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A Miocene Flora from the Northern Part of the Jōban Coal Field, Japan*

by

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Abstract

In the northwestern part of the Iwaki district of the Jōban coal field, the lignite-bearing deposits are distributed on the uppermost of the Paleogene marine sediments. These lacustrine sediments have many well-preserved plant fossils. In this paper, the writers dealt with the studies of the fossil flora, and also the stratigraphy of the fossil-bearing formation.

The fossil flora comprising 49 species, consists mainly of deciduous broad-leaves trees such as grown in temperate zone, and also includes some conifers. Among broad-leaves trees, the leaves of Betulaceae, Ulmaceae and Aceraceae are plentiful in numbers of their species and specimens, while scarcely Fagaceae. The composition and components of this flora coincide with the characteristics of the so-called "Aniai-type flora" found in Japanese Miocene sediments. These plant-bearing sediments do not belong to the uppermost of the Shiramizu group of Paleogene as once generally considered, but to the lowermost of the Yunagaya group of Neogene.

Such lignite-bearing formations accompanying with the Aniai-type flora are distributed in scattered condition in the Taga and Futaba districts of the Jōban coal field. They occupy rather the basement of the Neogene sediments stratigraphically. Considering the abundance of *Hemitrapa* and the fairly-preservation of plant remains, the fossil flora is considered to have grown near the estuary- or lake-side. Accordingly, these lignite-bearing sediments were probably products in the early stage of the considerable transgression which had begun from early Miocene age.

I. Introduction

In the north of Ishimori-yama of the Jōban coal field, the lacustrine deposits with some lignite seams have a great number of plant fossils, and these deposits are considered to belong to the uppermost of the Shirasaka formation as reported by S. Satō and H. Matsui.[21] In 1950, they made a small collection of fossil plants at that locality, and this was studied preliminarily by the senior writer. The senior writer have been doubtful of its stratigraphical position, judging from the floral composition. The flora indicates distinctly one of the Miocene types, though the Shirasaka formation is considered as Oligocene in age.

To describe the characteristics of the fossil flora and to ascertain the geological age of the formation which includes the plant-bearing member is the purpose of this paper. And also, this study is one of "the studies on the original plant materials of Japanese coal", of which theme had been once done by the writers in the Coal Section of Geological Survey of Japan.

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II. Geologic Occurrence

The principal locality, Shichiku of Ono-mura, as shown in Figs. 1 and 2, is situated about 12 km west of Yotsukura city, Fukushima prefecture. The area including the fossil locality is situated in the northern part of the Iwaki district of the Jōban coal field. The general geology in this area has been already reported by many geologists.

The fossil plants are preserved in the tufaceous rocks lying on the uppermost of a series of sandstone and siltstone, which was named the Shiramizu group. The group is subdivided into three formations, the Iwaki, Asagai and Shirasaka formations in ascending order, and is covered unconformably by the Goyasu formation which is the basal part of the Yunagaya group. The Asagai formation includes many marine molluscs and foramini-

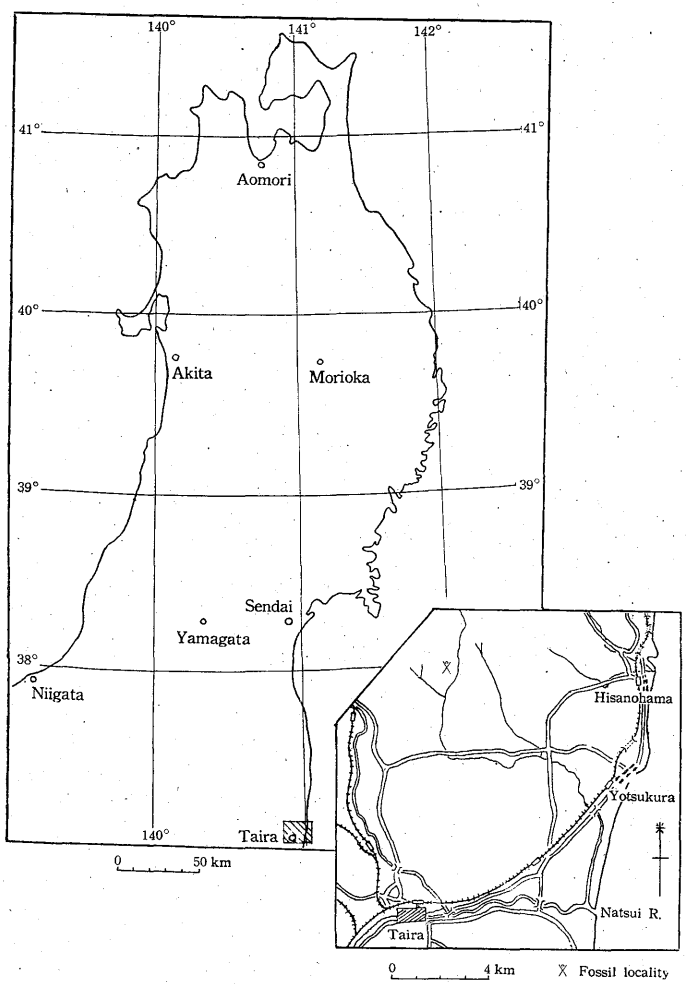
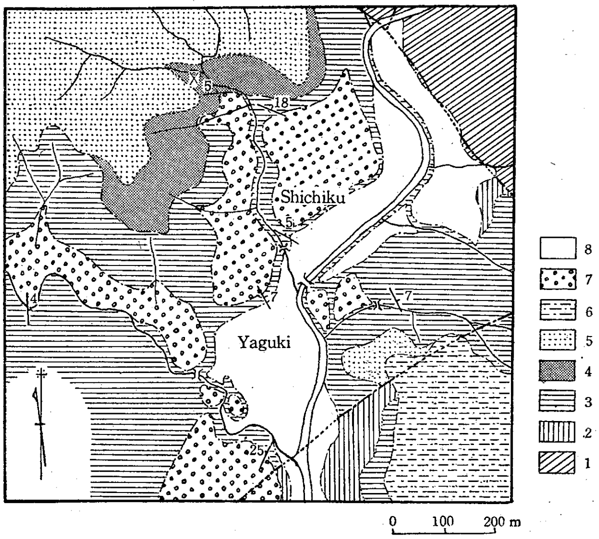


Fig. 1 Location of fossil plants



1. Paleozoic formations 2. Asagai formation 3. Shirasaka formation
4. Taki formation 5. Goyasu formation 6. Numabara formation
(Pleistocene sand deposits) 7. Terrace deposits 8. Alluvium
☓ Fossil locality

Fig. 2 Geologic map near the fossil locality (originated by S. Satō & H. Matsui, and emended by the writers)

feras, and is late Oligocene in age. The Shirasaka formation overlies conformably the Asagai, and consists mainly of gray shale. The Yunagaya group contains many marine molluscs, and is middle Miocene in age.

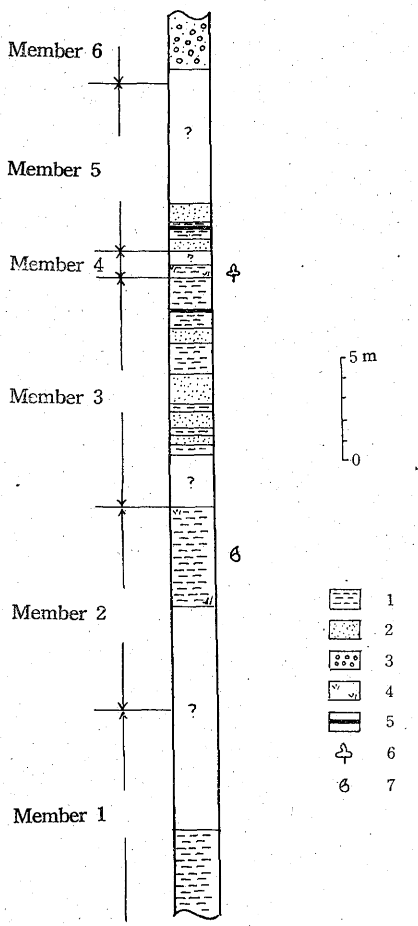
The following description of the stratigraphical succession at the fossil locality is quoted from the paper by S. Satō and H. Matsui[21] :

"The Shirasaka formation in the Shichiku area has the members consisting of greenish gray siltstone, green tufaceous sandstone, lignite seams and plant-bearing platy shale, and these members are situated several meters stratigraphically under the unconformable plane between the Yunagaya and Shiramizu groups. Such lignite-bearing members of the upper part of the Shirasaka formation are not known in other districts of the Jōban coal field, and it is noteworthy that the upper part of the Shirasaka formation has a lacustrine or littoral deposits in this area."

When collecting the fossil plants, the senior writer re-investigated the stratigraphical relation between the fossil-bearing member and other formations. According to his survey, the stratigraphy at the fossil locality is as shown in Table 1 and Fig. 3.

Table 1 Stratigraphic Succession at the Fossil Locality

upper		
Member	6.	Conglomerate
//	5.	Bluish gray medium- or fine-grained sandstone
//	4.	Dark gray platy shale
//	3.	Alternation of tufaceous sandstone and siltstone (lignite seams intercalated)
//	2.	Gray tufaceous shale
		～～～～～ ? ～～～～～
//	1.	Gray hard shale



1. siltstone 2. sandstone 3. conglomerate 4. tufaceous
5. lignite 6. plant fossil 7. molluscan fossil

Fig. 3 Geologic section in the fossil locality

In the above-described section, member 1 consists of the typical shale of the Shirasaka formation, and member 6 has been once considered as the basal part of the so-called "Goyasu formation". The tufaceous gray shales of member 2 occur some fragmental marine molluscs such as *Cyclocardia siogamensis* (NOMURA), *Lucinoma kamenooensis* (OTUKA) and *Yoldia* sp., etc., and also frequently fish-scales and fragments of fossil crabs. The rocks from member 2 to member 5 are tufaceous, and had never been observed in the uppermost of the Shirasaka formation or the basal part of the Goyasu formation in the Jōban coal field. In member 3, several thin lignite seams are intercalated, and in the tufaceous shales above, these seams and platy shales of member 4, the well-preserved plant fossils are occurred abundantly.

III. Composition and Modern Relationships of the Flora

There are 49 species known from the locality. They are divided among 26 genera, 19 families and 11 orders. Most of them are dicotyledons, and only four species are gymnosperms. Taking growth form into account, only one is herbaceous, 16 were shrubs, 2 vines and remaining 30 were trees.

The systematic relationships of this flora are shown in Table 2. Among the fossil materials, the leaves and bracts of Betulaceae are most abundant in number of species and specimens, and they occupy about one-third of the total species. The family Betulaceae includes five genera, and is plentiful in the following order — *Carpinus*, *Betula*, *Ostrya*, *Alnus* and *Corylus*. Eight species of *Carpinus* are determined by very abundant fairly-preserved bracts and leaf-impressions. And most of the living species being close to these fossil hornbeams are now found in China and Japan, especially in the former.

Next to Betulaceae, the samaras and leaves of *Acer* are comparatively abundant, and they are over ten species. Besides above-described materials, the specimens of *Metasequoia*, *Hemitrapa* and *Ulmus* are commonly found.

In the writers' consideration of the composition of the Shichiku flora, it may have some significances that certain popular genera are absent, or at least have not yet been found. Considering from their modern or Tertiary distribution in Asia, the writers expected naturally the presences of the coniferous trees such as *Glyptostrobus*, *Taxodium* and *Abies*, or the broad-leaved trees such as *Populus*, *Salix* and *Cercidiphyllum* in the Shichiku flora. This fossil flora consists mostly of elements of the so-called "Aniai-type flora", as shown in Table 2, though the above-mentioned genera are not found. Judging from the floral composition in that time, their absences are difficult to explain, and so the writers may fail to find them in collecting.

Among the 49 plants which can be definitely assigned, there are scarcely found the specimens belonged to Fagaceae, and only the genus of Fagus are found. It is a characteristic of the Aniai-type floras in Japanese Miocene sediments that the genera of the Family Fagaceae are few.

With due allowance made for leaf texture and proximity to the site of deposition, it is apparent that the forest of that time was a mixed assemblage of deciduous broad-leaved trees and conifers. And considering from the abundant occurrence of fairly well-preserved *Hemitrapa*, the site of deposition is supposed to be partly lacustrine or marshy at least.

Among 26 genera of this fossil flora, almost all are found now in the present flora of Japan, and only one genus *Hemitrapa* is extinct. The most equivalent plants to fossil species grow now in Japan and China. Table 3 gives a list of the fossil species with the most similar living species, their habits and distributions of the living species in East Asia.

These living species having the closest relationship to the fossil plants are classified according to habits, which gives a general idea of the representation of trees, shrubs, vines and herbs in the flora. The trees make up 61.2% (30 plants) of the total, the shrubs 32.6% (16 plants), the vines 4.1% (two plants) and herbs 2% (only one plant) respectively. The figure for the latter group has little significance, since herbaceous plants are less likely to be preserved than trees and shrubs which have thicker, more coriaceous leaves. Omitting the consideration of herbs altogether, and combining shrubs and vines, the tree-shrub ratio is 65 to 35.

It is reasonable to consider that the number of shrubs and vines represented in the fossil record is somewhat less than the original number of such plants. On the contrary, the greater size of trees, affecting both the number of leaves borne and greater ease of their dispersal, may make such conclusion that they have a disproportionately large representation in the fossil records. Accordingly, the tree-shrub ratio in the Shichiku flora may

Table 2 Systematic List of the Shichiku Species

- Spermatophyta
  - Gymnospermae
    - Coniferae
      - Pinales
        - Pinaceae
          - *Picea Sugaii* sp. nov.
        - Taxodiaceae
          - *Metasequoia occidentalis* (NEWBERRY) CHANEY
          - *M. miocenica* sp. nov.
        - Taxaceae
          - *Cephalotaxus* sp.
  - Angiospermae
    - Dicotyledoneae
      - Juglandales
        - Juglandaceae
          - *Juglans shanwangensis* HU et CHANEY
          - *Pterocarya asymetrosa* KONNO
      - Fagales
        - Betulaceae
          - *Alnus* sp.
          - *Betula mioluminifera* HU et CHANEY
          - *B. Mitai* sp. nov.
          - *Betula* sp.
          - *Carpinus miocordata* HU et CHANEY
          - *C. miofargesiana* sp. nov.
          - *C. protoerosa* TANAI
          - *C. ishikiensis* sp. nov.
          - *C. miofangiana* HU et CHANEY
          - *C. s-Satoi* sp. nov.
          - *Carpinus* cfr. *mioturczaninowii* HU et CHANEY
          - *Carpinus* cfr. *simplicibracteata* HUZIOKA
          - *Ostrya japonica* SARGENT var. *oblongibracteata* HUZIOKA
          - *O. subvirginiana* sp. nov.
          - *Corylus miochinensis* sp. nov.
        - Fagaceae
          - *Fagus Antipofi* (ABICH) HEER
      - Urticales
        - Ulmaceae
          - *Ulmus miodavidiana* TANAI (MS)
          - *Ulmus* cfr. *appendiculata* HEER
          - *Zelkova Ungeri* (ETTINGSHAUSEN) KOVATS
      - Rosales
        - Saxifragaceae
          - *Hydrangea lanceolimba* HU et CHANEY
        - Rosaceae
          - *Crataegus* sp.
        - Leguminoceae
          - *Wistaria* sp.
          - *Sophora miojaponica* HU et CHANEY
      - Sapindales
        - Aceraceae
          - *Acer ezoanum* OISHI et HUZIOKA
          - *A. palaeodiabolicum* ENDO
          - *A. palaeoplatanoides* ENDO

Acer protojaponicum sp. nov.
A. subpictum SAPORTA
A. prototrifidium TANAI
A. pseudoginnala sp. nov.
A. Matsuii sp. nov.
A. miohenrii HU et CHANEY
Acer cfr. *kokangenense* ENDO
Hippocastanaceae
Aesculus majus (NATHORST) TANAI
Rhamnales
Rhamnaceae
Berchemia sp.
Malvales
Tiliaceae
Tilia distans NATHORST
Tilia cfr. *subnobilis* (HUZIOKA)
Tilia sp.
Myrtales
Alangiaceae
Marlea aequalifolia (GOEPPERT) OISHI et HUZIOKA
Trapellaceae
Hemitrapa borealis (HEER) MIKI
Apiales
Araliaceae
Aralia celtisfolia sp. nov.
Kalopanax acerifolium (NATHORST) HU et CHANEY
Rubiales
Caprifoliaceae
Viburnum protoparvifolium TANAI

be less than that of the original vegetation in that time.

In order to facilitate considerations on the probable ecologic conditions which those plants lived, the nearest equivalent living species to the fossil plants are grouped according to their habitats, — four types of upland, mixed-slope, stream-side or riparian, and lake or marshy elements. On the basis of the data as showing in Table 4, the upland plants make up 8.2%, plants from mixed-slope to stream-side 26.5%, mixed-slope plants 59.2%, riparian plants 4.1% and marshy plants 2% of the total respectively. In addition, judging from the consideration of the preservation and transportation of the plant remains, the Shichiku flora seems to be most predominant in the elements of mountain-slope, and probably similar to the flora distributed from the mixed-slope to the stream-side.

While, as already described, all of the genera consisting of the Shichiku flora are mostly common in the modern vegetation of East Asia except only one genus *Hemitrapa*, and some of them are confined in East Asia. The distribution of modern equivalents in East Asia is shown in Table 3. East Asia has been divided into 12 districts by T. Nakai[17], on the basis of its phytogeography. For abbreviation, among these districts, North China district includes the Shantung district, and Ogasawara Island district is omitted. These ten districts are shown in Fig. 4, which indicates also the percentage of modern equivalents in each.

As showing in Table 3 and Fig. 4, it is apparent that Shichiku flora is most similar to the flora which is now distributed from central to north-

Table 3 Nearest Equivalents of the Shichiku Species and their Modern Distribution in East Asia

Fossil Species	Equivalent Modern Species	Present Distribution of their Modern Species											
		1	2	3	4	5	6	7	8	9	10	11	Habits
Cephalotaxus sp.	*Cephalotaxus drupacea* S. et Z.		×										T
Picea Sugaii	*Picea jessoensis* CARR.	×	×		×	×			×				T
Metasequoia occidentalis	*Metasequoia glyptostroboides* HU et CHENG								×				T
Metasequoia miocenica	*Metasequoia glyptostroboides* HU et CHENG								×				T
Juglans shanwangensis	*Juglans sieboldiana* MAXIM.	×	×										T
Pterocarya asymetrosa	*Pterocarya paliurus* BATAL.								×	×	×		S
Alnus sp.	*Alnus multinervis* CALL.	×	×										S
Betula mioluminifera	*Betula luminifera* WINKL.								×				T
Betula Mitai	*Betula luminifera* WINKL.								×				T
Betula sp.	*Betula luminifera* WINKL.								×				T
Carpinus miocordata	*Carpinus cordata* BLUME	×	×					×					S
Carpinus protoerosa	*Carpinus cordata* BLUME	×	×					×					S
Carpinus miofangiana	*Carpinus fangiana* HU								×		×		T
Carpinus miofargesiana	*Carpinus fargesiana* WINKL.							×	×		×		S
Carpinus ishikiensis	?												S
Carpinus s-Satoi	*Carpinus henryana* WINKL.								×				S
Carpinus cfr. *simplicibracteata*	*Carpinus cordata* BLUME	×	×					×					S
Carpinus cfr. *mioturczaninowii*	*Carpinus turczaninowii* HANCE							×	×		×		S
Ostrya subvirginiana	*Ostrya virginiana* (MILL.)											×	S
Ostrya japonica oblongibracteata	*Ostrya japonica* SARG.	×	×						×				S
Corylus miochinensis	*Corylus chinensis* FRANCH.								×		×		S
Fagus Antipofi	*Fagus longipetiolata* SEEMEN								×	×	×		T
Ulmus miodavidiana	*Ulmus davidiana* PLANCH.							×					T
Ulmus cfr. *appendiculata*	*Ulmus davidiana* PLANCH.							×					T

Zelkova Ungeri	*Zelkova serrata* MAKINO		×			×			×	×			T
Hydrangea lanceolimba	*Hydrangea umbellata* REHDER									×			S
Crataegus sp.	*Crataegus cuneata* S. et Z.		×					×	×	×	×		S
Wistaria sp.	*Wistaria floribunda* DC.												V
Sophora miojaponica	*Sophora japonica* L.		×			×		×					T
Acer prototrifidium	*Acer trifidum* HOOK								×	×			T
Acer palaeoplatanoides	*Acer platanoides* L.											×	T
Acer pseudoginnala	*Acer Ginnala* MAXIM.		×		×	×		×					T
Acer subpictum	*Acer mono* MAXIM.	×	×		×	×		×					T
Acer miohenrii	*Acer henrii* PAX.							×	×	?	?		T
Acer ezoanum	*Acer Miyabei* MAXIM.	×											T
Acer palaeodiabolicum	*Acer diabolicum* BLUME	×											T
Acer protojaponicum	*Acer japonicum* THUNB.	×	×										T
Acer Matsuii	*Acer mono* MAXIM.	×	×		×	×		×					T
Acer cfr. *kokangenense*	?												T
Aesculus majus	*Aesculus turvinata* BLUME	×	×										T
Berchemia sp.	*Berchemia racemosa* S. et Z.		×					×					V
Tilia distans	*Tilia amurensis* RUPR.				×	×		×					T
Tilia cfr. *subnobilis*	*Tilia nobilis* REHD. et WILS.							×					T
Tilia sp.	*Tilia amurensis* RUPR.				×	×		×					T
Marlea aequalifolia	*Marlea chinensis* (LOUR.)							×	×	×	×		T
Aralia celtisfolia	*Aralia californica* S. WATS.											×	S
Kalopanax acerifolium	*Kalopanax septemblos* KOIDZ.		×			×		×	×	×	×		T
Viburnum protoparvifolium	*Viburnum parvifolium* HAYATA						×						S
Hemitrapa borealis	?												H

Modern Distribution 1. Saghalien, Kurile Isl., Hokkaidō 2. Japan (Honshū, Shikoku, Kyūshū) 3. Primorskaya Prov., Kamchatka Pen. 4. Manchuria, Ussuri Region 5. Korea 6. Loochoo Isl., Formosa 7. North China 8. Central China 9. Southeast China 10. Southwest China 11. North America and others

Habits T: Tree S: Shrub V: Vine H: Herb

Table 4. Habitat of the Shichiku Species as judged from Similar Living Species

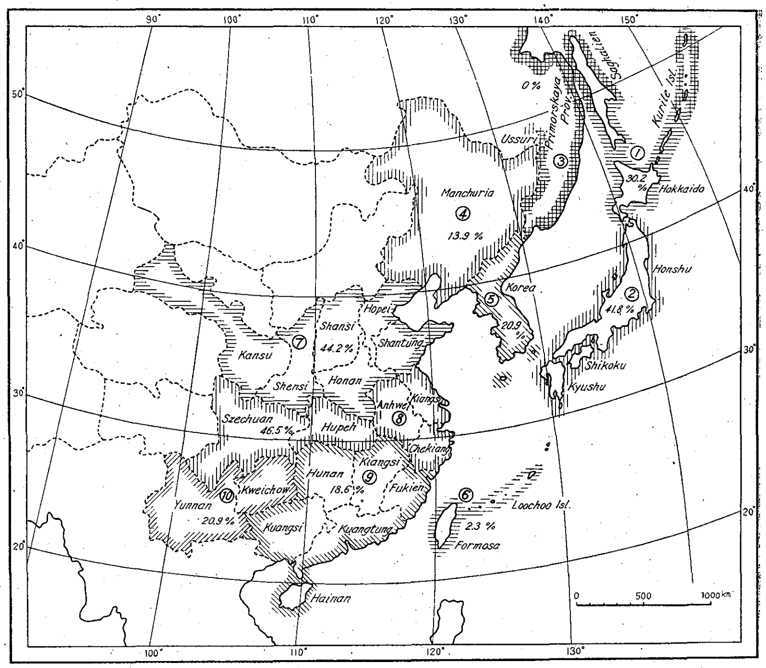
1) Lake or marshy
   - *Hemitrapa borealis*
2) Stream-side or riparian
   - *Pterocarya asymetrosa*
3) Stream-side to mixed-slope
   - *Juglans shanwangensis*
   - *Alnus* sp.
   - *Carpinus miocordata*
   - *C. protoerosa*
   - *Carpinus* cfr. *simplicibracteata*
   - *Ostrya subvirginiana*
   - *Zelkova Ungeri*
   - *Crataegus* sp.
   - *Acer prototrifidium*
   - *A. miohenrii*
   - *Berchemia* sp.
   - *Kalopanax acerifolium*
   - *Wistaria* sp.
4) Mixed-slope
   - *Cephalotaxus* sp.
   - *Picea* sp.
   - *Betula mioluminifera*
   - *B. Mitai*
   - *Betula* sp.
   - *Carpinus miofangiana*
   - *C. miofargesiana*
   - *C. s-Satoi*
   - *C. ishikiensis*
   - *Carpinus* cfr. *mioturczaninowii*
   - *Ostrya japonica* var. *oblongibracteata*
   - *Corylus miochinensis*
   - *Ulmus miodavidiana*
   - *Ulmus* cfr. *appendiculata*
   - *Fagus Antipofi*
   - *Hydrangea lanceolimba*
   - *Acer palaeodiabolicum*
   - *A. protojaponicum*
   - *A. palaeoplatanoides*
   - *A. ezoanum*
   - *A. pseudoginnala*
   - *A. subpictum*
   - *A. Matsuii*
   - *Acer* cfr. *kokangenense*
   - *Aesculus majus*
   - *Aralia celtisfolia*
   - *Tilia distans*
   - *Tilia* sp.
   - *Marlea aequalifolia*
5) Uplands
   - *Metasequoia occidentalis*
   - *M. miocenica*
   - *Tilia* cfr. *subnobilis*
   - *Viburnum protoparvifolium*

ern China. And also the fossil flora has some relationships with the living flora distributed from Honshū to Hokkaidō, Japan. The climatic conditions in these districts are temperate or cool-temperate, and precipitation is moderate: in summer, it is somewhat wet and in winter, slightly dry. In these districts, it is snowy in winter at present. In Szechwan province of China, where *Metasequoia glyptostroboides* Hu et Cheng is living now, some of moisture may have been in the form of freezing, but it is not snowy.

Thus, such facts may indicate that although frosts or snows were present in that time, when the Shichiku flora distributed in that time, they probably were not heavy or long in duration. And temperature were generally mild, with moderate ranges in summer.

IV. Correlation and Geologic Age

The stratigraphic distribution of most species in the Shichiku flora is confined in the Japanese Miocene sediments, especially the lower half of Miocene. Only five species, *Metasequoia occidentalis*, *Carpinus miocordata*,



① Southern Saghalien, Southern Kurile Isl., Hokkaidō ② Japan (Honshū, Shikoku, Kyūshū) ③ Primorskaya Prov., Northern Saghalien, Kamchatka Pen., etc. ④ Manchuria, Ussuri Region ⑤ Korea ⑥ Loochoo Isl., Formosa ⑦ North China ⑧ Central China ⑨ Southeast China ⑩ Southwest China

Fig 4. Phytogeographic districts of East Asia and the percentages of modern equivalents found in them

Zelkova Ungeri, *Sophora miojaponica* and *Tilia distans*, are distributed to the Pliocene.

As already mentioned, the Shichiku flora is closely identical to the so-called "Aniai-type flora" in the floral composition and their components. The Aniai-type flora in Japan, as the senior writer discussed already, comprises mainly the deciduous broad-leaved trees such as grown in the temperate region, and also includes some conifers. Among these broad-leaved trees, the plants of Betulaceae, Ulmaceae, Fagaceae and Aceraceae are plentiful in number of species and specimens. These Aniai-type floras yield mostly from the Miocene coal-bearing formations in Japan, especially are known in the Miocene coal fields of Northeast Japan.*

The floras having such composition as the Aniai-type, are also found from the upper Miocene sediments in Japan. Their floras are predominant in the deciduous broad-leaved trees such as Betulaceae, Ulmaceae, Fagaceae and Aceraceae, and also contains conifers such as *Metasequoia*, *Glyptostrobus*, *Picea* and *Abies*. However, most species of broad-leaved trees are more modernized than those of the Aniai-type, and their fossil species are very closely similar to each living species distributed now in Japan. Furthermore, such genus as *Liquidambar*, *Sassafras*, *Quercus*, *Magnolia* and *Catalpa*, are commonly found in the upper Miocene floras, though they are not included in the Aniai-type flora. Accordingly, these both two floras are distinguishable each other in their floral components.

* The distribution of the Aniai-type flora in Japan is already reported by the senior writer.

In the middle Miocene sediments, the so-called "Daishima-type flora" are found in many localities of Japan. The most floras of this type occur from the lacustrine or littoral sediments, which are close middle Miocene marine formations in the stratigraphic succession. These marine sediments contain frequently such molluscs lived in warm current as *Vicarya*, *Vicaryella*, *Batillaria*, *Chicoreus*, *Telescopium*, etc. As already reported by the senior writer, the Daishima-type flora is characterized by the abundance of the ever-green-leaved trees, among which broad-leaved trees, the Fagaceae, Lauraceae and Sapindaceae are abundant in number of species and specimens. The present equivalents of the Daishima-type species are living mostly in the subtropical or warmer region in East Asia.

Accordingly, the Shichiku flora is apparently distinct from the above-mentioned two floras — the upper Miocene and the Daishima-type floras in their floral compositions and components. The Aniai-type flora is considered to be the lower half of middle Miocene in age. Furthermore, the tufaceous hard shales (member 2 in Table 1) lying conformably under the plant-bearing rocks, contain some molluscan fossils as already mentioned, and their fossils are confined in the Miocene marine sediments in Japan. Thus, the formation from member 2 to member 5, which includes the Shichiku flora, is correlated to the most coal-bearing formations contained the Aniai-type flora, and is early or middle Miocene in age.

V. Strrtigraphic Significance of this Plant-bearing Formation in the Jōban Coal Field

As already mentioned, the fossil-plant bearing formation was once considered as a lacustrine or littoral deposit in the uppermost of the Shirasaka formation. This fossil flora, however, consists entirely of Japanese Miocene plants, and it is apparently one of the so-called "Aniai-type flora". The tufaceous shales (member 2) under the plant-bearing rocks contain also some Miocene marine molluscs. The hard shales of member 1 are identical to those of the Shirasaka formation, which is Paleogene in age. Accordingly, the writers consider that the boundary between the Neogene and Paleogene in this district is bordered between member 1 and 2. The rocks from member 2～5 are very tufaceous, and conglomerate of member 6 is the basal conglomerate of the Goyasu formation, which was once considered to be the basal part of the Neogene in the Jōban coal field.

In the northern part of the field, the Futaba district, the lower half of the Goyasu formation consists of tufaceous rocks, intercalating several lignite seams, rhyolitic tuff and lava layers. Near Hisanohama-machi in the Futaba district, these lignite seams have been once worked. From the shales above the lignite seams, plant fossils such as *Metasequoia occidentalis*, *Carpinus miocordata*, *Ulmus* sp. and *Acer subpictum*, were once collected by the senior writer.

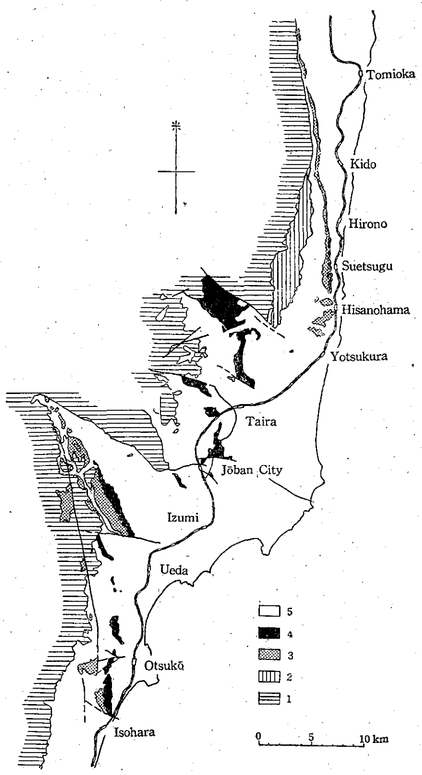
In the Kadono and Kuroda areas of the south Iwaki district, tufaceous rocks with some coal seams are distributed in scattered condition on the basement complex, and these coals are worked now. As already reported by the senior writer and others, these rocks occur many Miocene molluscan and vegetable fossils, and were dealt as the lower half member of the Goyasu formation.

In the southern part of the Taga district, the lowermost of the

Yunagaya group, which is named as the Kunugidaira formation by M. Eguchi and R. Shoji[3], is composed of tufaceous sandstone, siltstone, rhyolitic tuff, lignite, etc., and also contains some molluscs such as *Vicarya* and *Ostrea*. Concerning the distribution and horizon of the Kunugidaira formation, S. Hanzawa[9] described that this lignite-bearing formation is distributed under the Goyasu formation in several areas of the Jōban field, and excluded from the so-called Goyasu formation.

Lately, H. Matsui and S. Satō described on this formation that as the above-described tufaceous member with lignite seams has a comparatively wide distribution in the Jōban coal field, the member was named as the Taki coal-bearing formation, and it is equivalent to the basal part of the Yunagaya group, which is Neogene in age.

The Taki formation distributed in each district of the Jōban coal field, occurs such littoral or brackish molluscs as *Vicaryella*, *Cerithidea*, *Ostrea*, *Corbicula*, *Mitylus*, etc., and also occurs plant remains in the shales above some lignite seams or coaly shales. The Yunagaya group being upper from this formation, is entirely marine sediments, and contains plentiful marine molluscs. In the early time of Neogene deposition, fluctuating movement was responsible for the shallow-sea sediments of the Taki formation as indicated by fossil fauna and rock facies. And due to progressive transgression, the entirely marine sediments such as the Mizunoya, Kamenoo and Honya formations, were formed in this field. Such transgression of the basin are



1. Pre-Cretaceous rocks 2. Cretaceous 3. Taki formation
4. Goyasu formation 5. Tertiary sediments (except the Taki and Goyasu formations) and Quaternary sediments

Fig. 5 Distribution of the Taki and Goyasu formations in the Jōban coal field indicated by the abundance of marine fossils and argillaceous facies. Accordingly, The Taki formation was the shallow-water sediments in the early stage of considerable transgression which had begun from early Miocene age and then extended widely over this field.

As shown in Fig. 5, the development of the Taki formation is known mainly in the marginal areas of this coal field, and under the plain area of the north Iwaki district, its distribution was ascertained partly by the boreholes. The Taki formation does not develop partially at all between the Goyasu and Shirasaka formations in the Jōban coal field. Considering from such distribution of the Taki formation, the depositional basin seems to have a relief at least during the early deposition of the lower Yunagaya group. Although the Shichiku flora seems likely to be grown from the mixed-slope to the flood-plain, due to the abundance of *Hemitrapa* and fairly-preservation of plant remains, it is rather supposed that the accumulation occurred within the near-shore area. It may be unreasonable to consider that the mixed-slope plants, occupied about 60 % of the Shichiku species, were carried by stream in a long distance and accumulated on the bottom of the sea or lake. It is rather reasonable to consider that the climate was so cooly temperate as the Shichiku flora grew on the lowland or flood-plain areas in that time.

Therefore, the topographic condition during that time when the Taki formation was deposited, was like that of a lowland which was nearly sea-level in altitude, and the land area might be transgressed widely by the sea if the land caused slightly to sink. The Taki formation has several thick coal seams in the marginal areas of this field. For instance, in the Kadono and Kuroda areas, the coal seams are thick and worked now, though the formation are thin in thickness than that of other areas. These thick coal seams were probably formed in the area as the extended inlet.

VI. Conclusion

Though the Shichiku flora was once considered to be of Paleogene time, it is apparently one of the Miocene floras in its composition and components. This flora consists mainly of many broad-leaved trees and some conifers, which were grown in temperate region, and is one of the so-called "Aniai-type flora" in Japan. The plant-bearing sediments, lately named as the Taki formation, is not the uppermost of the Shiramizu group of Paleogene, but the lowermost of the Yunagaya group of Neogene. All the evidences indicate the conclusion that the Shichiku flora is between early and middle Miocene in age.

The Kamenoo and Honya formations, which are the middle part of the Yunagaya group, occur some plant fossils being grown in warmer or subtropical regions, and these floras are one of the so-called "Daishima-type flora". The Aniai-type flora is generally considered to be lower in the stratigraphic horizon than the Daishima-type in Miocene floral succession of Japan. Therefore, the stratigraphic relationship between the both floras is similar in the Neogene of the Jōban coal field.

The Taki formation is distributed not only in this area, but found in many areas of the Jōban field. These coal-bearing sediments were products in the early stage of the considerable transgression which had begun from early Miocene age, as same as in other provinces of Japan.

(Submitted in Jan. 30, 1958)

Description of Some Noteworthy Species

Metasequoia miocenica TANAI et ONOE sp. nov.
(Plate I, figs. 3, 4)

1952. *Metasequoia japonica*, TANAI (in part); Jap. Jour. Geol. Geogr., Vol. 22, pl. IV, fig. 3

Description: Foliage shoots bearing acicular leaves and staminate cones are obtained, though fragmental.

Shoot slender, nearly straight or slightly curving, up to 2.5 cm long, bearing at 12 or more leaves which are arranged with regular spaces. Leaves linear, 5~7 mm long and 1 mm wide, decussately attached but always rotated into distichous position. Their leaves gradually narrowed to the base and having a short petiole at base, bluntly rounded at apex with a mucronate tip.

Staminated cones borne on laterally in axils of decussate leaves. Cones globular to ovoid, 0.4~1.2 mm in diameter, scales very small decussately arranged.

Remarks: These foliaged shoots bearing staminate cones of *Metasequoia* are found in Japan at first. These foliaged shoots apparently belong to the genus *Metasequoia* by its decussate arrangement of leaves. The senior writer collected this fossil material at first from the Miocene coal-bearing formation in the Nishitagawa coal field, Japan. However, owing to only one occurrence, he assigned to *M. japonica* (ENDO) MIKI. In this time, the writers found such staminated-cones-bearing shoots again from the Shichiku flora.

Foliaged shoots bearing staminate cones of *Metasequoia* had been reported from Elko, Nevada in North America by R. W. Chaney[1)], and staminated cones non-bearing leaves were also reported from many localities of North America by him. American specimens, which are assigned to *Metasequoia occidentalis* (NEWBERRY) CHANEY, are large both in cones and leaves than Japanese specimens. And also the former are different from the latter in the other characters.

Collection: GSJ. Holotype Nos. 4001, 4002 (Nishitagawa's specimens); Paratype No. 4003

Cephalotaxus sp.
(Plate I, fig. 1)

Description: Twigs fragmental, missing at a half portion. Leaves linear and slightly falcate, 1.7~2.0 cm long, the largest nearly 3 mm wide, acute at their tips and with round bases, attached spirally on the twigs with closely spaced arrangement, and having scarcely the petioles, medial groove well developed; texture thick.

Remarks: This specimen is so fragmental that the writers assigned to the genus *Cephalotaxus* with some hesitation. Among the conifers having such leaves, this fossil specimen is most close to *Cephalotaxus*. In East Asia, the fossil leaves of *Cephalotaxus* have scarcely occurred.

Among the living *Cephalotaxus*, the present material is close to *C. drupacea* S. et Z., which is distributed in Japan proper. But the leaves of the latter are larger in dimension than those of the former.

Collection: GSJ. No. 4057

Picea Sugaii TANAI et ONOE sp. nov.

(Plate I, figs. 5～7)

1952. *Picea* sp., TANAI; Jap. Jour. Geol. Geogr., Vol. 22, pl. IV, fig. 4

Description: Fruits small in size, 0.8～1.0 cm long and 0.3 cm wide: wing elliptically lanceolate with a cuneate base; seeds with pointed tip. Nervation indistinct, radial from the seed, and trending along the major axis.

Remarks: This genus is represented by some fruits and by fragments of twigs.

The occurrence of this genus has been scarcely known in the Miocene deposits in Japan. S. Miki[14] described many cones or shoot fragments of *Picea* from the Pliocene and Pleistocene deposits of Japan. The senior writer finds many fruits of *Picea* from the Miocene coal-bearing formations in Japan.

These fruits are identical with those of *P. jessoensis* CARR., which is widely distributed in cool or cold regions of East Asia. Among the fossil fruits, the present materials are somewhat close to *P. lahontense* MACG. and *Picea* sp. from the Miocene deposits of North America, but they are different from the latters in their shape of wing.

This species is named in honour of Mr. K. Sugai, who is the chief geologist of Coal Section of Geological Survey of Japan.

Collection: GSJ. Holotype No. 4055 (Nishitagawa's specimen); Paratype No. 4058

Alnus sp.

(Plate I, fig. 9)

Description: Leaves incomplete, basal and upper parts missing; leaves ovate-oblong or oblong-lanceolate in shape; 8.5 cm (estimated) long and 3.4 cm wide, apex and base unknown; midrib relatively stout, almost straight; secondary nerves 16～18 pairs (estimated), opposite or subopposite, diverging at angles of 40～50°, nearly straight, all craspedodrome and ending in the teeth; margin duplicately serrate, the teeth somewhat obtuse; tertiary nerves irregularly percurrent; texture firm.

Remarks: As these leaves are fragmental in the collection, the writers cannot designate the specific name.

Among the living alder in East Asia, this fossil leaf resembles *Alnus firma* S. et Z. and *A. multinervis* CALL. in shape, especially resembles the latter. These living alders are distributed in Japan and Korea.

Collection: GSJ. Holotype No. 4007

Betula Mitai TANAI et ONOE sp. nov.

(Plate II, figs. 1～3)

Description: Leaves medium to small in size, elliptically ovate, 4.5～6.5 cm long and 1.8～4.0 cm wide; base almost asymmetrical, truncate or very broadly rounded, apex abruptly acuminate; midrib relatively stout, slightly curved; 8～10 pairs of secondaries alternate or subalternate, the basal pairs short, spreading nearly at right angles to the midrib, other secondaries diverging at angles of 30~40°, slightly arched up near the margin, lower and middle ones with one or two branches, all craspedodrome and ending in the teeth; margin entire at the base, thence coarsely compound-serrate, the teeth somewhat obtuse, and the teeth which the secondaries end are larger than the other; tertiary nerves irregularly percurrent, nervilles numerous and forming a irregularly quadranglar network; petiole fragile, 3~8 mm long, texture firm.

Remarks: These materials are plentiful in the writers' collection, but the complete leaves are scarcely obtained.

The present specimens closely resemble *B. mioluminifera* Hu et Chaney from the Shatung Miocene flora of North China, but the latter has a more ovate shape and a symetrical base, and the latter's teeth are almost equal in size. This new species are also to *B. fairii* Knowlton which is one of the common species of Miocene birch in North America. This fossil materials are comparable to *B. prisca* Ettings. and *B. Brongniartii* Ettings., which are wide-spread species in the so-called "Arctic Miocene floras".

Among the living birches in East Asia, these fossil specimens are close to *B. luminifera* Winkler and *B. sollenis* Koidzumi, and especially close to the former. The fossil leaves are somewhat close to *B. lenta* L. which is living in the eastern part of North America, though differing in the number of lateral veins.

The species is named in honour of Mr. M. Mita, who rendered many geological suggestions to the writers about the fossil locality.

Collection: GSJ. Holotype No. 4008; Paratype, Nos. 4009, 4010

Betula sp.

(Plate II, figs. 5, 6)

Description: Bractlet trilobate, very small in size, 4 mm long and 6 mm wide; each lobe unequal in size and shape, and middle lobe smaller than the lateral lobes; base broadly cuneate.

Remarks: The present materials are somewhat compressed, but surely characteristic bractlet of the genus *Betula*. These bractlets are rather comparatively common in the writers' collections.

These fossil bractlets are closely similar to those of the living *B. lenta* L. of North America in their shape and dimension. Accordingly, these fossil specimens may be the bractlets of the above-described new species.

Among the fossil bractlets of birch, there are no comparable specimens to these materials. S. Endo[5] described a bractlet of *B. Maximowicziana* Regel from the Pleistocene flora of Shiobara, Japan, but it differs in its shape.

Collection: GSJ. Holotype No. 4012

Carpinus miofangiana Hu et Chaney

(Plate III, figs. 1, 2)

1940. *Carpinus miofangiana,* Hu et Chaney: Carnegie Inst. Wash. Pub. No. 507, pl. 10, figs. 2, 3

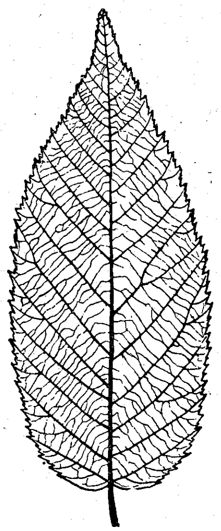
Remarks: The leaf impressions of this species are comparatively plentiful in this flora. This fossil leaves are elongate-ovate in shape, and unequally shallow-cordate at the base. The present specimens have 18~21 pairs of secondary nerves, though the secondaries are 15 pairs in the original description. The specimens are more or less fragmental and the plesiotype (No. 4015) is shown by the restoration in Text-fig. 1.

Most of fossil leaves named as *Carpinus grandis* UNGER and *C. pyramidalis* (GOEPPERT) HEER from the Miocene deposits in Japan, probably belong to *C. miofangiana*.

In the collections, a involucre of hornbeam which is closely similar to that of living *C. fangiana*, was found, though its specimen is broken in the upper portion.

These fossil leaves are closely similar to that of *Carpinus fangiana* HU, which is of limited distribution in Southwest and West China.

Collection: GSJ. Plesiotype Nos. 4014, 4015



Text-fig. 1 Restoration of *Carpinus miofangiana* HU et CHANEY (Plesiotype No. 4015) ×3/5

Carpinus miofargesiana TANAI et ONOE sp. nov.

(Plate V, figs. 4~6, 9~11)

Description: Involucres obliquely ovate, asymetrically rounded at the base, acuminated at the apex, 1.8~2.8 cm long and 0.9~1.3 cm wide; palmately three-nerved, craspedodrome, and some weak intermediate nerves diverge from the base; a few secondaries diverge from the primary nerves and occasionally enter into smaller teeth; smaller nerves at nearly right angles from the main nerves, forming a transverse network; margin lobately serrate on the large side and entire on the smaller side; stipe stout, thick, curved, 3 mm long. Nutlet poorly preserved, ovate, 3 mm long and 2 mm in diameter.

Remarks: These specimens are very plentiful in this flora. The nerves and the fine areolation of the present materials are closely similar to *Carpinus fargesiana* WINKLER, which is living in central and southern China. In the writers' collection, the fragmental leaves close to the latter species are found. Accordingly, the fossil species is probably a progenitor of the living *C. fargesiana*. There is no known fossil species to which it corresponds closely.

Collection: GSJ. Holotype No. 4014; Paratype Nos. 4015, 4016

Carpinus s-Satoi TANAI et ONOE sp. nov.

(Plate V, figs. 1, 2, 13, 14)

Description: Involucres asymetrically ovate, broadly rounded or slightly cordate at the base and bluntly pointed at the apex; 2.3~2.9 cm long and 1.3~1.5 cm wide; stipe stout, thick, 4 mm long; palmately veined with 1 or 2 primary veins on small side, and 2 or 3 on large side of the midrib, all spreading, craspedodrome, rarely a primaries of small side camptodrome; secondaries branch from the primaries, generally ending in the smaller teeth; margin coarsely serrate, the teeth thick, obtusely pointed. Nutlet poorly preserved, ovate, 5 mm long and 3 mm in diameter.

Remarks: The present materials are somewhat similar in the nervation and shape to *Carpinus fargesiana* WINKLER, *C. turczaninowii* HANCE and *C. henryana* WINKLER which are living now in central or southern China. The last species is most similar in nervation to this new species, but distinctly different in their shapes.

Among the bracts of fossil *Carpinus*, these fossil materials are most similar to *C. mioturczaninowii* HU et CHANEY.

The species is named in honour of Mr. S. Sato, who gave to the writers many fossil materials and geological suggestions about the fossil locality.

Collection: GSJ. Holotype No. 4017; Paratype Nos. 4018, 4019

Carpinus ishikiensis TANAI et ONOE sp. nov.

(Plate V, figs. 3, 15)

Description: Involucres obliquely ovate, 1.8 cm long and 1.2 cm wide; the base cordate on one side, obliquely cuneate on the other, the apex acute; palmately veined, with two primary nerves on one side, and 5 on the other side of the midrib, all spreading, craspedodrome; secondaries branch from the primaries entering into the smaller teeth; margin irregularly serrate, the teeth triangular and acute; stipe stout, 2 mm long.

Nutlet ovate, with an acute tip, poorly preserved, 2.5 mm long and 1.5 mm in diameter.

Remarks: The shapes and nerves of these fossil involucres are closely similar to those of *Carpinus megabracteata* HU et CHANEY. The former is smaller in size than the latter, and the margin of the latter is distinct double-serrate. None of the living species of the hornbeam in East Asia have fruits comparable to these specimens.

Collection: GSJ. Holotype Nos. 4020, 4021

Ostrya subvirginiana TANAI et ONOE sp. nov.

(Plate III, fig. 4; Plate IV, figs. 3, 4)

Description: Involucre elliptically oval, 13 mm long and 6.5~7.5 mm wide at the middle part; apex roundly obtuse, base obtusely round; main nerves parallel, 6~7 in number on the impression, and intermediate slender nerves parallel to main nerves; fine nerves perpendicular to the main and intermediate nerves; nutlets oblong-ovate with pointed apex, 4 mm long and 1.5~2.0 mm wide.

Leaves incomplete, ovate-oblong, rounded or slightly cordate often inequilateral at the base, upper portion lacking, 8.5 cm long (estimated) and 4.5 cm wide; midnerve strong, somewhat curved; lateral veins subopposite or alternate, 14~16 pairs (estimated), slightly curved upwards, and entering into main teeth; tertiaries irregularly percurrent; margin double-serrate; petiole stout, 5 mm long.

Remarks: The present bladdery fruits are so characteristic of the genus that there can be no doubt of the presence of *Ostrya* in this flora. These involucral sacs are most closely similar to those of *Ostrya virginiana* (MILL.), which is living in southeastern North America. The present material somewhat resembles *O. japonica* SARGENT, but distinctly different from the latter in their rounded apex. There are scarcely occurred the fossil involcres of *Ostrya* in East Asia, and among them there are no fruits which resemble these specimens.

The fossil leaves are fragmental, but the features of their lower part are very close to those of *O. virginiana*.

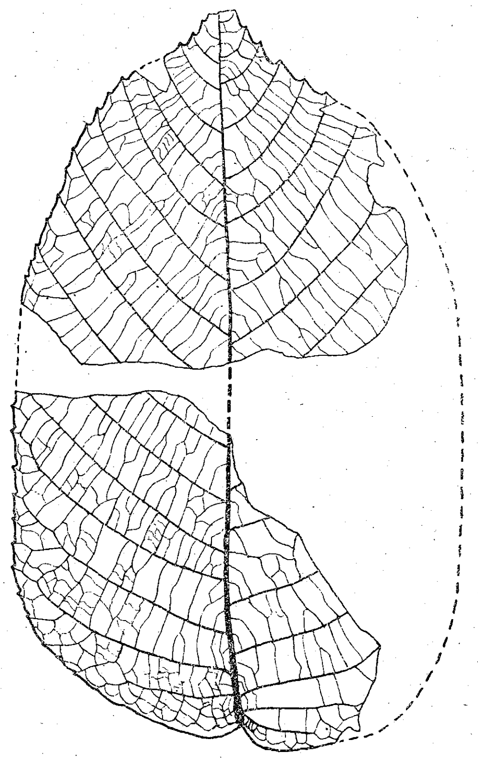
Collection: GSJ. Holotype Nos. 4025, 4026, 4027

Corylus miochinensis TANAI et ONOE sp. nov.

(Plate IV, fig. 1)

Description: Leaves large to medium in size, oval in shape, 8.2 cm wide and about 14.5 cm long (holotype specimen); base asymetrically cordate, apex abruptly acuminate, margin entire at the base, thence doubly serrate, the teeth small and acute; midrib strongly stout and almost straight; secondary nerves 15~17 pairs, opposite or subalternate, 2 or 3 pairs of basal part short, spreading nearly at right angles to the midrib, other secondaries diverging at angles of 40~55°, slightly curved upwards, the secondaries in the lower half branching and looping near the margin, the ones in the upper half entering the primary marginal teeth, while the branches enter into the secondary teeth; internal marginal tertiaries well-marked and transversely percurrent; a coarse polygonal areolation of quaternary veins, enclosing a reticulate mesh of finer veinlets; texture firm; petiole missing.

Remarks: This large fossil leaves are somewhat fragmental, and restored as shown in Text-fig. 2. The present materials are most similar to *Corylus chinensis* FRANCH., which is living now in central and southern



Text-fig. 2 Restoration of *Corylus miochinensis* sp. nov. (Holotype No. 4030) ×7/10

China. But the living leaves are less in number of secondary nerves than the fossil leaves, and have 10~12 pairs.

This fossil leaves have a characteristic margin and venation, and are assigned to the genus *Corylus* with some hesitation. These characters have some resemblances to those of some leaves of *Ulmus*, *Pyrus*, *Malus* or *Juglans*, and especially to the last genus. In the leaves of *Juglans* the secondary nerves curves upwards and form a series of loops within the margin.

Collection: GSJ. Holotype Nos. 4030, 4031

Wistaria sp.
(Plate VII, fig. 5)

Description: Pod incomplete, and a half part missing; pod elongate in shape, large, 2 cm wide and over 10 cm (estimated) long, abruptly acuminated distad; seeds not visible.

Remarks: Only one incomplete pod was obtained. The present material is apparently a pod of Leguminoceae, and corresponds to that of *Wistaria* in its shape and size.

In Japan, the fossil pods of *Wistaria* were reported from the Pliocene sediments by S. Miki[14]: *W. floribunda* Dc. and *W. liginiatum* MIKI. Among these fossil remains, the present material is closely related to the pod of *W. floribunda* which is occurred from the Pliocene *Stegodon* beds near Akashi City, Japan. *W. floribunda* is living now in Japan and China.

Collection: GSJ. Holotype No. 4034

Acer palaeoplatanoides ENDO
(Plate VI, figs. 3, 4, 10)

1950. *Acer palaeoplatanoides*, ENDO; Short Papers IGPS., No. 1, pl. 3, figs. 1, 9

Remarks: Though the samaras are somewhat incomplete, the nervation of wing and seeds are very well-preserved. These samaras are about 4.5 cm long, and 1.3~1.5 cm wide in the middle part. Seeds are semi-ellipsoidal in shape, and about 7 mm in width and 9~10 mm in length.

These materials are closely similar to *Acer palaeoplatanoides* ENDO in their many characters, which is reported from the Miocene Kantindo formation in Korea by S. Endo[6]. The fossil specimen is similar to Norway maple (*Acer platanoides* L.), which is now existing in Europe and western Asia.

Collection: GSJ. Plesiotype Nos. 4036, 4037

Acer protojaponicum TANAI et ONOE sp. nov.
(Plate VI, figs. 5, 7, 8)

Description: Samaras small or medium in size, 2.0~2.3 cm long; wing with rounded apex, 0.6~0.7 cm at middle part, convex at inner side and somewhat incurved at junction with fruits; seeds comparatively large, semi-ellipsoidal, 0.5~0.7 mm long, base nearly perpendicular to posterior side of seed.

Remarks: The present materials closely resemble the samaras of *Acer japonicum* THUNBERG, which is now living in Hokkaidō and northern

Honshū, Japan. The fragmental leaf-impressions closely to those of *Acer japonicum* are also occurred abundantly in this flora. This new species is probably a progenitor of the living species.

Collection: GSJ. Holotype No. 4038; Paratype No. 4039

Acer pseudoginnala TANAI et ONOE sp. nov.

(Plate VI, fig. 2).

Description: Samara about 4.2 cm long; wing 1 cm broad at the middle, and about 3.2 cm long, and about 1.2 cm broad near the distal end and narrows rapidly towards the base, apex obtusely rounded, outer margin nearly straight, inner margin convex; veins about 16 in number at the base, curving inwards and irregularly dichotomously branching. Seed elliptical in shape, 9 mm long and 6 mm wide, angle between outer margin of wing and contact line of seeds 15° or nearly parallel. Contact line of seeds about 7 mm long.

Some fragmental leaves which is closely similar to the living *Acer Ginnala* MAXIM., occur from the Shichiku flora. Though the leaves fragmental, leaves 3-lobed and doubly serrate in the margin of each lobes; middle lobe larger than lateral ones, and often asymmetrical in shape.

Remarks: Among the fossil samaras, the present material is somewhat similar to that of *Acer protodistylum* ENDO, which was reported from the Upper Eocene of the Fu-shun Coal Field in Manchuria by S. Endo, but the former is distinct easily from the latter by the dimension of seeds and other characters. Another allied one is the samara of *Acer* cfr. *trilobatum* (STERN.) AL. BR., which was described by H. Weyland[26] from the Oligocene of Rott in Siebengebirge of Rhineland, but the samara is smaller than the present material. S. Endo[6] described the fossil samara of *Acer Ginnala* from the Upper Miocene near Kobe City in Japan, but the samara is smaller than the Shichiku material. And the seed of the former is trigonal in shape, while the Shichiku's is elliptical.

The fossil species is closely similar to *Acer Ginnala* MAXIM., which is living in China, Japan, Korea and Manchuria. The fossil samaras are different from the living one by the dimension and shape of seeds. The samara of the living *Acer Ginnala* (Amur maple) is commonly 2.5～3.5 cm long, and its seeds are trigonal in shape.

Collection: GSJ. Holotype Nos. 4040, 4041

Acer Matsuii TANAI et ONOE sp. nov.

(Plate VI, figs. 1, 13)

1943. *Acer* sp. (samara), OISHI et HUZIOKA; Jour. Fac. Sci. Hokkaidō Imp. Univ., Ser. IV, Vol. 7, No. 1, pl. XI, fig. 5

Description: Samara 3.5 cm long; wing 1 cm broad at the middle, and about 2.8 cm long gradually narrowed to the base and apex, outer margin slightly concave and inner convex, apex rounded; veins fine, 18 in number at the base, curving inwards and dichotomously branching. Seed small, not thick semicircular in shape, about 0.6 cm in diameter; angle between the outer margin of wing and the contact line of the seeds about 45°, contact line of seeds about 0.8 cm long.

Remarks: Though only one fossil samara was obtained, it is apparently a type of *Acer mono* MAXIM.. Among the fossil samara named under *Acer mono* or *A. pictum* in East Asia, the present material is not similar to any specimens. But *Acer* sp. which was described from the Middle Miocene in southern Hokkaidō by Oishi and Huzioka[20], is entirely similar to the Shichiku specimen, though the former is large in dimension than the latter.

In the Shichiku flora, the fragmental leaves of *Acer subpictum* SAPORTA are comparatively abundant. This fossil maple species, which is common in the Tertiary sediments in East Asia, was defined by leaf impressions. The present fossil samara seems to be that of *Acer subpictum.*

This new species is named in honour of Mr. H. Matsui, who gave to the writers some fossil materials and geological suggestions about the fossil locality.

Collection: GSJ. Holotype No. 4042

Acer cfr. *kokangenense* ENDO

(Plate VI, fig. 9)

Cfr. 1950. *Acer kokangenense,* ENDO; Short Papers IGPS., No. 1, pl. 3, fig. 10

Remarks: This large fruit of maple is closely similar to *Acer kokangenense* ENDO which was reported from the Miocene lignite beds of Kokangen in Korea by S. Endo, though the lowest portion is missing. Seed seems triangular or ellipsoidal in shape, though incompletely preserved, and they are about 0.5 cm in width and over 1.5 cm in length. The seed of the Shichiku specimen seems to be somewhat longer than the Korean specimens. This fossil samara is not comparable to any existing and fossil samaras of *Acer.*

Collection: GSJ. No. 4043

Tilia sp.

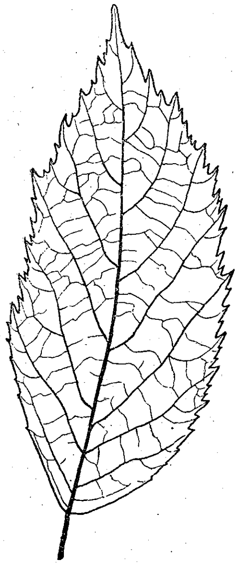
(Plate VII, figs. 2, 3)

Description: Pedunculate bract elongate-oblong, more than 5 cm long and 2 cm wide, truncately rounded at the apex, rounded at the base; central nerve distinct, bifurcating near the apex; lateral veins distinct, nearly perpendicular to the midvein; nervilles reticulated, making a fine-polygonal mesh; peduncle stalk over 1 cm long.

Remarks: This floral bract is fragmental, but fairly preserved. Among the living lindens, these specimens are closely similar to the bract of *Tilia amurensis* RUPER. In this flora, the leaves of *Tilia* are determined two species, *Tilia distans* NATHORST and *T. subnobilis* HUZIOKA. Comparing to the living species, the former fossil species similar closely to *T. amurensis* RUPER, and the latter fossil to *Tilia nobilis* REHD. et WILS.. The fossil materials are distinctly different from the bract of *T. nobilis.* Accordingly, the present specimens are probably the bract of *Tilia distans* NATHORST.

The pedunculate bract of the fossil lindens have scarcely reported in Japan. Among them the present fossils are most close to *Tilia* sp. which was reported by K. Huzioka from Abura, Shiribeshi Province, Hokkaidō.

Collection: GSJ. Cotype Nos. 4045, 4046



Text-fig. 3 Restoration of Aralia celtisfolia sp. nov. (Cotype No. 4045) ×3/5

Hemitrapa borealis (HEER) MIKI
(Plate IV, figs. 6～9)

1869. *Trapa borealis*, HEER; Königl. Akad. d. Wiss. Bd. 38, Taf. 8, figs. 9, 10

1952. *Hemitrapa borealis*, MIKI: Palaeobotanist, Vol. 1, fig. 1, F

Remarks: In this flora, many fossil nuts of *Hemitrapa* are found. These fossil nuts with well-developed brushy haired part are spindle-shaped and somewhat curved. And this characteristics correspond to *Hemitrapa borealis* (HEER). The nuts in the writers' collection are 10～15 mm wide, and 26～33 mm long. Their peduncles are 0.8 cm, and two appendages are short, and diverged from the nut.

The genus of *Hemitrapa* are established by S. Miki in 1941. From the Mio-Pliocene deposits in Gifu and Aichi Prefectures, Miki found many nuts of *Hemitrapa trapelloidea* MIKI, which has some resemblances to *H. borealis*.

Collection: GSJ. Plesiotype Nos. 4047, 4048, 4049, 4050, 4051

Aralia celtisfolia TANAI et ONOE sp. nov.
(Plate VII, fig. 1)

Description: Leaflet ovate or ovate-lanceolate, 4.5 cm wide and 10 cm long; base asymmetrically cuneate or rounded, apex acuminate; margin double-compound serrate, the teeth acute, usually pointing upward; midrib stout, slightly arched; secondary nerves irregularly spaced, alternate to subopposite, 9～10 pairs, leaving the midrib at angle of 40～55°, most of secondaries flexuous, forking, and their branches entering into the secondary smaller teeth; tertiary nerves comparatively distinct, irregularly percurrent; petiole broken, over 7 mm long; texture firm.

Remarks: This leaflet is broken and incomplete. This leaf-impression is assigned to the genus *Aralia* with some hesitation, and it is somewhat similar to *Hydrangea* or *Celtis*. But the fossil features of venation are closely similar to some leaves of *Aralia*.

Among leaves of the living angelica trees, the present material is closely similar in venation and marginal features to *Aralia californica* S. WATS. which grows now in North America. This fossil species is also similar to *Aralia spinosa* L., which is living in southeastern North America and central or southern China.

The fossil leaves similar to the present material are scarcely found in the Tertiary flora of East Asia, but *Aralia taurinensis* (WARD) in the Comstock flora of west central Oregon, the United States, is mostly close to the present species.

Collection: GSJ. Holotype No. 4052

Kalopanax acerifolium (NATHORST) HU et CHANEY
(Plate VII, fig. 4)

1883. *Acanthopanax acerifolium,* (NATHORST) ; K. Svensk. Vetens Handl., Vol. 20, No. 2, pl. 8, figs. 1, 2

1940. *Kalopanax acerifolium,* HU et CHANEY ; Carnegie Inst. Wash. Pub., No. 507, pl. 47, figs. 3, 5

Remarks : The fossil specimens are fragmental, and their marginal characters of each lobes are indistinct. Though the writers' leaves seem to be palmately 7-lobed, the basal pairs of primary nerves are weaker than the others.

The fossil leaves are closely similar to *Kalopanax ricinifolius* MIQ., which is living in Japan and China.

Collection : GSJ. No. 4053

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常磐炭田石城地区北西部大野村産の中新世植物群について

棚 井 敏 雅　尾 上 亨

要 旨

常磐炭田石城地区の北西部，すなわち久ノ浜町西方 8 km にあたる大野村字紫竹附近において，かつて白水層群最上位の白坂頁岩層の最上部と考えられた含亜炭層が小区域に分布している。この含亜炭層は凝灰質砂岩・泓泥岩などからなり，数枚の亜炭層を挾在し，近年の層序学的研究によると，古第三紀白水層群のものではなく，新第三紀のものではないかという考えが有力になつている。

筆者らの1人棚井は，この含亜炭層に伴なつて産出する化石植物を採集し，その後筆者らはこれらを検討し，その含植物化石層の地質時代と層位学的位置，および堆積機構などについて2，3の考察を行なつた。

すなわち，この植物群はカンバ科・ニレ科・カエデ科のものを主体とし，これらにその他の温帯性落葉濶葉樹および毬果類を混交して，植物群の組成やその構成種から考えても本邦中新世における，いわゆる“阿仁合型植物群”に属することが明らかになつた。したがつて，この植物化石を伴なう含亜炭層は，白水層群最上部のものではなく，むしろ湯長谷層群最下部すなわち新第三系基底部の堆積物と考える方が妥当である。

しかも，これらの化石葉の大部分は保存がよく，また，*Hemitrapa* などの水生植物を有することなどから考えても，これらの植物が堆積地の比較的近くに生育していたことを物語るものといえよう。本論においては，この植物群を構成する化石種の，東亜における最も近似の現生種を求め，その現在の生育の条件や分布地を検討し，この植物群の生育した当時の環境的状態を推定している。

常磐炭田の各地においては，新第三系の基底部に，このような植物化石を伴なう含亜炭層がみいだされる。したがつて，その層序的位置や古植物群の示す環境などから考えると，常磐炭田においては古第三系が堆積した後に陸化して侵食され，その凹所または入り込んだ地形の所において，新第三紀海進の最も初期に，このような含亜炭層が堆積・形成されたのであろう。

PLATES

AND

EXPLANATIONS

(with 7 Plates)

Plate I

1. *Cephalotaxus* sp. GSJ. No. 4057
2. *Metasequoia occidentalis* (NEWBERRY) CHANEY GSJ. No. 4004
3. *Metasequoia miocenica* TANAI et ONOE GSJ. Holotype No. 4001
4. *Metasequoia miocenica* TANAI et ONOE GSJ. Paratype No. 4003
5. *Picea Sugaii* TANAI et ONOE GSJ. Paratype No. 4058
6. *Picea Sugaii* TANAI et ONOE (Sketched from 5)
7. *Picea Sugaii* TANAI et ONOE GSJ. Holotype No. 4055
8. *Juglans shanwangensis* HU et CHANEY GSJ. No. 4006
9. *Alnus* sp. GSJ. Holotype No. 4007

(All natural size)

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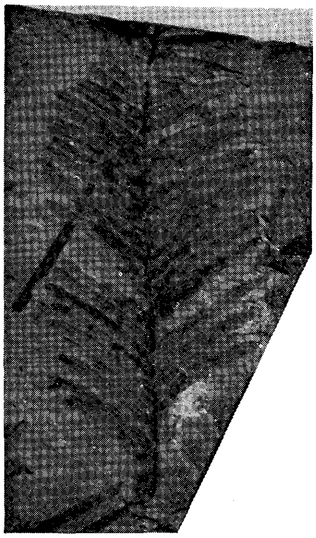

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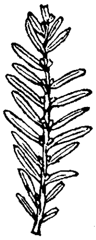

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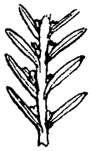

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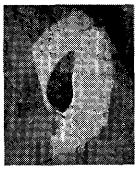

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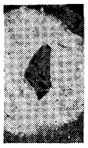

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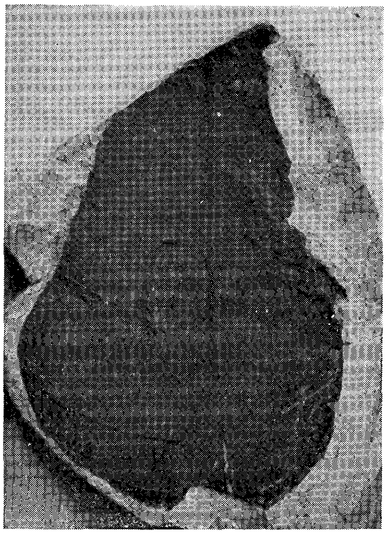

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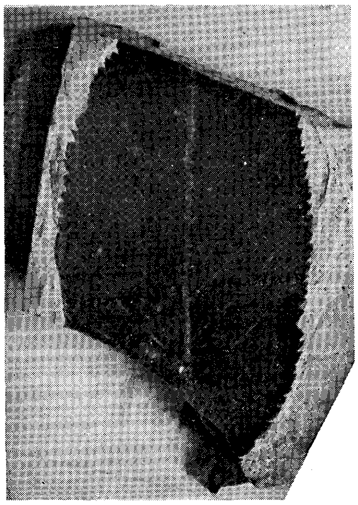

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Plate II

1, 3. *Betula Mitai* TANAI et ONOE GSJ. Holotype No. 4008

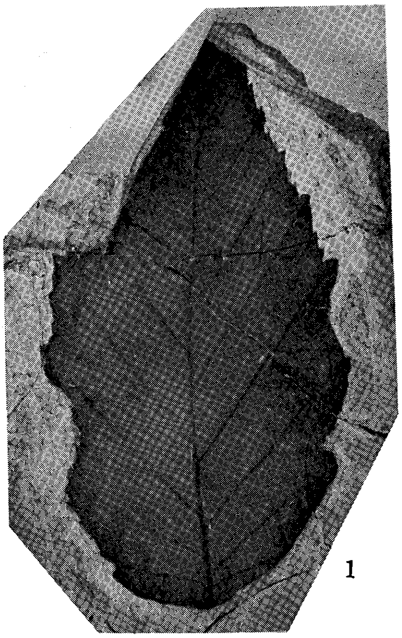
2. *Betula Mitai* TANAI et ONOE GSJ. Paratype No. 4009

4. *Betula mioluminifera* HU et CHANEY GSJ. Plesiotype No. 4011

5. *Betula* sp. ×1.4, GSJ. Holotype No. 4012

6. *Betula* sp. (Sketched from 5)

(All natural size unless otherwise stated)



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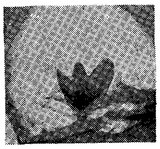

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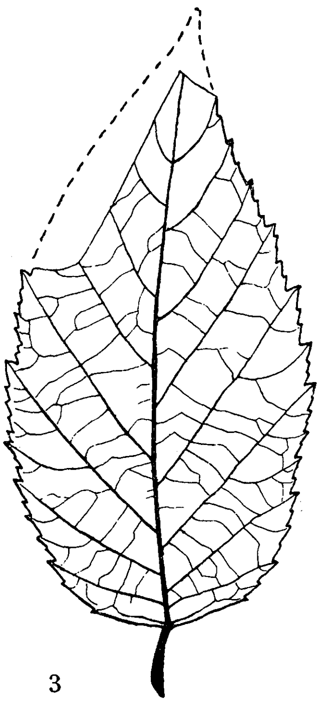

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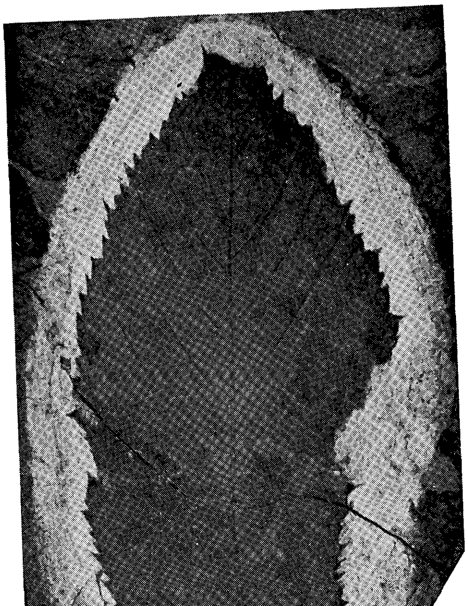

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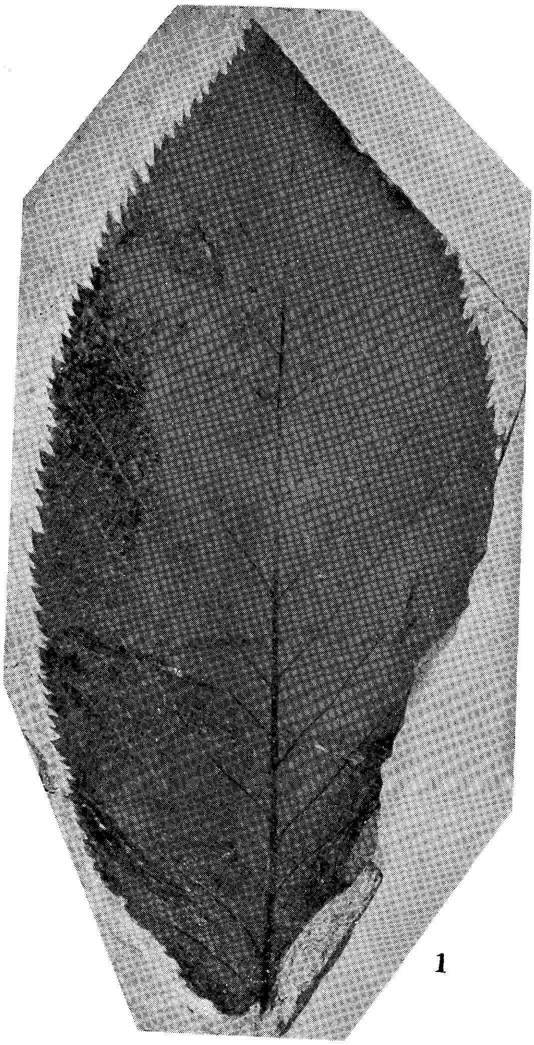
Plate III

1.	*Carpinus miofangiana* HU et CHANEY	GSJ. Plesiotype No. 4014
2.	*Carpinus miofangiana* Hu et CHANEY	GSJ. Plesiotype No. 4015
3.	*Carpinus miocordata* HU et CHANEY	GSJ. No. 4013
4.	*Ostrya subvirginiana* TANAI et ONOE	GSJ. No. 4027

(All natural size)



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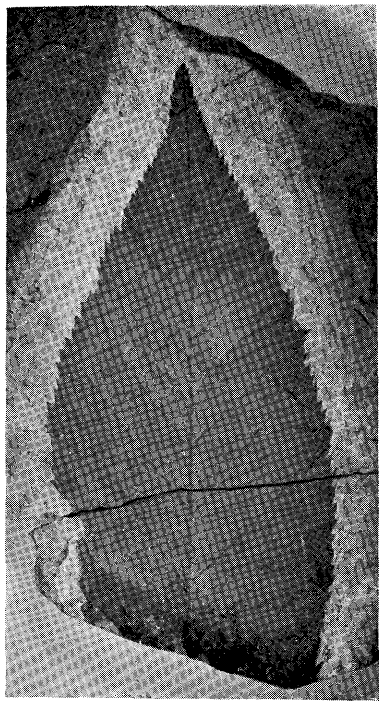

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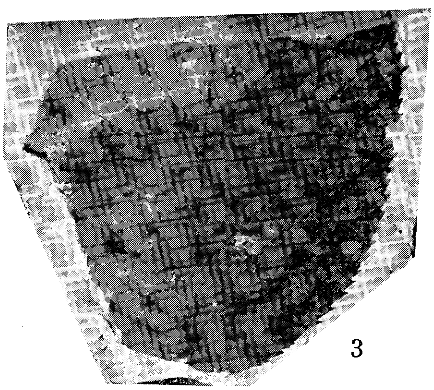

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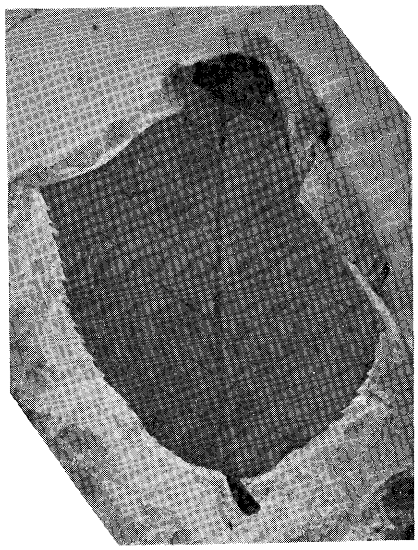

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Plate IV

1. *Corylus miochinensis* TANAI et ONOE GSJ. Holotype No. 4030
2. *Zelkova Ungeri* (ETTINGS.) KOVATS ×1.4 GSJ. 4032

3a, 3b. *Ostrya subvirginiana* TANAI et ONOE GSJ. Holotype No. 4025 (3a Sketched from 3b)

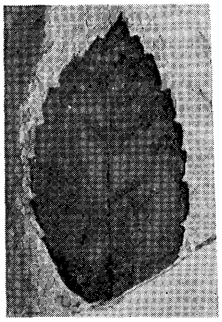
4. *Ostrya subvirginiana* TANAI et ONOE GSJ. No. 4026
5. *Ostrya japonica* SARG. subsp. *oblongibracteata* HUZIOKA GSJ. Plesiotype No. 4028

6, 8. *Hemitrapa borealis* (HEER) MIKI GSJ. Nos. 4048, 4049

7. *Hemitrapa borealis* (HEER) MIKI GSJ. Plesiotype No. 4047
9. *Hemitrapa borealis* (HEER) MIKI (Sketched from 7)

(All natural size unless otherwise stated)

1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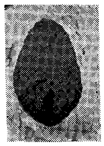
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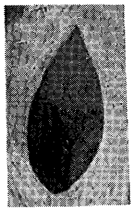
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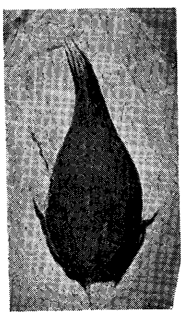
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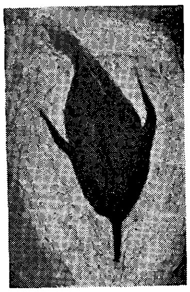
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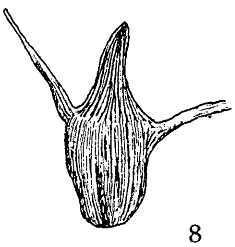
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Plate V

1. *Carpinus s-Satoi* TANAI et ONOE GSJ. Holotype No. 4017
2. *Carpinus s-Satoi* TANAI et ONOE GSJ. Paratype No. 4018
3. *Carpinus ishikiensis* TANAI et ONOE GSJ. Holotype No. 4021
4. *Carpinus miofargesiana* TANAI et ONOE ×1.3 GSJ. Holotype No. 4014

5, 6. *Carpinus miofargesiana* TANAI et ONOE GSJ. Paratypes Nos. 4015, 4016

7. *Carpinus protoerosa* TANAI GSJ. Plesiotype No. 4022
8. *Carpinus* cfr. *miofargesiana* TANAI et ONOE

9, 10, 11. *Carpinus miofargesiana* TANAI et ONOE (Sketched from 4~6)

12. *Carpinus* cfr. *simplicibracteata* HUZIOKA GSJ. No. 4023

13, 14. *Carpinus s-Satoi* TANAI et ONOE (Sketched from 1 and 2)

15. *Carpinus ishikiensis* TANAI et ONOE (Sketched from 3)

16. *Carpinus miocordata* HU et CHANEY GSJ. No. 4024

(All natural size unless otherwise stated)


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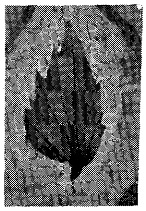
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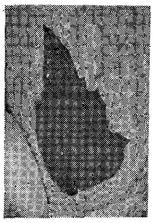
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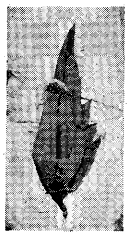
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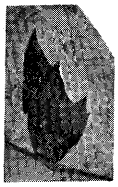
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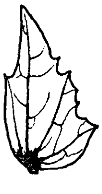
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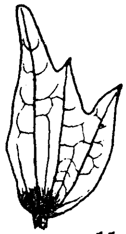
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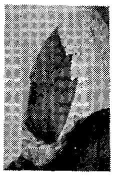
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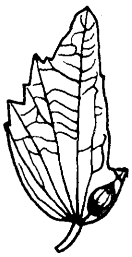
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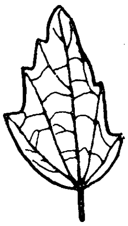
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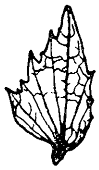
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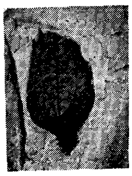
16

Plate VI

1. *Acer Matsuii* TANAI et ONOE GSJ. Holotype No. 4042
2. *Acer pseudoginnala* TANAI et ONOE GSJ. Holotype No. 4040
3. *Acer palaeoplatanoides* ENDO GSJ. Plesiotype No. 4037
4. *Acer palaeoplatanoides* ENDO ×1.3 GSJ. Plesiotype No. 4036
5. *Acer protojaponicum* TANAI et ONOE GSJ. Holotype No. 4038
6. *Acer palaeodiablicum* ENDO GSJ. Plesiotype No. 4054
7. *Acer protojaponicum* TANAI et ONOE GSJ. Paratype No. 4039
8. *Acer protojaponicum* TANAI et ONOE (Sketched from 5)
9. *Acer* cfr. *kokangenense* ENDO GSJ. No. 4043
10. *Acer palaeoplatanoides* ENDO (Sketched from 4)
11. *Acer miohenrii* HU et CHANEY GSJ. No. 4056
12. *Acer pseudoginnala* TANAI et ONOE GSJ. No. 4041
13. *Acer Matsuii* TANAI et ONOE ×1.3 (Enlarged figure of Holotype specimen)

(All natural size unless otherwise stated)

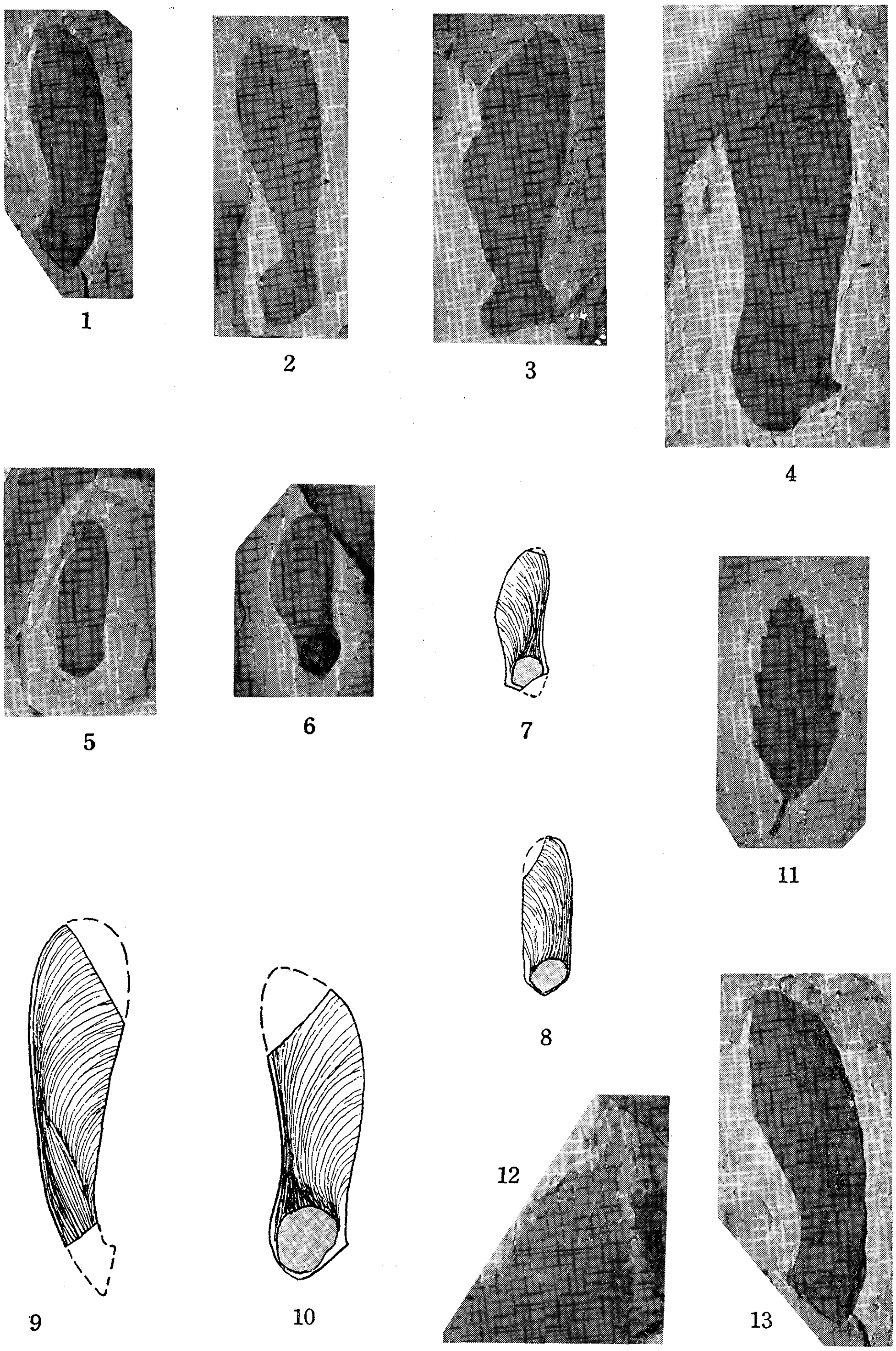
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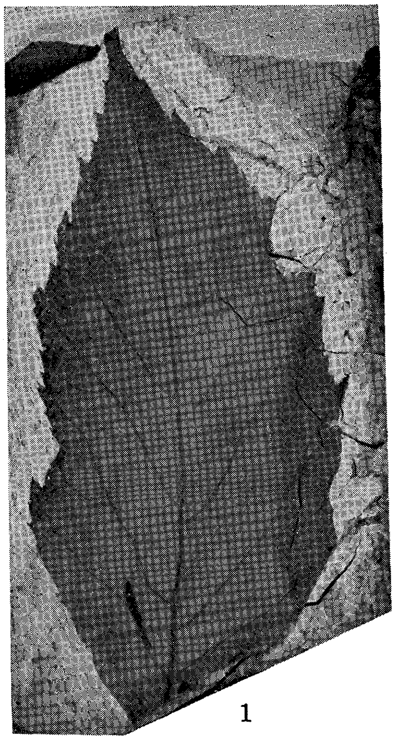
Plate VII

1. *Aralia celtisfolia* TANAI et ONOE GSJ. Holotype No. 4052
2. *Tilia* sp. GSJ. Cotype No. 4045
3. *Tilia* sp. (Sketched from 2)
4. *Kalopanax acerifolium* (NATHORST) HU et CHANEY GSJ. No. 4053
5. *Wistaria* sp. GSJ. Holotype No. 4034

(All natural size)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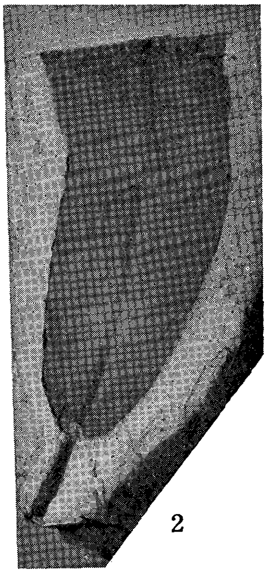
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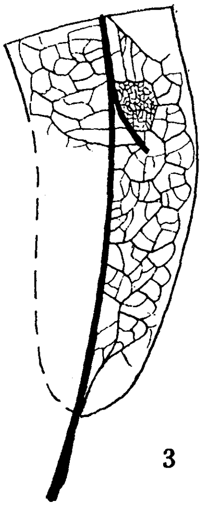
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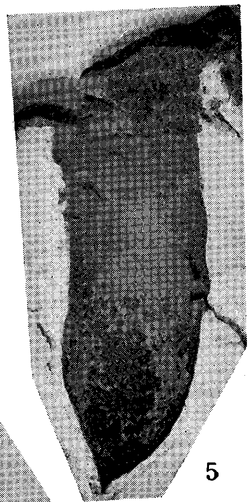
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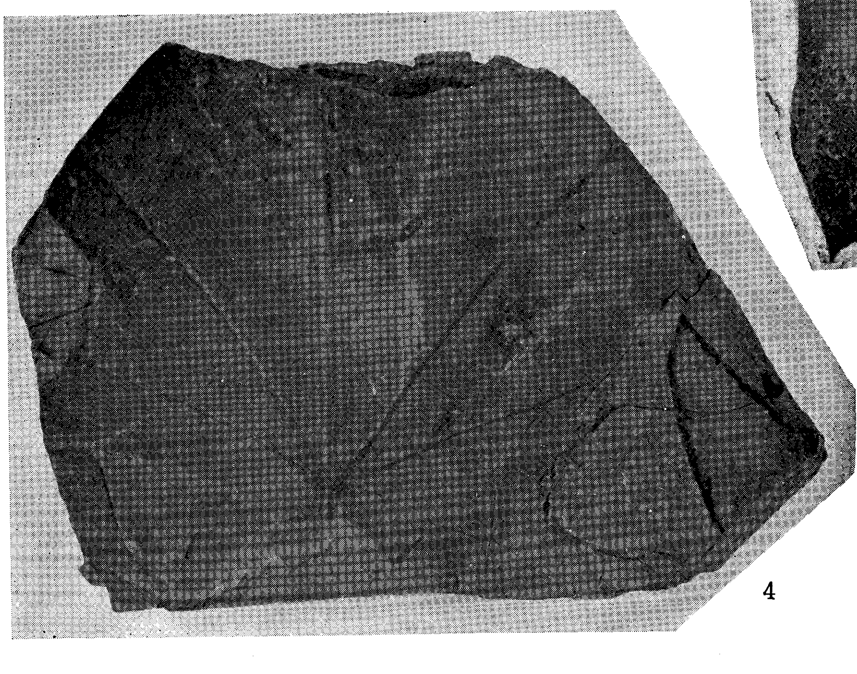
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