima-type flora is evidently Middle or upper-Middle Miocene age. Thus, the fossil floras of this stage are generally correlative on the basis of the characteristic floristic composition and the warm climatic condition indicated by it. The Hiramaki formation contains the Daijima-type flora, and also yields Middle Miocene mammalian fossils such as *Bunolophodon annectens, Anchitherium hypohippoides, Rhinoceros pugnator,* etc. The above age evaluation of this type flora is also confirmed by such mammalian occurrence.

The lacustrine sediments bearing the Aniai-type flora, are usually lower in stratigraphic sequence than those of the Daijima-type flora. This stratigraphic relationship of these two floras are confirmable in various areas, for instance, the Monzen and Daijima formations in Oga peninsula, the Aniai and Uttô formations of the Ani coal field, the Aburato and Kamigô formations of the Nishitagawa coal field, the Fukuyama and Yoshioka formations in southwestern Hokkaidô and others. The Aniai-type flora includes many species closely similar to the characteristic elements of the so-called "Arctic Miocene flora*." However, in the Sasebo coal field, Kyûshû, the Yunoki-Fukui formations containing the Aniai-type flora are underlain by the above-noted Ainoura formation. Accordingly the Aniai-type flora is generally Middle Miocene, especially lower-Middle Miocene in age. This age evaluation is supported by the occurrence of *Brachyodus japonicus* from the Nakazato formation which is situated between the Fukui and Ainoura formations.

The lacustrine or littoral sediments including the Mitoku-type flora mostly seem to have been formed under isolated or nearly separated condition from any marine depositional basin, so that most of these plant-bearing formations are difficult to be considered their geologic age in connection with marine fauna. However, in northern Japan these lacustrine sediments were frequently deposited in the marginal area of marine basins: the interior basin area of northeastern Honshû, the northern part of central Hokkaidô, the central Shinano basin of central Honshû, etc. These plant-bearing formations in such areas are, in general, slightly above or nearly contemporaneous in stratigraphic sequence to the marine formations which contain the Buccinidae-Cardiidae assemblage of the Late Miocene Yama-Tôgeshita fauna. Some of their lacustrine formations are unconformably covered by Pliocene marine formations. The Mitoku-type floras is very similar in generic composition to the Daijima-type flora of the previous age, although its component species show evolutional development. It commonly contains exotic elements which are abundantly found in the Daijima-type, though there are many temperate elements such as Fagaceae, Betulaceae, Ulmaceae, Salicaceae, Aceraceae, etc. It is commonly found in Late Miocene floras of Europe and western United States that the modernized species of Fagaceae, Betulaceae and Salicaceae, are dominant, and accompanied with exotic elements. On the other hand, the Shinjô-type flora consists mainly of modernized species, and rather rarely contains exotic elements tho there are some exceptions. Accordingly, the Mitoku-type flora is rather related to the Daijima-type of Middle Miocene age, and probably is Late Miocene in age. The fossil floras of this stage are somewhat different in floristic composition according to the locality: in northern Japan the northern temperate species are dominant, while in central and western Japan southern elements are dominant and exotic elements are abundantly contained. However, this type flora is generally distinguishable from

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* The fossil floras described from the Arctic region by HEER (1868–1883) contain plant fossils of various ages, from Late Cretaceous to Miocene. However, the Miocene flora from Switzerland (HEER, 1855–1859) is evidently Early or Middle Miocene in age.

other floras by the floristic components and climatic implications. In some areas where lacustrine sediments continuously developed into the next stage, there are sometimes several transitional floral elements between the Mitoku and Shinjô-type floras: for instance, the Onbara florule in western Honshû, the Sudani and Upper Nenoshiroishi florules in northeastern Honshû and others. These florules are probably of Mio-Pliocene age.

The lacustrine sediments containing the Shinjô-type flora, are mostly isolated from the marine depositional basins of that time, so that most of these sediments are not directly related to any marine formation. However, some of them are known to be slightly lower in stratigraphic sequence than the marine Pliocene sediments including the Omma-Manganzi molluscan fauna. On the other hand, the Shinjô-type flora is closely similar to the modern vegetation of Japan with some exception, although there are a few exotic elements. Thus, the Shinjô-type flora is generally considered to be Lower or Middle Pliocene in age. This evaluation as to age is supported by the fact that *Stegodon elephantoides* was found from the Agé formation in Mié Prefecture, which also yields the Shinjô-type flora. The fossil floras of this stage are considerably differentiated in the distribution of vegetation: montane species are frequently dominant in various localities, while in central Honshû the Mitoku-type components survived in the lowland areas of that time. Accordingly, in Kinki and Gifu-Aichi regions Late Miocene and Early Pliocene floras are frequently confusable respectively.

As already discussed by MIKI (1947, 1954, etc.), IKEBE (1954), HUZITA (1954), and other workers, the Akashi-type flora is the latest Neogene flora containing *Metasequoia, Glyptostrobus, Sequoia, Liquidambar, Juglans megacinerea,* etc., which plants locally remained at that time in Japan; since then, most of these exotic plants have disappeared from the Japanese Archipelago. The fossil floras younger than the Shinjô-type, consist nearly of modern species living in Japan, although some of them are not growing now in the vicinity of the fossil locality. Thus, the Akashi-type flora is probably Late or Latest Pliocene in age according to the views of several palaeontologists and geologists. This evaluation is supported by two facts: the lacustrine sediments including this type flora frequently yield *Parastegodon akashiensis,* also and they are slightly higher in stratigraphic sequence than the marine formation containing the Omma-Manganji fauna in northern Japan.

As already stated, fossil floras since Late Miocene time tended more and more to differentiate regionally in floristic composition and compo-

TABLE 15. Stratigraphic and Geographic

Region / Age			Hokkaidô			Northeastern Honshû		
			Southwest	Central	Eastern	inner	interior	outer
Pliocene	up.	Akashi-type		Sarabetsu	Ikeda	Sakae	Fukurohara	Tatsuno-kuchi-Yagiyama
	low.	Shinjô-type					Koyanaizu Shinjo Aterazawa	Kameoka
Mio-Pliocene		Mitoku-type				Fukaura		upper-Nenoshiroishi
Miocene	up.			Bifuka Ogawa	Shanabuchi Nukabira Utanobori	Noshiro	Takamine Obayashi Gosho	Low-Nenoshiroishi
	Mid.	Daijima-type	Setana Wakamatsu Kumaishi Yoshioka	Haboro		Kamigo Daijima Oguni Kwannonzawa	Utto Higashiyama Tozawa Kuroiwa	Tsukinoki Ouchi Soma
	low.	Aniai-type	Kaminokuni Kayanuma	Nokanan Asahi Sôya		Nishitagawa Iwadate Monzen	Aniai	Shichiku Tanakura
	lowest	Ainoura-type						

nents. Accordingly, the evaluation of the time factor during Pliocene must be made on the basis of an established floristic and climatic trend in each of the several provinces. However, the writer lacks definite knowledge concerning Pliocene flora in comparison to Miocene flora, so the above discussion of Pliocene flora may be confused.

On the basis of the above-noted considerations, various Neogene floras are grouped in Table 15 according to their relative ages.

3. Comparison with Neogene floras of adjacent regions.

The writer subdivided Neogene flora of Japan into 6 types, and has discussed their floristic composition, palaeoecology and geologic age. In order to facilitate consideration of Neogene floral changes in Japan, these

Distribution of Neogene floras in Japan

Kwantô	Central Honshû		Kinki	Westean Honshû	Shikoku	Kyûshû
	inner	outer				
Mashiko		Tokoname	Shirakawaike Awaji Akashi Aburahi			Tabira Oita Hirado
		Up-Pinus-trifolia		Ningyo-toge		Higashi-wasada Honda Mogi
Iwafune Funaishi	Bodaira	Low-Pinus-trifolia		Onbara		
	Yamazaki-kangawa Chausuyama		Zigokudani up-Shirakawa Tsugeno	Heigun Mitoku	Motoura	Higashi-Shonai
Daigo Nakagawa	Orito Irihirose Kunimi	Hiramaki	Yosa Low-Shirakawa Mitsuno	Tsuyama Toyooka Takakubo		Fukazuki
	Seki	Hiyoshi	Miyai Seki-kabuto			Fukui-Yunoki
	Kita-aigi			Daibo		Ainoura

six type floras shall be briefly compared with the related floras of adjacent regions, especially of Korea, China and Saghalien. However, in East Asia accurate knowledge concerning Tertiary floral composition has been comparatively scant up to the present, though many individual species have been described from Neogene sediments of these regions.

Korea

Along the coastal area of eastern Korea, Miocene coal-bearing formations are distributed, from which formations well-preserved plant fossils can be abundantly found. These plant fossils has been investigated by ENDO (1938, 1939, 1950, 1951), HUZIOKA (1943, 1951, 1954, 1955) TANAI (1952, 1953) and others. Among many Miocene flora, 7 floras are comparatively well known in their floristic composition and components; their main localities are shown in Fig. 7.

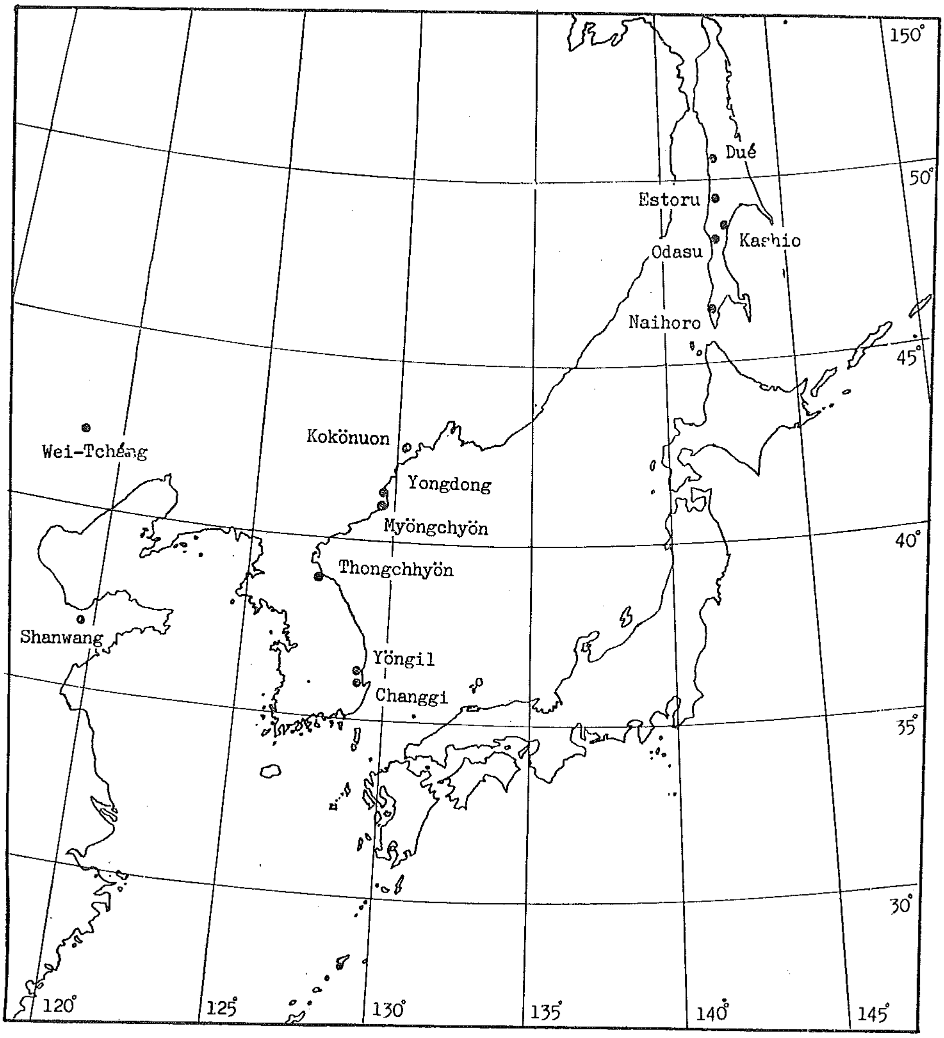

Fig. 7. The Distribution of Neogene Floras in the Adjacent Region of Japan.

The fossil flora from Yondong and Changgi groups consists mainly of temperate deciduous broad-leaved trees such as Betulaceae, Ulmaceae, Aceraceae, Tiliaceae, accompanied with several conifers such as *Metasequoia* and *Glyptostrobus*.

In addition, *Cercidipyllum, Salix,* and *Aesculus* are commonly contained. Most species of these temperate genera are Aniai-type elements; warm elements ar rarely present. Accordingly, these two Yondong and Changgi floras are closely similar to the Aniai-type flora of Japan in their floristic composition and components. The changgi flora situated far to the south of the Yondong, contains warm-temperate species such as *Platycarya, Quercus* and others. That is somewhat similar to the fact the Hiyoshi flora of central Honshû, Japan, contains several warm temperate elements despite its being one of the Aniai-type floras.

The Yöngil flora from Yöngil group of southeastern Korea, consists mainly of Juglandaceae, Betulaceae, Fagaceae, Lauraceae, Aceraceae and Sapindaceae; most of these genera are Daijima-type components. It is characteristic in the floristic composition that this flora frequently includes warm or subtropical genera such as *Lithocarpus, Phoebe, Cryptocarya, Cinnamomum* and *Entada.* Thus, the Yöngil flora is entirely similar to the just typical flora of the Daijima-type, and indicates existence of warm or warm-temperate climatic condition.

The Yöngchyöng and Kokönuon floras in North Hamgyöndo, northeastern Korea consist mainly of the Daijima-type species of Fagaceae, Betulaceae, Lauraceae and Aceraceae and include several exotic elements such as *Pteroceltis, Sassafras, Engelhardtia, Liriodendron* and others. These two floras are, as a whole, similar to the Daijima-type in their floristic composition, however, they frequently contain several northern elements such as *Ulmus shiragica, Cercidiphyllum crenatum, Acer ezoanum* and *Fagus antipofi,* which are commonly found in the Aniai-type flora of Japan. In view of floristic composition and components, the Myöngchyöng and Kokönuon floras are closely similar to the Yoshioka, Wakamatsu and Setana floras of southwestern Hokkaidô, though the former two contain few coniferous trees. These two Korean floras and three Daijima-type floras of southwestern Hokkaidô are situated at nearly the same latitude of 40 to 42 degrees North. Accordingly, the differentiated distribution of Middle Miocene vegetation seems to show a close similarity at the same latitude between Korea and the Japanese Islands. This fact may partially support the idea of isoflora which was advanced by CHANEY (1940) in respect of Tertiary floral distribution of northern hemisphere.

Beside these floras, the Kungsing and Thongchhyön floras are similar to the Daijima-type in their floristic composition and components. In Korea, there are no fossil floras comparable to Late Miocene and Pliocene floras so far as known up to the present.

China

Several Neogene floras have been reported from China; their localities are shown in Fig. 7. These investigations were made by CHANEY (1933, 1935), CHANEY & HU (1940), COLANI (1920) and DEPAPE (1932) on the basis of megafossils. Lately, pollen analysis for Tertiary sediments has been made by SUNG (1959) in several localities.

The Miocene Shanwang flora in Shantung province was investigated in detail as to the floristic composition and components by CHANEY & HU (1940), and assigned to be of Late Miocene age on the basis of precise discussion of palaeoecology and correlation. The Shawang flora abundantly contains temperate and warm-temperate species such as *Quercus, Castanea, Magnolia, Betula, Carpinus, Ulmus, Cornus, Diospyros, Acer, Rosa* and *Cedrela,* accompanied with many subtropical elements such as *Liquidambar, Fothergilla, Castanopsis,* etc. This flora is closely similar to the Daijima-type flora of Honshû, Japan in its floristic composition and components, and probably is Middle Miocene in age. Lately, SUNG (1959) found from the plant-bearing rocks of Shanwang many fossil spores and pollens such as those of *Salvinia, Picea, Pinus, Tsuya, Juglans, Pterocarya, Ulmus, Alnus, Quercus, Zelkova* and others, and he suggested this flora to be Middle Miocene in age. The Shanwang flora is at same latitude as the Orito flora of Noto peninsula, Central Honshû, and these two floras are closely similar to each other in their composition and components.

The Wei-Tch'ang flora of Jehol province (DEPAPE, 1932) consists of temperate elements such as *Pinus, Fagus, Carpinus, Betula, Castanea, Populus, Zelkova, Tilia, Cornus* and *Buxus,* and has been considered to be Late Miocene in age. This flora is similar to some of the Mitoku-type or Shinjô-type floras in floristic composition. Furthermore, it should be noted that the geographic position of this fossil locality is similar to the position of the northern floras of Hokkaidô.

Beside these two floras, several Pliocene floras were reported from the interior districts of China: the Taiku flora (CHANEY, 1933) and Tungyen flora (CHANEY, 1935) of Shansi province, the Kucha flora of Kansu and Sinkiang (CHANEY, 1935). These Pliocene floras contain a very small number of species, so they cannot be compared with Japanese Pliocene floras. However, these Pliocene floras of China indicate a progressive trend of cooling and aridity in this region since Late Miocene time; such climatic change somewhat corresponds to that of Japan in Late Tertiary time.

Saghalien

Tertiary plants of Saghalien were first reported by HEER (1871, 1878) from Dué, Mgratch and Satrutu areas, and then by KRYSHTOFOVICH (1921), YABE & ENDO (1940), OISHI & HUZIOKA (1941, 1943, 1954, etc.), BORSK (1956) and others. These many contributions contain information concerning Palaeogene and Miocene floras, some of which are confused in their stratigraphic position: for instance, the Dué floras seems to contain fossil plants of two or three horizons such as Eocene, Oligocene and Middle Miocene materials.

HUZIOKA (1949) described several Miocene floras from the Estoru and Naihoro formations of southern Saghalien. These floras, the Estoru, Odasu, Kashio and Naihoro, consists mainly of Juglandaceae, Salicaceae, Betulaceae, Ulmaceae and Aceraceae, with accompanying *Metasequoia, Glyptostrobus, Salvinia,* etc. These 4 floras are closely similar to the Aniai-type of Honshû, though there are somewhat abundant northern elements in number of species and specimens, compared with the Aniai-type flora of Honshû. However, considering the geographic position of these floras, the above-noted difference is rather naturally understood.

Reports on Late Miocene and Pliocene floras of Saghalien are nearly non-existent up to the present.

VIII. Neogene Floral Change and Palaeogeography in Japan

The geologic occurrence, composition, palaeoecology and geologic age of six Neogene type floras have been considered in the above chapters. In concluding the present work, the writer will briefly review the nature of Neogene floral change in Japan in connection with climatic change and palaeogeographic history.

In the Japanese Islands a land condition prevailed in the Cretaceous —Tertiary intervals, and then Palaeogene deposition progressed gradually with eustatic movement in central and eastern Hokkaidô, northern Kyûshû and part of Honshû, to which movement was due Palaeogene coal formation in many coal fields of these regions. Palaeogene vegetation of Japan is represented by many fossil floras found in these coal-bearing formations of various areas. Palaeogene floras of Japan are generally dominant in broad-leaved deciduous trees of Arcto-Tertiary type, and are frequently accompanied with subtropical elements such as *Sabalites, Musophyllum, Liquidambar, Artocarpus, Cinnamomum* and *Eugenia.* The Eocene and Late Oligocene floras of Japan generally have a more temperate aspect than those of western North America at corresponding latitudes, where the floras of the same age were largely made up of subtropical vegetation.

The Late Oligocene floras consist mainly of temperate or warm-temperate vegetation including *Metasequoia, Glyptostrobus, Cephalotaxus, Populus, Quercus, Platanus, Acer, Crataegus, Smilax, Alangium* and others. Some of these component species survived in earliest Miocene flora, but most of these genera evolved with specific renewals in Neogene flora.

In the early half of Miocene age, the major depositional sites removed to the inner zone of Honshû, southwestern Hokkaidô and partly to the outer zone of Honshû, where regions have been rested as land area till this stage. The early-Middle Miocene flora, as indicated by the Aniai-type, is composed mainly of temperate deciduous broad-leaved trees such as birch, alder, hornbeam, elm, zelkoua, beech, maple, basswood, willow, etc., but also abundantly of temperate conifers such as spruce, fir, bald cypress, *Metasequoia, Glyptostrobus* and others. This vegetation which represents the mountain-slope forest, grew probably under a cool-temperate climatic condition, which was rather slightly influenced by the sea. The cool-temperate climate in this stage brought out a luxuriant growth of temperate deciduous trees on the old land area, which trees survived or had evolved from Arcto-Tertiary elements of the Palaeogene.

The succeeding Miocene transgression prevailed with a wide extension over Japan, and exerted marine influence upon the flora of Middle Miocene age. The flora of this stage consists largely of warm-temperate or subtropical broad-leaved trees such as ever-green oak, chestnut, *Cinnamomum, Liquidambar, Machilus, Dodonaea,* etc. and temperate deciduous trees such as alder, birch, hornbeam, maple, walnut, etc. This flora was a lowland vegetation, distinctly influenced by a warm sea current which is indicated by the fossil faunas; it seems to have grown under warm or warm-temperate and rather humid climatic conditions. The floral change from the mountain-slope vegetation of the Aniai-type to the lowland vegetation of the Daijima-type, corresponds with increasing subsidence of depositional sites during Middle Miocene time, and at the same time was sensitively affected by marine influence. Thus, warm-temperate vegetation was distributed not only in Japan, but extended to Korea and to parts of northern China. However, the distribution of forest seems to have been differentiated in northern and southern areas of Japan; towards the northern part, the cool-temperate elements luxuriantly grew in the lowland, while warm or subtropical trees declined in number.

Miocene transgression in Japan attained its climax at the close of Middle Miocene time; the upper part of Miocene sediments consists mostly of marine argillaceous rocks in most areas. As indicated by the fact that these marine sediments frequently contain plant fossils of the Daijima-type components, the warm-temperate vegetation succeeded with luxuriant growth till upper-Middle Miocene time.

The regional emergence and submergence at the close of Middle Miocene time began to take place over the whole area of Japan, and consequently the sea gradually differentiated to various depositional basins in Late Miocene time. In consequence, lacustrine or littoral deposits were regionally formed in various areas of Japan, though marine facies generally are predominant in most of Late Miocene deposits. Late Miocene floras are excellently well preserved in these lacustrine deposits. These floras consist predominantly of temperate deciduous broad-leaved trees such as birch, alder, hornbeam, elm, zelkoua, beech, oak, maple, walnut and poplar, and commonly include coniferous trees such as pine, spruce, *Sequoia, Metasequoia* and *Glyptostrobus*. They have also commonly warm elements such as *Liquidambar, Sassafras, Liriodendron, Ilex, Cinnamomum* and others, though they are not abundant in number of specimens. Considering from the floristic composition, Late Miocene flora seems to be a mingled vegetation of warm- and cool-temperate elements, although the latter are predominant. Furthermore, though the flora of this stage is nearly not different in respect of generic composition from those of the previous stages, the temperate broad-leaved trees of this stage are entirely modernized.

In Late Miocene time, the physiographic conditions were probably more complicated than in the previous age, due to regional uplift or subsidence. Accordingly, the floristic composition of each flora is somewhat or partly very different respectively in each of their localities: for example, in western Honshû the warm elements are more abundantly contained, continuing from the previous stage, than in northern Honshû and Hokkaidô. Such floral change in Late Miocene time is probably due to regional differentiation of crustal movements which prevailed in Japan and to a lowering of temperature. As indicated by most of Late Miocene marine fauna, a cool or even boreal sea current seems to have extended to northern Japan, and such boreal sea probably caused a decline of temperature.

Following Late Miocene time, Pliocene depositional site differentiated still more into small basins: the regional uplift continued to form the Palaeo-Seto inland depression of western Honshû, the interior basin area and the Kitakami lowland area of northeastern Honshû, the north-south segregation of Later Tertiary basin of central Hokkaidô and others. Early Pliocene floras are mostly preserved in the lacustrine sediments which were formed in basins segregated from the sea in this age. Early Pliocene flora consists of abundant temperate deciduous broad-leaved trees accompanied commonly with conifers such as pine, spruce, fir, *Thuja* and *Metasequoia.* It is characteristic in the flora of this stage that coniferous trees had, in comparison with the preceding flora, increased gradually in number of species or specimens, while warm elements had decreased considerably. Such tendency of floristic change seems to be comparatively evident in northern Japan, but not so distinct in the lowland flora of western Japan . However, generally speaking, temperature seems to have lowered gradually during the Pliocene age succeeding from Late Miocene time, and the distribution of vegetation regionally differentiated without any considerable revolution of general floristic composition.

At last, the Neogene sea regressed gradually from most of the area of Japan except the southern Kwantô-Shizuoka region and some other areas, and performed the finale of its main rôle at the close of Tertiary time. Accordingly, the lacustrine or littoral environments prevailed in various areas of Japan, and caused to form the lacustrine sediments which have preserved Late Pliocene flora. Such floras in western Honshû are, as indicated by the Akashi-type flora, closely similar to Early Pliocene floras in floristic composition: they consist mainly of temperate deciduous broad-leaved trees and coniferous trees, with some warm elements accompanying such as *Liquidambar, Ilex, Parabenzoin, Cunninghamia.* However, many southern or exotic elements merely survived as relicts from the previous-age flora, most of which elements disappeared in the close of Pliocene age. In Late Pliocene age many aquatic plants such as *Nuphur, Euryale* and *Trapa* luxuriantly appeared, and carried on their luxuriant growth into Pleistocene age. In northern Japan, the vegetation of this stage seems to have been somewhat simpler than that of western Japan; it contains few warm elements. Thus, in the close of Pliocene times, many exotic elements such as *Metasequoia, Glyptostrobus, Sequoia, Liquidambar,* etc. disappeared from the Japanese Islands, though most of them were found throughout Tertiary flora of Japan.

In short, corresponding with changes of physical conditions, the warm- and cool-temperate floras have presented vicissitudes of luxuriant growth during Neogene time in Japan, occasionally accompanied with short periods of luxuriant growth of subtropical trees. During the age of Neogene flora of Japan, there was nearly no considerable revolution of generic composition, although specific evolution conspicuously arose after Late Miocene time; furthermore the warm or exotic elements gradually disappeared in accord with the decline of temperature.

Such tendency of lowering temperature since Late Miocene time is observed during the period of the flourishing of Tertiary flora at nearly the same latitude in western North America as already described by CHANEY (1944, 1959a, b) AXELROD (1957, 1958, 1959). In western North America, such tendency was accentuated by the up-building of the Cascade Ranges and the Sierra Nevada, bringing a more continental climate to broad areas on their leeward sides. Accordingly, Pliocene floras are somewhat variable in western North America, with restriction of temperate forests and a wide expansion of chaparral and grassland. On the other hand, Japan seems to have been unable to be free from the insular climate also during the Neogene as much as at present. Thus, increasing insularity in Japan appears to have compensated for the Pliocene progressive trends towards lowering temperatures; the temperate vegetation has been probably maintained itself without considerable change, although there were increasing diversities of floral distribution.

IX. Summary

This discussion of the historical change of Neogene floras as now known in Japan, from Hokkaidô in the north to Kyûshû in the south, may be concluded with the following remarks.

1) The Neogene flora of Japan is subdivided into six types, considering the floristic composition and components, along with the geologic ages indicated by them. They are the Ainoura, Aniai, Daijima, Mitoku, Shinjô and Akashi types in ascending order; the former four types are Miocene and the latter two Pliocene in age. These fossil floras are preserved mostly in lacustrine or littoral sediments of the respective ages of th Neogene.

2) Considering the floristic composition and components, the Neogene flora of Japan has in general, constantly maintained a temperate aspect throughout all stages of Neogene time: the warm- and cool-temperate forests have left evidence of their vicissitude of luxuriant growth, corresponding with changes of physical conditions. The Ainoura-type flora of earliest Miocene age contains several Palaeogene relicts, while the Daijima-type flora of Middle Miocene age is accompanied with many subtropical elements.

3) The warm or exotic elements gradually disappeared from Japan

according to the lapse of geologic time, though there was practically no considerable revolution of generic associations. However, a specific evolution of temperate broad-leaved trees distinctly arose in Late Miocene time.

4) The climatic environments have been discussed on the basis of the leaf character analysis, comparison with the modern equivalents of fossil species and habitat. On the basis of these considerations, it may be said that the climatic conditions during Neogene time in Japan seem to have changed within a limited extent between cool- and warm-temperate, and to have been more or less affected by sea-influence. A tendency is observed of gradual decline of temperature since Late Miocene time in Japan.

5) Diversity of floral distribution is more or less found throughout all of Neogene floras of Japan, being especially considerable since Late Miocene time: the fossil floras since Late Miocene time are somewhat different in floristic composition compared with others of same age.

X. Systematic Description of Neogene Species

Phylum PTERIDOPHYTA
Class FILICINAE
Family OSMUNDACEAE
Genus *Osmunda* L.

This genus composing of about 15 living species, is widely distributed in the world, excluding Australia. Fossil records of this genus have been known since Cretaceous flora in the world, and especially abundant in Palaeogene flora. In Japan, the fossil leaves of this genus are commonly found from Palaeogene coal-bearing formation in Hokkaidô and Kyûshû, but scarcely from Neogene sediments. The writer found only two species, *Osmunda japonica* THUNB. fossilis subsp. OISHI et HUZ. and *O. tsunemoriensis* MATSUO from Miocene flora in Hokkaidô or Honshû. Beside this species, *O. kuragatakensis* MATSUO was found from Miocene flora of central Honshû.

Osmunda japonica THUNB. fossilis subsp. OISHI et HUZIOKA

1941a. *Osmunda japonica* THUNB. fossilis subsp., OISHI et HUZIOKA: Jour. Fac. Sci. Hokkadô Imp. Univ. Ser. 4, vol. 6, No. 2, p. 179, Pl. 39, Figs. 1-4, 4a, 5-8.

1941. *Osmunda* cfr. *japonica*, MIKI: Jap. Jour. Bot. vol. 11, p. 253, Fig. 5 A, B.

Remarks: Though the present leaves are fragmental, they are identical to this species in nervation character. This species is very rarely found from Neogene flora, however rather commonly from Palaeogene coal-bearing sediments in various localities of Hokkaidô. It is closely related to the modern *Osmunda japonica* THUNB. which is widely distributed from Hokkaidô in the north to Kyûshû in the south.

Geological horizon: Late Eocene to Middle Miocene.

Osmunda tsunemoriensis MATSUO

(Pl. 1, Fig. 1)

1953. *Osmunda tsunemoriensis*, MATSUO: Sci. Rep. Kanazawa Univ. vol. 2, No. 1, p. 142, Text-fig. 3.

Remarks: The present only one specimen, though somewhat incomplete in preservation, is nearly identical to this species by nervation character. Namely, the present leaves are closely similar to the above-noted *O. japonica* fossilis in character of secondary nerves. However, the original specimen of this species is undulate in margin, while the present leaf is generally undulate but somewhat with very small and acute-tipped teeth. Further, the former was described from Middle Miocene flora of Central Honshû, while the latter was found from Late Miocene flora of northern Hokkaidô. Although there are slightly difference in marginal character, the writer ventures to identify the present leaf to *O. tsunemoriensis* by nervation character.

Geological horizon: Middle to Late Miocene.

Family SALVINIACEAE

Genus *Salvinia* ALLIONI

This genus being one of the aquatic ferns, has about 10 living species in the world, most of which species are mainly distributed in Africa and the tropical region of America, and a few in warm and temperate region of East Asia, Europe and North America. Fossil records of this genus have been known since Late Cretaceous flora in the world, and the fossil leaves have been commonly found throughout Tertiary flora in various localities. In Japan, this genus has been recorded from Palaeogene and Neogene floras, and the following two species are described from Miocene flora in Honshû and Hokkaidô: *Salvinia formosa* HEER and *S. pseudoformosa* OISHI et HUZIOKA.

Salvinia formosa HEER

(Pl. 1, Figs. 38, 39)

1859. *Salvinia formosa*, HEER: Flora Tertiaria Helvetiae, vol. 3, p. 156, Pl. 145, Figs. 13, 13b, 15.
1940. *Salvinia formosa*, FLORIN: Svensk. Bot. Tid. vol. 34, No. 4, p. 270.
1943d. *Salvinia formosa*, OISHI et HUZIOKA: Jour. Fac. Sci. Hokkaidô Imp. Univ. Ser. 4, vol. 7, No. 1, p. 67–70. Text-figs. 1–4.

Remarks: The present leaves are comparatively large-sized (2 to 2.1 cm long and about 1.7 cm wide), cordate at base round at apex, and about 20 in number of secondary nerves. They are fairly identical to *Salvinia formosa* in the nervation and arrangement of tubercles or spine. This species was, at first, described from Miocene flora of Switzerland (HEER, 1859), and then known from Miocene flora in various localities of the world.

It is also not rare in Miocene flora of Japan, and rarely found from Late Eocene flora of Ishikari coal field, Hokkaidô.

Geological horizon: Late Eocene to Middle Miocene.

Salvinia pseudoformosa OISHI et HUZIOKA

(Pl. 1, Figs. 30, 31, 50)

1941b. *Salvinia formosa*, OISHI et HUZIOKA: Jour. Fac. Sci. Hokkaidô Imp. Univ. Ser. 4, vol. 6, No. 2, p. 197, Pl. 44, Figs. 5–9; Text-fig. 2.
1943d. *Salvinia pseudoformosa*, OISHI et HUZIOKA: op. cit. p. 67–70.
1943. *Salvinia pseudoformosa*, HUZIOKA: Jour. Fac. Sci. Hokkaidô Imp. Univ. Ser. 4, vol. 7, No. 1, p. 120, Pl. 22, Fig. 1.

Remarks: The present small fossil leaves from Miocene flora of Hokkaidô and northern Honshû, are fairly identical to this species. The present species is close to the above-noted *Salvinia formosa* in general outline, but distinguished from the latter by following characters: the former leaves have single row of tubercles and secondary nerves straightly end in the margin, nor forming marginal loops. The fossil specimens of this species are generally small-sized, and the present materials are 8 to 13 mm long and 5 to 10 mm wide.

Geological horizon: Early (?) to Middle Miocene.

Class GYMNOSPERMAE

Family PINACEAE

Genus *Abies* MILL.

About 40 living species of this genus are distributed in the temperate and subboreal regions of the northern hemisphere, and furthermore some are growing in northern Mexico and Guatemala. The fossil remains of fir have been commonly found throughout Tertiary flora in the northern hemisphere. In Japan the fossil fir has not been reported its occurrence from Palaeogene flora, but only from Late Tertiary flora commonly found. The fossil pollens of this genus were, however, reported from Palaeogene coals in Hokkaidô by TOKUNAGA (1958). The writer could found the following 4 Neogene species on the basis of cone-scales, seeds or leaves: *Abies aburaensis* TANAI, *A. honshuensis* TANAI, *A. protofirma* TANAI and *A. n-suzukii* TANAI. Beside these species, MIKI (1957) described the fossil remains of the following 5 living species from Pliocene to Pleistocene flora in Honshû: *A. firma* S. et Z., *A. homolepis* S. et Z., *A. mariesii* MAST., *A. veitchii* LINDL. and *A. sachalinensis* SCHM.

Abies aburaensis TANAI sp. nov.

(Pl. 1, Figs. 8, 9)

Description: Samara medium in size, wedge-shaped in general outline, widest in the upper part, 9.5 mm long and 7 mm wide at the top; seed oblongly ovate in shape, rounded at the apex and obtuse at the base, 4 to 5 mm long and 3 to 3.5 mm wide; wing obovate in general outline, terminated in the upper half of the seed.

Remarks: The present new species is represented by well-preserved samaras from Miocene flora of southwestern Hokkaidô. They are fairly identical to the genus *Abies* by their wedge-like shape. The present specimens are closely related to the seeds of the modern *Abies firma* SIEB. et ZUCC. or *A. homolepis* SIEB. et ZUCC., and most closely similar to the latter. This most related species, *A. homolepis*, is distributed from central Honshû to Shikoku, and luxuriantly grows at altitudes of 1000 to 2000 meters above sea level in central Honshû. The fossil cone-scales and leaves of this living species were found from Pleistocene sediments in various localities of Honshû by MIKI (1957).

Among the fossil samaras in the world, this new species is closely similar to *Abies sonomensis* AXELROD from Pliocene Sonoma flora in California, the United States (AXELROD, 1944: Pl. 36, fig. 4).

Geological horizon: Middle Miocene.

Abies honshuensis TANAI sp. nov.

(Pl. 1, Figs. 2, 44)

1952. *Abies* sp., TANAI: Jap. Jour. Geol. Geogr. vol. 22, Pl. 4, Fig. 5.

1955. *Abies* sp., TANAI: Geol. Surv. Jap. Report No. 163, Pl. 1, Fig. 5.
1955. *Pseudotsuga* sp., TANAI: Ibid. Pl. 1, Fig. 4.

Description: Cone-scale semicircular in general outline, 1.2 cm high and 1.4 cm wide; stalk 4.5 mm long and 1.2 to 1.5 mm wide; base subcordate, sometimes with small appendage-like flange on the lower side; upper margin broadly rounded, with small and irregular teeth; bract unknown. Samara incomplete, probably wedge-shaped in outline, 1.2 cm long; seed oblongly elliptical in shape, 7.5 mm long and 2 mm wide; rounded pointed at apex and base; wing flanking the seed and terminated on the upper half of the seed.

Remarks: The present specimens are doubtlessly identical to the genus *Abies* by the cone-scale having cordate base and wedge-shapd samara, though its cone-scale somewhat resembles some of the genus *Picea* in outline. This new species is closely similar to *A. concolaroides* BROWN from Miocene to Pliocene flora in the United States (BROWN, 1940: p. 347; AXELROD, 1956: Pl. 2, figs. 4-6; Pl. 17, figs. 5, 6), but the samara of the latter is generally twice larger than that of the former. These two species is also different in size and shape of cone-scales respectively.

Among the living species of firs, the present new species is closely related to *A. homolepis* S. et Z. in Japan, *A. concolor* (GORDON) PARRY in North America and *A. nephrolepis* TRANTV. in North China.

Geological horizon: Middle Miocene.

Abies protofirma TANAI sp. nov.
(Pl. 1, Fig. 10)

1961. *Abies* sp., TANAI et ONOE: Geol. Surv. Jap. Report No. 187, p. 16, Pl. 1, Fig. 2.

Description: Cone-scale large in size, half circular in general outline, 3.2 cm wide (estimated) and 2.5 cm high, cordate to subcordate at base, with appendage-like flange on the lower side; upper margin irregularly and finely serrulate; stalk 0.5 cm long; bract broken, reversely trigonal.

Remarks: The present incomplete scale is closely similar to the modern *Abies firma* SIEB. et ZUCC. in general outline and size of scale. Many fossil cone-scales of this living species were described from Pliocene floras in various localities of Honshû by MIKI (MIKI, 1937: Fig. 1 K; 1957: Pl. 1, H-K), and they are probably included into the present new species. This new species is somewhat similar to the above-described *A. honshuensis*, in having serrulate margin, but the former scale is smaller in the ratio of height to width. *Abies protofirma* is close to *A. klamathensis* AXELROD from the Alvord Creek flora in California, the United States AXELROD, 1944: Pl. 42, figs. 12, 13).

The close living species, *A. firma,* is distributed in Honshû, Shikoku and Kyûshû, Japan, and frequently forms the mixed forest with deciduous broad-leaved trees.

Geological horizon: Late Miocene (?) to Pliocene.

Abies n-suzukii TANAI sp. nov.

(Pl. 1, Figs. 11, 13, 14; Pl. 32, Fig. 1)

Description: Cone-scale somewhat incomplete, fan-shaped in general outline, 13 mm high and 16 mm wide, broadly cuneate at base; appendage-like flange on the lower side not so conspicuous; upper margin broadly rounded, finely serrulate; bract linear in shape, with trifid apex, 4 mm long and 1.5 mm wide. Samaras variable in size, wedge-shaped, obovate-trigonal in outline, cuneate at base, rounded at apex, 6 to 8 mm long and 3 to 3.5 mm wide at the top; wing flanking the seeds and terminated in the upper half of the seeds, 6 to 9 mm long and 5 to 8 mm at the top.

Staminate twig bearing spirally disposed leaves. Leaves linear-lanceolate in outline, 14 to 26 mm long and 1 to 1.8 mm wide; tip blunt and with slightly emerginate apex; base cuneate; petiole very short, attached to the twig by a sucker-like base; underside of the blade marked by a prominent midrib. In the axels of the leaves are mammalated bodies which are interpreted as mashed staminated strobili; staminate cone very small, oval in shape, 4 mm long and 2 mm wide.

Remarks: The present new species of fir is represented by cone-scales, fruits and staminate twigs occurred from Middle Miocene flora of southwestern Hokkaidô. The present cone-scales and fruits are closely similar to the modern *Abies lasicarpa* (HOOK) NUTT. growing in northern Pacific slope of North America. They are also close to the living *A. mariesii* MASTERS in northern and central Honshû, Japan. Among the fossil firs, the present fossil species is closely related to *A. parviseminis* LAMOT. from Pliocene flora of western United States (LAMOTTE, 1936: Pl. 4, figs. 2-4). The present leafy twigs are, at least, probably of the second year's growth because of having staminate strobili in the axils.

This new species is named in honour of Mr. N. SUZUKI of Hokkaidô University who collected some of these specimens.

Geological horizon: Middle Miocene.

Genus *Larix* MILL.

About 10 living species of this genus are distributed in northern part of the northern hemisphere and Hymalaya region: these living larch trees inhabit under cooler or subalpine climate. The fossil remains of this genus have been scarcely reported from Tertiary flora in the world, and most of them have been described from Pleistocene flora. In Japan, the fossil cones, seeds, twigs and leaves of 2 living species, *Larix kampferi* SARG. and *K. gmelini* GORD., were commonly found from Pleistocene sediments in Honshû and Hokkaidô by MIKI (1957). The writer found only one species from Neogene flora in Honshû. However, it is somewhat doubtful in identification on account of ill-preservation.

Larix onbaraensis TANAI et ONOE

1961. *Larix onbaraensis*, TANAI et ONOE: op. cit. p. 17, Pl. 1, Figs. 6, 7.

Hemarks: The present species is characterized by prolonged-triangular-shaped wing and triangular seeds. It is closely similar to the modern *Larix kaempferi* SARG. in general outline, which grows now in central and northeastern Honshû. *Larix onbaraensis* is also close to *Tsuga diversifolia* MAST. and *T. sieboldii* CARRIERE in general appearance, and especially most close to the latter in having triangular seed. However, *T. sieboldii* is shorter in wing of samara than the present fossil species.

Geological horizon: Late Miocene (?) to Pliocene.

Genus *Keteleeria* CARRIERE

The distribution of this genus is confined to East Asia, and only two species is living in southern China and Formosa. The fossil remains of this genus have been described from Neogene flora in Europe and North America. On the other hand, the fossil cones and leaves of this genus were not rarely found from Pliocene sediments in various localities in Honshû, Japan, and they were identified by MIKI (1957) to two species: *Keteleeria davidiana* BEISSN. and *K. robusta* MIKI. Lately, the writer found the cone-scales and seeds belonging to this genus from Miocene sediments in Honshû and southwestern Hokkaidô.

Keteleeria ezoana TANAI sp. nov.

(Pl. 1, Figs. 16, 40, 41)

Description: Cone-scales nearly orbicular in shape, 2.5 cm high and 2.4 cm wide; base nearly truncate, and somewhat cordate; apex round, slightly emerginate; 3 mm long; bract with tridentate apex, 5 mm long and 2 mm wide. Samara triangular in general outline, 25 to 17 mm long and 9 to 6 mm wide at the greatest part of wing; wing slightly concave at the inner margin, convex at the outer margin, acute at apex, obtuse at base; seed elliptical in shape, 6 to 3.3 mm long and 3 to 1.8 mm wide.

Remarks: This new species is represented by both cone-scale and seed occurred from Miocene flora in Honshû and southwestern Hokkaidô. These present specimens are, at a glance, close to the genus *Abies* or *Picea,* however, they are identical to the genus *Keteleeria* by orbicular cone-scale retused at distal end. These specimens are closely similar to the scales and seeds of the modern *K. davidiana* BEISSN. which is now growing in southern China and Formosa. The scale and seed of this new species closely resemble Pliocene specimens of *K. davidiana* BEIS. (MIKI, 1941: Pl. 4, H-K) and *K. robusta* MIKI (MIKI, 1957: Pl. 2, D-E) described from Gifu Prefecture. This new species is distinctly different from the later two in their shape of scales.

Geological horizon: Middle Miocene.

Genus *Picea* A. DIETRICH

This genus consists of about 40 living species confined to the north temperate and subarctic regions of the northern hemisphere. On the other hand, the fossil remains of this genus have been found throughout Tertiary flora in the northern hemisphere, but they are more common in Late Tertiary rather than in Early Tertiary. In Japan the fossil cone-scales and seeds of spruce are not rare in Neogene flora, though they have not yet been found from the Palaeogene. The writer found the following 6 species from Neogene flora in Honshû and Hokkaidô: *Picea kaneharai* TANAI et ONOE, *P. kanoi* HUZIOKA, *P. magna* MACG., *P. miocenica* TANAI, *P. sugaii* TANAI et ONOE and *P. ugoana* HUZIOKA. Beside them, the fossil cone and leafy twigs of the living *P. bicolor* MAYR., *P. koyamai* SHIRAS., *P. glehnii* MAST., *P. polita* CARP. and *P. maximowiczii* REGEL and cones of *P. koribai* MIKI and *P. latibracteata* MIKI are found from Pliocene or Pleistocene sediments in various localities of Japan by MIKI (1957).

Picea kaneharai TANAI et ONOE

(Pl. 1, Figs. 3, 4)

1961. *Picea Kaneharai*, TANAI et ONOE: op. cit. p. 17, Pl. 1, Fig. 9.

Description: The present species represented by fossil fruits, is closely similar to the modern *Picea polita* CARRIERE in the shape and size of fruits. This living species is distributed in the mountains of central Honshû, Shikoku and Kyûshû. This fossil species is somewhat similar to *P. magna* MACG. from Miocene flora of western United States (MACGINITIE, 1953: Pl. 18, figs. 5-7; AXELROD, 1956: Pl. 4, figs. 7-12; Pl. 25, figs. 8, 9), but distinctly different from the latter by the shape of seed.

Geological horizon: Late Miocene to Pliocene.

Picea kanoi HUZIOKA

(Pl. 1, Fig. 20)

1949. *Picea kanoi*, HUZIOKA: Daijimaian deposits and floras in the inner zone of northeastern Japan (MS). Pl. 1, Figs. 5, 6.

Description: Samara small in size, obovate in general outline; seeds very small in size, obovate-trigonal in shape, 2.5 mm long and 0.8 to 1 mm wide, pointed at base, rounded at apex; wing spatulate in outline, rather large for the size of seeds, 6.5 to 8 mm long and 4 to 5 mm wide at the middle.

Remarks: This species was established by HUZIOKA (1949, MS) on the basis of several fossil fruits from Miocene flora of northeastern Honshû, but this description has not yet been published. The writer found several specimens identical to this species from Miocene flora in Honshû and Hokkaidô. The present species is characterized by small size of seed and spatulate-shaped wing. These specimens are closely similar to the samara of *Picea lahontoensis* MACG. from Late Miocene Trout Creek flora of Oregon, the United States (MACGINITIE, 1933: Pl. 3, fig. 4).

Among the modern spruce, this fossil species is closey simiar to *P. koyamai* SHIRASAWA, which grows only on Mt. Yatsugatake in central Honshû. The present species is also close to the modern *P. jessoensis* CAR. var. *hondoensis* REHDER in central Japan or *P. engelmanni* ENGELM. in the Pacific slope of North America.

Geological horizon: Middle Miocene.

Picea magna MACGINITIE

(Pl. 1, Figs. 5–7)

1953. *Picea magna*, MACGINITIE: Carnegie Inst. Wash. Publ. No. 599, p. 38, Pl. 18, Figs. 5–7.
1933. *Picea lahontense*, MACGINITIE (in part): Carnegie Inst. Wash. Publ. No. 416, p. 46, Pl. 3, Fig. 6. (not Fig. 4, 8).
1936. *Picea masoni*, MACGINITIE: Carnegie Inst. Wash. Publ. No. 476, p. 107, Pl. 1, Fig. 3.
1949. *Pseudotsuga Moritoi*, HUZIOKA: op. cit. Pl. 1, Figs. 3, 4.
1959. *Picea magna*, CHANEY et AXELROD: Carnegie Inst. Wash. Publ. No. 617, p. 140, Pl. 12, Figs. 10–15.

Remarks: The present specimens are fairly identical to the present American species in general characters. This species has been known from Oligocene and Miocene floras of the United States. It is closely similar to the living *Picea polita* CARRIERE in Japan and *P. neoveitchii* MASTERS in China. This fossil species is somewhat close to the above-described *P. kaneharai* TANAI et ONOE in general outline, but differs in shape of seeds.

The present species is commonly found from Miocene flora in north-eastern Honshû and southwestern Hokkaidô.

Geological horizon: Middle Miocene.

Picea miocenica TANAI sp. nov.

(Pl. 1, Figs. 12, 15)

Description: Cone-scale obcordate in general outline, broadly cordate at base, upper margin of scale rounded, finely serrulate, slightly cordate at apex, 2.0 cm height and 1.9 cm wide; bract small, short, 3 mm long and 2 mm wide, with pointed tip. Samaras medium in size, obovate in general outline; seed obovate-trigonal in shape, pointed at base, rounded at apex, 5 to 5.5 mm long and 3.0 to 3.5 mm wide at widest part; wing ovate in shape, rounded at apex, 10 to 11 mm long and 6.5 mm wide at the middle of wing, flanking the seeds and terminated in the upper half of the seeds.

Remarks: The present new species is represented by both cone-scales and samaras which are occurred from Miocene flora in Gifu Prefecture, central Honshû. These specimens are close to the modern *Picea polita* CARRIERE and *P. glehnii* MASTERS, especially more close to the former. However, the cone-scale of *P. polita* is generally larger than that of this fossil species. The fossil cones of the modern *P. polita* were found from Pliocene and Pleistocene sediments in various localities of Honshû by MIKI (1957), but their scales of this Pliocene cones are distinctly different from the present specimens in their shape. The samaras of this new species are closely similar to the above-noted *P. kaneharai* in general outline, but the latter is generally larger in size and longer in wing for the size of seed than the former.

Geological horizon: Middle Miocene.

Picea sugaii TANAI et ONOE

1952. *Picea* sp., TANAI: op. cit. p. 4, Fig. 4.
1959a. *Picea Sugaii*, TANAI et ONOE: Bull. Geol. Surv. Japan, vol. 10, No. 4, p. 276, Pl. 2, Figs. 1-3.

Remarks: The present species represented by small fruits, is rarely found from Miocene flora in Honshû. It is closely similar to the modern *Picea jessoensis* CARR. distributed in cooler region of East Asia. This species is somewhat similar to the above-described *P. kanoi*, but it is smaller than the latter.

Geological horizon: Middle Miocene.

Picea ugoana HUZIOKA

(Pl. 1, Figs. 28, 29)

1888. *Pinus* sp., NATHORST: Palaeont. Abhandl, heraus. v. Dam. Kays. vol. 4, p. 30, Pl. 7, Figs. 11, 12.
1949. *Picea ugona*, HUZIOKA: op. cit. Pl. 1, Fig. 7.

Description: Fruits oblong in general outline; seeds oval or obovate in shape, slightly pointed at base, 2 to 4 mm long and 1.5 to 2.0 mm wide; wing oblong in outline, rounded at apex, 7 to 8 mm long and 3 to 5 mm wide.

Remarks: The present species was described on several fossil fruits from Miocene flora in northeastern Honshû by HUZIOKA (1949, MS), but their description has not yet been given. The present specimens are fairly identical to this species. The fossil fruits described as *Pinus* sp. from Sado island by NATHORST, does not seem to be a pine, but rather belong to this species of spruce. This species is somewhat similar in general appearance to the above-described *Picea miocenica*, but it is larger in size and more spreading in wing than the latter. *Picea ugoana* is somewhat close to *P. malmgreni* HEER from Miocene flora of Spitzbergen (HEER, 1870: Pl. 5, figs. 64-67).

The present species is closely similar to the modern *P. bicolor* MAYR.

which is distributed in the mountains of central Honshû. On Mt. Fuji, this living spruce grows at altitudes of 500 to 1200 meters above sea level, associating with deciduous broad-leaved trees such as *Fagus crenate* BLUME, *Acer mono* MAXIM., etc.

Geological horizon: Middle Miocene.

Genus *Pinus* LINNE

About one hundred living species of this genus are widely distributed in various areas of the northern hemisphere being northwards from North Africa, West Indies and Malaysia. On the other hand, this genus dates back to Late Cretaceous time, and the fossil remains of pine were commonly found through Tertiary and Quaternary floras in North America, Europe and East Asia. In Japan the fossil leaves, seeds and cones of *Pinus* has been found from Late Cretaceous to Pleistocene sediments. The following 4 Neogene species are found by the writer: *Pinus fujiii* (YASUI) MIKI, *P. miocenica* TANAI, *P. palaeopentaphylla* TANAI et ONOE and *P. trifolia* MIKI.

Pinus fujiii (YASUI) MIKI

(Pl. 2, Fig. 9; Pl. 3, Fig. 10)

1928. *Pinus fujii*, YASUI: Jour. Fac. Sci. Imp. Univ. Tokyo, vol. 3, pt. 4, p. 431, Pl. 20–21, Fig. 12.
1941. *Pinus fujii*, MIKI: op. cit. p. 255, Pl. 4, Fig. G; Fig. 5 K–L.
1957. *Pinus fujii*, MIKI: Jour. Inst. Polytech. Osaka City Univ., Ser. D, vol. 8, p. 250, Pl. 7, Fig. H–K; Fig. 7 B.

Remarks: The present species is represented by fossil cones and leaves. The cone is characterized by having persistent peduncle, cordate base and arrangement of cone-scales in 5 : 8 conjugated parastichous rows. Many cones of this species have been found from Pliocene flora in various localities of Honshû, and lately the writer found some cones identical to this species from Middle Miocene flora in Honshû. The present species is closely similar to the modern *Pinus thubergii* PARL. which is distributed from northern Honshû to Kyûshû, extending to Korea. This fossil species is distinctly different from the latter in having stipitated cone and hook-line umbo.

Geological horizon: Middle Miocene to Pliocene.

Pinus miocenica TANAI sp. nov.
(Pl. 2, Fig. 2)

1888. *Pinus* sp., NATHORST: op. cit. p. 8, Pl. 2, Fig. 1.

Description: Leaves linear, in bundle of two, closely fasciled toward end of branch, about 10 cm long or more, 1 mm wide, nearly straight to the tip; a single ridge existing below; sheath persistent, 8 to 10 mm long.

Remarks: The present new species of pine is represented by many fossil leaves occurred from Miocene flora in Honshû and Hokkaido, but no fossil fruit comparable to this species has not yet been found by the writer. This fossil species is closely similar to the modern two-leaved pine (Diploxylon) of Japan, *Pinus thunbergii* PARL. and *P. densiflora* S. et Z., and in particular more similar to the last species. Namely, *P. thunbergii* is generally longer and thicker in leaves than *P. densiflora*: *P. thunbergii* 7 to 15 cm in length of leaves, *P. densiflora* 8 to 18 cm.

The closely related living pine, *P. densiflora,* is now distributed in Honshû, Shikoku and Kyûshû. The present new species is now confined to Middle Miocene flora, and one of the representatives of the Daijima-type flora.

Geological horizon: Middle Miocene.

Pinus palaeopentaphylla TANAI et ONOE
(Pl. 2, Fig. 4)

1961. *Pinus palaeopentaphylla,* NANAI et ONOE: op. cit. p. 18, Pl. 1, Figs. 8, 10.

Remarks: The present species is a five-needles pine closely similar to the modern *Pinus pentaphylla* MARY. which grows now from Hokkaidô to central Honshû, Japan. Lately, MIKI (1957) described the fossil cones or seeds of five-leaved pines, *P. parviflora* S. et Z., *P. koraiensis* S. et Z. and *P. amamiana* KOIDZ., from Pliocene or Pleistocene flora in various localities of Japan. In North America, the five-leaved pines were found from Tertiary flora: for instance, *P. florissanti* LESQ., *P. wheeleri* COCKER., etc. However, they are twice longer in leaves than the present species.

Geological horizon: Middle Miocene to Pliocene.

Pinus trifolia MIKI
(Pl. 2, Fig. 8)

1939. *Pinus trifolia,* MIKI: Bot, Mag. Tokyo vol. 53, p. 239, Pl. 4, Fig. 3.
1941. *Pinus trifolia,* MIKI: op. cit. p. 255.
1957. *Pinus trifolia,* MIKI: op. cit. p. 253, Pl. 6, Figs. A-I.

Remarks: The present species is characterized by large cone and three- or four-needles, which were found from Pliocene or Late Miocene floras in Seto and Tazimi districts of central Honshû. The cone-scales of this pine have hook-like prolonged umbo, and they are arranged in 8 : 13 conjugated parastichous rows. This species has not been found from other region of Japan, excluding the above-noted districts.

Geological horizon: Late Miocene (?) to Early Pliocene.

Genus *Pseudolarix* GORDON

This monotypic genus is limitedly distributed now in Central China and a part of Southeast China, where only one living species, *Pseudolarix kaempferi* GORD., grows at altitudes of about 1000 meters above sea level. This fossil remains of this genus were, however, discribed from Tertiary flora in the northern hemisphere. In Japan, the fossil cone-scales, seeds or twigs of golden larch have been reported from Late Miocene to Pliocene flora, but lately the writer found the cone-scale of this genus from Middle Miocene flora in Honshû and Hokkaidô.

Pseudolarix japonica TANAI et ONOE

(Pl. 1, Figs. 18, 19, 24, 27, 33–35)

1941. *Pseudolarix kaempferi*, MIKI: op. cit. p. 255, Pl. 4, Figs. C–F; Fig. 6, A–E.
1948. *Pseudolarix kaempferi*, MIKI: Min. and Geol. No. 2, p. 111.
1950. *Pseudolarix kaempferi*, MIKI: Nat. et Cult. No. 1, p. 72, 74.
1957. *Pseudolarix kaempferi*, MIKI: op. cit. p. 253, Pl. 1, Figs. L, M, O.
1961. *Pseudolarix japonica*, TANAI et ONOE: op. cit. p. 17, Pl. 1, Fig. 5.

Remarks: The present species is characterized by spate-like cone-scales which are closely similar or nearly identical to the modern *Pseudolarix kaempferi* GORDON. The fossil remains described as *P. kaempferi* by MIKI are nearly identical to the present species, and probably included into this species. The cone-scale from Miocene flora near Toki-machi of central Honshû (Pl. 1, fig. 19) is somewhat larger than original specimen, but identified to this species by other characters.

This Japanese species is closely similar to *P. americana* BROWN from Oligocene flora of North America (BROWN, 1940: p. 348; ARNOLD, 1955: Pl. 3, figs. 1-3), and also close to *P. fossilis* JARM. from eastern Central Asia (KRYSHTOFOVICH, 1956: Pl. 1, figs. 4-14).

Geological horizon: Middle Miocene to Pliocene.

Genus *Pseudotusga* CARRIERE

This genus has about 7 living species which are limitedly distributed in East Asia and western North America, but fossil remains have been described from Neogene flora in the northern hemisphere. In Japan the writer found only one species, *Pseudotsuga ezoana* TANAI from Miocene flora, but the other 2 species, *P. subtrotunda* MIKI and *P. gondylocarpa* MIKI, were described from Pliocene flora of Honshû by MIKI (1957).

Pseudotsuga ezoana TANAI sp. nov.

(Pl. 1, Fig. 21)

Description: Fruit obovate in general outline; wing ovate in outline, 11 mm long and 6 mm wide at the middle part, obliquely rounded at apex; seed obvate-triangular in shape, with a slightly snubbed nose, somewhat cuneate or pointed at base, 4 mm long and 2 mm wide.

Remarks: This new species was established on the basis of fossil fruit occurred from Middle Miocene flora of southwestern Hokkaidô. Though the present specimen is closely similar or nearly identical to the modern *Pseudotsuga japonica* BEISSN. which is distributed in Kii peninsula and southern Shikoku, Japan. However, the seed in this living species is larger for size of wing than in this fossil species.

Among the fossil species of *Pseudotsuga*, *P. ezoana* is closely similar to *P. sonomensis* DORF from Miocene and Pliocene flora in western United States (DORF, 1930: Pl. 6, figs. 2-4; AXELROD, 1944: Pl. 36, fig. 3, etc.).

Geological horizon: Middle Miocene.

Genus *Tsuga* CARRIERE

This genus has 9 living species in the world, and their modern distribution is confined to North America and East Asia. However, the fossil remains of hemlocks have been found from Tertiary flora in the northern hemisphere, and especially from Late Tertiary flora. In Japan the fossil cones, leaf or seeds of five species of this genus have been reported from Pliocne and Pleistocene flora by MIKI (1957). Lately, the writer found the following 2 species from Miocene flora in Hokkaidô: *Tsuga aburaensis* TANAI, *T. miocenica* TANAI.

Tsuga aburaensis TANAI sp. nov.

(Pl. 1, Fig. 49)

Description: Fruits very small in size; wing ovate in outline, subacute at apex, rounded at base, 4 mm long and 1.5 mm wide; seed small, obovate-trigonal in shape, with a snubbed nose, obliquely attached for wing, 2 mm long and 1 mm wide at the widest part.

Remarks: The present small fruits are fairly identical to the genus *Tsuga* by its shape and size. This new species is closely similar to the modern *Tsuga diversifolia* MASTERS which grows from northern to central Honshû and Shikoku at altitudes of 1700 to 2000 meters above sea level. The fossil cones of this living species were abundantly found from Pleistocene flora in various localities of Honshû by MIKI (1957). No fossil fruit of *Tsuga* is comparable to this new species in the world. *Picea sugaii* TANAI is somewhat similar in general outline to this species, but distinctly different in size of wing and shape of seed.

Geological horizon: Middle Miocene.

Tsuga miocenica TANAI sp. nov.

(Pl. 1, Figs. 25, 26, 32)

Description: Cone-scales broadly ovate in general outline, rounded and slightly cordate at base, rounded and then abruptly pointed at apex, 14 to 16 mm long and 10 to 11 mm wide; stalk about 2 mm long; bract linear, with acute apex, 6 mm long and 2 mm wide. Fruits small, obovate in outline, 9 mm long and 6 mm wide on the middle part of wing rounded at apex, acute at base; wing extended under seed, widest at or near middle; seed very small, oval in shape, 1.2 mm long and 0.8 mm wide.

Remarks: The present species is represented by cone-scales and seeds occurred from Miocene flora in southwestern Hokkaidô. This new species belongs to subgenus *Palaeotsuga* on account of long linear bract on the cone-scales. The present cone-scale is closely similar to that of *Tsuga longibracteata* CHENG living now in southern China. The fossil cone of this living species were described from Pliocene flora of Honshû by MIKI (MIKI, 1954: Figs. F-K), but these Pliocene cone-scales are elliptical in shape and rounded at the apex. On the other hand, the seed of this fossil species is closely similar to *T. sonomensis* AXELROD from Pliocene flora of California, the United States (AXELROD, 1944: Pl. 36, figs. 5, 6; 1955: Pl. 4, figs. 17, 18). This American species is closely similar to the modern *T. heterophylla* SARGENT which grows in the western part of the United States.

Geological horizon: Middle Miocene.

Family CUPRESSACEAE

Genus *Junipers* LINNE

About 50 living species of this genus are widely distributed in the northern hemisphere, from northern region to the high altitudes of the tropics. The fossil remains of junipers have been found throughout Tertiary flora in the northern hemisphere. However, in Japan the fossil juniper has been found since Late Miocene time as far as known up to the present. Only one species, *Juniperus honshuensis* TANAI et ONOE, was found from Neogene flora, but the fossil shoots or cones of 3 living species, *J. chinensis* L., *J. conferta* PARL. and *J. rigida* S. et Z., were described from Pleistocene flora of Honshû.

Juniperus honshuensis TANAI et ONOE

(Pl. 1, Fig. 47)

1958. *Juniperus chinensis*, MIKI: Jour. Inst. Polutech. Osaka City Univ. Ser. D, vol. 9, p. 131, Pl. 2 E; Fig. 1 E.
1961. *Juniperus honshuensis*, TANAI et ONOE: op. cit. p. 20, Pl. 1, Fig. 3.

Remarks: This species is represented by twigs spirally arranged by lapidoid leaves. It is nearly identical to the modern *Juniperus chinensis* LINNE which is widely distributed in Honshû, Shikoku and Kyûshû, Japan, extending to China and Mongolia. The present species is nearly similar to *J. alvordensis* AXELROD from Pliocene flora of Oregon, the United States (AXELROD, 1944: Pl. 43, figs. 1, 2, 5). *Libocedrus lantenoisii* LAURENT described from Miocene Kawanonzawa flora of northern Honshû (KRYSHTOFOVICH, 1926: Pl. 1, fig. 3) is very close to juniper rather than *Libocedrus*, and it strongly resembles the present species.

Geological horizon: Late Miocene to Pliocene (Pleistocene ?).

Genus *Thuja* LINNE

This genus composed of about 6 living species is confined in distribution to East Asia and North America, and only one species is living now in Japan. On the other hand, the fossil remains of this genus have been not rarely described from Tertiary flora in North America and Europe. However, as already described by MIKI (1958), the genus *Thuja* is difficult to be distinguished from the genus *Thujopsis* only by leafy twig remains, so that the fossil leaves described as *Thuja* in the world seem to include *Thujopsis*. In Japan, the writer found only one species, *Thuja nipponica* TANAI et ONOE, from Neogene flora of Honshû, but another species, *T.*

protojaponica MIKI was described from Pliocene and Pleistocene flora in several localities of central Honshû.

Thuja nipponica TANAI et ONOE
(Pl. 1, Fig. 45)

1931. *Thuja japonica,* MIKI: op. cit. p. 308, Fig. 1 D.
1939. *Thuja japonica,* SHIMAKURA: Jub. Publ. Comm. Prof. YABE's 60th Birthday vol. 2, 144, Pl. 17, Fig. 9.
1954. *Thuja standishii,* TAKAHASHI: Mem. Fac. Sci. Kyûshû Univ. Ser. D, vol. 5, No. 1, Pl. 1, Fig. 3.
1958. *Thuja standishii,* MIKI: op. cit. p. 134, Pl. 1, F, G; Fig. 1 B.
1961. *Thuja nipponica,* TANAI et ONOE: op. cit. p. 19 Pl. 1, Figs. 11a, b.

Remarks: The present species represented by leafy twig and cone, is closely similar or nearly identical to the modern *Thuja standishii* CARR. growing from northeastern to central Honshû, Japan. This species is closely related to another Japanese fossil species, *T. protojaponica* MIKI (MIKI, 1941b: Fig. 2C; 1958: Pl. 1E, etc.), but the latter is constricted more tenuous in leaves than the former. The leafy twig of the present species is characterized by presence of leaf axis composed of basal part of lateral leaves, while the shoots of latter species have no leaf axis, as stated by MIKI (1958). This species has been comparatively common in Pliocene flora in Honshû.

Geological Horizon: Late Miocene to Pliocene (Pleistocene).

Family TAXODIACEAE

Genus *Cunninghamia* R. BROWN

The modern distribution of this genus consisting of only 2 living species is confined to East Asia: one is *Cunninghamia konishii* HAYATA in Formosa, and another species is *C. lanceolata* HOOK in central and southern China. The fossil remains of this genus have been very rarely reported their occurrence from North America and Europe. In Japan, fossil records of this genus have been known from Middle Miocene to Late Pliocene flora, especially many fossil cones or shoots were found from Early Pliocene sediments by MIKI (1941).

Cunninghamia protokonishii TANAI et ONOE

1941. *Cunninghamia konishii*, MIKI: op. cit. p. 257, Fig. 7 A, B.
1950. *Cunninghamia konishii*, MIKI: op. cit. p. 73, Fig. 2, A–D.
1960. *Cunninghamia protokonishii*, TANAI et ONOE: op. cit. Pl. 1, Figs. 8, 10, 12.

Remarks: The present species is represented by foliaged shoots and cones, and the foliaged shoot is characterized by the spiral arrangement and serrate margin of leaves. This fossil species is closely similar or nearly identical to the modern *Cunninghamia konishii* HAYATA in Formosa. This fossil species is not rarely found from Neogene flora in Honshû.

Geological horizon: Middle Miocene to Late Pliocene.

Genus *Glyptostrobus* ENDLICHER

This genus has only one living species in the world, which species is now growing in southeastern China. However, the fossil remains of this genus have been abundantly found from Late Cretaceous and Tertiary sediments in Europe, North America, East Asia, Arctic region, etc. Accordingly, *Glyptostrobus* is one of the widely-distributed genera in the old world, though it is now in a limited distribution. In Japan, the fossil leaves and cones are found throughout Tertiary flora, and in particular commonly from Neogene flora.

Glyptostrobus europaeus (BRONGNIART) HEER

(Pl. 2, Figs. 3, 6, 7, 10, 11)

1883. *Taxodium europauem*, BRONGNIART: Annales Sci. Nat. Botanique, vol. 30, p. 168.
1855. *Glyptostrobus europaeus*, HEER: Flora tertiaria Helvetia, vol. 1, p. 51, Pl. 20, Fig. 1.
1936. *Glyptostrobus europaeus*, ENDO et OKUTSU: Proc. Imp. Acad. Tokyo, vol. 12, p. 138, Fig. 1–3.
1942. *Glyptostrobus pensilis*, MIKI: op. cit. p. 295, Pl. 5, Fig. 7 C–G.
1950. *Glyptostrobus pensilis*, MIKI: op. cit. p. 73, Fig. 3.
1952a. *Glyptostrobus europaeus*, TANAI: op. cit. Pl. 4, Fig. 1.
1953. *Glyptostrobus europaeus*, ENDO: Kumamoto Jour. Sci. Ser. B, No. 2, p. 1, Pl. 4, Figs. 8, 9.
1955. *Glyptostrobus europaeus*, TANAI: op. cit. Pl. 1, Figs. 17–19.

Remarks: The present species represented by both leafy twigs and cones, was widely distributed in the northern hemisphere in Tertiary time. This species is also commonly found from Eocene to Pliocene floras in Japan. The present specimens are close similar to the modern *Glyptostro-*

bus pensilis KOCH. existing now in southeastern China, and these two species are nearly indistinguishable each other.

Geology horizon: Eocene to Late Pliocene.

Genus *Metasequoia* MIKI

This genus was established by MIKI (1941) on the basis of fossil cones and leafy shoots from Pliocene flora in various localities of Honshû, Japan. These remains had been once referred to the genus *Sequoia* or *Taxodium*: actually, the cones are close to those of *Sequoia,* while foliaged shoots are somewhat similar to those of *Taxodium.* However, this genus is distinctly different from the latter two genera in decussate arrangement of cone-scales and distichous arrangement of leaves on shoot, etc. Then, the living species of this genus was found in Szechuan province, Central China by HU (1948), and the recent occurrence of this genus was confirmed in botanical taxonomy. This genus has only one living species in China, but the fossil remains of this genus have been abundantly found throughout Tertiary flora over the world. Furthermore, fossil record of this genus backed to Cretaceous time in the world. In Japan, the fossil cones and foliaged shoots have abundantly occurred from Tertiary sediments, and this genus became extinct from Japanese Islands at the end of Pliocene time.

Metasequoia occidentalis (NEWBERRY) CHANEY
(Pl. 3, Figs. 1–3, 5–8, 14)

1863. *Taxodium occidentalis*, NEWBERRY: Boston Soc. Nat. Hist., vol. 7, p. 516.
1863. *Sequoia langsdor*, HEER: Flora fossils Arctica vol. 1, p. 136, Pl. 21, Figs. 1–8.
1869. *Taxodium distichum miocenum*, HEER: Do vol. 2, No. 2, p. 21, Pl. 1, Fig. 6; Pl. 3, Fig. 11c, Pl. 4, Fig. 5b, c.
1883. *Taxites* sp., NATHORST: Kongl. Sv. Vet. Acad. Handl. vol. 20, No. 2, p. 35, Pl. 1, Fig. 8.
1888. *Sequoia disticha*, NATHORST: op. cit. p. 5, Pl. 1, Fig. 1; p. 11, Pl. 2, Fig. 11.
1931. *Taxodium distichum miocenum*, KONNO: Geology of central Shinano (by HONMA) Pl. 8, Figs. 1, 2.
1936b. *Sequoia japonica*, ENDO: Proc. Imp. Acad. Tokyo vol. 12, No. 6, p. 172, Figs. 5, 7, 8–13.
1939. *Sequoia japonica*, ENDO: Jub. Publ. Comm. Prof. YABE's 60th Birthday, vol. 1, p. 337, Pl. 23, Fig. 15.
1941. *Metasequoia japonica*, MIKI: op. cit. p. 262, Pl. 5, Fig. D: Fig. 8 Ab, H.
1951. *Metasequoia occidentalis*, CHANEY: Trans. Amer. Philosoph. Soc. New. Ser. vol. 40, pt. 3, p. 225, Pl. 1, Fig. 3; Pl. 2, Figs. 1–3; Pl. 4, Figs. 1, 2, 9; Pl. 5, Figs. 1–3; Pl. 6, Fig. 2; Pl. 7, Figs. 1–6; Pl. 7, Figs. 1–3; Pl. 9, Figs. 3, 5, 6, 7; Pl.

10, Figs. 1a, 2a, 3-6; Pl. 11, Figs. 7, 8; Pl. 11, Figs. 7, 8; Pl. 12, Figs. 1, 2, 5-8.
1952a. *Metasequoia japonica*, TANAI (in part): op. cit. p. 123, Pl. 4, Fig. 2 (not Fig. 3)
1954. *Sequoia japonica*, ENDO: Kumamoto Jour. Sci. Ser. B, No. 4, p. 1, Pl. 1, Fig. 8; Pl. 2, Figs. 4, 6.
1955. *Metasequoia japonica*, TANAI: op. cit. Pl. 1, Figs. 11, 12.
1959. *Metasequoia occidentalis*, TANAI et ONOE: op. cit. Pl. 1, Fig. 2.

Remarks: This species is one of the most common species in Cenozoic flora of the world. Abundant shoots and cones belonging to this species occurred from Neogene and Palaeogene flora at the various localities of Japan. Recently, many fossil shoots and cones of this genus from North America have been re-examined by CHANEY (1951), and many remains given various specific names was revised to the following two species: *M. cuneata* and *M. occidentalis*. The fossil materials asigned to *M. japonica* are almost indistinguishable from *M. occidentalis* in all characters, and so the former species is probably conspecific to the latter.

The present species is nearly identical to *Sequoia disticha* HEER from Miocene flora of Spitzbergen in characters of foliaged shoots. *S. disticha* was determined by HEER on the basis of foliaged shoots without cones, then, *M. disticha* revised by MIKI (1941) on the basis of fossil cones is doubtful to be correctly coincided with HEER's original specimens. Accordingly, the writer would use the specific name of *M. occidentalis* for these specimens of *Metasequoia* from Japanese Neogene flora.

Geological horizno: Eocene to Late Pliocene (in Japan).

Metasequoia miocenica TANAI et ONOE

1952a. *Metasequoia japonica*, TANAI (in part): op. cit. p. 123, Pl. 4, Fig. 3 (not Fig. 2).
1955. *Metasequoia miocenica*, TANAI: op. cit. Pl. 1, Figs. 13, 14.
1959. *Metasequoia miocenica*, TANAI et ONOE: op. cit. p. 275, Pl. 1, Figs. 3, 4.

Remarks: This species is represented by foliaged shoots bearing staminate cones from Miocene flora in two localities of northeastern Honshû. The present specimens are vary rare in Japan, while such staminate-cone-bearing foliaged shoots of this genus have been not so rarely reported from Tertiary flora of North America. Those American specimens are larger in leaves and cones than Japanese specimens.

Geological horizon: Middle Miocene.

Genus *Sequoia* ENDLICHER

This genus consists of a single living species: it is the coast red-wood (*Sequoia sempervirens* ENDL.) restricted in its distribution to Oregon and California, the United States. However, the fossil records of this genus in the world have been commonly or abundantly known from Cretaceous to Tertiary sediments, even backing to Late Jurassic time. In Japan, the fossil remains of *Sequoia* have been found through Tertiary flora, but they are not so abundant as the remains of *Metasequoia.*

Sequoia affinis LESQUEREUX

(Pl. 3, Fig. 11)

1876. *Sequoia affinis*, LESQUEREUX: U. S. Geol. Geogr. Surv. Terr., Bull. No. 5, 2nd Ser. B. 384.
1878. *Sequoia affinis*, LESQUEREUX: Rep. U. S. Geol. Surv. Terr., vol. 7, p. 75, Pl. 65, Figs. 1-4 (not Pl. 7, Figs. 3-5).
1941. *Sequoia sempervirens*, MIKI: op. cit. p. 262, Pl. V, Figs. Cb, E, F; Fig. 7 G-J.
1951. *Sequoia affinis*, CHANEY: op. cit. p. 231, Pl. 1, Fig. 2; Pl. 3, Figs. 2-4; Pl. 4, Figs. 3, 4, 7; Pl. 6, Fig. 6; Pl. 7, Figs. 7-9, 12; Pl. 8, Fig. 10; Pl. 12, Figs. 3, 4.

Remarks: This species is one of the widely-distributed conifers in the old world. In Japan, it has been found throughout Tertiary flora in the various localities from Hokkaidô in the north to Kyûshû in the south. The present species is closely similar or nearly identical to the modern *Sequoia sempervirens* ENDL. in western United States.

Geological horizon: Eocene to Late Pliocene (in Japan).

Genus *Taiwania* HAYATA

This genus is one of the endemic genera in East Asia; only one living species is confined in its distribution to Formosa, southern China and Burma. The fossil remains of this genus have been found from Late Tertiary flora in various localities of Japan, however no fossil record of this genus has not yet been known from Europe and North America.

Taiwania japonica TANAI et ONOE

(Pl. 1, Fig. 48)

1954. *Taiwania cryptomeroides*, MIKI: Proc. Jap. Acad. vol. 30, No. 10, p. 976, Figs. A-D.
1961. *Taiwania japonica*, TANAI et ONOE: op. cit. p. 19, Pl. 1, Fig. 4.

Remarks: The present species is represented by foliaged shoots from

Neogene flora in Honshû and Hokkaidô, but fossil cones identical to this species were found by MIKI (1954) from Pliocene flora of Honshû. This species is closely similar to the living *Taiwania cryptomeroides* HAYATA. Recently, the writer found a fragmental shoots being referable to this species from Middle Miocene flora of southwestern Hokkaidô, Japan.

Geological horizon: Middle Miocene to Pliocene.

Genus *Taxodium* RICHARD

This genus consists of 2 or 3 living species in the world, and has a limited distribution from eastern United States to Mexico. However, the fossil remains of this genus have been commonly found from Tertiary flora of the northern hemisphere, and even from Pleistocene flora in North America. In Japan, the fossil leaves of this genus have been not commonly found from Neogene flora, and rarely from Palaeogene flora. No fossil cones identical to this genus has been found from Japan. This genus is frequently difficult to be distinguished from the genus *Sequoia* by only fossil foliaged shoots.

Taxodium dubium (STERNBERG) HEER

(Pl. 3, Fig. 13)

1824. *Phyllites dubius*, STERNBERG: Flora der Vormelt, vol. 1, p. 37, Pl. 24, Fig. 2; Pl. 36, Figs. 3, 4.
1855. *Taxodium dubium*, HEER: Flora Tertiaria Helvetiae, vol. 1, p. 49, Pl. 17, Figs. 3, 15.
1888. *Taxodium distichum miocenum*, NATHORST: op. cit. p. 7, Pl. 1, Fig. 4.
1951. *Taxodium dubium*, CHANEY: op. cit. p. 233, Pl. 1, Fig. 1; Pl. 3, Fig. 1; Pl. 4, Figs. 5, 6; Pl. 6, Fig. 4; Pl. 7, Fig. 11; Pl. 8, Figs. 4, 6–9; Pl. 9, Figs. 1, 2; Pl. 10, Fig. 1b, 2b; Pl. 11, Fig. 9; Pl. 12, Fig. 9·
1954. *Taxodium* cfr. *distichum*, ENDO: op. cit. p. 4, Pl. 1, Fig. 1; Pl. 2, Fig. 5.
1955. *Taxodium dubium*, TANAI: op. cit. Pl. 1, Figs. 15, 16.

Rmearks: This species is one of the widely-described conifers in Tertiary flora in the northern hemisphere, but in Japan rather rare in Neogene flora. The present species is closely similar to the modern *Taxodium distichum* (LINN.) RICH. in southeastern region of North America.

Geological horizon: Eocene to Pliocene (in Japan).

Class ANGIOSPERMAE
Subclass MONOCOTYLEDONES
Family LILIACEAE
Genus *Smilax* L.

The living species of this genus are common in the tropical region of the world, and about 300 species are now distributed mainly in East Asia and North America, partly in Mediterranean region. The fossil leaves of this genus have been not rarely found throughout Tertiary flora in North America and Europe. In Japan, this genus has not yet been reported from Palaeogene flora, but the fossil leaves of this genus have been rarely found from Neogene flora.

Smilax trinervis MORITA
(Pl. 4, Figs. 2–5)

1930. *Smilax china*, KONNO: op. cit. Pl. 8, Fig. 4.
1931. *Smilax trinervis*, MORITA: Jap. Jour. Geol. Geogr. vol. 9, Nos. 1–2, p. 7, Pl. 1, Figs. 10–12.
1931. *Smilax minor*, MORITA: Do. p. 8, Pl. 1, Figs. 13–19.
1955. *Smilax trinervis*, TANAI: op. cit. Pl. 21, Fig. 14.
1955. *Smilax minor*, TANAI: op. cit. Pl. 13.

Description: Leaves somewhat variable in size and shape, broadly ovate to nearly orbicular, 1.5 to 7.5 cm long, 1.2 to 5 cm wide; base breadly rounded and slightly decurrently cuneate; apex variable, acute, obtuse or sometimes emerginate; trinerved at very base; midrib stout, acrodrome, making initial angles of 40 to 45 degrees with midrib, curving upward from about halfway between midrib and leaf-margin; another pair of slender basal primaries very rarely leaving from the base, curving up along the margin to the middle of the blade; tertiaries thin, generally arranged transverse to the primaries, and usually inosculating; nervilles forming fine polygonal meshes; margin entire; texture firm, subcoriaceous; petiole short.

Remarks: The present sepcimens are identical to this species by trinervation, though they are somewhat different in foliar shape. The present species established by MORITA (1931) on the basis of leaf-impressions, is closely similar to the modern *Smilax china* L. or *S. biflora* S. et Z. in shape and nervation. The leaves of *S. china* are usually 3- or 5-plinerved, while those of *S. biflora* are usually 3-pinerved, though the latter is smaller-sized. The fossil leaves of *S. minor* MORITA described from the same localities of the original specimens of the present species, are not essentially different from the present species in nervation, although they are somewhat smaller than the latter leaves. Furthermore, the writer frequently found several fossil leaves being intermediate in shape and size between *S. minor* and *S. trinervis* from Neogene flora in Japan. Accordingly, these two species are probably conspecific. This species is somewhat similar in nervation to *S. goshenensis* CHANEY et SANBORN from Eocene Goshen flora of Oregon, the United States, but the latter is more longer than the former.

Among the close living species, *S. biflora* grows only in the Yaku island of Kyûshû, and *S. china* is widely distributed from Hokkaidô to Kyûshû, Japan, extending to China and Korea.

Geological horizon: Middle Miocene to Pliocene.

Subclass DICOTYLEDONES

Family SALICACEAE

Genus *Populus* LINNE

About 30 living species of this genus are distributed mainly in the temperate region of the northern hemisphere. The fossil leaves of poplar have been found since Late Cretaceous time in the vegetable world; The genus *Populus* is one of the most ancient genera of dicotyledons. In Japan only 2 species are now living, but fossil poplar has been known its abundant occurrence from Late Cretaceous and Palaeogene flora. The poplar leaves are not rare in Neogene flora of Japan, and the following three Neogene species are acertained by the writer: *Populus aizuana* HUZ. et SUZ., *P. balsamoides* GOEP. and *P. latior* AL. BROWN. Beside these, *P. sambonsugii* HUZ. et SUZ. was described from Late Miocene flora.

Populus aizuana HUZIOKA et SUZUKI

1954. *Populus aizuana*, HUZIOKA et SUZUKI: Trans. Proc. Palaeont. Soc. Jap. N. S. No. 14, p. 137, Pl. 16, Figs. 1-4.
1961. *Populus aizuana*, TANAI et ONOE: op. cit. p. 21, Pl. 1, Fig. 13.

Remarks: Though this species is somewhat variable in foliar shape and size, it is charatcerized by crenate or crenato-dentate margin. The present species is rather more close to some American poplars than any Japanese poplar. Namely, this fossil species is closely related in marginal and venation characters to *Populus grandidentata* MICHX. or *P. tremuloides* MICHX., which are now living in North America.

Geological hoirzon: Late Miocene.

Populus balsamoides GOEPPERT

(Pl. 4, Figs. 8, 9)

1855. *Populus balsamoides*, GOEPPERT: Fossil Flora von Schossnitz. p. 23, Pl. 15, Figs. 5, 6.
1930. *Populus balsamoides*, KONNO: op. cit. Pl. 16, Fig. 1.
1955. *Populus balsamoides*, ENDO: op. cit. Pl. 28, Fig. 2.

Remarks: The present species, along with the above-described *Populus balsamoides*, was commonly found from Miocene flora in Europe, Siberia, etc. In Japan it is commonly found from Middle Miocene flora in Honshû and Hokkaidô. The leaves of this fossil poplar are charatcerized by foliar shape and dentate margin. This species is closely related to the modern *P. nigra* L. in Europe and *P. tremuloides* MICHX. in North America.

Geological horizon: Middle to Late Miocene.

Genus *Salix* LINNE

This genus consisting of more than 300 living species are widely distributed mainly in the temperate and subboreal regions of the northern hemisphere, and very partly in the southern hemisphere. This genus has been found throughout Tertiary flora in the northern hemisphere; it was one of the common genera in the past vegetable world. In Japan, the fossil leaves of *Salix* have been commonly found since Palaeogene flora, and following 2 Neogene species are ascertained: *Salix k-suzukii* TANAI and *S. varians* GOEPPERT. Beside them, the fossil leaves of the modern *S. amygdalina* L., *S. lasiogyne* SEEM. and *S. lakschwitziana* TAEP. were described from Late Miocene or Pliocene floras of Honshû by MIKI (1937, 1938), HUZIOKA and SUZUKI (1954), etc.

Salix k-suzukii TANAI sp. nov.

(Pl. 4, Fig. 12)

1954. Cfr. *Salix jessoensis*, HUZIOKA et SUZUKI: op. cit. p. 138, Pl. 16, Fig. 9.

Description: Leaves lanceolate in general outline, about 4.7 cm long and 1 cm wide; base rounded; apex lacking, but probably acuminate; midrib stout and thick, nearly straight; secondary nerves and conspicuous intersecondaries 9 to 12 alternate pairs respectively, diverging from midrib at angles of 40 to 50 degrees, looping upwards symetrically and following just within the margin for some distance along the blade, subcamptodrome, jointing the secondadries above by numerous crossities; tertiaries irregularly percurrent; nervilles distinct, forming coarse network; margin finely serrate; texture thin; petiole short but thick, about 3 mm long.

Remarks: The present materials are doubtlessly identical to the genus *Salix* by the characteristic nervation and shape. They are closely similar or identical to the leaf of Cfr. *S. jessoensis* described from Late Miocene flora of Fukushima Prefecture, though the latter is smaller than these specimens. The present species is related to the modern *S. jessoensis* SEEMEN distributed in northern Honshû and Hokkaidô, Japan.

Geological horizon: Late Miocene.

Salix varians GOEPPERT

1855. *Salix varians*, GOEPPERT: op. cit. p. 26, Pl. 20, Figs. 1, 2.
1869. *Salix varians*, HEER: op. cit. p. 27, Pl. 2, Fig. 8; Pl. 3, Figs. 1-3.
1952. *Salix varians*, HUZIOKA: Shinseidai-no-kenkyû (Cenozoic Research) No. 12, p. 23, Pl. 20, Fig. 158.

Remarks: The present species is one of the common species in the Tertiary flora of Europe, Siberia and North America, and also comparatively common in Miocene flora in Japan. This species is closely similar to *S. miosinica* HU et CHANEY from Miocene Shantung flora of China (HU et CHANEY, 1940: Pl. 4, figs. 4, 5). The writer found this species only from Miocene flora in Japan, but ENDO (in IMAI, 1924) found from Palaeogene flora of Ishikari coal field, Hokkaidô.

Geological horizon: Late Eocene to Middle Miocene (in Japan).

Family MYRICACEAE

Genus *Myrica* LINNE

Many living species of this genus are widely distributed in the northern hemisphere, among which species 2 is now existing in Japan and 4 in China. All of these Asiatic species have lanceolate leaves. Neogene species in Japan, treating in this paper, have pinnate leaves, which are closely similar to *Myrica* (*Comptonia*) *asplenifolia* BANKE now living in North America. Such fossil leaves have been once identified to the genus *Comptoniphyllum*, which was established on the basis of Miocene leaves occurred from Japan by NATHORST in 1888. Such fossil pinnate leaves of *Myrica* were not rarely found from the Tertiary floras in North America and Europe. From Tertiary flora of Japan are known four species, and among them the following two species are found from Neogene flora: *Myrica* (*Comptonia*) *kidoi* (ENDO) and *M.* (*C.*) *naumanni* (NATHORST).

Myrica (*Comptonia*) *kidoi* (ENDO) TANAI

(Pl. 5, Figs. 4, 5, 17)

1954. *Comptonia kidoi*, ENDO: op. cit. p. 4, Pl. 1, Figs. 4, 5, 7; Pl. 2, Figs. 3, 8.

Description: Leaves lanceolte in shape, 4 to 6 cm long and 1.1 to 1.6 cm wide on the middle, with lamina dissected nearly to the midrib; apex gradually narrow, acuminate; base cuneate; midrib stout, nearly straight or slightly falcate. Lobes 7 to 9 pairs, nearly alternate; each lateral lobe trigonal in shape, nearly straight on upper side and rounded on lower side, slightly pointed or rounded at apex, 5 to 8 mm long and 6 to 8 mm wide in the middle lobes; 2 or 3 subparallel veins containing, the upper one extending into the tip, the lower camptodrome; margin of lobes entire; texture firm, coriaceous.

Remarks: The present sepcimens are quite identical by their peculiar foliar shapes to *Comtponia kidoi* ENDO described from Pliocene flora in Yamagata Prefecture, Japan. This species is distinctly distinguishable from the Miocene species of this genus, *Myrica* (*Comptonia*) *naumanni*, by the characteristic features that the sinuses between the lobes never reach to the midrib of leaf. However, it is closely related to the latter in general outline, and so the former is probably derived from the Miocene species by gradual adaptation to climatic change. This species is closely similar to *Myrica* (*Comptonia*) *asplenifolia* BANKE, which is now existing in northeastern United States and adjacent Canada.

The occurrence of this fossil species is, up to the present, confined in Pliocene flora in northeastern Honshû.

Geological horizon: Early Pliocene.

Myrica (*Comptonia*) *naumanni* (NATHORST) TANAI

(Pl. 5, Figs. 1–3, 6–10, 13, 14, 16, 18)

1888. *Comptoniphyllum Naumanni*, NATHORST: op. cit. p. 8, Pl. 2, Fig. 2.
1888. *Comptoniphyllum japonicum*, NATHORST: Ibid. p. 13, Pl. 4, Figs. 2–3.
1926. *Comptoniphyllum japonicum*, KRYSHTOFOVICH: Ann. Russ. Pal. Soc., vol. 6, p. 8, Pl. 1, Fig. 5.
1931b. *Comptoniphyllum japonicum*, ENDO: "Cenozoic flora" Iwanami Kôza p. 17, Fig. 11.
1932. *Comptoniphyllum Naumanni*, ENDO et MORITA: Sci. Rep. Tôhoku Imp. Univ. Ser. 2, vol. 15, No. 2, p. 43, Pl. 5, Figs. 3–16.
1938. *Comptoniphyllum Naumanni*, SHIKAMA: Jour. Geol. Soc. Jap. vol. 45, Pl. 19, Fig. 2.
1941. *Comptoniphyllum Naumanni*, OISHI et HUZIOKA: Jour. Fac. Sci. Hokkaidô Imp. Univ. Ser. 4, vol. 6, No. 2, pp. 202, Pl. 45, Figs. 1–6.

1954. *Comptonia Naumanni*, ENDO: op. cit. Pl. 1, Fig. 10; Pl. 2, Fig. 1.
1954. *Comptonia nipponica*, ENDO: Do. p. 5, Pl. 2, Fig. 2.
1955. *Myrica Naumanni*, TANAI: op. cit. Pl. 2, Figs. 5-7.
1955. *Comptoniphyllnm Naumanni*, OKUTSU: op. cit. Pl. 1, Figs. 1-4.

Description: Leaves variable in shape and size, but always lanceolate, with lamina dissected deeply near or to the midrib, broadest in the middle portion, thence gradually narrowed toward apex and base; midrib stout, nearly straight or somewhat flexuous; apex acuminate; base cuneate or broadly cuneate. Lobes 15 to 20 pairs, alternate in the middle part of leaves and nearly opposite in the lower and upper; each lobe trigonal in shape, variable in size, largest in the middle part, the middle lobes 0.5 to 1.5 cm long and 0.4 to 1.5 cm wide; apex variable, acutely pointed to rounded; 2 or 3 subparallel strong veins diverging from the midrib of leaves at angles of 60 to 80 degrees, the upper one extending into the tip, the lower running to the upcurved abaxial side of lobes, frequently among these veins a few thinner subsecondaries diverging from the midrib and parrallel to them; tertiaries on marginal sides of main veins taking off oblique angles, becoming camptodrome along the margin; margin entire; texture subcoriaceous.

Remarks: The present species is very commonly found from the Middle Miocene sediments in Japan, and one of the representative fossils in the Daijima-type flora. The genus *Comptoniphyllum* was, at first, established by NATHORST (1888), and on account of abundant occurrence of the specimens this generic name has been familiar to the Japanese geologists. However, the present specimens which are quite identical to the original figures of *Comptoniphyllum naumanni,* is closely similar to the American living *Myrica*(*Comptonia*) *asplenifolia* BANK., though the latter is generally of smaller size than the former. In respect of characters of nervation and foliar shape, these modern and fossil genera are rather unseparable respectively, so that the genus *Comptoniphyllum* should be treated as *Myrica* (*Comptonia*).

The fossil leaves of the present species are variable in shape of lobes as noted in description. They are generally divided into two different types, acutely trigonal and rounded-trigonal forms, furthermore the intermediate form of the above two is also frequently found. The present species is closely similar to the above-described *M. kidoi,* but it clearly differs from the latter by deeply-dissected sinuses of the lamina. It is also nearly identical to *Comptonia nipponica* ENDO from Miocene flora or the Jôban coal field in Honshû. According to ENDO's original description, these two species are different in the mode of the dissection of lamina: the lamina of *C. nipponica* is regularly divided to near midrib, while in the lamina of *Myrica naumanni* deeply dissected to the midrib. However, in respect of the dissection of the lamina, such distinct difference between these two species is not found by the writer, so that *C. nipponica* is better to be included into the present species. Another allied species is *Comptonia hesperia* BERRY from Miocene flora of the United States (BERRY, 1929: Pl. 50, fig. 6: BROWN, 1937: Pl. 46, figs. 11-14.).

Geological horizon: Early (?) to Middle Miocene.

Family JUGLANDACEAE

Genus *Carya* NUTTAL

The living species of this genus are confined to the temperate regions of North America and East Asia; 15 species are existing in North America and 3 species in China. On the contrary, the fossil materials identified to the genus *Carya* have been reported from Neogene floras in the northern hemisphere. However, it is, in general, very difficult to identify this genus by only leaf-impressions, while the nuts of *Carya* are commonly characteristic in general feature. The writer could identified only one species, *C. miocathayensis* HU et CHANEY, from Miocene flora of Japan by the fossil leaflets. But MIKI (1955) described the following four Pliocene species by the nut remains: *C. leicarpa* MIKI, *C. ovatocarpa* MIKI, *C. striata* MIKI and *C. ventricosa* UNGER. Accordingly, this genus probably had a luxuriant growth in Neogene time in Japan.

Carya miocathayensis HU et CHANEY

(Pl. 6, Figs. 3, 4)

1940. *Carya miocathayensis*, HU et CHANEY: Carneg. Inst. Wash. Publ. No. 507, p. 26, Pl. 6, Fig. 1; Pl. 7, Figs. 5-7.
1961. *Carya miocathayensis*, TANAI et ONOE: op. cit. p. 22, Pl. 2, Fig. 6.

Remarks: Leaf-impressions representing this species are commonly found from Miocene floras in various localities of Japan, especially abundant in the Daijima-type flora. The leaves of this species are characterized by widely extending secondary nerves and their large number, though they are frequently difficult to be distinguished from the leaves of other genera of Juglandaceae by only leaf-impression. Among the living *Carya*, the present fossil species is closely related to *C. cathayensis* SARGENT, which is existing in Central China.

Geological horizon: Middle Miocene to Late Miocene.

Genus *Juglans* LINNE

About 15 living species of this genus are widely distributed in the temperate region of the northern hemisphere. The fossil remains of this genus have been also abundantly found throughout Tertiary flora in the world. Namely, this genus was one of the common genera in Tertiary flora of the world. In Japan, the fossil leaves or nuts of *Juglans* have been found from Palaeogene and Neogene flora. Neogene species are following 3: *Juglans cinereae* L. var. *megacinerea* (CHANEY) MIKI, *J. japonica* TANAI and *J. shanwangensis* HU et CHANEY. Beside them, the fossil nuts of the modern *J. manshurica* MAX. were found from Late Pliocene flora in western Honshû.

Juglans cinerea L. var. *megacinerea* (CHANEY) MIKI

(Pl. 6, Figs. 1, 2, 7)

1915. *Juglans cinerea*, KRYSHTOFOVICH: Mem. Comite Geol. N. S. Livr. No. 124, p. 21, Pl. 1, Figs. 3-7.
1926. *Juglans cinerea*, HAYASAKA: Jour. Geogr. Tokyo, vol. 38, p. 55, Pl. 6.
1934a. *Juglans cinerea*, ENDO: Jap. Jour. Geol. Geogr. vol. 11, p. 345, Pls. 34, 35.
1934b. *Juglans cinerea*, ENDO: Jour. Geol. Soc. Tokyo, vol. 42, p. 61, Pl. 3.
1935. *Juglans cinerea*, SHIMAKURA: Jour. Geol. Soc. Tokyo, vol. 42, p. 45, Fig. 2.
1936. *Juglans cinerea*, SHIMAKURA: Jour. Geol. Soc. Tokyo, vol. 43, p. 573, Pl. 27, Fig. 5.
1937. *Juglans cinerea*, MIKI: Jap. Jour. Bot. vol. 8, p. 310, Pl. 8 L; Fig. 2 A.
1940. *Juglans cinerea*, ONISHI: Hakubutsugaku Zasshi, vol. 38, p. 19, Fig. 2.
1941. *Juglans cinerea*, MIKI: op. cit. p. 265, Fig. 9 F.
1954. *Juglans cinerea*, ENDO: op. cit. p. 1, Pl. 1, Figs. 2, 3.
1955. *Juglans cinerea*, OKUTSU: op. cit. p. 83, Pl. 8, Figs. 1-3.
1955. *Juglans cinerea*, KOKAWA: Jour. Geol. Soc. Jap. vol. 61, p. 98, Pl. 1-3.
1955. *Juglans cinerea* L. var. *megacinerea*, MIKI: op. cit. p. 133, Pl. 2 A; Fig. 2 B.

Remarks: The present species represented by fossil nuts was widely distributed in Pliocene flora of northeastern Asia. These fossil nuts are characterized by outer ornamentation and two-celled inner features. This species is closely similar or nearly identical to the modern *Juglans cinerea* L. distributed in eastern part of North America. The fossil nuts of this species in Japan are, as far as known up to the present, found only from Late Pliocene sediments from Hokkaidô at the north to Kyûshû at the south.

Geological horizon: Late Pliocene.

Juglans japonica TANAI sp. nov.

(Pl. 6, Figs. 9, 10)

1883. *Juglans sieboldiana* fossilis, NATHORST: op. cit. p. 37, Pl. 1, Figs. 13–17.
1888. *Juglans nigella*, NATHORST: op. cit. p. 16, Pl. 5, Fig. 8; Pl. 8, Figs. 10, 11.
1961. *Juglans* sp., TANAI et ONOE: op. cit. p. 21, Pl. 11, Fig. 4.

Description: Leaflets oblong to elliptical in general outline, 10 to 15 cm long (estimated) and 3.2 to 4 cm. wide; base somewhat asymmetrical, cuneate in the terminal leaflets and rounded in the laterals; apex abruptly pointed and acute; midrib stout and straight; secondary nerves rather slender, about 20 alternate or subopposite pairs, closely spaced, diverging from the midrib at angles of about 60 degrees, curving upwards, forked or branched near the margin, then forming loops; tertiaries branched from the secondaries forming fine loops or entering to marginal teeth; tertiaries in the inter-secondary spaces irregularly percurrent; nervilles thin but distinct, finely reticulate; margin serrulate or argute-serrulate, with acute teeth; texture thin membranaceous.

Remarks: The present specimens are incomplete in preservation, but they are closely similar to the leaves of the modern *Juglans ailanthifolia* CARP. This new species is very close or nearly identical to *J. miocathayensis* HU et CHANEY from Miocene Shuntung flora of China (HU et CHANEY, 1940: Pl. 11, fig. 1; Pl. 12, figs. 9, 10), however, somewhat different in marginal character and shape of leaflets. Another allied species is *J. nigella* HEER which was widely distributed in Miocene flora of the northern hemisphere. *J. florissanti* LESQ. from Oligocene flora of Colorado, the United States (KNOWLTON, 1916: Pl. 17, fig. 2), is also similar to this new species.

The most similar living species, *J. ailanthifolia,* is now widely distributed from Hokkaidô at the north to Kyûshû at the south, Japan.

Geological horizon: Middle Miocene to Late Pliocene.

Juglans shanwangensis HU et CHANEY

1940. *Juglans shanwangensis*, HU et CHANEY: op. cit. p. 28, Pl. 7, Fig. 4; Pl. 8, Figs. 1–6.
1959. *Juglans shanwagensis*, TANAI et ONOE: op. cit. Pl. 1, Fig. 8.

Remarks: The leaves of this species are rarely found from Miocene flora of Japan, and they are characterized by having commonly entire margin. The present specimens are closely similar to the leaves of *Juglans acuminata* AL. BROWN which is one of most widely distributed species in

Tertiary flora of the northern hemisphere. This species has a close resemblance to *J. kjellmani* NATHORST from Pliocene Mogi flora of Kyûshû (NATHORST, 1883: Pl. 2, figs. 10-12), however, the leaves of the latter are generally wider than those of the former.

Among the living species of *Juglans*, this fossil species is closely similar to the so-called English walnut, *J. regia* L., which is native from southeastern Europe to India.

Geological horizon: Middle Miocene (in Japan).

Genus *Platycarya* SIBE. et ZUCC.

The modern distribution of this genus is confined to East Asia, and only one species is now living in Japan, southern Korea and China. The fossil specimens of *Platycarya* has been very rarely found in the past vegetable world; only one species was known from Miocene flora in China and Korea. For, it is generally difficult that the genus *Platycarya* is identified by only leaflet-impression. In Japan, only one Neogene species, *P. miocenica* HU et CHANEY was ascertained by the writer.

Platycarya miocenica HU et CHANEY

(Pl. 5, Fig. 11)

1940. *Platycarya miocenica*, HU et CHANEY: op. cit. p. 27, Pl. 4, Figs. 6, 7; Pl. 5, Figs. 1, 3, 4.

Remarks: The present species was, at first, described from the Miocene Shantung flora in China on the basis of many leaflet-impressions. The lateral leaflets of this species is characterized by falcately lanceolate shape, coarsely-compound serrate margin, etc. This fossil species is closely similar in general appearance to the above-described *Carya miocathayensis* HU et CHANEY, but the latter is commonly larger than the former. It is also very close to *Pterocarya denticulata* (WEBER) HEER from Miocene flora of Switzerland (HEER, 1859: Pl. 131, Figs. 5-7). The present fossil species is closely similar to the modern *Platycarya strobilacea* SIEB. et ZUCC. which is distributed in Japan, southern Korea, Central China and southwards.

Geological horizon: Middle Miocene.

Genus *Pterocarya* KUNTH.

Living species of the genus *Pterocarya* grow only in Asia, and most of them are the representative of deciduous trees in temperate forest. However, the fossil leaves of this genus are found from Palaeocene to Pleistocene floras in North America and Europe. Among about 10 living species in Asia, seven is existing in China and one in Japan. Fossil specimens of *Pterocarya* are commonly found from Neogene sediments in Japan, and they are classified into three species: *P. asymmetrosa* KONNO, *P. nipponica* TANAI et ONOE and *P. protostenoptera* TANAI. Beside these species, fossil nuts of *P. paliurus* SKAN. and *P. rhoifolia* S. et Z. were found from Pliocene and Pleistocene floras in Japan by MIKI. In Japan, no fossil materials of this genus have yet been described from Palaeogene flora.

Pterocarya asymmetrosa KONNO

(Pl. 4, Figs. 6, 7)

1931. *Pterocarya asymmetrosa*, KONNO: op. cit. Pl. 16, Figs. 5–7; Pl. 17, Figs. 1–5; Pl. 19, Fig. 3.
1952a. *Pterocarya asymmetrosa*, TANAI: op. cit. p. 124,
1955. *Pterocarya asymmetrosa*, TANAI: op. cit. Pl. 3, Fig. 3.
1955. *Pterocarya asymmetrosa*, HUZIOKA: Trans. Proc. Palaeont. Soc. Jap. N. S., No. 19, p. 60, Pl. 10, Fig. 9.

Remarks: The present materials are quite identical to *Pterocarya asymmetrosa*, which is described from Late Miocene Omi flora in Nagano Prefecture, Japan. This species is commonly found from the lower half of Miocene sediments in Japan, namely it is one of the representatives in the Aniai- and Daijima-type flora.

These specimens are rather more closely similar to the living *P. paliurus* SKAN. in China than the modern *P. rhoifolia* TANAI et ONOE described below, and these two are frequently indistinguishable respectively. However, the leaves of the latter species have more number of secondaries and cuneate base. Another allied species is *P. mixta* (KNOWLT.) BROWN from the Miocene Latah flora of the United States (BROWN, 1937: Pl. 47, figs. 2, 3).

Geological horizon: Early to Middle Miocene.

Pterocarya nipponica TANAI et ONOE

1955. *Pterocarya rhoifolia*, OKUTSU: op. cit. p. 82, Pl. 1, Fig. 6a, 6b.
1961. *Pterocarya nipponica*, TANAI et ONOE: op. cit. p. 21, Pl. 2, Figs. 2, 4, 5.

Remarks: The present species is found from Late Miocene to Late Pliocene floras in the various localities in Japan. It closely resembles to the living *Pterocarya rhoifolia* S. et Z., which is now distributed from Hokkaidô at the north to Kyûshû at the south. Many fossil nuts of this living species were described by MIKI (1955) from the Late Pliocene and Pleistocene sediments on the various areas of western Honshû and Shikoku.

The fossil leaves of this species are close to *P. asymetrosa* KONNO, but they are less number of secondaries than the latter. They are also somewhat similar to *Platycarya miocenica* HU et CHANEY, 1940: Pl. 4, figs. 6, 7; etc.) and to *Pterocarya denticulata* (WEBER) HEER (HEER, 1855: Pl. 131, figs. 5-7; etc.) in general foliar appearance. In general, it is frequently difficult that each genus of Juglandaceae is too variable in shape to be distinguished respectively by only foliar characters.

Geological Horizon: Late Miocene to Early Pliocene.

Pterocarya protostenoptera TANAI sp. nov.

(Pl. 4, Fig. 10)

1937. *Pterocarya stenoptera*, MIKI: op. cit. p. 310, Pl. 8 K; Fig. 2 B.
1955. *Pterocarya stenoptera*, MIKI: op. cit. p. 139, Pl. 3 D, Fig. 4 B.

Description: Fruits V-shaped in general outline, with two wings. Nuts small, oval in shape, 6 mm long to 3 mm wide, rounded at the base apex round and then acutely pointed; on the surface having many radiated striations. Wings oblong-lanceolate, gradually narrowed at apex, 1.6 cm long and 5 mm wide on the middle; the two wings extending at an angles of about 60 to 70 degrees; numerous nerves thin, nearly straight and parallel to the margin; texture thin.

Remarks: The present materials were found from Late Miocene flora in the Okitama lignite field, northeastern Honshû. They are closely similar in general features to the fruit of *Pterocarya stenoptera* DC. existing now in Central China. Fossil nuts of this living species were described by MIKI from Late Pliocene flora in the Kinki district, western Honshû. These specimens being four-celled in basal part are probably included into the present new species.

The present new species is characterized by having V-shaped outline and two lanceolate wings. The fruits of the Japanese modern species, *P. rhoifolia*, has also two wing, but their wings are nearly circular in shape and smaller in size. Except the above-noted MIKI's species, no fossil fruits of *Pterocarya* is comparable to the present new species in Tertiary flora of the world. Lately, ISHIDA, S. of Kyôto University collected the fossil fruit being nearly identical to *Pterocarya stenoptera* from Middle Miocene flora of Noto peninsula, Central Honshû. It is somewhat smaller than the present specimen, but nearly identical to the present species.

Geological horizon: Late Miocene to Late Pliocene.

Family BETULACEAE

Genus *Alnus* GAERTN.

The modern alders inhabit mainly in the temperate region of the northern hemisphere, and partly in South America. There are about 30 living species in the world, among which alders 10 species are existing in Japan and 7 in China. Many fossil leaves and cones of *Alnus* have been found throughout the Tertiary sediments in the world. In Japan the alder remains are also comparatively common from Eocene to Pleistocene floras. The following 7 Neogene species are acertained by th writer: *Alnus arasensis* HUZIOKA, *A. kefersteinii* (GOEPPERT) UNGER, *A. miojaponica* TANAI, *A. prenepalensis* HU et CHANEY, *A. protohirsuta* ENDO, *A. protomaximowiczii* TANAI and *A. usyuensis* HUZIOKA. Beside these species, the writer collected several leaves and cones of alder from Miocene flora in Japan, but they are too fragmental to give description or specific identification.

Alnus arasensis HUZIOKA

(Pl. 9, Fig. 2)

1920. *Alnus nostratum*, KRYSHTOFOVICH: Jour. Geol. Soc. Tokyo vol. 27, p. 15, Pl. 3, Fig. 4.

1949. *Alnus arasensis*, HUZIOKA: op. cit. Pl. 2, Figs. 7, 8.

Description: Leaves elliptic-oval to oval in general outline, 5.5 to 6.3 mm long and 3 to 3.5 cm wide; apex acutely pointed, somewhat acuminate; base obtuse or rounded, sometimes obliquely truncate, very slightly decurrent at the very base; midrib rather slender, nearly straight; secondary nerves slender, 8 to 11 pairs, opposite at the lower part and subopposite at the upper, diverging from the midrib at angles of 40 degrees on the middle part of blade, less at the upper part, 2 or 3 basal pairs short, diverging from the midrib at nearly right angles, all secondaries nearly straight, gently curving up near the margin, then entering marginal teeth; a few tertiaries branching from secondaries near the margin, and entering into teeth; tertiaries among intersecondary spaces very thin, irregularly percurrent; nervilles very thin, forming fine polygonal meshes; margin serrulate, with fine and acute teeth; nearly equal-sized; texture firm, membranaceous; petiole slender, about 7 mm long.

Rmarks: The present species was established by HUZIOKA on the basis of leaves occurred from Miocene flora of northeastern Honshû, but the specific description has not yet been published. The writer found several species identical to this species from Middle Miocene flora of Honshû. This fossil species is closely similar in shape and nervation to *Alnus schmalhausenii* GRUB. from Neogene flora of Kazakh region, Soviet Union (KRYSHTOFOVICH, 1956: Pl. 24, figs. 1-3, figs. 8-11; Pl. 25, figs. 1-9; Pl. 26, figs. 1-8; Pl. 27, figs. 2-4). This Soviet species are variable in base of leaves, ranging from obtusely rounded to roundly truncate, as much as the present species. *A. nostratum* HEER described from Late Miocene (?) flora near Sendai by KRYSHTOFOVICH (1920) is nearly similar in shape and venation to this species, and probably included into *A. arasensis*.

Among the living species of alders in the world, this fossil species is closely similar to *A. serrulata* (AIT.) WILD. in eastern United States or *A. crispa* (AITA.) PURSH. in Canada, Alaska and eastern United States. *A. arasensis* is somewhat related to the living *A. japonica* S. et Z. in Japan in the marginal character, but distinctly different in foliar shape.

Geological horizon: Middle to Late (?) Miocene.

Alnus kefersteinii (GOEPPERT) UNGER
(Pl. 6, Fig. 11)

1848. *Alnus kefersteinii*, UNGER: Choloris protogaea, p. 115, Pl. 33, Figs. 1-6.
1868. *Alnus kefersteinii*, HEER: Flora Fossilis Arctica, vol. 1, p. 146, Pl. 25, Figs. 4-9.
1940. *Alnus kefersteinii*, HU et CHANEY: op. cit. p. 29, Pl. 9, Figs. 3-5, 8.

Remarks: The present species widely ranged from Eocene to Miocene flora in the northern hemisphere. However, the fossil leaves described as this species by many authors are somewhat variable in foliar shape, and some of them are similar in general outline to the genus *Betula*. As already stated by HU et CHANEY (1940), all of the leaves referred to the present species from the Tertiary deposits of Eurasia must be reexamined in future. *Alnus keferstinii* is closely similar to the modern *A. sitchensis* (REGEL) SARGENT which is now distributed in the Pacific slope of Canada.

Geological horizon: Middle Miocene (in Japan).

Alnus miojaponica TANAI
(Pl. 6, Fig. 8; Pl. 9, Fig. 5; Pl. 10, Fig. 10)

1940. *Alnus japonica*, MIKI: op. cit. p. 267, Fig. 10 G.
1954. *Alnus japonica*, HUZIOKA et SUZUKI: op. cit. p. 138.

1955. *Alnus miojaponica*, TANAI: op. cit. Pl. 6, Fig. 8.
1961. *Alnus miojaponica*, TANAI et ONOE: op. cit. p. 23, Pl. 2, Fig. 7.

Description: Leaves elliptical in general outline, 6 to 7.5 cm long, 3.0 to 3.2 cm wide; apex acuminate; base cuneate or slightly rounded; midrib stout, nearly straight; secondaries 8 to 9 pairs, opposite to subalternate, leaving the midrib at angles of 40 to 45 degrees, gently curved up near the marginal border, craspedodrome, running into large marginal teeth; tertiary nerves thin, coarsely percurrent, a few tertiary laterals branching off to the marginal teeth and forming prominent intramarginal loops; nervilles indistinct, forming a fine polygonal mesh; margin doubly serrate, with acutely tipped teeth; petiole stout, about 4 mm long; texture firm, membranaceous. Cones ellipsoidal in general outline, 13 to 15 mm in height and 15 to 17 mm in width; peduncle stout, thick, over 2 cm long.

Remarks: The present species is represented by many leaves and cones, which were found from various localities in Japan. It is one of the common species in Neogene flora of Japan, but has not yet been found in the Aniai-type flora being the lower half of Middle Miocene in age. However, such narrow leaves of fossil alder are abundantly found from Palaeogene flora in Hokkaidô, Japan: for instance, *Alnus gracilis* UNGER are commonly occurred from the Ishikari and Urahoro groups in Hokkaidô. Accordingly, such narrow leaves of alder is probably an archaic type than the orbiculate leaves such as *A. protohirsuta* ENDO described below.

The present species is closely similar to the modern *Alnus japonica* S. et Z., which is widely distributed over Japan and extending also to China and Korea. Among the fossil leaves of alder, the present species is very close to, or almost unseperable from *A. relatus* (KNOWLTON) BROWN (BROWN, 1937: Pl. 49, figs. 1-6), which is one of the narrow leaves of Miocene alder in North America. Another allied species is *A. prenepalensis* HU et CHANEY described below, but it is distinctly different by the shape and marginal serration.

Geological horizon: Middle to Late Miocene.

Alnus prenepalensis HU et CHANEY

(Pl. 7, Fig. 3)

1940. *Alnus prenepalensis*, HU et CHANEY: op. cit. p. 30, Pl. 10, Figs. 1, 4, 6.

Description: Leaves elliptical in general shape, 7 to 10 cm long and 3.5 to 5.0 cm wide; apex abruptly acuminate; base rounded and slightly asymmetrical; primary nerve stout, nearly straight; secondaries 8 to 10 alternate or subopposite pairs, diverging from the midrib at angles of 40 to 50 degrees, nearly straight, then curving up near the margin and forming broad loops; tertiaries thin, indistinct, irregularly percurrent, near the margin a few tertiaries branching off from each secondaries; margin remotely to closely serrate; petiole stout and thick, more than 1 cm in length; texture thin, membranaceous.

Remarks: The present species described from Miocene flora of Shantung Province, China, is comparatively rare in Tertiary flora of Japan: the occurrence of this species was only known from Miocene flora of the Sasebo coal field, Kyûshû.

No fossil species of alder is comparable to this species in Tertiary flora of the world. This species is closely similar to the living *A. nepalensis* D. DON, which is distributed from Southwest China to India.

Geological horizon: Early to Middle Miocene.

Alnus protohirsuta ENDO

(Pl. 6, Fig. 6; Pl. 7, Fig. 1)

1940. *Alnus hirsuta*, OKUTSU: Saitô Ho-on kai Mus, Res. Bull. No. 19, p. 157, Pl. 9, Figs. 3, 4.
1954. *Alnus tinctoria*, HUZIOKA ec SUZUKI: op. cit. p. 139.
1955. *Alnus protohirsuta*, ENDO: op. cit. Pl. 27, Fig. 5.
1961. *Alnus protohirsuta*, TANAI et ONOE: op. cit. p. 22, Pl. 2, Figs. 1, 5.

Remarks: The present species was, at first, based on a leaf-impression from Late Miocene flora near Sendai, and then it was found from the Late Miocene sediments of various areas in Japan. Such alder leaves having duplicately-denticulate margin have not yet been found in Early Tertiary flora of Japan, and they probably belong to an alder of the advanced type. The present species is closely similar to the living *Alnus hirsuta* THRCZ. which is now widely distributed in Kurile islands, Japan, Korea, Manchuria, eastern Siberia and Kamchatka. The fossil leaves of *A. hirsuta* were reported their abundant occurrence from Late Pliocene and Pleistocene floras in Japan.

The present species is somewhat similar to *A. smithiana* AXELROD described from Mio-Pliocene floras of west-central Nevada, the United States (AXELROD, 1956: Pl. 6, figs. 5, 10-14) in general features. However, the former is generally larger in size, and more duplicately-serrate in margin than the latter. Another allied living species is *A. tenuifolia* NUTTALL, which grows now in the Pacific slope of North America.

Geological horizon: Late Miocene.

Alnus protomaximowiczii TANAI sp. nov.

(Pl. 7, Fig. 4)

1940. *Alnus Maximowiczii*, OKUTSU: op. cit. p. 158, Pl. 10, Fig. 3; Pl. 12, Figs. 2, 3.

Description: Leaves medium to large in size, 5.0 to 11 cm long and 5.5 to 8.2 cm wide, broadly ovate in general outline; base truncate; apex prolongly acute; margin doubly serrulate with callous tips; midrib stout, straight or slightly arched, becoming thin in the upper portion; secondaries stout, slightly curved upwards, often branching near the margin, subparallel, 9 to 10 pairs, subopposite or alternate, diverging angles from the midrib 35 to 45 degrees on the middle portion, acute to tip and obtuse to base, somewhat inequilateral on the both side of the midrib; tertiaries thin, percurrent; petiole stout, thick, more than 2.3 cm long; texture more or less thick, subcoriaceous.

Remarks: The present specimens are closely similar to the existing *Alnus maximowiczii* CALL. in general outline and marginal character, which grows now in Kurile islands, Saghalien, Hokkaidô, northern and central Honshû. The present fossil species is quite similar to the fossil leaves of *Alnus maximowiczii* described from the Late Miocene flora near Sendai, Japan (OKUTSU, 1940). This species is also close to *B. protoermanni* ENDO in general outline, but differs by having a truncate base and serrulate margin. *A. protomaximowiczii* somewhat resembles the modern *A. rugosa* (DUROI) SPREG. existing in eastern Canada.

Geological horizon: Middle to Late Miocene.

Alnus usyuensis HUZIOKA

(Pl. 6, Figs. 12, 13; Pl. 7, Figs. 2, 5, 6; Pl. 9, Fig. 8)

1888. *Alnus* cfr. *incana*, NATHORST: op. cit. p. 30, Pl. 17, Fig. 9.
1949. *Alnus usyuensis*, HUZIOKA: op. cit. Pl. 2, Figs. 8, 11; Pl. 3, Figs. 6, 7.
1949. *Alnus* aff. *usyuensis*, HUZIOKA: Do. Pl. 2, Figs. 12, 13.
1952a. *Betula Maximowicziana*, TANAI: op. cit. p. 125.

Description: Leaves variable in size, slightly inequilateral, oval to elliptical-oval in outline, 3.0 to 12 cm long and 2.2 to 8.5 cm wide; apex abruptly acute or pointed; base somewhat asymmetrical, broadly to strongly cordate; midrib stout, straight to the apex; secondary nerves rather slender, 9 to 12 subopposite pairs, diverging from the midrib at angles of about 60 degrees on the middle part of blade and about 30 degrees on the upper, 2 or 3 basal pairs of secondaries short, more densely arranged than the others, diverging from the midrib at right angles or more; all secondaries nearly straight or gently curving up, entering into marginal large teeth; a few tertiaries branching from the secondaries near the margin, then entering into marginal small teeth; tertiaries among inter-secondary spaces distinctly percurrent; nervilles obscure, forming fine polygonal meshes; margin duplicately serrate, with acute or bluntly pointed teeth; texture thin, membranaceous; petiole stout and thick, 1.0 to 1.8 cm long. Psilitate cones ellipsoidal in general outline, 1.7 to 2.7 cm high and 1.3 to 1.7 cm wide; cone-scales wedge-shaped in outline, 4 to 5 mm high, gently arched at the distal margin, ornamented by some rigid longitudinal ridges; peduncle stout, about 2 mm thick, more than 1 cm long.

Remarks: The present species established by HUZIOKA on the basis of leaf-impressions from Miocene flora of northeastern Honshû, however the description has not yet been given. Then, the writer collected many fossil leaves and psilitate cones identical to this species from Miocene sediments in Honshû and Hokkaidô. The leaves of this species is closely similar to *Alnus palibinii* GRUB. from the Neogene flora of Kazakh region of Soviet Union in the foliar shape and nervation (KRYSHTOFOVICH, 1956: Pl. 27, fig. 1, Text-fig. 39), but somewhat different in marginal serration. Namely, the latter species is irregularly crenato-dentate with small teeth in margin. The present species is also close or nearly identical to *A. corylina* KNOWLTON et COCKEREL from Eocene flora of Alaska (HOLLICK, 1936: Pl. 46, figs. 1; Pl. 49, figs. 8, 9; Pl. 50, fig. 1) and the above-described *A. kefersteinii* (GOEPP.) UNGER. The present specimens closely resemble some leaves of the genus *Corylus* in general characters. Namely, they are closely related to *Corylus macquarrii* (FORB.) HEER or *C. americana fossilis* NEWBERRY which are widely distributed in Early Tertiary flora of North America and Europe.

Among the living alders, this fossil species is close to *A. sitchensis* (REGEL) SARGENT in the Pacific slope of North America, *A. hirsuta* TURCZ. in Japan and *A. incana* WILD. in Europe, however, it is distinctly different from the latter 3 species in basal form of leaves.

Geological horizon: Early (?) to Middle Miocene.

Genus *Betula* LINNE

The genus *Betula* has about 40 living species in the world, and most of them are widely distributed in Europe, North America and East Asia. Namely, this genus is one of the main elements of temperate forest in the northern hemisphere. In East Asia the birch is comparatively abundant in number of living species, and this genus has, for instance, 15 living species in China. 9 species are now existing in Japan, and they have a luxuriant growth mainly in lowland area of northern Japan or in rather higher altitude of central Honshû. Whereas, the birch was widely distributed in the world of past time, and many fossil leaves of *Betula* abundantly occurred from Tertiary flora of the world. In Japan the fossil leaves and other remains of *Betula* have been also commonly found throughout the Tertiary sediments; this genus is one of most representative genera in Tertiary flora of Japan. Neogene species of birch ascertained by the writer in Japan are following 9: *Betula kamigoensis* TANAI, *B. mioluminifera* HU et CHANEY, *B. miomaximowicziana* ENDO, *B. nipponica* TANAI, *B. onbaraensis* TANAI et ONOE, *B. protoermanni* ENDO, *B. protoglobispica* TANAI et ONOE, *B. protojaponica* TANAI and *B. uzenensis* TANAI. Beside these species, *B. adstigma* MIKI was described by MIKI (1941) from Pliocene flora of Gifu Prefecture, central Honshû.

Butula kamigoensis TANAI
(Pl. 9, Fig. 1)

1955. *Betula kamigoensis*, TANAI: op. cit. Pl. 4, Fig. 6.

Description: Leaves ovate to broadly deltoid, 6.0 to 7.2 cm long and 4.2 to 4.5 cm wide; apex acute or abruptly acuminate; base obliquely truncate, slightly asymmetrical; midrib stout and straight, gradually thin toward apex; secondaries 11 to 14 pairs, opposite or subopposite, nearly straight or slightly curved upwards, the lower secondaries down-curved at the point of attachment to the midrib, angles diverging from the midrib about 40 degrees in the middle of blade, entering into large marginal teeth; a few tertiaries from the secondaries branching off to the small marginal teeth, tertiary nerves among intrasecondary spaces thin but distinct, percurrent; areolation finely polygonal; margin doubly serrate with forward pointing teeth; petiole thick, but nearly missing; texture thin, membracaceous.

Remarks: The present species is based on the leaf-impressions which were found from Middle Miocene flora in the Nishitagawa coal field, Yamagata Prefecture. It is comparatively rare in Tertiary flora of Japan, but some leaves of this species were found from the Daijima-type flora in several localities of Honshû.

This species is closely similar to *Betula protoermanni* ENDO and *B. mioluminifera* HU et CHANEY, which are described below, in their general shape and marginal appearance, and particularly most similar to the former. However, this fossil birch leaves are characterized by obliquely-truncate base, while the leaves of the latter two species is rounded or broadly cuneate at base. Among existing birch in East Asia, the leaves of present species is similar in shape and margin of leaves to those of the living *B. ermanni* CHAM. and smaller leaves of *B. maximowicziana* REGEL, which two living species are now growing in northern Japan. They also somewhat resemble some leaves of *B. luminifera* WINKL. growing now in Central China. This Chinese living species has a great variation in the base of leaves: the base varies from cuneate in the narrow-lonceolate leaves to truncate in the deltoid ones.

Geological horizon: Middle Miocene.

Betula mioluminifera HU et CHANEY

(Pl. 8, Fig. 3)

1920. *Betula Brongniarti*, KRYSHTOFOVICH: op. cit. p. 14, Pl. 3, Figs. 1, 2.
1940. *Betula mioluminifera*, HU et CHANEY: op. cit. p. 30, Pl. 5, Figs. 5, 6; Pl. 7, Figs. 1–3; Pl. 9, Fig. 1.
1955. *Betula mioluminifera*, TANAI: op. cit. Pl. 4, Figs. 7, 8.
1955. *Betula Mitai*, TANAI: op. cit. Pl. 4, Figs. 3, 4.
1959. *Betula mioluminifera*, TANAI et ONOE: op. cit. Pl. 2, Fig. 4.
1959. *Betula Mitai*, TANAI et ONOE: Do. p. 276, Pl. 2, Figs. 1–3.
1959. *Betula* sp., TANAI et ONOE: Do. p. 277, Pl. 2, Figs. 5, 6.

Description: Leaves variable in size, medium to small, ovate to elliptical-ovate, 4.5 to 10 cm long and 1.8 to 4.8 cm wide; base slightly asymmetrical, rounded or broadly rounded, sometimes nearly truncate; apex abruptly acuminate; midrib relatively stout, slightly curved; 8 to 11 pairs of secondaries alternate or subopposite, the basal pairs short, spreading nearly at right angles to the midrib, other secondaries diverging at angles of 30 to 40 degrees, curving up only slightly at the margin, lower and middle ones with one or two branches, all craspedodrome and ending in the marginal teeth; tertiaries irregularly percurrent, nervilles numerous and forming a irregularly quadranglar mesh; margin entire at the base, thence coarsely compound-serrate, the teeth somewhat obtuse, the teeth which secondaries end are larger than others; petiole fragile, 0.3 to 1.2 cm long; texture firm. Cone-scales trilobate, very small in size, 4 mm long and 6 mm wide; lobes unequal in size and shape, middle lobe smaller than the lateral lobes; base broadly cuneate.

Remarks: This species is common in Middle Miocene flora of Japan, and especially one of the representative species of the Aniai-type flora. The write once distinguished *Betula mitai* from this species by its general shape of leaves and marginal serration. However, according to the increasement of collected specimens the above two species has been unable to be separable respectively. Thus, *B. mitai* should be included into the present species. This fossil species is closely similar to *B. fairii* KNOWLTON and *B. largei* KNOWLTON which are the common species of Miocene birches in North America. It is comparable to *B. prisca* ETTINGS. and *B. brongniarti* ETTINGS., which are widely-distributed birch species in the so-called "Arctic Miocene flora". Many Miocene birch leaves were reported under the fossil name of these two species from various localities of Japan, but they are probably included into the present species.

Among the living birches in East Asia, the present species is most close to *B. luminifera* WINKLER growing in central China and *B. grossa* S. et Z. in Japan. It is also somewhat close to *B. lenta* L. which is living in the eastern part of North America, but differs in the number of lateral veins. However, the cone-scales of this species is closely similar to those of *B. lenta* in their shape.

Geological horizon: Early to Middle Miocene.

Betula miomaximowicziana ENDO
(Pl. 10, Figs. 1–3, 5–7)

1940. *Betula Maximowicziana*, OKUTSU: op. cit. p. 159, Pl. 8, Figs. 1, 2; Pl. 9, Fig. 4; Pl. 10, Fig. 4.
1955. *Betula Maximowicziana*, OKUTSU: op. cit. p. 89, Pl. 4, Figs. 3, 4.
1955. *Betula miomaximowicziana*, ENDO: op. cit. Pl. 28, Fig. 3.
1959. *Betula* cfr. *miomaximowicziana*, SUZUKI: Monograph Assoc. Geol. Collab. Jap. No. 9, p. 31, Pl. 1, Figs. 4, 5.

Description: Leaves comparatively large in size, ovate-orbiculate in general shape, 6 to 14 cm long and 4.5 to 11 cm wide; base deeply cordate at base; apex acute or slightly acuminate; midrib stout below, then gradually thin towards the apex, nearly straight; secondaries stout, 8 to 13 pairs, subopposite to alternate, diverging from the midrib at angles of 40 to 50 degrees on middle portion, basal pairs spreading at more large angles, all secondadries nearly parallel, curving upwards, crapedodrome and ending in the large teeth; tertiaries in inter-secondary spaces thin, irregularly percurrent; near the margin a few thin secondaries branching off, entering into small teeth, tertiaries from basal secondaries somewhat distinct, about 6 in number, extending outwards; nervilles indistinct, forming a polygonal network; margin subduplicately serrulate with long callous tips; petiole stout, more than 3 cm long; texture thin, membranaceous. Cone-scales very small in size, elongate in shape, trilobate, 2.5 to 3 mm wided and 5 to 7 mm long; lobes lanceolate in general outline, rounded at apex medial lobe largest than lateral lobes; base cuneate. Seeds very small in size, with two stigmas at apex, subrhomboidal or broad obovate, about 1 mm long and 0.5 mm broad, acute at apex, cuneate or pointed at base; wings 2 in number, then, nearly orbicular in shape, 2 to 2.5 mm in diameter.

Remarks: The present species was at first designated by ENDO (1955) on the basis of a well-preserved leaf-impression occurred from Late Miocene flora near Sendai. It is closely similar to the living *Betula maximowicziana* REGEL in their peculiar features of leaves, which is now existing in northern Japan. From the Late Miocene sediments in the various localities of northern Japan, the writer found many fossil seeds and cone-scales of birch being similar to those of the living species with the abundant occurrence of fossil leaves. Accordingly, the present species is represented by leaves, seeds and cone-scales.

The present species is common in Late Miocene floras of Japan, and especially abundantly found from northern Japan. *B. maximowicziana* is distributed in Hokkaidô and northern Honshû, and luxuriantly grows at altitudes of 1400 to 1700 meters above sea level in central Japan. Considering such distribution of the living equivalent, the present fossil species is probably one representative of the cool-temperate elements in Late Miocene flora of Japan.

Geological horizon: Late Miocene.

Betula nipponica TANAI sp. nov.

(Pl. 9, Figs. 3, 7; Pl. 10, Figs. 9, 11)

Description: Leaves ovate to oblong-ovate in general outline, 4.5 to 7 cm long and 2.2 to 3.9 cm wide; base rounded and slightly cordate; apex acuminate to acutely pointed; midrib stout, straight to the tip; secondary nerves 9 to 11 pairs, opposite to subalternate, regularly spaced, diverging from the midrib at angles of 35 to 40 degrees on the middle part of blade, nearly straight, entering into smaller marginal teeth; tertiaries among intersecondary spaces thin, irregularly percurrent; nervilles indistinct, reticulate; margin deeply double serrate, with acute teeth; texture thin, membranaceous; petiole rather slender, more than 4 mm long.

Remarks: The present specimens are somewhat similar to some leaves of the genus *Crataegus* in their marginal character, but they differ distinctly from that genus in the secondary nervation. These fossil leaves are rather identified to the genus *Betula* by their marginal and vanation characters. No fossil birch leaves are close to the present specimens. This new species is somewhat similar to *B. fairii* KNOWLTON from Miocene flora of the United States (KNOWLTON, 1926: Pl. 17, fig. 4; BROWN, 1937: Pl. 47, figs. 5-7; etc.), but distinctly different in marginal serration.

Among the living birches, the leaves of this new species is closely similar in marginal character to *B. corylifolia* REG. et MAX. in Japan and *B. nigra* L. in North America, especially more close to the last species. However, the leaves of this American River birch are wider than those of this new species, and cuneate at the base. This most close living species, *B. nigra* is rather a southern element among American birches, and distributed in southeastern part of the United States.

Geological horizon: Middle Miocene.

Betula onbaraensis TANAI et ONOE

(Pl. 11, Fig. 9)

1959. *Betula* cfr. *Schmidtii*, SUZUKI: op. cit. p. 32, Pl. 2, Fig. 1.
1961. *Betula onbaraensis*, TANAI et ONOE: op. cit. p. 25, Pl. 4, Figs. 1, 2.

Remarks: The present species is closely similar to the living *Betula grossa* S. et Z. var. *ulmoides* MAKINO, which is now growing Honshû, Shikoku and Kyûshû, Japan. *Betula* cfr. *Schmidtii* REGEL. described from Late Miocene Tennôji flora of Fukushima Prefecture (SUZUKI, 1959), is nearly or fairly identical to the present species in general character, and probably included into this species. *Alnus kefersteinii* (GOEPPERT) has some resemblance to this species in general appearance, but different in number of secondary nerves and marginal serration. This fossil birch is not so common in Neogene flora of Japan, and was found from Late Miocene flora in several localities of Honshû and Hokkaidô.

Geological horizon: Late Miocene.

Betula protoermanni ENDO

(Pl. 8, Fig. 10; Pl. 10, Figs. 4, 8)

1940. *Betula Ermanni*, OKUTSU: op. cit. p. 158, Pl. 11, Figs. 1, 2.
1954. Cfr. *Betula Ermanni*, HUZIOKA et SUZUKI: op. cit. p. 139.
1959. *Betula protoermanni*, SUZUKI: op. cit. p. 32, Pl. 1, Figs. 6-8.
1961. *Betula protoermanni*, TANAI et ONOE: op. cit. p. 24, Pl. 3, Fig. 4.

Remarks: The present species has a great resemblance to the living *Betula ermanni* CHAM. in general shape and marginal appearance of leaves. The leaves of this species are variable in basal character as much as the living close species displays: the base is truncate, broadly rounded, or sometimes slightly cordate in shape. It is also somewhat similar to the living *B. papylifera* MARSH., which is widely distributed in northern United States and adjacent Canada, and extending to Alaska.

Among many fossil birches in East Asia, this fossil species is similar to *B. mioluminifera* HU et CHANEY in general outline, and to *B. kamigoensis* TANAI in marginal serration. It is also somewhat similar to *B. lacustris* MACGIN. in general feature, which was described from Miocene Trout Creek flora of Oregon, the United States (MACGINITIE, 1933: Pl. 4, figs. 1, 3).

The present species is comparatively common in Late Tertiary flora of Japan, and along with *B. miomaximowicziana*, it is an indicator of cool-temperate climate in Late Miocene time. The most close living equivalent, *B. ermanni*, is distributed in Hokkaidô, and northern and central Honshû, and also extending to Korea, Manchuria, eastern Siberia, Amur, Kamchtka, Saghalien, etc.

Geological horizon: Late Miocene.

Betula protoglobispica TANAI et ONOE

1940. *Betula globispica*, OKUTSU: op. cit. p. 159, Pl. 10, Figs. 1, 2.
1961. *Betula protoglobispica*, TANAI et ONOE: op. cit. p. 24, Pl. 3, Figs· 1, 2.

Remarks: The present species is rare in Tertiary flora of Japan, and found only from Late Miocene sediments in several localities of Honshû. It is closely similar to the fore-described *Betula protoermanni* ENDO in their general character, but distinguishable from the latter by the cuneate base.

This fossil species is closely related to the living *B. globispica* SHIRAI, which is now growing in central Honshû. It is also somewhat similar in general shape to the modern *B. nigra* L. growing now in southwestern United States, but the latter is more deeply double-serrate than the former.

Geological horizon: Late Miocene.

Betula protojaponica TANAI sp. nov.

(Pl. 9, Figs. 4, 6)

1940. *Betula japonica*, OKUTSU: op. cit. p. 159, Pl. 9, Fig. 5.

Description: Leaves medium in size, deltoid-ovate in general outline, 4.6 to 5.5 cm long and 2.7 to 4.5 cm wide; apex acuminate; base truncate, broadly rounded, or broadly cordate; midrib stout below, becoming thin distantly, nearly straight; secondary nerves rather stout, 8 to 9 subopposite pairs, diverging from the midrib at angles of about 40 degrees on the middle part of leaves, less angles on the upper and more spreading at the basal part, nearly straight or somewhat curving up, entering into large dents; tertiaries obscure, but irregularly percurrent, a few tertiaries branching off from the basal pair of secondaries, entering into smaller marginal teeth; margin duplicate-serrulate, with acute teeth; texture thin, membranaceous: petiole thick.

Rmarks: The present new species is represented by leaf-impressions which are characterized by deltoid-ovate shape and duplicate-serrate margin. Thse specimens are closely similar to the modern *Betula platyphylla* SUKAT. var. *japonica* (MIQ.) HARA in all foliar characters which is distributed in Hokkaidô and northern or central Honshû, Japan.

This fossil species is close to the above-described *B. protoermanni* in general appearance, but differs by foliar shape and basal character. Namely, the leaves of *B. protoermanni* are more longer for the width than those of this new species, and furthermore the former is not always cordate at the base. The present new species is also closely related to the modern *B. populifolia* MARSH. distributed in eastern part of North America.

This new species occurs not commonly from Neogene flora of Japan, and found from Late Miocene flora in Honshû and Hokkaidô.

Geological horizon: Late Miocene.

Betula uzenensis TANAI

(Pl. 8, Figs. 7, 9)

1952. *Betula sollenis*, TANAI: op. cit. p. 124.
1955. *Betula uzenensis*, TANAI: op. cit. Pl. 4, Fig. 2.

Description: Leaves medium in size, ovate-elliptic, slightly asymmetrical, in general outline, 5 to 7.2 cm long 3.5 to 4.5 cm wide, acute at apex, obtuse or rounded at base; midrib rather slender, nearly straight, somewhat zigzag in upper portion of blade; secondaries 10 to 13 pairs, thin, alternate to subopposite, diverging from the midrib at angles of 45 to 60 degrees on middle portion, slightly curved upward, ending in marginal teeth; tertiary nerves thin, indistinct, irregularly percurrent; nervilles indistinct, forming fine polygonal networks; margin duplicately serrate, with relatively small and acute teeth; petiole stout, 0.7 to 1 cm long; texture thin, membranaceous.

Remarks: This species is characterized by ovate-elliptic shape of leaves and nearly equal size of marginal teeth. It is not common in Neogene flora of Japan, and some leaves of this species were found from the Miocene coal-bearing formations of the Nishitagawa and Ani coal fields, northeastern Honshû, Japan. The leaves of this fossil species have the general shape and marginal appearance of a living Japanese birch, *Betula schmidti* REGEL, which grows now in Honshû, Shikoku and Kyûshû, Japan.

Among the fossil birches in East Asia, the present species closely resembles the fore-described *B. mioluminifera* in general features. However, on their biserrate margin the former has teeth of nearly equal size, while the latter has unequal sized teeth. In respect to marginal character, the present species is most close to *B. vera* BROWN (BROWN, 1937: Pl. 48, figs. 7-11) from Miocene flora of North America. The American living birch being similar to this species is *B. lutea* MICHAUX, which is distributed in northeastern United States and adjacent Canada.

Geological horizon: Early to Middle Miocene.

Genus *Carpinus* LINNE

The modern distribution of this genus is confied to the northern hemisphere, and about 25 living species are distributed in Japan, China, Formosa, Himalaya, Europe, Central and North America, etc. However, in East Asia this genus has abundant number of living species, and nearly twenty endemic species are enumerated in this region. Whereas, the fossil leaves and fruits have been abundantly found from Tertiary flora, in particular from Neogene flora in the world. The fossil hornbeams are also abundantly found from Tertiary sediments in Japan, and the genus *Carpinus* is one of the genera having a large number of species in Neogene flora. At present, the writer identifies the following 13 Neogene species in Japan: *Carpinus ishikiensis* TANAI et ONOE, *C. kodairae-bracteata* HUZIOKA, *C. laciniobracteata* HU et CHANEY, *C. miocenica* TANAI, *C. miofangiana* HU et CHANEY, *C. miofargesiana* TANAI et ONOE, *C. nipponica* ENDO, *C. shimizui* TANAI, *C. simplicibracteata* HUZIOKA, *C. s-satoi* TANAI et ONOE, *C. stenophylla* NATHORST, *C. subcordata* NATHORST and *C. subyedoensis* KONNO. Beside these species, ENDO (1950) described the following species on the basis of fossil involucres from Middle or Late Miocene flora of Japan: *C. protojaponica* ENDO, *C. sendaiensis* ENDO, *C. rankanensis* HAYATA and *C. nakosoensis* ENDO.

Carpinus ishikiensis TANAI et ONOE

(Pl. 11, Figs. 8, 12, 15)

1955. *Carpinus ishikiensis*, TANAI: op. cit. Pl. 5, Fig. 11.
1955. *Carpinus protojaponica*, ENDO (in part): op. cit. Pl. 35, Figs. 13, 16.
1959. *Carpinus ishikiensis*, TANAI et ONOE: op. cit. p. 279, Pl. 5, Figs. 3, 15.

Remarks: This species having characteristic nervation, is very rarely found from Miocene flora of Honshû, Japan. The fossil involucres of this species is very close in nervation and general outline to *Carpinus megabracteata* HU et CHANEY from Miocene Shantung flora of China (HU et CHANEY, 1940: Pl. 12, fig. 5), though the latter is about two times larger in size than the former. However, the the marginal teeth of the latter are almost equal in size, while in the former the teeth which the primaries enter are more prominent and larger than others. Other allied species is *C. cuspidata* SAPORTA from Miocene flora of southern France (SAPORTA, 1863: Pl. 12, fig. 5), but its primary nervation is somewhat different.

BERGER (1953) grouped many involucres of modern *Carpinus* in the world and stated also their relationships with fossil species. According to his grouping, the present fossil species belongs to the form-group of "*Carpinus orientalis*".

Geological horizon: Middle Miocene.

Carpinus kodairae-bracteata HUZIOKA

(Pl. 11, Fig. 4)

1943. *Carpinus Kodairae-bracteata,* HUZIOKA: Jour. Geol. Soc. Jap. vol. 50, No. 602, p. 322, Pl. 14, Figs. 14.

1955. *Carpinus Kodairae-bracteata,* TANAI: op. cit. Pl. 5, Fig. 18.

Description: Involucres 3-lobed, asymmetrically rounded at the base; medial lobe largest than others, lonceolate in shape, 2.0 to 2.4 cm long and 0.5 to 0.6 cm wide at the middle portion, acutely pointed at apex, coarsely serrate at margin; lateral lobes small, unequal in size, trigonal in shape, acute apex, nearly entire or slightly serrate at margin; primary nerves about 10 in number, extending from the base, then entering into apex of lobes or marginal teeth, the medial primary strongest than others; a few distinct secondaries diverging from the medial primary at angles of about 30 degrees, ending in marginal teeth; tertiaries thin, indistinct, irregularly percurrent; stalk stout, about 4 mm long; nutlets unknown.

Remarks: The present species was, at first, described from the Miocene sediments in the Kokangen coal field, Korea. It is characterized by trilobate shape and numerous primary nervation. It is somewhat similar in general shape to *C. honshuensis* ENDO from Early Pliocene flora, Fukushima Prefecture (ENDO, 1950b: Pl. 6, Fig. 6) and *C. nipponica* ENDO described below in this paper, but the latter two species are three in number of primary nerves. It also resembles in primary nervation to *C. laci-*

niobracteata HU et CHANEY from Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 12, figs. 3, 4) and the above-described *C. ishikiensis* TANAI et ONOE, however these latter two are not lobated.

Among the living hornbeams of the world, the present species is essentially related to *C. laxiflora* BL. existing now in Japan and *C. caroliniana* WALT. in North America. Namely, this fossil species evidently belongs to *C. caroliniana*-type of BERGER's grouping.

Geological horizon: Middle Miocene.

Carpinus laciniobracteata HU et CHANEY
(Pl. 11, Fig. 7)

1940. *Carpinus laciniobracteata*, HU et CHANEY: op. cit. p. 34, Pl. 12, Figs. 3, 4.

Remarks: The present specimen from the Miocene Yoshioka flora of Hokkaidô, is fairly identical to the present species, which was originally described from Miocene Shanwang flora of China. This large bract is characterized by laciniate margin. The present species is close to *C. megabracteata* HU et CHANEY in general outline, but it is more laciniate in margin.

Geological horizon: Middle Miocene.

Carpinus miocenica TANAI
(Pl. 8, Figs. 6, 13; Pl. 14, Fig. 14, Fig. 6)

1955. *Carpinus laxiflora*, OKUTSU: op. cit. p. 86, Pl. 1, Fig. 8.
1955. *Carpinus miocenica*, TANAI: op. cit. Pl. 5, Figs. 1, 2.
1961. *Carpinus miocenica*, TANAI et ONOE: op. cit. p. 26, Pl. 3, Fig. 3; Pl. 4, Fig. 4.

Remarks: The present species is represented by fossil leaves and involucres, which are closely similar to those of the living *Carpinus laxiflora* BLUME existing now in Japan. Among the fossil involucres of the world, this fossil species is very close to *C. honshuensis* ENDO in general character, and nearly unseparable respectively. The above-described *C. kodairae-bracreata* somewhat resembles this species, but distinctly differs in venation of lobes. The involucres of this fossil species are related to *C. londoniana* WINKL., *C. lanceolata* HANDEL-MAZZ. and *C. viminea* WALL., all of which species are living in southern China or India.

This fossil species is comparatively common in the Daijima-type flora, and also not rare in Late Miocene flora in Japan.

Geological horizon: Middle to Late Miocene.

Carpinus miofangiana HU et CHANEY
(Pl. 11, Fig. 16)

1888. *Carpinus* cfr. *grandis*, NATHORST: op. cit. p. 214, Pl. 7, Fig. 4.
1940. *Carpinus miofangiana*, HU et CHANEY: op. cit. p. 32, Pl. 10, Figs. 2, 3.
1955. *Carpinus miofangiana*, TANAI: op. cit. Pl. 5, Fig. 4.
1959. *Carpinus miofangiana*, TANAI et ONOE: op. cit. p. 277, Pl. 3, Figs. 1, 2.

Description: Leaves elongate-ovate in shape, comparatively large in size, 6 to 11 cm long and 2.5 to 4.0 cm wide; base broadly rounded and slightly shallow-cordate; apex acuminate or bluntly pointed; midrib rather slender, nearly straight, near the apice slightly curving; secondaries closely spaced, 15 to 21 pairs, opposite to subalternate, diverging from the midrib at angles of 40 to 50 degrees, nearly straight, ending in the larger teeth, frequently forking at the middle or near the margin, then entering into smaller teeth, craspedodrome; tertiaries thin but distinct, irregularly percurrent; several abaxial tertiaries branching outward from the basal secondaries; nervilles thin, indistinct, forming fine meshes; margin closely double-serrate; petiole stout, 5 to 8 mm long; texture thin, membranaceous.

Remarks: This species was established by HU et CHANEY (1940) on the basis of leaf impression from Miocene flora of Shantung Province, China. In Japan many fossil leaves identical to it have been described by various arthors under the name of *C. grandis* UNGER or *C. pyramidalis* (GOEP.) HEER from Miocene flora in the various localities. Most of these fossil leaves are included into the present species. However, no fossil involucre referable to this species has not yet been found in Tertiary flora of Japan, though many fossil involucrs of hornbeam have been found. The writer found a fossil involucre closely similar to the living *C. fangiana*, but it is too incomplete in preservation to refer to the present species.

This fossil species is closely similar to *C. fangiana* HU, which is now existing in Southwest and West China.

Geological horizon: Early to Middle Miocene.

Carpinus miofargesiana TANAI et ONOE

1955. *Carpinus miofargesiana*, TANAI: op. cit. Pl. 5, Figs. 15–17.
1959. *Carpinus miofargesiana*, TANAI et ONOE: op. cit. p. 278, Pl. 5, Figs. 4–6, 9–11.

Remarks: This species is not common in Neogene flora of Japan, and has been found from the Middle Miocene sediments in a few localities. It is represented by only fossil involucres, and no fossil leaves referable to this species are closely similar to those of the living *C. fargesiana* WINKLE in the general shape and nervation, which species grows now in central and southern China. The present fossil involucres belong to "*C. tchonoskii*-type group", according to BERGER's grouping.

Geological horizon: Middle Miocene.

Carpinus nipponica ENDO

(Pl. 14, Fig. 8; Pl. 11, Fig. 18)

1950b. *Carpinus nipponica,* ENDO: op. cit. p. 53, Pl. 6, Figs. 8.
1955. *Carpinus nipponica,* ENDO: op. cit. Pl. 34, Fig. 5; Pl. 35, Figs. 1, 7, 9, 11.
1961. *Caapinus nipponica,* TANAI et ONOE: op. cit. p. 26, Pl. 4, Figs. 5, 8.

Description: Involucres with short and thick stalk, 2 or 3 lobed at the base, variable in size, medial lobe largest than others, 1.6 to 3.0 cm long and 0.4 to 0.8 cm wide, lanceolate in shape, slightly falcate, acute at apex and rounded to broadly rounded at base; lateral lobes small, unequal sized at the two side of medial lobe, acute or obtuse at apex; primary nerves one on each lobe, distinct; primaries nearly straight, diverging from medial primary at angles of 60 to 80 degrees; secondary nerves numerous, thin but distinct, diverging from the primaries at nearly right angle, curved upwards near the margin, forming loops, camptodrome; nervilles thin, forming irregularly polygonal meshes; margin of lobes nearly entire, the medial lobes sometimes with a few serrations on margin; texture thin, membranaceous. Nutlets ovate in shape, about 5 mm in diameter, with 3 distinct longitudinal striae, obtuse at apex, rounded at base.

Remarks: Though this species is commonly found from Late Miocene to Pliocene flora in various areas of Honshû, Japan, it is represented only by fossil involucres. No fossil leaves referable to this species have not yet been found. This species is characterized by three-lobed shape and nervation, though it is somewhat variable in size. Some specimens have occasionally a short lobe between the main and lateral large lobes.

Among the living *Carpinus* of the world, the present species is closely similar to *C. londoniana* WINKL, or *C. lanceolatum* HADEL-M., which are living in southern China, and especially most close to the latter species. It is also similar to *C. caroliniana* WALT. existing in eastern United States and adjacent Canada. According to form-grouping of *Carpinus*-involucres described by BERGER (1953), this species belongs to "*C. caroliniana*-group".

Geological horizon: Late Miocene to Early Pliocene.

Carpinus shimizui TANAI
(Pl. 14, Figs. 2, 9)

1955. *Carpinus Shimizui*, TANAI: op. cit. Pl. 5, Fig. 22.

Description: Involucre ovate-oblong in general outline, 3.0 to 3.2 cm long and 1.5 to 2.2 cm wide, unequally cordate at base, acute at apex; palmately veined, with 5 to 6 primaries diverging radially on each side of midrib, craspedodrome; secondary and tertiary nerves thin but distinct, forming a fine areolation; margin serrate, with small and acute teeth; stip stout, 4 mm long; texture thin, membranaceous. Nutlets spheroidal in shape, about 3 mm in diameter, poorly preserved.

Remarks: This large fossil bract somewhat resemble *C. oblongibracteata* HU et CHANEY from Miocene Shantung flora of China (HU et CHANEY, 1940: Pl. 12, figs. 7, 8) and *C. nakosoensis* ENDO from the Miocene Goyasu formation in the Jôban coal field, Honshû (ENDO, 1950: Pl. 6, fig. 5), but it is quite different from the later two in their shape and secondary venation. In particular, the latter two species have several distinct secondary nerves originating from the midrib. None of the living and fossil hornbeam has the involucres being similar to the present species. According to BERGER's grouping, the present species belongs to "*C. orientalis*-type".

This species is named in honour of Mr. I. SHIMIZU, who collected one of these specimens.

Geological horizon: Middle Miocene.

Carpinus simplicibracteata HUZIOKA

1943. *Carpinus simplicibracteata*, HUZIOKA: op. cit. p. 290, Pl. 14, Figs. 13, 13a.
1959. *Carpinus* cfr. *simplicibracteata*, TANAI et ONOE: op. cit. Pl. 5, Fig. 12.

Remarks: The present species described from Miocene flora of Korea, is rarely found from Miocene flora of Japan. It is characterized by general outline, small size and tri-plinerves. Though these specimens are small, they are apparently close to the involucres of the modern *C. cordata* BL. in Japan.

Geological horizon: Middle Miocene.

Carpinus s-satoi TANAI et ONOE
(Pl. 11, Figs. 3, 17)

1955. *Carpinus s-Satoi*, TANAI: op. cit. Pl. 5, Figs. 7, 8.
1959. *Carpinus S-Satoi*, TANAI et ONOE: op. cit. p. 178, Pl. 5, Figs. 1, 2, 13, 14,

Remarks: The present species is rarely found from Miocene flora of Honshû and southwestern Hokkaidô, and represented by only fossil involucres. It is closely similar in general shape and nervation to *Carpinus fargesiana* WINKL., *C. turczaninowii* HANCE and *C. henryana* WINKL. existing now in central and southern China, and especially most close to the last species. This fossil species evidently belongs to the *C. tschonoskii*-type of BERGER's grouping. There is no known fossil species similar to the present species, although the above-described *C. miofargesiana* TANAI et ONOE or *C. mioturczaninowii* HU et CHANEY, (HU et CHANEY, 1940: Pl. 9, figs. 6, 7) have some resemblance in nervation of involucres.

Geological horizon: Middle Miocene.

Carpinus stenophylla NATHORST

(Pl. 11, Figs. 2, 5, 6; Pl. 8, Fig. 8)

1883. *Carpinus stenophylla*, NATHORST: op. cit. p. 41, Pl. 3, Fig. 16.

1939. *Carpinus japonica*, ENDO: op. cit. p. 340, Pl. 23, Figs. 3, 4.

1941. *Carpinus carpinoides*, MIKI: op. cit. p. 267, Figs. 10 C, F.

1950b. *Carpinus protojaponica*, ENDO: op. cit. p. 52, Pl. 6, Fig. 2.

1952. *Carpinus protojaponica*, TANAI: Taans. Proc. Palaeont. Soc. Japan, N. S. No. 8, Pl. 22, Fig. 1.

1954. *Carpinus carpinoides*, TAKAHASHI: op. cit. p. 55, Pl. 2, Figs. 1–10; Pl. 3, Figs. 1–5.

1955. *Carpinus carpinoides*, OKUTSU: op. cit. p. 85, Pl. 1, Fig. 7.

1955. *Carpinus protojaponica*, ENDO (in part): op. cit. Pl. 34, Fig. 2; Pl. 35, Figs. 2, 13 (not Figs. 12, 16).

1955. *Carpinus japonica*, ENDO: Ibid. Pl. 34, Fig. 8.

1961. *Carpinus subcarpinoides*, TANAI et ONOE: op. cit. p. 28, Pl. 4, Fig. 9.

Remarks: The present species was, at first, established by NATHORST (1883) on the basis of a leaf-impression occurred from Pliocene Mogi flora of Kyûshû, and this fossil leaf is closely related to the modern *C. carpinoides* MAKINO in Japan. Then, fossil leaves and involucres being close to this living species have been abundantly found from Neogene flora in various localities of Japan, and they were given various specific name by various authors. Their fossil leaves are, however, nearly identical to *C. stenophylla* in general outline and marginal serration, though they are somewhat variable in size. Furthermore, accompanying with these fossil leaves, fossil involucres being close to *C. carpinoides* frequently occurred from same localities of the leaves.

Accordingly, these Neogene various species of *Carpinus* which are very close to modern *C. carpinoides*, are better to be identified to *C. steno-*

phylla representing by leaves and involucres.

Geological horizon: Middle Miocene to Late Pliocene.

Carpinus subcordata NATHORST

(Pl. 11, Figs. 11, 14; Pl. 8, Fig. 4; Pl. 14, Fig. 7)

1883. *Carpinus subcordata*, NATHORST: op. cit. p. 39, Pl. 2, Figs. 13-18, 20.
1931. *Carpinus cordata*, KONNO: op. cit. Pl. 1, Fig. 7; Pl. 2, Fig. 4; Pl. 8, Figs. 9, 10.
1931. *Carpinus subcordata*, KONNO: Do. Pl. 1, Figs. 2-6, 10, 12.
1939. *Carpinus corata*, ENDO: op. cit. p. 339, Pl. 23, Fig. 5.
1940. *Carpinus miocordata*, HU et CHANEY: op. cit. p. 31, Pl. 12, Figs. 1, 2.
1943. *Carpinus erosa* subsp. *ellipticibracteata*, HUZIOKA: op. cit. p. 290, Pl. 14, Figs. 6-9, 7a, 8a, 9a.
1950b. *Carpinus cordata*, ENDO: op. cit. p. 51, Pl. 6, Fig. 1.
1954. *Carpinus miocordata*, HUZIOKA: Trans. Proc. Palaeont. Soc. Japan, N. S. No. 13, p. 120, Pl. 13, Figs. 5, 6.
1954. *Carpinus erosa*, HUZIOKA et SUZUKI: op. cit. p. 139.
1955. *Carpinus cordata*, ENDO: op. cit. Pl. 34, Fig. 1.
1959. *Carpinus miocordata*, TANAI et ONOE: op. cit. Pl. 3, Fig. 3.
1961. *Carpinus subcordata*, TANAI et ONOE: op. cit. p. 27, Pl. 4, Fig. 11.

Remarks: The present species is represented by leaf- and involucre-impressions being similar to those of the modern *Carpinus cordata* BLUME, which is widely distributed in East Asia at present. The fossil leaves and involucres close to the living species have been already described from Neogene and Pleistocene floras in Japan and Korea, and given varoius names. *Carpinus subcordata* was given to such fossil leaves from the Pliocene Mogi flora near Nagasaki, Kyûshû by NATHORST (1883). HU and CHANEY (1940) distinguished *C. miocordata* from the above-noted species on the basis of leaves and involucres from the Miocene Shanwang flora in China. Then, on the basis of the morphological resemblance of *cordata*-type species the writer included these various species into the present species.

This fossil species is commonly found from Early Miocene to Late Pliocene floras not only in Japan, but in Korea. Namely, it is abundantly found from nearly all of Neogene floras in very various localities of Japan as much as the modern distribution of the living equivalent species.

Geological horizon: Early Miocene to Late Pliocene.

Carpinus subyedoensis ENDO

(Pl. 11, Figs. 1, 10, 13)

1888. *Carpinus* cfr. *yedoensis*, NATHORST: op. cit. p. 38, Pl. 13, Figs. 12, 12a.

1926. *Carpinus* cfr. *yedoensis*, KRYSHTOFOVICH: op. cit. p. 8, Pl. 1, Figs. 8.
1931. *Carpinus subyedoensis*, KONNO: op. cit. Pl. 8, Figs. 1-4.
1933. *Carpinus yedoensis*, ENDO: op. cit. p. 40, Fig. 9.
1938. *Carpinus heigunensis*, HUZIOKA: Jour. Fac. Sci. Hokkaidô Imp. Univ., Ser. 4, vol. 4, Nos. 1-2, p. 149, Text-fiig. 1.
1941. *Carpinus Tschonoskii*, MIKI: op. cit. p. 268, Fig. 10 D, E.
1947. *Carpinus Tschonoskii*, SZAFER: Rozpr. Akad. Uniej. wydz. mat. -przyr. 72 B, p. 66, Pl. 5, Figs. 20-24.
1954. *Carpinus Tschonoskii*, TAKAHASHI: op. cit. s. 55, Taf. 2, Fig. 11; Taf. 3, Fig. 6.
1955. *Carpinus subyedoensis*, TANAI: op. cit. Pl. 5, Figs. 9, 10.
1955. *Carpinus protojaponica*, ENDO (in part): op. cit. Pl. 35, Fig. 12, (not Figs. 2, 13).
1955. *Carpinus Tschonoskii*, OKUTSU: op. cit. p. 87, Pl. 7, Fig. 6.
1961. *Carpinus subyedoensis*, TANAI et ONOE: op. cit. p. 28, Pl. 4, Figs. 3, 6, 7, 10.

Remarks: The present species represented by leaves and involucres, is abundantly found from Middle Miocene to Late Pliocene sediments in various localities of Japan. It is closely similar to the living *Carpinus tschonoskii* MAXIM. which is now distributed in Honshû, Shikoku and Kyûshû, Japan, also extending to Korea. Many fossil leaves and involucres of this living species were found from Pleistocene flora in various area of Honshû. As already stated by BERGER (1953), the hornbeam of *C. tschonoskii*-type belongs to a comparatively advanced type. In Japan, *C. fargesiana*-type which is an old type of the *tschonoskii*-type, is found only in Early-Middle Miocene flora, while the distinct *tschonoskii*-type was appeared at Middle Miocene time, then has been luxuriantly grown till today.

Geological horizon: Middle Miocene to Late Pliocene.

Genus *Corylus* LINNE

About 20 living species of this genus are widely distributed in the northern hemisphere. The fossil remains of this genus have been also commonly found throughout Tertiary flora in the northern hemisphere, and rather abundant in Palaeogene flora. In Japan the fossil leaves and seeds of this genus occurred throughout Tertiary flora, though their specimens were rather rare. The writer found the following 2 species from Neogene flora of Japan: *Corylus macquarrii* (FORBES) HEER and *C. miochinensis* TANAI et ONOE. Beside these 2 species, *C. ligniatus* MIKI was found from Pliocene flora of Honshû by MIKI (1941).

Corylus Macquarrii (FORBES) HEER

(Pl. 8, Figs. 1, 12)

1851. *Alnites? Macquarrii*, FORBES: Quart. Jour. Geol. Soc. London, vol. 7, pt. 1, p.

103, Pl. 4, Fig. 3.
1862. *Carpinus Macquarrii*, HEER: Naturf. Gesell. Zurich Uierteli-jaherssohr., vol. 7, p. 198.
1868. *Carylus Macquarrii*, HEER: op. cit. p. 138, Pl. 8, Figs. 9–12; Pl. 9, Figs. 1–8; Pl. 17, Fig. 5d, Pl. 19, Fig. 7c.
1937. *Corylus Macquarrii*, BROWN: U. S. Geol. Surv. Prof. Pap. 186, p. 171, Pl. 50, Fig. 6.
1940. *Corylus macquarrii*, HU et CHANEY: op. cit. p. 35, Pl. 13, Figs. 1, 4.

Description: Leaves obovate-elliptic in general outline, 3 to 9.5 cm long and 2.1 to 6.5 cm wide; apex abruptly acuminate; base somewhat inequilateral, shallowly to deeply cordate; midrib stout, nearly or slightly curved; secondary nerves 8 to 12 pairs, opposite to subopposite, diverging from the midrib at angles of about 40 degrees on the middle, more angles at the basal part, slightly curving upwards, entering into large dents, craspedodrome; near the margin a few tertiaries branching off from the secondaries, tertiary nerves among intrasecondary spaces distinct, percurrent; margin dentato-serrate, with acute teeth; texture thin, membranaceous; petiole stout, 3 to 10 mm long.

Remarks: The present species is one of the widely-distributed plants from Palaeocene to Miocene time in the northern hemisphere. The fossil leaves refered to this species in the world, are somewhat variable in shape and some other characters. Several Miocene leaves from Japan are probably asigned to *C. macquarrii* in a wide sense, but these specimens should be re-examined. Among the living species of *Corylus*, this species is closely similar to *C. heterophylla* FISHER which is widely distributed in North China, Korea, Manchuria, Siberia and Japan. It is also close to *C. heterophylla* var. *thunbergii* BLUME living in Hokkaidô, Honshû and Kyûshû, Japan.

Among the fossil leaves of *Corylus*, the present species is closely similar to *C. kenaiana* HOLLICK from Palaeogene flora of Alaska (HOLLICK, *jarmolenkoi* GRUB. from Tertiary flora of Siberia (KRYSHTOFOVICH, 1956: 1936: Pl. 45, figs. 1-3a; Pl. 46, figs. 1b, 2-5; Pl. 47, figs. 1-5) and *C.* Pl. 19, Figs. 1, 6; Pl. 20, 21).

Geological horizon: Eocene to Middle Miocene (in Japan).

Corylus miochinensis TANAI et ONOE

1959. *Corylus miochinensis*, TANAI et ONOE: op. cit. p. 281, Pl. 4, Fig. 1, Text-fiig. 2.

Remarks: The present species established by incomplete leaves from Miocene flora of the Jôban coal field, is similar to the modern *Corylus* *chinensis* FRANCH. in central and southern China. This species is rather rarely found from Early and Middle Miocene flora of Honshû and Kyûshû.

Geological horizon: Early to Middle Miocene.

Genus *Ostrya* SCOP.

About 8 living species of this genus are distributed in the northern hemisphere, and three species and one variety are existing in East Asia. The fossil remains of *Ostrya* have been abundantly found from Tertiary flora in North America and Europe. This genus is not so common in Tertiary flora of Japan, and the following 2 species are ascertained from Neogene flora by the writer: *Ostrya huziokai* TANAI and *O. subvirginiana* TANAI et ONOE. Beside them, a fossil involucre of *O. knowltonii* CONVIL. ? was found from Pliocene flora in Honshû by ENDO (1933), and fossil leaves of *O. virginiana* K. KOCH. were found Pliocene flora in Kyûshû and Honshû by NATHORST (1883) and KONNO (1931).

It is sometimes difficult to identified to this genus by only leaf impressions, but characteristic fossil involucres of *Ostrya* frequently occurred with leaf impressions.

Ostrya huziokai TANAI sp. nov.

(Pl. 8, Fig. 2)

1943. *Ostrya japanica* var. *oblongibracteata*, HUZIOKA: op. cit. p. 289, Pl. 14, Figs. 1, 1a, 2.

1955. *Ostrya japonica* var. *oblongibracteata*, TANAI (in part): op. cit. Pl. 6, Fig. 4 (not Fig. 3).

1959. *Ostrya japonica* var. *oblongibracteata*, TANAI et ONOE: op. cit. Pl. 4, Fig. 5.

Description: Leaves medium in size, ovate to oblong-ovate in general outline, 4.2 to 7.5 cm long and 2.9 to 4.0 cm wide; base rounded and slightly cordate; apex slightly acuminate; midrib stout, nearly straight, near the apice slightly curved; secondaries 7 to 9 opposite pairs, nearly regular-spaced, diverging from the midrib at angles of 30 to 40 degrees, nearly straight to the margin, craspedodrome; tertiaries irregularly percurrent; nervilles distinct, finely reticulate; margin doubly serrate, with nearly equal-sized teeth; petiole stout but short, 2 mm long; texture thin, membranaceous.

Involucres ovate-elliptical in shape, 16 to 21 mm long, 6 to 9 mm wide at the middle; apex gradually narrowed, acute; base obtuse to rounded; main nerves originating from the base and ending in the apex, parallel, 6 to 7 in number on the impression; intermediate nerves slender, parallel to the main nerves; fine nerves nearly perpendicular to the main nerves. Nutlets oblong ovate in shape, with acutely pointed apex and rounded base; 6 to 9 mm long, 3 to 4 mm wide.

Remarks: The present new species is represented by leaf impressions and involucres occurred from Miocene flora in several localities of Japan. These fossil leaves are closely similar in general characters to the living *Ostrya japonica* SARGENT. The present fossil involucres are also close to those of the above-noted living species, and fairly identical to *O. japonica* var. *oblongibracteata* HUZIOKA described from Miocene Abura flora in Hokkaidô. Accordingly, these specimens are considered to be represented by one species, and the writer includes the above-noted fossil variety into the present new species. Among the fossil *Ostrya,* this new species is most closely similar to *O. subviriginiana* TANAI et ONOE described below. However, the leaves of the former are generally less in number of secondary nerves and smaller in diverging angles of secondaries than those of the latter. Namely, *O. subvirginiana* is, in general, 14 to 16 pairs of secondaries, which diverge from the midrib at angles of 40 to 50 degrees. Furthermore, the involucres of this new species are narrower in width and smaller in nutlet than those of the latter species.

The most close living species, *O. japonica,* is widely distributed from Hokkaidô in the north to Kyûshû in the south, and extends to Korea and North China.

Geological horizon: Middle Miocene.

Ostrya subvirginiana TANAI et ONOE

(Pl. 8, Figs. 5, 11)

1955. *Ostrya subvirginiana,* TANAI: op. cit. Pl. 6, Figs. 1, 2.
1959. *Ostrya subvirginia,* TANAI et ONOE: op. cit. p. 279, Pl. 3, Fig. 4; Pl. 4, Figs. 3, 4.

Remarks: The present species is represented by leaf impressions and involucres, which are closely similar in general characters to an American living species, *Ostrya virginiana* (MILL.) KOCH. This fossil leaves are ovate to ovate-oblong in general outline, and rounded or slightly cordate at the base. The involucres of this species are characterized by oval shape and roundly obtuse base. The fossil leaves of *O. virginiana* described from Pliocene Mogi and Late Miocene Omi flora of Japan (NATHORST, 1883: Pl. 3, fig. 2; KONNO, 1931: Pl. 9, figs. 1, 2) are somewhat similar to those of this species, but these leaves are generally narrower than the present specimens. The fossil involucre described as *O. kowltonii* CONVILLE ? from Japan (ENDO, 1933: Fig. 10) is closely similar to this species, though the former is larger than the latter. This fossil species is known from Miocene flora in several localities of Honshû and Hokkaidô.

Geological horizon: Middle Miocene.

Family FAGACEAE

Genus *Castanea* ADAMS.

About 10 living species of this genus are growing in the temperate region of the northern hemisphere, and among these species 3 are distributed in East Asia. Plentiful fossil leaves of chestnuts have been described from Tertiary flora in the world, but some of them seem to be confused with other genera in their identification. In Japan the fossil leaves of *Castanea* are abundantly from Neogene flora, in particular from Middle Miocene flora in various localities. Japanese Neogene species are following 2: *C. miocrenata* TANAI et ONOE and *C. ungeri* HEER.

Castanea miocrenata TANAI et ONOE

1883. *Castanea vulgaris*, NATHORST: op. cit. p. 84, Pl. 15, Fig. 10a.
1961. *Castanea miocrenata*, TANAI et ONOE: op. cit. p. 30, Pl. 5, Figs. 1–4.

Remarks: The present species is nearly identical to the living *Castanea crenata* S. et Z. which is widely distributed from southwestern Hokkaidô at the north to Kyûshû at the south in Japan. This species is closely related to *C. Kubinyi* KOVAT. which is one of common fossil chestnut in European Miocene flora, but the latter is thicker in marginal teeth than the former. A Miocene chestnut, *C. ungeri* described below, is distinguishable from the present species by having thicker teeth and wider leaves.

Gological horizon: Late Miocene to Early Pliocene.

Castanea ungeri HEER

(Pl. 12, Figs. 1, 2, 5, 6, 8; Pl. 13, Figs. 10, 11; Pl. 14, Figs. 1, 3–5)

1869. *Castanea Ungeri*, HEER: op. cit. p. 470, Pl. 45, Figs. 1–3; Pl. 46, Fig. 8; p. 32, Pl. 7, Figs. 1–3.
1888. *Castanea Ungeri*, NATHORST: op. cit. p. 16, Pl. 5, Fig. 5; p. 18, Pl. 6, Fig. 4.
1888. *Castanea Kubinyi*, NATHORST: Do. p. 18, Pl. 6, Fig. 8.
1920. *Castanea Ungeri*, KRYSHTOFOVICH: op. cit. p. 8, Pl. 1, Fig. 5; Pl. 2, Fig. 1.
1931. *Quercus* cfr. *grönlandica*, KONNO: op. cit. Pl. 11, Fig. 5.

1955. *Castanea Ungeri*, TANAI: op. cit. Pl. 9, Fig. 5.
1955. *Castanea Kanekoi*, TANAI: Do. Pl. 9, Figs. 3, 4.
1955b. *Castanea atavia*, HUZIOKA: Illustrated Fossil Catalog. in Hukui Pref. No. 6, p. 6, Pl. 2, Fig. 6.

Description: Leaves variable in size and shape, but generally large-sized, lanceolate to oval-lanceolate in shape, 10 to 18 cm long and 3 to 7.5 cm wide; base asymmetrical, bluntly cuneate to broadly rounded; apex acute or slightly acuminate; midrib stout and very thick, prominent on the lower surface of blade; secondary nerves stout and generally thick, regularly spaced, 15 to 20 pairs, opposite to subopposite, leaving out from the primary at angles of 45 to 60 degrees on the middle part, craspedodrome to the marginal teeth; the tertiaries distinct, closely spaced, percurrent; nervilles reticulate; margin coarsely dentate, the teeth tipped with somewhat thick spine; texture firm, probably subcoriaceous; petiole stout and thick, 3 to 4 cm long.

Remarks: The present species is commonly found in Middle Miocene flora of Japan, and especially abundant in the Daijima-type flora. These fossil leaves are characterized by large-size, thick nerves and marginal teeth, though they are variable in size and shape. They are fairly identical to the type-figures of *Castanes ungeri* HEER from Eocene flora of North Greenland and Miocene flora of Alaska.

Beside this pecies, many fossil leaves of chestnut have been recorded from Tertiary flora of the world under the following various names: *Castanea castanaefolia* (UNGER) KOWLTON, *C. kubinyi* KOVAT and *C. orientalis* CHANEY. These four species are frequently difficult to be distinguished each other. For instance, LAMOTTE (1952) stated that *C. ungeri* was included into *C. castanaefolia*. However, some foliar difference seems to be observed between the original figures of these two species. The leaves of *C. castanaefolia* is more slender in secondary nerves and generally more obtuse in marginal teeth than those of *C. ungeri*. Accordingly, the writer intends to use the name of *C. ungeri* for the fossil chestnut leaves having the above-described characters. The present fossil species is very closely similar to *C. miomollissima* HU et CHANEY from the Miocene Shantung flora in China (HU et CHANEY, 1940: Pl. 13, figs. 3, 7), and at a glance frequently indistinguishable respectively. However, the former has generally longer and thicker teeth than the latter. Among the modern chestnut, this fossil species is closely related to *C. mollissima* BLUME in China or *C. dentata* (MARSH.) BORKH. in North America.

Geological horizon: Middle Miocene.

Genus *Fagus* LINNE

About 10 living species of this genus are confined to the temperate region of the northern hemisphere. 2 species of beech are now living in Japan, of which *Fagus crnata* BLUME is one of the main representatives in the temperate forest of Japan. The fossil beeches have been abundantly found throughout Tertiary flora in the northern hemisphere. In Japan, the fossil remains of beeches have been also commonly found from Neogene flora in various localities over Japan, however, no specimens being identical to this genus have been yet found from Palaeogene flora of Japan as far as known up to the present. Several species of this genus from Neogene flora of Japan have been described by various authors, but their species are frequently difficult to be distinguished each other by only leaf impressions.

The writer determined following 3 Neogene species from Japan: *Fagus antipofi* HEER, *F. palaeocrenata* OKUTSU and *F. protojaponica* SUZUKI. Beside these 3 species, *F. microcarpa* MIKI was described from Pliocene Akashi flora of Honshû by MIKI (1937).

Fagus antipofi HEER

(Pl. 15, Fig. 1; Pl. 16, Figs. 1, 2, 4–10)

1858. *Fagus Antipofi*, HEER: Acad. Imp. Sci. St-Pétersbourg Mém., Sér. 6, vol. 7, p. 572, Pl. 8, Fig. 2.
1869. *Fagus Antipofi*, HEER: op. cit. p. 30, Pl. 5, Fig. 4a: Pl. 7, Figs. 4–8.
1887. *Fagus Antipofi*, SCHMALHAUSEN: Tert. Pfl. aus Buchtarma, p. 204, Pl. 22, Fig, 10.
1888. *Fagus Antipofi*, NATHORST: op. cit. p. 10, Pl. 3, Figs. 2, 3: p. 16, Pl. 5, Figs. 2–4.
1888. *Fagophyllum Gottschei*, NATHORST: op. cit. p. 5, Pl. 1, Fig. 2.
1888. *Fagus* sp. indet., NATHORST: op. cit. p. 9, Pl. 2, Fig. 3.
1939. *Fagus multinervis*, ENDO: op. cit. p. 341, Pl. 23, Fig. 10.
1951. *Fagus Antipofi*, HUZIOKA: Cainozoic Research (Shinseidai no Kenkyû) No. 10. pp. 168, Pl. 14, Figs. 11–114.
1952. *Fagus Antipofi*, TANAI: op. cit. p. 125.
1952. *Fagus aburatoensis*, TANAI: op. cit. p. 127, Pl. 4, Fig. 6.
1952. *Fagus multinervis*, TANAI: op. cit. p. 127.
1955. *Fagus americana*, ENDO (in part): op. cit. Pl. 32, Fig. 6.
1956. *Fagus Antipovii*, KRYSHTOFOVICH: Palaeobotanica vol. 1, p. 98, Pl. 28, Figs. 1–5; Pl. 29, Fig. 2; text-figs. 41, 42.

Remarks: This species is one of the widely-distributed dicotyledons in Tertiary flora of the northern hemisphere. The fossil leaves identical to this species abundantly occurred from Miocene flora in various localities of Japan. Accompanying with these fossil leaves, some fossil cupules and bud-scales were found from several localities, and these specimens are probably included into this species. Most of the present specimens are generally found from the Aniai-type flora of Middle Miocene age in Japan, however, in Hokkaidô this species is commonly found with several warm elements from the Daijima-type flora.

Many fossil leaves identified to this species in Japan, are somewhat variable in shape, size and some other characters as much as many specimens occurred from Europe, North America, etc. Among the leaves of *F. antipofi* collected from Japan by the writer, the large one is more than 25 cm long and 10 cm wide, while the small one is 4.5 cm long and 1.5 cm wide. Furthermore, these leaves are variable from ovate-lanceolate to lanceolate in shape, and undulate or simply serrate with small teeth in margin. They are also very variable in mode of base and apex. However, comparing to the fossil leaves of other Japanese species of beech, the leaves of this spcies are generally narrower for the length and more in number of secondary nerves than others. Namely, secondary nerves of the present species are 12 to 24 in number, and usually from 16 to 20 pairs.

Among many Japanese specimens identical to this species, the above-described variable characters are, however, so gradual that they are rather unable to be separated to some new species. Accordingly, the writer treatises *F. antipofi* as a form-species, and the leaves being similar to *F. antipofi* occurred in Japan are, at present, better to be given this specific name. HEER subdivided the leaves of this species into five leaf-forms, and all of these forms are observed among Japanese specimens. Some specimens of *Fagus oblongus* SUZUKI described from Late Miocene Tennôji flora (SUZUKI, 1959: Pl. 3, fig. 1) are closely similar to the present specimens, while another ones of the former species (Do: Pl. 2, figs. 2, 3) are rather nearly identical to *F. palaeocrenata* OKUTSU described below. The present species is also closely similar to *F. bonnevillensis* CHANEY from Miocene and Oligocene floras in North America (CHANEY, 1920: Pl. 11, fig. 1; etc.) or *F. pristina* SAPORTA from Tertiary flora of France.

Among the living species of beeches, this species has a close resemblance in general appearance to *F. americana* SWEET in the eastern part of North America and *F. longipetiolata* SEEMEN in Fukien and Hupeh province of China.

Geological horizon: Early to Middle Miocene (in Japan).

Fagus palaeocrenata OKUTSU

(Pl. 15, Figs. 3, 4, 8)

1883. *Fagus ferruginea*, NATHORST: op. cit. p. 43, Pl. 4, Figs. 11–17; Pl. 5, Figs. 3, 9, 11; Pl. 6, Fig. 1.
1920. *Fagus ferruginea*, FLORIN: Kgl. Svensk. Vetensk. Acad. Handl., vol. 61, p. 18, 36, Pl. 1, Figs. 3, 4, 12.
1931. *Fagus ferruginea*, KONNO: op. cit. Pl. 10, Fig. 3.
1941. *Fagus ferruginea*, MIKI: op. cit. p. 270, Fig. 11 B, Cc.
1954. Cfr. *Fagus crenata*, HUZIOKA et SUZUKI: op. cit. p. 139, Pl. 16, Fig. 10.
1954. *Fagus crenata*, TAKAHASHI: op. cit. p. 56, Pl. 3, Figs. 7–12; Pl. 4, Figs. 1–8.
1955. *Fagus palaeocrenata*, OKUTSU: op. cit. p. 92, Pl. 6, Figs. 4–9.
1957. *Fagus palaeocrenata*, MURAI: Rep. Tech. Iwate Univ. No. 10, p. 44, Pl. 1, Fig. 4; Pl. 2, Figs. 1–6.
1959. *Fagus palaeocrenata*, SUZUKI: op. cit. p. 35, Pl. 2, Figs. 3–8.
1959. Cfr. *Fagus Hayatae*, SUZUKI: Do. p. 36, Pl. 1, Fig. 9.
1960. *Fagus palaeocrenata*, TANAI: Trans. Proc. Palaeont. Soc. Jap. N. S. No. 37, p. 197, Pl. 1, Figs. 2–7, 9–11.
1961. *Fagus palaeocrenata*, TANAI et ONOE: op. cit. p. 33, Pl. 6, Figs. 3–5; Pl. 8, Figs. 1–7; Pl. 9, Figs. 1–6.

Remarks: The present species represented by leaves, cupules and bud-scales, are commonly found from Late Miocene to Pliocene floras in various localities over Japan. This species is generally characterized by number of secondary nerves and marginal serration. The fossil leaves of this pecies are variable in shape, size and secondary nerves, and recently the writer considered about the extent of these variable characters. Some leaves of *Fagus oblongus* lately established by SUZUKI (1959), must be rather included into this species in the extent of foliar variation.

Geological horizon: Late Miocene to Late Pliocene.

Fagus protojaponica SUZUKI

(Pl. 15, Figs. 5, 6)

1883. *Fagus sieboldi*, NATHORST: op. cit. p. 84, Pl. 15, Fig. 6.
1888. *Fagus japonica*, NATHORST: op. cit. p. 227, Pl. 9, Figs. 3–8.
1958. *Fagus japonica*, MURAI: Rep. Tech. Iwate Univ. No. 11, p. 20, Pl. 2, Figs. 1–3.
1959. *Fagus protojaponica*, SUZUKI: op. cit. p. 33, Pl. 2, Fig. 10.
1960. *Fagus palaeojaponica*, TANAI: op. cit. p. 798, Pl. 1, Figs. 1, 8.
1961. *Fagus palaeojaponica*, TANAI et ONOE: op. cit. p. 35, Pl. 7, Figs. 3–5.

Remarks: This species was established by SUZUKI (1959) on the basis of leaf-impression from the Tenôji flora. It is fairly conspecific to *Fagus palaeojaponica* established by TANAI et ONOE (1961) in the Hôki flora of western Honshû. The leaves of the present species are close to those of the above-noted *F. palaeocrenata*, but different in average leaf-index* and number of secondaries, and less in leaf-index than the latter. Among 3 Neogene and 1 living species of Japanese beeches, leaf-index and number of secondary nerves are shown as follows:

Beech Species	Average leaf-index	Number of the secondaries
F. antipofi	266	12—24
F. palaeocrenata	183	6—12
F. protojaponica	200	13—16
F. crenata	160	6—12

The present species is closely related to the modern *F. japonica* MAXIM. in Honshû, Shikoku and Kyûshû, Japan.

Geological horizon: Late Miocene to Late Pliocene.

Genus *Quercus* LINNE

The modern oaks are widely distributed in temperate, warm or subtropical regions of the northern hemisphere; more than 200 living species inhabit from the north temperate regions to high altitudes of the tropics. In particular, the genus *Quercus* is one of the main components in modern temperate forest of the northern hemisphere. In East Asia the living oaks are abundant in number of species: for instance, 15 species in Japan, 20 in China and 14 in Formosa. Whereas, the fossil oaks have been commonly found throughout Tertiary flora in the world, and especially abundant in Neogene flora. In Japan the fossil remains of *Quercus* are not so common in Palaeogene flora, however, this genus was very abundantly found in number of specimens and species since Middle Miocene time. Especially, the genus *Quercus* is one of the representative genera in the Daijima-type flora.

From Neogene flora in Japan, the writer ascertained the following 8 species: *Quercus koraica* TANAI, *Q. mandraliscae* GAUDIN, *Q. miocrispula* HUZIOKA, *Q. nathorsti* KRYSHTOFOVICH, *Q. protodentata* TANAI et ONOE, *Q. protoserrata* TANAI et ONOE, *Q. sinomiocenicum* HU et CHANEY and *Q. subvariabilis* TANAI. Beside these 8 species, *Q. protoacuta* SUZUKI and *Q. protosalicina* SUZUKI were lately described from Late Miocene flora in Fukushima Prefecture by SUZUKI (1959).

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* Leaf-index = length/width × 100.

Quercus koraica TANAI
(Pl. 13, Fig. 13)

1926. *Quercus* sp., KRYSHTOFOVICH: op. cit. p. 12, Pl. 2, Fig. 8.
1953. *Quercus koraica*, TANAI: Trans. Proc. Palaeont. Soc. Japan, N. S. No. 9, p. 5, Pl. 1, Figs. 11, 12.
1953. *Clylobalanopsis Huziokai*, TANAI: Ibid. p. 4, Pl. 1, Fig. 10.
1955. *Quercus koraica*, TANAI: op. cit. Pl. 8, Figs. 1, 2.

Description: Leaves medium in size, oblong-ovate to ovate in general outline, 4.0 to 6.5 cm long and 2.0 to 2.7 cm wide; apex acute to slightly acuminate; base rounded or broadly cuneate; midrib rather slender, slightly arcuate; secondary nerves thin, 7 to 10 pairs, opposite to subopposite, diverging from the midrib at angles of 30 to 40 degrees, slightly curving upward, then entering into the marginal teeth, craspedodrome; tertiaries thin, irregularly percurrent; nervilles finely reticulate; margin aristate-serrate, with spine-tipped teeth; texture firm, membranaceous to subcoriaceous; peitole thick but rather slender, 5 to 10 mm long.

Remarks: The present species was, at first, described on the basis of several fossil leaves from Miocene flora of southern Korea, and then rarely found from Middle Miocene flora in Japan. This species is mainly characterized by medium-sized leaves and aristate-serrate margin.

The present fossil species is closely similar to *Cyclobalanopsis Huziokai* from Miocene flora of southern Korea, and probably conspecific. Among many species of fossil oak in the world, it is closely similar to *Q. pregrahami* MACGINIT. from Oligocene flora of California, the United States (MACGINITIE, 1937: Pl. 8, fig. 3; Pl. 12, fig. 2). Among the modern oaks, this fossil species is closely similar in general outline to *Q. tarokoensis* HAYATA which is one of the endemic oaks in Formosa.

Geological horizon: Middle Miocene.

Quercus mandraliscae GAUDIN
(Pl. 12, Figs. 4, 7)

1858. *Quercus Mandraliscae*, GAUDIN: Mém. quelques Gisem. de la Toscane, p. 33, Pl. 2, Fig. 11.
1859. *Quercus drymeia* var. *Mandraliscae*, GAUDIN: Contrin à la flora fossil Italienne. p. 45, Pl. 4, Figs. 2-5.
1953. *Cyclobalanopsis Mandraliscae*, TANAI: op. cit. p. 3, Pl. 1, Fig. 6-9.
1954. *Cyclobalanopsis Mandraliscae*, HUZIOKA: Trans. Proc. Palaeont. Soc. Jap. N. S. No. 15, p. 197, Pl. 25, Figs. 1, 2.
1955. *Cyclobalanopsis Mandraliscae*, TANAI: op. cit. Pl. 8, Figs. 6, 7.
1955. *Quercus mioglauca*, ENDO (in part): op. cit. Pl. 26, Fig. 6, (not Fig. 1).

Remarks: The leaves of present species are characterized by narrowly-lanceolate shape, longly-acuminate apex and bristle-like serrate margin. These characteristic leaves of oak are commonly found from Miocene flora in Japan and Korea. As already stated by the writer, this species is fairly identical to some type of *Q. drymeia* UNGER, which species has many variation-forms. Most of oak leaves reported under the name of *Q. drymeia* in Japan, were probably included into the present species.

Q. mandraliscae is somewhat variable in foliar shape; especially the base of leaves is variable from cuneate to narrowly cuneate. Among the fossil oaks in Japan, this species is similar to *Q. subvariabilis* TANAI described below, but the latter has thicker and longer teeth on margin of leaves. It is nearly identical to a specimen of *Q. mioglauca* ENDO from the Miocene Kwannonzawa flora, Niigata Prefecture, and the latter should be probably included into the present species. *Q. mandraliscae* is one of the most common fossil oaks in Miocene flora of Japan, it is a representative of the Daijima-type flora.

Geological horizon: Middle Miocene.

Quercus miocrispula HUZIOKA

(Pl. 13, Fig. 2; Pl. 15, Figs. 2, 7)

1930. *Quercus dentata*, KONNO (in part): op. cit. Pl. 3, Fig. 4.
1937. *Quercus crispula*, MIKI: op. cit. p. 313, Figs. 3 H.
1940. *Quercus crispula*, OKUTSU: op. cit. p. 160, Pl. 10, Fig. 3.
1954. *Quercus miocrispula*, HUZIOKA: op. cit. p. 196, Pl. 25, Fig. 3.
1961. *Quercus miocrispula*, TANAI et ONOE: op. cit. p. 30, Pl. 6, Figs. 1, 2, 6.

Remarks: The fossil leaves of this species are closely similar to the living *Quercus mongolica* FISCHER var. *grosseserrata* (BLUME) R. et W., which grows now in Hokkaidô, Honshû, Shikoku, Kyûshû, Saghalien and southern Kurile islands. The present fossil species is somewhat variable in foliar shape, namely from oblong-laceolate to obovate. However, this species is characterized by marginal dentation.

The present species is comparatively common in Neogene flora of Japan, and especially abundant in Late Miocene flora.

Geological horizon: Middle Miocene to Early Pliocene.

Quercus nathorsti KRYSHTOFOVICH

(Pl. 12, Fig. 3)

1888. *Querciphyllum* sp., NATHORST: op. cit. p. 19, Pl. 7, Figs. 1–3.
1926. *Quercus Nathorsti*, KRYSHTOFOVICH: op. cit. p. 10, Pl. 2, Figs. 3, 4.

1955. *Cyclobalanopsis Nathorsti,* TANAI: op. cit. Pl. 8, Fig. 8.
1955. *Quercus mioglauca,* ENDO (in part): op. cit. Pl. 26, Fig. 1 (not Fig. 6).
1959. *Quercus Nathorsti,* SUZUKI: op. cit. p. 38, Pl. 3, Fig. 10, 11.

Remarks: The present leaves are fairly identical to *Quercus nathorsti* KRYSH. which was described from Miocene Kwannonzawa flora in northeastern Honshû, Japan. The leaves of this species are closely similar to those of the living *Q. glauca* THUNB. The living species is distributed in Honshû, Shikoku and Kyûshû, Japan, extending to Formosa and China. The present fossil species is characterized by ovate-lanceolate shape, cuneate base, longly-acuminate tip and acute marginal teeth. It is nearly idntical to a leaves of *Q. mioglauca* ENDO which was reported by ENDO from the Kwannonzawa flora, and probably conspecific. The fossil leaves described as *Q. nathorsti* from the Tennôjo flora by SUZUKI (1959), are somewhat broader than the original specimens, and more slender in marginal teeth. This species is closely related to the above-described *Q. mandraliscae* GAUDIN in general appearance. However, the latter is commonly narrower in leaves and thinner marginal teeth than the former. Furthermore, the former is entire only in the margin of basal part, while the latter is entire in the margin of one-third or one-second part.

This fossil species is commonly found from Middle Miocene flora in Japan, and is a representaitve of the Daijima-type flora.

Geological horizon: Middle to Late Miocene.

Quercus protodentata TANAI et ONOE

1930. *Quercus dentata,* KRYSHTOFOVICH: Ann. Soc. Palaeont. Russie, vol. 8, p. 27, Pl. 4, Fig. 39.
1931. *Quercus dentata,* KONNO (in part): op. cit. Pl. 3, Fig. 5 (not Fig. 4), Pl. 11, Figs. 2, 3.
1954. Cfr. *Quercus dentata,* HUZIOKA: op. cit. p. 197.
1961. *Quercus protodenta,* TANAI et ONOE: op. cit. p. 31, Pl. 7, Figs. 1, 2.

Remarks: The fossil leaves of this oak species are characterized by a large and obtusely-rounded dentation. They are closely similar to the modern *Quercus dentata* THUNB. which is widely distributed in northeastern Asia. The present fossil species is close in general outline to the above-described *Q. miocrispula,* but distinctly different in the marginal dentation. This species has appeared from Late Miocene time in Tertiary flora of Japan, and probably belongs to a advanced type of oak.

Geological horizon: Late Miocene to Early Pliocene.

Quercus protoserrata TANAI et ONOE

1931. *Quercus aliena,* KONNO: op. cit. Pl. 11, Fig. 1.
1961. *Quercus protoserrata,* TANAI et ONOE: op. cit. p. 32, Pl. 7, Fig. 9.

Remarks: The present species is not so common in Neogene flora of Japan. The fossil leaves of this species are closely similar to the living *Quercus serrata* THUNB. which is widely distributed in East Asia. They are somewhat similar to the above-described *Q. nathorsti* in general appearance, but differ in their marginal character and secondary venation.

Geological horizon: Late Miocene to Early Pliocene.

Quercus sinomiocenicum HU et CHANEY

(Pl. 13, Figs. 1, 4, 9)

1930. *Quercus acutissima,* KONNO: op. cit. Pl. 10, Figs. 6–8.
1940. *Quercus sinomiocenicum,* HU et CHANEY: op. cit. p. 37, Pl. 14, Fig. 7; Pl. 15, Fig. 7.
1940. *Quercus miovariabilis,* HU et CHANEY: Do. p. 36, Pl. 15, Figs. 5, 6.
1941. *Quercus acutissima,* MIKI: op. cit. p. 270, Fig. 12–D.

Description: Leaves variable in size and shape, lanceolate to oblong-lanceolate, sometimes ovate in general outline, 7.0 to 19.0 cm long and 1.8 to 4.8 cm wide; apex acute to acuminate; base rounded or bluntly cuneate; midrib stout, nearly straight or slightly curving; secondary nerves thin but distinct, 11 to 15 pairs, opposite to subopposite, regularly spaced, diverging from the midrib at angles of 45 to 55 degrees, craspedodrome, entering into the marginal teeth; tertiaries irregularly percurrent; nervilles finely reticulate; margin dentate, with spine-tipped teeth; texture firm, membranaceous; petiole stout, 1.0 to 3.6 cm long.

Remarks: The present specimens are fairly identical to *Q. sinomiocenicum* described from the Miocene Shanwang flora of China. *Q. miovariabilis* described from the same flora, is very closely similar to this species, and probably conspecific. For, the difference between the foliar characters of these two species described by HU et CHANEY, is gradually changing. This species is closely similar in general outline to *Q. subvariabilis* TANAI described below, but differs from the latter in the marginal character. Namely, the marginal teeth of the latter is longer and more forwards-pointing than that of the former. This species is also close to *Q. kazanskyi* KRYSHTOFOVICH from the Miocene Kwannonzawa flora in Japan (KRYSHTOFOVICH, 1926: Pl. 2, figs. 5, 6).

The present fossil oak is closely similar to the modern *Q. acutissima*

CARR., which is distributed in Japan and China.

Geological horizon: Middle Miocene.

Quercus subvariabilis TANAI
(Pl. 13, Figs. 5–8)

1955. *Quercus subvariabilis,* TANAI: op. cit. Pl. 8, Figs. 3–5.
1955. *Castanea angustifolia,* HUZIOKA: op. cit. p. 6, Pl. 2, Fig. 5.

Description: Leaves lanceolate to oblong-lanceolate in general outline; .base slightly asymmetrical, bluntly cuneate; apex acute to bluntly acuminate; length 8.5 to 10.0 cm and width 2.0 to 3.0 cm; midrib stout below, thin distantly; secondary nerves 12 to 16 pairs, opposite to subopposite, diverging at an angle of 50 degrees on the middle part, nearly straight to the margin, craspedodrome; tertiaries obscure, somewhat irregularly percurrent; nervilles finely reticulate; margin coarsely dentate, the teeth tipped with thick spine being more than 2 mm long; texture firm, membranaceous; petiole slender, more than 5 mm long.

Remarks: The leaves of this species are somewhat variable in shape and size, but have a characteristic marginal dentation which closely resembles the living *Q. variabilis* BLUME. This existing oak is a medium-sized tree, and widely didstributed at present in China, Formosa, Korea and Japan. Among the fossil oak leaves of the world, the present fossil leaves are most close to *Q. miovariabilis* HU et CHANEY from the Shanwang Miocene flora in China (HU et CHANEY, 1940: Pl. 15, figs. 5, 6). However, the present species is more coarsely dentate in the margin than the Chinese species, and the spiny teeth of the former is longer and thicker than that of the latter. The present species is also related to the above-described *Q. nathorsti* KRYSHT. and *Q. sinomiocenicum* HU et CHANEY from Miocene flora in Japan.

The present species is commonly found from Miocene flora in Japan, and especially abundant in the Daijima-type flora. The fossil leaves being similar to this species have been abundantly recorded from Oligocene to Miocene floras in the world.

Geological horizon: Middle Miocene.

Family ULMACEAE

Genus *Celtis* LINNE

About 70 living species of this genus are now distributed from tropical to temperate region in the world. Among them, about 30 species are now existing in temperate or subtropical region of East Asia. The fossil specimens of *Celtis* in Japan are not commonly found from Neogene flora, and have not yet been found from Palaeogene flora. However, this genus is known throughout Tertiary flora in Europe and North America, although it is, in particular, commonly found in Neogene flora. Japanese Neogene species are classified to the following 4: *C. miobungeana* HU et CHANEY, *C. nathorsti* TANAI et ONOE, *C. nordenskiökdii* NATHORST and *C. kitamiensis* OISHI et HUZIOKA.

Celtis miobungeana HU et CHANEY
(Pl. 17, Fig. 7)

1940. *Celtis miobungeana,* HU et CHANEY: op. cit. p. 39, Pl. 13, Figs. 2, 5, 6.

Remarks: The present species described from Miocene Shantung flora of China, is closely similar in general features to the living *Celtis bungeana* BLUME which is widely distributed in China and Korea. This fossil species is close to *C. nathorsti* TANAI et ONOE described below, but the former is generally larger in size and more asymmetrical in shape than the latter. It is also similar to *C. obliquifolia* CHANEY from Miocene flora of Oregon, the United States (CHANEY, 1925: Pl. 1, figs. 1, 3, 5), though the former is larger than American species.

This species is not so commonly found in Neogene flora of Japan, and up to the present confined to the Daijima-type flora.

Geological horizon: Middle Miocene.

Celtis nathorsti TANAI et ONOE
(Pl. 17, Fig. 8)

1883. *Celtis Nordenskiöldii,*NATHORST (in part): op. cit. p. 47, Pl. 15, Fig. 2.
1954. *Celtis* sp., TAKAHASHI: op. cit. p. 57, Pl. 5, Fig. 7.
1961. *Celtis Nathorsti,* TANAI et ONOE: op. cit. p. 36, Pl. 10, Fig. 1.

Remarks: This species somewhat similar to *C. nordensköldii* NATHORST described below, is characterized by asymmetrical form and small number of secondary nerves. As already stated, it is also closely related to *C. miobungeana,* but distinguishable respectively in shape and size. In particular, marginal teeth of the former are large and obtuse, on the contrary those of the latter are fine and more acute. Among the living species of *Celtis,* the present species is closely similar to *C. bungeana* Bl. var. *jessoensis* KUDO, which is existing in Japan and Querlpart islands.

Geological horizon: Late Miocene to Pliocene.

Celtis nordenskioldii NATHORST

(Pl. 17, Fig. 1)

1883. *Celtis Nordenskiöldi,* NATHORST (in part): op. cit. p. 47, Pl. 6, Figs. 14-17.
1920. *Celtis* sp. cfr. *occidentalis,* FLORIN: op. cit. p. 19, Pl. 2, Figs. 4.
1955. *Celtis occidentalis,* OKUTSU: op. cit. p. 94, Pl. 1, Fig. 5.
1961. *Celtis Nordenskiöldii,* TANAI et ONOE: op. cit. p. 36, Pl. 10, Fig. 7.

Remarks: The fossil specimens, at first, described as *C. nordenskioldii* by NATHORST from Pliocene Mogi flora of Kyûshû, contains two different types, and so this species was lately redesignated by the writer. The present species is characterized by having 4 to 6 strong secondary nerves and coarsely serrate margin with acutely pointed teeth. Among the modern *Celtis* this fossil species is more closely similar to *C. occidentalis* L. than any other species. This most close modern species is now existing in southeastern part of North America.

Geological horizon: Late Miocene to Late Pliocene.

Genus Ulmus LINNE

About 20 living species of this genus are distributed in temperate region of the northern hemisphere, and 3 species is existing in Japan and 8 in China. Among the genera of Ulmaceae the modern distribution of *Ulmus* extends to most northward region than those of others. The fossil specimens of *Ulmus* have been abundantly found from Late Cretaceous to Pleistocene floras in the world. Namely, the genus *Ulmus* is one of the most common trees distributed in Cenozoic flora of the world. In Japan this genus is one of the representative genera in Tertiary flora, and 11 fossil species have been known up to the present. Among them, the following 7 spcies are identified from Neogene flora of Japan by the writer: *U. appendiculata* HEER, *U. carpinoides* GOEPPERT, *U. longifolia* UNGER, *U. protolaciniata* TANAI et ONOE, *U. protojaponica* TANAI et ONOE, *U. shiragica* HUZIOKA and *U. subparvifolia* NATHORST. Beside these 7 species, *U. pseudolongifolia* OISHI et HUZ. and *U. elegantior* NATHORST were described from Miocene flora.

Ulmus appendiculata HEER

(Pl. 17; Figs. 3, 6, 11)

1878. *Ulmus appendiculata,* HEER: Flora fossilis arctica Bd. 5, Abt. 3, p. 40, Pl. 9, Figs. 7-9.
1931. *Ulmus appendiculata,* HAHLOV: Bull. Geol. Prosp. Serv. West. Siberia, vol. 11, p. 52, Text-fig. 34.

1933. *Ulmus appendiculata*, VVEDNTKY: Trans. Arct. Inst. vol. 12, p. 63, Text-fig. 6.
1954. *Ulmus appendiculata*, OISHI et HUZIOKA: Jap. Jour. Geol. Geogr. vol. 24, p. 127, Pl. 14, Fig. 6; Pl. 15, Fig. 5; Pl. 16, Fig. 1.

Remarks: This species was established by HEER in 1878 on the basis of fragmental leaf-impressions occurred from the Dué coal-bearing formation in North Saghalien. After then, this species was mainly found from Tertiary flora in northern region of East Asia. Lately, OISHI and HUZIOKA (1954) reported the abundant occurrence of this species from Miocene floras in South Saghalien and Hokkaidô.

The leaves of this species are characterized by strongly asymmetrical base and generally large size: they are commonly 10 to 15 cm long and 5 to 9 cm wide. The present species is closely similar in general characters to *U. speciosa* NEWBERRY (NEWBERRY, 1896: Pl. 45, figs. 2-4, 7) from Miocene flora of the United States. It is closely related to the living *U. davidiana* PLANCH. in China and *U. americana* L. in North America.

As already stated by OISHI and HUZIOKA, this fossil species is one of the common elms found from the lower half of Miocene sediments in northern region of East Asia, and especially abundant in Siberia, Saghalien and Hokkaidô.

Geological horizon: Middle Miocene.

Ulmus carpinoides GOEPPERT

(Pl. 17, Fig. 2)

1852. *Ulmus carpinoides*, GOEPPERT: Braunkholenfl. nordostl. Deutsch. p. 492.
1855. *Ulmus carpinoides*, GOEPPERT: op. cit. p. 28, Pl. 13, Figs. 4-8; Pl. 14, Fig. 1.
1855. *Ulmus minuta*, GOEPPERT: Ibid. p. 31, Pl. 14, Figs. 12-14.
1883. *Ulmus campestris*, NATHORST: op. cit. p. 173, Pl. 10, Fig. 1.
1917. *Ulmus carpinoides*, REIMANN (in KRAÜSEI): Jahrb. preus. Geol. L-A., vol. 38, No. 2, p. 83, Pl. 5, Fig. 2; Pl. 6, Fig. 11; Pl. 8, Figs. 13, 14, 16-23; others.
1930. *Ulmus* cfr. *carpinoides*, FLORIN: op. cit. p. 31, Pl. 5, Figs. 12-14.
1931. *Ulmus* cfr. *carpinoides*, KONNO: op. cit. Pl. 9, Fig. 3.
1951. *Ulmus carpinoides*, HUZIOKA: op. cit. p. 70.
1954. *Ulmus carpinoides*, OISHI et HUZIOKA: op. cit. p. 128, Pl. 14, Fig. 5.
1956. *Ulmus carpinoides*, KRYSHTOFOVICH: op. cit. p. 107, Pl. 37, Fig. 3a; Pl. 38, Figs. 1-3, 6-11; Pl. 39, Figs. 1, 3, 5, 6, 8-11, 13; Text-fig. 48.

Remarks: This species is comparatively common in Tertiary flora in Europe, and rare in North America. It is somewhat variable in shape and size, but the specimens occurred from Japan are comparatively small in size and broadly ovate in shape. The ovate leaves of this species are closely similar to *Ulmus shiragica* HUZ. described below, though they are smaller than the latter. Most of other fossil elms are generally asymmetrical in base, on the contrary the leaves of the present species are, in general, not so asymmetrical. This fossil species in Japan are rarely found from Neogene flora.

Geological horizon: Middle Miocene to Late Pliocene.

Ulmus longifolia UNGER

(Pl. 17, Figs. 5, 14)

1848. *Ulmus longifolia*, UNGER: Chlor. protog. Taf. 26, Figs. 5, 6,
1888. *Carpiniphyllum pyramidale*, NATHORST: op. cit. p. 23, Pl. 8, Figs. 1-3, 6-8 (no 4, 5).
1931. *Carpiniphyllum pyramidale*, KONNO: op. cit. Pl. 2, Figs. 1, 2.
1952. *Ulmus longifolia*, TANAI: op. cit. p. 128, Pl. 5, Fig. 2.
1954. *Ulmus longifolia*, OISHI et HUZIOKA: op. cit. p. 130, Pl. 15, Fig. 6.
1955. *Ulmus longifolia*, TANAI: op. cit. Pl. 10, Figs. 1, 2.

Description: Leaves medium in size, lanceolate in shape, 5.5 to 7.6 cm long and 1.5 to 2.5 cm wide; apex gradually narrowed, bluntly pointed; base slightly cordate, somewhat asymmetrical; midrib rather slender, nearly straight to the apex; secondary nerves 11 to 18 pairs, opposite to subalternate, regularly spaced, diverging from the midrib at angles of 30 to 35 degrees, a few pairs at basal part more spreading; all secondaries curving upwards, ending marginal teeth; craspedodrome; near the margin a few tertiaries branching from the secondaries to the biserrate teeth, the tertiaries of inter-secondary space irregularly prcurrent; nervilles indistinct, forming networks; margin double-serrate, with bluntly pointed teeth; petiole thick and short, about 4 mm in length; texture thin.

Remarks: This species is one of the widely-distributed elms in Neogene flora of Europe. It is characterized by lanceolate shape and nearly equal-sized marginal teeth. Though it is somewhat doubtful whether the present specimens belong to the genus *Ulmus* or *Carpinus*, they are quite identical to the European species. The present species is closely similar in general features to *Ulmus pseudolongifolia* OISHI et HUZIOKA, 1954: Pl. 14, figs. 1-3; Pl. 15, fig. 4), but the latter is generally larger in size and more inequilateral at the base than the former.

This fossil species is commonly found from the lower half of Miocene sediments in Japan. Among the living elms, the fossil leaves of this species is close to *U. lanceaefolia* ROXB. which is now distributed in southeastern China and India.

Geological horizon: Early to Middle Miocene.

Ulmus protojaponica TANAI et ONOE
(Pl. 17, Fig. 4; Pl. 18, Fig. 10)

1961. *Ulmus protojaponica*, TANAI et ONOE: op. cit. p. 38, Pl. 10, Figs. 3, 8.

Remarks: The present species is closely related to the modern *Ulmus davidiana* PLANCH. var. *japonica* NAKAI in general characters. The modern leaves have a wide range of variation in foliar shape and size, and similarly the leaves of this fossil species are also somewhat variable in general outline. Among the fossil elms, this species is more closely similar to *U. miopumila* HU et CHANEY from Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 14, figs. 2, 3) than any other species. However, the former is, in general, larger number of secondary nerves than the latter.

The most close living species, *U. davidiana* var. *japonica*, is one of the common trees in northern Japan.

Geological horizon: Late Miocene.

Ulmus protolaciniata TANAI et ONOE
(Pl. 17, Figs. 12, 13)

1920. *Ulmus* sp., FLORIN: op. cit. p. 31, Pl. 5, Figs. 15.
1961. *Ulmus protolaciniata*, TANAI et ONOE: op. cit. p. 37, Pl. 10, Fig. 1.

Remarks: The present species is commonly found from Late Miocene flora in various localities of Japan. The leaves of this species are somewhat variable in shape: obovate, oblong-obovate, broadly-obovate, and frequently trilobate. Such variation of foliar shape is also observed in the leaves of the living *Ulmus laciniata* MARY., which is closely similar to the present fossil species. In spite of variable foliar shape, these specimens are generally obovate in form, and distinctly characterized by secondary nervation and marginal serration.

U. protolaciniata is closely related to *U. paralacinata* HU et CHANEY from Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 16, figs. 4, 5) and *U. eolaciniata* SANBORN from Eocene Weaverville flora of the United States (SANBORN, 1937: Pl. 5, fig. 3), but the latter two are distinctly different from this species by the broadly rounded base and less number of secondaries.

The present species is also similar to *U. drepanodonta* GRUBOV from Neogene flora of Siberia (KRYSHTOFOVICH, 1956: Pl. 35, fig. 2; Pl. 36, figs. 1, 4; Pl. 37, figs. 1, 2; Text-figs. 52-54), and nearly unseparable respectively in having trilobate shape. The most close living equivalent, *U. laciniata,* is now distributed in northern Honshû and Hokkaidô, Japan, and also extends to North China, Manchuria and Siberia.

Geological horizon: Late Miocene.

Ulmus shiragica HUZIOKA

(Pl. 18, Fig. 5)

1951. *Ulmus shiragica,* HUZIOKA: op. cit. p. 70, Pl. 5, Fig. 8; Pl. 6, Fig. 6.
1952. *Ulmus harutoriensis,* TANAI: op. cit. p. 128.
1955. *Ulmus miodavidiana,* TANAI: op. cit. Pl. 10, Fig. 6.

Description: Leaves generally large in size, broadly oval to elliptically oval in shape, 6 to 11 cm long and 5 to 7 cm wide; apex abruptly acuminate or pointed; base slightly asymmetric, shallowly cordate; primary and secondary nerves distinct, prominent on the lower side of leaf; midrib stout, nearly straight, near the apice rather slender; secondaries 15 to 18 pairs, opposite to subopposite, diverging from the midrib at angles of 40 to 50 degrees on the middle portion, nearly parallel each other, near the margin slightly curving up, ending in larger teeth; a few tertiaries branching off at the marginal border, entering into small teeth, the tertiaries of inter-secondary spaces thin, irregularly percurrent; nervilles indistinct, forming finely polygonal meshes; margin duplicately serrate with obtuse and trigonal teeth, sometimes single-serrate on basal margin; petiole stout and thick, 1.0 to 1.3 cm long; texture thin, membranaceous.

Remarks: The present species was, at first, described from Miocene flora of Korea. *Ulmus miodavidiana* which was described from the Aniai-type flora of Japan by the writer (1955), is quite identical to this species. It is one of the representatives of the Aniai-type flora, and found commonly from Early Miocene sediments in northeastern Honshû. It is closely similar to *Ulmus harutoriensis* OISHI et HUZ. from Oligocene flora of Kushiro coal field, Hokkaidô (OISHI et HUZIOKA, 1954: Pl. 15, fig. 2) in general character. However, the latter is more inequilateral in shape and more deeply biserrate in margin than the former. *U. shiragica* is somewhat related to the above-described *U. appendiculata* HEER, but the latter is strongly asymmetrical in the base. Another allied species is *U. speciosa* NEWBERRY which is a common Miocene elm in the western United States.

Among the living elms of the world, the present fossil species is closely similar in general outline to *U. davidiana* PLANCH. and *U. bergmanniana* SCHNELD. existing in China, and also to *U. macrocarpa* NAKAI in Korea.

Geological horizon: Middle Miocene.

Ulmus subparvifolia NATHORST
(Pl. 17, Fig. 9)

1883. *Ulmus subparvifolia*, NATHORST: op. cit. p. 77, Pl. 15, Figs. 5a–e.
1937. *Ulmus parvifolia*, MIKI: op. cit. p. 312, Fig. 3 A.
1940. *Ulmus protoparvifolia*, HU et CHANEY: op. cit. p. 40, Pl. 14, Figs. 4, 5.
1954. *Ulmus protoparvifolia*, OISHI et HUZIOKA: op. cit. p. 130, Pl. 15, Fig. 3.
1955. *Ulmus protoparvifolia*, TANAI: op. cit. Pl. 10, Fig. 5.

Description: Leaves small in size, elliptical to ovate-elliptical in shape, 3.0 to 3.5 cm long and 1.5 to 1.9 cm wide; base asymmetrical, rounded to obtuse; apex bluntly acute; midrib stout, slightly twisted at the base; secondaries slender, 10 to 12 pairs, opposite to subopposite, somewhat irregularly spaced and diverging from the midrib at variable angles, occasionally forking well within the margin, craspedodrome; tertiaries irregularly percurrent, not closed; magin bluntly and simply serrate, partially double-serrate, with 1 minute secondary tooth; petiole stout, 3 to 5 mm long; texture firm, subcoriaceous.

Remarks: The present species is abundantly found in the Daijima-type flora. It is, at first, described from unknown localities in Japan by NATHORST (1883), and it is unable to be distinguished from *Ulmus protoparviolia* of Miocene Shanwang flora, China by their foliar characters. Accordingly, the writer considers that these two are same species. The fossil fruits of the living *U. parvifolia* JACQ. were found from Late Pliocene flora near Akashi, Japan, they are probably included into the present species.

The fossil leaves of this species are closely similar to the living *U. parvifolia* JACQ. in their small size, margin and venation. This living species is widedly distributed in China, Formosa, Korea and southern Japan. The fossil species has some resemblance to *U. campestris* L. existing now in Europe.

Geological horizon: Middle Miocene to Late Pliocene.

Genus *Zelkova* SPACH

This genus has about 7 living species in the world, and their modern distribution is rather limited in the Near East and the Far East. Among 7 species the four are now existing in temperate region of East Asia. However, the fossil leaves have been abundantly found throughout Tertiary formation in the world. In Japan many fossil leaves of *Zelkova* have been commonly found from Eocene to Pleistocene floras; four species are known up to the present. However, Neogene species is only one: *Zel-*

kova ungeri (ETTINGS.).

Zelkova ungeri (ETTINGS.) KOVATS

(Pl. 18, Figs. 1–4, 6–9, 11)

1851. *Planera Ungeri*, ETTINGSHAUSEN: L. k. geol. Reichsanst. Abh. vol. 1, pt. 3, p. 14, Figs. 5–18.
1856. *Zelkova Ungeri*, KOVATS: Art, Geol. Ges. Ungarn, vol. 1, p. 27.
1883. *Zelkova keaki*, NATHORST: op. cit. p. 45, Pl. 7, Figs. 2–6; Pl. 3, Fig. 1.
1888. *Planera Ungeri*, NATHORST: op. cit. p. 201, 203, Pl. 1, Figs. 5, 7–11.
1931. *Zelkova Ungeri*, KONNO: op. cit. Pl. 9, Figs. 4, 5.
1937. *Zelkova Ungeri*, MIKI: op. cit. p. 312, Pl. 9 F–O; Fig. 3 D–D.
1938. *Zelkova serrata*, SHIKAMA: op. cit. Pl. 18, Fig. 4.
1941. *Zelkova* cfr. *Ungeri*, MIKI: op. cit. p. 272, Fig. 12 I.
1951. *Zelkova Ungeri*, HUZIOKA: op. cit. p. 71, Pl. 5, Fig. 9.
1952. *Zelkova Ungeri*, TANAI: op. cit. p. 129, Pl. 5, Fig. 3.
1952. *Zelkova praelonga*, BERGER: Palaeontgr. Bd. 92, Abt. B, s. 99, Taf. 4, Figs. 81, 82.
1954. *Zelkova Ungeri*, TAKAHASHI: .p. cit. s. 57, Taf. 5, Figs. 8 a–g.
1954. *Zelkova Ungeri*, HUZIOKA et SUZUKI: op. cit. p. 140.
1954. *Zelkova praelonga*, OISHI et HUZIOKA: op. cit. p. 138, Pl. 14, Fig. 2; Pl. 16, Fig. 2.
1955. *Zelkova praelonga*, HUZIOKA: op. cit. p. 6, Pl. 2, Fig. 3.
1959. *Zelkova Ungeri*, TANAI et ONOE: op. cit. Pl. 4, Fig. 2.
1961. *Zelkova Ungeri*, TANAI et ONOE: op. cit. p. 38, Pl. 10, Fig. 4; Pl. 11, Fig. 1.

Remarks: The fossil leaves quite identical to this species is abundantly found from Neogene flora in Japan, and they are closely similar to *Zelkova serrata* MAKINO living in Japan, China, Korea, etc. and *Z. crenata* SPACH living in western Asia. The present fossil species is one of the most widely distributed trees in Tertiary flora of the world.

Lately, *Z. praelonga* (UNGER) was distinguished by BERGER (1952) from *Z. ungeri* by having elongate shape and acutely-prolonged apex. However, in many specimens collected by the writer the difference between the above two species gradually changes, and the both species is unable to be separable to 2 species. Namely, there are found many intermediate forms between the above two species.

Geological horizon: Early Miocene to Late Pliocene.

Family NYMPHAECEAE

Genus *Nelumbo* ADANS.

The modern species of this genus are mainly limited in distribution in the tropical or subtropical regions of the world, and there are only 2 living species. A species, *Nelumbo nucifera* GAERT., is distributed in the tropical or subtropical regions of Asia and Australia, and another species, *N. lutea* WILLD. in North America. On the contrary, the fossil remains of *Nelumbo* have been commonly found from Cretaceous to Tertiary sediments in North America and Europe. In Japan fossil *Nelumbo* is not rarely found from Eocene and Miocene flora, and in particular common in Palaeogene coal-bearing formation in Hokkaidô and Kyûshû. The Neogene species in Japan is following two: *Nelumbo nipponica* ENDO and *N. endoana* OISHI et HUZ.

Nelumbo endoana OISHI et HUZIOKA

(Pl. 19, Fig. 3)

1934b. *Nelumbo nipponica*, ENDO (in part): Jap. Jour. Geol. Geogr. vol. 11, Nos. 3-4, p. 255, Pl. 38, (not Pls. 36, 37).
1949. *Nelumbo Endoana*, HUZIOKA: op. cit. Pl. 9, Fig. 4.
1955. *Nelumbo Endoana*, TANAI: op. cit. Pl. 22.

Description: Leaves orbicular in general outline, more than 30 cm in diameter (estimated), peltate; primary nerves rather slender, straightly radiating from the center of the leaf, commonly 21 in number, dichotomously forking 3 or 4 times, the first dichotomy is about one-second distance to the margin; the angles of dichotomies are about 30 degrees; marginal dichotomy is tiny, ultimate forked primaries forming large networks; areolation very fine but distinct; marin entire, frequently undulate; texture coriaceous; petiole stout, about 1 cm wide in compressed materials.

Remarks: The present species was established by OISHI et HUZIOKA on basis of many specimens from Miocene floras in Hokkaidô and Saghalien, but its original description has not yet been published. This fossil species is closely similar to *Nelumbo nipponica* ENDO described below, however, the two species are distinctly distinguished by the characters of nervation. The number of primaries is commonly 21 in the present species, while 23 in the latter. The first dichotomy in the former is one-second distance from the margin, and one-third in the latter. The dichotomous angles are about 30 degrees in the former, while 40 to 45 degrees in the latter. Furthermore, the primaries of *N. endoana* are generally more slender and thinner than those of *N. nipponica*.

The present fossil species is found from Miocene coal-bearing deposits in Hokkaidô and northeastern Honshû, but not common.

Geological horizon: Early to Middle Miocene.

Nelumbo nipponica ENDO

(Pl. 19, Figs. 1, 2)

1934b. *Nelumbo nipponica*, ENDO (in part): op. cit. p. 255, Pls. 36, 36, 37 (not Pl. 38).
1955. *Nelumbo nipponica*, ENDO: op. cit. Pls. 11a, 12.

Remarks: The present species is commonly found from Palaeogene coal-bearing formation in various areas of Hokkaidô, Kyûshû and Honshû. It has been considered to be one of the Palaeogene index fossils in Japan. Lately, the writer found many fossil leaves of *Nelumbo* from Early or Middle Miocene coal-bearing formations in Kyûshû and Hokkaidô, which leaves are fairly identical to this Palaeogene species. Accordingly, the present Palaeogene species is considered to have survived until Early time of Neogene age.

Geological horizon: Eocene to Middle Miocene.

Family MENISPERMACEAE

Genus *Cocculus* DC.

About 11 living species of this genus are distributed in southeastern Asia, North America and Africa, and among them 2 species in living in Japan. Fossil leaves of this genus have been rarely found in Tertiary flora of the world, and also in Japan they are scarcely found.

Cocculus heteromorpha (KNOWLTON) BROWN

(Pl. 21, Fig. 7)

1926. *Populus heteromorpha*, KNOWLTON: U. S. Geol. Surv. Prof. Pap. No. 140, p. 30, Pl. 12, Figs. 8–10; Pl. 13, Figs. 1–7; Pl. 14, Figs. 1–3; Pl. 15, Figs. 3–5.
1926. *Populus fairii*, KNOWLTON: Ibid. p. 30, Pl. 15, Figs. 1–3.
1931. *Cebatha heteromorpha*, BEERY: U. S. Geol. Surv. Prof. Pap. No. 170, p. 37.
1946. *Cocculus heteromorpha*, BROWN: Jour. Wash. Acad. Sci. vol. 36, p. 352.
1955. *Populus* sp., TANAI: op. cit. Pl. 2, Figs. 1, 2.

Description: Leaves variable in size and shape, broadly ovate to deltoid in outline, the height generally less than the width, 3.5 to 5.5 cm long and 5 to 6 cm wide; apex obtuse or irregularly rounded; base truncate or broadly cordate; primaries trinerved; midrib stout, nearly straight or slightly undulate; a pair of basal primaries originating from the base and diverging from the midrib at angles of 30 to 50 degrees, curving upwards along the margin, camptodrome; lateral secondaries from the midrib subalternate, 2 or 3 pairs, curving up; abaxial secondaries from the basal primaries 5 to 6 in number, forming loops near the margin; tertiaries distinct, forming an irregularly coarse mesh; nervilles finely reticulate; margin nearly entire, irregularly undulate, sometimes having a few obtuse lobes separated by shallow sinuses; texture firm, membranaceous; petiole thick, 3.5 to 4.0 cm long.

Remarks: The present specimens are somewhat close to the some leaves of *Hedera, Sinomenium* or *Populus,* however, they are most closely similar to the genus *Cocculus* in the marginal and venation characters. Though these fossil leaves are somewhat variable in shape, they are fairly identical to *Cocculus heteromorpha* which was found from Miocene flora of North America. American specimens of this species are variable in shape, but they are characterized by trinerved venation and irregularly-undulated or shallowly-lobed margin. The present species is somewhat related to some leaf-form of the modern *C. trilobus* (THUNB.) DC. existing in Japan and China.

The present fossil specimens show the first occurrence of this genus in Tertiary flora of Japan.

Geological horizon: Early to Middle Miocene.

Family CERCIDIPHYLACEAE

Genus *Cercidiphyllum* SIEB. et ZUCC.

The modern distribution of this genus is confined to East Asia; 2 or 3 living species are existing in northern Japan and China. The fossil remains of this genus have been, however, commonly found from Tertiary flora in the northern hemisphere, and in particular, abundantly in Palaeogene flora. In Japan, the fossil leaves and fruits are abundantly found from Palaeogene coal-bearing formations in Hokkaidô, and also commonly from the lower half of Miocene sediments in Honshû, Kyûshû and Hokkaidô. Considering the occurrence of fossil remains, this genus seems to be one of the declining genera in the vegetable world.

Cercidiphyllum crenatum (UNGER) BROWN

(Pl. 19, Figs. 1, 2)

1850. *Dombeyopsis crenata,* UNGER: Genera et Species plantarum fossilium, p. 448.
1859. *Grewia crenata,* HEER: op. cit. p. 42, Pl. 109, Figs. 12–21; Pl. 110, Figs. 1–11; Pl. i, Fig. 8.
1935. *Cercidiphyllum crenatum,* BROWN: Jour. Palaeont. vol. 9, p. 575, Pl. 68, Figs. 1, 6, 8–10.
1939. *Cercidiphyllum japonicum,* ENDO: op. cit. p. 345, Pl. 23, Fig. 7.
1952. *Cercidiphyllum crenatum,* TANAI: op. cit. p. 129, Pl. 5, Fig. 4.

1955. *Cercidiphyllum crenatum*, HUZIOKA: op. cit. p. 61, Pl. 10, Figs. 6, 7.

Remarks: The present species widely distributed in Neogene flora of the northern hemisphere, is closely similar to the modern *Cercidiphyllum japonicum* SIEB. et ZUCC., which grows now in Hokkaidô and northern Honshû. This fossil species is more or less variable in foliar shape and size, as much as in the living species, but characterized by nervation and marginal characters. *C. crenatum* is closely related to Palaeogene species. *C. arcticum* (HEER) BROWN and *C. ellipticum* (NEWBERRY) BROWN which are abundantly found from Palaeogene coal-bearing formation in Hokkaidô, and sometimes indistinguishable each other. This Neogene species is found from Miocene flora in Japan, and generally common from the Aniai-type flora in Honshû.

Geological horizon: Early to Late Miocene.

Family HAMAMELIDACEAE

Genus *Fothergilla* MURR.

The modern distribution of this genus is confined to southeastern United States and Kashmir region of India, where several living species are now living. The fossil leaves of *Fothergilla* are very rare in the world, and only a few species belonging to this genus have been known from Neogene flora of northeastern Europe and northeastern China. This genus are closely similar to those of the genus *Parrotia* or *Hamamelis* in foliar shape and nervation, and the fossil leaves of these genera have been discussed on their identification by many palaeobotanists. In Japan some fragmental leaves of *Fothergilla* are found by the writer from Miocene flora of Honshû and Hokkaidô.

Fothergilla viburnifolia HU et CHANEY

(Pl. 20, Figs. 1, 3–5)

1940. *Fothergilla vibunifolia*, HU et CHANEY: op. cit. p. 44, Pl. 20, Fig. 3; Pl. 21, Figs. 1, 2; Pl. 22, Figs. 2, 3; Pl. 49, Fig. 4.

1955b. *Parrotia fagifolia*, HUZIOKA: op. cit. p. 6, Pl. 2, Fig. 1.

Remarks: The present specimens are somewhat fragmental, but they are nearly identical to *Fothergilla viburnifolia* HU et CHANEY from Miocene Shantung flora in China. This species is closely similar to the modern *F. gardeni* MURRAY exitsing in southeastern United States. The present fossil species is close to *F. trugaica* GRUB. lately described from

Neogene flora of eastern USSR (KRYSHTOFOVICH, 1956: Pl. 44, fig. 5), but the latter is more narrowly cuneate at base than the former. *Forthergilla viburnifolia* is close similar or nearly identical to *Parrotia fagifolia* (GOEPPERT) HEER from the Schossnitz flora in Germany (MEYER in KRAUSEL, 1920: Pl. 11, fig. 11; Pl. 12, figs. 15-20), which is close to the monotypic species, *P. persica* MEYER, living in northern Iran. Lately, HUZIOKA described *P. fagifolia* from Miocene flora in Fukui Prefecture, but its specimens in probably identical to the present species. This species is not rarely found in Miocene flora of Japan, especially common in the Daijima-type flora.

Genus *Liquidambar* LINNE

4 living species of *Liquidambar* is distributed in Asia, North America and Central America, but the fossil leaves and fruits are abundantly found through Tertiary flora of the world. Though the leaves of this genus resemble those of *Acer* in their foliar appearance, the former is distinctly different by closely fine serration of margin and existence of a gland at each tooth. In Japan, the two fossil pecies have been known from Tertiary flora, and Neogene species is only one, *L. mioformosana* TANAI.

Liquidambar mioformosana TANAI

(Pl. 20, Figs. 2, 6–9)

1883. *Liquidambar formosana*, NATHORST: op. cit. p. 55, Pl. 8, Figs. 6–9.
1888. *Liquidambar formosana*, NATHORST: op. cit. p. 24, Pl. 6, Figs. 14–15.
1920. *Liquidambar formosana*, FLORIN: op. cit. p. 20, Pl. 3, Fig. 4, p. 32, Fig. 4.
1920. *Liquidambar formosana*, KRYSHTOFOVICH: op. cit. p. 9, Pl. 2, Figs. 3–4.
1931. *Liquidambar formosana*, KONNO: op. cit. Pl. 4, Fig. 1; Pl. 12, Fig. 7.
1932. *Liquidambar formosana*, ENDO & MORITA: Sci. Rep. Tôhoku Imp. Univ. Ser. 2, vol. 15, No. 2, p. 47, Pl. 6, Figs. 1–10; Pl. 7, Figs. 1–8.
1941. *Liquidambar formosana*, MIKI: op. cit. p. 275, Pl. 6 A–B, Fig. 14, A–C.
1948. *Liquidambar formosana*, MIKI: op. cit. p. 58, Taf. 6, Fig. 4.
1954. *Liquidambar* cfr. *formosana*, TAKAHASHI: op. cit.
1954. *Liquidambar formosana*, ENDO: Kumamoto Jour. Sci. Ser. B, No. 4, p. 5, Pl. 4, Fig. 10, 11.
1955. *Liquidambar formosana*, OKUTSU: op. cit. p. 98, Pl. 2, Figs. 1–3.
1961. *Liquidambar mioformosana*, TANAI et ONOE: op. cit. p. 40, Pl. 12, Figs. 2–4.

Description: Leaves variable in size, 3 palmately lobed with incised sinuses, orbicular to semiorbicular in general outline, 5 to 12 cm and 6 to 16 cm wide; lobes prolonged, ovate to ovate-lanceolate, and acute or slightly acuminate at apex, lateral lobes nearly at right angle to the medial lobe; margin finely serrate, with acute glandular teeth; base cordate or concave, middle primary nerve stout and straight, lateral primaries leaving middle one at angles of 45 to 60 degrees, nearly straight and then slightly curving upwards near the tips, all primaries run to the tips from the base; secondary nerves from the middle primary 4 to 8 pairs, subopposite to alternate, curving upwards, camptodrome; secondaries fom the lateral pimaries 4 to 6 pairs on outer side and 3 to 5 on inner side, curving upwards, camptodrome; the basal pair of secondaries diverging outwards from the lateral primaries very stout, extending almost parallel to marginal border of later lobes; teriaries thin, irregularly percurrent; nervilles thin, indistinct, coarsely reticulate; petiole stout and thick, 2 to 4 cm long, texture thin, membranaceous. Fruits orbicular in general shape, spiny globose; head hemispherical, composed of coherent capsule; 1.0 to 2.0 cm in diameter; stalk stout, more than 4 cm long.

Remarks: The present species is closely similar to the living *Liquidambar formosana* HANCE which grows now in formosa and South China. Many fossil leaves and fruits fairly identical to this species have been found from Miocene to Pliocene floras in Japan, and especially abundant in Middle Miocene flora, the Daijima-type flora. Though this species was once considered to be one of the index fossils in Cenozoic stratigraphy of Japan, it is, at present, rather available for the climatic indicator.

Among many fossil species of *Liquidambar* in the world, the present species is closely similar in general feature to *L. californicum* LESQ. from Miocene flora of California (LESQUEREUX, 1878; Pl. 6, fig. 7 C; Pl. 7, figs. 3, 6) and *L. pachyphyllum* KNOWLTON from Miocene Latah flora of Washington, the United States (KNOWLTON, 1926: Pl. 9, fig. 1). *L. miosinica* HU et CHANEY from Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 23, figs. 1, 2) is also close to this Japanese species, but the former is more slender and elongate in shape of lobe than the former.

Geological horizon: Early Miocene to Late Pliocene.

Family TROCHODENDRACEAE

Genus *Eucommia* OLIVER

This genus has only one living species in the world, and the modern distribution of it is confined to Central China. The fossil specimens of *Eucommia* were, however, found from Tertiary flora in Europe, North America and Japan. Several fossil fruits of *Eucommia* in Japan were found from Palaeogene to Neogene floras, and only one Neogene species, *E. japonica* TANAI are known up to the present.

Eucommia japonica TANAI sp. nov.

(Pl. 21, Fig. 3)

1941. *Eucommia ulmoides*, MIKI: op. cit. p. 277, Fig. 14 F.

Description: Fruits ovate-elliptical in general outline, with an axial and thickened seeds, about 2 cm long and 0.9 cm wide; seeds fusiform in shape, notched at apex, 0.4 cm wide and 1.3 cm long, surrounded by fibrous wing; wing thin, membrane, with thin venation composed of transversely directed fibrous structure; margin of wing entire but slightly irregular.

Remarks: The present fruits are doubtlessly identified to the genus *Eucommia* by their peculiar shape. Their seeds are ligneous in appearance as preserved as a carbonaceous impression. The fossil seed of *E. ulmoides* OLIVER described from Pliocene flora in Gifu Prefecture by MIKI (1941) is unable to be distinguished from the present new species in general character, though the former is somewhat large in size than the latter. The present species is somewhat similar to *E. eocenica* (BERRY) BROWN from Eocene flora of North America (BROWN, 1940: p. 349).

The present new species is nearly identical to the fruit of the modern *E. ulmoides* OLIVER growing in Central China. Lately, several fruits of *Eucommia* were found from the Eocene Yûbari formation of the Ishikari coal field, Hokkaidô by HUZIOKA, but its description has not yet been given. However, that Eocene specimens are large in wing part comparing to the seed, and they are not so close to the living specimens.

Geological horizon: Middle Miocene to Early Pliocene.

Family PLATANACEAE

Genus *Platanus* LINNE

This genus consisting of about 6 living species is distributed in North America, eastern Europe and southwestern Asia. In Japan there are no living species, but the plane-trees are widely cultivated as roadsite trees in various cities. On the other hand, the fossil remains of this genus have been abundantly described since Late Cretaceous flora in the world, and the genus *Platanus* is one of older genera of dicotyledons in the world. Considering occurrence of fossil remains, this genus appeared from Late Cretaceous time supremely flourished in Early Tertiary, and then gradually declined in Late Tertiary. In Japan, the fossil leaves of this genus were also reported their occurrence since Late Cretaceous time, but they are most abundantly found from Palaeogene flora of Hokkaidô, Honshû and

Kyûshû. While, the fossil remains of this genus have been rarely found from Miocene sediments of Japan, and two species, *Platanus aceroides* GOEP. and *P. guillelmae* GOEP., were found from Early or Middle Miocene flora of Hokkaidô. Lately, *P. huziokae* described from Late Miocene flora of Honshû by SUZUKI (1958), shows a latest occurrence in Japan.

Platanus aceroides GOEPPPERT

(Pl. 25, Fig. 1)

1852. *Platanus aceroides*, GOEPPERT op. cit. p. 21, Pl. 9, Figs. 1-3.
1855. *Platanus aceroides*, HEER: op. cit. p. 71, Pl. 87; Pl. 88, Figs. 5-15.
1937. *Platanus aceroides*, ENDO: Tokyo Hakubutsugaku Zasshi, vol. 35, No. 60, pp. 365-392, Figs. 2, 5.
1943. *Platanus aceroides*, OISHI et HUZIOKA: Jour. Fac. Sci. Hokkaidô Imp. Univ. Ser. 4, vol. 7, No. 1, p. 106, Pl. 15; Pl. 2; Pl. 17, Fig. 4.

Remarks: The present species is one of the widely distributed planetrees in Palaeogene flora of the northern hemisphere. The leaves of this species are somewhat variable in shape and size, but they are generally characterized by stout nervation and cordate base. Though the present specimens from Miocene flora of Hokkaidô, are somewhat incomplete, they are probably identical to this species by nervation and marginal characters. This species along with *P. guillelmae* described below, is one of the Palaeogene elements in Japan, and considered to have survived from Palaeogene flora. *P. aceroides* is commonly found from Palaeogene flora in North America, and also rarely known from Miocene flora.

Geological horizon: Eocene to Middle Miocene (in Japan).

Platanus guillelmae GOEPPERT

1852. *Platanus Guillelmae*, GOEPPERT: op. cit. p. 21, Pl. 11, Figs. 1, 2; Pl. 12, Fig. 5.
1869. *Platanus Guillelmae*, HEER: op. cit. p. 473, Pl. 48, Figs. 1-3; Pl. 49, Fig. 4.
1937. *Platanus Guillelmae*, ENDO: op. cit. p. 388, Fig. 4.
1943. *Platanus Guillelmae*, OISHI et HUZIOKA: op. cit. p. 110, Pl. 17, Figs. 2, 3; Pl. 18, Figs. 2, 3.

Remarks: The present species has been commonly found from Palaeogene flora in North America and Europe, and also from Japan. The rare occurrence of this species from Miocene flora of Japan evidently shows a survival of such Palaeogene elements in Neogene time. This species is somewhat related to *Platanus huziokae* SUZUKI from Late Miocene flora of Yamagata Prefecture (SUZUKI, 1958: Pl. 2, figs. 1, 2; Pl. 3, figs. 1-3) in having cuneate base of leaves.

Geological horizon: Eocene to Middle Miocene (in Japan).

Family MAGNOLIACEAE

Genus *Liriodendron* LINNE

This genus is now in limited distribution, and there are only two living species in the world. One is *Liriodendron tulipifera* L. extensively distributed throughout eastern states of North America, and another is *L. chinensis* SARG. in Central China. However, the fossil leaves or fruits of the tulip-tree have been known since Late Cretaceous time in Europe and North America. In East Asia the fossil remains of this genus have been described only from Neogene flora. Japanese Neogene species are only two: *L. honshuensis* ENDO and *L. fukushimaensis* SUZUKI. The latter is lately described from Late Miocene flora in Fukushima Prefecture by SUZUKI (1959).

Liriodendron honshuensis ENDO

1934. *Liriodendron honshuensis*, ENDO: Proc. Imp. Acad. Tokyo, vol. 10, No. 9, pp 590, Figs. 1, 2.
1940. *Liriodendron honshuensis*, OKUTSU: Jubl. Publ. Prof. YABE's 60th Birthday, vol. 2, p. 629, Pl. 33, Figs. 1, 2.
1943. *Liriodendron honshuensis*, OKUTSU: Acta Phytotax. Geobot. vol. 13, p. 153, Pl. 1, Figs. 1-6.
1955. *Liriodendron honshuensis*, OKUTSU: op. cit. p. 95, Pl. 6, Figs. 1-3.
1958. *Liriodendron* cfr. *honshuensis*, MURAI: op. cit. p. 19, Pl. 1, Fig. 1.
1961. *Liriodendron honshuensis*, TANAI et ONOE: op. cit. p. 40, Pl. 9, Fig. 7.

Remarks: The present species is closely similar in general features to the modern *Liriodendron tulipifera* L. which is growing in southeastern part of North America. This fossil species has been rarely found from Miocene flora in Honshû, and most specimens of it are rather common in Late Miocene flora. It is now represented only by leaf impressions, and there has been found no fossil fruit corresponding to this species.

Geological horizon: Middle to Late Miocene.

Genus *Magnolia* LINNE

About 35 living species of this genus are distributed in the temperate and tropical region of eastern North America, Mexico, East Asia and Himalayas. Among them 5 species are growing in Japan, and 10 species in China. On the other hand, the fossil leaves of this genus have been described from Late Cretaceous to Pleistocene flora in the world. In Japan the fossil *Magnolia* has been reported its occurrence throughout Tertiary time, and the following 2 Neogene species was ascertained by the writer: *Magnolia elliptica* TANAI et ONOE and *M. nipponica* TANAI. Beside them, *M. dicksoniana* NATHORST, *M. ueharae* KONNO and the fossil remains of the living *M. obovata* THUNB. and *M. kobus* DC. are known from Late Miocene or Pliocene flora in Honshû.

Magnolia elliptica TANAI et ONOE

1883. *Magnolia* sp., NATHORST: op. cit. p. 68, Pl. 12, Fig. 1.
1961. *Magnolia elliptica*, TANAI et ONOE: op. cit. p. 40, Pl. 12, Figs. 1, 5.

Remarks: This species is rather rarely found in Neogene flora in Japan. It is closely similar in venation character to *Magnolia eharae* KONNO from Late Miocene Omi flora in Nagano Prefecture, Japan (KONNO, 1930: Pl. 3, figs. 1, 2). Among the living species of *Magnolia* in the East Asia, this fossil species is most close in general outline to *M. liliflora* DESR. living in central China.

Geological horizon: Late Miocene.

Magnolia nipponica TANAI sp. nov.

(Pl. 21, Fig. 9)

1954. *Magnolia* cfr. *Kobus*, TAKAHASHI: op. cit. p. 57, Pl. 5, Fig. 5.

Description: Leaves medium in size, obovate to elliptical in shape, 7.5 to 11 cm long and 4.0 to 6.0 cm wide; base cuneate to obtusely cuneate; apex acute or obtusely pointed; midrib stout, nearly straight; secondary nerves 10 to 12 pairs, subopposite to subalternate, diverging from the midrib at angles of 45 to 60 degrees, gently curving up, branching near the margin, forming marginal loops, sometimes a few slender laterals leaving out from the midrib among main secondaries: tertiaries thin, irregularly percurrent; nervilles finely reticulate, forming polygonal meshes; margin entire; petiole missing; texture thin, membranaceous.

Remarks: Though the present specimens are somewhat variable in foliar shape, the vanation character is fairly identical to those of the genus *Magnolia*. This new species is closely similar in general characters to the modern *Magnolia kobus* DC., which is widely distributed in Japan and southern Korea. This fossil species is close to *M. miocenica* HU et

CHANEY from the Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 20, fig. 2; Pl. 21, figs. 3-5), and sometimes indistinguishable each other. The fossil seeds of the modern *Magnolia kobus* was described from Pliocene fora in western Honshû, Japan by MIKI (1937, 1940).

Geological horizon: Middle Miocene to Pliocene.

Family LAURACEAE

Genus *Actinodaphne* NEES

About one hundred living species of this genus are distributed in the tropical or subtropical region of Asia and Malaysia. However, the fossil remains of this genus has been scarcely known in the world. Lately, the writer could find some fossil leaves being identical to this genus from Miocene flora in Honshû, Japan.

Actinodaphne nipponica TANAI sp. nov.

(Pl. 21, Figs. 1, 9, 10; Pl. 22, Fig. 6; Pl. 24, Fig. 19)

Description: Leaves lanceolate in general outline, 8.5 to 14 cm (estimated) long and 1.8 to 2.6 cm wide; base somewhat inequilateral, gradually narrowed, cuneate; apex lacking, but gradually narowed, probably acuminate; midrib stout and thick, nearly straight to slightly arched, prominent on the under surface of leaf; secondaries 18 to 20 pairs, subopposite to subalternate, diverging from the midrib at angles of 60 to 70 degrees at the basal narrow part, above at 40 to 55 degrees, curving up in the outer half of the leaf and forming loops with the tertiary branches within the margin; tertiaries in the intersecondary spaces thin but distinct, irregularly percurrent; nervilles obscure, forming fine meshes; margin entire; petiole stout, and thick; texture thick, subcoriaceous.

Remarks: The present specimens being in well-preservation, are most closely similar to the modern *Actinodaphne longifolia* (BLUME) NAKAI living in southern Japan and Loochoo islands, although they have some resemblance in outline to the genus *Lithocarpus*. This new species is characterized by a falcately-lanceolate shape and secondary nervation. It is the first occurrence of this genus in Japan, and no fossil leaves are comparable to this species. However, among many fossil leaves described as various generic name such as *Persea, Laurus, Quercus, Ocotea,* etc. in the world, some of them are closely similar to the present specimens. For instance, *Laurus princeps* HEER from Europe and *Persea lanceolata* (BERRY) BROWN (BROWN, 1946: p. 348; BERRY, 1929: Pl. 59, fig. 1) from

North America are closely similar to the present new species.

Geological horizon: Middle Miocene.

Genus *Cinnamomum* BLUME

About one hundred living species of this genus are now distributed in the tropical or subtropical region of Asia, and also several species is growing in Australia. On the contrary, the fossil cinnamons have been widely distributed throughout Tertiary flora in the world, and particularly abundant from Eocene to Miocene floras. In Japan the fossil leaves of cinnamons are not rarely found from Late Eocene to Late Pliocene floras and, in particular, common in Middle Miocene flora. Neogene species of *Cinnamomum* in Japan are following two: *Cinnamomum miocenum* MORITA and *C. oguniense* MORITA. Beside these two species, *C. lanceolatum* HEER and *C. scheuchzeri* HEER was figured from Miocene flora in Yamagata nd Hyôgo Prefectures. Some fragmental leaves of *Cinnamomum* was known from Neogene flora in Honshû.

Cinnamomum miocenum MORITA

(Pl. 23, Fig. 6)

1888. *Cinnamophyllum* sp., NATHORST: op. cit. p. 9, Pl. 2, Fig. 7.
1931. *Cinnamomum miocenum*, MORITA: Jap. Jour. Geol. Geogr. vol. 9, Nos. 1–2, p 6, Pl. 1, Fig. 6.
1954. *Cinnamomum* cfr. *Camphora*, TAKAHASHI: op. cit. p. 58, Pl. 6, Fig. 2.
1955. *Cinnamomum miocenum*, TANAI: op. cit. Pl. 12, Fig. 2.

Remarks: The present species was, at first, described from Miocene Oguni flora, and then commonly found from Miocene and Pliocene floras in several localities of Honshû by the writer. Though the fossil leaves from Pliocene flora are generally small in outline, they are fairly identical to the present species in the shape and venation character. This fossil species is closely similar to the modern *Cinnamomum camphora* NEES et EBERM., which is living in Honshû, Shikoku and Kyûshû, and extends to Formosa and China. The present species is one of the representatives in the Daijima-type flora, along with next species, and becomes an indicator for warm climate at Middle Miocene time.

Geological horizon: Middle Miocene to Late Pliocene.

Cinnamomum oguniense MORITA
(Pl. 23, Fig. 3)

1931. *Cinnamomum oguniense*, MORITA: op. cit. p. 6, Pl. 1, Figs. 7–9.
1955. *Cinnamomum oguniense*, TANAI: op. cit. Pl. 12, Fig. 3.

Remarks: The present species is characterized by elliptical shape and triplinervation being diverging at very base, and distinctly distinguishable from the fore-described species, *C. miocenum*, by such characters. This species is closely similar to *Cryptocarva ennichiensis* TANAI from Miocene flora in southern Korea (TANAI, 1952b.: Pl. 22, fig. 3), but different in secondary nervation. *C. oguniense* is somewhat close to *C. scheuchzeri* HEER which is widely-distributed in Miocene flora of Europe, but differs in nervation and basal character. Among the living cinnamon trees, the leaves of this fossil species is closely similar in nervation to those of *C. reticulata* HAYATA in Formosa, but different in basal character.

Geological horizon: Middle Miocene.

Genus *Lindera* THUNB.

About one hundred living species of this genus are distributed in the warm and tropical regions of the northern hemisphere, and a great number of them are living in East Asia. The fossil leaves of this genus have been described from Tertiary flora of the northern hemisphere, but they are not abundant in number of species and specimens. In Japan, the fossil *Lindera* has been rarely found from Neogene flora, though there are 7 living species at present.

Lindera gaudini (NATHORST) TANAI n. emend.
(Pl. 22, Fig. 1)

1888. *Lauriphyllum Gaudini*, NATHORST: op. cit. p. 9, Pl. 2, Fig. 6.

Description: Leaves elliptical or elliptical-obovate in general outline, 6 to 7 cm long and 2.7 to 3 cm wide; base rounded or broadly cuneate; apex obtusely pointed; midrib stout below, thinner distantly, nearly straight to the tip; secondary nerves rather slender, somewhat irregularly spaced, 7 to 9 pairs, diverging from the midrib at angles of 35 to 45 degrees, gently curving up, then ascending along the margin; tertiaries and nervilles indistinct; margin entire; texture thick, subcoriaceous; petiole stout, over 3 mm long.

Remarks: The present materials are identified to the genus *Lindera* with some hesitation, however they are close to the modern *L. glauca* (S. et Z.) BLUME in their foliar shape and venation. This species is distinctly different in secondary nervation from the leaves of *L. sericea* BL. fossilis NATHORST which was described from Pliocene Mogi flora of Kyûshû (NATHORST, 1883: Pl. 8, figs. 2, 3). Another allied species are *Benzoin umbellta* REHD. from Pliocene flora of Gifu Prefecture (MIKI, 1941: fig. 13 K) and *Parabenzoin protopraecox* (ENDO) described below, but the latter two differ from this species in foliar shape and venation. Some leaves of *Diospyros nordqvisti* NATHORST somewhat similar to the present specimens (NATHORST, 1883: Pl. 8, fig. 4), but the former is more stout in secondary nerves than the latter.

The close living species, *L. glauca,* is distributed in central and western Honshû, Shikoku and Kyûshû, extending China, Formosa and Korea.

Geological horizon: Middle Miocene.

Genus *Machilus* NEES.

The modern distribution of this genus is confined to the warm or warm-temperate regions of East Asia, and about 60 species are living in China, Japan and southeastern Asia. The fossil remains of this genus have been scarcely known from Tertiary flora in the world. This genus is difficult to be determined by only leaf-impression as much as other most genera of Lauraceae.

Machilus ugoana HUZIOKA

(Pl. 22, Fig. 3)

1949. *Machilus ugoana,* HUZIOKA: op. cit. Pl. 11, Fig. 4.

Description: Leaves lanceolate in general outline, 7 to 7.5 cm long (estimated) and 1.7 to 2 cm wide; apex gradually narrowed, but with rather obtuse tip; base narrowly cuneate; midrib rather stout, nearly straight, prominent on the lower surface, secondary nerves slender and thin, 8 to 11 pairs, subopposite to alternate, diverging from the midrib at angles of 30 to 40 degrees on the middle part of blade, and at more angles at the basal part, gently curving upward, then ascending along the margin to connect the above one, branching off a few finer tertiaries, camptodrome; intersecondary tertiaries and nervilles indistinct; margin entire; texture firm, subcoriaceous; petiole missing.

Remarks: The present species was established by HUZIOKA (1949) on the basis of leaf-impressions from Miocene flora of Oga peninsula, northeastern Honshû, but the description has not yet been published. The present specimens are fairly identical in shape and nervation to this species. The leaves of this fossil species is closely similar to those of the modern *Machilus japonica* S. et Z., though they are somewhat less in number of secondary nerves than the latter. This related living species is now distributed in southern Honshû and Kyûsh, extending to southern Korea and Loochoos. The present fossil species is the first occurrence of the genus *Machilus* in Japan.

Geological horizon: Middle Miocene.

Genus *Neolitsea* MERRILL.

The modern distribution of this genus is confined from warm-temperate to subtropical region in Asia, and about 60 living species are distributed in Japan, China, Malaysia and India. The fossil remains of this genus are very rare in the world: several fossil species have been known from Tertiary flora in North America and Europe. Only one species, *Neolitsea japonica* TANAI, is found by the writer from Miocene flora of Japan, but MIKI (1938) described the fossil leaves of *N. aciculata* KOIDZ. from Late Pleistocene flora in Kinki district, western Honshû.

Neolitsea japonica TANAI sp. nov.

(Pl. 22, Fig. 8)

Description: Leaves lanceolate in shape, 8 to 11 cm (estimated) long and 2.5 to 3 cm wide; base gradually narrowed or cuneate; apex unknown but probably acute; tri-plinerved at the portion distant from the base; midrib stout, slightly curved; a pair of lateral primary nerves emerging a little above from the base, diverging from the midrib at angles of about 20 degrees, then curving up along the margin somewhat beyond the middle part of the blade; slender secondaries irregularly diverging from the midrib in the upper half of the leaf, 3 or 4 pairs subparallel to the lateral primaries, curving upward, forming loops within the margin; tertiaries thin, indistinct but finely reticulate; petiole lacking; texture coriaceous.

Remarks: Though the present specimens are somewhat fragmental incomplete in preservation, they are characterized by tri-plinervation being apart from the base. They are closely similar in general character to the modern *Neolitsea sericea* (BLUME) KOIDZ. which is living in Honshû, Shikoku and Kyûshû, Japan, extending to Formosa and China. The present specimens at somewhat close to the fossil leaves of *N. aciculata* KOIDZ. from Pleistocene flora near Biwa Lake of western Honshû (MIKI, 1938: Fig. 5 L), but differs in secondary venation. They also resemble *Laurus styracifolia* WEBER from Oligocene flora of Germany (WEYLAND, 1937: Pl. 37, fig. 3; Text-fig. 19). Another close fossil is *Lindera oregoniana* (KOWLTON) CHANEY et AXELROD from Miocene Mascall flora of Oregon, the United States (CHANNEY et AXELROD, 1959: Pl. 34, fig. 5).

Geological horizon: Middle Miocene.

Genus *Parabenzoin* NAKAI

The modern distribution of this genus is confined to East Asia, and 2 living species are growing in Japan and China. On the other hand, the fossil leaves of this genus has been commonly found from Miocene sediments in Japan. However, no fossil record has been found from Tertiary flora in Europe and North America. Because, it is frequently difficult that this genus is distinguished from other genera of Lauraceae. The writer found only one species, *Parabenzoin protopraecox* (ENDO), from Miocene flora of Japan, and MIKI (1937) found the fossil seeds of *P. trilobum* (S. et Z.) NAKAI from Late Pliocene flora, near Akashi City.

Parabenzoin protopraecox (ENDO) TANAI new comb.

(Pl. 21, Figs. 5, 8, 11; Pl. 22, Figs 4, 5)

1955. *Lindera protopraecox*, ENDO: op. cit. Pl. 27, Fig. 2.

Description: Leaves medium in size, ovate to elliptical in shape, 4.5 to 7 cm long and 2.5 to 4 cm wide; apex acute or slightly acuminate, sometimes tapered; base broadly cuneate, rarely rounded; midrib stout, straight, thick below and gradually thin toward apex; secondaries thin, 5 to 7 pairs, opposite to subopposite diverging from the midrib at angles of about 40 degrees, curving up along the margin and then forming loops; tertiaries inconspicuous, forming a coarse and irregular network in the inter-secondary spaces; margin entire, sometimes slightly revolute; petiole stout but short, 2 to 4 mm long; texture thin, subcoriaceous.

Remarks: The present specimens are commonly found from Middle Miocene flora in Honshû and southwestern Hokkaidô. They are fairly identical to *Lindera protopraecox* ENDO figured from Late Miocene flora in Akita Prefecture by ENDO (1955), which is closely similar to the modern

Parabenzoin praecox (SEIB. et ZUCC.) NAKAI existing in Honshû, Shikoku and Kyûshû, Japan. This fossil species is closely similar to *Nectandra presanguinea* CHANEY et SANBORN from the Goshen Eocene flora of Oregon, the United States (CHANEY et SANBORN, 1933: Pl. 18, figs. 1, 2, 5, 7). It is also very close to the fossil leaves of *Benzoin umbellata* REHD. described from Pliocene flora in Gifu Prefecture (MIKI, 1941: Fig. 13 J-K), though the latter is generally larger-sized than the former.

Geological horizon: Middle to Late Miocene.

Genus *Sassafras* NEES.

The modern distribution of this genus is confined in southeastern part of the United States, Central China and Formosa. There are only 3 species in the world: *S. Sassafras* KARST in North America, *S. tzumu* HEMSL. in China and *S. randaiense* (HAYATA) REHD. in Formosa. However, many fossil species of *Sassafras* have been found from Cretaceout to Tertiary floras in Europe, Arctic region, North America and Japan. Namely, this genus is one of the most ancient genera of dicotyledons in the vegetable world.

In Japan 5 species of *Sassafras* were described from Tertiary flora, and among them the following 4 were known from Neogene flora: *S. subtriloba* (KONNO), *S. yabei* ENDO et OKUTSU, *S. endoi* HUZIOKA and *S. yamanei* IMAMURA. Among these 4 species, the former two were confirmed by the writer at this time. All of Japanese Neogene leaves of *Sassafras* are characterized by decurrent base and commonly trilobate shape.

Sassafras subtriloba (KONNO) TANAI et ONOE

(Pl. 22, Fig. 7; Pl. 23, Figs. 4, 5, 7)

1931. *Lindera subtriloba*, KONNO: op. cit. Pl. 18, Figs. 1–8.
1952. *Sassafras Oishii*, OKUTSU: Saitô Hô-on Kai Mus. Res. Bull., No. 23, p. 9, Pl. 1, Fig. 2.
1955. *Sassafras Oishii*, OKUTSU: op. cit. p. 96, Pl. 3, Figs. 2a, 2b.
1959. *Sassafras Oishii*, SUZUKI: op. cit. p. 39, Pl. 4, Figs. 4, 5.
1961. *Sassafras subtriloba*, TANAI et ONOE: op. cit. p. 40, Pl. 13, Figs. 1–5.

Remarks: The present species is characterized by secondary nervation of decurrent basal part of leaves. Namely, a pair of prominent secondaries in decurrent part diverges from the midrib at angles of 30 to 50 degrees, and then extends nearly parallel to the basal margin. The leaves of this species are usually trilobate, but rarely not lobate. For example, the fossil leaf from Miocene flora of Nishitagawa coal field, northeastern Honshû (Pl. 23, fig. 7), has a characteristic venation of *Sassafras subtriloba,* but it has a very small lobe on one side of the blade. Such variation of leaf-form is usually observed in the modern *Sassafras.*

Among the fossil leaves of *Sassafras* in the world, the present species is most closely similar to *S. hesperia* BERRY, (BERRY, 1929: Pl. 59, fig. 2; BROWN, 1937: Pl. 53, figs. 7-10), which was described from Miocene flora of the United States. *S. subtriloba* is closely related to the modern *S. tzumu* HEMSL. in Central China and *S. sassafras* KARST. in eastern United States in their general character. The present species is not always abundantly found in Neogene flora of Japan, however, it is comparatively common from Late Miocene flora, and rare from Middle Miocene.

Geological horizon: Middle to Late Miocene.

Sassafras yabei ENDO et OKUTSU

(Pl. 23, Fig. 1)

1936. *Sassafras Yabei,* ENDO et OKUTSU: Proc. Imp. Acad. vol. 12, No. 2, p. 47, Figs. 2-4.
1952. *Sassafras Yabei,* OKUTSU: op. cit. p. 10, Pl. 1, Figs. 1a, 1b.
1955. *Sassafras Yabei,* OKUTSU: op. cit. p. 97, Pl. 3, Figs. 1a, 1b.

Remarks: This species, along with the above-described *S. subtriloba,* is found from Late Miocene flora of Honshû. It is closely similar in general appearance to *S. subtriloba,* but differs from the latter in shape of lobes and nervation. The lobes of the latter species are generally more elongate in shape than those of the former. The present fossil species is closely related to the living *S. tzumu* in China, and also somewhat close in general outline to the modern *Lindera obtusiloba* BLUME which is growing in southern Honshû, Shikoku and Kyûshû, Japan, extending to Korea and China.

Geological horizon: Late Miocene.

Family SAXIFRAGACEAE

Genus *Schizophragma* S. et Z.

This genus is confined to East Asia in modern distribution, and only several species are living there. The fossil remains of this genus have been very rarely found from Late Tertiary and Pleistocene flora of Honshû, Japan.

Schizophragma mitokuensis TANAI et ONOE

1961. *Schizophragma mitokuensis*, TANAI et ONOE: op. cit. p. 42, Pl. 11, Fig. 4.

Remarks: The present species is very rare in Neogene flora of Japan and only one specimen was found from western Honshû. The modern species being close to this fossil species is *Schizophragma hydrangeoides* S. et Z. widely distributed in Japan. The fossil leaves of this living species occurred from Pleistocene Shiobara flora of Honshû.

Geological horizon: Late Miocene.

Genus *Hydrangea* LINNE

More than 50 living species of this genus are distributed in the temperate and warm region of East Asia, India and North America. The fossil leaves of calyxes of this genus have been known throughout Tertiary flora in the northern hemisphere. However, the fossil remains of *Hydrangea* are rather rare in Tertiary flora of Japan, and the writer found only two species, *H. lanceolimba* HU et CHANEY and *H. miobretshneideri* HU et CHANEY from Miocene flora. Beside this species, OKUTSU (1940) described *H. sendaiensis* OKUTSU on the basis of fossil calyx occurred from Late Miocene flora near Sendai.

Hydrangea lanceolimba HU et CHANEY

(Pl. 25, Fig. 11a)

1940. *Hydrangea lanceolimba*, HU et CHANEY: op. cit. p. 50, Pl. 25, Figs. 5, 6.

Remarks: The present species represented by fossil leaves is found from Miocene flora in various localities of Hokkaidô, Honshû and Kyûshû. This species established in Miocene Shanwang flora, is closely similar to the modern *H. umbellata* REHDER living in southeastern China.

Geological horizon: Early to Middle Miocene (in Japan).

Hydrangea miobretshneideri HU et CHANEY

(Pl. 25, Fig. 11b)

1940. *Hydrangea miobretschneideri*, HU et CHANEY: op. cit. p. 50, Pl. 25, Fig. 7.

Remarks: The several fossil leaves occurred from the Sasebo coal field, are nearly identical to this species, though they are somewhat fragmental. The present sepcies is close to the above-noted *H. lanceolimba*, but distinctly different in foliar shape, marginal serration and character of secondary nerves. The modern equivalent of this fossil species, *H. bretschneideri* DIPPEL, is now distributed in North China.

Geological horizon: Early to Middle Miocene (in Japan).

Family ROSACEAE

Genus *Prunus* LINNE

About 200 living species of this genus are widely distributed in the temperate and warm regions of the world, and some of them are of great economic value. In Japan native or cultivate species are 25 in number, and some of them are famous by beautiful blossom. Fossil leaves or seeds have been found throughout Tertiary sediments in North America and Europe, and also several fossil species of *Prunus* has been also described from Neogene flora in East Asia. The writer ascertained two Neogene species, *Prunus protossiori* TANAI et ONOE and *P. miobrachypoda* HU et CHANEY in Japan. Beside them, the fossil seeds of *P. haussknechti* SCH., *P. sibirica* L. and *P. triloba* MAX. were found from Pliocene sediments in Honshû by MIKI (1937, 1938).

Prunus protossiori TANAI et ONOE

1955. *Prunus Ssiori*, OKUTSU: op. cit. p. 100, Pl. 4, Fig. 2.
1961. *Prunus protossiori*, TANAI et ONOE: op. cit. p. 44, Pl. 13, Figs. 6, 7.

Remarks: This species represented by leaves and seeds, is closely similar to the modern *Prunus ssiori* SCHMIDT., which is now distributed from Southern Kruile islands at the north to central Honshû at the south. The present fossil species is not so abundant in Neogene flora of Japan, but commonly found from Late Miocene flora of Honshû.

Geological horizon: Late Miocene.

Prunus miobrachypoda HU et CHANEY

(Pl. 5, Fig. 15)

1940. *Prunus miobrachypoda*, HU et CHANEY: op. cit. p. 48, Pl. 23, Figs. 3, 4; Pl. 24, Fig. 7; Pl. 25, Fig. 4.

Remarks: The present species is represented by leaf-impressions being closely related to the modern *Prunus brachypoda* BATAL or its varieties living in central and western China. The leaves of this fossil species are variable in shape and marginal character; ovate to obovate in general outline, and in margin entire or obscurely dentate or rarely with sharp, closely-spaced teeth.

The present fossil leaves are ovate in shape, rounded at the base, and apparently entire in margin. They are fairly identical to some leaves of original specimens from Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 23, fig. 4). This species is very rarely found from Miocene flora of Japan, and from Middle Miocene flora of northern Hokkaidô as far as known up to the present.

Geological horizon: Middle Miocene (in Japan).

Genus *Rosa* LINNE

About one hundred species of the living rose are distributed in warm or temperate regions of the northern hemisphere. In Japan about 9 species are growing, but there are also found many varieties of these species. The fossil remains of this genus are not so common in the Tertiary flora of the world, however they are found from Palaeogene to Pleistocene sediments. In Neogene flora of Japan, fossil rose is comparatively rare, and only one species was ascertained by the writer. However, beside this species, *R. akashiensis* MIKI and *R. polyantha S.* et Z. were described by MIKI (1937) from Late Pilocene flora Honshû.

Rosa usyuensis TANAI

(Pl. 24, Figs. 5, 6, 9)

1955. *Rosa usyuensis*, TANAI: op. cit. Pl. 13, Fig. 5.

Description: Leaflets small, ovate to broadly elliptic, 1.8 to 2.2 cm long and 1.2 to 1.3 cm wide; apex obtuse; base rounded or broadly cuneate; midrib rather slender, somewhat flexuous; secondaries thin and slender 6 to 8 subalternate pairs, diverging from the midrib at angles of about 50 degrees, curving upward near the margin, then forming loops with small branches which enter into the marginal teeth; tertiaries indistinct, reticulate; margin finely serrate, with small and acute teeth; petiolules short and slender, 1 mm in length; texture thin, membranaceous.

Remarks: Though the present materials are somewhat in ill-preservation, they are identical to the genus *Rosa* by the vanation and marginal character. These specimens are most closely similar to the living *Rosa taiwanensis* NAKAI, which is one of the endemic species in Formosa and distributed in central and northern Formosa. They are also close to *R. multiflora* THUNB. which is now widely distributed in Japan, North Japan and Korea. Among the fossil roses, the present species is very close to *R. akashiensis* MIKI (MIKI, 1937: Fig. 5 A-E), which was described from the Pliocene deposits near Akashi, Hyôgo Prefecture. The present species is also similar to *R. alvordensis* AXELROD from Early Pliocene flora of Oregon, United States (AXELROD, 1944: Pl. 44, fig. 5).

Geological horizon: Early to Middle Miocene.

Genus *Sorbus* LINNE

About 80 living species of this genus are widely distributed in the temperate and subboreal region of the northern hemisphere. The fossil leaflets of this genus have been known throughout Tertiary flora in North America and Europe, though their species are not so abundant. From Neogene flora of Japan, the writer found only one species: *Sorbus nipponica* TANAI et ONOE.

Sorbus nipponica TANAI et ONOE

(Pl. 24, Figs. 7, 8)

1955. *Sorbus* sp., TANAI: op. cit. Pl. 12, Figs. 3, 4.
1961. *Sorbus nipponica*, TANAI et ONOE: op. cit. p. 44, Pl. 14, Fig. 8.

Remarks: The fossil leaflets of this species are closely similar to those of the modern *Sorbus comixta* HEDL. in Hokkaidô, Honshû, Shikoku and Kyûshû, Japan. The present fossil species is commonly found from the Aniai-type flora of Middle Miocene time, and rarely from Late Miocene flora.

Geological horizon: Middle to Late Miocene.

Family LEGUMINOCEAE

This family is widely distributed over the world, especially in the tropical region. The family Leguminoceae contains 550 genera and about 13000 living species in the world. While, about 30 genera of this family have been known as the fossil records in the past vegetable world. It is frequently difficult to identify to this family by only leaf-impressions.

Genus *Cercis* LINNE

About 9 living species of this genus are distributed in East Asia, North America and Europe. Fossil *Cercis* has been found throughout

Tertiary flora in the northern hemisphere, and rather common in the Palaeogene. The living trees of this genus are cultivate in various areas of Japan, but they are not native at present. However, this genus has been found from Neogene flora in Honshû, and the following 2 species are known: *Cercis endoi* SUZUKI and *C. japonica* KRYSHTOFOVICH. The fossil leaf of the latter is, however, so fragmental to be identified to this genus.

Cercis endoi SUZUKI

(Pl. 24, Fig. 1)

1958. *Cercis Endoi*, SUZUKI: Trans. Proc. Palaeont. Soc. Japan, N. S. No. 29, p. 170, Pl. 25, Figs. a, b.

Remarks: The present specimens doubtlessly belong to the genus *Cercis* in their shape and nervation, and are identical to *C. endoi* which was lately described from Late Miocene flora in Fukushima Prefecture. They are more deeply cordate at the base than the original specimens. However, the modern leaves of *Cercis* are variable in basal form, from broadly to deeply cordate. This fossil species is closely similar in foliar shape and nervation to *C. miochinensis* HU et CHANEY from Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 26, figs. 3, 4). *C. endoi* is related to the modern *C. chinensis* OLIVER in China or *C. canadensis* L. in North America.

Geological horizon: Late Miocene.

Genus *Entada* ADANS.

The living species of this genus are distributed in the tropical region of the world. The fossil remains of *Entada* are very rarely found from Tertiary flora of the world, and only one species, *Entada mioformosana* TANAI has been known from Neogene flora in Japan.

Entada mioformosana TANAI

(Pl. 24, Fig. 2)

1952. *Entada formosana*, TANAI: op. cit. p. 233, Pl. 22, Figs. 6, 7.
1954. *Entada formosana*, TAKAHASHI: op. cit. p. 59, Pl. 6, Figs, 1a–i.
1955. *Entada mioformosana*, TANAI: op. cit. Pl. 13, Figs. 10, 11.

Description: Leaflets small in size, elliptical to ovate in general shape, 1.8 to 3.5 cm long and 0.9 to 1.8 cm wide; base rounded, slightly asymmetrial; apex rounded and slightly emarginate; midrib stout, straight; secondaries slender, irregularly spaced, diverging from the midrib at angles of 35 to 45 degrees, curving upward along the margin, then forking and forming marginal loops; tertiaries irregularly percurrent; nervilles finely reticulate; texture firm; petiole very short, 1 to 2 mm long.

Remarks: The present small leaflets are closely similar in shape and nervation to *Entada formosana* KANEHIRA which is one of the endemic species in Formosa. They are somewhat similar to some leaflets of the genus *Dalbergia* or *Gledtchia.* This fossil species is similar to *Cassia emarginata* BERRY from Eocene flora of North America (BERRY, 1916: Pl. 45, fig. 17 b; Pl. 48, fig. 5).

The present species is commonly found from the Middle Miocene Daijima-type flora, and became one of indicators of warm climate at that time.

Geological horizon: Middle Miocene to Late Pliocene.

Genus *Robinia* LINNE

About 20 living species of this genus are found in North and Central America, and native tree of *Robinia* is not existing in East Asia. However, the fossil materials of this genus were frequently found from Tertiary flora in the world. The occurrence of *Robinia* has been reported from Miocene floras of Japan and Korea by ENDO, KANEHARA and others, but their fossils are not yet described. The writer found the fossil leaflets and fruits of *Robinia* from Miocene floras in Honshû and Hokkaidô.

Robinia nipponica TANAI sp. nov.

(Pl. 24, Figs. 10, 11, 16; Pl. 25, Fig. 3)

Description: Leaflets small in size, oval and slightly inequilateral in general outline, 1.2 to 2.7 cm long and 0.9 to 1.8 cm long; apex obtusely pointed or emarginate; base rounded or broadly rounded; midrib stout, straight to the tip; secondaries slender and thin, 5 to 7 subopposite pairs, irregularly spaced, diverging from the midrib at angles of 40 to 50 degrees on the middle, more extending near the base, curving upward, camptodrome; tertiaries indistinct; margin entire; petiolules short, 1 to 2 mm in length; texture thin, membranaceous.

Pods linear-lanceolate in shape, about 6 cm long (estimated) and 0.9 to 1.0 cm wide on the middle, flat and comparatively thin.

Remarks: The present leaflets are closely similar to the genus *Robi-*

nia in their outline and nervation, and the identification is strengthened by the fact that several pods quite identical to *Robinia* were found with these leaflets from some localities. These specimens are closely similar to the leaflets and pods of *R. californica* AXELROD from Miocene to Pliocene floras in western part of the United States (AXELROD, 1939: Pl. 9, figs. 10-12; 1956: Pl. 30, figs. 2-6). However, the leaflets of the latter are generally narrower in width and cuneate in base than those of the former. It is also similar to *R. lesquereuxi* (ETTING.) MAGGIN. from Oligocene Florissant flora of Colorado, the United States (MAGGINITIE, 1953: Pl. 45, figs. 1, 2, 4; Pl. 46, fig. 3), but differs in foliar shape.

The present fossil leaflets are nearly identical with those of the living *R. viscosa* VENT., which is now restricted to the high slopes of the Alleghany Mountains in eastern United States. The pod of living species usually are covered with glandular-hispid hairs, where as the present fossil specimens appear to be glabrous. However, their hairs were considered to be lost in transport. The leaflets also resemble those of *Sophora*, *Amorpha* or *Cladrastis* in general feature.

Geological horizon: Middle Miocene.

Genus *Sophora* LINNE

About 20 living species of this genus are distributed in tropical or warm region of the world, and in Japan only one species is existing now. While, the fossil leaflets of this genus have been known from Tertiary flora in the northern hemisphere. It is frequently difficult to identify to this genus by only leaflets-impressions as well as other genera of the pea family.

Sophora miojaponica HU et CHANEY

(Pl. 24, Figs. 13, 14, 21, 22)

1940. *Sophora miojaponica*, HU et CHANEY: op. cit. p. 53, Pl. 27, Figs. 1, 3.
1955. *Sophora miojaponica*, TANAI: op. cit. Pl. 13, Fig. 8.

Remarks: The present species described at first from Miocene Shanwang flora of China, was represented by only leaflet-impressions, and it is commonly found from Middle Miocene flora in Japan. The leaflets of this fossil species are closely similar in general character to the modern *Sophora japonica* LINNE which is widely distributed in the whole of China, extending to Korea. This species resembles *Rhus miosuccedanea* HU et CHANEY described below in general appearance.

Geological horizon: Early to Late Miocene.

Genus *Wistaria* NUTT.

Several living species of this genus is distributed in temperate region of Eastern Asia and North America. The fossil *Wistaria* is rare in Tertiary flora of the world, however, in Japan fossil leaflets and pods have been occurred from upper half of Neogene sediments. The following two species are known from Honshû and Kyûshû: *Wistaria fallax* (NATHORST) and *W. ligniata* MIKI.

Wistaria fallax (NATHORST) TANAI et ONOE

(Pl. 25, Fig. 4)

1883. *Sophora* (?) *fallax*, NATHORST: op. cit. p. 58, Pl. 10, Figs. 11, 12; Pl. 12, Figs. 1, 2.
1931. *Krauhia fallaxi*, KONNO: op. cit. Pl. 16, Fig. 8; Pl. 18, Figs. 9, 10; Pl. 19, Figs. 2, 4-8, 10; Pl. 20, Figs. 1, 2.
1937. *Wistaria floribunda*, MIKI: op. cit. p. 318, Fig. 6 F-H.
1938. *Wistaria floribunda*, MIKI: op. cit. p. 220, Fig. 5 G; p. 224, Fig. 6 J; p. 237, Fig. 14 K.
1954. Cfr. *Wistaria floribunda*, HUZIOKA et SUZUKI: op. cit. p. 140.
1954. *Wistaria* cfr. *brachybotys*, TAKAHASHI: op. cit. S. 58, Taf. 6, Figs. 7a, b.
1959. *Wistaria* sp., TANAI et ONOE: op. cit. p. 281, Pl. 7, Fig. 5.
1961. *Wistaria fallax*, TANAI et ONOE: op. cit. p. 45, Pl. 10, Fig. 6; Pl. 14, Fig. 2-4.

Remarks: The present sepcies represented by both leaflets and pods, is rather commonly found from Neogene flora in Japan, and especially abundant in Late Miocene and Pliocene floras. This species is closely similar to the modern *Wistaria floribunda* DC. which is distributed from Honshû to Kyûshû, extending to China. The leaflets of this fossil species are closely similar to those of *W. ligniata* MIKI from Pliocene flora of Gifu Prefecture, (MIKI, 1940: Fig. 15, C, D) and some of them are frequently indistinguishable from some of the latter.

Geological horizon: Middle Miocene to Late Pliocene.

Family ANACARDIACEAE

Genus *Pistacia* L.

About 9 living species of the genus *Pistacia* is distributed mainly in warm or subtropical regions of China, Formosa, India, Mexico, etc. The fossil specimens of this genus are rather rare in the past flora of the world. Though this genus is extinct at present in Japan, several fossil leaves has been found from Miocene flora.

Pistacia miochinensis HU et CHANEY
(Pl. 24, Fig. 12)

1940. *Pistacia miochinensis*, HU et CHANEY: op. cit. p. 62, Pl. 36, Figs. 1-3, 5, 9.
1955. *Pistacia miochinensis*, TANAI: op. cit. Pl. 14, Figs. 3, 4.

Remarks: The present specimens are quite identical to this species described from Miocene Shanwang flora of China, by their narrow-lanceolate leaves and asymmetrical base. These fossil leaves closely correspond in all aspects to those of the living *Pistacia chinensis* BUNGE. which is widely distributed from North China southward to India, Phillipine and Formosa. The living species in Formosa are scattered in the ravines and river beds, mostly in the southern part of this island.

This fossil species is only known from the Daijima-type flora in several localities of Honshû.

Geological horizon: Middle Miocene.

Genus *Rhus* LINNE

About 150 living species of this genus are widely distributed in the world, and growing mainly in the tropical or subtropical regions and the warmer part of temperate region. Among these living species 5 are native in Japan and 8 in China. The fossil leaflets of *Rhus* have been commonly found from Tertiary flora in North America and Europe, while in Japan not so common. Japanese Neogene species are the following 3: *Rhus ezoense* TANAI, *R. miosuccedanea* HU et CHANEY and *R. protoambigua* SUZUKI.

Rhus ezoense TANAI sp. nov.
(Pl. 24, Fig. 23)

Description: Leaflets oblong-ovate in general outline, more than 4.2 cm long and 1.7 cm wide, nearly equilateral and rounded at base, acuminate at apex; midrib stout below, distantly slender, somewhat flexous, extending to the tip; 9 to 11 pairs of secondaries irregularly spaced, diverging from the midrib at variable angles ranged from 45 nearly 90 degrees, arched up, near the margin abruptly arising up, then entering into the teeth, craspedodrome; slender subsecondaries among above-noted secondaries diverging from the midrib, curving upwards, reaching to the notches among the teeth; tertiaries thin, irregularly percurrent; areolation fine; margin strongly dentate except at base and apex, with acute and deltoid teeth; petiole short, 2 mm in length; texture firm.

Remarks: The present specimens somewhat resemble the leaves of *Myrica* or *Sorbus* in general outline, but they are identical to some leaves of *Rhus* by shape, nervation and marginal serration. This species is closely similar to the living *R. typhina* L. which is distributed in eastern United States and southeastern Canada. The present new species is somewhat similar to *Rhus obscula* (LESQ.) MACG. from Oligocene Florissant flora in eastern United States (MACGINITIE, 1953: Pl. 54, fig. 1; Pl. 55, fig. 6), but leaflets of the latter are narrower and larger number of secondaries than those of the former.

Geological horizon: Middle Miocene.

Rhus miosuccedanea HU et CHANEY

(Pl. 24, Fig. 18)

1920. *Rhus succedanea*, FLORIN: op. cit. p. 22, Pl. 3, Fig. 13.
1940. *Rhus miosuccedanea*, HU et CHANEY: op. cit. p. 63, Pl. 35, Fig. 3b; Pl. 36, Figs. 6, 8; Pl. 37, Figs. 1-3.
1955. *Rhus miosuccedanea*, TANAI: op. cit. Pl. 14, Figs. 1, 2.

Description: Leaflets lanceolate, frequently falcate in shape, 4.5 to 8 cm long and 1.6 to 3 cm wide; apex elongate-acuminate; base asymmetrically cuneate or rounded; midrib stout, curving; secondaries 10 to 16 pairs, subalternate, somewhat irregularly spaced, diverging from the midrib at variable angles of 40 to 90 degrees, along the margin curving upward and forking, camptdrome, frequently forming loops; tertiaries thin but distinct irregularly percurrent; margin entire; petiolule short and slender, 1 to 5 mm in length; texture firm.

Remarks: The present specimens here figured, appear to resemble most closely *R. miosuccedanea,* although they are incomplete in preservation of leaves. They are not so lanceolate as the smaller of their two types, but close to the larger one. The present specimens bear a superficial resemblance to the leaflet of some types of *Cedrela oregonianus* (LESQUE.) BROWN from Miocene flora of the United States, but quite differ in the tertiary vanation. This fossil leaves are closely related to the existing *R. succedanea* L., which is widely distributed in China, Formosa and southern Japan.

The present species is found from the Miocene to Pliocene floras in Japan, and in particular common in the Daijima-type flora.

Geological horizon: Middle Miocene to Late Pliocene.

Rhus protoambigua SUZUKI

(Pl. 24, Fig. 20)

1959. *Rhus protoambigua*, SUZUKI: op. cit. p. 39, Pl. 5, Fig. 8.

Remarks: The present specimens occurred from Miocene Yoshioka flora of southwestern Hokkaidô, are fairly identical to this species by the foliar shape and nervation, though they are somewhat smaller than the original specimens. This fossil species is closely related to some leaves of the modern *Rhus ambigua* LAV. et DIP., which is growing in Saghalien and Japan.

Geological horizon: Middle to Late Miocene.

Family BERBERIDACEAE

Genus *Berberis* LINNE

There are about 200 living species of this genus in the world. Most of them are distributed in South America, Central and East Asia, and some of them are growing in North America, Europe and northern Africa. The fossil leaves of *Berberis* are comparatively rare in Tertiary flora of the world. Only one species, *B. saseboensis* TANAI, is found from Neogene flora in Japan.

Berberis saseboensis TANAI sp. nov.

(Pl. 21, Figs. 4, 6)

Description: Leaves small, obovate in general shape, 1.3 to 2.5 cm long and 1.1 to 1.8 cm wide; base narrowly cuneate, decurrent below along the petiole; apex acute to cuspidate; midrib stout, nearly straight to the tip; secondaries thin and slender, about four subopposite pairs, diverging from the midrib at angles of 35 to 45 degrees on the middle, basal pair arising along the margin, near the margin entire; petiole stout, 0.4 to 1.0 cm long; texture thin, membranaceous.

Remarks: The present materials are commonly found from the Ainoura formation in the Sasebo coal field, northern Kyûshû. They are fairly identical by peculiar foliar shape to the genus *Berberis*. This new species is closely similar in general shape to the living *B. morrisonensis* HAYATA, which is growing in Formosa. It is also close to the living *B. tschonoskana* REGER growing now in southern Japan. There is no fossil species of *Berberis* comparing to the present new species. This species is the first record of the genus *Berberis* in Japan.

Geological horizon: Early Miocene.

Family SAPINDACEAE

Genus *Dodonaea* LINNE

About 50 living species of this genus are widely distributed in the tropical or subtropical regions of the world: for instance, Australia, many islands of Oceania, South America, Florida Peninsula and other areas of North America, West India, southern China, Formosa, etc. The fossil leaves and fruits of *Dodonaea* have been found from Eocene to Pliocene floras in North America and Europe. In East Asia several fruits of *Dodonaea* are found from Miocene floras in Japan and Korea, and they are identified to *D. japonica* (MORITA).

Dodonaea japonica (MORITA) TANAI

(Pl. 24, Fig. 15)

1936. *Terminalia japonica*, MORITA: Jour. Geol. Soc. Jap. vol. 40, p. 355.
1952. *Dodonaea japonica*, TANAI: op. cit. p. 233, Pl. 22, Fig. 8; Text-fig. 1.
1955. *Dodonaea japonica*, TANAI: op. cit. Pl. 15, Fig. 1, 2.

Remarks: The present specimens are somewhat incomplete caspsules, but they are quite identical to this species previously reported by the writer from the Ennichi (Yongil) group in southern Korea. This species is represented only by fossil capsules, and no fossil leaves comparable to it have yet been found. However, these fossil capsules are frequently found from Middle Miocene sediments of Japan, and this species is one of the representative in the Daijima-type flora. In North America many fossil leaves and several fruits of *Dodonaea* were described from Eocene to Pliocene floras.

The present species is closely similar to the living *D. viscosa* (LINNE) JACQ., which xeric shrub is widely distributed in India, Formosa, Australia, South America and other tropical or subtropical regions. This fossil species is one of the indicators of warmer climate under which the Daijima-type flora grew at that time.

Geological horizon: Middle Miocene.

Genus *Sapindus* LINNE

About 15 living species of this genus now distributed mainly in tropical or subtropical region of the southern and northern hemisphere. In particular, this genus has luxuriant growth from eastern Asia to Himalaya, or from southern United States to the northern part of South America. The fossil *Sapindus* has been commonly known its occurrence since Palaeocene time in North America. However, the fossil remains of this genus has been scarcely found from Tertiary flora in Japan, and only one species was found from Miocene flora.

Sapindus kaneharai TANAI

(Pl. 24, Fige. 2, 4)

1952. *Sapindus Kaneharai*, TANAI: op. cit. p. 235, Pl. 22, Figs. 14, 15.
1955. *Sapindus Kaneharai*, TANAI: op. cit. Pl. 14, Figs. 7, 8.

Remarks: The present leaflets agree in all aspects with those of *Sapindus kaneharai* which was previously described by the writer from the Ennichi (Yongil) group in southern Korea. This fossil leaflets correspond to those of *S. mukurossi* GAERT., which is widely distributed in Eastern Asia. The excellent preservation of the nervation details may be to make possible the reference of these leaves to *Rhoura volubilis* (BLANCO) MEER., which is distributed from Formosa to Philippine.

This fossil species is now confined to Middle Miocene flora of Japan, namely to the Daijima-type flora.

Geological horizon: Middle Miocene.

Family CELASTRACEAE

Genus *Euonymus* LINNE

About 150 living species of this genus are widely distributed in the temperate and warm region of North and Central America, Europe and Asia. The fossil leaves of this genus have been found through Tertiary flora in the northern hemisphere, but their specimens were not common. In Japan, 15 living species of this genus are distributed from Hokkaidô to Kyûshû, while the fossil remains are generally rare. The writer found the following 2 species from Neogene flora: *Euonymus protobungeana* HU et CHANEY and *E. palaeosieboldinus* TANAI et ONOE.

Euonymus palaeosieboldianus TANAI et ONOE

1961. *Euonymus palaeosienoldiana*, TANAI et ONOE: op. cit. p. 47, Pl. 14, Fig. 6.

Remarks: The leaves of present species is characterized by oblong-ovate shape, secondary nervation and finely-serrulate margin. The present species is closely related to the modern *Euonymus sieboldianus* BLUME which is widely distributed from Hokkaidô at the north to Kyûshû at the south in Japan.

Geological horizon: Late Miocene (?) to Pliocene.

Euonymus protobungeana HU et CHANEY

(Pl. 24, Fig. 17)

1940. *Eunymus protobungeana*, HU et CHANEY: op. cit. p. 56, Pl. 31, Figs. 2-4, 6, 7.

Remarks: The leaves of the present species are characterized by secondary nervation and foliar shape, though they vary in marginal character, ranging from closely serrulate to entire margin. The present fossil leaves from the Sasebo coal field, are closely-serrulate-margined with bluntly tipped teeth. The present species is closely similar to the modern *Euonymus bungeana* MAXIM. which is now widely distributed in northern and southeastern China, Manchuria and Korea. This fossil species is also related to the modern *E. macropterus* RUPR. growing in Hokkaidô, Honshû and Shikoku.

Geological horizon: Early Miocene (in Japan).

Family BUXACEAE

Genus *Buxus* LINNE

About 30 living species of this genus are distributed in southeastern Asia, Central America, eastern Europe, etc., and only one species is existing in Japan. The fossil remains of this genus have been rarely found from Europe, while from North America this genus has never been reported up to the persent. In Japan, the fossil leaves or fruits of *Buxus* have been described from Late Tertiary flora in Hokkaidô, Honshû and Kyûshû.

Buxus protojaponica TANAI et ONOE

(Pl. 25, Fig. 6)

1937. *Buxus japonica*, MIKI: op. cit. p. 320, Fig. 7 A, B.
1941. *Buxus japonica*, MIKI: op. cit. p. 281, Fig. 16, D.
1954. *Buxus japonica*, TAKAHASHI: op. cit. p. 60, Pl. 7, Figs. 13a-g.
1961. *Buxus protojaponica*, TANAI et ONOE: op. cit. p. 46, Pl. 14, Fig. 5.

Remarks: The leaves of the present species are very small in size, and characterized by densely-crowed secondary nervation and well-developed cuticle. They are closely similar or nearly identical to the modern *Buxus japonica* were described from Pliocene flora of central Honshû by MIKI, and they are probably included into the present fossil species. The present species is somewhat similar to *B. pliocenica* SAPORTA from Pliocene flora of Europe (SAPORTA, 1876: Pl. 32, figs. 6-8).

Geological horizon: Middle Miocene to Late Pliocene.

Family ACERACEAE

Genus *Acer* LINNE

The genus *Acer* has more than 100 living species in the world, most of which species are widely distributed over the northern hemisphere and only one species in Sumatra and Java, extending south of the equator. In East Asia there are about 50 living species of the maple. This genus is one of the most familiar trees to us in the modern vegetation. Most of them have peculiar foliar shape and characteristic seeds.

Fossil maples have been very abundantly found throughout Tertiary flora in world, and plentiful species were described from various localities. In Japan fossil remains of *Acer* were also commonly found from Palaeogene to Pleistocene flora, and this genus has a largest number of species among the other genera of the past vegetable world of Japan. More than 20 species of *Acer* has been reported from Neogene flora of Japan by many authors, and among them the writer could ascertain the following 21 species: *Acer arcticum* HEER, *A. ezoanum* OISHI et HUZIOKA, *A. fatisiaefolia* HUZIOKA, *A. florinii* HU et CHANEY, *A. megasamarum* TANAI et SUZUKI, *A. meisenense* ENDO, *A. nordenskiöldi* NATHORST, *A. palaeodiabolicum* ENDO, *A. palaeoplatanoides* ENDO, *A. palaeorufinerve* TANAI et ONOE, *A. protodistylum* ENDO, *A. protojaponicum* TANAI et ONOE, *A. protonegundo* TANAI, *A. protosieboldianum* TANAI et ONOE, *A. prototataricum* TANAI et SUZUKI, *A. prototrifidium* TANAI, *A. pseudocarpinifolium* ENDO, *A. pseudoginnala* TANAI et ONOE, *A. submayrii* TANAI et ONOE, *A. subpictum* SAPORTA and *A. yoshiokaense* TANAI et SUZUKI.

Besides the above-noted species, *Acer rubrum* L. var. *ligniatum* MIKI, *A. sugawarai* ENDO, *A. trilobatum* var. *tricuspidatum* HEER, *A. debilum* HUZIOKA et SUZUKI, *A. miyagiense* ENDO, *A. yabei* ENDO, *A. higendorfi* NATHORST, *A. akagawaensis* SUZUKI had been described by various authors from Neogene flora in Japan.

Acer arcticum HEER

(Pl. 26, Figs. 8, 9; Pl. 27, Fig. 6)

1876. *Acer arcticum*, HEER: Flora Fossilis Arctica, vol. 4, Abt. 1, p. 86, Pls. 22-14, Figs. 1, 2; Pl. 25, Fig. 1.

1883. *Acer arcticum*, HEER: Ibid. vol. 7, No. 2, p. 126, Pl. 94, Fig. 2.

1883. *Acer arcticum*, LESQUEREUX: U. S. Geol. Surv. Terr. Report, vol. 8, p. 233, Pl. 49, Figs. 8, 9.

1936. *Acer arcticum*, HOLLICK: U. S. Geol. Surv. Prof. Paper No. 182, p. 133, Pl. 77, Fig. 1; Pl. 78, Figs. 7, 8.

1943. *Acer arcticum*, OISHI et HUZIOKA: Jour. Fac. Sci. Hokkaidô Imp. Univ., Ser. 4, vol. 7, No. 1, Pl. 9, Figs. 1-5.

Remarks: The present species characterized by nearly non-lobed leaves, has been commonly found from Palaeogene floras in the northern hemisphere. It is also abundantly found from Eocene and Oligocene sediments in Hokkaidô, Japan, and lately the writer found several leaves of this species from Early Miocene flora in the Sasebo coal field, Kyûshû. Namely, these Miocene specimens are probably the survivals from Palaeogene time.

As already described by HEER (1876), *Acer arcticum* is somewhat five leaf-types. The present Miocene specimens are broader than being long, and roughly dentate in margin. They are quite identical to some leaves of *A. arcticum* occurred from the Palaeogene Ishikari group, Hokkaidô.

Geological horizon: Eocene to Early Miocene. (However, this species is known only from Palaeocene to Oligocene floras in North America and Europe.)

Acer ezoanum OISHI et HUZIOKA

(Pl. 26, Figs. 1, 2, 5)

1940. *Acer Miyabei*, OKUTSU: op. cit. p. 162, Pl. 7, Figs. 5, 7.

1943. *Acer ezoanum*, OISHI et HUZIOKA: op. cit. p. 98, Pl. 10, Figs. 1-4, Pl. 11, 1-4; Pl. 12, Fig. 2 (excluding fig. 1).

1943. *Acer* sp., OISHI et HUZIOKA: Do. Pl. 11, Fig. 6.

1943. *Acer ezoanum*, HUZIOKA: op. cit. p. 130, Pl. 23, Fig. 6.

1943. *Acer* sp., HUZIOKA: Do. p. 136, Pl. 23, Fig. 5.

1950. *Acer Miyabei*, ENDO Short Papers I. G. P. S., No. 1, p. 13, Pl. 3, Figs. 5, 8.

1950. *Acer protomiyabei*, ENDO: Do. No. 1, p. 15, Pl. 3, Fig. 11.

1951. *Acer Miyabei*, ENDO: Short Papers I. G. P. S., No. 3, p. 52, Pl. 8, Fig. 3.

1952. *Acer ezoanum*, TANAI: op. cit. p. 130, Pl. 4, Fig. 8.

1955. *Acer Miyabei*, TANAI: op. cit. Pl. 17, Figs. 4, 5.

1955. *Acer protomiyabei*, TANAI: Do. Pl. 17, Fig. 9.

1955. *Acer ezoanum*, TANAI: Do. Pl. 17, Fig. 1. (excluding Fig. 2).

1955. *Acer Miyabei*, ENDO: op. cit. Pl. 36, Fig. 8; Pl. 37, Figs. 5, 8.
1955. *Acer protomiyabei*, ENDO: Do. Pl. 37, Fig. 11.
1960. *Acer ezoanum*, TANAI et SUZUKI: Jour. Fac. Sci. Hokkaidô Univ. Ser. 4, vol. 10, No. 3, p. 556, Pl. 1, Figs. 1, 2; Pl. 2, Figs. 1, 2; Pl. 3, Figs. 1–4; Pl. 4, Figs. 20, 21, 24–27.

Remarks: The present species was originally described by OISHI and HUZIOKA (1943) on the basis of leaf-impressions from Miocene flora of Hokkaidô and Saghalien. Then, this species is commonly found from Middle Miocene flora in Hokkaidô and Honshû, and redesignated by both leaves and samaras by the writer. The leaves of this species are characterized by the unstable foliar shape, presence of a pair of prominent and irregularly-sized dents in each lobe and abruptly-narrowed lobes, etc.

The present fossil species is closely similar to the modern *Acer diabolicum* BLUME and *A. miyabei* MAXIM. living in Japan, *A. saccharum* MARSHAL and *A. saccharinum* L. in North America and *A. italum* LAUTH in Europe.

Geological horizon: Middle Miocene.

Acer fatisiaefolia HUZIOKA

(Pl. 26, Fig. 6)

1943. *Acer fatisiaefolia*, HUZIOKA: op. cit. p. 131, Pl. 23, Fig. 7.
1943. *Acer ezoanum*, OISHI et HUZIOKA (in part): op. cit. p. 89, Pl. 12, Fig. 1. (excluding Pl. 10, Figs. 1–4; Pl. 11, Figs. 1–4; Pl. 12, Fig. 2).
1955. *Acer fatisiaefolia*, TANAI (in part): op. cit. Pl. 16, Fig. 7.
1955. *Acer ezoanum*, TANAI (in part): Do. Pl. 17, Fig. 2 (not Fig 1).
1960. *Acer fatisiaefolia*, TANAI et SUZUKI: op. cit. p. 559, Pl. 6, Fig. 2; Pl. 7, Figs. 1, 2.

Remarks: The present species represented by leaf-impressions, was originally described from Miocene flora of Korea, and then has been found from Middle Miocene flora in several localities of Honshû and southwestern Hokkaidô by the writer. It is closely similar to the above-described *Acer ezoanum* in general appearance, but differs in shape of lobes and marginal serration. Among the modern maples, the present species is closely related to *Acer diabolicum* BLUME growing in Japan and *A. saccharinum* L. in North America.

Geological horizon: Middle Miocene.

Acer florinii HU et CHANEY

1940. *Acer florinii*, HU et CHANEY: op. cit. p. 56, Pl. 31, Figs. 5, 8.
1960. *Acer florinii*, TANAI et SUZUKI: op. cit. p. 560, Pl. 5, Fig. 3.

Remarks: The present species originally described from Miocene Shanwang flora of China, is rarely found from Miocene flora of southwestern Hokkaidô, Japan. It is closely similar to the modern *Acer buergerinum* MIQ. (synonym; *Acer trifidium* HOOK) growing in China and Formosa.

Geological horizon: Middle Miocene (in Japan).

Acer megasamarum TANAI et SUZUKI
(Pl. 29, Fig. 3)

1960. *Acer megasamarum*, TANAI et SUZUKI: op. cit. p. 560, Pl. 5, Fig. 1.

Remarks: This species representing by large fossil samaras, is rarely found from Middle Miocene flora of northeastern Honshû and southwestern Hokkaidô. No living and fossil samaras of maple are comparable to the present species as far as known at present.

Geological horizon: Middle Miocene.

Acer meisenense ENDO

1950. *Acer meisenense*, ENDO: op. cit. p. 12, Pl. 3, Fig. 4.
1955. *Acer meisenense*, ENDO: op. cit. Pl. 37, Fig. 4.
1960. *Acer meisenense*, TANAI et SUZUKI: op. cit. p. 561, Pl. 9, Figs. 1, 2.

Remarks: The present species is represented by fossil samaras, which are characterized by large and circular seeds. It is rarely found from Middle Miocene flora of southwestern Hokkaidô. Among the modern maples in East Asia, no samara is related to the present species.

Geological horizon: Middle Miocene.

Acer nordenskiöldi NATHORST
(Pl. 28, Fig. 6)

1883. *Acer Nordenskiöldi*, NATHORST: op. cit. p. 60, Pl. 11, Figs. 10-17.
1920. *Acer palmatum*, FLORIN: op. cit. p. 23, Pl. 4, Figs. 1-4.
1931. *Acer palmatum*, KONNO: op. cit. Pl. 4, Fig. 9; Pl. 13, Fig. 8.
1931. *Acer Nordenskiöldi*, KONNO: Do. Pl. 13, Fig. 3; Pl. 21, Figs. 4, 5.
1937. *Acer Nordenskiöldi*, MIKI: op. cit. p. 322, Pl. 9 A, Fig. 8 P-Q.
1940. *Acer Nordenskiöldi*, HU et CHANEY: op. cit. p. 60, Pl. 34, Figs. 1, 6.
1941. *Acer palmatum*, MIKI: op. cit. p. 283, Fig. 17 B-Cd.
1943. *Acer ornatum*, HUZIOKA: op. cit. p. 133, Pl. 23, Fig. 9.
1952. *Acer ornatum*, TANAI: op. cit. p. 234, Pl. 22, Figs. 10, 11.
1954. *Acer palmatum*, TAKAHASHI: op. cit. p. 60, Pl. 7, Figs. 5, 6, 7a, 7b.

1955. *Acer ornatum*, TANAI: op. cit. Pl. 16, Figs. 5, 6; Pl. 17, Fig. 10.

1955. *Acer Nordenskiöldi*, BERGER: Palaeontographica Bd. 97, Abt. B, s. 101, Abb. 137–139.

1961. *Acer Nordenskiöldi*, TANAI et ONOE: op. cit. p. 47, Pl. 15, Fig. 1; Pl. 17, Fig. 12.

Remarks: This species was, at first, described on the basis of several leaf impressions occurred from the Pliocene Mogi plant beds near Nagasaki, Japan by NATHORST (1883). Many fossil maple leaves described under the name of *Acer ornatum* CARR. or *A. palmatum* THUNB., have been reported from the Neogene sediments in Japan, and they are closely similar to the original figures of this species in general features. Though the former two species are frequently smaller in size and coarser in marginal serration than the latter, no essential difference is found among these specimens. The living *A. palmatum* is variable in foliar shape, so that it is divided into several varieties. Consequently, the fossil leaves of *A. palmatum* type may be better at present to be treated as the present species as already described by TANAI et ONOE (1961). In the writer's collection, there are several fossil samaras closely similar to those of the living *A. palmatum*. The present species was originally designated only by impressions, but it should be represented by both leaves and samaras.

Geological horizon: Middle Miocene to Late Pliocene.

Acer palaeodiabolicum ENDO

(Pl. 28, Fig. 5)

1930. *Acer diabolicum*, KONNO: op. cit. Pl. 13, Fig. 4.

1940. *Acer diabolicum*, OKUTSU: op. cit. p. 161, Pl. 7, Fig. 7.

1950. *Acer palaeodiabolicum*, TANAI: op. cit. p. 12, Pl. 3, Fig. 3.

1952. *Acer palaeodiabolicum*, TANAI: op. cit. Pl. 22, Fig. 12.

1954. *Acer* cfr. *diabolicum*, TAKAHASHI: op. cit. s. 61, Taf. 7, Fig. 2.

1955. *Acer palaeodiabolicum*, ANAI: op. cit. Pl. 17, Figs. 6–8.

1955. *Acer palaeodiabolicum*, ENDO: op. cit. Pl. 37, Fig. 3.

1958. *Acer Miyabei*, MURAI: op. cit. p. 18, Pl. 1, Fig. 4.

1959. *Acer palaeodiabolicum*, TANAI et ONOE: op. cit. p. Pl. 6, Fig. 6.

1959. *Acer diabolicum*, SUZUKI: op. cit. p. 40, Pl. 4, Fig. 7.

1960. *Bcer palaediabolicum*, TANAI et SUZUKI: op. cit. p. 562.

1961. *Acer palaeodiabolicum*, TANAI et ONOE: op. cit. p. 48, Pl. 15, Figs. 2, 4; Pl. 16, Fig. 1; Pl. 17, Figs. 1–4.

Remarks: This species was originally described by ENDO (1950) on the basis of only one fruit which occurred from the Miocene Kankyôdô formation in Korea. Since then, the occurrence of the fossil fruits belonging to this species was reported by the writer (1955) from the Miocene sediments in various areas of Japan. The fossil leaves being closely identical to the living *Acer diabolicum* BLUME was described by OKUTSU (1940) from the Late Miocene sediments near Sendai, Japan. Recently, the writer found a plenty of fossil maple leaves and fruits being closely similar to the living *A. diabolicum* in the Hôki flora of western Japan, which is Mio-Pliocene in age. Thus, the present species was redesignated by the fossil leaves and fruits (TANAI et ONOE, 1961).

The present species is more or less similar to the above-described *A. ezoanum* in general foliar shape, but differs distinctly from the latter in the marginal dentation and shape of lobes. The marginal dents and tips of lobes of the latter species are more acuminate than those of the former. The leaves of the both species, however, are sometimes not distinguishable in general outline, but the samaras of the two species are different and very characteristic respectively.

Among the leaves of living maples in the world, the present species is closely similar to *Acer saccharum* MARSH. and *A. nigrum* MICHX. growing now in the eastern half of North America, and *A. diabolicum* BLUME and *A. miyabei* MAXIM. living now in Japan. The most close living species is *A. diabolicum* in view of the characters of leaves and samaras, which is now growing luxuriantly in Honshû, Shikoku and Kyûshû, Japan. The present fossil species is probably one of the direct progenitors of the above-noted living species.

The present species is one of the most common species in the Neogene flora of Japan and Korea, especially in Miocene flora. It is very interesting that the present species, along with *A. ezoanum,* is considered to represent rather in archaeic type of maples in the world. Because, the fossil maples of such type leaves are appeared from Eocene flora in Japan and North America*, and luxuriantly grew in Miocene time. After then, they decreased in their occurrence, and have been replaced by more dissected type such as *A. japonicum* or *A. sieboldianum* in Pliocene and Pleistocene flora. Furthermore, among the more than 60 species of maples living now in China the leaves of the former type are not found, though they are found in the living flora of Japan, North America and Europe.

Geological horizon: Early Miocene to Early Pliocene.

Acer palaeoplatanoides ENDO

1950. *Acer palaeoplatanoides*, ENDO: op. cit. p. 12, Pl. 3, Figs. 1, 9.

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* For example, they are *Acer eodiabolicum*, TANAI (MS) in Japan, *A. bendrei* LESQ. and *A. osmonti* KOWLTON in North America and *A. palaeosaccharum* STUR. and *A. recognitum* SAP. in Europe.

1955. *Acer palaeoplatanoides*, ENDO: op. cit. Pl. 37, Figs. 1, 9.
1959. *Acer palaeoplatanoides*, TANAI et ONOE: op. cit. p. 281, Pl. 6, Figs. 3, 4, 10.
1960. *Acea palaeoplatanoides*, TANAI et SUZUKI: op. cit. p. 563, Pl. 9, Fig. 8.

Remarks: This species is represented only by fossil samaras, which were described from Miocene flora of Korea by ENDO (1950). It is closely similar to the living *Acer palatanoides* L. growing in Europe and Western Asia. The present fossil species are known from Miocene flora in several localities of Honshû, but the fossil leaf being referable to this species has not yet been found.

Geological horizon: Middle Miocene.

Acer palaeorufinerve TANAI et ONOE

1930. *Acer* cfr. *rufinerve*, KONNO: op. cit. Pl. 5, Fig. 1.
1937. *Acer rufinerve*, MIKI: op. cit. p. 322, Fig. 8 O.
1940. *Acer rufinerve*, OKUTSU: op. cit. p. 164, Pl. 6, Figs. 1, 2.
1940. *Acer Nomurai*, OKUTSU: Do. p. 162, Pl. 6, Fig. 5.
1951. *Acer rufinerve*, ENDO: op. cit. p. 53, Pl. 8, Figs. 4, 5.
1957. *Acer Nomurai*, MURAI: op. cit. p. 43, Pl. 1, Fig. 3.
1960. *Acer palaeorufinerve*, TANAI et SUZUKI: op. cit. p. 563, Pl. 5, Fig. 4.
1961. *Acer palaeorufinerve*, TANAI et ONOE: op. cit. p. 49, Pl. 16, Figs. 2, 3.

Remarks: Though the present species is based on some incomplete leaf-impresions and fruits occurred from the Neogene sediments in Japan, they are closely similar to the living *Acer rufinerve* S. et Z. in general character. The fossil maples being quite identical to this species, were described under the name of *A. rufinerve* from the Neogene and Pleistocene sediments in various areas of Japan.

Geological horizon: Middle to Late Miocene.

Acer protodistylum ENDO

1950. *Acer protodistylum*, ENDO: op. cit. p. 12, Pl. 3, Fig. 2.
1955. *Acer protodistylum*, ENDO: op. cit. Pl. 37, Fig. 2.
1960. *Acer protodistylum*, TANAI et SUZUKI: op. cit. p. 564, Pl. 9, Figs. 3, 4.

Remarks: The present species is, at first, described from Late Eocene flora of Fu-shun coal field, Manchuria, and then it was found from Miocene flora of southwestern Hokkaidô, Japan. But it is rather rare in the Tertiary flora of Japan. Among the modern maples, this species is closely related to *Acer macrophyllum* PURSH living in the Pacific coastal region of North America and *A. distylum* S. et Z. existing now in eastern Honshû, Japan.

Geological horizon: Middle Miocene (in Japan).

Acer protojaponicum TANAI et ONOE

(Pl. 26, Fig. 4; Pl. 27, Fig. 8)

1943. *Acer japonicum*, HUZIOKA: op. cit. p. 143, Pl. 24, Fig. 7.
1955. *Acer protojaponicum*, TANAI: op. cit. Pl. 17, Figs. 11, 12.
1955. *Acer palaeojaponicum*, ENDO: op. cit. Pl. 36, Fig. 1.
1959. *Acer protojaponicum*, TANAI et ONOE: op. cit. p. 281, Pl. 6, Figs. 5–7.
1960. *Acer protojaponicum*, TANAI et SUZUKI: op. cit. p. 565 Pl. 5, Fig. 4; Pl. 9, Figs. 18, 19.

Remarks: The present species appeared at first in Middle Miocene time in Japan, but rather showed a luxuriant growth since Late Miocene time. Namely, such more dissected leaves of maple are considered to belong to an advanced type in morphological features of maple in the world. Among the modern species of maple in the world, the present species is closely similar to the living *Acer japonicum* THUNB., which grows now in Hokkaidô and Honshû, and luxuriantly at 1000 to 1600 meters above sea level in the mountains of central Honshû, Japan.

The leaves of the present species are closely similar to those of *A. protosieboldianum* described below, but the leaves of the latter are generally more dissected and smaller-sized than those of the former. The samaras of the above two species are quite different in their shapes and other character. Beside the latter species, there is no fossil maple being similar to this species in Tertiary flora of the world.

Geological horizon: Middle to Late Miocene.

Acer protonegundo TANAI sp. nov.

(Pl. 27, Figs. 2, 4, 5)

1943. *Acer* sp. (Samara), HUZIOKA: op. cit. p. 136, Pl. 23, Fig. 2.
1959. *Acer miohenryi*, TANAI et ONOE: op. cit. Pl. 6, Fig. 11.
1960. *Acer crataegifolium*, TANAI et SUZUKI: op. cit. p. 555, Pl. 8, Figs. 1–4; Pl. 9, Fig. 6.

Description: Leaves 3 foliate with medium-sized leaflets; leaflets elongate-ovate in shape, 3 to 10 cm long and 1.5 to 4.0 cm wide, cuneate or narrowly rounded at base, abruptly acute or pointed at apex; margin remotely and irregularly dentate, with pointed teeth; primary nerve slender, straight or curving near the tip; secondary nerves 6 to 8 pairs, diverging from the midrib at the angles of 40 to 50 degrees, curving upwards, then entering into the marginal teeth; craspedodrome; tertiaries thin, indistinct, forming an irregular mesh, near the margin branching to the sinuses; petioles stout and thick, 0.3 to 1.0 cm long; texture thin, membranaceous. Samaras elongate in shape, 3.6 to 3.8 cm long; wing slender, narrowly oblong, 2.5 to 2.8 cm long and 0.5 to 0.7 cm wide, outer margin nearly straight, inner margin gently curved, rounded at apex; veins numerous in number, curving inwards and dichotomously branching; seeds ellipsoidal in shape, 1.0 to 1.2 cm long and 0.4 to 0.6 cm wide, buldged outside; angles between outer margin of wing and contact line of seeds about 20 degrees; contact line of seeds about 3 mm long.

Remarks: The present new species represented by the compound 3-leaflets and characteristic samaras, has been found from Miocene flora of Hokkaidô, Honshû and Kyûshû. As already stated in another paper (TANAI et SUZUKI, 1960), the present specimens apparently belong to the Negundo-type maple, and they were identified to an American fossil species, *Acer crataegifolium* (KNOWLTON) LAMOTTE, by the writer. Whereas, most of fossil remains belonging to the box-elder type from Miocene flora of the Columbia Plateau, the United States, were very lately revised to *Acer minor* KNOWLTON by CHANEY and AXELROD (1959). Because, the original specimens of *A. crataegifolium* described as *Rulac crataegifolium* by KNOWLTON (1902) are too fragmental to be identified to the box-elder type. However, the present specimens are distinctly represented by 3-leaflets, and nearly identical to the modern box-elder by all character.

The samaras of the present new species are somewhat different from those of *A. minor* (CHANEY et AXELROD, 1959: Pl. 41, figs. 3-5) in shape of seeds: the seed of the latter is narrower and more acuminate at apex than the former. Accordingly, the writer gives the new specific name, *Acer protonegundo*, to Japanese Miocene fossils of Negundo-type maple. The living maples of the Negundo-type are *Acer henryi* PAX. growing in China and *A. negundo* L. in North America. This new species is more identical to American species than Chinese species in foliar shape and samara. It is probably one of the direct progenitors of the American box-elder.

Geological horizon: Early to Middle Miocene.

Acer protosieboldianum TANAI et ONOE

1961. *Acer protosieboldianum*, TANAI et ONOE: op. cit. p. 50. Pl. 15, Fig. 5.

Remarks: The present species is closely similar to the living *Acer sieboldianum* S. et Z. which is widely distributed over Japan, extending to Korea and Manchuria. It is closely similar or nearly identical to the leaves of *A. protojaponicum* described before, but the former is generally small in size than the latter. It is also close to the living *A. circinatum* PURSH growing in Pacific slope of North America, but differs in marginal serration.

Geological horizon: Late Miocene to Early Pliocene.

Acer prototataricum TANAI et SUZUKI

1960. *Acer prototataricum*, TANAI et SUZUKI: op. cit. p. 566, Pl. 9, Figs. 7, 12.

Remarks: The present species was lately established on the basis of fossil samaras which occurred from Miocene flora of southwestern Hokkaidô. It has been, up to the present, not found from Tertiary flora in other areas of Japan. This species is closely similar to the modern *Acer tataricum* L. distributed in southeastern Europe, and Central and Southeast China.

Geological horizon: Middle Miocene.

Acer prototrifidium TANAI

(Pl. 25, Fig. 2)

1931. *Acer* cfr. *trifidium*, KONNO: op. cit. Pl. 4, Fig. 8.
1952. *Acer prototrifidium*, TANAI: op. cit. p. 234, Pl. 22, Fig. 13.

Remarks: Some fragmental leaves identical to this species are found from Miocene flora in several localities of Honshû. The present species is closely similar in general feature to the living *A. trifidium* HOOK. which grows in Central China. It is characterized by trilobate leaves and entire margin, though somewhat variable in shape of base. Among the fossil maples, the present fossil species is closely similar to the above-noted *A. florinii* HU et CHANEY. The latter is, however, tuncate or broadly cordate at the base, while the former is generally rounded at the base. Furthermore, lateral primaries in the latter species are more broadly diverging from the midrib than in the former.

Geological horizon: Middle to Late Miocene.

Acer pseudocarpinifolium ENDO

1950. *Acer pseudocarpinifolium*, ENDO: op. cit. p. 14, Pl. 3, Fig. 6.
1961. *Acer* cfr. *pseudocarpinifolium*, TANAI et ONOE: op. cit. p. 51, Pl. 15, Fig. 3.

Remarks: The present species represented by samara, is rarely found from Late Miocene flora in Honshû. It is characterized by general outline of samara and spindle-shaped seed. This species is closely related to the modern *Acer carpinifolium* S. et Z. in Japan. No fossil leaves comparable to those of this living species have not yet been known from Neogene flora of Japan at present.

Geological horizon: Late Miocene.

Acer pseudoginnala TANAI et ONOE

(Pl. 26, Fig. 3)

1943. *Acer* sp. (Samara), HUZIOKA: op. cit. p. 137, Pl. 24, Fig. 8.
1959. *Acer pseudoginnala*, TANAI et ONOE: op. cit. p. 282, Pl. 6, Figs. 1, 12.
1960. *Acer pseudoginnala*, TANAI et SUZUKI: op. cit. p. 566, Pl. 9, Figs. 13–15, 16.

Remarks: The present species described on the basis of fossil samaras, is not common in the Tertiary flora of Japan. The fragmental leaves being probably to belong to this species were known from Miocene flora in the Jôban coal field, Japan. These leaves are palmately 3-lobed, and doubly serrate in the margin of lobes. Among samaras of the living maples, the present species is closely similar to *A. ginnala* MAX. in their shapes and diverging angles of fruits, but different in shape of seeds. This related living species is now growing from Hokkaidô to Kyûshû, Japan, and extends its distribution to Korea, Manchuria, Central and North China and eastern Siberia.

Geological horizon: Middle Miocene.

Acer submayrii TANAI et ONOE

(Pl. 26, Fig. 7)

1951. *Acer Mayrii*, FNDO: op. cit. p. 57, Pl. 8, Fig. 2.
1960. *Acer submayrii*, TANAI et SUZUKI: op. cit. p. 568, Pl. 9, Fig. 9.
1961. *Acer submayrii*, TANAI et ONOE: op. cit. p. 50, Pl. 17, Fig. 5.

Remarks: The present species represented by fossil samaras, is rather rare in Neogene flora of Japan. These specimens are closely similar in general appearance to the samaras of *Acer mono* MAXIM. var. *mayrii* (SCHWERIN) KOIDZ. which grows now in Hokkaidô and Honshû, Japan.

Geological horizon: Middle to Late Miocene.

Acer subpictum SAPORTA

(Pl. 27, Fig. 1; Pl. 28, Fig. 2)

1873. *Acer subpictum*, SAPORTA: Bull. Soc. Géol. France, Sér. 3, vol. 1.

1883. *Acer pictum*, NATHORST: op. cit. p. 60, Pl. 12, Figs. 2–8.
1888. *Acer pictum*, NATHORST: op. cit. p. 38. Pl. 13, Figs. 1, 2.
1920. *Acer pictum*, FLORIN: op. cit. p. 24, Pl. 4, Fig. 5.
1931. *Acer pictum*, KONNO: op. cit. Pl. 4, Fig. 7; Pl. 13, Fig. 7.
1940. *Acer subpictum*, HU et CHANEY: op. cit. p. 61, Pl. 34, Figs. 3–5, 7; Pl. 35, Fig. 1.
1940. *Acer pictum*, OKUTSU: op. cit. p. 163, Pl. 7, Fig. 3; Pl; 8, Figs. 1–4.
1943. *Acer subpictum*, OISHI et HUZIOKA: op. cit. p. 93, Pl. 13, Figs. 1–4; Pl. 14, Figs. 3, 4.
1943. *Acer* sp. (Samara), OISHI et HUZIOKA: Ibid. p. 99, Pl. 11, Fig. 5.
1943. *Acer subpictum*, HUZIOKA: op. cit. p. 129, Pl. 24, Figs. 4–6; Pl. 25, Fig. 3.
1952. *Acer subpictum*, TANAI: op. cit. p. 131. Pl. 4, Fig. 7.
1954. *Acer pictum*, TAKAHASHI: op. cit. p. 60, Pl. 7, Figs. 3, 4a, 4b.
1955. *Acer pictum*, OKUTSU: op. cit. p. , Pl. 7, Figs. 1, 2, 8.
1955. *Acer pictum*, TANAI: op. cit. Pl. 16, Figs. 3, 4.
1959. *Acer Matsuii*, TANAI et ONOE: op. cit. p. 282, Pl. 6, Figs. 1, 13.
1960. *Acer subpictum*, TANAI et SUZUKI: op. cit. p. 567, Pl. 4, Figs. 1–4; Pl. 7, Figs. 3–6.
1961. *Acer subpictum*, TANAI et ONOE: op. cit. p. 51, Pl. 16, Figs. 4–6.

Remarks: The present species represented by leaves and samaras, is abundantly found from Neogene flora of Japan, and it is one of the most common dicotyledons in Japan. It is nearly identical to the living *Acer mono* MAXIM. widely distributed in East Asia. The leaves of the present species show many variable shape as much as in the modern *A. mono*. This fossil species is also commonly found from Neogene flora of various areas of Europe. It is closely similar or nearly identical to *A. scottiae* MACG. from Miocene flora of western United States (MACGINITIE, 1933: Pl. 12, fig. 4; Pl. 11, figs. 4, 8; CHANEY et AXELROD, 1959; Pl. 41, figs. 6-10; Pl. 42, fig. 1).

Geological horizon: Early Miocene to Late Pliocene.

Acer yoshiokaense TANAI et SUZUKI

1960. *Acer yoshiokaense*, TANAI et SUZUKI: op. cit. p. 568, Pl. 2, Figs. 5, 6.

Remarks: The present species represented by fossil samaras, was very lately described from Miocene Yoshioka flora of southwestern Hokkaidô, but it has not yet occurred from other localities of Japan. This species is closely similar or nearly identical to *Acer bolanderi* LESQ. from Miocene flora of the Columbia Plateau, the United States (CHANEY et AXELROD, 1959: Pl. 39, figs. 7-9) in general character. The present species is, as already pointed out by the writer, closely related to the modern *A. sacchurum* MARSH. growing in eastern half of North America.

Geological horizon: Middle Miocene.

Family HIPPOCASTANACEAE

Genus *Aesculus* LINNE

About 24 living species of this genus are distributed in Europe, North America, East Asia and India. The fossil leaves of *Aesculus* have been found from Tertiary flora in the northern hemisphere. In Japan two fossil species, *A. majus* (NATHORST) and *A. miochinensis* HU et CHANEY, are known from Neogene flora.

Aesculus majus (NATHORST) TANAI

(Pl. 28, Fig. 1; Pl. 29, Figs. 4, 5; Pl. 30, Fig. 3)

1888. *Aesculiphyllum majus*, NATHORST: op. cit. p. 6, Pl. 1, Fig. 3.
1888. *Aesculiphyllum minus*, NATHORST: Ibid, p. 11, Pl. 2, Fig. 9.
1952. *Aesculus majus*, TANAI: op. cit. p. 131.
1955. *Aesculus majus*, HUZIOKA: op. cit. p. 62, Pl. 10, Figs. 1, 2.

Remarks: The present specimens are fairly identical to this species in the venation and marginal appearance, though they are somewhat fragmental. Among the leaflets of the living Aesculus, this species is most closely related to *A. turbinata* BLUME, which is now widely distributed from southwestern Hokkaidô at the north to northern Kyûshû at the south. The present species is commonly found from Miocene flora of Japan, and one of the representatives in the Aniai-type flora.

Geological horizon: Middle to Late Miocene.

Aesculus miochinensis HU et CHANEY

1940. *Aesculus miochinensis*, HU et CHANEY: op. cit. p. 63, Pl. 38, Figs. 4, 5; Pl. 39, Fig. 1.
1955. *Aesculus* cfr. *miochinensis*, HUZIOKA: op. cit. p. 62, Pl. 10, Fig. 1.

Remarks: Some fragmental leaves of *Aesculus* from Miocene flora of Hokkaidô, are identical to the present species described from Miocene Shanwang flora of China. The leaflets of present species are closely similar to the above-noted *A. majus* in general appearance, but the latter differs from the former by having more closely-spaced secondaries. They are also similar to *A. hesperia* BERRY from Miocene flora of Washington, the United States (BERRY, 1929: Pl. 56, fig. 8). The present species is closely related to modern *A. chinensis* BUNGE in North and Southeast China.

Geological horizon: Middle Miocene.

Family TILIACEAE

Genus *Tilia* LINNE

About 30 living species of this genus are widely distributed in temperate region of the northern hemisphere, and among them 4 species are existing in Japan. Fossil *Tilia* has been commonly found from Palaeocene to Pleistocene sediments in the world. In Japan the fossil leaves and bracts of *Tilia* have been reported their common occurrence throughout Tertiary flora, and especially abundant in Neogene flora. The writer found following 4 Neogene species: *Tilia distans* NATHORST, *T. miohenryana* HU et CHANEY, *T. protojaponica* ENDO and *T. subnobilis* HUZIOKA. Beside them, the fossil leaves of the modern *T. kiusiana* MAK. et SHIRAS. were found from Early Pliocene flora of Gifu Prefecture by MIKI (1941).

Furthermore, from Miocene or Pliocene floras there were many fragmental leaves and bracts which were too ill-preserved to be given specific names.

Tilis distans NATHORST

(Pl. 28, Figs. 3, 4; Pl. 29, Fig. 2; Pl. 30, Fig. 6)

1883. *Tilia distans*, NATHORST: op. cit. p. 56, Pl. 6, Figs. 5-13.
1920. *Tilia distans*, FLORIN: op. cit. p. 25, Pl. 2, Fig. 9.
1931. *Tilia distans*, KONNO: op. cit. Pl. 14, Fig. 4.
1943. *Tilia distans*, HUZIOKA: op. cit. p. 121, Pl. 21, Figs. 1-4, 7, 8.
1952. *Tilia distans*, TANAI: op. cit. p. 132, Pl. 4, Fig. 9.
1955. *Tilia distans*, OKUTSU: op. cit. p. 105, Pl. 5, Figs. 4a, 4b.
1959. *Tilia* sp., TANAI et ONOE: op. cit. p. 283, Pl. 7, Figs. 2, 3.

Remarks: The present species represented by leaf impressions and floral bracts, is closely similar to the modern *Tilia miqueliana* MAXIM. in Central China or *T. amurensis* RPR. in North China, Manchuria, etc. The leaves of this species is, in general, characterized by deeply oblique-cordate base. This species is close to *T. preamurensis* HU et CHANEY from Miocene Shanwang flora of China in having oblique-cordate base, but distinctly different in the marginal character. This fossil species is most commonly found throughout Neogene flora of Japan among the 4 fossil lindens.

Geological horizon: Middle Miocene to Late Pliocene.

Tilia miohenryana HU et CHANEY

1940. *Tilia miohenryana*, HU et CHANEY: op. cit. p. 69, Pl. 33, Fig. 3a; Pl. 44, Figs. 1, 2; Pl. 45, Fig. 3.

1961. *Tilia miohenryana*, TANAI et ONOE: op. cit. p. 52, Pl. 14, Fig. 9.

Remarks: The present species of linden originally described from Miocene Shanwang flora of China, is rarely found from Neogene flora in Japan. This species is close in general appearance to the other two Japanese linden species, *Tilia distans* and *T. protojaponica*, but different from the latter two by having large and acute teeth of margin. This fossil species is closely related to the modern *T. henryana* SZYS. in China, or *T. maximowicziana* SHIRAS. in northern Japan.

Geological horizno: Late Miocene.

Tilia protojaponica ENDO

(Pl. 30, Fig. 7)

1941. *Tilia japonica*, MIKI: op. cit. p. 286, Fig. 18 B, C.
1943. *Tilia japonica*, HUZIOKA: op. cit. p. 123, Pl. 21, Fig. 6.
1954. *Tilia* cfr. *japonica*, TAKAHASHI: op. cit. p. 62, Pl. 7, Fig. 9.
1955. *Tilia protojaponica*, ENDO: op. cit. Pl. 27, Fig. 1.

Description: Leaves somewhat incomplete in preservation, orbicular or reniform in general outline; base shallowly to deeply cordate, slightly asymmetrical; apex abruptly acuminate; palmately 5 nerved; midrib stout and thick; lateral primaries 2 on each side of midrib, diverging from the midrib at angles of 45 degrees, opposite; primaries and secondaries of midrib gently curving up, craspedodrome; 4 or 5 tertiaries from lateral primaries branching off, curving up, craspedodome; margin serrate with callous tip; teeth acute and somewhat upcurved; texture thin, membranaceous; petiole stout and thick, over 1.5 cm long; 1.8 mm wide.

Remarks: The present species was established by ENDO (1955) on the basis of leaf-impression from Late Miocene flora of Akita Prefecture, but the specific description has not yet been given. Though the present spcimens are so fragmental, they are fairly identical to this species by their shap, venation and marginal character. The leaves and bracts of this species are closely similar or nearly identical to the modern *Tilia japonica* SIMONK. which is widely distributed from Hokkaidô at the north to Kyûshû at the south, Japan. The fossil leaves described as *T. japonica* from Miocene Meisen flora of Korea and Pliocene flora of Gifu Prefecture, Japan is nearly identical to this fossil species, though the former is somewhat smaller than the present leaves.

Geological horizon: Middle Miocene to Late Pliocene.

Tilia subnoilis HUZIOKA

(Pl. 29, Fig. 1)

1943. *Tilia subnobilis*, HUZIOKA: op. cit. p. 125, Pl. 22, Figs. 2, 3.

Remarks: Several fragmental leaves identical to this species have been found from Miocene flora of Honshû and Hokkaidô. The leaves of this species are close to those of the above-described *Tilia distans* in having deeply-cordate base, but differs in shape and marginal serration. This species is closely related to the modern *T. nobilis* R. et W. in central China.

Geological horizon: Middle Miocene.

Family RHAMNACEAE

Genus *Paliurus* MILL.

Only several living species of this genus are distributed in East Asia and southern Europe, but fossil remains of *Paliurus* have been reported from Tertiary flora in Europe and North America. In Japan, only one species has been ascertained by the writer from Neogene flora of Honshû.

Paliurus nipponicus MIKI

(Pl. 31, Fig. 2; Pl. 32, Figs. 11, 12)

1888. *Zizyphus tiliaefolia*, NATHORST: op. cit. p. 208, Pl. 4, Fig. 5.
1933. *Paliurus nipponicus*, MIKI: Bot. Mag. Tokyo, vol. 47, p. 624, Pl. Q-V, Fig. 2 F-J.
1937. *Paliurus nipponicus*, MIKI: op. cit. p. 324, Pl. 9 H-I, Fig. 8 A-E.
1938. *Paliurus nipponicus*, MIKI: op. cit. p. 216, Fig. 2 A.
1941. *Paliurus* cfr. *nipponicus*, MIKI: op. cit. p. 285, Fig. 17 G.
1954. *Paliurus nipponicus*, TAKAHASHI: op. cit. p. 61, Pl. 7, Figs. 11a-d.
1961. *Paliurus nipponicus*, TANAI et ONOE: op. cit. p. 52. Pl. 14, Fig. 1.

Remarks: This species represented by leaves, fruits or twigs is commonly found from Pliocene flora in various localities of Japan. The fossil leaves and fruits of this species are somewhat similar to those of *Paliurus miosenicus* HU et CHANEY from Miocene Shanwang flora of China (HU et CHANEY, 1940: Pl. 41, figs. 2, 3, 5, 7, 8). The present species is closely related to *P. spina-christii* MILL. living in Mediterranean region and Iran.

Geological horizon: Mio-Pliocene to Late Pliocene.

FAMILY ALANGLACEAE

Genus *Alangium* LAM.

The family Alangiaceae is represented by a single genus *Alangium*, which is widely distributed in Asia, Africa and Australia. However, the fossil leaves of this genus are found from Tertiary floras in various localities of Europe and East Asia. Among the living species of *Alangium*, 2 species are now growing in China, and 2 varieties of Chinese species exist in Japan. The fossil leaves of this genus are abundantly found from Eocene to Pleistocene floras in Japan, and Neogene 3 species are ascertained by the writer: *A. aequalifolium* (GOEP.), *A. basiobliquum* (OISHI et HUZ.) and *A. koyamae* (KONNO). Beside these 3 species, *A. macrocarpum* MIKI and the fossil endocarps of the living *A. begoniifolium* (ROXB.) BALL. and *A. platanifolium* (S. et Z.) HARMS. were described from Pliocene and Pleistocene floras in various localities of Honshû by MIKI (1956).

Alangium aequalifolium (GOEPPERT) KRYSHT. et BORSUK

(Pl. 30, Fig. 1; Pl. 31, Fig. 9)

1852. *Dombeyopsis aequalifolia*, GOEPPERT: Palaeontographica Bd. 2, s. 277, Taf. 26, Fig. 3.
1920. *Büttoneria aequalifolia*, MEYER (in KRAÜSEL): Jahrb. Konig. preus. geol. L. A. Bd. 38, s. 174, Pl. 18, Figs. 2–4; Pl. 26, Fig. 12.
1939. *Alangium aequalifolium*, KRYSHTOFOVICH et BORSUK: Problems Palaeont. No. 5, p. 390, Pl. 5, Figs. 1–8; Pl. 6, Fig. 12.
1950. *Marlea aequalifolia*, OISHI et HUZIOKA (in OISHI): Illust. Catalog. East-Asia. Fossil Plants, p. 171, Pl. 50, Fig. 1.
1952. *Marlea aequalifolia*, TANAI: op. cit. p. 132, Pl. 5, Fig. 5.
1952. *Marlea iragawense*, TANAI: Do. p. 133, Pl. 5, Fig. 5.
1955. *Marlea aequalifolia*, TANAI: op. cit. Pl. 19, Fig. 2.
1955. *Marlea iragawense*, TANAI: Do. Pl. 19, Fig. 1.
1955. *Marlea aequalifolia*, HUZIOKA: op. cit. p. 8, Pl. 3, Figs. 6–8.

Remarks: The present species is abundantly found from the lower half of Miocene sediments in Japan and Saghalien, and also not rare in Miocene flora of Europe. Namely, it is one of the representatives in the Aniai- and Daijima-type floras. The leaves of this species are characterized by strongly oblique and cordate base, and often arched midrib, though variable in size. Such fossil leaves were once identified to the genus *Dombeyipsis* or *Büttoneria*, and then they were acertained by KRYSHTOFOVICH and BORSUK (1939) to belong to the genus *Alangium*. OISHI and HUZIOKA (1950) gave the generic name of *Marlea* to such specimens. However, *Marlea* and *Alangium* are synonymous, and the latter is at present used in plant-taxonomy.

Most of the fossil leaves which has been reported under the name of *Ficus tiliaefolia* HEER from the Miocene flora of Japan, are probably included into this species. For instance, the fossil leaves of *Ficus tiliaefolia*

A. BR. in Europe was revised to *Alangium tiliaefolium* by KRYSHTOFOVICH (1957, p. 415, Fig. 407), which is nearly identical to the present species.

The present species is closely similar to *A. basiobliquum* (OISHI et HUZ.) and *A. koyamae* (KONNO) described below, but the latter two are distinguishable from the former by having ovate shape and acuminate apex. It is similar in venation character to the living *A. chinense* REHD. in China or *A. premnifolium* OHWI in Kyûshû and Loochoo islands, but differs in foliar shape.

Geological horizon: Early to Middle Miocene.

Alangium basiobliquum (OISHI et HUZIOKA) TANAI n. comb.

(Pl. 30, Fig. 5; Pl. 31, Fig. 11)

1950. *Marlea basiobliqua*, OISHI et HUZIOKA (in OISHI): op. cit. p. 171, Pl. 49, Fig. 8.

Description: Leaves small to medium in size, oblong-ovate and asymmetrical in shape, 5 to 7.5 cm long, 3 to 4.5 cm wide, palmately veined with 3 stout primaries; apex abrutply acuminate; base asymmetrical, obliquely truncate or cordate; midrib stout, nearly straight, often tapered at apice; lateral primaries slightly slender than the midrib, diverging from the midrib at angles of 20 to 25 degrees, extending nearly straightly, or curving upward, arising up along the margin, camptodrome, with 3 to 5 abaxial branches, subparallel; secondaries 2 to 3 subopposite pairs, diverging from the midrib at angles of 25 to 30 degrees, curving upward and arising along the margin, at marginal border several abaxial tertiaries branching off, making loops with secondaries; tertiaries in inter-secondary spaces thin, percurrent; nervilles obscure, reticulate; margin entire; petiole stout, more than 1 cm long; texture firm, subcoriaceous.

Remarks: The above characters are described on the basis of many specimens which were collected from Palaeogene flora of Hokkaidô, Japan by the writer. The present specimens occurred from Early Miocene flora in the Sasebo coal field are quite identical to this species in shape and nervation, though they are missing in the upper part. This species which was originally described from Eocene flora of the Ikushumbetsu formation in the Ishikari coal field by OISHI et HUZIOKA, has been abundantly found from Palaeogene floras in the various localities of Hokkaidô and Kyûshû. Namely, this fossil species has been considered to be confined to Palaeogene flora of Japan. The present Miocene specimens are probably the relics of Palaeogene species.

The present species is closely similar in general outline to *A. koyamae* (KONNO) described below, but the former is generally smaller in size and less in number of secondaries than the latter. *A. basiobliquum* closely resembles *Ficus tiliaefolia* (AL. BR.) HEER in general appearance. Accordingly, among many fossil leaves listed under the name of *F. tiliaefolia* in Japanese Palaeogene flora, some are probably included into this species.

Geological horizon: Eocene to Early Miocene.

Alangium koyamae (KONNO) TANAI n. comb.

(Pl. 30, Figs. 2, 4)

1931. *Dolichites Koyamai*, KONNO: op. cit. Pl. 19, Figs. 9, 11; Pl. 20, Figs. 3–5; Pl. 21, Fig. 3.

Description: Leaves variable in size and shape, commonly ovate or sometimes oval, strongly asymmetrical, palmately veined, with 3 to 5 primaries, 8 to 11 cm long and 4 to 4.5 cm wide; base oblique to asymmetrically rounded; apex longly acuminate; primary and secondary nervation prominent on lower site of blade; midrib stout, nearly straight or often slightly curved; basal primary pair generally slender, a basal primary on one side very slender, along the margin arising from the base, another one somewhat stout, diverging from the midrib at angles of about 70 degrees, with about 6 abaxial branches; upper lateral primaries diverging from the midrib at angles of 25 to 45 degrees, curving upward near the margin, camptodrome, with 7 to 8 abaxial branches, subparallel; 5 to 6 pairs of secondaries alternate to subopposite, nearly parallel to the upper lateral primaries; tertiary venation distinct, percurrent; lateral tertiaries from the lowest secondaries 4 to 5 in number, curving upward, looping within margin; nervilles thin and indistinct, forming polygonal meshes; margin entire; petiole stout, 1.5 to 2 cm long; texture firm, subcoriaceous.

Remarks: The present specimen excellently preserved, are identical to the genus *Alangium* by the foliar shape and nervation. They are also referable to the genus *Mallotus* in general feature, but generally different from *Mallotus* by the nervation and length of petiole. However, fossil leaves of the above-noted two genera are frequently difficult to be distinguished respectively by only the foliar characters.

Among the living *Alangium*, the present materials are closely similar to some leaves of *A. chinense* REHD. existing in China, which is somewhat variable in foliar shape. However, the latter living leaves distinctly differ from the former in having frequently lobate leaves and obtuse apex. These specimens are somewhat close to the living *Mallotus paniculata* MUEL-ARG. in Formosa, but the latter is three in primary nervation and has a pair of honey-glands at the base of leaf. *Dolichites Koyamai* KONNO described from the Omi flora in Nagano Prefecture is quite identical to the present fossil specimens.

This species is somewhat similar to the above-described *A. aequalifolium* in the venation, but distinctly different in shape. It has also a close resemblance in foliar shape to *Mallotus protojaponicus* MIKI from Pliocene flora in Gifu Prefecture (MIKI, 1941: Fig. 16 A), but differs from the latter in secondary nervation. The fossil fruits of *A. begoniifolium* BAILL. (synonym: *A. chinense* REHD.) were described from Pliocene flora in Kinki district, western Honshû, and they probably have some relationships with the present species.

Geological horizon: Late Miocene.

Family THEACEAE

Genus *Stewartia* L.

This genus consisting of about 8 living species is distributed in East Asia and North America. On the other hand, the fossil remains have been not commonly reported from Tertiary flora of Europe and Japan, but this genus is frequently difficult to be distinguished from some other genera by only leaf-impressions. In Japan, the fossil leaves or seeds of this genus have been found since Late Miocene flora, and the following two species are identified: *Stewartia okutsui* TANAI and *S. submonadelpha* TANAI et ONOE.

Stewartia okutsui TANAI sp. nov.

(Pl. 25, Figs. 7, 10)

1955. *Stewartia pseudo-camellia*, OKUTSU: op. cit. p. 107, Pl. 5, Figs. 2, 3.

Description: Leaves medium in size, elliptical in general outline, 6.5 to 8.0 cm and 3.8 to 5 cm wide; apex missing, but probably acute at apex; base gradually narrowed, broadly cuneate; midrib stout, nearly straight, prominent on under site of blade; secondaries thin but distinct, about 6 alternate to subopposite pairs, diverging from the midrib at angles of 40 to 50 degrees, nearly straight, curving upwards near the margin, then connecting of festoon within the margin; sometimes short and slender secondaries diverging from the midrib among intersecondary spaces; tertiaries indistinct, forming large polygonal network; margin slightly crenate or coarsely serrate with small and blunt teeth; texture subcoriaceous; petiole missing.

Remarks: The present specimens are probably identical to the genus

Stewartia by their venation and marginal characters, though they are incomplete in preservation. The leaves of this new species are closely similar to those of the living *Stewartia pseudo-camellia* MAXIM. in central and southern Honshû, Shikoku and Kyûshû, Japan. The fossil leaves of *S. pseudo-camellia* described from Late Miocene flora near Sendai by OKUTSU (1955), are nearly identical to this species, and included into this new species. The fossil fruits of this related living species were described from Late Pliocene flora of various localities in Honshû (MIKI: 1937, 1941), and the fossil leaves were described from Pleistocene Shiobara flora in Tochigi Prefecture (ENDO, 1940). These Pleistocene leaves are close in general appearance to *S. submonadelpha* described below, though the latter is generally small than the former. However, the latter leaves distinctly differ from the former in having fine and well-defined marginal teeth.

Geological horizon: Late Miocene.

Stewartia submonadelpha TANAI et ONOE

(Pl. 25, Fig. 9)

1883. *Stuartia monadelpha*, NATHORST: op. cit. p. 66, Pl. 14, Figs. 11, 12.
1920. *Stuartia monadelpha*, FLORIN: op. cit. p. 26, Pl. 5, Fig. 4.
1931. *Stuartia monadelpha*, KONNO: op. cit. Pl. 14, Fig. 6.
1937. *Stuartia monadelpha*, MIKI: op. cit. p. 324, Fig. 8 K.
1941. *Stewartia monadelpha*, MIKI: op. cit. p. 288, Fig. 13 E, G.
1954. *Stewartia monadelpha*, TAKAHASHI: op. cit. p. 62, Pl. 7, Fig. 12.
1961. *Stewartia submonadelpha*, TANAI et ONOE: op. cit. p. 53, Pl. 18, Fig. 6.

Remarks: The leaves of this species is closely similar to the modern *Stewartia monadelpha* S. et Z. growing in Honshû, Shikoku and Kyûshû, Japan. The present species represented by leaf-impressions and fruits have been commonly found Late Miocene to Pliocene flora in various localities of Japan.

Geological horizon: Late Miocene to Late Pliocene.

Family ARALIACEAE

Genus *Aralia* LINNE

About 30 living species of this genus are now distributed mainly in North America, Australia, Malay, East and Southern Asia, and more than a half of them are living in Asia. In Japan 3 species are existing now, and 5 species in China. This genus is one of the older genera among dicotyledonous trees in vegetable world, and appeared since Late Cretaceous time. The fossil leaves or leaflets of *Aralia* has been found throughout

Tertiary flora in the world. In Japan the following 3 species are known from Neogene flora of Honshû: *A. celtisfolia* TANAI et ONOE, *Aralia miobippinata* TANAI and *A. yabei* MORITA. The former two species are represented by leaflets, while the latest by lobated leaves.

Aralia celtisfolia TANAI et ONOE

1955. *Aralia celtisfolia*, TANAI: op. cit. Pl. 19, Fig. 5.
1959. *Aralia celtisfolia*, TANAI et ONOE: op. cit. p. 284, Pl. 7, Fig. 1.

Remarks: Though the present specimens somewhat resemble the genus *Hydrangea, Viburnum* or *Celtis,* they are closely similar to the living *Aralia californica* S. WATS. which grows in North America. Among the fossil *Aralia,* the present fossil species is close in secodary nervation and marginal serration to *A. taurinensis* (WARD) SANBORN from Eocene Comstock flora in the United States (SANBORN, 1935: Pl. 10, figs. 1, 2). The present species is very rare in Tertiary flora of Japan.

Geological horizon Middle Miocene.

Aralia miobippinata TANAI
(Pl. 31, Fig. 6)

1955. *Aralia miobippinata*, TANAI: op. cit. Pl. 19, Fig. 4.

Description: Leaflets medium in size, ovate in general outline, 4.0 to 4.5 cm long and 2.0 to 2.2 cm wide, rounded at base, obtusely pointed at apex; midrib stout, nearly straight below, somewhat flexous near the apex; secondaries 7 to 9 subopposite pairs, somewhat irregularly percurrent, near the margin branching from the secondaries to form loops from which small nerves enter into the teeth; nervilles finely reticulate; margin coarsely serrate, with rather obtuse teeth; texture thin, membranaceous; petiole short, about 1 mm in length.

Remarks: The present specimens occurred from the Nishitagawa coal field, are limited to only 2, both of which are in general poorly preserved. They are similar to some leaves or leaflets of *Rhamnus, Vaccinium, Aralia* or *Crataegus.* They are, however, closely similar to the living *Aralia bippinata* BLANCO., which is distributed in Formosa, and also from Loochoo island to Philippines. Among the leaflets of fossil *Aralia,* this species is somewhat similar to *A. taurinensis* (WARD) SANBORN from Palaeogene flora in various localities of the United States (BERRY, 1916: Pl. 60, figs. 1-3; etc.), though the latter is generally larger-sized than this species. The present species is also related to the above-described *A. celtis-*

folia TANAI et ONOE.

Geological horizon: Middle Miocene.

Genus *Kalopanax* MIQ.

This monotypic genus is confined in distribution to East Asia, and only one species, *Kalopanax septemlobus* (THUNB.) KOIDZUMI, is widely distributed in Japan, Saghalien, Southern Kurile islands, Korea, Manchuria and China. The fossil leaves of this genus have been scarcely recorded from Europe and North America, but they are not rarely found from Neogene flora in East Asia. In Japan, only one species is found from Neogene flora in Honshû and Kyûshû, but it is not so common.

Kalopanax acerifolium (NATHORST) HU et CHANEY

1883. *Acanthopanax acerifolium*, NATHORST: op. cit. p. 54, Pl. 8, Fig. 5; Pl. 9, Figs. 1, 2.
1940. *Kalopanax acerifolium*, HU et CHANEY: op. cit. p. 70, Pl. 47, Figs. 3, 5.
1955. *Kalopanax ricinifolium*, OKUTSU: op. cit. p. 110, Pl. 5, Fig. 1.
1960. *Kalopanax acerifolium*, TANAI et ONOE: op. cit. p. 285, Pl. 7, Fig. 4.

Remarks: The present species is represented by large-sized 7-palmate leaves with closely mucronate-serrate margin. This species is closely similar or nearly identical to the modern *Kalopanax septemlobus* in the all foliar characters. The fossil leaves of this living species were described from Pleistocene Shiobara flora by ENDO (1940), and they are nearly similar to the present fossil species.

Geological horizon: Middle Miocene to Late Pliocene.

Family CORNACEAE

Genus *Cornus* LINNE

Among about 50 living species of this genus, most of them are widely distributed in temperate region of the northern hemisphere. Fossil leaves and endocarps have been found throughout Tertiary flora of the world. From Neogene flora of Japan the following 3 species are known up to the present: *Cornus megaphylla* HU et CHANEY, *C. saseboensis* TANAI and *C. subkousa* TANAI et ONOE, all of which species are represented by only fossil leaves. Beside them, fossil endocarpus of the living species in Japan, *C. brachypoda* C. A. MEY. and *C. controversa* HEMSL., were found from Pliocene to Pleistocene flora in Honshû by MIKI (1956). This genus has not yet been found from Palaeogene flora in Japan, and at first appeared at Early Miocene. In East Asia there are more than 20 living species of *Cornus,* among which 6 species now existing in Japan and 17 in China.

Cornus megaphylla HU et CHANEY

1940. *Cornus megaphylla,* HU et CHANEY: op. cit. p. 71, Pl. 48, Figs. 3–5; Pl. 49, Fig. 2.
1955. *Cornus megaphylla,* TANAI: op. cit. Pl. 20, Fig. 1.
1961. *Cornus megaphylla,* TANAI et ONOE: op. cit. p. 54, Pl. 17, Fig. 9.

Remarks: The present specimens are somewhat incomplete in preservation, but they are quite identical in their shape and venation to this species which was described from Miocene Shanwang flora of China. This species is closely similar to *C. miowalteri* HU et CHANEY from the same flora (HU et CHANEY, 1940: Pl. 47, figs. 1, 2, 4), but the former is generally broader in leaves and more in number of secondaries than the latter. The present fossil species is closely similar to the living *C. macrophylla* WALL. widely now distributed in China, Korea and Japan.

Geological horizon: Early Miocene to Late Miocene.

Cornus saseboensis TANAI sp. nov.

(Pl. 32, Fig. 10)

Description: Leaves oval or broadly ovate in general outline, 6.0 to 7.5 cm long and 4.5 to 5.4 cm wide; base cuneate; apex broadly rounded and abruptly acuminate; midrib stout below, then distantly slender; secondaries 5 to 6 subopposite to opposite pairs, diverging from the midrib at the angles of 40 to 50 degrees, gently curved up, broadly camptodrome; tertiaries thin and indistinct, percurrent, at right angles to the secondaries, near the margin forming broad loops with the secondaries; nervilles obscure, forming close network; margin entire or obscurely crenate-toothed; petiole stout, more than 1.5 cm in length; texture thin, membranaceous.

Remarks: The present specimens are very well-preserved in details, so that they are doubtlessly identified to *Cornus.* They are somewhat similar in general outline to *C. kousa* BUERG. existing now in Japan and China, or *C. florida* L. living in North America, but distinctly different in the secondary nervation. Namely, the leaves of the latter two are more acrodromous in their secondary nerves. No fossil leaves of *Cornus* has been found which closely resemble this species.

The present new species is rare in Neogene flora of Japan, and only known from the Ainoura-type flora up to the present.

Geological horizon: Early Miocene.

Cornus subkousa TANAI et ONOE

(Pl. 31, Fig. 4)

1920. *Cornus buchii*, FLORIN: op. cit. p. 26, Pl. 3, Fig. 2.
1961. *Cornus subkousa*, TANAI et ONOE: op. cit. p. 53, Pl. 17, Figs. 6, 7.

Remarks: The present species is closely related to the living *Cornus kousa* BUERG. in general characters, which is widely distributed in Japan, Korea and China. However, the leaves of the modern species are generally acute or slightly acuminate at apex. Among fossil species of *Cornus*, this fossil species is closely similar to *C. miowalteri* HU et CHANEY from Miocene flora of China and *C. ovalis* LESQ. from Mio-Pliocene flora of california, the United States (LESQUEREUX, 1878; Pl. 6, figs. 1, 2). It is distinctly different from the above-described species, *C. megaphylla*, in having broader forms and less number of secondary nerves. The above-described new species, *C. saseboensis*, is somewhat similar to this species, but quite differs in secondary nervation. Namely, secondary nerves of this species is typically acrodrome, while lower pairs of secondaries in *C. saseboensis* are not arising over the middle of the blade.

Geological horizon: Late Miocene to Early Pliocene.

Family ERICAEAE

Genus *Rhododendron* LINNE

More than 600 living species of this genus are widely distributed in the northern hemisphere, Malaysia and Australia. Among them, the living Rhododendrons in the northern hemisphere inhabit from boreal region to high altitudes of the tropics. However, the fossil remains of this genus have been not always common in Tertiary flora of the world. In general, the fossil leaves of Ericaceae are not so common in Tertiary flora of the world, while the pollen grains belonging to this family have been reported their common occurrence throughout Tertiary coals. Accordingly, the leaves of Ericaceae, including the genus *Rhododendron*, seem to have been difficult to be preserved as remains.

In Japan the fossil leaves of *Rhododendron* are also rare in Tertiary flora, and only one species has been described from Neogene flora. Some specimens belonging to this genus are too fragmental to determine the species.

Rhododendron protodilatatum TANAI et ONOE

(Pl. 25, Fig. 8)

1959. *Rhododendron dilatatum*, SUZUKI: op. cit. p. 42, Pl. 5, Fig. 3.
1961. *Rhododendron protodilatatum*, TANAI et ONOE: op. cit. p. 55, Pl. 18, Figs. 2, 4.

Remarks: The leaves of this species are characterized by rhomboidal or broadly-ovate shape and secondary nervation, though they are somewhat variable in size. This species is closely similar or nearly identical to the modern *Rhododendron dilatatum* MIQ. in Honshû, Shikoku and Kyûshû, Japan. The present fossil species is confined to Late Miocene flora in Japan up to the present, but the fossil leaves of related living species were described from Pleistocene flora in Honshû.

Geological horizon: Late Miocene.

Genus *Tripetaleia* SIEB. et ZUCC.

The modern distribution of this genus is confined to Japan, where only 2 species are living now. The fossil remains of this genus are also scarcely found in the world, and in Japan 2 species, *Tripetaleia pseudopaniculata* TANAI et ONOE and *T. almquisti* NATHORST, were described from Neogene flora in Honshû or Kyûshû.

Tripetaleia pseudopaniculata TANAI et ONOE

1961. *Tripetaleia pseudopaniculata* TANAI et ONOE: op. cit. p. 55, Pl. 18, Fig. 3.

Remarks: The present species is closely similar to the modern *Tripetaleia paniculata* S. et Z. which leaves are characterized by secondary nervation. *T. almquisti* NATHORST from Pliocene Mogi flora of Kyûshû (NATHORST, 1883: Pl. 9, figs. 12, 13; etc.), somewhat resembles the present fossil species, but distinctly different in secondary nervation. The related living species, *T. paniculata,* is widely distributed from Hokkaidô at the north to Kyûshû at the south.

Geological horizon: Late Miocene (?) to Early Pliocene.

Family EBENACEAE

Genus *Diospyros* LINNE

About 200 living species of this genus are widely distributed in tropical regions of the world, and in particular a great number of these living species are existing in southern Asia. Fossil leaves of this genus have been not rarely found in Tertiary flora of the world. From Neogene flora in Japan two species, *Diospyros miokaki* HU et CHANEY and *D. nordqvisti* NATHORST, have been found.

Diospyros miokaki HU et CHANEY

1931. *Diospyros Kaki* fossilis, KONNO: op. cit. Pl. 16, Fig. 2.
1938. *Diospyros* sp., SHIKAMA: op. cit. Pl. 18, Fig. 7.
1940. *Diospyros miokaki*, HU et CHANEY: op. cit. p. 72, Pl. 46, Figs. 1–3.
1954. *Diospyros Kaki*, TAKAHASHI: op. cit. p. 63, Pl. 8, Fig. 3.

Remarks: Though the leaves of this species are somewhat variable in shape, they are closely similar to the modern *Diospyros kaki* L. existing in Japan. The present species is close to *D. nordqvisti* NATHORST described from the Pliocene Mogi flora of Kyûshû (NATHORST, 1883: Pl. 8, fig. 1; Pl. 14, figs. 7, 8), but somewhat different in their secondary nervation. This fossil species are found throughout Neogene flora in Japan, but abundantly in Middle Miocene flora of Honshû.

Geological horizon: Middle Miocene to Late Pliocene.

Family OLEACEAE

Genus *Fraxinus* LINNE.

About 70 living species of this genus are widely distributed in the northern hemisphere, and some are living in subtropical or tropical region such as Java and Mexico. The fossil remains of this genus have been commonly found throughout Tertiary flora in North America and Europe. In Japan, the fossil leaves and samaras of this genus not commonly occurred from Neogene flora, and the writer found following 2 species: *Fraxinus ennichiensis* TANAI and *F. honshuensis* TANAI et ONOE.

Fraxinus ennichiensis TANAI

1953. *Fraxinus ennichiensis*, TANAI: op. cit. p. 6, Pl. 1, Fig. 15.

Remarks: This species represented by leaflets is rarely found from the Daijima-type flora in Honshû, Japan. These specimens are asigned to the genus *Fraxinus* with some hesitation. Among the fossil leaflets of this genus, the present species is close to *F. leii* BERRY from Cretaceous and Palaeocene flora of North America (BERRY, 1934: Pl. 25, figs. 5, 6).

Geological horizon: Middle Miocene.

Fraxinus honshuensis TANAI et ONOE
(Pl. 31, Fig. 10)

1941. *Fraxinus* cfr. *japonica*, MIKI: op. cit. p. 295, Fig. 21 c.
1961. *Fraxinus honshuensis*, TANAI et ONOE: op. cit. p. 57, Pl. 18, Fig. 7.

Remarks: The present species represented by fossil samara, is rarely found from Neogene flora of Hokkaidô and Honshû. This species is closely similar to the modern *Fraxinus japonica* BL. distributed in central and northern Honshû.

Geological horizon: Late Miocene to Pliocene.

Family TRAPELLACEAE

Genus *Hemitrapa* MIKI

This genus was established by MIKI in 1941 on the basis of many fossil nuts which had been found from Pliocene sediments in Seto area, Aichi Prefecture, Japan. The nuts of this genus were generally characterized by the brushy hairs on the top, appendages, shape of receptacle, etc. They are somewhat similar to the nuts of the genus *Trapella* or *Trapa*, however, the nuts of these three genera are different respectively in apical crown or size of cotyledon and stem of embryo. From Tertiary flora of East Asia, MIKI (1953) distinguished the following 5 species: *Hemitrapa trapelloides* MIKI, *H. sachalinensis* (OKUTSU) MIKI, *H. yokoyamae* (NATHORST) MIKI, *H. borealis* (HEER) MIKI, and *H. hokkaidoensis* (OKUTSU) MIKI. Among them the writer could found the last two species from Miocene flora in Honshû and Hokkaidô.

Hemitrapa borealis (HEER) MIKI
(Pl. 32, Figs. 6, 7)

1869. *Trapa borealis*, HEER: op. cit. p. 38, Pl. 8, Figs. 9, 19. (not fig. 11).
1953. *Hemitrapa borealis*, MIKI: Palaeobotanist vol. 1, p. 349, Text-fig. 2 F.
1959. *Hemitrapa borealis*, TANAI et ONOE: op. cit. p. 284, Pl. 4, Figs. 6–9.

Remarks: This species was found from Palaeogene flora in Alaska, or other arctic region and California of the United States, while in Japan and Saghalien it was found from Miocene flora. The nuts of this species are characterized by spindle-like shape, two appendages and 30 to 40 degrees of angles formed by appendages. The present species is closely similar to *Hemitrapa yokoyamae* from Miocene flora in Honshû, but the latter is like expanded-egg in shape and 4 in number of appendages.

Geological horizon: Middle Miocene.

Hemitrapa hokkaidoensis (OKUTSU) MIKI

(Pl. 32, Figs. 2, 5, 9)

1939. *Trapa hokkaidoensis*, OKUTSU: Jour. Geol. Soc. Jap. vol. 46, p. 329, Fig. 2.
1953. *Hemitrapa hokkaidoensis*, MIKI: op. cit. p. 349, Text-fig. 2–I.

Remarks: The present species was, at first, described as the genus *Trapa* from the Miocene Sakipempetsu flora in Ishikari coal field, Hokkaidô, Japan. However, by having the brushy haired part, spindle-like shape and other characters, it was included into the genus *Hemitrapa* by MIKI. This species is characterized by having 4 long appendages and spindle-like shape. It is closely similar to *H. yokoyamae* and *H. sachalinensis* in having 4 appendages. However, *H. hokkaidoensis* is different from *H. yokoyamae* by shape of nuts, and from *H. sachalinensis* by having longer appendages.

Geological horizon: Middle Miocene.

Family STYRACEAE

Genus *Styrax* LINNE

This genus is mainly distributed in warm or temperate regions of the northern hemisphere, and about a hundred living species are found in these region. In Japan 3 species and 1 variety are existing now, 10 species living in China and 5 species in Formosa. The fossil specimens of this genus have been found from Palaeogene to Pleistocene floras in Europe and North America, but their specimens are not always so commonly found. In Japan the fossil remains of this genus were found from Miocene to Pleistocene sediments in Honshû. The writer identified the following two species: *Styrax protoobassia* TANAI et ONOE and *S. saseboense* TANAI. Beside these two, fossil leaves or seeds of *S. rugosa* MIKI and *S. leaevigata* MIKI are described from Late Pliocene flora of Honshû by MIKI (1941). Furthermore, the fossil seeds of the living species, *S. shiraiana* MAKINO and *S. japonica* S. et Z. were described from Pliocene floras of various localities in Honshû.

Styrax protoobassia TANAI et ONOE

(Pl. 31, Fig. 5)

1883. *Styrax obassia*, NATHORST: op. cit. p. 50, Pl. 10, Figs. 2-6; Pl. 11, Fig. 7.
1920. *Styrax obassia*, FLORIN: op. cit.
1930. *Styrax obassia*, KONNO: op. cit. Pl. 15, Figs. 1, 2.
1937. *Styrax obassia*, MIKI: op. cit. p. 327, Fig. 9 N-O.
1938. *Styrax obassia*, MIKI: op. cit. p. 217, Fig. 2 L.
1940. *Styrax obassia*, OKUTSU: op. cit. p. 165, Pl. 13, Fig. 3; Pl. 14, Fig. 4.
1941. *Styrax obassia*, MIKI: op. cit. p. 295, Fig. 20_aB.
1961. *Styrax protoobassia*, TANAI et ONOE: op. cit. p. 56, Pl. 18, Figs. 1, 8.

Description: Leaves large in size, 10 to 15 cm long and 8 to 13 cm wide, orbicular or broadly ovate in general outline; apex obtusely cuspidate; base rounded or slightly cordate; midrib stout, straight below, and becoming thin, slightly sinuate near the apex; secondaries 7 to 12 pairs, alternate or subalternate, diverging from the midrib at angles of 40 to 60 degrees, slightly curving upward near the margin, camptodrome or subcamptodrome, sometimes forking near the margin, the lower secondaries given off prominent abaxial tertiaries; tertiaries thin, forming irregular elongate-quadrangular meshes; margin entire or remotely denticulate, with minute teeth; petiole stout, more than 2 cm long; texture thin or medium, membranaceous.

Seeds ovate to oblong-ovate in shape, 1.3 to 1.5 cm long and 1.0 to 1.2 cm broad, with distinct raphe and large hilum; three ridges existing between 3-pericarp constrictions.

Remarks: This species was at first represented by only leaf-impressions commonly found from Late Tertiary flora of Japan, which leaves are very close in general characters to the living *Styrax obassia* S. et Z. These fossil leaves are somewhat variable in marginal appearance as much as the most close living species displays. While, the fossil seeds being nearly identical to those of *S. obassia* were abundantly found from Pliocene flora in various localities of Honshû by MIKI, the writer and others. Accordingly, the writer redesignates at this time that the present species is represented by both leaves and seeds.

The most close modern species, *S. obassia,* is now distributed in Hokkaidô, Honshû and Shikoku of Japan, and extends to Korea. It is one of common trees in northern Japan. This fossil species is probably one of the direct progenitors of the above living species. It is commonly found from Late Tertiary flora in various localities of Japan.

Geological horizon: Late Miocene to Late Pliocene.

Styrax saseboense TANAI sp. nov.

(Pl. 31, Figs. 1, 3, 7)

Description: Leaves small to medium in size, nearly orbicular or broadly ovate in general outline, 3.3 to 5.0 cm long and 2.5 to 4.6 cm wide; apex acute or obtusely cuspidate; base broadly rounded or truncate; margin remotely denticulate, with minute and acute teeth; midrib stout below, becoming thin distantly, straight to the tip; secondaries thin 6 to 7 opposie pairs, diverging from the midrib at the angles of about 50 degrees on the middle, more spreading near the base, nearly regularly spaced, gently curving upward, near the margin arising up, frequently entering into the teeth, subcamptodrome, sometimes forking within the margin, at the lower margin given off abaxial branches; tertiary nerves thin, indistinct; petiole stout, 0.7 to 1.0 cm long; texture firm, subcoriaceous.

Remarks: The present specimens abundantly occurred from the Miocene Ainoura formation in the Sasebo coal field, Kyûshû, and are excellently preserved. They are identical to the genus *Styrax* by general features, although they have some resemblance to the genus *Malus* or *Pyrus*. These fossil leaves are closely similar to *S. matsumurae* PERK. in general outline, which is now growing in central Formosa. However, this relating species is crenulate in margin of leaves, and less in number of secondaries. There are no fossil leaves which are comparable or similar to this new species.

Geological horizon: Early Miocene.

Family CAPRIFOLIACEAE

Genus *Lonicera* LINNE

This genus composed about 180 living species is distributed mainly in the northern hemisphere, and partly in central America and northern Africa. However, the fossil remains of this genus have been scarcely found in the world. In Japan, only one species of this genus was described from Neogene flora, and the specimens of that species has been rarely found in Pliocene sidements.

Lonicera protojaponica TANAI et ONOE

1883. *Phyllites* sp., NATHORST: op. cit. p. 75, Pl. 12, Figs. 9, 10; Pl. 14, Fig. 20.
1961. *Lonicera protojapanica*, TANAI et ONOE: op. cit. p. 57, Pl. 18, Fig. 5.

Remarks: This species is represented by some leaf-impressions which are close to the modern *Lonicera japonica* THUNB. in their secondary nervation. This close living species is distributed from Honshû, Shikoku and Kyûshû, Japan, extending to China.

Geological horizon: Late Miocene (?) to Pliocene.

Genus *Viburnum* LINNE

About 120 living species of this genus are widely distributed in South America and temperate or warm regions of the northern hemisphere. The fossil remains of this genus have been commonly found throughout Tertiary flora in the world, and in particular more commonly in the Palaeogene. In Japan the fossil leaves of *Viburnum* have been also common since Palaeogene time, and the writer identified the following 3 species from Neogene flora: *Viburnum otsukae* TANAI, *V. protoparvifolium* TANAI and *V. protofurcatum* TANAI. Beside those species, several specimens belonging to this genus were found, but they are too fragmental to determine species.

Viburum otukae TANAI

(Pl. 32, Fig. 3)

1952. *Viburnum Otukae*, TANAI: op. cit. p. 134, Pl. 5, Fig. 7.

Remarks: The leaves of the present species rarely found from Miocene flora of Honshû, are closely similar to the modern *Viburnum thefernum* REHD. or *V. betulifolium* BATAL in central China. This fossil species is closely similar to *V. obliquum* HOLLICK from Palaeogene flora of Alaska (HOLLICK, 1936: Pl. 105, figs. 7, 8), but differs in basal character.

Geological horizon: Middle Miocene.

Viburnum protoparvifolium TANAI

(Pl. 32, Fig. 4)

1952. *Viburnum parvifolium*, TANAI: op. cit. p. 134, Pl. 5, Fig. 8.
1955. *Viburnum protoparvifolium*, TANAI: op. cit. Pl. 20, Fig. 7.

Description: Leaves small in size, obovate in general outline, 2.5 cm long and 1.8 cm wide; base cuneate; apex obtuse; midrib stout, slightly arched; secondary nerves 5 to 6 subalternate pairs, diverging from the midrib at angles of about 50 degrees, slightly curving up, entering into marginal teeth, a pair of basal secondaries short; tertiaries obscure; a few tertiaries branching from the secondaries, entering into small teeth;

margin coarsely double-serrate; petiole short, about 2 mm long; texture thin.

Remarks: The present specimens are somewhat doubtful to belong to the genus *Viburnum,* but they resemble the leaves of the modern *V. parvifolium* HAYATA growing in a high altitude of Formosa. They are also somewhat similar to the modern *V. phylebotrichum* S. et Z. in Japan, but distinctly different in foliar shape.

Geological horizon: Middle Miocene.

Viburnum protofurcatum TANAI sp. nov.

(Pl. 32, Fig. 9)

1955. *Vicurnum furcatum,* OKUTSU: op. cit. p. 111, Pl. 7, Figs. 3a, 3b.

Description: Leaves comparatively large in size, somewhat inequilateral, orbicular or ovoid in general outline, 8 to 11 cm long and 8.5 to 9 cm wide; base asymmetric, deeply cordate; apex rounded or obtusely pointed; midrib stout, prominent, nearly straight; secondary nerves stout, 6 to 8 subalternate pairs, diverging from the midrib at angles of about 30 degrees on the middle of the blade, less on the upper, more angles on the lower; a basal pair of secondaries making nearly right angle with the midrib, and sending off several tertiaries; generally secondaries in the lower half of blade sending off several tertiary branches on lower side of them; tertiaries among inter-secondary spaces thin but distinct, irregularly percurrent; margin duplicately serrate, with nearly equal-sized and acute teeth; texture thin, membranaceous; petiole stout, over 1 cm long.

Remarks: The leaves of present new species are characterized by prominent secondary and tertiary venation, though they are somewhat variable in shape. The fossil leaves of *Viburnum furcatum* BL. described from Pliocene flora near Sendai, Japan, by OKUTSU (1955), are fairly identical to this new species by their characteristic vanation. This new species is closely similar to the living *V. furcatum* BLUME which is widely distributed from Kurile islands at the north to Kyûshû at the south, extending to Cheju and Ullung islands. The fossil leaves or seeds of this living species were described from Pleistocene flora in Honshû (ENDO, 1940, MIKI, 1941b).

Geological horizon: Late Miocene to Pliocene.

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Explanation of Plate 1

Explanation of Plate 1

(All natural size unless otherwise stated)

Fig. 1. *Osmunda tsunemoriensis* MATSUO; Utanobori, Esashi-machi, Esashi-gun, Hokkaidô. Tachikarabetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15060.

Fig. 2. *Abies honshuensis* TANAI sp. nov.; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Holotype G. S. J. Reg. No. 4210. ×1.5

Fig. 3. *Picea kaneharai* TANAI et ONOE; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15061.

Fig. 4. *Picea kaneharai* TANAI et ONOE; Ningyo-tôgé in the border between Tottori and Okayama Prefectures. Ningyô-tôgé formation (Early Pliocene). Holotype G. S. J. Reg. No. 4062.

Fig. 5. *Picea magna* MACGINITIE; Wakamatsu coal mine, Kita-hiyama-machi, Setana-gun, Hokkaidô. "Kudo" coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15062.

Figs. 6, 7. *Picea magna* MACGINITIE; Abura, Setana-machi, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Hypotypes U. H. Reg. No. 15063; No. 15120 (Wakamatsu coal mine).

Figs. 8, 9. *Abies aburaensis* TANAI sp. nov.; Abura, Holotype U. H. Reg. No. 15064, Hypotype No. 15065.

Fig. 10. *Abies protofirma* TANAI sp. nov.; Onbara, Kami-saibara-mura, Tomada-gun, Okayama Prefecture. Onbara formation (Mio-Pliocene). Holotype G. S. J. Reg. No. 4059.

Fig. 11. *Abies n-suzukii* TANAI sp. nov.; Yoshino, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Paratype U. H. Reg. No. 15066.

Figs. 12, 15. *Picea miocenica* TANAI sp. nov.; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Holotype G. S. J. Reg. No. 4211 (Fig. 15), Paratype No. 4212 (Fig. 12).

Fig. 13. *Abies n-suzukii* TANAI sp. nov.; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation. Holotype U. H. Reg. No. 15067.

Fig. 14. *Abies n-suzukii* TANAI sp. nov.; Abura. Hypotype U. H. Reg. No. 15068.

Figs. 16, 40, 41. *Keteleeria ezoana* TANAI sp. nov.; Yoshioka. Holotype U. H. Reg. No. 15069 (Fig. 16), Paratypes Nos. 15070, 15071 (Figs. 40, 41).

Figs. 17, 36, 37. *Pseudolarix kaempferi* GORD.; the living cone-scale and seeds for comparison, collected from the Botanical Garden of Kyôto University.

Figs. 18, 33-35. *Pseudolarix japonica* TANAI et ONOE; Yoshioka. Hypotypes U. H. Reg. Nos. 15072, 15073, 15074, 15075.

Figs. 19, 27. *Pseudolarix japonica* TANAI et ONOE; Hiyoshi. Hypotypes G. S. J. Reg. Nos. 4213, 4214.

Fig. 20. *Picea kanoi* HUZIOKA; Abura. Hypotype U. H. Reg. No. 15213.

Fig. 21. *Pseudotsuga ezoana* TANAI sp. nov.; Wakamatsu coal mine. Holotype U. H. Reg. No. 15076.

Fig. 22. *Pseudotsuga japonica* BEISSN.; the living seed for comparison, collected from Odaigahara, Wakayama Prefecture, by S. MIKI.

Figs. 23, 42, 43. *Keteleeria davidiana* BEISSN.; the living cone-scale and seeds for comparison, collected from the Botanial Garden of Kyôto University.

Fig. 24. *Pseudolarix japonica* TANAI et ONOE; Onbara. Holotype G. S. J. Reg. No. 4063.

Fig. 25. *Tsuga miocenica* TANAI sp. nov.; Hiyoshi. Hypotype G. S. J. Reg. No. 4215.

Figs. 26, 32. *Tsuga miocenica* TANAI sp. nov.; Yoshino. Holotype U. H. Reg. No. 15077 (Fig. 32), Yoshioka Paratype No. 15078 (Fig. 26).

Figs. 28, 29. *Picea ugoana* HUZIOKA; Abura. Hypotypes U. H. Reg. Nos. 15079, 15080.

Fig. 30. *Salvinia pseudoformosa* OISHI et HUZIOKA; Kusaidani, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4216.

Fig. 31. *Salvinia pseudoformosa* OISHI et HUZIOKA; Sakipembetsu, Ashibetsu City, Hokkaido. Nokanan coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15218b.

Figs. 38, 39. *Salvinia formosa* HEER; Hiramaki, Mikasa-machi, Kani-gun, Gifu Prefecture. "Hiramaki" formation (Middle Miocene). Hypotypes G. S. J. Reg. Nos. 4217.

Fig. 45. *Thuja nipponica* TANAI et ONOE; Kami-shanabuchi. Hypotype U. H. Reg. No. 15084.

Fig. 46. *Taiwania cryptomeroides* HAYATA; the living leafy twig for comparison, collected from the Botanical Garden of Kyôto University.

Fig. 47. *Juniperus honshuensis* TANAI et ONOE; Mitoku, Misasa-machi, Tottori Prefecture. Mitoku formation (Late Miocene). Holotype G. S. J. Reg. No. 4072.

Fig. 48. *Taiwania japonica* TANAI et ONOE; Yoshioka. Hypotype U. H. Reg. No. 15082.

Fig. 49. *Tsuga aburaensis* TANAI sp. nov.; Abura. Holotype U. H. Reg. No. 15083.

Fig. 50. *Salvinia pseudoformosa* OISHI et HUZIOKA; Hiyoshi. Hypotype G. S. J. Reg. No. 4315.

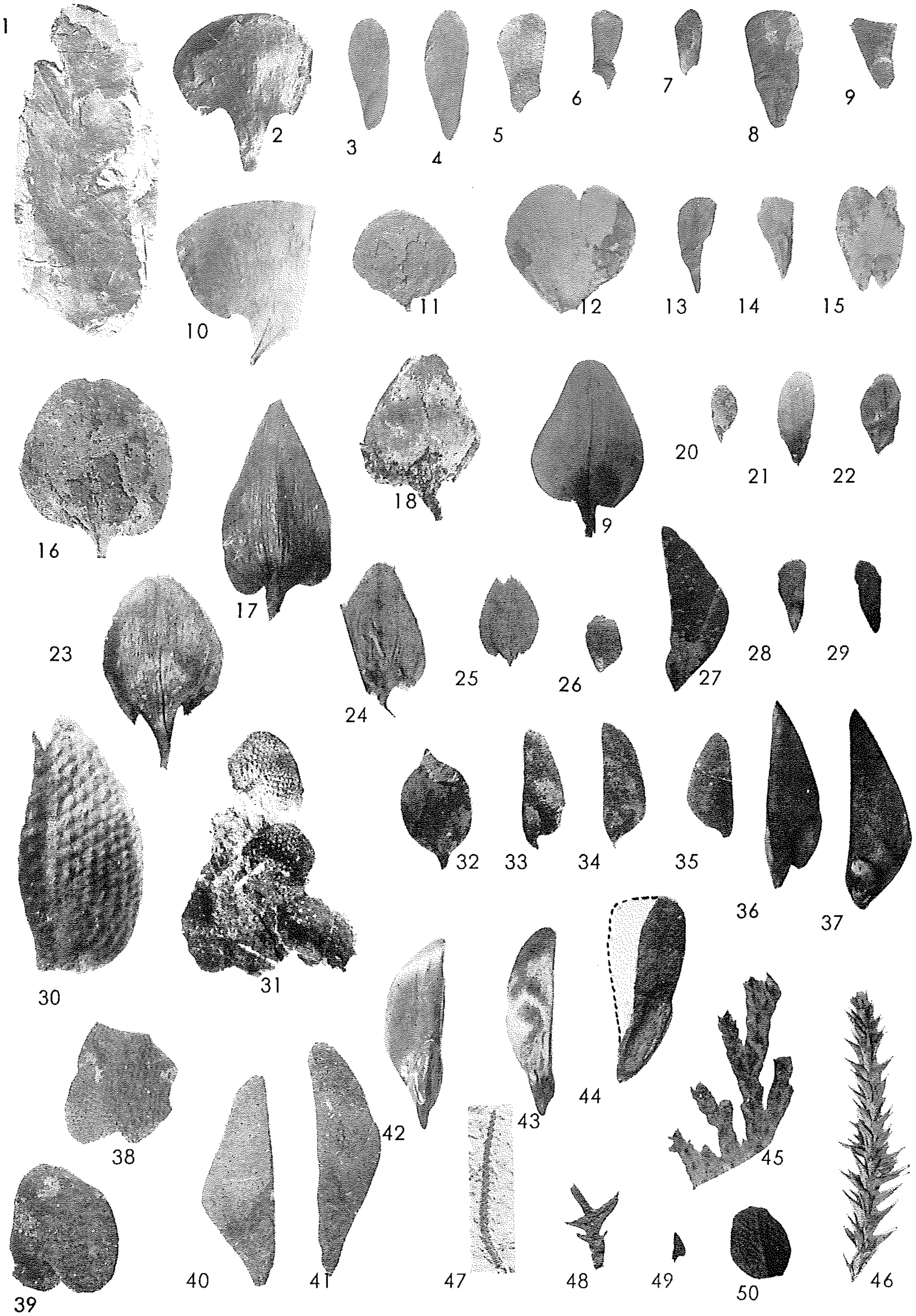


Photo T. TANAI & N. SUZUKI

Explanation of
Plate 2

Explanation of Plate 2

(All natural size)

Figs. 1, 5. *Glyptostrobus pensilis* KOCH.; the living leafy twig and cone for comparison, collected from the Botanical Garden of Kyôto University.

Fig. 2. *Pinus miocenica* TANAI sp. nov.; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Holotype U. H. Reg. No. 15085.

Figs. 3, 11. *Glyptostrobus europaeus* (BRONG.) HEER; Aburato coal mine, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotypes G. S. J. Reg. Nos. 4219, 4220.

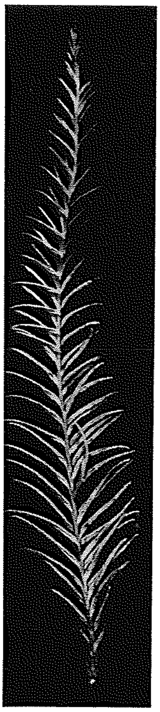
Fig. 4. *Pinus palaeopentaphylla* TANAI et ONOE; Yoshioka. Hypotype U. H. Reg. No. 15086.

Fig. 6. *Glyptostrobus europaeus* (BRONG.) HEER; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4221.

Figs. 7, 10. *Glyptostrobus europaeus* (BRONG.) HEER; Koishi coal mine, Sarufutsu-mura, Sôya-gun, Hokkaidô, Sôya coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. Nos. 15087, 15088.

Fig. 8. *Pinus trifolia* MIKI; Tokitsu-machi, Gifu Prefecture. Seto formation (Late Miocene or Early Pliocene). Hypotype U. H. Reg. No. 15089.

Fig. 9. *Pinus fujiii* (YASUI) MIKI; Hachiman-yama, Utsunomiya City, Tochigi Prefecture. Terazawa formation (Middle Miocene). Hopotype U. H. Reg. No. 15090.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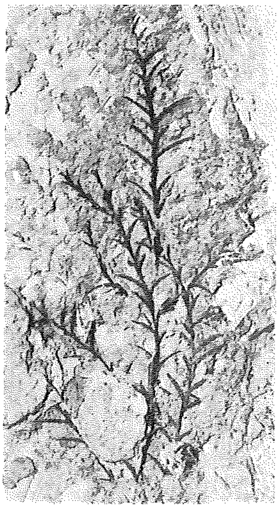
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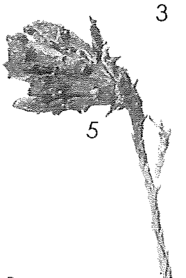
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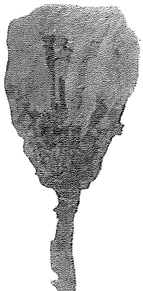
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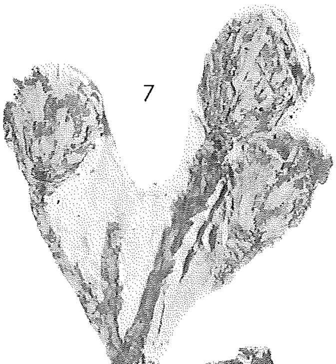
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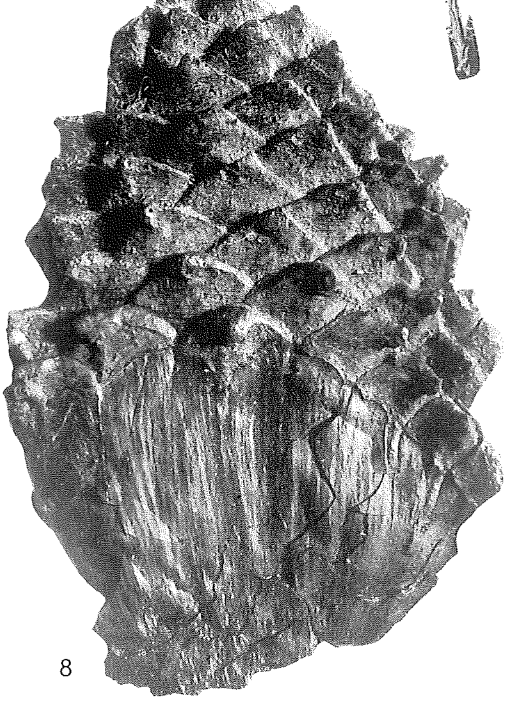
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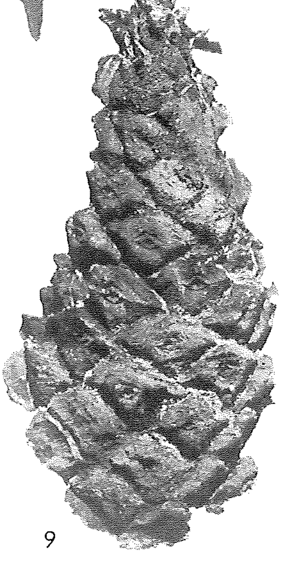
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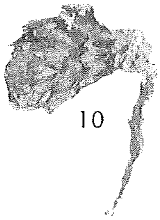
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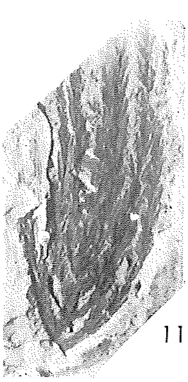
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 3

Explanation of Plate 3

(All natural size)

Figs. 1, 2. *Metasequoia occidentalis* (NEWBERRY) CHANEY; Abura, Setana-machi, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15091, 15092.

Fig. 3. *Metasequoia occidentalis* (NEWBERRY) CHANEY; Soya-magaribuchi coal mine, Wakkanai City, Hokkaidô. Sôya coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15093.

Figs. 4, 12. *Metasequoia glyptostroboides* HU; the living cone and foliar short for comparison, collected from Botanical Garden of Kyôto University.

Fig. 5. *Metasequoia occidentalis* (NEWBERRY) CHANEY; Takamine coal mine, Tenokomura, Nishi-okitama-gun, Yamagata Prefecture. Takamine coal-bearing member (Late Miocene). Hypotype G. S. J. Reg. No. 4222.

Figs. 6, 7. *Metasequoia occidentalis* (NEWBERRY) CHANEY; Koishi coal mine, Sarufutsumura, Soya-gun, Hokkaidô. Sôya coal-bearing member (Middle Miocene). Hypotypes U. H. Reg. Nos. 15094, 15095.

Fig. 8. *Metasequoia occidentalis* (NEWBERRY) CHANEY; Soya-magaribuchi coal mine. Hypotype U. H. Reg. No. 15096.

Fig. 9. *Pinus* sp.; Usetsu-machi, Noto peninsula, Ishikawa Prefecture. Higashi-innai formation (Middle Miocene). Holotype U. H. Reg. No. 15097.

Fig. 10. *Pinus fujiii* (YASUI) MIKI; Do. Hypotype U. H. Reg. No. 15098.

Fig. 11. *Sequoia affinis* LESQUEREU; Kida coal mine, Emukae-machi, Kita-matsuura-gun, Nagasaki Prefecture. Ainoura formation (Early Miocene). Hypotype G. S. J. Reg. No. 4223.

Fig. 13. *Taxodium dubium* (STERNB.) HEER; Takamine coal mine. Hypotype G. S. J. Reg. No. 4224.

Fig. 14. *Metasequoia occidentalis* (NEWBERRY) CHANEY; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15099.


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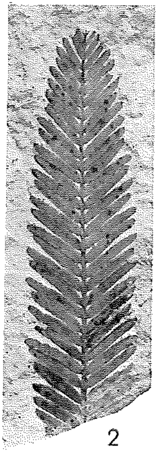
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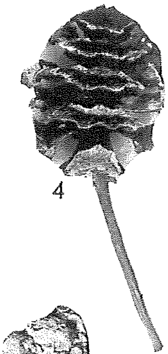
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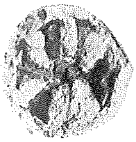
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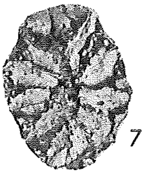
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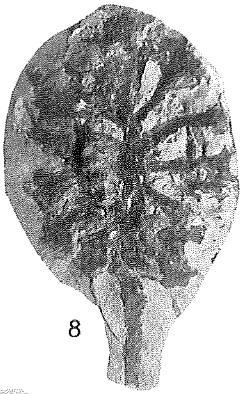
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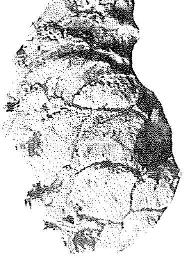
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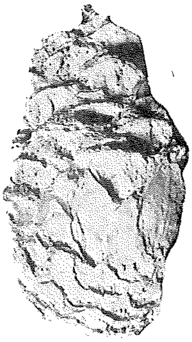
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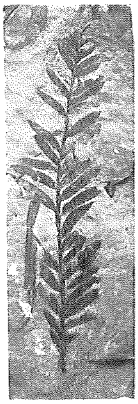
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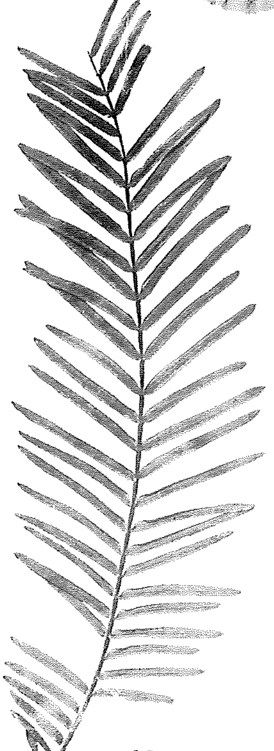
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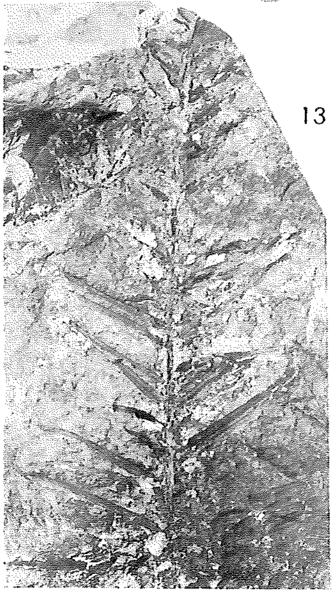
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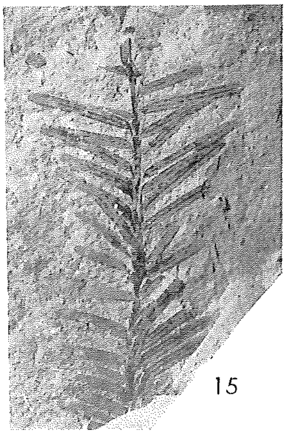
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 4

Explanation of Plate 4

(All natural size)

Fig. 1. *Populus latior* AL. BRAUN; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. Fo. 15100.

Figs. 2, 4. *Smilax trinervis* MORITA; Kitomo coal mine, Funakata-machi, Mogamigun, Yamagata Prefecture. Orewatari formation (Early Pliocene). Hypotypes U. H. Reg. Nos. 15101, 15102.

Figs. 3, 5. *Smilax trinervis* MORITA; Yoshioka. Hypotype U. H. Reg. Nos. 15103, 15104.

Fig. 6. *Pterocarya asymmetrosa* KONNO; Yoshioka. Hypotype U. H. Reg. No. 15105.

Fig. 7. *Pterocarya asymmetrosa* KONNO; Aburato coal mine, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype G. S. J. Reg. No. 4225.

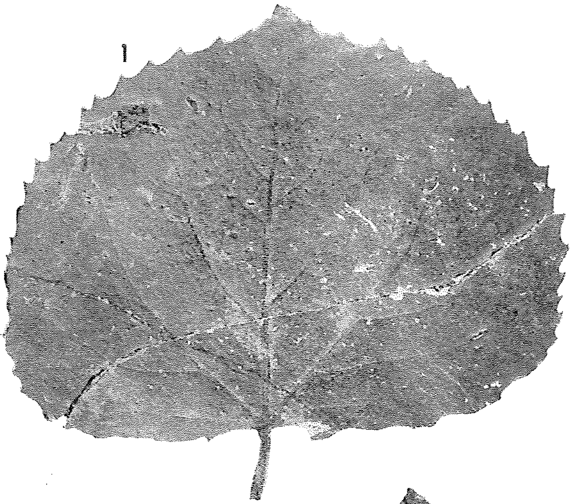
Fig. 8. *Populus balsamoides* GOEPPERT; Takamine coal mine, Tenoko-mura, Nishiokitama-gun, Yamagata Prefecture. Takamine coal-bearing member (Late Miocene). Hypotype G. S. J. Reg. No. 4226.

Fig. 9. *Populus* cfr. *balsamoides* GOEPPERT; Kinoko, Kaminokuni-mura, Hiyama-gun, Hokkaidô. "Fukuyama" formation (Middle Miocene). Hypotype U. H. Reg. No. 15106.

Fig. 10. *Pterocarya protostenoptera* TANAI sp. nov.; Takamine coal mine. Holotype G. S. J. Reg. No. 4227.

Fig. 11. *Pterocarya stenoptera* DC.; the living fruit for comparison, collected from the Botanical Garden of Kyôto University.

Fig. 12. *Salix k-suzukii* TANAI sp. nov.; Funaishi, Ashio-machi, Tochigi Prefecture. Funaishi formation (Late Miocene). Hypotype U. H. Reg. No. 15107.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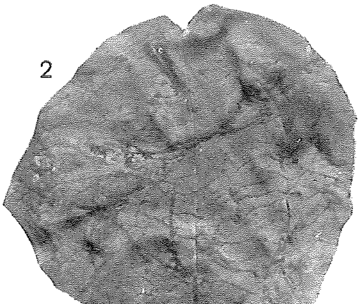
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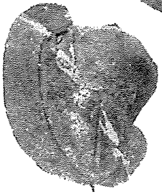
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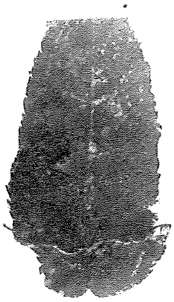
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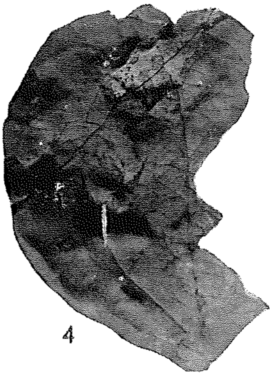
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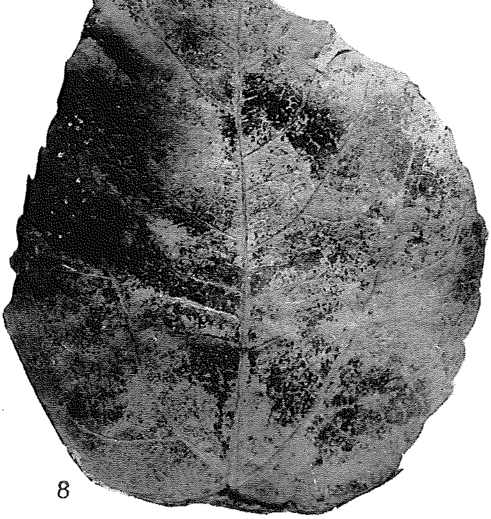
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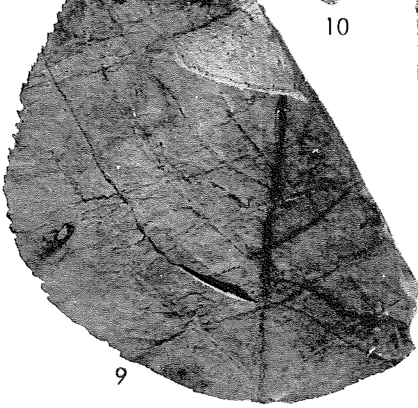
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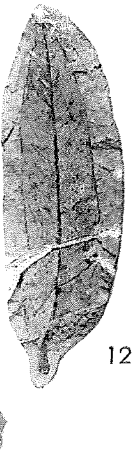
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 5

Explanation of Plate 5

(All natural size)

Fig. 1. *Myric* (*Comptonia*) *naumanni* (NATHORST) TANAI; Yamaguchi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Hypotype G.S. J. Reg. No. 4228.

Fig. 2. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Kusaidani, Tsuruoka City, Yamagata Prefecture. Kamigo formation. Hypotype G.S.J. Reg. No. 4229.

Fig. 3. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Yoshino, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U.H. Reg. No. 15108.

Figs. 4, 5, 17. *Myrica* (*Comptonia*) *kidoi* (ENDO) TANAI n. emd.; Kitomo coal mine, Funakata-machi, Yamagata Prefecture. Orewatari formation (Early Pliocene). Hypotypes U.H. Reg. Nos. 15109, 15110, 15111.

Fig. 6. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Ueda coal mine, Kadonomura, Ishiki-gun, Fukushima Prefecture. Taki coal-bearing formation (Middle Miocene). Hypotype G.S.J. Reg. No. 4230.

Fig. 7, 16. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Kumaishi-mura, Nishi-gun, Hokkaidô. "Kudo" coal-bearing formation (Middle Miocene). Hypotypes U.H. Reg. Nos. 15112, 15113.

Figs. 8, 9. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Sakipembetsu, Ashibetsu City, Hokkaidô. Nokanan coal-bearing formation (Middle Miocene). Hypotype U.H. Reg. Nos. 15114, 15115.

Fig. 10. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Hachimori-mura, Kita-akita-gun, Akita Prefecture. "Green tuff" formation (Middle Miocene). Hypotype U.H. Reg. No. 15116.

Fig. 11. *Platycarya miocenica* HU et CHANEY; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotype G. S.J. Reg. No. 4231.

Fig. 12. *Myrica* (*Comptonia*) *asplenifolia* BANK.; the living leaf for comparison, collected from Montreal, western Canada.

Fig. 13. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Abura, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Hypotype U.H. Reg. No. 15117.

Fig. 14. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotype G.S.J. Reg. No. 4232.

Fig. 15. *Prunus miobrachypoda* HU et CHANEY; Koishi coal mine, Sarufutsu-mura, Sôya-gun, Hokkaidô. Sôya coal-bearing formation (Middle Miocene). Hypotype U.H. Reg. No. 15118.

Fig. 18. *Myrica* (*Comptonia*) *naumanni* (NATHORST) TANAI; Tachimata-zawa, Animachi, Akita Prefecture. Utto formation (Middle Miocene). Hypotype U.H. Reg. No. 15119.


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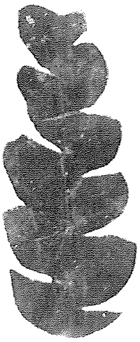
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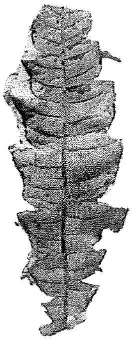
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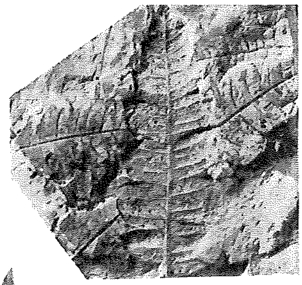
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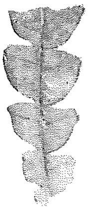
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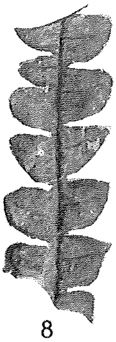
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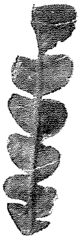
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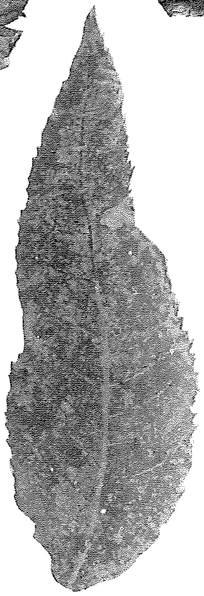
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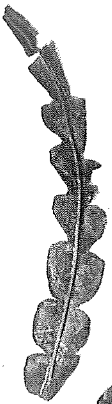
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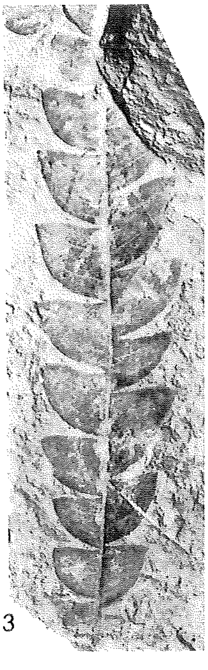
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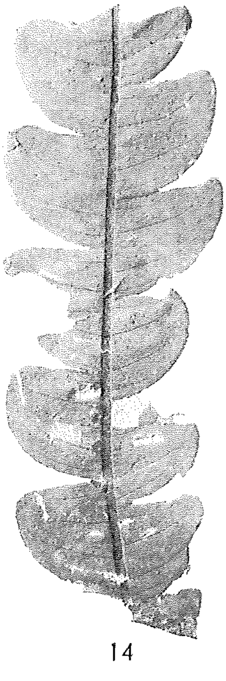
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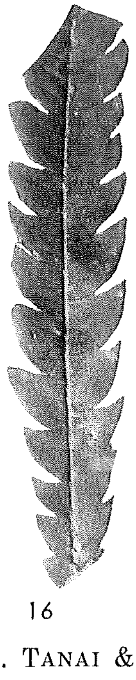
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 6

Explanation of Plate 6

(All natural size)

Figs. 1, 2, 7. *Juglans megacinerea* (CHANEY) MIKI; Kofunado, Hanamaki City, Yamagata Prefecture. "Tamazasa" formation (Late Pliocene). Hypotypes U. H. Reg. Nos. 15121, 15122, 15123.

Figs. 3, 4. *Carya miocathayensis* HU et CHANEY; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotype G. S. J. Reg. Nos. 4233, 4234.

Fig. 5. *Juglans miocathayensis* HU et CHANEY; Aburato coal mine, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype U. H. Reg. No. 15124.

Fig. 6. *Alnus protohirsuta* ENDO; Takamine coal mine, Tenoko-mura, Nishi-okitama-gun, Yamagata Prefecture. Takamine coal-bearing member (Late Miocene). Paratype G. S. J. Reg. No. 4235.

Fig. 8. *Alnus miojaponica* TANAI; Utanobori, Esashi-machi, Esashi-gun, Hokkaidô. Tachikarabetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15125.

Fig. 9. *Juglans japonica* TANAI sp. nov.; Koishi coal mine, Sarufutsu-mura Sôya-gun, Hokkaidô. Sôya coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15126.

Fig. 10. *Juglans japonica* TANAI sp. nov.; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Holotype U. H. Reg. No. 15127.

Fig. 11. *Alnus kefersteinii* (GOEP.) UNGER; Hiyoshi. Hypotype G. S. J. Reg. No. 4236.

Figs. 12, 13. *Alnus usyuensis* HUZIOKA; Sôya-magaribuchi coal mine, Wakkanai City, Hokkaidô. Sôya coal-bearing formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15128, 15129.


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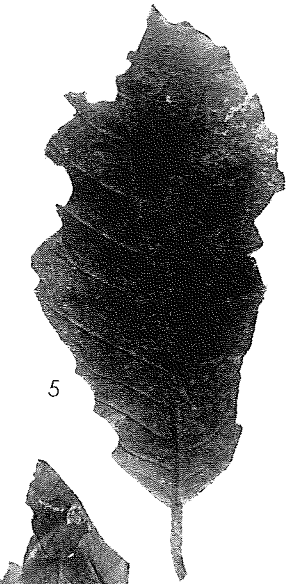
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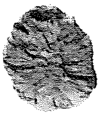
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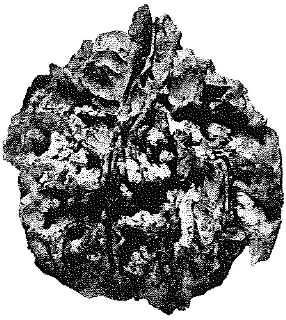
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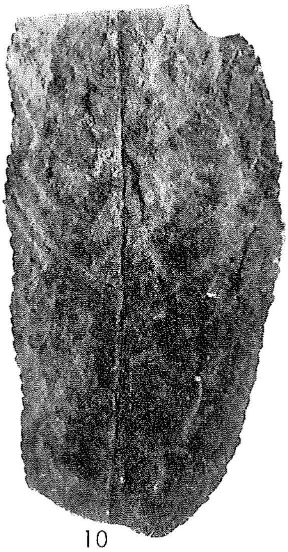
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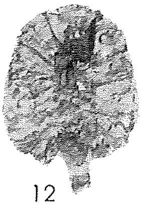
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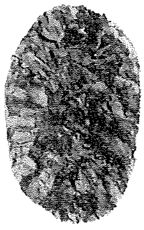
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 7

Explanation of Plate 7

(All natural size)

Fig. 1. *Alnus protohirsuta* ENDO; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15130.

Figs. 2, 5, 6. *Alnus usyuensis* HUZIOKA; Kinoko, Kaminokuni-mura, Hiyama-gun, Hokkaidô. "Fukuyama" formation (Middle Miocene). Hypotype U. H. Reg. Nos. 15131, 15132, 15133.

Fig. 3. *Alnus prenepalensis* HU et CHANEY; Kida coal mine, Emukae-machi, Kitamatsuura-gun Nagasaki Prefecture. Ainoura formation (Early Miocene). Hypotypes U. H. Reg. No. 15134.

Fig. 4. *Alnus protomaximowiczii* TANAI sp. nov.; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Holotype U. H. Reg. No. 15135.

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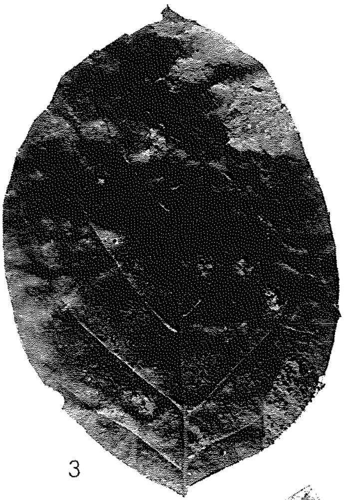

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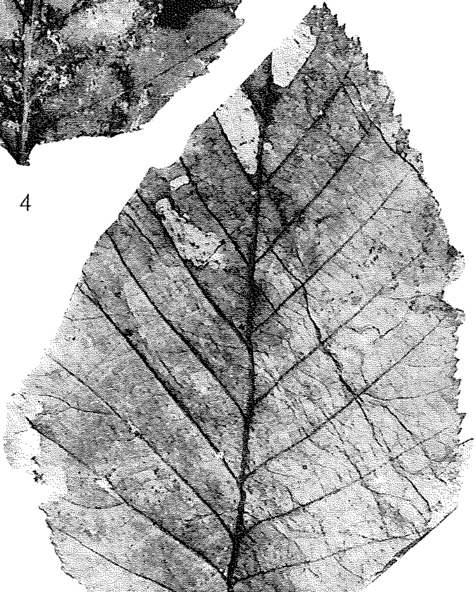

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Photo T. TANAI & N. SUZUKI

Explanation of Plate 8

Explanation of Plate 8

(All natural size)

Figs. 1, 12. *Corylus macquarrii* (FORBES) HEER; Kinoko, Kaminokuni-mura, Hiyama-gun, Hokkaidô. "Fukuyama" formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15136, 15137.

Fig. 2. *Ostrya huziokai* TANAI sp. nov.; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Holotype G. S. J. Reg. No. 4237.

Fig. 3. *Betula mioluminifera* HU et CHANEY; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15138.

Fig. 4. *Carpinus subcordata* NATHORST; Nukabira, Kami-shihoro-machi, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15139.

Fig. 5. *Ostrya subvirginiana* TANAI et ONOE; Shichiku, Ono-mura, Ishiki-gun, Fukushima Prefecture. Taki coal-bearing formation (Middle Miocene). Paratype G. S. J. Reg. No. 4028.

Fig. 6. *Carpinus miocenica* TANAI; Takamine coal mine, Tenoko-mura, Nishi-okitama-gun, Yamagata Prefecture. Takamine coal-bearing member (Late Miocene). Hypotype G. S. J. Reg. No. 4238.

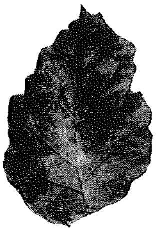
Figs. 7, 9. *Betula uzenensis* TANAI; Aburato coal mine, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Holotype U. H. Reg. No. 15140, Hypotype No. 15141.

Fig. 8. *Carpinus stenophylla* NATHORST; Kigo, Miyatsu City, Yosa peninsula, Kyôto Prefecture. Yosa group (Middle Miocene). Hypotype U. H. Reg. No. 15142.

Fig. 10. *Betula protoermanni* ENDO; Kami-saibara-mura, Tamada-gun, Okayama Prefecture. Onbara formation (Mio-Pliocene). Hypotype G. S. J. Reg. No. 4087.

Fig. 11. *Ostrya subvirginiana* TANAI et ONOE; Kinoko, Hokkaidô. Hypotype U. H. Reg. No. 15143.

Fig. 13. *Carpinus miocenica* TANAI; Kusaidani, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Holotype G. S. J. Reg. No. 4239.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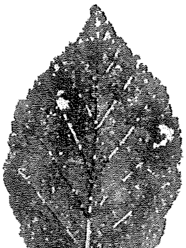
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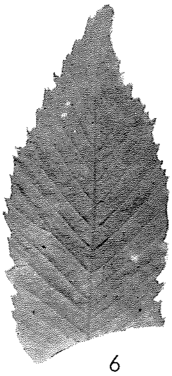
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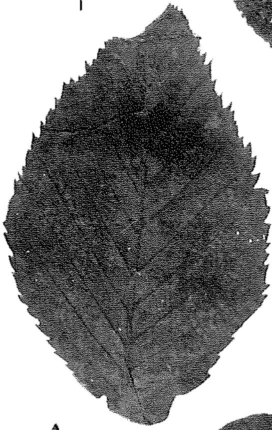
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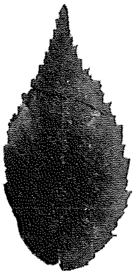
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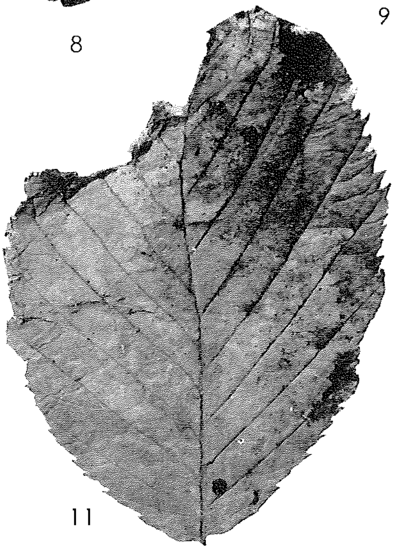
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 9

Explanation of Plate 9

(All natural size)

Fig. 1. *Betula kamigoensis* TANAI; Yamaguchi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Holotype G. S. J. Reg. No. 4240.

Fig. 2. *Alnus arasensis* HUZIOKA; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype U. H. Reg. No. 15144.

Figs. 3, 7. *Betula nipponica* TANAI sp. nov.; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Holotype U. H. Reg. No. 15145, Hypotype No. 15146.

Figs. 4, 6. *Betula protojaponica* TANAI sp. nov.; Nukabira, Kami-shihoro-machi, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Holotype U. H. Reg. No. 15147 (Fig. 6), Paratype No. 15148 (Fig. 4).

Fig. 5. *Alnus miojaponica* TANAI; Kusaidani, Tsuruoka City, Yamagata Prefecture. Kamigo formation. Holotype G. S. J. No. 4241.

Fig. 8. *Alnus usyuensis* HUZIOKA; Koishi coal mine, Sarufutsu-mura, Sôya-gun, Hokkaidô. Sôya coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15149.


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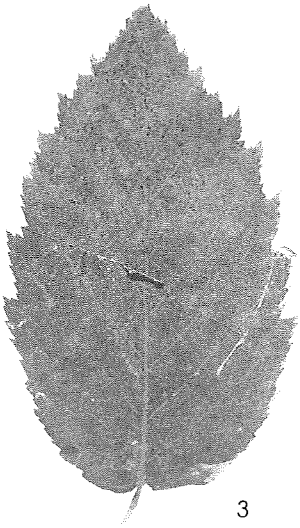
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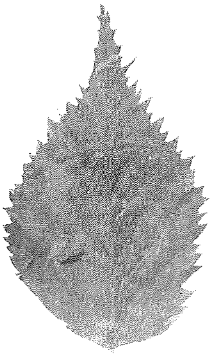
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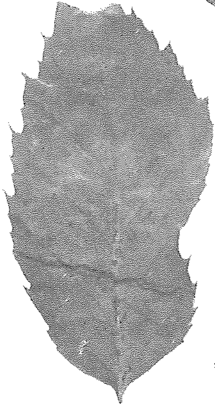
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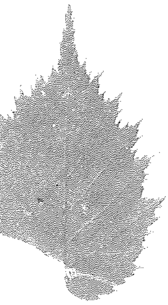
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 10

Explanation of Plate 10

(All natural size)

Figs. 1-3, 5-7. *Betula miomaximowicziana* ENDO; Nukabira, Kami-shihoro-machi, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotypes U. H. Reg. Nos. 15150, 15151, 15152, 15153, 15154, 15155.

Figs. 4, 8. *Betula protoermanni* ENDO; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotypes U. H. Reg. Nos. 15156, 15157.

Figs. 9, 11. *Betula nipponica* TANAI sp. nov.; Kigo, Miyatsu City, Yosa peninsula, Kyôto Prefec- ture. Yosa group (Middle Miocene). Hypotypes U. H. Reg. No. 15158 a, b.

Fig. 10. *Alnus miojaponica* TANAI; Abura, Setana-machi, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Hypotype U. H. Reg. No. 15160.

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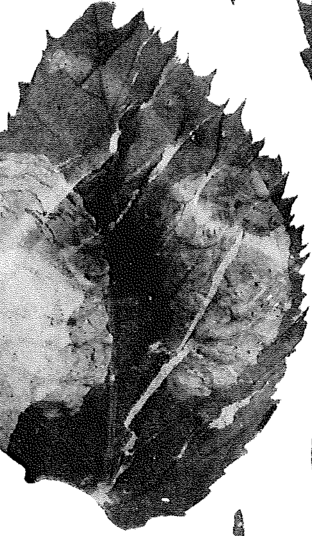

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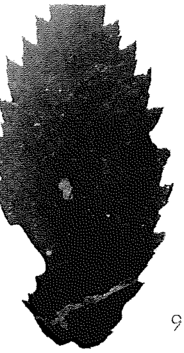

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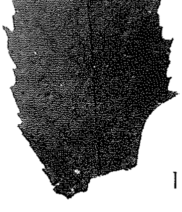

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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 11

Explanation of Plate 11

(All natural size)

Figs. 1, 10. *Carpinus subyedoensis* KONNO; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15161, 15162.

Figs. 2, 5, 6. *Carpinus stenophylla* NATHORST; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotypes G. S. J. Reg. Nos. 4242, 4243, 4244.

Figs. 3, 17. *Carpinus s-satoi* TANAI et ONOE; Hiyoshi. Hypotype G. S. J. Reg. No. 4245, 4246.

Fig. 4. *Carpinus kodairae-bracteata* HUZIOKA; Yoshioka. Hypotype U. H. Reg. No. 15163.

Fig. 7. *Carpinus laciniobracteata* HU et CHANEY; Yoshioka. Hypotype U. H. Reg. No. 15164.

Figs. 8, 15. *Carpinus ishikiensis* TANAI et ONOE; Yoshioka. Hypotypes U. H. Reg. No. 15165, 15166.

Fig. 9. *Betula onbaraensis* TANAI et ONOE; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15167.

Figs. 11, 14. *Carpinus subcordata* NATHORST; Yoshioka. Hypotypes U. H. Reg. Nos. 15168, 15169.

Fig. 12. *Carpinus ishikiensis* TANAI et ONOE; Hiyoshi. Hypotype G. S. J. Reg. No. 4247.

Fig. 13. *Carpinus subyedoensis* KONNO; Kinoko, Kaminokuni-mura, Hiyama-gun, Hokkaidô. "Fukuyama" formation (Middle Miocene). Hypotype U. H. Reg. No. 15170.

Fig. 16. *Carpinus miofangiana* HU et CHANEY; Yoshioka. Hypotype U. H. Reg. No. 15171.

Fig. 18. *Carpinus nipponica* ENDO; Onbara, Kami-saibara-mura, Okayama Prefecture. Onbara formation (Mio-Pliocene). Hypotype G. S. J. Reg. No. 4095.


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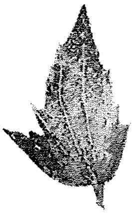
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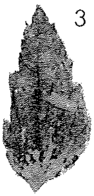
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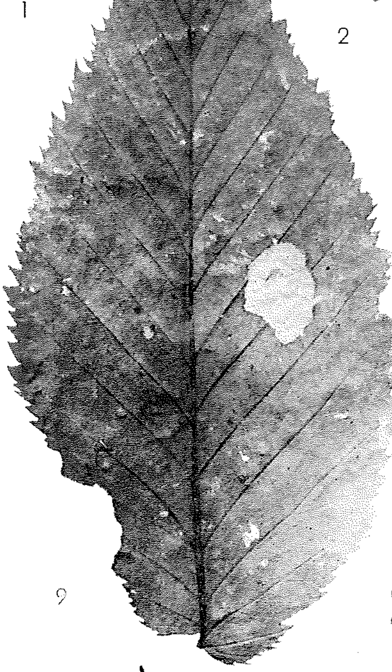
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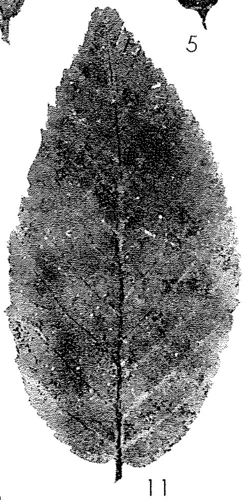
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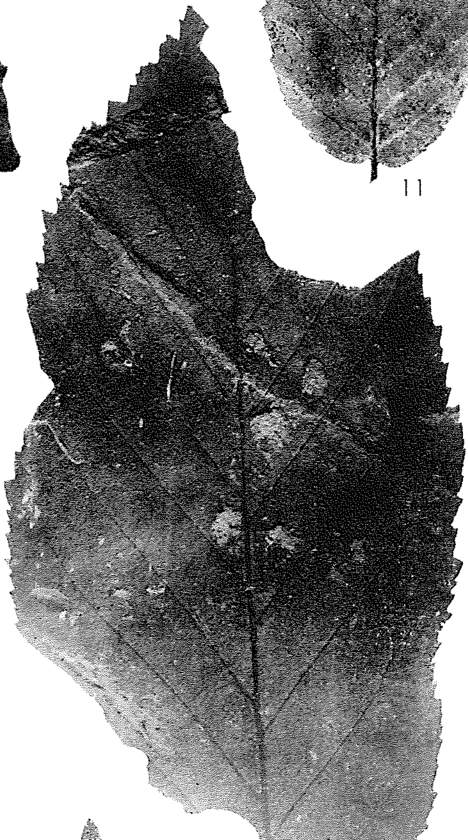
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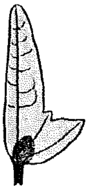
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 12

Explanation of Plate 12

(All natural size)

Fig. 1, 2, 8. *Castanea ungeri* HEER; Kusaidani Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4248, 4249 (Fig. 1 & 8), U. H. Reg. No. 15172.

Fig. 3. *Quercus nathorsti* KRYSHTOFOVICH; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama foamation (Middle Miocene). Hypotype G. S. J. Reg. No. 4250.

Figs. 4, 7. *Quercus mandraliscae* GAUDIN; Do. Hypotypes G. S. J. Reg. No. 4251, 4252.

Figs. 5, 6. *Castanea ungeri* HEER; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15173, 15174.


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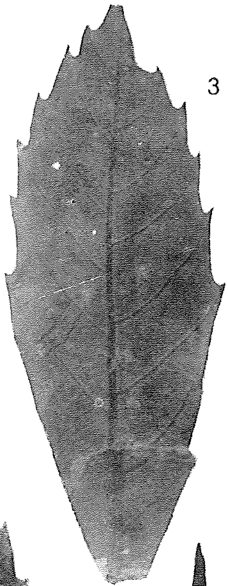
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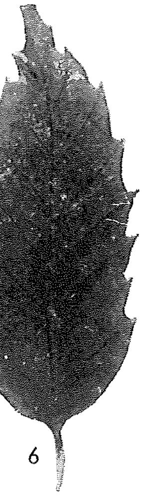
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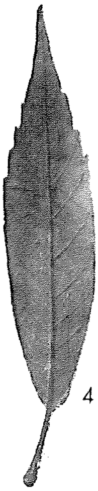
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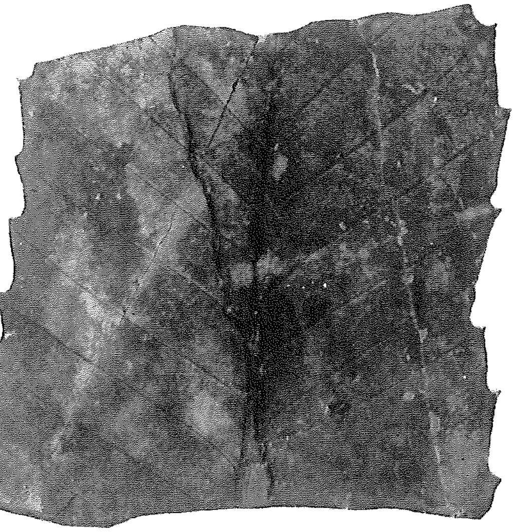
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 13

Explanation of Plate 13

(All natural size unless otherwise stated)

Fig. 1. *Quercus sinomiocenicum* HU et CHANEY; Kigo, Miyatsu City, Yosa peninsula, Kyôto Prefecture. Hypotype U. H. Reg. No. 15175. ×1/2

Fig. 2. *Quercus miocrispula* HUZIOKA; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15176.

Fig. 3. *Quercus koraica* TANAI; Do. Hypotype U. H. Reg. No. 15177.

Fig. 4. *Quercus sinomiocenicum* HU et CHANEY; Wakamatsu coal mine, Kita-hiyama-machi, Setana-gun, Hokkaidô. "Kudo" coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15178.

Figs. 5, 8. *Quercus subvariabilis* TANAI; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotypes G. S. J. Nos. 4253, 4254.

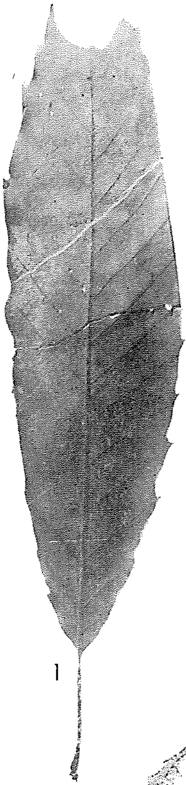
Fig. 6. *Quercus subvariabilis* TANAI; Yoshino, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation. Hypotype U. H. Reg. No. 15179.

Fig. 7. *Quercus subvariabilis* TANAI; Yamaguchi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Holotype G. S. J. Reg. No. 4255.

Fig. 9. *Quercus sinomiocenicum* HU et CHANEY; Kusaidani, Tsuruoka City, Yamagata Prefecture. Kamigo formation. Hypotype G. S. J. Reg. No. 4256.

Fig. 10. *Castanea ungeri* HEER; Kigo, Kyôto Prefecture. Hypotype U. H. Reg. No. 15180. ×1/2

Fig. 11. *Castanea ungeri* HEER; Kusaidani. Hypotype U. H. Reg. No. 15181.



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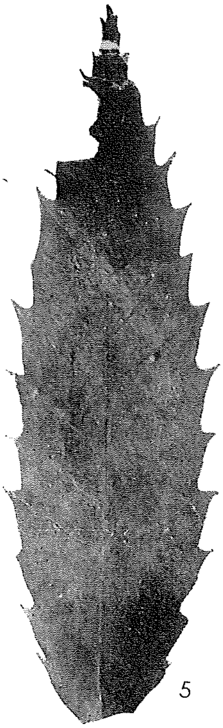

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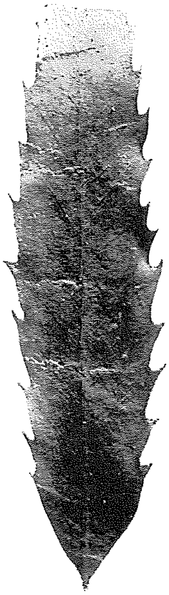

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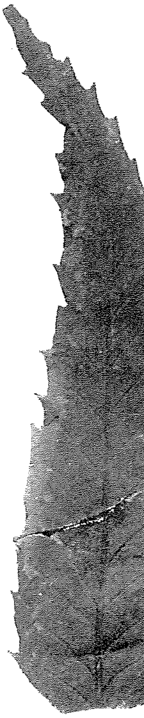

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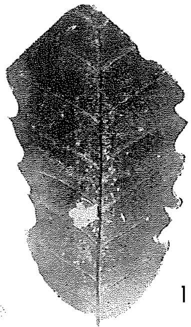

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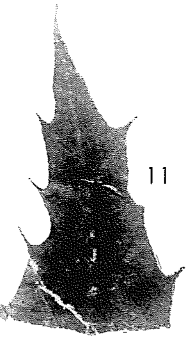

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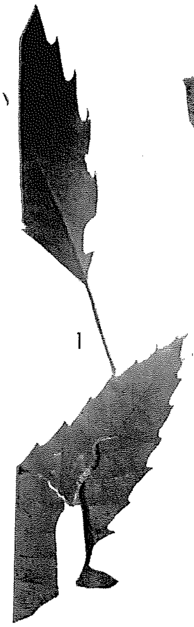
Photo T. TANAI & N. SUZUKI

Explanation of Plate 14

Explanation of Plate 14

(All natural size unless otherwise stated)

- **Fig. 1.** *Castanea ungeri* HEER; Kigo, Yosa peninsula, Kyôto Prefecture. Yosa group (Middle Miocene). Hypotype U. H. Reg. No. 15182. ×1/2
- **Fig. 2.** *Carpinus shimizui* TANAI; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Paratype G. S. J. Reg. No. 4257.
- **Fig. 3.** *Castanea ungeri* HEER; Do. Hypotype G. S. J. Reg. No. 4258.
- **Fig. 4.** *Castanea ungeri* HEER; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15183. ×1/2
- **Fig. 5.** *Castanea ungeri* HEER; Kusaidani, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4259. ×3/5
- **Fig. 6.** *Carpinus miocenica* TANAI; Do. Paratype G. S. J. Reg. No. 4260.
- **Fig. 7.** *Carpinus subcordata* NATHORST; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype U. H. Reg. No. 15184.
- **Fig. 8.** *Carpinus nipponica* ENDO; Ningyô-tôgé in the border between Tottori and Okayama Prefectures. Ningyô-tôgé formation (Early Pliocene). Hypotype G. S. J. Reg. No. 4094. ×1.5
- **Fig. 9.** *Carpinus shimizui* TANAI; Kusaidani. Holotype G. S. J. Reg. No. 4261.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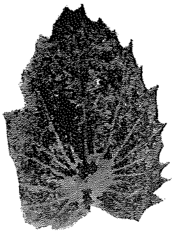
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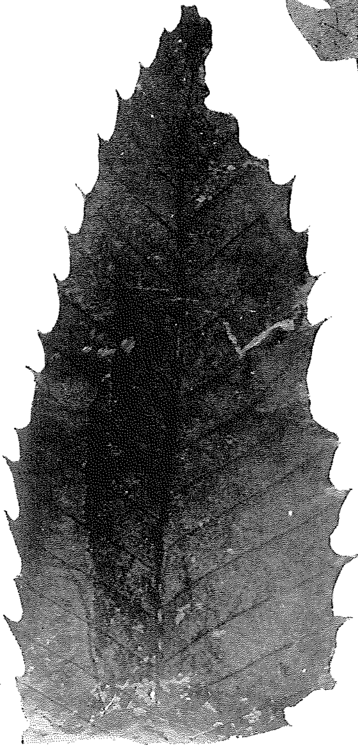
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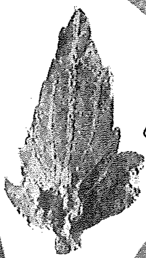
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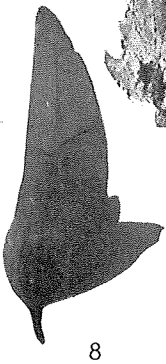
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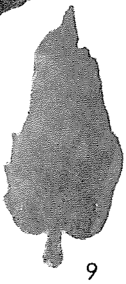
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 15

Explanation of Plate 15

(All natural size unless otherwise stated)

Fig. 1. *Fagus antipofi* HEER; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4262.

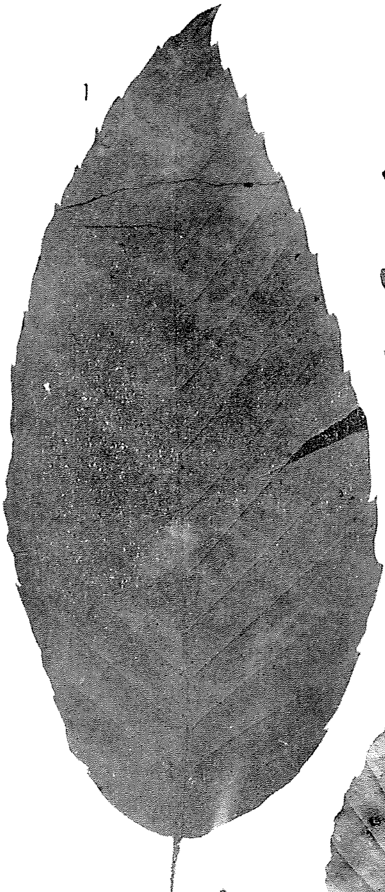
Figs. 2, 7. *Quercus miocrispula* HUZIOKA; Funaishi, Ashio-machi, Tochigi Prefecture. Hunaishi formation (Late Miocene). Hypotypes U. H. Reg. Nos. 15159, 15081.

Fig. 3. *Fagus palaeocrenata* OKUTSU; Horinouchi-mura, Mogami-gun, Yamagata Prefecture. Obayashi formation (Late Miocene). Hypotype U. H. Reg. No. 15185.

Figs. 4, 8. *Fagus palaeocrenata* OKUTSU; Mogi, Nagasaki City, Nagasaki Prefecture. Mogi formation (Early Pliocene). Hypotypes G. S. J. Reg. Nos. 4265, 4266.

Fig. 5. *Fagus protojaponica* SUZUKI; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15186.

Fig. 6. *Fagus protojaponica* SUZUKI; Do. Hypotype U. H. Reg. No. 15187. ×2/3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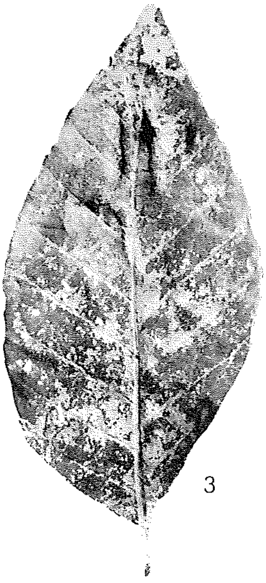
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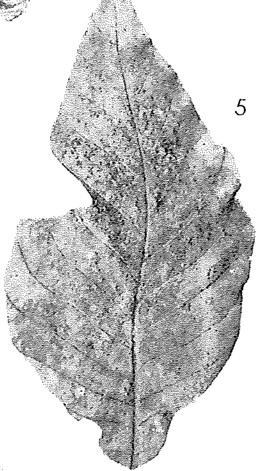
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 16

Explanation of Plate 16

(All natural size)

Figs. 1, 4-7. *Fagus antipofi* HEER; Abura, Setana-machi, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15188, 15189, 15190, 15191, 15192.

Figs. 2, 10. *Fagus antipofi* HEER; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotypes G. S. J. Reg. Nos. 4267, 4268.

Fig. 3. *Fagus americana* SWEET; the living leaf for comparison, collected near Boston City, eastern United States by Y. SASA.

Figs. 8, 9. *Fagus antipofi* HEER; Kigo, Miyatsu City, Yosa penincula, Kyôto Prefecture. Yosa group (Middle Miocene). Hypotypes U. H. Reg. Nos. 15193, 15194.


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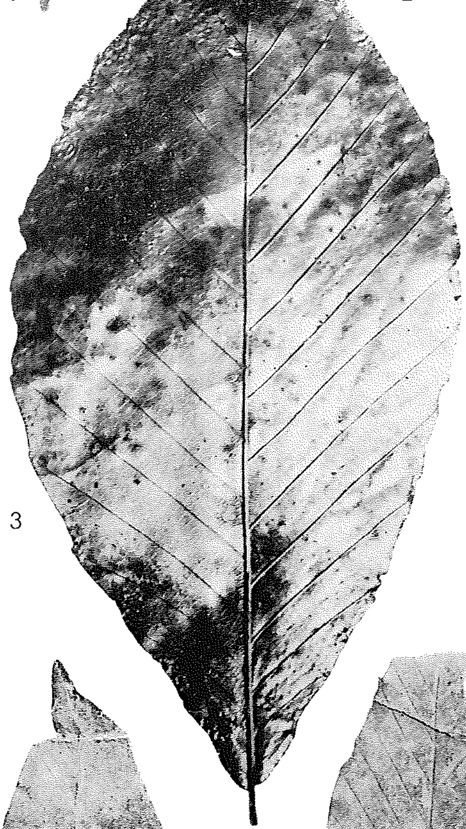
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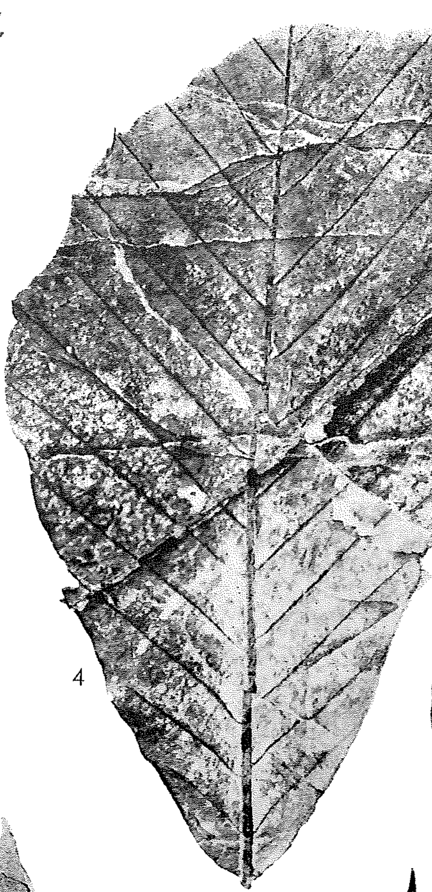
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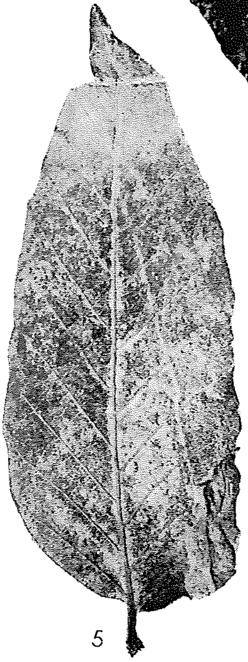
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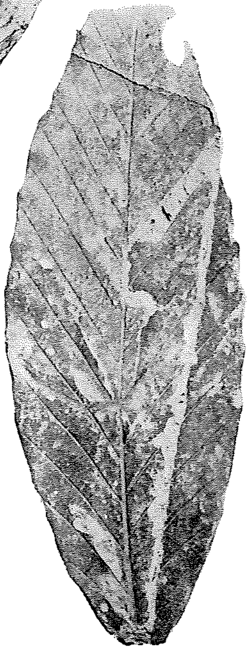
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 17

Explanation of Plate 17

(All natural size)

Fig. 1. *Celtis nordenskiordii* NATHORST; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15195.

Fig. 2. *Ulmus carpinoides* GOEPPERT; Kigo, Miyatsu City, Yosa peninsula, Kyôto Prefecture. Yosa group (Middle Miocene). Hypotype U. H. Reg. No. 15196.

Figs. 3, 6. *Ulmus appendiculata* HEER; Koishi coal mine, Saruhutsu-mura, Sôya-gun, Hokkaidô. Sôya coal-bearing formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15197, 15198.

Fig. 4. *Ulmus protojaponica* TANAI et ONOE; Nukabira, Kami-shihoro-mura, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15199.

Fig. 5. *Ulmus longifolia* UNGER; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype G. S. J. Reg. No. 4269.

Fig. 7. *Celtis miobungeana* HU et CHANEY; Kusaidani, Kamigô-machi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4270.

Fig. 8. *Celtis nathorsti* TANAI et ONOE; Kami-shanabuchi. Hypotype U. H. Reg. No. 15200.

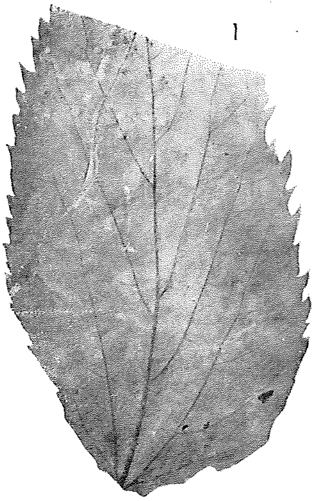
Fig. 9. *Ulmus subparvifolia* NATHORST; Yamaguchi, Kamigo-machi, Tsuruoka City, Yamagata Prefecture. Kamigo formation. Hypotype G. S. J. Reg. No. 4271.

Fig. 10. *Ulmus pseudolongifolia* OISHI et HUZIOKA; Sakipempetsu, Ashibetsu City, Hokkaidô. Nokanan coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15201.

Fig. 11. *Ulmus appendiculata* HEER; Sakipempetsu. Hypotypes U. H. Reg. No. 15202.

Figs. 12, 13. *Ulmus protolaciniata* TANAI et ONOE; Nukabira. Hypotypes U. H. Reg. Nos. 15203, 15204.

Fig. 14. *Ulmus longifolia* UNGER; Kigo. Hypotype U. H. Reg. No. 15205.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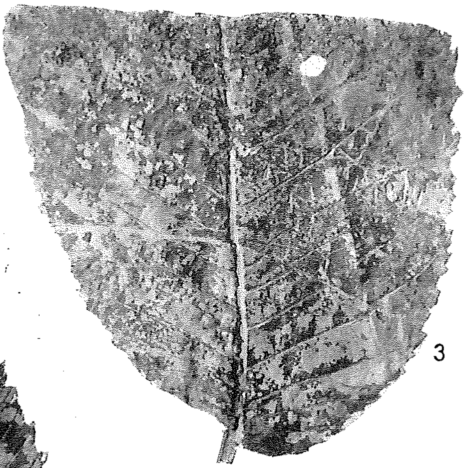
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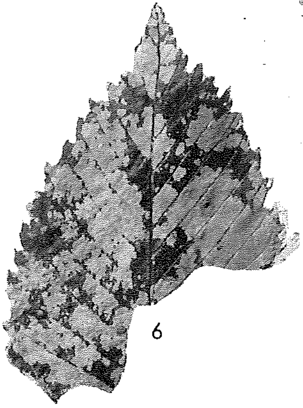
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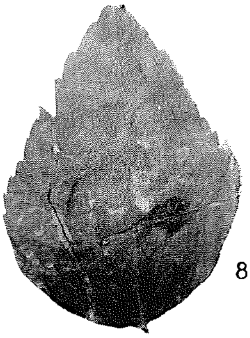
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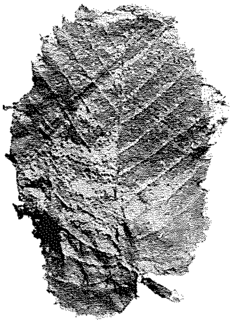
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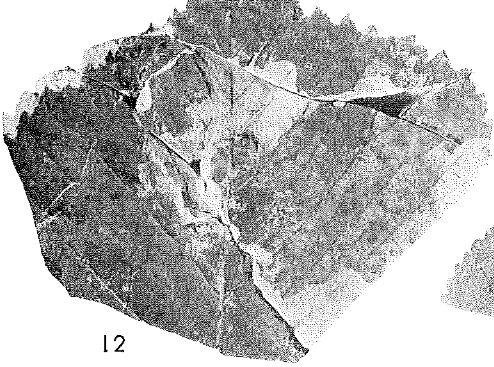
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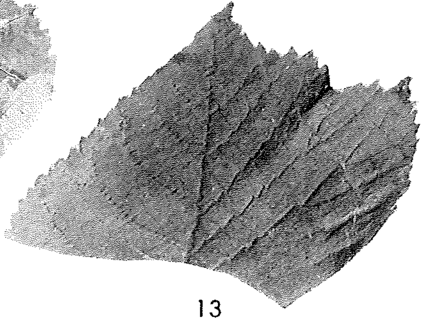
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 18

Explanation of Plate 18

(All natural size)

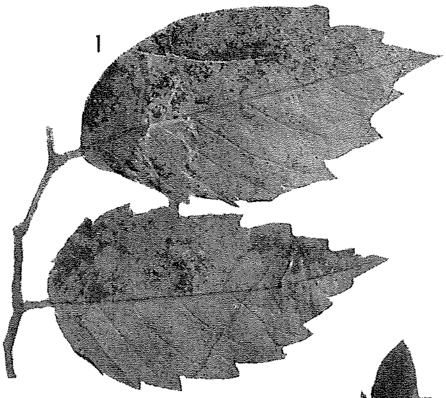
Figs. 1-3, 6-9. *Zelkova ungeri* (ETTING.) KOVATS; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotypes U.H. Reg. Nos. 15206, 15207, 15208, 15209, 15210, 15211, 15212.

Fig. 4. *Zelkova ungeri* (ETTING.) KOVATS; Kigo, Miyatsu City, Yosa peninsula, Kyôto Prefecture. Yosa group (Middle Miocene). Hypotype U.H. Reg. No. 15180 b.

Fig. 5. *Ulmus shiragica* HUZIOKA; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing formation (Middle Miocene). Hypotype G.S.J. Reg. No. 4272.

Fig. 10. *Ulmus protojaponica* TANAI et ONOE; Nukabira, Kami-shihoro-machi, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotype U.H. Reg. No. 15214.

Fig. 11. *Zelkova ungeri* (ETTING.) KOVATS; Kayanuma coal mine, Tomari-mura, Furuu-gun, Hokkaidô. Kayanuma coal-bearing formation (Middle Miocene). Hypotype U.H. Reg. No. 9383.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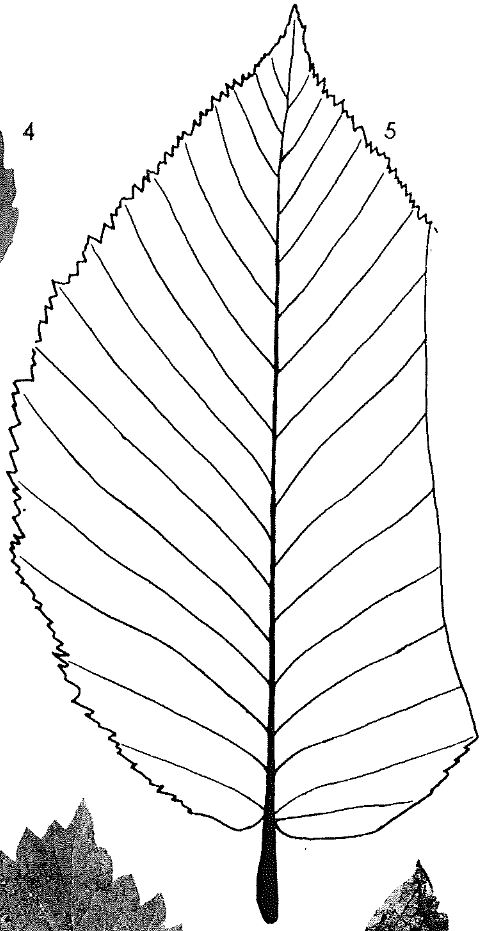
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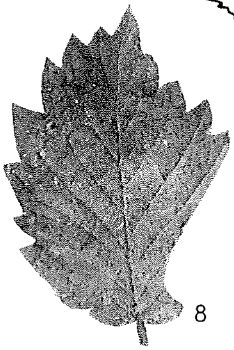
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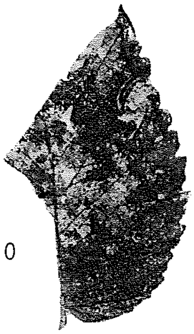
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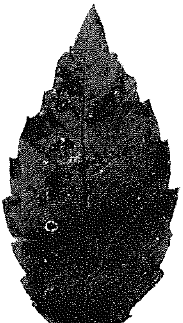
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 19

Explanation of Plate 19

(All natural size unless otherwise stated)

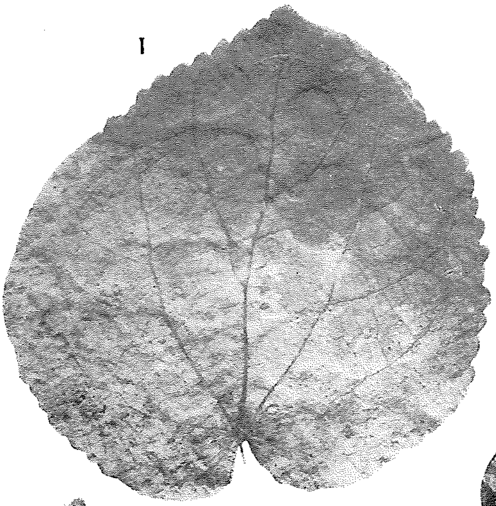
Fig. 1. *Cercidiphyllum crenatum* (UNGER) BROWN; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15215.

Fig. 2. *Cercidiphyllum crenatum* (UNGER) BROWN; Utanobori, Esashi-machi, Esashi-gun, Hokkaidô. Tachikarabetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15216.

Fig. 3. *Nelumbo endoana* OISHI et HUZIOKA; Sakipempetsu, Ashibetsu City, Hokkaidô. Nokanan coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15127.

Fig. 4. *Nelumbo nipponica* ENDO; Do. Hypotype U. H. Reg. No. 15218.

Fig. 5. *Nelumbo nipponica* ENDO; Emukaé coal mine, Emukaé-machi, Kita-matsuura-gun, Nagasaki Prefecture. The uppermost part of Ainoura formation (Early Miocene). Hypotyye G. S. J. Reg. No. 4273. ×7/10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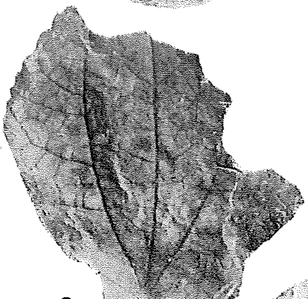
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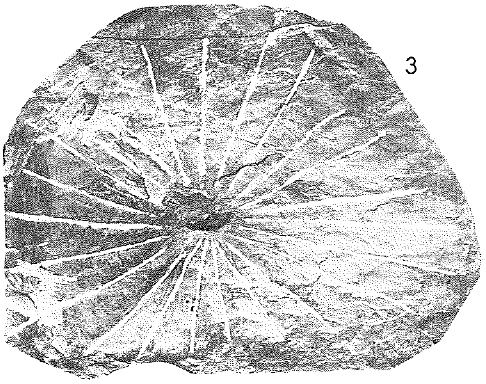
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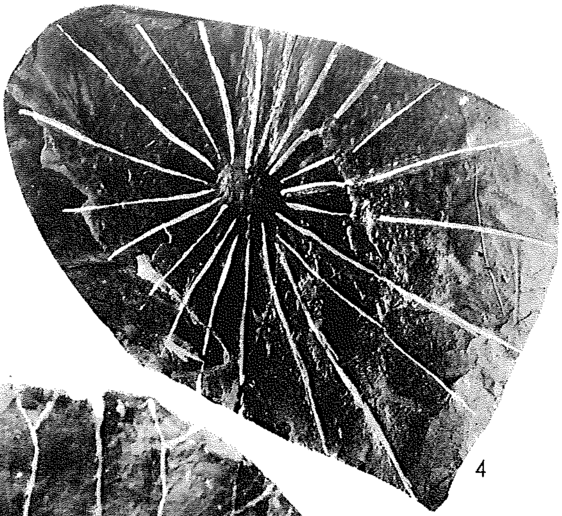
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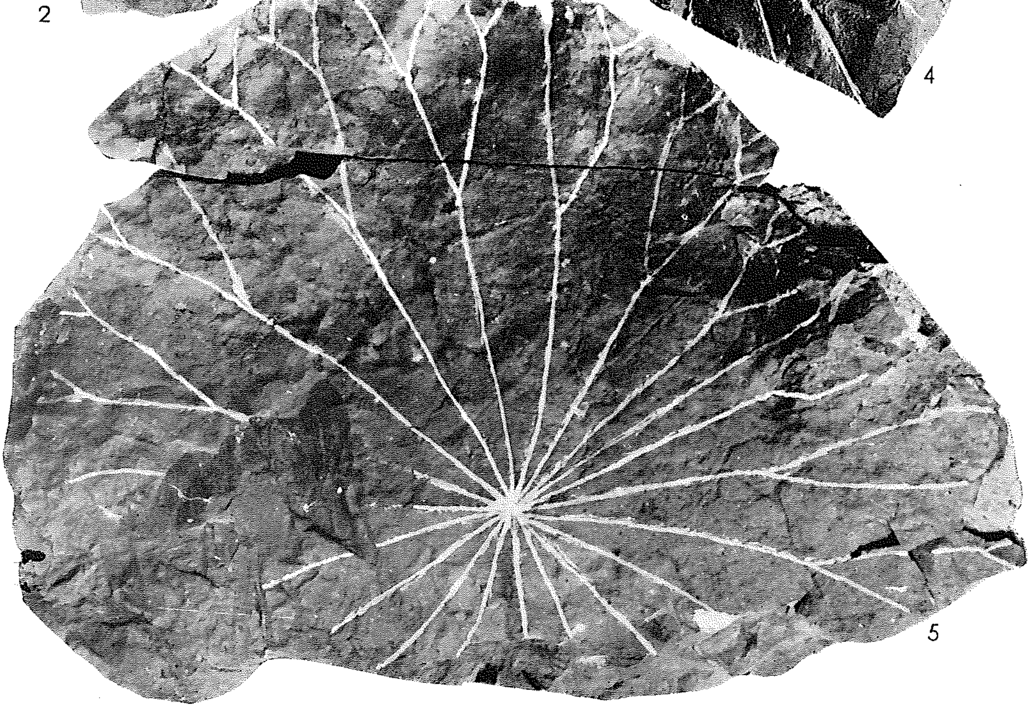
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 20

Explanation of Plate 20

(All natural size unless otherwise stated)

Figs. 1, 5. *Fothergilla viburnifolia* HU et CHANEY; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15219, 15220.

Figs. 2, 6. *Liquidambar mioformosana* TANAI; Do. Hypotypes U. H. Reg. Nos. 15221, 15222.

Figs. 3, 4. *Fothergilla viburnifolia* HU et CHANEY; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotypes G. S. J. Reg. Nos. 4274, 4275.

Fig. 7. *Liquidambar formosana* HANCE; the living fruit for comparison, collected from the Botanical Garden of Kyôto University.

Fig. 8. *Liquidambar mioformosana* TANAI; Hiramaki-mura, Kani-gun, Gifu Prefecture. Hypotype U. H. Reg. No. 7564.

Fig. 9. *Liquidambar mioformosana* TANAI; Yamaguchi, Kamigô-machi, Tsuruoka City, Yamagata Prefecture. Kamigô formation (Middle Miocene). Holotype G. S. J. Reg. No. 4276. ×7/10

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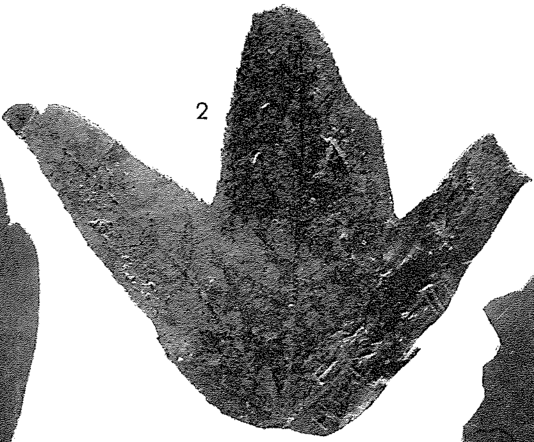

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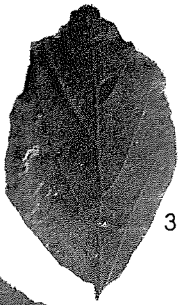

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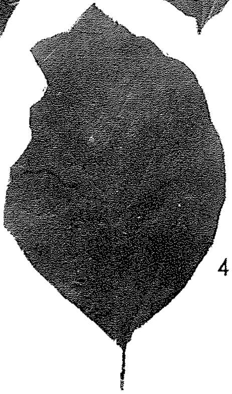

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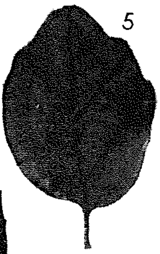

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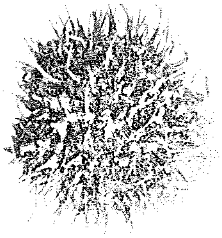

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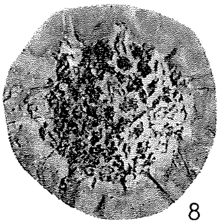

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Photo T. TANAI & N. SUZUKI

Explanation of Plate 21

Explanation of Plate 21

(All natural size)

Figs. 1, 10. *Magnolia nipponica* TANAI sp. nov.; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Holotype U. H. Reg. No. 15223 (Fig. 1), Paratype No. 15224 (Fig. 10).

Fig. 2. *Eucommia ulmoides* OLIVER; the living fruit for comparison, collected from the Botanical Garden of Kyôto Uniuersity.

Fig. 3. *Eucommia japonica* TANAI sp. nov.; Kusaidani, Kamigô-machi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Holotype U. H. Reg. No. 15225.

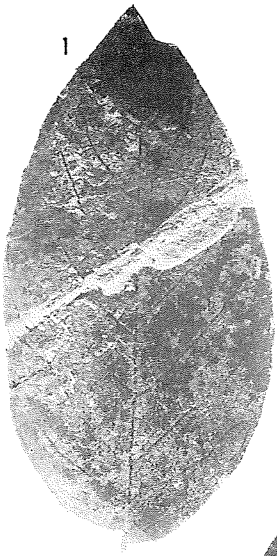
Figs. 4, 6. *Berberis saseboensis* TANAI sp. nov.; Shin-minato coal mine, Sasebo City, Nagasaki Prefecture. Ainoura formation (Early Miocene). Holotype U. H. Reg. No. 15226 (Fig. 6), Paratype Fo. 15227 (Fig. 4).

Figs. 5, 8, 11. *Parabenzoin protopraecox* (ENDO) TANAI; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotypes G. S. J. Reg. Nos. 4277, 4278, 4279.

Fig. 7. *Cocculus heteromorpha* (KNOWLTON) BROWN; Chikubetsu coal mine, Haboro-machi, Tomamae-gun, Hokkaidô. Haboro coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15228.

Fig. 9. *Magnolia nipponica* TANAI sp. nov.; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4280.

Fig. 12. *Mangolia miocenica* HU et CHANEY; Koishi coal mine, Sarufutsu-mura, Sôya-gun, Hokkaidô. Sôya coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15229.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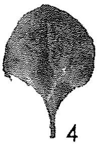
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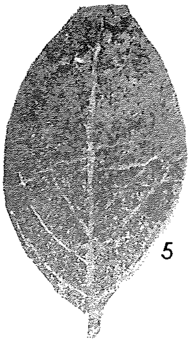
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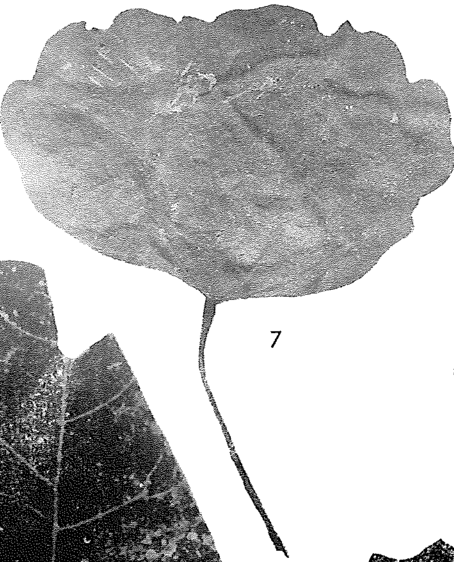
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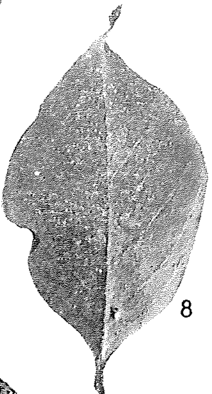
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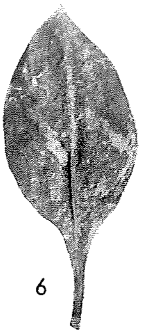
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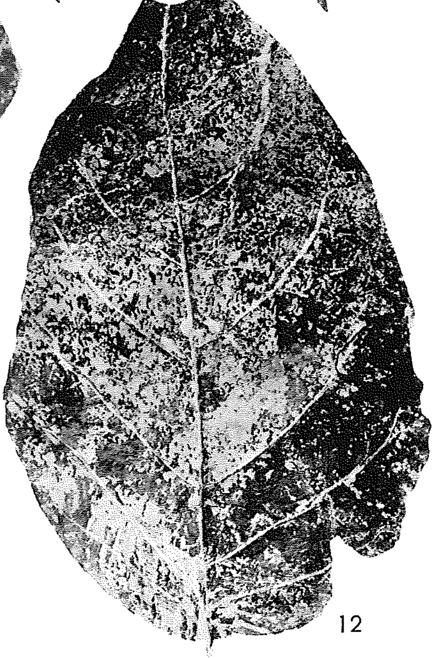
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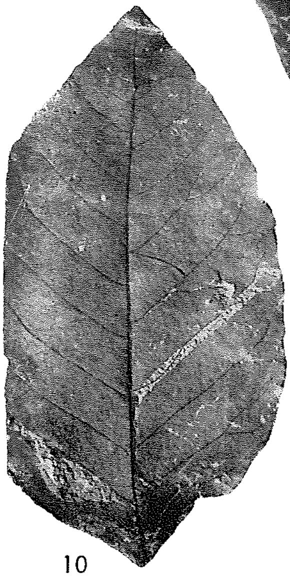
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 22

Explanation of Plate 22

(All natural size)

Fig. 1. *Lindera gaudini* (NATHORST) TANAI; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4281.

Fig. 2. *Lindera* sp.; Do. Holotype G. S. J. Reg. No. 4282.

Fig. 3. *Machilus ugoana* HUZIOKA; Do. G. S. J. Reg. No. 4283.

Figs. 4, 5. *Parabenzoin protopraecox* (ENDO) TANAI; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15230, 15231.

Fig. 6. *Actinodaphne nipponica* TANAI sp. nov.; Tachimata-zawa, Ani-machi, Akita Prefecture. Uttô formation (Middle Miocene). Holotype U. H. Reg. No. 15232.

Fig. 7. *Sassafras subtriloba* (KONNO) TANAI et ONOE; Hiyoshi, Mizunami City, Toki-gun, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4284.

Fig. 8. *Neolitsea japonica* TANAI sp. nov.; Ouchi. Hypotype G. S. J. Reg. No. 4285.


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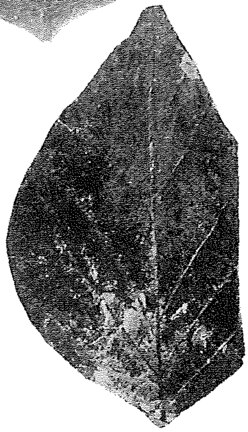
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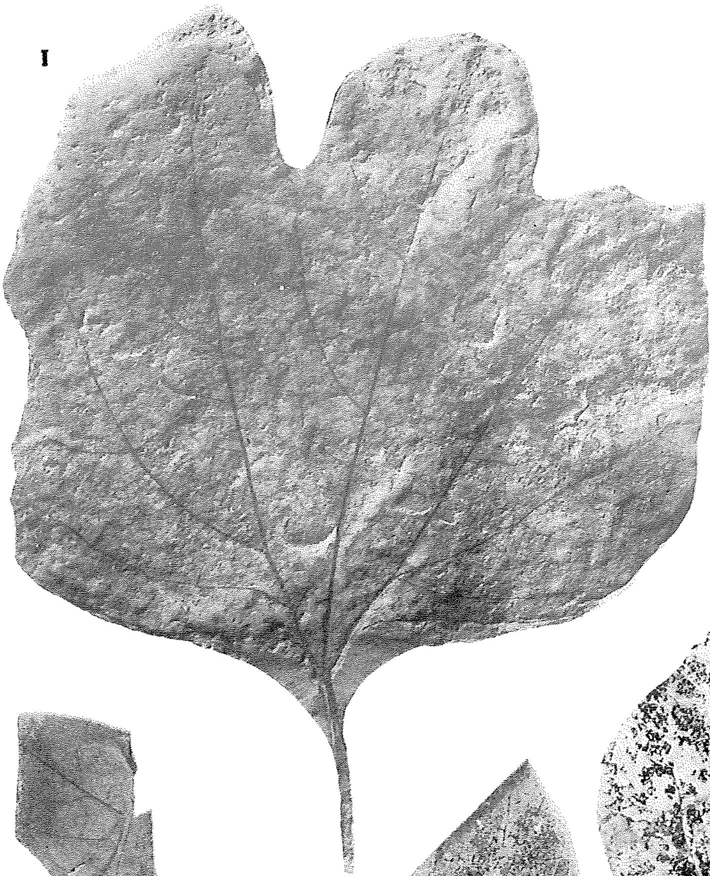
Photo T. TANAI & N. SUZUKI

Explanation of
Plate 23

Explanation of Plate 23

(All natural size)

- **Fig. 1.** *Sassafras yabei* ENDO; Funaishi, Ashio-machi, Tochigi Prefecture. Funaishi formation (Late Miocene). Hypotype U. H. Reg. No. 15233.
- **Fig. 2.** *Actinodaphne* sp.; Tachimata-zawa, Ani-machi, Akita Prefecture. Uttô formation (Middle Miocene). Holotype U. H. Reg. No. 15234.
- **Fig. 3.** *Cinnamomum oguniense* MORITA; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4286.
- **Fig. 4.** *Sassafras subtriloba* (KONNO) TANAI et ONOE; Abura, Setana-machi, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Hypotype U. H. Reg. No. 15235.
- **Fig. 5.** *Sassafras subtriloba* (KONNO) TANAI et ONOE; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15236.
- **Fig. 6.** *Cinnamomum miocenum* MORITA; Chausu-yama, Shinonoi City, Nagano Prefecture. "Ogawa" formation (Late Miocene). Hypotype U. H. Reg. No. 15237.
- **Fig. 7.** *Sassafras subtriloba* (KONNO) TANAI et ONOE; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype U. H. Reg. No. 15238.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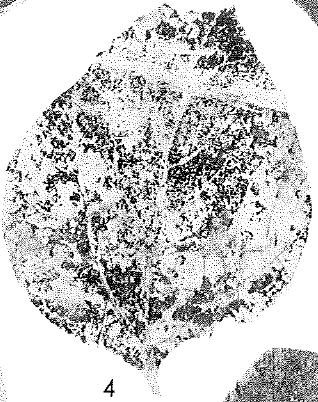
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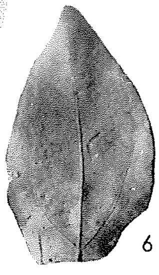
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Photo T. Tanai & N. Suzuki

Explanation of Plate 24

Explanation of Plate 24

(All natural size unless otherwise stated)

Fig. 1. *Cercis endoi* SUZUKI; Mitoku, Misasa-machi, Tottori Prefecture. Mitoku formation (Late Miocene). Hypotype G. S. J. Reg. No. 4287.

Fig. 2. *Entada mioformosana* TANAI; Takaya-machi, Tamasu City, Noto peninsula, Ishikawa Prefecture. Orito member (Middle Miocene). Hypotype Kyôto University Reg. No. ?

Fig. 3. *Sapindus kaneharai* TANAI; Kusaidani, Kamigô-machi, Tsuruoka City, Yamagata Prefecture. Kamigô formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4288.

Fig. 4. *Sapindus kaneharai* TANAI; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4289.

Fig. 5. *Rosa usyuensis* TANAI; Eri coal mine, Emukae-machi, Kita-matsuura-gun, Nagasaki Prefecture. The uppermost part of Ainoura formation (Early Miocene). Hypotype G. S. J. Reg. No. 4290.

Fig. 6. *Rosa usyuensis* TANAI; Hiyoshi, Mizunami City, Toki-gun, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Paratype G. S. J. Reg. No. 4291.

Figs. 7, 8. *Sorbus nipponica* TANAI et ONOE; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotypes U. H. Reg. Nos. 15239, 15240.

Fig. 9. *Rosa usyuensis* TANAI; Kusaidani. Holotype G. S. J. Reg. No. 4292.

Figs. 10, 11, 16. *Robinia nipponica* TANAI sp. nov.; Yoshioka. Holotype U. H. Reg. No. 15241 (Fig. 16), Paratypes Nos. 15242, 15243 (Figs. 10, 11).

Fig. 12. *Pistacia miochinensis* HU et CHANEY; Kusaidani. Hypotype G. S. J. Reg. No. 4293.

Figs. 13, 21. *Sophora miojaponica* Hu et CHANEY; Kida coal mine, Emukae-machi, Kita-matsuura-gun, Nagasaki Prefecture. Hypotypes U. H. Reg. Nos. 15244, 15245.

Figs. 14, 22. *Sophora miojaponica* HU et CHANEY; Utanobori, Esashi-machi, Esashi-gun, Hokkaidô. Tachikarabetsu formation (Late Miocene). Hypotypes U. H. Reg. Nos. 15246, 15247.

Fig. 15. *Dodonaea japonica* (MORITA) TANAI; Yamaguchi, Kamigô-machi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4294.

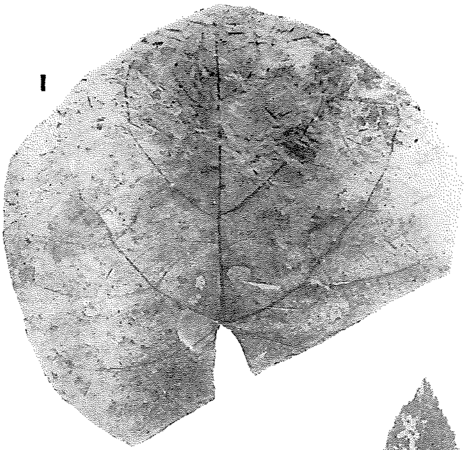
Fig. 17. *Euonymus protobungeana* HU et CHANEY; Hiyoshi. Hypotype G. S. J. Reg. No. 4295.

Fig. 18. *Rhus miosuccedanea* HU et CHANEY; Kusaidani. Hypotype G. S. J. Reg. No. 4303. ×4/5

Fig. 19. *Actinodaphne nipponica* TANAI sp. nov.; Ouchi. Hypotype G. S. J. Reg. No. 4296.

Fig. 20. *Rhus protoambigua* SUZUKI; Yoshioka. Hypotype U. H. Reg. No. 15248.

Fig. 23. *Rhus ezoense* TANAI sp. nov.; Yoshioka. Holotype U. H. Reg. No. 15249.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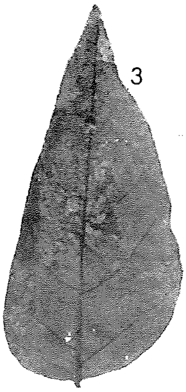
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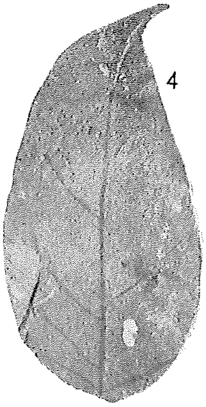
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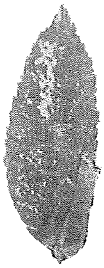
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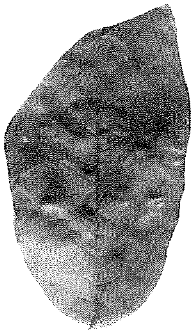
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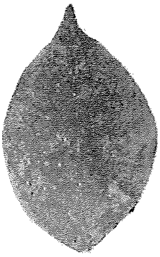
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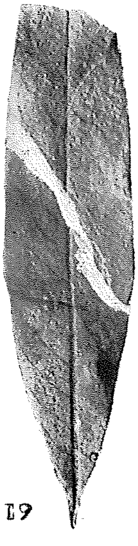
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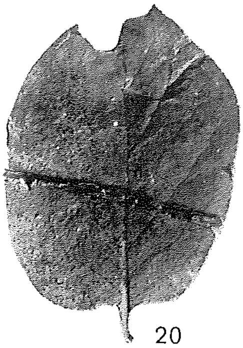
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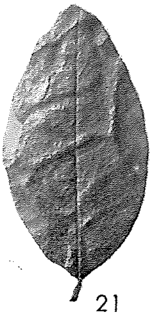
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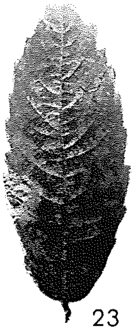
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 25

Explanation of Plate 25

(All natural size unless otherwise stated)

Fig. 1. *Platanus aceroides* GOEPPERT; Sakipempetsu, Ashibetsu City, Hokkaidô. Nokanan coal-bearing formation (Middle Miocene). Hypotype U. H. Reg. No. 15250.

Fig. 2. *Acer prototrifidium* TANAI; Noroshi-shin-machi, Tamasa City, Ishikawa Prefecture. Orito member (Middle Miocene).

Fig. 3. *Robinia nipponica* TANAI sp. nov.; Kusaidani, Kamigô-machi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Hypotype U. H. Reg. No. 15251.

Fig. 4. *Wistaria fallax* (NATHORST) TANAI et ONOE; Onbara, Kami-saibara-mura, Okayama Prefecture. Onbara formation (Mio-Pliocene). Paratype G. S. J. Reg. No. 4177.

Fig. 5. *Hamamelis miomollis* HU et CHANEY; Kida coal mine, Sasebo City, Nagasaki Prefecture. The lower part of Ainoura formation (Early Miocene). Hypotype U. H. Reg. No. 15252.

Fig. 6. *Buxus protojaponica* TANAI et ONOE; Onbara. Holotype G. S. J. Reg. No. 4170. ×2

Fig. 7. *Stewartia okutsui* TANAI; Nukabira, Kami-shihoro-machi, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15253.

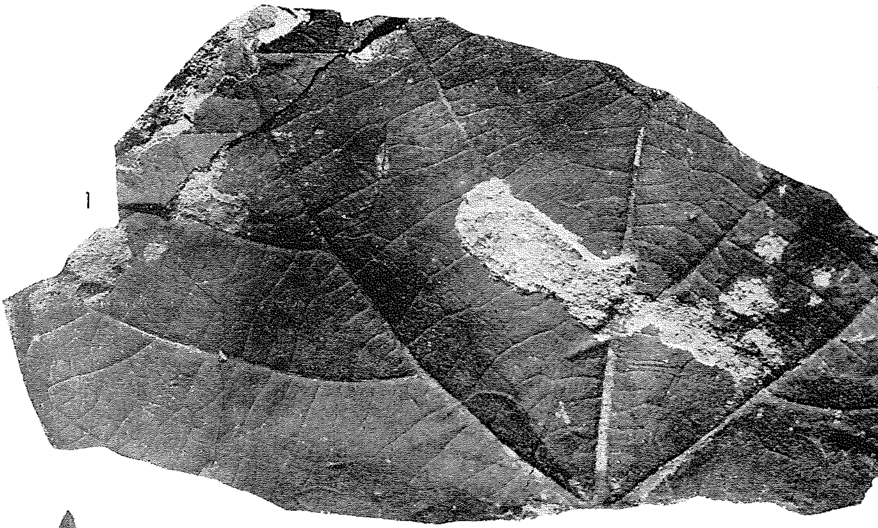
Fig. 8. *Rhododendron protodilatatum* TANAI et ONOE; Mitoku, Misasa-machi, Tottori Prefecture. Mitoku formation (Late Miocene). Holotype G. S. J. Reg. No. 4198.

Fig. 9. *Stewartia submonadelpha* TANAI et ONOE; Chausu-yama, Shinonoi City, Nagano Prefecture. "Ogawa" formation (Late Miocene). Hypotype U. H. Reg. No. 15254.

Fig. 10. *Stewartia okutsui* TANAI sp. nov.; Do. Holotype U. H. Reg. No. 15255.

Fig. 11a. *Hydrangea lanceolimba* HU et CHANEY; Kida coal mine, Emukae-machi, Kitamatsuura-gun, Nagasaki Prefecture. Ainoura formation (Early Miocene). Hypotype U. H. Reg. No. 15256 a.

Fig. 11b. *Hydrangea miobretschneideri* HU et CHANEY; Do. Hypotype U. H. Reg. No. 15256 b.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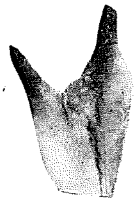
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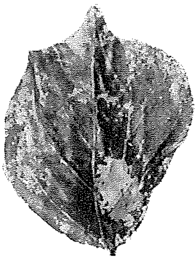
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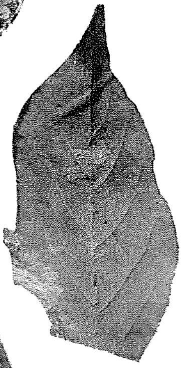
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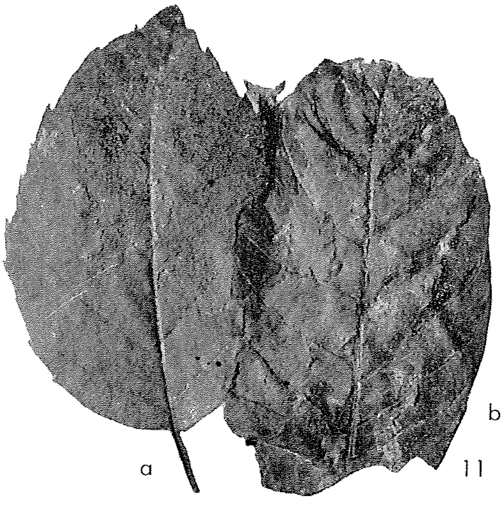

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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 26

Explanation of Plate 26

(All natural size)

Fig. 1, 2. *Acer ezoanum* OISHI et HUZIOKA; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotypes G. S. J. Reg. Nos. 4296, 4297.

Fig. 3. *Acer pseudoginnala* TANAI et ONOE; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15043.

Fig. 4. *Acer protojaponicum* TANAI et ONOE; Kinoko, Kaminokuni-mura, Matsumae-gun, Hokkaidô. "Fukuyama" formation (Middle Miocene). Hypotype U. H. Reg. No. 15257.

Fig. 5. *Acer ezoanum* OISHI et HUZIOKA; Yoshioka. Hypotype U. H. Reg. No. 15009.

Fig. 6. *Acer fatisiaefolia* HUZIOKA; Hiyoshi. Hypotype G. S. J. Reg. No. 4298.

Fig. 7. *Acer submayrii* TANAI et ONOE; Wakamatsu coal mine, Hypotype U. H. Reg. No. 15258.

Figs. 8, 9. *Acer arcticum* HEER; Shin-minato coal mine, Sasebo City, Nagasaki Prefecture. Ainoura formation (Early Miocene). Hypotype U. H. Reg. Nos. 15259, 15260.


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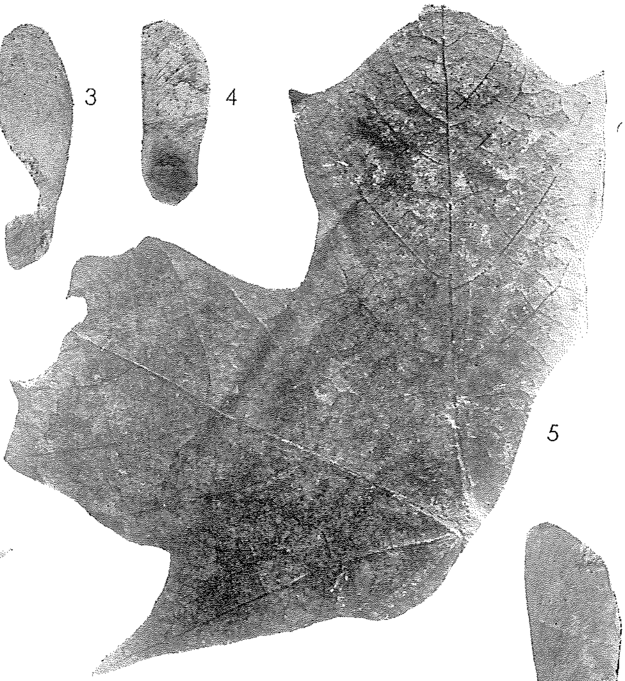
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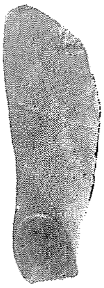
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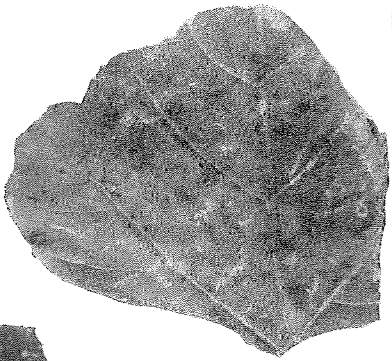
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 27

Explanation of Plate 27

(All natural size)

Fig. 1. *Acer subpictum* SAPORTA; Nukabira, Kami-shihoro-machi, Nakagawa-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15261.

Figs. 2, 4. *Acer protonegundo* TANAI sp. nov.; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaido. Yoshioka formation (Middle Miocene). Holotype U. H. Reg. No. 15004, Hypotype No. 15005.

Fig. 3. *Acer negundo* LINNE; the living samara for comparison, collected from the Botanical Garden of Kyôto University.

Fig. 5. *Acer protonegundo* TANAI sp. nov.; Abura, Setana-machi, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Paratype U. H. Reg. No. 15006.

Fig. 6. *Acer arcticum* HEER; Damma-no-sawa, Takikawa City, Hokkaidô. Ikushumbetsu formation (Early Oligocene). Hypotype G. S. J. Reg. No. 4299.

Fig. 7. *Acer miodavidii* HU et CHANEY; Hiyoshi, Mizunami City, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4300.

Fig. 8. *Acer protojaponicum* TANAI et ONOE; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15262.


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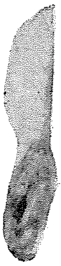
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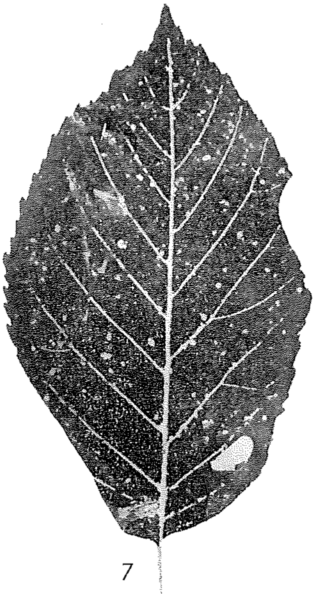
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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 28

Explanation of Plate 28

(All natural size)

Fig. 1. *Aesculus majus* (NATHORST) TANAI; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15263.

Fig. 2. *Acer subpictum* SAPORTA; Shirokura, Mizunami City, Toki-gun, Gifu Prefecture. "Hiramaki" formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4301.

Fig. 3. *Tilia distans* NATHORST; Kinoko, Kaminokuni-mura, Hiyama-gun, Hokkaidô. "Fukushima" formation (Middle Miocene). Hypotype U. H. Reg. No. 15264.

Fig. 4. *Tilia distans* NATHORST; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype G. S. J. Reg. No. 4302.

Fig. 5. *Acer palaeodiabolicum* ENDO; Onbara, Kami-saibara-mura, Okayama Prefecture. Onbara formation (Mio-Pliocene). Hypotype G. S. J. Reg. No. 4176.

Fig. 6. *Acer nordenskiöldi* NATHORST; Ningyô-tôgé, in the border of Tottori and Okayama Prefecture. Ningyô-tôgé formation (Early Pliocene). Hypotype G. S. J. Reg. No. 4173.

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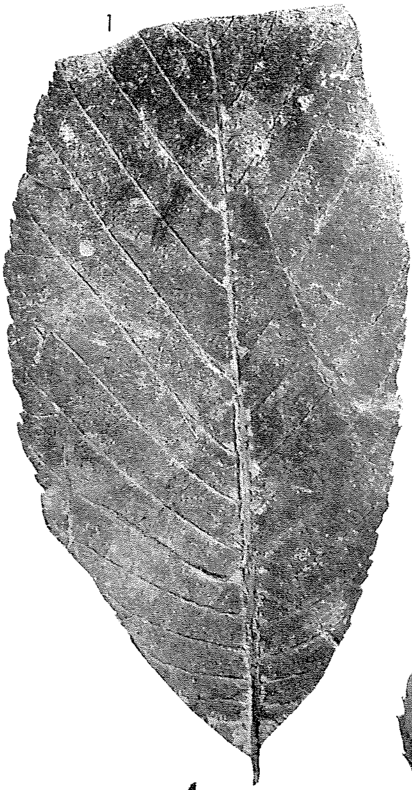

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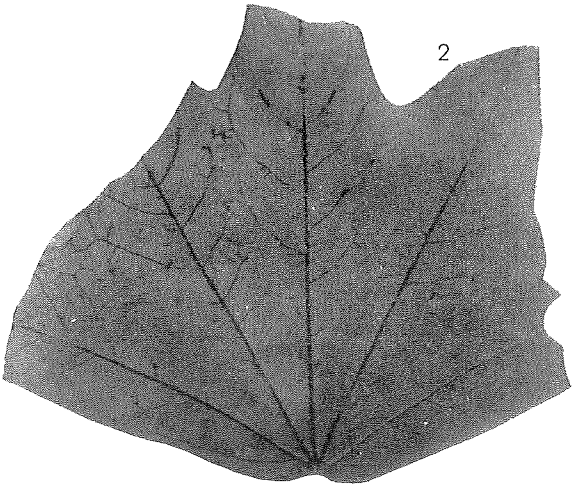

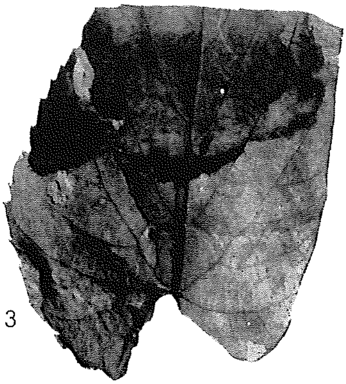

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Photo T. TANAI & N. SUZUKI

Explanation of
Plate 29

Explanation of Plate 29

(All natural size)

Fig. 1. *Tilia subnobilis* HUZIOKA; Kinoko, Kaminokuni-mura, Hiyama-gun, Hokkaidô. "Fukuyama" formation (Middle Miocene). Hypotype U. H. Reg. No. 15265.

Fig. 2. *Tilia distans* NATHORST; Do. Hypotype U. H. Reg. No. 15268.

Fig. 3. *Acer megasamarum* TANAI et SUZUKI; Abura, Setana-machi, Setana-gun, Hokkaidô. "Kunnui" formation (Middle Miocene). Hypotype U. H. Reg. No. 15027.

Fig. 4. *Aesculus majus* (NATHORST) TANAI; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15266.

Fig. 5. *Aesculus majus* (NATHORST) TANAI; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Rag. No. 15267.


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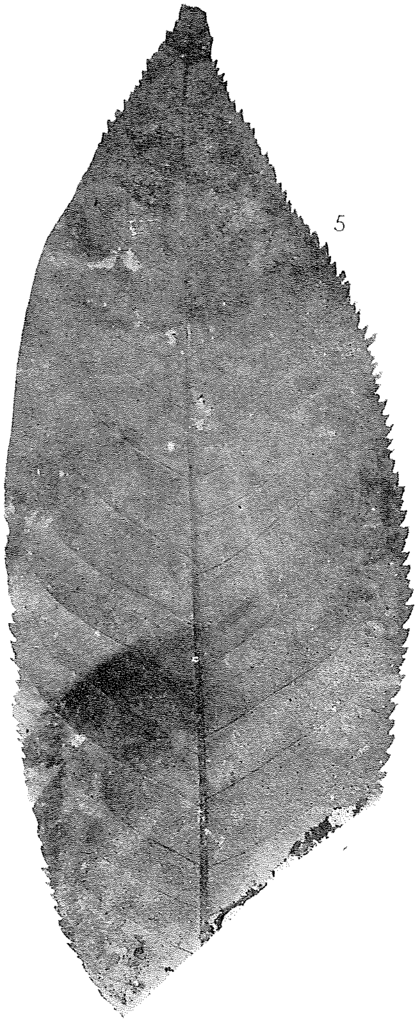
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 30

Explanation of Plate 30

(All natural size unless otherwise stated)

Fig. 1. *Alangium aequalifolium* (GOEPPERT) KRYSHT. et BORSUK; Kida coal mine, Emukae-machi, Kita-matsuura-gun, Nagasaki Prefecture. Ainoura formation (Early Miocene). Hypotype G. S. J. Reg. No. 4304. ×3/4

Figs. 2, 4. *Alangium koyamae* (KONNO) TANAI; Chausu-yama, Shinonoi City, Nagano Prefecture. "Ogawa" formation (Late Miocene). Hypotype U. H. Reg. Nos. 15269, 15270.

Fig. 3. *Aesculus majus* (NATHORST) TANAI; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Hypotype G. S. J. Reg. No. 4305.

Fig. 5. *Alangium basiobliquum* (OISHI et HUZ.) TANAI; Kamui coal mine, Sunagawa City, Hokkaidô. Noborikawa formation (Late Eocene). Hypotype G. S. J. Reg. No. 4306.

Fig. 6. *Tilia* cfr. *distans* NATHORST; Kinoko, Kaminokuni-mura, Hiyama-gun, Hokkaidô. "Fukuyama" formation (Middle Miocene). Hypotype U. H. Reg. No. 15271.

Fig. 7. *Tilia protojaponica* ENDO; Nukabira, Kami-shihoro-mura, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15272.


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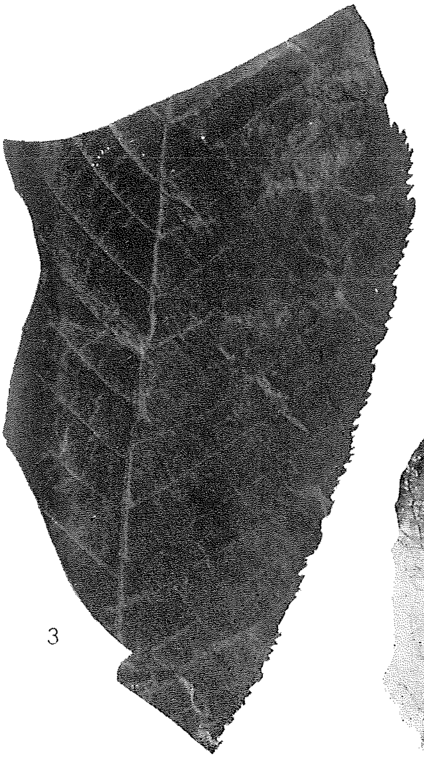
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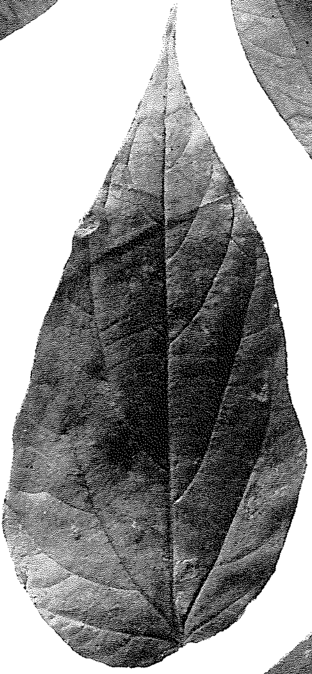
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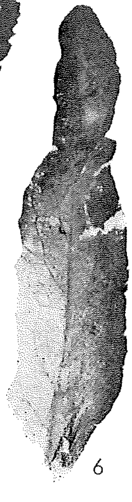
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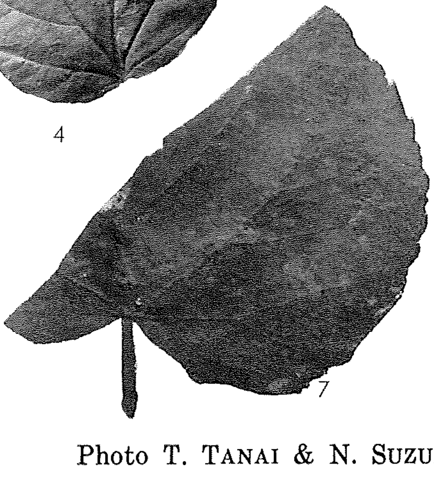
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 31

Explanation of Plate 31

(All natural size unless otherwise stated)

Figs. 1, 3, 7. *Styrax saseboense* TANAI sp. nov.; Kida coal mine, Emukae-machi, Kita-matsuura-gun, Nagasaki Prefecture. Ainoura formation (Early Miocene). Holotype G. S. J. Reg. No. 4307 (Fig. 7), Hypotype G. S. J. Reg. No. 4308 (Fig. 3), Hypotype U. H. Reg. No. 15273 (Fig. 1).

Fig. 2. *Paliurus nipponicus* MIKI; Onbara, Kami-saibara-mura, Okayama Prefecture. Onbara formation (Mio-Pliocene). Hypotype G. S. J. Reg. No. 4190.

Fig. 4. *Cornus subkousa* TANAI et ONOE; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. No. 15275.

Fig. 5. *Styrax protoobassia* TANAI et ONOE; Ningyô-togé, in the border area between Tottori and Okayama Prefectures. Ningyô-togé formation (Early Pliocene). Holotype G. S. J. Reg. No. 4203.

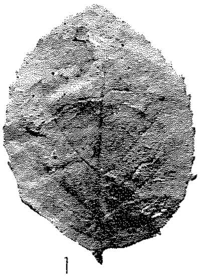
Fig. 6. *Aralia miobippinata* TANAI; Kusaidani, Kamigô-machi, Tsuruoka City, Yamagata Prefecture. Kamigo formation (Middle Miocene). Holotype G. S. J. Reg. No. 4309.

Fig. 8. *Aesculus turbinata* BLUME; the living leaflet for comparison, collected from the Botanical Garden of Hokkaidô University. ×1/2

Fig. 9. *Alangium aequalifolium* (GOEPPERT) KRYSHT. et BORSUK; Ouchi, Marumori-machi, Igu-gun, Miyagi Prefecture. Uenoyama formation (Middle Miocene). Hypotype G. S. J. Reg. No. 4310.

Fig. 10. *Fraxinus honshuensis* TANAI et ONOE; Nukabira, Kamishihoro-machi, Nakagawa-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Hypotype U. H. Reg. No. 15274.

Fig. 11. *Alangium basiobliquum* (OISHI et HUZ.) TANAI; Kida coal mine, Emukae-machi, Kita-matsuura-gun, Nagasaki Prefecture. Ainoura formation (Early Miocene). Hypotype U. H. Reg. No. 15276.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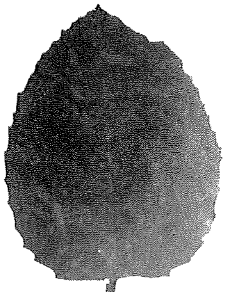
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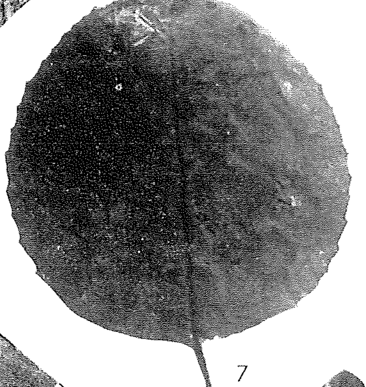
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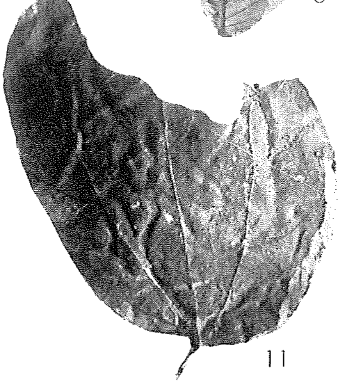
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Photo T. TANAI & N. SUZUKI

Explanation of Plate 32

Explanation of Plate 32

(All natural size unless otherwise stated)

Fig. 1. *Abies n-suzukii* TANAI sp. nov.; Yoshioka, Fukushima-machi, Matsumae-gun, Hokkaidô. Yoshioka formation (Middle Miocene). Hypotype U. H. Reg. No. 15277.

Fig. 2. *Hemitrapa hokkaidoensis* (OKUTSU) MIKI; enlarged figure of Fig. 8. ×2

Fig. 3. *Viburnum otukae* TANAI; Aburato coal mine, Kamo-machi, Tsuruoka City, Yamagata Prefecture. Aburato coal-bearing member (Middle Miocene). Holotype G. S. J. Reg. No. 4311.

Fig. 4. *Viburunum protoparvifolium* TANAI; Do. Holotype G. S. J. Reg. No. 4312.

Fig. 5, 9. *Hemitrapa hokkaidoensis* (OKUTSU) MIKI; Hiyoshi, Mizunami City, Toki-gun, Gifu Prefecture. "Nakamura" coal-bearing formation (Middle Miocene). Hypotype G. S. J. Reg. Nos. 4313, 4314.

Figs. 6, 7. *Hemitrapa borealis* (HEER) MIKI; Shichiku, Ono-mura, Ishiki-gun, Fukushima Prefecture. Taki formation (Middle Miocene). Hypotype G. S. J. Reg. Nos. 4047, 4048.

Fig. 9. *Viburnum protofurcatum* TANAI sp. nov.; Nukabira, Kami-shihoro-machi, Kato-gun, Hokkaidô. Taushibetsu formation (Late Miocene). Holotype U. H. Reg. No. 15278.

Fig. 10. *Cornus saseboensis* TANAI sp. nov.; Kida coal mine, Emukae-machi, Kitamatsuura-gun, Nagasaki Prefecture. Ainoura formation (Early Miocene). Holotype U. H. Reg. No. 15279.

Figs. 11, 12. *Paliurus nipponicus* MIKI; Kami-shanabuchi, Engaru-machi, Monbetsu-gun, Hokkaidô. Shanabuchi formation (Late Miocene). Hypotype U. H. Reg. Nos. 15280, 15281.

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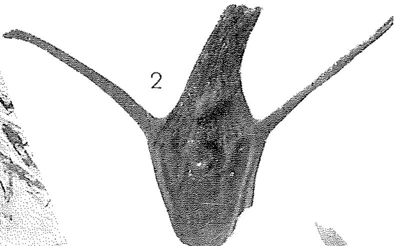

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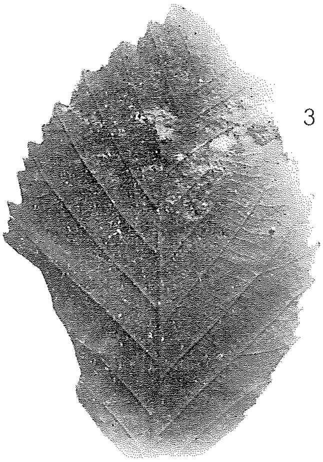

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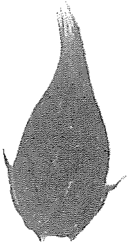

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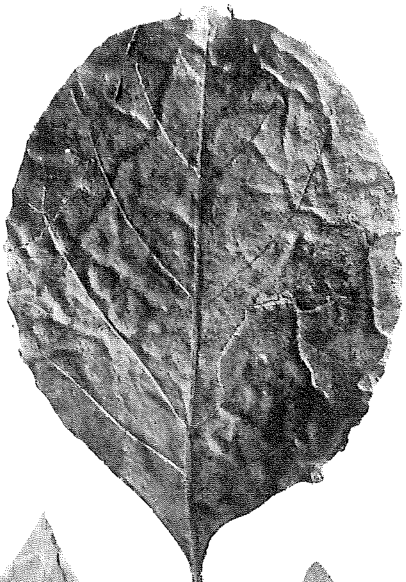

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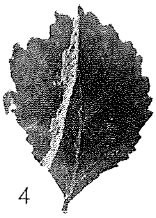

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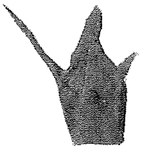

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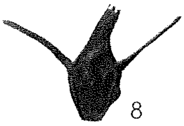

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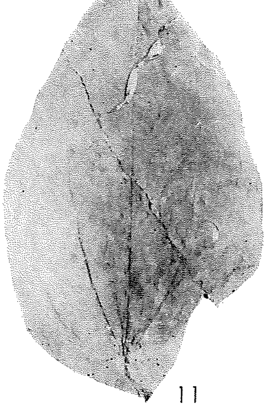

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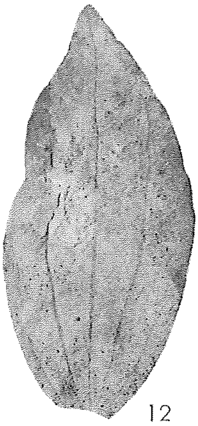

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