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The Noroshi Flora of Noto Peninsula, Central Japan

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Abstract

The beautiful abundant fossil plants are preserved in the lagoonal beds of the Yanagida formation in Noroshi area locating at the northeastern extremity of Noto Peninsula, sea-coast of central Japan. The Yanagida formation is mainly composed of dacite tuffs resting conformably on the Anamizu formation which consists mainly of andesites and makes a basal part of the Miocene in this part of the Green Tuff Region. The overlying Suzu formation has a rich fauna in the lower part, indicating the Middle Miocene age. The fossil plants of the Yanagida formation, the Noroshi flora, are obtained from tuffaceous shales about 10 m thick intercalated in the dacite tuffs of about 200 m in thickness.

The Noroshi flora is composed of 84 species which have living equivalents of 69 species in China, 51 in Japan, 15 in western North America, and 22 in eastern North America. The living equivalents of the Sub-element are found mostly in the warm temperate forests of southwest Japan. Many species of the Chinese Sub-element are found living in central China and Taiwan. Three associations are discriminated in the Noroshi flora, that is, lake border or flood plain and valley slope association. The former association consists of 41 species occupying 54.62% of the total number of specimens. Main species are Comptonia, Elaeocarpus, Liquidambar, Quercus, Rhus and Zelkova. A valley slope association includes 58 species attaining 74.60% in quantity. Representative species are Acer, Elaeocarpus, Keteleeria, Libocedrus, Perrottetia, Quercus, Rhus and Zelkova. A mountain association, such as Picea and *Pinus palaeopentaphylla*, is rather poor, represented by only 13 species, 0.81% of the all.

The annual precipitation of the Noroshi flora is assumed to have been at least 1,600 mm, presumably even as much as 2,000 mm. The coldest monthly mean temperature, the warmest mean temperature and the annual mean temperature are estimated to have been about 4–5°C, 26–27°C and 14.5–15.0°C, respectively. Autumn was the rainiest season, and even drier months have a precipitation of over 100 mm.

Comparing with the correlative Middle Miocene floras along the coast of the Sea of Japan, such as, those of Noto-nakajima in central Japan, of Utto in northeast Japan and of southwestern Hokkaido, the southern limit of the deciduous forest zone in Japan Sea side must have been nearly two degrees further north than the present position.

THE NOROSHI FLORA

INTRODUCTION

The Noroshi flora is preserved in the Yanagida formation, which is mainly composed of dacite tuff, as a facies of the "Miocene Green Tuff", and is widely exposed at the northeastern end of Noto Peninsula, Inner Central Japan. The geology of this region has been worked out by the following authors:— Ogawa, 1907, 1908; Mochizuki, 1932; Kubo and Suzuki, 1948; Otuka, 1949; Suzuki, 1950; Ichikawa, 1950; Nagahama, 1951; Akamine, 1952; Suzuki and Kitazaki, 1952; Suzuki and Kubo, 1953; Masuda, 1954. The first mention of fossil plants was by Endo and Morita, 1932, who recorded the occurrences of *Comptoniphyllum naumanni* from Noroshi-shin in their paper on the Genera Comptoniphyllum and Liquidambar. My own studies began in 1952 when I visited the area during the preparation of my graduation thesis. These have continued, and in 1959 were intensified as a part of a project made possible by a grant from the National Science Foundation of the United States, under the direction of Ralph W. Chaney of the University of California.

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GEOLOGIC OCCURRENCE

The principal plant-bearing outcrops of the Yanagida formation are in the environs of Noroshi-machi, at the northeastern end of Suzu City. During his first visit in 1952, the writer made a collection of fossil plants at the mountain pass near the sea between Orito and Takaya. These were listed in my graduation thesis proposed in the following year. There were 18 species in 15 genera and 12 families. In 1955, on the basis of larger collections from 14 localities, 36 species in 23 genera and 16 families were listed in the thesis for the Master of Science degree. After a further investigation of the same material, he published a paper on the general geology of Suzu City with Masuda as co-author in the Journal of the Geological Society of Japan, 1956. A collection from seven localities included the following 27 taxa, which fall in 23 genera and 15 families:

Metasequoia occidentalis
Taiwania sp.
Libocedrus sp.
Myrica naumanni
Pterocarya sp.
Betula sp.
Carpinus miocenica
Carpinus shimizui
Carpinus subyedoensis
Ostrya sp.
Cyclobalanopsis mandraliscae
Cyclobalanopsis sp.
Quercus subvariabilis
Fagus sp.
Celtis sp.
Zelkova ungeri
Liquidambar formosana
Cinnamomum miocenum
Machilus sp.
Gleditschia sp.
Podogonium knorrii
Rhus miosuccedanea
Acer paleodiabolicum
Acer subpictum
Dodonea japonica
Berchemia miofloribunda
Hemitrapa borealis

It will be noted that ten plants were too poorly represented to justify the specific assignment at that time; but later collections have made it possible to assign them specific names. Only one species, *Dodonea japonica* in the prior list is now rejected from the Noroshi flora, while many other species falling in some forty genera have been added.

Ishida and Masuda assigned the plant fossils to the Orito member of the Higashi-innai formation, which they described as follows: "The Orito member comprises greenish gray-coloured tuff breccia, lapilli tuff and pumiceous tuff, intercalating stratified fine tuff and tuffaceous mudstone and sandstone in which plant fossils are contained. This member is lacustrine and interfingers with Fujio member. The Middle Miocene age of the Fujio member is based on the occurrence in it of *Vicarya callosa japonica, Vicaryella notoensis,* Operculina and Miogypsina. The beds containing the plants are contemporaneous with or a little older than those containing the fossil invertebrates." This assignment was followed by Tanai in his paper entitled Neogene Floral Change in Japan, 1961.

Between 1956 and 1958, the writer has worked out the geology of the area

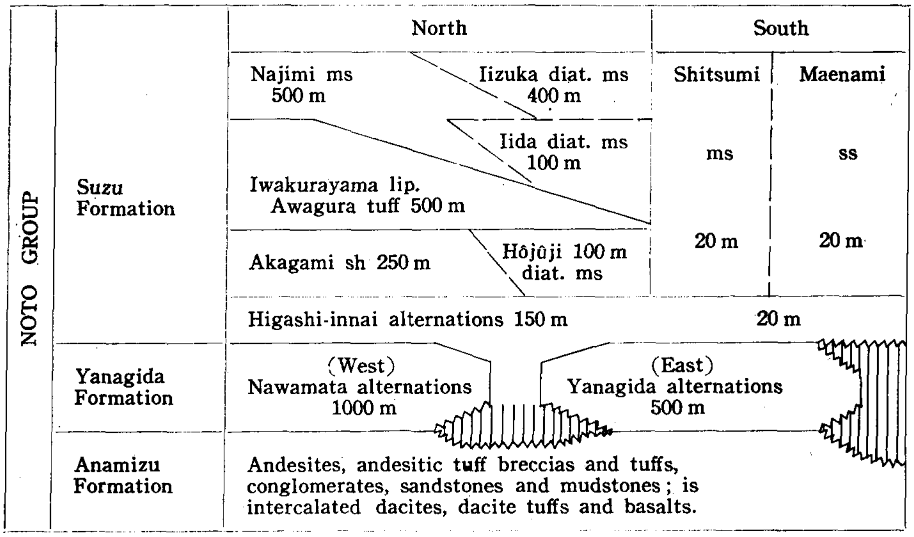

Fig. 1. Division and correlation of the Neogene formations of Noto Peninsula (S. ISHIDA, 1959).

surrounding Suzu City, and has made additional collections from the seven localities which provided the material for his 1956 paper. On the basis of these later stratigraphic studies, he has came to a conclusion that the Orito member is overlain by the Fujio member, and that it corresponds to the Yanagida formation as recognized in other areas of Noto. These relations are shown by the section in figure 1 of the present paper, and are discussed in my paper on the Cenozoic Strata of Noto (1959) as follows: "The Yanagida formation, consisting of dacites, basalts and dacite tuffaceous sediments about 500 m thick, lies over the basal Anamizu formation which consists of alternating andesites, andesite tuffs and its tuff breccias and conglomerates with alternations of sandstone and mudstone.

"In the northeast end of the peninsula, the dacite tuff, about 200 m thick, intercalates the light orange- and light gray-coloured tuffaceous shales about 10 m thick with the plant fossils. The tuff conformably overlies the alternations of conglomerate, sandstone and shale of the Anamizu. The sandstones of the alternations contain some foraminifers. The tuffaceous shales of the Yanagida have in them the fossil plants, and do not give any evidence for the marine origin, but there is a lacustrine form, Hemitrapa.

"The Suzu formation conformably overlies the Yanagida. The Higashi-innai alternations is the lowest member of the Suzu formation, about 150 m thick. The lower part of the Higashi-innai consists of alternations of conglomerate, sandstone and mudstone. The characteristics of conglomerates relate to the basements

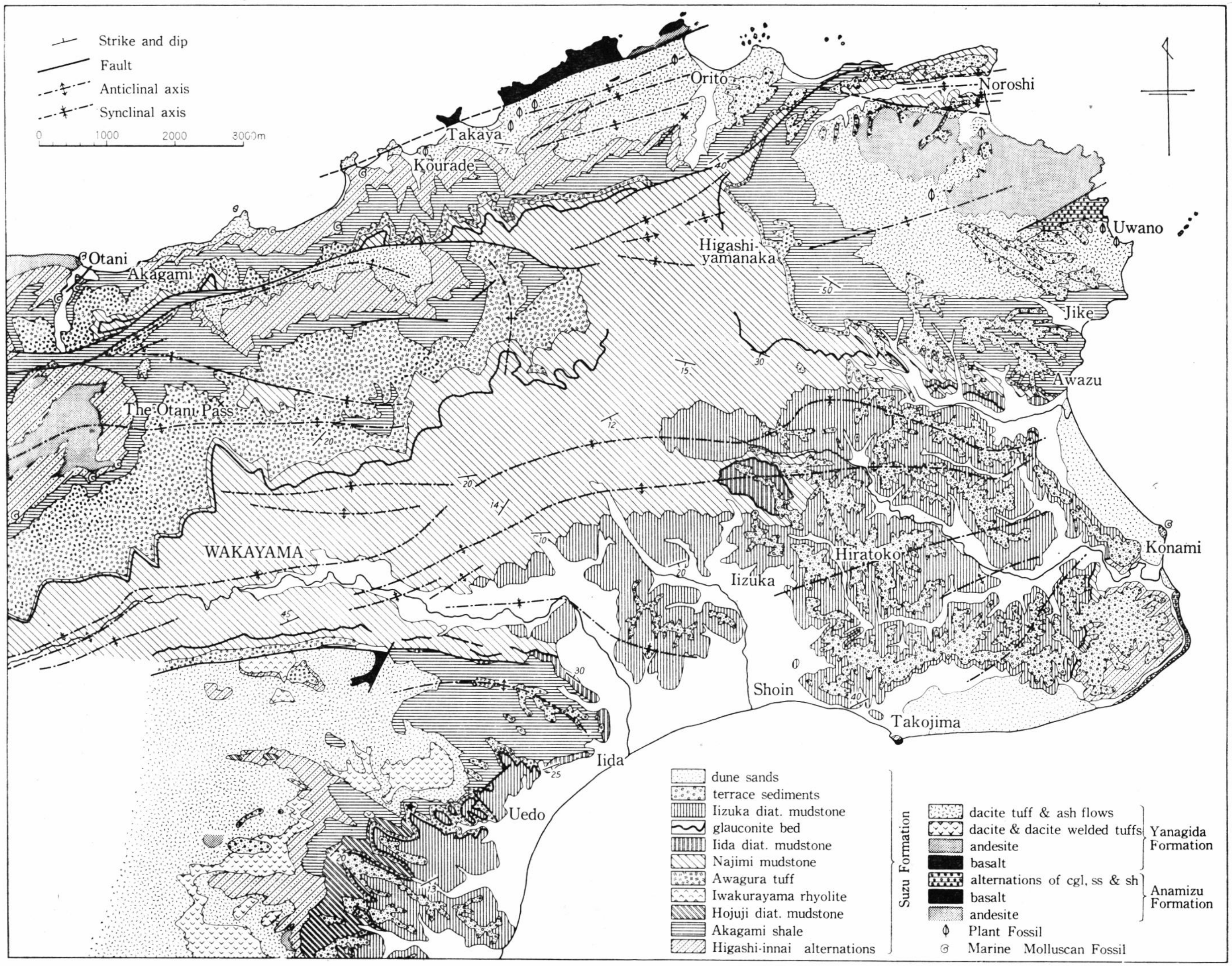

Fig. 2. Geological map in northeastern part of Noto Peninsula.

in situ. They are rich in marine origanisms such as: *Miogypsina kotoi*, *Operculina complanata japonica*, *Astriclypeus manni*, Bryozoa, *Protolobophyllia* sp., *Meandra* sp., *Montastrea* sp., *Lithothamnium* sp. The fossil fauna shows a shallow and warm environment and contains some mollusks as follows: *Anadara kurosedaniensis*, *Ostrea* sp., *Ctena* sp., *Turbo parvuloides*, *Nerita* sp., *Cypraea* sp., *Proterato* sp., *Vicaryella notoensis*, *Conus tokunagai*. Akagami shale overlying the Higashi-innai is gray or light orange in colour, siliceous and hard, about 250 m thick, with *Sagarites chitanii* and some foraminifers. It yields *Paramusium* sp. and *Shizaster* sp. in the lower part. At the northeast end, the Akagami is thick and overlies the dacite tuff of the Yanagida."

Recently Mr. Yasuyo Noguchi, Suita High School in Osaka Prefecture, studied the diatom fossils of the plant bed, and has recognized the taxa listed in Table 1. They indicate a lagoonal environment in a warm, shallow sea.

TABLE 1

Fossil diatom from Noroshi plant bed (Y. Noguchi)

		1	2	3	4	5	
Coscinodiscus	argus			×			marine
C.	asteromphalus		×				marine
C.	brockmanni			×			marine
C.	decrescens	×					marine
C.	devisius			×			marine
C.	endoi	×					marine
C.	cf. lacustris	×					marine to brackish
C.	morginatus	×					marine
C.	oculis iridis	×	×			×	marine
C.	rothii		×				marine
C.	soloensis			×			marine
C.	cf. wailesii				×		marine
Diploneis smithii						×	fresh water to brackish
Melosira salcata		×		×			marine
Nitzshia sp.			×				marine to brackish

Sample 1. Tuffaceous shale with fossil plants (2 m low from top of 6 m thick) at 500 m west of Kourade, one of the Noroshi plant localities.

Sample 2. Coaly mudstone about 10 m below Sample 1.

Sample 3. Lower part of tuffaceous shale east of Takaya, one of the Noroshi plant localities.

Sample 4. Upper part of tuffaceous shale east of Takaya.

Sample 5. Tuffaceous shale of Orito, one of the Noroshi plant localities.

The framework of Noto Peninsula is composed of andesites, andesite tuff-breccia and tuff, and alternations of conglomerate and sandstone. These were deposited in fresh water, and locally there was terrestrial eruption. In the north-eastern end of Noto there was marine deposition during the last stage of sediment-ation. Successively dacite and basalt were erupted, and dacite-welded tuffs, mainly ash-flows, were deposited in wide areas over middle Noto. To the northeast Noto dacite-tuffaceous sediments were deposited in marine embayments. The tuffaceous shales containing fossil plants accumulated during times of arrested volcanic activity. Silicified driftwood is found here and there in tuff-breccias and tuffs. The uppermost of these may have been laid down in the sea just prior to a wide transgression. Conglomerates and sandstones were deposited around islands of andesite; these contain a warm-water fauna. Shales were deposited on dacite tuff off-shore. As the depression and transgression progressed, uniformly muddy sediments of the Akagami member were deposited over a wide area.

During the 1959 and 1960 field seasons, the writer made a fairly large collection from another locality at Takaya, comprising some one thousand specimens. Noro-shi seems to be more appropriate than the prior name Orito, since some of the Orito localities of the Higashi-innai formation are now known to be part of the Yanagida formation subjacent to the Higashi-innai. The hamlet of Noroshi is a well-known place in Ishikawa Prefecture, and is located at the northeastern end of Noto Peninsula.

Following are descriptions of the eight localities in the Yanagida formation.

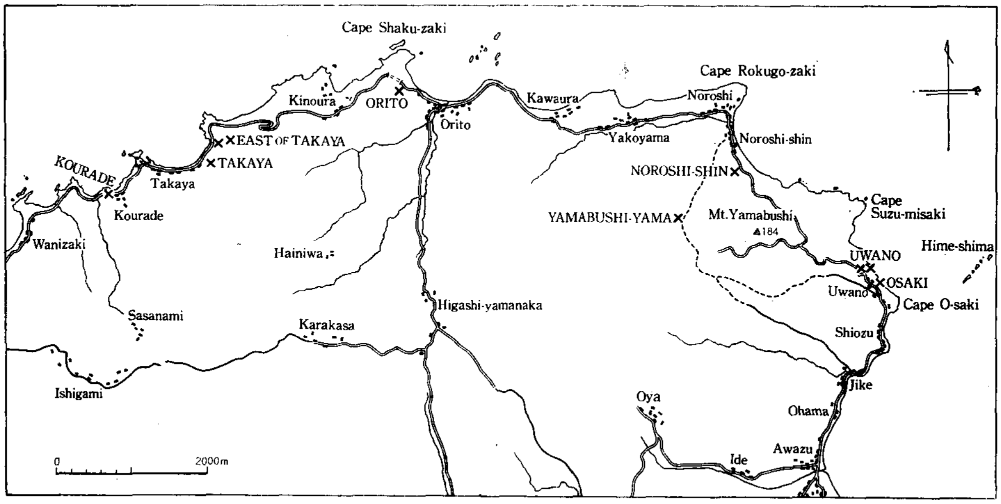

Fig. 3. Locality map of Noroshi flora in Noto Peninsula.

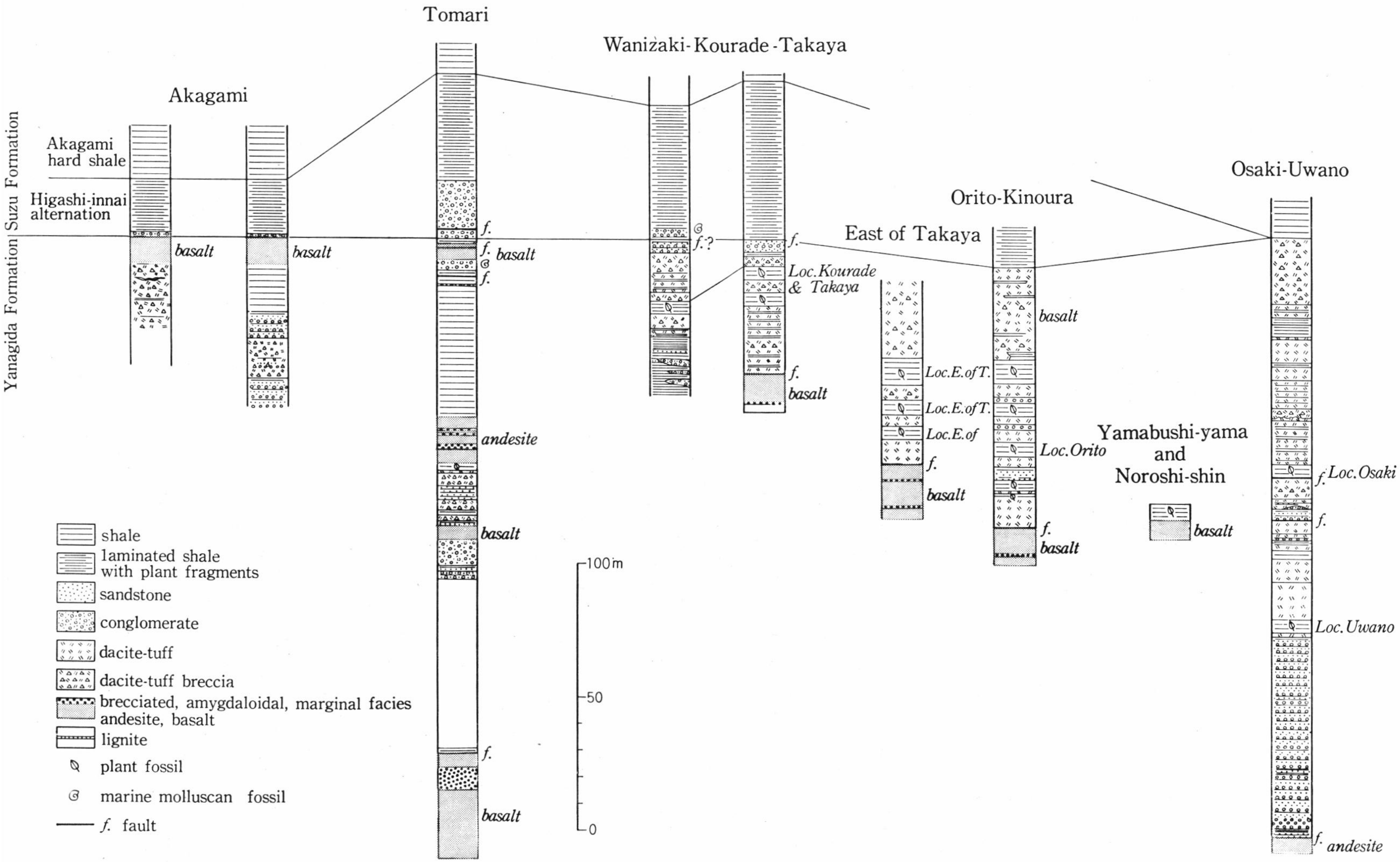

Fig. 4. Geological columns of area near eight localities of Noroshi flora.

Kourade. Road-side cuts at the west end of Kourade, Takaya-machi, Suzu City. Dacite tuff and tuffaceous shale are exposed in alternating layers, with a 30° dip toward the south. The section shows:

Top		Thickness in meters
(4)	Dacite tuff associated with granular dacite breccias	3
(3)	Tuffaceous shale with thin layers of fine tuff containing plant remains	6
(2)	Dacite tuff, partly granule and pebble breccias	2
(1)	Dacite tuffs and bituminous shales alternating	10

Takaya. About 20 meters south of a house at the east end of Takaya. Tuffaceous shale only a meter thick is exposed here, with a dip about 10° to northwest.

East of Takaya. Along a path, at about 1 kilometer east of Takaya, tuffaceous shale dipping 10° southward shows the following section:

Top		Thickness in meters
(3)	Dacite pebble tuff breccia	5
(2)	Tuffaceous shale containing abundant plant remains	6
(1)	Dark and light yellow tuffs, dark green tuff and tuff breccias, with silicified wood	40

Orito. A path-side exposure, *en route* between Orito and Kinoura, Orito-machi, Suzu City. Here the section shows:

Top		Thickness in meters
(3)	Alternating layers of tuff and tuffaceous shale	5
(2)	Tuffaceous mudstone containing a few impressions of leaves and seeds	2
(1)	Dacite tuff breccia	10

Yamabushi-yama. Tuffaceous shale about a meter thick is exposed for 20 meters upon the ground of a mountain path 1.5 kilometers southwest of Noroshi-shin, Noroshi-machi, Suzu City.

Noroshi-shin. Along a path about 20 meters west of the main road, 200 meters south of Noroshi-shin, an exposure of a meter of finely laminated white tuff and tuffaceous shale containing leaf impressions, underlain by 3 meters of tuffaceous shale.

Uwano. A high coastal cliff at Misaki-machi, Suzu City, two meters of dacite tuff are underlain by 3 meters of tuffaceous shale containing leaf and fruit impressions.

Osaki. At Misaki-machi, 200 meters west of Osaki, the low coastal cliff shows tuffaceous shales dipping southwards at about 30°. Here ten meters of coarser tuff are underlain by five meters of tuffaceous shale with leaf and fruit impressions.

COMPOSITION

The Noroshi flora contains 33 families, — Polypodiaceae of ferns, four families of conifers, and 28 of angiosperms. All except four genera are now living in eastern Asia. Several of them are found in southern China and Taiwan, and are not recorded in Japan. The families and genera represented indicate that the Noroshi is largely a part of the Arcto-Tertiary Geoflora of the northern Hemisphere, though there is also a minority representation of the Paleotropical-Tertiary Geoflora. There are considerable numbers of such typical temperate families as Pinaceae, Taxodiaceae, Juglandaceae, Betulaceae, Fagaceae, Leguminosae and Aceraceae. Three genera of Pinaceae, three genera of Betulaceae, a genus of Juglandaceae, four species of Acer, indicate a lower representation than has been recorded from the Neogene floras of northeastern Japan, while six genera of Taxodiaceae and nine genera of Leguminosae, neither of which are typically temperate families, are found in larger numbers. The genus Quercus, one of four genera of Fagaceae, is represented largely by evergreen oaks, and Fagus is not common. New discoveries of Palmae and Elaeocarpaceae are a noteworthy addition to the Neogene floras of Japan. This flora and the adjacent Noto-nakajima (Matsuo, 1962) are not typical indicators of temperate climate as in the case with the more northerly Middle Miocene Daijiman floras of Japan. The latter contain Pterocarya, Betula, Ostrya, Castanea and Acer, none of which are members of the Noto-nakajima flora, and with the exception of Acer are poorly represented from the Noroshi. Both the floras of Noto Peninsula include *Diploclisia notoensis*, *Ternstroemia maekawai* and *Osmanthus chaneyi*, though in small numbers; none of these are recorded from flora of the same age farther north. In addition the occurrence of evergreen oaks and Camellia give the Noto Peninsula floras a warm temperate aspect.

Sixty-six genera have been designated. From the total of 84 species, five are not represented by material which is sufficiently well preserved to warrant their assignment to specific status. A fruit is referred to Incertae Sedis with no taxonomic status. Podogonium and Hemitrapa are assigned to extinct genera. Twelve species are described as new.

Most of the fossils are represented by leaf impressions. Fruits or seeds of the following genera are at hand: Keteleeria, Picea, Pinus, Metasequoia, Sequoiadendron, Taiwania, Libocedrus, Pterocarya, Betula, Carpinus, Ostrya, Zelkova, Liquidambar, Eucommia, Cladrastis, Milletia, Podogonium, Ailanthus, Acer, Fraxinus, Hemitrapa. A list of the members of the Noroshi flora is given here:

Systematic List of Families and Species

Polypodiaceae
- Onoclea sp.
- Athyrium sp.

Taxaceae
- Torreya yoshiokaensis Tanai and Suzuki

Pinaceae
- Keteleeria ezoana Tanai
- Picea kaneharai Tanai and Onoe
- Pinus miocenica Tanai
- Pinus oishii new species
- Pinus palaeopentaphylla Tanai and Onoe

Taxodiaceae
- Cunninghamia protokonishii Tanai and Onoe
- Glyptostrobus europaeus (Brongniart) Heer
- Metasequoia occidentalis (Newberry) Chaney
- Sequoia langsdorfi (Brongniart) Heer
- Sequoiadendron primarium Miki
- Taiwania japonica Tanai and Onoe

Cupressaceae
- Libocedrus notoensis (Matsuo) new combination
- Thuja nipponica Tanai and Onoe

Palmae
- Livistona sp.

Liliaceae
- Smilax trinervis Morita

Salicaceae
- Populus tuberculata new species

Myricaceae
- Comptonia naumanni (Nathorst)Huzioka

Juglandaceae
- Pterocarya asymmetrosa Konno
- Pterocarya ezoana Tanai
- Pterocarya protostenoptera Tanai

Betulaceae
- Betula sekiensis Huzioka and Nishida
- Betula uzenensis Tanai
- Carpinus miocenica Tanai
- Carpinus mioturczaninowii Hu and Chaney
- Carpinus subyedoensis Konno
- Ostrya shiragiana Huzioka

Fagaceae
- Castanea miomollissima Hu and Chaney
- Castanopsis miocuspidata Matsuo
- Fagus sp.
- Quercus(Cyclobalanopsis) mandraliscae Gaudin
- Quercus miovariabilis Hu and Chaney
- Quercus(Cyclobalanopsis) nathorstii Kryshtofovich
- Quercus(Cylocbalanopsis) praegilva Kryshtofovich
- Quercus ament

Ulmaceae
- Celtis miobungeana Hu and Chaney
- Ulmus subparvifolia Nathorst
- Zelkova ungeri (Ettingshausen)Kovats

Menispermaceae
- Diploclisia notoensis new species

Magnoliaceae
- Magnolia miocenica Hu and Chaney
- Michelia notoensis new species

Lauraceae
- Cinnamomum miocenum Morita
- Cinnamomum oguniense Morita
- Machilus nathorsti Huzioka
- Machilus ugoana Huzioka

Hamamelidaceae
- Liquidambar miosinica Hu and Chaney
- Parrotia fagifolia (Goeppert)Heer

Sycopsis chaneyi new species
Rosaceae
Rosa usyuensis Tanai
Eucommiaceae
Eucommia japonica Tanai
Leguminosae
Albizzia miokalkora Hu and Chaney
Cassia notoensis new species
Cladrastis aniensis Huzioka
Entada mioformosana Tanai
Gleditschia miosinensis Hu and Chaney
Milletia notoensis new species
Mucuna chaneyi new species
Podogonium knorrii A. Brown
Wistaria fallax (Nathorst)Tanai and Onoe
Simaroubaceae
Ailanthus yezoensis Oishi and Huzioka
Buxaceae
Buxus protojaponica Tanai and Onoe
Anacardiaceae
Pistacia miochinensis Hu and Chaney
Rhus miosuccedanea Hu and Chaney
Rhus protoambigua Suzuki
Celastraceae
Perrottetia notoensis new species
Aceraceae
Acer ezoanum Oishi and Huzioka
Acer palaeodiabolicum Endo
Acer protojaponicum Tanai and Onoe
Acer subpictum Saporta
Rhamnaceae
Berchemia miofloribunda Hu and Chaney
Paliurus protonipponicus Suzuki
Elaeocarpaceae
Elaeocarpus notoensis new species
Theaceae
Camellia protojaponica Huzioka
Ternstroemia maekawai Matsuo
Elaeagnaceae

Elaeagnus mikii new species

Alangiaceae

Alangium aequalifolium (Goeppert)Kryshtofovich and Borsuk

Cornaceae

Cornus megaphylla Hu and Chaney

Oleaceae

Fraxinus honshuensis Miki

Osmanthus chaneyi Matsuo

Syringa notoensis new species

Trapellaceae

Hemitrapa yokoyamae (Nathorst)Miki

Incertae Sedis

Carpolithes japonica (Morita) new combination

Miss Akiko Tai, of the Kamogawa Middle School, Kyoto Prefecture, has identified the following genera of pollen from the Takaya locality, in 14 families and 20 genera. Starred genera and families are also represented by megafossils in the Noroshi flora.

List of Microfossils

Filicineae
- Gleicheniaceae

Gymnospermae
- Pinaceae
  - *Keteleeria
  - *Picea
  - *Pinus
  - Pseudolarix
  - Pseudotsuga
  - Tsuga
- Taxodiaceae
  - *Metasequoia — *Sequoia
  - *Cunninghamia
  - *Cupressaceae — *Taxaceae

Angiospermae
- Gramineae
- Salicaceae
  - Salix

Juglandaceae
- Carya ?
- Juglans — *Pterocarya

Betulaceae
- Alnus
- Corylus

Fagaceae
- *Quercus

Fagaceae — Nyssaceae
- *Fagus — Nyssa ?

Ulmaceae
- *Ulmus — *Zelkova

Caryophyllaceae
- Stellaria

Hamamelidaceae
- *Liquidambar ?

Aquifoliaceae
- Ilex

Ericaceae

The pollen of Quercus, making up 21 per cent of the total, show the characters of evergreen oaks (Cyclobalanopsis), and reflect their abundance as megafossils. Pollen identified only as Cupressaceae — Taxaceae represent 12 per cent of the total; the genus Libocedrus is abundant in the megafossil record. Although Pinus and Picea produce winged pollen in large quantities and are easily recognized, their pollen are included in relatively small quantity in this flora.

Numerical Representation

The collection contains 1,480 specimens, of which nearly one half have been obtained from the Takaya locality, and a total of three fourths from localities in the Takaya environs.

An exceptionally large number of species appear to have been abundant in the Noroshi forest. Six conifers and 20 angiosperms of the 84 species are each represented by more than one per cent. The samples of this group of numerous species make some 80 per cent of the total. Ten species of the remainder, including the two ferns, are represented by only a single specimen. This poor representation, especially in the case of the ferns, is by no means reliable evidence of their rarity in the forest; fern fronds commonly dry and become readily disintegrated if separated from the parent plants; even pinnae or pinnules are seldom detached as units. But in case of the Noroshi flora, as well as other Neogene floras, ferns were probably scarce in comparison with the Paleogene floras in this country and in western North America. It is also conceivable that no ferns had large fronds in the Neogene.

Only 2 species, *Zelkova ungeri* and *Acer subpictum,* occur at all 8 localities, although the most abundant species, *Zelkova ungeri,* is rare at 3 localities, and *Acer subpictum* at 4 localities; the latter form is represented only by samaras at 4 localities. *Podogonium knorrii, Comptonia naumanni* and *Quercus miovariabilis* are missing from only one locality. Almost all of the records of *Libocedrus notoensis, Keteleeria ezoana, Sycopsis chaneyi, Perrottetia notoensis,* and *Taiwania japonica* are of foliage. It will be mentioned that in contrast to some of the species not well represented, these specified easily determinable species have leaves or fruits suitable for preservation, and that their relative frequencies may be more apparent than real. It is worthy of note that this group of well-represented species include about half of the known conifers of the Noroshi flora, and that the Noroshi forest was of a mixed-deciduous type. Considering the absence of *Metasequoia occidentalis* at three localities, and its relatively infrequent occurrence at the other localities, there is a certain consistency with the Noto-nakajima flora, described by Matsuo, 1963 (p. 225). Chaney,

TABLE 2

Numerical representation of Noroshi species

Note: Unless otherwise indicated the specimens represent leaves.

Species	Number of specimens at localities 1	2	3	4	5	6	7	8	Total	Per cent
Zelkova ungeri (total)	9	42	60	2	65	16	2	2	198	13.42
Leaves	(7)	(37)	(47)	(2)	(64)	(16)	(2)	(2)	(177)	
Branchlets	(2)	(5)	(13)		(1)				(21)	
Libocedrus notoensis (total)	1	63	30	15			3	1	113	7.66
Foliage branchlets	(1)	(61)	(30)	(15)			(3)	(1)	(111)	
Pistillate cones		(2)							(2)	
Podogonium knorrii (total)		17	29	22	8	3	9	6	94	6.37
Leaflets		(13)	(25)	(22)	(8)	(2)	(7)	(6)	(83)	
Pods		(4)	(4)			(1)	(2)		(11)	
Comptonia naumanni	8	26	19		16	6	4	5	84	5.69
Keteleeria ezoana (total)	9	33	5	2		1	8	1	59	4.00
Leaves	(8)	(23)	(2)	(1)		(1)	(6)		(41)	
Seeds	(1)	(10)	(3)	(1)			(2)	(1)	(18)	
Sycopsis chaneyi		28	16	1		1		3	49	3.32
Quercus miovariabilis	13	5	9	5	2		6	7	47	3.19
Perrottetia notoensis	4	19	15	1			2	3	44	2.98
Quercus nathorstii	1	34	7				1		43	2.92
Rhus miosuccedanea (Leaflets)		23	16		2		2		43	2.92
Quercus mandraliscae	6	25	9	1				1	42	2.85
Acer subpictum (total)	1	14	6	1	11	5	1	1	40	2.71
Leaves	(1)	(10)	(5)			(3)	(1)		(20)	
Samaras		(4)	(1)	(1)	(11)	(2)		(1)	(20)	
Liquidambar miosinica (total)	2	23	9		1			1	36	2.44
Leaves	(1)	(11)	(5)		(1)			(1)	(19)	
Fruits	(1)	(12)	(4)						(17)	
Elaeocarpus notoensis		28	3						31	2.10
Quercus praegilva		18	11					1	30	2.03
Carpinus mioturczaninowii (total)	4	4	5	3			11	2	29	1.96
Leaves		(3)	(2)	(1)			(4)	(1)	(11)	
Bracts	(4)	(1)	(3)	(2)			(7)	(1)	(18)	
Carpinus subyedoensis (total)	5	7	10		1		2	3	28	1.90
Leaves	(3)	(6)	(8)				(1)	(1)	(19)	
Bracts	(2)	(1)	(2)		(1)		(1)	(2)	(9)	
Taiwania japonica (total)	3	6	8	1			3	3	24	1.63
Foliage branchlets	(3)	(6)	(7)	(1)			(3)	(3)	(23)	
Pistillate cone			(1)						(1)	
Carpolithes japonica (Capsules)	3	6	10	3			2		24	1.63
Pinus oishii (total)	1	9	8	2			2		22	1.49
Fascicles		(5)	(2)						(7)	
Staminate aments	(1)	(4)	(6)	(2)			(2)		(15)	
Populus tuberculata		12	8						20	1.36
Mucuna chaneyi		14	4				1		19	1.28
Cladrastis aniensis (total)	3	12	3						18	1.22

TABLE 2—*Continued*

Species	1	2	3	4	5	6	7	8	Total	Per cent
	Number of specimens at localities									
Leaflets	(3)	(12)	(2)						(17)	
Pod			(1)						(1)	
Torreya yoshiokaensis (total)	4	4	3				2	2	15	1.02
Leaves	(4)	(4)	(2)				(2)	(2)	(14)	
Branchlet			(1)						(1)	
Castanea miomollissima		6	3	1		2	3		15	1.02
Metasequoia occidentalis (total)	1				5	1	5	3	15	1.02
Foliage shoots	(1)				(4)	(1)	(4)	(3)	(13)	
Seeds					(1)		(1)		(2)	
Sequoiadendron primarium (Foliage shoots)		8	6						14	0.95
Michelia notoensis		9	5						14	0.95
Albizzia miokalkora (Leaflets)		6	6	1				1	14	0.95
Fraxinus honshuensis (Samaras)		6	3				2	3	14	0.95
Machilus ugoana	1	5	3				2	2	13	0.88
Picea kaneharai (Seeds)		1	8	2					11	0.75
Sequoia langsdorfii (Foliage shoots)		5	3				2		10	0.68
Elaeagnus mikii		6	4						10	0.68
Pterocarya asymmetrosa (total)	2	3	4						9	0.61
Leaflets	(2)	(2)	(3)						(7)	
Fruits		(1)	(1)						(2)	
Milletia notoensis (total)	2	4	1					2	9	0.61
Leaflet	(1)								(1)	
Pods	(1)	(4)	(1)				(2)		(8)	
Acer palaeodiabolicum (Samaras)			2		7				9	0.61
Camellia protojaponica		9							9	0.61
Simlax trinervis		3	3	2					8	0.54
Carpinus miocenica (total)		1	1	1	1		4		8	0.54
Leaves		(1)	(1)	(1)	(1)		(2)		(6)	
Bract							(1)		(1)	
Diploclisia notoensis		6	2						8	0.54
Cinnamomum miocenum		5	2					1	8	0.5y
Entada mioformosana (Leaflets)	1	4	2				1		8	0.54
Pterocarya ezoana (total)		3	1	1				1	6	0.41
Leaflets		(1)	(1)	(1)				(1)	(4)	
Fruits		(2)							(2)	
Castanopsis miocuspidata		4	2						6	0.41
Gleditschia miosinensis (Leaflets)		5			1				6	0.41
Hemitrapa yokoyamae (Nuts)		3	2				1		6	0.41
Pinus miocenica (total)		3	2						5	0.34
Staminate ament		(1)							(1)	
Seeds		(2)	(2)						(4)	
Cunninghamia protokonishii (Foliage shoots)		3	2						5	0.34
Glyptostrobus europaeus (Foliage shoots)		5							5	0.34

TABLE 2—*Continued*

Species	Number of specimens at localities 1	2	3	4	5	6	7	8	Total	Per cent
Pterocarya protostenoptera (Fruits)		4					1		5	0.34
Cassia notoensis (Leaflets)		1	4						5	0.34
Ulmus subparvifolia				3			1		4	0.27
Cinnamomum oguniense		3	1						4	0.27
Machilus nathorsti	1	1	1	1					4	0.27
Paliurus protonipponicus	1	3							4	0.27
Ternstroemia maekawai		2	1			1			4	0.27
Betula uzenensis		2						1	3	0.20
Betula sekiensis (total)	1		1				1		3	0.20
Leaf	(1)								(1)	
Seeds			(1)				(1)		(2)	
Ostrya shiragiana (total)	1		1					1	3	0.20
Leaves	(1)		(1)						(2)	
Bract								(1)	(1)	
Wistaria fallax (Leaflets)		2				1			3	0.20
Pistacia miochinensis (Leaflets)		2				1			3	0.20
Rhus protoambigua (Leaflets)		2	1						3	0.20
Acer protojaponicum (Samaras)		1	1		1				3	0.20
Berchemia miofloribunda		1		1			1		3	0.20
Osmanthus chaneyi		3							3	0.20
Fagus sp.				1	1				2	0.14
Quercus sp. (Staminate aments)		1	1						2	0.14
Celtis miobungeana				1	1				2	0.14
Magnolia miocenica		1	1						2	0.14
Parrotia fagifolia					2				2	0.14
Eucommia japonica (Fruits)		1	1						2	0.14
Buxus protojaponica		1	1						2	0.14
Acer ezoanum (total)					1		1		2	0.14
Leaf					(1)				(1)	
Samara							(1)		(1)	
Onoclea sp.			1						1	0.06
Athyrium sp.		1							1	0.06
Pinus palaeopentaphylla (Fascicle)			1						1	0.06
Thuja nipponica (Foliage branchlet)		1							1	0.06
Livistona sp. (Isolated ray)		1							1	0.06
Rosa usyuensis (Leaflet)			1						1	0.06
Ailanthus yezoensis (Fruit)			1						1	0.06
Alangium aequalifolium		1							1	0.06
Cornus megaphylla		1							1	0.06
Syringa notoensis		1							1	0.06
Totals	88	622	392	71	126	39	85	57	1,480	

Localities:
1. Kourade
2. Takaya
3. East of Takaya
4. Orito
5. Yamabushi-yama
6. Noroshi-shin
7. Uwano
8. Osaki

1924, 1959 (pp. 22–26) and Suzuki, 1959 (pp. 20–28) discuss the several factors which may affect the numerical representation of modern plants in contemporary deposits, and of fossil plants in those of Tertiary age. The conclusion is that the important factor is proximity of plants to sites of deposition, and that the rare species may generally be considered to have lived in situations remote from these sites.

PALEOECOLOGY

Most of the genera of the Noroshi flora are still living, and modern equivalents of its species can be found with a few exceptions. An assumption that the modern plants reflect environments of the similar Tertiary plants seems to be not at all unreasonable, but care must be paid in the procedure. The abundant species provide the most reliable evidence. Small number occurrences have to be examined in case certain forms were derived from high places. In such cases the proposition must be checked by the geologic criteria, for instance the lithofacies of the sediment containing the flora. Known orogenic history of the region should also be considered. Rarity itself may be due to the sparse existence of that species in the forest. Infrequent occurrence of a given living species in a modern forest may reflect its relict existence, although this may be difficult to ascertain. Comparisons of the representation of such species in floras of succeeding age in one area may provide clues as to whether they are being eliminated, whether they may just be establishing themselves, or whether they actually represent upland species whose remains were less frequently brought down to sites of deposition in the lowlands, even though they may have been abundant members of the vegetation at the elevations they occupied.

Physical Conditions Indicated by the Flora

Distributional Considerations

European scientists made much progress in the study of Tertiary floras in the 19th century. Oswald Heer, the pioneer in this field, has pointed out in his Flora Fossilis Arctica, 1868, that there were intercontinental relationships between floras of this age. Previous to this opinion, Gray mentioned the resemblance between the living vegetation of Japan and that of the United States (1846). The linkage between the Tertiary and the living forests is a subject of paramount importance when dealing with the history of plants.

Study of Tertiary floras in eastern Asia began much later than in Europe and

North America. Japan is blessed with an abundance of Tertiary floras, which attracted the interest of Nathorst and Kryshtofovich, followed by numerous contemporary paleobotanists. Colani in Indo-china, Hu and Chaney in Shantung, Florin in Manchuria, and Kryshtofovich in Siberia, have made noteworthy contributions, though the area involved represent only small parts of an extensive area. These works are listed in the bibliography; they are concerned with the macrofossils only.

To the interest of Japanese paleobotanists, there are a considerable number of survivals that are extinct in other countries. Some of these surviving genera are found in Japan, and others are known in central and southern China, as well as in Taiwan, as shown in Table 3.

Modern Distribution of Noroshi Genera

We can make approximate estimates of the physical conditions of Noroshi time by considering the distribution of the genera in terms of latitude and altitude. Only Parrotia is not now living in eastern Asia or North America, laying aside the extinct genera, Podogonium and Hemitrapa. Actually, however, the determination of Parrotia is still in doubt, for the leaves of Hamamelis and Fothergilla also resemble our fossils. Hamamelis grows in eastern Asia and eastern North America, and Fothergilla in eastern North America. Among the other 63 genera, there are only three that are not living in eastern Asia; two monospecific genera, Sequoia and Sequoiadendron, are confined to western North America; Comptonia is represented by a species in the eastern United States. Fourty eight genera now live in Japan, all of which are found elsewhere in eastern Asia. Of the 12 Asiatic genera not now native to Japan, none is living farther north, and most of them range farther south. At these lower latitudes they largely occupy upland habitats. They grow well if transplanted in Honshu, Shikoku and Kyushu. They became extinct in Japan during the severe climates of Plio-Pleistocene. Although the climate has improved later, there has been no migration route available from the continent.

Thirty genera live in the eastern part and 21 in the western part of North America. Most of these are members of the Arcto-Tertiary Geoflora, of which Picea, Pinus, Betula, Carpinus, Ostrya, Quercus, Castanea, Ulmus and Acer are the characteristic genera. The Noroshi genera still found living in eastern Asia are also largely members of the Arcto-Tertiary Geoflora, with a minority representation of members of the Paleotropical-Tertiary Geoflora.

All of the Noroshi genera now found living in Central and South China and Taiwan show that the flora lived in the warm temperate zone with the exception

TABLE 3

Present-day distribution of the Noroshi genera

Genus	East Asia		North America		Genus	East Asia		North America	
	China	Japan	Western	Eastern		China	Japan	Western	Eastern
Onoclea	×	×	...	×	Cinnamomum	×	×	...	...
Athyrium	×	×	×	×	Machilus	×	×	...	...
Torreya	×	×	×	×	Liquidambar	×	...	...	×
Keteleeria	×	...	...	...	Parrotia*	...	...	...	...
Picea	×	×	×	×	Sycopsis	×	×	...	...
Pinus	×	×	×	×	Rosa	×	×	×	×
Cunninghamia	×	...	...	...	Eucommia	×	...	...	...
Glyptostrobus	×	...	...	...	Albizzia	×	×	...	...
Metasequoia	×	...	...	...	Cassia	×	×	...	...
Sequoia	...	...	×	...	Cladrastis	×	×	...	×
Sequoiadendron	...	...	×	...	Entada	×	×	...	...
Taiwania	×	...	...	...	Gleditschia	×	×	...	×
Libocedrus	×	...	×	...	Milletia	×	×	...	...
Thuja	×	×	×	×	Mucuna	×	×	...	...
Livistona	×	×	...	...	Wistaria	×	×	...	×
Smilax	×	×	×	×	Ailanthus	×	...	...	...
Populus	×	×	×	×	Buxus	×	×	...	...
Comptonia	...	...	...	×	Pistacia	×	...	...	...
Pterocarya	×	×	...	...	Rhus	×	×	×	×
Betula	×	×	...	×	Perrottetia	×	...	...	...
Carpinus	×	×	...	×	Acer	×	×	×	×
Ostrya	×	×	×	×	Paliurus	×	×	...	...
Castanea	×	×	...	×	Berchemia	×	×	...	×
Castanopsis	×	×	×	...	Elaeocarpus	×	×	...	...
Fagus	×	×	...	×	Camellia	×	×	...	...
Quercus	×	×	×	×	Ternstroemia	×	×	...	...
Celtis	×	×	×	×	Elaeagnus	×	×	×	×
Ulmus	×	×	...	×	Alangium	×	×	...	...
Zelkova	×	×	...	...	Cornus	×	×	×	×
Diploclisia	×	...	...	...	Fraxinus	×	×	×	×
Magnolia	×	×	...	×	Osmanthus	×	×	...	×
Michelia	×	×	...	...	Syringa	×	×	...	...
					Total genera 64	60	48	21	30

* Persia

TABLE 4
Distribution of the Noroshi flora by elements

<table>
<tr><th rowspan="3">Noroshi species</th><th colspan="4">Living equivalents</th></tr>
<tr><th colspan="2">East Asia</th><th colspan="2">North America</th></tr>
<tr><th>China</th><th>Japan</th><th>Western</th><th>Eastern</th></tr>
<tr><td>Onoclea sp.</td><td colspan="2">O. sensibilis var. interrupta</td><td>............</td><td>O. sensibilis</td></tr>
<tr><td>Athyrium sp.</td><td colspan="2">A. nipponicum</td><td>A. spp.</td><td>A. spp.</td></tr>
<tr><td>Torreya yoshiokaensis</td><td>............</td><td>T. nucifera</td><td>............</td><td>............</td></tr>
<tr><td>Keteleeria ezoana</td><td>K. davidiana</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Picea kaneharai</td><td>P. neoveitchii</td><td>P. polita</td><td>............</td><td>............</td></tr>
<tr><td>Pinus miocenica</td><td>P. tabulaeformis</td><td>P. thunbergii, densiflora</td><td>............</td><td>(P. echinata)</td></tr>
<tr><td>Pinus oishii</td><td>P. massoniana, yunnanensis</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Pinus palaeopentaphylla</td><td>............</td><td>P. parviflora</td><td>(P. monticola)</td><td>(P. strobus)</td></tr>
<tr><td>Cunninghamia protokonishii</td><td>C. konishii</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Glyptostrobus europaeus</td><td>G. pensilis</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Metasequoia occidentalis</td><td>M. glyptostroboides</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Sequoia langsdorfii</td><td>............</td><td>............</td><td>S. sempervirens</td><td>............</td></tr>
<tr><td>Sequoiadendron primarium</td><td>............</td><td>............</td><td>S. gigantea</td><td>............</td></tr>
<tr><td>Taiwania japonica</td><td>T. cryptomerioides</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Libocedrus notoensis</td><td>L. formosana</td><td>............</td><td>(L. decurrens)</td><td>............</td></tr>
<tr><td>Thuja nipponica</td><td>T. orientalis</td><td>T. standishii</td><td>(T. plicata)</td><td>(T. occidentalis)</td></tr>
<tr><td>Livistona sp.</td><td colspan="2">L. subglobosa</td><td>............</td><td>............</td></tr>
<tr><td>Smilax trinervis</td><td colspan="2">S. china</td><td>S. sp.</td><td>S. sp.</td></tr>
<tr><td>Populus tuberculata</td><td>P. simonii</td><td>............</td><td>(P. acuminata)</td><td>............</td></tr>
<tr><td>Comptonia naumanni</td><td>............</td><td>............</td><td>............</td><td>C. peregrina</td></tr>
<tr><td>Pterocarya asymmetrosa</td><td colspan="2">P. rhoifolia</td><td>............</td><td>............</td></tr>
<tr><td>Pterocarya ezoana</td><td>P. paliurus</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Pterocarya protostenoptera</td><td>P. stenoptera</td><td>............</td><td>............</td><td>............</td></tr>
<tr><td>Betula uzenensis</td><td colspan="2">B. schmidtii</td><td>............</td><td>............</td></tr>
<tr><td>Betula sekiensis</td><td colspan="2">B. platyphylla var. japonica</td><td>(B. occidentalis)</td><td>(B. papyrifera)</td></tr>
<tr><td>Carpinus miocenica</td><td colspan="2">C. laxiflora</td><td>............</td><td>............</td></tr>
<tr><td>Carpinus mioturczaninowii</td><td colspan="2">C. turzaninowii</td><td>............</td><td>............</td></tr>
<tr><td>Carpinus subyedoensis</td><td colspan="2">C. tschonoskii</td><td>............</td><td>............</td></tr>
<tr><td>Ostrya shiragiana</td><td colspan="2">O. japonica</td><td>(O. knowltonii)</td><td>(O. virginiana)</td></tr>
<tr><td>Castanea miomollissima</td><td>C. mollissima</td><td>............</td><td>............</td><td>(C. dentata)</td></tr>
<tr><td>Castanopsis miocuspidata</td><td colspan="2">C. cuspidata</td><td>(C.chrysophylla)</td><td>............</td></tr>
<tr><td>Quercus mandraliscae</td><td>(Q. longinux)</td><td>Q. myrsinaefolia</td><td>............</td><td>............</td></tr>
<tr><td>Quercus miovariabilis</td><td colspan="2">Q. variabilis</td><td>............</td><td>(Lithocarpus densiflora)</td></tr>
<tr><td>Quercus nathorstii</td><td colspan="2">Q. glauca</td><td>............</td><td>............</td></tr>
<tr><td>Quercus praegilva</td><td colspan="2">Q. gilva</td><td>............</td><td>............</td></tr>
<tr><td>Celtis miobungeana</td><td>C. bungeana</td><td>(C. jessoensis)</td><td colspan="2">(C. occidentalis)</td></tr>
<tr><td>Ulmus subparvifolia</td><td colspan="2">U. parvifolia</td><td>............</td><td>(U. crassifolia)</td></tr>
<tr><td>Zelkova ungeri</td><td colspan="2">Z. serrata</td><td>............</td><td>............</td></tr>
</table>

TABLE 4.—*Continued*

Noroshi species	Living equivalents: East Asia, China	East Asia, Japan	North America, Western	North America, Eastern
Diploclisia notoensis	D. chinensis	....	....	....
Magnolia miocenia	M. kobus	(M. delavayi)	....	(M. portoricensis)
Michelia notoensis	(M. compressa var. formosana)	M. compressa	....	....
Cinnamomum miocenum	C. camphora		....	....
Cinnamomum oguniense	C. reticulata	....	....	....
Machilus nathorsti	M. thunbergii		....	....
Machilus ugoana	(M. salicina)	M. japonica	....	....
Liquidambar miosinica	L. formosana	....	....	(L. styraciflua)
Sycopsis chaneyi	S. formosana	....	....	....
Rosa usyuensis	R. taiwanensis	(R. multiflora)	....	....
Eucommia japonica	E. ulmoides	....	....	....
Albizzia miokalkora	A. kalkora	....	....	....
Cassia notoensis	C. siamea	....	....	....
Cladrastis aniensis	C. platycarpa		....	(C. lutea)
Entada mioformosana	E. formosana	....	....	....
Gleditschia miosinensis	G. sinensis	(G. japonica)	....	(G. triacantha)
Milletia notoensis	M. reticulata	M. japonica	....	....
Mucuna chaneyi	M. ferruginea	....	....	....
Wistaria fallax	(W. sinensis)	W. floribunda	....	(W. frutescens)
Ailanthus yezoense	A. altissima	....	....	....
Buxus protojaponica	(B. microphylla var. sinica, intermedia)	B. microphylla var. japonica	....	(B. microphylla var.)
Pistacia miochinensis	P. chinensis	....	....	....
Rhus miosuccedanea	R. succedanea		....	....
Rhus protoambigua	(R. intermedia)	R. ambigua	....	....
Perrottetia notoensis	P. arisanensis	....	....	....
Acer ezoanum	....	A. miyabei	....	....
Acer palaeodiabolicum	....	A. diabolicum	....	....
Acer protojaponicum	....	A. japonicum	(A. circinatum)	....
Acer subpictum	A. mono		....	....
Paliurus protonipponicus	P. orientalis (hemsleyana)	....	....	....
Berchemia miofloribunda	B. floribunda	(B. racemosa)	....	(B. scandens)
Elaeocarpus notoensis	E. japonicus		....	....
Camellia protojaponica	C. japonica		....	....
Ternstroemia maekawai	T. gymnanthera		....	....
Elaeagnus mikii	E. umbellata		....	....
Alangium aequalifolium	A. platanifolium var. trilobum		....	....
Cornus magaphylla	C. brachypoda		(C. nuttallii)	(C. florida)
Fraxinus honshuensis	....	F. japonica	(F. oregona)	(F. americana)
Osmanthus chaneyi	O. ilicifolium		....	....
Syringa notoensis	S. reticulata		....	....
Totals 78	69	51	15	22

TABLE 5

Modern equivalents of the Noroshi flora and their distribution in Asia

Fossil species	Modern equivalent species	Saghalien and Kurile Isl. 1	Hokkaido 2	Northern Honshu 3	Central Honshu 4	Southwestern Honshu 5	Kyushu and Shikoku 6	Taiwan 7	Korea 8	North China 9	Central China 10	Southwest China 11	Southeast China 12	Manchuria 13
Onoclea sp.	O. sensibilis													
	(s. var. interrupta)		×	×	×	×	×							
Athyrium sp.	A. nipponicum		×	×	×	×	×	×	×	×	×	×	×	×
	(spp.)													
Torreya yoshiokaensis	T. nucifera			×	×	×	×							
Keteleeria ezoana	K. davidiana										×	×	×	
	(d. var. formosana)							×						
Picea kaneharai	P. polita				×	×	×							
	(neoveichii)									×	×			
Pinus miocenica	P. thunbergii			×	×	×	×		×					
	(densiflora)		×	×	×	×	×		×					
	(tabulaeformis)								×	×	×	×	×	×
	(echinata)													
Pinus oishii	P. massoniana							×		×	×	×	×	
	(yunnanensis)										×	×		
Pinus palaeopentaphylla	P. parviflora		×	×	×	×	×							
	(monticola)													
	(strobus)													
Cunninghamia protokonishii	C. konishii							×						
Glyptostrobus europaeus	G. pensilis												×	
Metasequoia occidentalis	M. glyptostroboides										×			
Sequoia langsdorfii	S. sempervirens													
Sequoiadendron primarium	S. gigantea													
Taiwania japonica	T. cryptomerioides							×			×	×		
Libocedrus notoensis	L. formosana							×						
	(decurrens)													
Thuja nipponica	T. standishii			×	×	×	×							
	(orientalis)							×	×	×	×	×	×	×
	(plicata)													
	(occidentalis)													
Livistona sp.	L. subglobosa						×	×						
Smilax trinervis	S. china		×	×	×	×	×		×	×				×
	(spp.)													
Populus tuberculata	P. simonii								×	×	×			×
	(acuminata)													
Comptonia naumanni	C. peregrina													

TABLE 5—*Continued*

Fossil species	Modern equivalent species	1	2	3	4	5	6	7	8	9	10	11	12	13
Pterocarya asymmetrosa	P. rhoifolia		×	×	×	×	×			×	×			
Pterocarya ezoana	P. paliurus										×		×	
Pterocarya protostenoptera	P. stenoptera									×	×	×	×	
Betula uzenensis	B. schmidtii		×	×	×				×					×
Betula sekiensis	B. platyphylla var. japonica (occidentalis) (papyrifera)		×	×	×					×				×
Carpinus miocenica	C. laxiflora		×	×	×	×	×				×			
Carpinus mioturczaninowii	C. turczaninowii					×	×		×	×	×			
Carpinus subyedoensis	C. tschonoskii		×	×	×	×	×		×		×			
Ostrya shiragiana	O. japonica (knowltonii) (verginiana)		×	×	×	×	×		×		×			
Castanea miomollissima	C. mollissima (dentata)									×	×	×	×	
Castanopsis miocuspidata	C. cuspidata (chrysophylla)				×	×	×		×			×	×	
Fagus sp.	F. multinervis								×					
Quercus mandraliscae	Q. myrsinaefolia				×	×	×				×			
	(longinux)							×						
Quercus miovariabilis	Q. variabilis (Lithocarpus densiflora)				×	×	×	×	×	×	×	×	×	
Quercus nathorstii	Q. glauca			×	×	×	×	×			×	×	×	
Quercus praegilva	Q. gilva				×	×	×	×			×			
Celtis miobungeana	C. bungeana								×	×	×	×		×
	(jessoensis)		×	×	×	×	×		×					
	(occidentalis)													
Ulmus subparvifolia	U. parvifolia (crassifolia)				×	×	×	×	×	×	×		×	
Zelkova ungeri	Z. serrata			×	×	×	×		×	×	×		×	×
Diploclisia notoensis	D. chinensis												×	
Magnolia miocenica	M. kobus		×	×	×	×	×		×					
	(delavayi)											×		
	(portoricensis)													
Michelia notoensis	M. compressa				×	×	×							
	(c. var. formosana)							×						
Cinnamomum miocenum	C. camphora				×	×	×	×			×		×	
Cinnamomum oguniense	C. reticulata							×						
Machilus nathorsti	M. thunbergii			×	×	×	×	×	×		×		×	
Machilus ugoana	M. japonica					×	×		×					
	(salicina)												×	
Liquidambar miosinica	L. formosana (styraciflua)							×			×		×	

TABLE 5—*Continued*

Fossil species	Modern equivalent species	1	2	3	4	5	6	7	8	9	10	11	12	13
Parrotia fagifolia	P. persica													
Sycopsis chaneyi	S. formosana							×			×			
Rosa usyuensis	R. taiwanensis							×						
	(multiflora)		×	×	×	×	×							
Eucommia japonica	E. ulmoides									×	×		×	
Albizzia miokalkora	A. kalkora									×	×	×	×	
Cassia notoensis	C. siamea												×	
Cladrastis aniensis	C. platycarpa				×	×	×				×		×	
	(lutea)													
Entada mioformosana	E. formosana							×						
Gleditschia miosinensis	G. sinensis									×	×			
	(japonica)				×	×	×							
	(triacantha)													
Milletia notoensis	M. japonica				×	×	×							
	(reticulata)							×						
Mucuna chaneyi	M. ferruginea							×						
Wistaria fallax	W. floribunda			×	×	×	×		×					
	(sinensis)							×						
	(frutescens)													
Ailanthus yezoensis	A. altissima									×	×	×	×	×
	(a. var. tanakai)							×						
Buxus protojaponica	B. microphylla var. japonica				×	×	×							
	(m. var. sinica)									×				
	(m. var.) (intermedia)							×						
Pistacia miochinensis	P. chinensis							×		×	×	×	×	
Rhus miosuccedanea	R. succedanea				×	×	×	×			×	×	×	
Rhus protoambigua	R. ambigua	×	×	×	×	×	×							
	(intermedia)							×						
Perrottetia notoensis	P. arisanensis							×						
Acer ezoanum	A. miyabei		×	×										
Acer palaeodiabolicum	A. diabolicum			×	×	×	×							
Acer protojaponicum	A. japonicum		×	×	×	×	×							
	(circinatum)													
Acer subpictum	A. mono	×	×	×	×	×	×		×	×	×			×
Paliurus protonipponicus	P. orientalis											×		
	(hemsleyana)										×	×	×	
Berchemia miofloribunda	B. floribunda											×		
	(racemosa)			×	×	×	×	×	×					
	(scandens)													
Elaeocarpus notoensis	E. japonica					×	×	×	×				×	
Camellia protojaponica	C. japonica			×	×	×	×		×				×	
Ternstroemia maekawai	T. gymnanthera			×	×	×	×	×	×			×	×	
Elaeagnus mikii	E. umbellata		×	×	×	×	×		×	×				×

TABLE 5—*Continued*

Fossil species	Modern equivalent species	1	2	3	4	5	6	7	8	9	10	11	12	13
Alangium aequalifolium	A. platanifolium var. trilobum		×	×	×	×	×							×
Cornus megaphylla	C. brachypoda (nuttallii) (florida)			×	×	×	×		×	×	×	×		
Fraxinus honshuensis	F. japonica (oregona) (americana)		×	×	×									
Osmanthus chaneyi	O. ilicifolium				×	×	×	×						
Syringa notoensis	S. reticulata	×	×	×	×	×	×		×					
Totals 80	132	3	22	34	47	47	48	34	30	25	39	23	30	13

of a few subtropical forms such as Glyptostrobus, Diploclisia, Cinnamomum and Cassia. On the other hand, there are genera that may grow in subalpine forests. Six of the 12 genera of Noroshi conifers, Torreya, Keteleeria, Cunninghamia, Metasequoia, Taiwania and Libocedrus are found in the warm temperate zone, and Glyptostrobus is found in the subtropical zone. Picea has many species in subalpine forests; the equivalent of Noroshi is one of the two Japanese species that grow mostly in the cool temperate zone. Pinus includes species growing in both the subalpine and the warm temperate; the three species of Noroshi are all of temperate zone in a wide sense. Thuja is very common in the subalpine forests, and ranges over the cool temperate zone, with a few exceptional species that grow in the warm temperate zone.

The broad-leaved trees of Noroshi found in subalpine forests are Betula, Carpinus, Magnolia, Rhus, Acer, Cornus and Syringa; they all have wider ranges over the temperate zone.

The Elements of the Noroshi Flora

The distribution of the living equivalents of the Noroshi species centers in eastern Asia and eastern North America. Three species are omitted from the Table 4 i.e. *Parrotia persica* being a species of north Iran, and two others belonging to extinct genera, Podogonium and Hemitrapa. These three species and the Incertae sedis make up 8.55% of the total number of specimens.

The Japanese Sub-element

Many species of the Noroshi plants are found living in southwestern Japan, mostly in the warm temperate forests. Castanopsis and *Machilus thunbergii* are dominant in such a forests. Sato (1946) has designated the forests of the western shore line of the Inland Sea of Seto as the Laurisilvae, with 5 layers. The dominants are shown in Table 6 from which the 4th and 5th layers are omitted. The listed

TABLE 6
Plants in the western shore of the Inland Sea of Seto and Noroshi equivalents

Western Shore of Inland Sea	Noroshi flora
1st layer	
Castanopsis sp.	C. miocuspidata
Machilus thunbergii	M. nathorsti
Cinnamomum camphora	C. miocenum
Quercus glauca	Q. nathorstii
Q. stenophylla	
Q. myrsinaefolia	Q. mandraliscae
Elaeocarpus elliptica	
E. japonicus	E. notoensis
2nd•3rd layers	
Bobya glauca	
Sakakia ochnacea	
Neolitsea sieboldii	
Cinnamomum japonicum	
Ternstroemia gymnanthera	T. maekawai
Illicium anisatum	
Camellia japonica	C. protojaponica
Ligustrum japonicum	
Daphniphyllum glaucescens	
Textoria trifida	
Meliosma rigida	
Eurya japonica	

forests are those of the four selected Shinto Shrines in Yamaguchi, Hiroshima and Ehime Prefectures, respectively either close to the shoreline or on the lowlands.

The habitat of the living equivalents of the Noroshi species in Fukuoka Prefecture has been described by Nakajima (1952). Fukuoka Prefecture, 33°50′–33°52′N, 129°52′–131°04′E, about 4,900 km², lies at the north end of Kyushu Island, facing the Genkai Sea to the north-west, the Suoh Sea to the north-east, and being bounded by a mountain range over 600–1,200 m high on the south-east border. Here the deciduous forests are higher than about 800 m.

Thirty nine species among 50 Japanese living equivalents of the Noroshi species, except for ferns, are recorded in Fukuoka Prefecture.

Twenty nine species of them are in the evergreen forests and elswhere on the lowlands; the dominant species are *Castanopsis cuspidata, Quercus glauca, Cinnamomum camphora, Machilus thunbergii* and *Milletia japonica*. *Quercus glauca* is dominant at

TABLE 7
Habitat of the living equivalents of Noroshi species in Fukuoka Prefecture

Living equivalents of Noroshi species	Sea-side & roadside	Mountaineous & hilly forest	Evergreen forest	Upper Evergreen forest	Lower Deciduous forest	Deciduous forest
Picea polita						R
Pinus thunbergii	C	C				
P. densiflora		VC		VC	VC	
P. parviflora						R
Smilax china		C	C	C	C	C
Pterocarya rhoifolia						R
Carpinus laxiflora				C	C	
C. tschonoskii				C	C	
C. turczaninowii				R		
Ostrya japonica						SR
Castanopsis cuspidata			VC			
Quercus myrsinaefolia				SC		
Q. variabilis		R				
Q. glauca			VC			
Q. gilva			SR			
Celtis jessoensis				SR	SR	
Ulmus parvifolia	SC					
Zelkova serrata				SC	SC	
Magnolia kobus				SR	SR	
Michelia compressa			SR			
Cinnamomum camphora			SR			
Machilus thunbergii			C			
M. japonica			C			
Rosa multiflora	C	C				
Milletia japonica			C			
Wistaria floribunda			SC			
Buxus microphylla var. japonica					R	
Rhus succedanea			SC			
R. ambigua						SC
Acer diabolicum						SR
A. mono						SC
Berchemia racemosa				C	C	C
Elaeocarpus japonicus			SR			
Camellia japonica			SC	SC	SC	
Ternstroemia gymnanthera			SC			
Elaeagnus umbellata		C				
Alangium platanifolium var. macrophyllum						SC
Cornus brachypoda				SC	SC	SC
Syringa reticulata						R
Totals 39	3	6	14	12	11	12

VC: very common C: common SC: somewhat common SR: somewhat rare R: rare

Noroshi. Thirteen species live in the transitional zone between the evergreen and deciduous forests, nine of them in this zone only. The abundant species here are *Pinus densiflora, Carpinus laxiflora* and *C. tschonoskii*; Zelkova the most abundant form in Noroshi is also very common. Ten species are limited in the deciduous forests. Among these ten, only *Acer mono* is common at Noroshi, the others being rather sparse.

The following 11 species are not recorded here: *Torreya nucifera, Thuja standishii Livistona subglobosa, Betula schmidtii, B. platyphylla* var. *japonica, Cladrastis platycarpa, Gleditschia japonica, Acer miyabei, A. japonicum, Fraxinus japonica, Osmanthus ilicifolium.* But Torreya, Thuja, Livistona, Cladrastis, Gleditschia and *Acer japonicum* are found in the other districts of Kyushu. Thuja, Gleditschia and *Acer japonicum* are found in deciduous forests; Thuja is especially abundant in the coniferous forests of northern Japan. The five remainder are not living in Japan except at the extreme north.

The assemblage of plants in the monumental zones under conservation around the two Great Shrines of Ise is the best living representative referable to the Noroshi flora. The zones lie between 34°23′–29′N and 136°39′–47′E, with a total area of about 180 square kilometers. The living plants of the two zones, the Inner and the Outer Shrines, were investigated by Honda, 1927. The zone of the Inner Shrine is the larger, covering a hilly region of 400 to 550 m in average height, extending to the south of the shrine. The zone of the Outer Shrine covers an area 0.88 square kilometers wide, with an altitude from 10 to 116 meters.

The plants found in these areas are as follows: Pteridophyta 11 families, 35 genera, 97 species; Gymnospermae 3 families, 8 genera, 10 species; Angiospermae; Monocotyledoneae 17 families, 93 genera, 139 species; Dicotyledoneae: Archiclamydae 73 families, 201 genera, 376 species; Metachlamydeae 30 families, 132 genera, 209 species.

Among the living equivalents of Noroshi species, 26 species are recorded in this area. They occupy an area lower below 100 m, except for two species, *Carpinus laxiflora* and *Cornus brachypoda.*

The next list shows the plants at four altitudes along Kurobe valley in Toyama Prefecture, not far distant from Noroshi. These lists are based on the studies of Takenaka, 1934 and Takahashi, 1962. Starred species are living equivalents of Noroshi species. They may afford some additional criteria, for comparison between the lowland forests floras at various locations of southwestern Japan and the Noroshi flora.

Unazuki (180 m): **Torreya nucifera*, **Pinus densiflora*, **Carpinus laxiflora*, *C. japonica, Quercus serrata, Castanea crenata*, **Zelkova serrata*, *Hamamelis japonica, Sorbus commixta*, **Wistaria floribunda*, **Acer japonicum*, **A. mono*, *Camellia rusticana*, **Alangium plantanifolium* var. *macrophyllum*, **Cornus brachypoda*, *C. controversa, Rhododendron nudipes,*

TABLE 8
Plants in the area of the Great Shrine of Ise and their Noroshi equivalents

Main tree species in the area of Great Shrine of Ise	Noroshi species
Torreya nucifera	T. yoshiokaensis
Pinus densiflora	P. miocenica
Smilax china	S. trinervis
Carpinus laxiflora	C. miocenica
C. tschonoskii	C. subyedoensis
Castanopsis cuspidata	C. miocuspidata
Quercus gilva	Q. praegilva
Q. glauca	Q. nathorstii
Q. myrsinaefolia	Q. mandraliscae
Zelkova serrata	Z. ungerii
Michelia compressa	M. notoensis
Cinnamomum camphora	C. miocenum
Machilus thunbergii	M. nathorsti
Rosa multiflora	R. usyuensis
Gleditschia japonica	G. miosinensis
Milletia japonica	M. notoensis
Wistaria floribunda	W. fallax
Buxus microphylla var. japonica	B. protojaponica
Rhus succedanea	R. miosuccedanea
Acer mono	A. subpictum
Berchemia racemosa	B. miofloribunda
Camellia japonica	C. protojaponica
Trenstroemia gymnanthera	T. maekawai
Elaeagnus umbellata	E. mikii
Cornus brachypoda	C. megaphylla
Osmanthus ilicifolium	O. chaneyi

Tripetaleia paniculata var. *latifolia, Hugeria japonica, *Fraxinus japonica, Viburnum dilatatum, V. furcatum.*

At the junction of the Kuronagi River and Shiai Valley (400–800 m): **Thuja standishii, *Pterocarya rhoifolia, Alnus hirsuta, Carpinus japonica, *C. laxiflora, Quercus mongolica* var. *grosseserrata, Castanea crenata, Fagus crenata, *Zelkova serrata, Magnolia obovata, Lindera membranacea, Hamamelis japonica* var. *obtusata, Sorbus commixta, *Rhus ambigua, R. chinensis, Acer micranthum, A. rufinerve, *A. mono, *A. japonicum, A. negundo, Aesculus turbinata, Camellia rusticana, Aralia elata, Tilia japonica.*

Babadani (845 m): **Pinus parviflora, *Thuja standishii, Toisusu urbaniana, *Pterocarya rhoifolia, *Carpinus laxiflora, Fagus crenata, Prunus grayana, P. jamasakura, Euonymus sieboldianus, Acer tschonoskii, *A. mono, *A. japonicum, A. rufinerve, Cornus controversa, Fraxinus sieboldiana, *F. japonica.*

Taira hut (1,400 m): (1) on the plain *Populus maximowiczii, *Betula platyphylla* var. *japonica, Quercus mongolica* var. *grosseserrata, Fagus crenata, Prunus grayana,* **Acer mono,* **A. japonicum, Cornus controversa.*

(2) on the mountain slope *Tsuga diversifolia,* **Pinus parviflora, P. koraiensis, Larix leptolepis,* * *Thuja standishii.*

Summary

The Japanese Sub-element of Noroshi plants is found in southwestern Japan except for two species living in northern Honshu, *Betula schmidtii* and *Acer miyabei.* The horizontal and altitudinal distributions of the components were described on the four areas in southwestern Japan from Kyushu to Hokuriku. Most of the warm components are living in lowlands from Kyushu to Kinki; the cool components are found in about 1,000 m altitudes of Hokuriku district.

Eight species of 20 dominant plants in the western shore of the Inland Sea of Seto are Noroshi equivalents.

Thirty nine species among 51 Japanese living equivalents of the Noroshi species are recorded in Fukuoka Prefecture. Twenty nine species of them are in the evergreen forests and elswhere on the lowlands. Ten species are limited in the deciduous forests. Thirteen species live in the transitional zone between the evergreen and deciduous forests. Many of the dominant Noroshi species are found in the evergreen forest and in the transitional zone between the evergreen and deciduous forests. Six of 12 species not recorded here are found in the other districts of Kyushu. The six remainder are seen in northern Japan.

Twenty six of Noroshi equivalents are recorded in the area of Great Shrine of Ise. They occupy an area lower below 100 m, except for two species, and include *Osmanthus ilicifolium* which is not found in Kyushu.

Sixteen Noroshi equivalents occur at four altitudes along Kurobe Valley as follows: Unazuki (180 m) 11 species, at the junction of the Kuronagi River and Shiai Valley (400–800 m) 7 species, Babadani (845 m) 7 species, Taira hut (1,400 m) (1) on the plain 3 species, (2) on the mountain slope 2 species. *Fraxinus japonica* and *Betula platyphylla* var. *japonica,* which were not redorded in the southern three areas, are both found at Babadani and on the plain of Taira hut.

The Chinese Sub-element

Twenty five species among the 39 living equivalents of Noroshi species living in central China are listed by Wang (1961) in the mixed mesophytic forests of the Yangtze Valley. More living equivalents are recorded in the upper than in the lower Yangtze. They are especially numerous in western Hupeh and eastern Szechuan, totalling 23 species. The latter area includes the well-known locality of *Metasequoia glyptostroboides.* The mixed mesophytic forest occupies the altitudes of 700–1,100 m between the lower evergreen broad-leaved forest and the higher deciduous and coniferous forest on Omei-Shan (39°30′N) in Szechuan Province.

TABLE 9
Plants in the Mixed Mesophytic forest of Upper Yangtze

Living equivalents of Noroshi species	W. Hupeh & E. Szechuan	W. Szechuan	E. Kweichow
Keteleeria davidiana	×		×
Pinus tabulaeformis	×	×	×
P. massoniana	×	×	×
Metasequoia glyptostroboides	×	×	
Taiwania cryptomerioides	×		
Pterocarya paliurus	×	×	×
P. stenoptera	×	×	×
Carpinus laxiflora	×	×	×
C. turczaninowii		×	×
Ostrya japonica	×		
Quercus glauca	×	×	×
Q. myrsinaefolia	×	×	×
Q. variabilis	×	×	×
Ulmus parviflora	×		
Cinnamomum camphora	×	×	×
Machilus thunbergii			×
Liquidambar formosana	×	×	×
Eucommia ulmoides	×	×	×
Albizzia kalkora	×		
Ailanthus altissima	×		
Pistacia chinensis	×	×	×
Rhus succedanea	×	×	
Acer mono	×	×	
Paliurus orientalis	×	×	
Alangium platanifolium	×	×	×
	23	18	16

Among the Chinese, *Picea neoveichii* is found in the northern provinces as well as upon the south-eastern plateaus; *Betula* spp. are in the northern and north-eastern provinces. They are both growing in the montane-boreal coniferous forests. Castanopsis, Quercus and Machilus are numerous in the evergreen broad-leaved forests. *Quercus glauca, Q. myrsinaefolia* and *Q. variabilis* are in the mixed mesophytic forests or the evergreen broad-leaved forests. *Cinnamomum camphora* and *Machilus thunbergii* live in a wider area below these forests. *Castanopsis cuspidata* and *Quercus gilva* are seen in the evergreen broad-leaved forests. Glyptostrobus, Cassia and Diploclisia are represented by tropical species and live in the rain forests.

In Taiwan there are 34 of the Noroshi equivalents and 5 among them are found only in Taiwan. Among the equivalents of the common species in the Noroshi flora, *Cunninghamia konishii* lives at about 1,300 m in the north and 1,800 m in the central part; *Taiwania cryptomerioides* is found at 1,800–2,600 m in the central ranges of the island. They are both usually scattered through the forests of Chamaecyparis. *Keteleeria davidiana* var. *formosana* Hayata occurs at 300–600 m in the extreme northern sections and at 500–900 m in other parts. It is usually found in association with broad-leaved trees in open situations. *Libocedrus formosana* lives at 300–1,900 m in northern and central parts. *Liquidambar formosana* is found in secondary forests or along streams throughout the island, more common at about 900–2,000 m in the central parts. *Sycopsis formosana* lives in primary forests at medium altitudes (about 2,200 m) often forming pure stands. *Mucuna ferruginea* is found in forests at low and medium altitudes, and *Perrottetia arisanensis* at 650–2,500 m throughout the island.

Considering the above evidence, the Noroshi flora may be considered a transition between a mixed mesophytic forest and an evergreen broad-leaved forest; it corresponds to the uppermost part of the evergreen broad-leaved forest of western Hupeh and eastern Szechuan. It represents the warm temperate zone.

The Western North American Element

The list of living equivalents of this element, as given in Table 4, is admittedly incomplete. But it is at once apparent that the summer-dry climate of western North America has been an important factor in eliminating from the forests there many of the genera which have survived in eastern Asia, and to a somewhat lesser extent in eastern North America, where summer-wet climate has persisted.

Reference to Table 4 will show that many of the Tertiary genera which have survived in western America have had the advantage of the relatively moist montane climate there, as in the case of several conifers, or are restricted to riparian habitats. The two monotypic genera which are now found only on the east side of the Pacific, Sequoia and Sequoiadendron, are examples. According to Sargent (1957), "the Sequoia distributes in Valley of the Chetco River, Oregon, 8 miles north of the California state line, southward near the coast to Monterey County, California; rarely found more than twenty or thirty miles from the coast, or beyond the influence of the ocean fogs, or over 900 m above the sea-level; often forming in northern California pure forests occupying the sides of revines and the banks of stream; southward growing usually in small groves scattered among other trees; most abundant and of its largest size north of Cape Mendocino". Sequoiadendron lives in Western slopes of the Sierra Nevada of California, in an interrupted belt at elevations of 1,400–2,400 m above of the sea, from the middle fork of the American River to the head of Decr Creek just south of latitude 36° N; north of King's River in isolated groves, southward forming forests of considerable extent, and best developed on the north fork of the Tule River."

Sequoia sempervirens, the coast redwood, has survived only in valleys near the Pacific coast where summer fogs provide humid conditions during the dry season, and where winter temperature is moderated by ocean influence. *Sequoiadendron giganteum*, the Sierra redwood, occupies medium elevations with summer rains. The former has been grown in Japan with success, but the introduction of the latter has met with difficulties.

The Eastern North American Element

Eastern North America is a region somewhat resembling central China and Japan in its mixed mesophytic forest, and in its rainfall regime. The survival of many living equivalents of Noroshi species is therefore to be expected. The area of distribution of the living equivalents of the Eastern North American Element covers most of North America, east of the Cordillera, with the Appalachian Mountains the region of its richest development.

Comptonia and Liquidambar are noteworthy genera. The monotypic species, *Comptonia peregrina*, is the living plant nearest to *Comptonia naumanni*, an important index fossil in the Miocene of Japan, including Noroshi. Taxodium, represented in many Tertiary floras of North America, inhabits the swamps of this area, but it is not found in the Noroshi flora.

The living survivors of the Eastern North American Element appear to be made up of species suited to a little colder climate than corresponding Asian species.

Noroshi Plant Associations

According to the above criteria, the Noroshi plants are reasonably divided into the following three associations, (1) lake-border or flood plain association. (2) valley slope association. (3) mountain association.

· deciduous broad-leaf, ∘ evergreen broad-leaf, + deciduous conifer, * evergreen conifer, v vine, s sharub, t tree

1. *Lake-border or flood plain association*

The 41 species of the lowlands are represented by 54.62% of all the specimens collected.

•t	Ailanthus yezoensis	∘v	Mucuna chaneyi
•t	Albizzia miokalkora	∘s	Osmanthus chaneyi
∘t	Camellia protojaponica	*t	Pinus miocenica
∘•t	Cassia notoensis	*t	Pinus oishii
•t	Castanea miomollissima	•t	Pistacia miochinensis
∘t	Castanopsis miocuspidata	•t	Populus tuberculata
•t	Celtis miobungeana	•t	Pterocarya ezoana
∘t	Cinnamomum miocenum	•t	Pterocarya protostenoptera
∘t	Cinnamomum oguniense	∘t	Quercus mandraliscae
∘s	Comptonia naumanni	•t	Quercus miovariabilis
v	Diploclisia notoensis	∘t	Quercus nathorstii
•s	Elaeagnus mikii	∘t	Quercus praegilva
∘t	Elaeocarpus notoensis	•t	Rhus miosuccedanea
+t	Glyptostrobus europaeus	t	Rosa usyuensis
	Hemitrapa yokoyamae	•v	Smilax china
•t	Liquidambar miosinica	∘t	Ternstroemia maekawai
	Livistona sp.	*t	Torreya yoshiokaensis
∘t	Machilus nathorsti	•s	Ulmus subparvifolia
∘t	Machilus ugoana	•v	Wistaria fallax
∘t	Michelia notoensis	•t	Zelkova ungeri
•v	Milletia notoensis		

Thirty two of the above 41 species can also be considered as members of the valley slope association, on the basis of the habitats of their modern equivalents. They are represented by 74.60% of all the specimens collected.

2. *Valley slope association*

•t	Ailanthus yezoensis	•t	Elaeocarpus notoensis
•t	Albizzia miokalkora	∘v	Entada mioformosana
•t	Acer ezoanum	∘t	Eucommia japonica
•t	Acer palaeodiabolicum	•t	Fraxinus honshuensis
•t	Acer protojaponicum	*t	Keteleeria ezoana
•t	Acer subpictum	*t	Libocedrus notoensis
•v	Berchemia miofloribunda	∘t	Machilus nathorsti
•t	Betula uzenensis	∘t	Machilus ugoana
∘s	Buxus protojaponica	•t	Magnolia miocenica
∘t	Camellia protojaponica	+t	Metasequoia occidentalis
•t	Carpinus miocenica	∘t	Michelia notoensis
•t	Carpinus mioturczaninowii	•v	Milletia notoensis
•t	Carpinus subyedoensis	∘v	Mucuna chaneyi
•t	Castanea miomollissima	∘s	Osmanthus chaneyi
∘t	Castanopsis miocuspidata	•t	Ostrya shiragiana
•t	Celtis miobungeana	•t	Paliurus protonipponica
∘t	Cinnamomum miocenum	•ts	Perrottetia notoensis
•t	Cladrastis aniensis	*t	Pinus miocenica
•t	Cornus megaphylla	*t	Pinus oishii
v	Diploclisia notoensis	•t	Pistacia miochinensis
•s	Elaeagnus mikii	•t	Populus tuberculata

•t	Pterocarya asymmetrosa	•v	Smilax trinervis
ot	Quercus mandraliscae	•s	Syringa notoensis
•t	Quercus miovariabilis	*t	Taiwania japonica
ot	Quercus nathorstii	ot	Ternstroemia maekawai
ot	Quercus praegilva	*t	Torreya yoshiokaensis
•t	Rhus miosuccedanea	•s	Ulmus subparvifolia
ov	Rhus protoambigua	•v	Wistaria fallax
v	Rosa usyuensis	•t	Zelkova ungeri

3. *Mountain association*

•t	Acer protojaponicum	•ts	Perrottetia notoensis
•t	Acer subpictum	*t	Picea kaneharai
•v	Berchemia miofloribunda	*t	Pinus palaeopentaphylla
•t	Betula sekiensis	ot	Sycopsis chaneyi
•t	Cornus megaphylla	*t	Taiwania japonica
*t	Cunninghamia protokonishii	*t	Thuja nipponica
*t	Libocedrus notoensis		

Only two of these 13 species are typically montane. They make up only 0.81% of the specimens collected.

This analysis makes it clear that the Noroshi flora is rich in lake border, flood plain and valley slope species, and poor in montane species. This suggests a hilly slope adjacent to a flood plain, with high mountains at a distance as the environment of the Noroshi flora.

Physical Conditions Indicated by the Fauna

The tuffaceous shales containing the Noroshi flora have yielded two insects and undeterminable vertebrae a small fish. Both the insects are headless, but were identified *Heliocoporis antiquus* and *Phyllopertha?* sp. by Fujiyama (1968). They are a scavenger, and a burrower underneath excreta. The genus Heliocopris lives in south China, Indo-china, Malaya, Sudan Is., Burma, India, central Africa and southward.

The faunal evidence from the Noroshi shales is too limited to provide significant data as to the environment. The Yanagida formation mainly consist of dacite tuffs which intercalate the Noroshi shales. This formation in Hosoya, some 40 kilometers southwest of Noroshi, contains beds of alternating conglomerates, sandstones and shales. *Bunolophodon annectens* has been recorded here (Shikama, 1936; Takai, 1939). Supposedly this Proboscidean inhabited a swampy area.

The uppermost shales of the Yanagida formation contains some marine shell and radiolarian fossils, but there is no faunal evidence in the remainder of the formation. The Suzu formation that lies over this formation shows marine transgression during the Middle Miocene in Japan. The Higashi-innai, the basal member of this formation, yields mollusks, echinoids, corals, foraminifera and radiolaria. Masuda (1967) studied the molluscan fauna of these beds and concluded as follows, "From the faunal elements and the paleogeography it is considered that the Higashi-innai Formation was deposited under the influence of a warm and shallow sea as shown by the occurrence of tropical to subtropical molluscs as Ctena, Katelysia, Euchelus, Monilea, Turbo, Nerita, Littorinopsis, Rissoina, Architectonica, Vicarya, Vicaryella, Pachycrommium, Cypraea, Apollon, Oliva, Vexillum, Mitra, Philberta, Cythara, Conus, etc. This view is upheld by the associated occurrence of reef building corals and by the assemblages of the smaller foraminifera as pointed out by Asano (1953)."

Topography

The Noroshi flora represents a mixed mesophytic forest type, which lived on slopes and plains along a lagoonal embayment. Some plants also grew upon the mountainous land made of volcanic rocks — westwardly andesite of the Anamizu age and southwardly the succeeding Yanagida of dacitic ash. The mountains of andesite had been rich in relief, cliff, talus and soil. On the other hand, the dacitic ash flows had consisted of the wide skirts of a mountain.

Summary

The flora includes among its major species several narrow leaved oaks such as the living *Quercus pseudomyrsinifolia* of Taiwan. Most probably there was a forest consisting of *Quercus praegilva* as the major member with a subordinate *Cinnamomum miocenum*. Machilus now seen on the land close to Japan Sea represents the similar environment. The mixed forest of Cinnamomum, Liquidambar and *Pinus miocenica* indicates a talus or a rocky crag, especially the latter form indicating the edaphic climax.

The plants such as Machilus, Quercus, Michelia, Elaeocarpus, Camellia, Ternstroemia and Osmanthus representing the humid temperate zone formed the forest on flood plain and slope below 100 m. Some plants those showing a subtropical climatic condition, for instance Glyptostrobus and Livistona seemingly lived on river side. Diploclisia climbed up the sunny cliff faced to the waters. Moist, well-drained places suited Metasequoia, in part merged into the talus. It is sure that forests suitable for more temperate climate also existed above the Quercus forests. The plants of this habitat are divided into two floral types — the valley type and the type of mountain slopes and ridges. The valley type consists of Zelkova,

Torreya, Cunninghamia, Taiwania, Pterocarya, Ostrya, *Acer ezoana* and *Acer paleodiabolicum*. The type of mountain slope and ridge contains the coniferous trees such as Libocedrus, Keteleeria and Sequoia. Below these, there grew Camellia and Osmanthus. Michelia and *Machilus ugoana* were surely rather numerous understory members of the *Quercus praegilva* forest. It is possibly inferred that these forests grew at elevations between 100 to 800 meters.

In the deciduous forest at higher levels there were conifers such as *Picea kaneharai* and *Acer protojaponicum*, *A. subpictum* and *Betula sekiensis*. Presumably *Pinus paleopentaphylla* and Thuja grew on rocky crags as seen in the present Kurobe Valley.

Considering the relation of altitude and temperature, the difference among the above forest zones may correspond to those between 1,200 meters and sea level in Kyushu District. Roughly speaking, the top 400 meters zone was presumably above the winter snow line. The second zone (100 to 800 m) was foggy and the lower 100 meters was a low land zone. The climate of the warm temperate ruled over the low land zone, the warm and temperate over the foggy zone and the northern temperate over the lingering snow zone. The climate was rather cool in summer and relatively warm in winter.

Climate

It is neccessary to have full knowledges of variations in local climate at different elevations and topographic settings in order to arrive at a reasonable interpretation of the Noroshi flora. In this chapter a general view of the climate compared to that of the present day will be stated.

The living equivalents of the Noroshi species are mostly found in a wide area over southeastern and central China, extending eastward to Taiwan and southwestern Japan. We see that this region is a rainy zone of Asia, with an annual precipitation over 1,000 mm, up to 4,000 mm. The mean annual temperatures are 14.5 to 15.0°C and the annual ranges are 10 to 25°C. Geologists and paleontologists of this country have pointed out that the climate of the Middle Miocene of Japan was so mild that there was but small seasonal changes, but still the true climate is not clarified very well.

At Fukuoka, Hiroshima and Tsu (see Table 3) in southwestern Japan, where vegetation related to the Noroshi flora is found, the mean monthly temperature of the coldest winter month does not fall lower than zero, while the annual precipitation reaches over 1,500 mm. The Setouchi district (countries around the Inland Sea) is known as a dry place; nevertheless the annual precipitation is about 1,000–1,500 mm. There are Laurisilvae characterized by *Quercus phyllyraeoides*; it is compared to the Olive climate of the Mediterranean Sea area, but not comparable to that of

TABLE 10
Climatic data for several localities in Japan, China and North America

Locality	Latitude	Altitude	Average annual Precipitation	Rainiest season	Lowest average precipitation in any month	Mean annual temperature	Maximum average temperature in any month	Minimum average temperature in any month
Akita	39 43	9.9	1786	summer	104	10.5	24.4	−1.6
Wajima	37 23	6.9	2178	autumn	104	12.5	24.8	1.9
Toyama	36 42	9.6	2299	autumn	128	13.0	25.8	1.3
Hamada	34 54	19.7	1627	autumn	93	14.6	26.0	4.9
Fukuoka	33 35	3.8	1596	summer	64	15.1	26.8	4.8
Hiroshima	34 22	30.4	1527	summer	40	14.6	26.9	3.7
Tsu	34 42	3.4	1688	autumn	40	14.6	26.6	3.8
Chungking	29 33	217	1054	summer	19	15.0	29.4	7.3
San Francisco	37 47	16	521	winter	0	13.7	16.4	10.1
New York	40 42	3	1068	summer	77	11.9	23.7	0.4
Knoxville	35 49	290	1156	spring	64	15.2	25.8	4.7

Noroshi flora.

The climate of Shui-hsa Valley, the natural habitat of Metasequoia in China, was discussed by Chu and Cooper (1950). In Annual Report of Science of Japan, the climate of Chungking has a mean annual temperature of 15°C. Chungking is 217 m in altitude, and that of Shui-hsa Valley is about 1,000–1,100 m. An amount of the annual precipitation, 1,203.9 mm of Kweiyang, may be nearer to Shui-hsa Valley than 1,094.8 mm of Chungking due to the height, according to Chu and Cooper. Compared with the climate of southwestern Japan, however, the annual precipitation of Noroshi flora may be assumed to be at least 1,600 mm; presumably even as much as 2,000 mm. The coldest monthly mean temperature is reasonably supposed to have been about 4°–5°C, while 26°–27°C be the warmest temperature. Thus an annual mean temperature is estimated to have been 14.5°–15.0°C. The same result is deduced also by the relative climatology of eastern North America. Autumn is the rainiest season, but even relatively dry months have a precipitation of over 100 mm. A severe climatic condition similar to the well-known heavy snow of Japan Sea side at present is not recorded.

COMPARISONS WITH OTHER MIDDLE MIOCENE FLORAS OF THE ADJACENT AREAS

Studies of the fossil plants in Neogene strata of Japan since 1880 were recently

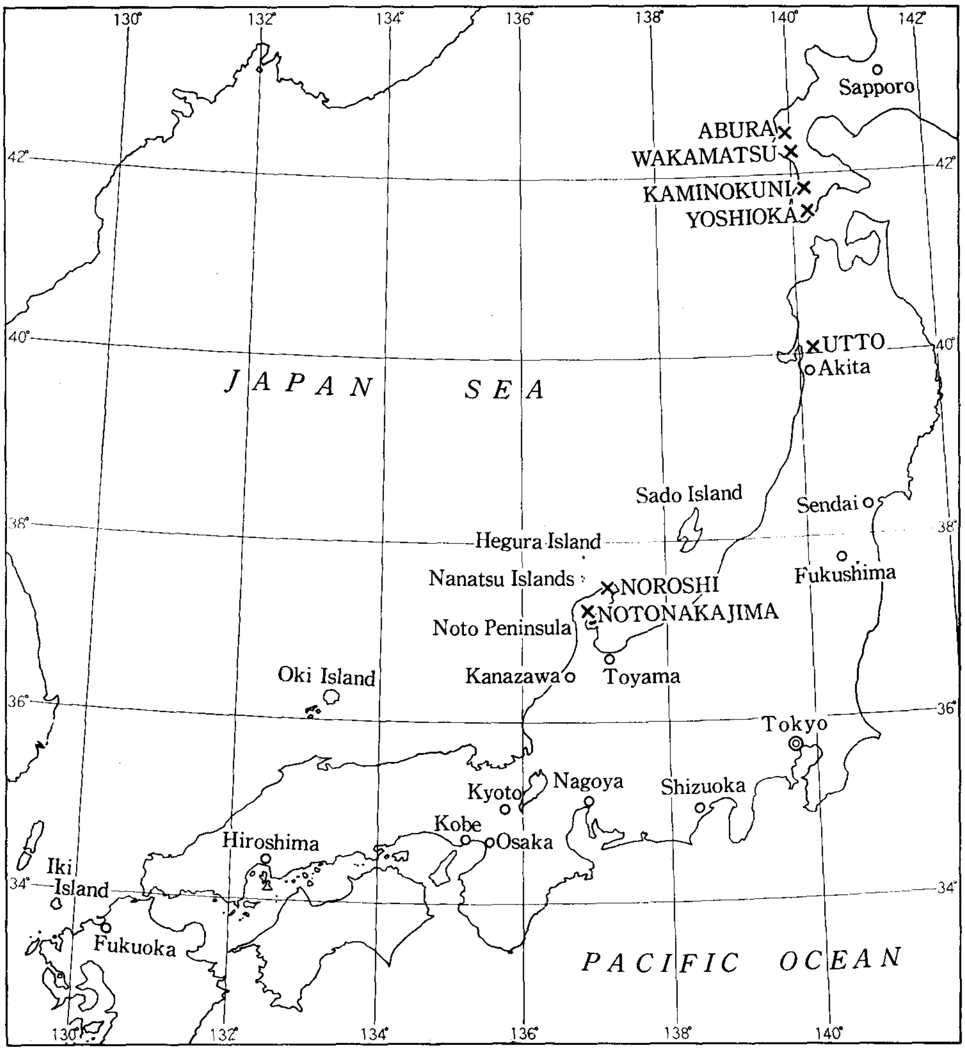

Fig. 5. Showing geographic locations indicated in chapter of Japanese Elements and of Compared Middle Miocene Floras.

summarized by Tanai (1961). References will be made to other papers on the same subject in recent years by Huzioka (1962), Matsuo (1962), Okutsu (1955), Suzuki (1959, 1961) and Tanai (1962). First of all the Daijima type floras of the green tuff region of the Japan Sea coast, as described by Huzioka, Matsuo and Tanai, will be considered. These authors give correlations of the strata in detail, including an account of likeness in paleogeography and in paleoecology. Comparison between the floras of the interior of Japan and the Pacific coast seems to be

TABLE 11

Fossil plants of some Middle Miocene Floras in Japan Sea side

Species	Southwestern Hokkaido						
	Abura 1	Wakamatsu 2	Kamino-Kuni 3	Yoshioka 4	Utto 5	Noroshi 6	Noto-nakajima 7
Nitella notoensis							R
Plenasium lignitum							R
Lygodium mioscandens							R
Pteris mioinequalis							R
Onoclea sp.						R	
Athyrium sp.							
Dryopteris uttoensis					R		
Equisetum sp.			R				
Cephalotaxus akitaensis					R		
Torreya yoshiokaensis				R		R	
Abies aburaensis	R	R					
A. honshuensis							R
A. nsuzukii	R		R	R			
Keteleeria ezoana		R		C	R	C	C
Picea kaneharai	R	R	R	R	R	R	C ?
P. ugoana	C	R	R	R			
Pinus miocenica	R	R		C	C	R	A
P. oishii					R	R	R
P. palaeopentaphylla				R ?		R	
P. trifolia?				R			
Tsuga miocenica	R	R	R	R			
Cunninghamia protokonishii					R	R	R
Glyptostrobus europaeus	R		R	R	A	R	R
Metasequoia occidentalis	C	R		R	A	R	R
Sequoia langsdorfii					R	R	R
Sequoiadendron primarium						R	
Taiwania japonica				R	R	C	R ?
Libocedrus notoensis					R	A	A
Thuja nipponica	R	R		R		R	
Thujopsis miodolabrata			R				
Livistona sp.						R	
Potamogeton sp.							R
Smilax trinervis				R	R	R	C

TABLE 11—*Continued*

Species	1	2	3	4	5	6	7
Populus spp.	R		R	R		R	
Comptonia naumanni	R	R		R	A	A	C
Juglans japonica						R	
Pterocarya asymmetrosa			R		A	R	
P. ezoana	R	R		R		R	
P. protostenoptera						R	
Alnus miojaponica	R	R	R	R	R		
A. protomaximowiczii	R	R		R	R		
A. usyuensis			A				
Betula kamigoensis					R		
B. mioluminifera			C	R			
B. sekiensis				R		R	
B. sublutea	R			R			
B. uzenensis			C		R ?	R	
Carpinus chaneyi				R			
C. miocenica						R	
C. miofangiana	R	R	C	C			
C. mioturczaninowii				R		C	
C. subcordata	C	R	A	C	R		
C. subyedoensis	R	R	R	R	R	C	C
Corylus macquarrii	R		A	R			
Ostrya shiragiana	R		R		R	R	
Castanea miomollissima	R	A		A	A	C	
Castanopsis miocuspidata						R	C
Fagus antipofi	A	C	R		R		
F. sp.					R	R	
Quercus mandraliscae					R	C	R
Q. miovariabilis				R	R	C	R
Q. nathorstii					R	C	R
Q. praegilva					R	C	R
Q. spp.					R	R	R
Celtis miobungeana						R	
Ulmus carpinoides					C		
U. longifolia	R	R	C	R	R		
U. shiragica	R		C				
U. subparvifolia						R	
Zelkova ungeri	R	C	R	A	A	A	C
Diploclisia notoensis						R	R
Menispermum sp.	R						

TABLE 11—*Continued*

Species	1	2	3	4	5	6	7
Cercidiphyllum crenatum	R		R	R			
Ficus mioretusa							C
Ranunclus mioaquatilis							R
Berberis huziokai				R			
Mahonia lanceofolia				R			
Magnolia miocenica	R	R		C		R	C ?
M. uttoensis					R ?		
Michelia notoensis						R	
Cinnamomum lanceolatum					R		
C. miocenum					R	R	
C. oguniense						R	R
Lindera gaudini					R		
L. paraobtusiloba							C
Machilus nathorsti					R	R	C
M. ugoana					C	R	
Parabenzoin protopraecox				C			
Sasafras subtriloba	R			R			
Hydrangea lanceolimba	R		R				
Platanus aceroides			R				
Phellodendron mioamurense			R				
Liquidambar miosinica	R			C	A	C	R
Parrotia fagifolia				C	A	R	
Sycopsis chaneyi						C	
Prunus matsumaensis				R			
Rosa usyuensis	R			R		R	
Sorbus nipponica				R			
Eucommia japonica						R	
Albizzia miokalkora						R	
Cassia notoensis						R	
Cladrastis aniensis				R	R	R	R
Entada mioformosana						R	
Gleditschia miosinensis				R	R	R	
G. tanaii							R
Milletia notoensis				R		R	
Mucuna chaneyi						R	
Podogonium knorrii						A	
Robinia nipponica	R	R		R			
Sophora miojaponica				R			
Wistaria fallax					R	R	

TABLE 11—*Continued*

Species	1	2	3	4	5	6	7
Ailanthus yezoensis	R					R	R
Buxus protojaponica					R	R	
Pistacia miochinensis						R	
Rhus miosuccedanea				C	R	C	
R. protoambigua				R	R	R	
Euonymus protobungeana				R			
Cedrela nipponica				R			
Perrottetia notoensis						C	
Ilex spp.					R		
Acer ezoanum	C	R	R	C		R	
A. miohenryi	R	R	R	R			
A. palaeodiabolicum	R			R		R	
A. palaeorufinerve			R	R			
A. protodistylum				R			
A. protojaponicum	R	R	R			R	
A. pseudoginnala		R		R			
A. subpictum	C	R	C	C	R	C	
Aesculus majus	R			R			
Paliurus akitanus					R		
P. protonipponicus						R	
Berchemia miofloribunda						R	
Elaeocarpus notoensis						C	
Camellia protojaponica		R		R	R	R	C
Ternstroemia maekawai						R	R
Tilia protojaponica	R	R	C				
T. subnobilis			R				
Elaeagnus mikii						R	
Alangium aequalifolium					C	R	R
Tripetaleia almquisti					R		
Cornus megaphylla						R	
Diospyros minor					R		
D. miokaki				R	C?		A
Osmanthus chaneyi						R	R
Fraxinus honshuensis						R	
F. wakamatsuensis	R	R					
Syringa notoensis						R	
Hemitrapa borealis		R					
H. cf. hokkaidoensis			R	R			
H. yokoyamae					C	R	

TABLE 11—*Continued*

Species	1	2	3	4	5	6	7
Trapa ezoana			R				
Nyssa japonica				R			
Viburunum spp.					R		
Carpolithes japonica					R	C	R
Totals 154	42	30	35	64	58	84	43

A: abundant C: common R: rare

interesting in connection with the paleoecology, but at present it is still premature. Latitudinal analyses are only disposed here in discussing the floras. Four floras of southwestern Hokkaido, namely of Abura, Wakamatsu, Kaminokuni and Yoshioka have been worked out by Tanai. Huzioka observed the Utto flora of Tohoku area, and Matsuo studied Noto-nakajima flora of Hokuriku area in central Japan. All these floras as well as Noroshi are covered by the strata characterized by the warm and shallow sea fauna, represented by Vicarya, Vicaryella, Operculina and Miogypsina. It is evident that the Middle Miocene transgression took place in the green tuff region after the prevalence of these floras. Before this transgression either brackish or fresh water sediments were deposited in this region. The latitude of these localities are as follow: Abura, 42°21′N; Wakamatsu, 42°11′N; Kaminokuni 41°36′N; Yoshioka, 41°17′N; Utto, 39°55′N; Noroshi, 37°31′N; Noto-nakajima 37°07′N.

Each flora in the table is partly changed or omitted here. Concerning Abura flora, Tanai assumes that the place of deposition was fairly high above the sea level, since it is characterised by sediment and by superiority of conifers to others. This statement might be interesting if the correlation of the strata is correct, but any further discussion on the Abura or other southwestern Hokkaido floras will be postponed.

The comparison with southwestern Hokkaido floras

Thirtysix species of 84 Noroshi plants are common to southwestern Hokkaido with 86 plants. In southwestern Hokkaido, Noroshi species are common to 19 of 42 Abura, 15 of 30 Wakamatsu, 10 of 35 Kaminokuni and 31 of 64 Yoshioka. The following species are found commonly in southwestern Hokkaido, but they are not found in Noroshi.

Picea ugoana
Tsuga miocenica
Alnus miojaponica
A. protomaximowiczii
Carpinus miofangiana
C. subcordata
Corylus macquarrii
Fagus antipofi
Ulmus longifolia
U. shiragica
Cercidiphyllum crenatum
Acer miohenryi
Tilia protojaponica

These are northern plants generically or specifically. Especially it is interest that *Fagus antipofi* is abundant towards the north in southwestern Hokkaido and not found in Yoshioka of the most southern part.

The main species occurring in Noroshi but not in southwestern Hokkaido.

Pinus oishii
Cunninghamia protokonishii
Sequoia langsdorfii
Libocedrus notoensis
Quercus mandraliscae
Q. nathorstii
Q. praegilva
Celtis miobungeana
Diploclisia notoensis
Michelia notoensis
Cinnamomum miocenum
C. oguniense
Machilus nathorsti
M. ugoana
Cassia notoensis
Mucuna chaneyi
Wistaria fallax
Buxus protojaponica
Paliurus protonipponicus
Elaeocarpus notoensis
Ternstroemia maekawai
Elaeagnus mikii
Osmanthus chaneyi

These plants are southern genera or species. There are some plants of Noroshi found only from Yoshioka of southwestern Hokkaido. They are:

Torreya yoshiokaensis
Taiwania japonica
Smilax trinervis
Betula sekiensis
Carpinus mioturczaninowii
Quercus miovariabilis
Cladrastis aniensis
Milletia notoensis
Rhus miosuccedanea
R. protoambigua

Thus the difference between the southwestern Hokkaido and Noroshi floras is distinct. However the Yoshioka is more similar to the Noroshi than other three floras in southwestern Hokkaido in having the following:

Juglans japonica	I. heeri
Betula kamigoensis	I. ohashii
Carpinus subcordata	Paliurus akitanus
Ulmus carpinoides	Diospyros minor
U. longifolia	D. miokaki
Ilex daijimaensis	Vibrunum uttoensis

The important Noroshi species not found from Utto are the following southern plants.

Sequoiadendron primarium	Cassia notoensis
Celtis miobungeana	Milletia notoensis
Ulmus subparvifolia	Mucuna chaneyi
Michelia notoensis	Paliurus protonipponicus
Diploclisia notoensis	Elaeocarpus notoensis
Sycopsis chaneyi	Ternstroemia maekawai
Eucommia japonica	Elaeagnus mikii
Albizzia miokalkora	Osmanthus chaneyi

The difference is not remarkable in conifers. The Utto flora is rich in northern Carpinus and Ulmus; thick-textured evergreen broad-leaved trees of the warmer zone which characterize the Noroshi flora are relatively few in member.

The comparison with Noto-nakajima flora

Noto-nakajima is the nearest locality located 70 km southwest of Noroshi. The sediment of Noto-nakajima is different from that of Noroshi. The diatomaceous lacustrine sediment with fossil plants is filling an eroded valley of the basement being the lower Miocene andesite rocks of. The dacite material of Noroshi is almost absent here. Over the lacustrine bed there are strata representing the Middle Miocene transgression with a well-marked unconformity. Therefore, the flora of Noto-nakajima should be approximately contemporaneous with the Noroshi. The diatomaceous mudstone accumulated in the quiet lake within the andesite inland. The rock is massive, neither compacted nor inclinated under the thin overburden.

Noto-nakajima flora was described by Matsuo (1963). It is composed of 27 families, 41 genera, 44 species and *Phyllites* sp. and *Carpolithes* 2 sp. of incertae sedis. In the opinion of the writer the names Podocarpus, Pseudotsuga and Salix shall be erased from the list, besides Dodonea is removed to *Carpolithes japonica, Phyllites* sp. A to *Diploclisia notoensis* and Fokienia to Libocedrus.

32 of 43 Noto-nakajima species are common to Noroshi. Noto-nakajima plants are shown in order of their frequencies as follows:

Pinus miocenica
Diospyros miokaki
Quercus nathorstii
Libocedrus notoensis
Machilus nathorsti
Maackia onoei
Camellia protojaponica
Quercus sinomiocenicum
Magnolia miocenica
Lindera paraobtusiloba
Carpinus subyedoensis
Ficus mioretusa
Comptonia naumanni
Castanopsis miocuspidata
Zelkova ungeri
Picea kaneharai
Smilax trinervis
Quercus praegilva
Quercus mandraliscae
Platycarya miocenica
Carpolithes sp. A
Plenasium lignitum
Cunninghamia protokonishii
Liquidambar miosinica
Alangium aequalifolium
Nitella notoensis
Carpolithes japonica
Quercus protosalicina
Cinnamomum oguniense
Abies honshuensis
Taiwania (?) sp.
Glyptostrobus europaeus
Ranunclus mioaquatilis
Sequoia langsdorfii
Sapindus miocenicus
Ternstroemia maekawai
Potamogeton sp.
Osmanthus chaneyi
Phyllites sp. B
Lygodium mioscandens
Keteleeria cf. ezoana
Najas (?) sp.
Gleditschia tanaii
Ailanthus yezoensis
Diploclisia notoensis

The first four species are abundant, *Pinus miocenica* 16.91%, *Diospyros miokaki* 15.07%, *Quercus nathorstii* 11.64%, *Libocedrus notoensis* 10.44%, totalling 54%.

Among the 44 species, the following species are not found in Noroshi: 4 species of ferns, Potamogeton, Ficus, Ranunclus, Lindera, *Gleditschia tanaii* and Diospyros. The remaining 34 species and *Carpolithes* sp. B are found in Noroshi, too. Among the common Noroshi species, *Podogonium knorrii*, *Sycopsis chaneyi*, *Quercus miovariabilis*, *Perrottetia notoensis*, *Rhus miosuccedanea*, *Acer subpictum* and *Elaeocarpus notoensis* are not found at Noto-nakajima.

Only 30 specimens (1.10%) of Zelkova was collected at Noto-nakajima while it is one of the most numerous forms in Noroshi. Fascicles of Pinus and leaves of Diospyros are abundant, but are not recorded in the Noroshi flora. *Quercus nathorstii* and Libocedrus are numerous; *Carpinus subyedoensis* and Comptonia are common. These features are common to both floras. Even though *Machilus nathorsti* and Castanopsis are found in Noroshi as well, the fact that they are very common here makes a difference from Noroshi. In general, the warm plants are more abundant in Noto-nakajima than in Noroshi. On the other hand northern trees like Zelkova are rather rare. So it will be conceivable that Noto-nakajima shows a little warmer climate than those of Noroshi. This concept is supported further more by the fact that *Ficus mioretusa* which is not found in Noroshi is common here. In addition, a dry climate can be assumed, observing the abundant occurrences of Pinus, *Quercus nathorstii* and *Machilus nathorsti* those adapted for a dryer atmosphere than in Noroshi. However, need of a considerable amount of water can also be imagined because there were abundant Machilus.

This apparent contradiction is caused by that Pinus and Quercus grew upon hills and mountains while Machilus on valley bottoms. A relatively dry climate was possible for a mountain range interrupted the monsoon from the west.

Noto-nakajima flora has a following sequence of frequency, *Quercus nathorstii* > *Machilus nathorsti* ≫ *Quercus sinomiocenicum* ≫ *Castanopsis miocuspidata* > *Quercus praegilva*, *Quercus mandraliscae*.

The thermoscopic gradation is Machilus > Castanopsis > Cyclobalanopsis. The Cyclobalanopsis-type represent by species of narrow-leaved *Quercus gilva*, *Q. myrsinaefolia* etc.

Machilus was attached to the most moist soil that prevailed in valley bottoms. In relation to sunshine and water, Machilus and Castanopsis lived separately, one in valleys and the other on high ridges. In choice of living place, Cyclobalanopsis preferred a high humidity in comparison with Castanopsis.

On the basis of the above mentioned criteria, the flora of Noto-nakajima is assumed to represent a little warmer vegetation than that of Noroshi. The monthly mean temperature is presumed to have been 28°–29°C during the most heated season, about 5° higher than in the coldest month, *Quercus gilva* and *Q. sinomiocenicum* and Castanopsis must have been growing on slopes and ridges and Machilus in valleys. Owing to differences in topography, presumably a foggy zone existed at high levels where *Quercus praegilva* and *Q. mandraliscae* lived. On the ridges and slopes Pinus was prosperous. As was in the case of Noroshi, most probably there was no wide plain between the mountain-land and the lake; so the slope confronted directly the intermontane lakes. A west-side mountain range shut off the westerly monsoon of winter made the air dryer than at Noroshi, seemingly warmer days predominate. However, summer rainfall was enough for vegetation attaining an annual precipitation of about 1,500 mm. Judging from the occurrences of seeds of *Picea kaneharai* and *Abies honshuensis*, some mountains above 1,000 meters high to the west is a reasonable supposition. The number of species is smaller than at

Noroshi, especially deciduous broad-leaved trees are very few. This fact suggests that there was but little influence of volcanism on burials of plants or that the dry climate prohibited the luxuriant growths of various trees.

Summary

The Noroshi flora is compared with the Middle Miocene floras of Japan Sea coast; southwestern Hokkaido, Utto and Noto-nakajima. Their differences are larger by latitudinal distance from Noroshi. It is certain at least anyway, that during the Middle Miocene time of Japan Sea coast, there was distinct climate zonation parallel to the latitude. Therefore the paleoclimatic summary of he lower Middle Miocene of Japan Sea-side is described as follows.

The paleogeography of the Japan Sea coast before the Middle Miocene transgression has not been made fully clear. However, it has been shown that there were shallow seas and brackish waters as indicated by the occurrence of fossil shells in northeast Japan. Previous to this time there was a broad fresh water environment. Andesite volcanic activities were vigorous, and lavas and coarse pyroclastic material rapidly buried the area. Next the dacite volcanic material and basalt flows were accumulated in the rest of the basin, burying the plants of the Noroshi flora. Then the conglomerates and sandstones were deposited conformably over the dacite formation and unconformably on the andesite. They have marine fossils in them indicating the Middle Miocene transgression.

The floras in the northern areas were under influence of the sea, while there was deposition in a lagoonal embayment in the Noroshi region. Southwardly there were the land of dacitic pyroclastics, lake and lagoonal embayment. Noroshi and

TABLE 12
The number of joint species between Middle Miocene Flora in Japan Sea side

	Abura	Wakamatsu	Kaminokuni	Yoshioka	Southwestern Hokkaido	Utto	Noroshi	Noto-nakajima
Abura	42							
Wakamatsu	26	30						
Kaminokuni	21	15	35					
Yoshioka	31	24	19	64				
Southwestern Hokkaido					86			
Utto	16	14	12	23	29	65		
Noroshi	19	15	10	31	36	41	83	
Noto-nakajima	7	9	4	16	16	27	32	43

TABLE 13
The annual average temperature of some localities in Japan Sea coast

Recent			Early Middle Miocene Estimates		
Hakodate	41°49′N	8.5°C	Yoshioka	41°17′N	10°C
Akita	39°43′N	10.5°C	Utto	39°55′N	12–13°C
Wajima	37°32′N	12.5°C	Noroshi	37°31′N	14–15°C
Kanazawa	36°33′N	13.3°C	Noto-nakajima	37°07′N	15°C
Tottori	35°31′N	13.9°C			
Hamada	34°54′N	14.6°C			
Shimonoseki	33°57′N	15.2°C			
Fukuoka	33°35′N	15.1°C			

the similar environments spread southward Kaga and further southwestward to San'in area through Fukui, Tango and Tajima. Since there was no dacite activity around Noto-nakajima, it can be inferred that there an upheaved mass of granite-gneiss and andesite that was making mountains surrounding a basin widely opened to the east. In other words the basin was a site or inlet fairly apart westward from the main water in the east. No more detail of the paleogeography is known. Any influence of the warm current has not been disclosed, though the zonal structure of climate in a belt about 5° in latitudinal width, between the Oshima Peninsula of Hokkaido and Noto Peninsula of central Honshu, is apparently distinguishable.

Table 13 shows that the present climate of Utto, which is on the southern limit of the cool temperate zone, was some 170 km to the north, near the site of the Yoshioka flora. Utto of the Middle Miocene was nearly same as the present Noroshi in climate. Noroshi at that time was just like the west part of the present San'in. Noto-nakajima, only 70 km southwest of Noroshi, was less influenced by the westerly or northwesterly monsoon. However, the climate was not so dry as that of the present Inland Sea coast, þut more or less similar to the west end of the Inland Sea, though probably a little warmer and wetter.

CORRELATION AND AGE

Tanai has discussed the correlation and age of Japanese Neogene floras, and his opinions are considered to be correct in general. Tanai arranged Japanese Tertiary floras in six chronological types. He calls the Middle Miocene flora the Daijima-type flora. Most probably the Noroshi flora belongs to the Daijima-type, as evidenced by its geologic occurrence, composition and paleoecologic conditions.

Geologic Evidence

The Paleogene sediments are found on the Pacific coast of main islands.

None is found in the southwestern Hokkaido and on the coast of the Japan Sea excepting the volcanic rocks. Miocene sediments are divided into 3 areas: Pacific coast, Japan Sea coast and Inland Sea. Those of the Japan Sea coast have a common succession from Hokkaido down to San'in, and the area occupied by them is called "the green tuff region". The most remarkable common characters are the volcanic activity, lithology and paleontology. Therefore, any correlation within the green tuff region is not so complex as others in this country.

The general succession is as follows: first, lacustrine sediment covers unconformably the rocks of pre-Miocene — mainly pre-Paleogene, then strata of tremendous amount of andesite rocks come; some of them erupted on the land. At the beginning of Middle Miocene, great quantities of pyroclastic materials derived from dacite rocks were accumulated on the land, and to some extent under water. The land made of the pre-Neogene rocks and the andesite had a very complicate shore-line. The Tohoku and Hokkaido regions were invaded locally by the sea. In the middle of Middle Miocene a large area of the green tuff region was submerged under the sea, so that the most of andesite rocks of the Lower Miocene were covered by this sea. In some small areas, however, for instances Oga, Sado and Noto, the andesite became the bases of islands, which were united to make a larger land in early Middle Miocene time. The sediment of this transgression yields the warm current foraminifers such as *Globorotalia* cf. *fohsi*, *Globigerinoides triloba*, *G. cyclostoma*, *Orbulina universa* etc. The beds yield also *Operculina complanata* and *Miogypsina kotoi* and a large amount mollusks lived in the warm, shallow sea, such as Vicarya and Vicaryella etc. This fauna is similar to that of the Middle Miocene of Pacific side of Japan, which contains *Lepidocyclina makiyamai*. It bears some resemblances also to the fauna from the strata of the Inland Sea region.

In some parts of the green tuff region all these strata are conformable, but in other places the marine sediments lie directly over the andesite rocks with an unconformity, due to lack of the dacite rock. At other exceptional places all three formations are separated by unconformities.

The Noroshi flora is found in the tuffaceous shales intercalated in dacite tuff. Here the dacite formation unconformably covers the andesite formation and is conformably covered by the marine sediments.

The above interpretations suggest that the Noroshi flora is determinable to be early Middle Miocene in age. The four floras of southwestern Hokkaido, including the Yoshioka, Utto, and Noto-nakajima floras are referred to the same age as the Noroshi for the same reason. As has been stated, rich floras of this age are known from many various localities in other parts of Japan. They are show similarity in lithologic and paleozoologic relations, and in the occurrence of overlying marine sediments containing Middle Miocene fossils. The age determination on the basis of geologic relations seems to be wholly satisfactory.

Evidence of Floral Composition

The Daijima-type, Middle Miocene flora includes both those from the aforementioned dacite formation and the overlying marine formation. Since Tanai's "Neogene Floral Change in Japan" (1961) there was but few additional floras of this type described. It appears unnecessary to go into detail regarding floral composition, but I shall comment on some plants added to the flora.

First of all, the discovery of a long two-leaved *Pinus oishii* among the Daijima-type flora shall be mentioned here. (An oral information by Huzioka, Tohoku area only)

Secondly, that Glyptostrobus is widely found in the flora of this type. It is supposed to have lived in a colder environment than at present. It is found also in the Aniai-type flora of the andesite formation of preceding age.

Sequoiadendron has been found at Noroshi, and at Seto (Miki, 1963). The Seto flora includes *Pinus trifolia* and is considered to be Pliocene in age.

Recently numerous samples of Libocedrus were discovered in the Daijima-type flora of Honshu. Plants suited for warm climate such as Diploclisia, Ternstroemia and Osmanthus were obtained at Noroshi and Noto-nakajima, both representing the Daijima-type localities in Noto. Most of the other plant members at the Noroshi locality are the typical species in the catalogue of the Daijima-type flora given by Tanai (1961). *Comptonia naumanni* is found at almost all localities of this type as a good index fossil. Huzioka classifies Comptonia into three species each representing the Paleogene, Middle Miocene and Mio-Pilocene form respectively. The coexistence of *Comptonia naumanni* and *Liquidambar miosinica* is a well-marked characteristic of the Daijima-type flora.

Abundance of evergreen oaks is another characteristic of this type flora in Honshu. Those broad-leaved trees of the Daijima were replaced by species of new type in the succeeding stage (Upper Miocene).

It should be noticed that an extinct species *Podogonium knorrii* is abundant at Noroshi. It is known in Oligocene to Pliocene strata in Europe, in the Sarmatic Nasravchev and Caucasus, and in the Middle Miocene of Shantung. In Europe it is a member of the southern flora, and considering the abundant occurrence at Noroshi, it will be expected to be found in the flora of Daijima-type at other places in southern Japan. It is also noteworthy that the age of this type of flora seems correlative with the lower portion of upper Mollasse in Switzerland. Recently I found *Podogonium knorrii* from the Chojabaru flora of Iki Island of North Kyushu. This was contained in a bed of diatomaceous mudstone containing *Coscinodiscus* *divisus*. The environment was supposedly a quiet shallow inland sea. This bed is accompanied by the dacite rocks characteristic of green tuff region. The flora seems to represent another portion of the Daijima-type showing forests on the northern end of Kyushu.

Evidence of Paleoecology

Floras of the Early Miocene earlier than the Noroshi flora are not so well known in southwestern Japan. Tanai states that the flora of that age with the name "Aniai-type flora" indicates cooler climate than Daijima-type. It is presumed that the paleogeography of the Japan Sea side was a part of a continental environment little influenced by the warm current. For this reason, instead of broad-leaved tree of the new type, trees suit to the warmer climate occur abundantly. This is a well-marked characteristic of Daijima-type flora. As explained in the preceeding chapters, there is a remarkable parallelism between the past and that of the present days, even though the former was warmer than now. It was warm and wet under the influence of the warm current. The annual mean temperature was 0.8°–1.3°C higher than that of the present days at southwest Hokkaido and Tohoku, 1.7°–2.0°C in Noto.

Summary

Bunolophodon annectens is the only vertebrate found in the Yanagida formation which contains the Noroshi flora and there is no evidence of any other fossil land animal. The geological sequence shows successive accumulations of andesite, dacite and marine formation. This stratigraphy is common throughout the green tuff region. The Noroshi flora is intercalated in the dacite formation and its stratigraphic position within the green tuff group is accurately determinable with so many helpful criteria. The overlying marine formation has a very rich fauna which enables it to be correlated with equivalent formations in other areas of Japan, for instance the Pacific coast and the Inland Sea areas. This fauna corresponds to the beds of the Middle Miocene, with *Lepidocyclina makiyamai* akin to *L. rutteri* of f_3 horizon in Indonesia. Miogypsina from the uppermost part of f and *Vicarya callosa* of f_{1-3} also suggest contemporaneity. *Vicarya yokoyamai* akin to *V. verneuili* of Gaj in India, is found in the upper and lower parts of this formation. Thus the age of the Daijima-type flora is considered to be equal to that of the lower portion of f_3 of Indonesia, and the marine formation with the upper portion of f_3. Thus the stage of the Noroshi flora is correlated with upper Vindobonian or the lower Upper Mollasse of Europe, as well as Tortonian and Luisian-Mohnian of western North America.

Floral composition consists largely of plants of the Arcto-Tertiary Geoflora, and is called Japanese Liquidambar-Comptonia flora. The warm environment and the abundant findings of *Podogonium knorrii* suggest correlation with the Shanwang flora of China.

CONCLUSION

In the Noroshi area, on rocks representing andesite, basalt and dacite flows and pyroclastics, grew a forest of warm to cool temperate zones during the early Middle Miocene. The floral composition is characterized by living Chinese elements, and contains some North American elements. It consists largely of plants of the Arcto-Tertiary Geoflora, with lesser representation of the Paleotropical-Tertiary Geoflora and is termed the Daijima-type flora in Japan.

The Noroshi forest lived under similar conditions of temperature and precipitation to those of modern southwestern Japan. It ranged from a flood plain up adjacent slopes, with a few members extending into the mountains.

The flora indicates the following climate: annual mean temperature of 14.5° to 15.0°C, between the warmest mean of 26° to 27°C and the coldest mean of 4° to 5°C; annual precipitation of about 2,000 mm. Autumn appears to have been the rainiest season, and even the relatively dry season had a precipitation of over 100 mm. A severe climatic condition with the well-known heavy snow of Japan Sea side at present is not indicated.

Comparisons are made with other Middle Miocene floras of adjacent areas, including latitudinal analyses. The present southern limit of the deciduous forest zone in Japan Sea side was nearly two degrees further north.

SYSTEMATIC DESCRIPTIONS

The Miocene Noroshi plants here described comprise 84 taxa, including 12 new species, a new combination, and five taxa whose specific relations are indeterminate. Specimens whose generic status has not been determined are assigned to Incertae Sedis. Tai's pollen analysis of the rocks from Takaya represent 11 of our genera.

The prefix JC88 preceding the collection numbers refers to paleobotanical collections from Cenozoic strata of Japan in the Department of Geology and Mineralogy, Kyoto University.

Family POLYPODIACEAE

Onoclea sp.

(Plate 1, figure 1)

Remarks. A fragmentary sterile leaf is referred to the genus Onoclea by its characteristic venation. This genus has been known from the Paleogene of eastern Asia, North America and Europe. The living *O. sensibilis* Linnaeus is a monotypic species now found in eastern Asia and eastern North America.

This is the first record of Onoclea in the Miocene of Japan. The specimen at hand is not well preserved.

Occurrence: East of Takaya.

Collection: Holotype JC88–24.

Athyrium sp.

(Plate 1, figure 2)

Description. Part of pinnule diverging segments, 1.9 cm wide; pinnule spatulate, 0.9 cm long; apex mucronate; venation delicate but distinct; midvein giving off two to three secondary veins on each side.

Remarks. This fragmentary specimen is assignable to the genus Athyrium on the basis of its sterile foliage. No fossil species like this has been described. The only other fossil record in this country is *A. delicatulum* Oishi and Huzioka from the Eocene Ikushunbetsu formation of Hokkaido, which differs in having small, ovate pinnules. Our specimen resembles the living *A. niponicum* (Mett.)Hance, widely distributed in eastern Asia.

Occurrence: Takaya.
Collection: Holotype JC88–25.

Family TAXACEAE

Torreya yoshiokaensis Tanai and Suzuki

(Plate 1, figures 3, 5–8)

1962. *Torreya yoshiokaensis* Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ. p. 105, pl. 1, figs 5, 15.

Supplementary description. Leaves linear-lanceolate, 1.2 to 2.2 cm long, 2.2 to 4.0 mm wide at the base, gradually narrowed towards apex, abruptly aristate, pointed at apex; convex above, with two bands below, nearly right angled to twig; texture thick, hard-coriaceous.

Remarks. This species is based on a seed and foliage which closely resemble the living *T. nucifera* Siebold and Zuccarini found in Honshu, Shikoku and Kyushu. Fourteen leaves and a twig are referred to *T. yoshiokaensis* because of their resemblance to *T. nucifera.* Our specimens also resemble *T. borealis* Heer from the Atanakerdluk Paleocene of Greenland, but the latter show a smaller angle of attachment to the shoot. The leaves and seeds of *T. nucifera* occur from the Plio-Pleistocene of Japan.

Occurrence: Kourade, Takaya, East of Takaya, Uwano and Osaki.

Collection: Hypotypes JC88–26–28 (Kourade), 30(Takaya), 31(East of Takaya).

Family PINACEAE

Keteleeria ezoana Tanai

(Plate 1, figures 4, 9, 10)

1961. *Keteleeria ezoana* Tanai, Jour. Fac. Sci. Hokkaido Univ. Ser. 4, vol. 11, p. 251, pl. 1, figs. 16, 40, 41.
1962. Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 99, pl. 1, figs. 2–4; pl. 2, figs. 1, 2, 31.

Remarks. This species was described on the basis of needles a cone-scale and winged seeds from the Middle Miocene flora of southwestern Hokkaido and Honshu by Tanai. In the Noroshi flora, 18 winged seeds and 41 leaves referred to this species were found at 7 localities.

K. davidiana Beissner is the nearest living equivalent of this fossil species; it is distributed in central and southern China, and the variety occurs in Taiwan. *K. heterophylloides* (Berry)Brown, the American fossil species, is similar to *K. davidiana*. The cones and leaves of *K. davidiana* occur from the Upper Pliocene of Japan.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Noroshi-shin, Uwano and Osaki.

Collection: Hypotypes JC88–33(Kourade), 35, 39(Takaya).

Picea kaneharai Tanai and Onoe

(Plate 1, figures 11–14)

1961. *Picea kaneharai* Tanai and Onoe, Geol. Surv. Japan, Report No. 187, p. 17, pl. 1, fig. 9.

Remarks. 11 winged seeds obtained from three localities are referred to this species. *P. kaneharai* has been described from the Pliocene of Honshu and the Miocene of Hokkaido. A similar living species, *P. polita* Carriere, is distributed in the mountains of central Honshu, Shikoku and Kyushu. This species may be related the fossil *P. magna* MacGinitie of North America. The cones of *P. polita* occur from the Plio-Pleistocene of Japan.

Occurrence: Takaya, East of Takaya and Orito.

Collection: Hypotypes JC88–51(Takaya), 52–54(East of Takaya).

Pinus miocenica Tanai

(Plate 1, figures 15, 16)

1961. *Pinus miocenica* Tanai, Jour. Fac. Sci. Hokkaido Univ. Ser. 4, vol. 11, p. 256, pl. 2, fig. 2.

1888. *Pinus* sp. Nathorst, Palaeont. Abhandl., heraus. v. Dam. Kays. vol. 4, p. 30, pl. 7, figs. 11, 12.

1962. *Pinus miocenica* Tanai. Matsuo, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 231, pl. 43, figs. 4–8.

Supplementary description. Windge seed obovate-elliptic, pointed at base, 0.9 to 1.0 cm long, 4.0 to 5.5 mm wide; wing blade-like, 1.4 to 2.0 cm long, 6 to 9 mm wide. Male flower cylindrical, spiculate, 11 mm long, 3 mm wide, curved, composed of numerous 2–celled anthers, imbricated in many ranks, the involucres

5 mm long.

Remarks. This species has been represented by leaves from the Middle Miocene in Honshu and Hokkaido. Recently Matsuo described cones, winged seeds and a staminate ament from the Miocene of southern Noto. *P. miocenica* appears to be similar to the living two-leafed pines of Japan, *P. thunbergii* Parl. and *P. densiflora* Siebold and Zuccarini. Our seed specimens are also similar to those of *P. densiflora*. The male flower here described is referred to *P. miocenica* because of its similarity to the male flower of *P. densiflora*. The cones of *P. densiflora* and *P. thunbergii* occur from the Lower Pleistocene of Japan.

Occurrence: Takaya and East of Takaya.

Collection: Hypotypes JC88–59, 61(Takaya).

Pinus oishii new species

(Plate 1, figures 17, 18; Plate 2, figures 1, 2)

Description. Leaves long and slender, in bundles of two; length up to 21 cm, 0.88 mm wide; acutely pointed at apex, with minute serration at margin, crescent-shaped in cross section; with 9 mm long basal sheath; male flowers cylindrical, spiculate; 14 to 20 mm long, 3 to 5 mm wide; sometimes curved; surrounded at the base by 4 to 6 mm long involucres, composed of numerous 2–celled anthers, imbricated in many ranks.

Remarks. This long and slender two-needled pine has been listed from the Middle Miocene Oguni flora by Huzioka as *Pinus oishii* MS. He identified our specimens with this species, and consented to our describing them. The foliage resembles that of several living pines: *P. luchuensis* Mayr, *P. massoniana* Lambert, *P. yunnanensis* Franchet, *P. merkusii* Jungh. and de Vries. The needles of *P. massoniana* are most similar in length and width. This species is widely distributed throughout the warmer parts of China from the sea level up to 1,800 m, and grows on lowlands and the basis of mountains in northern Taiwan.

The male flower also most closely resemble that of *P. massoniana*, which is longer than those of *P. densiflora* and *P. parviflora*.

Occurrence: Kourade, Takaya, East of Takaya, Orito and Uwano.

Collection: Holotype JC88–64(Takaya); Paratype JC88–69(Takaya); Hypotypes JC88–68(Takaya), 75(East of Takaya).

Pinus palaeopentaphylla Tanai and Onoe

(Plate 1, figure 19)

1961. *Pinus palaeopentaphylla* Tanai and Onoe, Geol. Surv. Japan Report No. 187, p. 18, pl. 1, figs. 8, 10, 12.

Remarks. This five-needled leaf with a sheath is referred to *Pinus palaeopentaphylla*, which has been described from the Middle Miocene to the Pliocene of Hokkaido and Honshu. This species closely resembles the living *P. parviflora* Siebold and Zuccarini, which now grows in the mountains of southern Hokkaido, Honshu, Shikoku and Kyushu. This may be related to *P. wheeleri* Cockerell, the fossil species of North America. The cones of *P. parviflora* occur from the Plio-Pleistocene of Japan.

Occurrence: East of Takaya.

Collection: Hypotype JC88–80.

Family TAXODIACEAE

Cunninghamia protokonishii Tanai and Onoe

(Plate 2, figure 3)

1961. *Cunninghamia protokonishii* Tanai and Onoe, Geol. Surv. Japan Report No. 187. p. 18, pl. 1, fig. 1.

Remarks. The original description is based upon materials from the Mio-Pliocene of western Honshu by Tanai and Onoe; another occurrence in the Utto flora from the Middle Miocene of northeastern Honshu is known. Its foliage shoots are similar to the living *C. konishii* Hayata, which is scattered in the northern and central mountains of Taiwan. The shoots of *C. konishii* occur from the Plio-Pleistocene of Japan.

Occurrence: Takaya and East of Takaya.

Collection: Hypotype JC88–81 (Takaya).

Glyptostrobus europaeus (Brongniart) Heer

1855. *Glyptostrobus europaeus* (Brongniart) Heer, Flora Tertiaria Helvetiae, vol. 1, p. 51, pl. 20, fig. 1.

1952. Tanai, Japanese Jour. Geol. Geography, vol. 22, p. 123, pl. 4, fig. 1.

1833. *Taxodium europaeum* Brongniart, Annales Sci. Naturelle, Paris, Botanique, vol. 30, p. 168.

1936. *Glyptostrobus europaeus* Heer. Endo and Okutsu, Proc. Imp. Acad. Japan, vol. 12, p. 138, figs. 1–3.

Remarks. Incomplete specimens represented by leafy shoots are referred to this species. It is abundant in Tertiary floras of the northern hemisphere, and is common from Eocene to Pliocene in Japan. The living *G. pensilis* Koch. grows along river borders in southeastern China. The remains of *G. pensilis* occur from the Upper Pliocene of Japan.

Occurrence: Takaya.

Metasequoia occidentalis (Newberry) Chaney

(Plate 1, figure 20)

1951. *Metasequoia occidentalis* (Newberry)Chaney, Trans. Amer. Phil. Soc., vol. 40, p. 225, pl. 1, fig. 3; pl. 2, figs. 1–3; pl. 4, figs. 1, 2, 9,; pl. 5, figs. 1–3; pl. 6, fig. 2; pl. 7, figs. 1–6; pl. 8, figs. 1–3; pl. 9, figs. 3, 5–7; pl. 10, figs. 1a, 2a, 3–6; pl. 11, figs. 7, 8; pl. 12, figs. 1, 2, 5–8.

1863. *Taxodium occidentale* Newberry, Boston Soc. Nat. Hist., vol. 7, p. 516.

1883. *Taxites* sp. Nathorst, Kongl. Svens. Akad. Handl, vol. 20, no. 2, p. 35, pl. 1, fig. 8.

Remarks. This species is one of the most widely distributed conifers in the Arcto-Tertiary Geoflora. Leafy shoots are common in the Noroshi flora two seeds have been found, but no cones.

The genus Metasequoia was established by Miki on the basis of leafy shoots and cones from the Plio-Pleistocene of Japan. The living *M. glyptostroboides* Hu and Cheng has a restricted range on the Szechuan-Hopeh border of central China.

Occurrence: Kourade, Takaya, East of Takaya, Yamabushi-yama, Noroshi-shin, Uwano and Osaki.

Collection: Hypotype JC88–88(Uwano).

Sequoia langsdorfii (Brongniart)Heer

(Plate 3, figure 2)

1855. *Sequoia langsdorfii* (Brongniart)Heer, Flora Tert. Helv. vol. 1, p. 54, pl. 20, fig. 2; pl. 21, fig. 4.

1962. Huzioka, Geol. Surv. Japan 80th Ann. Mem. Publ. p. 189, pl. 28, fig. 13; pl. 40, fig. 2.

1962. Matsuo, ibid., p. 233, pl. 43, figs. 9, 10; pl. 45, figs. 3–5.

1828. *Taxites langsdorfi* Brongniart, Prodr. Hist. Veget. Foss., pp. 108, 208.

1961. *Sequoia affinis* Lesquereux. Tanai, Jour. Fac. Sci. Hokkaido Univ. Ser. 4, vol. 11, p. 265, pl. 3, fig. 11.

Remarks. Several foliage shoots are referred to *S. langsdorfii*. The figured specimen shows the young leaves of spring and the leaves of last year. This species is similar to the living *S. sempervirens* Endl., which grows along the coast of the western United States. The leafy shoots and cones of *S. sempervirens* occur from the Upper Pliocene of Japan.

Occurrence: Takaya, East of Takaya and Uwano.

Collection: Hypotype JC88–90(East of Takaya).

Sequoiadendron primarium Miki

(Plate 3, figures 1, 3)

1965. *Sequoiadendron primarium* Miki, Bull. Mukogawa Women's Univ. 13, p. 1–5, pl. 1, figs. A-E.

1963. *Sequoiadendron* cf. *chaneyi* Axelrod. Miki, Jour. Soc. Earthscientists and Amateures Japan, spec. vol., p. 92, plate, figs. Aa, b.

Remarks. Miki reported as *S. primarium* several leafy shoots and cones showing the characteristics of the genus Sequoiadendron, from the Pliocene of Tokitsu and Homi, central Japan. Miki's cones are smaller, about 1.8–2.0 cm long, than Axelrod's cone. Our 14 leafy shoots with 3 stomata, and the basal part of a cone, are like *S. chaneyi* and also Miki's *S.* cf. *chaneyi*. Sequoiadendron differs from Sequoia in that the shoots and cone stalks do not have scales, as has been pointed out by Miki. Our cone is ill-preserved, but it appears small in size having no scales on its stalk. The Japanese Sequoiadendron differs from *Sequoiadendron chaneyi* in its smaller cone. The living *Sequoiadendron giganteum* (Lindley)Bucholtz grows at middle elevations in the Sierra Nevada of North America.

Occurrence: Takaya and East of Takaya.

Collection: Hypotypes JC88–91, 92(Takaya)

Taiwania japonica Tanai and Onoe

(Plate 2, figures 4, 5)

1961. *Taiwania japonica* Tanai and Onoe, Geol. Surv. Japan Report. No. 187, p. 19, pl. 1, fig. 4.

Supplementary description. Leaves of the young tree linear, acute at apex, 0.8 cm long, those on old trees triangular, awl-like, shortly acute at the apex;

cone oblong, 1 cm long, 5 mm wide.

Remarks. This species was originally described of the basis of leafy shoots from the Late Miocene of western Honshu. It is closely related to the living *T. cryptomerioides* Hayata. Foliage and a cone-bearing shoot from the Noroshi flora show similarity to those of young and old trees of the living species, which grows in the central ranges of Taiwan, and in northwestern Yunnan province of mainland China. The leafy shoots of *T. cryptomerioides* occur from the Upper Pliocene of Japan.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Uwano and Osaki.

Collection: Hypotypes JC88-100(Takaya), 102(East of Takaya).

Family CUPRESSACEAE

Libocedrus notoensis (Matsuo) new combination

(Plate 3, figures 4–7)

1962. *Fokienia notoensis* Matsuo, Geol. Surv. Japan 80th Ann. Mem. Publ. p. 233, pl. 44, figs. 1–4.

1962. Huzioka, ibid., p. 189, pl. 28, figs. 16–18a.

Supplementary description. Leafy shoots stout; leaves scale-like, flat; 1 mm long at the tips, to 1.4 cm long on leading shoots; middle ones obtuse and pointed in apex, lateral pair pointed, incurved; fruit woody, lateral pair 2 cm long, middle one longer.

Remarks. This species is similar to the living *L. formosana* Florin. Libocedrus from the Tertiary of North America resembles the living *L. decurrens* Torrey of that continent; its lateral leaves are gradually narrowed and acuminate at apex. *Fokienia hodginsii* Henry and Thomas, now living in southern China, also has similar leafy twig to *L. notoensis*. However, the leaves of Fokienia are wider, and become suddenly smaller towards the tips; the lateral pair more extends outside, and is less incurved near apex. *L. lantenoisi* Laurent from the Paleogene of Tonkin seems related both to *L. notoensis* and to the living *L. formosana*.

The living *L. formosana* grows in southwestern China and Hainan, and is scattered in broad-leaved forests of the northern and central parts of Taiwan. Cone ripens and rips in August-September in north Taiwan, and in October-November in central.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Uwano and Osaki.

Collection: Hypotypes JC88-107-110(Takaya).

Thuja nipponica Tanai and Onoe

(Plate 4, figure 2)

1961. *Thuja nipponica* Tanai and Onoe, Geol. Surv. Japan Report, No. 187, p. 19, pl. 1, fig. 11.

Remarks. A single specimen from the flora representing a leafy twig is referred to this species. It is closely similar to the living *T. standishii* Carr., which grows from northeastern to central Honshu, Japan. This species may be related to the living *T. plicata* Lamb. of western North America and *T. occidentalis* L. of eastern. The cones and shoots of *T. standishii* occur from the Plio-Pleistocene of Japan.

Occurrence: Takaya.

Collection: Hypotype JC88–121.

Family PALMAE

Livistona sp.

(Plate 4, figure 1)

Description. Isolated ray; midrib stout, straight, convex and 2 mm wide on the abaxial; conjunct part straight, concave and about 0.3 mm wide on the abaxial, 1 mm wide plate-shaped on the adaxial, pressed on the lateral side; width between the midvein and the conjunct part 1 to 14 mm; interposed vein fine, straight, parallel to the midvein, enter into the conjunct part towards the base; width between the each vein 1.4 to 1.8 mm; the transversal veinlet fine, irregularly waved; texture firm.

Remarks. This fragmental specimen represents part of a ray, and shows the lower surface from the right side of the leaf. I have compared it with Livistona, Trachycarpus, Thrinax, Acoelorraphe and Sabal. Trachycarpus differs in that the interposed fine veinlets are convex on the abaxial surface. This specimen is akin to the leaf of the living *L. subglobosa* (Hassk.) Mart. which is distributed in the southern extreme of Kyushu, Okinawa and Taiwan. Probably some of the specimens of Sabalites and Flabellaria from the Paleogene are also referable to Livistona.

Occurrence: Takaya.

Collection: Holotype JC88–122.

Family LILIACEAE

Smilax trinervis Morita

(Plate 4, figures 3, 5)

1931. *Smilax trinervis* Morita, Jap. Jour. Geol. Geography, vol. 9, p. 7, pl. 1, figs. 10–12.
1962. Huzioka, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 190, pl. 29, fig. 2.
1930. *Smilax china* Konno, Geology of Central Shinano (by Honma), pl. 8, fig. 4.
1931. *Smilax minor* Morita, Jap. Jour. Geol. Geography, vol. 9, p. 7, pl. 1, figs. 13–19.

Remarks. Eight leaves are referred to *S. trinervis* Morita, from the Middle and Upper Miocene of Honshu and Hokkaido. This species resembles the living *S. china* Linnaeus of eastern Asia.

Occurrence: Takaya, East of Takaya and Orito.

Collection: Hypotypes JC88–123(Takaya), 126(East of Takaya).

Family SALICACEAE

Populus tuberculata new species

(Plate 21, figures 1–4)

Description. Leaves orbicular to orbicular-ovate, 6 to 11.5 cm long, 5.5 to 8.5 cm wide; midrib stout, gradually narrow towards apex; base truncate or slightly cuneate; petiole stout, 2 to 5 cm in estimated length; secondary veins somewhat slender, 5 to 7 pairs, diverging from the midrib at angles of 50° to 70°, curving upwards, camptodrome, with tuberculatus at terminal side of the part diverging from the midrib; slender branches from the looped secondaries looping and entering the marginal sinus; tertiaries thin, irregularly percurrent; nervilles irregularly reticulate; margin shallow-serrate or rarely undulate; texture thick.

Remarks. Our specimens are referable to Populus on the basis of shape, venation, margin and texture. This species is characterized by the tubercles at the forks of secondaries, which may have been made by ticks. These leaves resemble *P. nipponica* Tanai and N. Suzuki from the Kaminokuni flora of Hokkaido. However this species has much smaller leaves, sometimes with a shallow cordate base. The living equivalent of *P. nipponica*, *P. heterophylla* L. of North America and *P.*

maximowiczii of Northeastern Asia, differ from *P. tuberculata* in having usually a slightly cuneate base and coarser serration, with a stouter tip. As regards the character of basal shape and teeth, our leaves are similar to *P. simonii* living in Korea and China, but this poplar commonly has small and diamond-shaped leaves. The leaves on young shoots of *P. simonii* are similar to this species in size and shape. Our specimens are also similar to *P. acuminata* Rydb. living in western North America in the shape, coarse serration and secondary veins. However no leaves of known fossil and living Populus have tubercles at the fork of secondaries.

Occurrence: Takaya, East of Takaya

Collection: Holotype JC88–627(Takaya); Hypotypes 628, 631, 633(Takaya).

Family MYRICACEAE

Comptonia naumanni (Nathorst)Huzioka

(Plate 4, figure 4)

1961. *Comptonia naumanni* (Nathorst)Huzioka, Jour. Mining College Akita Univ. Ser. A, vol. 1, p. 65, pl. 3, figs. 7, 8,

1888. *Comptoniphyllum naumanni* Nathorst, Palaeont. Abhandl. heraus. v. Dam. Kays., vol. 4, p. 8, pl. 2, fig. 2.

1932. Endo and Morita, Sci. Rep. Tohoku Imp. Univ., Ser, 2, vol. 15, p. 43, pl. 5, figs. 3–16.

1888. *Comptoniphyllum japonicum* Nathorst, Palaeont. Abhandl. heraus. v. Dam. Kays., vol. 4, p. 13, pl. 4, figs. 2–3.

1961. *Myrica(Comptonia) naumanni* (Nathorst)Suzuki, Sci. Reports Fac. Art and Sci., Fukushima Univ., No. 10, p. 28, pl. 2, figs. 9–13.

1961. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 271, pl. 5, figs. 1–3, 6–10, 13, 14, 16, 18.

Remarks. Leaves range in width from 4 to 30 mm. This species is common in the Middle Miocene of Japan, though it is represented only by leaves. It is closely related to the living monotypic species, *C. peregrina* (L.)Coult of eastern North America, whose leaves are not always dissected down to the midvein.

Occurrence: Kourade, Takaya, East of Takaya, Yamabushi-yama, Noroshi-shin, Uwano and Osaki.

Collection: Hypotype JC88–131(Takaya).

Family JUGLANDACEAE

Pterocarya asymmetrosa Konno

(Plate 4, figures 6–8)

1931. *Pterocarya asymmetrosa* Konno, Geology of Central Shinano (by Honma), pl. 16, figs. 5–7; pl. 17, figs. 1–5; pl. 19, fig. 3.

Supplementary description. Fruits representing nuts with two wings, 0.6 to 0.65 cm high and 0.93 to 1.2 cm wide; wings nearly circular or reniform, firm in texture; alate venation consisting of fine, numerous radiating veins, branching dichotomously once or twice near periphery; two wings joined at the base; nuts 3.3 to 4.0 mm in diameter at plan, pointed at apex.

Remarks. This species is one of the most common members of the Neogene floras of Japan, but it has previously been represented only by leaflets, which are similar to those of the living *P. rhoifolia* Sieb. and Zucc. Some leaflets and the above described nuts resemble those of *P. rhoifolia* in general character, though the figured leaflet has a few teeth near the apex. This living species is now growing in the mountains of Japan, and also extends into Shantung and Szechuan provinces, China.

Occurrence: Kourade, Takaya and East of Takaya.

Collection: Hypotype JC88–151, 152(Takaya), 154(East of Takaya).

Pterocarya ezoana Tanai and Suzuki

(Plate 5, figures 1, 2)

1962. *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.

1942. *Pteroceltis*? sp. Oishi and Huzioka, Jour. Geol. Soc. Japan, vol. 49, no. 584, p. 156, text. fig. 1.

Supplementary description. Samara broadly winged, semicircular, wing thin, but of firm consistency and radiately reticulate-veined, 3.3 cm in long axis and 2.3 cm in short axis; margin of wing irregularly undulated; seen nearly globular, about 5 mm in diameter.

Remarks. This species was originally described on the basis of some excellently preserved leaflets and a fragmentary winged nut from the Miocene of southwestern Hokkaido, which seems to be related to *P. paliurus* Batalin grown now in central China. Two excellently preserved winged nuts from the Noroshi flora match well those of this living species, fossils of which have been reported from the Plio-Pleistocene of Japan by Miki.

Occurrence: Takaya, East of Takaya, Orito and Osaki.

Collection: Hypotypes JC88–158(Takaya), 160(East of Takaya).

Pterocarya protostenoptera Tanai

(Plate 5, figures 4, 7)

1961. *Pterocarya protostenoptera* Tanai, Jour. Fac. Sci. Hokkaido Univ. Ser. 4, vol. 11, p. 278, pl. 4, fig. 10.

Remarks. This species was first described on the basis of fruits from the Late Miocene of northeastern Honshu by Tanai, and closely resembles the living *P. stenoptera* D.C. Candolle., which is widely distributed in central and southern China. The Noroshi specimens are smaller than those originally recorded, and have shorter wings. Miki has reported the fruit of *P. stenoptera* from the Plio-Pleistocene in western Honshu. This species is related *P. mixta* (Knowlton) Brown of North American fossil.

Occurrence: Takaya and Uwano.

Collection: Hypotypes JC88–163(Takaya), 166(Uwano).

Family BETULACEAE

Betula sekiensis Huzioka and Nishida

(Plate 5, figures 3, 5)

1960. *Betula sekiensis* Huzioka and Nishida, Publ. Sado Mus. no. 3, p. 13, pl. 1, figs. 10–13; pl. 2, figs. 1, 2.

1940. *Betula japonica* Siebold. Okutsu, Saitô-Hô-on Kai Mus. Res. Bull., no. 19, p. 159, pl. 9, fig. 5.

1961. *Betula protojaponica* Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 296, pl. 9, figs. 4, 6.

Supplementary description. Winged seeds 2.0 to 2.5 mm long and 3.4 mm wide; seeds narrowly obovate, narrowly cuneate at base; a pair of fine hairs at the obtuse apex; wings 1.6 to 2.2 mm long, 1.0 to 1.2 mm wide, semicircular, thin.

Remarks. A leaf and two seeds are referred to *B. sekiensis*. It closely resembles the living *B. platyphylla* Sukatchev var. *japonica* (Miq.)Hara, which is in the subalpine forest of northern Japan. Seeds of *B. miomaximowicziana* Endo from the Late Miocene of Japan differ from these specimens in having relatively large wings. The Noroshi specimens differ from *B. forchhammeri* Heer from the Paleocene of Iceland in their longer seeds, and from *B. dryadum* Brongniart of Europe in wing shape. This species may be also related to the living *G. occidentalis* Hook and *B. papyrifera* Marsh of North America.

Occurrence: Kourade, East of Takaya and Uwano.

Collection: Hypotypes JC88–170(Kourade), 171(East of Takaya).

Betula uzenensis Tanai

(Plate 5, figures 6, 7)

1955. *Betula uzenensis* Tanai, Geol. Surv. Japan Rep. no. 163, pl. 4, fig. 2.

1961. Tanai, Jour. Fac. Sci. Hokkaido Univ. Ser. 4, vol. 11, p. 291, pl. 8, figs. 7, 9.

1962. Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 115, pl. 7, figs. 3, 6; pl. 8, figs. 4–6, 10, 11; pl. 10, fig. 2.

1960. *Betula inouei* Huzioka. Huzioka and Nishida, Publ. Sado Mus. no. 3, p. 12, pl. 2, figs. 3, 4.

Remarks. Three leaves are referable to *B. uzenensis* Tanai, which is akin to the living *B. schmidtii* Regel of central and northeastern Honshu in Japan, Korea, Manchuria and Ussuri.

Occurrence: Takaya and Uwano.

Collection: Hypotypes JC88–167, 168(Takaya).

Carpinus miocenica Tanai

(Plate 6, figure 1)

1955. *Carpinus miocenica* Tanai, Geol. Surv. Japan Report No. 163, pl. 5, figs. 1, 2.

1961. Tanai and Onoe, Geol. Surv. Japan Report No. 187, p. 26, pl. 3, fig. 3; pl. 4, fig. 4.

1955. *Carpinus laxiflora* Blume. Okutsu, Sci. Rep. Tohoku Univ. Ser. 2, vol. 26, p. 86, pl. 1, fig. 8.

Remarks. A single involucre and 7 leaves represent *C. miocenica.* This species is known from the Middle to Late Miocene of Japan, and closely resembles the living *C. laxiflora* Blume of Japan and Korea. It also resembles *C. londoniana* Winkl., *C. lanceolata* Handel-Mazz. and *C. viminea* Wall. southern China and India.

Occurrence: Takaya, East of Takaya, Orito, Yamabushi-yama and Uwano.

Collection: Hypotype JC88–174(East of Takaya).

Carpinus mioturczaninowii Hu and Chaney

(Plate 6, figures 4, 7)

1938. *Carpinus mioturczaninowii* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, pp. 33–34, pl. 9, fig. 7 only.

1961. *Carpinus ishikiensis* Tanai and Onoe. Tanai, Jour. Fac. Sci. Hokkaido Univ. Ser. 4, vol. 11, p. 292, pl. 11, figs. 8, 15 only.

1963. *Carpinus shimizui* Tanai, ibid. p. 297, pl. 14, figs. 2, 9.
Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., pp. 116–117, pl. 9, figs. 7, 14; pl. 10, fig. 13.

Supplementary description. Leaves ovate, 2.7 to 3.0 cm long and 1.4 to 1.8 cm wide; base rounded or slightly cordate; apex acuminate to acute; midvein stout, straight; secondaries 10 to 14 pairs, opposite to subalternate, regularly spaces, diverging from the midvein at angles of 40° to 45°, nearly straight, entering the larger teeth; a fine tertiary pair diverges from the base at nearly right angles; tertiaries branching from secondaries near margin, entering the smaller teeth, tertiaries among the inter-secondary spaces thin; veinlets indistinct, reticulate; margin double serrate, apex of teeth blunt or pointed; texture rather thin; petiole not preserved.

Remarks. The Noroshi bracts are identical to *C. mioturczaninowii* Hu and Chaney, though they have wider range in size, 1.7 to 3.1 cm long and 0.8 to 2 cm wide. The Noroshi leaves do not resemble the leaf of this species from Shanwang, but they are closely similar to *C. turczaninowii*, the living equivalent of this species, as have been supplementary described. Therefore our leaves are identified to *C. mioturczaninowii* based on the bract from Shanwang being similar to that of *C. turczaninowii*.

The our leaves resemble also *C. subcordata* Nathorst in having a cordate base. However they are smaller in size, and not aristate at points of teeth and have fewer secondary veins.

C. shimizui Tanai based on bract has more elongate shape, finer serration and more palmate veins than the type specimen of *C. mioturczaninowii*. However *C. shimizui* may be contained in the variety of *C. mioturczaninowii* from the characters of nutlet position, cordate base and venation palmately radiating from the base.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Uwano and Osaki.

Collection: Hypotypes JC88–179(Kourade), 187(Takaya).

Carpinus subyedoensis Konno

(Plate 6, figures 2, 3, 8)

1931. *Carpinus subyedoensis* Konno, Geology of Central Shinano (by Honma), pl. 7, figs. 1–4.

1961. Tanai and Onoe, Geol. Surv. Japan Report No. 187, p. 29, pl. 4, figs. 3, 6, 7, 10.

1888. *Carpinus* cfr. *yedoensis* Max. Nathorst, Palaeont. Abhandl. heraus. v. Dam. Kays., vol. 4, p. 38, pl. 13, figs. 12, 12a.

1961. *Carpinus kon'noi* Suzuki, Sci. Rep. Fac. Art and Sci. Fukushima Univ., No. 10, p. 42, pl. 7, figs. 8–16.

Remarks. Leaves and involucres referred to this species are common in the Noroshi collection. They are closely similar to those of *C. tschonoskii* Maxim. (synonym *C. yedoensis* Max.) which is now distributed in Honshu, Shikoku and Kyushu, Japan, extending into Korea. According to Suzuki, *C. konnoi* differs from *C. subyedoensis* by its more elongate form, more asymmetric cuneate-round base, relatively much more numerous secondaries and relatively larger size. However, leaves figured as *C. konnoi* are very similar to those of the living *C. tschonoskii*, whose leaf variation well matches that of *C. konnoi* and *C. subyedoensis*. In respect of the above remarks, it is evident that there is no criterion to separate *C. konnoi* from *C. subyedoensis*.

Occurrence: Kourade, Takaya, East of Takaya, Yamabushi-yama, Uwano and Osaki.

Collection: Hypotypes JC88–201(Takaya), 203, 204(East of Takaya).

Ostrya shiragiana Huzioka

(Plate 6, figure 5)

1954. *Ostrya shiragiana* Huzioka, Trans. Proc. Palaeont. Soc. Japan N.S., No. 13, p. 121, pl. 13, figs. 7, 8.

1962. Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 119, pl. 11, figs. 1, 3, 5, 7.

1943. *Ostrya japonica* var. *oblongibracteata* Huzioka, Jour. Geol. Soc. Japan, vol. 50, no. 602, p. 289, pl. 14, figs. 1, 1a, 2.

1961. *Ostrya huziokai* Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 302, pl. 8, fig. 2.

Remarks. Two leaves and an involucre from the Noroshi flora are referred to

O. shiragiana, which was noticed in rocks of the Middle Miocene in Korea and Japan. This species is closely similar to *O. japonica* Sargent now distributed in the temperate forest of Japan, Korea and China. This also resembles the living *O. knowltonii* Coville and *O. virginiana* Koch of North America.

Occurrence: Kourade, East of Takaya and Osaki.

Collection: Hypotype JC88–208(East of Takaya).

Family FAGACEAE

Castanea miomollissima Hu and Chaney

(Plate 8, figure 1)

1938. *Castanea miomollissima* Hu and Chaney, Palaeont. Sinica, n. ser. vol. 1, pp. 35–36, pl. 13, figs. 3, 7.

1962. Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., pp. 120–121, pl. 12, figs. 3, 4; pl. 14, figs. 4–6; pl. 15, figs. 1, 2, 5, 6.

1962. Huzioka, ibid, p. 196, pl. 31, figs. 1, 2.

Remarks. Twelve leaves from the Noroshi flora are identical with *C. miomollissima*. This species is common in the Miocene floras of northeastern Asia.

Occurrence: Takaya, East of Takaya, Orito, Noroshi-shin and Uwano.

Collection: Hypotype JC88–210(Takaya).

Castanopsis miocuspidata Matsuo

(Plate 6, figures 6, 9, 10)

1962. *Castanopsis miocuspidata* Matsuo, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 236, pl. 47, fig. 9a.

1962. Huzioka, ibid., p. 196, pl. 31, figs. 3, 4.

Supplementary description. Leaves lanceolate, 5.5 to 9 cm long (estimated), 1.2 to 1.8 cm wide, apex acuminate, tip of apex blunt, base cuneate; midvein stout, straight, sometimes curving, narrowing towards apex; secondaries relatively fine, 10 to 15 pairs, diverging from primary vein at 40° to 50°, curving upwards, camptodrome; tertiaries fine, waved, transversely between each to secondaries or primary and secondaries; margin entire or sometimes undulate in upper part; petiole stout, curving, 1.1 to 1.8 cm in length; texture thick.

Remarks. Six leaves from the Noroshi flora are identified to the genus Castanopsis by the shape, the size and the texture. They are referred to *C. miocuspidata*, because they are somewhat similar to the narrow leaves of the living *C. cuspidata* (Thunb.)Schottky, distributed in southwest Japan and Korea. This species may be also related to the living *C. chrysophylla* A. DC. of western North America.

Occurrence: Takaya and East of Takaya.

Collection: Hypotypes JC88–216–218(Takaya).

Fagus sp.

(Plate 5, figure 8)

Description. Leaves elliptic-lanceolate, shallow-cordate in base, acuminate in apex, 2.9 cm long, 1.2 cm wide; midvein strong, straight; about 10 pairs of secondaries closely spaced and parallel, alternate, above diverging at 30° to 50°, near the margin abruptly curving up, the basal pairs somewhat spreading; tertiaries irregularly percurrent, forming a fine network with the nervilles; margin undulate; texture thin.

Remarks. Two small leaves seem to be referable to Fagus, but the material too poor to make an adequate specific determination. They resemble small leaves of *F. multinervis* Nakai growing in Utsuryo Island of Korea. Two beech species having small leaves have described from the Miocene of Korea by Huzioka, 1951, *F. koraica* Huzioka and *F. uotanii* Huzioka, but the Noroshi form is distinguishable in having the undulate margin and the shallowly cordate base.

Occurrence: Orito and Yamabushi-yama.

Collection: Holotype JC88–223(Yamabushi-yama).

Quercus*(*Cyclobalanopsis*) *mandraliscae Gaudin

(Plate 7, figures 1–7)

1858. *Quercus mandraliscae* Gaudin, Mem. quelques Gisem. de la Toscane, p. 33, pl. 2, fig. 11.

1953. *Cyclobalanopsis mandraliscae* (Gaudin)Tanai, Trans. Proc. Palaeont. Soc. Japan, N.S. no. 9, p. 3, pl. 1, figs. 6–9.

Remarks. Leaves identified to *Q. mandraliscae* occur frequently at the Noroshi localities as well as in the other Miocene localities of Japan. This species is similar to *Q. longinux* Hayata, which grows in a zone 800 to 1,400 m altitude in Taiwan, and *Q. myrsinaefolia* Blume in Japan. However, this fossil species contains leaf impressions having serrations in basal part.

Occurrence: Kourade, Takaya, East of Takaya, Orito and Osaki.

Collection: Hypotypes JC88–226–228, 230, 232(Takaya), 231(East of Takaya).

Quercus miovariabilis Hu and Chaney

(Plate 8, figures 2, 3, 6, 7)

1938. *Quercus miovariabilis* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 36, pl. 15, figs. 5, 6.

1955. *Quercus subvariabilis* Tanai, Geol. Surv. Japan, Rep. No. 163, pl. 8, figs. 3–5.

1961. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 314, pl. 13, figs. 5–8.

1961. *Quercus ryozenensis* Suzuki, Sci. Rep. Fac. Art and Sci., Fukushima Univ., No. 10, p. 54, pl. 12, fig. 7.

Remarks. Criteria for separating either living or fossil leaves of Castanea from leaves of certain species of Quercus are not wholly satisfactory. There is a tendency for the secondaries to be more spreading in such species as *Q. variabilis*, in which they curve up as they leave the midvein, especially in the basal part of the leaf; in contrast to that the secondaries of Castanea more typically branch out from the midvein without curving. There may be exceptions in defined dignoses of genera in some measure as in cases of Castanea and Quercus. I have attempted to apply the disposed distinctions for certain Noroshi fossil leaves, and on this basis I have stated certain leaves be referable to *Q. miovariabilis.* In his study of similar leaves from the Miocene floras of southwestern Hokkaido, Tanai, 1962 had an opinion that all the leaves he has collected are referable to *Castanea miomollissima*, and that leaves given the name *Q. miovariabilis* and *Q. sinomiocenicum* by Hu and Chaney from the Shanwang flora of China are actually referable to *Castanea miomollissima.* Without attempting the final decision, the numerous leaves under examination are assigned to *Q. miovariabilis*, and figures of several specimens are given for further discussion.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Yamabushi-yama, Uwano and Osaki.

Collection: Hypotypes JC88–238–240(Takaya), 245(Uwano).

Quercus*(*Cyclobalanopsis*) *nathorstii Krishtofovich

(Plate 9, figures 1–5; Plate 10, figures 1–3; Plate 11, figure 3)

1926. *Quercus nathorstii* Kryshtofovich, Ann. Russ. Pal. Soc., 6, p. 10, pl. 2, figs.

3, 4.
1962. Huzioka, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 197, pl. 31, fig. 5.
1962. Matsuo, ibid., p. 236, pl. 48, fig. 4, pl. 50, fig. 5.
1888. *Querciphyllum* sp. Nathorst, Palaeont. Abh. heraus. v. Dam. Kays. 4, p. 19, pl. 7, figs. 1–3.

Remarks. Fourtythree leaves from Takaya are identical to *Q. nathorstii.* This species is compared with the living *Q. glauca* Thunb., which is distributed in Honshu, Shikoku and Kyushu, Japan, extending to Taiwan and China. However, this species contains the leaf impressions having the serrations in basal part.

Occurrence: Kourade, Takaya, East of Takaya and Uwano.

Collection: Hypotypes JC88–248–255(Takaya), 264(East of Takaya).

Quercus*(*Cyclobalanopsis*) *praegilva Kryshtofovich

(Plate 11, figures 1, 2, 4, 5)

1926. *Quercus praegilva* Kryshtofovich, Ann. Russ. Pal. Soc., 6, p. 11. pl. 2.
1962. Huzioka, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 198, pl. 31, figs. 6, 7.
1962. Matsuo, ibid., p. 237, pl. 48, figs. 1–3.

Supplementary description. Leaves lanceolate to oblong-lanceolate or obovate, cuneate at the base, the apex acute or acuminate, 6 to 14 cm long, 2.0 to 3.5 cm wide; primary rib stout, nearly straight; secondaries irregularly alternate or opposite, nearly parallel, 10 to 23 pairs, diverging from primary vein at angles of 30°–50°; tertiaries somewhat indistinct, irregularly parcurrent. Margin acutely serrate in upper half, but serrate sometimes in basal part. Petiole stout, length 1.2 to 2.5 cm. Texture thick, firm-coriaceous.

Remarks. This species is common in the two localities of Takaya in the Noroshi flora. It is similar to the living *Q. gilva* Blume which is distributed in the southern temperate zone of Japan, Cheju Do in Korea, Taiwan and China. However, the fossil species contains more slender leaves and leaves with longer petiole than in the living form, moreover the leaves have serrations in the basal part.

Occurrence: Takaya, East of Takaya and Osaki.

Collection: Hypotypes JC88–268–271(Takaya).

Quercus ament

(Plate 8, figures 4, 5)

Description. Male flowers amentaceous, 5 cm in length, with 17 perianths at least on 4 cm long ament; perianth four rent, with four filaments and anthers; anther two thecae, parallel.

Remarks. Two specimens from the Noroshi flora are referred to the male flowers a species of the genus Quercus. The specimen from the Takaya locality is the ament preserved only perianths. The male flower of the living Quercus has 4–7 rent perianth and the fossil Quercus from the Noroshi, *Q. glauca* and *Q. gilva* differ from this species by more stamens. In central Japan, the living Quercus flowers almost in April or May.

Occurrence: Takaya and East of Takaya.

Collection: Holotype JC88–281(East of Takaya); Hypotype JC88–280(Takaya).

Family ULMACEAE

Celtis miobungeana Hu and Chaney

(Plate 11, figure 6)

1938. *Celtis miobungeana* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 39, pl. 13, figs. 2, 5, 6.
1961. Tanai, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, vol. 11, p. 315, pl. 17, fig. 7.
1883. *Celtis nordenskiöldii* Nathorst, Kongl. Svens. Akad. Handl., vol. 20, no. 2, p. 47, pl. 15, fig. 2.
1961. *Celtis nathorsti* Tanai and Onoe, Geol. Surv. Japan Report no. 187, p. 36, pl. 10, fig. 1.
1961. Tanai, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, vol. 11, p. 315, pl. 17, fig. 8.

Remarks. Two leaves are referred to *C. miobungeana* described from the Miocene Shantung flora of China. This species is similar to the living *C. bungeana* Blume which is widely distributed in China and Korea. It is also akin to the living *C. jessoensis* Koidzumi distributed in Japan and Korea.

Occurrence: Orito and Yamabushi-yama.

Collection: Hypotype JC88–283(Yamabushi-yama).

Ulmus subparvifolia Nathorst

(Plate 10, figure 4)

1883. *Ulmus subparvifolia* Nathorst, Kongl. Svens. Akad. Handl., vol. 20, no.

2, p. 77, pl. 15, figs. 5a-e.
1961. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 321, pl. 17, fig. 9.
1938. *Ulmus protoparvifolia* Hu and Chaney, Palaeont. Sinica n. ser. vol. 1, p. 40, pl. 14, figs. 4, 5.
1954. Oishi and Huzioka, Jap. Jour. Geol. Geography, vol. 24, p. 190, pl. 15, fig. 3.

Remarks. Some incomplete leaves referred to this species are under examination. They resemble leaves of the living *U. parvifolia* Jacq., which is widely distributed in the southern temperate zones of central and western Honshu, Shikoku and Kyushu, Japan, extending into Korea, Taiwan and China. Miki, 1948 reported the fossil fruits and leaves of *U. parvifolia* from the Plio-Pleistocene of western Japan. This species resembles *U. crassifolia* Nutt, the living equivalent of the fossil *U. moorei* Chaney and Elias of North America.

Occurrence: East of Takaya and Noroshi.

Collection: Hypotype JC88–284(East of Takaya).

Zelkova ungeri (Ettingshausen)Kovats

(Plate 10, figures 5, 6)

1856. *Zelkova ungeri* (Ettingshausen)Kovats, Arb. Geol. Ges. Ungarn, vol. 1, p. 27, pl. 5, figs. 1–12; pl. 6, figs. 1–6.
1961. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 322, pl. 18, figs. 1–4, 6–9, 11.
1851. *Planera ungeri* Ettingshausen, Abh. d. K.-K. Geol. Reichsanstalt, vol. 2, 1855, Part 3, Tert.-Floren Oesterreich. Monarchie, No. 1, p. 14, pl. 2, figs. 5–8.
1883. *Zelkova keaki* Siebold *fossilis* Nathorst, Kongl. Svens. Akad. Handl., vol. 20, no. 2, p. 45, pl. 7, figs. 2–6.
1962. *Zelkova ungeri* Kovats. Tanai, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 124, pl. 17, figs. 1–12; pl. 18, figs. 1–8; pl. 19, figs. 3, 6a, 6b.
1962. Matsuo, ibid., p. 237, pl. 47, figs. 6–8, 9b.

Remarks. A number of leaf impressions referred to this Arcto-Tertiary species have been collected from all localities in the Noroshi flora. Their various shape and size well match those shown by leaves of the living equivalent, *Z. serrata* (Thunb.)Makino, in temperate zones of Japan except Hokkaido. Some specimens in the author's collection represent twigs bearing young small leaves and fruits.

In the living tree, such a twig is found in May in western Honshu. This species is related to the fossil *Z. oregoniana* of North America. Miki has reported the leaves of *Z. ungeri* from the Plio-Pleistocene in western Honshu.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Yamabushi-yama, Noroshi-shin, Uwano and Osaki.

Collection: Hypotypes JC88-288(Takaya), 299(East of Takaya).

Family MENISPERMACEAE

Diploclisia notoensis new species

(Plate 12, figures 1-3)

1962. *Phyllites* sp. A. Matsuo, Geol. Surv. Japan 80th Ann. Mem. Publ. p. 243, pl. 55, fig. 7.

Description. Leaves broadly ovate to subreniform, with the base broadly truncate-rounded to shallowly cordate; apex acute; estimated length 5 to 9 cm, width 5 to 9 cm; primaries five plinerved; midvein nearly straight or slightly undulate; lateral primaries diverging decurrently from midrib and somewhat curving upwards at the half course, then arriving at obtuse or right angle in the margin; secondaries from midvein subalternate, two or three pairs; abaxial secondaries from lateral primaries two to four in number, obutse or right angled to the margin; tertiaries distinct, forming an irregularly coarse mesh; veinlets finely reticulate; margin entire or obscurely undulate; texture medium, firm.

Remarks. Leaves referred to *D. notoensis* were obtained from two localities in the Noroshi flora. They closely resemble those of the modern *D. chinensis* Merrill. This new species is *Phyllites* sp. A of Matsuo from the Miocene flora in the southern part of Noto Peninsula. The modern species grows in Kwangtung Province, China. *D. notoensis* is also similar to *Pericampylus formosanus* Diels and *P. glaucus* Merr. in shape and venation near the margin, but it differs from them in the curved up lateral primaries. The other genera of Menispermaceae, Cissampelos, Cocculus, Menispermum, Sinomemium and Stephania are clearly distinguishable from Diproclisia and Pericampylus by venation.

Occurrence: Takaya and East of Takaya.

Collection: Holotype JC88-314(Takaya); Paratype JC88-315(Takaya); Hypotype JC88-317(Takaya).

Family MAGNOLIACEAE

Magnolia miocenica Hu and Chaney

(Plate 12, figure 4)

1938. *Magnolia miocenica* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 44, pl. 20, fig. 2; pl. 21, figs. 3–5.
1962. Tanai and Suzuki. Geol. Surv. Japan 80th Ann. Mem. Publ., p. 126, pl. 21, figs. 1–3.
1954. *Magnolia* cfr. *kobus* DC. Takahashi, Mem. Fac. Sci. Kyushu Univ. Ser. D, vol. 5, no. 1, p. 57, pl. 5, fig. 5.
1961. *Magnolia nipponica* Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 322, pl. 21, figs. 1, 9, 10.

Remarks. Only two incomplete leaves are referred to *M. miocenica* from the Miocene Shanwang flora of China. This species is similar to the living *M. delavayi* Franchet, of West and Southwest China. Our specimens are also similar to the leaves of the living *M. kobus* DC. on Japan and China, and to the small leaves of *M. obovata* Thunberg on Japan and China. This species may be also related the living *M. portoricensis* Bello of eastern North America.

Occurrence: Takaya and East of Takaya.

Collection: Hypotype JC88–322(Takaya).

Michelia notoensis new species

(Plate 12, figures 5–8)

Description. Leaves oblong or lanceolate, 3.8–10 cm long (estimated), 1.3–2.7 cm wide, apex acute, tip of apex blunt, base acuminate, acute or round and decurrent; midvein somewhat stout, nearly straight, narrowing towards apex; secondaries relatively fine, about 10–12 pairs, diverging from primary vein at 30–40 degrees, curving upwards, camptodrome or looping near margin, sometimes inter-secondaries diverging from primary vein; tertiaries thin, waved, transversely between each two secondaries, and forming irregular coarse wavy meshes by anastomosing with other tertiaries, finer veins forming minute meshes; margin entire; petiole stout, at least 1.8 cm in length; texture rather thin, firm.

Remarks. This is the first record of the genus Michelia in the Tertiary of the world. Eight leaves from the Noroshi flora are similar to the leaves of the living *M. compressa* (Maximowicz)Sargent in the venations of the secondaries and the tertiaries, though the former is somewhat different from the latter in the shape of the leaf as a shole and of base. *M. compressa* is distributed in southern Honshu, Shikoku and Kyushu of Japan.

This species is similar to *Symplocos higashiyamaensis* Suzuki from the Middle Miocene of northeastern Honshu in Japan. However the latter differs from the former in the venation of the secondaries, and is more stout in petiole than the former.

Occurrence: Takaya and East of Takaya.

Collection: Holotype JC88–324(Takaya); Hypotypes JC88–325–327(Takaya).

Family LAURACEAE

Cinnamomum miocenum Morita

(Plate 13, figure 1)

1931. *Cinnamomum miocenum* Morita, Jap. Jour. Geol. Geogr., vol. 9, p. 6, pl. 1, fig. 6.

1888. *Cinnamophyllum* sp. Nathorst, Palaeont. Abhandl. heraus. v. Dam. Kays., vol. 4, p. 8, pl. 2, fig. 2.

Remarks. This species is found commonly in the Miocene and Pliocene flora of Honshu, Japan. It is similar to the modern *C. capmhora* Nees and Eberm., which now grows in Japan except Hokkaido, and extends into Taiwan and China.

Occurrence: Takaya, East of Takaya and Osaki.

Collection: Hypotype JC88–122(Takaya).

Cinnamomum oguniense Morita

(Plate 13, figures 2, 3)

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

Remarks. Some leaves from the Noroshi flora are referred to *C. oguniense* originally described from the Middle Miocene of Honshu. They closely resembles leaves produced by the living *C. reticulata* Hayata of Taiwan, which in growing at low altitudes in Kôsyun Peninsula, southernmost Taiwan.

Occurrence: Takaya and East of Takaya.

Collection: Hypotypes JC88–339, 340(Takaya).

Machilus nathorsti Huzioka

1962. *Machilus nathorsti* Huzioka, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 203, pl. 34, figs. 4–6; pl. 40, fig. 7.
1962. Matsuo, ibid., p. 239, pl. 50, figs. 2, 4.

Remarks. Four leaves are referred to *M. nathorsti* by shape, venation and texture. This species is closely similar to the living *M. thunbergii* Siebold and Zuccurini widely distributed in Honshu, Shikoku and Kyushu of Japan, southern Korea, Taiwan and southeastern China.

Occurrence: Kourade, Takaya and East of Takaya.

Machilus ugoana Huzioka

(Plate 13, figures 4–6)

1961. *Machilus ugoana* Huzioka. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 336, pl. 22, fig. 3.
1962. Huzioka, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 203, pl. 34, figs. 4–6, pl. 40, fig. 7.
1961. *Machilus protojaponica* Suzuki, Sci. Rep. Fac. Art. and Sci., Fukushima Univ., No. 10, p. 66, pl. 14, figs. 17, 18.

Remarks. Some incomplete leaves are identified to *M. ugoana*, which is closely related to the modern *M. japonica* Sieb. and Zucc. now growing in southern Honshu and Kyushu, southern Korea and Okinawa. *M. protojaponica* from Late Miocene flora of northern Honshu, is essentially similar to the Noroshi leaves, and is included in *M. ugoana*.

Occurrence: Kourade, Takaya, East of Takaya, Uwano and Osaki.

Collection: Hypotypes JC88–347, 348(Takaya), 355(Osaki).

Family HAMAMELIDACEAE

Parrotia fagifolia (Goeppert)Heer

(Plate 14, figure 7)

1859. *Parrotia fagifolia* (Goeppert)Heer, Flora Tert. Helv., vol. 3, p. 306.
1855. *Quercus fagifolia* Geoppert, Tert. Flora Schoss. Schl., p. 14, pl. 6, figs. 9–12.
1955. *Parrotia fagifolia* Heer. Huzioka, Ill. Cat. Foss. Fukui Pref., no. 6, p. 6,

pl. 2, fig. 1.
1962. *Parrotia fagifolia* (Goeppert)Heer. Tanai, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 129, pl. 19, fig. 5, pl. 20. figs. 1–3.
1962. Huzioka, ibid., p. 204, pl. 35, figs. 2–4.

Remarks. Two leaves from the Noroshi flora are referred to this species common in the Middle Miocene Daijiman flora in Hokkaido and northeastern Honshu, Japan. This species is similar to the modern *P. persica* C. A. Meyer of northern Iran, *Fothergilla gardeni* Murray of the southeastern United States and *Hamamelis japonica* Sieb. and Zucc. of southwestern Hokkaido, Honshu, Shikoku and Kyushu. Our specimens are also very similar to some leaves of *H. japonica.* The nomenclature by Tanai and Huzioka for the taxon is followed here though not it is not Hamamelis.

Occurrence: Yamabushi-yama.
Collection: Hypotype JC88–370.

Liquidambar miosinica Hu and Chaney

(Plate 13, figures 7, 8)

1938. *Liquidambar miosinica* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 46, pl. 23, figs. 1, 2.
1962. Tanai and N. Suzuki, Geol. Surv. Jap. 80th Ann. Mem. Publ., p. 128, pl. 23, figs. 6, 8, 11 (see synonymy).
1883. *Liquidambar formosana* Hance. Nathorst, Kongl. Svens. Akad. Vet. Handl., vol. 20, no. 2, p. 55, pl. 8, figs. 6–9.

Remarks. This species is common in the Miocene and Pliocene of Japan. Some leaves and fruits referable to this species are at the disposal. *L. miosinica* is closely resembled to the living *L. formosana* Hance of Taiwan and China. The leaves, though variable in shape, well match those of *L. formosana.* But fruit specimens are smaller than those of the living species. This species may be also related to the living *L. styraciflua* L. of North America, hasing a five-lobate leaf. The leaves and fruits of *L. formosana* occur from the Plio-Pleistocene of Japan.

Occurrence: Kourade, Takaya, East of Takaya, Yamabushi-yama and Osaki.
Collection: Hypotypes JC88–358(Takaya), 369(East of Takaya).

Sycopsis chaneyi new species

(Plat 18, figures 4, 6; Plate 19, figures 2–6)

Description. Leaves obovate to lanceolate-obovate, somewhat asymmetrical, 4.5 to 9 cm long and 2 to 3 cm wide; base acute to obtuse; margin entire or with irregularly pointed teeth especially in the terminal part; apex acute; petiole rater slender, 0.5 to 1.2 cm long; midvein stout, straight, gradually narrowing to apex; secondary veins rather slender, somewhat flexuous, a pair running from the base to nearly half part of leaves at subparallel to margin, other secondaries alternate with three to four pairs, diverging from the midvein at angle of about 45° to 60°, curving upwards, slender branches from the secondaries looping, camptodrome, or entering the pointed teeth; tertiaries thin, forming a poligonas mesh; texture thick.

Remarks. *S. chaneyi* is the first record of the genus Sycopsis from the Tertiary flora in Japan. These leaves resemble *S. formosana* (Kanehira) Kanehira and Hatusima in the shape, teeth and texture. The basal secondaries may be slightly asymmetrical, one of them branching off slightly above the base on most specimens. This feature also characterizes many leaves of *S. formosana*, Sheets in the Kyoto University Herbarium have been made for comparison.

This species is named in appreciation of Dr. R.W. Chaney to whom the writer wishes to express his acknowledgment for valuable advice.

Occurrence: Takaya, East of Takaya, Orito, Noroshi-shin, Osaki.

Collection: Holotype JC88-583(Takaya); Hypotypes JC88-584-587, 590 (Takaya), 595(East of Takaya).

Family ROSACEAE

Rosa usyuensis Tanai

(Plate 14, figure 1)

1961. *Rosa usyuensis* Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 343, pl. 24, figs. 5, 6, 9.

Remarks. A single leaf impression is identical with this species, which was reported from the Early to Middle Miocene in Japan by Tanai. *R. usyuensis* is similar to the living *R. taiwanensis* Nakai and *R. multiflora* Thunberg; the former is distributed in central and northern Taiwan, and the latter is widely distributed in Japan and Korea.

Occurrence: East of Takaya.

Collection: Hypotype JC88-372.

Family EUCOMMIACEAE

Eucommia japonica Tanai

(Plate 14, figures 2, 3)

1961. *Eucommia japonica* Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 329, pl. 21, fig. 3.

Remarks. Two excellently preserved specimens of winged fruits are identical with this species established on the basis of fruits from the Middle and Late Miocene of Honshu. *E. japonica* is very close to the modern *E. ulmoides* Oliver growing at the altitudes of 600–1,500 m in inner central China. The living species was described from the Pliocene in central Honshu, Japan by Miki also on the basis of fruit. No foliage of Eucommia is known from the Tertiary of Japan.

Occurrence: Takaya and East of Takaya.

Collection: Hypotypes JC88–373(Takaya); 374(East of Takaya).

Family LEGUMINOSAE

The problem of generic status of detached leaflets of this family has not been unraveled. Fortunately, presences of Cladrastis, Milletia and Podogonium are shown by well-preserved pods, none of which are found in attachment with the foliage. Following the general procedure of previous students of the Miocene in this country, the eight genera under their considerations will be adopted with certain reservations as remarked species by species.

Albizzia miokalkora Hu and Chaney

(Plate 14, figures 11, 12)

1938. *Albizzia miokalkora* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 50–51, pl. 27, fig. 6.

Supplementary description. Leaflets oblong, asymmetrically rounded at base, asymmetrically mucronate at apex, 1.1 to 1.8 cm long, 4.7 to 8 mm wide; midvein well-defined; secondaries fine, diverging at angles of about 50°, except in a clear secondary vein, diverging at angles of 30° to 40° from base, extending to the half of leaflet, camptodrome; tertiaries forming a coarse network; margin entire; texture firm.

Remarks. *A. miokalkora* from the Miocene Shanwang flora is larger and less asymmetrical than the Noroshi specimens. However, these specimens are similar to the leaves of the living *A. kalkora* Prain widely distributed from north to south China.

Occurrence: Takaya, East of Takaya, Orito and Osaki.

Collection: Hypotypes JC88-375, 380(Takaya).

Cassia notoensis new species

(Plate 14, figures 4, 5)

Description. Leaves oblong, 4 to 4.7 cm in length, 1.5 to 2 cm in width, apex round or retuse, base round; midvein stout, straight, narrowing towards apex; secondaries fine, 8 to 12 pairs, diverging from primary vein at 45° to 50°; curving upwards, camptodrome or looping near margin; tertiaries reticulate with inter-secondaries diverging from primary vein in parallel to secondaries; margine entire; petiole stout though ill-preserved, 2.5 mm in length (estimated): texture rather medium, firm.

Remarks. *C. notoensis* is the first record of the genus Cassia from the Tertiary flora in Japan. These specimens are closely allied to those of the living *C. siamea* Lam. in size, shape, venation and texture. The modern species is distributed throughout India, Ceylong, Burma, Malaya, Thailand and Phillippines.

Occurrence: Takaya and East of Takaya.

Collection: Holotype JC88-385(Takaya); Paratype JC88-386(Takaya).

Cladrastis aniensis Huzioka

(Plate 14, figures 6, 9, 10, 14, 15)

1962. *Cladrastis aniensis* Huzioka, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 205, pl. 35, figs. 5, 6.

1962. Tanai and N. Suzuki, ibid., p. 132, pl. 23, figs. 1, 7.

Supplementary description. Pod fusi-form, flattened, 4.7 cm in length, 1 cm in width, acuminate proximad and distad, blunt at distal end; veins forming irregulary network between dorsal and ventral ridges; with only large seed.

Remarks. Eight leaflets and only one pod at hand are referred to *C. aniensis*. This species is very similar to the living *C. platycarpa* (Maximowicz)Makino distributed in central and western Honshu and Shikoku. The well-preserved pod is an evidence of the existence of this genus in the Noroshi forest. There are numerous detached leaflets which conform in size, shape and venation with those of the living species of Cladrastis. But they are hardly be distinguished from the leaflets of Wistaria. Both the genera have been noted independently from the Miocene floras of Japan, without positive criterion convincible for identification with only poor materials not better than those under the present examination. Leaflets of modern representatives of these genera can usually be distinguished by the thicker texture of Cladrastis; however it is not always possible to determine the thickness of fossil leaves, and for this reason some errors have probable come into the works of the past including the writer himself. He has given the name *C. aniensis* to leaflets which appear to have been relatively thick, having an oval shape the characters of many leaflets of the living *C. platycarpa*. A difference in tertiary venation may also be mentioned, — Cladrastis has many more tertiary veins branching from the midrib in intersecondary spaces as compared with Wistaria. It is, however, premature to attempt a general revision of the identifications, though some appear to be incorrect in view of the present observation. This species may be also related to the living *C. lutea* C. Koch of eastern North America.

Occurrence: Takaya and East of Takaya.

Collection: Hypotypes JC88–393–396(Takaya), 403(East of Takaya).

Entada mioformosana Tanai

(Plate 15, figure 1)

1961. *Entada mioformosana* Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 345, pl. 24, fig. 2.

1952. *Entada formosana* Kanehira. Tanai, Trans. Proc. Paleont. Soc. Japan, N.S., No. 8, p. 233, pl. 22, figs. 6, 7.

Remarks. This species has been recorded from the Neogene of Korea and Japan. Leaflets at hand are akin to the living *E. formosana* Kanehira which grows in broad-leaved forests in southern Taiwan. They are, however, much broader at the base than any of those and seem to have a much thinner texture. Thus the generic determination may be seemed to be doubtful.

Occurrence: Kourade, Takaya, East of Takaya and Uwano.

Collection: Hypotype JC88–406(Takaya).

Gleditschia miosinensis Hu and Chaney

(Plate 15, figures 2, 3)

1938. *Gleditschia miosinensis* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 52, pl. 26, figs. 6, 7.

1962. Tanai, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 132, pl. 15, fig. 9; pl. 23, figs. 2, 10.

Remarks. Some leaflets from the Noroshi flora are identical with this species; it resembles the living *G. sinensis* Lamarck and *G. japonica* Miq. *G. sinensis* is distributed in parts of China, i.e. north, central and west China. *G. japonica* has an even wider distribution extending from southeast, through north China and southern Korea to southwestern Japan. *Gleditschia* sp. figured by Konno (1931) from the Miocene Bôdaira flora of central Honshu may be included in *G. miosinensis.* This species may be also related to the living *G. triacantha* L. of eastern North America.

Occurrence: Takaya and Yamabushi-yama.

Collection: Hypotypes JC88–413(Takaya), 416(Yamabushi-yama).

Milletia notoensis new species

(Plate 15, figures 4–6)

1962. *Robinia nipponica* Tanai. Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 133, pl. 15, figs. 3, 7, 8 only.

Description. Leaflet ovate, 2.8 cm long (estimated), 1.5 cm wide, apex acute, tip of apex absent, base round; midvein somewhat stout, nearly straight, narrowing towards apex; secondaries relatively fine, 4 or 5 pairs, diverging from primary vein at 50°–60°, curving upwards, looping near margin; tertiaries fine, reticulate; margin entire; petiole stout, 2.7 mm in length; texture medium. Pod straight, flat, about 10 cm long (estimated), 0.8 to 1.1 cm wide, acuminate or cuneate proximad, acute distad; dorsal ridge heavy, straight; ventral ridge relatively light, curving in proximal and distal part; undulate in pod with ripe seed; with about eight to ten round seeds about 3 to 7 mm in diameter, peduncle 0.5 to 1.1 cm long.

Remarks. Only a leaflet and eight narrow and long pods are in the collection. They are similar to those of the living *M. japonica* (Sieb. and Zucc.)A. Gray. It is distributed in open forests and thickets at low altitudes of central and southern Honshu, Shikoku and Kyushu. *M. notoensis* is the first record of the genus Milletia for Tertiary flora in Japan. The pods of this species have been identified as the genus Robinia by Tanai. But the pod of Robinia is shorter and wider than that of Milletia. Tanai inadequately supposed the seeds be reniform in shape. The leaflet of this species is also similar to that of *Wistaria fallax* (Nathorst)Tanai and Onoe, but the former is different from the latter by few and clearly looping secondaries.

Occurrence: Kourade, Takaya, East of Takaya and Osaki.

Collection: Holotype JC88–418(Takaya) ; Paratypes JC88–417(Kourade), 421(Takaya).

Mucuna chaneyi new species

(Plate 22, figures 3–5)

Description. Terminal leaflet oval-ovate, estimated 9 cm long, 4.5 cm wide; base truncate, apex incomplete, probably acute; midrib slender, straight; secondary nerves five subopposite pairs flexuous, diverging from the midrib at angles of 45° to 50°, pairs diverging from the base, somewhat curving upwards, slender branchs from the secondaries looping, camptodrome; tertiaries thin, irregularly percurrent, reticulate; margin entire, slightly waves; petiole rather slender, 3.3 cm long. Lateral leaflets orbicular-ovate, asymmetrical; 4 to 13 cm long, 4 to 11 cm wide estimated; base broadly obtuse or round, asymmetrical; apex obtuse or acute; petiolule incomplete, apparently stout, preserved 2 mm long; midrib stout, nearly straight; secondary veins relatively slender, five or six pairs subopposite, diverging from the midrib at angles of 35° to 50°, curving up slightly to the margin above the middle of the leaflets, at margin curving abruptly and tangent in margin, in some leaves subsecondaries branching abaxially from the basal one to three secondaries; tertiaries thin, but distinct, percurrent, veinlet forming fine meshes; margin entire, somewhat undulate; texture medium.

Remarks. These leaflets resemble *M. ferruginea* Matsum. of Taiwan and Okinawa except to having a somewhat more broadly truncate base at the terminal leaflet (Pl. 22, figure 4).

Occurrence: Takaya, East of Takaya.

Collection: Holotype JC88–638(Takaya) ; Paratypes JC88–603(Takaya); Hypotype JC88–640(Takaya).

Podogonium knorrii A. Braun

(Plate 15, figures 7–11)

1859. *Podogonium knorrii* A. Braun in Stizenb. Verzeichn, p. 90, Heer, Fl. Ter. Helv., vol. 3, p. 114, pl. 134, figs. 22–26, pl. 135, pl. 136 figs. 1–9.

Remarks. This species is common in the Miocene of Switzerland, and also has been reported from the Shanwang flora of China. Leaflets and pods of the species occur frequently in the Noroshi flora. This case is the first note on the occurrence of this species in the Middle Miocene strata of Japan. According to Heer, the seed of the tree ripen in August in the Switzerland of the Miocene.

Occurrence: Takaya, East of Takaya, Orito, Yamabushi-yama, Noroshi-shin, Uwano and Osaki.

Collection: Hypotypes JC88–425, 434(Takaya), 437–439(East of Takaya).

Wistaria fallax (Nathorst)Tanai and Onoe

(Plate 14, figures 8, 13)

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

1883. *Sophora*(?) *fallax* Nathorst, Kongl. Svens. Akad. Handl., vol. 20, no. 2, p. 58, pl. 10, figs. 11, 12; pl. 11, figs. 1, 2.

Remarks. Some leaflets from the Noroshi flora are identified with *W. fallax*, though the broad leaflets are similar to those of Cladrastis. In discussing *Cladrastis aniensis*, the difficulty in distinguishing leaflets of Cladrastis and Wistaria has been mentioned. Only three leaflets of *W. fallax* are recognized among the Noroshi materials. The identification is based upon their elongate shape, thin texture, and reduced development of the tertiaries branching from the midvein in the inter-secondary spaces. The small leaflet of *W. fallax* is also akin to those of *Milletia japonica* (Sieb. and Zucc.)A. Gray, but the latter is fewer in the secondaries than in the former. *W. fallax* is very similar to those of the living *W. floribunda* (Willd.)D.C. which is distributed from Honshu to Kyushu, Japan, and further to China. This species may be also related to the living *W. frutescens* Poir of eastern North America.

Occurrence: Kourade, East of Takaya and Noroshi-shin.

Collection: Hypotypes JC88–461, 462(Takaya).

Family SIMAROUBACEAE

Ailanthus yezoense Oishi and Huzioka

(Plate 15, figure 12)

1942. *Ailanthus yezoense* Oishi and Huzioka, Jour. Geol. Soc. Japan, vol. 49, p. 181, figs. 2–4.

1962. Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 134, pl. 16, figs. 4, 5.

Remarks. A characteristic fruit of Ailanthus from the Noroshi flora is referable to this species, which was originally described from the Miocene of southwestern Hokkaido. *A. yezoense* is closely resembled to the living *A. altissima* Swingle distributed in China. The fruits of the living species have been collected from the Pleistocene of western Honshu by Miki. No foliage has been found.

Occurrence: East of Takaya.

Collection: Hypotype JC88–465.

Family BUXACEAE

Buxus protojaponica Tanai and Onoe

(Plate 15, figures 13, 14)

1961. *Buxus protojaponica* Tanai and Onoe, Geol. Surv. Japan Report, No. 187, p. 46, pl. 14, fig. 5.

Remarks. This species was described from the Middle Miocene and Mio-Pliocene of Japan. Two Noroshi leaves have well preserved cuticle. *B. protojaponica* is closely related to the modern *B. microphylla* Sieb. and Zucc. var. *japonica* (Muell. Arg.)Rehd. and Wils. growing on the sunny land of the central and western Japan.

Occurrence: Takaya and East of Takaya.

Collection: Hypotypes JC88–466(Takaya), 467(East of Takaya).

Family ANACARDIACEAE

Pistacia miochinensis Hu and Chaney

(Plate 17, figure 9)

1938. *Pistacia miochinensis* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 62, pl. 36, figs. 1–3, 5, 9.

1961. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 349, pl. 24, fig. 12.

Remarks. *P. miochinensis* has been recorded from the Shanwang Miocene in China and the Middle Miocene, Daijima-type floras in Honshu, Japan. A few leaflets of this species were collected from the Noroshi flora, and they are very similar to those of the living *P. chinensis* Bunge, a widely distributed species which ranges from north China southward to India, Phillippines and Taiwan.

Occurrence: Takaya and Noroshi-shin.
Collection: Hypotype JC88–468(Takaya).

Rhus miosuccedanea Hu and Chaney

(Plate 17, figures 5, 6; Plate 18, figures 1–3, 5; Plate 19, figure 1)

1938. *Rhus miosuccedanea* Hu and Chaney, Palaeont. Sinica n. ser. vol. 1, p. 63, pl. 35, fig. 3b; pl. 36, figs. 6, 8; pl. 37, figs. 1–3.
1961. Tanai, Jour. Fac. Sci., Hokkaido Univ., Ser. 4, vol. 11, p. 350, pl. 24, fig. 18.
1920. *Rhus succedanea* Linnaeus. Florin, Kgl. Svensk. Vet. Akad. Handl., vol. 61, p. 22, pl. 3, ag. 13.

Remarks. Fourtythree leaflets are referred to *R. miosuccedanea* Hu and Chaney. Thirtythree of them (Pl. 18, Pl. 19) represent larger, broader and less acuminate-tipped leaflets than the specimens figured as *R. miosuccedanea* in the Shanwang flora, and in the Japan Miocene. And the petiolules on the asymmetrical specimens (Pl. 18, fig. 1, 3, 5) which may be supposed to represent a lateral leaflet are longer than those specimens. However, our specimens closely resemble this species in the venation. They can be considered as the same species to *R. miosuccedanea*.

Occurrence: Takaya, East of Takaya, Yamabushi-yama, Uwano and Osaki.
Collection: Hypotypes JC88–470, 471, 573, 576, 577(Takaya), 579, 580(East of Takaya).

Rhus protoambigua Suzuki

1959. *Rhus protoambigua* Suzuki, Monogr. Assoc. Geol. Collab. Japan, no. 9, p. 39, pl. 5, fig. 8.
1961. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 351, pl. 24, fig. 20.
1962. Tanai and N. Suzuki, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 136, pl. 22, figs. 1, 2.
1962. Huzioka, ibid., p. 207, pl. 36, figs. 4, 5.

Remarks. Only two leaflets are referred to *R. protoambigua* Suzuki from the Middle and Upper Miocene of Japan. This species is closely related to *R. ambigua* Lavallée and Dippel, a vine ranging from Saghalien to Kyushu, and extending into China.

Occurrence: Takaya and East of Takaya.

Family CELASTRACEAE

Perrottetia notoensis new species

(Plate 20, figures 1–6)

Description. Leaves lanceolate, lanceolate-ovate to elliptic, 6 to 9 cm long, 1.7 to 4 cm wide; base obtuse to truncate, or acute in the asymmetrical leaves; apex acute to acuminate; midvein stout, straight; secondary veins slender, flexuous, 12 to 13 pairs subopposite or alternate, diverging from the midvein at angles of 50° to 70°, curving upwards near margin, camptodrome, branches from the looped secondaries entering the teeth; tertiaries thin, percurrent, nervilles forming fine meshes; margin serrate with thick termination, something double serrate; petiole rather slender, 1.4 to 2.1 cm long; texture medium.

Remarks. *P. notoensis* is the first record of the genus Perrottetia from the Tertiary flora in Japan. This species resemble *P. arisanensis* Hayata, which live at medium to high altitudes of about 650–2,500 meters of Taiwan. *P. sandwicensis* Grey of Hawaiian Islands also resemble this species except for its sparse serration.

To Dr. R.W. Chaney the writer wishes to express his acknowledgment for valuable advice.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Uwano, Osaki.

Collection: Holotype JC88–606(Takaya); Hypotypes JC88–607–610(Takaya), 617, 620(East of Takaya).

Family ACERACEAE

Acer ezoanum Oishi and Huzioka

1943. *Acer ezoanum* Oishi and Huzioka, Jour. Fac. Sci. Hokkaido Imp. Univ., ser. 4, vol. 7, p. 98, pl. 10, figs. 1–4; pl. 11, figs. 1–4; pl. 12, fig. 2 (excluding fig. 1).

1960. Tanai and N. Suzuki, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 10, p. 556, pl. 1, figs. 1, 2; pl. 2, figs. 1, 2; pl. 3, figs. 1–4; pl. 4, figs. 20–25.

1940. *Acer miyabei* Maxim. Okutsu, Saitô Hô-on Kai Mus. Res. Bull. no. 19, p. 162, pl. 8, figs. 5, 6.

Remarks. A single leaf and a samara are identical with this species. It is closely similar to the modern *A. miyabei* Maximowicz growing in Hokkaido and Northern Honshu, Japan. The leaf specimen is compared with small leaf of *A. miyabei*, and also resembles that of the modern *A. diabolicum* Blume of Japan.

Occurrence: Yamabushi-yama and Uwano.

Acer palaeodiabolicum Endo

(Plate 15, figure 17)

1950. *Acer palaeodiabolicum* Endo, Short Papers Inst. Geol. Paleont. Tohoku Univ. Sendai, No. 1, p. 12, pl. 3, fig. 3.
1930. *Acer diabolicum* Blume. Konno, Geology Central Shinano (by Honma), pl. 13, fig. 4.
1940. Okutsu, Saitô Hô-on Kai Mus. Res. Bull. no. 19, p. 161, pl. 7, fig. 7.

Remarks. *A. palaeodiabolicum* has been commonly reported from the Early Miocene to Early Pliocene of Korea and Japan. Some samaras from the Noroshi flora are identified to this species, and they are very similar to those of *A. diabolicum* Blume now growing luxuriantly in Japan except in Hokkaido.

Occurrence: East of Takaya and Yamabushi-yama.

Collection: Hypotype JC88-484(East of Takaya).

Acer protojaponicum Tanai and Onoe

(Plate 15, figure 16)

1959. *Acer protojaponicum* Tanai and Onoe, Bull. Geol. Surv. Japan, vol. 10, p. 281, pl. 6, figs. 5, 7, 8.
1943. *Acer japonicum* Thunb. Huzioka, Jour. Fac. Sci. Hokkaido Imp. Univ. Ser. 4, vol. 7, p. 134, pl. 14, fig. 7.

Remarks. Three samaras are identified to *A. protojaponicum*, which has been reported from the Middle and Late Miocene rocks of Japan. This species is closely similar to the modern *A. japonicum* Thunb. growing now in Hokkaido and Honshu, Japan. This also resembles *A. circinatum* Pursh., the living of western North America.

Occurrence: Takaya, East of Takaya and Yamabushi-yama.

Collection: Hypotype JC88-490(Takaya).

Acer subpictum Saporta

(Plate 15, figure 15)

1873. *Acer subpictum* Saporta, Bull. Soc. Geol. France, Sér. 3, vol. 1, p. 217.

1943. Oishi and Huzioka, Jour. Fac. Sci. Hokkaido Imp. Univ., Ser. 4, vol. 7, p. 93, pl. 13, figs. 1–4; pl. 14, figs. 3, 4.

1883. *Acer pictum* Thunb. Fossilis Nathorst, Kongl. Svens. Acad. Handl. vol. 20, no. 2, p. 60, pl. 12, figs. 2–8.

Remarks. The Noroshi fruit specimens are referred to *A. subpictum* common in the Neogene flora of Europe and Asia. It resembles to the living *A. mono* Maximowicz widely distributed in the temperate region of eastern Asia. This species is related to *A. scottiae* MacGinitie, the fossil of western North America. Numerous leaves of this and other Noroshi maples are not figured.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Noroshi-shin, Yamabushi-yama, Uwano and Osaki.

Collection: Hypotype JC88–501 (Takaya).

Family RHAMNACEAE

Paliurus protonipponicus Suzuki

(Plate 15, figures 18, 19)

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

Remarks. This species is described by Suzuki on the basis of leaves and fruits from the Late Miocene of northeastern Honshu. The Noroshi leaves are referred to this species by the large size, the ovate form, the acute apex and the round base. It is distinguished from *P. nipponicus* Miki showing the small size and the obtuse apex.

Our specimens are similar to *P. orientalis* Hemsley in Yunnan and *P. hemsleyana* Rehder in central and southwest China.

Occurrence: Kourade and Takaya.

Collection: Hypotypes JC88–517, 518(Takaya).

Berchemia miofloribunda Hu and Chaney

1938. *Berchemia miofloribunda* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 65, pl. 39, fig. 5; pl. 40, figs. 2, 3.

Remarks. Several fragmentary leaves referred to this species were compared with those of the living vine, *B. floribunda* Brongniart, *B. pauciflora* Maximowicz and *B. racemosa* Siebold and Zuccarini of China and Japan. *B. floribunda* is distributed in southeast and southwest China, extending northward into Hunan. *B. racemosa* is distributed all over Japan and *B. pauciflora* is found in the central Honshu. Endocarps of *B. racemosa* were reported from the Plio-Pleistocene of Japan by Miki. This species also resembles the living *B. volubilis* DC. of eastern North America.

Occurrence: Takaya, Orito and Uwano.

Family ELAEOCARPACEAE

Elaeocarpus notoensis new species

(Plate 16, figures 1, 2, 4, 5)

Description. Leaves elliptic or ovate-elliptic; base round or obtuse; apex suddenly acuminate, blunt at the end; length 4.5 to 9 cm, width 2.5 to 5 cm; petiole long, stout; midvein strong, straight; four to five pairs of secondaries delicate, diverging at angles of 50° to 60°, forming broad loops at the margin; tertiaries coarsely reticulate, at the margin looping outside secondaries; marginal serration obtuse, pointed in the end; texture thick, probably hard-coriaceous.

Remarks. This species is very similar to the living *E. japonicus* Siebold and Zuccarini which is distributed in the warm and subtropcal regions of southern Honshu, Shikoku, Kyushu, Japan, extending into Okinawa, Taiwan and Szechuan province of China. The living species grows in broad-leaved forests at low altitudes in Taiwan. *E. notoensis* differs from *E. photiniaefolia* Hooker and Arnott *fossils* Nathorst in the Pliocene Mogi flora of Japan and *E. alaskensis* Hollick in the Oligocene of Alaska. The latter two species are oblong-lanceolate in the shape and acute in the base. Elaeocarpus may be distinguished from Camellia by long petiole and blunter teeth.

Occurrence: Takaya and East of Takaya.

Collection: Holotype JC88-532(East of Takaya); Hypotypes JC88-524-526 (Takaya).

Family THEACEAE

Camellia protojaponica Huzioka

(Plate 16, figures 3, 6, 7)

1955. *Camellia protojaponica* Huzioka, Ill. Cat. Foss. Fukui Pref., no. 6, p. 8, pl. 3, fig. 5.

1926. *Thea japonica* Nois. var. *fossilis* Kyrsthofovich, Ann. Rept. Russ. Pal. Soc., no. 6, p. 14, pl. 3, figs. 4, 5.

Remarks. This species closely resembles *C. japonica* Linnaeus widely distributed in Japan but for Hokkaido and northern extreme of Honshu, Korea, and Shantung province of China.

Occurrence: Takaya.

Collection: Hypotypes JC88–533–535.

Ternstroemia maekawai Matsuo

(Plate 17, figures 1, 2)

1962. *Ternstroemia maekawai* Matsuo, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 241–242, pl. 50, figs. 1, 3.

Remarks. Four leaves from the Noroshi flora are identified to *T. maekawai* by shape, size, texture, characteristic secondary venation and indistinct tertiaries.

This species is similar to the living *T. gymnanthera* (Wight and Arnold) Sprague, distributed in a wide area covering southern Honshu, Shikoku, Kyushu, Okinawa, Taiwan, southern Korea, China and India.

Occurrence: Takaya, East of Takaya and Noroshi-shin.

Collection: Hypotypes JC88–540(Takaya), 542(East of Takaya).

Family ELAEAGNACEAE

Elaeagnus mikii new species

(Plate 17, figures 3, 4, 7, 8)

Description. Leaves oblong or elliptic, 3.8 to 5.7 cm long, 1.8 to 3.0 cm wide, apex acute, tip of apex, blunt, base obtuse or acute spotted in surface; midvein somewhat stout, nearly straight, narrowing towards apex; secondaries fine, four to five pairs, diverging from primary vein at 40° to 45° curving upwards, looping near margin; tertiaries indistinct; margin entire; petiole stout, 0.3 to 1 cm long, spotted; texture medium.

Remarks. *E. mikii* is the first record of the genus Elaeagnus for the Miocene flora in Japan. This species is very similar to the living *E. umbellata* Thunberg, distributed widely in Japan, Okinawa, Korea, Manchuria and China. *E. akashiensis* Miki and *E. unbellata* are reported from the Pleistocene in central Japan by Miki. The leaf of *E. akashiensis* differs from this species in being round at apex, thick and coriaceous in texture, that is ever-green.

This species is named in appreciation of Professor S. Miki to whom the writer wishes to express his acknowledgment for valuable advice.

Occurrence: Takaya and East of Takaya.

Collection: Holotype JC88-549(East of Takaya); Hypotypes 544, 545(Takaya), 546(East of Takaya).

Family ALANGIACEAE

Alangium aequalifolium (Goeppert)Krysht. and Borsuk

1939. *Alangium aequalifolium* (Goeppert)Krysht. and Borsuk, Problems Palaeont. no. 5, p. 390, pl. 5, figs. 1–8; pl. 6, fig. 12.
1961. Tanai, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, vol. 11, p. 371, pl. 30, fig. 1; pl. 31, fig. 9.
1852. *Dombeyonsis aequalifolia* Goeppert, Palaeontolographica, vol. 2, p. 277, pl. 26, fig. 3.
1950. *Marlea aequalifolia* (Goeppert)Oishi and Huzioka. Oishi, Illust. Catalog. East-Asiatic Fossil Plants, p. 171, pl. 50, fig. 1.

Remarks. Although this species is abundant in the lower half of the Miocene in Japan and Saghalien, only an impression of leaf was obtained from the Noroshi flora. *A. aequalifolium* is similar to the living *A. platanifolium* (Sieb. and Zucc.)Harms var. *trilobum* (Miq.)Ohwi in southwestern Japan and Korea.

Occurrence: Takaya.

Family CORNACEAE

Cornus megaphylla Hu and Chaney

1938. *Cornus megaphylla* Hu and Chaney, Palaeont. Sinica n. ser., vol. 1, p. 71, pl. 48, figs. 3–5; pl. 49, fig. 2.
1955. *Cornus megaphylla* Hu and Chaney. Tanai, Geol. Surv. Japan Report No. 163, pl. 20, fig. 1.

Remarks. A single incomplete specimen at hand is identical with *C. megaphylla* in the shape and venation. Occurrences of this species have been reported from the Miocene of Japan. It is very much like the living species *C. macrophylla* Wallich.

of Japan proper except Hokkaido as a part of the wide distribution, Korea, central and southwestern China and Himalaya. This species also resembles *C. nuttallii* Aud. and *C. florida* L., the living species of North America.

Occurrence: Takaya.

Family OLEACEAE

Fraxinus honshuensis Tanai and Onoe

(Plate 17, figures 11–14)

1961. *Fraxinus honshuensis* Tanai and Onoe, Geol. Surv. Japan Report No. 187, p. 57, pl. 18, fig. 7.
1941. *Fraxinus* cfr. *japonica* Miki, Japanese Jour. Bot., vol. 11, p. 295, fig. 21c.

Remarks. This species has been reported from the Late Miocene to Pliocene of Japan on the basis of the samara, which is resembled to the modern *F. japonica* Blume in size and shape. The samara specimens from the Noroshi flora are identical with *F. honshuensis*, and they are 2.1 to 2.6 cm long and 4 to 5.5 mm wide. The seeds are 0.8 to 1.4 cm long and about 2 to 2.5 mm wide. Among the specimens of samara, there is an example with a notched apex that is often observed in the samara of *F. japonica*. No foliage has been found. This species may be related to *F. coulteriporf*, the fossil of Columbia Plateau.

Occurrence: Takaya, East of Takaya, Uwano and Osaki.

Collection: Hypotypes JC88–554(Takaya), 559, 560(Uwano), 561(Osaki).

Osmanthus chaneyi Matsuo

(Plate 7, figures 8, 9)

1962. *Osmanthus chaneyi* Matsuo, Geol. Surv. Japan 80th Ann. Mem. Publ., p. 242, pl. 54, figs. 2–4.

Remarks. Two nearly perfect leaves are referred to this species by the shape, venation and texture. This species closely related to the living *O. ilicifolium* Mouillefert which is widely distributed from central Honshu to Taiwan.

Occurrence: Takaya.

Collection: Hypotypes JC88–563, 564(Takaya).

Syringa notoensis new species

(Plate 17, figure 10)

Description. Leaf ovate-orbicular, 4.3 cm long, 2.9 cm wide, apex acuminate, base obtuse; midvein stout, straight, narrowing towards apex; secondaries relatively fine, five and six in each side, basal pair more fine, diverging from primary vein at 45° to 50° in lower part and 35° to 40° in upper part, curving upwards, looping near margin; inter-secondaries fine, diverging from primary vein to half part between primary vein and margin; tertiaries thin, waved, transversely between each two secondaries, and forming irregular coarse wavy meshes by anastomosing with other tertiaries, finer veinlets forming minute meshes; margin entire; petiole stout, 0.5 cm long; texture medium.

Remarks. Only one excellently preserved leaf is identified to the genus Syringa in the shape and the characteristic venation. *S. notoensis* is the first record of the genus Syringa from the Miocene flora in Japan. This species resembles the leaves of the living *S. reticulata* (Blume)Hara widely distibuted in eastern Asia, though the fossil species has somewhat short petiole. Miki reported an occurrence of *S.* cf. *amurensis* Rupr. in the Seto Pliocene of central Japan. Although the leaves of his collection are ovate in shape, they may be of *S. notoensis* considering their leaf-sizes and the short and stout petioles.

Occurrence: Takaya.

Collection: Holotype JC88–565.

Family TRAPELLACEAE

Hemitrapa yokoyamae (Nathorst)Miki

(Plate 17, figures 15, 16)

1953. *Hemitrapa yokoyamae* (Nathorst)Miki, Paleobotanist, vol. 1, p. 349, fig. 2G.

1888. *Trapa yokoyamae* Nathorst, Palaeont. Abhandl. heraus. v. Dam. Kays, vol. 4, pl. 7, fig. 6–8.

Remarks. *H. yokoyamae* is common in the Middle Miocene of Japan, and is characterized by four appendages and large broad nuts. Some nuts referred to this species are found from three localities of the Noroshi flora. This species is only one aquatic plant in the flora.

Occurrence: Takaya, East of Takaya and Uwano.

Collection: Hypotypes JC88–568, 569(East of Takaya).

INCERTAE SEDIS

Carpolithes japonica (Morita) new combination

(Plate 22, figures 1, 2, 6, 7)

1952. *Dodonea japonica* (Morita)Tanai, Proc. Paleont. Soc. Japan, NS. No. 8, pp. 233–234, pl. 22, fig. 8; tex. fig. 1.
1936. *Terminalia japonica* Morita, Jour. Geol. Soc. Japan, vol. 40, p. 355.

Description. Winged fruits cordate with slender peduncle; fruits composed of two parts spatulate to spatulate-cordate, flat; 5 to 7 mm long and 3 to 4 mm wide; folding at obtuse angle on upper side in axis, probably at angle of about 100° to 120°, may be apt to break at axis; peduncles slender, smoothly changing from fruits, 3 to 4 cm long (estimated); wing cordate, thin, membranous, 0.9 to 1.3 cm long and 1.6 to 3.6 cm wide, touching on upper side of fruit on axis to margin of wing, somewhat flexuous, something forked, especially in basal side, entering in dents of undulation of margin at right or obtuse angles; interveinlets thinner; margin slightly undulate.

Remarks. Similar seeds have been described as Terminalia by Morita from the Miocene flora in Oguni of northeastern Honshu, and afterwards revised as Dodonea by Tanai. Our winged fruits are more like acheniums than capsules, and the junction between fruit and peduncle is not like that of Tanai's restoration. Their reference to Dodonea must for the present remain in doubt.

Occurrence: Kourade, Takaya, East of Takaya, Orito, Uwano.

Collection: Hypotypes JC88–648, 649(Takaya), 651, 652(East of Takaya).

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PLATE

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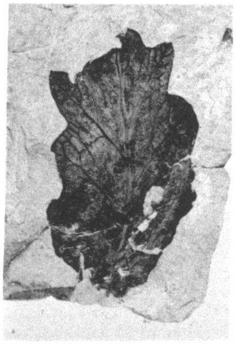
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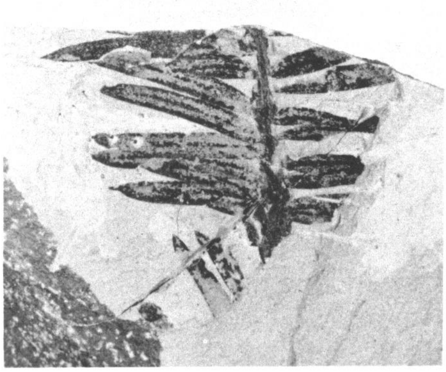
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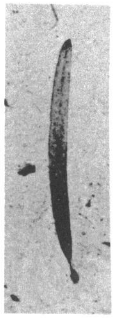
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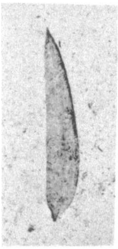
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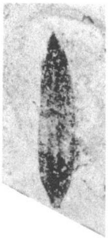
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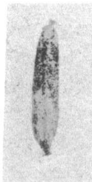
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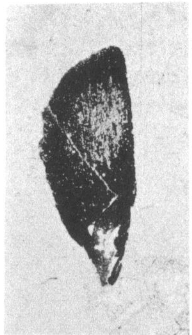
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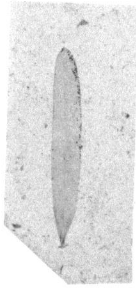
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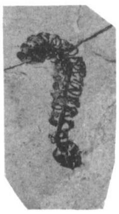
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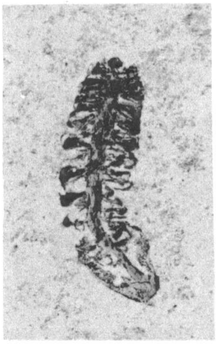
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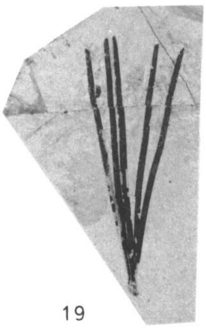
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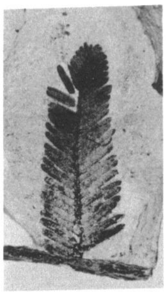
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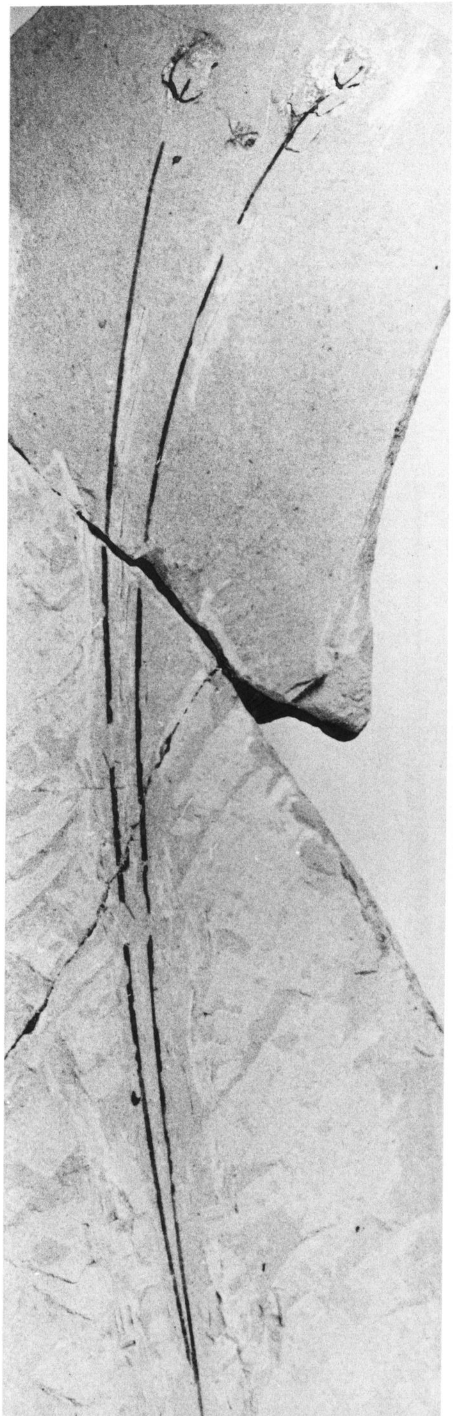

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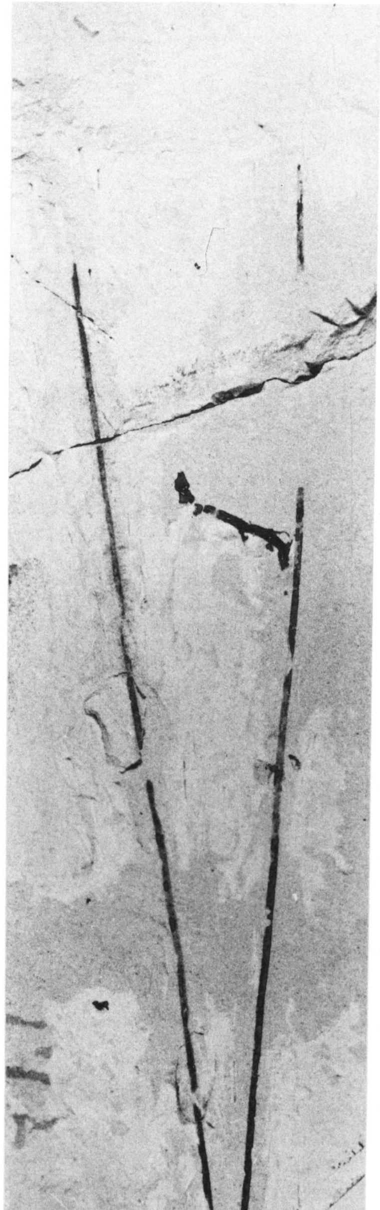

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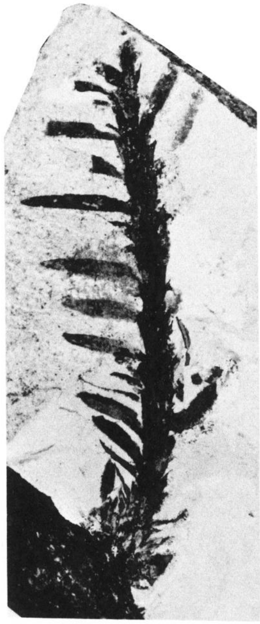

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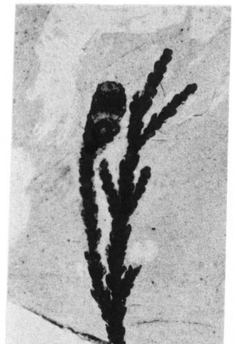

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Ishida : Noroshi Flora

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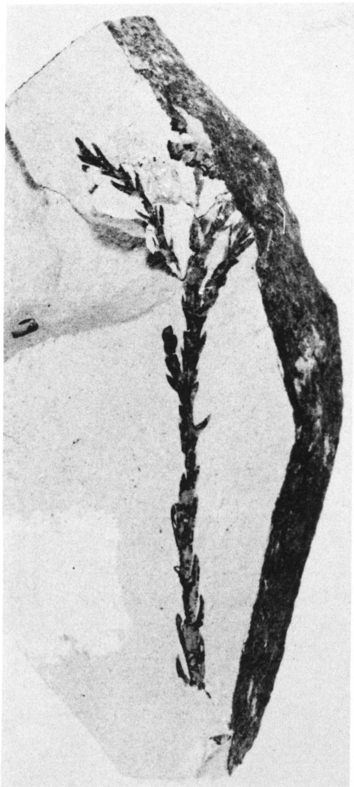
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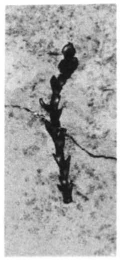
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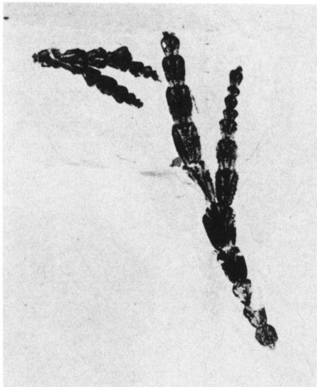
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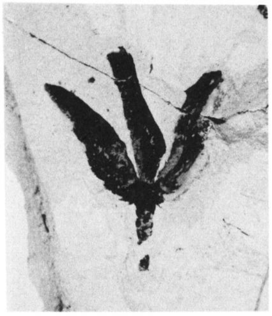
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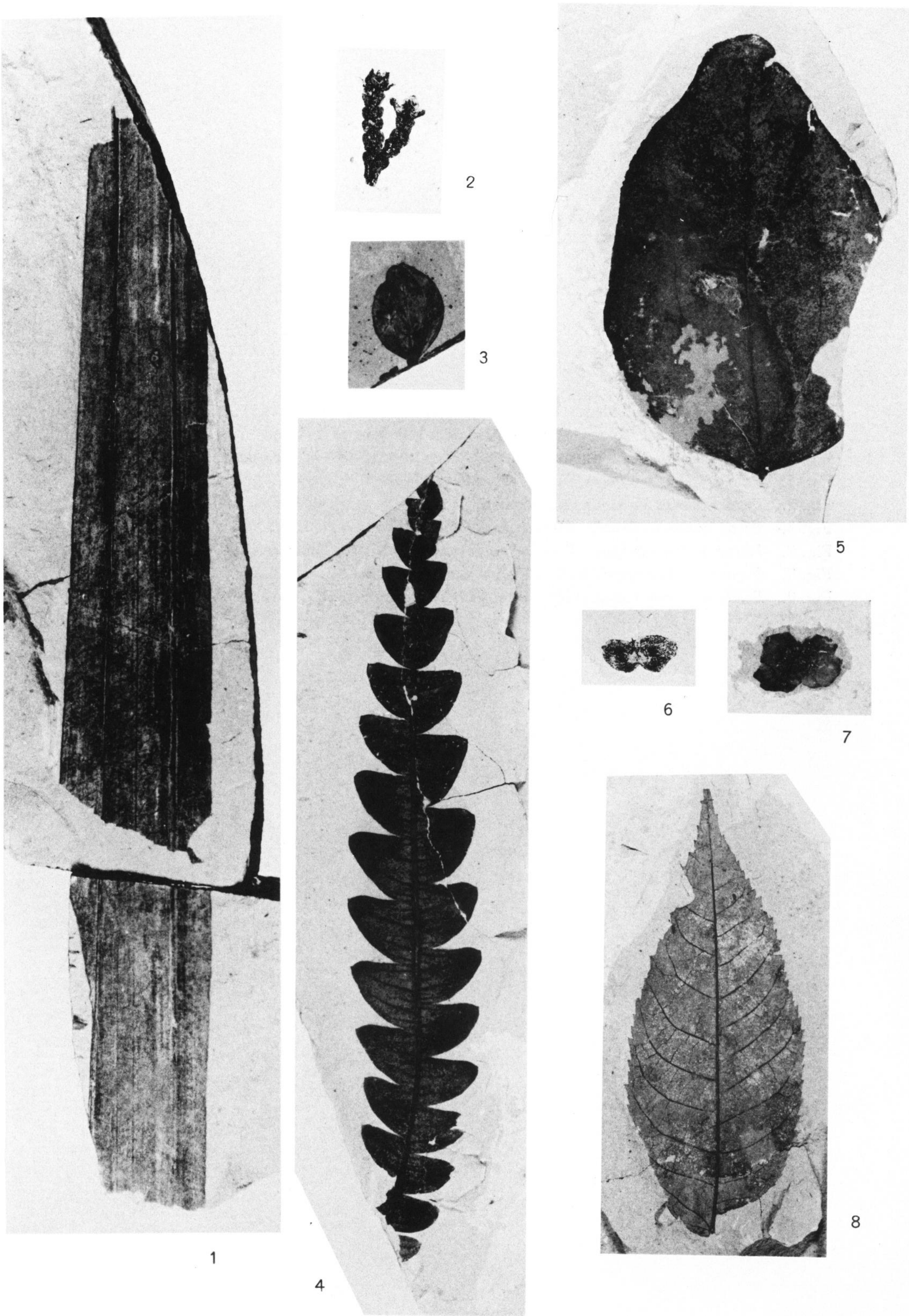

Ishida: Noroshi Flora

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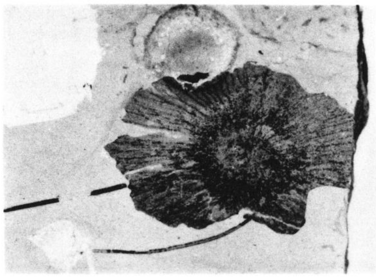
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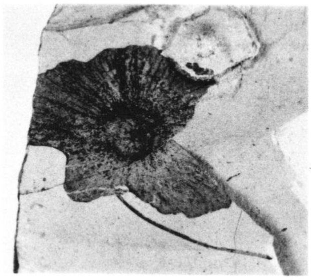
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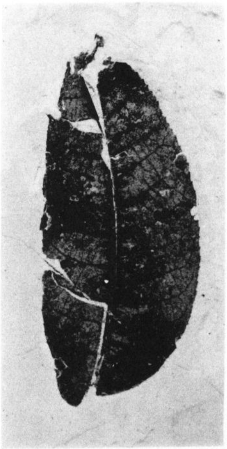
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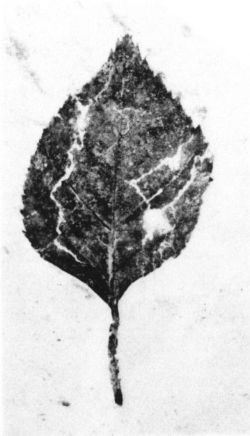
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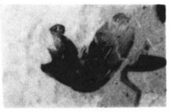
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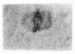
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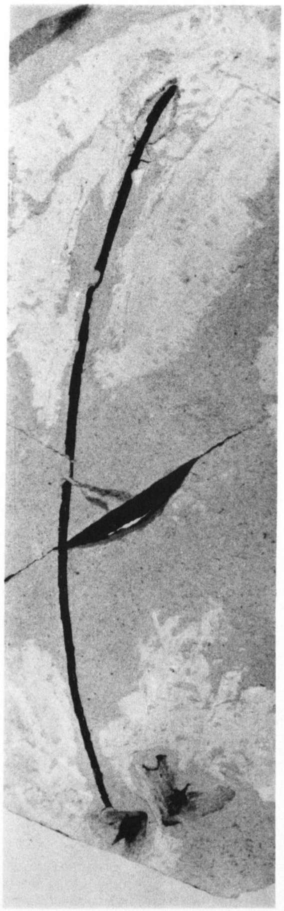
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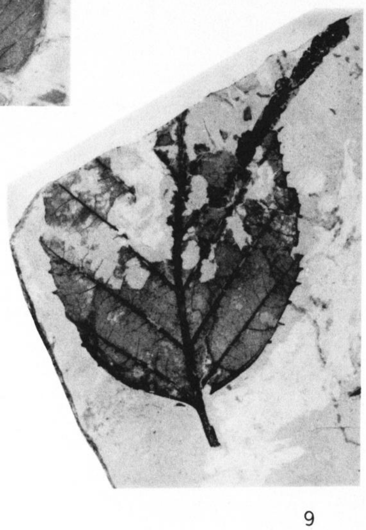
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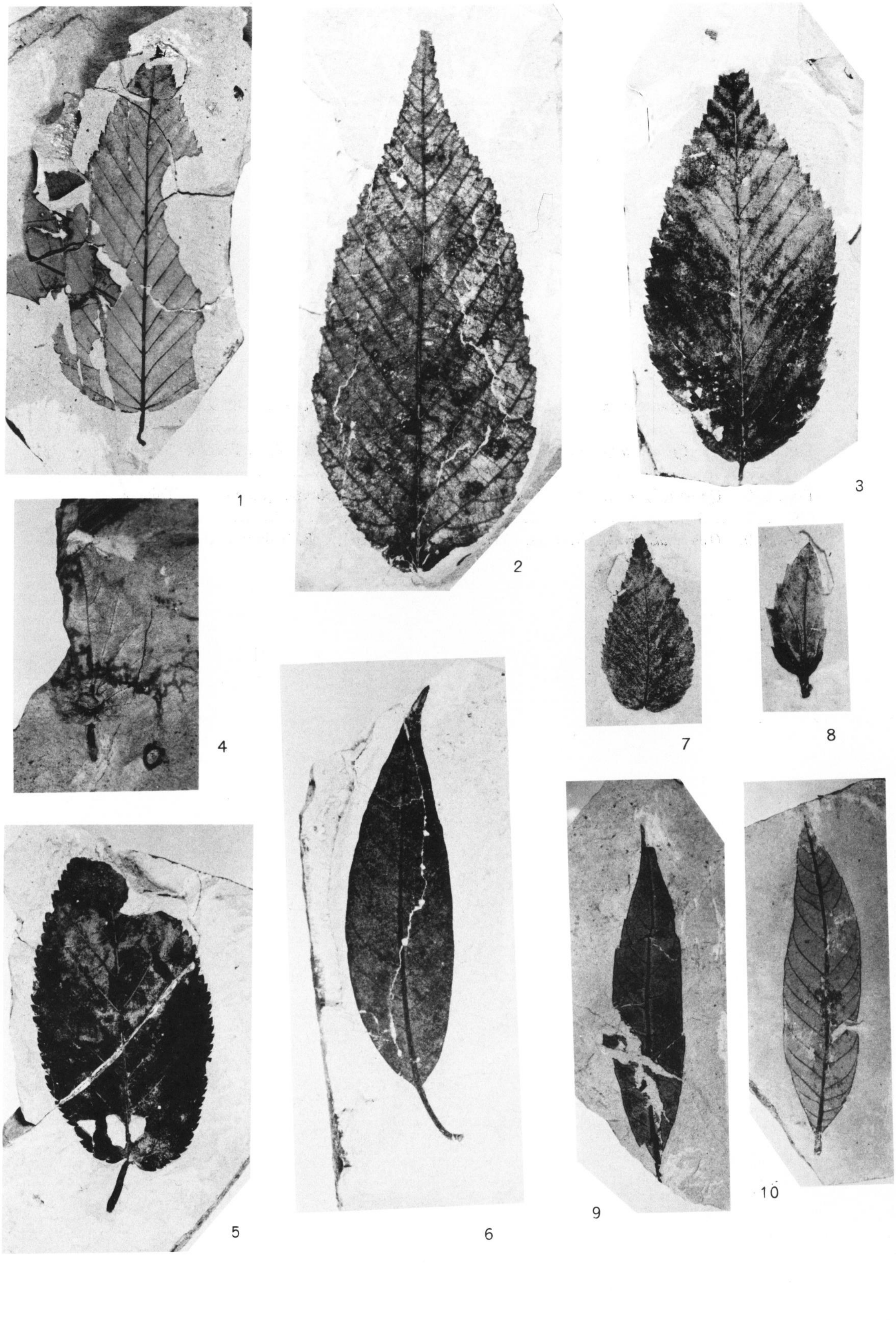

Ishida : Noroshi Flora

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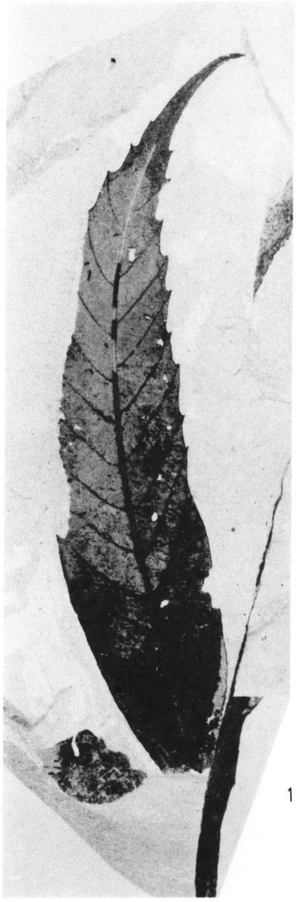
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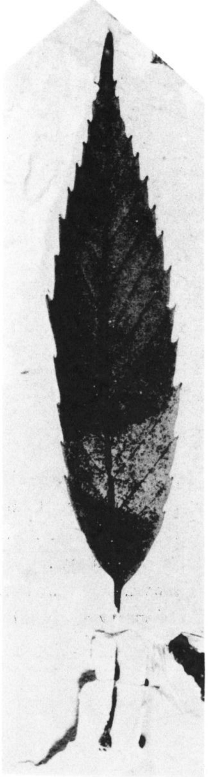
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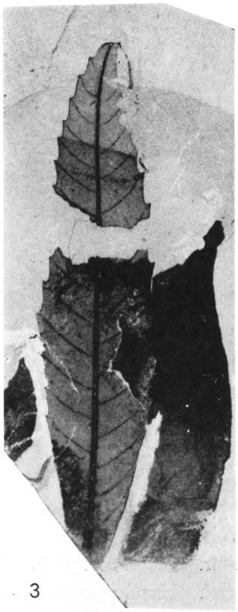
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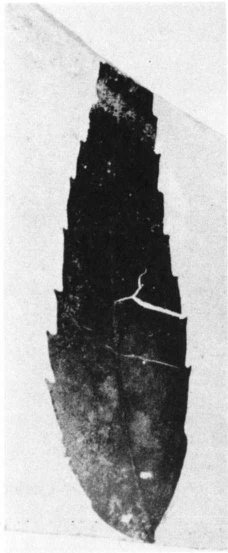
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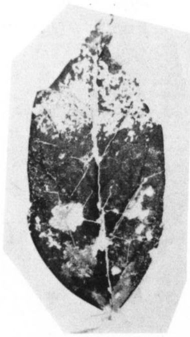
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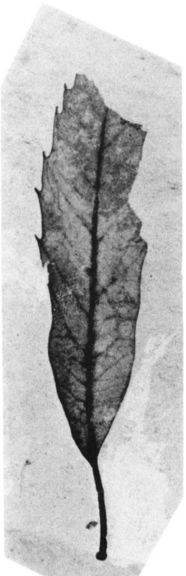
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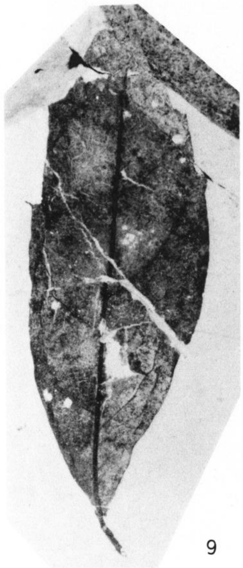
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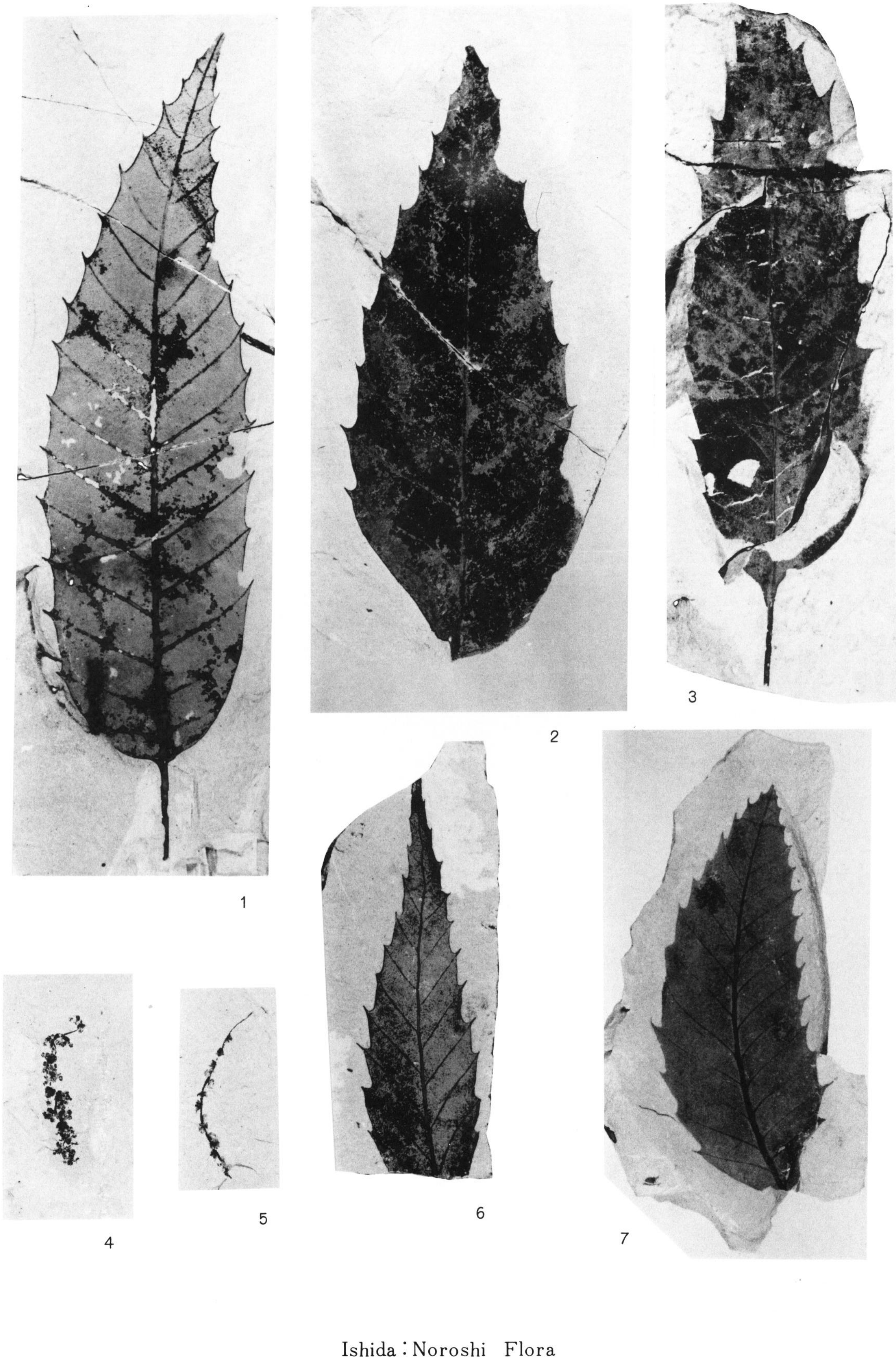

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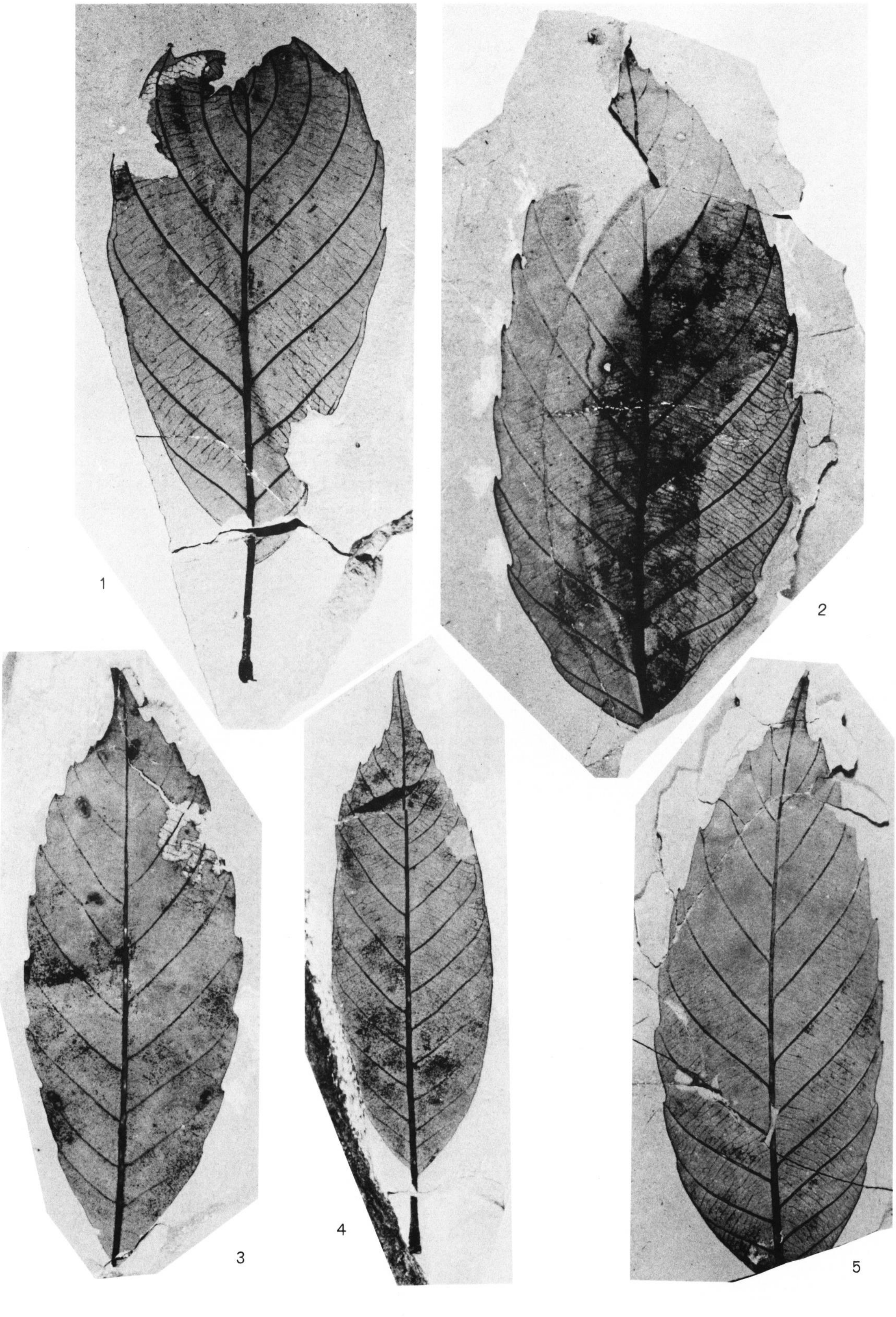

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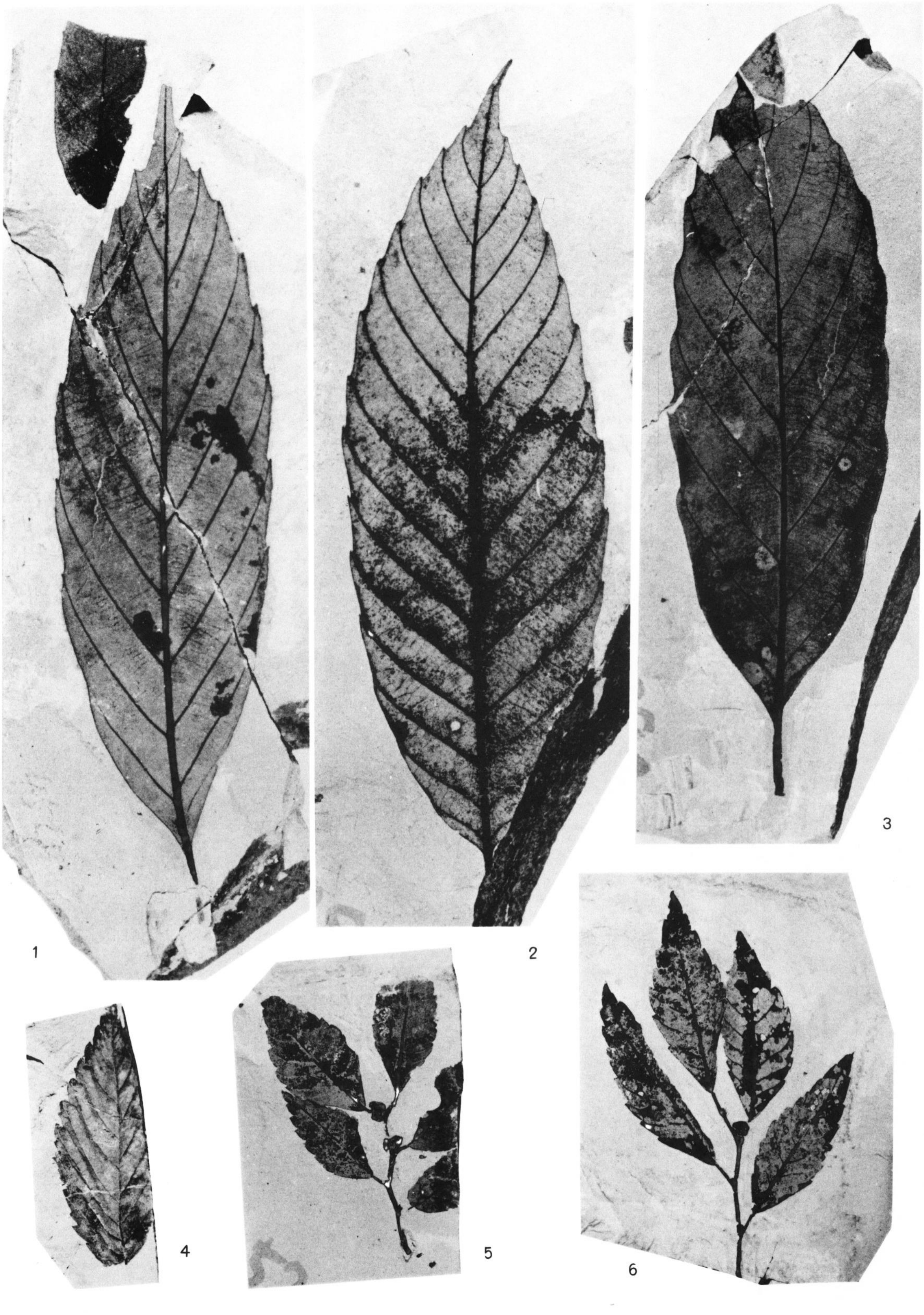

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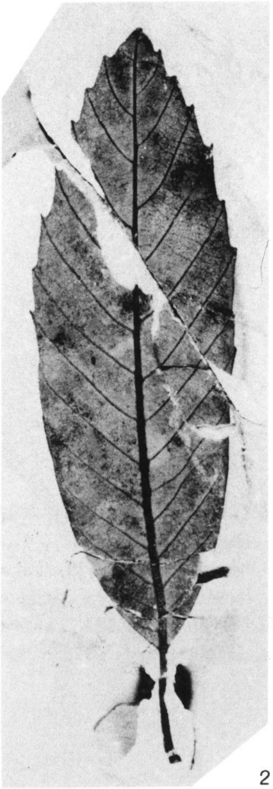
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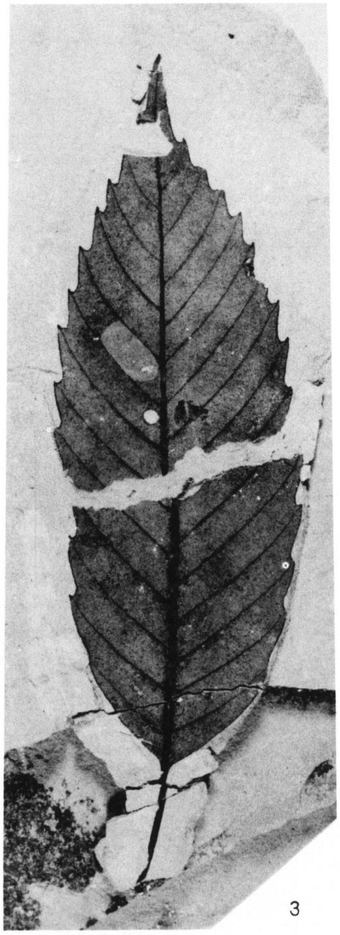
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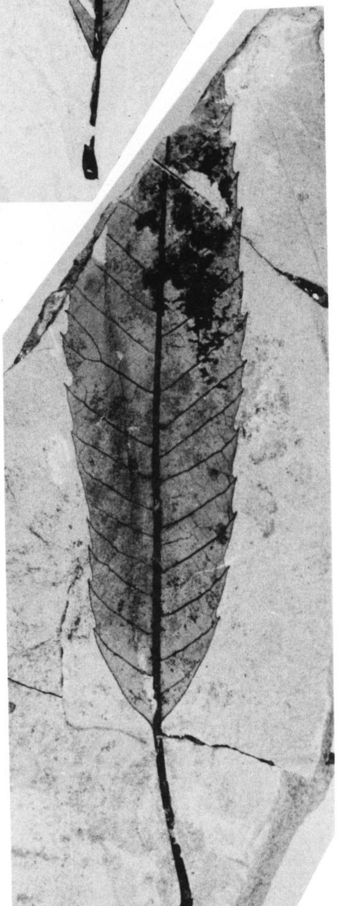
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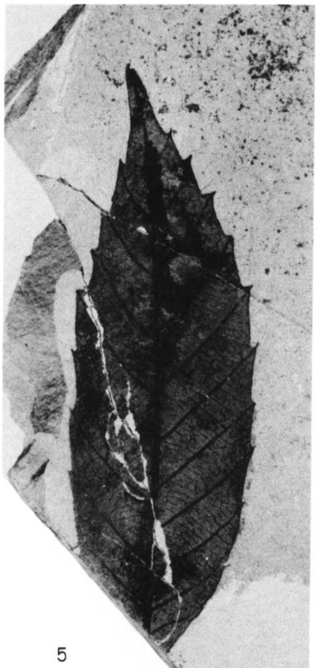
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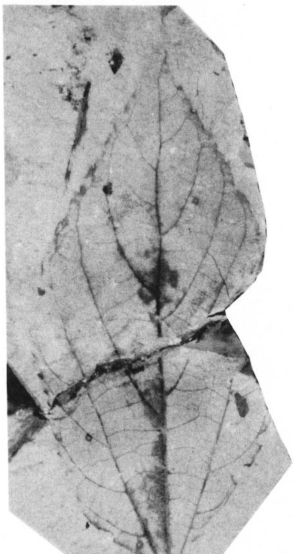
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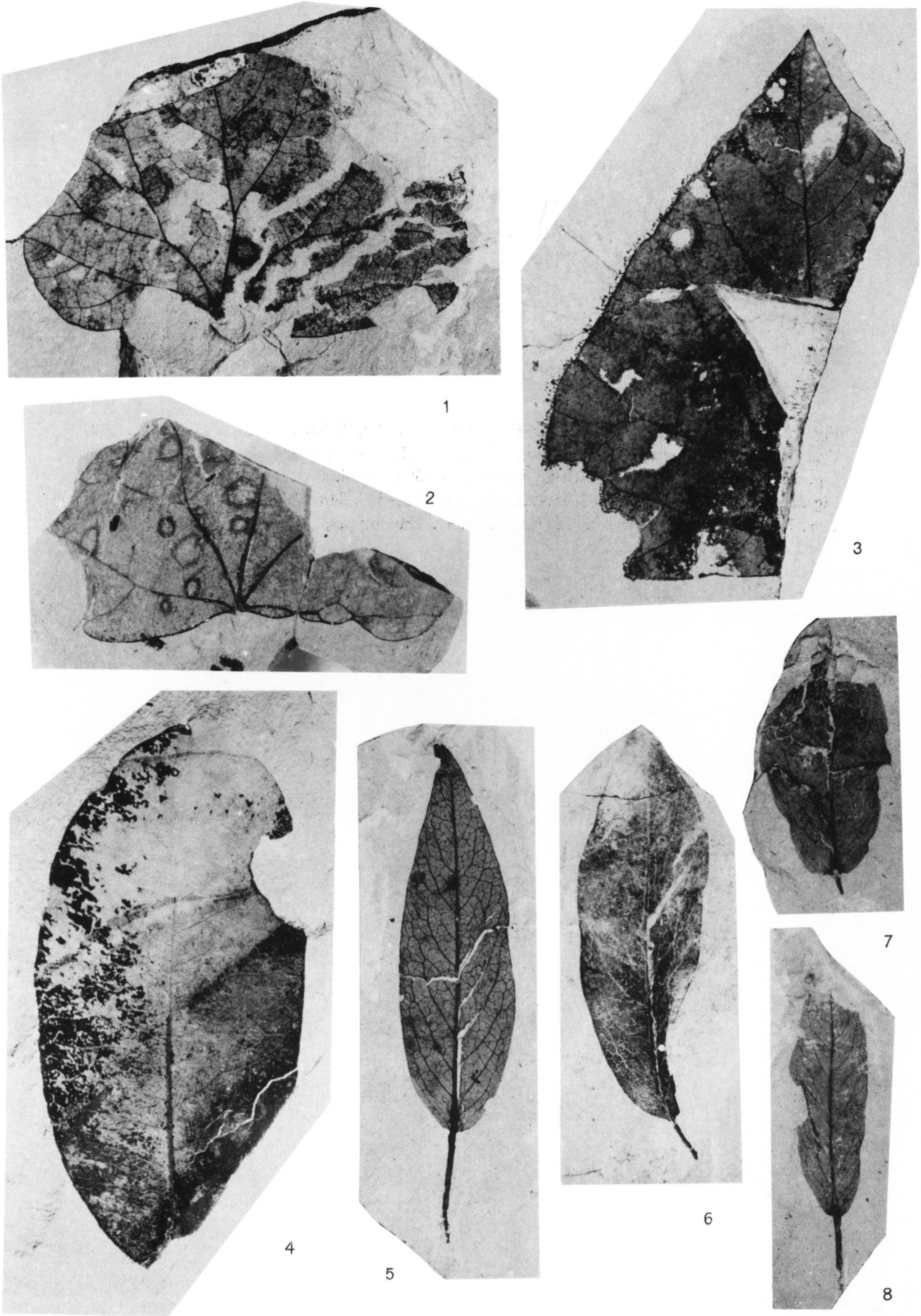

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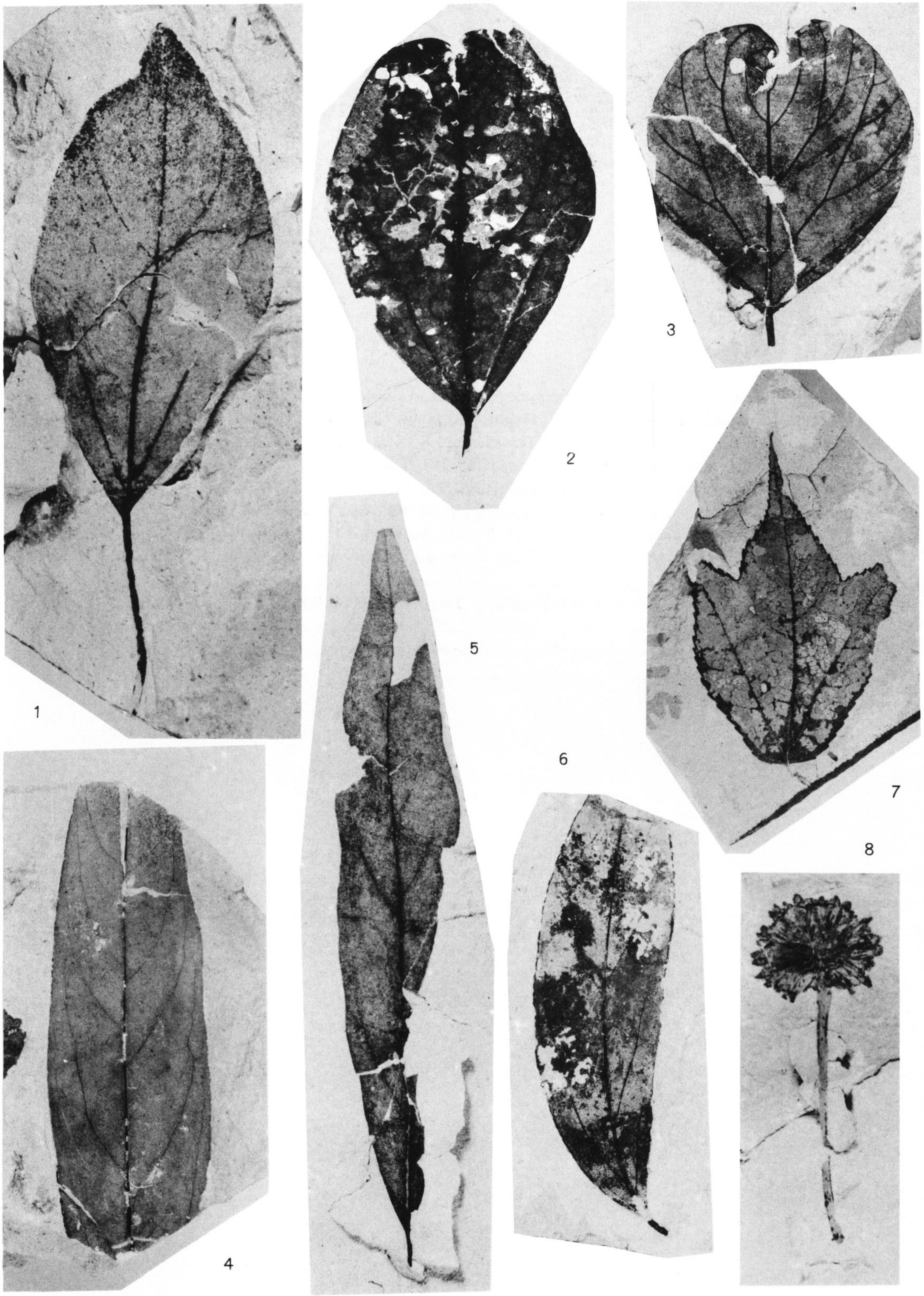

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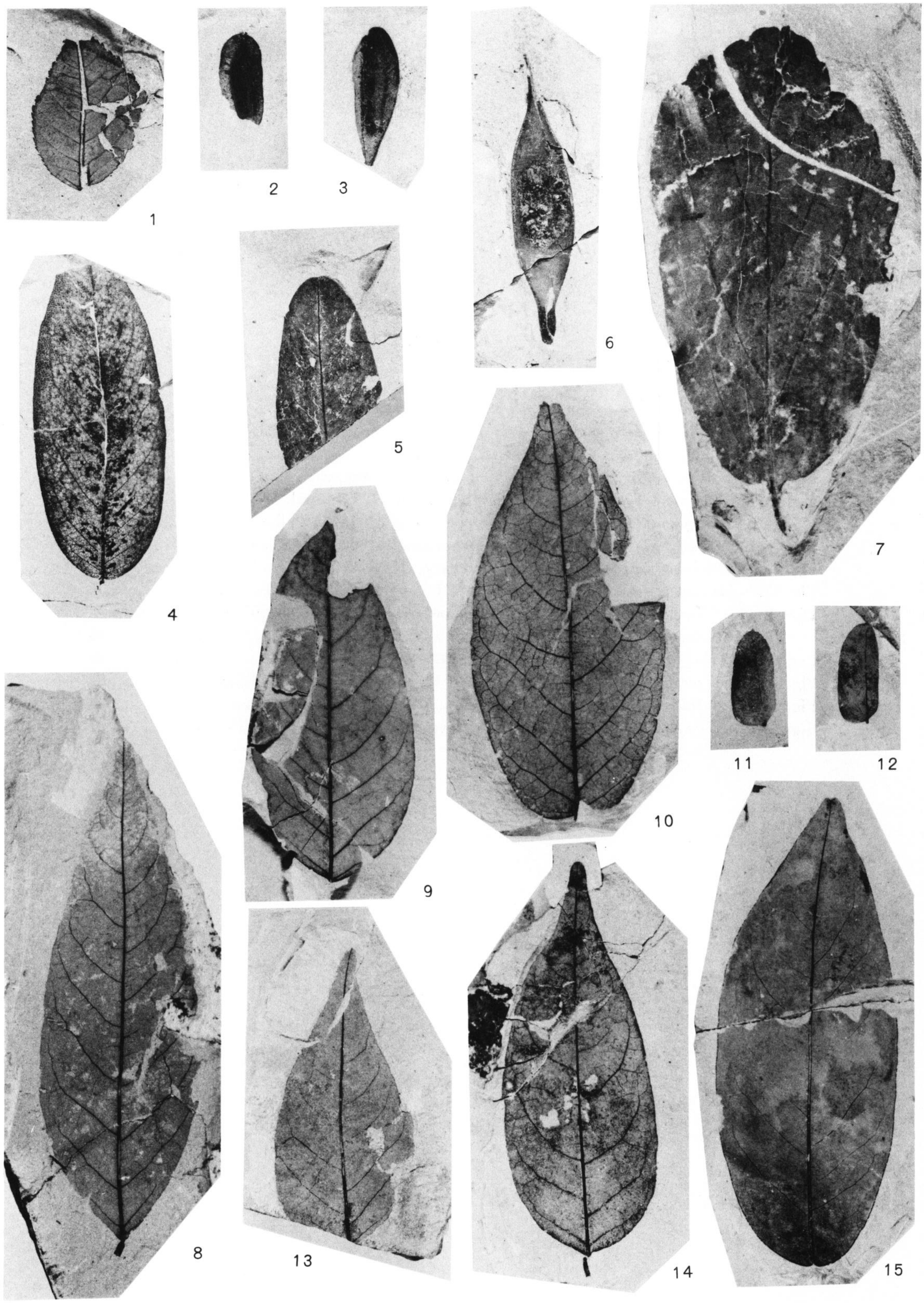

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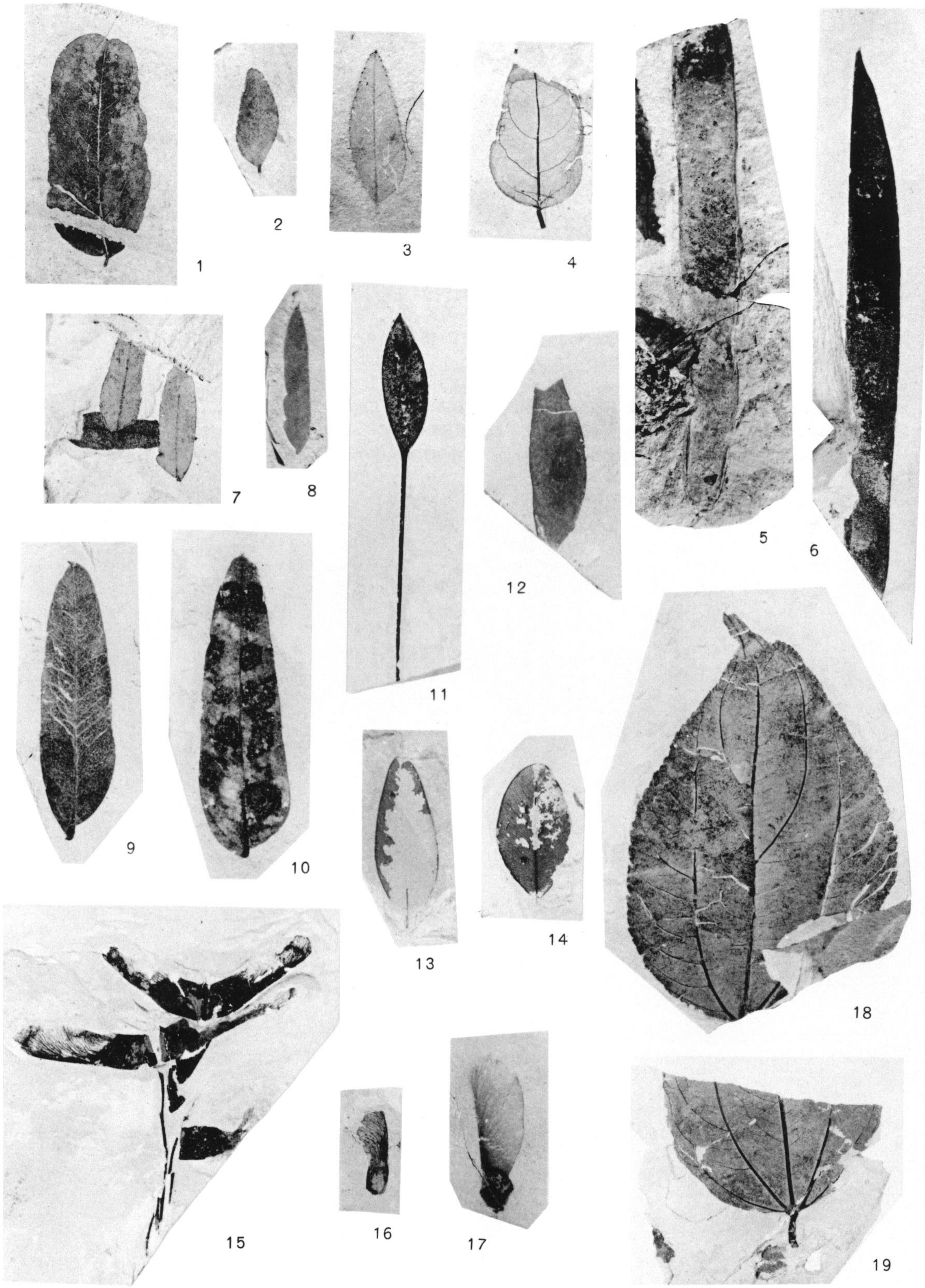

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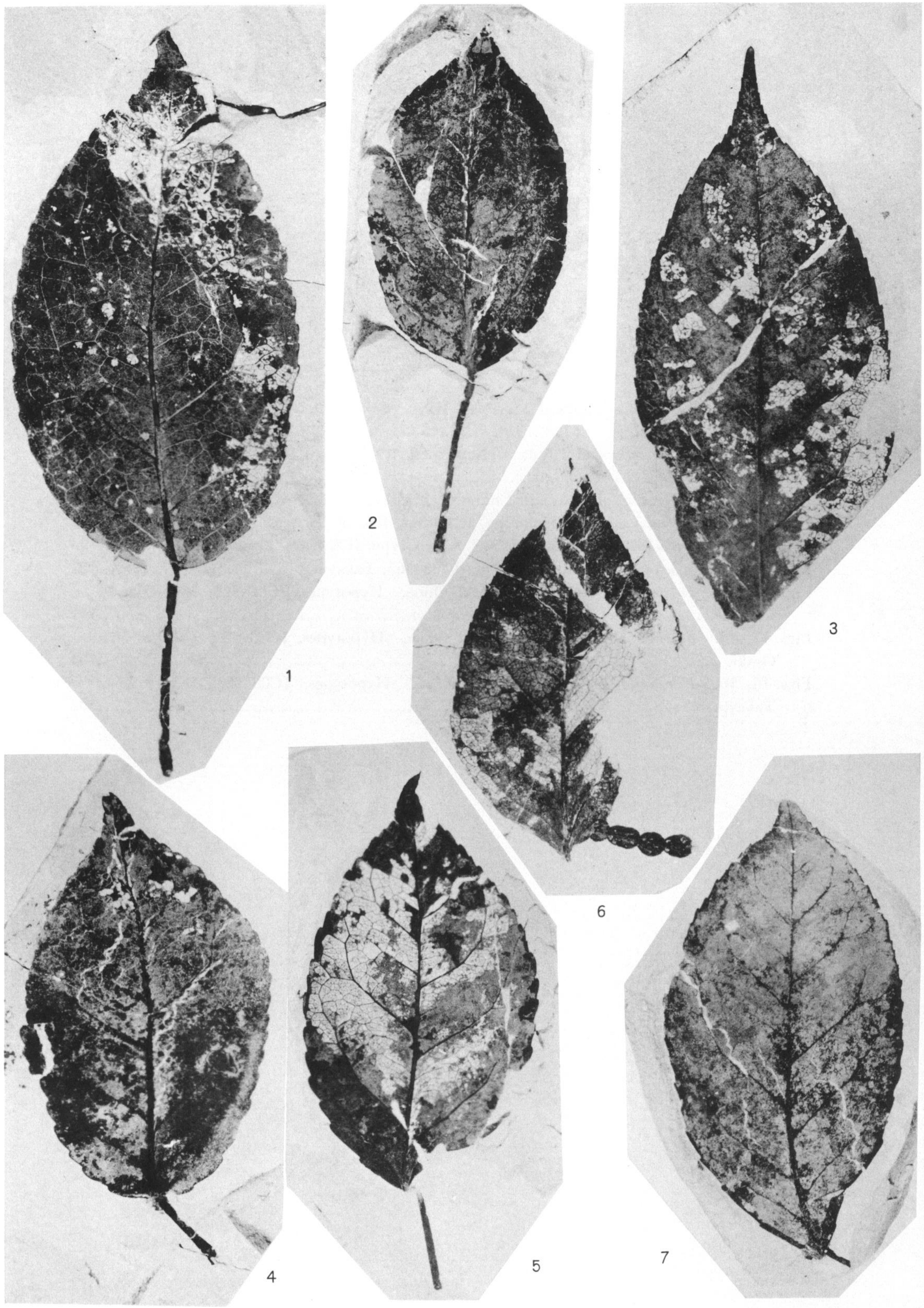

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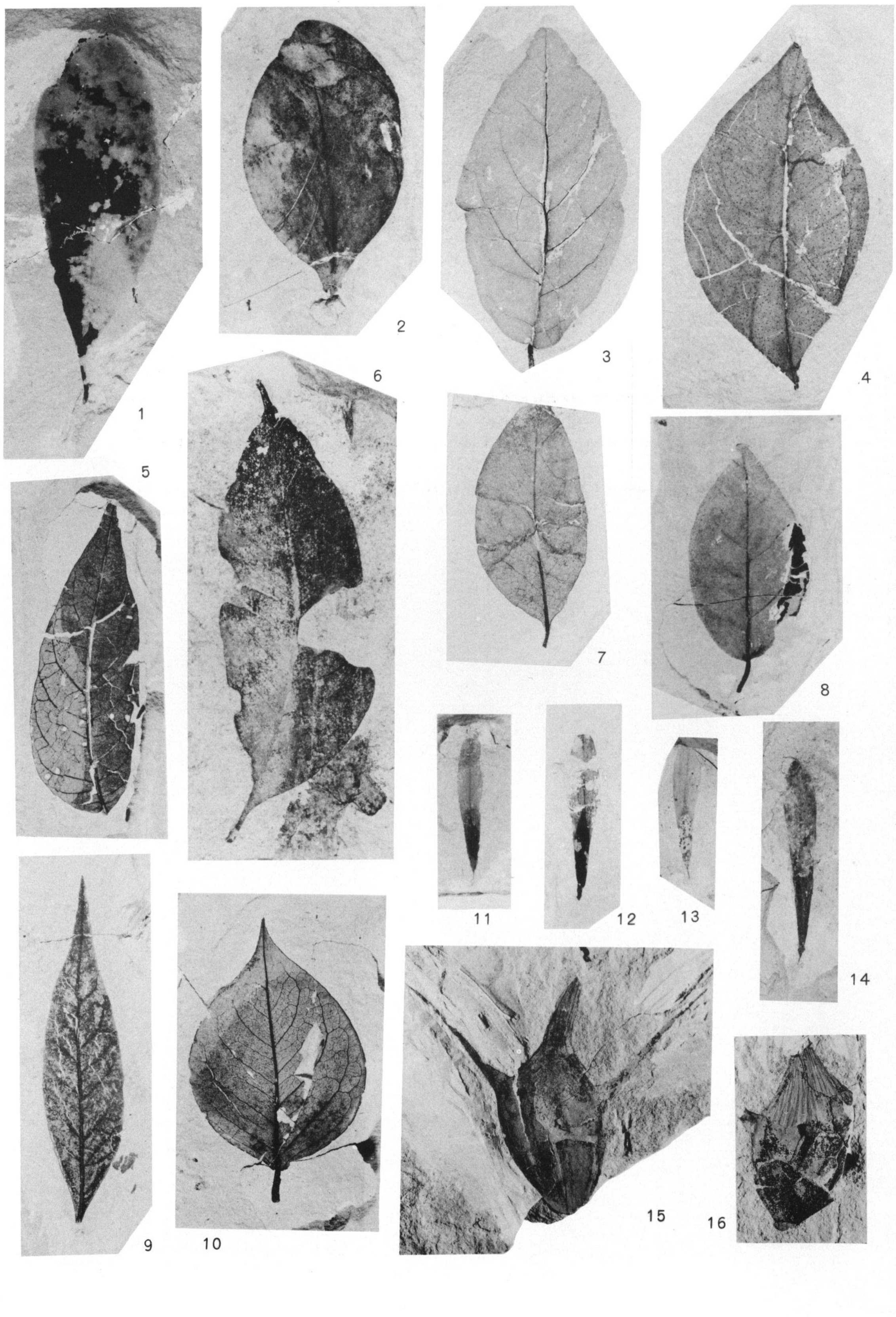

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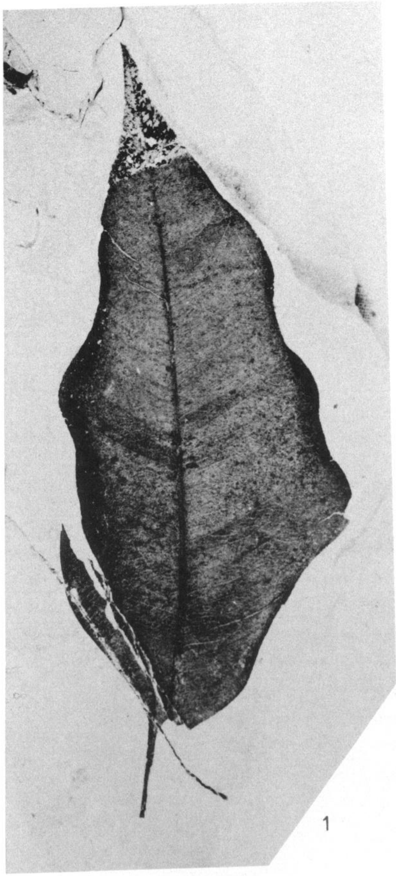
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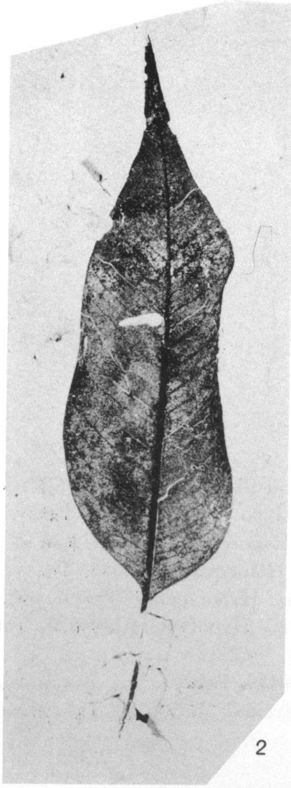
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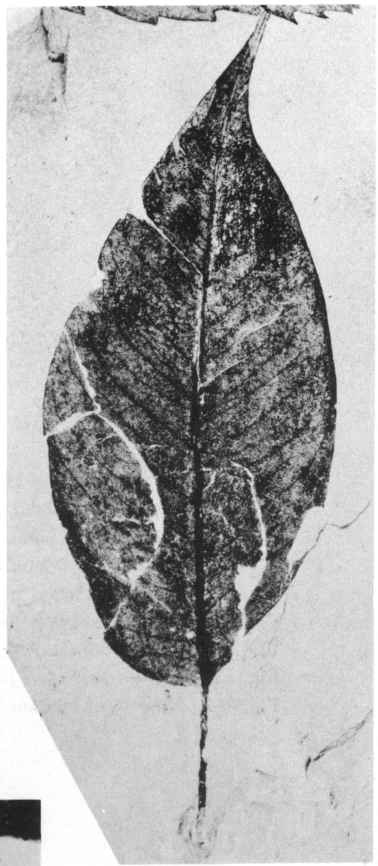
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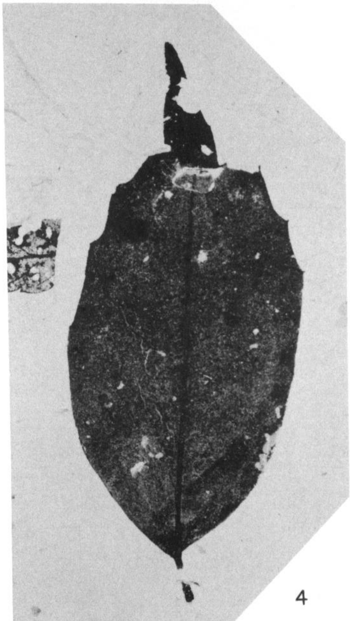
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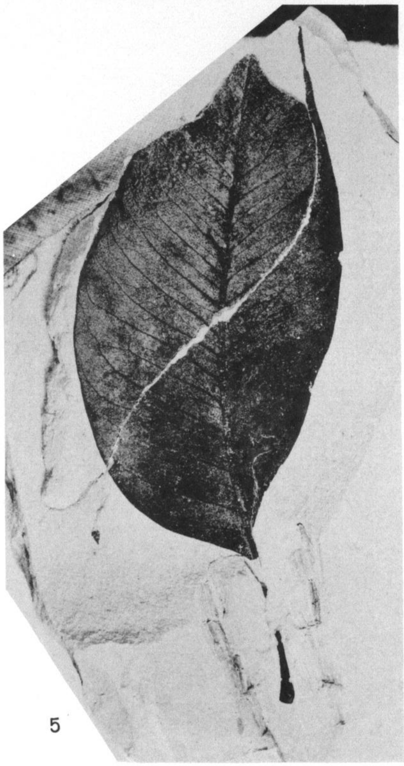
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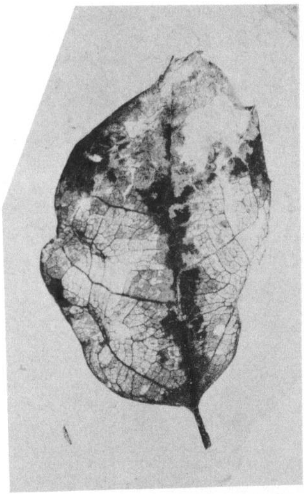
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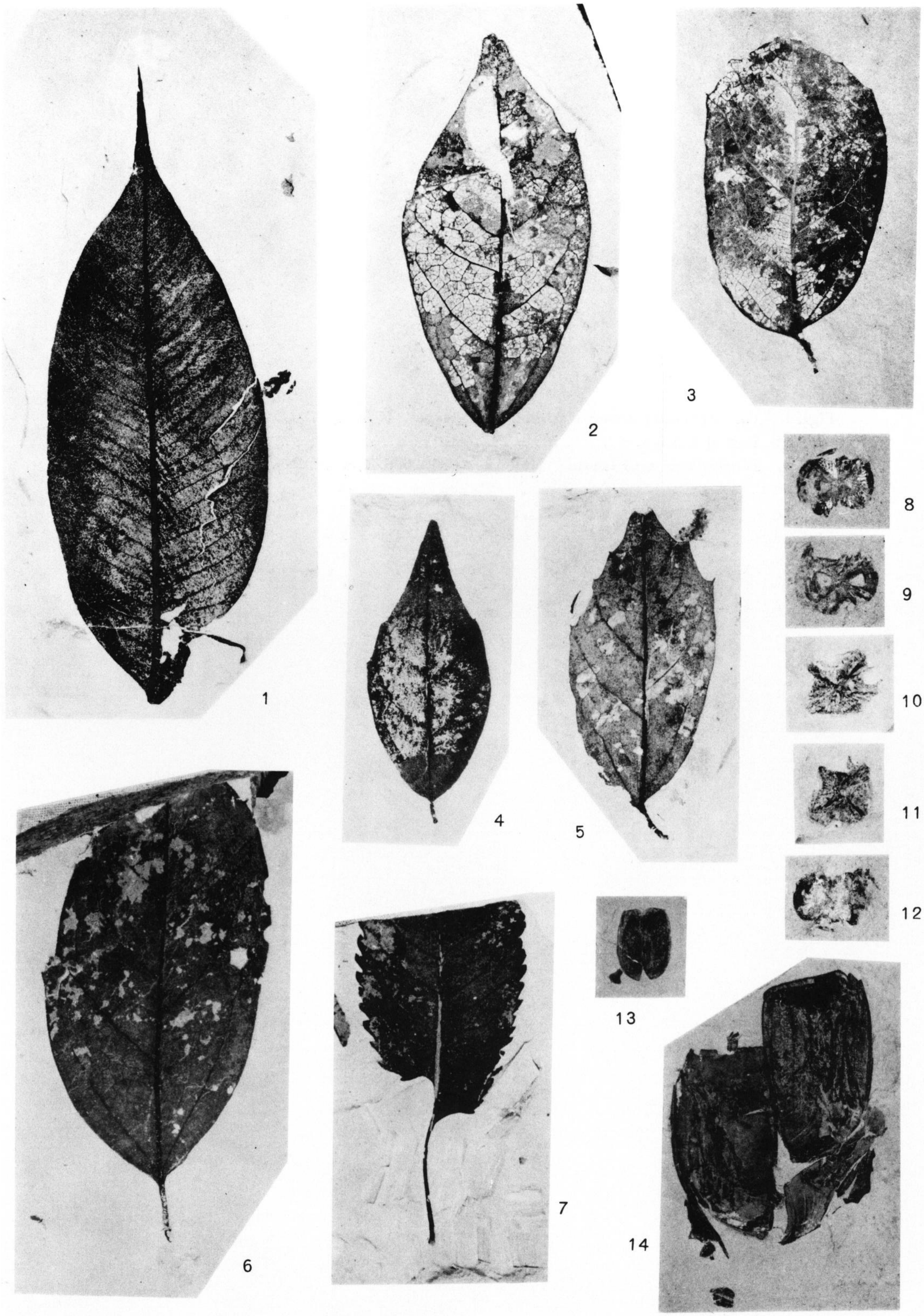

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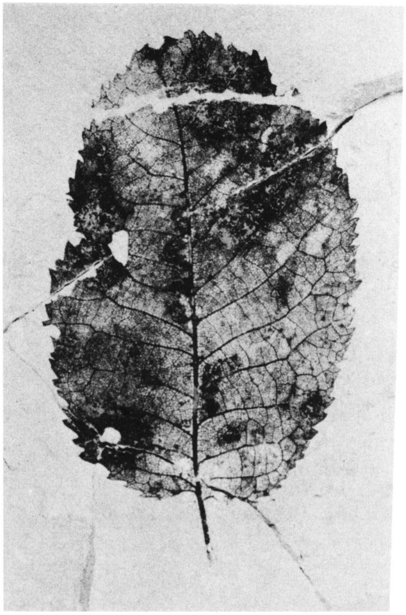

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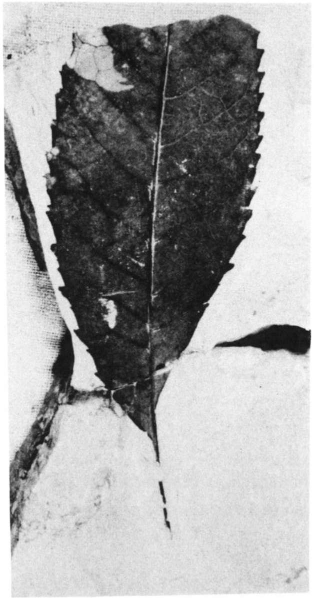

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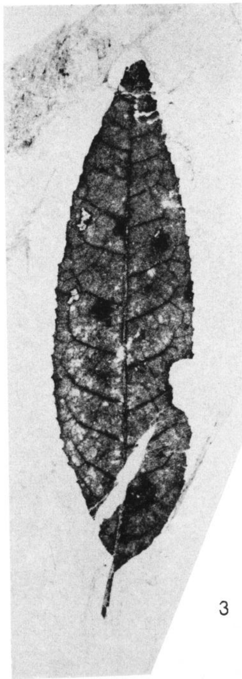

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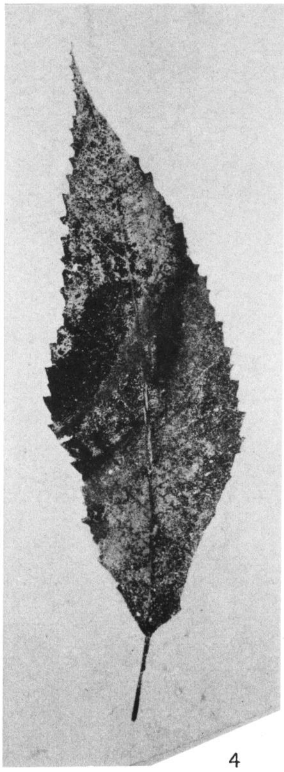

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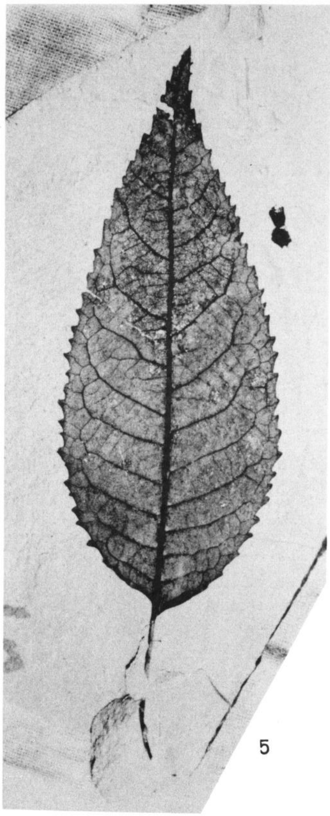

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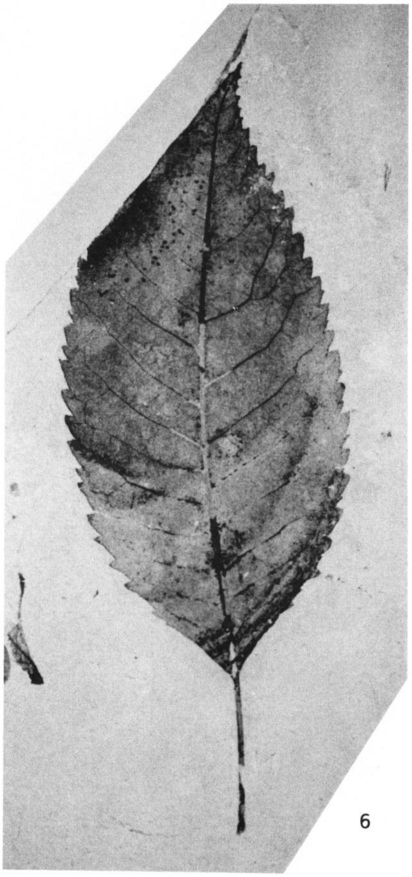

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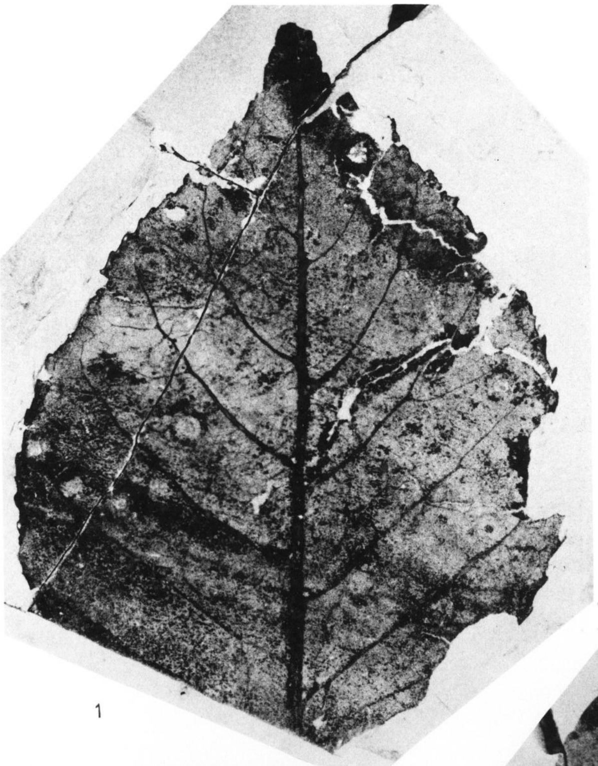

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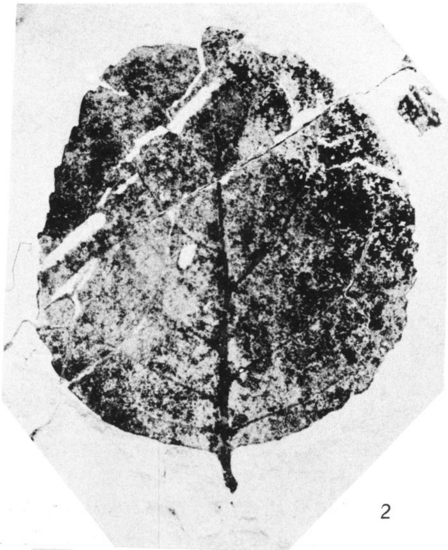

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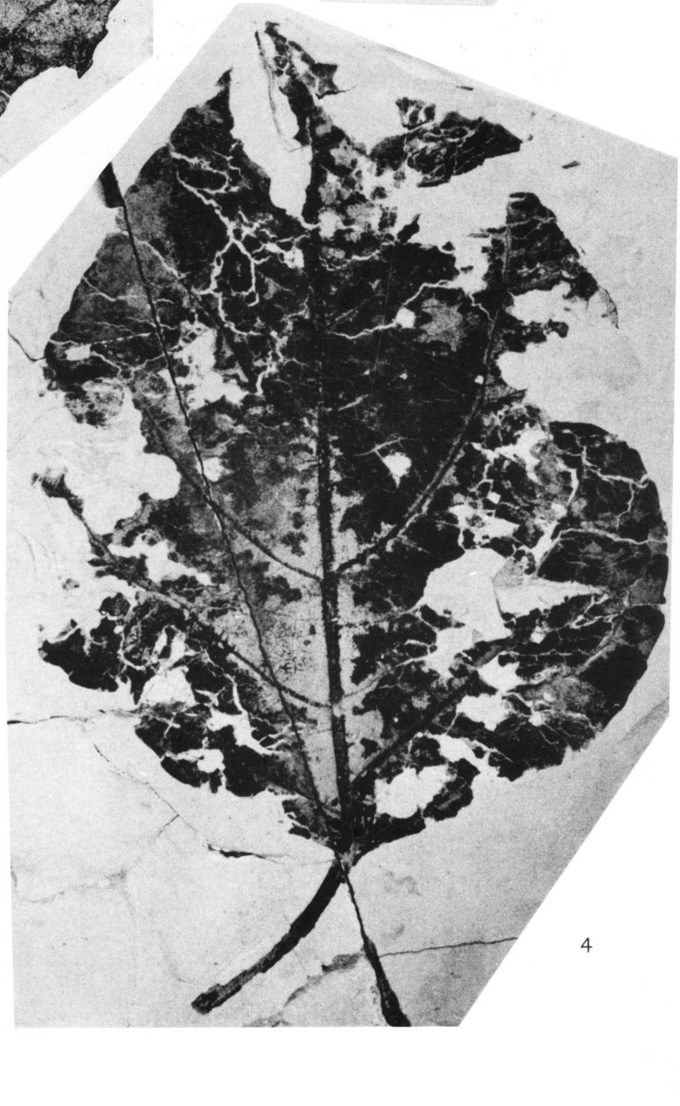

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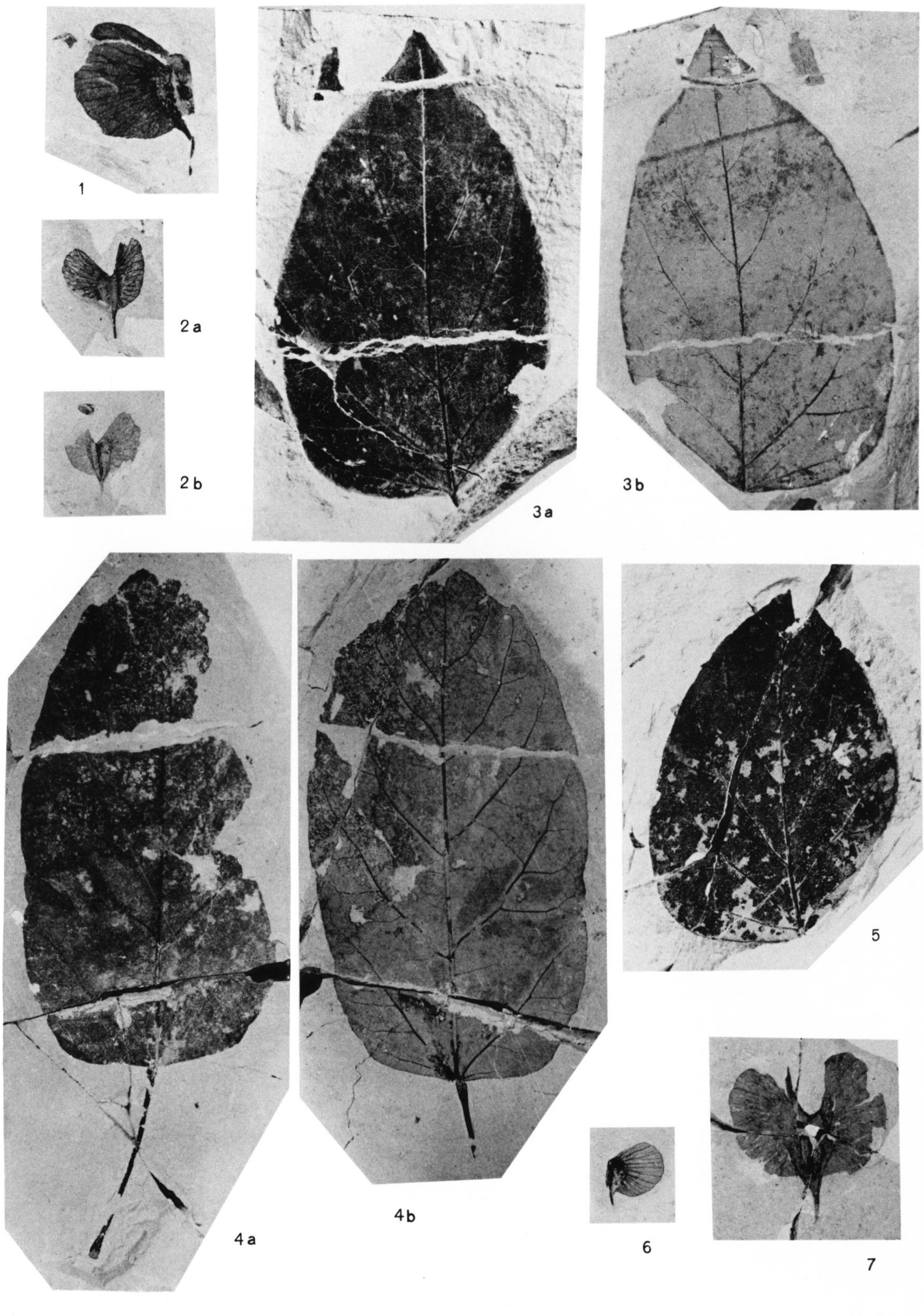
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