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Juglandaceae from the Paleogene of Hokkaido, Japan

By

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Abstract The Juglandaceae is one of the common members in the Paleogene of Hokkaido, Japan; the fossils of this family are represented mostly by detached leaflet impressions, and a few are by winged fruits. Based principally on leaf architecture, the fossil impressions are investigated, and 7 genera (*Palaeocarya*, *Carya*, *Ezocarya*, *Juglans*, *Cyclocarya*, *Pterocarya* and *Vinea*) and 11 species of the Juglandaceae are discriminated in the Eocene and Oligocene of Hokkaido. Of these 7 genera, the genus *Ezocarya* proposed here has the combination features of leaflets of *Carya*, *Juglans* and *Pterocarya*. New taxa and combinations proposed are: *Carya yubarica*, n. sp.; *Carya yubetsuensis*, n. sp.; *Cyclocarya kushiroensis*, n. sp.; *Ezocarya ishikariensis*, n. gen. and n. sp.; *Pterocarya ezoensis*, n. comb.; and *Vinea hokkaidoana*, n. sp. In addition, all the fossils of the Juglandaceae hitherto described from the Neogene of Hokkaido are reinvestigated, and the taxonomic alterations are presented.

Introduction

The Juglandaceae is a small family of deciduous trees, consisting of eight extant genera (*Alfaroa*, *Carya*, *Cyclocarya*, *Engelhardia*, *Juglans*, *Platycarya*, *Pterocarya*, and *Oreommunea*) and about 60 species. A monotypic genus *Annamocarya* that is native in Southeast China and northern Viet Nam is included in the genus *Carya* (MANNING, 1978). Most of the extant species of the family are widely distributed in the temperate and subtropic forests of the Northern Hemisphere. Furthermore, some genera extend south to the tropics across the equator except in Africa.

The Juglandaceae is one of the most common dicots in the Tertiary of the Northern Hemisphere. A number of juglandaceous fossil taxa have been described by various authors, based on foliage, wood, fruits, and dispersed pollen. Many critical reviews of the Juglandaceae in the fossil record have been presented by many authors. Especially, a comprehensive study by MANCHESTER (1987) is an important contribution to the evolutionary history of this family, including a critical review of fossil record of pollen, inflorescences, fruits, and foliage. It is, however, unfortunate that a few fossils of East Asia are included in his review.

Juglandaceous fossils are abundant in the Tertiary of East Asia, especially in the Neogene, represented by both leaflets and fruits. Detached leaflet fossils of Juglandaceae that were hitherto described from East Asia by many authors need to be reinvestigated in combination of fruit fossils, because their generic assignment seems to be confused. Compared with common occurrence of fruit fossils in the Neogene,

juglandaceous fossils in the Paleogene of East Asia are mostly represented by detached leaflets. These Paleogene fossil record may provide a basis for discussing the East Asian evolutionary history of the Juglandaceae, although generic assignments may be sometimes difficult only by leaflet. It is the subject of this paper to descibe Paleogene julandaceous taxa of Hokkaido, and to discuss their modern relationships.

Juglandaceous taxa from the Paleogene of Hokkaido

Juglandaceous fossils abundantly occur in the Paleogene of Hokkaido: from the Eocene coal-bearing formations of the Kushiro, Ishikari and Uryu coal fields, and the Oligocene Wakamatuzawa Formation of Kitami region. Many detached leaflets (*Carya* and *Platycarya*) from the Kushiro field (TANAI, 1970) and some winged fruits (*Engelhardia*) of Kitami region (TANAI & UEMURA, 1983) were already described. Most of the Kushiro specimens, however, are poorly preserved in the fine venation features, leading the generic misidentification. Combined with many well-preserved specimens of the Ishikari field, the Kushiro specimens are reinvestigated. Thus, the Paleogene specimens of the Juglandaceae from Hokkaido consist of 7 genera and 11 species as follows:

Platycaryoideae

Palaeocarya koreanica (OISHI) MANCHESTER

Juglandoideae

Carya yubarica TANAI sp. nov.
Carya yubetsuensis TANAI sp. nov.
Cyclocarya kushiroensis TANAI sp. nov.
Cyclocarya sp.
Ezocarya ishikariensis TANAI gen. et sp. nov.
Ezocarya sp.
Juglans sp.
Pterocarya ezoensis (TANAI) TANAI comb. nov.
Pterocarya sp. cf. *P. nigella* (HEER) WOLFE
Vinea hokkaidoana (TANAI) TANAI comb. nov.

Of the plants listed above three genera of *Palaeocarya*, *Ezocarya* and *Vinea* are the extinct genera, and others are the extant. *Palaeocarya* based on trilobed winged fruits and foliage was originally described by SAPORTA (1878); this extinct genus was recently emended by MANCHESTER (1987) to be represented by only winged fruit similar to both *Engelhardia* and *Oreomunnea*, excluding foliage fossils. *Palaeocarya* is widely known in the Eocene to Miocene of the Northern Hemisphere, especially of Europe and North America.

Ezocarya and *Vinea* are represented only by leaflets; the former is proposed in this paper on the basis of many Eocene specimens of Hokkaido, and the latter was described by WOLFE (1969), based on Eocene specimens of Washington. *Ezocarya* is closely similar to some of the extant *Carya* in major venation, but it is also similar

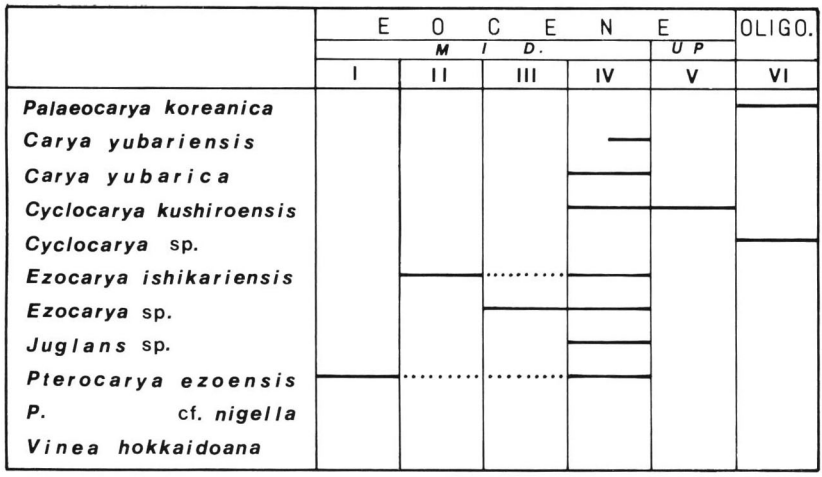

Fig. 1. Stratigraphic distribution of the Juglandaceae in the Paleogene of Hokkaido.
The Roman numerals (I-VI) show the plant-bearing horizons of Hokkaido. (see TANAI, 1990)

to some of the extant *Juglans* and *Pterocarya* in margin, foliar shape and stalk features; this extinct genus indicates a combination feature of *Carya*, *Juglans* and *Pterocarya*. *Vinea* is suggested to be related to the monotypic genus *Platycarya* by WOLFE (1977) and MANCHESTER (1887), but it is rather related to some of *Carya* and *Juglans* as discussed later in detail.

Among 11 species of the Juglandaceae from Hokkaido only *Cyclocarya* is repersented by both leaflet and winged fruit. The specimens of Hokkaido show the oldest recored of this genus in East Asia so far as known at the present. *Cyclocarya*, a monotypic genus native in China, has been well recongnized from the Miocene and Pliocene of Japan, even from the Lower Pleistocene, based on winged fruit and leaflet. The leaf architecture of Hokkaido specimens confirms the presence of *Juglans*, *Pterocarya* and *Carya* during the Eocene. These three genera are commonly known in the Miocene to the Pleistocene in Japan, based on leaflet and fruit, although their leaflets appear to be confused in identification.

It is noteworthy that few fossils doubtlessly referable to *Platycarya* have been found in the Tertiary of East Asia. My reinvestigation reveals that three leaflets described as *Platycarya* from the Eocene of Kushiro coal field, Hokkaido (TANAI, 1970) are transferred to *Vinea* and *Carya*. Several leaflets known as *Platycarya miocenica* have been desribed from the Miocene of China, Korea and Japan by several authors, although they are uncommon. The original specimens from Shanwang, China (HU and CHANEY, 1938) may be a complex of *Platycarya* and *Carya* as already pointed out by SZE (1951). The leaflet specimens hitherto described as *Platycarya* by many authors need to be reinvestigated. However, some specimens supplemented from

Shanwang (Acad. Sinica, 1978: pl. 61, fig. 2b; pl. 61, fig. 1) appear to represent *Platycarya* in the termination features of the secondary vein. So far as reinvestigated, there is no fossil leaflet doubtlessly referable to *Platycarya* in the Miocene of Hokkaido. Furthermore, no fossil pollen of *Platycarya* has been reported in the Tertiary of East Asia up to the present. On the other hand, there have been abundant records of *Platycarya* in the Paleogene of North America (LEOPOLD and MACGINITIE, 1972; WOLFE, 1977; WING and HICKEY, 1984; MANCHESTER, 1987; others) and of Europe (CHANDLER, 1964), based on leaflet, pistillate cone, winged seed and pollen. So far as known up to the present, these fossil records may indicate that *Platycarya* originated in North America, although the modern distribution of this genus is confined in China and Japan. However, it needs to be further investigated whether or not *Platycarya* inhabited during the older Tertiary of East Asia.

Eleven species of the Juglandaceae are confirmed from the Middle Eocene to the Middle Oligocene in Hokkaido, and their stratigraphic distribution is shown in Fig. 1. The fossil localities of each species and stratigraphic names of fossil bearing beds are indicated in systematic chapter, and their abbreviated numbers are referred to those of the previous paper (TANAI, 1981, 1989).

Systematic Descriptions

Order Juglandales

Family Juglandaceae

Genus *Palaeocarya* SAPORTA

Palaeocarya koreanica (OISHI) MANCHESTER

Palaeocarya koreanica (OISHI) MANCHESTER. 1987. Monogr. Syst. Bot., 21: 55, Fig. 30 E.
Engelhardia koreanica OISHI. 1936. J. Geol. Soc. Jap., 43: 58, fig. 1–3.
TANAI and UEMURA. 1983. J. Fac. Sci., Hokkaido Univ., [4], 20: 251, pl. 1, figs. 1–7; pl. 2, 4gs. 1, 7; pl. 3, figs. 1, 2 (see synonymy for *E. koreanica*).

Discussion: MANCHESTER (1987) redesignated engelhardioid winged fruit fossils as *Palaeocarya* which was originally described by SAPORTA (1873): this extinct genus includes trilobed fruits not only with the tri-veined pattern, but those with a single medial vein and pinnate secondary veins; the former represents the section *Palaeocarya*, and the latter represents the section *Monocarya*.

Engelhardia koreanica, represented by trilobed winged fruit, was known from the Oligocene of Hokkaido, Sikhote-Alin and North Korea; it was recently included in the genus *Palaeocarya* sect. *Palaeocarya* by MANCHESTER (1987). However, the two sections, *Palaeocarya* and *Monocarya*, are not always distinctive in the venation of wing lobe, because there are intermediate forms between tri-veined and pinnate features. Especially, the fossils whose secondary veins of lobes diverge at narrower angles are sometimes difficult to distinguish from those with tri-veined pattern. As already discussed by TANAI and UEMURA (1983), the lobe venation of "*E. koreanica*"

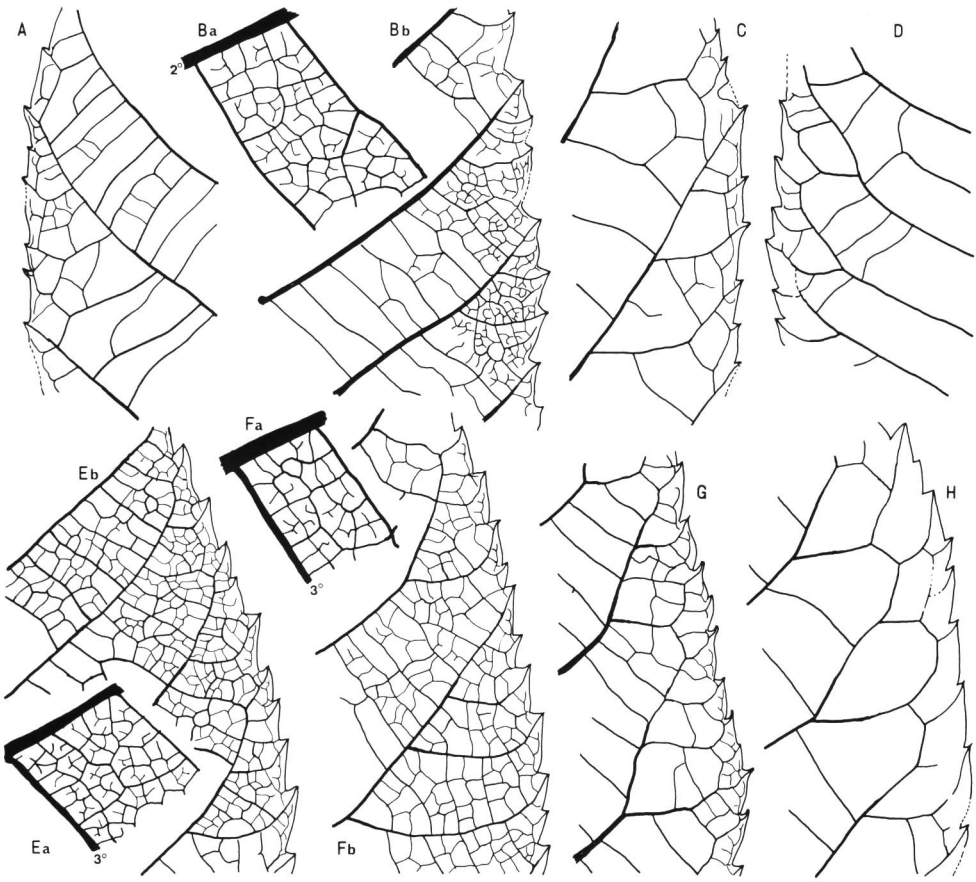

Fig. 2. The venation features of marginal area and areoles of Paleogene *Carya* and *Cyclocarya* and their related extant species.

A. *Carya yubarica* TANAI. NSM-PP 1782 (pl. 2, fig. 2). ×2.5

Ba, b. *Carya yubetsuensis* TANAI. HUMP 26911 (pl. 2, fig. 1). Ba: ×15 Bb: ×4

C. *Carya yubarica* TANAI. Holotype NSM-PP 10403 (pl. 1, fig. 1). ×2.5

D. *Cyclocarya kushiroensis* TANAI. Holotype HUMP 26906 (pl. 8, fig. 1). ×2.5

Ea, b. *Carya cordiformis* (WANG.) K. KOCH. NSM Paleobot. Ref. Coll. T-1212. Ea: ×15 Eb: ×2.5

Fa, b. *Carya ovalis* (WANG.) SARGENT. NSM Paleobot. Ref. Coll. T-1556. Fa: ×15 Fb: ×2.5

Ga, b. *Cyclocarya paliurus* (BATAL.) ILJINSKAYA. NSM Paleobot. Ref. Coll. T-1756. Ga: ×15 Gb: ×2.5

H. *Cyclocarya ezoensis* TANAI. NSM-PP 10488 (pl. 8, fig. 4) ×2.5

is not tri-veined but a single medial-veined with pinnate scondaries. These venation feature indicates that "*E. koreanica*" may be included in the sect. *Monocarya*, if the Manchester's classification is accepted. It should be furthermore noted that

"*E. koreanica*" is distinguishable from the European and North American fossil fruits of the sect. *Palaeocarya* in having long persistent pedicel and in lacking prophyllum (fourth lobe).

Occurrence: Futamata, Yubari City, Hokkaido (Poronai Formation); Minamigaoka and Wakamatsuzawa, Kitami City, Kokkaido (Wakamatsuzawa Formation).

Collection: NSM-PP 1777 (=NSM 10461), 16333, 16334, 16351.

Genus *Carya* NUTT.

Carya yubarica TANAI sp. nov.

(pl. 1, figs. 1–4; pl. 2, fig. 2–4; Fig. 2-A, C)

Betula brongniarti auct. non ETTIGSHAUSEN, ENDO. 1968(part). Bull. Natn. Sci. Mus. 11(4): 423. pl. 7. fig. 2.

Carya ezoensis TANAI. 1970(part). J. Fac. Sci. Hokkaido Univ. [4]. 14(4): 464. pl. 6. fig. 4; pl. 15. fig. 7.

Typus: Holotype NSM-PP 10403; Reisui-zan, Yubari, Hokkaido; Ikushunbetsu Formation (early Late Eocene). Paratypes UHMP nos. 26907, 26908; Harutori coal mine, Kushiro, Hokkaido; Harutori Formation (early Late Eocene).

Diagnosis: The specimens are represented both by detached terminal and lateral leaflets, 8.5–14 cm long and 4.2–6.8 cm wide, length/width ratio 1.87–2.39. Terminal leaflets elliptic in shape, acute at apex, rounded at base; petiolule more than 1 cm long. Lateral leaflets narrow-oblong to narrow elliptic, acute at apex, asymmetrically cuneate to rounded, or rarely cordate at base; sessile. Margin serrate; teeth small, acute with glandular pointed tips; teeth between two principal teeth typically four, and each accompanied sometimes by one minute tooth. Venation pinnate; midvein thick, straight; secondary veins 15–20 pairs, somewhat irregularly spaced, subopposite, diverging at 50° to 80°, gently curving up, typically craspedodromous or sometimes camptodromous; intersecondary present but uncommon, parallel to secondaries; 3 marginal tertiary veins departing basally, angularly arising upward, craspedodromous or camptodromous; intercostal tertiaries percurrent, straight or slightly convex, simple or branching, perpendicular to secondaries, with 1.5–2.2 mm distance; quaternary veins well defined, perpendicular to tertiaries, straight or forking; the highest order venation seventh; areoles four or five sided, 0.15–0.26 mm across; freely ending veinlets once branching.

Discussion: The numerous secondary veins that are craspedodromous and camptodromous, well-defined tertiary veins, and cuneate base of lateral leaflets are features of certain extant species of *Carya*. Especially, the serrate margin with acute teeth, and termination features of secondary and marginal tertiary veins indicate that these fossil leaflets are closely similar to *C. ovalis* (WANG.) SARGENT of eastern North America.

Combined many juglandaceous specimens of the Kushiro coal field together with those of the Ishikari field, the reinvestigation reveals that leaflets of *C. ezoensis* (TANAI, 1970) are a complex of those of the Juglandaceae such as *Carya*, *Cyclocarya*

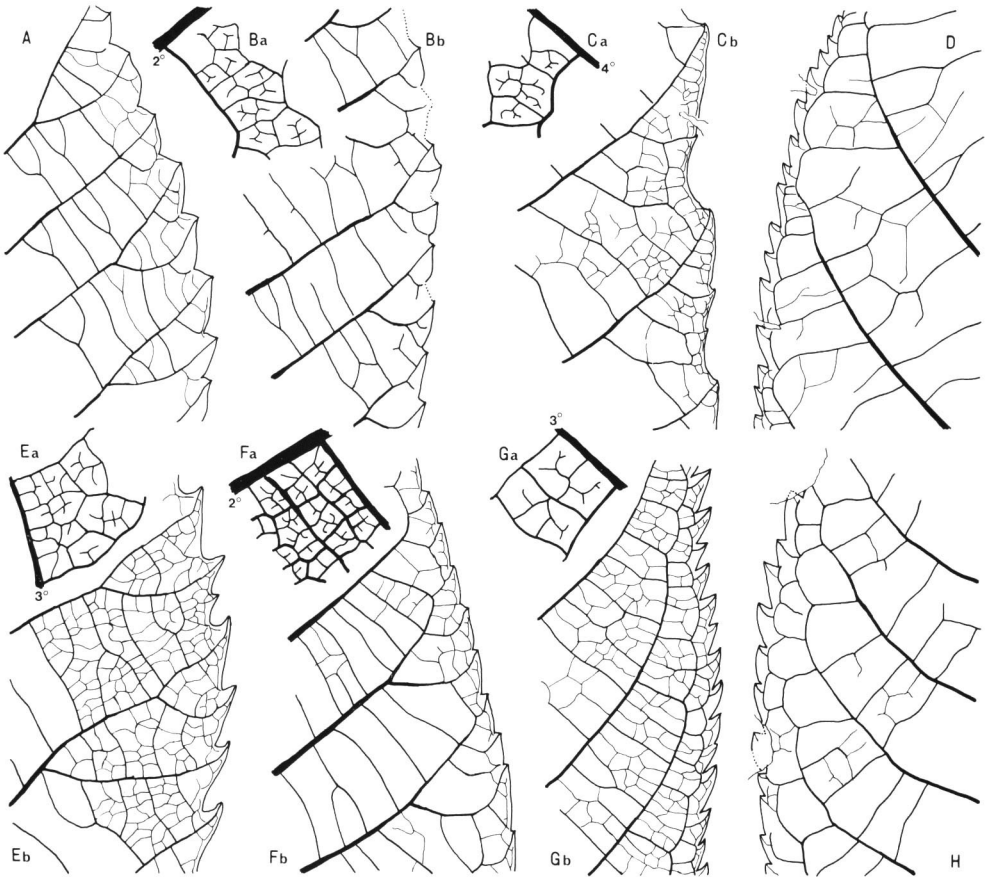

Fig. 3. The vention features of marginal area and areoles of *Vinea*, *Ezocarya* and Paleogene *Pterocarya* and their related extant plants.

A. *Vinea hokkaidoana* (TANAI) TANAI. Holotype HUMP 26910 (pl. 3, fig. 5). ×2.5

Ba, b. *Vinea hokkaidoana* (TANAI) TANAI. NSM-PP 10340 (pl. 7, fig. 3). Ba: ×15 Bb: ×2.5

Ca, b. *Ezocarya ishikariensis* TANAI. Holotype NSM-PP 10411 (pl. 3, fig. 3). Ca: ×15 Cb: ×2.5

D. *Pterocarya ezoensis* (TANAI) TANAI. NSM-PP 10427 (pl. 6, fig. 3). ×2.5

Ea, b. *Carya laciniosa* (MICHX.) LOUD. NSM Paleobt. Ref. Coll. T-1865. Ea: ×15 Eb: ×2.5

Fa, b. *Carya ovata* (MILL.) K. KOCH. NSM palaeobot. Ref. Coll. T-1214. Fa: ×15 Fb: ×2.5

Ga, b. *Pterocarya rhoifolia* SIEB. et ZUCC. NSM Palaeobot. Ref. Coll. T-39. Ga: ×15 Gb: ×2.5

H. *Pterocarya* sp. cf. *P. nigella* (HEER) WOLFE. NSM-PP 10452 (pl. 5, fig. 3). ×2.5

and *Pterocarya*. Such misidentification was partly due to the fact that these Kushiro specimens were poorly preserved in the venation and marginal features. Some specimens of *C. ezoensis* are valid in identification as indicated in the above synonymy, although its holotype and paratype are transferred to other genera of Juglandaceae. Among Paleogene species of the Juglandaceae in Hokkaido, *Carya yubarica* is most common.

Occurrence: Kushiro coal field Kh-1; Ishikari coal field Ic-3, Ic-9, Ic-11.

Collections: Holotype NSM-PP 10403; paratype NSM-PP 10404; hypotype NSM-PP 10405; NSM-PP 10406–10410; HUMP nos. 26907, 26908.

Carya yubetsuensis TANAI sp. nov.

(pl. 2, figs 1; Fig. 2–B)

Platycarya hokkaidoana TANAI. 1970(part). J. Fac. Sci., Hokkaido Univ. [4]. 14(4): 465. pl. 7. fig. 6.

Typus: Holotype HUMP no. 26911; Nakanosawa, Yubetsu coal mine, Akan-cho, Hokkaido; Yubetsu Formation (Late Eocene).

Diagnosis: Leaflet lanceolate in shape, 7.8 cm long and 2.7 cm wide; apex slightly long acuminate; base asymmetrical, rounded; margin serrate with broadly triangular, small dentate teeth; teeth two per secondary vein on the upper margin while three on the lower. Venation pinnate; midvein slightly arcuate; secondary veins 15 pairs, diverging at 50°—80°, gently curving up, typically craspedodromous; one or two marginal tertiary veins departing basally, then curving or bending up to enter teeth; intercostal tertiary veins percurrent, perpendicular to secondaries, single or branching, irregularly spaced with 1 to 3 mm distance; quaternary veins forming irregular networks; the highest order venation 7th; areoles mostly four-sided, 0.2–0.3 mm across; freely ending veinlets mostly single.

Discussion: Of the specimens described as *Platycarya hokkaidoana* from the Kushiro coal field (TANAI, 1970), two leaflets including its holotype are transferred to *Vinea*, and the remaining one is here reassigned to *Carya* in the termination features of secondary veins. The secondary veins of *C. yubetsuensis* enter directly teeth, while those of *Platycarya* bifurcate just befor the bottom sinus, and one enters teeth apically and the other arises along the margin.

C. yubetsuensis is apparently different from *C. yubarica* in teeth shape and tooth number per secondary. The craspedodromy of secondary veins with 1 or 2 abmedial tertiary branches, and small dentate teeth are features that ally *C. yubetsuensis* to the extant *C. cordiformis* (WANG.) K. KOCH. This extant species, however, is usually wider in the distance of tertiary veins than *C. yubetsuensis*.

Occurrence: Kushiro coal field Ky-2.

Collection: Holotype HUMP no. 26911.

Genus *Cyclocarya* ILJINSKAYA

Cyclocarya kushiroensis TANAI sp. nov.

(pl. 8, figs. 1, 2, 4; Fig. 2-D, H)

Carya ezoensis TANAI. 1970(part). J. Fac. Sci., Hokkaido Univ. [4]. 14(4): 464. pl. 6. fig. 3.
FOTJANOVA, 1984. Bot. Zhur., 69(4): 432. pl. 2, figs. 4, 7; text-fig. 1–10.

Typus: Holotype HUMP no. 26906; Harutori coal mine, Kushiro, Hokkaido; Harutori Formation (early Late Eocene). Paratype NSM-PP 10448; Chinomizawa, Shoro, Shiranuka-cho, Hokkaido; Shakubetu Formation (late Late Eocene).

Diagnosis: Leaflets inequilateral, narrow oblong, 5.3–8.9 cm long and 2.5–3.9 cm wide, length/width ratio 2.12–2.28; apex acute to obtuse; base rounded; margin serrate; teeth acute with slightly acuminate pointed tip (teeth type typically D4), irregularly spaced, 3 to 4 per secondary vein; sessile. Venation pinnate; midvein nearly straight but arcuate at apical part; secondary veins 13–16 pairs, diverging at 50°–70°, gently curving, becoming sinuous toward margin, angularly camptodromous; intersecondary veins sometimes present; two or three subsecondary veins branching basally as bifurcation of secondary, craspedodromous or camptodromous, subsecondary bifurcation from the secondary first occurring usually in approximately two-thirds or three-fourths the distance to the margin; intercostal tertiary veins percurrent, irregularly spaced (3–4.5 mm distance), somewhat sinuous, single or branching, perpendicular to secondaries; quaternary veins reticulate; the higher order venation ill-preserved.

Fruit composed of a small nut in the center of a wing. Wing circular, somewhat undulate on margin, 2 cm in diameter; fine veins radiating from the center, closely spaced, dichotomizing; nut quadrangular in overlooking outline, 7 mm in diameter.

Discussion: Of several leaflets described as *Carya ezoensis* (TANAI, 1970), a single leaflet is transferred to the monotypic genus *Cyclocarya*. Adding two leaflets from the Shakubetsu Formation of the Kushiro coal field, the above diagnosis is here described. The bifurcation features of secondary veins, subsecondary branches that are both craspedodromous and camptodromous, and irregularly spaced teeth with apiculate tip (3–4 teeth per secondary), are characteristic of *Cyclocarya*. A leaflet of *Carya ezoensis* described from the Eocene of northern Kamchatska (FOTJANOVA, 1984) is also included in *Cyclocarya ezoensis* by secondary venation features and apiculate marginal teeth.

A single winged fruit from the Ishikari coal field is referable to *Cyclocarya* in its circular wing with dichotomizing fine veins, although the wing is a half smaller than the average size of the extant *C. paliurus* (BATAL.) ILIJINSKAYA. No. fossil leaflet referable to *Cyclocarya* has been yet found in the Ishikari Group, but this fruit specimen is probably conspecific with the Kushiro leaflet.

The Miocene species, *C. ezoana* (TANAI & N. SUZUKI) WOLFE & TANAI, is distingushable from *C. kushiroensis* in having sharper teeth of leaflets and more larger wing fruit.

Occurrence: Kushiro coal field Kh-1, Ks-3; Ishikari coal field Ic-11.
Collections: Holotype HUMP no. 26906; paratype NSM-PP 10448; hypotype NSM-PP 10426; NSM-PP 10449.

Cyclocarya sp.

(pl. 3, fig. 1)

Discussion: The irregularly spaced secondary veins, irregularly angular marginal loops, marginal tertiary veins that are camptodromous or extending to the margin, and flexuous or sometimes forked intersecondary tertiaries indicate that a specimen from the Oligocene Wakamatsuzawa flora is referable to *Cyclocarya*. This specimen, however, is too ill-preserved to be determined its specific status.
Occurrence: Wakamatsuzawa, Kitami, Hokkaido (the Oligocene Wakamatsuzawa Formation).
Collection: NSM-PP 10451.

Genus *Ezocarya* TANAI gen. nov.

Type species: *Ezocarya ishikariensis* TANAI.
Diagnosis: Leaflets wide oblong to oblong, slightly asymmetric in shape; margin serrate; principal teeth small, broadly triangular, accompanied by 1 or 2 minute triangular teeth; sinus broadly opened; venation pinnate; numerous secondary veins regularly spaced, craspedodromous; 1 or 2 marginal tertiary veins branching basally, then upturned to enter minute teeth or to form irregularly angular loops; intersecondary vein absent; intercostal tertiary veins thin, somewhat irregularly spaced, convex percurrent; areoles small, intruded by once or twice, irregularly branching veinlets; terminal leaflets rounded at base, long petiolulate; lateral leaflets asymmetrically broadly rounded or cordate at base, subsessile.
Discussion: The compoundness of *Ezocarya* leaf is deduced from the fact that a few long-stalked, nearly symmetric laminae are associated by a number of subsessile, asymmetric laminae, although no complete leaf has been found. The asymmetric shape, numerous secondary veins, and thin but distinctly percurrent tertiary veins suggest that these fossils are leaflets of the Juglandaceae. The craspedodromous secondary veins with a few basally branching tertiaries that are craspedodromous or camptodromous, are features of certain extant species of *Carya*, such as *C. cordiformis* (WANG.) K. KOCH, *C. illinoensis* (WANG) K. KOCH and *C. myristiciformis* NUTT. Also in leaflets of the extant *C. laciniosa* (MICHX.) LOUD. and *C. tonkinensis* LECOMTE, the secondary veins end straightly in the teeth, although they usually fork.

The broadly deltoid teeth separated by broadly opened sinus are common in *Juglans* rather than in *Carya*, although found only in the extant *Carya ovata* (MILL.) K. KOCH. The oblong shape and broadly rounded or cordate base in lateral leaflets of *Ezocarya* are unusual in those of *Carya*, and are common features in those of *Juglans* and *Pterocarya*. Furthermore, the long petiolulate terminal leaffet of *Ezocarya* are

characteristic of *Juglans*, *Pterocarya* and *Cyclocarya*, whereas it is rather uncommon in *Carya*.

Ezocarya is closely related to *Carya* in major venation, but its foliar shape is not similar to *Carya* but to *Juglans*. It is noteworthy that *Ezocarya* has once or twice branching veinlets. The ultimate veinlets of the Juglandaceae are single or once branching within the areoles, except for *Pterocarya fraxinifolia* (LAM.) SPACH. whose veinlets are more than twice branching. The foliar shape, venation, margin and stalk features of *Ezocarya* indicate the combination of those of *Carya*, *Juglans* and *Pterocarya*; *Ezocarya* is a new genus of the Juglandaceae now considered to be extinct. *Juglandicarya*, based on endocarp fossils having combined features of *Carya* and *Juglans*, was reported from the Lower Eocene London Clay flora of England (REID & CHANDLER, 1933; CHANDLER, 1961); it may support that such a juglandaceous taxon as *Ezocarya* once inhabited in the Northern Hemisphere during the Early Tertiary.

The prefix, Ezo, is the old name of Hokkaido.

Ezocarya ishikariensis TANAI sp. nov.

(pl. 2, figs. 2–4; pl. 4, figs. 1–4; pl. 5, figs. 5, 7; Fig. 3–C)

Typus: Holotype NSM-PP 10411, Paratypes NSM-PP 10412, 10413; Reisui-zan, Yubari, Hokkaido; Ikushunbetsu Formation (early-Late Eocene).

Diagnosis: Leaflets typically wide oblong to oblong, rarely narrow ovate; 2.1–21 cm (estimated) long and 1.3–10.6 cm wide, length/width ratio 1.61–2.03; apical part abruptly narrowed with acuminate apex; terminal leaflets slightly asymmetric, rounded at base, laterals asymmetric, broadly rounded or cordate at base; margin serrate with small, broadly triangular teeth (type C1 or C2); principal teeth usually associated with 1 or 2 minute teeth; texture chartaceous; petiolule subsessile (about 5–9 mm long) in lateral leaflets, while long (more than 2 cm) in terminals. Venation pinnate; midvein thick, nearly straight or slightly arcuate; secondary veins 16–18 pairs, opposite to subopposite, nearly regularly spaced, departing at 40° to 50° from the midvein in the middle and upper parts of blade, but at wider or right angles in the lower part, straight at first but gently curving up from approximately two-third point to the margin, rarely forking, ending directly in the principal teeth; intercostal tertiary veins thin but distinct convex-percurrent, mostly simple but rarely forking, nearly perpendicular to the secondaries, 1.4–4 mm in distance; 2 or 3 tertiary branches from the secondaries basally departing near the margin, the uppermost one entering a minute tooth, the lower ones camptododromous; quaternary and higher order veins generally thin, forming reticulation; the highest order veins seventh; areoles four or five sided, small (0.15–0.2 mm across); freely ending veinlets once or twice branching.

Discussion: This species is represented by leaflets of variable size; the smaller ones (less than 2.1 cm in length) are probably leaflets of lower part of leaf. Most leaflets are revolute in margin, and the sinuses on margin look to be arcuate, although in actual obtusely angular.

Ezocarya ishikariensis is common in the Ikushunbetsu Formation, and is rarely known from the Yubari Formation in the Ishikari coal field.
Occurrence: Ishikari coal field Yc-2, Ic-3, Ic-9, Ic-11.
Collection: Holotype NSM-PP 10411, Paratypes 10412, 10413; hypotypes 10414–10417; NSM-PP 2100, 10418–10422, 10446, 10450.

Ezocarya sp.

(pl. 5. fig. 1)

Discussion: The asymmetric shape with obtuse base, numerous craspedodromous secondary veins that bend apically sharply within the deltoid teeth, 1 or 2 subsidiary minute teeth, and the marginal tertiary veins basally departing from the secondaries enter minute tooth, are featues of *Ezocarya*. These large leaflets, although missing in apical and basal parts, are estimated to have more than 25 pairs of the secondary veins. Compared with largest leaflet of *E. ishikariensis*, these specimens are distinguishable in having much more secondaries, but they are too incomplete to descibe as a name-bearing species.
Occurrence: Uryu coal field Ur-1; Ishikari coal field Ic-9.
Collection: NSM-PP 10423, 10424.

Genus *Juglans* L.

Juglans sp.

(pl. 8, fig. 6)

Discussion: Although incompletely preserved, a single specimen and its counterpart show the following features: more than 11 secondary veins that distinctly arise up along the margin to form a large loop, 2 to 4 marginal tertiary veins that branch off basally from the secondary at nearly right angle and then considerably bent up to enter directly the teeth, marginal obtuse teeth that are adaxially oriented, densely arranged percurrent and thin tertiaries, and four or five sided areoles that are intruded by a single freely ending veinlets. These characters indicate that the fossil specimens are doubtlessly referable to *Juglans*. The specimens are probably a phylad of the section Cardicaryon by their obtuse tooth features.
Occurrence: Ishikari coal field Ic-9.
Collection: NSM-PP 10425.

Genus *Pterocarya* Kunth.

Pterocarya ezoensis (TANAI) TANAI comb. nov.

(pl. 6; figs. 1–5; Fig. 3–D)

Carya ezoensis TANAI. 1970(part). J. Fac. Sci., Hokkaido Univ. [4], 14(4): 464. pl. 6. fig. 1 (only).

Typus: Holotype HUMP no. 26905; Okotsu pit, Harutori mine, Kushiro, Hokkaido;

Harutori Formation (early-Late Eocene).

Diagnosis: The specimens represented both by detached lateral and terminal leaflets, 7.8–10 cm long and 4.2–5.5 cm wide, length/width ratio 1.8–2.0. Terminal leaflets narrow obovate to elliptic, occasionaly oblong in shape, acute at apex, acute or occasionally rounded at base; petiolule about 2.2–2.7 cm long. Lateral leaflets oblong to wide oblong in shape, acute at apex, rounded to broadly rounded at base, sessile. Margin serrate; teeth obtuse to acute, nearly equal-sized (type B1 or C1), 5–7 per secondary vein. Venation pinnate; midvein stout, straight; secondary veins thick except for a basal pair, 12–14 in pair, opposite to subalternate, diverging at angles of 50°—70°, broadly curving, conspicuously arising up along the margin, gradually thinning and connecting angularly with superadjacent secondary; intercostal tertiary veins rather thin, obliquely transverse to secondary veins, slightly sinuate or convex percurrent, typically simple or occasionally forking; marginal tertiary veins obliquely originating from the secondaries, then markedly arising up to form a single series of loops; marginal quaternary veins from marginal loops ending in teeth; intercostal quaternary and higher order veins reticulate; areoles mostly quadrangular, 0.2–0.3 mm across; ultimate veinlets ill-preserved.

Discussion: The reinvestigation of the specimens described as *Carya ezoensis* from the Kushiro coal field reveals that only the holotype specimen is transferred to *Pterocarya* by the following characters: closely spaced triangular teeth, the secondary veins markedly arise up along the margin, and then suddenly turn admedially to connect with superadjacent secondary vein; a single series of marginal tertiary loops; the marginal quaternary veins entering the teeth from marginal loops.

Many leaflets represented by both terminals and laterals are found with well preservation in the Ishikari coal field, and they are referable in the venationa and marginal features to *Pterocarya ezoensis* here emended. The above-noted venation characters indicate that *P. ezoensis* belongs to a lineage of the section *Platyptera*, especially being similar to the extant *Pterocarya rhoifolia* Sieb. et Zucc. of Japan and China.

Occurrence: Ishikari coal field Nc-4, Ic-3, Ic-9; Kushiro coal field Kh-1.

Collections: Holotype HUMP no. 26905; hypotyps NSM-PP 10427–10430; NSM-PP 10431–10433.

Pterocarya sp. cf. *P. nigella* (HEER) WOLFE

(pl. 5, figs. 3, 6; Fig. 3–H)

cf. *Pterocarya nigella* (HEER) WOLFE, 1966. U. S. Geol. Surv., Prof. Paper, 398-B: 16, pl. 3, fig. 3.
Juglans nigella HEER, 1869. Kgl. Svenska Vet.-Akad. Handl., (8): 38, pl. 9, figs. 2–4.

Discussion: The closely-spaced and triangular teeth (type A1 or C1), asymmetrical base, evenly spaced secondary veins, a series of marginal tertiary veins, and simple-percurrent tertiary veins indicate that these specimens of the Oligocene Wakamatsu-zawa flora are leaflets of *Pterocarya*. The marginal teeth are usually less than five

in number, typically four per secondary vein. In these venation and marginal characters the Wakamatsuzawa specimens are probably referable to *P. nigella* of the Miocene of Alaska.

The Wakamatsuzawa specimens are distinguishable from those of *P. ezoensis* in having less marginal teeth per secondary vein, and loops of secondary veins more distant from the margin. These features may suggest that the Wakamatsuzawa specimens are related to the extant *P. insignis* REHD. et WILS. of Central China.

P. nigella which was described as originally *Juglans* by HEER (1869) was transferred to *Pterocarya* by WOLFE (1966); it seems to have two types of the secondary vein termination. The one type has the secondary veins that markedly extend up along the margin as illustrated in the original figures (HEER, 1868: pl. 9, figs. 2–4) and WOLFE's figure (WOLFE, 1966; pl. 3, fig. 3), while the another type has the secondary veins curving up abruptly near the margin to connect with the superadjacent secondary as illustrated in the figures of WOLFE and TANAI (1880: pl. 11, figs. 4, 6). These two types are also included in Wakamatsuzawa specimens.

Occurrence: Wakamatsuzawa and Minamigaoka, Kitami City, Hokkaido (the Oligocene Wakamatsuzawa Formation).

Collection: NSM-PP 10452–10455.

Genus *Vinea* Wolfe

Vinea hokkaidoana (TANAI) comb. nov.

(pl. 1, fig. 5; pl. 3, fig. 5; pl. 5; figs. 2, 4; pl. 7, figs. 1–5; pl. 8, figs. 3, 5; Fig. 3–A, B)

Platycarya hokkaidoana TANAI. 1970(part). J. Fac. Sci., Hokkaido Univ., [4]. 14(4): 465. pl. 6, figs. 5, 6.
Ulmus pseudobraunii auct. non HOLLICK. BUDANTSEV. 1983. History of Arctic floras of Early Cenozoic time. pl. 27. fig. 1.
Ulmus ulmifolia (SCHLOEMER-JAGER) BUDANTSEV. 1983. ditto., pl. 27, fig. 2.

Typus: Holotype, HUMP no. 26910; Harutori coal mine, Kushiro, Hokkaido; Harutori Formation (early Late Eocene).

Diagnosis: Leaflets ovate to narrow ovate in shape, mostly quadrate in basal half of lamina, long acuminate at apex, 4.3–11 cm long and 1.8–5.5 cm wide, length/width ratio 1.5–2.16; lateral leaflets asymmetric, broadly rounded, sometimes cordate at base, subsessile (petiolule less than 3 mm in length); terminal leaflets nearly symmetric, cordate at base, missing in petiolule; margin serrate; teeth large, broadly triangular, dentate (type D1 or D4), with glandular tip, typically two or rarely three per secondaries. Venation pinnate; midvein straight or slightly arcuate at apical part; secondary veins stout, 15–17 pairs, somewhat irregularly spaced, opposite to subopposite, diverging at 50° to 80° (nearly at right angles in basal 2 pairs), straight or gently curving up, craspedodromous centrally; typically one or rarely two thick subsecondary veins extending basally as bifurcation of secondaries, curving up, entering teeth; intersecondary present but uncommon, parallel to secondaries; intercostal tertiary veins distinct, percurrent, simple or branching, with 2–3 mm distance; quaternary veins

distinct, parallel or perpendicular to tertiaries; quinternary veins forming irregular meshes; highest order venation seventh; areoles quadrangular, 0.15–0.25 mm across, intruded by once branching freely-ending veinlets.

Discussion: The tapered apex, rounded or cordate base, broadly triangular dentate teeth, usually forking and craspedodromy of numerous secondary veins and percurrent tertiary veins indicate that these specimens are referable to the extinct genus *Vinea*, which was described from the Eocene of Washington (WOLFE, 1968). These foliages are distinctly different from North American species, *Vinea pugetensis* WOLFE, in having no subsidiary tooth on the principal teeth. The fossil leaflets are somewhat variable in marginal dentate teeth from distinct triangular to inconspicuous, low triangular shape. The leaflets having inconspicuous teeth are similar to *Ezocarya* in general appearance, but are different in usual bifurcation of secondary veins and dentate teeth.

The reinvestigation of the original specimens from the Kushiro coal field reveals that *Platycarya hokkaidoana* TANAI is assignable to *Vinea* except one specimen (TANAI, 1970: pl. 7, fig. 6), and that *Vinea hokkaidoana* is represented rather by well-preserved foliages of the Ishikari coal field. WOLFE (1977) and MANCHESTER (1987) suggested that *Vinea* is related to *Platycarya*. However, *V. hokkaidoana* is rather unlike to *Platycarya* in which the teeth are usually acute and tertiary veins are not percurrent. Furthermore, the secondary veins of *Platycarya* are craspedodromous to subcraspedodromous; they typically branch just below the sinus: one branch reaches sinus bottom, while other branch enters teeth centrally. *V. hokkaidoana* is most closely related to certain species of *Carya* such as *C. laciniosa* (MICHX.) LOND. and *C. tonkinensis* LECOMTE in having large teeth and usual bifurcation of secondary veins. *C. laciniosa*, however, is acute in tooth and typically single in percurrent tertiary veins, while *C. tonkinensis* is mostly craspedodromous but sometimes camptodromous in the secondary veins. The cordate base of leaflets is unusual for *Carya* as already stated in the case of *Ezocarya*, and is commonly found in the section *Cardicaryon* of *Juglans* such as *J. ailanthifolia* Carr. and *J. cathayensis* DODE.

V. hokkaidoana shows a close resemblance to leaves of *Ulmus* in having bifurcate secondary veins and asymmetric shape, but it is distinctly different in percurrent tertiary veins and once branching veinlets. In *Ulmus* leaves the tertiary veins originating from both sides of the secondaries join at the midway with some crossing, or sometimes fork to immerse into large reticulation; and the ultimate veinlets several times branch. Two specimens figured as *Ulmus pseudobraunii* from the Eocene of northwestern Kamchatska and *Ulmus ulmifolia* from the Eocene of Spitsbergen (BUDANTSEV, 1983) are included in *V. hokkaidoana*, because these specimen has large dentate teeth and usual bifurcation of secondary veins.

V. hokkaidoana is commonly found in the Eocene of eastern and central Hokkaido. It is noteworthy that this extinct genus was distributed in the both border regions of the northern Pacific during the Eocene.

Occurrence: Kushiro coal field Kh-1; Ishikari coal field Ic-3, Ic-8, Ic-9, Ic-11.

Collections: Holotype HUMP no. 26910; hypotypes NSM-PP 10434–10439; NSM-PP 10440–10445; HUMP no. 26912.

Systematic Revisions of Neogene Juglandaceae from Hokkaido

Many fossils of the Juglandaceae have been described from the Miocene of Hokkaido (TANAI, 1961, 1971; TANAI and N. SUZUKI, 1963, 1965, 1972). However, these fossils represented mostly by leaflet impressions are sometimes confused in generic taxonomy, because the earlier works were done principally by comparing the gross features with the extant leaflets. All the specimens described earlier are here reinvestigated, and taxonomic revisions are presented. Some new names seem to be given for several specimens; but, it retains to be given by completion of revisions of all the Juglandacear specimens which were hitherto reported from the Neogene by many authors.

Carya sp.

Platycarya miocenica auct. non HU and CHANEY, TANAI & N. SUZUKI. 1963(part). Tertiary floras of Japan, Miocene floras. p. 109, pl. 6, figs. 1, 7.

Discussion: These two leaflets from the Yoshioka flora have no indication of *Platycarya* in termination feature of the secondary veins. The combination of camptodromous and craspedodromous secondary veins, acuminate teeth, 2 or 3 marginal tertiary veins which branch basally from the secondary and enter the teeth centrally indicate that these fossils are terminal and lateral leaflets of *Carya*. The closely spaced, large teeth and camptodromous and craspedodromous secondary veins that fork sometimes ally these Yoshioka specimens to the extant *C. tonkinensis* LEC., although less in the secondary veins.

Cyclocarya ezoana (TANAI & N. SUZUKI) WOLFE & TANAI

Cyclocarya ezoana (TANAI & N. SUZUKI) WOLFE & TANAI, 1980. U. S. Geol. Surv. Prof. Paper, 1105: 34, pl. 10, figs. 4–6, 8, 9.

Pterocarya ezoana TANAI & N. SUZUKI, 1963(part). Tertiary floras of Japan, Miocene floras. p. 110, pl. 6, figs. 2–5, 8, 9, 11.

Discussion: The leaflets from the Abura and Yoshioka floras of southwestern Hokkaido are confirmed to be referable to *Cyclocarya* by the features of venation and marginal teeth. The secondary veins are irregularly spaced, typically bend sharply toward the apex about two-thirds of the distance from the midvein to the margin, and form angular loops with the tertiary veins. The marginal tertiary veins are camptodromous or craspedodromous. The intercostal tertiary veins are simple or forked percurrent. The marginal teeth are irregularly spaced with sharp and acuminate tips. Lateral leaflets has sometimes petiolule of 1–2 mm length.

Platycarya ? sp.

Pterocarya asymmetrosa auct. non KONNO, TANAI and N. SUZUKI, 1972. J. Fac. Sci., Hokkaido Univ., [4], 15(1–2): 352, pl. 2, figs. 1, 2.

Discussion: The remotely serrate margin having small acute teeth excludes these two specimens from *Pterocarya*. The secondary veins that arise up abruptly along the margin and are semicraspedodromous (Cunonioid type teeth) indicate that these specimens of the Kudo flora may be referable to *Platycarya*. The ill-preservation of the specimens, however, does not allow a satisfactory reinvestigation.

Pterocarya japonica (TANAI) UEMURA

Pterocarya japonica (TANAI) UEMURA, 1988. Late Miocene floras in Northeast Honshu, Japan. p. 132, pl. 8, fig. 1.

Juglans japonica TANAI, 1961(part). J. Fac. Sci., Hokkaido Univ., [4], 11(2): 275, pl. 6, fig. 10.
TANAI & N. SUZUKI, 1965. Palaeont. Soc. Japan, Spec. Paper (10): 12, pl. 18, fig. 4.

Pterocarya asymmetrosa auct. non KONNO, TANAI & N. SUZUKI, 1965, ditto, (10): 12, pl. 11, fig. 5; pl. 21, figs. 7, 8.

Aesculus majus TANAI. 1961 (part). J. Fac. Sci., Hokkaido Univ., [4], 11(2): 367, pl. 29, fig. 5.

Discussion: As already revised by UEMURA (1988), the holotype specimen of *Juglans japonica* from the Late Miocene Shanabuchi flora represents a leaflet of *Pterocarya*, which is closely similar to the extant *P. rhoifolia* SIEB. & ZUCC. of Japan. This fossil species is also represented by two-winged fruits which resemble those of *P. rhoifolia*.

The leaflets of *P. japonica* are characterized by the following features: the evenly spaced secondary veins that arise markedly to be nearly parallel to the margin, a single series of marginal loops, and closely spaced and narrow-oblong teeth (typically C1). All the specimens of Hokkaido listed in the above synonymy are included in *P. japonica*.

Pterocarya sp. *P. nigella* (Heer) WOLFE

cf. *Pterocarya nigella* (HEER) WOLFE, 1966. U. S. Geol. Surv., Prof. Paper, 398-B: 15, pl. 3, fig. 3.

Pterocarya asymmetrosa auct. non KONNO, TANAI & N. SUZUKI, 1963. Tertiary Floras of Japan, Miocene floras, p. 109, pl. 6, fig. 10.
TANAI. 1971(part). Bull. Nat'n. Sci. Mus. Tokyo, (4): 155, pl. 5, figs. 3, 8.

Carya miocathayensis auct. non HU & CHANEY, TANAI & N. SUZUKI, 1963. ditto, p. 108, pl. 5, figs. 1, 2.

Discussion: Leaflets described as *Carya miocathayensis* and *Pterocarya asymmetrosa* from the Sakipenpetsu, Kaminokuni and Abura floras have the similar features in the venation and marginal teeth. The secondary veins are evenly spaced and gently arcuate, and then abruptly curve axially to connect with the superadjacent secondary veins. The marginal loops are composed of a single series of marginal tertiary veins. The marginal teeth are narrowly triangular (type C1 or D1), and less than five in number (typically four). These venation and margin features indicate that the three specimens are probably referable to *Pterocarya nigella* of the Alaskan Miocene.

Pterocarya asymmetrosa KONNO has been described from the Miocene of Japan by various authors, since fossil leaflets similar to those of the extant *P. rhoifolia* were referred to this species (TANAI, 1961). However, *P. asymmetrosa* was unfortunately nomen nudum, as KONNO (1936) showed only the illustrations for this species. Furthermore, Neogene leaflets of Honshu hiterto referred to *P. asymmetrosa* include some different types as already stated by WOLFE and TANAI (1980); most leaflets from the Upper Miocene seem to be referable to *P. japonica*, while some leaflets from the Lower Miocene seem to be referable to *P. nigella*. A further reinvestigation needs for "*P. asymmetrosa*", combined with co-occurred winged fruit specimens.

Pterocarya protostenoptera TANAI

Pterocarya protostenoptera TANAI, 1961. J. Fac. Sci., Hokkaido Univ., [4], 10(2): 278, pl. 4, fig. 10.
TANAI & N. SUZUKI, 1965. Palaeont. Soc. Jap., Spec. Paper, (10): 13, pl. 21, figs. 4, 5.
TANAI, 1971(part). Bull. Nat'n. Sci. Mus. Tokyo, (4): 155, pl. 4, fig. 6.
TANAI & N. SUZUKI, 1972. J. Fac. Sci., Hokkaido Univ., [4], 15(1–2): 326, pl. 2, fig. 7.

Discussion: This species was first established by fruits having two oblong wings, and then was supplemented by detached leaflets which were closely similar to the extant *Pterocarya stenoptera*. Leaflets of *P. protostenoptera* are characterized by irregularly speced and slender secondary veins, and small and blunt marginal teeth.

Winged fruits described as *P. protostenoptera* from the Lower Miocene of Honshu (ISHIDA, 1970; ONOE, 1974; INA, 1981) are usually smaller in general outline, and wider in oblong wing, compared with Late Miocene specimens. These winged fruits from the Lower Miocene may be separated from *P. protostenoptera*.

Rejected from the Juglandaceae

Salix sp. cf. *S. picroides* (HEER) WOLFE

cf. *Salix picroides* (HEER) WOLFE, 1966. U. S. Geol. Surv. Prof. Paper, 398-B: 14.
Juglans japonica TANAI, 1961(part). J. Fac. Sci., Hokkaido Univ., [4], 10(2): 275, pl. 6, fig. 9.

Discussion: As already pointed out by UEMURA (1988), a single incomplete specimen from the Miocene Soya Formation of the Tenpoku coal field is transferred to *Salix*. This leaf has the 1–3 well-developed intersecondary veins, angular loops of marginal tertiary veins, irregularly percurrent intercostal terrtiaries, and apically pointing small teeth. This specimen is probanly referable to *S. picroides* of the Miocene of Alaska, which was transferred from *Juglans picroides* by WOLFE (1966).

Salix ? sp.

Pterocarya ezoana auct. non TANAI and N. SUZUKI, TANAI. 1971. Mem. Natn. Sci. Mus. Tokyo, (4): 156, pl. 5, figs. 2, 4.

Discussion: The finely serrate margin and features of the camptodromous secondary veins exclude these two specimens from *Cyclocarya* and *Pterocarya*. These specimens

may be leaves of *Salix*, but it is too incomplete to determine definitely.

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Explanation of Plates

Plate 1. (All figures in natural size unless otherwise stated)

Fig. 1. *Carya yubarica* TANAI. Holotype NSM-PP 10403 (Ic-9).
Figs. 2, 3. *Carya yubarica* TANAI. Parartyes NSM-PP 10404, 10405 (Ic-3).
Fig. 4. Showing the marginal venation and serration of *Carya yubarica* TANAI (holotype: pl. 1, fig. 1). ×10
Fig. 5. *Vinea hokkaidoana* (TANAI) TANAI. Hypotype NSM-PP 10439 (Ic-3).

Plate 2. (All figures in natural size unless otherwise stated)

Fig. 1. *Carya yubteuensis* TANAI. Holotype UHMP no. 26911. (Ky-2).
Fig. 2. *Carya yubarica* TANAI. Hypotype NSM-PP 1782 (=NSM 10466) (Ic-11).
Fig. 3. Showing the fine venation of *Carya yubarica* TANAI (Fig. 2). ×30
Fig. 4. Showing the marginal serration and venation of *Carya yubarica* TANAI (pl. 2, fig. 2). ×6
Fig. 5. Showing the marginal serration and venation of *Carya yubteuensis* TANAI (holotype: pl. 2, fig. 1). ×6

Plate 3. (All figures in natural size)

Fig. 1. *Cyclocarya* sp. NSM-PP 10451. (Wakamatsuzawa)
Figs. 2, 3. *Ezocarya ishikariensis* TANAI. Paratypes NSM-PP 10412, 10413 (Ic-9).
Fig. 4. *Ezocarya ishikariensis* TANAI. Holotype NSM-PP 10411 (Ic-9).
Fig. 5. *Vinea hokkaidoana* (TANAI) TANAI. Holotype HUMP no. 26910 (Kh-1).

Plate 4. (All figures in natural size unless otherwise stated)

Figs. 1, 2. *Ezocarya ishikariensis* TANAI. Hypotypes NSM-PP 10414, 10415 (Ic-9).
Fig. 3. Showing the fine venation of *Ezocarya ishikariensis* TANAI (holotype: pl. 3, fig. 4). ×30
Fig. 4. Showing the marginal dentation and venation of *Ezocarya ishikariensis* TANAI (holotype: pl. 3, fig. 4). ×6

Plate 5. (All figures in natural size unless otherwise stated)

Fig. 1. *Ezocarya* sp. NSM-PP 10423 (Ur-1).
Figs. 2, 4. *Vinea hokkaidoana* (TANAI) TANAI. Hypotypes NSM-PP 2001 (=NSM 10685) (Ic-11), 10436-a (Ic-9).
Figs. 3, 6. *Pterocarya* sp. cf. *P. nigella* (HEER) WOLFE. Hypotypes NSM-PP 10452, 10453 (Wakamatsuzawa).
Figs. 5, 7. *Ezocarya ishikariensis* TANAI. Hypotypes NSM-PP 10416 (Ic-9), 10417 (Ic-3). fig. 4: ×1.5

Plate 6. (All figures in natural size)

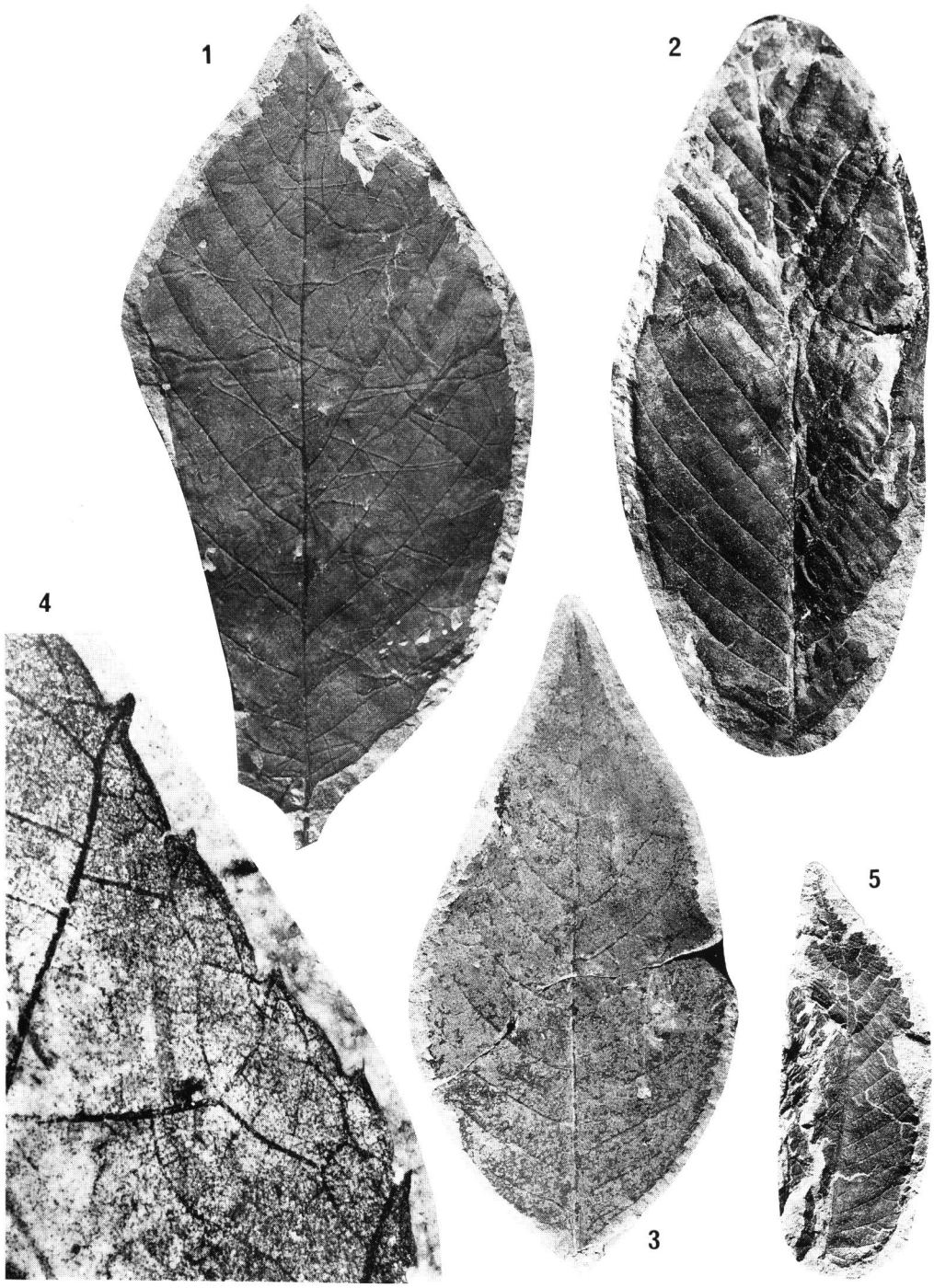
Fig. 1. *Pterocarya ezoensis* (TANAI) TANAI. Hypotype NSM-PP 10429 (Ic-9).
Figs. 2, 3. *Pterocarya ezoensis* (TANAI) TANAI. Hypotypes NSM-PP 10428 (Ic-3), 10427 (Nc-4).
Fig. 4. *Pterocarya ezoensis* (TANAI) TANAI. Holotype HUMP no. 26905 (Kh-1).
Fig. 5. *Pterocarya ezoensis* (TANAI) TANAI. Hypotype NSM-PP 10430 (Ic-3).

Plate 7. (All figures in natural size unless otherwise stated)

Figs. 1, 2. *Vinea hokkaidoana* (TANAI) TANAI. Hypotypes NSM-PP 1882, 10435 (Ic-11).
Fig. 3. *Vinea hokkaidoana* (TANAI) TANAI. Hypotype NSM-PP 10434 (Ic-9).
Fig. 4. Showing the fine venation of *Vinea hokkaidoana* (TANAI) TANAI (pl. 7, fig. 3). ×30
Fig. 5. Showing the marginal dentation and venation of *Vinea hokkaidoana* (TANAI) TANAI (pl. 7, fig. 3). ×6

Plate 8. (All figures in natural size unless otherwise stated)

Fig. 1. *Cyclocarya kushiroensis* (TANAI) TANAI. Holotype HUMP no. 26901 (Kh-1).
Figs. 2, 4. *Cyclocarya kushiroensis* TANAI. Hypotype NSM-PP 10410 (Ic-11), paratype NSM-PP 10448 (Ks-3)
Figs. 3. *Vinea hokkaidoana* (TANAI) TANAI. Hypotype NSM-PP 10438 (Ic-10).
Fig. 5. *Vinea hokkaidoana* (TANAI) TANAI. Hyotype NSM-PP 10437 (Kh-1).
Fig. 6. *Juglans* sp. NSM-PP 10425 (Ic-9).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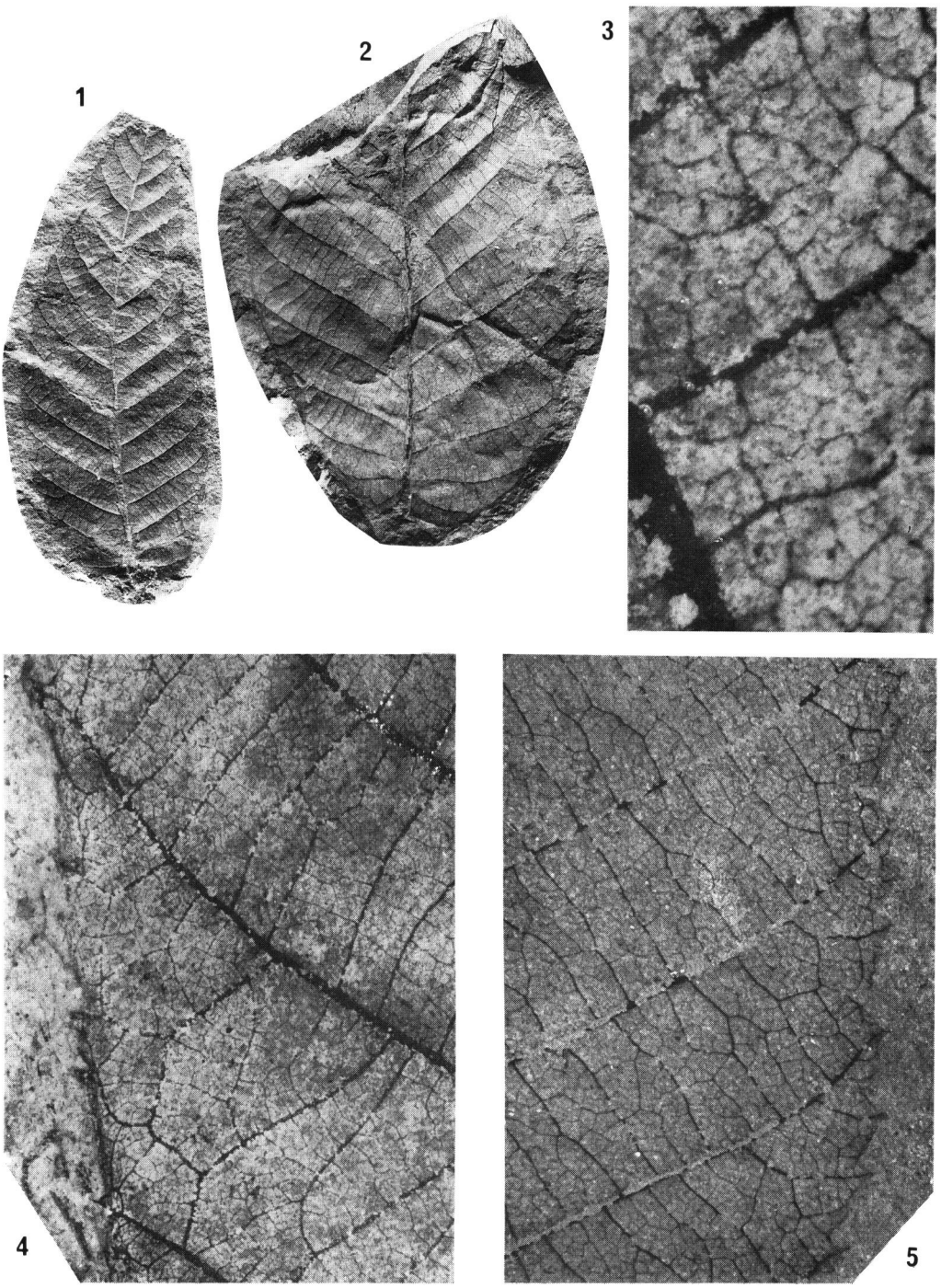
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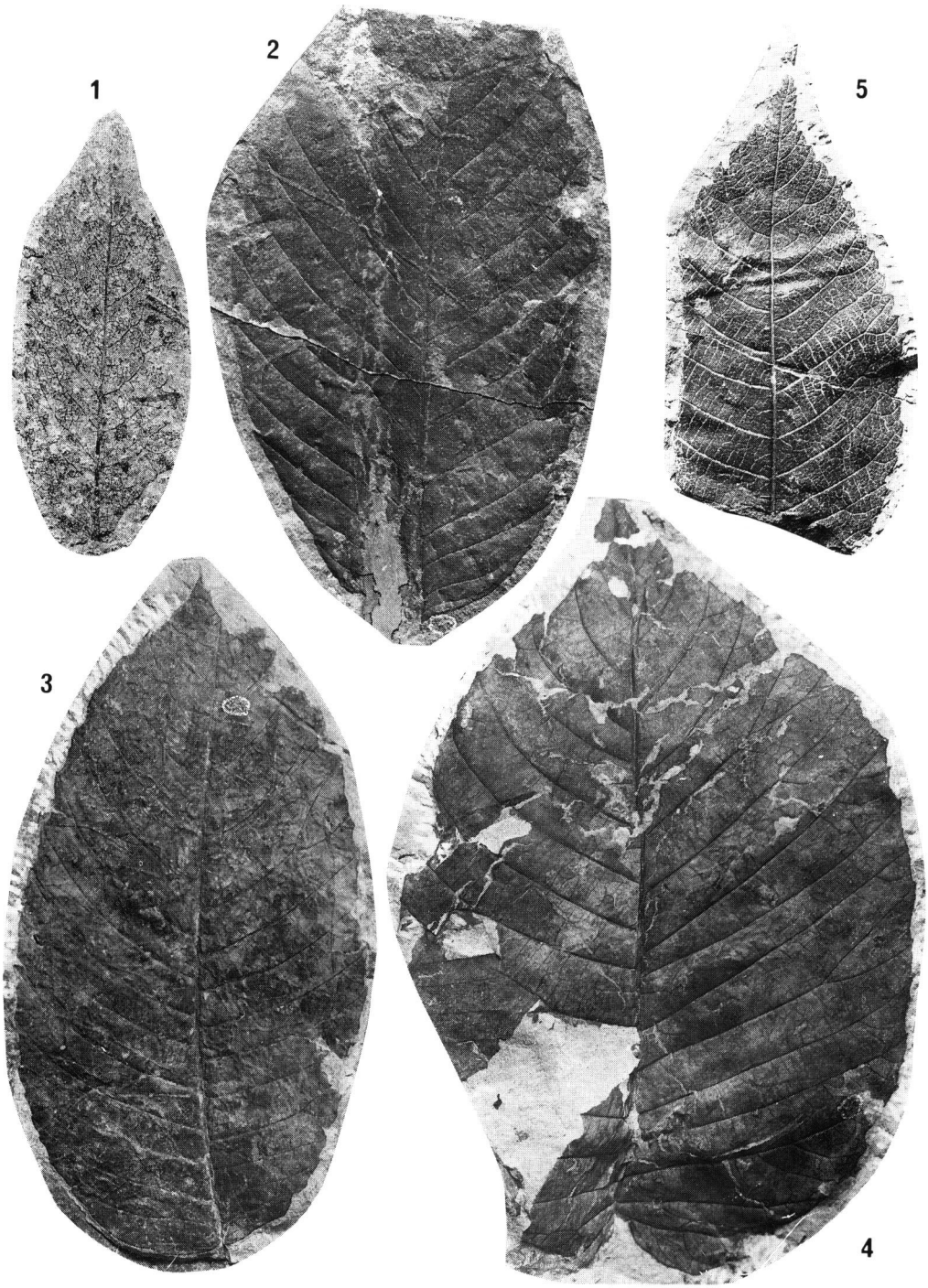
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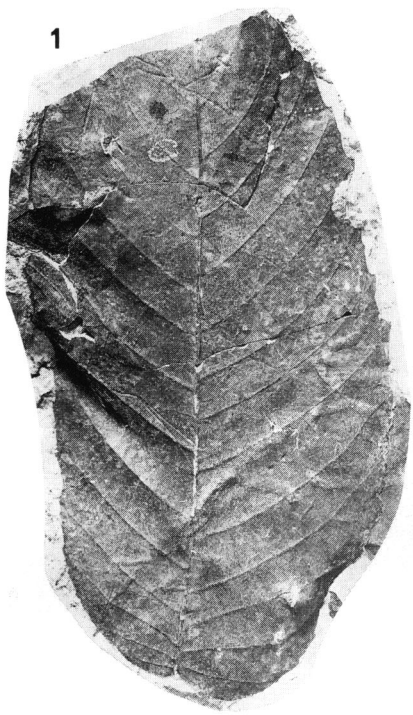
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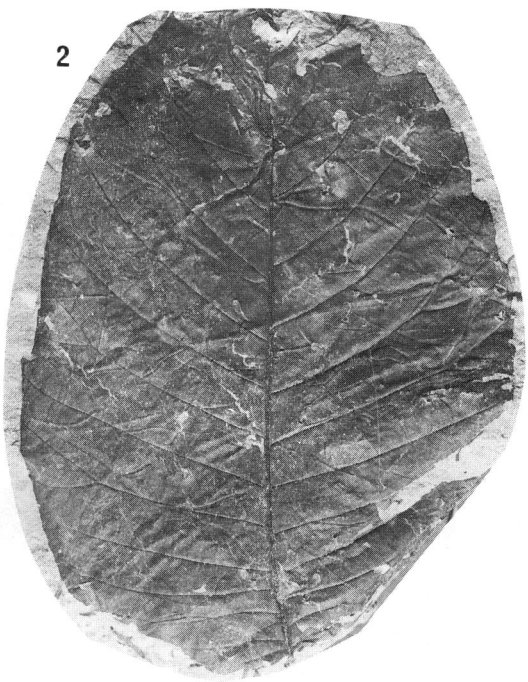
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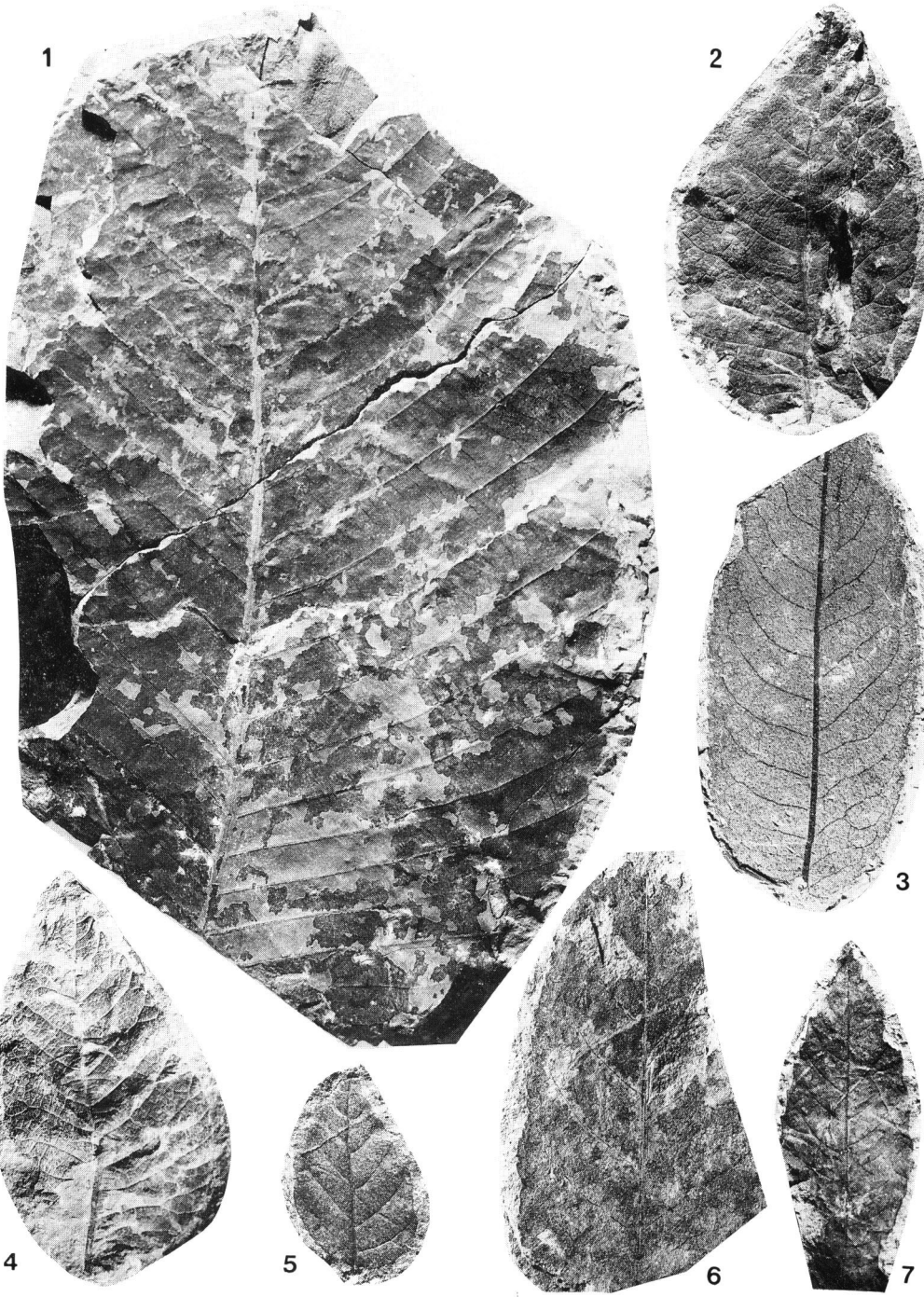
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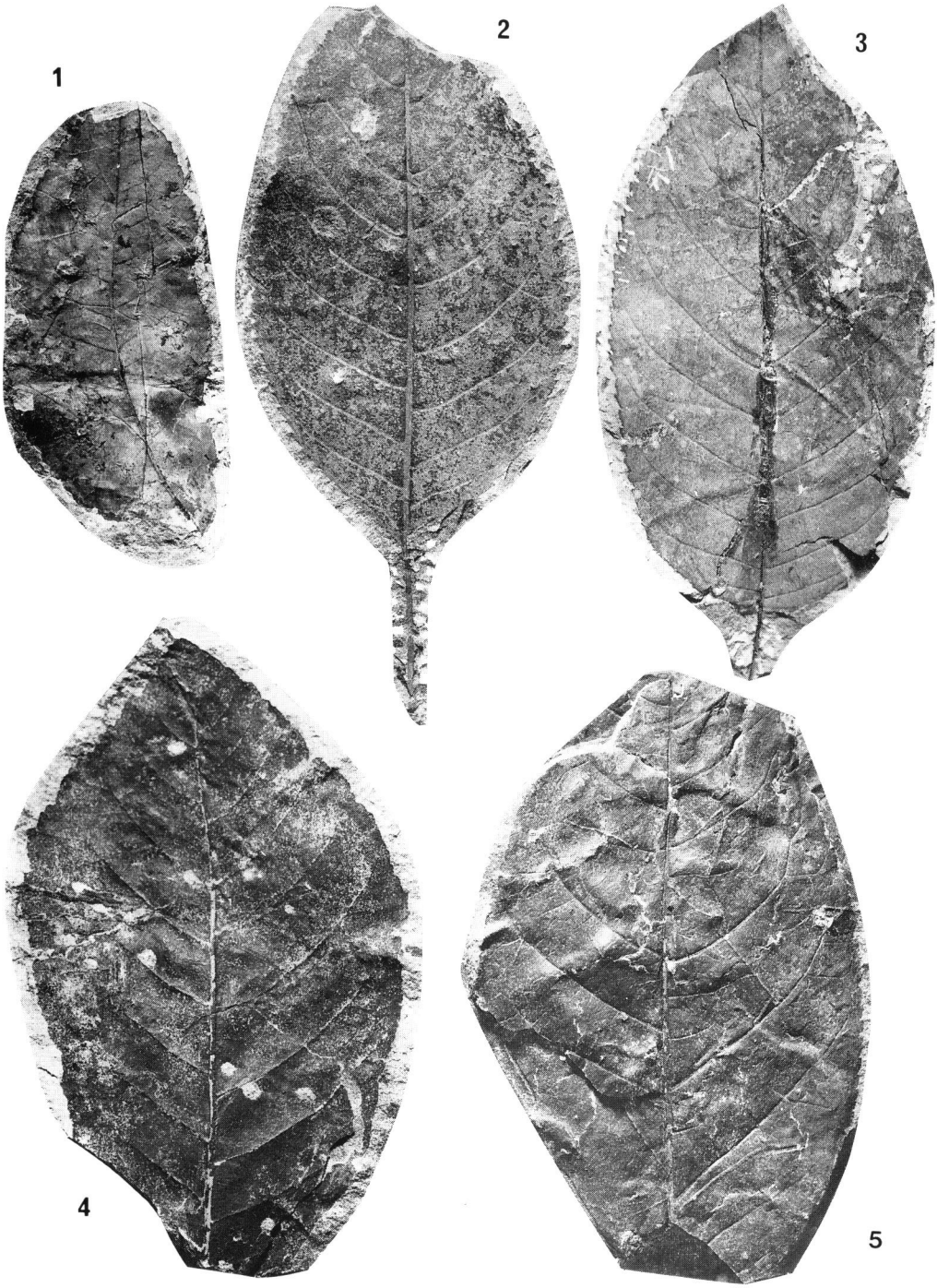
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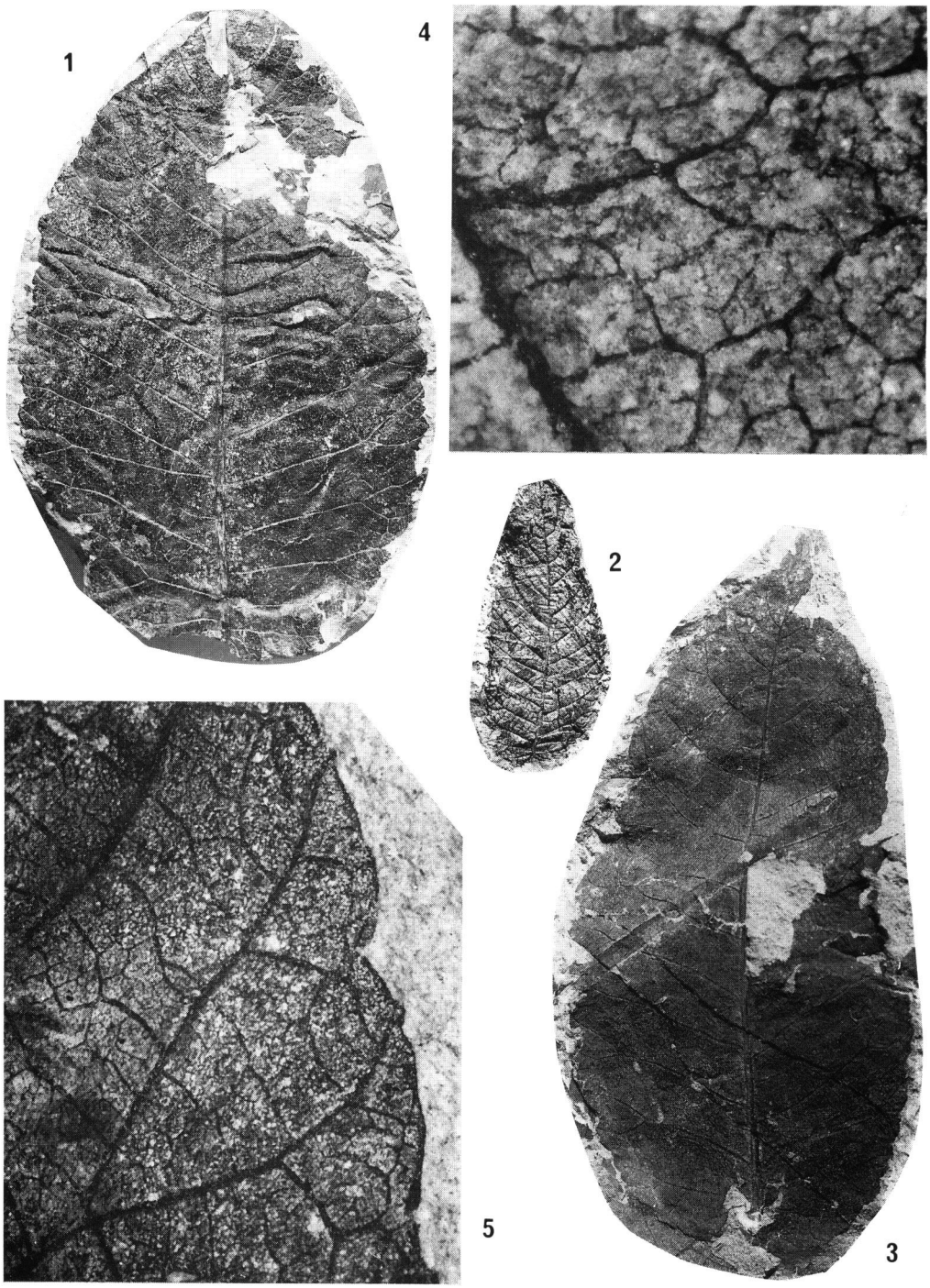
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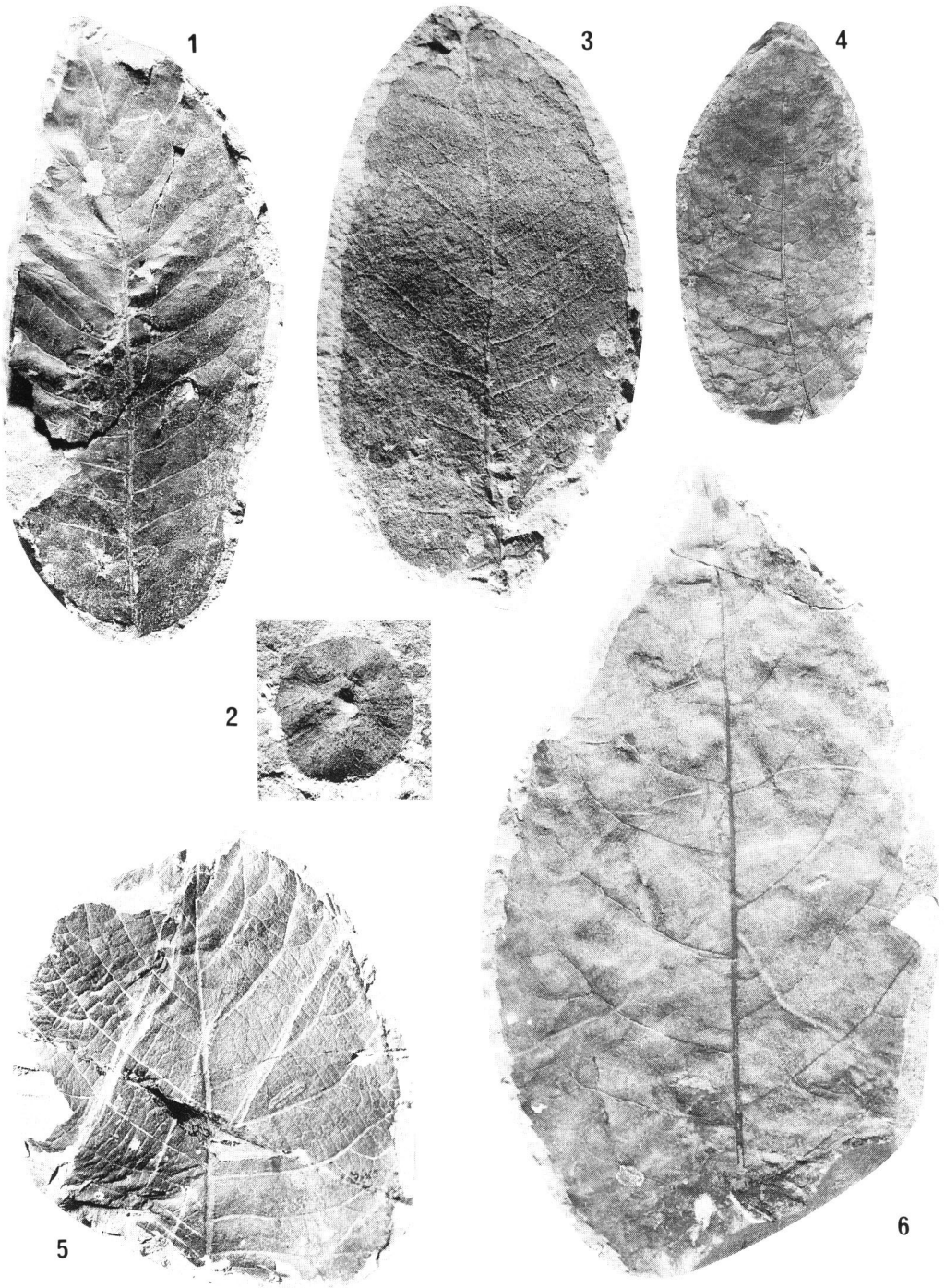
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