

## SYSTEMATIC DESCRIPTION OF THE SPECIES

The abbreviations for the depositories and localities of the fossils are as follows :

KPM oz- : Kanagawa Prefectural Museum, Ozaki's Paleobotany Collection.

ita- : Environs of Takasaki and Annaka Cities, Gunma Prefecture (the Itahana Formation).

The hyphenated alphabetical capital letters indicate the fossil localities shown in Fig. 3.

yag- : Southwest of Kumagaya City, Saitama Prefecture (Yagii Formation).

The hyphenated alphabetical letters indicate the fossil localities shown in Fig. 6.

yama : Yamazaki, Omi-mura, Nagano Prefecture (the "Ogawa" Formation). Showing in Fig. 11.

boud : Bodaira, Omi-mura, Nagano Prefecture (the "Ogawa" Formation.) Showing in Fig. 11.

maru : Maruyama, Omi-mura, Nagano Prefecture (the "Ogawa" Formation.) Showing in Fig. 11.

cha : Chausuyama, Shinonoi-cho, South of Nagano City, Nagano Prefecture (the "Ogawa" Formation). Shown in Fig. 13.

kaba : Kabauchi, Ohka-mura, Nagano Prefecture (the "Ogawa" Formation). Showing in Fig. 14.

ito : The Ito clay mine, Obata-machi, Toyota City, Aichi Prefecture (the Seto porcelain clay Formation\*). Showing in Fig. 16.

\*This formation is abbreviated to the Seto Formation.

Kabutoiwa : Valley cliff, NNW of Oogami, Nanmoku-mura, Gunma Prefecture (the "Kabutoiwa" Formation). Showing in Fig. 7. The specimens of the Kabutoiwa Formation have no abbreviation.

TNHM : Tyausuyama Natural History Museum, Chausuyama, Nagano

SU : Department of Geology, Faculty of Education, Shinsyu University, Nagano

NHS : Nagano High School, Nagano Prefecture

K : Mr. Koshimizu's collection from the Kabutoiwa Formation

O : Mr. Okabe's collection from the Kabutoiwa Formation

## GLOSSOPSIDA

Family **SELAGINELLACEAE**Genus *Selaginella* Beauv.*Selaginella* ? sp.

Fig. 24-1

*Description*: Shoot very small, composed of 6 branches, about 7 mm long; leaves cucullate in shape, apex acute, base decurrent, about 0.5 mm long and 0.3 mm wide, arranged nearly alternate.

*Discussion*: A single impression of very small shoot is similar to some species of the extant *Selaginella* in the shape and arrangement of the small leaves.

*Occurrence*: Ogawa Formation.

*Collection*: KPM oz-marul0.

## PTEROPSIDA

Family **OSMUNDACEAE**Genus *Osmunda* Linnaeus.*Osmunda* sp. cf. *O. japonica* Thunb.

Pl. 1, fig. 2b

*Description*: Detached pinnules lanceolate, 3.0 to 3.5 cm long and about 1.0 cm wide; apex apparently obtuse; base obliquely truncate to slightly rounded; margin serrulate; midvein nearly straight; secondary veins dichotomous, branching one or two times before terminating in the margin.

*Discussion*: Eight detached pinnules on one block from the Kabutoiwa Formation are closely similar to those of the modern *Osmunda japonica* Thunb.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1186.

Family **ATHYRIACEAE**Genus *Cornopteris* Nakai*Cornopteris* sp.

Pl. 1, fig. 4; Fig. 24-4

*Description*: Pinna lanceolate with more than 15 pinnules; pinnule oblong, closely and alternately arranged to the rachis, making an angle of 50 to 55 degrees with the pinna axis, midvein of the pinnule extending flexuous, secondaries once forking, apex rounded, margin ill-preserved but probably crenate.

*Discussion*: Except for well forked secondary veins, these leaves are similar to those of the modern *Cornopteris fluviatilis* (Hayata) Tagawa.

*Occurrence*: Ogawa Formation (Chausuyama).

*Collection*: TNHM 4203, 4204.

Family **ASPIDIACEAE**Genus *Displazium* Sw.*Displazium* sp.

Pl. 1, fig. 1; Fig. 24-2, 3

*Description*: Blade probably bipinnate; pinnule more than 10 pairs, equilateral, narrowly lanceolate in the proximal part, lanceolate in the distal part; pinnatilobed to deeply parted; ultimate pinnules semicircular to oblong, 3 to 5 mm wide, obsoletely crenate, forking generally five times in the longest part of pinnule.

*Discussion*: This specimen is closely similar to the modern *Displazium aquamigerum* (Mettenius) Matsum., except deeply parted ultimate pinnules and many times forking veins.

*Occurrence*: Ogawa Formation.



Collection : TNHM 4204.

Family **ASPLENIACEAE**

Genus *Asplenium* Linnaeus

*Asplenium* ? sp.

Pl. 1, fig. 3 ; Fig. 24-5

*Discussion* : A single fragmentary pinna is similar to those of some *Asplenium* in the narrow oblanceolate form, serrulate margin and the venation as shown in the Fig. 24-5.

*Occurrence* : Ogawa Formation.

*Collection* : KPM oz-yama18.

Family **BLECHNACEAE**

Genus *Woodwardia* J. E. Smith

*Woodwardia* sp.

Fig. 25-1, 2

*Description* : Fertile pinna with pinnatifid pinnules ; pinnules lanceolate with probably acute apices, about 3 cm long and 1 cm wide, making an angle of about 70 degrees with the rachis ; margin serrulate with minute teeth ; veins anastomosing, forming costal and costular areole.

*Discussion* : By the costal and costular areoles and sharp marginal teeth of the pinnule, these specimens are identical to those of *Woodwardia*, and are most similar to the modern *W. orientalis* Swartz., although its pinnules are shorter than those of the extant species. These specimens are separable from the leaves of *Onoclea* by lacking winged rachis and by the sharp marginal teeth of the pinnules.

*Occurrence* : Ogawa Formation.

*Collection* : TNHM 4206, 4209.

Family **SALVINIACEAE**

Genus *Salvinia* Adanson

*Salvinia* sp. cf. *S. natans* Allioni

Fig. 25-5

*Discussion* : Orbicular small foliar shape and quadrangular networks indicate that these leaves are *Salvinia*, although the leaves lack its marginal part and do not preserve the tubercles. These leaves are different from those of *S. pseudoformosana* Oishi et Huzioka known from the early Miocene Aniai-type floras of Japan in the arrangement of the networks. It is closely similar to those of the extant *S. natans* All.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-G36.

GYMNOSPERMAE

Family **PINACEAE**

Genus *Abies* Miller

*Abies protofirma* Tanai

Pl. 2, fig. 5

*Abies protofirma* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : 248-249, pl. 1, fig. 10.

*Discussion* : Two fossil species which are akin to the modern *Abies firma* Sieb. et Zucc. have been reported from the Miocene of Japan. The one species, *A. protofirma* Tanai, was reported from the Late Miocene Onbara flora on the basis of a single cone-scale (Tanai, 1961), and the another one, *A. ugoensis* Huzioka et Uemura, was described on the basis of winged seeds from the Late Miocene Miyata flora (Huzioka and Uemura, 1973). These two fossil species are probably conspecific. The wide leaves having large sucker-like proximal end of

petiole from the Itahana and Ogawa Formations are referable to the *A. protofirma*.

*Occurrence* : Itahana and Ogawa Formations.

*Collection* : KPM oz-ita-A2, 3 ; oz-cha13.

Genus *Keteleeria* Carrier

*Keteleeria ezoana* Tanai

Pl. 2, figs. 1, 2

*Keteleeria ezoana* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : 251, pl. 12, fig. 16, 40, 41.

Tanai and N. Suzuki, 1963, Tertiary Floras of Japan, Miocene floras. p. 99, pl. 1, fig. 2-4 ; pl. 2, fig. 1, 2, 31.

*Discussion* : The detached leaves characterized by long and wide foliar shape and slightly small sucking disk-like proximal end of petiole. The detached leaves from the Seto and Ogawa Formations are identical to the leaves of *Keteleeria*, and are identical with *Keteleeria ezoana* Tanai in the foliar shape and size.

*Occurrence* : Seto and Ogawa Formations.

*Collection* : KPM oz-ito37, 38 ; oz-bohd3, 7 ; oz-cha12.

Genus *Picea* A. Dietrich

*Picea* sp.

Pl. 1, fig. 9

*Discussion* : Twigs with densely arranged needled leaves of 5-7 mm length slightly curve toward the apical portion. These characters are indicative of the genus *Picea*. Several fossil species of *Picea* were reported from Japan, mainly based on the winged seeds, cone-scales and cones.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1101, 1277.

Genus *Pinus* Linnaeus

*Pinus miocenica* Tanai

Pl. 1, fig. 10 ; Pl. 20, fig. 8b

*Pinus miocenica* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : 256, pl. 2, fig. 2.

*Discussion* : Two-needled leaves having more than 6.5 cm in length belong to *Diploxylon* and are referable to *Pinus miocenica* Tanai in length.

*Occurrence* : Kabutoiwa and Ogawa Formations.

*Collection* : KPM oz-1155, 1233, 1254 ; oz-yama17.

*Pinus* sp. cf. *P. trifolia* Miki

Pl. 1, fig. 6a

*Pinus trifolia* Miki, 1939, Bot. Mag. Tokyo, 53 : 239, pl. 4, fig. 3.

Ooga, 1960, Geosci. Mag. 11(4) : 228-230, pl. B-E.

*Discussion* : Two fragmentary cones of *Pinus* from the Yagii Formation, although lacking its abaxial parts, are similar to those of *Pinus trifolia* Miki by the large size and prominent hooky umbo of scale-end.

*Occurrence* : Yagii and Seto Formations.

*Collection* : KPM oz-yag-N4, 5, 7.



Genus *Pseudolarix* Gordon  
*Pseudolarix japonica* Tanai et Onoe  
 Pl. 2, figs. 3, 4

*Pseudolarix japonica* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 17, pl. 1, fig. 5.  
 Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : 257, pl. 1, fig. 18, 19, 24, 27, 33-35.  
 Ozaki, 1979, Sci. Rep. Yokohama Natl. Univ. Sec. 2, 26 : 37, pl. 1, fig. 9-15.

*Discussion* : The detached leaves are slightly curved, acicular with obtuse apex, flat in transverse section, more than 4 cm long, 1 to 1.5 mm wide, and tapering in basal part with truncate proximal end. These leaves are referable to *Pseudolarix*, and to *P. japonica* Tanai et Onoe in the shape and size of the leaves.

*Occurrence* : Ogawa and Itahana Formations.

*Collection* : KPM oz-yamal, 3, 53 ; oz-ita-J49, 97.

Genus *Pseudotsuga* Carrier  
*Pseudotsuga tanaii* Huzioka  
 Pl. 2, figs. 6, 7

*Pseudotsuga tanaii* Huzioka, 1964, Jour. Min. Coll. Akita Univ. ser. A, 3(4) : 60, pl. 1, fig. 5, 5a, 6, 6a, 7, 7a.  
*Pseudotsuga huziokae* Ozaki, 1974, Sci. Rep. Yokohama Natl. Univ. sec. 2, 21 : 7, pl. 1, fig. 5-7.

*Discussion* : The detached leaves with slightly twisted small sucker-like base represent a species of *Pseudotsuga*. These leaves are referable to *P. tanaii* Huzioka in slender short shape. *P. huziokae* Ozaki reported on the basis of leaves from the Inkyoyama flora in Gifu Prefecture was distinguished from *P. tanaii* mainly in the longer leaf, but these two seem to be conspecific. The leaves of *Pseudotsuga* are closely similar to those of *Larix* or *Pseudolarix* in foliar shape, but are distinguishable in their basal shape. *Pseudotsuga tanaii* is closely akin to the living *P. japonica* Beissner growing in Kii and Shikoku. *P. subrotunda* Miki was reported from the Seto Formation based only on the cones by Miki (1957).

*Occurrence* : Kabutoiwa, Seto, Itahana, and Ogawa Formations.

*Collection* : KPM oz-1219 ; oz-ito3, 9, 10, 31, 39-41 ; oz-yama54 ; oz-cha12, 13.

Genus *Tsuga* Carrier  
*Tsuga miosieboldiana* Ozaki  
 Pl. 2, figs. 9, 10

*Tsuga miosieboldiana* Ozaki, 1974, Sci. Rep. Yokohama Natl. Univ. sec. 2, 21 : 8, pl. 1, fig. 8, 9.

*Discussion* : Some detached leaves are identical to *Tsuga* by the foliar shape and the fine petiole that bends to the lamina. From the Seto Formation, Miki (1957) reported *T. longibracteata* Cheng., *T. oblonga* Miki, and *T. rotundata* Miki based on cones, cone-scales and shoots. Tanai (1961) reported *T. aburaensis* based on a seed and *T. miocenica* based on a seed and a cone-scale. *T. miyataensis* was reported by Huzioka and Uemura (1973) based on cones, winged seeds and shoots. *T. miyataensis* is closely similar to the living *T. diversifolia* Mast. I reported *T. hokiana* based on cone, winged seed and leaves, and this species is closely similar to the modern *T. sieboldii* Carr. No fossil reproductive organs of *Tsuga* were found together with leaves, and the leaves from Kabutoiwa, Ito and Chausuyama localities are referred to *T. miosieboldiana*, which was described, based only on the leaves.

*Occurrence* : Kabutoiwa, Seto and Ogawa Formations.

*Collection* : KPM oz-1241 ; oz-ito25 ; oz-cha5, 13.

Family **TAXODIACEAE**  
 Genus *Glyptostrobus* Endlicher  
*Glyptostrobus europaeus* (Brongniart) Heer  
 Pl. 1, fig. 7a

*Glyptostrobus europaeus* (Bronn.) Heer, 1855, Flora Tert. Helvetia 1 : 51, pl. 19 ; pl. 20, fig. 1.  
 Endo and Okutsu, 1936, Proc. Imp. Acad. Tokyo, 12 : 138, fig. 1-3.



*Taxodium europaeum* Brongniart. 1853. Ann. Sci. Nat. Botanique. 30 : 168.

*Discussion* : This is one of the common species in the Tertiary floras of Japan. The modern relatives, *Glyptostrobus pensilis* Koch. is growing in southeastern China. The fossil shoots seem indistinguishable from the modern ones in gross features.

*Occurrence* : Ogawa Formation.

*Collection* : KPM oz-yama52, oz-cha6, 8-3, 14, 20.

Genus *Metasequoia* Miki ex Hu et Chen

*Metasequoia occidentalis* (Newberry) Chaney

Pl. 2, fig. 8a

*Taxodium occidentalis* Newberry, 1863, Boston Soc. Nat. History 7 : 516.

*Metasequoia occidentalis* (Newberry) Chaney, Trans. Amer. Philos. Soc. new ser. 40 (3) : 1951, p. 225 and all figs. there cited.

*Metasequoia distica* (Heer) Miki, 1941a, Japan Jour. Bot. 11 : 262, pl. 5A-Ca, fig. 8A-G.

*Metasequoia japonica* (Endo) Miki, ditto, p. 262, pl. 5-D, fig. 8, A-G.

*Discussion* : This species is widely known from most of late Miocene floras in central Honshu, except from Kabutoiwa flora. *Metasequoia* was first described by Miki (1941) from the Seto Formation.

*Occurrence* : Itahana, Yagii, Ogawa, and Seto Formations.

*Collection* : KPM oz-ita-B1, 2 ; oz-ita-C2 ; oz-ita-G19 ; oz-ita-K9, 16, 20 ; oz-ita-J62 ; oz-yag-A1, 2, 5, 7, 10-12, 17, 52 ; oz-yag-B1-5 ; oz-yag-Fa2, 4, 10, 14, 15 ; oz-yag-Fb8, 12, 21, 41, 54c ; oz-yag-K1-3 ; oz-yag-M3 ; oz-yag-P1-3 ; oz-yama51, 84.

Genus *Sequoia* Endlicher

*Sequoia langsdorfii* (Brongniart) Heer

Pl. 1, fig. 8

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

*Taxites langsdorfii* Brongniart, 1828, Prodr. hist. veget. foss. p. 108.

*Sequoia affinis* Lesquereux, Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11(2) : 256, pl. 3, fig. 11.

*Discussion* : Well-preserved foliage shoot impressions from Chausuyama locality are identical with *Sequoia langsdorfii* (Brongn.) Heer by the shape and arrangement of leaves.

*Occurrence* : Ogawa Formation.

*Collection* : KPM oz-cha8-3-d.

Genus *Taiwania* Hayata

*Taiwania japonica* Tanai et Onoe

Pl. 1, fig. 5

*Taiwania japonica* Tanai et Onoe, 1961, Geol. Surv. Jap. Rep. 187 : 19, pl. 1, fig. 4.

*Discussion* : Some shoots from the Kabutoiwa Formation are referable to *Taiwania japonica*. Leaves of this species have generally shorter and/or wider base than those of the extant *Taiwania cryptomerioides* Hayata. The extant *T. cryptomerioides* is growing in Taiwan and Yunnan Province of China.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1101, 1144.

Genus *Taxodium* Rich.

*Taxodium dubium* (Sternberg) Heer

Pl. 1, fig. 7b

*Taxodium dubium* (Sternberg) Heer, 1855, Flora Tert. Helvetiae, 1 : 49, pl. 17, fig. 3, 15.

*Discussion* : Some fragmentary foliage shoots with nearly alternatively arranged linear leaves are assigned to *Taxodium dubium* (Sternberg) Heer.

*Occurrence* : Itahana and Ogawa Formations.

*Collection* : KPM oz-ita-H59, 79 ; oz-cha8-3, 17.

Family **CUPRESSACEAE**

Genus *Thuja* Linnaeus

*Thuja nipponica* Tanai et Onoe

Pl. 2, fig. 11

*Thuja nipponica* Tanai et Onoe, 1961, Geol. Surv. Japan Rep. 187 : 19, pl. 1, fig. 11a, b.

*Discussion* : Fragmentary branchlets of about 1.5 mm width have scale-like leaves which show decussate arrangement and incurved blunt apex are identical with *Thuja nipponica* Tanai et Onoe. This species is similar to the extant *T. standishii* Carriere growing in northern to central Honshu of Japan.

*Occurrence* : Ogawa Formation.

*Collection* : KPM oz-cha5.

Genus *Thujopsis* Siebold et Zuccarini

*Thujopsis miodolabrata* Tanai et N. Suzuki

Fig. 25-3, 4

*Thujopsis miodolabrata* Tanai et N. Suzuki, 1963, Tert. Flora Japan 1 : 105, pl. 3, fig. 9, 10.

*Discussion* : Some impressions of fragmentary branchlets are identical to those of *Thujopsis*, and are referable to *T. miodolabrata* Tanai et N. Suzuki in the shape of the wide leaves. The shoot of this species is closely similar to those of the modern *T. dolabrata* Sieb. et Zucc. of Japan

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-A2, 3 ; oz-ita-C1.

ANGIOSPERMAE

DICOTYLEDONEAE

Family **MAGNOLIACEAE**

Genus *Liriodendron* Linnaeus

*Liriodendron honsyuensis* Endo

Pl. 2, fig. 15 ; pl. 3, fig. 2a.

*Liriodendron honsyuensis* Endo, 1934, Proc. Imp. Acad. Tokyo., 10(9) : 590, fig. 1, 2.

*Discussion* : Well-preserved, large leaves and fruits from the Kabutoiwa Formation are identified to *Liriodendron honsyuensis* Endo in their characteristic shape of leaves. Although fragmentary, a largest leaf exceeds about 20 cm in width. The leaves from the Kabutoiwa Formation are similar to those of the extant. *L. tulipifera* Linn. of U.S.A. and *L. chinense* Sarg. of China in number of secondary veins, basal shape, and apical feature of lobes.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1104, 1105, 1188, 1197, 1198, 1207, 1282.

Genus *Magnolia* Linnaeus

*Magnolia* sp. cf. *M. obovata* Thunberg

Pl. 2, fig. 14A

*Discussion* : A single large leaf is referable to the leaves of the genus *Magnolia* in the following characters : elliptical foliar shape, acuminate apex, entire margin, 15 to 16 brochidodromous secondary veins that form loops with the superadjacent secondary along the margin, and percurrent tertiary veins. This leaf is closely similar to that of the living *Magnolia obovata* Thunberg in the large elliptical foliar shape, and venation character.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1106a.



*Magnolia* sp.

Pl. 3, fig. 1

*Discussion*: Ill-preserved leaves are similar to *Magnolia* in a large size, elliptic shape, entire margin, and brochidodromous venation. Among the fossil species of *Magnolia*, these leaves are similar to those of *M. elliptica* Tanai in the widely spaced secondary veins.

*Occurrence*: Itahana, Yagii and Ogawa Formations.

*Collection*: KPM oz-ita-J45; oz-yag-A40; oz-yama38; TNHM 4229.

Family **ILLICIAACEAE**Genus *Illicium* Linnaeus*Illicium?* sp.

Pl. 2, fig. 13

*Discussion*: Some leaf impressions have lanceolate shape, entire margin, attenuate apex, cuneate base, and widely spaced secondary veins diverging at an acute angle from the midvein, although they lack the exmedial part. These features indicate that the specimens are similar to leaves of *Illicium religiosum* Sieb. et Zucc., but lack of the fine veinlets makes impossible to decide the precise taxon.

*Occurrence*: Ogawa Formation.

*Collection*: KPM oz-yama108, 116.

Family **EUPTELEACEAE**Genus *Euptelea* Sieb. et Zucc.*Euptelea* sp. cf. *E. polyandra* Sieb. et Zucc.

Pl. 2, fig. 12

*Description*: Leaves broad oval; 9.2 to 15 (estimated) cm long; 9.1 to 12.4 cm wide; length/width ratio 1.21 to 1.24; apex acuminate; base broadly cuneate; margin apiculate denticulate; marginal teeth with seta, formed by concave-concave sides and round sinuses, larger than the others at the ends of the secondary veins; petiole about 1 mm in width and more than 3 cm in length, extending nearly straight with almost same thickness. Venation pinnate, simple craspedodromous; primary vein slightly zig-zag in an apical half; secondary veins in 9 to 12 alternate pairs, gradually decreasing the angle of divergence from the midvein from the base to the apical part, 65 to 70 degrees in the lowest one or two pairs and about 45 degrees in the upper ones, extending nearly straightly in the basal pairs, upcurved in the middle to upper pairs, sending off 2-3 branches or bifurcating on the way with acute angles, some branches bending to be nearly parallel to the secondaries, then reach the tooth apex; tertiary veins thin, convex or forked percurrent, originating from the secondaries generally at high acute angles at the basal side and nearly right angle at the apical side; quaternary veins making some large (about 0.5 mm), quadrangular to hexagonal meshes with no or a single ultimate veinlet.

*Discussion*: The foliar shape, venation and glandular apiculate denticulate margin indicate that the fossils represent *Euptelea*. The fossil leaves closely similar to those of the extant *E. polyandra* Sieb. et Zucc. except for the smaller marginal teeth. These fossil leaves are different from those the extant *E. pleiospermum* Hook f. et Thoms. of China in the broadly oval shape, obtuse base, much secondary veins that have wide diverging angles, and larger size. This is the first fossil record of *Euptelea* from Japan, although *Euptelea orientalis* (Sanborn) Wolfe has been discriminated from the Eocene and Early Oligocene floras of the Pacific Northwest (Wolfe, 1977). The leaves here described are separable from North American leaves mainly in the wider foliar shape.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1194, 1234, 1284.



Family **CERCIDIPHYLLACEAE**Genus *Cercidiphyllum* Siebold et Zuccarini*Cercidiphyllum crenatum* (Unger) Brown

Pl. 3, fig. 7

*Cercidiphyllum crenatum* (Unger) Brown, 1935 (part), Jour. Palaeont. 9 : 575, pl. 68, fig. 8-10 (only).

*Discussion* : Fragmentary leaf impressions are referable to *Cercidiphyllum* by the foliar shape, crenate marginal teeth with small globose glands at the teeth apex, and the venation characters.

*Occurrence* : Ogawa and Yagii Formations.

*Collection* : KPM oz-kaba17 ; oz-yag-Fa1 ; oz-yag-Fb38.

Family **LAURACEAE**Genus *Actinodaphne* Nees*Actinodaphne nipponica* Tanai

Pl. 3, fig. 8 ; Fig. 26-2, 3, 4

*Actinodaphne nipponica* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11(2) : 333, pl. 22, fig. 6 : pl. 24, fig. 19.

*Discussion* : These fragmentary leaves are referable to the genus *Actinodaphne* by the long foliar shape, the fimbrial vein on the entire margin, somewhat irregularly spaced secondary veins which extend from the midvein at nearly right angle, and weakly percurrent tertiary veins. These leaves belong to *A. nipponica* Tanai in the widely diverging angles of the secondary veins. This species is similar to the modern *A. longifolia* (Bl.) Nakai.

*Occurrence* : Itahana and Yagii Formations.

*Collection* : KPM oz-ita-A10 ; oz-yag-Fa24, 30a ; oz-yag-Fb10.

*Actinodaphne* sp. cf. *A. lancifolia* Meissn.

Pl. 4, figs. 6, 7

*Discussion* : The linear oblong foliar shape, fimbrial vein on the entire margin, cuneate base, acute apex with the rounded tip, brochidodromous secondary veins, percurrent tertiary veins, well-developed orthogonal fourth and fifth networks with no or a single freely ending veinlets in the last fifth networks, and presence of the oil cells on the lamina in some specimens, are characteristics of some species of *Actinodaphne*. These fossil leaves are similar to those of the modern *A. lancifolia* Meissn. except for the narrower extending angles of the basal secondary veins.

*Occurrence* : Yagii Formation.

*Collection* : KPM oz-yag-Fb64a, 64c, 65.

Genus *Cinnamomum* Blume*Cinnamomum* sp. cf. *C. camphora* Sieb.

Pl. 3, figs. 9, 10

*Discussion* : Many leaves are nearly identical to those of the extant *Cinnamomum camphora* by the entire-margined ovate to elliptical shape, short acuminate apex, broadly cuneate base, imperfect suprabasal acrodromous venation, and thick and large ultimate networks which have generally no freely ending veinlets. Moreover, almost all the leaves from the Seto Formation have distinct axillary small gibbous regions of the primary veins. These fossil leaves are similar to those of the *C. miocenica* Morita but separable by narrower foliar shape and the presence of small axillary knobs (probably galls) of the primary veins.

*Occurrence* : Seto, Itahana, Yagii, and Ogawa Formations.

*Collection* : KPM oz-ito43, 44a, 52-59 ; oz-ita-C1 ; oz-yag-B2 ; oz-yama231.

*Cinnamomum* sp. cf. *C. japonicum* Sieb.

Pl. 4, fig. 1

*Discussion* : The oblong shape, suprabasal imperfect acrodromous venation, rounded to obtuse base, thick ultimate areoles with nearly no freely ending veinlets, and the fimbrial vein on the margin are features that closely ally these fossils to *Cinnamomum japonicum* Sieb.

*Occurrence* : Itahana, Yagii and Seto Formations.

*Collection* : KPM oz-ita-B42 ; oz-yag-A2, 50 ; oz-ito15, 29.

*Lindera* sp. cf. *L. erythrocarpa* Makino

Pl. 3, figs. 5, 6.

*Discussion* : These fossil leaves are similar to those of the *Lindera erythrocarpa* Makino in the linear-oblong shape, attenuate-acuminate apex, cuneate to attenuate base, imperfect acrodromous venation. These leaves are similar to some leaves of *Cinnamomum* such as the extant *C. japonicum* Sieb. in the imperfect acrodromous venation and the foliar shape, but are different from those of the extant ones in the narrowly cuneate base and in having no thick fimbrial vein.

*Occurrence* : Itahana Formation, Yagii Formations.

*Collection* : KPM oz-ita-B1, 83, 84, 86, 96, 107 ; oz-ita-G12 ; oz-yag-A12.

*Lindera paraobtusiloba* Hu et Chaney

Pl. 2, fig. 14b

*Lindera paraobtusiloba* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 48, pl. 18, fig. 1, 3 (exclude fig. 2) ; pl. 20, fig. 4.

Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plant China 3 : 23, pl. 11, fig. 2, 4 ; pl. 14, fig. 6 ; pl. 15, fig. 1, 6.

*Discussion* : Several leaves are identical with *Lindera paraobtusiloba* Hu et Chaney in the basal or infrabasal imperfect acrodromous venation and the characteristic shape. These leaves are closely similar to those of the extant *L. obtusiloba* Blume of Japan, Korea and China. These fossil leaves are separable from those of *Sassafras* or *Parabenzoin trilobum* (Sieb. et Zucc.) Nakai by the diverging point of the lateral primary veins.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1106b, 1112, 1149, 1163, 1177, 1202.

Genus *Neolitsea* (Benth.) Merrill*Neolitsea* sp.

Pl. 4, fig. 2 ; Fig. 27-2

*Discussion* : These leaves nearly ally to the extant *Neolitsea sericea* (Bl.) Koidz. of Japan and China ; they are characterized by the lanceolate foliar shape, attenuate apex, cuneate base, fimbrial veins on the entire margin, suprabasal imperfect acrodromous venation, and thick ultimate networks with nearly no veinlets. Some leaves of *Cinnamomum* have similar leaves, but they are separable mainly by the less secondary veins in the upper half of the lamina. My leaves are shorter and smaller than those of *N. japonica* Tanai.

*Occurrence* : Kabutoiwa, Yagii and Ogawa Formations.

*Collection* : KPM 1229 ; oz-yag-A2, 4.

Genus *Persea* Mill.*Persea* sp. cf. *P. thunbergii* (Sieb. et Zucc.) Kosterm.

Pl. 4, fig. 4

*Discussion* : Some fragmentary leaves are similar to those of the extant *Persea thunbergii* (Sieb. et Zucc.) Kosterm. and also to those of the extant *Pasania edulis* Makino in the oblanceolate foliar shape, mucronate apex, cuneate to decurrent base, brochidodromous



venation, and fimbrial marginal vein; the fossil leaves ally to the former species in the basal secondary veins that form narrower angles with the midvein. Four fossil species of *Persea* were reported from Japan; *Machilus ugoana* Huzioka ex Tanai, *M. nathorstii* Huzioka, *M. protojaponica* K. Suzuki and *M. ubensis* Huzioka et Takahashi. Of these 4 species *M. nathorstii* is similar to my leaves in the wide shape, but is different in less secondary veins.

*Occurrence*: Yagii and Seto Formations.

*Collection*: KPM oz-yag-Fa8, oz-yag-Fb54c; oz-ito31.

*Persea* sp.

Pl. 4, figs. 5, 8; Fig. 26-1

*Discussion*: Fragmentary thick leaves are closely similar to those of *Persea* by the following features: the wide elliptic shape, the fimbrial veins on the margin, brochidodromous secondary veins whose basal pairs are more closely spaced than the middle to the upper ones, well-developed marginal loops, weakly percurrent tertiary veins, nearly no or single ultimate veinlets among the fifth-order veined networks, and existence of the oil cells in some well preserved leaves.

*Occurrence*: Yagii Formation.

*Collection*: KPM oz-yag-Fb24, 44, 54a, 64b; oz-yag-K3.

Genus *Sassafras* Boehmer

*Sassafras* sp.

Pl. 4, fig. 3

*Description*: Leaf elliptical; about 10 cm long and 3.3 cm wide; base cuneate to slightly decurrent; apex missing; petiole missing; margin entire; primary vein extending nearly straight to the apex; secondary veins brochidodromous; a pair of the stout secondary veins arising from the midvein near the base at an acute angle and reaching about the middle of lamina, then forming angular loops with superadjacent ones; several upper secondaries extending from the middle to the upper part of the midvein, curving up and forming large marginal angular loops with the adjacent secondaries; some intersecondary veins composite; tertiary veins making quadrangular to polygonal large networks; finer veins not preserved.

*Discussion*: A single leaf lacking its fine venation are closely similar to non-lobed leaves of *Sassafras* in the foliar shape and venation characters. *Lindera subtriloba* reported from the Ogawa Formation by Konno (1931) was transferred to the genus *Sassafras* by Tanai and Onoe (1961). However, the leaves reported by Konno are considered to belong to *Parabenzoin*. As discussed by some authors and by me (1980a), the leaves of *Parabenzoin trilobus* and small fossil leaves of *Sassafras* are sometimes closely similar each other. The general gross differences between the two are as follows: the first, the distance from the base to the diverging point of a strong basal pair of secondary veins is shorter in *Parabenzoin* than in *Sassafras*; and the second, the apices of the lateral lobes are acute and exmedially bend in *Parabenzoin*. It is difficult to decide the precise taxa of *S. paratsumu* Chen reported from Yunnan of China in 1978, because it lacks its apices of the lobes and the basal part.

*Occurrence*: Ogawa Formation.

*Collection*: KPM oz-yama61.

Family **CORIARIACEAE**

Genus *Coriaria* Linnaeus

*Coriaria* sp. cf. *C. japonica* A. Gray

Pl. 3, figs. 3, 4; Fig. 27-3.

*Description*: Leaf lanceolate; length 6.7 to 7.8 cm; width 2.0 to 3.4 cm; length/width ratio 2.29 to 3.35; apex attenuate; base broadly cuneate to rounded with short decurrent part; petiole thick, about 1.5 mm wide and 2 to 3 mm long; margin entire. Venation basal perfect



acrodromous; midvein stout and slightly curved, thicker than the laterals; lateral primaries originating from the petiole, running about two-thirds the distance to the apex; several secondary veins diverging from the midvein at an angle of about 60 degrees and joining to the lateral primaries with an acute angle; secondaries in marginal area diverging from the lateral primaries at an angle of about 30 degrees in the lower part and at high acute angles in the middle to the upper parts, forming a series of loops along the margin; tertiary veins orthogonal reticulate among the secondaries, making a series of loops along the margin; ultimate veinlets fourth, once to twice branching but sometimes making meshes each other.

*Discussion*: These lanceolate entire-margined leaves which have perfect basal acrodromous venation, though the higher order veins ill-preserved, are closely similar to those of *Coriaria japonica* A. Gray. Tanai (1970) described two small leaves of *Coriaria* sp. from the Oligocene Harutori Formation of Hokkaido, but these leaves do not preserve well fine venation.

*Occurrence*: Kabutoiwa and Ogawa Formations.

*Collection*: KPM oz-1300, SU 88, K 54203-10.

### Family **ROSACEAE**

Genus *Crataegus* Linnaeus

*Crataegus* sp. cf. *C. hokiensis* Ozaki

Pl. 5, fig. 14

*Crataegus hokiensis* Ozaki, 1980a, Bull. Natl. Sci. Mus. ser. C. (Geol.) 6(2): 41, pl. 4, fig. 1-3, 6, 9; text-fig. 4D, E.

*Discussion*: Fragmentary lobed leaves are referable to *Crataegus hokiensis* by the oval shape, characteristic intersecondary veins, weakly percurrent to random reticulate tertiary veins and doubly-serrated margin.

*Occurrence*: Ogawa Formation.

*Collection*: KPM oz-yama212.

Genus *Malus* Mill.

*Malus* sp.

Pl. 5, fig. 4; Fig. 27-1

*Discussion*: Fragmentary leaves have following characters: ovate shape, serrulate margin, acute marginal teeth, several semicraspedodromous secondary veins, and percurrent tertiary veins that extend nearly perpendicular to the midvein. These characters appear to represent a species of *Malus*. These leaves are separable from those of *Pyrus* mainly in having less number and widely space of the secondary veins and somewhat irregular size of the marginal teeth.

*Occurrence*: Seto, Itahana and Ogawa Formations.

*Collection*: KPM oz-ito28b, 30; oz-ita-J5; oz-yama60.

Genus *Prunus* Linnaeus

*Prunus protossiori* Tanai

Pl. 5, fig. 1

*Prunus protossiori* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan. 187: 44, pl. 13, fig. 6, 7.

Tanai and N. Suzuki, 1965 (part), Palaeont. Soc. Jap. Sp. Pap. 10: 29, pl. 12, fig. 8 (only).

Tanai, 1971, Mem. Natl. Sci. Mus. 4: 161, pl. 10, fig. 5.

Ozaki, 1980a, Bull. Natl. Sci. Mus. Ser. C, 6(2): 43, pl. 4, fig. 11, 12.

*Discussion*: The elliptical shape, nearly single serrate margin, and a single marginal loops of secondary veins near margin indiate that these leaves are identical to *Prunus protossiori* Tanai et Onoe. This species is similar to the living *P. sargentii* Rehd. and *P. jamasakura* Sieb. and its varieties.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1151, 1169, 1171, 1188.

*Prunus* sp. cf. *P. apetala* Fr. et Sav.

Pl. 5, fig. 3

*Description* : Leaves ovate, about 6.5 cm long and about 4 cm wide ; apex acuminate ; base rounded and asymmetrical ; margin regularly serrate with double large teeth, principal teeth acuminate to acute, generally having one relatively large acuminate subsidiary teeth on the basal side ; petiole medium, length 0.7 cm or more, nearly straight on the symmetrical leaf, bending to the base of blade and weakly curved on the asymmetrical leaf. Venation semi-craspedodromous ; primary veins slightly curved ; secondary veins diverging at angles of 45 to 50 degrees from the midvein, extending nearly straight or slightly upcurved, making angular loops with adjacent secondaries near the margin, weak secondaries extending from the corner of the loops to the tooth apex ; tertiary veins percurrent in intercostal area, extending to the subsidiary tooth apex or sinus ; quaternary veins making orthogonal reticulation ; freely ending veinlets once to twice branching among the quaternary networks.

*Discussion* : The characteristic shape of large marginal teeth and a single series of loops of the secondary veins are characteristics of the leaves of the living *Prunus apetala* Fr. et Sav. The fossil leaves, however, are slightly different in the larger marginal teeth.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1101, 1175, 1197.

Genus *Pyrus* Linnaeus

*Pyrus hokiensis* Ozaki

Pl. 4, fig. 11 ; Pl. 16, fig. 13

*Pyrus hokiensis* Ozaki, 1980a, Bull. Natl. Sci. Mus. ser. C, 6(2) : 45, pl. 4, fig. 4, 5, 7, 8, 10 ; pl. 5, fig. 10 ; Fig. 4B.

*Discussion* : The small leaves characterized by densely spaced, acute small marginal teeth, acuminate apex, rounded to slightly cordate base, tertiary veins that are nearly perpendicular to the midvein are identical with *Pyrus hokiensis* Ozaki. Some leaves of *Malus* are similar to these leaves, but they are separable mainly by the number of the secondary veins.

*Occurrence* : Ogawa and Seto Formations.

*Collection* : KPM oz-yama106, 107, 121b, 211 ; oz-ito28 ; SU 135.

Genus *Rosa* Linnaeus

*Rosa usyuensis* Tanai

Pl. 4, fig. 12 ; Fig. 27-4, 5, 6

*Rosa usyuensis* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : pl. 24, fig. 5, 6, 9.

*Discussion* : Small slightly asymmetrical ovate leaflets are identical to those of *Rosa usyuensis* Tanai by the following characteristics : nearly single serrate margin, acuminate teeth, semicraspedodromous venation with orthogonally reticulate tertiary and quaternary veins, and simple to twice branched freely ending veinlets.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-G27 ; oz-ita-H32, 78, 80, 85, 114g.

Genus *Sorbus* Linnaeus

*Sorbus hokiensis* Ozaki

*Sorbus hokiensis* Ozaki, 1980a, Bull. Natl. Sci. Mus. ser. C, 6(2) : 46, pl. 6, fig. 2-6 ; text-fig. 6B, C.

*Discussion* : Fragmentary leaves that have slender long lobes and single small marginal teeth are closely similar to those of the *Sorbus hokiensis* Ozaki. This species was first described from the Late Miocene Tatsumitoge flora. This species is closely similar to the



extant *S. torminalis* Crantz growing in central to southwestern Europe. Another fossil species, *S. praetorminalis* Krysh. et Baik. reported from the Late Miocene of USSR is different from my leaves in less number of lobes and small foliar size.

*Occurrence* : Ogawa Formation.

*Collection* : SU 36.

*Sorbus lesquereuxi* Nathorst

Pl. 4, fig. 9

*Sorbus lesquereuxi* Nathorst, 1883, Kgl. Sv. Vet. Akad. Handl. 20(2) : 57, pl. 3, fig. 7-10, 12-15 ; pl. 5, fig. 1. Tanai, 1976, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11(2) : 326, pl. 4, fig. 5-7 ; text-fig. 4j.

*Discussion* : The type specimens of this species from the Pliocene Mogi flora in Nagasaki Prefecture are different from those of the modern equivalent species, *Sorbus alnifolia* Sieb. et Zucc., in the oblong shape, much more secondary veins, low double serrate margin, and sometimes forking secondary veins. The leaves from Kabutoiwa Formation have intermediate characters between the Mogi leaves and the extant ones in the ovate to oval foliar shape, regularly spaced secondary veins and double serrate margin.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1142, 1158, 1159, 1165, 1168, 1169, 1243.

*Sorbus palaeojaponica* Murai

Pl. 5, fig. 2

*Sorbus palaeojaponica* Murai, 1969, Technol. Rep. Iwate Univ. 4 : 61-62, pl. 3, fig. 6.

*Discussion* : The rhombic oval shape, double serrate margin, craspedodromous venation, and rather closely percurrent tertiary veins indicate that these leaves belong to *Sorbus palaeojaponica* Murai. The leaves from Ogawa Formation have no fine venation, but are referable to this species in the foliar shape and the marginal large principal teeth in which the secondary veins end.

*Occurrence* : Kabutoiwa and Ogawa Formations.

*Collection* : KPM oz-1159 ; oz-yama2, 231.

*Sorbus uzenensis* Huzioka

Pl. 4, fig. 10

*Sorbus uzenensis* Huzioka, 1964, Jour. Min. Coll. Akita Univ. Ser. A, 3(4) : 86, pl. 13, fig. 8, 8a, 9.

Huzioka and Nishida, 1960, Publ. Sado Mus. 3 : 17, pl. 4, fig. 8.

*Discussion* : The oblong shape, acuminate apex, rounded to obtuse and slightly asymmetrical base, and secondary veins which extend zig-zag and do not enter directly in the principal teeth indicate that these leaflets are identical to those of *Sorbus uzenensis* Huzioka. This species was first reported by Huzioka and Nishida in 1960 and was validly described by Huzioka in 1964.

*Occurrence* : Kabutoiwa, Itahana and Ogawa Formations.

*Collection* : KPM oz-1232 ; oz-ita-H29 ; oz-yama63, 64.

Genus *Spiraea* Linnaeus

*Spiraea protothunbergii* Tanai et N. Suzuki

Pl. 5, fig. 5

*Spiraea protothunbergii* Tanai et N. Suzuki, 1965, Palaeont. Soc. Japan Spec. Pap. 10 : 33, pl. 2, fig. 7.

*Discussion* : The leaves have following characteristics : small oblong shape, entire margin except the upper half, narrow angles between primary and secondary veins, brochidodromous secondary venation with well-developed composite intersecondaries. These features lead these leaves to *Spiraea protothunbergii* Tanai et N. Suzuki. Among the known fossil species of *Spiraea* from eastern Asia, *S. protothunbergii* is different from the others in the foliar shape,



size, and fine marginal teeth.

*Occurrence* : Ogawa and Itahana Formations.

*Collection* : KPM oz-yama23 ; oz-ita-H25, oz-ita-J39.

### Family CAESALPINIACEAE

Genus *Caesalpinia* Linnaeus

*Caesalpinia hokiana* Ozaki

Pl. 5, figs. 8, 15 ; Fig. 29-3, 4

*Caesalpinia hokiana* Ozaki, 1980, Bull. Natl. Sci. Mus. ser. C., 6(2) : 48, pl. 7, fig. 2, 2a ; text-fig. 9C.

*Discussion* : Small leaflets are considered to belong to *Caesalpinia hokiana* by the asymmetrically oblong shape, small size of the blade, brochidodromous venation with several pairs of secondary veins, and wide diverging angles of the secondary veins. This species is closely similar to *C. japonica* Sieb. et Zucc. growing in central to southern Japan and also to *C. crista* Linn. growing in southern China.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-E31 ; oz-itaH10a ; oz-ita-J65, 68.

Genus *Cercis* Linnaeus

*Cercis miochinensis* Hu et Chaney

Pl. 6, fig. 3a

*Cercis miochinensis* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 51-52, pl. 26, fig. 1, 3, 5, pl. 27, fig. 5.

Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plant China 3 : 105, pl. 87, fig. 6 ; pl. 89, fig. 4, 5 : pl. 90, fig. 1 ; pl. 91, fig. 1 ; pl. 93, fig. 1-3.

*Discussion* : My leaves are referred to the genus *Cercis* by the following features : entire-margined cordate foliar shape ; corrugatus and proximally swollen petiole ; brochidodromous secondary veins ; branches from the secondary veins extending rather straight ; irregularly percurrent tertiary veins in intercostal area ; and fine ultimate networks of fifth order veins in which freely ending veinlets are generally none or single but in some case once branched. The holotype leaf of *Cercis miochinensis* Hu et Chaney lacks its petiole and is slightly different in the venation characters from those of this genus. The Shanwang leaves except above cited in the synonymy are probably excluded from this species by the characters of the secondary veins.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-H11, 111a.

Genus *Gleditsia* Linnaeus

*Gleditsia miosinensis* Hu et Chaney

Pl. 5, fig. 16 ; Pl. 6, fig. 2

*Gleditsia miosinensis* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 52, pl. 26, fig. 6, 7.

*Discussion* : Mainly by the finely crenate or undulate margin and asymmetrically oblong small shape, these leaflets are referred to those of the *Gleditsia miosinensis* Hu et Chaney. The type specimen preserves no fine venation. My leaflets are similar to those of the extant *G. japonica* Miq. of Japan and also to *G. sinensis* Lam of China.

*Occurrence* : Kabutoiwa, Ogawa and Itahana Formations.

*Collection* : KPM oz-1150 ; oz-yama13 ; oz-ita-E36 ; oz-ita-K66 ; K 54212-6 ; SU36.

### Family FABACEAE

Genus *Cladrastis* Rafin.

*Cladrastis aniensis* Huzioka

Pl. 5, figs. 7, 10 ; Pl. 6, fig. 1

*Cladrastis aniensis* Huzioka, 1963, Tert. Fl. Japan. 1 : 205, pl. 35, fig. 5. 6.

*Discussion* : Many leaflets from many localities of central Honshu are referable to

*Cladrastis* in the shape, acute to acuminate apex, rounded base, corrugatus petiolule, brochidodromous several pairs of secondary veins, and weakly percurrent tertiary veins. These leaflets are nearly identical to those of *C. aniensis* Huzioka which was described as an allied species of the living *C. platycarpa* (Maxim.) Makino. The type specimens preserve no finer venation. My leaflets are closely similar to those of the extant *Cladrastis platycarpa* (Maxim.) Makino in the shape and the venation character.

*Occurrence*: Kabutoiwa, Itahana, Ogawa, Yagii, and Seto Formations.

*Collection*: KPM oz-1088, 1101, 1156, 1162, 1163, 1177, 1190, 1191, 1202, 1210, 1217, 1219; oz-yama9, 85; oz-kabal, 11; oz-yag-A1, 4, 10, 13, 15, 17, 20, 22, 32, 33, 36, 53; oz-yag-M3; oz-ita-B58, 84c; oz-ita-G1, 17; oz-ita-J12; oz-ita-K63; oz-ito12, 15, 19, 20, 21; K 54115-1.

*Cladrastis inouei* (Huzioka) Ozaki

Pl. 5, fig. 9; Fig. 28

*Cladrastis inouei* (Huzioka) Ozaki, 1980a, Bull. Natl. Sci. Mus. ser. C, 6(2): 49, pl. 7, fig. 5-8; text-fig. 7A, B. *Rhus inouei* Huzioka, 1963, Tertiary Flora Japan 1: 206, pl. 36, fig. 3.

*Cladrastis chaneyi* Tanai et N. Suzuki, 1965, Palaeont. Soc. Japan Special Pap. 10: 33, pl. 10, fig. 1; pl. 21, fig. 1.

*Diospyros sublotus* Tanai et N. Suzuki, 1965, ibid., 10: 45, pl. 12, fig. 7; pl. 13, fig. 1; pl. 18, fig. 5.

*Discussion*: These leaflets, though variable in the shape, are identical with those of “*Rhus*” *inouei* Huzioka. As shown in Fig. 28, the type specimen of “*Rhus*” *inouei* has the following venation characters: the secondary veins make a series of loops in its distal part; the tertiary veins are closely percurrent; and the quaternary veins make well developed orthogonal networks. These features are identical to those of the extant *Cladrastis shikokiana* Makino of Japan, and also close to those of *C. wilsonii* Takeda of China and *C. lutea* (Michx.) Koch of North America.

*Occurrence*: Kabutoiwa and Itahana Formations.

*Collection*: KPM oz-1176, 1215; oz-ita-K46; K5383-1.

Genus *Lespedeza* Michaux

*Lespedeza tatsumitogeana* Ozaki

Pl. 6, fig. 4

*Lespedeza tatsumitogeana* Ozaki, 1980, Bull. Natl. Sci. Mus. ser. C, 6(2): 54, pl. 7, fig. 16, 16a; text-fig. 9B.

*Discussion*: The specimens show a characteristic features of *Lespedeza tatsumitogeana*: small oblong shape, obtuse base, slightly mucronate apex, and many secondary veins which diverge at narrow angles from the midvein with parallel course, and form loops just near the margin.

*Occurrence*: Itahana Formation.

*Collection*: KPM oz-ita-E1; oz-ita-Jb2.

*Lespedeza* sp.

Pl. 5, figs. 6, 12; Fig. 29-1

*Description*: Leaflets asymmetric elliptical, 4 to 6 cm long and 3 to 4 cm wide, margin entire; base obtuse to rounded; apex obtuse to acute; petiolule short, sometimes extending oblique to the lamina; midvein straight or weakly curving; secondary veins brochidodromous, diverging from midvein at angles of 40 to 50 degrees, weakly curving up, making loops with adjacent secondary or intersecondary veins; intersecondary veins extending nearly parallel to the secondaries, composite; tertiary veins forming elongate large networks along the secondaries or intersecondaries in intercostal area, forming marginal loops along the margin; fourth order veins forming polygonal networks; finer veins not well preserved.

*Discussion*: The oblong shape, striate petiolule, weakly upcurved secondary veins that run nearly parallel each other and form marginal loops, well developed intersecondary veins,



and the characteristic arrangement of the tertiary networks are features that ally these fossil leaflets to those of *Lespedeza*. These fossil leaflets are separable from those of *L. tatsumitogeana* by the larger size and shape, and the wider diverging angles of the secondary veins. These fossil leaflets are similar to those of the extant *L. bicolor* Turcz. and *L. buergeri* Miq.

*Occurrence* : Kabutoiwa, Seto, Yagii, Itahana, and Ogawa Formations.

*Collection* : KPM oz-1214, 1218b ; oz-ito5, 34 ; oz-yag-Fb54, 60 ; oz-ita-G8, 34, 35, 45 ; oz-ita-K40 ; oz-yama10, 11, 14.

#### Genus *Pueraria* DC.

##### *Pueraria miothunbergiana* Hu et Chaney

Pl. 5, fig. 11 ; Fig. 29-2

*Pueraria miothunbergiana* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 ; 52-53, pl. 28, fig. 1.

Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plant China 3 : 109-110, pl. 85, fig. 3 ; pl. 91, fig. 5 ; pl. 92.

*Discussion* : A single leaflet is identical to the genus *Pueraria* by the following characters : rhombic orbicular shape, short and thick petiolule, upcurved secondary veins whose branches reach the margin. This leaflet is considered to be the small terminal and is referable to *P. miothunbergiana* Hu et Chaney. This species is closely similar to the extant *P. lobata* (Willd.) Ohwi of Japan, Korea and China.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1211.

#### Genus *Sophora* Linnaeus

##### *Sophora hokiana* Ozaki

Fig. 29-5

*Sophora hokiana* Ozaki, 1980, Bull. Natl. Sci. Mus. ser. C., 6(2) : 55, pl. 7, fig. 18, 18a ; text-fig. 9D.

*Discussion* : By the small slightly asymmetrically ovate foliolate shape, and the fine brochidodromous secondary veins that diverge with wide angles from the midvein and extend nearly straight to the margin, these leaflets are identified to those of *Sophora hokiana* Ozaki. This species is closely similar to the extant *S. flavescens* Ait. This fossil species is separable from *S. miojaponica* Hu et Chaney mainly by the small size and venation character.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-C2 ; oz-ita-E9 ; oz-ita-G68c.

#### Genus *Wisteria* Nuttall

##### *Wisteria fallax* (Nathorst) Tanai et Onoe

Pl. 5, fig. 13

*Wisteria fallax* (Nathorst) Tanai et Onoe, 1961, Rep. Geol. Surv. Japan 187 : 45, pl. 10, fig. 6 ; pl. 14, fig. 2-4.  
*Sophora* (?) *fallax* Nathorst, 1883, Kgl. Svensk. Vet. Akad. Handl. 20 : 58, pl. 10, fig. 11, 12 ; pl. 11, fig. 1, 2.

*Discussion* : The leaflets of this species are sometimes closely similar to those of *Maackia*, and *Cladrastis*, but are different generally in the obtuse base, acute to attenuate acuminate apex, and secondary veins that become thinner toward the distal part. The secondary veins of *Maackia* and *Cladrastis* are generally zig-zag in course and make rather angular loops with the adjacent veins. This species is akin to the extant *Wisteria floribunda* DC. of Japan.

*Occurrence* : Kabutoiwa, Seto, Yagii, Itahana, and Ogawa Formation.

*Collection* : KPM oz-1161 ; oz-ito20d ; oz-yag-A47, 52 ; oz-yag-B2 ; oz-yag-Fb11, 50 ; oz-yag-K2 ; oz-yag-M1 ; oz-ita-B75, 86 ; oz-ita-J93a ; oz-yama70.

Family **STYRACACEAE**Genus *Halesia* Ellis.*Halesia* sp.

Pl. 6, figs. 5, 6, 7

*Discussion*: The oblanceolate to oblong shape, acuminate apex, cuneate base, minute acute marginal teeth, semicraspedodromous venation, weakly percurrent tertiary veins, random reticulate fourth veins are characters indicative of the genus *Halesia*. These leaves are similar to those of the extant *H. monticola* (Rehd.) Sarg. and *H. caroliniana* Linn. of the eastern United States, but are different in the hook-shaped incurved minute marginal teeth.

*Occurrence*: Seto and Itahana Formation.

*Collection*: KPM oz-ito19e, 20, 27; oz-ita-J12, 14-16, 18, 37-39, 51, 53-61, 63, 67, 78, 91c, 98.

Genus *Styrax* Linnaeus*Styrax* sp. cf. *S. japonica* Sieb. et Zucc.

Pl. 6, fig. 8

*Discussion*: Rhombic elliptic shape, acute to acuminate apex, cuneate base, remotely and irregularly spaced minute teeth, semicraspedodromous venation and weakly percurrent tertiary veins, and once to twice branched freely ending veinlets among fifth order polygonal meshes are features that ally these leaves to those of the extant *Styrax japonica* Sieb. et Zucc. My leaves are different from those of *S. protojaponica* described by Tanai (1976) from the Pliocene Mogi plant-bearing Formation in Nagasaki Prefecture in having the cuneate to slightly decurrent base, marginal venation character. My leaves are similar to those of *Schisandra repanda* in the shape, marginal serration and secondary veins, but are separable from those of the extant leaves in lacking intersecondary veins and having weakly percurrent tertiary veins.

*Occurrence*: Itahana and Seto Formations.

*Collection*: KPM oz-ita-K17, 90; oz-ito18a.

*Styrax protoobassia* Tanai et Onoe

Pl. 6, fig. 11

*Styrax protoobassia* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187: 56, pl. 28, fig. 1, 8.

*Discussion*: Fragmentary leaves from Kabutoiwa and Chausuyama localities are nearly identical to those of *Styrax protoobassia* Tanai et Onoe. This species is characterized by widely elliptical to orbicular shape, remote and minute marginal teeth, and flexuous secondary veins forming angular loops with the tertiaries near the margin.

*Occurrence*: Kabutoiwa and Ogawa Formation.

*Collection*: KPM oz-1236.

Family **SYMPLOCACEAE**Genus *Symplocos* Jacq.*Symplocos* sp. cf. *S. coreana* (Lev.) Ohwi

Pl. 6, fig. 12; Pl. 13, fig. 9b

*Discussion*: Fragmentary leaves are referable to those of *Symplocos*; they are characterized by the elliptic shape, semicraspedodromous secondary veins that make a series of angular loops in the marginal area with the tertiaries, composite intersecondaries, and spiny-tipped marginal teeth.

*Occurrence*: Ogawa Formation.

*Collection*: KPM oz-yama6, 61, 81; oz-kaba18.



Family **CORNACEAE**Genus *Cornus* Linnaeus*Cornus megaphylla* Hu et Chaney

Pl. 7, fig. 8

*Cornus megaphylla* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 71-72, pl. 48, fig. 3-5 ; pl. 49, fig. 2.  
Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plant China 3 : 135, pl. 120, fig. 1, 2.

*Discussion* : Many number of the eucamptodromous secondary veins and large size are characteristic to *Cornus megaphylla* Hu et Chaney. Huzioka (1964) described *C. minoensis* from the Nakamura Formation of Gifu Prefecture, but the type specimen has brochidodromous venation. My leaves are similar to those of the extant *C. controversa* Hemsl. and *C. macrophylla* Wall. living in Japan, Korea and China, but are more similar to those of the latter species in the general shape.

*Occurrence* : Kabutoiwa and Ogawa Formations.

*Collection* : KPM oz-1159, 1204 ; oz-ito18.

*Cornus miowalteri* Hu et Chaney

Pl. 6, fig. 10b

*Cornus miowalteri* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 72, pl. 47, fig. 1, 2, 4.  
Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Pl. China 3 : 136, pl. 121, fig. 2, 3 : pl. 134, fig. 5.

Ozaki, 1980b, Sci. Rep. Yokohama Natl. Univ. ser. 2, 27 : 31, pl. 6, fig. 1, 8.

*Discussion* : These leaves are referable to *Cornus miowalteri* Hu et Chaney in the small size, generally 3 pairs of eucamptodromous secondary veins and smooth entire margin. The leaves of this species are similar to those of the extant *C. walteri* Wangerin of China and *C. officinalis* Sieb. et Zucc. of Japan. *C. miowalteri* is separable from *C. subkousa* Tanai et Onoe in the smooth margin.

*Occurrence* : Kabutoiwa, Itahana and Ogawa Formations.

*Collection* : KPM oz-1165, 1195, 1203-1205 ; oz-ita-E22 ; oz-ita-H74 ; oz-yamal.

Family **NYSSACEAE**Genus *Davidia* Baillon*Davidia kabutoiwana* Ozaki

Pl. 7, fig. 7

*Davidia kabutoiwana* Ozaki, 1984, Mem. Inst. Field. Educ. Yokohama Natl. Univ. 2 : 4, pl. 2, fig. 1 ; text-fig. 2A, B.

*Discussion* : This fossil leaf is identical to those of *Davidia* by the orbicularly cordate shape, ogee-shaped teeth and the characteristic venation. Compared to the leaves of the extant allied species, *D. involucrata* Baill., this fossil leaf is wider, although only a single fossil specimen is represented. This fossil leaf is similar to some leaves of genus *Tilia*, but is mainly separable in the closely percurrent tertiary veins. *Davidioidea hebridica* was reported by Jhonson (1937) from the Eocene of Mull Island of Scotland, but it is different from Japanese fossil in the longer leaf and small marginal teeth.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1082.

Family **CAPRIFOLIACEAE**Genus *Heptacodium* Rehd.*Heptacodium hokianum* Ozaki

Pl. 6, fig. 9

*Heptacodium hokianum* Ozaki, 1980b, Sci. Rep. Yokohama Natl. Univ. sec. 2, 27 : 40, pl. 9, figs. 1, 2, 5-7 ; text-figs. 8A-E.

*Discussion* : Some calyx-tube with fragmentary wings are referable to those of Capri-

foliaceae and are identical to those of *Heptacodium hokianum* Ozaki by the characteristic shape.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1192, 1302.

*Lonicera* sp.

Pl. 9, fig. 7

*Discussion* : Some fragmentary leaves show a characteristic feature of *Lonicera* : elliptical shape ; round base ; entire margin with marginal hairs in some specimens ; several number of brochidodromous secondary veins that are arranged closely each other and depart from the midvein at wider angles in the basal part than in the upper part ; and thin tertiary veins.

*Occurrence* : Kabutoiwa, Itahana and Ogawa Formations.

*Collection* : KPM oz-1195 ; oz-ita-K78 ; TNHM 4223.

Genus *Viburnum* Linnaeus

*Viburnum* sp. cf. *V. otukae* Tanai

*Viburnum otukae* Tanai, 1952, Jap. Jour. Geol. Geogr. 22 :134, pl. 5, 7.

*Discussion* : The small ovate shape, triangular marginal serration, about 9 pairs of alternate craspedodromous secondary veins that extend nearly straight into the teeth, and well-developed exmedial branches from the secondaries in the basal part of lamina, are features that ally these fossils to *Viburnum*. These leaves are most similar to those of *Viburnum otukae* Tanai in the foliar size, shape, and the number of the secondary veins. However, my leaves are somewhat different from this species in the narrower diverging angles of the secondaries from the midvein, wider basal region and well developed branches from the basal secondaries. My leaves are similar to those of the extant *V. erosum* Thunberg of Japan.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1142, 1231.

*Viburnum* sp. cf. *V. uttoensis* Huzioka

Pl. 7, fig. 4 ; Pl. 9, fig. 6

*Viburnum uttoensis* Huzioka, 1963, Tert. Floras of Japan, Miocene Floras, 1 : 215, pl. 39, fig. 12.

*Discussion* : In the foliar shape, marginal serration, number of the secondary veins and well-developed basal branches from the basal one or two secondaries, my leaf is nearly identical to *V. uttoensis* Huzioka. Compared to the type specimen, my leaf is slightly different in the larger size and the orbicular shape. My leaf is similar to those of the extant *V. brachyandrum* Nakai and *V. wrightii* Miq. of Japan, especially to those of the latter species.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1101, 1228 ; K 5383-2.

Genus *Weigela* Thunb.

*Weigela sanzugawaensis* Huzioka et Uemura

Pl. 7, fig. 6

*Weigela sanzugawaensis* Huzioka et Uemura, 1974, Bull. Natn. Sci. Mus. Tokyo, 17(4) : 358, pl. 10, figs. 8-12 ; text-fig. 7.

*Discussion* : The elliptical shape, acuminate apex, cuneate to attenuate base, serrulate margin, acute teeth, characteristic secondary veins whose distal part run parallel to the margin and form a series of loops with the superadjacent tertiary veins, percurrent tertiary veins that extend nearly perpendicular to the midvein or form obtuse angles to the midvein are features that ally these fossils to *Weigela*. The foliar shape, marginal serration, the number of the secondary veins and other venation characters of my leaf are well much to those of *W. sanzugawaensis* Huzioka et Uemura. My leaf is similar to those of the extant *W. sanguinea*



(Nakai) Nakai of central Japan.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1200.

*Weigela* sp. cf. *W. hortensis* K. Koch

Pl. 6, fig. 13; Fig. 30-3

*Description*: Leaves elliptical; apex acuminate; base missing but probably obtuse to cuneate; margin serrulate; teeth small with slightly spiny tip; midvein nearly straight; secondary veins five alternate pairs, diverging from the midvein at angles of about 30 to 40 degrees, gently curving up, forming a series of loops in the distal part, some secondary veins bifurcating on the way and forming a series of loops near the margin with the adjacent secondaries or strong tertiary veins, distal part of the upper secondaries curving up and running nearly parallel to the apical margin; tertiary veins in intercostal area percurrent, marginal tertiaries from the marginal loops entering teeth; quaternary veins making large elongate meshes among the tertiaries, nearly parallel to the tertiaries; ultimate veinlets mainly once branching among orthogonal fifth order vein networks.

*Discussion*: In the foliar shape, marginal serration and venation characters, these leaves belong to genus *Weigela*, and are closely similar to those of the extant *Weigela hortensis* K. Koch and *W. coraeensis* Thunberg of Japan. The fossil leaves are different from the extant ones in the marginal teeth and closely spaced percurrent tertiary veins.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1198, 1212, 1294.

#### Family **TETRACENTRACEAE**

Genus *Tetracentron* Oliver

*Tetracentron masuzawaense* (Murai) Ozaki

Pl. 7, figs. 2, 5

*Hovenia masuzawaensis* Murai, 1963, Rep. Tech. Iwate Univ. 16(2): 46-47, pl. 18, fig. 4, text-fig. 6.

*Tetracentron ibei* K. Suzuki, 1967, Proc. Japan Acad. 43(6): 527-530.

*Tetracentron masuzawaense* (Murai) Ozaki, 1987, Trans. Proc. Palaeont. Soc. Japan, N. S., no. 146: 77-87

*Description*: Leaves oval; length 5.8 to approximately 13.5 cm (average 10.0 cm) and width 4.5 to about 9 cm (average 6.3 cm); length/width ratio 0.52 to about 0.77 (average 0.64); apex caudate, length from the upper turning point of the marginal curvature to the tip of the apex 1.5 to 2.5 cm; base shallowly to deeply cordate; adaxial sides of the base lacking teeth, weakly curving down or adaxially with slightly decurrent part at petiole, making angles of 15 to 35 degrees by each side; margin regularly serrate with narrowly triangular teeth; teeth upcurved, separated by acute sinuses, marked by round glands which are located at the termination of a vein on the tooth apex; the basal side of the teeth convex, occasionally acuminate, rarely straight, while the upper side concave, rarely straight; petiole thick, length 1.5 to 3.0 cm, nearly straight or weakly curved, sometimes bending at the blade, gradually thickening to the proximal end with 2 to 3 mm width.

Venation perfect basal acrodromous with five to rarely seven primary veins; distal part of the lateral primaries brochidodromous, originating from the petiole, middle three veins nearly equal in thickness, the other pairs weaker than the middle three; distal part of primaries as thick as the secondary veins. Midvein stout, nearly straight. A pair of inner lateral primaries making an angle of 40 to 58 degrees with each other, average 48.7 degrees, reaching about four-fifth the distance from the base to the upper turning point of the marginal curvature; course weakly upcurved, slightly recurved to the midvein or nearly straight in the proximal part on some leaves, extending approximately parallel to the midvein; distal end bifurcating widely, the adaxial branch joining with a branch of the first stout secondaries from the midvein and making an angular loop, the straight abaxial branch bifurcating and making



angular loops with adjacent secondaries. A pair of outer lateral primaries making an angle of 105 to 130 degrees with each other, average 121.8 degrees, extending approximately straight or slightly upcurved with zig-zag course and reaching one-third to two-fifth of the leaf length; distal end bifurcating widely, the adaxial branch joining with a branch of the basal secondaries from the inner lateral primaries and making an angular loop, the straight abaxial branch bifurcating and making angular loops with adjacent secondaries. One alternate pair of secondary veins arising at angles of 30 to 50 degrees from the midvein, upcurved, forking at the distal end and joining with adjacent branches of the lateral primaries or upper weak secondaries; weak secondaries in the apex forming elongated net along the midvein; about six abaxial secondaries from the inner lateral primaries extending nearly parallel to the outer lateral primaries, bifurcating at its distal part and making angular loops with the adjacents; one stout secondary from near the base of the outer lateral primaries extending to the basal side, forking or sending off a stout tertiary vein on the way and making angular loops. Tertiary vein thin but distinct, some of the tertiaries that originate on the midvein are thicker than the average thickness of the tertiaries; angle of tertiary departure 45 to 75 degrees, average 60 degrees from the primary and secondary veins; intercostal tertiaries orthogonal reticulate to weakly percurrent; marginal tertiaries flanking secondary loops by generally pentagonal meshes. Quaternary veins from the corner of the tertiary loops extending to the teeth apex, in intercostal area making polygonal meshes. Higher order veins thin but distinct; fifth order veins around the teeth running from the both upper and basal sides of the teeth and join the teeth's midvein at the middle of or below the glands, in intercostal area making polygonal meshes about 0.7 to 1 mm across, ultimate veinlets mainly twice or sometimes thrice branching.

*Discussion*: The type specimen of "*Hovenia*" *masuzawaensis* has five primary veins that make a narrow angle with each other, narrowly triangular incurved marginal teeth which have glands at the terminal, presence of a pair of veins that converge toward tooth apex from the sinuses, and the large areolation which has commonly twice branching ultimate veins. These features indicate that the fossils represent a species of *Tetracentron*. The leaves of *Hovenia* have depressed glands at the top of the teeth and has very small, irregular areolation intruded by a single to once branching ultimate veinlets.

The narrowly triangular teeth set this species apart from the Paleogene species *Tetracentron piperoides*. The leaves of this fossil species differ from those of the extant *Tetracentron sinense* Oliver in the sharp teeth and from the *Tetracentron sinense* Oliver var. *himalense* Hara et Kanai in the large marginal teeth.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1088-1102.

#### Family **HAMAMELIDACEAE**

Genus *Fortunearia* Rehd. et Wils.

*Fortunearia kabutoiwana* Ozaki

Pl. 7, fig. 1

*Fortunearia kabutoiwana* Ozaki, 1984, Mem. Inst. Field. Educ. Yokohama Natl. Univ. 2: 3-4, pl. 1. fig. 1; text-fig. 1A, B.

*Discussion*: These specimens show a characteristic features of *Fortunearia*: asymmetrical base; basal secondary veins that are slightly curving proximally; secondary and tertiary veins which curve to the abaxial side around the marginal teeth; and more than once-branching ultimate veinlets. These leaves are closely similar to those of the extant *Fortunearia sinensis* Rehd. et Wils. growing in Central China, but are slightly different in the marginal teeth. The teeth are larger at the end of the secondary veins than that at the end of the marginal tertiary veins in the fossil leaves, but the marginal teeth of the extant leaves are generally nearly equal sized. These fossil leaves are similar to those of the *Sinowilsonia*



in general feature, but are distinguishable in the large teeth. Miki (1941) reported the seeds of *Fortunearia sinensis* from Obata locality of Seto Formation.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1081 ; K 531015-1.

Genus *Liquidambar* Linnaeus

*Liquidambar miosinica* Hu et Chaney

Pl. 7, fig. 9 ; Pl. 8, fig. 2 ; Pl. 13, fig. 9a

*Liquidambar miosinica* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 46, pl. 23, fig. 1, 2.

Academia Sinica, 1978. Chinese Foss. All Groups, Foss. Plant China 3 : 35, pl. 18, fig. 1, 5 ; pl. 19, fig. 4, 5 ; pl. 21, fig. 1, 2 ; pl. 23, fig. 2.

*Discussion* : The type specimens of this species described by Hu et Chaney (1940) have narrow lobes and obtuse basal shape, but the leaves of *Liquidambar miosinica* reported from the same bed of Shanwang by Academia Sinica (1978) have broad lobes and rounded to cordate base as in my leaves. Only one five-lobed leaf from the Kabutoiwa Formation has slightly palinactinodromous venation and is referable to this species. This species is closely similar to the extant *L. formosana* Hance of Taiwan.

*Occurrence* : Kabutoiwa, Seto, Yagii, Itahana, and Ogawa Formations.

*Collection* : KPMoz-1184 ; oz-ito24, 27, 35, 38 ; oz-yag-Fb17, 35, 36, 41, 43, 44-46, 51, 55, 59 ; oz-ita-G33, 34 ; oz-yama81a, 86-96 ; oz-maru22, 23.

Genus *Parrotia* C. A. Mey.

*Parrotia* sp.

Pl. 8, fig. 1

*Discussion* : The leaves are referable to *Parrotia* in the obovate and nearly equilateral shape, and mucronate marginal teeth. My leaves are similar to those of the *Fothergilla viburnifolia* Hu et Chaney described from Shanwang flora of China, but differ in the nearly symmetrical base. The fossil leaves are similar to those of the extant *Parrotia persica* (DC.) C. A. Mey. of western Asia.

*Occurrence* : Itahana and Yagii Formation.

*Collection* : KPM oz-ita-A4 ; oz-yag-Fb54, 63.

Family **BUXACEAE**

Genus *Buxus* Linnaeus

*Buxus protojaponica* Tanai et Onoe

*Buxus protojaponica* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 46, pl. 14, fig. 5.

*Discussion* : Small elliptical entire-margined thick leaves with characteristic ramified venation and thick fimbrial marginal vein indicate characteristic features of genus *Buxus*, and are referable to *Buxus protojaponica* Tanai et Onoe. My leaves are variable in size, 2 to 4 cm in length, and are similar to those of the extant *B. microphylla* Sieb. et Zucc. var. *major* Makino in size. But my leaves are slightly narrower than the extant ones.

*Occurrence* : Yagii, Ogawa and Seto Formations.

*Collection* : KPM oz-yag-Fb11, 14, 16, 21, 14, 30-33 ; oz-yama80.

Family **SALICACEAE**

Genus *Populus* Linnaeus

*Populus hokiensis* Ozaki

Pl. 8, fig. 7

*Populus hokiensis* Ozaki, 1979, Sci. Rep. Yokohama Natl. Univ. sec. 2. 26 : 41-43, pl. 3, fig. 4 ; pl. 4, fig. 1-4 ; text-fig. 2A, E.

*Discussion* : These leaves are referable to *Populus hokiensis* in the foliar shape, marginal

serration and venation characters. This species is a closely similar to the living *P. sieboldii* Miq, and has intermediate characters between *P. aizuana* and *P. sambonsgii* reported from Shiotsubo Formation in Fukushima Prefecture by Huzioka and K. Suzuki in 1954.

*Occurrence* : Kabutoiwa, Seto, Yagii and Ogawa Formations.

*Collection* : KPM oz-1152, 1153 ; ito3, 19, 20, 35 ; oz-yag-N-2 ; oz-ita-I1 ; oz-yama19.

*Populus kobayashii* K. Suzuki

Pl. 9, fig. 2

*Populus kobayashii* Suzuki, 1961, Sci. Rep. Fukushima Univ. 10 : 27, pl. 2, fig. 6, 7. j.

*Discussion* : The large deltoid leaves which have nearly truncate base, serrate margin and upcurved or incurved teeth are referable to those of *Populus kobayashii* reported from the Ryozen Formation in Fukushima and Miyagi Prefectures by K. Suzuki (1961). The leaves of this species are similar to those of the *P. kitamiana* Tanai et N. Suzuki, but are separable by the small incurved teeth.

*Occurrence* : Seto and Yagii Formations.

*Collection* : KPM oz-ito29, 44, 66, 68, 69 ; oz-yag-Fb20, 45, 50, 60, 66.

*Populus sanzugawaensis* Huzioka et Uemura

Pl. 8, fig. 5

*Populus sanzugawaensis* Huzioka et Uemura, 1974, Bull. Natl. Sci. Mus. Tokyo, 17(4) : 345, pl. 2, fig. 2-4 ; pl. 5, fig. 7-9.

*Discussion* : The orbicular leaf is characterized by serrulate margin, nearly acute apex, rounded base, and secondary veins that form a series of loops with the branches ; it is identical to *Populus sanzugawaensis* Huzioka et Uemura. The type specimen is closely similar to those of the extant *P. maximowiczii* Henry of eastern Asia and also somewhat similar to *P. balsamifera* Linn. of North America.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1310.

Genus *Salix* Linnaeus

*Salix akitaensis* Huzioka et Uemura

*Salix akitaensis* Huzioka et Uemura, 1974, Bull. Natl. Sci. Mus. 17(4) : 346, pl. 3, fig. 1.

*Discussion* : These leaves are identical to *Salix akitaensis* Huzioka et Uemura mainly in the long shape and wide diverging angles of the secondary veins, although most leaves are fragmentary.

*Occurrence* : Itahana and Ogawa Formations.

*Collection* : KPM oz-ita-K86, 87 ; oz-yama49.

*Salix hokkaidoensis* Tanai et N. Suzuki

Pl. 10, fig. 1 ; Fig. 34-4

*Salix hokkaidoensis* Tanai et N. Suzuki, 1965, Palaeont. Soc. Japan Spec. Pap., 10 : 9, pl. 15, fig. 6 ; pl. 16, fig. 7.

*Discussion* : Relatively long and slender leaves with small number of the secondary veins and minute marginal teeth are identical to those of the *Salix hokkaidoensis*.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-H1, 14, 15.

*Salix k-suzukii* Tanai

Pl. 8, figs. 3, 8 ; Pl. 9, fig. 5

*Salix k-suzukii* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : 269, pl. 4, fig. 12.

Huzioka and Uemura, 1973, Bull. Natl. Sci. Mus. 16(4) : 705, pl. 4, fig. 7.

Huzioka and Uemura, 1974, ibid. 17(4) : 347, pl. 3, fig. 2-4.



Cf. *Salix jessoensis* Seemen, Huzioka et K. Suzuki, 1954, Trans. Proc. Palaeont. Soc. Japan, N. S. 14 : 138, pl. 16, fig. 9.

*Discussion* : The leaves characterized by narrow oblong shape, bluntly serrulate margin and about 10 or more pairs of the secondary or intersecondary veins that are diverge from the midvein at an angle of about 45 degrees. These leaves are referable to *S. k-suzukii* Tanai. This species is similar to the extant *Salix jessoensis* Seemen.

*Occurrence* : Itahana, Ogawa and Yagii Formations.

*Collection* : KPM oz-ita-G43 ; oz-ita-I8, 50a, b, c ; oz-ita-J85 ; oz-ita-K1, 2a, b ; oz-yama-55 ; oz-yag-Fb58.

*Salix misaotatewakii* Tanai et N. Suzuki

Pl. 8, fig. 4

*Salix misaotatewakii* Tanai et N. Suzuki, 1965, Palaeont. Soc. Jap. Spec. Pap., 10 : 10, pl. 2, fig. 6 ; pl. 4, fig. 2.

*Discussion* : Among the known fossil species of *Salix* from eastern Asia, the fossil willow leaves from the Itahana Formation are nearly identical to those of *S. misaotatewakii* ; they are characterized by the relatively wide shape, fine marginal serration, angles between the primary and secondary veins which is around 45 degrees, and tertiary veins which are nearly perpendicular to the midvein. This species is similar to the extant *S. gracilistyla* Miq. of Japan, Korea and China. Some slender leaves of this fossil species from the Itahana Formation are similar to those of *S. parasachalinensis* Tanai et N. Suzuki, but are separable by the narrower diverging angles of the secondary veins and running features of the tertiary veins.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-K1, 13e, 17.

*Salix muraii* Huzioka et Uemura

Pl. 10, fig. 8

*Salix muraii* Huzioka et Uemura, 1974, Bull. Natl. Sci. Mus. 17(4) : 347, pl. 3, fig. 7-9 ; text-fig. 3.

*Discussion* : Nearly entire-margined small leaves of willow are referable to *Salix muraii* Huzioka et Uemura in the oblong to obovate shape, upcurved eucamptodromous secondary veins that diverge at a narrow angle from the midvein. This species is similar to the living *S. rorida* Lackschewicz of Japan, Korea and USSR.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-I6a ; oz-ita-J84.

*Salix parasachalinensis* Tanai et N. Suzuki

Pl. 8, fig. 6

*Salix parasachalinensis* Tanai et N. Suzuki, 1965, Palaeont. Soc. Japan, Spec. Pap., 10 : 11, pl. 2, fig. 5 ; pl. 4, fig. 1, 4a ; pl. 15, fig. 1.

*Discussion* : The leaves from the Itahana, Yagii and Ogawa Formations have following features: linear-lanceolate shape, serrulate margin, gently curving up secondary veins that make wide angles with the midvein and make loops with the superadjacent secondaries along the margin. Among the fossil species of willows, my leaves belong to those of *Salix parasachalinensis* Tanai et N. Suzuki except the clear marginal teeth and the narrow shape. Among the extant willow, my leaves are similar to those of *Salix sachalinensis* Fr. et Sav., *S. kinuyanagi* Kimura and *S. petsusu* Kimura.

*Occurrence* : Itahana, Yagii, and Ogawa Formations.

*Collection* : KPM oz-ita-H10, 86 ; oz-ita-I1, 8, 32, 38, 40, 50g ; oz-ita-K11, 14, 54, 62, 75, 80 ; oz-yag-A47, 50, 51 ; oz-yag-M1, 3 ; oz-yag-P1 ; oz-yama50 ; oz-maru31.

*Salix* sp. cf. *S. integra* Thunb.

Pl. 9, fig. 1

*Discussion* : The oblong shape, serrulate margin, acute apex, round base, obtuse diverging

angles of the secondary veins, well-developed simple intersecondary veins which reflex at distal part and join with the adjacent secondaries, strongly percurrent tertiary veins that are nearly perpendicular to the midvein are characteristic to some species of the genus *Salix*; these features indicate that the fossils are closely similar to those of the extant *Salix integra* Thunberg growing in East Asia. Among the fossil willow leaves, the fossil leaves are similar to those of *S. misaotatawakii*, but are different in the wider shape, wider diverging angles and many number of the secondary veins and clear marginal serrulation.

*Occurrence*: Itahana and Yagii Formations.

*Collection*: KPM oz-ita-G7, 9, 11, 12, 18, 29, 30; oz-yag-A22, 38, 41, 45, 46, 51; oz-yag-B1, 5; oz-yag-Fa5, 10, 14, 22, 34; oz-yag-K2; oz-yag-M2.

### Family **BETULACEAE**

Genus *Alnus* Mill.

*Alnus protohirsuta* Endo ex Tanai et Onoe

Pl. 10, fig. 9

*Alnus protohirsuta* Endo, Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187: 22, pl. 2, fig. 1; pl. 3, fig. 5.

*Discussion*: In the orbicular shape, double-serrate margin with low triangular teeth, craspedodromous secondary veins which are more narrowly spaced in the basal part than in the middle part, and percurrent intercostal tertiary veins, these leaves belong to *Alnus protohirsuta* Endo ex Tanai et Onoe. This species was first figured based on one specimen by Endo (1955), and the description of this species was given by Tanai and Onoe (1961). These fossil leaves are closely similar to those of the extant *Alnus hirsuta* Turcz. and *A. incana* (L.) Moench. Some leaves of *Sorbus* and *Crataegus* are similar to the fossil leaves in the shape and marginal serration. Although the leaves of *Alnus* are separable from similar leaves of *Crataegus* mainly by the percurrent intercostal tertiary veins and from those of the *Sorbus* by the wider diverging angles of the secondary veins and close arrangement of the secondary veins in the basal part of the lamina.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1193.

*Alnus protomaximowiczii* Tanai

Pl. 10, fig. 5; Pl. 11, fig. 1a

*Alnus protomaximowiczii* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11: 283, pl. 7, fig. 4.

*Discussion*: The leaves are identical to those of *Alnus protomaximowiczii* Tanai in the widely oval shape, caudate marginal teeth, craspedodromous secondary veins that have branches in the basal side near the margin, and percurrent intercostal tertiary veins. This species is closely akin to *A. maximowiczii* Callier of Japan.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1146, 1154, 1218a, 1244, 1245, 1254a, 1259, 1260.

*Alnus* sp. cf. *A. firma* Sieb. et Zucc.

Pl. 10, fig. 3

*Discussion*: The lanceolate-oblong foliar shape, cuneate base, acute apex, craspedodromous secondary veins, diverging angles of the secondary veins that gradually decrease from the base toward the apex, wider space of the secondaries in the middle part than in the basal and apical parts, percurrent tertiary veins and low marginal teeth indicate that these leaves are closely allied to the *Alnus firma* Sieb. et Zucc. My leaves are different from those of *Alnus subfirma* (Tanai and N. Suzuki, 1965) in the triangular large teeth. The less secondary veins and wider lamina distinguish these leaves from *A. pendula* Matsumura and its relatives.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1190, 1258, 1290, 1292.



*Alnus* sp. cf. *A. japonica* Steudel

Pl. 9, fig. 3, 4 ; Pl. 10, fig. 2, 4 ; Pl. 11, fig. 2

*Discussion* : These leaves are variable in foliar characters: shape is elliptic to wide elliptic; length is 4 to 12 cm; base is obtuse to slightly cordate; apex is acute to acuminate; secondary veins are sometimes bifurcate on the way or uniformly up-curved. However, the followings are relatively invariable characters: serrulate margin, about 8 pairs of secondary veins, and percurrent tertiary veins. The above-noted characters indicate that the fossils are referable to *Alnus*. Many species of *Alnus* have been described from the Neogene of East Asia by various authors. Of these Neogene alders, the fossil leaves from the Upper Miocene of central Honshu resemble leaves of *A. arasensis* Huzioka ex Tanai (Tanai, 1961), *A. proto-japonica* K. Suzuki (Suzuki, K., 1961) and *A. prenepalensis* Hu et Chaney (Hu and Chaney, 1940) in gross features, but differ in marginal teeth and secondary vein termination. Among the extant alders, my leaves are most allied to *Alnus japonica* Steud. of Japan and *A. formosana* Hayata of Taiwan, and also to those of the *A. trabeculosa* Hand. -Mazz. of Japan in the shape and venation character. Tanai (1961) reported *A. miojaponica* based on leaves and cones. Some leaves of the extant *A. japonica* have peculiar features as shown by the type leaves of *A. miojaponica*: doubly-serrate margin, elongate triangular teeth with acuminate to caudate tip, and gently curving-up secondary veins without bifurcation. In most leaves of *A. japonica*, however, the margin is simple serrate with small teeth, and the secondary veins often bifurcate just near the sinus to send one branch to the tooth apex and another branch to basal side of the superadjacent tooth. These features are also observed in my fossil leaves.

*Occurrence* : Itahana, Yagii, and Ogawa Formations.

*Collection* : KPM oz-ita-H22, 24, 26, 37, 38, 39, 40, 60; oz-ita-J1, 4, 5, 6, 9, 10, 13; oz-ita-K2a, b, 14; oz-yag-Fa7, 8, 9, 10, 14, 15, 19, 20, 30, 34; oz-bohd1-9; oz-kaba7, 8, 20; oz-chala, b, 3, 4, 7, 8, 9.

Genus *Betula* Linnaeus*Betula* sp. cf. *B. grossa* Sieb. et Zucc.

Pl. 11, figs. 3, 4

*Discussion* : These leaves are characterized by ovate shape, slightly asymmetrical rounded base, double-serrate margin with upward-turned acuminate teeth, about 13 pairs of craspedodromous secondary veins, and weakly percurrent intercostal tertiary veins. These features show a close resemblance to those of the living *Betula grossa* Sieb. et Zucc. of Japan. My leaves are similar to those of *B. onbaraensis* described by Tanai and Onoe (1961) from the Hoki flora in western Japan, but this species is established on the basis of two fragmentary leaves.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1238, 1264-70.

*Betula miomaximowicziana* Endo ex Tanai

Pl. 11, fig. 6

*Betula miomaximowicziana* Endo, Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2): 287, pl. 10. fig. 1-3, 5-7.

Endo, 1955 (nom. nud.), Icon. Fos. Pl. Jap. Isl. pl. 28, fig. 3.

*Discussion* : Only one leaf, though lacking its apical part, is identical to *Betula miomaximowicziana* (Endo) ex Tanai by the shape, marginal serration, basal feature of the secondary veins, and the ultimate veinlets which generally branch three times.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1147.

*Betula* sp. cf. *B. uzenensis* Tanai

Pl. 11, fig. 5

*Betula uzenensis* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11(2): 291, pl. 8, fig. 7, 9.

*Discussion*: Only two but well-preserved leaves are closely similar to those of *B. uzenensis* Tanai described from the early Miocene Aburato coal mine of northeastern Japan in the shape and marginal serration, but are slightly different in the rounded base and small teeth. This fossil species is akin to the extant *Betula schmidtii* Regel of Japan.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1261, 1262.

Genus *Carpinus* Linnaeus*Carpinus heigunensis* Huzioka

Pl. 11, fig. 12; Pl. 12, figs. 1, 6b

*Carpinus heigunensis* Huzioka, 1938, Jour. Fac. Sci. Hokkaido Imp. Univ. ser. 4, 4(1-2): 149, text-fig. 1.

Ozaki, 1979, Sci. Rep. Yokohama Natl. Univ. sec. 2, 26: 48, pl. 3, fig. 9: pl. 4, fig. 5-9 (see synonymy).

*Discussion*: These involucres and leaves are referable to the well-known *Carpinus subyedoensis*, which was reported by Konno (1931) from the Ogawa Formation without description. Then, the specimens are transferred to *C. heigunensis* by me (Ozaki, 1979), because *C. subyedoensis* is nomen nudum. These fossil species are closely allied to the extant *C. tschonoskii* Maxim.

*Occurrence*: Kabutoiwa, Seto, Yagii, Itahana and Ogawa Formations.

*Collection*: KPM oz-1124-28, 1133, 1249, 1250; oz-ito44b; oz-ita-K; oz-yama21.

*Carpinus* sp. cf. *C. nipponica* Endo

Pl. 11, fig. 11

*Carpinus nipponica* Endo, 1950, Short Paper I.G.P.S. 6: 53, pl. 6, fig. 8.

*Discussion*: Nearly entire-margined L-shaped involucres are closely similar to those of *C. nipponica* Endo. Among the extant species, these involucres are most similar to those of the *C. betulus* Linn. of Europe.

*Occurrence*: Kabutoiwa Formation.

*Collection*: K 54204-2; KPM oz-1129-7.

*Carpinus* sp. cf. *C. japonica* Maxim.

Pl. 10, fig. 7b; Pl. 11, figs. 7, 9; Pl. 12, fig. 9

*Discussion*: The lanceolate-oblong foliar shape, many secondary veins which diverge from the midvein at about 45 degrees except basal pairs, marginal double serration and generally two cauminate teeth with caudate apical tip for each secondary vein indicate that these leaves are closely similar to those of the extant *Carpinus japonica* Maxim. of Japan. My leaves are slightly similar to those of the *C. stenophylla* Nathorst, though the type specimen described by Nathorst was based on a fragmentary leaf which lacks its basal half. Moreover, the type specimen of the *C. stenophylla* Nathorst, as stated by Tanai (1976, text-fig. 2, c. d), has different characters from those of the extant *C. japonica* Maxim. in having three or four teeth par secondary vein, narrow diverging angles of the secondary veins, and larger ultimate networks.

*Occurrence*: Kabutoiwa, Seto, Itahana and Ogawa Formations.

*Collection*: KPM oz-1130, 1131, 1219, 1242, 1251-1253; oz-ito2; oz-ita-K16, 20; oz-yama80; K 53826-1.

*Carpinus miocenica* Tanai

Pl. 12, figs. 2-5, 7, 8, 10

*Carpinus miocenica* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11(2): 294, pl. 8, fig. 6, 13: pl. 14,



fig. 6.

*Discussion* : In the lanceolate shape, narrow diverging angles of the secondary veins and cuneate base, these leaves are referable to those of the *Carpinus miocenica* Tanai. These leaves are somewhat similar to those of the extant *C. laxiflora* Blume of Japan.

*Occurrence* : Kabutoiwa, Seto, Ogawa and Itahana Formations.

*Collection* : KPM oz-1128, 1129, 1197, 1241 ; oz-ito8, 9, 17, 24, 36, 44a, 76, 82, 86, 90 ; oz-yama20-24 ; oz-ita-J93.

*Carpinus subcordata* Nathorst

Pl. 11, fig. 10

*Carpinus subcordata* Nathorst, 1883, Kgl. Svensk. Vet. -Akad. Handl. 20(2) : 39, pl. 2, fig. 13-16, 18, 20.

*Discussion* : In the foliar shape, cordate base, double serrate margin with three to four teeth per secondary vein in the middle of margin, small acuminate teeth, and closely spaced percurrent tertiary veins, these leaves are referable to *Carpinus subcordata* Nathorst. This species is akin to the extant *C. cordata* Bl. of Japan and China. This fossil species is somewhat similar to the extant *C. japonica* Maxim. in having the small cordate base and a few branches from the basal secondaries.

*Occurrence* : Kabutoiwa, Itahana, and Ogawa Formation.

*Collection* : KPM oz-1130, 1245, 1248, 1251.

*Carpinus* sp. cf. *C. turczaninowii* Hance

Pl. 11, fig. 8 ; Pl. 12, fig. 6a

*Discussion* : The leaves are closely similar to those of the extant *Carpinus turczaninowii* Hance of Japan and China in the small ovate shape, short triangular teeth with blunt apical tip, and the number of the teeth that are generally three per secondary vein. Hu and Chaney (1940) described *C. mioturczaninowii* based on two involucre and one fragmentary leaf from the Shanwang flora of China, but the leaf is considered to belong to *Ulmus* in the marginal serration. My involucre may be different from those of the Shanwang species in the venation character and smaller size.

*Occurrence* : Kabutoiwa and Seto Formations.

*Collection* : KPM oz-1277 ; oz-ito44c, 71b.

Genus *Corylus* Linnaeus

*Corylus subsieboldiana* K. Suzuki

Pl. 12, fig. 11

*Corylus subsieboldiana* K. Suzuki, 1961, Sci. Rep. Fac. Arts & Sci., Fukushima Univ., 10 : 45, pl. 10, fig. 3, 4.

*Discussion* : The ovate foliar shape, rounded to slightly cordate base, double-serrate margin, triangular teeth, craspedodromous venation, well-developed branches from the basal secondary veins indicate that these leaves are referable to *Corylus subsieboldiana* K. Suzuki. The fossil leaves are similar to those of the extant *Corylus sieboldiana* Bl., but are different in the longer shape than those of the extant ones.

*Occurrence* : Kabutoiwa, Itahana, Yagii, and Ogawa Formations.

*Collection* : KPM oz-1136 ; oz-ita-E13, 14, 19 ; oz-yag-Fb30.

*Corylus* sp. cf. *C. heterophylla* Fisch.

Pl. 12, fig. 12

*Discussion* : Only one fragmentary leaf from the Kabutoiwa Formation is similar to those of the extant *Corylus heterophylla* Fisch. in the oval foliar shape, asymmetrically rounded base, triangular teeth, craspedodromous venation, several pairs of secondary veins which closely arrange in the basal part of the lamina and decrease diverging angles from the base to the apical part, and percurrent tertiary veins.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1263.

Genus *Ostrya* Scop.

*Ostrya aizuana* K. Suzuki

Pl. 12, fig. 14a

*Ostrya aizuana* K. Suzuki, 1961, Sci. Rep. Fac. Art & Sci. Fukushima Univ. 10 : 47, pl. 10, fig. 6, 7.

*Discussion* : The lanceolate-oblong foliar shape, cuneate base, attenuate apex, narrow secondary veins' diverging angles, well-developed branches diverging basally from the secondary veins at narrow angles, and slender acuminate marginal teeth indicate that these leaves belong to *Ostrya* and are referable to *O. aizuana* described from Fukushima Prefecture by K. Suzuki (1961). In having the cuneate base this species may be distant from those of the extant *O. japonica* Sargent to which the fossil leaves are similar.

*Occurrence* : Kabutoiwa, Ogawa, Itahana, and Seto Formations.

*Collection* : KPM oz-1244a ; oz-yamal15-119.

*Ostrya* sp. cf. *O. japonica* Sargent

Pl. 12, fig. 13

*Discussion* : Well-preserved leaves are closely similar to those of the extant *Ostrya japonica* Sargent in the shape, venation and marginal serration. These fossil leaves are distinguishable from *O. subjaponica* K. Suzuki in the subduplicately serrate margin with nearly equal-sized teeth. K. Suzuki et al. (1970) figured a single leaf as *O. subjaponica* from the Kabutoiwa Formation, although it preserves nearly no marginal teeth. My leaves are also separable from those of *O. aizuana* in the narrowly cuneate base.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1257, 1258.

Family **FAGACEAE**

Genus *Castanea* Miller

*Castanea miocrenata* Tanai et Onoe

Pl. 13, fig. 5

*Castanea miocrenata* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 30, pl. 5, fig. 1-4.

*Discussion* : These leaves show a characteristic features of *Castanea* : the oblong shape, spinose marginal teeth, asymmetrically rounded to slightly cordate base, irregularly and widely spaced secondary veins, and slightly weakly percurrent tertiary veins. These leaves are closely similar to those of *Castanea miocrenata* Tanai et Onoe and the extant *C. crenata* Sieb. et Zucc. of Japan, but slightly different from the latter in the wider shape and larger somewhat triangular teeth. My leaves are separable from those of the *C. miomollissima* Hu et Chaney reported from the Shanwang flora of China (Hu & Chaney, 1940) in the basal shape and marginal serration. The tertiary veins of the holotype of this species are not clear. The paratype of this species (Hu et Chaney, 1940, Pl. 13, fig. 3) has closely arranged percurrent tertiary veins, and it is considered that at least the paratype belongs to the genus *Quercus*. On the other hand, the paratype of *Quercus miovariabilis* figured by Hu et Chaney (1940, pl. 15, fig. 6) has lanceolate foliar shape, asymmetrically rounded base and widely percurrent tertiary veins, and it represents a species of *Castanea*. *Castanea lanceolata* described by Suzuki (1961) is also similar to my leaves in the marginal teeth, but it is considered that this specimen also belongs to the genus *Quercus* in having the closely spaced tertiary veins. My leaves are nearly identical with those of *C. rarinervis* Konno (nom. nud.) from the Ogawa Formation in marginal teeth, but this species was only figured by Konno (1931).

*Occurrence* : Kabutoiwa, Seto, Yagii, Ogawa, Formations.

*Collection* : KPM oz-1146, 1218 ; oz-ito14, 20, 69 ; oz-yag-Fb67 ; oz-bohd9 ; K 54212-4.



Genus *Fagus* Linnaeus*Fagus stuxbergii* (Nathorst) Tanai

Pl. 13, figs. 1, 3, 9c; Pl. 19, fig. 4, 5

*Fagus stuxbergii* (Nathorst) Tanai, 1976, Jour. Fac. Sci., Hokkaido Univ. ser. 4, 17(2): 296, pl. q. fig. 4, 5, 8, 10; text-fig. 2g-j.*Quercus stuxbergii* Nathorst, 1883, Kungl. Svensk. Vet.-Akad. Handl. 20: 44, pl. 3. fig. 18-20; pl. 4, fig. 4-9.*Fagus palaeocrenata* auct. non Okutsu, Tanai, 1974, Birbal Sahni Inst. Spec. Publ., 1: 70, pl. 4, fig. 4; pl. 5, fig. 1, 2, 4, 6, 7 (see synonymy).

*Discussion*: Most of my leaves have small teeth on the crenate margin, though some leaves from the Sashikiri Member of the Ogawa Formation have rather large teeth in the basal part. Together with this character, the number of the secondary veins and the arrangement of the tertiary veins indicate that these leaves are identical to those of *Fagus stuxbergii* (Nathorst) Tanai.

*Occurrence*: Seto, Itahana, Ogawa, and Kabutoiwa Formations.

*Collection*: KPM oz-1171, 1182, 1242; oz-ito2, 3, 14, 28, 33, 78, 79; oz-yama3, 4b, c, 11, 16, 17, 19-24, 34-37, 81c; oz-marul-5, 12, 17-19, 25, 28; oz-ita-A4, 6-8; oz-ita-E19, 33; oz-ita-J1, 5, 17, 25, 34, 37, 42, 43, 45; K 54202-4.

*Fagus palaeojaponica* Tanai et Onoe

Pl. 13, fig. 6

*Fagus palaeojaponica* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187: 35, pl. 7, fig. 3-5.

*Discussion*: The leaves are characterized by the crenate margin, many secondary veins and closely spaced percurrent tertiary veins, and they are referable to *Fagus palaeojaponica* Tanai et Onoe. These leaves are similar to the extant *F. japonica* Maxim. of Japan, *F. multinervis* Nakai of Japan and Korea, and *F. engleriana* Seem. of China.

*Occurrence*: Kabutoiwa, Itahana and Ogawa Formations.

*Collection*: KPM oz-1167, 1181; oz-ita-J41; oz-marul2.

*Fagus* sp.

Pl. 13, fig. 7

*Discussion*: The leaves are different from *F. palaeojaponica* Tanai et Onoe in having the small teeth on the margin, and also from those of *F. stuxbergii* (Nathorst) Tanai in having the many secondary veins and closely spaced percurrent tertiary veins. These leaves are closely similar to the toothed leaves of the extant *Fagus japonica* Thunb. of Japan. *F. protojaponica* described by K. Suzuki (1959) from the Early Miocene Shichiku Formation is somewhat similar to my leaves in the marginal character, but are different in the larger teeth and the wider shape.

*Occurrence*: Seto Formation.

*Collection*: KPM oz-ito28a, 36.

Genus *Quercus* Linnaeus*Quercus miocrispula* Huzioka

Pl. 13, fig. 8

*Quercus miocrispula* Huzioka, 1954, Trans. Proc. Palaeont. Soc. Japan, N. S., 15: 106, pl. 25, fig. 3.

Ozaki, 1979, Sci. Rep. Yokohama Natl. Univ. sec. 2, 26: 53-54, pl. 6, fig. 8; pl. 7, fig. 4, 5.

*Discussion*: The oblanceolate to obovate shape, serrate margin except in the basal part, large, acuminate-acuminate and remotely spaced teeth, mucronate apex, simple craspedodromous secondary veins entering nearly straightly the marginal teeth, and thick percurrent tertiary veins indicate that the fossils represent a species of *Quercus*. My leaves are identical to *Q. miocrispula* Huzioka in the shape, marginal serration, number of the secondary veins and short petiole.

*Occurrence*: Kabutoiwa and Ogawa Formations.

*Collection*: KPM oz-1166, 1226, 1278; oz-yama29.

*Quercus miovariabilis* Hu et Chaney

Pl. 14, fig. 4

*Quercus miovariabilis* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 36-37, pl. 15, fig. 5 (only).

Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plant China, 3 : 51, pl. 32, fig. 1, 4 : pl. 33, fig. 5 ; pl. 34, fig. 1.

*Quercus subvariabilis* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : 314, pl. 13, fig. 5-8.

*Discussion* : My leaves are referable to those of *Q. miovariabilis* Hu et Chaney in the oblong shape, marginal serration with spiny tip and venation character. This species is similar to the extant *Quercus variabilis* Blume and *Q. acutissima* Carr. As already mentioned, the paratype of this species (Hu et Chaney, 1940, pl. 15, fig. 6) is probably belong to *Castanea* in the oblanceolate shape, asymmetrically rounded base, and the widely spaced tertiary veins.

*Occurrence* : Ogawa, Yagii and Seto Formations.

*Collection* : KPM oz-marul6, 20 ; oz-yama1, 17, 30-32, 90 ; oz-yag-A36 ; oz-ito44f.

*Quercus protoaliena* Ozaki

Pl. 13, fig. 4a

*Quercus protoaliena* Ozaki, 1979., Sci. Rep. Yokohama Natl. Univ., ser. 2, 26 : 54, Pl. 7, fig. 1, 2.

*Discussion* : The oblanceolate shape, long and thick petiole, large marginal teeth and venation character are features that refer these leaves to *Quercus protoaliena* Ozaki. Among the similar leaves of *Quercus*, the leaves of this species are separable from those of *Q. protoserrata* Tanai et Onoe mainly by the obovate shape, many secondary veins and larger size. *Q. protoaliena* is also distinguishable from *Q. protodentata* Tanai et Onoe by the long petiole and large acute teeth, and from *Q. miocrispula* Huzioka by many secondary veins and long petiole. *Q. protoaliena* is closely similar to the extant *Q. aliena* Blume, although the fossil leaves have generally much more secondary veins and larger size.

*Occurrence* : Seto, Itahana, Ogawa, and Yagii Formations.

*Collection* : KPM oz-ito67, 70 ; oz-ita-K15 ; oz-yama26-28 ; oz-marul9 ; oz-yag-A1, 5, 21 ; oz-yag-Fb23, 28, 44 ; SU 36.

*Quercus protosalicina* K. Suzuki

Pl. 14, figs. 3, 5b

*Quercus protosalicina* K. Suzuki, 1959, Monogr. Assoc. Geol. Collab. Japan 9 : 36, pl. 2, fig. 13, pl. 3, fig. 5-7.

*Discussion* : The narrow lanceolate shape, serrate margin with short spinose apex in which nearly straight secondary veins end in the middle to the upper margin of the lamina, cuneate to obtuse base, and coriaceous texture of the lamina indicate that these leaves are referred to *Quercus protosalicina* K. Suzuki, although my leaves are slightly different in the basal shape. My fossil leaves are closely similar to those of the extant *Quercus salicina* Blume of Japan and *Q. incana* Roxb. of Himalaya.

*Occurrence* : Seto, Yagii, Itahana, Kabutoiwa and Ogawa Formations.

*Collection* : KPM oz-ito4, 9, 10, 11b, 28, 31, 67, 68, 98 ; oz-yag-N1 ; oz-ita-A13 ; oz-bohd12.

*Quercus protoserrata* Tanai et Onoe

Pl. 10, fig. 6

*Quercus protoserrata* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 32, pl. 3, fig. 6 ; pl. 6, fig. 7.

Ozaki, 1979, Sci. Rep. Yokohama Natl. Univ. sec. 2, 26 : 55-56, pl. 6, fig. 8 ; pl. 7, fig. 4, 5.

*Quercus miocrispula* auct. non Huzioka, Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 30, pl. 6, fig. 6 (only).

Huzioka and Uemura, 1973, Bull. Natl. Sci. Mus. 16 (4) : 711, pl. 9, fig. 1.

*Discussion* : Oblanceolate shape, rounded base, acute to acuminate teeth and long petiole are characteristics of *Quercus protoserrata* Tanai et Onoe, although the type specimen is different from my leaves in the elliptical shape. This fossil species is similar to *Q. sinomiocenica* Hu et Chaney reported from the Miocene Shanwang flora, but are different in the cuneate base.



*Occurrence* : Kabutoiwa and Ogawa Formations.

*Collection* : KPM oz-1166, 1226, 1278 ; oz-yama29.

*Quercus* sp. cf. *Q. glauca* Thunb.

Pl. 14, figs. 2, 5a

*Discussion* : The leaves are characterized by elliptic foliar shape, acute apex and acute base, simple and sharp teeth in the middle to the upper part, weakly upcurved secondary veins which are craspedodromous except the basal part of the lamina, percurrent tertiary veins and coriaceous texture. These fossil leaves are most similar to the modern *Quercus glauca* Thunb. of East Asia, except the foliar shape.

*Occurrence* : Seto Formation.

*Collection* : KPM oz-ito11a, 20i, 45, 67g.

### Family JUGLANDACEAE

Genus *Carya* Nutt.

*Carya miocathayensis* Hu et Chaney

Pl. 14, fig. 8

*Carya miocathayensis* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 26, pl. 6, fig. 1 ; pl. 7, figs. 5-7.

Tanai and Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 22, pl. 2, fig. 6.

Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11(2) : 273, pl. 6, fig. 2, 3.

Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plant China 3 : 74, pl. 56, fig. 3, 5, 6 ; pl. 63.

*Ailanthus youngi* Hu et Chaney, 1940, (part), *ibid.* pl. 30, fig. 4.

*Juglans* sp. Tanai et Onoe, 1961, *ibid.* p. 21, pl. 2, fig. 3.

*Platycarya miocenica* Hu et Chaney, 1940 (part), *ibid.* p. 27, pl. 5, fig. 4.

*Prunus miodavidiana* Hu et Chaney, 1940 (part), *ibid.* p. 48, pl. 25, figs. 2, 3.

*Discussion* : My leaflets are referable to *Carya miocathayensis* Hu et Chaney characterized by elliptical to oblanceolate shape, well forking and craspedodromous secondary veins, and closely spaced percurrent tertiary veins. Generally, the leaflets of *Carya* are separable from those of *Cyclocarya*, *Juglans*, *Pterocarya*, and *Platycarya* by the cuneate base, and many secondary veins. Academia Sinica (1978) suggested that some leaves which were identified to the leaves of the genus *Ailanthus*, *Platycarya*, and *Prunus* by Hu and Chaney (1940) are transferred to this species. One specimen described as *Juglans* sp. by Tanai et Onoe (1961) is also referable to this species by the craspedodromous secondary veins.

*Occurrence* : Itahana and Seto Formations.

*Collection* : KPM oz-ita-J4-7, 1, 11-13, 15, 16, 37, 75a ; oz-ito36.

### Genus *Cyclocarya* Iljinskaja

*Cyclocarya ezoana* (Tanai et N. Suzuki) Wolfe et Tanai

Pl. 14, figs. 1, 9 ; Fig. 30-1

*Cyclocarya ezoana* (Tanai et N. Suzuki) Wolfe et Tanai, 1980, Geol. Surv. Prof. Pap. 1105 : 34, pl. 10, fig. 4-6, 8, 9.

Ozaki, 1979, Sci. Rep. Yokohama Natl. Univ. sec. 2, 26 : 39, pl. 2, fig. 3, 4 ; text-fig. 2D.

*Pterocarya ezoana* Tanai et N. Suzuki, 1963, Tertiary Floras Japan, 1 : 110, pl. 6, fig. 2-5, 8, 9, 11 ; pl. 19, fig. 1 ; pl. 21, fig. 10.

Ishida, 1970 (part), Mem. Fac. Sci. Kyoto Univ. ser. Geol. & Mineral. 37(1) : 70, pl. 5, fig. 1.

*Pterocarya asymmetrosa* Konno, Ishida, 1970 (part), *ibid.* p. 70, pl. 4, fig. 8.

*Discussion* : The leaflets have somewhat irregularly spaced secondary veins which bend sharply toward the apex about two-thirds or three-fourths of the distance from the midvein to the margin and then bifurcate widely or send off branches to form angular loops. These leaflets are referable to *Cyclocarya ezoana* (Tanai et Suzuki) Wolfe et Tanai. Two well-preserved fruits are characterized by the orbicular wing resting a small nut in its center. The small nut has four chambers, and has many grooves on the surface. These fruits are identical to *Cyclocarya*, and probably are conspecific with the leaves.

*Occurrence* : Kabutoiwa and Seto Formations.

*Collection* : KPM oz-1187, 1190, 1235.

Genus *Juglans* Linnaeus

*Juglans japonica* Tanai

Pl. 14, fig. 10

*Juglans japonica* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11 : 275, pl. 6, figs. 10.

*Discussion* : Leaflets are characterized by the asymmetrical oblong shape, serrulate margin, secondary veins which are curving up and then enter the marginal teeth or make loop at the margin, and percurrent and nearly straight tertiary veins. Those leaflets are referable to those of *Juglans japonica* Tanai. The paratype of this species is excluded from this species by the well-developed intersecondary veins. My leaflets are similar to those of the extant *J. ailanthifolia* Carr. of northeastern Asia, but are different in the sharp and distinct marginal teeth.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1183.

Genus *Platycarya* Sieb. et Zucc.

*Platycarya miocenica* Hu et Chaney

Pl. 7, fig. 3

*Platycarya miocenica* Hu et Chaney, 1940, Carnegie Inst. Wash. Publ. 507 : 27 pl. 5, figs. 1, 3 (exclude pl. 5, fig. 4).

*Discussion* : The leaflets are characterized by the falcately lanceolate-oblong shape, asymmetrically cuneate to rounded base, serrate margin, secondary veins which sometimes bifurcate just before the sinus, and moderately percurrent tertiary veins. The leaflets are identical to *Platycarya miocenica* Hu et Chaney by these features. My leaflets are somewhat different from the type specimens in the well-branching or bifurcating secondary vein termination. This species is similar to the extant *P. strobilacea* Sieb. et Zucc.

*Occurrence* : Ogawa Formation.

*Collection* : KPM oz-yama59.

Genus *Pterocarya* Kunth.

*Pterocarya asymmetrosa* Konno ex Tanai

Pl. 14, fig. 6 ; Fig. 30-2

*Pterocarya asymmetrosa* Konno, Tanai, 1952, Jap. Jour. Geol. Geogr. 22 : 124, pl. 5, fig. 1.

Konno, 1931 (nom. nud), Geol. Cent. Shinano., pl. 17, fig. 1-5, pl. 19, fig. 3.

K. Suzuki 1961, Sci. Rep. Fac. Art & Sci., Fukushima Univ. 10 : 31, pl. 4, fig. 2.

*Discussion* : Slightly asymmetrically oblong shape, serrulate margin, and semicraspedodromous secondary veins which form a series of marginal loops existing somewhat distantly from the margin are characters of a species of the genus *Pterocarya*. Among the known fossil species of *Pterocarya*, my leaflets are referable to those of *P. asymmetrosa* Konno. This species was first reported without description by Konno (1931), based on a leaf and some leaflets from Kabauchi locality of Ogawa Formation in Nagano Prefecture. Tanai (1952) described this species on the basis of a single incomplete leaflet from the middle Miocene Aburato coal-bearing Member in Yamagata Prefecture.

*Occurrence* : Ogawa, Yagii and Kabutoiwa Formations.

*Collection* : KPM oz-1101, 1148 ; oz-yama69, 96 ; oz-maru26, 29 ; oz-kaba21 ; oz-yag-Fb6, 64.

*Pterocarya protostenoptera* Tanai

Pl. 14, fig. 7

*Pterocarya protostenoptera* Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11 : 278 pl. 14, fig. 10.



Tanai et N. Suzuki, 1965, Palaeont. Soc. Jap. Spec. Pap. 10 : 13, pl. 21, fig. 4, 5.

*Discussion* : The leaflets from the upper horizon of the Itahana Formation are identified to *Pterocarya protostenoptera* Tanai in the nearly oblong shape and the venation character. The leaflets and nut of this species are closely similar to those of the extant *P. stenoptera* DC. of China. The leaflets are similar to those of the extant *P. rhoifolia* Sieb. et Zucc., but are generally different from those in the oblong shape, acute apex, obtuse base, and secondary veins that form a series of loops with the tertiary veins. The leaflets of *P. rhoifolia* Sieb. et Zucc. have generally oblanceolate shape, acuminate apex, rounded to slightly cordata base, and irregularly spaced secondary veins that make a loop with a slightly strong tertiary vein from the superadjacent secondaries.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-J5, 13-18, 51, 75b, 1, 95.

### Family **ULMACEAE**

Genus *Celtis* Linnaeus

*Celtis hokiensis* Ozaki

Pl. 15, fig. 8

*Celtis hokiensis* Ozaki, 1980, Bull. Natn. Sci. Mus., ser. C, 6(2) : 34, pl. 1, fig. 3, 9.

*Discussion* : Among the fossil leaves of *Celtis* reported from East Asia, *C. hokiensis* are separable from those of the three species, *C. nordenskiöldii* Nathorst, *C. nathorstii* Tanai et Onoe and *C. miobungeana* Hu et Chaney, mainly by the marginal teeth. Fossil leaves from the Ogawa and Itahana Formations are identical to *C. hokiensis*, although smaller than the type specimens. This species is closely similar to those of the extant *C. jessoensis* Koid. of Japan and Korea.

*Occurrence* : Ogawa and Itahana Formations.

*Collection* : KPM oz-yama40-44, 93 ; oz-ita-G3 ; oz-ita-J6b, 8, 9, 15.

*Celtis nathorstii* Tanai et Onoe

Pl. 7, fig. 10

*Celtis nathorstii* Tanai & Onoe, 1961, Rep. Geol. Surv. Jap. 187 : 36, pl. 10, fig. 1.

*Celtis nordenskiöldii* Nathorst, 1883, Kungl. Svensk. Vet.-Akad. Handl. 20(2) : 47, pl. 15, fig. 2(only).

Tanai, 1976, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(2) : 300, pl. 2, fig. 3.

*Discussion* : My leaves are characterized by asymmetrically elliptic shape, and marginal teeth that develop mainly on the upper half of the margin. These leaves are identical to *Celtis nathorstii* Tanai et Onoe. The type specimen of this species is fragmentary and probably lacks the marginal teeth in the basal half of the lamina. This species is closely similar to those of the modern *C. sinensis* Pers. var. *japonica* Nakai.

*Occurrence* : Kabutoiwa and Ogawa Formation.

*Collection* : KPM oz-1224 ; oz-yama19, 89.

Genus *Ulmus* Linnaeus

*Ulmus protojaponica* Tanai et Onoe

Pl. 15, figs. 3, 5

*Ulmus protojaponica* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 37, pl. 10, fig. 8.

*Discussion* : Asymmetrical base, double serrate ogee-shaped teeth, craspedodromous secondary vein that sometimes bifurcate on the way, percurrent tertiary veins, and well branched ultimate veinlets indicate that the leaves represent a species of *Ulmus*. These leaves are referred to *U. protojaponica* Tanai et Onoe in the size, shape and double serrate margin. This species is closely similar to the extant *Ulmus davidiana* Planch. var. *japonica* Nakai of Japan.

*Occurrence* : Kabutoiwa, Seto, Yagii, Ogawa, and Itahana Formations.

*Collection* : KPM oz-1106, 1139, 1140, 1159, 1277 ; oz-ito2a, 17, 25, 33, 34 ; oz-yag-Fb7, 53 ; oz-maru34 ; oz-yamal05 ; oz-ita-E21, 34 ; oz-ita-J5, 11-15, 24, 25, 29, 37, 38, 52, 60, 61, 70, 77, 95.

Genus *Zelkova* Spach.

*Zelkova ungeri* Kovats

Pl. 2, fig. 8b ; Pl. 15, figs. 1, 6

*Zelkova ungeri* Kovats, 1851, Jahrb. d. k. k. Geol. Reinsanst. 2 : 178.

Kovats, 1856, Arb. Geol. Ges. Ungarn, 1 : 27-29, T. 5, f. 1-12 ; T. 6, f. 1-6.

*Discussion* : Leaves are variable in the size and shape, but are referable to *Zelkova ungeri* Kovats in the simple serrate margin, ogee-shaped teeth with acute apex, craspedodromous secondary veins which sometimes bifurcate on the way, percurrent tertiary veins and well branching ultimate veinlets. Leaves of the living *Z. serrata* Makino and *Z. formosana* Hayata are also variable in the size and shape, and also in the number of the secondary veins.

*Occurrence* : Kabutoiwa, Ogawa, Yagii, and Itahana Formations.

*Collection* : KPM oz-1091, 1122, 1123, 1154b, 1168c, 1277, 1292 ; oz-yamal, 24, 45-48, 97 ; oz-yag-Fb12, 17, 19, 22, 24, 33, 34, 40, 45, 46, 54b, 66 ; oz-ita-A15 ; oz-ita-E8, 18, 27, 33 ; oz-ita-J23, 30.

#### Family **PITTOSPORACEAE**

Genus *Pittosporum* Banks ex Soland.

*Pittosporum* sp. cf. *P. illicioides* Makino

Pl. 15, figs. 4, 10 ; Fig. 31-3

*Discussion* : The fossil leaves indicate the following features : the narrowly elliptical and slightly asymmetrical or falcate shape, attenuate apex, decurrent base, entire margin, brochidodromous secondary veins, intersecondary veins that run nearly parallel to the secondaries and turn down to connect with the basal secondaries, elongated orthogonal reticulate tertiary and quaternary veins. These leaves are most similar to those of the living *Pittosporum illicioides* Makino of Japan.

*Occurrence* : Seto and Ogawa Formations.

*Collection* : KPM oz-ito13b, 14b ; oz-yamal6.

#### Family **TILIACEAE**

Genus *Tilia* Linnaeus

*Tilia kabutoiwaensis* Suzuki, Ibe et Ogawa

Pl. 15, fig. 2

*Tilia kabutoiwaensis* K. Suzuki, Ibe et Ogawa, 1970, Monogr. Assoc. Geol. Collab. Japan, 16 : 24, pl. 4, fig. 3 ; pl. 5, fig. 1.

*Discussion* : This species, *T. kabutoiwaensis*, was described by Suzuki et al. (1970), based on leaves from the Kabutoiwa Formation. They are characterized by asymmetrical shape, asymmetrically cordate base, about 6 to 8 pairs of craspedodromous secondary veins, and serrate margin with triangular small teeth. My leaves are referable to this species in the small teeth, although their cordate base is slightly asymmetrical.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1106, 1168a, 1169.

*Tilia miohenryana* Hu et Chaney

Pl. 10, fig. 7a

*Tilia miohenryana* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub. 507 : 69, pl. 33, fig. 3a ; pl. 44, fig. 1, 2 ; pl. 45, fig. 3.

Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plant China 3 : 89, pl. 73, fig. 1, 5 ; pl. 74, fig. 1, 2, 5 ; pl. 75, fig. 2-4.



*Discussion* : Fragmentary large leaves from the Kabutoiwa Formation are referable to *Tilia miohenryana* Hu et Chaney in the large size and triangular marginal teeth. These leaves are similar to those of *T. kabutoiwaensis* K. Suzuki et al. in the shape, large size and venation characters, but are separable by the large triangular marginal teeth.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1273 ; K 53826-1.

*Tilia protojaponica* Endo

Pl. 15, fig. 9, 11 ; Pl. 16, fig. 1

*Tilia protojaponica* Endo, 1966, Trans. Proc. Palaeont. Soc. Japan, N. S. 61 ; 189, pl. 23, fig. 3.

Endo, 1955, Icon. Foss. Pl. Jap. Isl. pl. 27, fig. 1(nom. nud.).

*Discussion* : My leaves are referable to *Tilia protojaponica* Endo in the rather small size and small number of the secondary veins. This species is closely similar to the living *T. japonica* Shimonkai.

*Occurrence* : Kabutoiwa, Yagii and Ogawa Formations.

*Collection* : KPM oz-1101, 1138, 1169b, 1237, 1240, 1278 ; oz-yag-A4 ; oz-yama17.

Family STERCULIACEAE

*"Ficus" tiliaefolia* Heer

Pl. 16, fig. 8-10 ; Fig. 31-1, 2

*Alangium aequalifolium* (Goepp.) Krysh. et Bors., Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 11(2) : 371, pl. 30, fig. 1 ; pl. 31, fig. 9.

*Marlea aequalifolia* (Goepp.) Oishi et Huzioka, 1950, Illust. Catalog. East-Asia. Fossil Plants, p. 171, pl. 50, fig. 1.

*Acer megasamarum* auct. non Tanai et N. Suzuki, Huzioka, 1964, Jour. Min. Coll. Akita Univ. ser. A, 3(4) : p. 90, pl. 15, fig. 2(only).

*Discussion* : Leaves (or leaflets) and large winged-seeds are provisionally referred to *"Ficus" tiliaefolia* Heer, because the taxonomic investigation was incomplete. These leaves have the following features: the strongly asymmetrical shape, inequilaterally cordate to widely obtuse base, acuminate apex, entire margin, brochidodromous secondary veins, percurrent tertiary veins, small and thick areoles with nearly no or simple freely ending veinlets, and rather short petiole whose distal part is swollen and thick at the base of lamina. These leaves from the Neogene of Japan have been referred to *Alangium aequalifolium*, *Marlea aequalifolia* or *A. koyamae* (Konno) Tanai. As already mentioned by Tanai on the Paleogene species (oral presentation), the venation character of the extant, *Alangium* (or *Marlea*) are different in having the larger areoles with profusely branching veinlets. The leaves from the early Miocene Sasebo Formation of Nagasaki, Nakamura and Mizunami Formations of Gifu, Moriya Formation of Nagano, and Yagii, Itahana and Ogawa Formations are different from *Alangium* in the small, thick areoles with nearly no or simple freely ending veinlets. They have rather short petiole which is swollen and thick at the base of lamina. Large winged seeds which have been referred to *Banisteriaecarpum* or *Acer megasamarum* are probably conspecific with this leaves, because these leaves of *"Ficus"* and the large winged seeds, *"Banisteriaecarpum"*, are often found from the same locality. There is one locality in Kani City, Gifu Prefecture, where abundant leaves of *"Ficus"* and a number of winged seeds, *"Banisteriaecarpum"*, are obtained, although no other fossils were included.

Considering from the characters of the leaves and winged seeds, these specimens appear to represent a species of Sterculiaceae. Nathorst (1886) elected *Sterculiphyllum*, but I referred my specimens to *"Ficus" tiliaefolia*, followed to Czeckott (1967).

*Occurrence* : Yagii, Itahana and Ogawa Formations.

*Collection* : KPM oz-yag-Fa3, 7, 12, 13, 24, 26, 30, 34 ; oz-ita-C2 ; oz-ita-G1, 11, 20, 23, 47 ; oz-ita-I2, 6, 7, 33, 34, 37, 45, 54 ; oz-ita-H5, 22, 37, 47, 55, 59, 61, 64, 67-70, 72, 77, 98 ; oz-ita-K1, 4-10, 12-22, 24, 99 ; oz-kaba4-6, 15, 16, 25, 26, 30, 31.

Family **EUPHORBIACEAE**Genus *Sapium* P. Br.*Sapium hokianum* Ozaki

Pl. 16, fig. 14

*Sapium hokianum* Ozaki, 1980b, Sci. Rep. Yokohama Natl. Univ. ser. 2, 27 : 22, pl. 2, fig. 3.

*Discussion* : These leaves are referable to *Sapium hokianum* Ozaki in the shape and venation characters, although basilaminar glands are not preserved.

*Occurrence* : Ogawa Formation.*Collection* : KPM oz-yama121a.Family **THEACEAE**Genus *Elaeocarpus* Linnaeus*Elaeocarpus florinii* Tanai

Pl. 16, fig. 2

*Elaeocarpus florinii* Tanai, 1976, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(2) : 335, pl. 5, fig. 5 ; text-fig. 5-d.

*Discussion* : The oblanceolate shape, serrulate margin with remotely spaced minute teeth, the secondary veins that fork on the way and form large loops with the adjacents, large orthogonal tertiary meshes in intercostal area, and swollen petiole just at the lamina, are features that ally this leaf to *Elaeocarpus*. The leaf from the Seto Formation is referable to those of *E. florinii* Tanai. This species is closely similar to the extant *E. sylvestris* (Lour.) Poir.

*Occurrence* : Seto Formation.*Collection* : KPM oz-ito71a.Genus *Eurya* Thunb.*Eurya* sp.

Pl. 16, fig. 7

*Discussion* : The small size, elliptical shape, simple serrate margin with seta, semicraspedodromous secondary veins that diverge at wide angles from the midvein and reflex sigmoidally on the way, and thick texture are characters shown by a species of *Eurya*. The fossils are closely similar to those of *E. japonica* Thunb. These fossil leaves are, different from *Camellia* in the small size and wide diverging angles of the secondary veins.

*Occurrence* : Seto Formation.*Collection* : KPM oz-ito9, 42.Family **CLETHRACEAE**Genus *Clethra* Linnaeus*Clethra maximowiczii* Nathorst

Pl. 16, fig. 4 ; Pl. 17, fig. 1

*Clethra maximowiczii* Nathorst, 1883, Kungl. Sv. Vet. -Akad. Handl., 20(2) : 51, pl. 11, fig. 18-20.

Tanai, 1976, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 17(2) : 338, pl. 7, fig. 2 ; pl. 8, fig. 1 ; pl. 9, fig. 3 ; pl. 10, fig. 3 ; text-fig. 6ij.

*Discussion* : The elliptic shape, serrate margin, acute marginal teeth, acute to acuminate apex, cuneate to obtuse base, semicraspedodromous secondary veins and percurrent tertiary veins are features shown by those of a species of *Clethra*. The leaves are identical to *Clethra maximowiczii* Nathorst. This species is closely similar to the extant *C. barbinervis* Sieb. et Zucc. of Japan, Korea and China. The fossil leaves are slightly different from those of the extant leaves in the marginal tertiary veins which enter tooth apex centrally.

*Occurrence* : Kabutoiwa Formation.*Collection* : KPM oz-1091, 1168, 1169, 1172 ; K53812-1.



Family **ERICACEAE**Genus *Rhododendron* Linnaeus*Rhododendron hokiense* Ozaki

Pl. 15, fig. 12 ; Fig. 31-4

*Rhododendron hokiense* Ozaki, 1980b, Sci. Rep. Yokohama Natl. Univ. sec. 2, 27 : 37, pl. 5, fig. 6.

*Discussion* : This leaf is identical to those of the *Rhododendron hokiense* in the ovate shape and venation character. The leaves of this species are similar to those of *R. protodilatatum* Tanai et Onoe, but are different in the shape and small size. *R. hokiense* is closely similar to the extant *R. kaempferi* Planc. and its varieties of Japan.

*Occurrence* : Kabutoiwa Formation.

*Collection* : K 54129-2, 53820-1.

*Rhododendron protodilatatum* Tanai et Onoe

Pl. 16, fig. 3

*Rhododendron protodilatatum* Tanai et Onoe, 1961, Rep. Geol. Surv. Japan, 187 : 55, pl. 18, fig. 2, 4.

*Discussion* : These leaves are referable to *Rhododendron protodilatatum* Tanai et Onoe in the rhombic-ovate shape and a few brochidodromous secondary veins. This species is similar to the extant *R. dilatatum* Miq. and some other species of *Rhododendron* which have rhombic leaves.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1116, 1196.

Genus *Vaccinium* Linn.*Vaccinium* sp.

Fig. 35-2

*Discussion* : The leaves appear to represent a species of *Vaccinium* by the following characteristics : the elliptical shape, serrulate margin, closely spaced marginal attenuate teeth, several pairs of secondary veins that are straight or slightly flexuous and form marginal loops with the superadjacent secondaries or branches from the superadjacent secondaries, some intersecondary veins which are nearly parallel to the secondaries, and the tertiary veins in marginal area forming loops on the secondary loops and in intercostal area forming orthogonal reticulation.

*Occurrence* : Seto Formation.

*Collection* : KPM oz-ito17, 22.

Family **AQUIFOLIACEAE**Genus *Ilex* Linnaeus*Ilex subcornuta* Huzioka et Uemura

Pl. 16, fig. 12

*Ilex subcornuta* Huzioka et Uemura, 1973, Bull. Natl. Sci. Mus. 16(4) : 716-717, pl. 12, fig. 2-5.

*Discussion* : The characteristic pentagonal shape, spinose four angles and cleft apex with also spiny tip, set this leaf to *Ilex subcornuta* Huzioka et Uemura. A single specimen figured as unknown leaf from Sashikiri Member of the Ogawa Formation by Konno (1931), is included in this species.

*Occurrence* : Seto and Ogawa Formations.

*Collection* : KPM oz-ito1 ; Konno (1931). pl. 24, fig. 7.

Cf. *Ilex rotunda* Thunb.

*Discussion* : In the oblong shape, entire margin, acuminate apex, obtuse base, and short thick curved petiole, these leaf impressions, though lacking fine venation, are similar to those of the extant *Ilex rotunda* Thunb. These fossil leaves are similar to those of *Ilex heeri*

Nathorst, but are different in less secondary veins.

*Occurrence* : Ogawa Formation.

*Collection* : KPM oz-yama21, 219.

*Ilex* sp. cf. *I. serrata* Thunb.

Pl. 16, fig. 11

*Discussion* : Elliptic to ovate shape, acuminate apex, acute to obtuse base, serrulate margin, short acute marginal teeth, several secondary veins that form large marginal loops together with branches from the superadjacent secondary veins, and random reticulate tertiary veins indicate that the fossil leaves are closely similar to those of the extant *Ilex serrata* Thunb. of Japan.

*Occurrence* : Itahana Formation.

*Occurrence* : KPM oz-ita-B2a, 27, 54.

### Family CELASTRACEAE

Genus *Tripterygium* Hook. fil.

*Tripterygium kabutoiwanum* Ozaki n. sp.

Pl. 11, fig. 16 ; Pl. 16, figs. 5, 6 ; Pl. 17, fig. 2 ; Fig. 32

*Description* : Leaves oval to wide oval ; length 7 to 11.5 cm ; width 4.7 (estimated) to 9.3 cm ; length/width ratio 1.14 to 1.48 ; apex cuspidate ; base obtuse to slightly cordate with slightly decurrent part ; margin crenate-serrate ; teeth slightly irregularly spacing, with glandular protuberances at the incurved tooth apices ; marginal glandular seta triangular, pointed to abaxial side ; petiole weakly curving, thick with 2 to 3 mm width and 0.9 to 1.7 cm length. Venation camptodromous ; primary vein nearly straight ; secondary veins 6 to 7 alternate pairs, originating at angles of about 45 degrees, gently curving up, two basal pairs slightly curving exmedially in the proximal part, curving up and running flexuously in the distal part, secondaries making angular series of loops near the margin with branches or strong tertiary veins which diverge from the superadjacent secondaries ; tertiary veins in intercostal area percurrent and nearly perpendicular to the midrib in the middle to upper part of lamina, in marginal area extending from the corner of the marginal loops and making angular networks or entering marginal setae ; quaternary veins making angular meshes among the tertiaries ; ultimate veinlets single to thrice, but mainly twice branching among the quaternary areoles.

Samara rectangle with rounded corner in shape, 13 mm long and 9 mm wide ; apex slightly emarginate with thick style ; base missing but probably rounded, lateral margin nearly straight with minute irregular undulation ; midrib thick, undulate, having some irregular elongated meshes along the midvein ; lateral veins extending from the central meshes at obtuse angles in the proximal part and gradually decreasing the angles to the apical part where lateral veins make angles of about 60 degrees with the midrib, extending nearly parallel each other, sometimes bifurcating and connecting each other.

*Discussion* : The incurved marginal teeth with glandular seta, camptodromous secondary veins, percurrent tertiary veins are characters of leaves of the genus *Tripterygium*. The leaves of *Celastrus* exhibit similar features to those of *Tripterygium*, but they are separable by less secondary veins and weakly percurrent tertiary veins. These fossil leaves are closely similar to those of the extant *Tripterygium regelii* Sprague et Takeda and *T. doianum* Ohwi, especially to the former. The rectangle samara is also referable to this species by the shape and venation character. The fossil samara is closely similar to those of the extant *T. regelii*, but is slightly different in the networks in the axial area and swollen style. Miki (1941) once described some seeds as *Tripterygium multipterium* Miki from the Seto Formation, but these materials were transferred to the genus *Melioidendron* by Miki (1963).

*Occurrence* : Kabutoiwa Formation.

*Collection* : Holotype KPM oz-1188, Paratypes KPM oz-1157, 1301, 1254b ; K 53812.



Family **RHAMNACEAE**  
 Genus *Berchemia* Necker  
*Berchemia miofloribunda* Hu et Chaney  
 Pl. 17, fig. 6

*Berchemia miofloribunda* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub., 507 : 65, pl. 9, fig. 5 ; pl. 40, fig. 2,3.  
 Academia Sinica, 1978, Chinese Foss. All Groups, Foss. Plants China 3 : 140-141, pl. 1128, fig. 1, 2 ; pl. 130, fig. 3.

*Discussion* : The entire-margined elliptic shape, round base, rounded to obtuse apex, eucamptodromous secondary veins and tertiary veins nearly perpendicular to the midvein indicate that the fossil leaves are referable to *Berchemia miofloribunda* Hu et Chaney. This species is similar to the extant *B. racemosa* Sieb. et Zucc. of Japan.

*Occurrence* : Kabutoiwa, Ogawa and Itahana Formations.

*Collection* : KPM oz-1208, 1311 ; oz-kaba4, 13 ; oz-ita-K15 ; oz-ita-J64, 70.

Genus *Paliurus* Mill.  
*Paliurus protonipponicus* K. Suzuki  
 Pl. 17, fig. 3-5

*Paliurus protonipponicus* K. Suzuki, 1960, Sci. Tohoku Univ. 2nd Ser. (Geol.), Spec. Vol. 4 : 319-320, pl. 33, fig. 5-7.

Ishida, 1970, Mem. Fac. Sci. Kyoto Univ. ser. Geol. & Mineral., 37(1) : 97, pl. 15, fig. 18, 19.

*Description* : Leaves ovate, slightly asymmetrical, 4 to 12 cm (estimated) long (average 8.8 cm) and 2.5 to 8 cm (estimated) wide (average 5.2 cm) ; apex acute ; base asymmetrically rounded or slightly cordate ; petiole curved, stout and short, about 6 to 8 mm long and 3 mm wide in larger leaves ; margin serrulate ; teeth very small with acute seta ; three primary veins radiating from the base ; midvein weakly curved ; lateral primaries making an angle of about 30 degrees with the midvein, curving up and running gradually close to the margin, reaching the apical region ; 3 or 4 pairs of thick secondary veins diverging at 50 to 60 degrees from the midvein on the middle and apical part of blade, curving up to become nearly parallel to lateral primaries ; several pairs of weak secondary veins at 70 to 80 degrees from the midvein on the basal part, joining the tertiaries from lateral primaries ; 5 to 7 secondary veins diverging abaxially from the lateral primaries, curving up, forming loops along the margin ; tertiaries diverging from the midvein at angles, of 75 to 90 degrees (higher than those of the weak secondaries from the midvein) ; tertiaries from the lateral primaries or secondaries extending at angles of 70 to 80 degrees to the both sides, generally the abaxial veins weaker and diverging at larger angles than those of the adaxial ones, curving up and joining the adjacents or quaternaries from the outer veins ; tertiaries in marginal area making large loops ; quaternaries from the midvein making nearly a right angle with the midvein ; quaternaries percurrent among the tertiaries, forming loops with adjacents or entering marginal teeth ; fifth and higher order veins forming irregular polygonal networks ; the highest order vein seventh ; freely-ending veinlets hooked or once branching within quadrangular to polygonal meshes.

*Discussion* : The leaves from the Seto Formation are generally larger than those of *Paliurus protonipponicus* described from the Late Miocene Fujitoge Formation in Fukushima Prefecture by K. Suzuki (1960). This species are separable from *Paliurus miocenica* Hu et Chaney from the Miocene Shanwang flora of China in the asymmetrically cordate base. One winged seed from the Seto Formation is larger than the type specimens. Among the leaves of Rhamnaceae, those of *Hovenia dulcis* display somewhat similar venation characters, but are different in the running feature of the tertiary veins around lower half of the blade.

*Occurrence* : Seto Formation.

*Collection* : KPM oz-ito9, 13, 34, 45-51, 86.

Family **VITACEAE**Genus *Vitis* Linn.*Vitis naumannii* (Nathorst) Tanai

Pl. 17, figs. 7, 8

*Vitis naumannii* (Nathorst) Tanai et N. Suzuki, 1965, Palaeont. Soc. Japan Sp. Pap. 10: 41, pl. 11, fig. 3.

Tanai, 1955, Geol. Surv. Jap. Rep. 163: pl. 15, fig. 11.

Tanai, 1976, Jour. Fac. Sci. Hokkaido Univ., ser. 4, 17(2): 334.

*Vitis lubrusca* auct. non Linn. Nathorst, 1883, Kungl. Svensk. Vet.-Akad. Handl. 20(2): 61, pl. 7, fig. 8, 9.*Vitiphyllum naumannii* Nathorst, 1888, Palaeont. Abhandl. 4: 17, fig. 2.

*Discussion*: Leaves are variable in size and shape; but they are generally large, orbicularly cordate and palmately and shallowly trilobed. Marginal teeth are low triangular with nearly straight or slightly concave sides. The secondary and tertiary veins terminate at the cunonioid tooth apex.

*Occurrence*: Kabutoiwa, Seto and Itahana Formations.

*Collection*: KPM oz-1272; oz-ito32; oz-ita-J2, 4, 5, 12, 54, 98; K 540212-11.

Family **RUTACEAE**Genus *Euodia* J. R. & G. Forst.*Euodia* sp. cf. *E. rutaecarpa* Hock et Thom.

Pl. 18, fig. 3; Fig. 34-3

*Description*: Leaflet inequilaterally lanceolate-ovate, base slightly asymmetrically obtuse, apex cuspidate, margin entire but slightly irregularly undulate; midvein weakly curved; secondary veins 13 to 14 alternate pairs, diverging at angles of about 60 to 70 degrees from the midvein, weakly curving up, forking near the margin and forming marginal loops with adjacent secondaries or intersecondaries along the margin; intersecondary veins simple to slightly composite; tertiary veins weakly percurrent; finer veins ill-preserved.

*Discussion*: In the foliolate shape, slightly undulate entire margin and venation character, these leaflets are closely similar to those of the extant *Euodia rutaecarpa* Hock et Thom. of China. Hu et Chaney (1940) reported *E. miocenica* from the Miocene Shanwang flora, but it is different from my leaflets in the characters of the intersecondary and the tertiary veins.

*Occurrence*: Kabutoiwa Formation.

*Collection*: K 54203-1.

Family **SIMAROUBACEAE**Genus *Ailanthus* Desf.*Ailanthus yezoense* Oishi et Huzioka

Pl. 17, fig. 10

*Ailanthus yezoense* Oishi et Huzioka, 1942, Jour. Geol. Soc. Japan, 49: 181, fig. 2-4.

*Discussion*: A single well-preserved winged seed is referable to *Ailanthus yezoense* Oishi et Huzioka in the shape of the wings and the venation character.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1185.

Family **MELIACEAE**Genus *Cedrela* Linn.*Cedrela?* sp.

Pl. 17, fig. 11-13

*Discussion*: Winged seeds are similar to those of *Cedrela* in the small size, elliptical shape of wing and rounded seed. Hu et Chaney (1940) described leaf and seed of *Cedrela bienensis* from the Shanwang flora, but the leaf of this species was transferred to the genus *Rhus* by Academia Sinica (1978). The seed cited by Hu and Chaney (1940) is closely similar to those of *Pseudolarix* in the shape of the wing and seed. My specimens are different from those of *C.*



*nipponica* Tanai in the shape of the seed.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1094, 1095, 1295-1297.

### Family **SAPINDACEAE**

Genus *Koelreuteria* Laxman

*Koelreuteria miointegrifoliola* Hu et Chaney

Pl. 17, fig. 9

*Koelreuteria miointegrifoliola* Hu et Chaney, 1940, Carnegie Inst. Washing. Pub. 507: 64, pl. 38, fig. 1, 3; pl. 39, fig. 3.

*Discussion*: My leaves are referable to those of *Koelreuteria miointegrifoliola* Hu et Chaney in the oblongly falcate shape, asymmetrically rounded base, acuminate apex, remotely arranged small acuminate teeth and venation characters. This species is similar to the extant *K. integrifoliola* Merr. of China.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1170.

Genus *Sapindus* Linnaeus

*Sapindus tanaii* Onoe

Pl. 18, fig. 11

*Sapindus tanaii* Onoe, 1974, Rep. Geol. Surv. Japan, 253: 52-54, pl. 12, fig. 5-7, text-fig. 3.

*Discussion*: The fossils are similar to leaflets of *Sapindus* in the asymmetrically lanceolate-oblong shape, attenuate apex, asymmetrically rounded base, entire margin, and curving secondary veins whose distal part tangentially contacts with the margin. These leaflets are referable to *S. tanaii* in the shape, size and venation character.

*Occurrence*: Yagii Formation.

*Collection*: KPM oz-yag-Fb66.

### Family **SABIACEAE**

Genus *Meliosma* Blume

*Meliosma* sp. cf. *M. myriantha* Sieb. et Zucc.

Pl. 18, fig. 1

*Discussion*: The elliptical to obovate shape, cuneate base, remotely serrate margin, mucronate teeth, simple or slightly mixed craspedodromous secondary veins, weakly percurrent tertiary veins are features that ally these fossils to *Meliosma*. In the irregularly spaced secondary veins that diverge at wide angles from the midvein and sometimes bifurcate on the way, fine percurrent tertiary veins and spinose marginal teeth, these fragmentary leaves are closely similar to those of the extant *Meliosma myriantha* Sieb. et Zucc. of Japan and Korea. These Leaves are separable from those of *M. shanwangensis* Hu et Chaney in the wider diverging angles of the secondary veins. Academia Sinica (1978) also reported *M. obtusifolia* Tao from the Miocene of Shanwang, but it is different from my leaves in the weakly curved or nearly straight secondary veins.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM 1222.

*Meliosma* sp. cf. *M. tenuis* Maxim.

Pl. 18, fig. 2

*Discussion*: In oblanceolate shape, several pairs of nearly simple craspedodromous secondary veins, weakly percurrent tertiary veins, and low triangular marginal teeth with mucronate tip, these leaves are closely similar to those of the extant *Meliosma tenuis* Maxim. of Japan. These leaves are separable from those of the above noted *Meliosma myriantha* by the

foliar shape and small number of the secondary veins

*Occurrence* : Yagii and Kabutoiwa Formations.

*Collection* : KPM oz-yag-A41, 42 ; Ibaraki-1.

### Family ANACARDIACEAE

Genus *Rhus* Linnaeus

*Rhus* sp. cf. *R. trichocarpa* Miquel

Pl. 17, fig. 14

*Rhus* cf. *trichocarpa* Miq., K. Suzuki et al., 1970, Monog. Assoc. Geol. Collab. Japan, 16, pl. 3, fig. 7, 8(exclude fig. 13).

*Rhus* sp. indet A. Konno, 1931, Geology of central Shinano, pl. 13, fig. 2

*Discussion* : These leaflets have characteristic features of a species of *Rhus* : lanceolate shape, entire or slightly toothed on the margin, acuminate apex, asymmetrical cuneate base, secondary veins whose distal part ramify or form weak loops, well-developed nearly simple intersecondary veins, and transverse ramified tertiary veins. These leaflets are closely similar to those of the extant *Rhus trichocarpa* Miquel of Japan. One specimen shown as *Rhus* cf. *trichocarpa* from the Kabutoiwa by Suzuki et al. (1970, pl. 3, fig. 13) is considered to represent a leaflet of *Acer subnikoense* Tanai et Ozaki in the oblanceolate shape, narrow diverging angles of the basal secondary veins and low blunt marginal teeth.

*Occurrence* : Kabutoiwa and Ogawa Formation.

*Collection* : KPM oz-1201 ; K 530618-6.

*Rhus* sp. cf. *R. javanica* Linn.

Pl. 17, fig. 15

*Discussion* : The leaflets are closely similar to those of the extant *Rhus javanica* in the shape, marginal serration and venation characters. The fossils are separable from *R. ezoense* Tanai described from the Miocene Yoshioka flora and *Rhus palaeojavanica* Matsuo described from the Paleogene Sakito flora in having the small blunt or rounded marginal teeth.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1189b. 1309.

### Family ACERACEAE

Section Macrantha Pax

*Acer palaeorufinerve* Tanai et Onoe

Pl. 18, figs. 7, 8 ; Pl. 19, fig. 8

*Acer palaeorufinerve* Tanai et Onoe, 1961, Geol. Surv. Jap. Rept. 187 : 49, pl. 16, fig. 2, 3.

Tanai & N. Suzuki, 1960, Jour. Fac. Sci. Hokkaido Univ., ser. i, 11(4) : 688. pl. 3, fig. 5.

Huzioka & Uemura, 1973, Bull. Natl. Sci. Mus. 16(3) : 719, pl. 12, fig. 5-7.

Tanai & Ozaki, 1977, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(4) : 578, pl. 5, fig. 10 ; text-fig. 6-B.

Tanai, 1983, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 20(4) : 306-307, pl. 3, fig. 11 ; pl. 4, fig. 3 ; pl. 5, fig. 10.

*Acer rufinerve* auct. non Sieb. et Zucc., Miki, 1937, Japan Jour. Bot. 8 : 322, fig. 8-0.

Okutsu, 1940, Saito Ho-on Kai Mus. Res. Bull. 19 : 162, pl. 7, fig. 1, 2. Endo, 1951, Short Papers IGPS. 3 : 53, pl. 8, fig. 4, 5.

*Acer franchetii* auct. non Pax., Okutsu, 1940, Saito Ho-on Kai Mus. Bull. 19 : 162, pl. 7, fig. 4.

*Acer trilobatum* (Sternb.) Al. Br. var. *tricuspidatum* auct. non Heer. Endo, 1951, Short Papers IGPS. 3 : 56, pl. 8, fig. 1.

*Acer nomurae* auct. non Okutsu., Murai, 1957, Tech. Rept. Iwate Univ. 10 : 43, pl. 1, fig. 3.

*Acer protorufinerve* Endo, 1963, Trans. Prc. Palaeont. Soc. Japan N. S. 5 : 67, pl. 10, fig. 3.

*Discussion* : Well-preserved leaves are referable to *Acer palaeorufinerve* Tanai et Onoe in the foliar shape, marginal serration and venation character. Compared with those of the extant *A. rufinerve* sieb. et Zucc., my leaves have somewhat less subsidiary teeth on the principal teeth. One of the largest leaves, though fragmentary, are more than 20 cm in both width and length and 12 cm long in petiole. Winged seeds which have small globose seed with



about 130 degrees in the divergent angles of the two wings are also referable to this fossil species.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1112, 1113, 1116, 1159, 1168, 1169, 1191, 1292.

*Acer* sp. cf. *A. crataegifolium* Sieb. et Zucc.

Pl. 18, fig. 4

*Discussion* : A single relatively well-preserved leaf, though lacking its apical part, is closely similar to those of *Acer crataegifolium* Sieb. et Zucc. and *A. inslare* Makino. in the characteristic shape, low but doubly serrate margin, and once to twice branching freely ending veinlets. This is probably the first record of the fossil in the Tertiary of Japan that is allied to the extant *A. crataegifolium*.

*Occurrence* : Kabutoiwa Formation.

*Collection* : K 53123-3.

### Section Palmata Pax

*Acer nordenskiöldii* Nathorst

Pl. 19, fig. 1 ; Pl. 20, fig. 1, 2

*Acer nordenskiöldii* Nathorst, 1883, Kgl. Svens. Vet. Akad. Handl. 20(2) : 60, pl. 11, fig. 10-16.

Miki, 1937, Jap. Jour. Bot. 8 : 322, pl. 9A ; text-fig. 8P-Q.

Hu & Chaney, 1940, Palaeont. Sinica, s. A, 1 : 60, pl. 34, fig. 1, 6.

Tanai & Onoe, 1961, Geol. Surv. Jap. Rep. 187 : 47, pl. 15, fig. 1.

Tanai, 1961, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 11(2) : 358, pl. 28, fig. 6.

Ina, 1974, Bull. Mizunami Foss. Mus. 1 : 346, pl. 10, fig. 2, 3(only).

Hayashi, 1975, Fossil Iki Island. p. 26, pl. 21, fig. 5 (only).

Tanai, 1976, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(2) : 330, pl. 7, fig. 4, 8 : pl. 8, fig. 7 ; text-fig. 7-h, i.

Tanai & Ozaki, 1977, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(4) : 580, pl. 1, fig. 1-3, 5, 6, 8, 9 ; text-fig. 3, A-d ; text-fig. 4, B-D,F.

Academia Sinica, 1978, Cenozoic plants of China, p. 127, pl. 110, fig. 2 ; pl. 111, fig. 8 ; pl. 124, fig. 2.

Ina, 1981, Monogr. Mizunami Mus. 2, pl. 28, fig. 1, 2, 6.

Tanai, 1983, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 20(4) : 312-313, pl. 3, fig. 1-2.

*Acer* cf. *nordenskiöldii* Nathorst, Ina, 1977, Geol. & Palaeont. Kani Town, p. 83, pl. V-22, fig. 4, 5.

*Acer palmatum* Thunb., Florin, 1920, Kgl. sv. Vet. Akad. Handl. 61 (1) : 23 & 36, pl. 4, fig. 1-4.

Kryshtofovich, 1930, Ann. Russ. Palaeont. Soc. 8 : 22 & 27, pl. 3, fig. 34.

Miki, 1941, Japan Jour. Bot. 11 : 283, text-fig. 17B, Cd.

Takahashi, 1954, Mem. Fac. Sci. Kyushu Univ. ser. D, 5(1) : 60, pl. 7, fig. 5-7a, b.

*Acer palmatum* Thunb. subsp. *megamoenum* Murai, 1963, Rept. Tech. Iwate Univ. 16(1) : 99, pl. 11, fig. 6a-b ; pl. 16, fig. 5.

*Acer ornatum* auct. non Carr. Tanai, 1952, Trans. Proc. Palaeont. Soc. Japan N. S. 8 : 234, pl. 22, fig. 10, 11.

*Liquidambar europaeum* auct. non Al. Braun, Florin, 1920, *ibid.* 61(1) : 20, pl. 3, fig. 5.

*Discussion* : Many leaves are identical to *Acer nordenskiöldii* Nathorst by the nearly single serrated margin, small teeth, and once to thrice branching freely ending veinlets. The type specimens reported by Nathorst (1883) from Mogi flora have low and nearly single serrate margin except fragmentary ones. There are some regional differences of the foliar characters of this species : almost all leaves from the Seto Formation commonly have five lobes with minute low single serrate margin ; the leaves from the middle Itahana Formation are 5 to 7 lobed and have slightly large single serrate margin ; those from the upper of the Itahana Formation have generally 7 long lobes with small marginal teeth ; and those from the Ogawa Formation have relatively 5 to 7 wide lobes with slightly large teeth. However, all these leaves from these 4 localities are included in *A. nordenskiöldii* by the single serrate margin and generally twice branching veinlets.

*Occurrence* : Kabutoiwa, Yagii, Itahana, Ogawa and Seto Formations.

*Collection* : KPM oz-1111, 1117, 1121 : oz-ito9, 11, 12, 30, 62-65 ; oz-yag-A32 ; oz-yag-Fb23 ; oz-ita-C6, 17 ; oz-ita-E23, 24 ; oz-ita-J2, 4, 5, 9, 12-15, 17, 22, 23, 32, 36, 37, 39, 44, 58,

59, 91, 96, 97; oz-yama97, 101, 102, 109; oz-cha10; oz-ito62a; K 54202-5.

*Acer protomatsumurae* Tanai

Pl. 18, fig. 9

*Acer protomatsumurae* Tanai, 1983, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 20(4): 315, pl. 3, fig. 3, 5.

*Acer ornatum* auct. non Carr., Huzioka, 1943, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 20(2): 60, pl. 11, fig. 10-16.

*Acer nordenskiöldii* Nathorst. Tanai & Ozaki, 1977, (part). Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(4): 580, pl. 1, fig. 4, 7; text-fig. 4, A, E.

**Discussion:** A few leaves are identical to *Acer protomatsumurae* Tanai by the small and seven-lobed leaves with the doubly serrate margin, and the twice to thrice branching veinlets. This species was separated from those of *A. nordenskiöldii* Nathorst by Tanai (1983) in having the double-serrate margin.

**Occurrence:** Kabutoiwa, Itahana, and Yagii Formations.

**Collection:** KPM oz-1120, 1245, 1259; oz-ita-J54; oz-yag-Fb6.

Section Rubra Pax

*Acer tricuspidatum* Bronn.

Pl. 19, fig. 2

*Acer tricuspidatum* Bronn. 1838, Lethaea Geogn. 2. pl. 35, fig. 10a, b.

Walther, 1968, Monatsb. deutsch. Acad. Wiss. 10(8): 636, pl. 2, fig. 1-3.

Tanai, 1983, Jour. Fac. Sci. Hokkaido Univ., Ser. 4, 20(4): 323-325, pl. 8, fig. 5, 7, 8 (see synonymy).

**Discussion:** The leaves are characterized by three or five lobes with acute to caudate apex, remotely dentate margin with one pair of slightly larger dents on the central lobe, and no or single ultimate veinlets, and are referable to *Acer tricuspidatum* Bronn. This species is closely similar to both the extant *Acer pycnanthum* K. Koch of Japan and *A. rubrum* L. of eastern North America.

**Occurrence:** Seto, Yagii and Ogawa Formations.

**Collection:** KPM oz-ito8; oz-yag-A43; oz-yag-Fa6.

Section Platanoidea Pax

*Acer* sp. cf. *A. chiharae* Huzioka et Nishida ex Huzioka

*Acer chiharae* Huzioka et Nishida, Huzioka, 1964, Jour. Min. Coll. Akita Univ. ser. A, 3(4): 88, pl. 14, fig. 5.

Huzioka & Nishida, 1960, Publ. Sado Mus. 3: 18, pl. 5, fig. 6-8.

Tanai & N. Suzuki, 1963, Tert. Fl. Japan. 1: 137, pl. 114, fig. 7; pl. 24, fig. 6.

Tanai, 1971, Mem. Natl. Sci. Mus. 4: 162, pl. 10, fig. 4.

**Discussion:** Two leaves are similar to those of the *Acer chiharae* Huzioka et Nishida ex Huzioka in the minute marginal teeth and no or single freely ending veinlets within small areoles. The leaves from the Seto Formation are different from type specimens in the many number of the minute marginal teeth and the number of lobes. These leaves are closely similar to those of the *A. nordenskiöldii* Nathorst in the foliar shape and the marginal serration but is distinguishable by the single veinlets.

**Occurrence:** Seto Formation.

**Collection:** KPM Ito60, 61.

*Acer huziokae* Tanai

Pl. 19, fig. 6

*Acer huziokae* Tanai, 1983, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 20(4): 326-327, pl. 11, fig. 2.

*Acer florinii* auct. non Hu et Chaney, Huzioka & Uemura, 1973, Bull. Natl. Sci. Mus. 16(4): 718, pl. 13, fig. 8.

Tanai & Ozaki, 1977, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(4): 586, pl. 4, fig. 3; text-fig. 4-K.

**Discussion:** The small trilobed leaves are identified to *Acer huziokae* Tanai in the shape, no marginal fimbrial vein and no or single freely ending veinlets. These leaves are closely similar to those of *A. rotundatum* Huzioka except the small number of lobes.



*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1110a-d.

*Acer rotundatum* Huzioka

Pl. 3, fig. 2b ; Pl. 6, fig. 10a ; Pl. 15, fig. 7 ; Pl. 18, figs. 5, 6 ; Pl. 19, fig. 3

*Acer rotundatum* Huzioka, 1943, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 7(1) : 129, pl. 24, fig. 1-3 ; pl. 25, fig. 2. Tanai, 1983, ditto. 20(4) : 329-331, pl. 11, fig. 1, 3, 6. (see synonymy).

*Discussion* : The palmately five-lobed leaves which have entire margin and have nearly no freely ending veinlets are identical to *Acer rotundatum* Huzioka. The fossil leaves from the Neogene of East Asia have been generally referred to *A. subpictum* Saporta by many authors, but Tanai (1983) transferred this group to *A. rotundatum*. The leaves of this species from Kabutoiwa, Ogawa and Itahana Formations have generally five wide lobes with caudate apex except some leaves.

*Occurrence* : Kabutoiwa, Ogawa, Yagii, and Itahana Formation.

*Collection* : KPM oz-1104b, 1109, 1111, 1115, 1168b, 1195b ; oz-yama4a, 17, 96, 98, 208 ; oz-maru-21, 24 ; oz-yag-Fb1, 12, 17, 19, 38, 39, 44, 56 ; K 53826-1.

Section Campestris Pax

*Acer protomiyabei* Endo

Pl. 20, fig. 6

*Acer protomiyabei* Endo, 1950, Short Pap. IGPS (1) : 15, pl. 3, fig. 11.

Tanai, 1983, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 20(4) : 334-336, pl. 6, fig. 2, 3 ; pl. 7, fig. 4 ; pl. 8, fig. 1-3, 6. (see synonymy).

*Discussion* : Many leaves which have been referred to *Acer ezoanum* Huzioka by many authors were transferred to *Acer protomiyabei* Endo by Tanai (1983), based mainly on lacking the minute teeth on the basal side of dents. The leaves from the Itahana and Yagii Formations have also no small teeth except marginal blunt dents. Some characteristic winged seeds which are considered to belong to this species are also found from the Itahana Formation.

*Occurrence* : Itahana, Yagii and Kabutoiwa Formations.

*Collection* : KPM oz-ita-E24, 34 ; oz-ita-F1-3 ; oz-ita-J5, 21, 91 ; oz-yag-A1 ; oz-yag-K2 ; K54121-4.

Section Oblonga (Hu et Cheng) Delendick

*Acer prototrifidum* Tanai

Pl. 1, fig. 6b ; Pl. 12, fig. 6c ; Pl. 20, fig. 3

*Acer prototrifidum* Tanai, 1952, Trans. Proc. Palaeont. Soc. Japan, N. S. 8 : 234, pl. 22, fig. 13.

Tanai, 1983, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 20(4) : 338-340, pl. 15, fig. 1-8 ; pl. 17, fig. 1 (see synonymy).

*Discussion* : A few incomplete leaves and one pair of winged seeds belonging to this species are obtained from the Seto and Yagii Formations. Tanai(1983) distinguished the leaves of this species from the similar trilobed *Acer* by the existence of the fimbrial vein and thick higher order venation. A single leaf from the Seto Formation has also clear fimbrial vein on the margin and has small areoles (0.3 to 0.5 mm across) which are intruded by no or once-branching freely-ending veinlets. This species is similar to the extant *A. buergerianum* Miq. Well-preserved winged fruits from the Seto Formation are closely similar to those of the extant species except the less swollen seed.

*Occurrence* : Seto and Yagii Formations.

*Collection* : KPM oz-ito8, 44d, e ; oz-yag-Fb48 ; oz-yagN4b.

## Section Trifoliata Pax

*Acer subnikoense* Tanai et Ozaki

Pl. 18, fig. 10 : Pl. 20, fig. 8a

*Acer subnikoense* Tanai et Ozaki, 1977, Jour. Fac. Sci. Hokkaido Univ. ser. 4, 17(4) : 594, pl. 4, fig. 1, 2, 4-7 ; text-fig. 6-C.*Rhus* cf. *trichocarpa* Miq., K. Suzuki, Ibe and Ogawa, 1970, Monogr. Assoc. Geol. Callab. Japan, 16 : pl. 3, fig. 13.

**Discussion :** Many leaflets and one pair of well-preserved winged seeds of *A. subnikoense* Tanai et Ozaki were collected from Kabutoiwa Formation. A trifoliate leaf with a twig is included. The leaflet of this species is separable from those of trifoliate maples such as *Acer trifoliatum* Geng. mainly by the blunt marginal teeth.

**Occurrence :** Kabutoiwa and Ogawa Formations.

**Collection :** KPM oz-1108, 1238, 1238, 1254a, 1298 ; oz-yama103.

Family **HIPPOCASTANACEAE**Genus *Aesculus* Linnaeus*Aesculus majus* (Nathorst) Tanai

Pl. 19, fig. 7

*Aesculus majus* (Nathorst) Tanai, 1952a, Jap. Jour. Geol. Geogr. 22 : 131.*Aesculiphyllum majus* Nathorst, 1888, Pal. Abhandl. w. d. Dam. Key. 5(3) : 200, pl. 17, f. 3.*Aesculiphyllum minus* Nathorst, 1888, ibid. p. 205, pl. 18, fig. 9.

**Discussion :** The fossil leaves are referred to *Aesculus majus* (Nathorst) Tanai by the following characters: oblanceolate to elliptical shape ; double-serrate margin ; four or five marginal teeth per secondary vein ; rounded apices of the marginal teeth ; gently up-curved secondary veins that turn apically near the margin and send three or four branches to the marginal teeth, widely bifurcate distal end of the secondaries, one of which enters a marginal tooth and the other generally connects with a branch or tertiaries from the superadjacent secondary vein ; tertiary veins that are percurrent and nearly a right angles to the secondaries and bifurcate on the way ; and orthogonal reticulate fourth and fifth veins. My leaves are distinguishable in the clear marginal teeth from those of *A. miochinensis* Hu et Chaney described from the Shanwang flora. Among the extant species my leaves are closely similar to those of *A. turbinata* Blume of Japan and *A. chinensis* Bge. of China in the marginal characters.

**Occurrence :** Kabutoiwa Formation.

**Collection :** KPM oz-1109, 1137, 1168, 1209.

Family **STAPHYLEACEAE**Genus *Euscaphis* Linnaeus*Euscaphis* sp. cf. *E. japonica* Kanitz.

Pl. 20, fig. 9 ; Fig. 33-2

**Description :** Leaflets lanceolate, slightly asymmetrical ; length 9.0 cm ; width 3.0 cm ; length/width ratio 3.0 ; apex attenuate ; base acute, slightly asymmetrical ; petiolule short, about 1 mm in length and 0.8 mm in width ; margin serrulate ; teeth acute with minute seta. Venation semicraspedodromous ; primary vein thick, weakly curving ; about 10 secondary veins diverging from the midvein, rather thin ; angle of divergence in the concave side larger than in the convex side of lamina, the lowest weak one pair and lower convex side's secondaries diverging from the midvein at an angle of about 45 degrees, upper secondaries making nearly a right angle with the midvein, curving up and making large loops with branches or tertiaries from the superadjacent secondaries ; intersecondaries simple ; tertiaries in intercostal area weakly percurrent ; marginal tertiaries from the loops of the secondaries entering tooth seta centrally ; quaternary veins orthogonal reticulate ; higher order veins not preserved.

**Discussion :** In the slightly asymmetrically lanceolate shape, acuminate apex, asym-



metrically broadly cuneate base, characteristic semicraspedodromous venation, and fine marginal teeth with seta, these leaflets are closely similar to those of the extant *Euscaphis japonica* (Thunb.) Kanitz. growing in central to western Japan, southern Korea and central China.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1191, 1220.

Genus *Staphylea* Linn.

*Staphylea* sp. cf. *S. bumalda* DC.

Pl. 20, fig. 10 ; Fig. 33-1

*Description* : Leaflets lanceolate, slightly asymmetrical; length 7 to 9 cm; width 2.5 to 4.2 cm; length/width ratio 2.1 to 2.8; apex attenuate; base discrete, rounded to cuneate; petiolule about 3 mm in length and 0.8 mm in width; margin serrulate; teeth straight to concave in apical side and straight to convex in basal side with acute sinus. Venation semicraspedodromous; primary vein thick, weakly curving; about 9 secondary veins diverging from the midvein at an angle of 60 to 70 degrees except basal one or two weak pairs which make about a right angle with the midvein in the round basal side or make about 45 degrees in the straight basal side, extending slightly upcurved or sinuous in course, joining with or sending off tertiaries on the way, turning up near the margin to connect with a branch from the superadjacent secondaries or tertiaries and making large loops; tertiary veins in intercostal area weakly percurrent and flexuous, in marginal area making a series of angular loops and sending one branch from the corner of the angular loops to the teeth; quaternary veins forming large networks; freely-ending veinlets generally once branching within quaternary orthogonal areoles.

*Discussion* : These fossil leaflets are similar to the lateral leaflets of the extant *Staphylea* in the acuminate apex, asymmetrical base, semicraspedodromous venation, characteristic tertiary veins in intercostal and marginal areas, and fine marginal teeth. Compared to the leaflets of the extant *S. bumalda*, the fossils are slightly different in many secondary veins and features of veins around the marginal teeth. The extant *S. bumalda* DC. is growing in Japan, Korea and China.

*Occurrence* : Kabutoiwa Formation.

*Collection* : KPM oz-1119, 1221, 1234.

#### Family **BIGNONIACEAE**

Genus *Catalpa* Scop.

*Catalpa szei* Hu et Chaney

Pl. 20, fig. 7

*Catalpa szei* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub 507 : 73, pl. 49, fig. 5.

*Discussion* : The leaves show a characteristic feature of *Catalpa*, though fragmentary: broad-oval to broad-cordate shape; entire margin; actinodromous secondary veins that form marginal loops; weakly percurrent tertiary veins; orthogonal reticulate fourth and fifth order veins; generally once branching ultimate veinlets. These leaves are referable to *C. szei* Hu et Chaney reported from Shanwang flora of China.

*Occurrence* : Kabutoiwa Formation.

*Collection* : K 5383-3, 5399-2.

#### Family **CERATOPHYLLACEAE**

Genus *Ceratophyllum* Linnaeus.

*Ceratophyllum miodemersum* Hu et Chaney

Pl. 21, fig. 4

*Ceratophyllum miodemersum* Hu et Chaney, 1940, Carnegie Inst. Wash. Pub. 507 : 42, pl. 19, fig. 4-6.

*Discussion* : Verticillate leaves generally twice bifurcate and form filiform segments with some spiny teeth are characteristics that ally to a species of *Ceratophyllum*. The fossils are referable to *C. miodemersum* Hu et Chaney of the shanwang flora of China. My specimens are similar to those of the extant *C. demersum* Linn. in the spiny margin of the leaves.

*Occurrence* : Kabutoiwa and Itahana Formations.

*Collection* : KPM oz-1180 ; oz-ita-G7.

#### Family **MENISPERMACEAE**

Genus *Cocculus* DC.

*Cocculus* sp.

Pl. 20, fig. 5

*Discussion* : The fossil leaves have the following features: oval to elliptical-cordate shape ; entire margin but shallowly 3-lobed in some leaf ; basal acrodromous venation with 3 primaries ; lateral primary veins extending about a half or more upper part of the lamina, camptodromous, flanked by angular loops of the tertiary in the basal side ; weakly percurrent tertiary veins ; and orthogonal reticulate fourth and fifth order veins. These characters indicate that the fossil leaves are similar to those of the extant *Cocculus trilobus* (Thunb.) DC. The leaves from the Itahana Formation are slightly different from those of the Seto Formation in the shape and number of the secondary veins.

*Occurrence* : Seto and Itahana Formations.

*Collection* : KPM oz-ito6, 11, 35a ; oz-ita-J17, 18.

#### Family **HALORAGIDACEAE**

Genus *Myriophyllum* Linnaeus

*Myriophyllum* sp.

Pl. 1, fig. 2a ; Pl. 15, fig. 13

*Discussion* : The pinnately cleft and verticillate leaves in more than 3, probably in 4 whorls, are characters indicative of the genus *Myriophyllum*. Among the extant species, the fossil specimens are similar to those of *M. verticillatum* Linn. and *M. spicatum* Linn., especially close to the latter species in the length of the leaves and width of the segments. Suzuki et al. (1970) listed *M. cf. verticillatum* Linn. from the Upper Motojuku (Kabutoiwa) Formation.

*Occurrence* : Kabutoiwa and Seto Formations.

*Collection* : KPM oz-1179, 1186, 1216 ; oz-ito22, 64 ; K 53820-1.

#### Family **SAXIFRAGACEAE**

Genus *Deutzia* Thunb.

*Deutzia* sp.

*Discussion* : Small ovate shape, acute apex, round to slightly cordate base, remotely serrate margin, minute teeth with glandular seta, small number of camptodromous secondary veins, composite intersecondary veins, weakly percurrent to orthogonal reticulate tertiary veins are characteristics indicative of a species of *Deutzia*. These fossil leaves are similar to those of the extant *D. crenata* Sieb. et Zucc. of Japan.

*Occurrence* : Kabutoiwa Formation.

*Collection* : K 53812-7, 53826-4.

Genus *Hydrangea* Linnaeus

*Hydrangea* sp. cf. *H. petiolaris* Sieb. et Zucc.

Pl. 12, fig. 14b ; Pl. 21, figs. 2, 7

*Description* : Leaves ovate to oval ; apex acuminate ; base nearly round ; margin serrate ; marginal teeth triangular ; midvein thick, straight from the petiole and in some case slightly sinuous in the distal part ; secondary veins 7 to 8 alternate pairs, diverging from the midvein



at an angle of 60 to 70 degrees in the basal ones, about 50 degrees in the apical ones, camptodromous, gently curving up and bifurcating widely, then forming angular loops with the superadjacents, the basal secondary pair sending off strong tertiary veins to the margin which turn apically and forming marginal loops; tertiary veins weakly percurrent; fourth order veins orthogonal reticulate; ultimate veinlets single to once branching; petiole thick more than 1.5 cm.

*Discussion*: In the foliar shape, triangular marginal teeth, camptodromous secondary veins, and large areolation of the finer veins, these leaves are closely similar to those of living *Hydrangea petiolaris* Sieb. My leaves are different from those of fossil *H. lanceolimba* and *H. miobretschneideri*, both described by Hu et Chaney (1940) in the shape and marginal serration. In the general foliar characters, my leaves are similar to those of *Schizophragma*, but are different in the small teeth and camptodromous secondary veins.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1148, 1242, 1243, 1244.

Genus *Schizophragma* Sieb. et Zucc.

*Schizophragma* sp. cf. *S. hydrangeoides* Sieb. et Zucc.

Pl. 21, fig. 3; Fig. 35-1

*Discussion*: These leaves are referred to the genus *Schizophragma* by the following characters: ovate shape; long acuminate apex; nearly rounded base; serrate margin; triangular teeth with acicular tip; slightly curved midvein; four to six alternate pairs of secondary veins diverging from the midvein at angle of 60 to 70 degrees in the basal part and about 40 degrees in the apical part, craspedodromous; one or two pairs of basal secondary veins bifurcating or sending off several branches basally which enter teeth or form angular loops; the secondaries of apical part curving up, sometimes flexuous, sending basally two craspedodromous branches; weakly percurrent tertiary veins; single to once branching ultimate veinlets within orthogonal reticulate quaternary veins. These fossils are closely similar to leaves of the extant *Schizophragma hydrangeoides* Sieb. et Zucc. of Japan and Korea. My leaves are similar to those of *S. mitokuensis* Tanai et Onoe, but different in the single marginal serration. *S. protohydrangeoides* described from Kabutoiwa Formation by K. Suzuki et al. (1970) is different from my leaves in many secondary veins and fine marginal serration, and it may represent a species of *Euptelea*.

*Occurrence*: Kabutoiwa Formation.

*Collection*: KPM oz-1143, 1189, 1227, 1230.

## MONOCOTYLEDONEAE

### Family **ALISMATACEAE**

Genus *Caldesia* Parlat.

*Caldesia* sp.

Fig. 34-1, 2

*Description*: Leaf widely oblong; length 5 cm (estimated) and width approximately 4 cm; apex rounded; base missing; margin entire. Venation parallelodromous; midvein straight; lateral veins four or five, converging at apex, as thin as the midvein, outer lateral veins extending along the margin; fine veins running nearly parallel and close to the primary veins, but extending zig-zag by connecting with some intercostal veinlets; closely spaced fine and nearly straight veinlets in intercostal area extending oblique to the primary veins, running parallel each other, but in some case connecting each other.

*Discussion*: One fragmentary leaf, though lacking its basal half, is referable to the genus *Caldesia* by rounded apex, four or five lateral veins in the apical half of the lamina and closely spaced intercostal fine veinlets. This leaf is similar to some leaves of the genus *Alisma*, *Sagittaria*, *Potamogeton* and other monocot aquatic or marsh leaves, but my leaf is most similar

to those of the *Caldesia* in the closely spaced fine veinlets between the primaries. The extant species, *C. reniformis* (D. Don) Makino is growing in ponds of Japan, China, India to Madagascar, to which my leaf is most similar.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-G24.

#### Family **CYPERACEAE**

Genus *Carex* Linnaeus

*Carex* sp.

Pl. 21, fig. 8

*Discussion* : Fragmentary linear leaves of *Carex* which are characterized by parallelodromous venation and W-shaped transverse section are found in some localities.

*Occurrence* : Seto, Itahana and Ogawa Formations.

*Collection* : KPM oz-ito4, 8, 17, 34 ; oz-ita-G27 ; oz-ita-J81, 88 ; oz-yama56, 58 ; oz-cha18.

#### Family **GRAMINEAE**

Genus *Bambusites* Ettingshausen

*Bambusites* sp.

Pl. 21, fig. 9

*Discussion* : Linear shape, 3 to 4 cm width, parallelodromous venation and about five fine veins between thick veins in the middle part of lamina appear characteristics to the leaves of bamboo and the relatives. Ettingshausen proposed *Bambusites* in 1886 and Konno reported the fossil bamboo leaves from Ogawa Formation as *Bambusites yadakeides* without description.

*Occurrence* : Seto, Kabutoiwa, Itahana and Ogawa Formations.

*Collection* : KPM oz-ito33, 67, 68 ; oz-ita-B64, 86, 102 ; oz-ita-C2 ; oz-ita-J83, 91 ; oz-yama116 ; oz-kaba5, 6, 13, 15, 18 ; oz-1178.

Genus *Phragmites* Linnaeus

*Phragmites?* sp.

Pl. 6, fig. 3b

*Discussion* : The leaves are similar to those of *Bambusites* in the foliar feature, but are different in lacking the clear thick veins in every several fine parallel veins, though some thick veins are running with rather irregularly spacing.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-G5, 6, 8, 13, 25 ; oz-ita-H111b.

#### INCERTAE SEDIS

Genus *Carpolithes* Schlotheim

*Carpolithes japonicus* (Morita) Ishida

Pl. 21, fig. 1

*Carpolithes japonicus* (Morita) Ishida, 1970, Mem. Fac. Sci. Kyoto Univ., ser. Geol. Mineral. 37 : 103, pl. 22, fig. 1, 2, 6, 7.

*Terminalia japonica* Morita, 1936, Jour Geol. Soc. Japan 40 : 355.

*Discussion* : Small fruits of about 1 to 1.5 cm diameter which are composed of generally 3, sometimes 4 pieces of mitriform wings or three pairs of obreniform wings are referable to *Carpolithes japonicus* (Morita) Ishida. The wings have many radiating veinlets and have slightly undulate abaxial margin. The fossils are found generally as a single wing of mitriform, because the fruits are apt to break along the axis with straight line. In some case a pair of two wings generally making about 120 degrees is also found.

*Occurrence* : Itahana Formation.

*Collection* : KPM oz-ita-J20, 21, 23, 25, 28, 29, 37, 39, 46, 47, 49, 52, 77 ; oz-yag-Fb1.



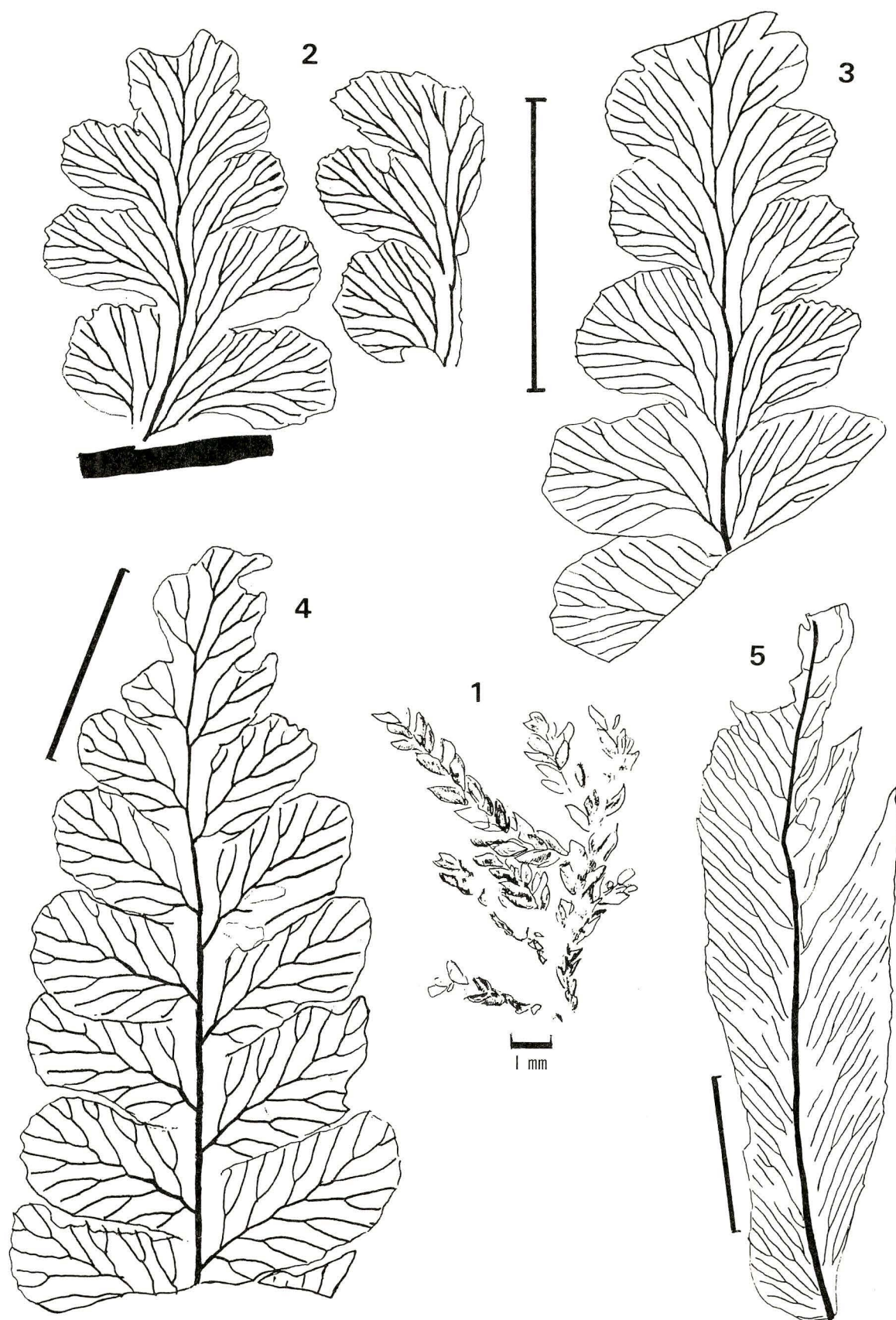
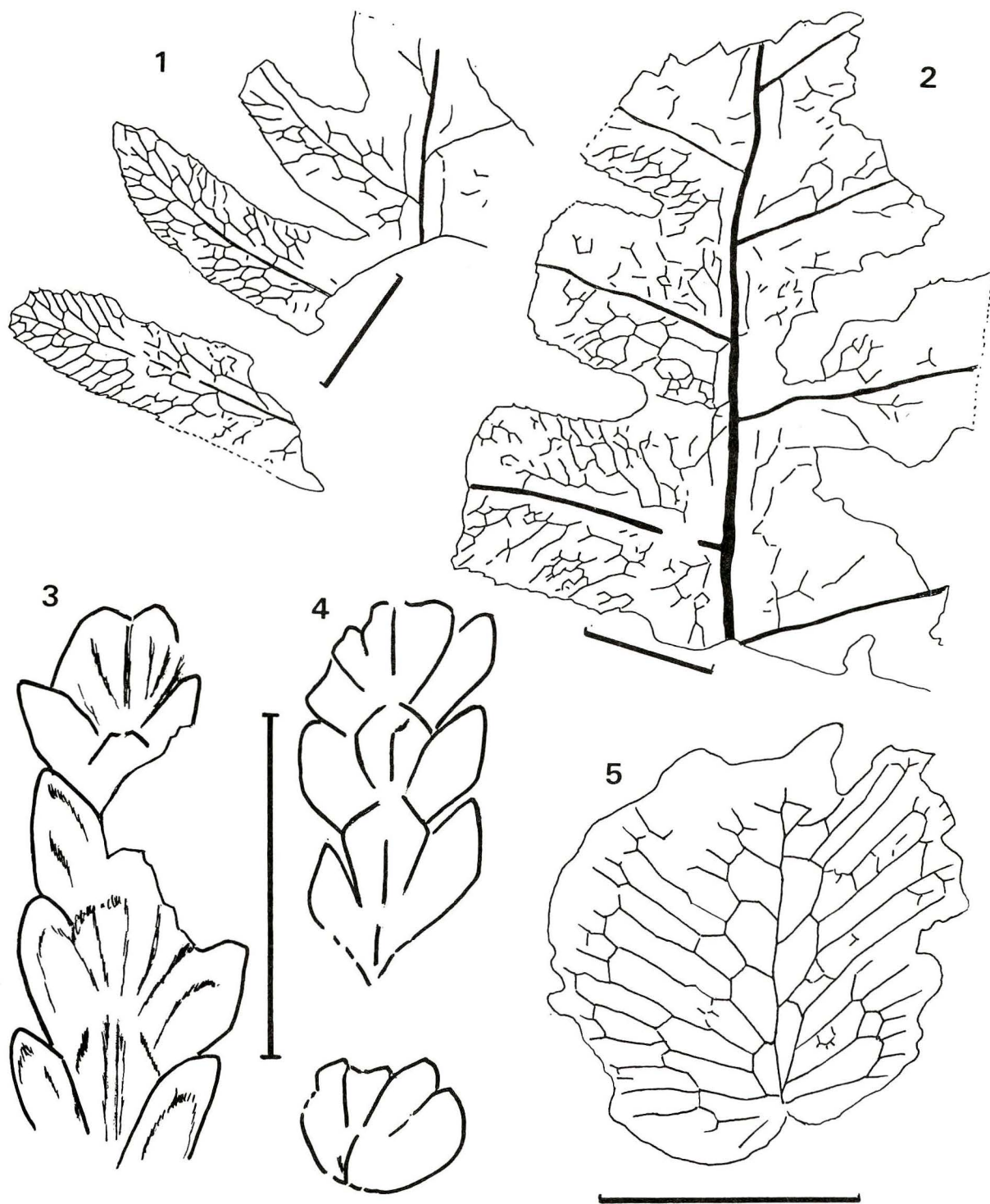


Fig. 24. The details of the venation characters (1).

Except as otherwise noted, the line for scale in each figure represents 1 cm.

1. *Selaginella* ? sp. KPM oz-marul0.
- 2,3. *Diplazium* sp. TNHM 4204 (Pl. 1, fig. 1), NHS 345.
4. *Cornopteris* sp. TNHM 4203 (Pl. 1, fig. 4).
5. *Asplenium* ? sp. KPM oz-yama18 (Pl. 1, fig. 3).



**Fig. 25.** The details of the venation characters (2).

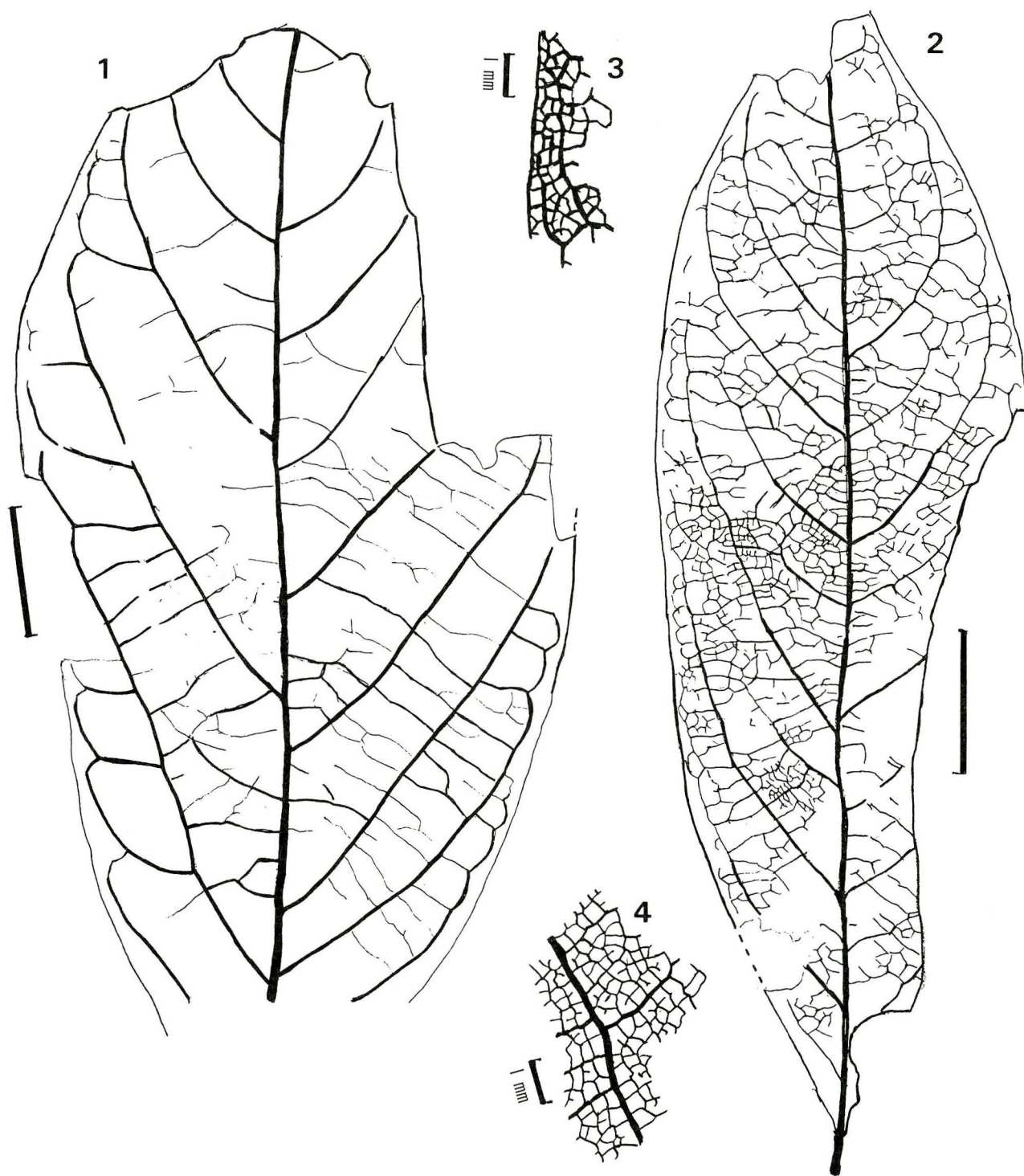
The line for scale in each figure represents 1 cm.

1,2. *Woodwardia* sp. TNHM 4206, 4209

3,4. *Thujopsis miodolablata* Tanai et N. Suzuki, KPM oz-ita-A2,3.

5. *Salvinia* sp. cf. *S. natans* Allioni.





**Fig. 26.** The details of the venation characters (3).

Except as otherwise noted, the line for scale in each figure represents 1 cm.

1. *Persea* sp. KPM oz-yag-Fb54a.
2. *Actinodaphne* sp. cf. *A. nipponica* Tanai, KPM oz-yag-Nl.
3. Ditto, a marginal part. It shows a fimbrial vein.
4. Ditto, a middle part. It shows simple or none ultimate veinlets among the areoles.

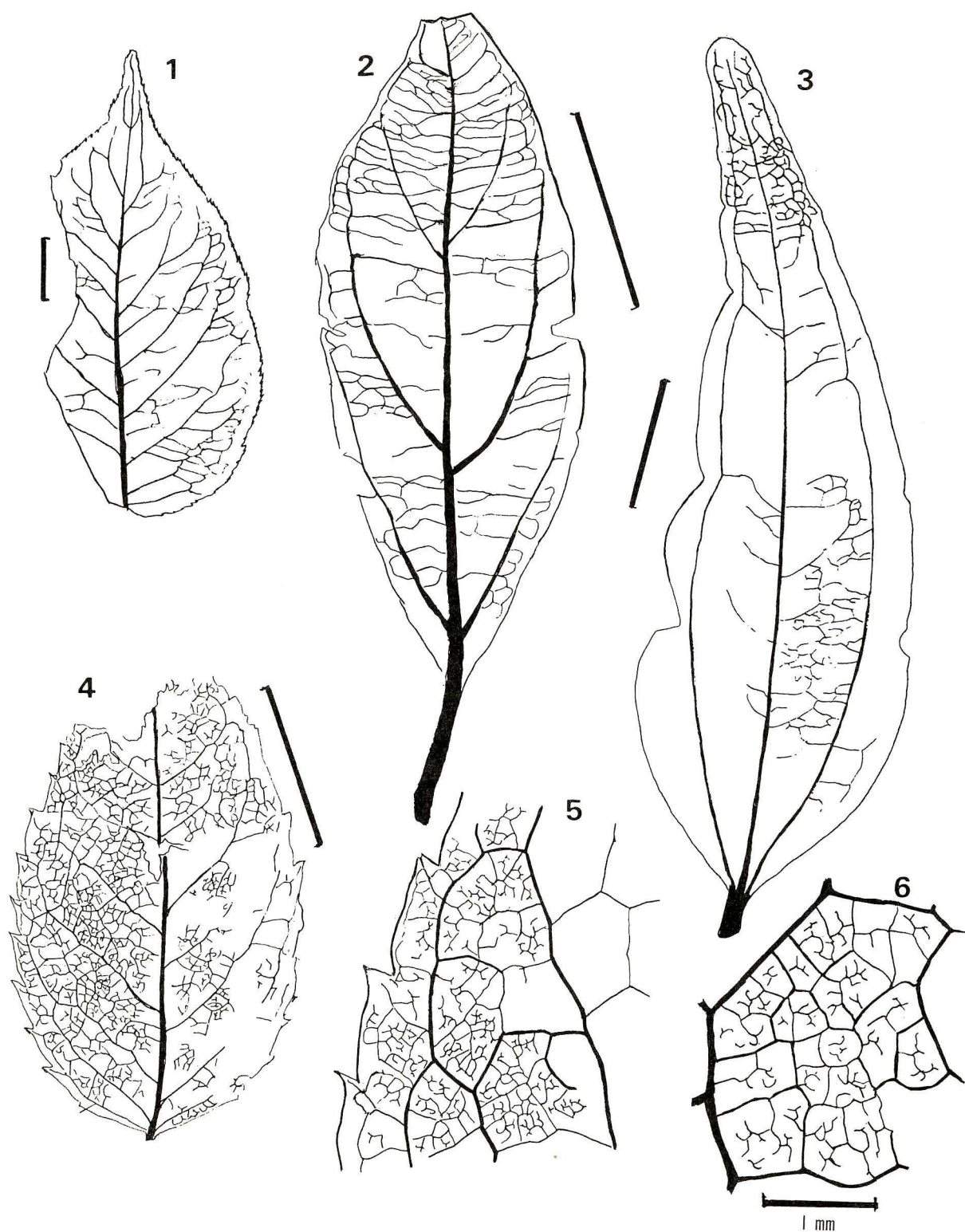


Fig. 27. The details of the venation characters (4).

Except as otherwise noted, the line for scale in each figure represents 1 cm.

1. *Malus* sp. O-1,
2. *Neolitsea* sp. K 54201-13.
3. *Coriaria* sp. cf. *C. japonica* A. Gray, K 54203-10. (Pl. 3, fig. 3).
- 4, 5, 6. *Rosa usyuensis* Huzioka, KPM oz-ita-G17a. 5: a part of 4; 6: a part of 5.



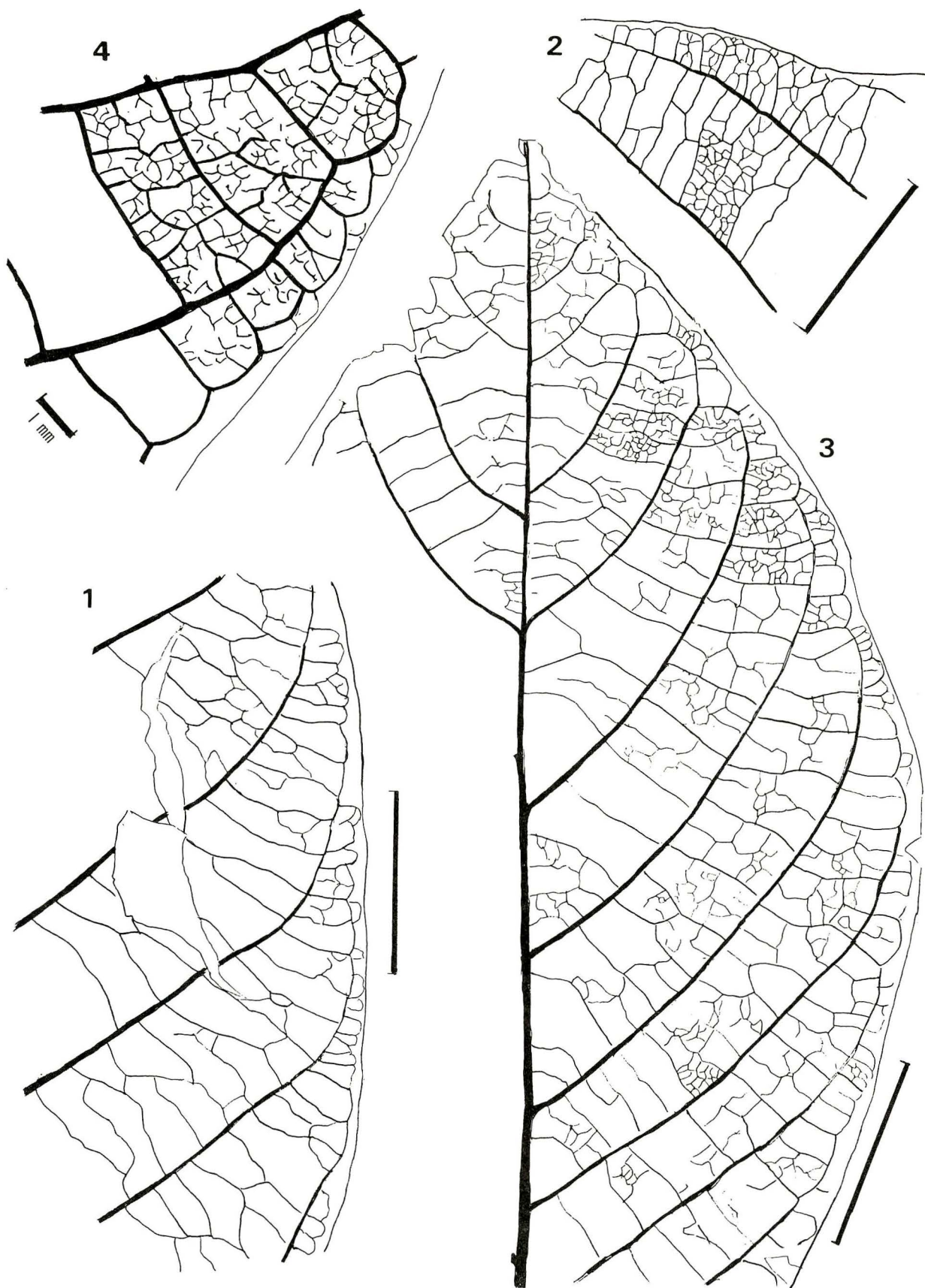


Fig. 28. The details of the venation characters (5).

Except as otherwise noted, the line for scale in each figure represents 1 cm.

1. *Cladrastis inouei* (Huzioka) Ozaki, K 5383-1 (Pl. 5, fig. 9).
2. Ditto, K 5364-2.
3. The Holotype of "*Rhus*" *inouei* Huzioka, AKMG 3130.
4. Ditto, the marginal part.

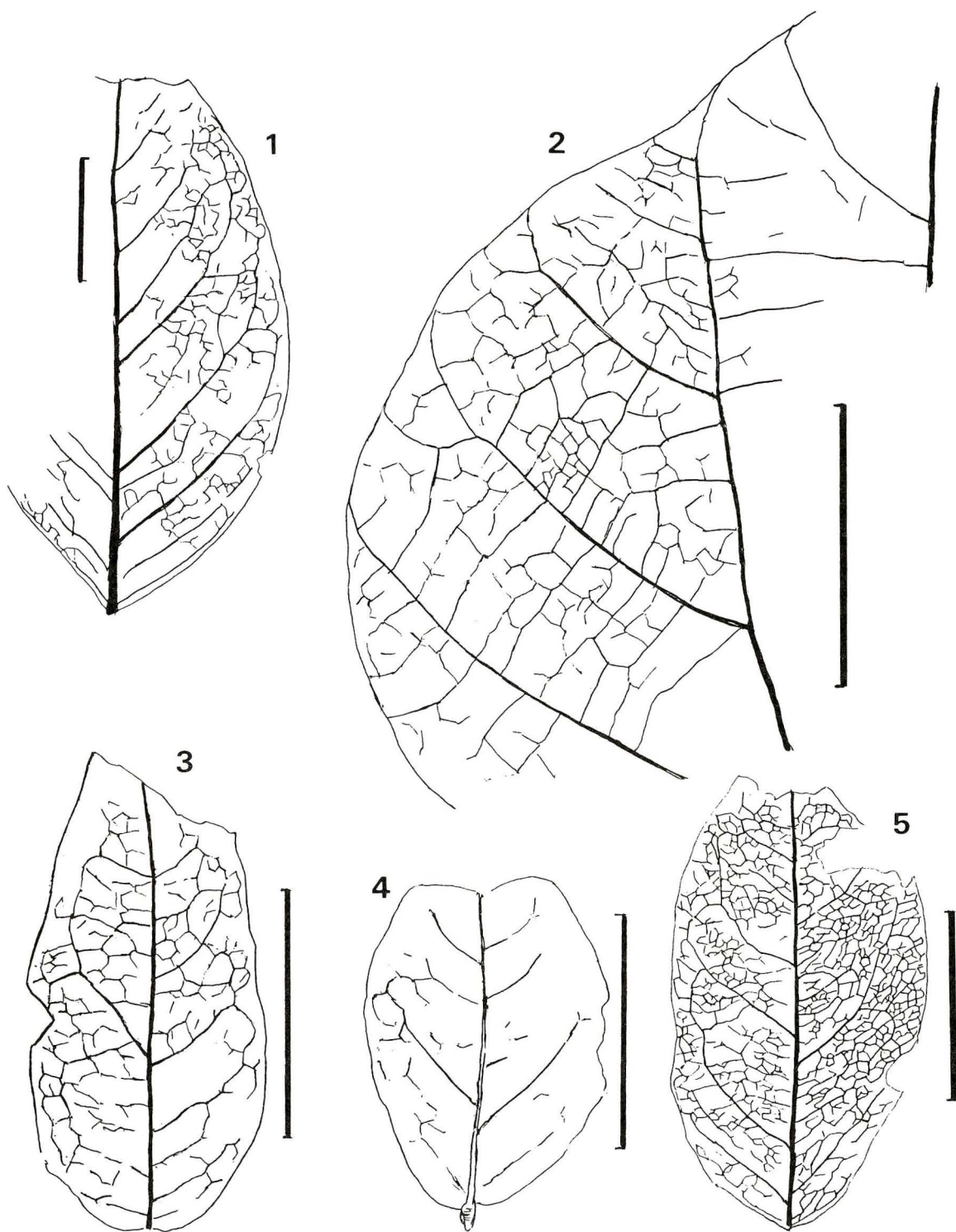
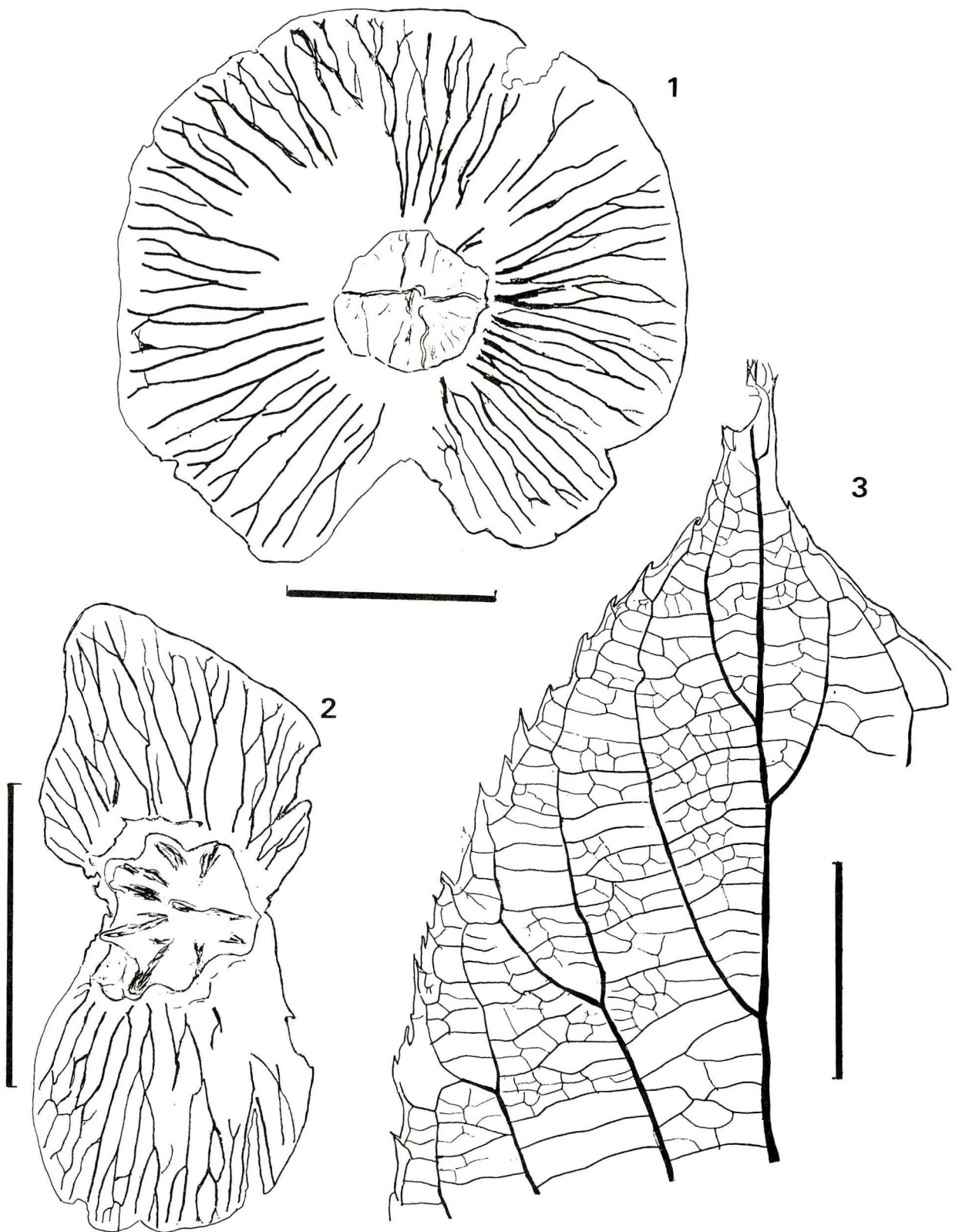


Fig. 29. The details of the venation characters (6).  
 The line for scale in each figure represents 1 cm.

1. *Lespedeza* sp. KPM oz-1214.
2. *Pueraria miothunbergiana* Hu et Chaney, KPM oz-1211.
- 3,4. *Caesalpinia hokiana* Ozaki, KPM oz-ita-G68c.
5. *Sophora hokiana* Ozaki, KPM oz-ita-H10a, oz-ita-K68.





**Fig. 30.** The details of the venation characters (7).

The line for scale in each figure represents 1 cm.

1. *Cyclocarya ezoana* (Tanai et N. Suzuki) Wolfe et Tanai, K 54231-8.
2. *Pterocarya asymmetrosa* Konno ex Tanai, K 54212-9.
3. *Weigela* sp. cf. *W. hortensis* K. Koch, KPM oz-1212.

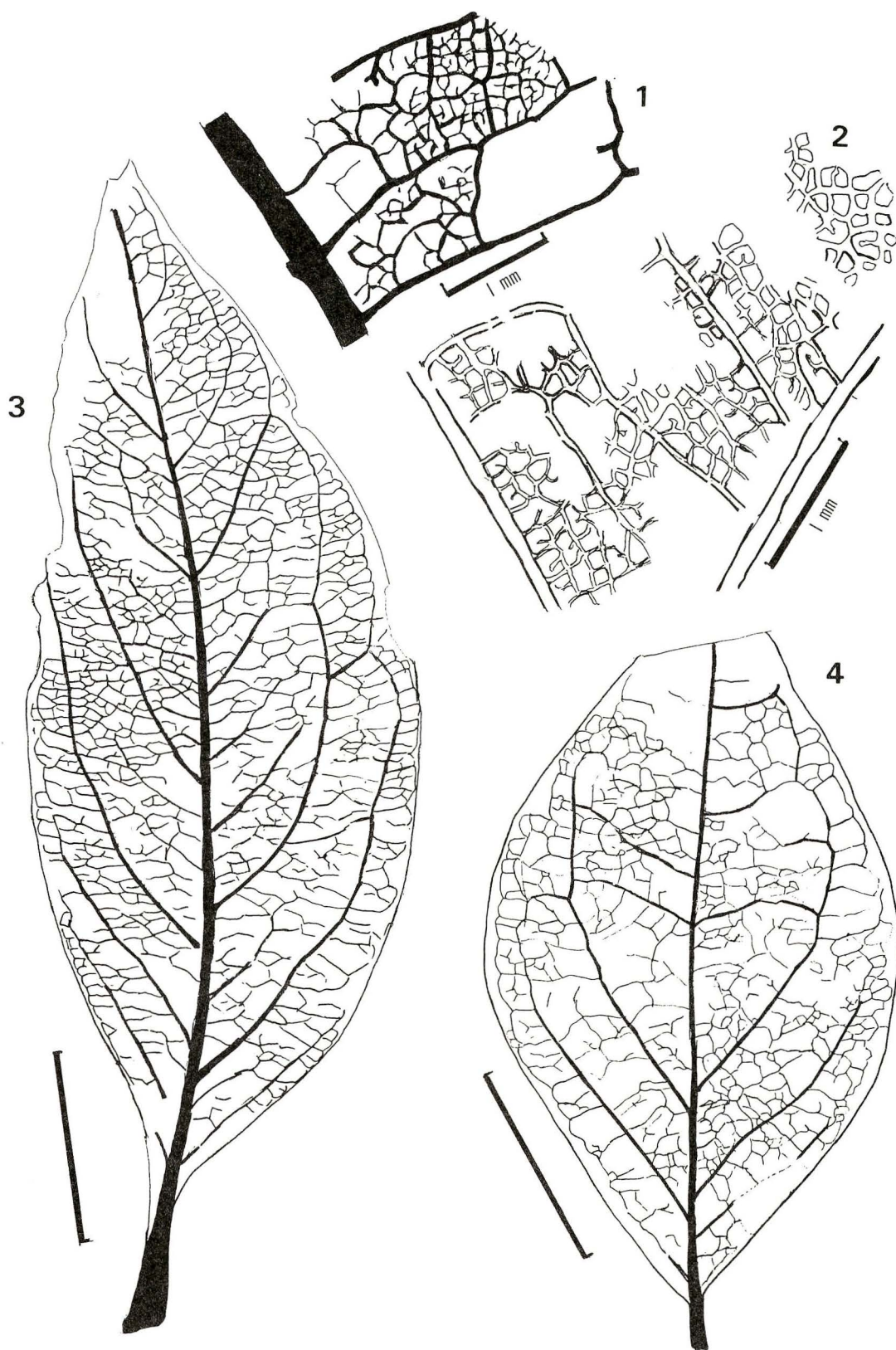
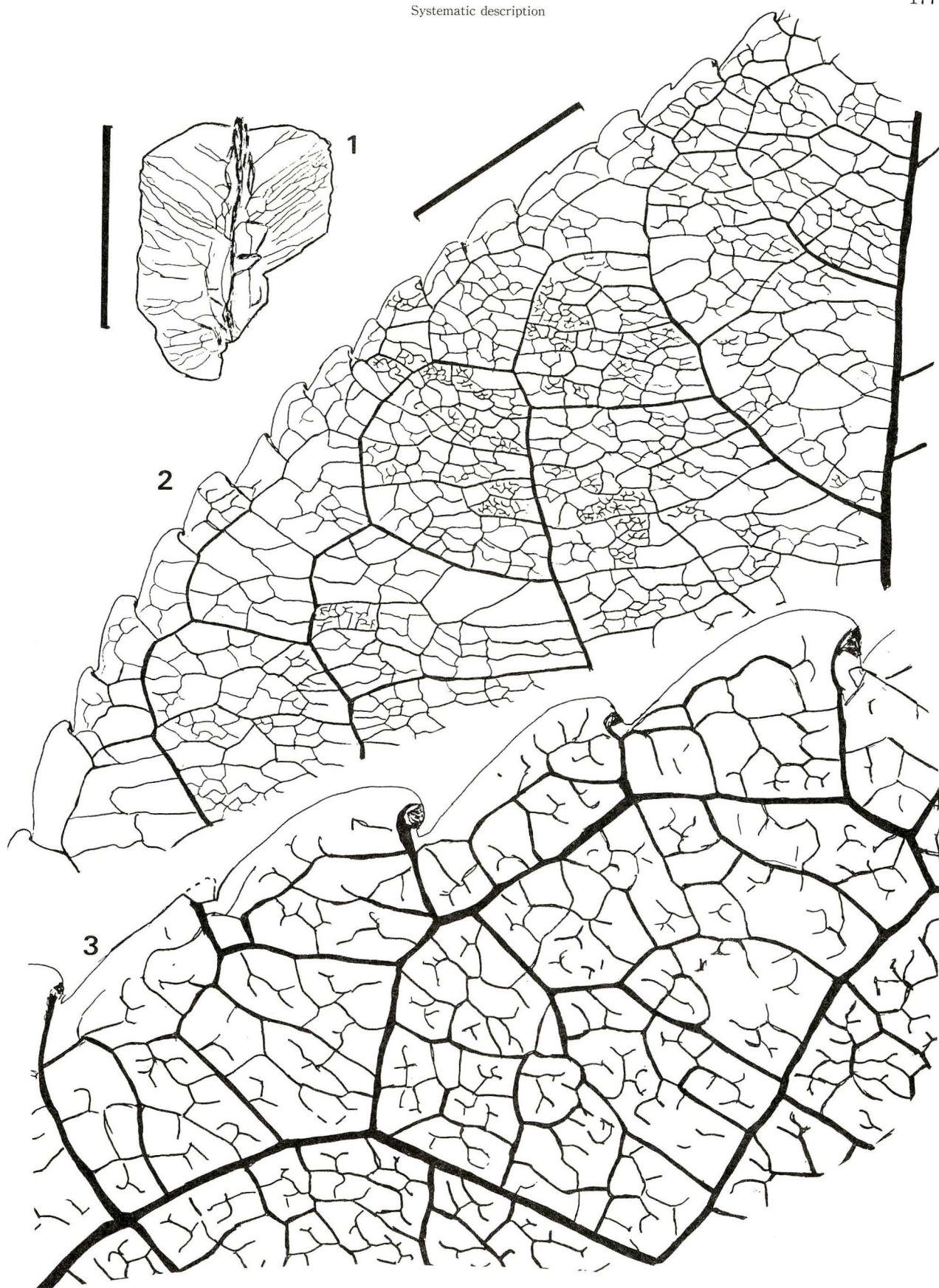


Fig. 31. The details of the venation characters (8).  
Except as otherwise noted, the line for scale in each figure represents 1 cm.

- 1,2. *"Ficus" tiliaefolia* Heer, 1, KPM oz-kabal: KPM oz-ita-K1.
3. *Pittosporum* sp. cf. *P. illicioides* Makino, KPM oz-ito13, (Pl. 15, fig. 10).
4. *Rhododendron hokiense* Ozaki, K 53820-1.

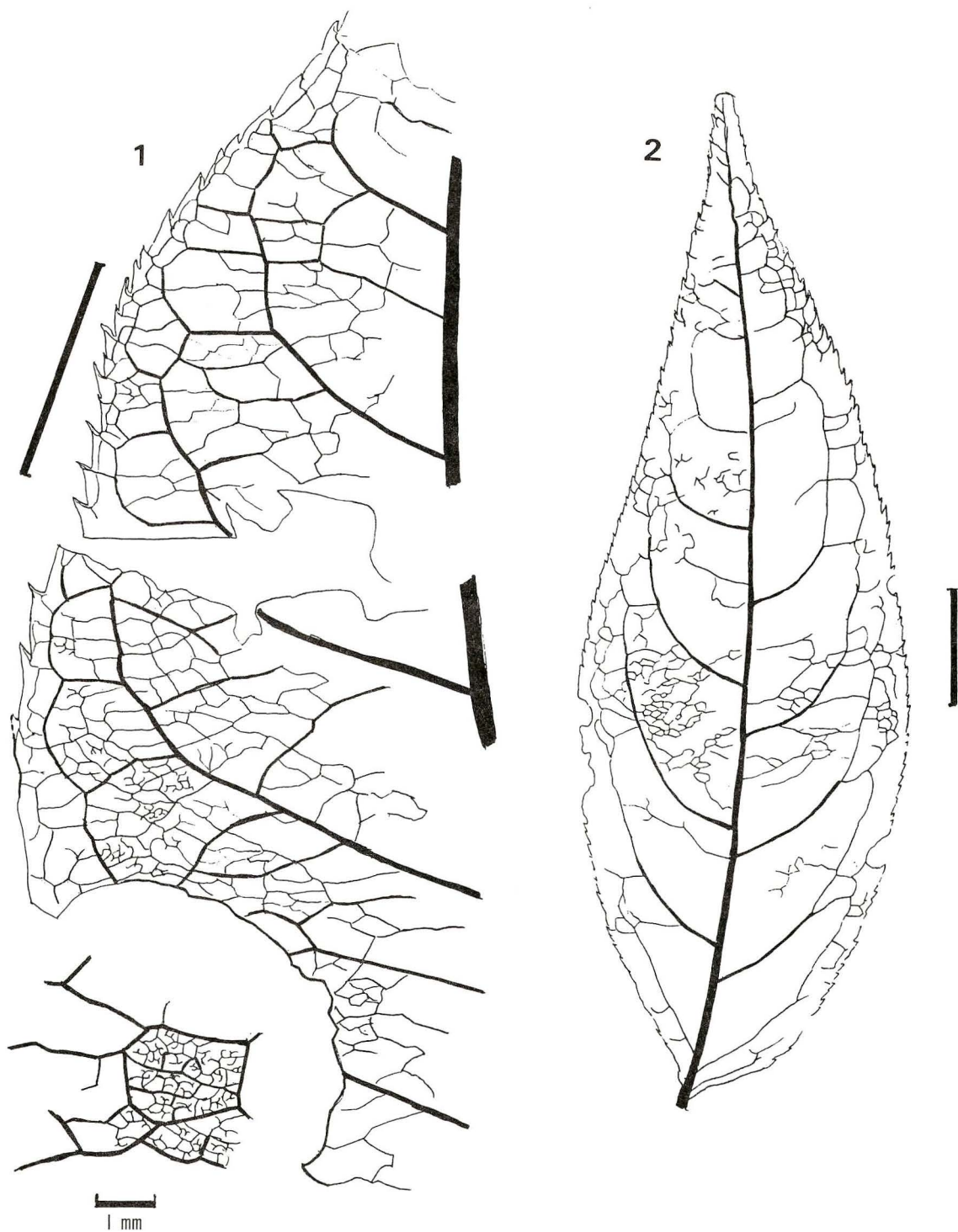




**Fig. 32.** The details of the venation characters (9).

The line for scale in each figure represents 1 cm.

1. Winged seed of *Tripterigium kabutoiwana* Ozaki n. sp. KPM oz-1254b, (Pl. 16, fig. 5).
- 2,3. Leaf of *Tripterigium kabutoiwana* Ozaki n. sp. Holotype, KPM oz-1188, (Pl. 16, fig. 6).

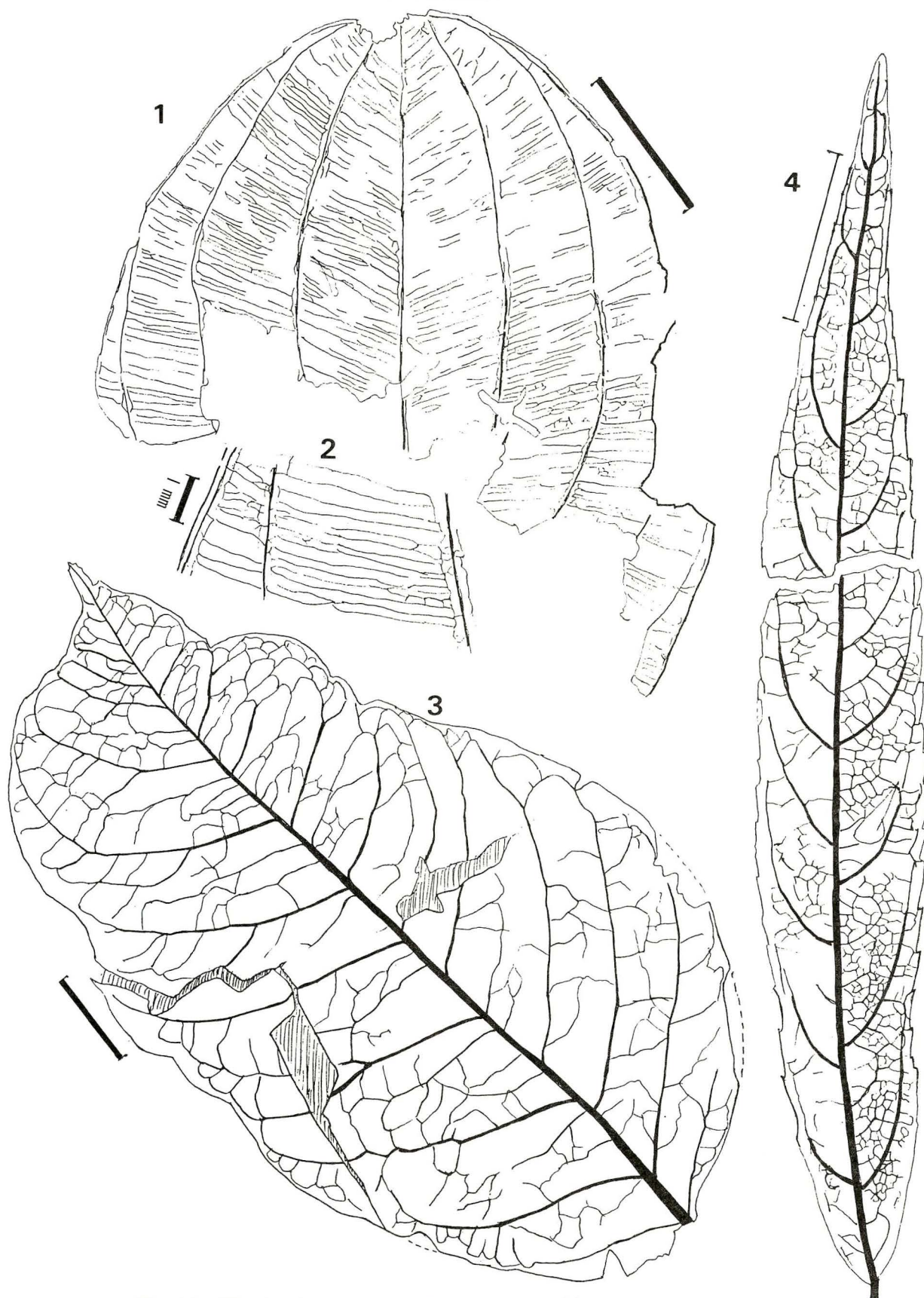


**Fig. 33.** The details of the venation characters (10).

Except as otherwise noted, the line for scale in each figure represents 1 cm.

1. *Staphylea* sp. cf *S. bumalda* DC., KPM oz-1221, (Pl. 20, fig. 10).
2. *Euscaphis* sp. cf *E. japonica* Cantiz., KPM oz-1220, (Pl. 20, fig. 9).

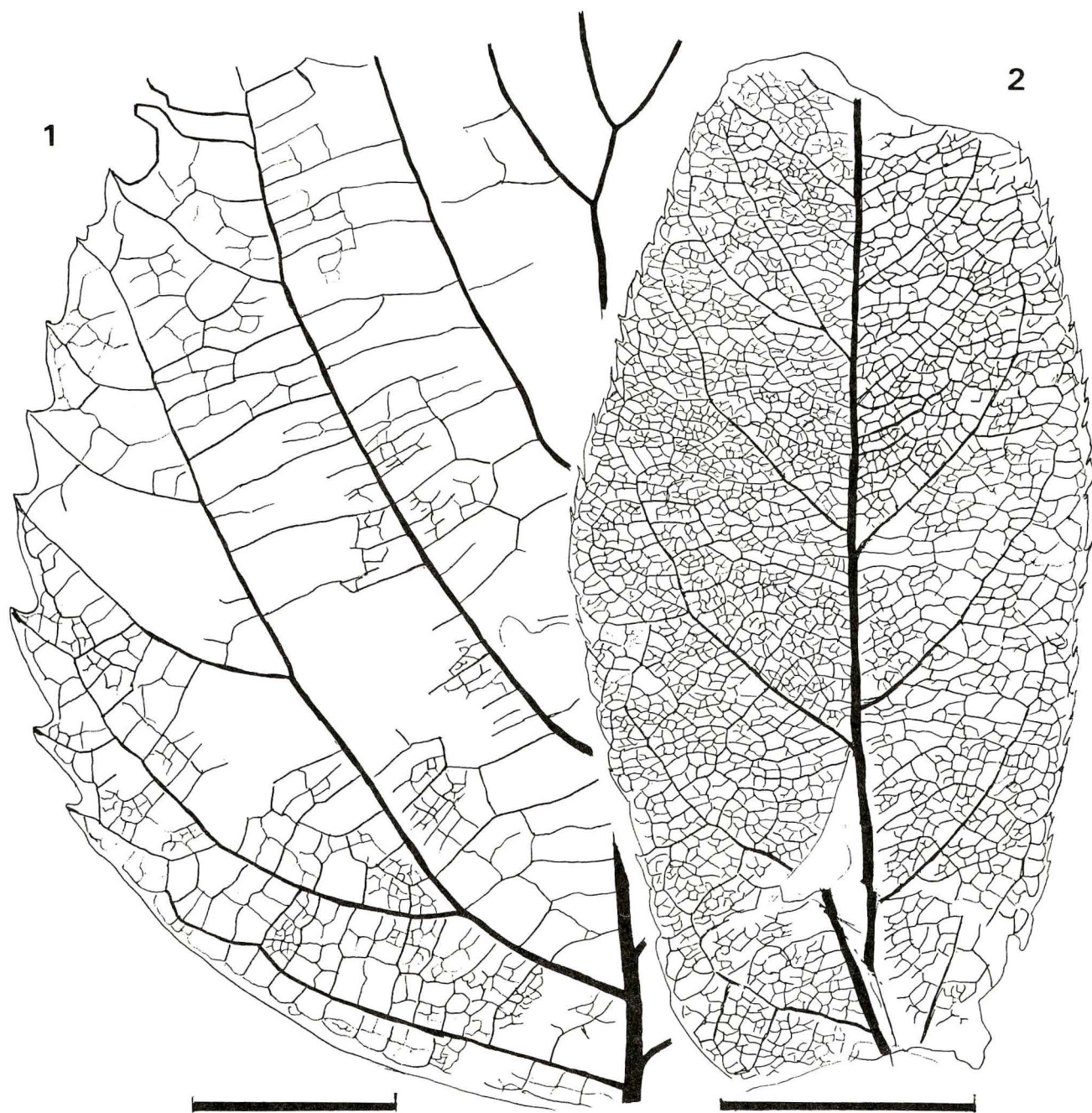




**Fig. 34.** The details of the venation characters (11).

Except as otherwise noted, the line for scale in each figure represents 1 cm.

1. *Caldesia* sp. KPM oz-ita-I24.
2. Ditto, the upper left part.
3. *Euodia* sp. cf. *E. rutaecarpa* Hock. et Thom. K 54203-1 (Pl. 18, fig. 3).
4. *Salix hokkaidoensis* Tanai et N. Suzuki, KPM oz-ita-H1 (Pl. 10, fig. 1).



**Fig. 35.** The details of the venation characters (12).  
The line for scale in each figure represents 1 cm.

1. *Shizophragma* sp. KPM oz-1189.
2. *Vaccinium* sp. KPM oz-ito22.