



Title	The Genus Acer from the Upper Miocene in Tottori Prefecture, Western Japan
Author(s)	Tanai, Toshimasa; Ozaki, Kimihiko
Citation	Journal of the Faculty of Science, Hokkaido University. Series 4, Geology and mineralogy, 17(4), 575-606
Issue Date	1977-08
Doc URL	http://hdl.handle.net/2115/36079
Type	bulletin (article)
File Information	17(4)_575-606.pdf



[Instructions for use](#)

THE GENUS *ACER* FROM THE UPPER MIOCENE
IN TOTTORI PREFECTURE, WESTERN JAPAN

by

Toshimasa Tanai and Kimihiko Ozaki*

(with 6 text-figures and 5 plates)

(Contribution from the Department of Geology and Mineralogy,
Faculty of Science, Hokkaido University, no. 1489)

Abstract

In Tatsumi-toge, southernmost of Tottori Prefecture, western Honshu, a Late Miocene flora was discovered first by Yamana et al. (1967); it contains a number of well-preserved dicotyledons, some of which genera are now extinct in Japan. The leaves and winged seeds assignable to the genus *Acer* L. belong to 9 sections and 12 species, of which five species are new. These maple fossils are taxonomically investigated in detail, and further are discussed on their modern relationships.

Introduction

The senior author reported the Hoki flora ranging from Late Miocene to Early Pliocene ages, from the border area between Okayama and Tottori Prefectures, western Honshu (Tanai & Onoe, 1961). This flora consists of three florules, the Mitoku, the Onbara and the Ningyotoge, all of which were found in three separated localities and in three independent formations. The Hoki flora was one of the representative leaf-floras of Late Tertiary time in Japan, which have been not common in western Honshu.

Several years later, Yamana et al. (1967) found a Late Miocene flora in the Tatsumitoge area, southernmost of Tottori Prefecture, which fossil locality is very close to the Onbara locality. Showing floristic list and illustrations of most component species with no taxonomical descriptions, they pointed out this flora was most similar to the Mitoku florule in floristic composition. The Tatsumitoge flora has attracted our much interests, because it appears to represent one of the most prolific Miocene floras in western Honshu, including many dicotyledonous plants which have been not yet described in the Tertiary of East Asia. Yamanas' collection has been deposited in the Tottori Prefectural Science Museum at Tottori. From the same locality Mr. K. Uemura of the National Science Museum and Mr. T. Onoe of the Geological Survey of Japan,

* Geological Institute, Yokohama National University.

also collected a number of well-preserved plants, all of which specimens have been deposited in these two institutions respectively.

The junior author, K. Ozaki, had a chance to study in the Paleobotanical Laboratory of Hokkaido University during six months from September of 1976, financially supported by a Research Fund of the Ministry of Education. The above-noted three institutions kindly permitted to loan all the collections of the Tatsumitoge plants for the junior author's investigation. His study of all the collections is now in progress, but needs more time for completion because of containing more than 100 distinguishable species. Through this investigation the authors found many well-established maples, some of which species are very important for the evolutionary history of the genus *Acer*. It is the purpose of this paper to describe all the species of *Acer* from Tatsumitoge area, and furthermore to discuss their taxonomical relationships with the modern species.

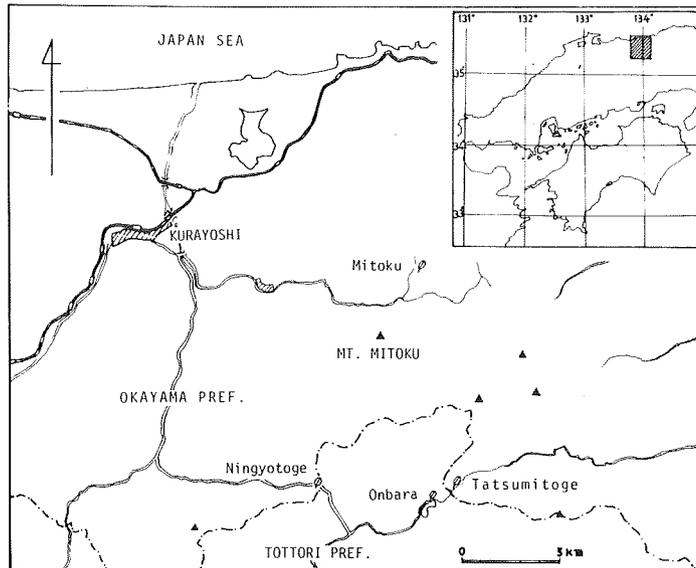
Acknowledgements

The authors acknowledge their debt of gratitude to Messrs. Iwao Yamana, Toru Onoe and Kazuhiko Uemura for their kindness to loan all of their fossil collections. Mr. Uemura kindly discussed on the final identification of the fossils with the authors. For the comparison with the modern species the authors could effectively use the data, which were obtained by the senior author through his investigation during staying in U. S. Geological Survey at Menlo Park, California in 1973. The senior author deeply thanks to Dr. Jack A. Wolfe of U. S. Geological Survey for his kindness to have permitted to use all his collection of the cleared leaf slides.

Geologic Setting

The fossil locality lies about 200 meters northeast of Tatsumitoge ("Tatsumi-pass"), which is situated in the head area of the Saji River, central-southernmost of Tottori Prefecture (Text-fig.1). The plant-bearing sediments called the Tatsumitoge formation, develop unconformably on biotite-grano-diorite of Late Mesozoic time widely distributed in western Honshu. The stratigraphy in this area has been not yet settled, and the stratigraphical relationships between the Tatsumitoge and the Hoki-flora-bearing formations has been not clarified. According to the preliminary report by Yamana et al. (1967), the Tatsumitoge formation, showing more than 100 meters in thickness, is composed principally of tuff breccia, andestic agglomerate, sandstone and siltstone. Well-preserved plants are included abundantly in the laminated siltstone in the middle of this formation, and are represented

mostly by impressions or rarely by carbonized materials.



Text-fig. 1 Map showing the fossil localities.

Taxonomical Descriptions

Most of the specimens investigated preserve excellently fine venation. The comparison of vein system, especially free-ending veinlets, with leaves of the extant species was very effective for the identification of fossil leaves. For this purpose are fully used the cleared leaf slides, which have been provided in the U. S. Geological Survey at Menlo Park and Hokkaido University at Sapporo. The leaves and winged seeds assignable to the genus *Acer* L. in the Tatsumitoge flora are classified into 9 sections and 12 species as follows:

Section *Macrantha* Pax

Acer palaeorufinerve Tanai et Onoe

Acer uemurae Tanai et Ozaki, sp. nov.

Section *Palmata* Pax

Acer nordenskiöldii Nathorst

Acer protojaponicum Tanai et Onoe

Section *Argutum* Rehder

Acer tottoriense Tanai et Ozaki, sp. nov.

Section *Cissifolia* Koidz.

Acer pseudocarpinifolium Endo

Section Rubra Pax

Acer trilobatum (Sternb.) A. Braun

Section Platanoidea Pax

Acer florinii Hu et Chaney*Acer integerrimum* (Viv.) Massalongo

Section Saccharina Pax

Acer yamanae Tanai et Ozaki, sp. nov.

Section Trifoliata Pax

Acer subnikoense Tanai et Ozaki, sp. nov.

Section Macrophylla (Pojark.) Ogata

Acer honshuense Tanai et Ozaki, sp. nov.

Of these 12 species five are newly found in the Tertiary of East Asia. Especially, it is very noteworthy for evolutionary history of the genus *Acer* that the fossil species belonging to sections Argutum, Cissifolia, Trifoliata and Macrophylla were well established by definite taxonomical basis.

All the specimens studied here are deposited in three institutions; the registered numbers for the types are referred to the museums of the following institutions.

NSM-PP: National Science Museum at Tokyo, Paleobotany collection.

G.S.J.: Geological Survey of Japan at Kawasaki.

TPM: Tottori Prefectural Science Museum at Tottori.

Section Macrantha Pax

Acer palaeorufinerve Tanai et Onoe

(pl.5, fig.10, text-fig.6, B)

Acer palaeorufinerve Tanai et Onoe, Geol. Surv. Japan Rept. 187:49, pl.14. f.5. 1961.

Huzioka et Uemura, Bull. Natl. Sci. Mus. 16(4): 719-720. pl.13. f.5-7. 1973.

Discussion: A single incomplete leaf is referable to *Acer palaeorufinerve* by trilobed shape, marginal serration and venation. It is closely similar to the extant *A. rufinerve* Sieb. et Zucc. of Japan in its general foliar characters, especially in venation. As far as investigated by the authors, the ultimate veinlets of this fossil specimen largely once branching within the quadrangular or pentagonal areoles, and are rarely simple free-ending or twice branching as in the case of the extant *A. rufinerve* (text-fig.6A). A comparatively small samara with ovate seed from our collections closely resembles those of the extant *A. rufinerve* in shape of seed and extension angle of two wings, and this fossil samara is included in *A. palaeorufinerve*.

Collections: NSM-PP 16052, GSJ 4779.

Acer uemurae Tanai et Ozaki, sp. nov.

(Pl.5, figs.3, 4, 9; text-fig.2, B. D)

Type: Holotype, TPM-293. Tatsumitoge formation (Late Miocene), Saji-mura, Tottori Prefecture.

Description: Leaves medium in size, pentagonal in outline, palmately five-lobed, deeply cordate at base, 8 (estimated) to 12 cm long and 7 to 10 cm (estimated) wide; margin doubly serrate with large, acuminate principal teeth clefted by angular sinus; basal side of principal teeth convex with 2 or 3 subsidiary teeth having additionally 1 minute tooth, while apical side convex or straight, accompanied mostly by one minute subsidiary teeth; central lobe largest, ovate with attenuate apex, defined by narrow, wedge-shaped sinus; upper lateral lobes medium, lanceolate-oblong with caudate apex; basal laterals rather small, ovate with acute apex; medial primary stout, nearly straight; upper laterals thick, making angles of 50° to 55° with the medial, straight; basal pair moderate, almost perpendicular to the medial, slightly flexuous; secondary veins distinct, opposite to subopposite, more than 8 pairs (excepting 5 or 6 pairs on abaxial side of basal lobes), diverging from the primaries at angles of 50° to 75°, gently curving up; the secondaries of central lobe terminating in principal teeth, while those of the lateral and basal abruptly arising up, and an intersecondary vein in the each costal area distinct, diverging at somewhat larger angles than in the secondaries, nearly straight, mostly forking near the margin, one branch arising up to connecting with the secondary and another branch ending in sinus bottom; tertiary veins random reticulate or weakly percurrent; the quaternaries thin, making quadrangular to hexagonal areoles; ultimate veinlets thin but well-developed, three or four times branching; petiole missing.

Discussion: This new species represented by incomplete leaves, is characterized by long-tipped lobes, compoundly double-serrate margin and well-branching veinlets. Our specimens resemble in general appearance those of *Acer subukurunduense* N. Suzuki from the Pliocene Rubeshibe flora of Hokkaido (N. Suzuki, 1963), but are distinctly distinguishable in lobe apex and marginal character. Beside this species no fossil species comparable to *A. uemurae* has been known from the Tertiary of the world.

Considering the venation characters together with foliar shape, *A. uemurae* is closely related to some species of the Section *Macrantha* and *Spicata*, especially to the extant *A. micranthum* S. et Z. and *A. tschonokii* Maxim. of Japan belonging to the former section. Of these two extant species, *A. tschonokii* is probably separable from our new species by acute apex of lobe, which is usually not longly caudate. There is a most close resemblance between *A. uemurae* and *A. micranthum* in all foliar characters, excepting for marginal

teeth. As shown in text-fig. 2, A and B, most of teeth especially principal teeth, of *A. uemurae* are generally acuminate, while those of the extant *A. micranthum* is generally acute with somewhat longer tips. On the one hand, our new species seems to be similar to the extant *A. tschonoskii* in having generally acuminate teeth. Thus, *A. uemurae* has partly characters of both *A. tschonoskii* and *A. micranthum*. It is interesting for us that *A. australe* (Momotani) Ohwi et Momotani living in western Japan has partly the characters of the above two extant species: *A. australe* is closely similar to *A. micranthum* in foliar shape, while it resembles also *A. tchonoskii* in samara and length of pedicel.

This new species is named in honor of Mr. K. Uemura, who permitted us to investigate his large collection of Tatsumitoge locality.

Collections: Holotype, TMP-293; paratypes NSM-PP-16067, TMP-484.

Section Palmata Pax

Acer nordenskoeldii Nathorst

(Pl. 1, figs. 1-9; text-fig. 3, A-D; text-fig. 4, A-F)

Acer nordenskoeldii Nathorst. Kgl. Sv. Vet. Akad. Handl. 20(2): 60. pl. 11. f. 1-17. 1883.

Tanai. J. Fac. Sci. Hokkaido Univ. ser. 4. 17(2): 330. pl. 7. f. 4, 8; pl. 8. fig. 7; pl. 9. fig. 4; text-fig. 7-h, i. 1976 (see synonymy).

Acer ablaevii Akhmetjev et Schmidt. Rept. Geol. Palaeont. Far. East. p. 17. pl. 10. f. 1; text-fig. 1-12. 1976.

Discussion: A number of leaves including two nearly complete ones, are referable to *A. nordenskoeldii*, which original specimens were reinvestigated by the senior author (Tanai, 1976, b). As in the case of the original specimens, our leaves are also variable in shape and marginal characters, but are grouped into the following three types:

- (1) leaves five-lobed with wide sinus; each lobe ovate with attenuate apex; margin finely serrate with small teeth; each tooth sometimes accompanied by a minute tooth between principal teeth.
- (2) leaves seven-lobed with wide sinus; each lobes ovate or lanceolate-ovate with attenuate apex; margin finely serrate; each tooth small, sometimes accompanied by a minute tooth between principal teeth.
- (3) leaves seven-lobed, deeply dissected by narrow sinus; each lobe lanceolate or lanceolate-oblong, attenuate at apex; margin doubly serrate; principal teeth comparatively large, accompanied by one or two subsidiary teeth on its basal side.

These three types may be distinguishable with no intergradation of characters among the leaf specimens collected from Tatsumitoge, although the first and second types are somewhat indistinct for separation, excepting for number of lobes.

As already shown in the synonymy list (Tanai, 1976b), a number of leaves included in *A. nordenskiöldii* have been described from the Neogene and the Lower Pleistocene of East Asia. Considering all these specimens together with our leaves, the above-noted three types are not always clear in their distinction. Thus, we are convinced that all of our specimens are better to be included in *A. nordenskiöldii*. A detailed investigation, based on a number of leaves, may classify *A. nordenskiöldii* into 2 or 3 independent species, if further abundant leaf specimens shall be additionally collected in the Late Cenozoic of East Asia.

A. nordenskiöldii belongs distinctly to the Section Palmata in the foliar shape, marginal serration and well-branching veinlets. This section is now one of the most differentiated maples, comprising 28 extant species, all of which are confined to East Asia with one exception of North American *A. circinatum* Pursh. Among these extant species, the above-noted first type is closely similar to leaves of *A. sinense* Pax, *A. oliverianum* Pax and *A. erianthum* Schw., all of which species are living in China. The third type is closely related to *A. palmatum* Thunb. and its variety, *A. palmatum* Thunb. var. *matsumurae* Koidz. of Japan. On the other hand, the second type is similar to leaves of *A. palmatum* Thunb. var. *amoenum* (Carr.) Hara, and also to seven-lobed leaves of *A. erianthum*. Several winged seeds similar to those of *A. palmatum* are also found in our collection, and are included in *A. nordenskiöldii*. These samaras are somewhat variable in size and seed character, and may be classified into 2 types in future.

Collections: NSM-PP-6440, 6441, 16024-16029, 16199-16201, 16203; G.S.J. no.4767, 4775-4778, 4783; TMP-102, 112, 140, 470, 485.

Acer protojaponicum Tanai et Onoe
(Pl.2, fig.2; pl.5, figs.1, 2)

Acer protojaponicum Tanai et Onoe. Bull. Geol. Surv. Japan. 10(4): 281. pl.6. f.5-7. 1959.
Tanai et N. Suzuki. Jour. Fac. Sci. Hokkaido Univ. ser.4. 10(3): 565. pl.5. f.6; pl.9. f.18, 19. 1960.

Discussion: These nine-lobed leaves are referable to *A. protojaponicum* by shallow sinus and doubly serrate margin, which species is closely related to the extant *A. japonicum* Koidz. growing in Japan. A small leaf specimen from Tatsumitoge may be unseparable from *A. protosieboldianum* Tanai et Onoe described from the Pliocene Ningyotoge flora of western Honshu (Tanai & Onoe, 1961). Several winged seeds similar to *A. protojaponicum* are also found in our collection.

Collections: TMP-217, 231, 480.

Section Argutum Rehder
Acer tottoriense Tanai et Ozaki, sp. nov.
(Pl.3, figs. 2-6)

Acer miodavidii auct. non Hu et Chaney. Akhmetjev et Schmidt. Geol. Palaeont. Rept. Far East. p.99. pl.5. f.5; text-fig.1-3. 1976.

Type: Holotype, TMP-235. Tatsumitoge formation (Late Miocene). Saji-mura, Tottori Prefecture.

Description: Leaf medium in size, palmately seven-lobed, pentagonal in general outline, cordate at base, about 6 cm long (estimated) and 5.5 cm wide (estimated); each lobe ovate or lanceolate-oblong in shape, attenuate at apex; margin doubly serrate with large principal teeth accompanied by one or two subsidiary teeth on basal side, medial lobe largest, a basal pair of lobes smallest like protrudent dents of lower lateral lobes; the medial primary vein stout, the upper lateral pair making angles of 35° to 45° with the medial, the lower laterals angles of 70° to 80°, and the basal pair about 115° with the medial; the secondary veins of the medial lobe about 8 pairs, alternate, diverging from the primary at angles of 50° to 70°, immediately turning up with angles of about 30° to the primary, ending at the marginal tooth; the secondaries of the laterals excepting the basal pairs 7 to 9, gently curving and making angles about 40° with the primaries on its half way, entering the marginal teeth; tertiary veins in costal areas percurrent or forking on the middle; fourth-order veins random reticulate; areoles ill-preserved; petiole thick, more than 1.5 cm.

Samaras medium in size, 1.8 to 2.8 cm long; wing oblanceolate in shape, rounded at apex, straight on outer margin and convex on inner margin, 13.5 to 22.5 mm long and 6 to 8 mm at the widest part; veins distinct, numerous, curving inward and then dichotomously branching more than three times; seed oval in shape, somewhat wrinkled on surface; contact line of seed straight, about 4 mm long; angle between contact line and outer margin of wing 70° to 75°.

Discussion: A single leaf with seven lobes, though somewhat incomplete, is characterized by foliar shape with prominent central lobe and doubly serrate margin. This new species, *Acer tottoriense*, is easily separable in marginal serration and absence of intersecondary veins from *A. uemurae* described in earlier pages, and is also distinguishable in slender lateral lobes and acute teeth from *A. subukurunduense* N. Suzuki of the Pliocene Rubeshibe flora (N. Suzuki, 1964). No fossil species similar to *A. tottoriense* has been not recorded in the Tertiary of the world.

As the ultimate veinlets are not preserved in our leaf specimen, *A. tottoriense* is regrettably difficult to search correctly for its living analogue. However, among the extant species of the genus *Acer* our new species shows a

most close resemblance to *A. argutum* Maxim. of Japan in foliar shape, margin and well-defined tertiary veins. Accompanied by our leaf specimen in the same fossil locality, there was found three well-preserved samaras which closely resemble those of the extant *A. argutum* in shape of wing, bulged seed and extension angles of both wings. These fossil samaras are included in *A. tottoriense*, and may show a convincing evidence of its modern relationship. A single samara figured as *A. miodavidii* Hu et Chaney from Prymorie (Akhmetjev & Schmidt, 1976) is closely similar to our samaras in shape of seed and extension angles of wings, and is probably included in *A. tottoriense*.

Collections: Holotype, TMP-235; paratypes NSM-PP-16168, 16202, 16213.

Section *Cissifolia* Koidz.
Acer pseudocarpinifolium Endo
(Pl.4, fig.8)

Acer pseudocarpinifolium Endo, Short Paper I.G.P.S. (1): 14. pl.3. f.6. 1950.

Huzioka, Jour. Min. Coll. Akita Univ. ser.A. 3(4): 92. pl.15. f.7-8. 1964.

Acer cf. *pseudocarpinifolium* Endo. Tanai et Onoe. Geol. Surv. Jap. Rept. 187:51. pl.15. f.3. 1961.

Type: Lectotype, Inst. Geol. Palaeont. Sendai, cat. no.44246. (Endo, 1950: pl.3. fig.5), Shirasawa formation (Late Miocene), Hirose, Miyagi-cho, Miyagi Prefecture.

Discussion: A single samara, though missing its upper part of wing, is distinctly identical with *A. pseudocarpinifolium* Endo in seed shape and extension angle of the two wings. An original specimen described from the Late Miocene flora near Sendai was compared with winged seeds of the extant *A. carpinifolium* Sieb. et Zucc. by Endo (1950) as shown in its proposed specific epithet. However, the original specimen is not similar to *A. carpinifolium*, but is rather close to the extant *A. cissifolium* (S. et Z.) Koch. The fossil seeds including the original are elliptical in shape and longitudinally striated with 2 or 3 ridges as observed in *A. cissifolium*, while seeds of *A. carpinifolium* show ovate shape and no conspicuous ridge on the surface. Furthermore there is another distinction between the samaras of *A. carpinifolium* and *A. cissifolium*: the extension angles of the two wings in the former are mostly twice wider than in the latter, although the former angles are somewhat variable.

Several winged seeds and leaves were reported as *A. pseudocarpinifolium* from the Neogene of Japan by some authors. Of them two winged seeds figured as *A. pseudocarpinifolium* by Huzioka (1964) are fairly identical to the original specimens. An incomplete samara figured from the Hoki flora (Tanai & Onoe, 1961) is also probably included in *A. pseudocarpinifolium*, though lacking in distal end of seed. However, four leaves and one samara described as *A.*

pseudocarpinifolium from the Late Neogene floras of Hokkaido (N. Suzuki, 1963; Tanai & N. Suzuki, 1965) should be excluded, because these specimens are represented by single-form leaves and seed character closely similar to *A. carpinifolium*.

Collection: NSM-PP-16054.

Section Rubra Pax

Acer trilobatum (Sternb.) A. Braun

(Pl.2, figs.5-7; text-fig.5, A, B)

Phyllites trilobatus Sternberg. Versuch geolgn. bot. Darst. Fl. Vorwelt. 1(4): 42. pl.50. f.2. 1826.

Acer trilobatum (Sternb.) A. Braun. Tert. flora Oenigen. 172. 1845.

Oishi et Huzioka. Jour. Fac. Sci. Hokkaido Imp. Univ. ser.4. 7(1): 97. pl.12. f.4. 1943.

Huzioka. Tertiary floras of Japan. Miocene floras. 209. pl.37. f.2. 1963.

Hantke. Neujahrsbl. Naturforsch. Gesells. Zürich 1965:62. pl.2. f.4; pl.7-13; pl.14. f.3, 4, 6. 1965. (see synonymy and discussion).

Tanai. Mem. Nat. Sci. Mus. 4:163. pl.11. f.4. 1971.

Hojo. Prof. Matsushita Mem. Volume. 153. pl.12. f.3, 5. 1971.

Acer trilobatum (Sternb.) A. Br. var. *productum* auct. non A. Braun. Huzioka. Jour. Fac. Sci. Hokkaido Imp. Univ. ser.4. 7(1): 132. pl.23. f.8. 1943.

Endo. Short Pap. I.G.P.S. (3): 54. pl.8. f.6. 1951.

Huzioka. Jour. Min. Coll. Akita Univ. ser.A. 5(1): 67. pl.9. f.3. 1972.

Acer trilobatum tricuspidatum auct. non Heer. Endo. Short Pap. I.G.P.S. (3): 56. pl.8. f.1. 1951.

Acer yabei auct. non Endo. N. Suzuki (in part). Jour. Fac. Sci. Hokkaido Univ. ser.4. 11(4): 691. pl.4. f.3. (excluding f.4, 6). 1963.

Tanai et N. Suzuki (in part). Palaeont. Soc. Jap. Spec. Pap. (10): 39. pl.10. f.2 (excluding pl.10. f.10 and pl.13, f.4). 1965.

Acer tigilensis Chelebaeva. The Mio-Pliocene of the West Kamtchatka. 192. pl.24. f.3-5; pl.39. f.g, v, d; pl.40. f.A, B. 1976.

Acer lebedevii Akhmetjev et Schmidt. Rept. Geol. Palaeont. Far East. 81. pl.9. f.13; text-f.1-27. 1976.

Acer amuguenum Akhmetjev et Schmidt. ditto. p.93. pl.10. f.12; text-f.1-16. 1976.

Acer sp. Akhmetjev et Schmidt. ditto. p.96. ol.9. f.1; text-f.1-2. 1976.

Discussion: Two incomplete leaves are identical with *Acer trilobatum* in trilobed shape and marginal serration, which has been commonly known in the Tertiary of Europe. As pointed out by many authors, *A. trilobatum* is closely related to the extant *A. rubrum* Linn. of eastern North America, though this fossil maple is highly variable in foliar character. In actual, the variation of leaf forms and marginal serration displayed by *A. trilobatum* is well consistent with that of *A. rubrum* (Hantke, 1965). Investigating the specimens including the type, assigned to *A. trilobatum* by Hantke (1959, 1965), the senior author could confirm that most of their specimens are closely similar to leaves of *A.*

rubrum and *A. pycnanthum* in the areoles and veinlets, as shown in text-fig. 5, D and E. Regarding the areoles and veinlets, our two leaves from Tatsumitoge well match with the original specimens (text-fig. 5, C) deposited in the Palaeontological Museum of Eidgönesse Technische Hochschule, Zürich.

Compared with abundant occurrence of leaves and samaras in Europe and western North America similar to the extant *A. rubrum*, the specimens referable to *A. trilobatum* have been not always commonly known in the Tertiary of East Asia. All the leaf specimens based on the above-listed citation are included in *A. trilobatum*. Five leaves described as *A. tigilensis* from the Upper Miocene of West Kamtchatka (Chelebaeva, 1976), are essentially unseparable from *A. trilobatum*, although some of them appear to be five-lobed, bearing a pair of small basal lobes on the basal side of the laterals. Such five-lobed leaves as *A. tigilensis* are usually found among leaves of the extant *A. rubrum*. One small samara with ovate seed from Tatsumitoge is closely similar to those of *A. rubrum*, and is included in *A. trilobatum*.

Regarding the epithet "*trilobatum*", we have had one problem on its application. Based on the reinvestigation of maple leaves described from Oehningen of Switzerland by Heer (1855, 1859), Hantke (1965) claimed to conserve the epithet "*trilobatum*" by choosing a specimen (Heer, 1859: pl. 114. f. 2) as the lectotype. On the one hand, Walther (1972) reinvestigated extensively maple leaves from the Tertiary of middle Europe by cuticle analysis, and he adopted the epithet "*tricuspidatum*" (*A. tricuspidatum* Bronn. 1838) instead of "*trilobatum*". Walther's opinion was followed by Prochazka and Bůzek (1975) who recently published a comprehensive works on Tertiary maples of Bohemia. It seems difficult for us to determine which epithet is valid for the maple leaves now discussed. Though Walther (1972) did not clearly described in his paper, the reason why he adopted "*tricuspidatum*" may be that "*A. trilobatum*" was earlier used by Lamarck (1776) for one of the recent maples which was a later synonym of *A. monspessulanum* Linn. living in southern Europe. However, according to the Article 13 of the International Code of Botanical Nomenclature, the valid publication for all the fossil plants started on Dec. 1, 1820 (Sternberg: Flora der Verwelt, versuch 1): "*Phyllites trilobatus*" is included in Sternberg's works. Thus, we prefer to use the epithet "*trilobatum*", following Hantke's opinion, if the original specimen, "*Phyllites trilobatus*" is doubtlessly referable to the genus *Acer*.

Collections: TPM 280; NSM-PP-16163; G.S.J. no. 4826.

Section Platanoidea Pax
Acer florinii Hu et Chaney
 (Pl.4, fig.3; text-fig.4, K)

Acer florinii Hu et Chaney. Palaeont. Sinica. New Ser.A. 1:56. pl.31. f.5, 8. 1938.

Tanai et Suzuki. Jour. Fac. Sci. Hokkaido Univ. ser.4. 10(3): 560. pl.5. f.3. 1960.

Huzioka. Jour. Min. Coll. Akita Univ. ser.A. 3(4): 89. pl.14. f.10. 1964.

Huzioka et Uemura. Bull. Natl. Sci. Mus. 16(4): 718. pl.13. f.8. 1973.

Huzioka. Jour. Min. Coll. Akita Univ. Ser.A. 5(2): 103. pl.5. f.8. 1974.

Discussion: The entire-margined fossil leaves of trilobed maple have been mostly referred to *Acer florinii* in East Asia. This species was originally compared with the extant *A. mono* Maxim. by Hu & Chaney (1938), though *A. mono* bears mostly 5 to 7 lobate leaves. Some workers including the senior author, have also compared with the extant *A. buergerianum* Miq. of Southern China, based merely on its trilobed shape.

Our specimen is ill-preserved in fine venation character. As far as investigated under the microscope, our specimen is consistent with *A. mono* in size and shape of areoles, quite different from further smaller areoles of *A. buergerianum*. In actual, there is known *A. mono* var. *glaucum* (Koidz.) Kitamura living in northeastern Honshu, which leaves are usually 3- to 6-lobed.

Through his extensive investigation of Tertiary maples from central Europe, Walther (1972) redesignated *A. integrilobum* Weber which is represented by trilobed leaves. He compared this species with the extant *A. cappadocicum* Gleditsch. of western Asia, which belongs to the Section Platanoidea. *A. integrilobum* closely resembles *A. florinii* in general outline, though it has sometimes weak dents on lobe margin. The epithet. "*florinii*", is better to be retained for the trilobed, entire-margined maple leaves of the Asian Tertiary, until a further detailed comparison is done on cuticle and fine venation of the both species.

Collection: TMP-400.

Text-fig. 2 The details of venation characters of fossils and their related extant species (1).

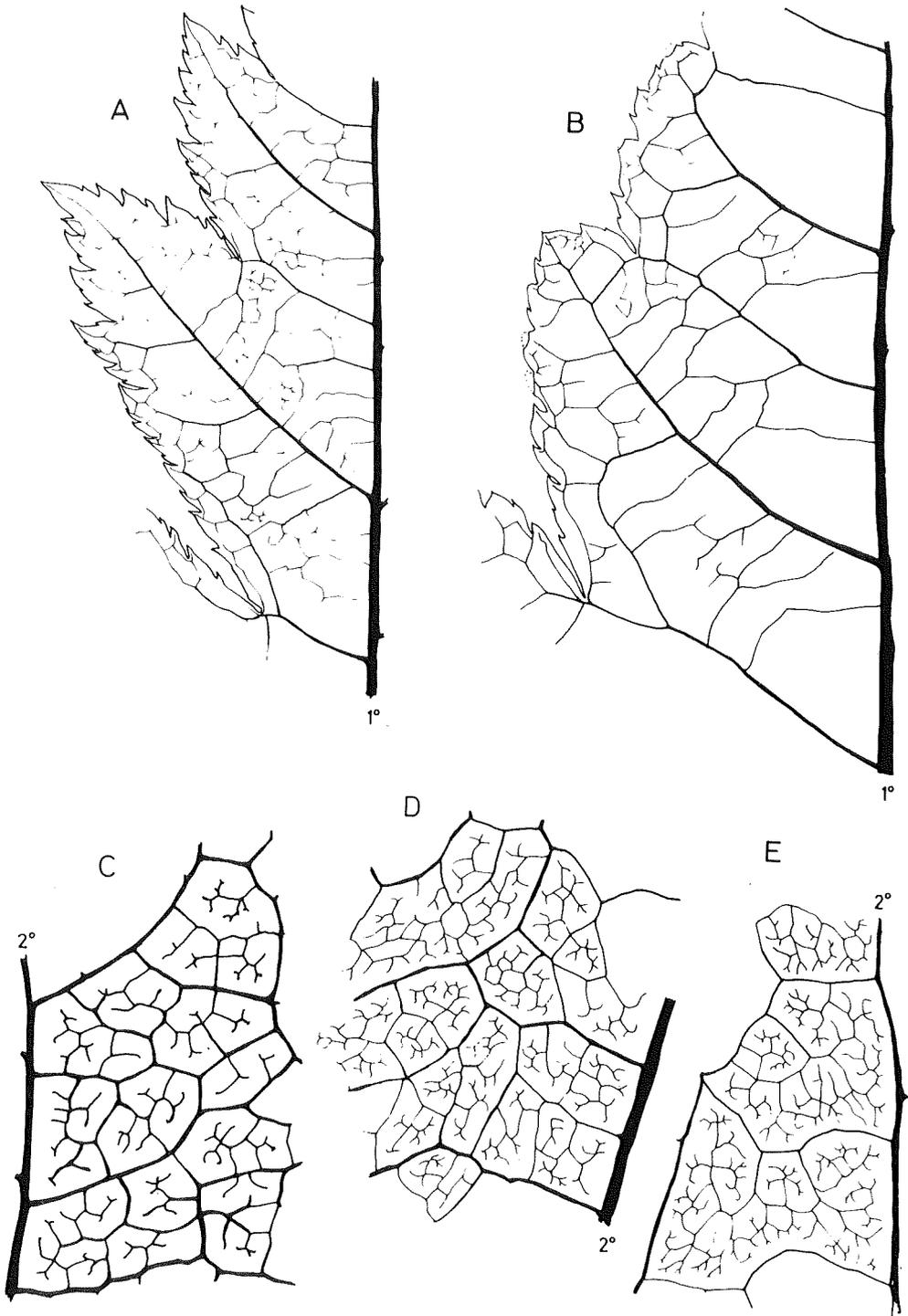
A. *Acer micranthum* Sieb. et Zucc. X3 (H.U.P.B. no.244)

B. *Acer uemurae* Tanai et Ozaki. X3 (TPM-293, pl.5, fig.9).

C. *Acer tschonoskii* Maxim. X12 (H.U.P.B. no.876).

D. *Acer uemurae* Tanai et Ozaki. X12 (TPM-293, pl.5, fig.9).

E. *Acer micranthum* Sieb. et Zucc. X12 (H.U.P.B. no.244)



Acer integerrimum (Viviani) Massalongo

(Pl.2, figs.1, 3, 4; text-fig.4, G, H)

Acer integerrimum (Viviani) Massalongo, Massalongo and Scarabelli. Stud. Flora foss. Geol. Stra. Senigall. 1859:341, pl.18. f.3; pl.41. f.10. 1859.

Tanai. Jour. Fac. Sci. Hokkaido Univ. ser.4, 17(2): 329 text-fig.7, K, 1976 (see synonymy).

Discussion: These five-lobed leaves are referred to *A. integerrimum* by nearly entire (sometimes wavy) margin and simple or none ultimate veinlets, and closely resemble the modern *A. mono* Maxim. of East Asia. *A. integerrimum* has been commonly recorded through the Neogene of East Asia under the epithet of “*subpictum*” as discussed recently by the senior author (Tanai, 1976b). No fossil samara from Tatsumitoge locality is referable to *A. integerrimum*.

Collections: NSM-PP-16023, 16065; TPM-362, 0383.

Section Saccharina Pax

Acer yamanae Tanai et Ozaki, sp. nov.

(Pl.3, figs.1, 7-11; text-fig.5, F, G; text-fig.6, E, F)

Acer palaeodiabolicum auct. non Endo. Tanai et Onoe. Geol. Surv. Jap. Rept. 182:48. pl.52 f.2 4; pl.16. f.1; pl.17. f.1-3 (excluding f.4). 1961.

Type: Holotype NSM-PP-16081. Tatsumitoge formation (Late Miocene). Saji-mura, Tottori Prefecture.

Description: Leaves pentagonal in general outline, 5 to 6 cm long and 5.5 to 8 cm wide, palmately five-lobed, somewhat deeply cordate at base, nearly entire or slightly undulate on margin; each lobe ovate in shape with abruptly acuminate apex; lateral lobes slightly undulate, with an obtuse point on the margin of basal side; primary veins palmately five, midvein strongest, straight; upper lateral primaries making angles of 50° to 60° with the midvein; the basal primaries about 110° to midvein; the lateral primaries almost straight or gently curving up; secondary veins about 5 pairs, subopposite to alternate, diverging from the primaries at angles of about 50°, brochidromous; intersecondary veins simple, joining principal marginal loops, or forming coarse reticulation with

Text-fig. 3 The details of venation characters of fossils and their related extant species (2).

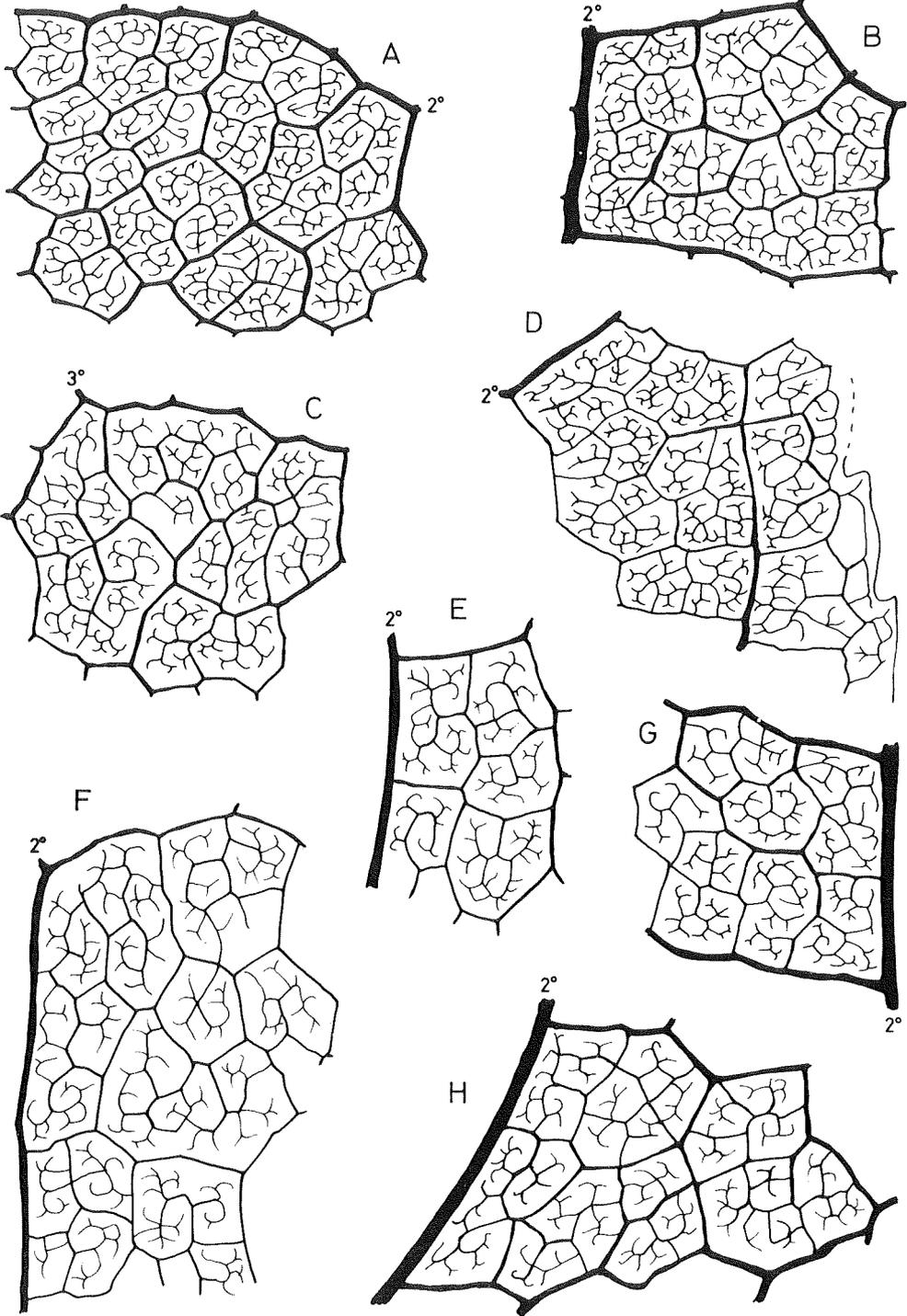
A-D. *Acer nordenskiöldii* Nathorst. A: X15 (TPM-470), B: X15 (NSM-PP-16025, pl.1, fig.2), C: X15 (TPM-471, pl.1, fig.1), D: X12 (NSM-PP-6440, pl.1, fig.3).

E. *Acer oliverianum* Pax. X15 (U.S.G.S. no.8615a).

F. *Acer sinense* Pax. X15 (U.S.G.S. no.7622)

G. *Acer amoenum* Carr. X15 (U.S.G.S. no.8577a).

H. *Acer erianthum* Schw. X15 (U.S.G.S. no.762a).



tertiary and quaternary veins; tertiary veins irregularly percurrent in intercostal areas; fourth- and fifth-order veins forming quadrangular or pentagonal areoles; ultimate veinlets none or single free-ending, very rarely once branching; petiole missing.

Samaras medium in size, 2.75 to 3.2 cm long; wing 2 to 2.4 cm long and 0.8 to 1 cm wide at the middle, gradually narrowed toward base and rounded at apex; outer margin of margin of wing straight, inner margin gently convex; veins distinct, numerous, gently incurving, more than thrice dichotomizing, seeds nearly globular, bulged outside, 5 to 7 mm in diameter; angles between outer margin of wing and contact line of seeds 30° to 35° degrees; contact line of seeds 4.5 mm long.

Discussion: Considering from the foliar shape, nearly entire margin and ultimate veinlets, these five-lobed leaves appear to belong to the Sections Platanoidea, Campestrina and Saccharina. The above-described characters suggest that our fossil leaves are most closely related to some of Saccharina such as the extant *A. nigrum* Michx., *A. leucoderme* Small and *A. barbatum* Michx. of eastern North America, especially close to the latter two in bluntly tipped lobe. The areolation of our fossil leaves is consistent in size and shape with that of all species belonging to Saccharina, excepting *A. saccharum* whose areoles are somewhat larger than others (text-fig.5 and 6). Leaves of *A. campestre* Linn. resemble our specimens, but are distinguishable by larger, conspicuous dents of lobes.

Our collections include two well-preserved samara, which closely resemble those of Saccharina, especially *A. nigrum* or *A. barbatum*, in extension angle of two wings and shape of seed. These fossil samaras resemble *A. yoshiokaense* Tanai et N. Suzuki from the Miocene of Southwestern Hokkaido (Tanai & N. Suzuki, 1960) in general character; however, our samaras are globular in shape, while *A. yoshiokaense* is ellipsoidal as similar to those of *A. saccharum*.

Text-fig. 4 The details of venation characters of fossils and their related extant species (3). (all figures X15).

A, E. *Acer nordenskiöldii* Nathorst. type 3. A: (G.S.J. no.4777, pl.1, fig.4), E: (G.S.J. no.4778, pl.1, fig.7).

B-D, F. *Acer nordenskiöldii* Nathorst. B, C: (NSM-PP-16027, pl.1, fig.8), D: (G.S.J. no.4783a, pl.1, fig.6), F: (TPM-112).

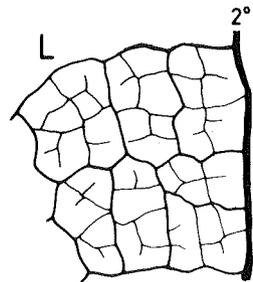
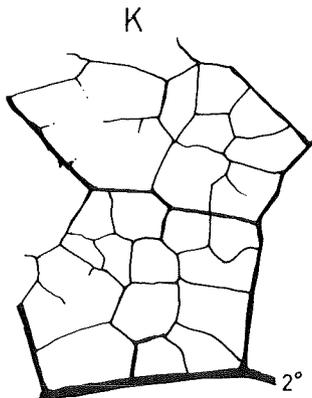
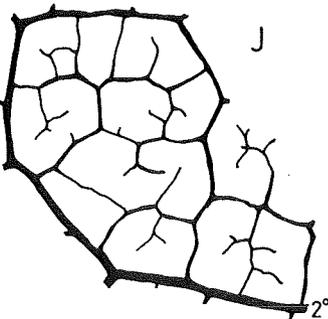
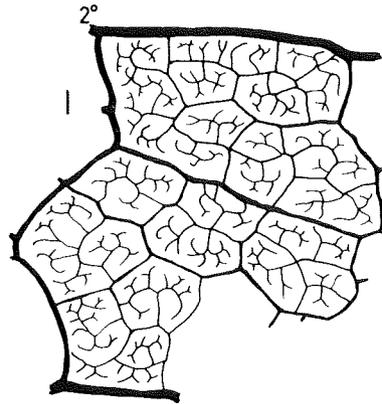
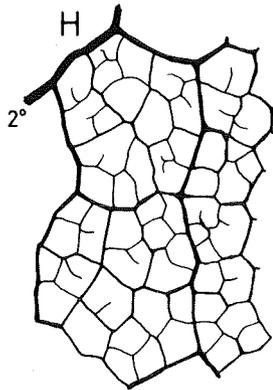
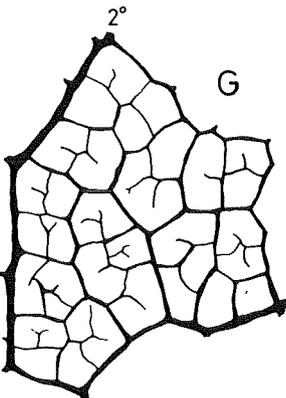
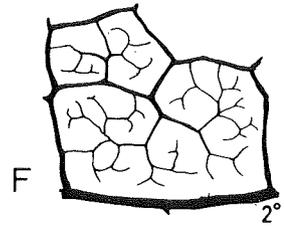
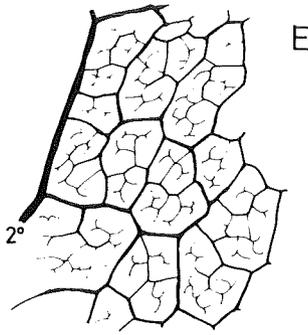
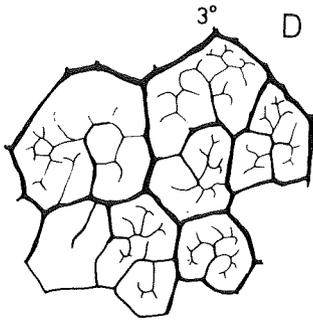
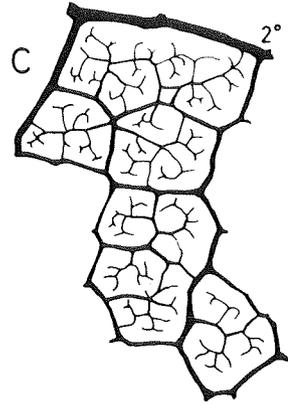
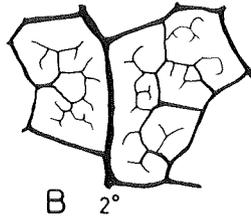
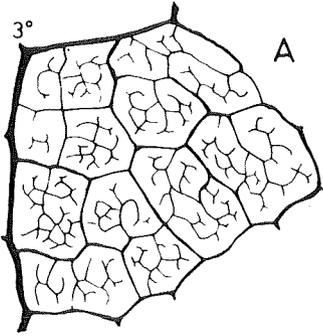
G, H. *Acer integerrimum* (Viviani) Massalongo. G: (NSM-PP-16065), pl.2, fig.4), H: (TPM-362, pl.2, fig.3).

I. *Acer palmatum* Thunb. (U.S.G.S. no.8616a).

J. *Acer mono* Maxim. (H.U.P.B. no.248).

K. *Acer florinii* Hu et Chaney. (TPM-400, pl.4, fig.3).

L. *Acer mono* Maxim. (U.S.G.S. no.8609).



Three leaves figured as *A. palaeodiabolicum* from Ningyotoge area (Tanai & Onoe, 1961) closely resemble our leaf specimens, though they are somewhat more prominent in marginal dents of lobes. Our detailed reinvestigation of these Ningyotoge leaves confirms that they are similar not to leaves of the extant *A. diabolicum* but to those of the extant *A. leudoderme* or *A. barbatum* in marginal serration and secondary veins. Leaves of the latter two American species are few in marginal dentation, and are also less in number of secondary veins in each lobe than those of *A. diabolicum*. Another distinction is also found in the characters of the lower-order veins: leaves of *A. diabolicum* are more prominently percurrent in tertiary veins, and are generally larger in size of areoles than the two American species. Considering all the above-noted characters, three leaves from Ningyotoge are doubtlessly referable to our new species, *A. yamanae*. The modern leaves of *A. saccharum* group are frequently variable in shape; especially, leaves of *A. nigrum*, *A. leucoderme* and *A. barbatum* are variable in marginal dentation, from prominently dentate to weakly dentate, as similarly seen in all the fossil leaves referred here to *A. yamanae*. Of four samaras figured as *A. palaeodiabolicum* from Ningyotoge, three specimens (Tanai & Onoe, 1961: pl.17, figs.1-3) are referable to those of *A. yamanae* in globular seeds and extension angles of two wings.

Some of our fossil leaves are somewhat similar to *A. integerrimum* (Viviani) Massal., which is closely related to the extant *A. mono* Maxim. (Section Platanoidea). But no leaves of *A. integerrimum* has been recorded to have obtuse dents on margin and bluntly-tipped lobes. As far as investigated by the authors, no leaves similar to our fossil leaves are also found in the extant *A. mono*.

A. yamanae, based on both leaves and winged seed, belongs to the Section Saccharina, whose extant species is now confined to North America in the modern distribution. This new species is named in the honor of Mr. I. Yamana, who has done an extensive collection from Tatsumitoge locality.

Collections: Holotype, NSM-PP-16022; paratypes NSM-PP-16081, 16202, GSJ. nos.4800b, 4827, TPM-457.

Text-fig. 5 The details of venation characters of fossils and their related extant species (4). (all figures X15).

A, B. *Acer trilobatum* (Sternb.) A. Braun. (TPM-280, pl.2, fig.7).

C. *Acer trilobatum* (Sternb.) A. Braun. (Hantke, 1954: pl.13, fig.10).

D. *Acer rubrum* Linn. (U.S.G.S. no. 1181c).

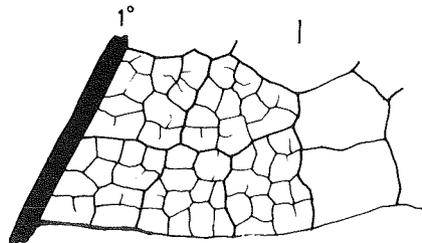
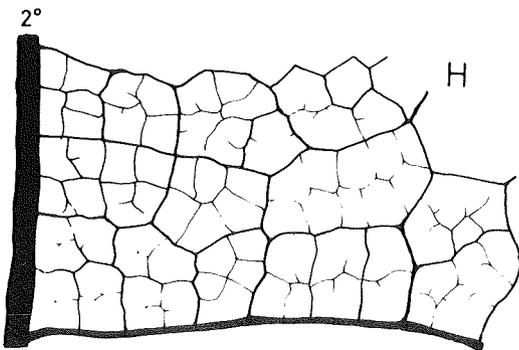
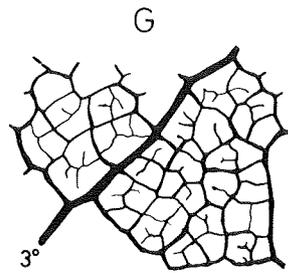
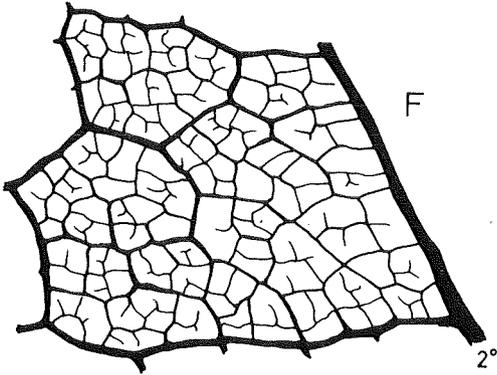
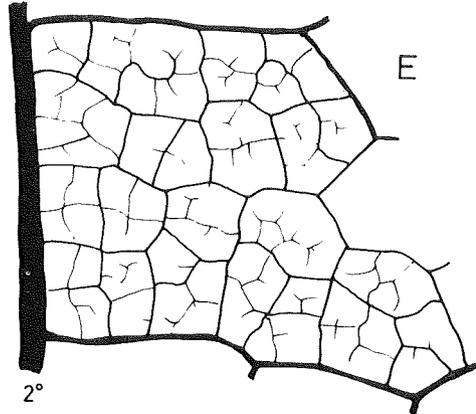
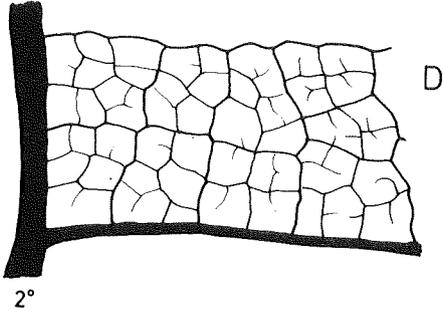
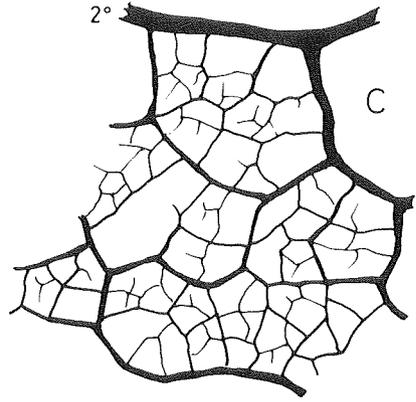
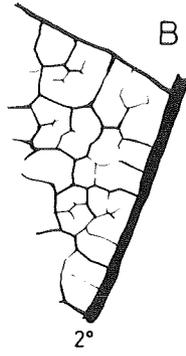
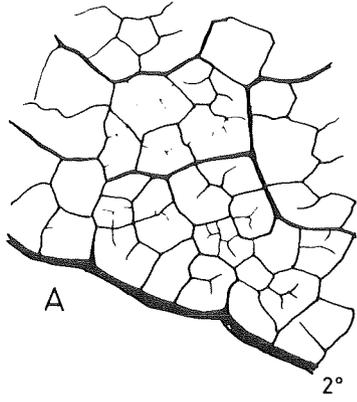
E. *Acer pycnanthum* K. Koch. (U.S.G.S. no.8619b).

F. *Acer yamanae* Tanai et Ozaki. (TPM-457, pl.3, fig.11).

G. *Acer yamanae* Tanai et Ozaki. (NSM-PP-16022, pl.3, fig.8).

H. *Acer saccharum* Marsh. (U.S.G.S. no.815).

I. *Acer nigrum* Michx. (U.S.G.S. no.1183b).



Section Trifoliolate Pax

Acer subnikoense Tanai et Ozaki, sp. nov.

(Pl.4, figs.1, 2, 4-7; text-fig.6, C)

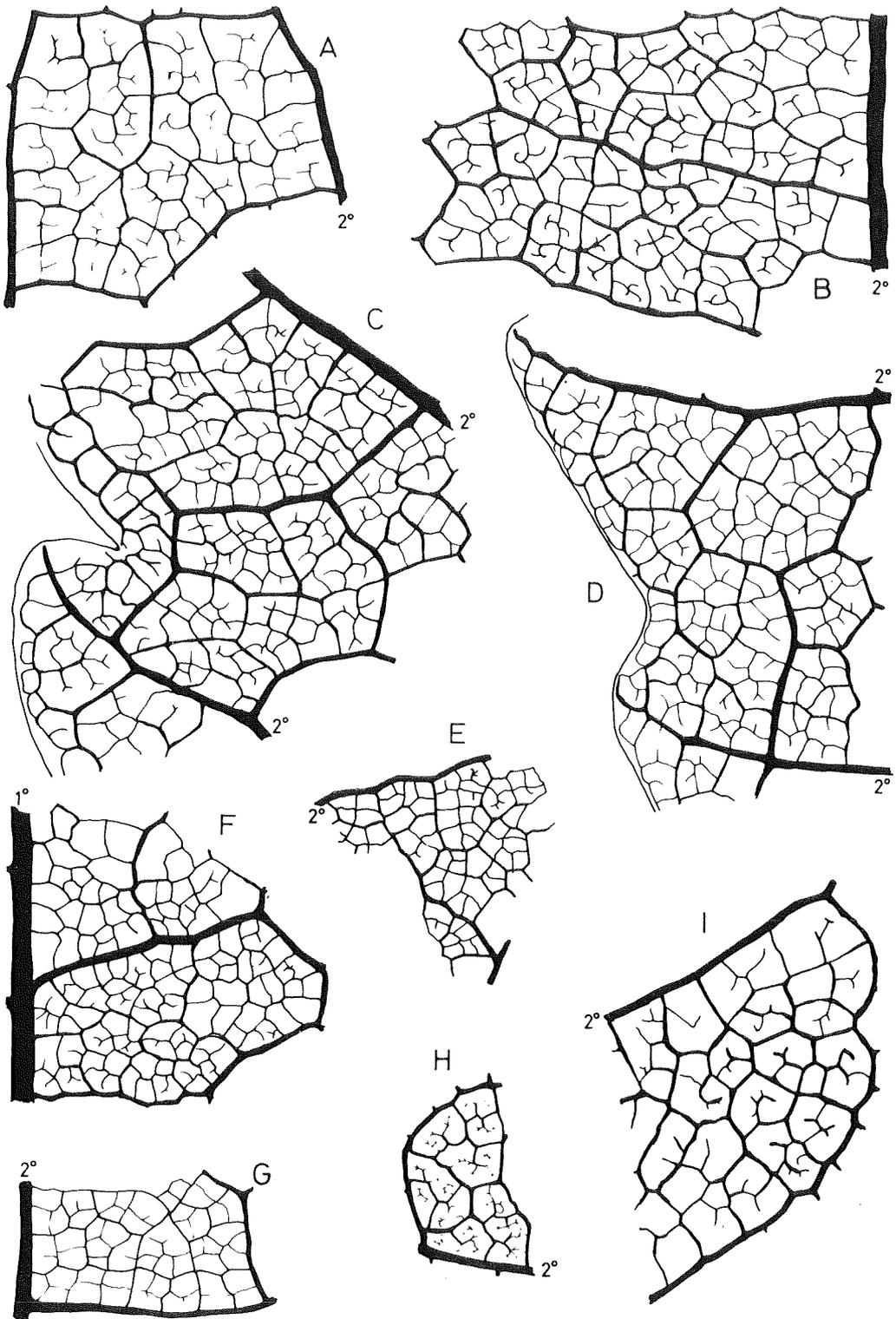
Type: Holotype, NSM-PP-16017. Tatsumitoge formation (Late Miocene). Saji-mura, Tottori Prefecture.

Description: Leaves composed compoundly of three leaflets; petiole stout, nearly straight, about 2.5 cm long; leaflets elliptical to ovate, nearly symmetrical in shape, acute at base, acute or slightly acuminate at apex, dentate with nearly right angle in marginal sinus; lateral leaflets asymmetrically elliptic in shape, obliquely rounded at base (convex on one side and nearly straight on the other side), acute or slightly acuminate at apex, undulately dentate with obtuse teeth on the margin excepting the lower or basal part (teeth on convex side generally larger or more distinct than on straight side); midvein stout, straight or slightly curving; secondary veins distinct, 8 to 13 pairs, alternate to subopposite, irregularly spaced, diverging from the midrib at angles of 45° to 60°, slightly curving up or rarely forking on a half or two-third way to the margin, entering directly the marginal dents, or abruptly arising up within dents and a branch entering the dents; the secondaries of the lower part gently curving up, near the margin joining superadjacent secondary at various angles; slender intersecondaries rarely giving off, connecting with the tertiaries on the half way; tertiary veins in costal areas weakly percurrent or orthogonal-reticulate; fourth- and fifth-order veins forming quadrangular or pentagonal areoles; the tertiaries in marginal areas forming loops, enclosed by quaternary arches; ultimate veinlets mostly none, or rarely single or once branching; petiolules 2 to 7 mm long in the laterals and about twice longer in the terminals.

Discussion: Three trifoliolate leaves and a number of detached leaflets resemble those of such genera as *Acer*, *Rhus* and *Fraxinus* in their general appearance, but are referable to the genus *Acer* by the venation and marginal characters. Among the extant maples of the world, there are eight species with the trifoliolate (or five-foliolate) leaves similar to our specimens. According to Ogata (1967), these extant species belong to three different Sections: the Section

Text-fig. 6 The details of venation characters of fossils and their related extant species (5).

- A. *Acer rufinerve* Sieb. et Zucc. ×13, (H.U.P.B. no.237).
- B. *Acer palaeorufinerve* Tanai et Onoe. ×13, (G.S.J. no.4779, pl.5, fig.10).
- C. *Acer subnikoense* Tanai et Ozaki. ×15, (NSM-PP-16012, pl.4, fig.2).
- D. *Acer nikoense* Maxim. ×15, (H.U.P.B. no.228).
- E. *Acer yamanae* Tanai et Ozaki. ×15, (G.S.J. no.4828, pl.3, fig.1).
- F. *Acer yamanae* Tanai et Ozaki. ×15, (TPM-136, pl.3, fig.7).
- G. *Acer leucoderme* Small. ×15, (U.S.G.S. slide no.7631)
- H. *Acer macrophyllum* Pursh. ×15, (H.U.P.B. no.242).
- I. *Acer honshuense* Tanai et Ozaki. ×15, (TPM-382, pl.5, fig.8).



Negundo (*Acer negundo* Linn.), the Section Cissifolia (*A. cissifolium* K. Koch. and *A. henryi* Pax) and the Section Trifoliata (*A. sutchuense* Pax, *A. nikoense* Pax, *A. griseum* Pax, *A. mandshuricum* Maxim. and *A. triflorum* Komarov). All of these species are now living in East Asia, excepting for *A. negundo* living in North America.

As far as investigated by the senior author (Tanai, 1967a), leaflets of the Section Trifoliata are easily distinguishable from those of the Sections Negundo and Cissifolia by the fine veinlets, although their leaflets are similar each other in foliar characters. The ultimate veinlets in the Trifoliata are none or single free-ending within the areoles, while those of the other two Sections are more than twice branching, showing the complicate patterns. Comparing the fine veinlets with those of the extant species (text-fig.6, C, D.), our fossil leaflets from Tatsumitoge belong doubtlessly to the Trifoliata; especially they are closely similar to leaflets of the extant *A. nikoense* in general shape and marginal character. However, our new species, *A. subnikoense*, is generally more distinct in marginal dentation than averaged leaflets of the related extant species. No fossil samara similar to *A. nikoense* is found in our collections.

Trifoliate leaves and their detached leaflets have been commonly from the Tertiary of the world; most of them are related to *A. negundo* Linn. For instance, *A. subnikoense* is somewhat similar in general appearance to *A. miohenryi* Hu et Chaney which is known in the Miocene of East Asia, but is distinctly distinguishable in acute marginal teeth and more branching veinlets. Another similar specimens are trifoliate leaves figured as *A. aegopodifolium* (Geopp.) Baik. ex Iljinskaja from the Tertiary of Transcaspian Plateau (Zhilin, 1974; p.57, text-fig.30); however, these Zhilin's leaflets are more acute in marginal teeth, while our species are obtuse or rather rounded-tipped.

Based on an incomplete leaflet from the Miocene of Sikhote-Alin, Akhmetjev (1973) established *A. trifloriformis*, which is similar to the extant *A. triflorum*. Our leaflets are distinguishable from the Sikhote-Alin species in general outline and marginal characters. *A. subnikoense* is the first Tertiary record of the section Trifoliata in Japan.

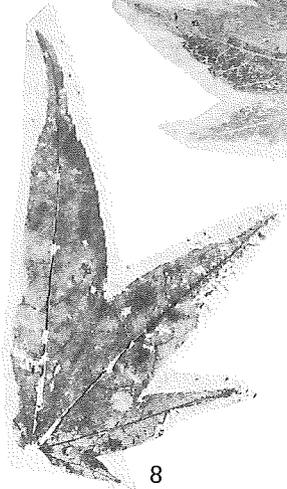
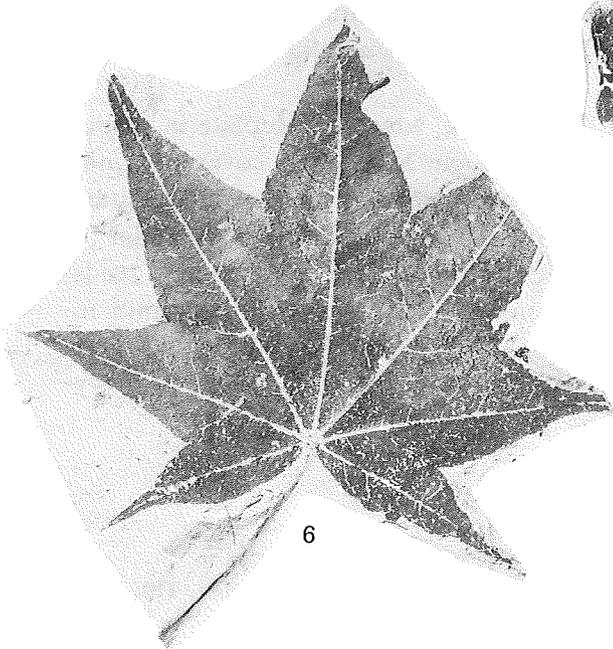
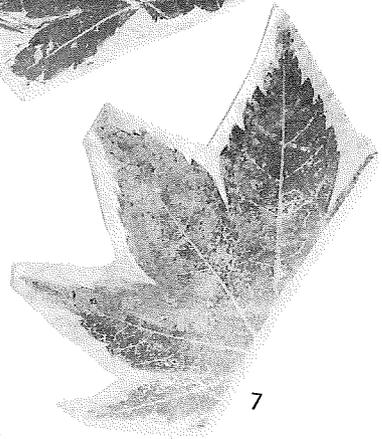
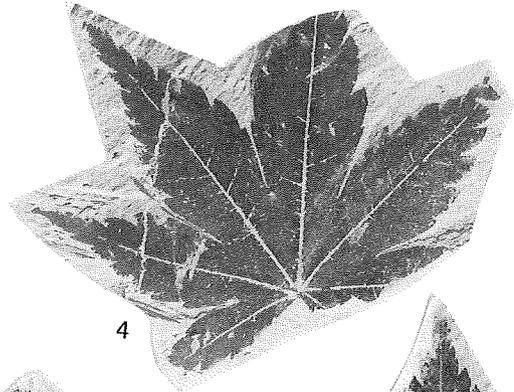
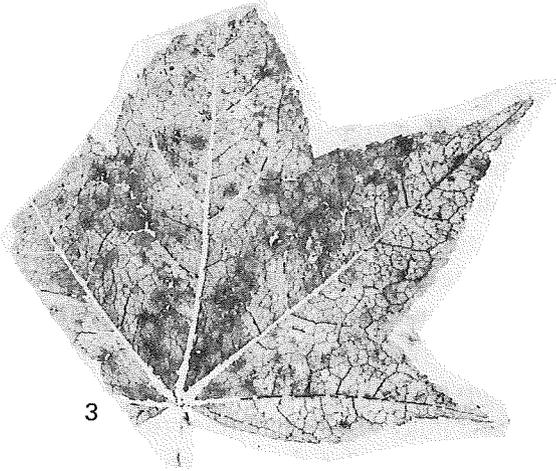
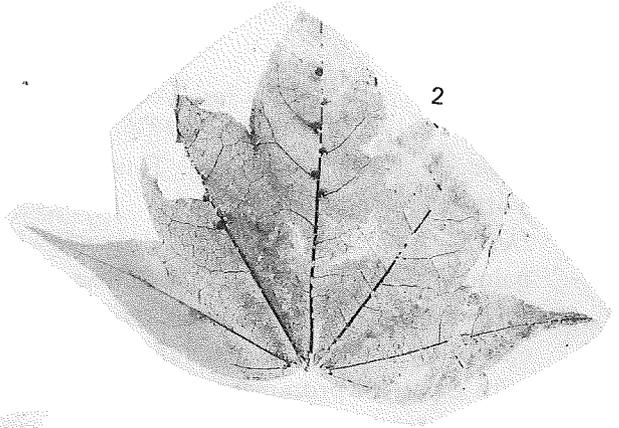
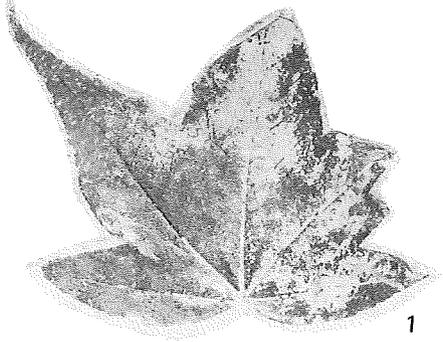
Collections: Holotype, NSM-PP-16017; paratypes, NSM-PP-16005, 16007, 16012, G.S.J. no.4796, TPM-487.

Explanation of Plate 1 (all natural size)

Figs. 1-9. *Acer nordenskiöldii* Nathorst. fig.1 TPM-471; figs.2, 3 NSM-PP-16025, 6440; fig.4 G.S.J. no.4777; fig.5 NSM-PP-16200; figs.6, 7 G.S.J. no.4783a, 4778; figs.8, 9 NSM-PP-16027, 16021.

THE GENUS *ACER*

Plate 1



Section Macrophylla (Pojarkov) Ogata
Acer honshuense Tanai et Ozaki, sp. nov.
 (Pl.5, fig.5-8; text-fig.6, I)

Acer sp. cf. *franchetii* Pax foss., Akhmetjev & Schmidt. Rept. Geol. Palaeont. Far East. 98. pl.10. f.7; text-fig.1-26. 1976.

Type: Holotype, TPM-382. Tatsumitoge formation (Late Miocene).Sajimura, Tottori Prefecture.

Description: Leaf pentagonal, somewhat inequilateral in general outline, palmately five-lobed, cordate at base, 7.3 cm high and 8.5 cm (estimated) wide; each lobe attenuate at apex, with long-caudate tip, nearly entire on margin excepting for large dents; central lobe largest, pentagonal in outline, provided with a pair of prominent, long-caudate tipped dents and a pair of small, obtuse teeth; lateral lobes medium in size, lanceolate in shape, provided with a large, attenuate teeth on the middle of basal side of margin; basal lobes smallest, lanceolate in shape; each sinus acute but rounded at bottom; primary veins five in number, nearly straight but sinuous on caudate apical part; medial and lateral primaries stronger than the basal; upper laterals making angles of about 45° and the basal making angles 90° with the medial respectively; secondary veins generally slender 6 or 7 pairs, opposite to subopposite, diverging at angles of 35° to 50° from the primaries, mostly arising up near the margin, camptodrome, but a few secondaries entering marginal dents or teeth, somewhat more stout than others; an intersecondary veins sometimes running in costal areas, parallel to the secondaries; tertiaries slender, weakly percurrent or random reticulate; fourth and fifth-order veins forming quadrangular or pentagonal meshes; ultimate veinlets ill-preserved but usually more than once branching; petiole missing.

Samaras medium in size, 3.4 to 4.2 cm long; wing oblanceolate in shape, rounded at apex, nearly straight on outer margin and gently convex on inner margin, 1.1 to 1.55 cm at widest part; veins numerous, running in a bundle along the outer margin, then curving abruptly inward (nearly perpendicular to outer margin) and dichotomously branching more than three times; seeds compressed-globose in shape, partly covered by long hairs, 6 to 11 mm in

Explanation of Plate 2

(all natural size unless otherwise stated)

Fig. 1. *Acer integerrimum* (Viviani) Massalongo. X0.75, TPM-383.

Fig. 2. *Acer protojaponicum* Tanai et Onoe. TPM-231.

Figs. 3, 4. *Acer integerrimum* (Viviani) Massalongo. TPM-362, NSM-PP-16065.

Figs. 5-7. *Acer trilobatum* (Sternb.) A. Braun. NSM-PP-16163, G.S.J. no.4826, TPM-280.



diameter; contact line of seed distinct, straight, 6 to 8 mm long; angles between contact line and outer margin of wing 35° to 45° .

Discussion: This nearly complete leaf is closely similar in general appearance to leaves described as *Acer palaeodiabolicum* Endo and *A. ezoanum* Oishi et Huzioka, which are common in the Miocene of Japan; especially it is most close to some leaves of the former from the Upper Miocene of Hokkaido (N. Suzuki, 1963: pl.2, fig.3) and of northern Honshu (Huzioka & Uemura, 1973: pl.14, fig.2.). But our leaf is distinguishable in more slender secondary and tertiary veins and long-caudate dents on lobe margin. The distinction is also found in areolation and veinlets between these specimens.

Our leaf seems to belong to the Section Saccharina in its general shape, especially in its long-caudate tipped lobes; in actual, this fossil specimen shows a close resemblance to leaves of the extant *A. saccharum* Marsh. of eastern North America. However, our specimen is easily separable from the Section Saccharina in fine venation character. The ultimate veinlets appear once or twice branching in our leaf specimen, though the final branches are sufficiently unconfirmed due to ill-preservation. On the other hand, the ultimate veinlets are none or single within the areoles in the Section Saccharina. Considering the leaf shape and veinlets, our specimen is rather similar to leaves of *A. macrophyllum* Pursh. living in the western coast of North America, although it is further more long-caudate in apices of lobes and dents than in the extant species. The ultimate veinlets of *A. macrophyllum* are irregular but mostly more than twice branching; as shown in text-fig.6, H, their fine branches appear too slender to be well preserved in fossil leaf, comparing to the free-ending veinlets of most species of *Acer*. Adding the above characters, slender venation character (secondary and tertiary) is common between our leaf and the extant species. Thus, our fossil leaf probably belongs to the Section Macrophylla, which extant species is now confined to western North America. However, it is noteworthy that our leaf is twice larger in areoles than the extant *A. macrophyllum*.

Explanation of Plate 3

(all natural size)

Fig. 1. *Acer yamanae* Tanai et Ozaki. G.S.J. no.4828.

Fig. 2. *Acer tottoriense* Tanai et Ozaki. Holotype, TPM-235.

Fig. 3. *Acer tottoriense* Tanai et Ozaki. Sketch of figure 2.

Figs. 4-6. *Acer tottoriense* Tanai et Ozaki. NSM-PP-16213, 16202, 16168.

Fig. 7. *Acer yamanae* Tanai et Ozaki. TPM-136.

Fig. 8. *Acer yamanae* Tanai et Ozaki. Holotype, NSM-PP-16022.

Fig. 9, 10. *Acer yamanae* Tanai et Ozaki. G.S.J. nos.4827, 4800b.

Fig. 11. *Acer yamanae* Tanai et Ozaki. TPM-457.



Our collections include three samaras with hairy seeds, which are closely similar to those of the extant *A. macrophyllum* in extension angles of both wings and seed shape. These samaras are included in *A. honshuense*, and may support this new species is related to *A. macrophyllum*. A large samara described as *Acer* cf. *franchetii* Pax fossilis from Prymorie region of USSR (Akhmetjev & Schmidt, 1976) is included in our new species by half-circular seed and shape of wing. *A. honshuense* represented by both leaves and samaras, is the first record of the Section Macrophylla in Japan. It is noteworthy for the phytogeography of the genus *Acer* that the Section Macrophylla was recorded in the Miocene of Japan and Prymorie.

Collections: Holotype, TPM-382; paratypes, NSM-PP-16215, 16216, TPM-486.

References

- Akhmetjev, M. A., 1973. Sikhote-Alin Miocene flora. *Red. Banner Labour Geol. Inst., Acad. Sci. USSR, Trans.* 247: 1-123.
- Akhmetjev, M. A. and Schmidt, I. N., 1976. Studies of *Acer* from the southern continental part of Far East, USSR, and Stratigraphical implication and their remains. In: Ablav, A. G. (Edit.), *Reports of Geology and Paleontology of the Far East*. Far-Eastern Geol. Inst., Vladivostok, pp. 79-103. (in Russian).
- Baikovskaya, T. N., 1974. *Late Miocene floras from southern Primorya*. Acad. Sci. U.S.S.R., Komarov Bot. Inst., Leningrad, 136 pp. (in Russian)
- Braun, A., 1845. Die Tertiär-Flora von Oeningen. *N. Jb. Mineral.* (1845): 164-173.
- Endo, S., 1950. On the fossil *Acer* from Japan, Korea and south Manchuria. *Short Papers I.G.P.S.*, (1): 11-17.
- Endo, S., 1951. On the fossil *Acer* from Japan, Korea and South Manchuria. II. *Short Papers I.G.P.S.*, (3): 52-58.
- Hantke, R., 1965. *Die fossilen Eichen und Ahorne aus der Molasse der Schweiz und von Oehningen (Sud-Baden)*. Neujahrsblatt herausg. Naturforsch. Gesell., Zurich, 140 pp.
- Heer, O., 1855, 1856, 1859. *Flora tertiaria Helvetiae*. Winterthur, bd.1, 2, 3.
- Hoyo, Y., 1971. Notes on some Miocene *Acer* from the Island of Iki, Nagasaki Prefecture, *Prof. H. Matsushita, Spec. vol.*: 151-153.

Explanation of Plate 4.

(all natural size unless otherwise stated)

Figs. 1, 2. *Acer subnikoense* Tanai et Ozaki. TPM-487, NSM-PP-16012.

Fig. 3. *Acer florinii* Hu et Chaney. TPM-400.

Fig. 4. *Acer subnikoense* Tanai et Ozaki. Holotype, NSM-PP-16017.

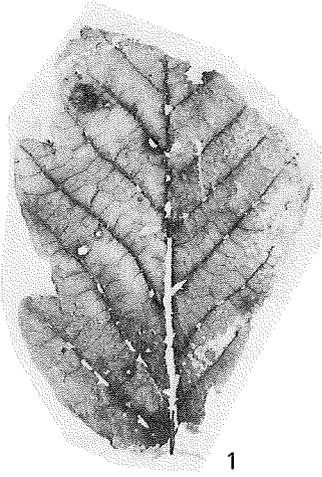
Fig. 5. *Acer subnikoense* Tanai et Ozaki. $\times 1.5$, NSM-PP-16007.

Figs. 6, 7 *Acer subnikoense* Tanai et Ozaki. NSM-PP-16005, 16006.

Fig. 8. *Acer pseudocarpinifolium* Endo. $\times 1.5$, NSM-PP-16054.

THE GENUS *ACER*

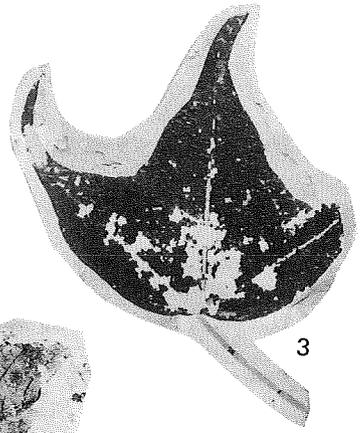
Plate 4



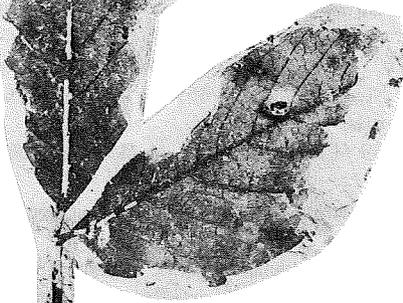
1



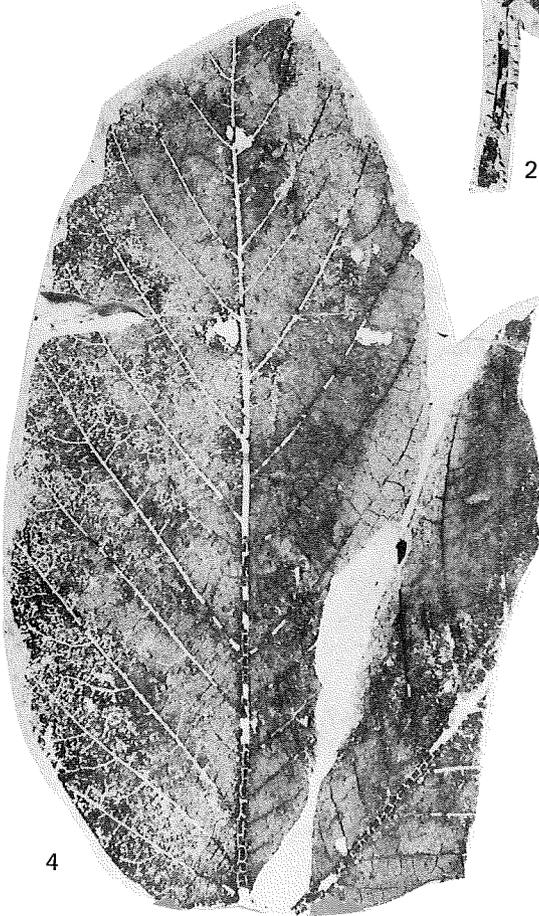
2



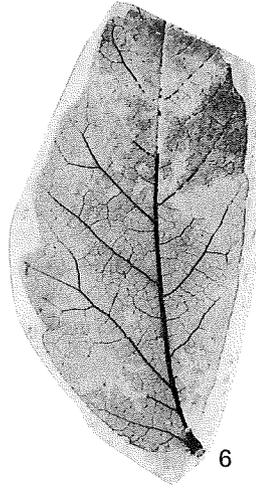
3



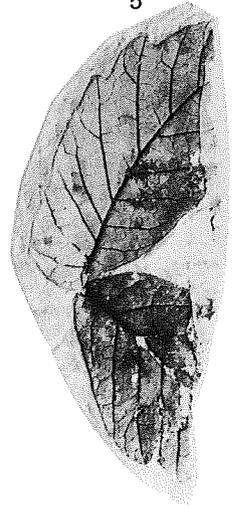
5



4



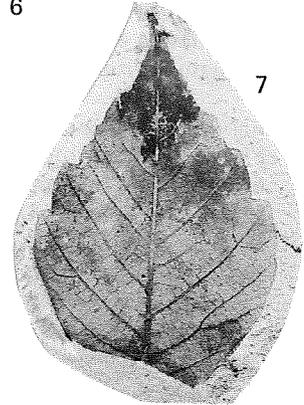
6



7



8



- Hu, H. H. and Chaney, R. W., 1938. A Miocene flora from Shantung Province, China. *Palaeont. Sinica*, new ser.A, (1): 118-141.
- Huzioka, K., 1943. Notes on some Tertiary plants from Tyosen. I. *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser.4, 7(1): 118-141.
- Huzioka, K., 1963. The Utto flora of northeastern Honshu. *Tertiary floras of Japan, Miocene floras*. 3, Collab. Assoc. Commem. 80th Anniv., Geol. Surv. Japan, Tokyo, pp. 153-216.
- Huzioka, K., 1964. The Aniai flora of Akita Prefecture, and the Aniai-type floras in Honshu, Japan. *Jour. Min. Coll., Akita Univ.*, ser.A, 3(4): 1-105.
- Huzioka, K., 1974. The Tertiary floras of Korea. *Jour. Min. Coll., Akita Univ.*, ser.A, 5(1): 1-83.
- Huzioka, K., 1974. The Miocene Daibo flora from the western end of Honshu, Japan. *Jour. Min. Coll., Akita Univ.*, ser.A, 5(2): 1-24.
- Huzioka, K. and Uemura, K., 1973. The late Miocene Miyata flora of Akita Prefecture, northeast Honshu, Japan. *Bull. Nat. Sci. Mus.*, 16(4): 661-738.
- Lamarck, J. B., 1776. *Encyclopedie methodique Botanique*. 2. paris.
- Massalongo, A. and Scarabelli, G., 1859. *Studi sulla flora fossile e geologia stratigrafica del Senigalliese, Imola*.
- Nathorst, A. G., 1883. Contribution à la flore fossile du Japan. *Kgl. Svensk. Vet. Akad. Handl.* 20: 3-92.
- Ogata, K., 1967. A Systematic Study of the Genus *Acer*. *Bull. Tokyo Univ. For.*, 63: 89-206.
- Ohwi, J., 1972. *Flora of Japan*. Shibundo, Tokyo, 1560 pp.
- Oishi, S. and Huzioka, K., 1943. Tertiary Acers from Hokkaido and Karahuto. *Jour. Fac. Sci. Hokkaido Imp. Univ.* ser.4, 7(1): 81-101.
- Prochazka, M. and Bůžek, C., 1975. Maple leaves from the Tertiary of North Bohemia. *Rozpr. Ustr. Ust. Geol.*, 41: 1-86.
- Simelnikova, V. N., Fotjanova, L. I. and Chelebaeba, A. I., 1976. The Mio-Pliocene of the west Kamtschatka. *Acad. Nauk. U.S.S.R., Transact.*, 294: 67-198.
- Sternberg, K., 1823, 1835. *Versuch einer geognostisch-gotanischnen Darstellung der Flora der Vorwelt*. 1(3, 4): Regensburg, Praha.
- Suzuki, N., 1963. Late Tertiary Maples from northeastern Hokkaido, Japan. *Jour. Fac. Sci., Hokkaido Univ.*, ser.4, 11(4): 683-693.
- Tanai, T., 1961. Neogene floral change in Japan. *Jour. Fac. Sci., Hokkaido Univ.*, ser.4, 11(2): 119-398.
- Tanai, T., 1971. The Miocene Sakipenpetsu flora from Ashibetsu area, central Hokkaido, Japan. *Mem. Nat. Sci. Mus.*, (4): 127-172.

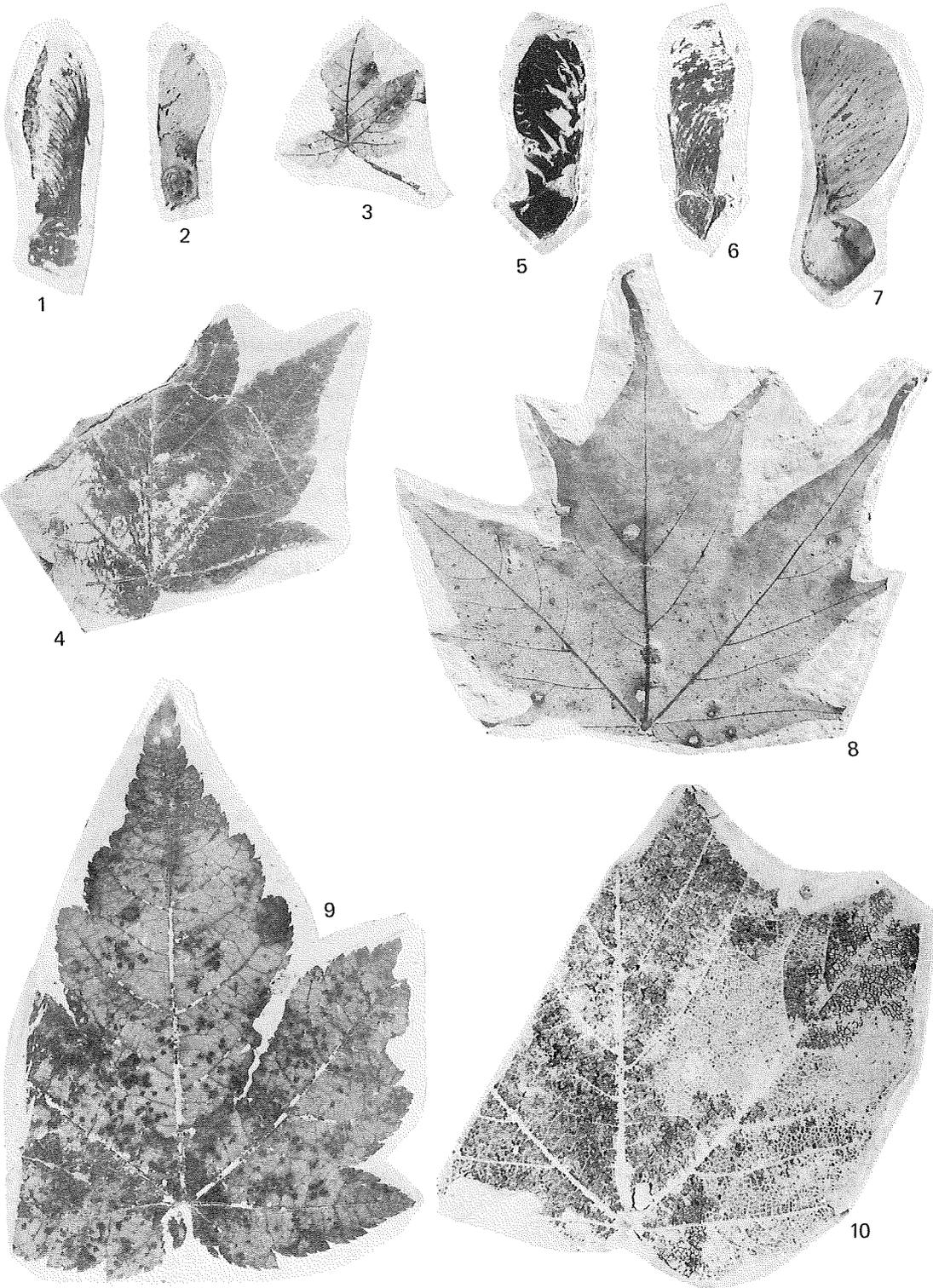
Explanation of Plate 5

(all natural size unless otherwise stated)

- Fig. 1. *Acer protojaponicum* Tanai et Onoe. ×1.5, TPM-217.
- Fig. 2. *Acer protojaponicum* Tanai et Onoe. TPM-480.
- Figs. 3, 4. *Acer uemurae* Tanai et Ozaki. TPM-484, NSM-PP-16067.
- Figs. 5-7. *Acer honshuense* Tanai et Ozaki. TPM-486, NSM-PP-16215, 16216.
- Fig. 8. *Acer honshuense* Tanai et Ozaki. Holotype, TPM-382.
- Fig. 9. *Acer uemurae* Tanai et Ozaki. Holotype, TPM-293.
- Fig. 10. *Acer palaeorufinerve* Tanai et Onoe. G.S.J. no.4779.

THE GENUS *ACER*

Plate 5



- Tanai, T., 1976a. Neogene evolutionary history of the genus *Acer* in the northern Pacific basin. *Abstracts Papers 1st Inter. Congress Pacific Neogen Stratigraphy.*, Sci. Council. Japan and Geol. Soc. Japan, Tokyo, pp. 202-205.
- Tanai, T., 1976b. The Revision of the Pliocene Mogi flora, described by Nathorst (1883) and Florin (1920). *Jour. Fac. Sci., Hokkaido Univ.*, ser.4, 17(2): 277-346.
- Tanai, T. and Onoe, T., 1959. A Miocene flora from the northern part of the Joban Coal Field, Japan. *Bull. Geol. Surv. Japan*, 10(4): 1-24.
- Tanai, T. and Onoe, T., 1961. A Mio-Pliocene flora from the Ningyotoge area on the border between Tottori and Okayama Prefecture, Japan. *Geol. Surv. Japan Rept.*, (187): 1-62.
- Tanai, T. and Suzuki, N., 1960. Miocene Maples from southwestern Hokkaido, Japan. *Jour. Fac. Sci., Hokkaido Univ.*, ser.4, 10(3): 551-570.
- Tanai, T. and Suzuki, N., 1963. Miocene floras of southwestern Hokkaido, Japan. *Tertiary floras of Japan, Miocene floras*, 2. Collab. Assoc. Commem. 80th Anniv., Geol. Surv. Japan, Tokyo, pp. 9-149.
- Tanai, T. and Suzuki, N., 1965. Late Tertiary floras from northeastern Hokkaido, Japan. *Palaeont. Soc. Japan Spec. Paper*, (10): 1-117.
- Walther H., 1972. Studien über tertiäre *Acer* Mitteleuropas. *Abh. Staatl. Mus. Mineral. Geol.*, 19: 1-309.
- Yamana, I. Ozaki, H. and Endo, S., 1967. Geology and Miocene flora of the Tatsumitoge Area in Tottori Prefecture, Japan. *Bull. Tottori Sci. Mus.* (5): 1-12 (in Japanese).
- Zhilin, S. G., 1974. *The Tertiary floras of the Plateau Ustjurt.* Acad. Sci. U.S.S.R., Komarov. Bot. Inst., Leningrad, 124 pp.

(Received on May 24, 1977)