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A MIDDLE MIOCENE FLORA FROM OGUNI-MACHI, YAMAGATA PREFECTURE, JAPAN

By

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Isamu KOBAYASHI, Director

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Toru ONOE*

Abstract

This paper deals with mainly the palaeoclimatic condition and palaeogeographical environment of the Oguni basin at the time when the ancient plants had grown. The plant-bearing sediments, so-called upper green-tuff members, are distributed in Oguni-machi, southwestern part of Yamagata Prefecture.

The fossil flora, which is called the "Oguni flora" contains 61 species and 48 genera, and the majority of these plants are warm-temperate elements, while some are subtropical and a few are cool-temperate ones. The most abundant species is *Zelkova ungeri*, followed by *Quercus miovariabilis*, *Comptonia naumanni*, *Castanea miomollissima* and *Carpolithes japonica*.

More than a half of the Oguni plants grow now in Japan as the equivalents, and the Oguni forest in the Middle Miocene time is closely similar to the warm-temperate forest of central to southwestern Japan except the Loochoo Islands, and is mainly distributed on the lowland and its adjacent slopes. The climate is assumed that the mean annual precipitation is about 2,500 mm and the mean annual temperature is 15° to 17°C.

From its composition and stratigraphic position, the Oguni flora shows a similarity to the Daijima-type flora, and its geologic age is considered to be Middle Miocene.

I. Introduction

The Neogene sediments widely distributed in the northeastern Honshu, have abundant fossil plants which have been investigated by many geologists and palaeobotanists. The Oguni flora is one of the number, and there are following reports, since the fossil plants were first discovered more than fifty years ago from Oguni-machi by the late KUSAKABE, a graduate of the Institute of Geology and Palaeontology, Tohoku University.

At first, MORITA (1931) reported 32 species in this flora with two new species of *Cinnamomum* and *Smilax* respectively, and he (1933) also described *Terminalia* as a new species. ENDO and MORITA (1932) examined the genera of *Comptoniphyllum* and *Liquidambar* from Neogene sediments in Japan, and they applied *Comptoniphyllum* of the Oguni flora to the species of *naumanni* type, though the genus was lately revised to the *Comptonia* by HUZIOKA (1961).

HUZIOKA (1949) studied the Miocene floras from the Inner Zone of northeastern Honshu, then he divided the floras into two of the "Aniai-" and the "Daijima-type" floras based on their floristic composition and component, and he first pointed out that the Oguni flora belonged to the "Daijima-type flora". SUZUKI (1959) reported "Neogene

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floral changes in the southern part of northeastern Honshu"; he subdivided the Neogene flora of this region into 7 floral zones, and placed the Oguni flora in the second zone from the bottom.

TOKUNAGA (1960) discovered new localities in the Imaichi formation and described over ten species under the name of "Okiniwa flora". TANAI (1961) discussed the Neogene floral change in Japan. In his paper, he reexamined this flora and determined that the Oguni flora belonging to "Daijima-type flora" which is the type flora of Middle Miocene in Japan indicated warm-temperate climate. ONOE (1966) reported the outline of the fossil plants regarding the present paper.

Many studies concerning the Oguni flora have been done as stated above, and the outline of this flora has become considerably clear. The works in the past, however, did not have enough a volume of treated fossils and of species, furthermore, no general reports were published up to this time.

Fortunately, the writer had a chance of visiting the Oguni fossil localities in the autumn of 1963, and collected 659 specimens consisting of 61 species in the present collection. He could deal with many materials more than those of the former investigations, though the volume of fossils was not satisfactory.

It is the purpose of this paper to deal with the flora on the basis of these data, and to re-examine it gaining the latest informations of palaeobotany for Neogene plants in Japan which have progressed favorably.

Acknowledgements

In publishing this work, the author wishes to express his appreciation to Dr. Toshimasa TANAI, Professor of Hokkaido University, for many valuable suggestions in making identification of fossils. Acknowledgement is due to Dr. Osao KADOTA, formerly the Chief of the Oguni Branch of Atomic Fuel Corporation (the present Power Reactor and Nuclear Fuel Development Corporation), and his staff, who gave to the author plentiful assistance for collection fossils. He wishes to thank Dr. Shigemoto TOKUNAGA, formerly Chief of the Fuel Department, Geological Survey of Japan, who has discovered some new fossil localities and has given many geological informations on fossil localities, and also read this manuscript. The author is indebted to Mr. Yoshinobu MINUSA, Teacher of Fujimi Junior High School in Chiba Prefecture, who gave to the author useful materials for arranging the present manuscript.

II. Physical Relationships

II. 1 Present physical conditions and vegetation

The fossil locality, Okiniwa of Oguni-machi, is situated in the western margin of the Yonezawa basin, the southern part of Yamagata Prefecture, and is located in the mountain region between Yamagata and Niigata Prefectures as shown in Figure 1. This region is made up largely of hills of 500–700 meters elevation extended northeastward with gradual increase in height, and connects with Mt. Asahidake (1,870 m).

This region is bordered northward by Mt. Asahidake, eastward by the Ou mountains including Mt. Zao (1,841 m) and Mt. Azuma (2,024 m), and southward by the Iide (2,105 m) mountain mass. Since this area is bounded by these mountain ranges north-, east- and southward, climate is mainly influenced by that of the Japan Sea. The mean temperature in summer is from 23° to 25°C (from June to August), and

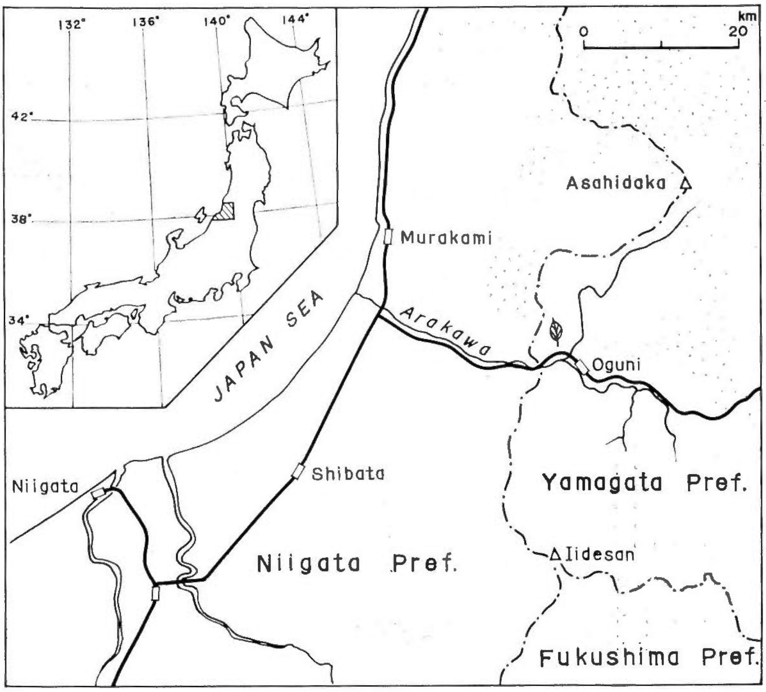


Fig. 1. Locality map of the Oguni flora.

in winter (from December to February) is from 1° to −1°C; monthly precipitation is from 170 to 250 mm in summer, and 200 to 400 mm in winter. The annual precipitation is about 2,700 mm on the average; this precipitation occupies a very high place, especially this is one of the heavy snowfall area in Japan.

The modern flora in the vicinity of the fossil locality (altitudes from 300 to 1,000 m) is composed mostly of temperate plants such as *Pinus densiflora, Pterocarya rhoifolia, Alnus hirsuta, Betula ermanii, Carpinus laxiflora, Castanea crenata, Fagus crenata, Quercus crispula, Q. serrata, Magnolia obovata, Sorbus alnifolia, Acer mono, Aesculus turbinata, Tilia japonica, Cornus controversa*, etc., and *Sasa kurilensis* grows at the feet of these trees. On the surrounding mountains, altitude more than 1,000 m, there is showed mixed type of subarctic and temperate forest, such as *Pinus pumila, P. pentaphylla, Tsuga diversifolia, Thuja standishii, Salix sachalinensis, Alnus matsumurae, Betula maximowicziana, Cercidiphyllum japonicum, Sorbus alnifolia* and so on. On the contrary, on lowlands and hillsides in this area, temperate plants live, companied with some warmer ones: *Zelkova serrata, Trochodendron aralioidea, Camellia japonica* and etc.

II. 2 Geologic occurrence

The area including the fossil locality was geologically investigated in detail by M. Shimazu, S. Tokunaga, and K. Koseki (1969). The following statement of the geologic relationships is a summary of these investigations.

Neogene sediments, consisting mainly of so-called "green-tuff" which is widely distributed in the coastal region of the Japan Sea, Northeast Honshu, overlie unconformably the Paleozoic sediments and granitic rocks. These granites penetrate the

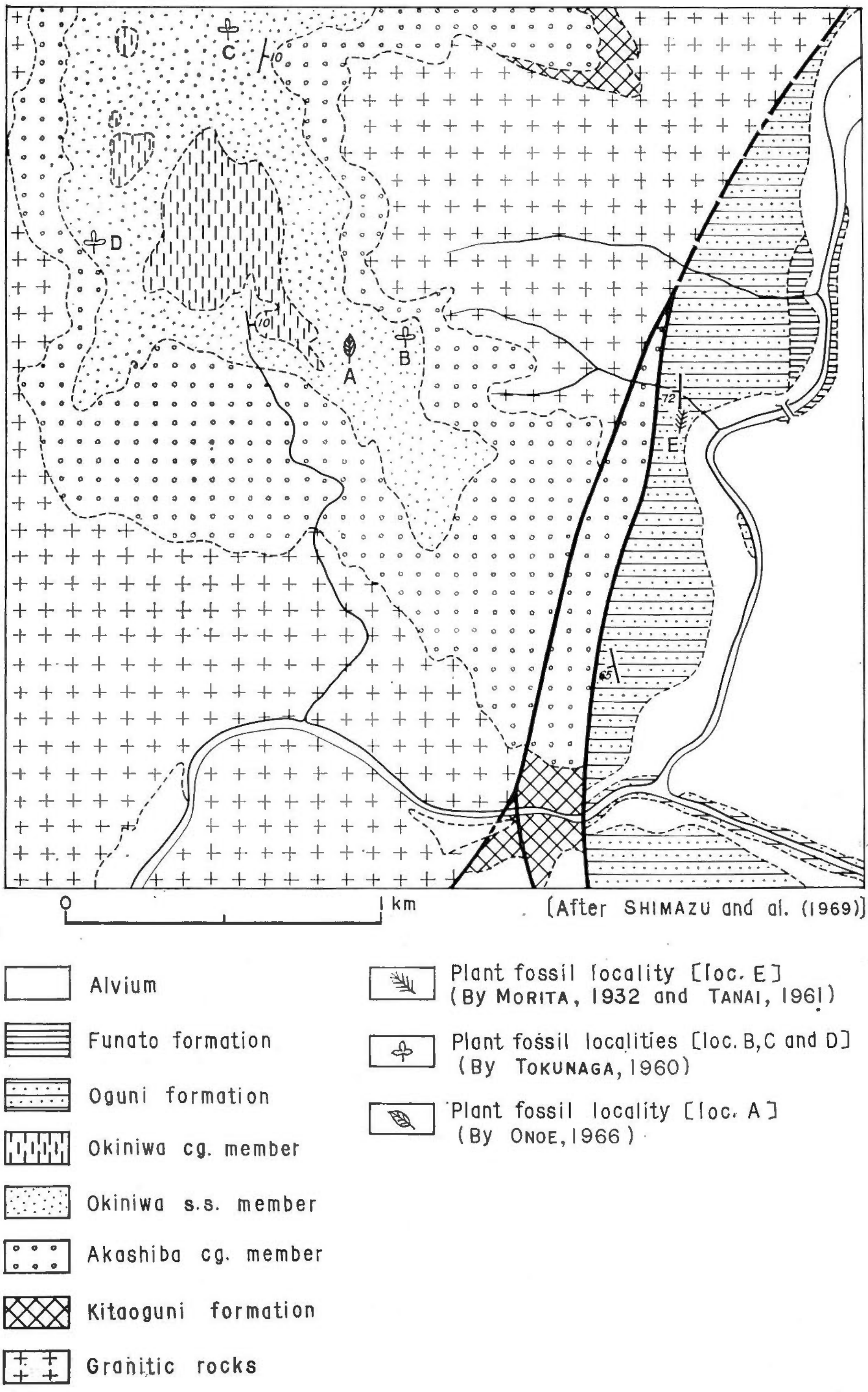


Fig. 2. Geologic map around the fossil localities.

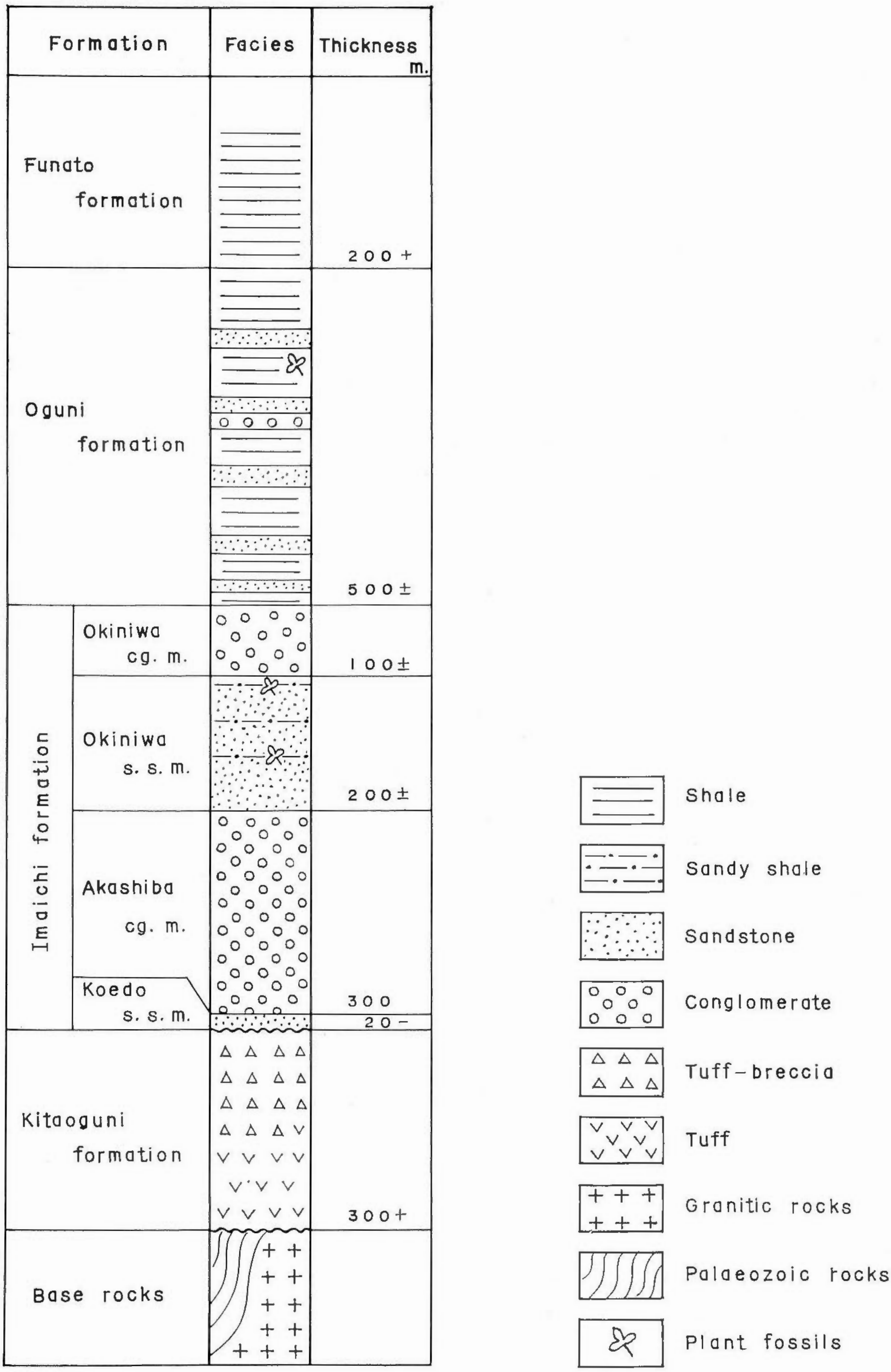


Fig. 3. Stratigraphic column of the Tertiary in the Oguni district.
(After SHIMAZU et al., 1969)

Paleozoic rocks, and are intruded by the basalt and andesitic rocks which are considered to be the volcanics in Tertiary period. The Neogene sediments around the fossil localities are divided into four formations; Kitaoguni, Imaichi, Oguni and Funato formations in ascending order. The Kitaoguni formation is composed of rhyolitic tuff, tuff-breccia and rhyolite, and overlies directly the basement of pre-Tertiary granites and Paleozoic formation unconformably. The Imaichi formation is non-marine deposits. It is subdivided into four members; Koedo sandstone, Akashiba conglomerate, Okiniwa sandstone and Okiniwa conglomerate members in ascending order, and the majority of plant fossils now under consideration is preserved in the sandy shale intercalated in the uppermost part of the Okiniwa sandstone member.

The Oguni formation rests conformabiy on the Imaichi formation, and consists mainly of an alternation of tuffaceous shale and coarse sandstone. The flora once reported as "The Oguni fossil flora" by H. MORITA (1931) and other paleobotanists is contained in the sandy shale of this formation. The Funato formation consists mainly of shale; its lower part consists of an alternation of pale green hard shale and sandy shale; its upper half is composed of dark gray or black well-bedded mudstone. The formation is considered to correspond to the hard shale and black shale member of the stratigraphic succession in the oil fields of northeastern Honshu. It has the marine elements such as some marine molluscs and fish-scales.

III. Composition of the Flora

The Oguni flora as now known is made up of 26 families, 48 genera and 58 generically named species, of which 4 are described as new. They are classified into conifers with 3 families 4 genera and 5 species, monocotyledons with 1 genus and 1 species, and the remainder are dicotyledons with 22 families 43 genera and 52 species. The largest family is the Leguminosae with 8 genera and 8 species; next come the Lauraceae with 4 genera and 5 species, Juglandaceae, Betulaceae and Fagaceae with 4 species each, and the Pinaceae, Ulmaceae, Hamamelidaceae and Aceraceae with 3 species each. The remaining families have one or two species.

Among 48 genera, only 7 are represented by more than single species, namely, *Pterocarya, Carpinus* and *Acer* are represented by 3, and *Picea, Quercus, Ulmus* and *Cinnamomum* by 2 species each, and the remaining genera are represented by only one species. All of the genera excepting *Comptonia, Parrotia, Robinia, Podogonium* and *Hemitrapa* now live in eastern Asia. *Podogonium* and *Hemitrapa* are assigned to extinct genera.

Like most of the Neogene floras, the Oguni flora is well represented by temperate families such as the Pinaceae, Salicaceae, Juglandaceae, Betulaceae, Ulmaceae and Aceraceae, and is also together with subtropical plants such as the Myricaceae, Lauraceae and Sapindaceae. It seems therefore that the Oguni plants are mixed members of the Arcto-Tertiary Geoflora and the Paleotropical-Tertiary Geoflora.

In addition to the 58 plants which can be assigned to genera, three plants are too inadequately known to permit their accurate assignment even to family, and are placed in Incertae Sedis. However, one of them, *Carpolithes japonica* has been commonly found in the Middle Miocene floras of Japan, so that it has as much stratigraphic significance as many of the well-established species.

The following is the list of plants being made up of the Oguni flora.

Systematic List of Families and Species

Pinaceae

Keteleeria ezoana TANAI
Picea kaneharai TANAI and ONOE
Picea ugoana HUZIOKA

Taxodiaceae

Metasequoia occidentalis (NEWB.) CHANEY

Cupressaceae

Libocedrus notoensis (MATSUO) ISHIDA

Salicaceae

Salix sp.

Myricaceae

Comptonia naumanni (NATHORST) HUZIOKA
Myrica sp.

Juglandaceae

Carya sp.
Pterocarya asymmetrosa KONNO
Pterocarya ezoana TANAI and N. SUZUKI
Pterocarya protostenoptera TANAI

Betulaceae

Carpinus mioturczaninowii HU and CHANEY
Carpinus stenophylla NATHORST
Carpinus subyedoensis KONNO
Ostrya shiragiana HUZIOKA

Fagaceae

Castanea miomollissima HU and CHANEY
Fagus antipofi HEER
Quercus mandraliscae GAUDIN
Quercus miovariabilis HU and CHANEY

Ulmaceae

Ulmus longifolia UNGER
Ulmus miopumila HU and CHANEY
Zelkova ungeri KOVATS

Magnoliaceae

Magnolia miocenica HU and CHANEY

Lauraceae

Actinodaphne oishii HUZIOKA
Cinnamomum miocenum MORITA
Cinnamomum oguniense MORITA

Machilus ugoana HUZIOKA
Parabenzoin protopraecox (ENDO) TANAI

Hamamelidaceae
Eustigma (?) sp.
Liquidambar miosinica HU and CHANEY
Parrotia fagifolia (GOEPPERT) HEER

Rosaceae
Sorbus nipponica TANAI and ONOE

Leguminosae
Cladrastis aniensis HUZIOKA
Entada mioformosana TANAI
Gleditsia miosinensis HU and CHANEY
Kummerowia pseudostriata new species
Podogonium knorrii A. BRAUN
Robinia nipponica TANAI
Sophora miojaponica HU and CHANEY
Wistaria fallax (NATHORST) TANAI and ONOE

Euphorbiaceae
Mallotus sp.

Buxaceae
Buxus protojaponica TANAI and ONOE

Aquifoliaceae
Ilex minusai new species

Aceraceae
Acer palaeodiabolicum ENDO
Acer pseudocarpinifolium ENDO
Acer subpictum SAPORTA

Sapindaceae
Koelreuteria miointegrifolia HU and CHANEY
Sapindus tanaii new species

Rhamnaceae
Paliurus protonipponicus SUZUKI
Zizyphus miojujuba HU and CHANEY

Theaceae
Camellia protojaponica HUZIOKA

Alangiaceae
Alangium aequalifolium (GOEPPERT) KRYSHTOFOVICH and BURSUK

Hydrocarpaceae
Hemitrapa borealis (HEER) MIKI

Ebanaceae
Diospyros miokaki HU and CHANEY

Oleaceae
Fraxinus sp.
Ligustrum tokunagai new species

Liliaceae
Smilax trinervis MORITA

Incertae Sedis
Carpolithes japonica (MORITA) ISHIDA
Phyllites sp. 1
Phyllites sp. 2

MORITA (1931, 1933) and TANAI (1961) reported the following fossil plants from the "Oguni plant-bearing formation" which is synonymous with the Oguni formation.

List of MORITA's species (name used in his paper)

Polypodiaceae
Aspidium sp.

Pinaceae
Pinus hepios UNGER

Taxodiaceae
Glyptostrobus ? europaeus HEER
Taxodium disticum miocenum HEER

Salicaceae
Salix denticulata HEER
Salix viminalis LINNE

Myricaceae
Comptoniphyllum japonicum NATHORST

Betulaceae
Betula prisca HEER
Carpinus grandis UNGER

Fagaceae
Castanea kubinyi KOVATS
Castanea ungeri HEER
Castanea vulgaris LAM.
Quercus glauca THUNBERG
Quercus glandulifera BLUME

Ulmaceae
Planera ungeri HEER

Ulmus carpinoides GOEPPERT

Moraceae
Ficus ungeri LESQUEREUX
Ficus subtruncata LESQUEREUX

Magnoliaceae
Magnolia angustifolia NEWBERY

Lauraceae
Cinnamomum miocenum MORITA
Cinnamomum lanceolatum UNGER
Cinnamomum oguniense MORITA
Laurus californica LESQUEREUX
Laurus nobilis LINNAEUS
Laurus princeps HEER
Persea sp.

Leguminosae
Bauhinia sp.
Sophora sp.

Euphorbiaceae
Sapium japonicum PAX. and K. H.

Rhamnaceae
Zizyphus cfr. *vulgaris* LAM.

Combretaceae
**Terminalia japonica* MORITA

Araliaceae
Hedera sp.

Ebenaceae
Diospyros kaki THUNBERG

Oleaceae
Fraxinus sp.

Liliaceae
Smilax minor MORITA
Smilax trinervis MORITA

* Starred species was described in 1933, and others were described in 1931.

List of TANAI's species (name used in his paper)

Pinaceae
Pinus miocenica TANAI

Taxodiaceae
Metasequoia occidentalis (NEWBERRY) CHANEY

Myricaceae
Myrica (Comptonia) naumanni (NATHORST) TANAI

Juglandaceae
Carya miocathayensis HU and CHANEY
Pterocarya asymmetrosa KONNO

Fagaceae
Castanea ungeri HEER
Quercus mandraliscae GAUDIN
Quercus subvariabilis TANAI

Ulmaceae
Ulmus carpinoides GOEPPERT
Ulmus longifolia UNGER
Zelkova ungeri (ETTINGSHAUSEN) KOVATS

Lauraceae
Cinnamomum miocenum MORITA
Cinnamomum oguniense MORITA
Machilus ugoana HUZIOKA

Hamamelidaceae
Fothergilla viburnifolia HU and CHANEY
Liquidambar mioformosana TANAI

Anacardiaceae
Rhus miosuccedanea HU and CHANEY

Sapindaceae
Dodonaea japonica (MORITA) TANAI

Alangiaceae
Alangium aequalifolium (GOEPPERT) KRYSHT. and BORSUK.

Liliaceae
Smilax trinervis MORITA

The author always tries to discuss the fossil flora on both mega and micro sides of plant. On the present study, he tried to get fossil pollen and spore using some analysis methods, but no fossil pollen and spore were obtained from the Oguni plant-bearing sediments. The author is now under discussing about the reason why micro-fossils could not be found.

There is the following list of microfossil flora studied by SHIMAZAKI, TOKUNAGA and ONOE (1972) from the Daijima formation of Oga Peninsula in Akita Prefecture which is considered to be essentially contemporaneous geologically with the Oguni plant-bearing sediments. This microfossil flora may be useful to some extent for examining the present flora, because the flora has comparatively numbers of genera in common with the Oguni megafossil flora, though the locality of the microfossil flora is in a fairly long distance from that of the Oguni flora.

List of Microfossils from the Daijima formation

Pteridophyta
Ginkgoaceae
  Ginkgo
Pinaceae
  Abies
  **Picea*
  Pinus
  Pseudolarix
  **Keteleeria*
  Tsuga
Taxodiaceae
  Glyptostrobus
  **Metasequoia*
  Sequoia
  Taxodium
  Sciadopitys
*Cupressaceae-Taxaceae
Myriceae
  **Myrica* (*Comptonia*)
Juglandaceae
  **Carya*
  Juglans
  **Pterocarya*
Salicaceae
  **Salix*?
Betulaceae
  Betula
  **Carpinus*
  Corylus
Fagaceae
  **Castanea*
  Castanopsis-Pasania
  **Fagus*
  **Quercus* (evergreen)
  **Quercus* (deciduous)
Ulmaceae
  Celtis
  **Ulmus*
  **Zelkova*
Polygonaceae
  Polygonum
Chenopodiaceae
Hamamelidaceae
  Distylium
  **Liquidambar*
Aceraceae
  **Acer*
Haloragaceae
  Myriophyllum
Nyssaceae
  Nyssa
Symplocaceae
  Symplocos
Compositae
  Artemisia
Gramineae

* Starred genera and family are represented also by megafossils in the Oguni flora.

III. 1 Assumed growth habit

The assumed growth habit of the Oguni plants is based upon most of the species judging from their similar living equivalents, and also includes an extinct species of *Hemitrapa borealis* which is considered to be aquatic herb. The data in Table 1 show that 42 trees are made up of 73.7 per cent of the total taxa, 10 small trees and shrubs comprise 17.4 per cent, vines 5.3 per cent and the remaining two species are herbs (3.6 per cent), though one species is an aquatic herb described above.

Judging from only these percentages, trees were predominant in the Oguni vegetation like most Japanese Tertiary floras. It is, however, suspected that herbs were flourished in the Oguni forest accompanied with the trees, because non-arboreal

Table 1. Assumed growth habit of the Oguni plants.

Trees	
Keteleeria ezoana	*Zelkova ungeri*
Picea kaneharai	*Magnolia miocenica*
Picea ugoana	*Actinodaphne oishii*
Metasequoia occidentalis	*Cinnamomum miocenum*
Libocedrus notoensis	*Cinnamomum oguniense*
Salix sp.	*Machilus ugoana*
Myrica sp.	*Liquidambar miosinica*
Carya sp.	*Parrotia fagifolia*
Pterocarya asymmetrosa	*Sorbus nipponica*
Pterocarya ezoana	*Cladrastis aniensis*
Pterocarya protostenoptera	*Gleditsia miosinensis*
Carpinus mioturczaninowii	*Sophora miojaponica*
Carpinus stenophylla	*Mallotus* sp.
Carpinus subyedoensis	*Acer palaeodiabolicum*
Ostrya shiragiana	*Acer pseudocarpinifolium*
Castanea miomollissima	*Acer subpictum*
Fagus antipofi	*Koelreuteria miointegrifolia*
Quercus miovariabilis	*Sapindus tanaii*
Quercus mandraliscae	*Camellia protojaponica*
Ulmus longifolia	*Diospyros miokaki*
Ulmus miopumila	*Fraximus* sp.
Small trees or shrubs	
Comptonia naumanii	*Ilex minusai*
Parabenzoin protopraecox	*Paliurus protonipponicus*
Eustigma (?) sp.	*Zizyphus miojujuba*
Robinia nipponica	*Alangium aequalifolium*
Buxus protojaponica	*Ligustrum tokunagai*
Vines	
Smilax trinervis	*Wistaria fallax*
Entada mioformosana	
Terrestrial herb	
Kummerowia pseudostriata	
Aquatic herb	
Hemitrapa borealis	

plants lived in northeastern Honshu at that time as shown by the Daijima microfossil flora listed above.

III. 2 Numerical representation

The sixty-one species in the Oguni flora have an important meaning on interpreting the distribution of plant communities in the basin, and also provide information that helps to reconstruct the physical setting of the area. The following quantitative analysis of the Oguni flora is mainly based on a count of 659 specimens from the loc. A of the Imaichi formation, collected by the writer and includes some specimens collected by TOKUNAGA from the loc. B-D and the loc. E of the Oguni formation.

Table 2. Numerical representation of the Oguni species.

Fossil species	Number of specimens	Percentage
Zelkova ungeri (leaves)	145	22.00
Quercus miovariabilis (leaves)	130	19.73
Comptonia naumanni (leaves)	83	12.59
Castanea miomollissima (leaves)	43	6.53
Carpolithes japonica (capsules)	36	5.46
Alangium aequalifolium (leaves)	26	3.95
Cinnamomum oguniense (leaves)	23	3.46
Keteleeria ezoana (total)	16	2.43
(seeds)	(12)	
(needles)	(4)	
Actinodaphne oishii (leaves)	12	1.82
Diospyros miokaki (leaves)	9	1.37
Paliurus protonipponicus (leaves)	8	1.21
Pterocarya asymmetrosa (total)	7	1.06
(leaflets)	(6)	
(fruit)	(1)	
Sophora miojaponica (leaflets)	7	1.06
Smilax trinervis (*leaves*)	7	1.06
Pterocarya protostenoptera (total)	6	0.91
(leaflets)	(5)	
(fruit)	(1)	
Gleditsia miosinensis (leaflet)	6	0.91
Ulmus miopumila (leaves)	5	0.76
Magnolia miocenica (leaves)	5	0.76
Cinnamomum miocenum (leaves)	5	0.76
Parrotia fagifolia (leaves)	5	0.76
Pterocarya ezoana (total)	4	0.61
(leaflets)	(3)	
(fruit)	(1)	
Machilus ugoana (leaves)	4	0.61
Liquidambar miosinica (total)	4	0.61
(leaves)	(3)	
(fruit)	(1)	
Mallotus sp. (leaves)	4	0.61
Sapindus tanaii (leaflets)	4	0.61
Picea kaneharai (seeds)	3	0.46
Quercus mandraliscae (leaves)	3	0.46
Ulmus longifolia (leaves)	3	0.46
Buxus protojaponica (leaves)	3	0.46
Acer pseudocarpinifolium (samara)	3	0.46
Picea ugoana (seeds)	2	0.30
Libocedrus notoensis (foliage branchlets)	2	0.30
Carpinus stenophylla (leaves)	2	0.30
Cladorastis aniensis (leaflets)	2	0.30

Fossil species	Number of specimens	Percentage
Acer subpictum (samaras)	2	0.30
Koelreuteria miointegrifolia (total)	2	0.30
(capsule)	(1)	
(leaflet(?))	(1)	
Zizyphus miojujuba (leaves)	2	0.30
Camellia protojaponica (total)	2	0.30
(leaf)	(1)	
(capsule(?))	(1)	
Hemitrapa borealis (fruits)	2	0.30
Metasequoia occidentalis (foliage shoot)	1	3.33
Salix sp. (capsule)	1	
Myrica sp. (leaf)	1	
Carya sp. (leaflet)	1	
Carpinus mioturczaninowii (involucre)	1	
Carpinus subyedoensis (involucre)	1	
Ostrya shiragiana (involucre)	1	
Fagus antipofi (cupule)	1	
Parabenzoin protopraecox (leaf)	1	
Eustigma (?) sp. (leaf)	1	
Sorbus nipponica (leaflet)	1	
Entada mioformosana (leaflet)	1	
Kummerowia pseudostriata (leaflet)	1	
Podogonium knorrii (pod)	1	
Robinia nipponica (leaflet)	1	
Wistaria fallax (leaflet)	1	
Ilex minusai (leaf)	1	
Acer palaeodiabolicum (samara)	1	
Fraxinus sp. (leaflet)	1	
Ligstrum tokunagai (leaf)	1	
Phyllites sp. 1. (leaf)	1	
Phyllites sp. 2. (leaf)	1	
Totals	659	100.00

Of the 61 Oguni species, 14 are among the numerous members, being made up of more than one per cent each, and are combined to constitute nearly 85 per cent of the total. 9 of them are included in trees and 3 are in small trees and shrubs listed in Table 1. *Zelkova ungeri* is the most predominant species, being made up of 22 per cent of specimens counted. It is followed by *Quercus miovariabilis, Comptonia naumanni, Castanea miomollissima and Carpolithes japonica*, and these 4 species are made up of 44.31 per cent of the total specimens. The next 3 species, *Alangium aequalifolium, Cinnamomum oguniense* and *Keteleeria ezoana* are made up of over 10 per cent. Each of the remaining species comprises less than 2 per cent of the total, and most of them are rare species, represented by only one or two specimens.

Forty-two plants listed as trees in Table 1 represent 73.01 per cent of the total specimens, ten small trees and shrubs represent 19.27 per cent, three vines 1.36 per cent, two herbs (terrestrial herb and aquatic herb) 0.45 per cent and others 5.91 per cent. As is analogized from these composition, there is more chance in leaves of trees to enter the fossil record than in those of small trees, shrubs and others. However the following three shrubs and small trees, *Comptonia naumanni, Paliurus protonipponicus* and *Alangium aequalifolium* and a single vine *Smilax trinervis*, show comparatively high scores, though they are represented by relatively large leaves which seem to be unsuited to resist transport for a long distance. Accordingly, these four species must have lived near the site of deposition, and they were dominant or common members of the Oguni forest as the bush layers.

Except *Keteleeria* of 2.43 per cent, conifers are rare, totalling 1.21 per cent; they are represented by winged seeds (*Picea*), foliage shoot (*Metasequoia*) and foliage branchlets (*Libocedrus*), and can hardly be considered to have been common near the site of deposition. From the loc. A of the Imaichi formation there were found not any fossils of *Metasequoia occidentalis* HU and CHANEY which is one of the common species in the Miocene floras of Japan, though TOKUNAGA (1960) reported from the loc. C of the Imaichi formation as the name of *M. japonica* (ENDO) and TANAI (1961) also reported *M. occidentalis* from the loc. E of the Oguni formation.

Trees with deciduous broad-leaves represent high percentage in occurrence, especially as in the case of *Zelkova ungeri, Quercus miovariabilis* and *Castanea miomollissima*. They appear to have lived near the sites of deposition. It is unexpected that *Liquidambar miosinica*, only four specimens have been collected, though it is one of the most familiar species in the Middle Miocene floras of Japan.

It may be concluded that warmer elements such as *Keteleeria ezoana, Comptonia naumanni, Castanea miomollissima, Quercus miovariabilis, Zelkova ungeri, Cinnamomum oguniense, Actinodaphne oishii* and *Paliurus protonipponicus* were dominant members of the forest near sites of deposition. It is noteworthy that *Liquidambar miosinica* and *Metasequoia occidentalis* show comparatively low scores in their occurrences. These wide-spread species, namely, appear to have been uncommon trees in the Oguni forest.

IV. Paleoecology

The environment of the Oguni Basin during Middle Miocene time may be reconstructed by the ecological analysis of the Oguni flora. The Oguni genera are almost all still living, and modern equivalents of these species can be found with some exceptions. Most of the Oguni species are closely similar to the living plants of Japan and China, and this comparison will be made largely with the modern forests of southwestern Japan.

IV. 1 Distributional consideration

The Oguni flora consists of temperate and subtropical genera, and most of them grow at the middle latitude of northern hemisphere, though several Oguni genera such as *Myrica, Cinnamomum, Eustigma, Mallotus, Ilex* and *Sapindus* now live at low latitudes, they regularly extend to temperate latitudes and altitudes.

Table 3 shows the modern distribution of the Oguni genera in six regions: in Japan, Korea, Formosa and China of East Asia; in North America east of the Rocky Mountains; and in North America westward of the Pacific coast. Though the Oguni plants consist of 48 genera, two extinct genera of *Podogonium* and *Hemitrapa* are excluded from the table. Nine out of the total 46 genera now live in all six regions. With the exception of *Comptonia* and *Robinia*, the Oguni genera exist in Asia, though

Table 3. Present-day distribution of the Oguni genera.

Genus	East Asia				North America	
	Japan	Korea	Formosa	China	West	East
Keteleeria	—	—	×	×	—	—
Picea	×	×	—	×	×	×
Metasequoia	—	—	—	×	—	—
Libocedrus	—	—	×	×	×	—
Salix	×	×	×	×	×	×
Comptonia	—	—	—	—	—	×
Myrica	×	×	×	×	×	×
Carya	—	—	—	×	×	—
Pterocarya	×	×	×	×	—	—
Carpinus	×	×	×	×	×	×
Ostrya	×	×	—	×	×	×
Castanea	×	×	×	×	—	×
Fagus	×	×	×	×	—	×
Quercus	×	×	×	×	×	×
Ulmus	×	×	×	×	—	×
Zelkova	×	×	×	×	—	—
Magnolia	×	×	×	×	—	×
Actinodaphne	×	×	×	×	—	—
Cinnamomum	×	×	×	×	—	—
Machilus	×	×	×	×	—	—
Parabenzoin	×	×	—	×	—	—
Eustigma	—	—	×	×	—	—
Liquidambar	—	—	×	×	×	—
*Parrotia**	—	—	—	—	—	—
Sorbus	×	×	×	×	×	×
Cladrastis	×	—	×	×	—	×
Entada	×	—	×	×	—	—
Gleditsia	×	×	×	×	—	×
Kummerowia	×	×	×	×	—	—
Robinia	—	—	—	—	—	×
Sophora	×	—	×	×	×	×
Wistaria	×	×	—	×	—	×
Mallotus	×	—	×	×	—	—
Buxus	×	×	×	×	—	—
Ilex	×	×	×	×	—	×
Acer	×	×	×	×	×	×
Koelreuteria	×	×	×	×	—	—
Sapindus	×	×	×	×	×	×
Paliurus	×	×	×	×	—	—
Zizyphus	—	×	×	×	—	—
Camellia	×	×	×	×	—	—
Alangium	×	×	×	×	—	—
Diospyros	×	×	×	×	—	×
Fraxinus	×	×	×	×	×	×
Ligustrum	×	×	×	×	—	—
Smilax	×	×	×	×	×	×
Totals	36	33	37	43	15	23
Per cent	78.2	71.7	80.4	93.5	32.6	50.0

* Distributed only in northern Iran, southwestern Asia.

(The extinct genera of *Podogonium* and *Hemitrapa* are excluded from this table) the genus *Parrotia* is limitedly surviving in southwestern Asia. *Comptonia* and *Robinia* which have become extinct in Asia are widely distributed in North America at present. *Comptonia* was abundant in Asia than in America during the Miocene, but is now found in the limited areas on the eastern side of the North American continent. The genus *Robinia* which was not an abundant member of Miocene floras in Asia and North America no longer lives in Asia, but is nowhere common today in North America. 43 out of the 46 Oguni genera making up 93 per cent of the total genera survive in East Asia, and 26 genera making up 56.5 per cent in North America. In Japan, 36 genera making up 78.2 per cent now live, all of which are found elsewhere in East Asia. Among 43 East Asian genera, 7 are not native in Japan, and most of them live in Formosa and China. Showing these generic consideration, most of the Oguni genera grow in the warm-temperate zone, some are in the subtropical and a few in the cool-temperate zone.

Table 4 shows the nearest living equivalent species of the Oguni plants and their modern distribution. The table indicates also similar living species growing in another geographic area with parenthesis. More than a half of the Oguni plants are found living in Japan, and mostly native in the warm-temperate forests of central to southwestern Japan except the Loochoo Islands, and about 57 per cent of the Oguni species are represented by closely similar living species in these regions. Northward there is a gradual reduction in the number of living species closely similar to the Oguni plants.

The Oguni forest in the Middle Miocene time is closely similar to the warm-temperate forest in its composition and components in southwestern Japan (for instance, Izu Peninsula, southern part of Kii Peninsula, Shikoku and southern Kyushu) along the Pacific coast. Following recent vegetation of the southern Izu region including the Amagi mountains is one of the example of the warm-temperate region in Japan, and there is mainly warm-temperate forest on the foot of mountains, the representative species are *Torreya nucifera, Pinus thunbergii, Myrica rubra, Quercus* (evergreen) spp., *Zelkova serrata, Actinodaphne lancifolia, Cinnamomum camphora, Machilus thunbergii, Mallotus japonica, Sapindus mukurossi and Camellia japonica.* On the lower to middle slope of the mountains, the upper part of the warm-temperate forest, there luxuriantly grow i.e. *Abies firma, Tsuga sieboldii, Pinus densiflora, Salix sachalinensis, Pterocarya rhoifolia, Carpinus carpinoides, Ostrya japonica, Zelkova serrata, Parabenzoin praecox, Prunus jamasakura, Cladrastis platycarpa, Acer mono, Sapindus mukurossi, Fraxinus spaethiana, Rhododendron amagianum* and etc. Many of the Oguni plants relate to modern species in these two forests. The top of the mountain and environs are covered with the cool-temperate forest, represented mainly by *Abies firma, Tsuga sieboldii, Fagus crenata, Acer carpinifolium, Rhododendron amagianum* and so on.

The Oguni flora contains twenty-three exotic species, namely nineteen of related living species exist in China, Korea and Formosa, most of which now grow in warm-temperate regions, and only three species are assigned to the North American Element which are poorly represented by specimens in the collection excepting *Comptonia.* These three living species are typical temperate species distributed on the eastern side of North America. The rest of exotic species, *Parrotia persica* now grows in north Iran, but the Oguni specimens may also be possible to be *Hamamelis japonica* SIEB. and ZUCC. which is distributed in the mountains of cool- and warm-temperate zones in Japan.

Table 4. The modern equivalents of the Oguni flora and their distribution.

Fossil species	Modern equivalent	Japan								China					North America		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Keteleeria ezoana	*K. davidiana*							×			×	×	×				
Picea kaneharai	*P. polita*				×	×	×										
Picea ugoana	*P. bicolor*				×												
Metasequoia occidentalis	*M. glyptostroboides*										×						
Libocedrus notoensis	*L. formosana*							×					×				
Salix sp.	*S. sachalinensis*	×	×	×	×	×	×										
Comptonia naumanni	*C. peregrina*															×	
Myrica sp.	*M. rubra*				×	×	×	×				×	×				
	(*M. cerifera*)															(×)	
Carya sp.	*C. cathayensis*										×	×					
Pterocarya asymmetrosa	*P. rhoifolia*		×	×	×	×	×										
Pterocarya ezoana	*P. paliurus*										×	×	×				
Pterocarya protostenoptera	*P. stenoptera*									×	×	×	×				
Carpinus mioturczaninowii	*C. turczaninowii*								×	×							
Carpinus stenophylla	*C. carpinoides*			×	×	×	×										
Carpinus subyedoensis	*C. tschonoskii*			×	×	×	×		×		×						
Ostrya shiragiana	*O. japonica*		×	×	×	×	×		×	×	×						
	(*O. virginiana*)															(×)	
Castanea miomollissima	*C. mollissima*								×	×	×	×	×				
Fagus antipofi	*F. grandifolia*															×	
Quercus miovariabilis	*Q. variabilis*			×	×	×	×	×	×	×	×	×	×				
Quercus mandraliscae	*Q. myrsinaefolia*				×	×	×				×						
Ulmus longifolia	*U. lanceofolia*											×					×
Ulmus miopumila	*U. pumila*										×						
	(*U. parvifolia*)				(×)	(×)	(×)	(×)	(×)			(×)	(×)				

Table 4. continued

Fossil species	Modern equivalent		Japan							China					North America		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Zelkova ungeri	*Z. serrata*			×	×	×	×		×		×		×				
	(*Z. formosana*)							(×)									
Magnolia miocenica	*M. delavayi*												×				
	(*M. kobus*)		(×)	(×)	(×)	(×)	(×)		(×)								
Actinodaphne oishii	*A. lancifolia*					×	×	×			×						
Cinnamomum miocenum	*C. camphora*				×	×	×	×			×	×					
Cinnamomum oguniense	*C. reticulatum*							×									
Machilus ugoana	*M. japonica*					×	×	×	×								
Parabenzoin protopraecox	*P. praecox*			×	×	×	×	×									
Eustigma (?) sp.	*E. oblongifolium*							×				×					
Liquidambar miosinica	*L. formosana*							×			×	×	×				
Parrotia fagifolia	*P. persica*																×
Sorbus nipponica	*S. comixta*			×	×	×	×										
Cladrastis aniensis	*C. platycarpa*				×	×	×				×	×	×				
Entada mioformosana	*E. formosana*							×									
Gleditsia miosinensis	*G. sinensis*									×	×						
	(*G. japonica*)			(×)	(×)	(×)	(×)										
Kummerowia pseudostriata	*K. striata*		×	×	×	×	×	×	×	×							
Robinia nipponica	*R. viscosa*															×	
Sophora miojaponica	*S. japonica*								×	×	×	×	×				
Wistaria fallax	*W. floribunda*			×	×	×	×		×								
Mallotus sp.	*M. japonica*			×	×	×	×	×	×			×	×				
Buxus protojaponica	*B. japonica*				×	×	×										
Ilex minusai	*I. serrata*			×	×	×	×										
Acer palaeodiabolicum	*A. diabolicum*			×	×	×	×										

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Acer pseudocarpinifolium	*A. carpinifolium*			×	×	×	×										
Acer subpictum	*A. mono*		×	×	×	×	×		×	×		×		×			
Koelreuteria miointegrifolia	*K. integrifolia*											×					
	(*K. bipinnata*)										(×)		(×)				
Sapindus tanaii	*S. mukurossi*				×	×	×	×	×		×						×
Paliurus protonipponicus	*P. orientalis*											×					
	(*P. hemsleyana*)										(×)	(×)	(×)				
Zizyphus miojujuba	*Z. jujuba*									×	×	×	×				
Camellia protojaponica	*C. japonica*			×	×	×	×	×	×	×							
Alangium aequalifolium	*A. platanifolium*		×	×	×	×	×		×	×	×	×	×	×			
Diospyros miokaki	*D. kaki*			×	×	×	×		×	×	×						
Fraxinus sp.	*F. spaethiana*				×	×	×										
Ligustrum tokunagai	*L. obtusifolium*		×	×	×	×	×	×									
Smilax trinervis	*S. china*		×	×	×	×	×		×	×	×						
Nearest species		1	8	21	30	31	31	17	17	14	23	19	15	2	0	3	3
Closely similar but not nearest species		0	1	2	3	3	3	2	2	0	2	2	3	0	0	2	0

Modern Distribution

1. Saghalien, Kurile Island.
2. Hokkaido.
3. Northern Honshu.
4. Central Honshu.
5. Southwestern Honshu.
6. Shikoku and Kyushu.
7. Formosa and Loochoo Island.
8. Korea.
9. North China.
10. Central China.
11. Southeast China.
12. Southwest China.
13. Manchuria.
14. Western North America.
15. Eastern North America.
16. Others.

Table 5. Plant communities represented in the Oguni flora.

Lowland Association

Salix sp.
Comptonia naumanni
Myrica sp.
Carya sp.
Pterocarya ezoana
Pterocarya protostenoptera
Carpinus stenophylla
Castanea miomollissima
Quercus miovariabilis
Quercus mandraliscae
Ulmus longifolia
Ulmus miopumila
Zelkova ungeri
Actinodaphne oishii
Cinnamomum miocenum
Cinnamomum oguniense
Machilus ugoana
Parabenzoin protopraecox
Liquidambar miosinica
Parrotia fagifolia
Kummerowia pseudostriata
Wistaria fallax
Mallotus sp.
Buxus protojaponica
Ilex minusai
Acer subpictum
Sapindus tanaii
Zizyphus miojujuba
Camellia protojaponica
Alangium aequalifolium
Hemitrapa borealis
Diospyros miokaki
Ligustrum tokunagai
Smilax trinervis

Slope Association

Keteleeria ezoana
Picea kaneharai
Picea ugoana
Metasequoia occidentalis
Libocedrus notoensis
Comptonia naumanni
Myrica sp.
Carya sp.
Pterocarya ezoana
Pterocarya asymmetrosa
Carpinus mioturczaninowii
Carpinus stenophylla
Carpinus subyedoensis
Ostrya shiragiana
Castanea miomollissima
Fagus antipofi
Quercus miovariabilis
Quercus mandraliscae
Ulmus longifolia
Ulmus miopumila
Zelkova ungeri
Magnolia miocenica
Actinodaphne oishii
Cinnamomum miocenum
Machilus ugoana
Parabenzoin protopraecox
Liquidambar miosinica
Sorbus nipponica
Wistaria fallax
Cladrastis aniensis
Entada mioformosana
Gleditsia miosinensis
Robinia nipponica
Sophora miojaponica
Buxus protojaponica
Ilex minusai
Acer palaeodiabolicum
Acer pseudocarpinifolium
Acer subpictum
Koelreuteria miointegrifolia
Sapindus tanaii
Paliurus protonipponicus
Camellia protojaponica
Alangium aequalifolium
Diospyros miokaki
Fraxinus sp.
Smilax trinervis

Montane Association

Picea kaneharai
Picea ugoana
Libocedrus notoensis
Fagus antipofi
Acer pseudocarpinifolium

IV. 2 The Oguni plant associations

According to the living equivalent species of the fossil plants, the habitat of the Oguni flora consists of three associations as shown in Table 5. Some of the species belong to more than one association, as similar plants in the present time.

Most of the lowland plants consist of subtropical to warm-temperate species, and may have luxuriantly grown near the site of depositions. Thirty-four species of this association comprise 83 per cent of the total specimens, of which twenty-five species making up about 67 per cent of the total specimens counted are also the member of the slope association. Forty-seven species of the Oguni plants belonging to the slope association occupy over 87 per cent of the specimens collected, but the typical slope plants are seventeen species and make up 9.38 per cent in the fossil record.

Five species of the montane association, though none of them are typically montane, are included in cool-temperate forest zone. These fossil specimens are represented by a few making up only 1.67 per cent of all the specimens collected, and moreover, these materials are tiny organs such as winged seed (*Picea kaneharai* and *P. ugoana*), samara (*Acer pseudocarpinifolium*) and cupule (*Fagus antipofi*) which are easily moved for a long distance. These facts may prove that the Oguni montane species are derived from the upper slope or the upland of higher mountains. Judging from these quantitative results, more than a half of the Oguni fossil materials seem to be derived from the slope association.

Although it cannot definitely conclude, the ecological analyses suggest that there is a plain and a hilly slope near the site of deposition with high mountains at the back of the Oguni basin, and if we make the assumption that the ancient environment of the Oguni region was similar to that of the modern south Izu region including the Amagi mountains, so that the Oguni forest fronted to the ancient Pacific Ocean and was influenced by the old Black Current (a warm current).

IV. 3 Climate

It is one of the important analysis to assume an ancient climate of the Oguni basin

Table 6. Climatic data* for several localities in eastern Asia.

	Latitude (N)	Longitude (E)	Altitudes (sea level) (m)	Mean ann. precip. (mm)	Mean ann. temp. (°C)
Yamagata	38.54	140.21	150.6	1,210	11.0
Kanazawa	36.33	136.39	26.1	2,662	13.7
Tottori	35.31	134.11	17.3	2,042	14.3
Shizuoka	34.58	138.24	14.1	2,355	15.7
Shionomisaki	33.27	135.46	73.2	2,785	16.8
Kochi	33.34	133.33	0.8	2,645	16.1
Miyazaki	31.55	131.25	6.5	2,594	16.8
Naha	26.14	127.41	34.8	2,118	22.3
Taipei	25.02	121.31	9.0	2,100	22.1
Chinan	36.42	117.04	29.0	630	14.7
Nanching	32.05	118.45	72.0	1,072	15.3
Changsha	28.15	112.15	49.0	1,323	17.8
Kuangchou	23.10	113.20	18.0	1,643	22.2

* These data are derived from the "Annual Report of Science in Japan, 1973."

from the fossil plants. The living equivalents of the Oguni flora are mainly included in the warm-temperate zone, and distributed in the lowland to medium altitudes of the Pacific Ocean side of central to southwestern Japan as discussed above. A few of the cool-temperate members in the higher mountain forest are also included.

As the vegetation of the Oguni region in the Middle Miocene time was almost the same as that of the modern "warm-temperate forest" of central to southwestern Japan, the climate, in which the Oguni forest lived, seems to be under the same condition as that of the regions. Table 6 shows the climatic data of related regions for comparison.

According to the climate classification of Japan, the regions on the Pacific Ocean side of central to southwestern Japan, belong to the Nankai type* as shown in Figure 4. The Nankai type region is one of the rainy zone of Japan (shown in Figure 6), in which the annual precipitation is about 2,500 mm and the mean annual temperatures are 15° to 17°C (shown in Figure 5).

Fig. 4. Climate classification of Japan (After NUMATA and ASANO, 1969)

1; "Back" Japan type,
1a; Okhotsk Sea type,
1b; Tohoku-Hokkaido type,
1c; Hokuriku-Sanin type,
2; Kyushu type,
3; Nankai type,
4; Seto Inland Sea type,
5; East Japan type,
5a; East Hokkaido type,
5b; Sanriku-Jyoban type,
5c; Tokai-Kanto type,
5d; Central Plateau type

* This type is characterized by little rain and snow and not so cold in winter, but rainy and warm in summer.

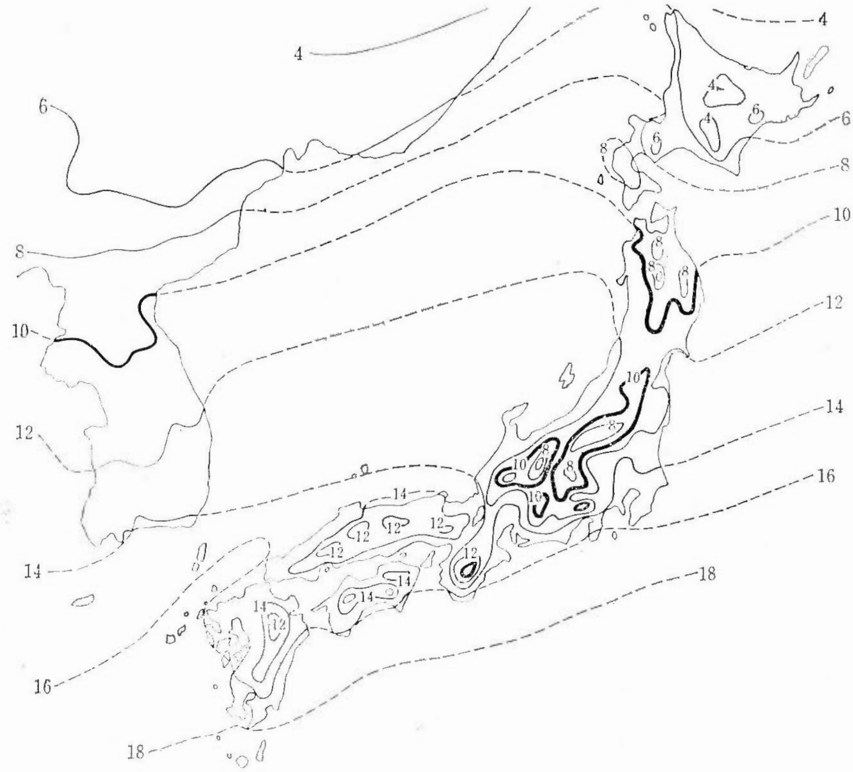


Fig. 5. Distribution of annual mean temperature in Japan.
(After NUMATA and ASANO, 1969)

The Oguni flora is considered to be essentially contemporaneous with the Noroshi flora in Ishikawa Prefecture located about 230 km to the west-northwest from Oguni-machi and the Utto flora in Akita Prefecture located about 210 km to the north-northeast, so that their climates were not great different among the three areas.

From the preceding discussion it is apparent that the Oguni fossil flora has a more warm-temperate aspect than that now living in the area of its occurrence.

V. Correlation and Age

V. 1 Stratigraphic evidence

No paleontologic evidence that suggests the age of Neogene sediments is provided except the plant fossils in the area.

The plant-bearing sediments now under discussion consist of the Imaichi and the Oguni formations. The Imaichi formation of non-marine deposit unconformably overlies the Kitaoguni formation which is the so-called lower green-tuff formation, and is composed of rhyolitic lava and tuff. The Oguni formation conformably covering the Imaichi formation is also non-marine deposit, and it is unconformably covered with the Funato formation which includes marine molluscan fossils in many parts,

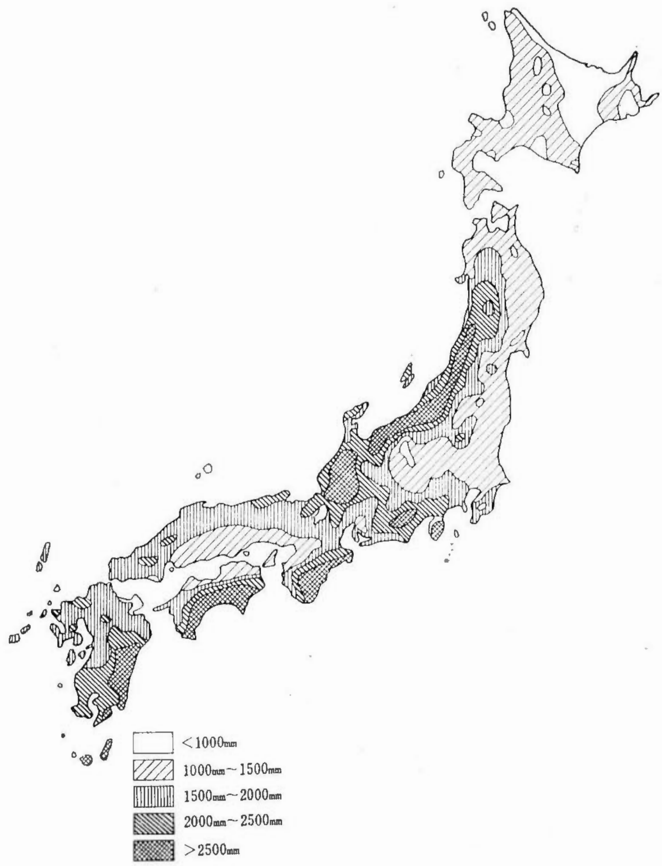


Fig. 6. Distribution of annual precipitation in Japan.
(After NUMATA and ASANO, 1969)

It is generally admitted that a Middle Miocene transgression gradually covers most of Japanese Archipelago, and in this stage there are widely distributed marine-originated sediments which are characterized by the warm sea fauna, but in its basal part there are frequently lacustrine or littoral deposits, containing well-preserved plants. These stratigraphic successions are also seen in the Oguni area described above as well as other green-tuff regions.

V. 2 Comparison with some Miocene floras of Japan and China

The stratigraphic distribution of most species in the Oguni flora is confined to Japanese Neogene sediments, and especially in the Miocene floristic composition of Japan.

There are many floras resembling the Oguni flora among those of Early to Late Miocene age in Japan: the Kaminokuni (TANAI, 1963), the Aniai (HUZIOKA, 1964), the Nishitagawa (TANAI, 1952), the Shichiku (TANAI and ONOE, 1959), the Hiyoshi (TOKUNAGA and ONOE, 1960; HUZIOKA, 1964) of Early Miocene, the Yoshioka (TANAI and N. SUZUKI, 1963), the Utto (HUZIOKA, 1963), the Ouchi (TOKUNAGA and ONOE, 1969), the Noroshi (ISHIDA, 1970), the Notonakajima (MATSUO, 1963), the Shimo-

Table 7. Occurrence of the Oguni species in some Miocene floras of Japan and China.

Species \ Floras	Lower			Middle				Upper			
	1	2	3	4	5	6	7	8	9	10	11
Keteleeria ezoana	—	—	×	×	—	—	×	—	—	—	—
Picea kaneharai	×	—	—	○	×	—	×	×	—	—	—
Picea ugoana	×	×	—	×	—	—	—	—	—	—	—
Metasequoia occidentalis	—	×	×	×	×	—	×	—	×	×	—
Libocedrus notoensis	—	—	—	—	×	○	×	—	—	—	—
Salix sp.	—	—	—	—	—	—	—	—	—	—	—
Comptonia naumanni	—	—	—	×	×	×	×	—	—	—	—
Myrica sp.	—	—	—	—	—	—	—	—	—	—	—
Carya sp.	○	—	○	○	—	○	—	—	—	—	○
Pterocarya asymmetrosa	×	×	×	—	×	×	×	×	×	—	—
Pterocarya ezoana	—	—	—	×	—	—	×	—	—	—	—
Pterocarya protostenoptera	—	—	—	—	—	—	×	×	—	—	—
Carpinus mioturczaninowii	—	—	○	×	—	○	×	—	—	—	×
Carpinus stenophylla	—	—	×	—	—	—	—	×	—	—	—
Carpinus subyedoensis	—	×	×	×	×	×	×	×	—	×	—
Ostrya shiragiana	×	×	×	—	○	—	×	—	○	—	—
Castanea miomollissima	—	—	×	×	×	×	×	—	—	○	×
Fagus antipofi	—	×	×	—	×	—	○	○	○	○	—
Quercus miovariabilis	—	○	—	—	—	×	—	—	×	×	×
Quercus mandraliscae	—	—	—	—	×	×	×	—	—	—	—
Ulmus longifolia	×	—	×	×	×	×	—	—	—	—	—
Ulmus miopumila	—	—	—	—	○	—	○	×	—	—	×
Zelkova ungeri	—	×	×	×	×	×	×	×	×	×	×
Magnolia miocenica	—	○	○	×	○	—	×	—	—	—	×
Actinodaphne oishii	—	—	—	—	×	○	—	—	—	—	—
Cinnamomum miocenum	—	—	—	—	×	—	×	—	○	○	—
Cinnamomum oguniense	—	—	—	—	—	×	×	—	—	—	—
Machilus ugoana	—	—	—	—	×	×	×	—	—	—	—
Parabenzoin protopraecox	—	—	—	×	—	×	—	—	—	—	—
Eustigma (?) sp.	—	—	—	—	—	—	—	—	—	—	—
Liquidambar miosinica	—	—	—	×	×	×	×	×	×	○	×
Parrotia fagifolia	—	—	—	×	×	×	×	—	—	—	×
Sorbus nipponica	—	—	—	×	—	—	—	—	—	—	—
Cladrastis aniensis	—	—	—	×	×	—	×	—	—	—	—
Entada mioformosana	—	—	—	—	—	—	×	—	—	—	—
Gleditsia miosinensis	—	—	—	×	×	—	×	×	—	—	×
Kummerowia pseudostriata	—	—	—	—	—	—	—	—	—	—	—
Podogonium knorrii	—	—	—	—	—	×	×	—	—	—	×
Robinia nipponica	—	—	—	×	—	—	—	—	—	—	—
Sophora miojaponica	—	—	—	×	—	—	—	—	—	—	×
Wistaria fallax	—	×	—	—	×	—	×	×	○	—	—
Mallotus sp.	—	—	—	—	—	—	—	—	—	—	○

Table 7. continued

Species \ Floras	Lower			Middle				Upper			
	1	2	3	4	5	6	7	8	9	10	11
Buxus protojaponica	—	—	—	—	×	—	×	—	—	—	—
Ilex minusai	—	—	—	—	—	—	—	—	—	—	—
Acer palaeodiabolicum	—	—	×	×	—	—	×	—	×	×	—
Acer pseudocarpinifolium	—	×	—	—	—	—	—	×	—	—	—
Acer subpictum	×	×	×	×	×	—	×	×	×	×	×
Koelreuteria miointegrifolia	—	—	—	—	—	—	—	—	—	—	×
Sapindus tanaii	—	—	—	—	○	—	—	—	—	—	—
Paliurus protonipponicus	—	—	×	—	○	—	×	—	—	—	○
Zizyphus miojujuba	—	—	—	×	×	—	—	×	—	—	×
Camellia protojaponica	—	—	—	×	×	×	×	—	—	—	—
Alangium aequalifolium	×	×	×	—	×	×	×	—	—	—	—
Hemitrapa borealis	×	×	×	—	—	×	—	—	—	—	—
Diospyros miokaki	—	—	—	×	×	×	—	—	—	○	×
Fraxinus sp.	—	—	—	—	—	—	—	—	—	—	—
Ligustrum tokunagai	—	—	—	—	—	—	—	—	—	—	—
Smilax trinervis	—	—	—	×	×	—	×	×	—	—	—
Carpolithes japonica	—	—	—	—	×	—	×	—	—	—	—
Total species in floras											
identical	8	12	15	25	27	18	33	14	7	6	15
similar	1	2	3	2	5	4	2	1	4	5	3
Total species in subseries											
identical	19			45				17			
similar	4			3				5			

(× : identical species; ○ : similar species)

Fossil Floras

1. Garo (Hokkaido)
2. Aniai (Akita)
3. Hiyoshi (Gifu)
4. Yoshioka (Hokkaido)
5. Utto (Akita)
6. Ouchi (Miyagi)
7. Noroshi (Ishikawa)
8. Shanabuchi (Hokkaido)
9. Gosho (Iwate)
10. Tennoji (Fukushima)
11. Shanwang (China)

noseki (Bojo and Onoe, 1966; Huzioka and Takahashi, 1973) of Middle Miocene, and the Gosho (Murai, 1962), the Tennoji (Suzuki, 1959) and the Mitoku (Tanai and Onoe, 1961) of Late Miocene.

Table 7 shows the distribution of the Oguni species in the principal Miocene floras of Japan and China, and Figure 7 shows the location of these floras. Compared with the Lower Miocene floras, the Oguni flora is somewhat similar to the Hiyoshi flora in Gifu Prefecture which has some common species such warmer elements as *Keteleeria ezoana, Carya miocathaensis, Castanea miomollissima,* and etc., but differs in their floristic compositions.

The Noroshi flora which is found from the Middle Miocene Yanagida formation of Noto Peninsula in Ishikawa Prefecture has the most abundant common species with the Oguni flora, and is followed by the Utto flora of Akita Prefecture and the Yoshioka flora of southwestern Hokkaido.

Judging from these data known at present, the Oguni flora has a great number of species in common with the Middle Miocene floras. On the other hand, it has a small

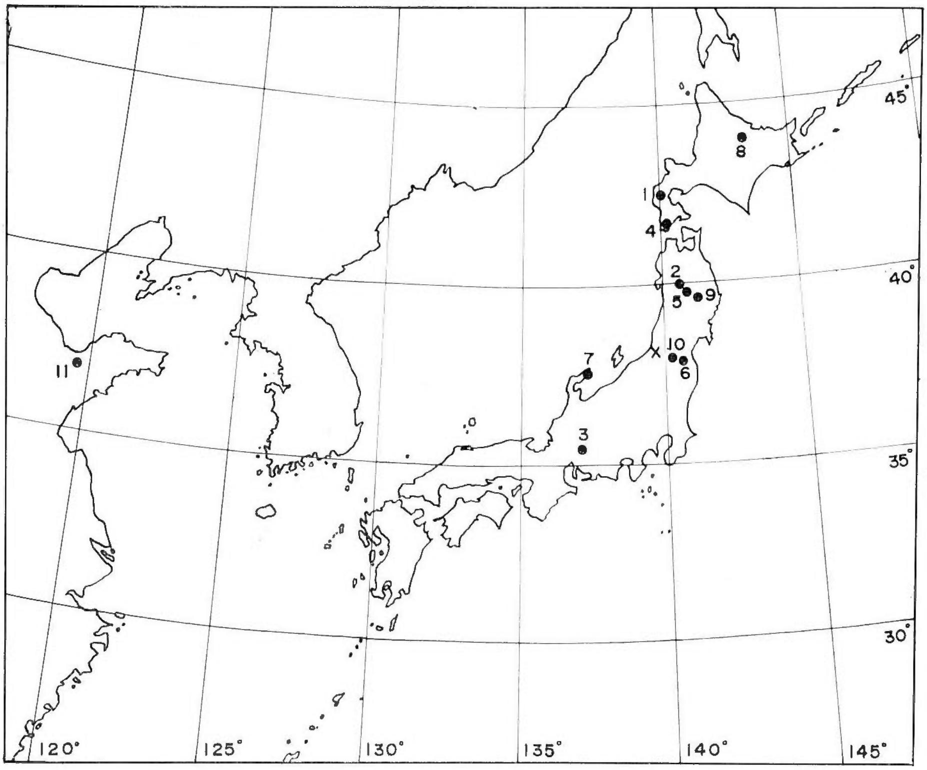


Fig. 7. Locality map concerning the floras shown in Table 7.
Locality numbers are common with the Table 7. × Locality of the Oguni flora.

number of species in common with the Early and the Late Miocene floras.

The Oguni flora also shows somewhat numbers of species in common with the Miocene Shanwang flora of China as shown in the Table 7. HUZIOKA and TAKAHASHI (1973) pointed out that the Shanwang flora was closely related to the Daijima-type floras of western Japan.

V. 3 Age of the flora

According to the previous discussion, the Oguni flora which is preserved in the Imaichi and the Oguni formations is largely composed of the warm-temperate members, and is typically included in the Daijima-type flora. It is, accordingly, considered that the geologic age of the flora is Middle Miocene. On the other hand, "The Working Group on Neogene biostratigraphy and geochronology in Japan" recently compiled [Correlation of some selected Neogene sequence in Japan] based on mainly planktonic foraminiferal biostratigraphy and radiometric data. According to the data, the Daijima stage corresponding to the Oguni plant-bearing sediments is dated as Early Miocene (IKEBE et al., 1972).

VI. Conclusion

This paper is described about the Oguni flora from the Middle Miocene sediments which is so-called "upper green-tuff members" in Oguni-machi, the southwestern part of Yamagata Prefecture.

The fossil flora, comprising 61 species of which 4 are described as new species, is represented mainly warm-temperate plants, and most of their modern equivalents are distributed on the lowland to medium altitudes of central to southwestern Japan except the Loochoo Islands and typically montane plants are not included. Thus, it can be estimated that the Oguni forest had mainly flourished on the lowland and its adjacent slopes in a region comparatively near the sea influenced by the "old Warm Current".

Judging from the climatic factors of the present equivalent regions, it is supposed that the mean annual temperature was 15° to 17°C, and the mean annual precipitation, about 2,500 mm in the Oguni region at the time when the flora was flourished.

The Oguni flora have a similarity to the Noroshi flora, the Utto flora and the Yoshioka flora of Middle Miocene age in their floristic composition and component, and all these floras as well as the Oguni flora belong to the "Daijima-type flora." Thus, it is concluded that the Oguni flora is Middle Miocene in age.

VII. Systematic Description

Family PINACEAE

Keteleeria ezoana TANAI
(*Pl.* 2, figs. 1–5)

1961. *Keteleeria ezoana* TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 251, pl. 1, figs. 16, 40, 41.

1963. TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 99, pl. 1, figs. 2–4, pl. 2, figs. 1, 2, 31.

1970. ISHIDA, *Mem. Fac. Sci. Kyoto Univ.*, ser. Geol. & Mine., vol. 37, no. 1, p. 60, pl. 1, figs. 4, 9, 10.

Remarks: This species represented by needles and winged seeds, is abundant in my collection. The winged seeds are quite resemble those described from the Yoshioka flora in Hokkaido and the needles are identical with those of the Noroshi flora of Noto Peninsula. This fossil species occur from the Middle Miocene sediments in Japan.

These specimens are closely similar to those of the modern *K. davidiana* BEISSN, which is now growing in central and southern China, and Formosa, but is not native in Japan. MIKI (1941, 1957) described *K. davidiana* on the basis of needles, cone, cone-scale and winged seeds from Pliocene floras of central Honshu and Kinki district. Recently ONOE (1972) collected needles and seeds from Pliocene sediments of southern Kyushu, and those specimens are quite identical with this living species.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4501–4505.

Picea kaneharai TANAI and ONOE
(*Pl. 2*, figs. 6, 7)

1961. *Picea kaneharai* TANAI and ONOE, *Geol. Surv. Japan, Rep.*, no. 187, p. 17, pl. 1, fig. 9.

Remarks: This species was described on the basis of three winged seeds, and these specimens have quite characteristics those of the living *Picea polita* CARR.

The fossil seeds of *P. kaneharai* TANAI and ONOE occur mainly from Middle Miocene to Lower Pliocene sediments in Honshu and Hokkaido. The fossil cones and needles of this living species were described from the Upper Pliocene sediments in Hyogo Prefecture (MIKI, 1937) and seeds from the Pleistocene Ebino flora in Miyazaki Prefecture, Japan (ONOE, 1971).

Picea polita is now living in the cool-temperate region of central Honshu, Shikoku and Kyushu, and growing in warmer part than any other Japanese spruces in Japan.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4506, 4507.

Picea ugoana HUZIOKA
(*Pl. 2*, figs. 8, 9)

1949. *Picea ugoana* HUZIOKA, *Daijimaian deposits and floras in the inner zone of northeastern Japan, Doctorate Thesis presented to Hokkaido University*, pl. 1, fig. 7.
1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 254, pl. 1, figs. 28, 29.

Remarks: The present specimens of complete seeds are fairly identical with this species in their shape and dimension. This fossil species is closely similar to the modern *P. bicolor* MAYR. which is distributed in the cool-temperate region of the mountains of central Honshu, Japan. As these seed specimens are vary rare in this flora, the materials seem to be derived from the higher mountain slope to the depositional position.

The present species was found from Early to Middle Miocene floras of northeastern Honshu and Hokkaido, especially common in the Aniai type floras. The fossil cones, cone-scales and winged seeds of the living species was described by MIKI (1957) from glacial ages of Pleistocene throughout Honshu.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4508a, 4509.

Family TAXODIACEAE

Metasequoia occidentalis (NEWB.) CHANEY
(*Pl. 2*, fig. 10)

1961. *Metasequoia occidentalis* (NEWB.) CHANEY. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 2, p. 263, 264, pl. 3, figs. 1–3, 14, 15, *Remarks:* Though this species is one of the most common species at various localities of Japan, ranging in age from Paleogene to Pliocene, neither shoots nor cones were found from the main locality (Imaichi formation loc. A) of this flora. But, TOKUNAGA (1961) collected from the Imaichi formation loc. C, and TANAI (1961) reported from the Oguni formation loc. E.

This fossil species quite resembles the living *Metasequoia glyptostroboides* HU and CHENG limitedly distributed on the Szechuan-Hopeh border of central China.

Occurrence: Imaichi formation loc. C and Oguni formation loc. E.
Collection: G. S. J. hypotype no. 4510.

Family CUPRESSACEAE

Libocedrus notoensis (MATSUO) ISHIDA
(*Pl. 2*, fig. 11)

1970. *Libocedrus notoensis* (MATSUO) ISHIDA, *Mem. Fac. Sci. Kyoto Univ.*, ser. Geol. & Mine., vol. 37, no. 1, p. 66, pl. 3, figs. 4–7.
1963. *Fokienia notoensis* MATSUO, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 233, pl. 44, figs. 1–4.

Remarks: Two leafy twigs clearly belong to the Cupressaceae, and resemble *Libocedrus notoensis* occur from the Middle Miocene Noroshi flora (ISHIDA, 1970). This species is similar to the modern *L. formosana* FLORIN, distributed in southwestern China and Formosa.

Occurrence: Imaichi formation loc. C.
Collection: G. S. J. hypotype no. 4511.

Family SALICACEAE

Salix sp.
(*Pl. 2*, fig. 12)

Description: Fruit, a part of ament more than 3 cm long, stalk stout and about 22 empty capsules attached; capsules long ovoid in general outline, but most of capsules are split deeply in two on tip, 3 to 5 mm long, 2 mm wide; pedicels stout, 1 mm long.

Remarks: The fruit impression though only one at hand, shows a close resemblance to fruit of the genus *Salix*, and is somewhat similar to those of the living *S. sachalinensis* FR. SCHM. by its mode including outline and dimension of capsules. The modern species of *Salix sachalinensis* is commonly distributed along streams in Japan.

This fossil specimen is not sufficiently to make possible a specific name, because most species of Salix are difficult to identify only by fruit.

MORITA (1931) reported *Salix denticulata* HEER and *S. viminalis* LINE from the Oguni formation, and the present material may be possible to be related with either species of the two.

Occurrence: Imaichi formation loc. C.
Collection: G. S. J. holotype no. 4512.

Family MYRICACEAE

Comptonia naumanni (NATHORST) HUZIOKA
(*Pl. 2*, figs. 13–18; *Pl. 3*, fig. 3)

1961. *Comptonia naumanni* (NATHORST) HUZIOKA, *Jour. Min. Coll. Akita Univ.*, ser. A, vol. 1, p. 65, pl. 3, figs. 7, 8.
1888. *Comptoniphyllum naumanni* NATHORST, *Palaeont. Abhandl.*, Bd. 4, p. 8, pl. 2, fig. 2.

Remarks: The present species was described on the basis of leaves, is one of the most abundant specimens in this flora as well as in the other Daijima type floras in Japan. *C. naumanni* closely resembles the recent species *Comptonia peregrina* (L.) COULT. of the northeastern and eastern part of North America.

As previously reported *Comptoniphyllum japonica* NATHORST by MORITA (1931) and *Myrica (Comptonia) naumanni* (NATHORST) TANAI (1961) from the Oguni formation are one with the present species.

Occurrence: Imaichi formation loc. A, B, C, D and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4513–4519.

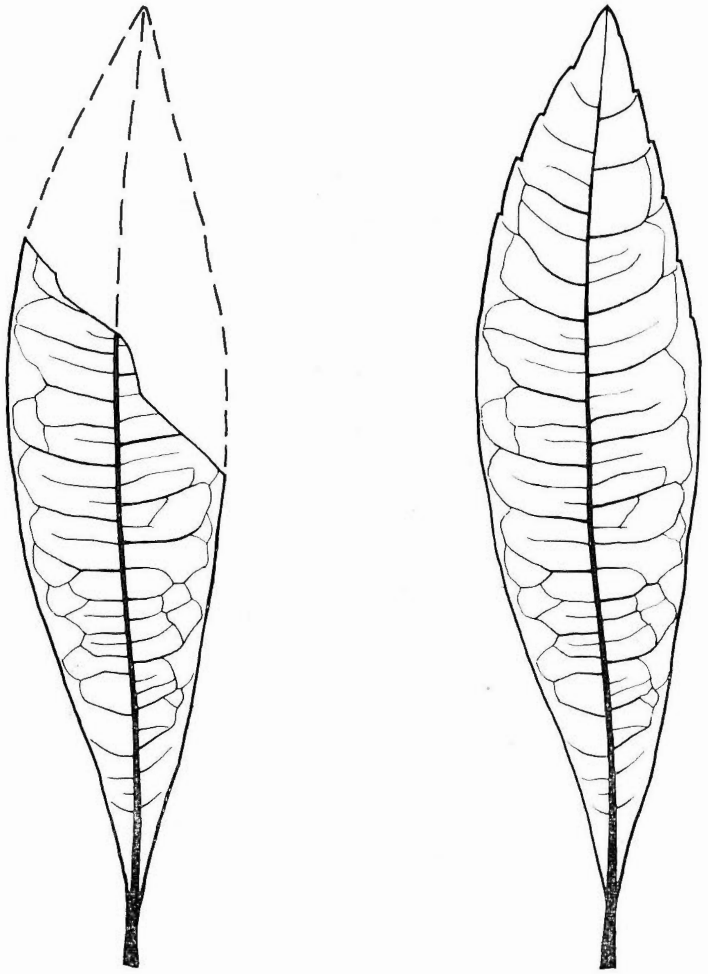
Myrica sp.
(*Pl. 3*, fig. 2)

Description: Leaf incomplete, oblong-lanceolate or oblanceolate (estimated), 12 cm long (estimated) and 2.9 cm wide on the middle of the blade; apex missing; base cuneate with the blade decurrent along the petiole; midrib conspicuously stout; secondary veins diverging from the midrib of leaf at angles of 80 to 90 degrees, curving upward and make loops; among these veins 1 to 3 thinner subsecondaries diverging from the midrib and parallel to them; tertiaries and nervilles obscure; camptodrome; margin entire; texture coriaceous.

Remarks: This specimen is, though missing in upper part of blade, similar to *Myrica* and *Pittosporum* in so far as their general outline are concerned, but the fossil differs from the latter in its character of secondary veins. The secondary veins of this specimen are quite identical to leaves of the living *Myrica rubra* SIEB. and ZUCC. as shown in *Pl. 3*, fig. 1, and Text figure 1, which is now distributed in southern Japan and adjacent warmer regions of Asia, and is also similar to the living *Myrica cerifera* L. of southeastern North America.

The characteristic lateral veins of this material also close to those of *Comptonia naumanni* collected abundantly from the same horizon, though the present material had no segments on the margin of blade. It may also be possible that the material belong to the species of *C. naumanni* as a deformed leaf.

The genus *Myrica* except *Comptonia* type specimens has been reported from the Eocene Ube flora (HUZIOKA and TAKAHASHI, 1970), the Oligocene Kishima flora (MATSUO, 1971) and Pleistocene sediments of Kinki district in Japan (MIKI, 1948).



A B

Text-fig. 1. A sketched *Myrica* sp. (A), and its restoration (B). (natural size)

Occurrence: Imaichi formation loc. B.
Collection: G. S. J. holotype no. 4520.

Family JUGLANDACEAE

Carya sp.

Description: Leaflet incomplete, elliptic-obovate (estimated) 12 cm long (estimated) and 4.2 cm wide, apex rather abruptly acuminate; base missing; midrib stout, slightly arched; secondary veins about 12 alternate or subalternate pairs, irregularly spaced; curving up regularly to the margin, camptodrome; tertiaries percurrent; nervilles clear forming a fine polygonal mesh; margin closely to remotely serrate, texture membranaceous.

Remarks: A single leaflet, one third of lower portion missing, is obtained. Though it resembles in shape and venations to *Carya miocathayensis* HU and CHANEY from the Shanwang flora in China, the writer had hesitated to determine the genus with such specimen. *C. miocathayensis*, however, found from the Oguni formation reported by TANAI (1961).

Leaves of *C. miocathayensis* in Japan are commonly found from Neogene floras of southwestern Hokkaido (TANAI and N. SUZUKI, 1963). This species is closely similar to modern *Carya cathayensis* distributed in Central and southwestern China.

Occurrence: Imaichi formation loc. A.

Pterocarya asymmetrosa KONNO
(*Pl. 3*, figs. 6–8)

1931. *Pterocarya asymmetrosa* KONNO, *Geology of Central Shinano*, pl. 16, figs. 5–7, pl. 17, fig. 3.
1965. TANAI and N. SUZUKI, *Palaeont. Soc. Japan, Special Paper*, no. 10, p. 12, pl. 11, fig. 5, pl. 21, figs. 7, 8.
1970. ISHIDA, *Mem. Fac. Sci. Kyoto Univ.*, ser. Geol. Mine., vol. 37, no. 1, p. 70, pl. 4, figs. 6–8.

Remarks: 6 leaflet impressions, including a terminal one, are referred to this species by their shape, venation and marginal serration. A complete winged seed is also found from the same locality.

Leaflet of this species is commonly found from Neogene flora of Japan, but winged seed of it is collected quite few up to present in Japan. TANAI and N. SUZUKI (1965) reported some winged seeds associated with many leaflets from the Upper Miocene Shanabuchi flora in northeastern Hokkaido, and ISHIDA (1970) also collected winged seeds from the Middle Miocene Noroshi flora of Noto Peninsula.

The winged seed specimen of Oguni flora is somewhat similar to *Carpolithes japonica* (MORITA) ISHIDA in its general outline, but differ from the latter by its shape of wings, venations and dimension. These leaflet and winged seed specimens are closely similar to those produced by the modern *P. rhoifolia* SIEB. and ZUCC., which is widely distributed in Japan.

Occurrence: Imaichi formation loc. A, D and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4526–4528.

Pterocarya ezoana TANAI and N. SUZUKI
(*Pl. 3*, figs. 9–12)

1963. *Pterocarya ezoana* TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 110, pl. 6, figs. 2–5, 8, 9, 11: pl. 19, fig. 1: pl. 21, fig. 10.

Remarks: Present specimens, represented by 3 leaflets and one winged seed, are quite identical with *P. ezoana* TANAI and N. SUZUKI. This species was first established by TANAI and N. SUZUKI (1963) from the Middle Miocene Yoshioka and Abura floras in southwestern Hokkaido, Japan. After that, ISHIDA (1970) was described a almost complete winged seed and some leaflets from the Middle Miocene Noroshi flora of Noto Peninsula.

Leaflets and winged seeds of this fossil species are closely similar to those of the modern *Pterocarya paliurus* BATALIN. which is now distributed in central to southern China.

Occurrence: Imaichi formation loc. A, B and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4521c, 4522, 4523.

Pterocarya protostenoptera TANAI
(*Pl. 3*, figs. 4, 5)

1961. *Pterocarya protostenoptera* TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 278, pl. 4, fig. 10.
1965. TANAI and N. SUZUKI, *Palaeont. Soc. Japan, Special Paper*, no. 10, p. 13, pl. 21, figs. 4, 5.

Remarks: One complete fruit and 5 leaflets are identical with this species, especially fruit with V-shaped outline and two lanceolate wings is characteristics of this species. This fossil species was first described by TANAI (1961) on the basis of fruits collected from Late Miocene sediments in the Okitama lignite field, northeastern Honshu. Then, TANAI and N. SUZUKI (1965) described fossil leaflets from the Late Miocene Shanabuchi flora in the northeastern Hokkaido associated with fruits.

Recently, ISHIDA (1970) reported fruits from the Middle Miocene Noroshi flora of Noto Peninsula, central Japan. The Oguni specimens of fruit and leaflets well match those of the living *P. stenoptera* DC., which is widely distributed in central and southern China.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4524, 4525.

Family BETULACEAE

Carpinus mioturczaninowii HU and CHANEY
(*Pl. 4*, figs. 3–5)

1938. *Carpinus mioturczaninowii* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 33–34, pl. 9, fig. 7.
1970. ISHIDA, *Mem. Fac. Sci. Kyoto Univ.*, ser. Geol. & Mine, vol. 37, no. 1, p. 73, pl. 6, fig. 4.

Remarks: A single involucre, though upper two thirds of it and lower one third of counter part impression, was obtained. It is nearly complete if restored with both sides of impression as shown in *Pl. 4*, figs. 3. The Oguni specimen is closely similar to the type specimen of *C. mioturczaninowii* from the Miocene Shanwang flora of China in its general outline and venations, but the Oguni involucre is much larger than the latter. However, the Noroshi involucre described by ISHIDA (1970) is quite identical with our specimen in its shape and also dimension. This fossil species is closely similar to modern *C. turczaninowii* HANCE, widely distributed in North China and Korea.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4529a, 4529b.

Carpinus stenophylla NATHORST
(*Pl. 4*, figs. 1, 2)

1883. *Carpinus stenophylla* NATHORST, *Kgl. Svensk. Vet. Akad. Handl.*, vol. 20, p. 41, pl. 3, fig. 16.
1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 298, pl. 8, fig. 8.

Remarks: Two almost complete leaf impressions are referable to this species, which is closely similar to those of the recent *Carpinus carpinoides* MAKINO. One of the Oguni specimens (*Pl. 4*, fig. 2) is quite identical with the original specimen of the Mogi flora on its oblong outline, close spaced secondaries and also obtuse at base.

The other specimen is closely similar to normal leaves of the modern species in having slightly cordate base. These two leaf impressions, however, fall within the variation displayed by the living equivalent species. This hornbeam is endemic to Japan and one of the trees most common in the cool-temperate region and the upper part of the warm-temperate region.

Occurrence: Imaichi formation loc. A and B.
Collection: G. S. J. hypotype nos. 4530, 4531a.

Carpinus subyedoensis KONNO
(*Pl. 4*, fig. 6)

1931. *Carpinus subyedoensis* KONNO, *Geology of Central Shinano*, pl. 8, figs. 1–4.
1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 299, 300.

Remarks: This fossil species represented by leaves and involucres found from Middle Miocene to Late Pliocene sediments in various localities of Japan. The Oguni flora has only one involucre impression, however, it is identical with that of *C. subyedoensis*. The present species closely resembles the modern *C. tchonoskii* MAXIM. which is very common in the warm-temperate to cool-temperate regions except Hokkaido in Japan, and is also distributed in Korea and continental China.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4532.

Ostrya shiragiana HUZIOKA
(*Pl. 4*, fig. 7)

1954. *Ostrya shiragiana* HUZIOKA, *Trans. Proc. Palaeont. Soc. Jap. N.S.*, no. 13, p. 123, pl. 13, figs. 7, 8.
1963. TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 119.
1959. *Ostrya subvirginiana* TANAI and ONOE, *Bull. Geol. Surv. Japan*, vol. 10, no. 4, p. 19, pl. 4, figs. 3, 4.

Remarks: The present species was first described on the base of leaves from the Changi flora of south Korea by HUZIOKA (1954). On the other hand, involucres of

Ostrya were found from Miocene flora in several localities of Honshu and Hokkaido, as *O. subvirginiana* TANAI and ONOE or *O. japonica* SARG. var. *oblongibracteata* and so on. These fossil species of *Ostrya* was recently treated as *O. shiragiana* by TANAI and N. SUZUKI (1963).

The Oguni involucre is, though only one specimen, identical with *O. shiragiana* characterized by oval shape and roundly obtuse base. The present species is closely similar to the modern *O. japonica* SARGENT which grows in Japan, Korea and North China. Our impression is also similar to involucre of the modern *Ostrya virginiana* (MILL.) KOCH., which is living in southeastern North America.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4533.

Family FAGACEAE

Castanea miomollissima HU and CHANEY
(*Pl. 4*, figs. 9, 10)

1938. *Castanea miomollissima* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 35, 36, pl. 13, figs. 3, 7.
1963. TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 120, 121, pl. 12, figs. 3, 4; pl. 14, figs. 4–6; pl. 15, figs. 1, 2, 5, 6.

Remarks: Leaves of this species is characterized by elliptical to lanceolate in shape, stout and thick midveins, coarsely dentate margin with thickly tipped spine and so on. Among the present leaves, some of them are quite identical to the original leaf impressions of *Castanea miomollissima* HU and CHANEY from the Miocene Shanwang flora of China, and the others are somewhat similar but uncertain. That is to say, these uncertain leaf impressions are liable to be confounded with other species of Fagaceae, such as *Quercus sinomiocenicum* HU and CHANEY and *Q. miovariabilis* HU and CHANEY, and these specimens are required further examination.

This fossil species is closely similar to the living *C. mollissima* BLUME, which is widely distributed in China and Korea. The fossil species reported as *Castanea ungeri* HEER from the Oguni formation by MORITA (1931) and TANAI (1961) is synonym of the present species.

Occurrence: Imaichi formation loc. A, B and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4534a, 4534b.

Fagus antipofi HEER
(*Pl. 5*, figs. 6, 7)

1961. *Fagus antipofi,* TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 2, p. 306, pl. 16, figs. 1, 2, 10.
1964. HUZIOKA, *Jour. Min. Coll. Akita Univ.*, ser. A, vol. 4, p. 78–79, fig. 6.

Supplementary description: Cupule ovoid, 2 valves impressed, covered with many prickles, 1.6 cm long and 1.1 cm wide; peduncle stout, more than 3 mm long.

Remarks: A single incomplete cupule and its counterpart are referred to those of the genus *Fagus* by there characters described above. This fossil cupule is assigned to *Fagus antipofi* with some hesitation, because the specimens are ill-preserved and, moreover, no fossil leaves of this species are collected.

The present species is one of the common elements among the Miocene floras of northern Asia and Europe, and is very common in the Lower Miocene floras of Japan. On the contrary, this species has been reported only a few in the Middle Miocene time of Japan such as the Utto flora of the northeastern Honshu (HUZIOKA, 1963) and the Abura flora of the southwestern Hokkaido (TANAI and SUZUKI, 1963).

This fossil species is very rare in this flora, so the material seemed to be carried long distance from high altitude of the background to the site of deposition to become fossil. *Fagus antipofi* is closely similar to the modern *F. grandifolia* EHRH. in eastern North America. The fossil species is considered to be ancestral species of *F. crenata* BLUME which is now widely distributed in Japan as a representing tree in the temperate forests, and of *F. japonica* MAXIM. distributed in Honshu, Shikoku and Kyushu of Japan, but it is scarcely found on the Japan Sea side of Central and Northern Honshu.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4543a, 4543b.

Quercus mandraliscae GAUDIN

1961. *Quercus mandraliscae* GAUDIN. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 2, p. 310, 311, pl. 12, figs. 4, 7.

Remarks: Three specimens, though incomplete, are probably referred to *Q. mandraliscae* by their lanceolately outline and marginal characters. TANAI (1961) reported the occurrence of *Q. mandraliscae* from the Oguni formation loc. E, though the specimens have not been figured.

This fossil species is similar to the living *Q. longinux* HAYATA, endemic species of Formosa.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.

Quercus miovariabilis HU and CHANEY
(*Pl. 4*, fig. 8; *Pl. 5*, figs. 1–5; *Pl. 6*, figs. 1–4)

1938. *Quercus miovariabilis* HU and CHANEY, *Palaeont. Sinica,* New ser. A, no. 1, p. 36, pl. 15, figs. 5, 6.

Remarks: A number of well-preserved leaves are assigned to the present species with some hesitation, because it is very difficult to distinguish certain leaves of *Quercus* from *Castanea* on the basis of only fossil foliage character. TANAI and N. SUZUKI (1963) pointed out that leaves given the name *Q. miovariabilis* and *Q. sinomiocenicum* by HU and CHANEY from the Shanwang flora of China are inseparable from *Castanea miomollissima.* However, the present leaf specimens except some uncertain leaves are quite similar to those of the living *Quercus variabilis* BLUME and are distinguished from *Castanea.* The fossil leaves determined as *Quercus subvariabilis* TANAI and *Q. sinomiocenicum* HU and CHANEY from the Imaichi formation by the writer (1966) are included in this species.

The living equivalent species of *Quercus variabilis* BLUME is widely distributed in Honshu, Shikoku, Kyushu of Japan and extending to Korea, Formosa and China.

Occurrence: Imaichi formation loc. A, B, C, D and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4521a, 4521b, 4535–4542.

Family ULMACEAE

Ulmus longifolia UNGER
(*Pl. 7*, figs. 1–4)

1848. *Ulmus longifolia* UNGER, *Chlor. Protog. Taf. 26*, figs. 5, 6.
1954. OISHI and HUZIOKA, *Jap. Jour. Geol. Geogr.*, vol. 24, p. 130, pl. 15, fig. 6.
1963. TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 123, pl. 16, figs. 1, 2.

Remarks: Three leaves including a single mostly complete specimen and its counterpart are obtained. These well-preserved leaves are characterized by lanceolate shape, slender secondary nerves, fine and acute marginal teeth, and are referable to *U. longifolia.* This species is related to modern species of *U. lanceaefolia* ROXB. and WALLICH living in southeastern China and India.

This fossil species is one of the widely-distributed elms in the Miocene and the Lower Pliocene floras of Europe. In Japan, it is found from Miocene floras such as the Garo and the Abura floras in southwestern Hokkaido, the Utto and the Ouchi floras in northeastern Honshu.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4547, 4548a, 4548b.

Ulmus miopumila HU and CHANEY
(*Pl. 6*, figs. 5, 6; *Pl. 7*, figs. 5, 6)

1938. *Ulmus miopumila* HU and CHANEY, *Palaeont. Sinica,* New ser. A, no. 1, p. 39, pl. 14, figs. 2, 3.
1965. TANAI and N. SUZUKI, *Palaeont. Soc. Japan, Special Paper,* no. 10, p. 23, pl. 14, fig. 1; Pl. 18, fig. 6.

Remarks: Five leaves, though variable in size and outline, are referred to *U. miopumila* HU and CHANEY by their regularly doubly serrate margin. A certain lanceolate shaped specimen (as shown *Pl. 6*, fig. 6) determined to this species is somewhat similar to *U. longifolia* UNGER described above, but it is distinctly different from the latter in having coarse and bluntly marginal teeth. *Plate 6*, figure 7 shows the lanceolate shaped leaf of the living *U. pumila* L. for comparison.

The occurrence of this fossil species has been scarcely known. It was first described by HU and CHANEY (1938) from the Miocene Shanwang flora of China, and recently TANAI and N. SUZUKI (1965) collected some leaf impressions from the Late Miocene Shanabuchi flora of northeastern Hokkaido, Japan.

The present species is closely related to the modern *U. pumila* L. which is distributed in northern and western China, Manchuria, Korea and India. The Oguni specimens are also similar to the living *Ulmus parvifolia* JACQ., which is native of western Japan, Korea, Formosa and southern China.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4531b, 4544, 4545, 4546.

Zelkova ungeri KOVATS
(*Pl.* 7, figs. 7–17)

1961. *Zelkova ungeri* KOVATS. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 322, pl. 18, figs. 1–4, 6–9, 11.
1851. *Planera ungeri* ETTINGSHAUSEN, *Die fossile Flora von Wien, Abh. Geol. Reichsanst.*, Bd. 2, p. 14, pl. 2, figs. 7–9, 13.

Remarks: The present materials are most abundant in the writer's collection, and occupied 22 per cent of the total specimens. This fossil species is quite similar to living *Z. serrata*, which is distributed in Honshu, Shikoku, Kyushu in Japan and extend to Korea, Manchuria and China. The Oguni leaves also resemble those of the living *Zelkova formosana* HAYATA, endemic of Formosa, in their elliptical outline and small size.

It is noteworthy that the leaves of this species found from the Imaichi formation are generally small in size as shown *Plate 7*, figs. 7–17 compared with those of other floras. Most of these specimens are under 3.5 cm long and 1.5 cm wide. Concerning to the living zelkova tree, such small leaves are found generally in warmer region of the temperate zone of Japan.

The fossil leaves reported by MORITA (1931) under the name of *Planera ungeri* from the Oguni formation is referable to the present species.

Occurrence: Imaichi formation loc. A, B, D and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4506b, 4549, 4550, 4551b, 4552–4556, 4557b, 4558.

Family MAGNOLIACEAE

Magnolia miocenica HU and CHANEY
(*Pl. 8*, fig. 1)

1938. *Magnolia miocenica* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 44, pl. 20, fig. 2; pl. 21, figs. 3–5.

Remarks: Our leaf impressions, though somewhat variable in shape and size, have the characteristic nervation of *Magnolia*, and are identified as *Magnolia miocenica* from the Miocene Shanwang flora of China.

There is elsewhere described this fossil species from the Miocene floras of Japan, such as the Noroshi (ISHIDA, 1970) and the Notonakajima (MATSUO, 1963) floras of central Honshu and the Yoshioka, the Abura and the Wakamatsu floras (TANAI and N. SUZUKI, 1963) in southwestern Hokkaido.

The present species is similar to the modern *Magnolia delavayi* FRANCHET, of West and Southwest China. The Oguni specimens are also similar to the leaves of the living *M. kobus* Dc. which is widely distributed in cool- to warm-temperate regions of Japan and Korea.

Occurrence: Oguni formation loc. E.
Collection: G. S. J. hypotype no. 4559.

Family LAURACEAE

Actinodaphne oishii HUZIOKA
(*Pl. 8*, fig. 4; *pl. 9*, fig. 3)

1963. *Actinodaphne oishii* HUZIOKA, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 201, pl. 33, figs. 3, 4.

Remarks: The present species was first described by HUZIOKA (1963) based on specimens from the Oguni flora, and many fragmentary leaf impressions collected by the author are quite identical with this species in their shape and secondary venation.

The modern *Actinodaphne lancifolia* (SIEB. and ZUCC.) MEISSN closely resembles this fossil species, it is a evergreen tree living in warm-temperate regions of Honshu, Shikoku, Kyushu, and also in central China and Formosa.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4560, 4561a.

Cinnamomum miocenum MORITA
(*Pl. 9*, figs. 1, 2)

1931. *Cinnamomum miocenum* MORITA, *Jap. Jour. Geol. Geogr.*, vol. 9, nos. 1–2, p. 6, pl. 1, fig. 6.
1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 334, pl. 23, fig. 6.

Remarks: These leaf impressions in having characteristic triplinervation are identical to *Cinnamomum miocenum* MORITA (1931). The present species is closely similar to the modern *C. camphora* NEES and EBERM., which is now growing in Honshu, Shikoku, Kyushu, and extend to Formosa and China. The fossil camphora is commonly found from Miocene and Pliocene floras in several localities in Japan, and is one of the representatives in the Daijima-type flora.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4564a, 4565.

Cinnamomum oguniense MORITA
(*Pl. 8*, fig. 6; *Pl. 9*, fig. 4)

1931. *Cinnamomum oguniense* MORITA, *Jap. Jour. Geol. Geogr.*, vol. 9, nos. 1–2, p. 6, pl. 1, figs. 7–9.

1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 335, pl. 23, fig. 3.

Remarks: A number of incomplete impressions are referable to *C. oguniense* MORITA in their elliptical shape and triplinervation being diverging at very base. The present species has been reported from Middle Miocene floras of Japan such as the Noroshi, the Notonakajima floras in the Noto Peninsula and the Ouchi flora in Miyagi Prefecture, since originally described from the Oguni flora by MORITA (1931).

The fossil leaves of this species are closely similar to *C. reticulatum* HAYATA distributed now in Formosa.

Occurrence: Imaichi formation loc. A, D and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4566, 4567.

Parabenzoin protopraecox (ENDO) TANAI
(*Pl. 9*, fig. 5)

1961. *Parabenzoin protopraecox* (ENDO) TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 338, pl. 21, figs. 5, 8, 11; pl. 21, figs. 4, 5.

Remarks: A single fragmentary leaf impression is identified as *P. protopraecox* by its shape and venation. This fossil species is closely similar to the living *P. praecox* NAKAI which is a deciduous shrub-tree in Honshu, Shikoku and Kyushu of Japan. The occurrence of the present species has mostly been known from Miocene floras of Japan such as the Yoshioka flora in southwestern Hokkaido and the Ouchi flora in northeastern Honshu.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4568.

Machilus ugoana HUZIOKA
(*Pl. 8*, figs. 2, 3, 5)

1961. *Machilus ugoana* HUZIOKA. TANAI, *Jour Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 2, p. 336, pl. 22, fig. 3.
1963. HUZIOKA, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 203, pl. 34, figs. 4–6, pl. 40, fig. 7.

Remarks: Four lanceolate leaf impressions, including almost complete one, are referred to *Machilus ugoana* in their shape and venation, and closely resemble those of the modern *M. japonica* SIEB. and ZUCC. distributed in southwestern Japan including Loochoo Islands, and extend to southern Korea and Formosa.

This fossil species is found from the Middle Miocene Utto flora (HUZIOKA, 1963), the Ouchi flora (TOKUNAGA and ONOE, 1969) and the Noroshi flora (ISHIDA, 1970).

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4562a, 4562b, 4563.

Family HAMAMELIDACEAE

Eustigma (?) sp.
(*Pl. 10*, fig. 4)

Description: Leaf incomplete, missing in upper half of blade, estimated lanceolate or oblong in shape, 6 cm long (estimated) and 2 cm wide; apex missing; base cuneate with the blade somewhat decurrent along the petiole; midrib stout and thick, nearly straight; secondary veins slender, variable as to spacing and angle of divergence, considerably incurved, creeping up along margin, making angular loops and connecting with upper ones; several subsecondary veins leaving midrib, slender; tertiaries among the inter-secondary thin but distinct; nervilles forming a coarse polygonal network in middle part of blade and a fine mesh in basal part of it; margin entire; texture coriaceous; petiole stout, 7 mm long.

Remarks: This specimen is, though missing in upper part of the leaf, closely similar to *Eustigma oblongifolium* GARDN. and CHAMP. in its general outline and especially identical with characteristic secondary veins as described above. This fossil leaf is assigned to *Eustigma* with some hesitation, because it is only a single and incomplete specimen. The living similar species, *Eustigma oblongifolium* GARDN. and CHAMP. is now growing Formosa and southeastern China.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4569.

Liquidambar miosinica HU and CHANEY
(*Pl. 9*, figs. 6–8)

1938. *Liquidambar miosinica* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 46, pl. 23, figs. 1, 2.
1963. TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 128, pl. 23, figs. 6, 8, 11.

Remarks: Although the present species is very common found from the Middle Miocene sediments in Japan, and one of the representative fossils together with *Comptonia naumanni* in the Daijima-type flora, the writer obtained only four specimens from the Imaichi formation. These specimens of three palmate leaves and a single fruit are quite identical with this species. *Liquidambar mioformosana* TANAI reported from the Oguni formation by TANAI (1961) is also referable to *L. miosinica.*

The present species is closely similar to modern *Liquidambar formosana* HANCE, growing in Formosa and South China.

Occurrence: Imaichi formation loc. A, B and Oguni formation E.
Collection: G. S. J. hypotypes nos. 4562c, 4570, 4571.

Parrotia fagifolia (GOEPPERT) HEER
(*Pl. 9*, fig. 9; *Pl. 10*, figs. 1, 2)

1869. *Parrotia fagifolia* HEER, *Konigl. Physikalish. Okonomisch. Gesellshaft zu Konigsberg*, 104, p. 42, pl. 10, fig. 9.

1963. TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 129, pl. 19, fig. 5; pl. 20, figs. 1–3.

1961. *Fothergilla viburnifolia* HU and CHANEY. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 326, pl. 20, figs. 1, 3–5.

Remarks: Five fragmentary leaf impressions from the Imaichi formation are identified by their shape, coarse undulate margin and nervation as *Parrotia fagifolia* (GOEPP.) HEER. Although the genus *Parrotia* has been known from Oligocene to Pliocene floras in Europe, it is commonly found in the Middle Miocene Daijima-type flora of Japan. The present species is closely similar to the modern *P. persica* C.A. MEYER of northern Iran. The living species of *Hamamelis japonica* SIEB. and ZUCC. distributed cool- to warm-temperate zones in Japan, has wide range of variation in foliar shape, and the Oguni leaf specimens of the present species are somewhat resemble *Hamamelis japonica*, so that the Oguni leaves may be possible to fall within the range of variation displayed by them.

Fothergilla viburnifolia HU and CHANEY reported from the Oguni formation by TANAI (1961) is referred to this species.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4572–4574.

Family ROSACEAE

Sorbus nipponica TANAI and ONOE
(*Pl. 10*, fig. 3)

1961. *Sorbus nipponica* TANAI and ONOE, *Geol. Surv. Japan Rep.*, no. 187, p. 44, pl. 14, fig. 8.

Remarks: This species originally described from the Mio-Pliocene Hoki flora of Chugoku district in Japan, and our specimen, though only one leaflet, is identical with the present species in having small and oblong-elliptical outline, fine and simply-serrate margin and very short petiolule. This fossil species is related to the living *Sorbus commixta* var. *rufo-ferruginea* C. K. SCHNEIDER which is distributed in Honshu, Shikoku and Kyushu, Japan.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4575b.

Family LEGUMINOSAE

Cladrastis aniensis HUZIOKA
(*Pl. 10*, figs. 5, 6)

1963. *Cladrastis aniensis* HUZIOKA, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 205, pl. 35, figs. 5, 6.

Remarks: A single mostly complete leaflet and a fragmentally one from the

Imaichi formation are referred to *Cladrastis aniensis* HUZIOKA from the Middle Miocene Utto flora of northeastern Honshu by its ovate shape, broadly rounded and slightly asymmetrical at base and short petiolule. The present species closely resemble those of the modern *C. platycarpa* (MAX.) MAKINO, which is mostly distributed in warm-temperate regions of Honshu, Shikoku, Tsushima-islands and China, but never detected in Kyushu.

Our fossil leaflets are considerably larger than the specimens originally described from the Utto flora, but fall within the variation of leaflets displayed by the living equivalent species. Occurrence of the present species is also known from the Middle Miocene Yoshioka flora of southwestern Hokkaido, Japan.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotypes nos. 4551a, 4576.

Entada mioformosana TANAI
(*Pl. 10*, fig. 7)

1955. *Entada mioformosana* TANAI, *Geol. Surv. Japan Rep.*, no. 163, pl. 13, figs. 10, 11.
1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 345, pl. 24, fig. 2.

Remarks: A single complete leaflet from the Imaichi formation is closely similar to that of the modern *Entada formosana* KANEHIRA in their ovate shape, size and characteristic petiolule. This fossil species is known from the Middle Miocene Noroshi flora of Noto Peninsula in Central Japan.

The modern related species *E. formosana* is a large evergreen climber in Formosa.

Occurrence: Imaichi formation A.
Collection: G. S. J. hypotype no. 4577.

Gleditsia miosinensis HU and CHANEY
(*Pl. 10*, figs. 8–10)

1938. *Gleditsia miosinensis* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 52, pl. 26, figs. 6, 7.

Remarks: This species is represented by 6 well-preserved leaflet impressions from the Imaichi formation. These specimens are referable to *Gleditsia sinensis* LAMARCK of northern and central China by their appearance, secondary venation and characteristic short petiolule. Another similar species, *G. japonica* MIQ. is distributed in Honshu, Shikoku and Kyushu.

The present species is originally discribed from the Miocene Shanwang flora of China, and it is also found from the Middle Miocene Daijima-type flora of Japan.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4578–4580.

Kummerowia pseudostriata new species
(*Pl. 10*, fig. 12)

Description: Leaflet very small in size, 9.5 mm long and 6.0 mm wide (estimated), obovata in shape; blade gradually narrowed below and cuneate at base; apex emarginate with a short process in the middle; margin entire; midrib stout, straight; secondary veins extend almost straightly near the margin quite parallel, and then turn up along the margin, 7 to 8 pairs, subalternate, leaving midrib at angles of about 35 degrees; tertiaries obscure, texture thin, petiolule short and stout.

Remarks: This new species based on a well-preserved impression from the Imaichi formation is surely referred to the family Leguminosae by its characteristic apex, venation and petiolule. Among the family, my collection is comparatively similar to *Kummerowia striata* SCHINDL, which is annual herb and widely distributed in Japan.

This fossil leaflet is very rare in this flora, the writer is therefore setting up a new species with some hesitation, and denominate the specific name *pseudostriata.*

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4581.

Podogonium knorrii AL. BRAUN
(*Pl. 10*, fig. 11)

1938. *Podogonium knorrii,* HU and CHANEY, *Palaeont. Sinica,* New ser. A, no. 1, p. 76, pl. 50, figs. 10, 11.
1970. ISHIDA, *Mem. Fac. Sci. Kyoto Univ.*, vol. 37, no. 1, p. 91, pl. 15, figs. 7–11.

Remarks: A legume pod impression of oblong-ovate in the collection is identical with this species, especially quite resembles *Podogonium knorrii* from the Miocene Shanwang flora of China in general appearance. In Japan, many fossil leaflets and pods of the present species are reported from the Middle Miocene Noroshi flora by ISHIDA (1970).

There is elsewhere described from the Miocene flora of Japan, another species of leguminous pods named *Gleditsia miocinensia* HU and CHANEY (TANAI, 1963) and *G. tanaii* MATSUO (MATSUO, 1963). The Oguni pod specimen is, however, wholly unlike them under discussion.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4582.

Robinia nipponica TANAI
(*Pl. 10*, fig. 13)

1961. *Robinia nipponica* TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 2, p. 346, pl. 24, fig. 16; pl. 25, fig. 3.

Remarks: One almost complete leaflet impression is quite similar those of modern *Robinia viscosa* VENT characterized by its oval shape, secondary venation and petiolule, though it has a wide range of variation in foliar shape and size. The modern species is living on the high slopes of the Alleghany mountains in eastern United States. The present material also somewhat resembles some leaves of the genus *Maackia* in general outline, but differ in mode of venation.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4583.

Sophora miojaponica Hu and Chaney
(*Pl. 10*, fig. 14)

1938. *Sophora miojaponica* Hu and Chaney, *Palaeont. Sinica*, New ser. A, no. 1, p. 53, pl. 27, figs. 1, 3.
1961. Tanai, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 2, p. 347, pl. 24, figs. 13, 14, 21, 22.

Remarks: Seven leaflet impressions with a single complete one from the Imaichi formation are identified as *S. miojaponica* by its general outline, nervation and petiolule. The present species is commonly found from the Middle Miocene floras of Japan. *Sophora* sp. reported from the Oguni formation by Morita (1931) may be referred to the present species.

The fossil species is closely similar to the living *Sophora japonica* Linne. which is widely distributed in the whole of China and Korea.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E. (?)
Collection: G. S. J. hypotype no. 4584.

Wistaria fallax (Nathorst) Tanai and Onoe
(*Pl. 10*, fig. 15)

1961. *Wistaria fallax* (Nathorst) Tanai and Onoe, *Geol. Surv. Japan Rep.*, no. 187, p. 45, pl. 10, fig. 6; pl. 14, figs. 2–4.

Remarks: A single fragmental impression appears to represent this species. All the preserved characters are typically leguminous, especially it has lateral striped petiolule. Though the Oguni specimen is incomplete, it seems to be referred to *Wistaria fallax* as a latteral leaflet. This fossil species is similar to the living *W. floribunda* (Willd.) D. C. which is distributed Honshu, Shikoku, Kyushu Japan and extend to China.

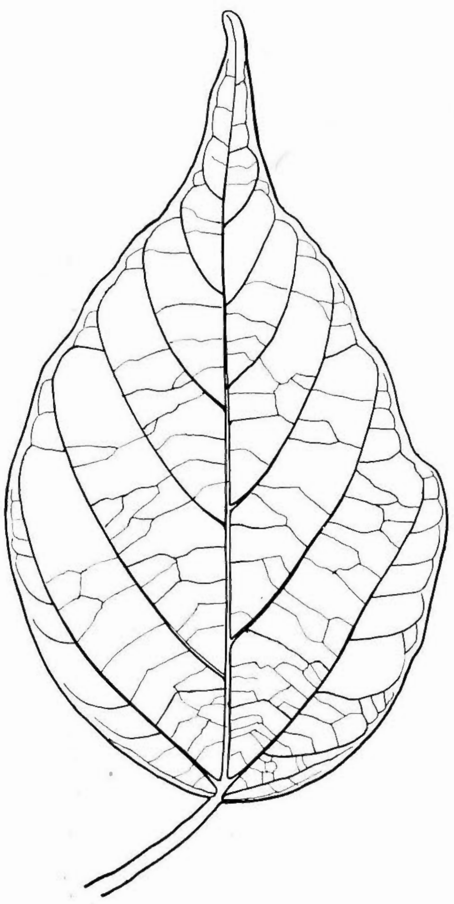
Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4585.

Family EUPHORBIACEAE

Mallotus sp.
(*Pl. 11*, figs. 4, 5)

Description: Leaves orbicular-ovate, somewhat asymmetrical, 8.0 to 10.0 cm long (estimated) and 4.4 to 5.8 cm wide; apex acute or acuminate; base rounded;

trinerved; midrib stout, straight without tip; lateral pair of primaries rather thin, making angles of 35 to 45 degrees with midrib, gently curving up, camptodrome; 3 to 5 pairs of secondaries, opposite to alternate, rather variable as spacing and angle of divergence, subparallel to the lateral primaries, lateral primaries and secondaries abruptly curving up just within the margin, forming various loops near the margin; tertiaries in inter-secondary spaces irregularly, percurrent; nervilles thin, reticulate, margin entire, but, undulate, texture firm; petiole stout, more than 1.7 cm long.



Text-fig. 2. A restoration of *Mallotus* sp.
(natural size)

Remarks: Four incomplete impressions of triplinerved leaves from the Imaichi formation are referred to *Mallotus* in the venation character. They are closely similar to leaves of the modern *Mallotus japonicus* MUELL.-ARG. (as shown *Plate 11*, figure 3) which is one of the representative trees of the secondary forest in the warm-temperate and subtropical zones of eastern Asia.

Mallotus populifolia HU and CHANEY from the Miocene Shanwang flora in China is somewhat similar to our specimens in general outline, but differ their marginal character. The occurrence of this fossil genus has been scarcely known in Japan. TANAI

(1970) reported fossil leaves of *Mallotus hokkaidoensis* from Oligocene sediments in the Kushiro Coal Field of eastern Hokkaido. Our specimens are comparatively similar to them. Recently, MATSUO (1972) studied about the "Daijima-type floras" from Innerside of Central Japan, and he reported *Mallotus* sp. and *Mallotus* cfr. *japonicus* MUELL. from various localities, though the specimens have not been figured.

Our specimens are somewhat similar to *Alangium aequalifolium* (GOEPP.) KRYSHTOFOVICH and BURSUK, which is one of the abundant member of the Oguni flora.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4586; paratype no. 4557a.

Family BUXACEAE

Buxus protojaponica TANAI and ONOE
(*Pl. 11*, figs. 1, 2)

1961. *Buxus protojaponica* TANAI and ONOE, *Geol. Surv. Japan Rep.*, no. 187, p. 46, pl. 14, fig. 5.

Remarks: Only three obscured specimens, though nearly complete, are obtained. These materials are closely similar to *Buxus protojaponica* in characteristic densely secondary veins and shape, especially resembles a leaf reported by HUZIOKA (1963) from the Utto flora of northern Honshu. This fossil species is closely similar to the modern *B. japonica* MUEL. of southern Honshu, Shikoku and Kyushu.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4561b, 4587.

Family AQUIFOLIACEAE

Ilex minusai new species
(*Pl. 11*, fig. 6)

Description: Leaf oblong in shape, 6.6 cm long and 2.5 cm wide; base cunate; apex acute; margin serrulate with acute teeth; midrib stout and nearly stright; secondary veins slender, 8 pairs, alternate or subalternate, diverging from the midrib at angles of 45 to 50 degrees; tertiary nerves indistinct; nervilles fine mesh; texture membranaceous; petiole stout; 0.6 cm long.

Remarks: One almost complete leaf impression is similar to those of modern *Euonymus lanceolata* YATABA and *Ilex serrata* THUNBERG in their general appearance. The present fossil is more closely similar to leaves of *Ilex serrata* in shape and marginal serration, which is distributed in Honshu, Shikoku and Kyushu. HUZIOKA (1963) described three fossil species of the genus *Ilex*; *I. daijimaensis* HUZIOKA, *I. heeri* NATHORST and *I. ohashii* HUZIOKA, from the Middle Miocene Utto flora of northern Honshu, but they are clearly differ from the Oguni specimen in their mode of leaf characters.

This species is named in appreciation of Teacher Yoshinobu MINUSA of Fujimi

Junior High School in Chiba Prefecture, who gave many materials arranging the present manuscript.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4575a.

Family ACERACEAE

Acer palaeodiabolicum ENDO
(*Pl. 11*, fig. 9)

1950. *Acer palaeodiabolicum* ENDO, *Short papers Inst. Geol. Palaeont. Tohoku Univ.*, no. 1, p. 12, pl. 3, fig. 3.

Remarks: This species is represented by a single well preserved samara from the Imaichi formation. Among the living maple, our specimen well match samaras of the modern *Acer diabolicum* BLUME, which is now growing in Honshu, Shikoku and Kyushu. The present species is one of the most common species in the Neogene flora of Japan, especially in Miocene flora.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4588.

Acer pseudocarpinifolium ENDO
(*Pl. 11*, figs. 10, 11)

1950. *Acer pseudocarpinifolium* ENDO, *Short Papers I.G.P.S.*, no. 1, p. 15, pl. 3, fig. 6.
1963. N. SUZUKI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 4, p. 689, pl. 3, fig. 2.

Remarks: These specimens represented only by samaras are identical to *Acer pseudocarpinifolium*. This species is closely similar to the living *Acer carpinifolium* SIEB. and ZUCC. widely distributed in Honshu, Shikoku and Kyushu.

The occurrence of this species has been scarcely known in Middle Miocene deposites in Japan. The fossil leaves and samaras of this species are reported from the Late Miocene Shanabuchi flora and the Early Pliocene Rubeshibe flora of northeastern Hokkaido, Japan.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4589, 4590.

Acer subpictum SAPORTA
(*Pl. 11*, fig. 8)

1873. *Acer subpictum* SAPORTA, *Bull. Coc. Geol. France*, ser. 3, vol. 1.
1963. N. SUZUKI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 690, pl. 5, figs. 1–3.

Remarks: The present maple specimens obtained only samaras from the Imaichi formation, are referred to *Acer subpictum* SAPORTA. This fossil species is closely similar to living *Acer mono* MAXIMOWICZ (syn. *A. pictum* THUMBERG), widely distributed in the temperate zone of Japan and extends to Korea, Manchuria and northern China. This and allied species are common in the Tertiary of northern hemisphere.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4591.

Family SAPINDACEAE

Koelreuteria miointegrifolia HU and CHANEY
(*Pl. 12*, figs. 2, 4(?))

1938. *Koelreuteria miointegrifolia* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 64, pl. 38, figs. 1, 3; pl. 38, fig. 3.

Remarks: HU and CHANEY (1938) first described leaflets and capsules of *K. miointegrifolia* from the Miocene Shanwang flora of China. In Japan, MATSUO (1970) reported leaves of this fossil species from the Oligocene Sakito flora of Kyushu. Then, ISHIDA and al. (1970) and HOJO (1971) reported from the Middle Miocene Chojabaru flora in the Iki island. Moreover, HUZIOKA and TAKAHASHI (1973) also described it from the Shimonoseki flora.

A single fragmental capsule from the Oguni flora is referred to this species on the basis of its shape and nervation. Our collection at Imaichi formation has a fragmentary leaflet which is seemed to be included in the present species, but it is too ill-preserved to be confident.

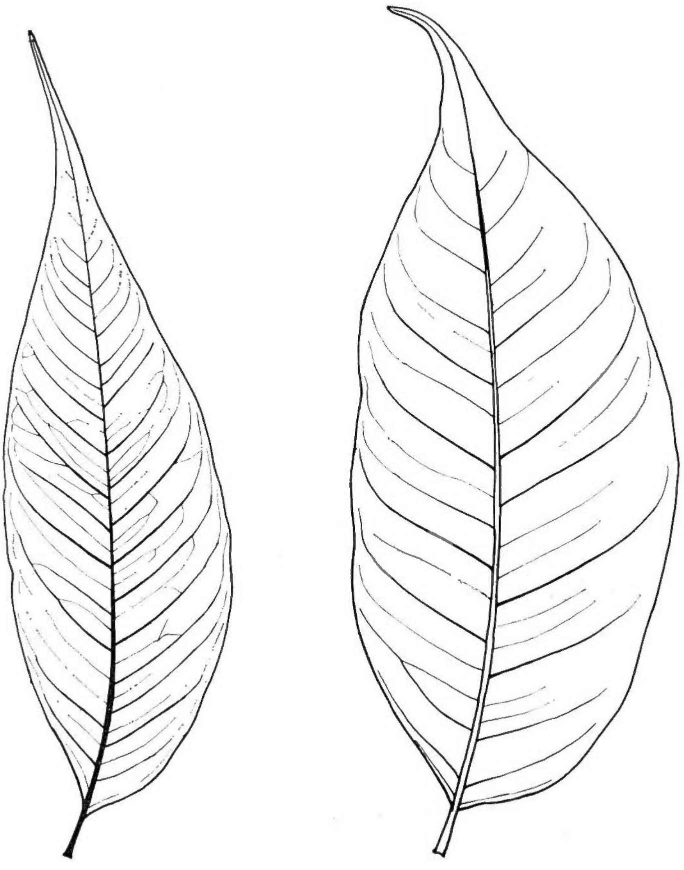
The present species is closely similar to the modern *K. integrifolia* FRANCHET, distributed southeastern China. The Oguni fossil specimens are also similar to the living *K. bipinnata* FRANCHET (*Pl. 12*, figs. 1, 3) of western China, and these two living species are difficult to be distinguished each other.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4592, 4593.

Sapindus tanaii new species
(*Pl. 12*, figs. 5–7)

Description: Leaflets elliptical to oblong in general outline, 8 to 11 cm long (estimated) and 3 to 4.4 cm wide; base acute or obtuse, somewhat asymmetrical; apex caspidate; midrib stout, slightly curved; secondary veins thin and indistinct, 15 to 20 subalternate paris, irregularly spaced, diverging from the midrib at angles from 50 to 60 degrees curving up along the margin, camptodrome; some intermittent secondaries diverging from the midrib between the prominent secondaries; Tertiaries obscure; margin entire; petiolules stout, 0.7 cm long.

Remarks: Four leaflet impressions are closely similar to typical leaflets of the modern *Sapindus mukurossi* GAERT. which is widely distributed in eastern Asia. They



Text-fig. 3. A restoration of *Sapindus tanaii* new species.
(natural size)

are characterized by oblonged shape, somewhat wavy margin, a large number of secondaries, asymmetrical acuted base and short petiolule.

In the Neogene floras of Japan and Korea, four fossil species of *Sapindus* have been recorded, namely, *S. mukurossi* GAERTN. (KONNO, 1931) from the Upper Miocene to Lower Pliocene Omi flora in Nagano Prefecture; *S. kaneharai* TANAI (TANAI, 1952) from the Miocene Ennichi (Yongil) group in southern Korea, *S. miocenicus* HUZIOKA (HUZIOKA, 1963) from the Middle Miocene Utto flora in Akita Prefecture and *S. Protomukurossi* MURAI (MURAI, 1963) from the Miocene upper Gomyojin flora in Iwate Prefecture. These fossil species are clearly distinguishable from the Oguni species by their shape, size and venation character. The present species is the most similar to leaflets of the living *S. mukurossi* than those of the other fossil species.

From the Pleistocene Ebino flora in Miyazaki Prefecture, the writer (1971) described fossil leaflets of *Sapindus mukurossi* and they are quite identical with the Oguni specimens. The leaflets figured as *Rhus miosuccedanea* HU and CHANEY from the Miocene Noroshi flora of Central Japan (ISHIDA, 1970) are somewhat similar in general outline, but differ in length of petiolule.

This new species is named in honour of Professor Toshimasa TANAI of Hokkaido University, who gave me many technical suggestions for identification of this flora.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4595; Paratype nos. 4594e, 4596.

Family RHAMNACEAE

Paliurus protonipponicus SUZUKI
(*Pl. 12*, figs. 8, 9)

1960. *Paliurus protonipponicus* SUZUKI, *Sci. Rep. Tohoku Univ.*, 2nd ser., Special Volume, no. 4, p. 319, pl. 33, figs. 5–7.

Remarks: Eight fragmentary leaf impressions are closely similar to the leaves of *P. protonipponicus* described from the Late Miocene Fujitoge formation of north-eastern Honshu by K. SUZUKI. The leaves of this fossil species are closely similar to those of the living *P. orientalis* HEMSLEY in Yunnan and *P. hemsleyana* REHDER in central and southwest China. *Paliurus* is not a common genus in the Middle Miocene of Japan, only discribed from the Utto flora by HUZIOKA (1963) named *P. akitanus* and the present species from the Noroshi flora by ISHIDA (1970). The Oguni specimens are distinguishable from *P. akitanus* in mode of vanations and outline.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype nos. 4513b, 4513c.

Zizyphus miojujuba HU and CHANEY
(*Pl. 13*, fig. 2)

1938. *Zizyphus miojujuba* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 66, pl. 41, figs. 1, 4.

Remarks: Two fragmentary leaves from Imaichi and Oguni formations show characteristic venation and marginal serration, though their upper portion is missing. They resemble some leaves of the *Paliurus* and *Zizyphus*, and have a close similarity to leaves of *Zizyphus miojujuba* of the Miocene Shanwang flora in China. The leaves of this fossil species are so closely similar to those of the living *Z. jujuba* MILLER as to suggest a close relationship. *Z. jujuba* is widely distributed over most of China, and is common in North China.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.
Collection: G. S. J. hypotype no. 4597.

Family THEACEAE

Camellia protojaponica HUZIOKA
(*Pl. 13*, figs. 3, 7(?))

1955. *Camellia protojaponica* HUZIOKA, *Illust. Fossil Cat. Fukui Pref.*, no. 6, p. 8, pl. 3, fig. 5.

1963. TANAI and N. SUZUKI, *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 144, 145, pl. 24, figs. 7, 8; pl. 25, figs. 5, 7.

Remarks: A single almost complete specimen and its counterpart are referred to *C. protojaponica* by the characteristic secondary nervation and marginal serration. Our fossil leaf is closely similar to leaves of the living *C. japonica*, which is now distributed along the coast in Honshu, Shikoku, Kyushu, Loochoo, Korea and Shantung Province of China.

The specimen showing *Pl. 13*, fig. 7 is apparently a dehiscent capsule, but this capsule specimen might be unsuitable for this fossil species, because our specimen is smaller in size than those of the related living species. No capsule of the present species have previously been recorded from the Miocene floras of Japan.

Occurrence: Imaichi formation loc. A and B(?)
Collection: G. S. J. hypotype nos. 4599, 4600.

Family ALANGIACEAE

Alangium aequalifolium (GOEPPERT) KRYSHTOFOVICH and BURSUK
(*Pl. 13*, fig. 4; *Pl. 14*, figs. 1–3)

1939. *Alangium aequalifolium* (GOEPPERT) KRYSHTOFOVICH and BURSHUK, *Prob. Palaeont.*, no. 5, p. 390, pl. 5, figs. 1–8; pl. 6, figs. 12.

1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 371, pl. 30, fig. 1; pl. 31, fig. 9.

Remarks: The present species is one of the common collection in this flora as well as in the other lower half of Miocene floras in Japan, and the Oguni leaf impressions are characterized by oval to cordate in shape, inequilateral round or cordate base and triple-nervation.

TANAI (1961) and TOKUNAGA (1963) reported fossil leaves of this species from the Oguni formation. The present species is similar to the living *A. platanifolium* (SIEB. and ZUCC.) HARMS., of Japan and China.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4601–4604.

Family HYDROCARPACEAE

Hemitrapa borealis (HEER) MIKI
(*Pl. 13*, fig. 5)

1952. *Hemitrapa borealis* (HEER) MIKI, *Palaeobotanist*, vol. 1, p. 349, Text-fig. 2F.
1961. TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 2, p. 382, 383, pl. 32, figs. 5, 7.

Remarks: Two fragmentary impressions of nut from this flora resemble *Hemitrapa borealis* in its two appendages and spindle-like shape, and it differ from *H. yokoyamae,* (NATH.) MIKI in the shape and number of appendages. The present species is, along with *H. yokoyamae*, commonly found in Middle Miocene floras of Japan. This is the only species of aquatic plant in our collection. Though the genus *Hemitrapa* is now extinct, it has been confined to the Miocene of East Asia and appears to have been an endemic genus in East Asia.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. hypotype no. 4564b.

Family EBENACEAE

Diospyros miokaki HU and CHANEY
(*Pl. 13*, fig. 6)

1938. *Diospyros miokaki* HU and CHANEY, *Palaeont. Sinica*, New ser. A, no. 1, p. 72, pl. 46, figs. 1–3.

Remarks: Many fragmentary leaf impressions collected from the Imaichi formation are identical with this species in their general outline. TOKUNAGA (1963) collected several leaves of this fossil species from the Imaichi and the Oguni formations. The fossil leaves of *Diospyros kaki* reported from the Oguni formation by MORITA (1931) may also belong to this species. The present species closely similar to the modern *D. kaki* THUNBERG existing in Japan.

Occurrence: Imaichi formation loc. A, B and Oguni formation loc. E.
Collection: G. S. J. hypotype no. 4605.

Family OLEACEAE

Fraxinus sp.
(*Pl. 14*, fig. 6)

Description: Leaflet incomplete, missing in basal part of blade, oblong-ovate in shape (estimated), 4.6 cm long (estimated) and 2.4 cm wide; apex bluntly wedge; base probably asymmetrically rounded or somewhat cordate; midrib tapered at apex and arched; secondary veins weak, 10 subalternate pairs, leaving midrib at angles of

60 to 75 degrees on the lower portion and 50 to 60 degrees on the upper portion; most of the secondaries curving up and forming loops well within the margin, with large tertiary branches which also form loops or enter the marginal teeth; other tertiary nerves irregularly percurrent, nervilles forming a network; margin serrate, the teeth formed obtuse or rounded tip; petiolule missing; texture membranaceous.

Remarks: A single fragmentary leaflet specimen is closely similar to those of modern *Fraxinus spaethiana* KINGELSHEIM by their shape, oblique base, venation, and especially characteristic marginal teeth. Two fossil species of *Fraxinus; F. wakamatsuensis* TANAI and N. SUZUKI and *Fraxinus* sp., are described from the Middle Miocene floras of southeastern Hokkaido by TANAI and N. SUZUKI (1963), but our specimen quite differ from them in marginal serration.

The living species which is seemed to relate with this specimen, is a dominant tree of the forests along the mountain-streams in central and western Japan, accompanying with *Pterocarya rhoifolia* SIEB. and ZUCC.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4606.

Ligustrum tokunagai new species
(*Pl. 14*, fig. 4)

Description: Leaf small, oblong in shape; obtuse, rounded or rather emarginate at apex; 4 cm long and 1.4 cm wide; midrib stout and straight, secondary veins thin and slender, 5 subopposite pairs, leaving midrib at angles of 40 to 45 degrees, gently arched, curving up along margin, tertiary veins missing; margin entire; texture thin; petiole 5 mm long.

Remarks: This leaf specimen is suggestive some leaflets of Legminosae in general outline, but is clearly distinguished from them by its venation character and petiole. This fossil species is similar to the living *L. obtusifolium* SIEB. and ZUCC. (*Plate 14*, figure 5) which is distributed from Japan to Formosa. The Oguni leaf is formed slenderer than typical leaves of the modern L. obtusifolium, but the modern leaves have a wide range of variation in shape and size, so it is seemed to fall within the variation displayed by the living ones.

This new species is named in honor of Dr. Shigemoto TOKUNAGA, the formerly chief of Fuel Department of Geological Survey of Japan, who gave to the writer many fossil materials and geological suggestions about the fossil localities.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4607.

Family LILIACEAE

Smilax trinervis MORITA
(*Pl. 14*, fig. 7)

1931. *Smilax trinervis* MORITA, *Japan Jour. Geol. Geogr.*, vol. 9, nos. 1–2, p. 7, pl. 1, fig. 10–12.

Remarks: The present species, at first, described from the Oguni formation by

MORITA (1931) together with *Smilax minor*. After that, TANAI (1961) pointed out that *Smilax trinervis* is not distinguishable from *S. minor* in shape and size, and he stated these two species are probably conspecific. In this paper, the writer also include *S. minor* in the present species. Our seven specimens with a complete one from the Imaichi formation are characterized by trinervation and rather rounded shape, and are quite similar to the genus *Smilax*. The present species closely resembles *Smilax china* L., living from Hokkaido to Kyushu, extending to China and Korea.

Occurrence: Imaichi formation loc. A, D and Oguni formation loc. E.
Collection: G. S. J. hypotype no. 4608.

Incertae Sedis

Carpolithes japonica (MORITA) ISHIDA
(*Pl. 14*, figs. 8, 9)

1970. *Carpolithes japonica* (MORITA) ISHIDA, *Mem. Fac. Sci. Kyoto Univ.*, vol. 37, no. 1, p. 103, pl. 22, figs. 1, 2, 6, 7.
1961. *Dodonaea japonica* (MORITA) TANAI, *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, p. 352, pl. 24, fig. 15.
1933. *Terminalia japonica* MORITA, *Jour. Geol. Soc. Japan*, vol. 40, p. 355.

Remarks: MORITA (1933) first described winged fruits of this fossil species as *Terminalia japonica* from the Oguni formation. By the subsequent investigation, TANAI (1953) reconsidered the fossil species with the winged fruits from the Ennichi (Yongil) Group in southern Korea, then he concluded that they were similar to living *Dodonaea viscosa* (LINNE) JACQ., which is now widely distributed in India, Formosa, Australia, South America and other tropical or subtropical regions, and he named it newly *Dodonaea japonica* (MORITA). ISHIDA (1970) recently pointed out that the fossil species is different from *Dodonaea* on the basis of his collection. Our specimens which is one of the abundant collection in this flora are identical with the winged fruits of *Carpolithes japonica* from the Noroshi flora, and they are commonly found from the Middle Miocene floras of Japan.

Occurrence: Imaichi formation loc. A and Oguni formation loc. E.
Collection: G. S. J. hypotype nos. 4609, 4610.

Phyllites sp. 1.
(*Pl. 14*, fig. 10)

Description: Leaf elongate-elliptical in shape, 3.9 cm long and 1.3 cm wide; apex probably acuminate, though cannot be seen at tip because of bending it backward; base rounded; midrib slender; lateral primaries leaving at base, gently curving up and extending upward to the top of blade; 5 pairs of slight secondaries in intersecondary spaces; tertiaries make loops within marginal border; nervilles indistinct; texture thick; margin entire; petiole missing as bent it backward;

Remarks: Only one complete leaf impression is somewhat similar to leaves of the modern genus *Smilax*. It has something in common between present fossil and modern *Smilax* such as entire margin, triplinervation and characteristic feature of leaf which usually bend backward. This elliptical leaf specimen, however, differ from typical leaves of *Smilax* in their outline, so that the writer cannot designate the specific name.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4517a.

Phyllites sp. 2.
(*Pl. 14*, fig. 11)

Description: Leaf elliptical in shape, 8 cm long and 3.1 cm wide; base gradually narrowed, obtuse somewhat oblique; apex acute; midrib stout and almost straight from the base to apex; secondary vein 6 subalternate paris, irregularly spaced, diverging at various angles ranging from 40 to 75 degrees, arched; tertiary vein thin; margin nearly entire, rather irregularly undulate; texture firm.

Remarks: A single nearly complete leaf impression though lacking top and petiole, is obtained. This fossil leaf cannot be distinguished from leave of living *Glochidion phillippicum* C. B. Rob. in Euphorbiaceae, characterized by elliptical outline, somewhat oblique base, rather undulate margin and small number of secondaries. The writer has no detailed data about *Glochidion phillippicum* except leaves, so that he cannot designate the specific name.

Occurrence: Imaichi formation loc. A.
Collection: G. S. J. holotype no. 4611.

References

Chaney, R. W. (1967): Miocene Forests of the Pacific basin: their ancestors and their descendants. *Jubil. Publ. Commem. Prof. Sasa's 60th Birthday*, p. 209–239.

———— and Axelrod, D. I. (1959): Miocene forests of the Columbia Plateau. *Carnegie Inst. Wash. Pub.*, 617, p. 135–229.

Endo, S. (1931): *Cenozoic plants* (in Japanese). Iwanami's series of Geology, 44 p., Tokyo.

———— (1933): *Cenozoic plants of Japan. Additional Note* (in Japanese). Iwanami's series of Geology, p. 31–50, Tokyo.

———— (1934): Some Japanese Cenozoic Plants. I. On the fossil *Acer* from Shiobara Pleistocene Plant Beds. *Jap. Jour. Geol. Geogr.*, vol. 11, nos. 3–4, p. 239–253.

———— (1938): On the fossil plants from the environs of Sendai (1), (2) (in Japanese). *Jour. Geol. Soc. Jap.*, vol. 45, p. 85–90, p. 326–328.

———— (1940): A Pleistocene flora from Shiobara. *Sci. Rept. Tohoku Imp. Univ.*, 2nd ser., vol. 21, no. 2, p. 47–80.

———— (1950): On the fossil *Carpinus* from Japan and Korea. *Short Papers I.G.P.S.*, no. 2, p. 51–57.

———— (1953): Note on the Cainozoic Plants of East Asia 1, 2. *Kumamoto Jour. Sci.*, ser. B, no. 4, p. 1–4.

———— (1955): *Icones Fossil Plant from Japanese Islands* (in Japanese). 104 p., Sangyo-Tosho.

ENDO, S and MORITA, H. (1932): Notes on the genera *Comptoniphyllum* and *Liquidambar*. *Sci. Rept. Tohoku Imp. Univ.*, 2nd ser., vol. 15, no. 2, p. 41–53.

FUJITA, Y. (1960): On the lows concerning to the paleogeography and geotectonics the green tuff geosyncline in northeastern Japan (in Japanese, with English abstract). *Earth Sci.*, nos. 50–51, p. 22–35.

———— (1962): Origin of Japan Sea (in Japanese, with English abstract). *Earth Sci.*, no. 62, p. 21–28.

HAMACHI, T. and SHIMAZU, M. (1969): The uraniferous deposits in the Asahi-Iide Mountainland, Niigata and Yamagata Prefectures (in Japanese, with English abstract). *Geol. Surv. Japan Rep.*, no. 232, p. 11–24.

HAYASHI, Y. (1960): *Taxonomical and phytogeographical study of Japanese conifers* (in Japanese). 246p., Norin-shuppan, Tokyo.

HOJO, Y. (1971): Notes on some Miocene *Acer* from the island of Iki, Nagasaki Prefecture. *Prof. H. Matsushita, Special volume*, p. 151–153.

HOUGH, R. S. (1950): *Handbook of the trees of the Northern States and Canada.* 470 p., MacMillan, New York.

HU, H. H. and CHANEY, R. W. (1938): A Miocene flora from Shantung province, China. *Palaeont. Sinica*, New ser. A, no. 1, 147 p.

HUZIOKA, K. (1943): On some fossil involucres of *Ostrya* and *Carpinus* from the Miocene deposits of Hokkaido and Tyosen (in Japanese). *Jour. Geol. Soc. Jap.*, vol. 50, no. 602, p. 285–295.

———— (1949): Two Daijimaian floral types in the Inner zone of northeastern Japan (in Japanese). *Jour. Geol. Soc. Jap.*, vol. 55, nos. 648–649, p. 177.

———— (1961): A new Palaeogene species of the genus *Comptonia* from Joban coal-field, with reference to the stratigraphical consideration on the Tertiary *Comptonia* in northeastern Japan. *Jour. Min. Coll. Akita Univ.*, ser. A, vol. 1, no. 1, p. 60–68.

———— (1963): The Utto Flora of Northern Honshu. *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 153–216.

———— (1964): The Aniai flora of Akita Prefecture, and the Aniai-type floras in Honshu, Japan, *Jour. Min. Coll. Akita Univ.*, ser. A, vol. 3 no. 4, p. 1–105.

———— (1972a): Geohistorical review on the development of the Japan Sea (in Japanese). *Jour. Japanese Assoc. Petroleum Technol.*, vol. 37, no. 5, p. 233–244.

———— (1972b): The Tertiary floras of Korea. *Jour. Min. Coll. Akita Univ.*, ser. A, vol. 5, no. 1, p. 1–83.

———— and TAKAHASHI, E. (1970): The Eocene Flora of the Ube Coalfield, southwest Honshu, Japan. *Jour. Min. Coll. Akita Univ.*, ser. A, vol. 4, no. 5, p. 1–88.

———— and ———— (1973): The Miocene Flora of Shimonoseki, southwest Honshu, Japan. *Bull. Natn. Sci. Mus. Tokyo*, vol. 16, no. 1, p. 115–148.

IKEBE, N., TAKAYANAGI, Y., CHIJI, M. and CHINZEI, K. (1972): Neogene biostratigraphy and radiometric time scale of Japan—An attempt at intercontinental correlation. *Pacific Geology 4*, p. 39–78.

ISHIDA, S. (1970): The Noroshi flora of Noto Peninsula, central Japan. *Mem. Fac. Sci. Kyoto Univ.*, ser. Geo. and Mine., vol. 37, no. 1, p. 1–122.

ISHIDA, S., FUJIYAMA, I., NOGUCHI, Y. and TOMODA, Y. (1970): Geology and Palaeontology of the Chojabaru Diatomite, Iki, Japan (in Japanese). *Mem. Nat. Sci. Mus.*, 3: 49–63.

KANEHIRA, R. (1936): *Formosan Trees* (Rev. edit.) (in Japanese). Dep. Forest. Govern. Res. Inst., 754 p., Taihoku.

KRYSHTOFOVICH, A. (1926): Contribution to the Tertiary flora of Kwannon-zawa, Prov. Echigo, Japan (in Russian, with English summary). *Ann. Russ. Pal. Soc.*, vol. 6, p. 1–24.

MAEDA, T. and SHIMAZAKI, Y. (1951): Studies on the vegetation of Chichibu mountain forest. (I) The plant communities of the subalpine and alpine zones (in Japanese). *Bull. Tokyo Univ. Forests*, no. 39, p. 171–184.

———— and YOSHIDA, J. (1952): Studies on the vegetation of Chichibu mountain forest. (II) The plant communities of the temperate mountain zones (in Japanese). *Bull. Tokyo Univ. Forests*, no. 42, p. 129–150.

MATSUO, H. (1963): The Notonakajima Flora of Noto Peninsula. *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 219–243.

———— (1970): Palaeogene Floras of Northwestern Kyushu. part II: The Sakito Flora. *Ann. Sci. Coll. Liberal Arts, Kanazawa Univ.*, vol. 7, p. 13–62.

———— (1972): A Study of the so-called "Daijima-type" floras from Fukui, Ishikawa and Toyama Prefectures, Innerside of Central Japan (in Japanese, with English summary). *Ann. Sci. Kanazawa Univ.*, vol. 9, p. 81–98.

MIKI, S. (1941): On the change of flora in eastern Asia since Tertiary Period. I. The clay or lignite beds flora in Japan with special reference to the *Pinus trifolia* beds in central Hondo. *Jap. Jour. Bot.*, vol. 11, p. 237–303.

———— (1952a): *Trapa* of Japan with special reference to its remains. *Jour. Inst. Polytech. Osaka City Univ.*, ser. D, vol. 3, p. 1–30.

———— (1952b): On the systematic position of *Hemitrapa* and some other fossil *Trapa*. *Palaeobot.*, vol. 1, p. 346–350.

———— (1953): *On Metasequoia, fossil and living* (in Japanese). 141p., Nihon-kobutsu Shumino-Kai, Kyoto.

———— (1955): Nut remains of Juglandaceae in Japan. *Jour. Inst. Polytech. Osaka City Univ.*, ser. D, vol. 6, p. 131–144.

———— (1957): Pinaceae of Japan, with special reference to its remains. *Jour. Inst. Polytech.*, ser. D, vol. 8, p. 221–272.

———— (1959): Evolution of *Trapa* from ancestral *Lythrum* through *Hemitrapa*. *Proc. Jap. Acad.*, vol. 35, no. 6, p. 289–294.

MINAKAWA, S. (1959a): Stratigraphical and Paleontological studies on the Neogene Formations in the surrounding areas of the Yonezawa Basin (Part 1). Stratigraphy of the Western and Southwestern Environs (in Japanese, with English abstract). *Jour. Geol. Soc. Japan*, vol. 65, no. 765, p. 364–373.

———— (1959b): Stratigraphical and Paleontological studies on the Neogene Formations in the surrounding areas of the Yonezawa Basin (Part 2). Change of Lithofacies, Igneous Activity and Correlation of the Western and Southwestern Environs (in Japanese, with English abstract). *Jour. Geol. Soc. Japan*, vol. 65, no. 767, p. 483–493.

MORITA, H. (1931): On new species of the genera *Cinnamomum* and *Smilax* from the Miocene deposits of Oguni-machi, Uzen province, Japan. *Jour. Geol,* *Geogr.*, vol. 9, nos. 1–2, p. 1–8.

MORITA, H. (1933): On the *Terminalia* discovered from the Miocene flora of the Oguni-machi, Yamagata Prefecture (in Japanese). *Jour. Geol. Soc. Japan*, vol. 40, p. 355–356.

NATHORST, A. G. (1883): Contribution à la flore fossile du Japon. *Kgl. Svensk. Vet-Akad. Handl.*, Bd. 20, p. 3–92.

——— (1888): Zur fossilen Flora Japans. *Pal. Abhandl.*, Bd. 4, p. 197–250.

NODA, M. (1971): *Flora of the N-E. Province (Manchuria) of China*. 1,613 p., Kazama-Shobo.

NUMATA, M. and ASANO, S. (1969): *Biological Flora of Japan*. 39 p., Tsukiji-Shokan.

OHWI, M. (1956): *Flora of Japan* (in Japanese). 1,383 p., Shibundo, Tokyo.

OISHI, S. (1950): *Illustrated catalogue of East Asiatic fossil plants* (in Japanese). 235 p., Kyoto.

——— and HUZIOKA, K. (1941a): Studies on the Cenozoic plants of Hokkaido and Karahuto. VII. On the Tertiary *Marlea* (= *Alangium*) from Hokkaido and Karahuto (in Japanese). *Jour. Geol. Soc. Japan*, vol. 48, no. 574, p. 354–356.

——— and ——— (1941b): Studies on the Cenozoic plants of Hokkaido and Karahuto. III. *Comptoniphyllum* from Hokkaido and Karahuto. *Jour. Fac. Sci. Hokkaido Imp. Univ.*, ser. 4, vol. 6, no. 2, p. 201–204.

——— and ——— (1943): Studies on the Cenozoic plants of Hokkaido and Karahuto. V. Tertiary *Acer* from Hokkaido and Karahuto. *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 7, no. 1, p. 81–101.

——— and ——— (1954): Studies on the Cenozoic plants of Hokkaido and Karahuto. VIII. Tertiary Ulmaceae from Hokkaido and Karahuto (Saghalien). *Jap. Jour. Geol. Geogr.*, vol. 24, p. 121–144.

OKUTSU, H. (1940a): Fossil plants from the Nenoshiroishi plant beds. *Saito Ho-on kai Mus. Res. Bull.*, no. 19, p. 153–169.

——— (1940b): On the Nenoshiroishi plant beds and its flora. *Jubl. Publ. Comm. Prof. Yabe's 60th Birthday*, vol. 2, p. 613–634.

——— (1952): Cenozoic fossil plants from Sendai and the Environs. *Saito Ho-on kai Mus. Res. Bull.*, no. 34, p. 7–11.

——— (1955): On the stratigraphy and palaeontology of Cenozoic plant beds of Sendai area. *Sci. Rep. Tohoku Univ.*, ser. 2, vol. 26, p. 1–114.

ONOE, T. (1966): On some Characteristics of the Okiniwa Flora at Oguni-machi, Yamagata Prefecture (in Japanese, with English abstract). *Bull. Geol. Surv. Japan*, vol. 17, no. 8, p. 41–46.

——— (1971): A Pleistocene Flora from Ebino City, Miyazaki Prefecture, Japan (in Japanese, with English Descriptions and abstract). *Geol. Surv. Japan Rep.*, no. 241, 44 p.

——— (1972): On the Late Cenozoic Floras from the Northwestern part of Kagoshima Prefecture (in Japanese, with English abstract). *Jour. Geol. Soc. Japan*, vol. 78, no. 7, p. 369–375.

SARGENT, C. (1922): *Manual of the trees of North America*. Houghton Mifflin., vol. 1, 433 p.; vol. 2, 477 p.

SHIMAZAKI, T., TOKUNAGA, S. and ONOE, T. (1972): Some Stratigraphic Considerations Concerning the Fossil Pollen and Spores in the Oil Bearing Regions of Honshu, Japan (in Japanese). *Jour. Jap. Assoc. Petro. Technol.*, vol. 37, no. 7, p. 391–398.

SHIMAZU, M., TOKUNAGA, S. and KOSEKI, K. (1969): Geology of the Uranium-bearing Deposits in the Area, between Yamagata and Niigata Prefectures (in Japanese, with English abstract). *Geol. Surv. Japan Rep.*, no. 232, p. 563–580.

SUZUKI, K. (1959a): On the flora of the upper Miocene Tennoji formation in Fukushima basin, Japan (in Japanese, with English summary). *Monogr. Assoc. Geol. Collab. Jap.*, no. 9, 48 p.

———— (1959b): On the stratigraphic succession of the Miocene and Pliocene flora in the northeastern Japan. *Cenozoic Research*, no. 30, p. 1–24.

———— (1960): On the Rhamnaceae from the Late Miocene and Pliocene in the western border of the Aizu basin, Fukushima Prefecture, Japan. *Sci. Rep. Tohoku Univ.*, ser. 2, Spec. vol. no. 4, p. 316–322.

———— (1961): The important and characteristic Miocene and Pliocene species of plants from the southern part of the Tohoku district, Japan. *Sci. Rep. Fac. Art. Sci. Fukushima Univ.*, no. 10, p. 1–95.

———— (1968): The Chronostratigraphical Change of the Vegetation and the Functions of Plants—the Morphology and Functions of the leaves—(in Japanese, with English abstract). *Memor. Geol. Soc. Japan*, no. 3, p. 57–71.

SUZUKI, N. (1963): Late Tertiary Maples from Northeastern Hokkaido, Japan. *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 4, p. 683–693.

TANAI, T. (1952a): Des fossiles végétaux dans le bassin houiller de Nishitagawa, Préfecture de Yamagata, Japon. (1). *Jap. Jour. Geol. Geogr.*, vol. 22, p. 119–135.

———— (1952b): Historical review of research on the original plants of Japanese Cenozoic coals. —Outline of Cenozoic Flora in Japan (in Japanese)—. *Coal Expl. Advis. Commit. Rep.*, no. 2, p. 61–83.

———— (1952c): Notes A propos de quelques plantes fossiles dans le groupe d'Ennichi (Yongil) du Corée meridionale 1. *Trans. Proc. Palaeont. Soc. Japan*, N. S., no. 8, p. 231–236.

———— (1953): Notes on some plant fossils from Ennichi (Yongil) group in southern Korea. *Trans. Proc. Palaeont. Soc. Jap.*, N. S. no. 9, p. 1–7.

———— (1955): Illustrated catalogue of Tertiary plants in Japanese Coal Fields. I. Early and Middle Miocene Floras. *Geol. Surv. Japan Rep.*, no. 163, 16 p.

———— (1959): On the formation of the coal-bearing deposits in northeastern Honshu, Japan. *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 10, no. 1, p. 209–233.

———— (1960): On the fossil beech leaves from the Ningyo-toge area, in the Chugoku, Japan. *Trans. Proc. Palaeont. Soc. Jap.*, N. S. no. 37, p. 193–200.

———— (1961): Neogene floral change in Japan. *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 11, no. 3, p. 119–398.

————(1967a): Miocene floras and climate in East Asia. *Abhandl. Zentr. Geol. Inst. Berlin*, p. 195–205.

———— (1967b): Tertiary Floral Chages of Japan. *Jubil. Publ. Commem. Prof. Sasa's 60th Birthday*, p. 317–334.

———— (1970): The Oligocene Floras from the Kushiro Coal Field, Hokkaido, Japan. *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, Geol. Mine., vol. 14, no. 4, p. 383–514.

———— (1971a): Tertiary phytogeography of the northern hemisphere (in Japanese, with English abstract). *Prof. Hisamichi Matsushita Memorial Volume*, p. 201–216.

TANAI, T. (1971b): The Miocene Sakipenpetsu Flora from Ashibetsu Area, Central Hokkaido, Japan. *Mem. Natn. Sci. Mus. Tokyo*, (4), p. 127–172.

——— and ONOE, T. (1956): Fossil Flora from the Sasebo coal field in northern Kyushu (in Japanese, with English abstract). *Bull. Geol. Surv. Japan*, vol. 7, no. 2, p. 69–74.

——— and ——— (1959): A Miocene flora from the northern part of the Joban coal field, Japan. *Bull. Geol. Surv. Japan*, vol. 10, no. 4, p. 261—286.

——— and ——— (1961): A Mio-Pliocene flora from the Ningyo-Toge area on the boarder between Tottori and Okayama Prefectures, Japan. *Geol. Surv. Japan Rep.*, no. 187, 62 p.

——— and SUZUKI, N. (1960): Miocene maples from southwestern Hokkaido, Japan. *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 10, no. 3, p. 551–570.

——— and ——— (1963): Miocene Floras of southwestern Hokkaido, Japan. *Geol. Surv. Japan 80th Ann. Mem. Publ.*, p. 9–149.

——— and ——— (1965): Late Tertiary Floras from Northeastern Hokkaido, Japan. *Palaeont. Soc. Jap. Spec. Paper*, no. 10, 117 p.

——— and ——— (1972): Additions to the Miocene Floras of Southwestern Hokkaido, Japan. *Jour. Fac. Sci. Hokkaido Univ.*, ser. 4, vol. 15, nos. 1–2, p. 281–359.

TOKUNAGA, S. (1960): New knowledges on the Oguni plant bed in Yamagata Prefecture (in Japanese). *Bull. Geol. Surv. Japan*, vol. 11, no. 8, p. 36.

——— and ONOE, T. (1969): Biostratigraphic and Paleobotanical Problems of Important Uraniferous Deposits in Japan (in Japanese, with English abstract). *Geol. Surv. Japan Rep.*, no. 232, p. 295–316.

——— and TANAI, T. (1954): On geologic structure and coal seams in the Okitama lignite field, Yamagata Prefecture (in Japanese, with English abstract). *Bull. Geol. Surv. Japan*, vol. 5, no. 12, p. 657–664.

WADACHI, K. (1958): *Climate of Japan* (in Japanese). 492 p., Tokyo-do, Tokyo.

(Written in November 1973)

山形県小国町産中新世中期植物群

尾上　亨

要　旨

山形県西置賜郡小国町から産出する小国化石植物群は，森田（1931）によって初めて公表されて以来，数人の研究者によって検討され，その概要が明らかにされている．しかし，これらはいずれも化石の量および種数において充分満足できるものではなく，詳細についてはこれまで検討されていなかった．今回，筆者は同植物群の化石標本を大量に採集する機会をえたので，それを総合的に検討し，主として含植物化石層堆積当時の古環境と生層序学的検討とを行なった．

化石産地周辺の地質は第 2，3 図に示したように，古生層およびそれをつらぬく先第三紀花崗岩類を基盤としていわゆる“グリーンタフ”を主体とした新第三紀層がおおっている．これら新第三紀層は下位から北小国層（下部グリーンタフ層に相当），今市層，小国層（以上 2 層は上部グリーンタフ層に相当）および舟渡（ふなど）層に細分されている．このうち今市層および小国層は非海成層で，小国化石植物群を挟有し，それらを不整合に海成の舟渡層がおおっている．

小国化石植物群は 26 科，48 属，61 種から成り，その内 4 種は新種，3 種は所属不明種となっている．同植物群の構成種はその大部分が暖温帯性植物に属し，亜熱帯樹木とわずかの冷温帯種をも含んでいる．産出傾向は Leguminosae の 8 属・8 種を筆頭に Lauraceae 4 属・5 種，Juglandaceae, Betulaceae および Fagaceae がそれぞれ 4 種の順となっている．個体数においては *Zelkova ungeri* が最も多く，全産出個体数(659個)の22%を占め，次いで*Quercus miovariabilis*, *Comptonia naumanni*, *Castanea miomollissima* および *Carpolithes japonica* の順となって，これら 4 種の合計が 44.31% におよんでいる．

第 1 表に示したように，小国化石植物群は42種が高木（産出個体数の73.01%），10種が低木（19.27%）で，大型化石（葉・実など）のみから判断すれば日本の第三紀における多くの植物群と同じように，樹木が大半を占めている．

しかも，これら樹木類は *Zelkova ungeri*, *Quercus miovariabilis*, *Castanea miomollissima* をはじめとして落葉広葉樹が非常に多く，常緑広葉樹類も比較的高い比率を占めている．一方，針葉樹類では暖温種である *Keteleeria ezoana* が全産出個体数の 2.43 %を占めているのを除いて非常に少なく，全体の 1.21 %に過ぎない．中新世中期植物群の代表種の 1 つと考えられている *Liquidambar miosinica* と中新世に世界的に広く分布していた *Metasequoia* の産出が非常に少なかったことが注目される．

小国植物群を構成している化石種の近似現生種とその分布状態を第 4 表に示した．それによると小国化石植物群の半数以上が現在日本の主として中部・近畿南部・四国および南九州の太平洋岸に面した地方に分布している．さらに，23種におよぶ外来種中19種は，日本を除いた東アジアの暖温帯地方に現在生育している．一方，小国植物群の垂直分布を推定すると，第 5 表に示されているように低地から山地斜面に生育する植物が大半を占めており，山地性植物はわずかに 5 種（産出個体数の1.67%）で，それらはいずれも山地斜面群集にも見られる．

以上のような検討資料から小国化石植物群が示すかつての森林は，当時黒潮の影響下にあった海域に比較的近い低地およびそれに隣接する山地斜面に分布していたものと考えられ，その背後にはわずかながら温冷性植物が生育できた山地があったものと想定される．そしてこのような環境を示す当時の気候は，年平均降水量約 2,500mm および年平均気温 15～17°C で，現在の化石産地付近の気温より数度高かったものと推定される．

小国化石種の多くは，日本の新第三紀植物群に見られるが，特に狼煙植物群(石川県)，打当植物群（秋田県)，吉岡植物群（北海道）など台島型植物群と最も多くの共通種を有している．したがって，小国化石植物群の地質時代は中新世中期と推定される．

PLATES

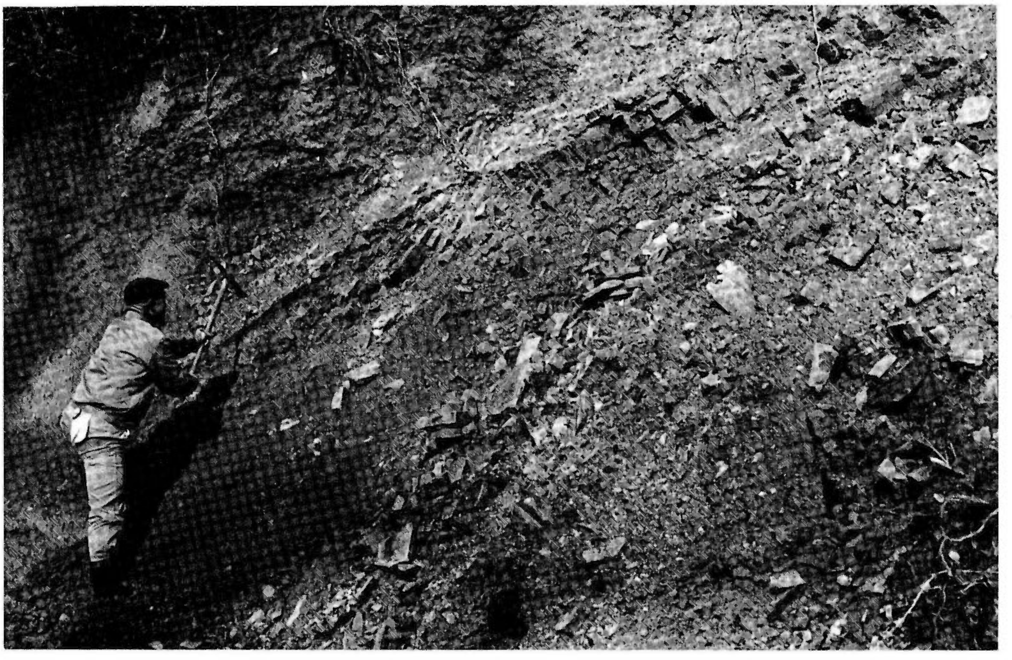
AND

EXPLANATIONS

(with 14 Plates)

Plate 1

Fig. 1. The principal locality of the Oguni flora, Imaichi formation loc. A.
Fig. 2. Mixed temperate forest near the fossil localities.



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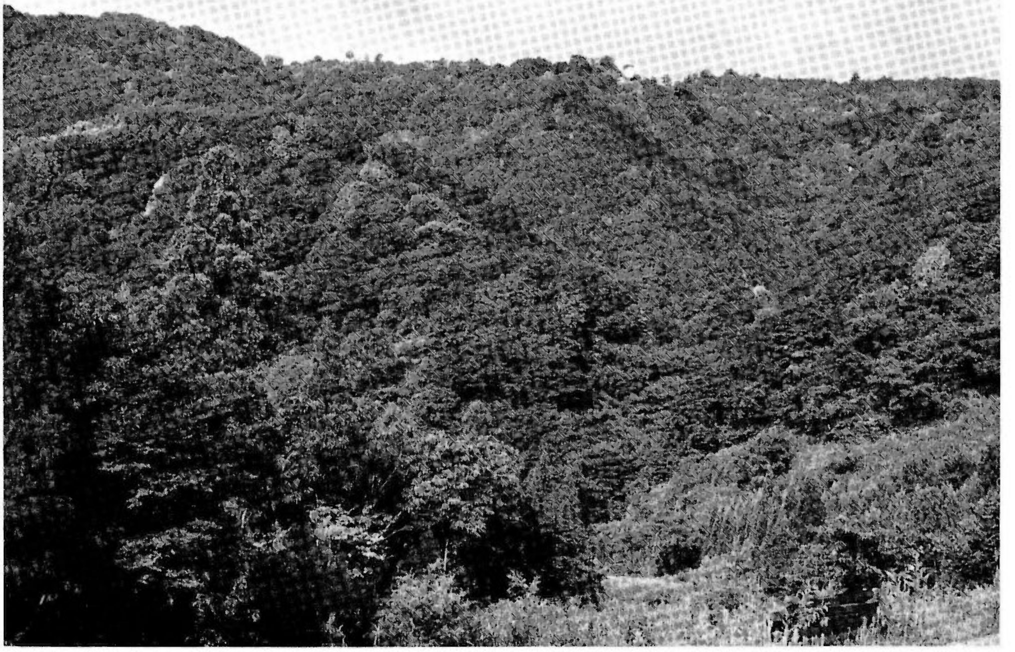

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Plate 2

Figs. 1–4. *Keteleeria ezoana* TANAI. G. S. J. hypotype nos. 4501, 4502, 4503, 4504.

Fig. 5. *Keteleeria ezoana* TANAI. G. S. J. hypotype no. 4505. ×1.5.

Figs. 6, 7. *Picea kaneharai* TANAI and ONOE. G. S. J. nos. 4506, 4507.

Figs. 8, 9. *Picea ugoana* HUZIOKA. G. S. J. hypotype nos. 4508a, 4509.

Fig. 10. *Metasequoia occidentalis* (NEWB.) CHANEY. G. S. J. hypotype no. 4510.

Fig. 11. *Libocedrus notoensis* (MATSUO) ISHIDA. G. S. J. hypotype no. 4511.

Fig. 12. *Salix* sp. G. S. J. holotype no. 4512.

Figs. 13–18. *Comptonia naumanni* (NATHORST) HUZIOKA. G. S. J. hypotype nos. 4513, 4514, 4515, 4516, 4517, 4518.

(All natural size unless otherwise stated)

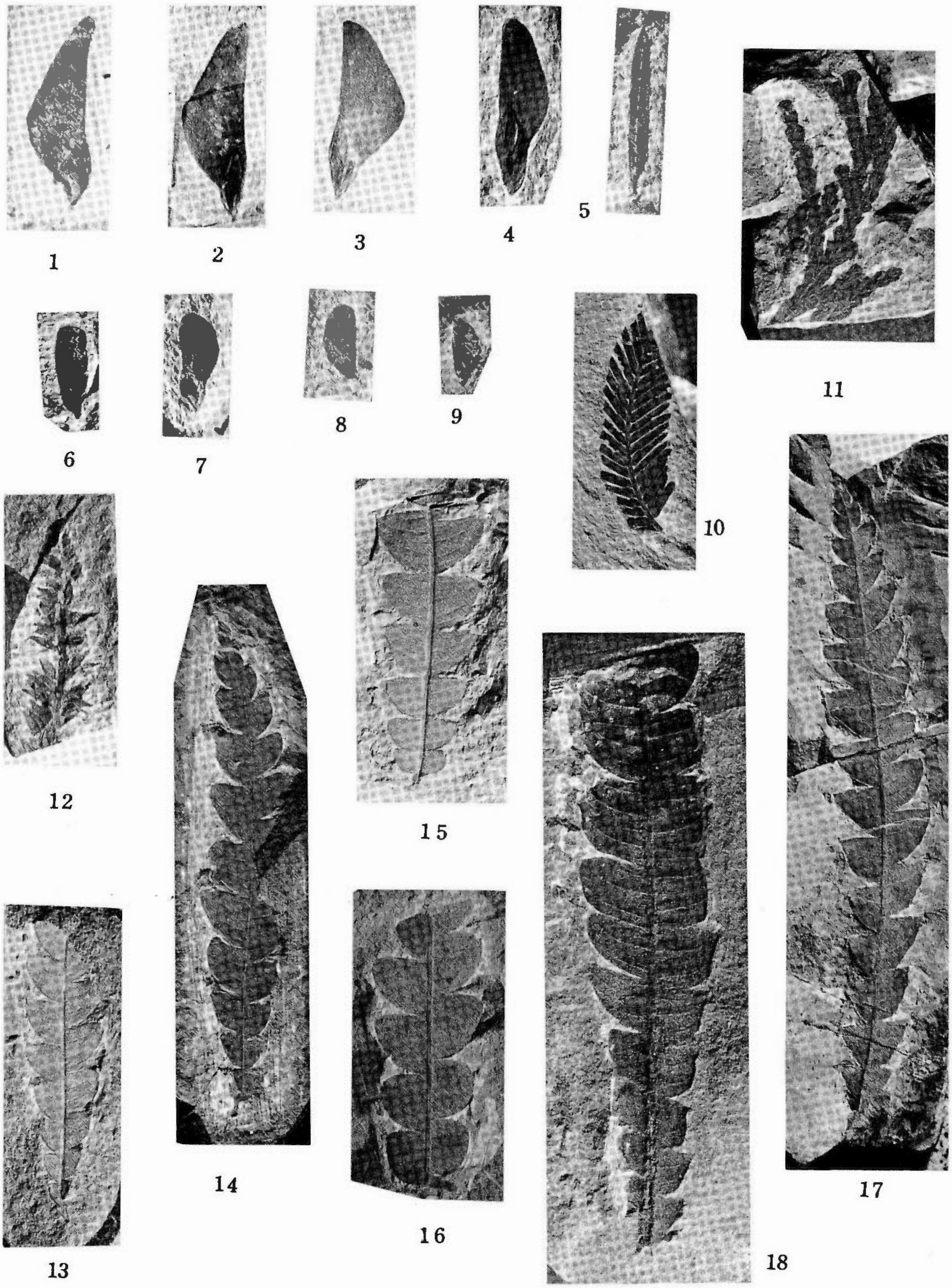
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Plate 3

Fig. 1. *Myrica rubra* SIEBOLD and ZUCCARINI. Leaf of the living species for comparison.

Fig. 2. *Myrica* sp. G. S. J. holotype no. 4520.

Fig. 3. *Comptonia naumanni* (NATHORST) HUZIOKA. G. S. J. hypotype no. 4519.

Figs. 4, 5. *Pterocarya protostenoptera* TANAI. G. S. J. hypotype nos. 4524, 4525.

Figs. 6–8. *Pterocarya asymmetrosa* KONNO. G. S. J. hypotype nos. 4526, 4527, 4528.

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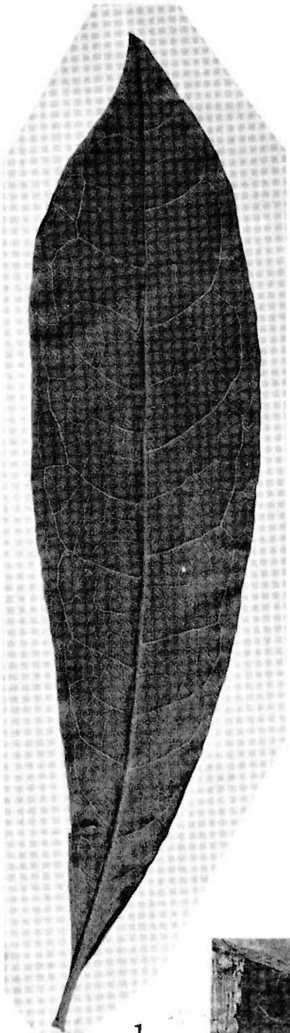
(All natural size unless otherwise stated)



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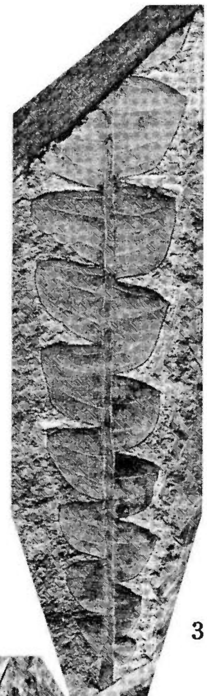

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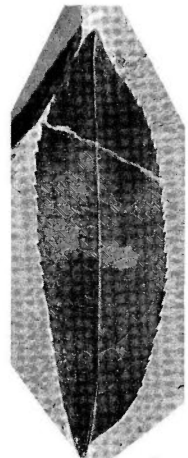

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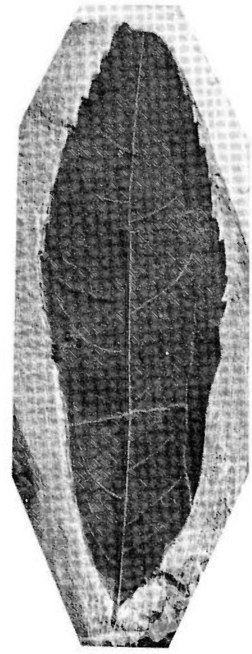

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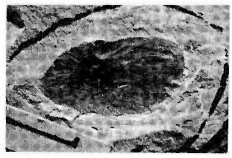

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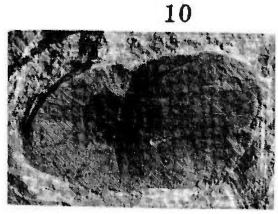

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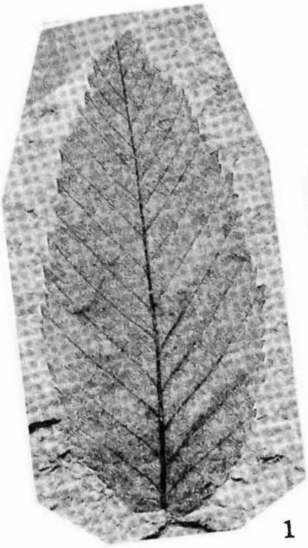
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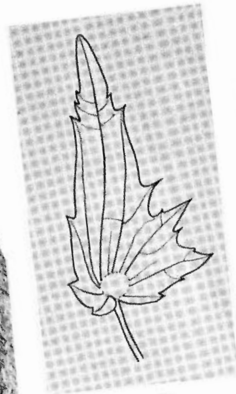
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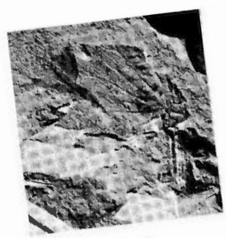
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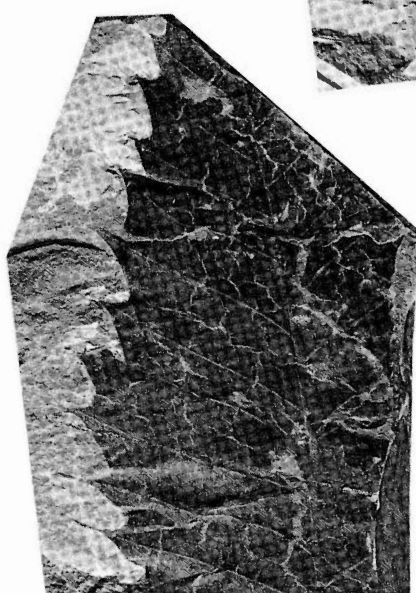
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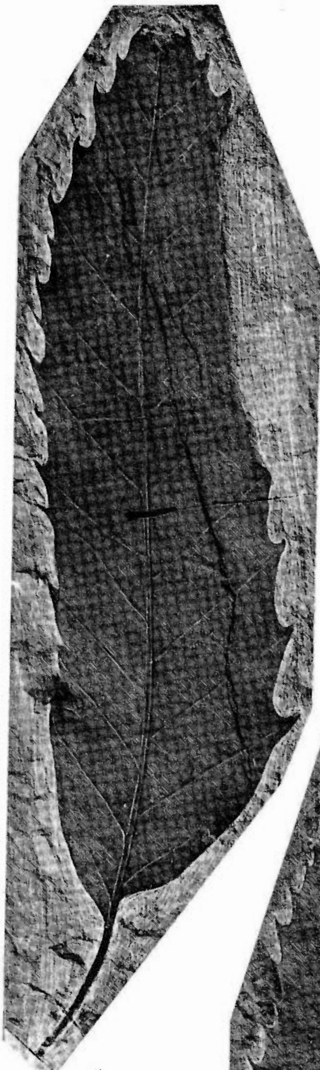
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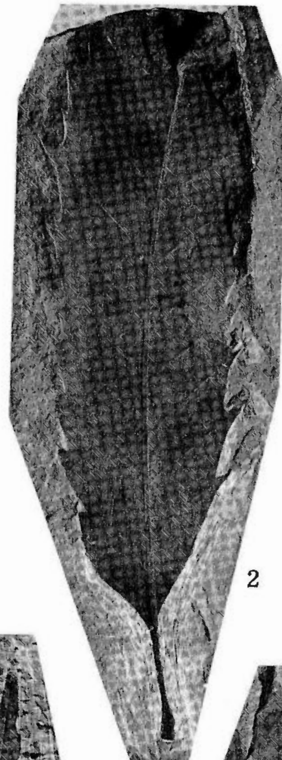
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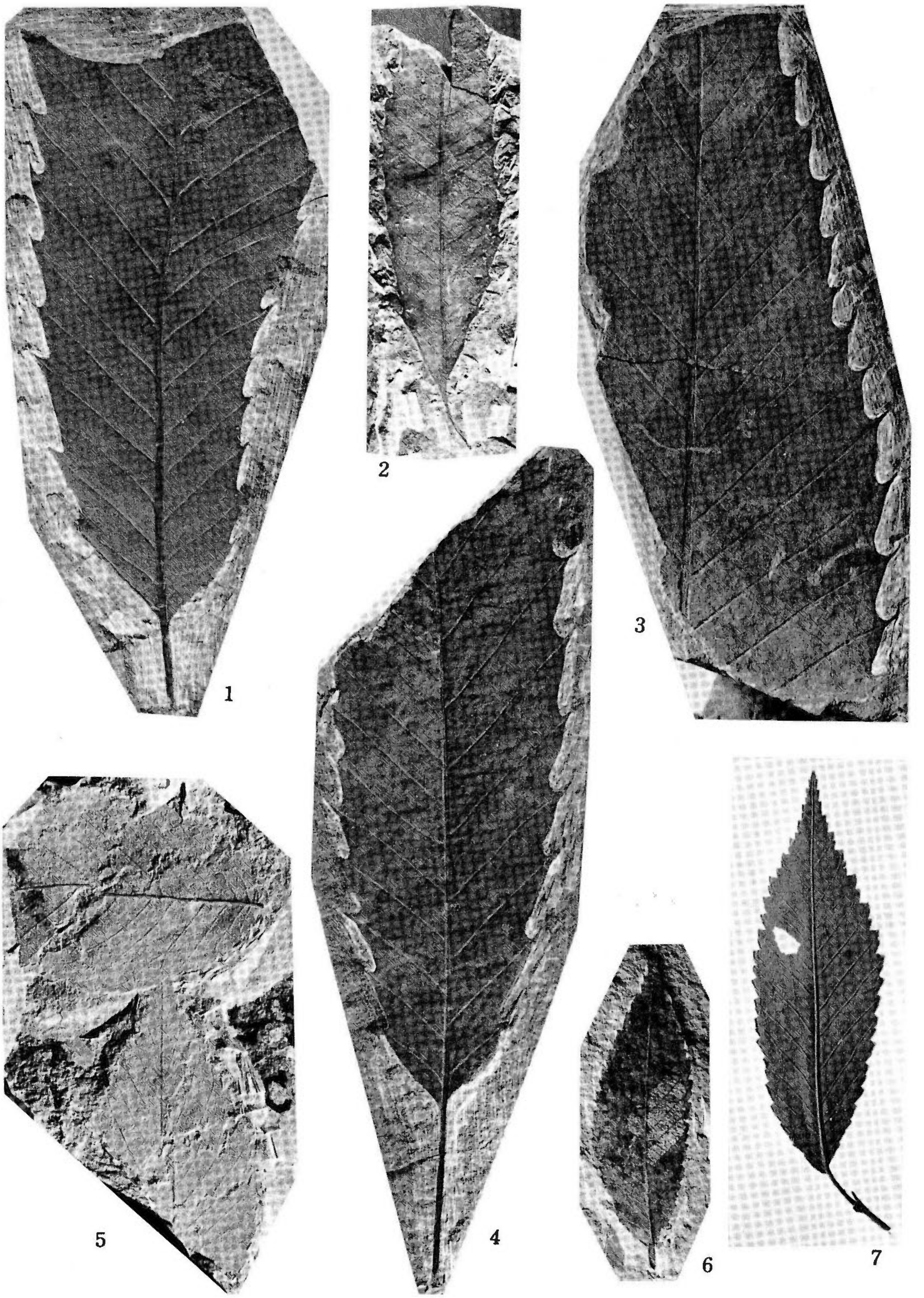

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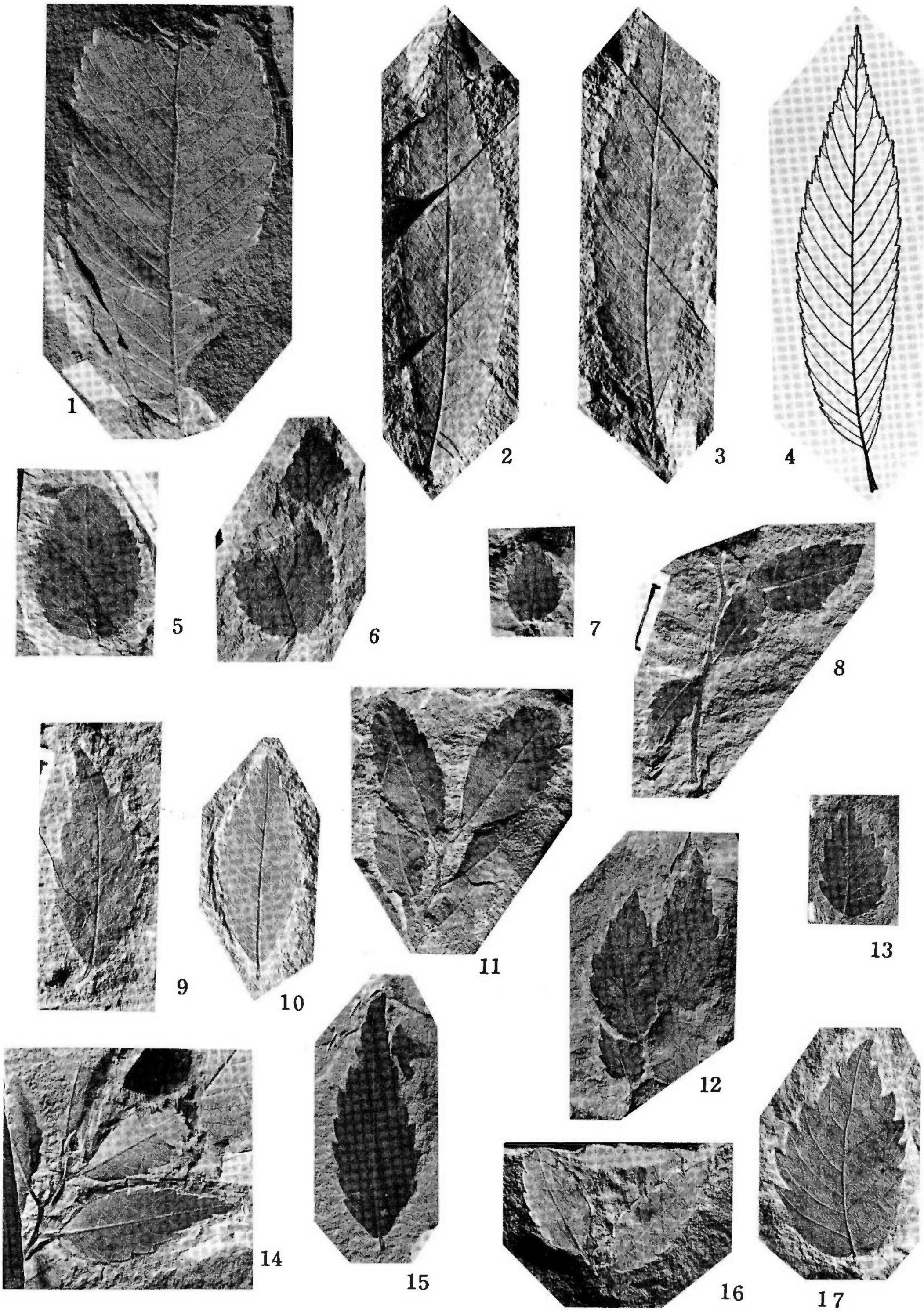
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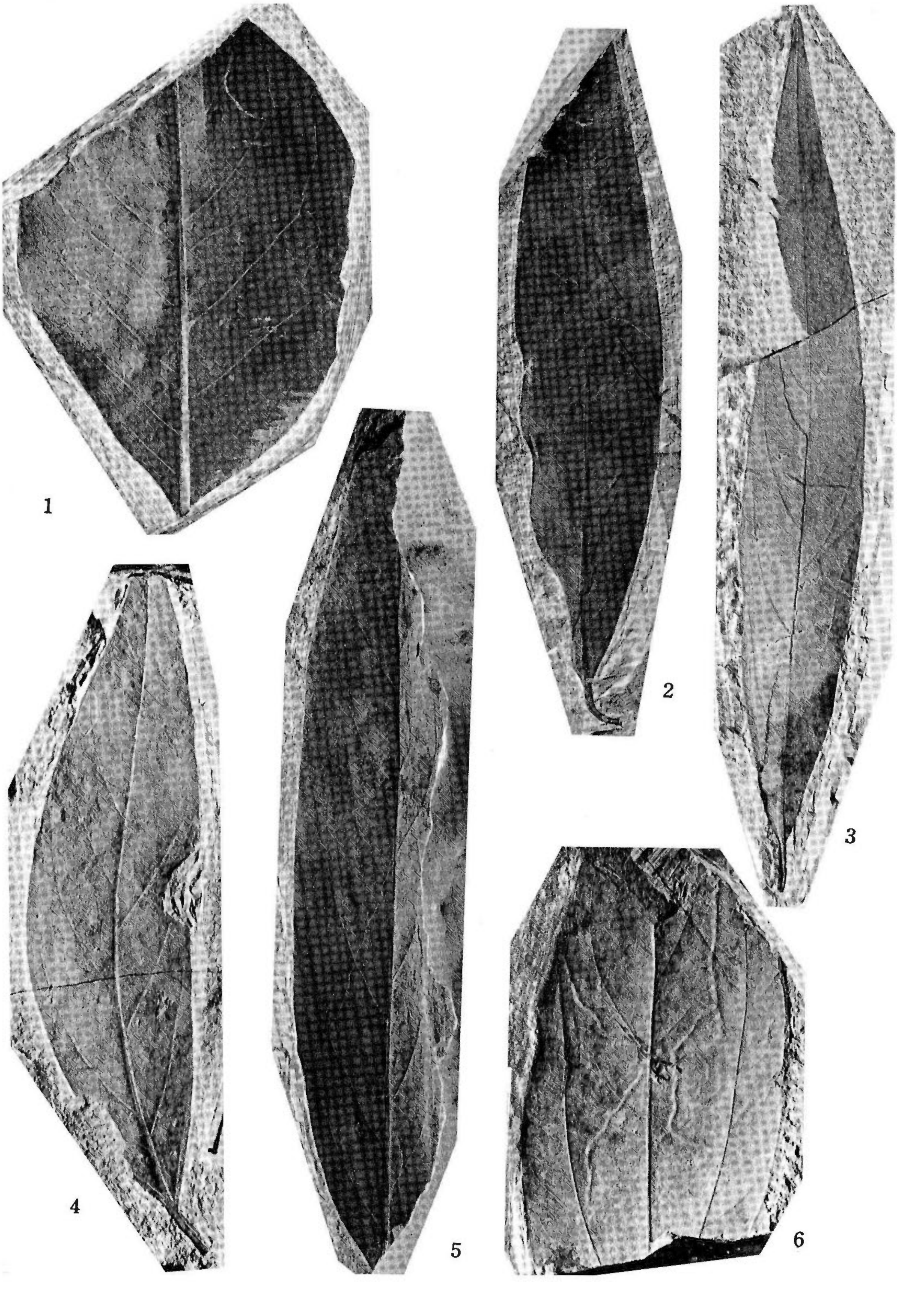
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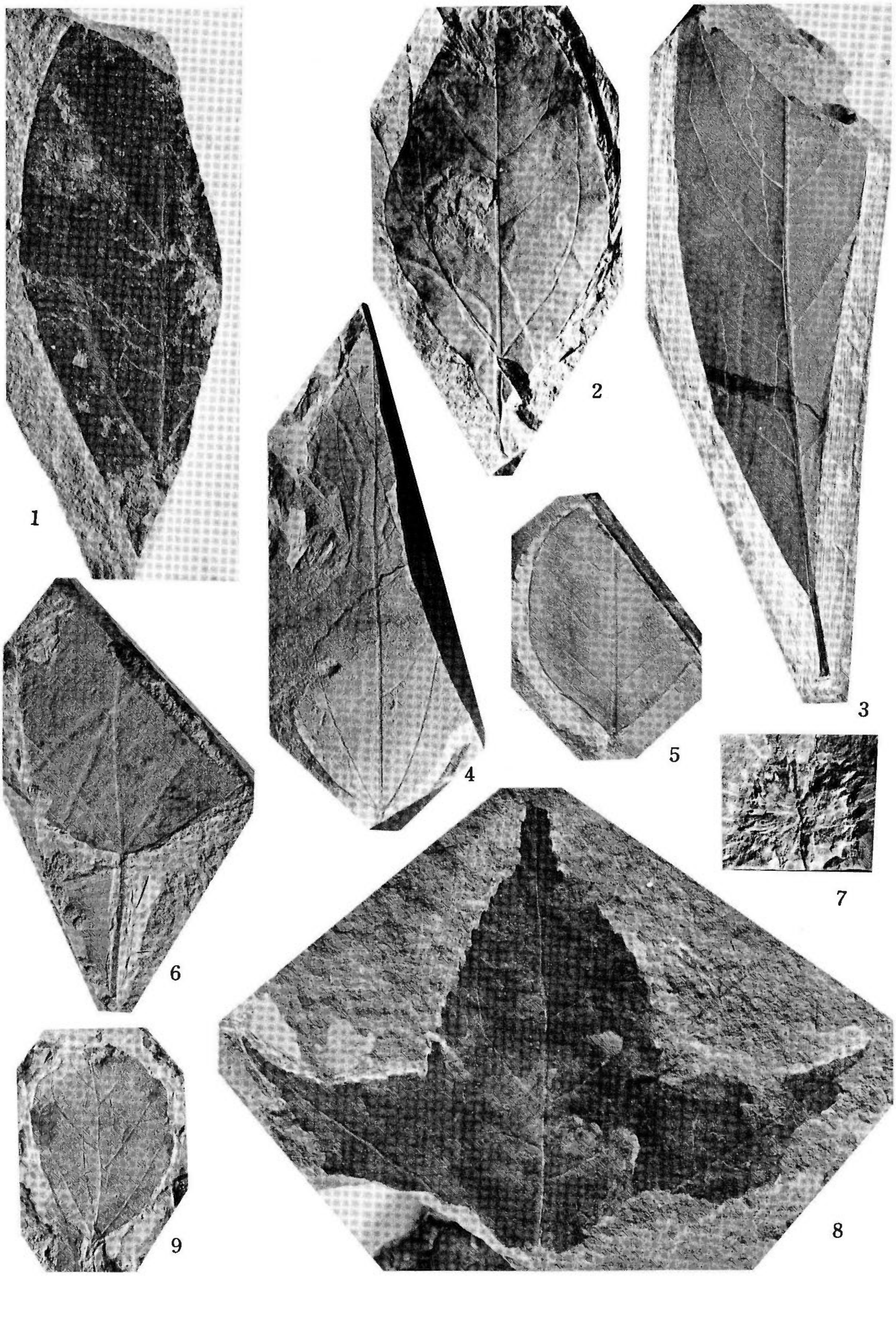
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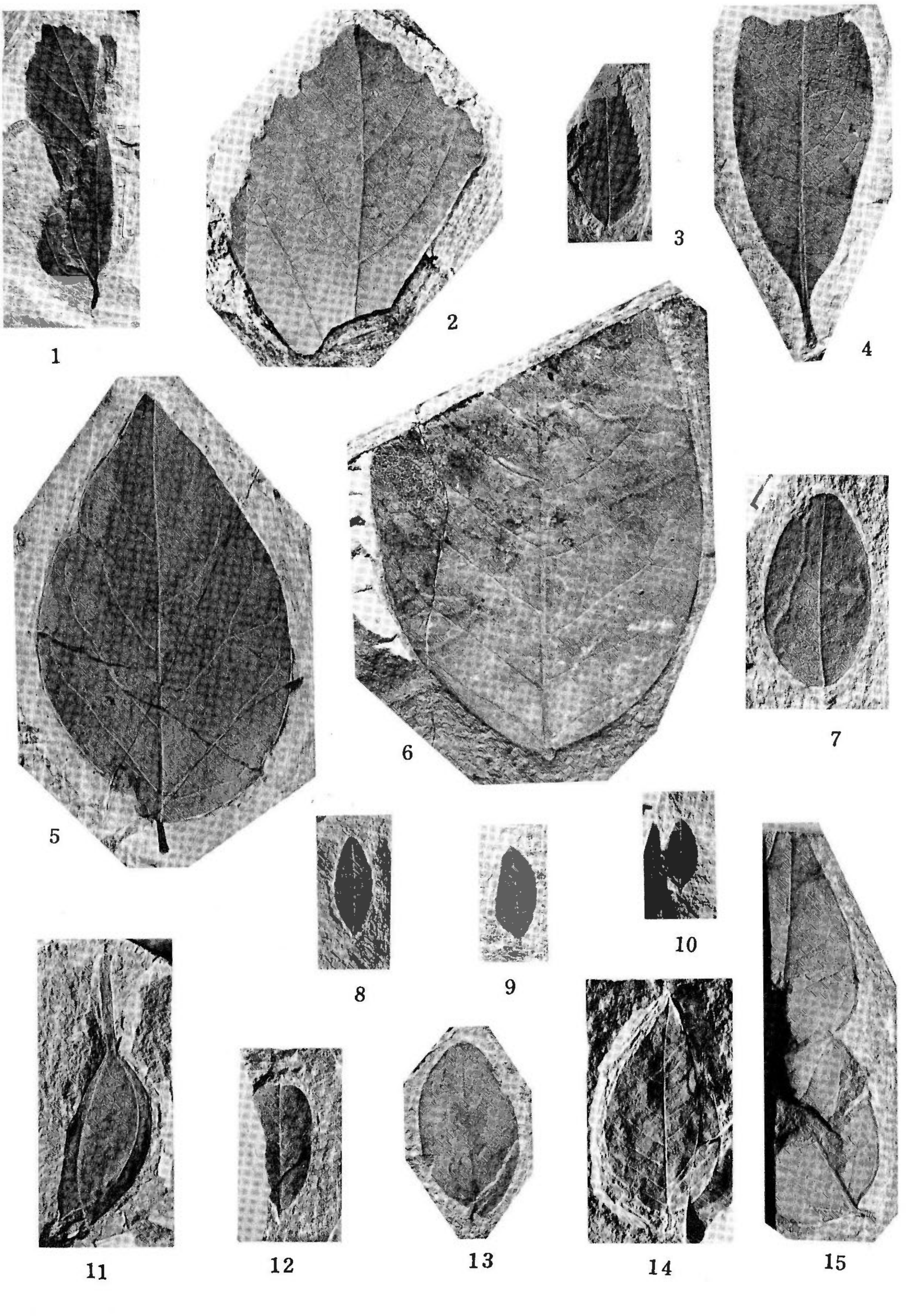
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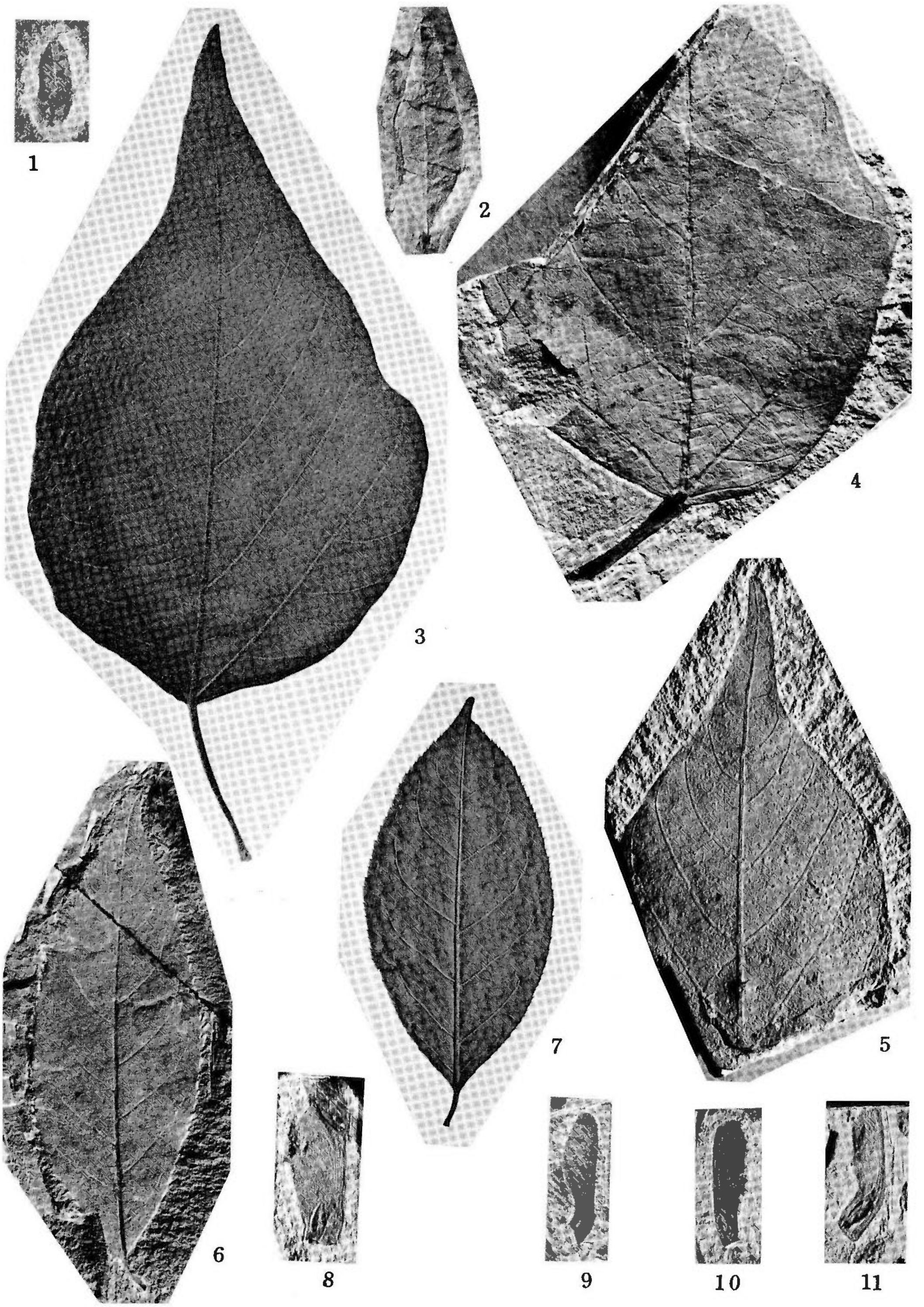
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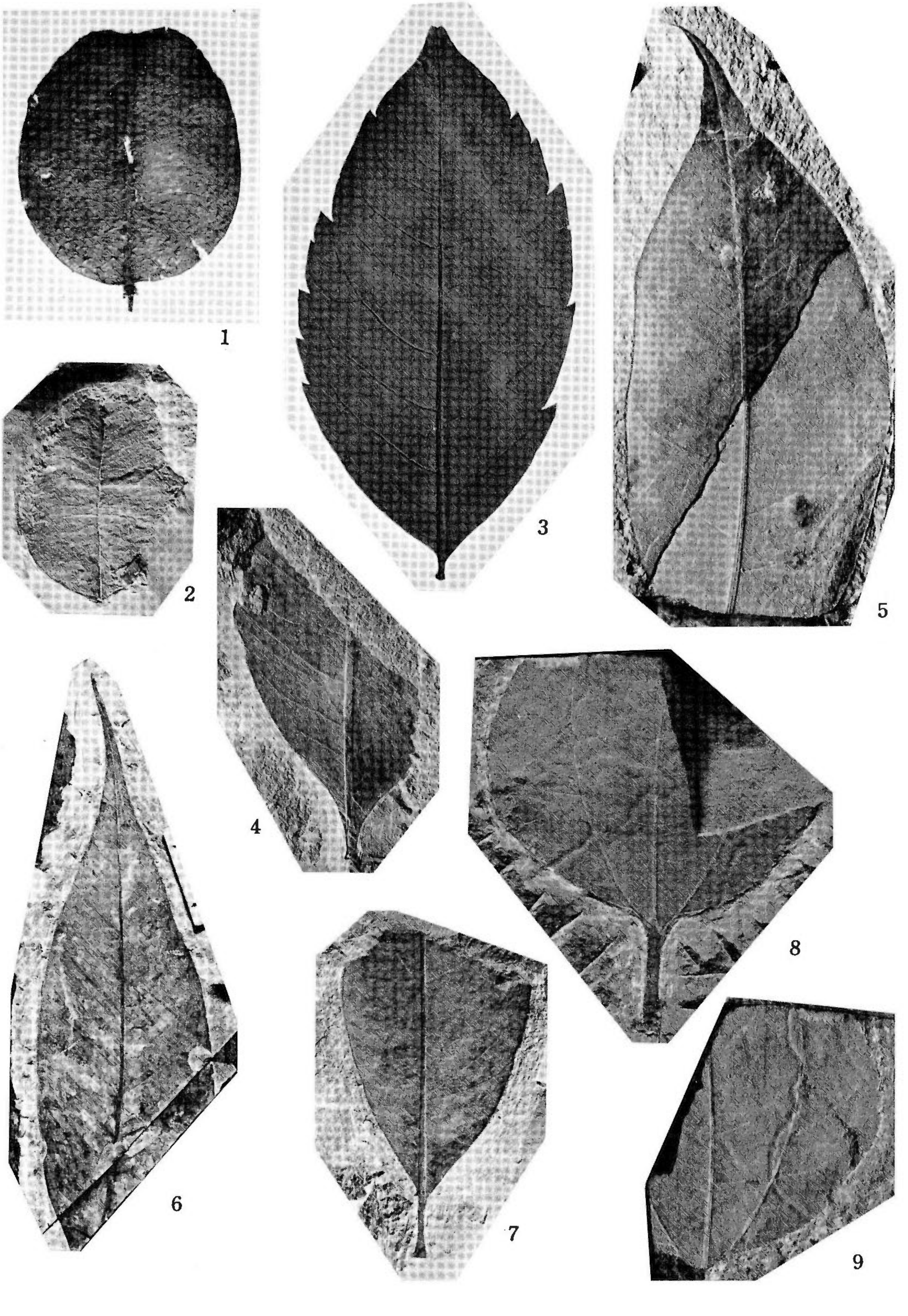
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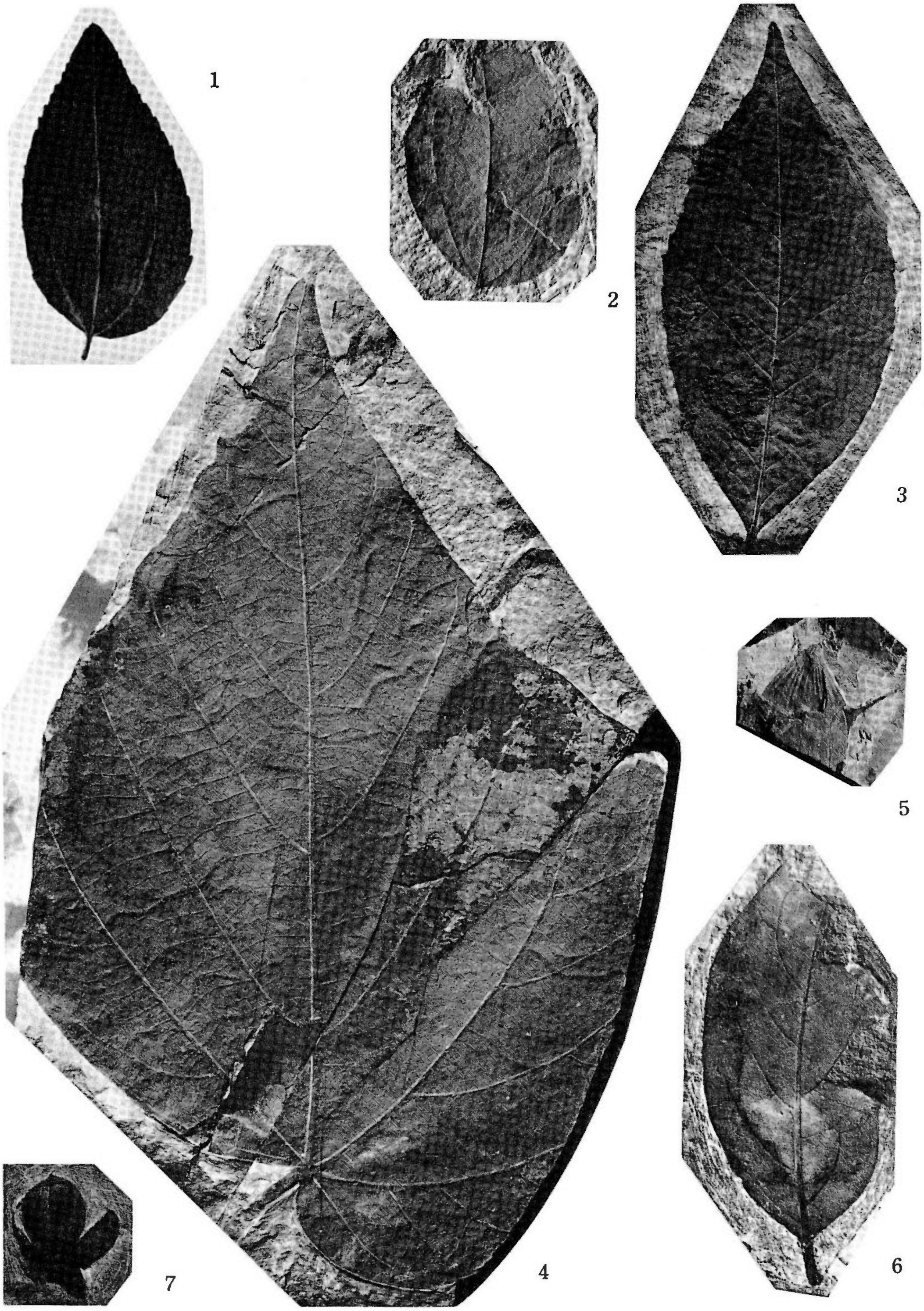
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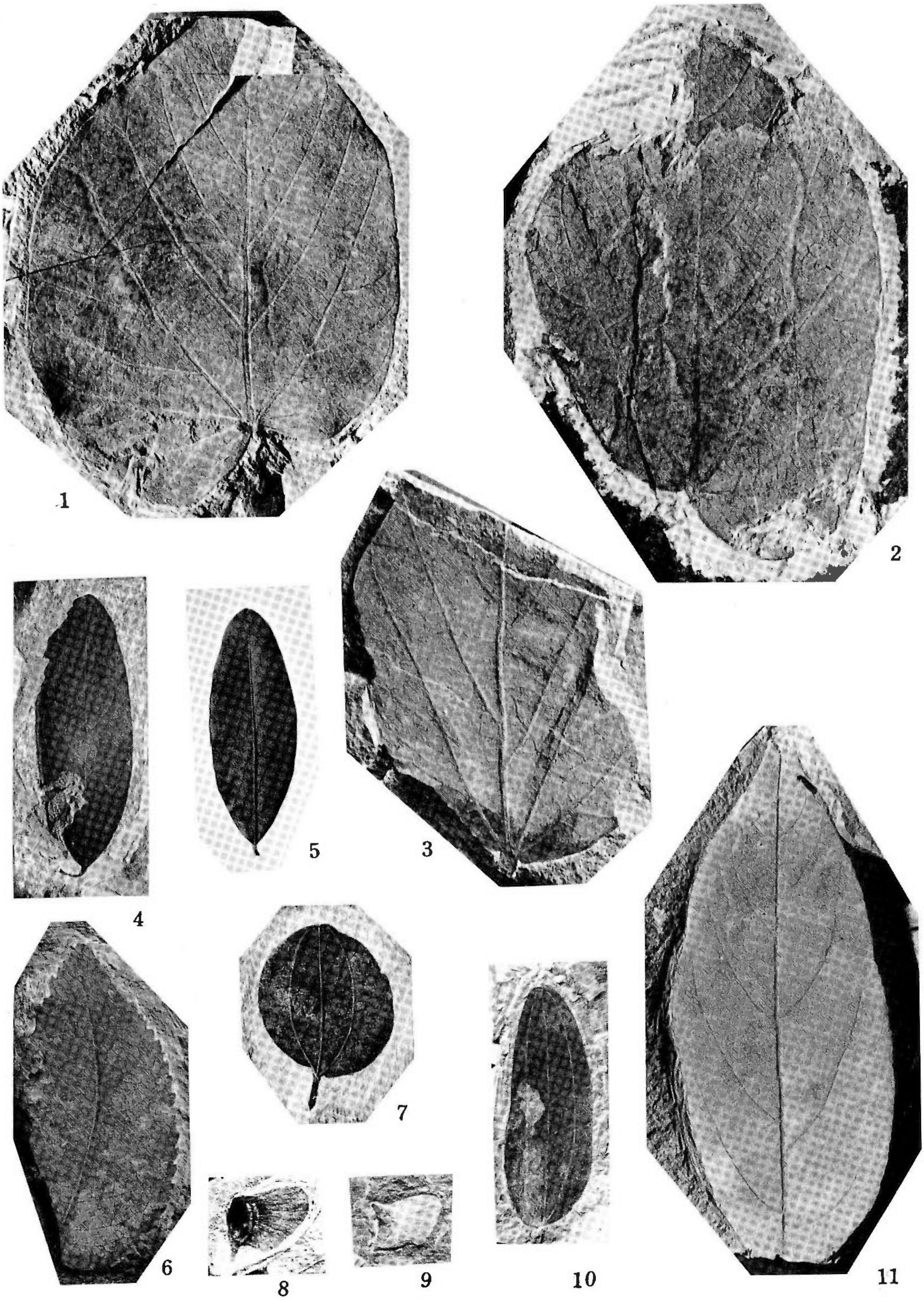
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- b. 岩石・鉱物
- c. 古生物
- d. 火山・温泉
- e. 地球物理
- f. 地球化学

B. 応用地質に関するもの
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- f. 物理探鉱・化学探鉱および試錐

C. そ の 他

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C. Miscellaneous

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地 質 調 査 所 報 告

第 248 号

IGI, S.: The metagabbros and related rocks of the "Yakuno Complex" in the inner zone of southwest Japan, 1973

第 249 号

尾崎次男：地下水位の観測記録，1973

第 250 号-1

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REPORT, GEOLOGICAL SURVEY OF JAPAN

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GEOLOGICAL SURVEY of JAPAN: Cretaceous granitic rocks in the Kitakami mountains—Petrography and zonal arrangement—, 1974 (in Japanese with English abstract)

No. 252

HASE, H.: Geologic remote sensing of the Kusatsu—Manza geothermal area, cenrtal Japan, 1974 (in English)

Onoe, T.

A Middle Miocene Flora from Oguni-machi, Yamagata Prefecture, Japan

Toru Onoe

Report, Geological Survey of Japan, no. 253, p. 1~64, 1974
10 illus., 14 pl., 7 tab.

The Oguni flora, found from Oguni-machi, southwestern part of Yamagata Prefecture is described in this paper. 659 specimens collected from the Imaichi and Oguni formations were examined and 61 species were determined. The flora was studied palaeoecologically, palaeoclimatically and biostratigraphically. In the result of this study, composition and stratigraphic position of this flora show a marked resemblance to the "Daijima-type flora", thus the flora is presumed Middle Miocene in geological age.

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