MIOCENE MAPLES FROM SOUTHWESTERN HOKKAIDO, JAPAN

By

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The genus *Acer* has more than 100 living species in the world, most of which species are widely distributed over the northern hemisphere and only one species in Sumatra and Java, extending south of the equator. In East Asia, there are about 50 living species of the maple. To people this genus is one of the most familiar trees in modern vegetation. Most of them have peculiar foliar shape and characteristic seeds.

Fossil maples have been very abundantly found throughout Tertiary flora in the world, and many fossil species of maples have been described from various localities by various authors. In Japan, fossil remains of the maple have been commonly found also from Palaeogene to Pleistocene flora. This genus presents the largest number of species among the genera of the past vegetable world in Japan. In general, fossil maples in Neogene flora are rather more abundant in number of species and specimens than in Palaeogene flora.

In Tertiary sediments of Hokkaidô, fossil maples commonly occur; some of them have already been described by OISHI and HUZIOKA (1943). Lately, the writers have studied on Miocene flora of various localities in southwestern Hokkaidô, and already identified more than 100 species of conifers and dicotyledons. Many specimens of maples from that Miocene flora include various species represented by their fruits and leaves; some of them are interesting for information on the past distribution of plants. Recently, the writers were able to determine 16 species of *Acer* through a careful comparison of fossil leaves and samaras with those of modern maples now living in the world. They are described in the following paragraph.

Acknowledgements

The National Academy of Science, U. S. A., provided funds for field work to collect plant fossils from southwestern Hokkaidô in the summer of 1959. The writers wish to acknowledge their great indebtedness to Prof. R. W. CHANEY of the University of California for his valuable sug-

gestions and for kindly offering funds for the research. Thanks are also extended to Prof. Y. SASA of Hokkaido University for his kind information on the general geology in the vicinity of the fossil localities.

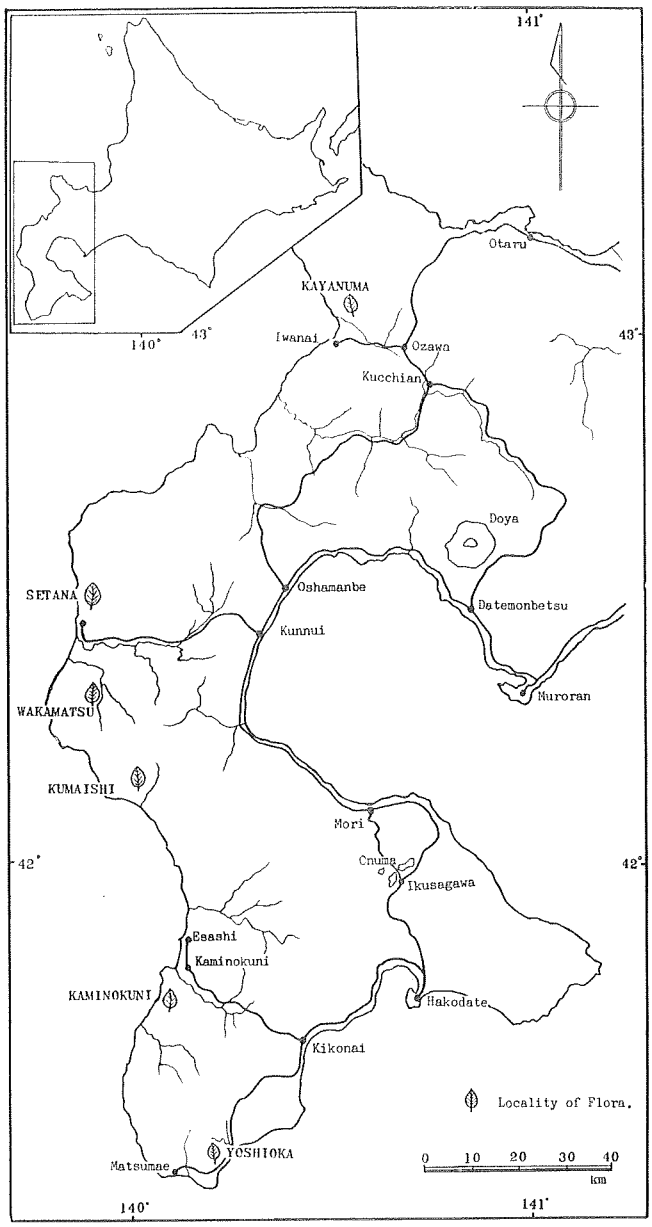
Fossil Localities and Occurrence

Neogene sediments in southwestern Hokkaidô overlie Palaeozoic or other older rocks, lacking Palaeogene and Mesozoic sediments. These Neogene sediments consist of considerable pyroclastic rocks from the basal part of the uppermost. In particular, the lower part of them which is Early or Middle Miocene in age, has been called "green tuff formation" consisting of green tuff, lava, propylite and other tuffaceous rocks. In the view point of the geologic province, southwestern Hokkaidô belongs to the so-called "green tuff region", and occupies the northern extension of the inner zone of the Honshû arc. Accordingly, Neogene sediments in southwestern Hokkaidô are not only similar in lithology and palaeontology to those of the inner zone of northeastern Honshû, but also in stratigraphic sequence. Further more, the fossil flora in southwestern Hokkaidô is also similar in occurrence and components to that of the "green-tuff region" of northeastern Honshû.

In southwestern Hokkaidô, Neogene sediments are divided into the following 5 formations in ascending order: the Fukuyama, Kunnui, Yakumo, Kuromatsunai and Setana formations. The terrestrial sediments including plant fossils, are partly intercalated in the Fukuyama, Kunnui and Setana formations, though most of these five formations are of marine origin. The fossil maples treated in the present paper, are found from the Fukuyama and Kunnui formations of Miocene age. Six localities having abundant plant fossils in southwestern Hokkaidô, were ascertained by the writers, and listed as providing the Kayanuma, Setana, Wakamatsu, Kumaishi, Kaminokuni and Yoshioka floras as shown in Text-Fig. 1. Among floras, the Yoshioka, Kumaishi, Wakamatsu and Setana are found from the basal or lower part of the Kunnui formation, while the Kaminokuni and Kayanuma floras are from the uppermost part of the Fukuyama formation.

These floras, excluding the Kumaishi flora, contain abundant fossil maples representing by leaves and samaras; they are generally excellent in preservation. The writers could identify the following 16 species of maples:

Acer crataegifolium (KNOWLTON) LAMOTTE
Acer ezoanum OISHI et HUZIOKA



Text-Figure 1. Localities of Miocene Flora in Southwestern Hokkaidô.

Acer fatsiaefolia HUZIOKA
Acer florinii HU et CHANEY
Acer megasamarum TANAI et SUZUKI sp. nov.
Acer meisenense ENDO
Acer palaeodiabolicum ENDO
Acer palaeoplatanoides ENDO
Acer palaeorufinerve TANAI et ONOE
Acer protodistylum ENDO
Acer protojaponicum TANAI et ONOE
Acer prototataricum TANAI et SUZUKI sp. nov.
Acer pseudoginnala TANAI et ONOE
Acer subpictum SAPORTA
Acer submayrii TANAI et ONOE
Acer yoshiokaense TANAI et SUZUKI sp. nov.

Among these 16 species, *Acer ezoanum* is most abundant in number of specimens, followed by *A. subpictum, A. crataegifolium* and *A. palaeodiabolicum*. The remaining 12 species are less than 10 in number of respective total specimens occurring from the above-noted five floras. The occurrence and number of specimens of Miocene maples from southwestern Hokkaidô, are shown in Table 1.

TABLE 1. Occurrence of Miocene Maples in Southwestern Hokkaidô.

locality / fossil species	Yoshioka	Kaminokuni	Wakamatsu	Setana	Kayanuma	Total in each species
Acer crataegifolium	13		4	1		18
Acec ezoanum	81	2	10	17	3	113
Acer fatsiaefolia	10			1		11
Acer florinii	4					4
Acer megasamarum				4		4
Acer meisenense				2		2
Acer palaeodiabolicum	13		1	2		16
Acer palaeoplatanoides	1					1
Acer palaeorufinerve	1	2				3
Acer protodistylum	2					2
Acer protojaponicum	2	1	1	1		5
Acer prototataricum	1			1		2
Acer pseudoginnala	5		3			8
Acer subpictum	36	25	1		1	63
Acer submayrii			1			1
Acer yoshiokaense	2					2
Total in each locality	171	30	21	29	4	

Description of Species

Acer crataegifolium (KOWLTON) LAMOTTE

Pl. VIII, Figs. 1–4: Pl. IX, Figs. 6, 11.

1902. *Rulac crataegifolium*, KOWLTON: U. S. Geol. Surv. Bull. No. 204, p. 77, Pl. 16, Fig. 7.
1920. *Acer completum*, CHANEY: Contr. Walker Mus., vol. 2, p. 179, Pl. 18, Fig. 2.
1920. *Acer aquilum*, CHANEY: loc. cit. p. 178, Pl. 17, Figs. 4, 5; Pl. 18, Fig. 1; Pl. 19, Fig. 1.
1929. *Acer oregonianum*, KOWLTON: U. S. Geol. Surv. Prof. Paper No. 154, p. 255, Pl. 57, Fig. 2; Pl. 63, Fig. 11.
1933. *Acer negundoides*, MACGINITIE: Carnegie Inst. Wash. Publ. No. 416, p. 62, Pl. 11, Figs. 2, 3.
1936. *Acer negundoides*, LAMOTTE: Carnegie Inst. Wash. Publ. No. 455, p. 136, Pl. 12, Figs. 3, 4.
1938. *Acer negunoides*, BROWN: U. S. Geol. Surv. Prof. Paper No. 186, p. 180, Pl. 58, Fig. 1.
1943. *Acer* sp. (samara), HUZIOKA: Jour. Fac. Sci. Hokkaido Imp. Univ., Ser. IV, vol. 7, No. 1, p. 136, Pl. 23, Fig. 2.
1944. *Acer negunoides*, CHANEY: Carnegie Inst. Wash. Publ. No. 553, p. 320, Pl. 53, Figs. 2, 4.
1959. *Acer miohenryi*, TANAI et ONOE: Bull. Geol. Surv. Japan vol. 10, No. 4, Pl. 6, Fig. 11.

Description: Leaves 3 to 5 foliate with medium-sized leaflets; leaflets elongate-ovate in shape, 3 to 10 cm. long 1.5 to 4.0 cm. wide, cuneate or narrowly round at base, abruptly acute or pointed at apex; margins remotely and irregularly dentate, with pointed teeth; primary nerve slender, straight or curving near the tip; secondary nerves 6 to 9 pairs, diverging from the midrib at the angles of 40 to 50 degrees, curving upwards, then entering into the marginal teeth, craspedodrome; tertiaries thin, indistinct, forming irregular mesh, near the margin branching to the sinuses; petiolules stout and thick, 0.3 to 0.6 cm. long; texture thin, membranaceous.

Samaras elongate in shape, 3.6 cm. long; wing slender, narrowly oblong, 2.6 cm. long and 0.6 cm. wide, outer margin nearly straight, inner margin gently curving, rounded at apex; veins numerous in number, curving inwards and dichotomously braching; seeds ellipsoidal in shape 1.0 cm. long and 0.4 cm. wide, bulged outside; angles between outer margin of wing and contact lines of seeds about 20 degree; contact line of seeds about 3 mm. long.

Remarks: The present specimens are closely to the living maples of Negundo-type, and definitely identified to *Acer crataegifolium* (KOWLTON) LAMOTTE which is commonly found from Oligocene to Pliocene floras in

North America. The fossil leaves and samaras of Negundo-type maple occurred from various localities in North America, have been given various specific names by many authors, but lately most of them were included into *A. crataegifolium* (KNOWLTON) (not SIEB. et ZUCC.) by LAMOTTE (1952: p. 53). The present fossil species from southwestern Hokkaidô is represented by the compound 3 leaflets and characteristic samaras. The present species which apparently belongs to a maple of Negundo-type, is very rare in Tertiary flora of Japan, while fossil maple of such type are abundantly found from Tertiary and Pleistocene floras of North America and Europe.

Among the fossil maples, the present species closely resembles *Acer miohenryi* HU et CHANEY from Miocene Shantung flora of China (HU et CHANEY, 1940: Pl. 33, Figs. 1, 3a; Pl. 34, Fig. 2; Pl. 35, Figs. 2, 4). Another allied species is *A. indivisum* WEBER and *A. sclerophyllum* HEER from Miocene flora of Switzerland (HEER, 1859; Pl. 1, Fig. 10; Pl. 116, Fig. 12; Pl. 117, Fig. 8). *Acer* sp. (samara) described by HUZIOKA (1934) from Miocene of Korea is probably identical to the samara of the present fossil species, though it is somewhat incomplete.

The living maples of Negundo-type are *Acer Henryii* PAX. growing in China and *A. Negundo* LINNE in North America. On the contrary, no living maple of such type is found in the existing flora of Japan, though about 23 species of maple are now living. Accordingly, the living maple of Negundo-type is probably one of the relics which once flourished in Tertiary flora of the world.

Occurrence: Yoshioka and Wakamatsu flora.

Collections: Hypotypes, U. H. Reg. No. 15001–15006.

Acer ezoanum OISHI et HUZIOKA

Pl. I, Figs. 1, 2; Pl. II, Figs. 1, 2; Pl. III, Figs. 1–4; Pl. IX, Figs. 20–25.

1940. *Acer Miyabei*, OKUTSU: Saito Hô-on kai Mus. Res. Bull. No. 19, p. 162, Pl. 7, Figs. 5, 7.
1943. *Acer ezoanum*, OISHI et HUZIOKA: Jour. Fac. Sci. Hokkaido Imp. Univ. Ser. IV, vol. 7, No. 1, p. 89, Pl. 10, Figs. 1–4; Pl. 11, Figs. 1–4; Pl. 12, Fig. 2 (excluding Fig. 1).
1943. *Acer* sp., OISHI et HUZIOKA: Ibid. Pl. 11, fig. 6.
1943. *Acer ezoanum*, HUZIOKA: op. cit. p. 130, Pl. 23, Fig. 6.
1943. *Acer* sp., HUZIOKA: Ibid. p. 136, Pl. 23, fig. 5.
1950. *Acer Miyabei*, ENDO: Short Papers I.G.P.S. No. 1, p. 13, Pl. 3, Figs. 5, 8.
1950. *Acer protomiyabei*, ENDO: Ibid. No. 1, p. 15, Pl. 3, Fig. 11.
1951. *Acer Miyabei*, ENDO: Ibid. No. 3, p. 52, Pl. 8, Fig. 3.
1952a. *Acer ezoanum*, TANAI: Jap. Jour. Geol. Geogr. vol. 22, p. 130, Pl. 4, Fig. 8.

1955. *Acer Miyabei*, TANAI: Geol. Surv. Japan Report No. 163, Pl. 17, Figs. 4, 5.
1955. *Acer protomiyabei*, TANAI: Ibid. Pl. 17, Fig. 9.
1955. *Acer ezoanum*, TANAI: Ibid. Pl. 17, Fig. 1. (excluding fig. 2)
1955. *Acer Miyabei*, ENDO: Icones Fossil Plants from Jap. Isl., Pl. 36, Fig. 8; Pl. 37, Fig. 5, 8.
1955. *Acer protomiyabei*, ENDO: Ibid. Pl. 37, Fig. 11.

Description: Leaves variable but generally large in size, 5 to 10 cm. in height and 6 to 13 cm. in width, pentagonal in shape; palmately five-lobed, middle largest, basal lobes smallest, sinus between middle and lateral lobes deep, rounded; base cordate or nearly straight; middle and lateral lobes abruptly acute or slightly acuminate in apex, provided with a pair of prominent dents in the middle and sometimes less defined dents in the distal part; basal pair of lobe acute or acuminate in apex and nearly entire in margin; primary nerves 5 in number, rigid and prominent, entering straightly into the tips of each lobe, upper lateral primaries diverging from the medial primary at the angles of 40 to 50 degrees, and basal primaries at the angles of 90 to 100 degrees; secondary nerves less strong than the primaries, 5 to 7 pairs in each lobes, opposite to sub-opposite, diverging from the primaries at the angles of 30 to 45 degrees, nearly straight or slightly curving up, then entering into marginal dents; tertiary nerves indistinct, percurrent; nervilles obscure, forming fine polygonal meshes; petiole thick and stout; texture firm, membranaceous.

Samaras medium in size, 1.8 to 3.5 cm. long; wing 1.2 to 2.5 cm. long and 0.7 to 1.0 cm. wide, outer and inner side straight and nearly parallel in the lower half, then gradually narrowed upwards, rounded at apex; veins about 20 in number at base, curving inwards, dichotomously branching; seeds large, semicircular in shape, 0.7 to 1.2 cm. in diamater, slightly bulged outside; angles between outer margin of wing and contact line 90 to 135 degrees; contact line of seeds 0.6 to 1.0 cm. long.

Remarks: This species is abundantly found in Miocene flora of Japan, and especially common in the Aniai-type flora. The present fossil leaves are characterized by the comparatively large size, unstable shape, presence of pairs of prominent and irregularly-sized dents in lobes and also abruptly-narrowed lobes. This species was originally described by OISHI and HUZIOKA (1943) from Miocene flora of Hokkaidô and Saghaline, and they described that the leaves of the present species were three-lobed. However, in many materials collected by the writers, five primaries extending from the base are generally prominent, though a pair of basal primaries is sometimes more slender than the others. Namely, this species is rather considered to have five-lobed leaves.

As already described OISHI and HUZIOKA, the fossil leaves allied to this species have been reported by many authors from Tertiary flora in various areas of North America and Europe under the various specific names: *Acer Chaneyi* KNOWLTON, *A. Merriami* KNOWLTON, *A. Osmonti* KNOWLTON, *A. Bolanderi* LESQ. in North America, and *A. palaeosaccharinum* STUR., *A. submiyabei* MAEDLER, *A. subcampestere* GOEPP., etc. in Europe. Recently, these many fossil species in North America were redesignated to two following species by LAMOTTE (1952): *A. bendrei* LESQ. and *A. Osmonti* KNOWLTON. The present species is closely similar to *A. bendrei* in the foliar characters, but distinctly different from the latter in the shape of samara. Among the fossil maples of Japan, the present species is close to *A. palaeodiabolicum* ENDO and *A. fatsiaefolia* HUZIOKA in their foliar features, but different from the latter two in the shape and marginal serration of lobes. Especially, the present species is distinctly different from the latters in the character of their samars.

The samara of the present species is very characteristic; the angles between the outer margin and contact line of seeds are more than 90 degrees. The samaras having such characters are scarcely found among the living species of the world, and they are only *A. platanoides* L. in Europe. The samaras of the present species are very closely similar to thos of the living *A. Miyabei*. The fossil samaras of Miyabei-type are abundantly found with the leaves of *A. ezoanum* from Miocene flora in various localities of Japan. Accordingly, the fossil samaras described from the Tertiary flora of Japan and Korea under the name of *A. Miyabei* and *A. protomiyabei*, are included into the present *A. ezoanum*.

Among the living maples of the world, the leaves of present species are comparable to those of *Acer diabolicum* BLUME and *A. Miyabei* MAXIM. in Japan, *A. Saccharum* MARSHAL and *A. saccharinum* L. in North America and *A. platanoides* L. and *A. italum* LAUTH in Europe in their morphological resemblace. Among these living close species, the present species is most closely similar to *A. Miyabei* and *A. Saccharum* than the others in the unstable shape of lobes and presence of a pair of large dents. It is probably one of the direct progenitors of the living *A. Miyabei* MAX. which is distributed in Hokkaidô and northern Honshû, Japan.

Occurrence: Yoshioka, Kaminokuni, Wakamatsu, Setana and Kayanuma floras.

Collections: Hypotypes, U. H. Reg. Nos. 15007–15020.

Acer fatsiaefolia HUZIOKA

Pl. VI, Fig. 1; Pl. VII, Figs. 1, 2.

1943. *Acer fatsiaefolia*, HUZIOKA: op. cit. p. 131, Pl. 23, Fig. 7.
1943. *Acer ezoanum*, OISHI et HUZIOKA: op. cit. p. 89, Pl. 12, Fig. 1 (excluding Pl. 10, Figs. 1–4; Pl. 11, Figs. 1–4; Pl. 12, Fig. 2)
1955. *Acer fatsiaefolia*, TANAI: op. cit. Pl. 16, Fig. 7.
1955. *Acer ezoanum*, TANAI: op. cit. Pl. 17, Fig. 2. (excluding Fig. 1)

Description: Leaves comparatively large in size, 10 to 12 cm. high and 9 to 14 cm. wide, pentagonal in shape, palmately five-lobed; lobes oblong in shape, acuminate at apex, being separated from one another by narrow and deep sinus, a pair of basal lobes smaller than others; margin roughly dentate with sharply pointed teeth directed forwards and numbering 3 or 4 on one side of lobe; base deeply cordate; primary nerves five in number, prominent near the base, gradually thin distantly, entering into the tips of lobes, medial primary nearly straight, a pair of upper lateral primaries diverging from the medial primary at the angles of 40 to 50 degrees, nearly straight of slightly curving upwards, basal pair diverging at the angles of about 90 degrees; secondary nerves about six in number in each lobe, diverging from the primaries at the angles of 40 to 45 degrees, slightly arched, some entering into the marginal dents, while others curving up near the margin and camptodrome; tertiary nerves thin, indistinct, percurrent; nervilles obscure, forming irregularly fine meshes; petiole stout, 1 mm. thick; texture thin, membranaceous.

Remarks: This fossil species was, at first, described from Miocene flora of Korea, and lately found from Middle Miocene flora in Hokkaidô, Japan by the writers. It is very closely similar to the above-described *Acer ezoanum*, and these two species are frequently unseparable respectively. Actually, the two species have been somewhat confused in their identification. Lately, the senoir writer collected many specimens of these two species from various localities of Japan, and he investigates them.

According to original description by HUZIOKA (1943), *A. ezoanum* is three in number of primary nerves, while *A. fatsiaefolia* is five. However, as described before, the former is considered to be also five in number of primaries, so that the two species are difficult to be distinguished by only the nervation. On the contrary, the two species are distinctly different in shape of lobes and marginal sernation. In particular, *A. ezoanum* has distinct and large dents in each lobe, while *A. fatsiaefolia* has smaller teeth. There are, however, some intermediate forms between the both species in the writers' collection, and so the two may be redesignated as one species in future.

The present species is closely similar to *A. sub-Miyabei* MAEDLER from Pliocene flora in Germany (MAEDLER, 1939: Pl. 9, Figs. 15–17) and *A. palaeodiabolicum* ENDO described below. Among the leaves of living maples, *A. fatsiaefolia* is closely related to *A. diabolicum* BLUME, *A. Miyabei* MAX. and *A. sacharinum* L., and most closely related to the first species.

Occurrence: Yoshioka and Setana floras.

Collections: Hypotypes, U. H. Reg. Nos. 15021–15023; Nos. 15024, 15025.

Acer florinii HU et CHANEY

Pl. V, Fig. 3.

1940. *Acer florinii*, HU et CHANEY: Carnegie Inst. Washing. Publ. No. 507, p. 56, Pl. 31, Figs. 5, 8.

Remarks: The present specimen is fairly identical to the present species, though somewhat incomplete. This species was, at first described from Miocene flora of Shantung, China by HU and CHANEY. This fossil species is closely similar to *Acer prototrifidium* TANAI from Miocene Yongil flora of Korea (TANAI, 1952: Pl. 22, Fig. 13) and *A. decipiens* AL. BRAUN from Miocene flora of Switzerland, Italy and France (HEER, 1855–1859: Pl. 117, Figs. 15–22; MARTY, 1903: Pl. 9, Fig. 1; etc.). The present species is, however, more longer and acuminate in shape of lobes than the latter two species.

Among the living maples in the world, the present species is related to *A. Mono* MAXIM. widely distributed in East Asia and *A. Saccharum* MARSH. and *A. nigrum* MICHX. in eastern half of North America. The leaves of these living species are, in general, from 5 to 7 lobed, but sometimes 3-lobed. Namely, the present specimen is closely similar to the 3-lobed leaves of these living species. It is also closely similar to the living *A. buergerinum* MIQ., which is distributed in Central and Southeast China, extending to Formosa.

Occurrence: Yoshioka flora.

Collection: Hypotype, U. H. Reg. No. 15026.

Acer megasamarum TANAI et SUZUKI sp. nov.

Pl. V, Figs. 1, 2.

Description: Samaras very large in size, 6.0 to 7.5 cm. long. Wings 5 cm. long and 2.0 cm. wide at the middle part, gradually narrowed to

base, rounded at apex; outer margin convex, inner margin nearly straight; veins distinct, about 20 in number at base, curving inwards and dichotomously branching. Seeds very large in size, ovate in general outline, 2.5 cm. long and 1.7 cm. wide; angles between outer margin and contact line of seeds 70 to 75 degrees, contact line of seeds 1.5 cm. long.

Remarks: The present new species represented by large samaras, is found from the Setana flora of southwestern Hokkaidô, and also rarely from Middle Miocene flora (Daishima-type flora) of northeastern Honshû by the senior writer. There are no comparable species to the present new species among the samaras of fossil maples. In the view of large sized samara, it is somewhat similar to *Acer gigas* KNOWLTON* (KNOWLTON, 1902: Pl. 14, Fig. 1) from Miocene Oregon flora of the United States and some samaras of *A. bendirei* LESQUE. from Miocene-Pliocene flora of the United States (BROWN, 1936: Pl. 58, Fig. 22; etc.), however it is distinctly different from the latter two American species in general outline of wing, size of seed and other characters. *Acer nipponicum* HARA which is rarely existing in Honshû, Shikoku and Kyûshû, Japan, has frequently large samaras, but distinctly differs from the present new species in general outline of wing and size of seed. Accordingly, no living and fossil species of maple are related to this new species in the world.

Occurrence: Setana flora.

Collections: Holotype, U. H. Reg. No. 15027; Paratype, No. 15028.

Acer meisenense ENDO

Pl. IX, Figs. 1, 2.

1950. *Acer. meisenense*, ENDO: op. cit. p. 12, Pl. 12, Fig. 4.
1955. *Acer meisenense*, ENDO: op. cit. Pl. 37, Fig. 4.

Remarks: The present specimens from the Setana flora are nearly identical to *Acer meisenense* ENDO by the characteristic seeds, which is hemispherical in shape and abruptly bulged outside, though they are somewhat incompletely preserved in the upper half of wing. The present species represented by samara, was, at first, described from Miocene Meisen flora of Korea by ENDO (1950), and it is rather rarely found from Tertiary flora in Japan proper. No samara of the living maple species in East Asia is comparable to the present fossil species.

Occurrence: Setana flora.

Collections: Hypotypes, U. H. Reg. Nos. 15029, 15030.

* This species has been lately included into *A. Osmonti* KNOWLTON by LAMOTTE (1952).

Acer palaeodiabolicum ENDO

1930. *Acer diabolicum*, KONNO: Cenozoic flora of Central Shinano, Pl. 13, Fig. 4.
1940. *Acer diabolicum*, OKUTSU: op. cit. p. 161, Pl. 7, Fig. 7.
1950. *Acer palaeodiabolicum*, ENDO: op. cit. p. 12, Pl. 3, Fig. 3.
1952. *Acer palaeodiabolicum*, TANAI: Trans. Proc. Palaeont. Soc. Japan, N.S., No. 8, Pl. 22, Fig. 12.
1954. *Acer* cfr. *diabolicum*, TAKAHASHI: Mem. Fac. Sci. Kyushu Univ. Ser. D, vol. 5, No. 1, p. 61, Pl. 7, Fig. 2.
1955. *Acer palaeodiabolicum*, TANAI: op. cit. Pl. 17, Figs. 6–8.
1955. *Acer palaeodiabolicum*, ENDO: op. cit. Pl. 37, Fig. 3.
1958. *Acer Miyabei*, MURAI: Rep. Tech. Iwate Univ. No. 11, p. 18, Pl. 1, Fig. 4.
1959. *Acer palaeodiabolicum*, TANAI et ONOE: op. cit. Pl. 6, Fig. 4.
1959. *Acer* cfr. *diabolicum*, SUZUKI: Monogr. Assoc. Geol. Collab. Japan, No. 9, p. 40, Pl. 4, Fig. 7.
1960. *Acer palaeodiabolicum*, TANAI et ONOE: Geol. Surv. Jap. Report (in press), Pl. 15, Figs. 2, 4; Pl. 16, Fig. 1; Pl. 17, Figs. 1–4.

Remarks: The present species was described by ENDO (1950) on the basis of only one samara occurred from Miocene Kankyôdô formation in Korea. Since then, abundant occurrence of fossil samaras belonging to this species was reported by the senior writer (1955) from Miocene sediments in various areas of Japan. The fossil leaves being closely identical to the living *Acer diabolicum* BLUME, was described by OKUTSU (1940) from Late Miocene sediments near Sendai, Japan. Recently, the senior writer found a plenty of fossil maple leaves and fruits being closely similar to the living *A. diabolicum* in the flora of western Japan, which is from Late Miocene to Pliocene in age. Thus, the present species was redesignated by both fossil leaves and fruits (TANAI et ONOE, 1960).

The present species is more or less similar to the above-described *A. ezoanum* in general foliar shape, but differs distinctly from the latter in the marginal dentation and shape of lobes. The margin dents and tips of lobes of the latter species are more acuminate than those of the former. The leaves of the two species, however, are sometimes not distinguishable in general outline, but the samaras of these two species are distinctly different and very characteristic respectively.

Among the leaves of the living maples in the world, the present species is closely similar to *Acer Saccharum* MARSH. and *A. nigrum* MICHX. growing now in eastern half of North America, and *A. diabolicum* BLUME and *A. Miyabei* MAXIM. living now in Japan. The most close living species is *A. diabolicum* in view of the characters of leaves and samaras, which is now growing luxuriantly in Honshû, Shikoku and Kyûshû, Japan. The present fossil species is probably one of the direct progenitors of the

above-noted living species.

The present species is one of the most common species in Neogene flora of Japan and Korea, especially in Miocene flora.

Occurrence: Yoshioka, Wakamatsu and Setana floras.

Collections: U. H. Reg. Nos. 15031, 15032.

Acer palaeoplatanoides ENDO

Pl. IX, Fig. 8.

1950. *Acer palaeoplatanoides*, ENDO: op. cit. p. 12, Pl. 3, Figs. 1, 9.
1955. *Acer palaeoplatanoides*, ENDO: op. cit. Pl. 37, Figs. 1, 9.
1959. *Acer palaeoplatanoides*, TANAI et ONOE: op. cit. pp. 281, Pl. 6, Figs. 3, 4, 10.

Remerks: The present specimen is fairly identical to *Acer palaeoplatanoides* ENDO, which was described from Miocene flora of Korea by ENDO (1950). It is closely similar to the living *Acer platanoides* LINNE growing in Europe and western Asia. The present fossil species has been known from Miocene flora in several localities of Japan, however no fossil leaf being referable to this species has yet been found.

Occurrence: Yoshioka flora.

Collections: Hypotype, U. H. Reg. No. 15033.

Acer palaeorufinerve TANAI et ONOE

Pl. V, Fig. 4.

1930. *Acer* cfr. *rufinerve*, KONNO: op. cit. Pl. 5, Fig. 1.
1937. *Acer rufinerve*, MIKI: Jap. Jour. Botany vol. 8, p. 332, Fig. 8–0.
1940. *Acer rufinerce*, OKUTSU: op. cit. p. 164, Pl. 6, Figs. 1, 2.
1951. *Acer rufinerve*, ENDO: Short Papers I.G.P.S. No. 3, p. 53, Pl. 8, Figs. 4, 5.
1960. *Acer palaeorufinerve*, TANAI et ONOE: op. cit. Pl. 16, Figs. 2, 3.

Remarks: The present specimens are fairly identical to *Acer palaeorufinerve* TANAI et ONOE representing by fossil leaves and samaras, though they are incompletely preserved. The fossil maples being quite identical to this species, were described under the name of *Acer rufinerve* from Neogene and Pleistocene sediments in various aras of Japan. *Acer Nomurai* OKUTSU from Late Miocene flora near Sendai (OKUTSU, 1940: Pl. 6, Fig. 5), is closely similar to the present species, and any essential difference is not found between these two species. The present spcies is also closely similar to *A. akagawaensis* SUZUKI from Late Miocene Tennôji flora of north eastern Honshû (SUZUKI, 1959: Pl. 5, Fig. 2), though the latter is larger in leaves than the former.

The present species is close to *A. Pennsylvanicum* LINNE growing

in the eastern part of North America. The most close living equivalent, *A. rufinerve* S. et Z., is now growing in Honshû, Shikoku and Kyûshû, Japan.

Occurrence: Yoshioka and Kaminokuni floras.

Collections: Hypotype, U. H. Reg. No. 15034.

Acer protodistylum ENDO

Pl. IX, Figs. 3, 4.

1950. *Acer protodistylum*, ENDO: op. cit. p. 12, Pl. 3, Fig. 2.
1950. *Acer protodistylum*, ENDO: op. cit. Pl. 37, Fig. 2.

Description: Samaras medium in size, 3.0 to 3.4 cm. long; wing about 2.4 to 2.8 cm. long, 0.9 to 1.0 cm. wide at the middle, and gradually narrowed to apex and abruptly narrowed near base, rounded at apex; outer margin straight, inner margin convex or rounded; veins about 10 in number at base, stout, curving inwards and dichotomously branching; seeds comparatively small, semicircular, 0.5 to 0.7 cm. in diamater; angles between outer margin of wing and the contact line of fruits 20 to 30 degrees, contact line of seeds 5 mm. long.

Remarks: The present specimens are fairly identical to *Acer protodistylum* ENDO which was described from Late Eocene flora of the Fushun coal fild, Manchuria. This spcies representing by fossil samaras, is characterized by small seeds and the large wing being abruptly narrowed near the base. The present species is closely similar to the samaras of *Acer bendirei* LESQ. from Miocene Oregon flora of the United States (BROWN, 1936, Pl. 58, Figs. 21, 22). The samaras described as *Acer* sp. from Oligocene flora of Rhineland, Germany (WEYLAND, 1938: Pl. 13, Figs. 5–7), are somewhat similar to the present species.

Among the living species in the world, the present species is closely similar to *Acer macrophyllum* PURSH. in general feature of samara, which is living now in Pacific coastal region of North America, though it is somewhat smaller in size than the latter. It is also similar to *A. distylum* SIEB. et ZUCC. in eastern Honshû, Japan, but it is different from the latter in the shape of seeds. Namely, the seeds of the former is semi-circular in shape, while that of the latter is trigonal.

Occurrence: Yoshioka flora.

Collections: Hypotypes, U. H. Reg. Nos. 15035, 15036.

Acer protojaponicum TANAI et ONOE
Pl. V, Fig. 4: Pl. IX, Figs. 18, 19.

1943. *Acer japonicum*, HUZIOKA: op. cit. p. 134, Pl. 24, Fig. 7.
1955. *Acer protojaponicum*, TANAI: op. cit. Pl. 17, Figs. 11, 12.
1955. *Acer palaeojaponicum*, ENDO: op. cit. Pl. 36, Fig. 1.
1959. *Acer protojaponicum*, TANAI et ONOE: op. cit. pp. 281, Pl. 6, Figs. 5, 6, 7.

Description: Leaves orbicular in general outline, 6 cm (estimated) in diameter, palmately 9 lobate; lobes cinical and separated by sinuses extending one-third to base, acuminate at apex, middle lobe largest, basal lobes smallest: margin coarsely duplicate-serrate; base profoundly cordate; primary nerves 9 in number, radiating straightly from base, entering into the tips of each lobe; secondary nerves of middle and the next 2 or 3 lateral primaries distinct, 6 to 8 pairs, opposite to subopposite, curving upwards, entering ito marginal teeth, craspedodrome; texture thin, membranaceous.

Samaras small to medium in size, 1.6 to 2.3 cm. (estimated) long, ellongately elliptical in general outline; wing rounded at apex, 1.0 to 1.5 cm. long and 0.6 to 0.7 cm. wide at middle part, convex at inner side and somewhat incurved at junction with seeds; seeds comparatively large in size, semi-ellipsoid in shape, 0.6 to 0.8 cm. in diameter, base nearly perpendicular to posterior side of fruits, contact line of seeds 0.4 to 0.5 cm. in length.

Remarks: The present specimen are fairly identical to this species representing by fossil leaves and samaras. The leaves of the present species are closely similar or nearly identical to *Acer protosieboldianum* TANAI et ONOE from Mio-Pliocene Hôki flora of western Hoshû, Japan (TANAI et ONOE, 1960: Pl. 15, Fig. 5). However, the leaves of the former are generally more dissected and smaller-sized than those of the former. Furthermore, the samaras of the above-noted two species are quite different in their general shape and other characters.

Among the living maples in the world, the present species is closely similar to *Acer japonicum* THUNB., which grows now in Hokkaidô and Honshû, Japan ad luxuriantly at 1000 to 1600 meters above sea level in the mountains of central Honshû.

This fossil species is comparatively common in Neogene flora of Japan, and rather showed a luxuriant growth since Late Miocene age. Such more dissected leaves of the maple are considered to belong to an advanced type in morphological features of the maple in the world.

Occurrence: Yoshioka, Kaminokuni, Setana and Wakamatsu floras.

Collections: Hypotypes, U. H. Reg. Nos. 15037, 15038, 15039.

Acer prototataricum TANAI et SUZUKI sp. nov.
Pl. IX, Fig. 7, 12.

Description: Samaras mediu min size, 2.5 to 3.5 cm. long. Wing strongly curved, arcuate in general outline, strangulated at base, rounded at apex, 1.5 to 2.5 cm. long and 0.9 to 1.1 cm. wide at the middle, inner margin strongly concave, outer margin rounded or convex; veins distinct, 15 to 17 in umber at base, curving inwards and dichotomously branching; seeds triangularly semicircular in shape, about 0.7 to 1.0 cm. in diameter, bulged outer side; angles between basal outer margin of wing and contact line of seeds about 60 degrees, or between the line from apex to base and contact line 20 to 30 degrees; contact line of seeds 7 mm. long.

Remarks: The present specimens are closely similar to the samaras of the living *Acer Ginnala* MAXIM. and *A. tataricum* LINNE in East Asia. In particular, it is most close to the latest species. This nearest living equvalent, *A. tataricum,* is distributed in southeastern Europe and Central and Southeast China.

The present new species representing by fossil samaras, is characterized by an arcuate wing and large seed. It is somewhat close to the fossil samara of *A. Ginnala* described from Late Miocene Kôbe flora of western Japan (ENDO, 1943: Pl. 8, Fig. 8), but differs in shape of wing.

Occurrence: Yoshioka and Setana floras.

Collections: Holotype, U. H. Reg. No. 15040; Paratype No. 15041.

Acer pseudoginnala TANAI et ONOE
Pl. IX, Figs. 13–15, 16a, 16b.

1943. *Acer* sp. (samara), HUZIOKA: op. cit. p. 137, Pl. 14, Fig. 8.
1959. *Acer pseudoginnala,* TANAI et ONOE: op. cit. pp. 281, Pl. 6, Figs. 1, 13.

Remarks: The present specimens are fairly identical to this species described from Middle Miocene flora in the Jôban coal field, Japan by the senior writer. Among the fossil samaras of the maple in the world, the present species is somewhat similar in general shape and size to *Acer protodistylum* ENDO described before. The former is, however, distinctly different from the latter in the dimension of seeds and other characters. Another allied one is the samara of *Acer* cfr. *trilobatum* (STERNB.) AL. BRAUN, which was described from Pliocene Rhineland flora of Germany (WEYLAND, 1938: Pl. 13, Fig. 4), though it is smaller size than the present species.

Among the samaras of the living maple, the present species is closely

similar to *A. ginnala* MAXIM. in their shapes and diverging angles of fruits, but different in shape of seeds. The related living species is now growing from Hokkaidô to Kyûshû, Japan, extending its distribution to Korea, Manchuria, Central and North China and eastern Siberia.

Occurrence: Yoshioka and Wakamatsu floras.

Collections: Hypotypes, U. H. Reg. Nos. 15042–15045; No. 15046.

Acer subpictum SAPORTA

Pl. IV, Figs. 1–4; Pl. VII, Figs. 3–6.

1873. *Acer subpictum*, SAPORTA: Bull. Sec. Géol. France. Sér. 3, vol. 1.
1883. *Acer pictum*, NATHORST: Kgl. sv. Vet. Akad. Handl. Bd. 20, p. 60, Pl. 12, Figs. 2–8.
1888. *Acer pictum*, NATHORST: Pal. Abh. Bd. 4. p. 38, Pl. 13, Figs. 1, 2.
1920. *Acer pictum*, FLORIN: op. cit. p. 24, Pl. 4, Fig. 5.
1931. *Acer pictum*, KONNO: op. cit. Pl. 4, Fig. 7; Pl. 13, Fig. 7.
1940. *Acer subpictum*, HU et CHANEY: op. cit. p. 61, Pl. 34, Figs. 3–5, 7; Pl. 35, Fig. 1.
1940. *Acer pictum*, OKUTSU: op. cit. p. 163, Pl. 7, Fig. 3; Pl. 8, Figs. 1–4.
1943. *Acer subpictum*, OISHI et HUZIOKA: op. cit. p. 93, Pl. 13, Figs. 1–4; Pl. 14, Figs. 1–4.
1943. *Acer* sp. (samara), OISHI et HUZIOKA: Ibid. p. 99, Pl. 11, Fig. 5.
1943. *Acer subpictum*, HUZIOKA: op. cit. p. 129, Pl. 24, Figs. 4–6; Pl. 25, Fig. 3.
1952. *Acer subpictum*, TANAI: op. cit. p. 131, Pl. 4, Fig. 7.
1954. *Acer pictum*, TAKAHASHI: op. cit. p. 60, Pl. 7, Figs. 3, 4a, 4b.
1955. *Acer pictum*, OKUTSU: op. cit. Pl. 7, Figs. 1, 2, 8.
1955. *Acer pictum*, TANAI: op. cit. Pl. 16, Figs. 3, 4.
1959. *Acer Matsuii*, TANAI et ONOE: op. cit. p. 282, Pl. 6, Figs. 1, 13.
1960. *Acer subpictum*, TANAI et ONOE: op. cit. Pl. 16, Figs. 4–6.

Remarks: The present species represented by leaves and samaras, are commonly found throughout Neogene flora of Japan. It is closely similar or nearly identical to be modern *Acer Mono* MAXIM. widely distributed over Japan, extending to Korea, Manchuria, Saghaline, Amur and North China. The leaves of the living *Acer Mono* are considerably variable in shape, and also this species is subdivided into many varieties by their foliar or other characters. Accordingly, as already stated by HU et CHANEY (1940), it seems desirable to give the specific name of *Acer subpictum* for the fossil leaves and samaras which are closely similar to the modern *A. Mono*. Lately, from Miocene flora of the Jôban coal field, the senior writer established *Acer Matsuii* on the basis of samara being alike some samaras of *A. Mono*, but its species must be included into the present species by the above-noted reason.

Occurrence: Yoshioka, Kaminokuni, Wakamatsu and Kayanuma floras.

Collections: Hypotypes, U. H. Reg. Nos. 15047–15054.

Acer submayrii TANAI et ONOE
Pl. IX, Fig. 9.

1951. *Acer Mayrii*, ENDO: op. cit. p. 57, Pl. 8, Fig. 2.
1960. *Acer submayrii*, TANAI et ONOE: op. cit. Pl. 17, Fig. 5.

Remarks: The present specimens apparently belongs to the samaras of *Acer Mono* MAXIM. However, it is distinctly different from the samaras of the so-called *Acer subpictum*, so that the writers would treatise this specimens as *Acer submayrii*. The present species is closely similar in general appearance to the samaras of *Acer Mono* MAXIM. var. *Mayrii* (SCHWERIN) KOIDZ. growing now in Hokkaidô and Honshû, Japan.

Occurrence: Wakamatsu flora.

Collections: Hypotype, U. H. Reg. No. 15055.

Acer yoshiokaense TANAI et SUZUKI sp. nov.
Pl. II, Figs. 4–6.

Description: Samaras medium in size, 3.7 to 4.0 cm. (estimated) long; wing 2.8 to 3.0 cm. long and 1.0 cm. wide at the middle part, gradually narrowed to base and apex, rounded at apex; outer margin of wing nearly straight, inner margin rounded, slightly convex; veins distinct, about 15 in number at base, curving inwards and dichotomously branching; seeds ellipsoid in general shape, bulged outerside, 0.7 to 1.0 cm. long and 0.7 cm wide; angles outer margin of wing and contact line of fruits 25 degrees; contact line of seeds 5 mm. long.

Remarks: The present specimens are closely similar to the samaras of the living *Acer Saccharum* MARSH. in general outline of wing and bulged seeds. This nearest equivalent species is distributed in eastern half of North America. Among the fossil samaras of the maple, the present new species is somewhat similar to *Acer minor* KNOWLTON (in part) from Miocene Oregon flora of the United States (KNOWLTON, 1902: Pl. 14, Fig. 2), but the latter is more slender in wing than the former. No fossil samara of the maple in the world is close to the present species.

Occurrence: Yoshioka flora.

Collections: Holotype, U. H. Reg. No. 15056; Paratype No 15057.

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Explanation of Plate I

Explanation of Plate I

(All figures in natural size, except Fig. 3.)

Figs. 1, 2. *Acer ezoanum* OISHI et HUZIOKA: U. H. Reg. Nos. 15007, 15008 (Yoshioka)

Figs. 3, 4. *Acer Miyabei* MAXIM.: the living leaves for comparison.

3). Collected from the botanical garden of Hokkaido University, Sapporo. ×3/5

4). from the hill in Ombetsu-Mura, Shiranuka-Gun, Hokkaido, by T. TANAI.

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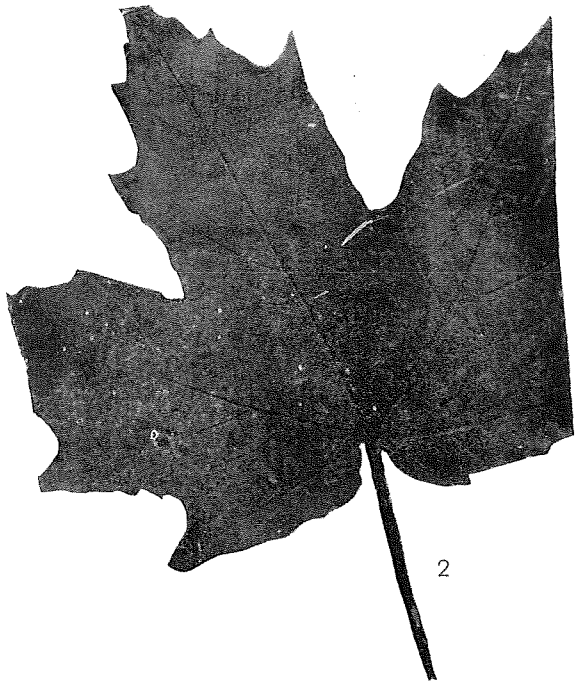

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T. TANAI and N. SUZUKI Photo.

Explanation of Plate II

Explanation of Plate II

(All figures in natural size)

Figs. 1, 2. *Acer ezoanum* OISHI et HUZIOKA: U. H. Reg. Nos. 15009, 15010 (Yoshioka).

Figs. 3, 4. *Acer Saccharum* MARSH.: the living leaf and samara for comparison, collected from the botanical garden of Boston, Massachusetts, U.S.A., by Y. SASA.

Figs. 5, 6. *Acer yoshiokaense* TANAI et SUZUKI sp. nov.: Holotype, U. H. Reg. No. 15056 (Yoshioka); Paratype, No. 15057 (Yoshioka).

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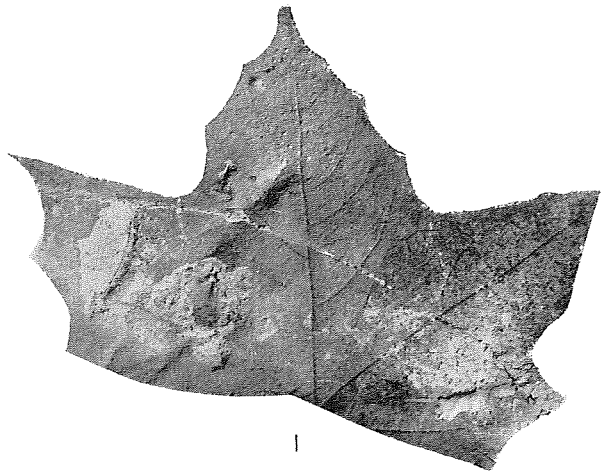
T. TANAI and N. SUZUKI Photo.

Explanation of Plate III

Explanation of Plate III

(All figures in natural size)

Figs. 1-4. *Acer ezoanum* OISHI et HUZIOKU: U. H. Reg. Nos. 15011, 15012, 15013, 15014 (Yoshioka).



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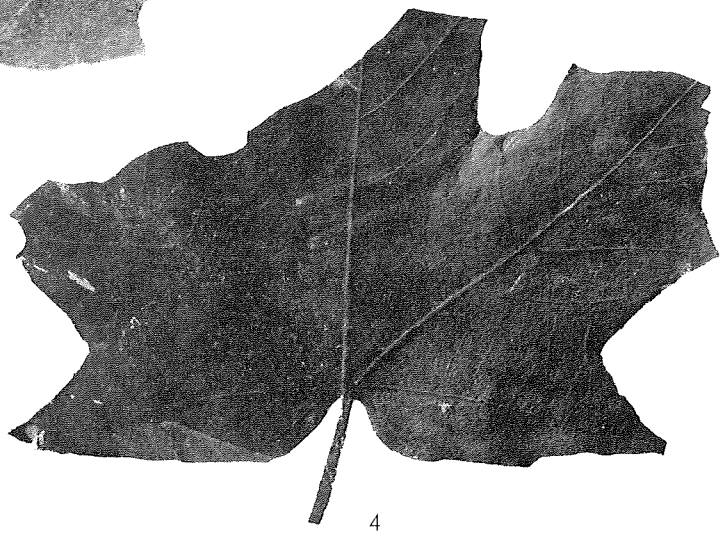

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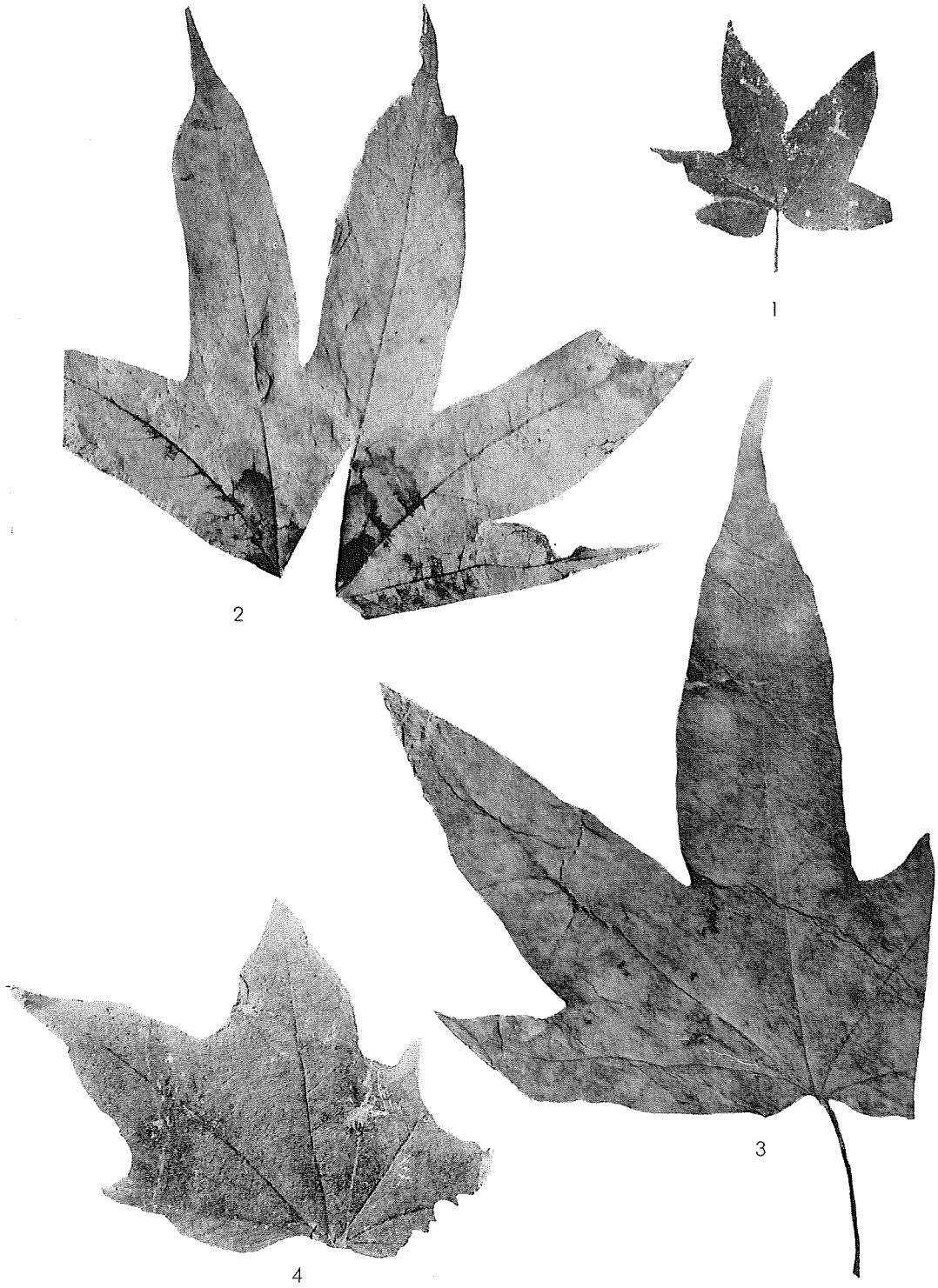
T. TANAI and N. SUZUKI Photo.

Explanation of Plate IV

Explanation of Plate IV

(All figures in natural size)

Figs. 1-4. *Acer subpictum* SAPORTA:
1, 4). U. H. Reg. Nos. 15047, 15048 (Yoshioka).
2, 3). U. H. Reg. Nos. 15049, 15050 (Kaminokuni).



T. TANAI and N. SUZUKI Photo.

Explanation of Plate V

Explanation of Plate V

(All figures in natural size)

Figs 1, 2. *Acer megasamarum* TANAI et SUZUKI sp. nov.: Holotype, U. H. Reg. No. 15027 (Setana); Paratype, No. 15028 (Setana).

Fig. 3. *Acer florinii* HU et CHANEY: U. H. Reg. No. 15026 (Yoshioka).

Fig. 4. *Acer palaeorufinerve* TANAI et ONOE: U. H. Reg. No. 15034 (Kaminokuni).

Fig. 5. *Acer japonicum* THUNB.: the living leaf for comparison, the botanical garden of Hokkaido University, Sapporo, by N. SUZUKI.

Fig. 6. *Acer protojaponicum* TANAI et ONOE: U. H. Reg. No. 15037 (Yoshioka).

Fig. 7. *Acer nipponicum* HARA: the living samara for comparison, collected from the botanical garden of Kyoto University by T. TANAI.

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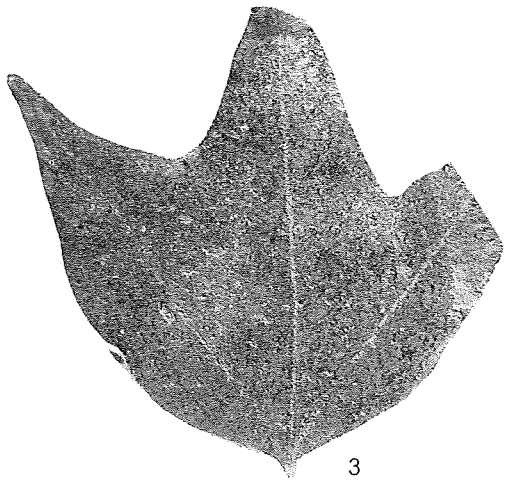

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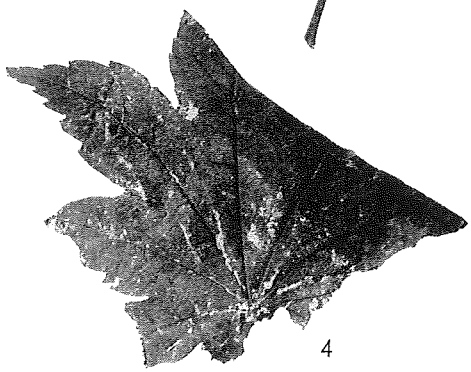

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T. TANAI and N. SUZUKI Photo.

Explanation of Plate VI

Explanation of Plate VI

(All natural size otherwise stated.)

Fig. 1. *Acer fatsiaefolia* HUZIOKA: U. H. Reg. No. 15021 (Yoshioka). ×2/3

Fig. 2. *Acer saccharinum* LINNE: the living leaf for comparison, collected from the botanical garden of Hokkaido University, Sapporo, by N. SUZUKI.

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T. TANAI and N. SUZUKI Photo.

Explanation of Plate VII

Explanation of plate VII

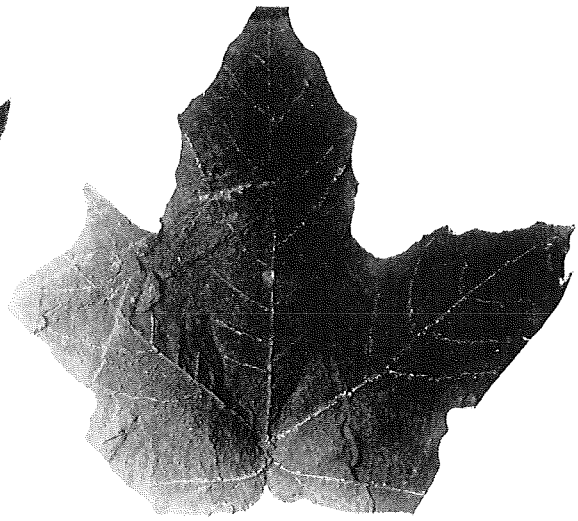
(All figures in natural size)

Figs. 1, 2. *Acer fatsiaefolia* HUZIOKA: U. H. Reg. No. 15022, 15023 (Yoshioka).

Figs. 3-5. *Acer subpictum* SAPORTA: U. H. Reg. No. 15051, 15052, 15053 (Yoshioka).

Fig. 6. *Acer subpictum* SAPORTA: U. H. Reg. No. 15054 (Kaminokuni).

1



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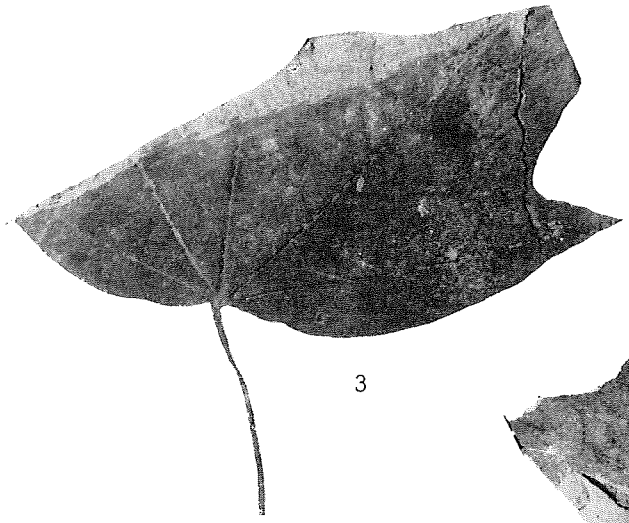

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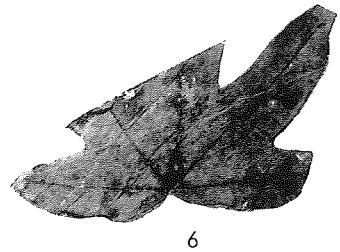

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T. TANAI and N. SUZUKI Photo.

Explanation of Plate VIII

Explanation of Plate VIII

(All figures in natural size)

Figs. 1-4. *Acer crataegifolium* (KNOWLTON) LAMOTTE: U. H. Reg. Nos. 15001, 15002, 15003, 15004 (Yoshioka).

Fig. 5. *Acer Negundo* LINNE: the living leaf for comparison, collected from the botanical garden of Kyoto University, by T. TANAI.

T. TANAI and N. SUZUKI Photo.

Explanation of Plate IX

Explanation of Plate IX

(All figures in natural size)

Figs. 1, 2. *Acer meisenense* ENDO: U. H. Reg. Nos. 15029, 15030 (Setana).

Figs. 3, 4. *Acer protodistylum* ENDO: U. H. Reg. Nos. 15035, 15036 (Yoshioka).

Fig. 5. *Acer Negundo* LINNE: the living samara for comparison, collected from the botanical garden of Hokkaido University, Sapporo, collected by N. SUZUKI.

Fig. 6, 11. *Acer crataegifolium* (KNOWLTON) LAMOTTE: 9). U. H. Reg. No. 15005 (Yoshioka). 11). No. 15006 (Setana).

Figs. 7, 12. *Acer prototataricum* TANAI et SUZUKI sp. now.: 7). Holotype, U. H. Reg. No. 15040 (Yoshioka). 12). Paratype, 15041 (Setana).

Fig. 8. *Acer palaeoplatanoides* ENDO: U. H. Reg. No. 15033 (Yoshioka).

Fig. 9. *Acer submayrii* TANAI et ONOE: U. H. Reg. No. 15055 (Wakamatsu).

Fig. 10. *Acer ginnala* MAXIM.: the living samara for comparison, collected from hilly mountain near Urahoro-machi, Tokachi-Gun, Hokkaidô, by T. TANAI.

Figs. 13-15. *Acer pseudoginnala* TANAI et ONOE: 13). U. H. Reg. No. 15042 (Wakamatsu; 14, 15). U. H. Reg. Nos. 15043, 15044 (Yoshioka).

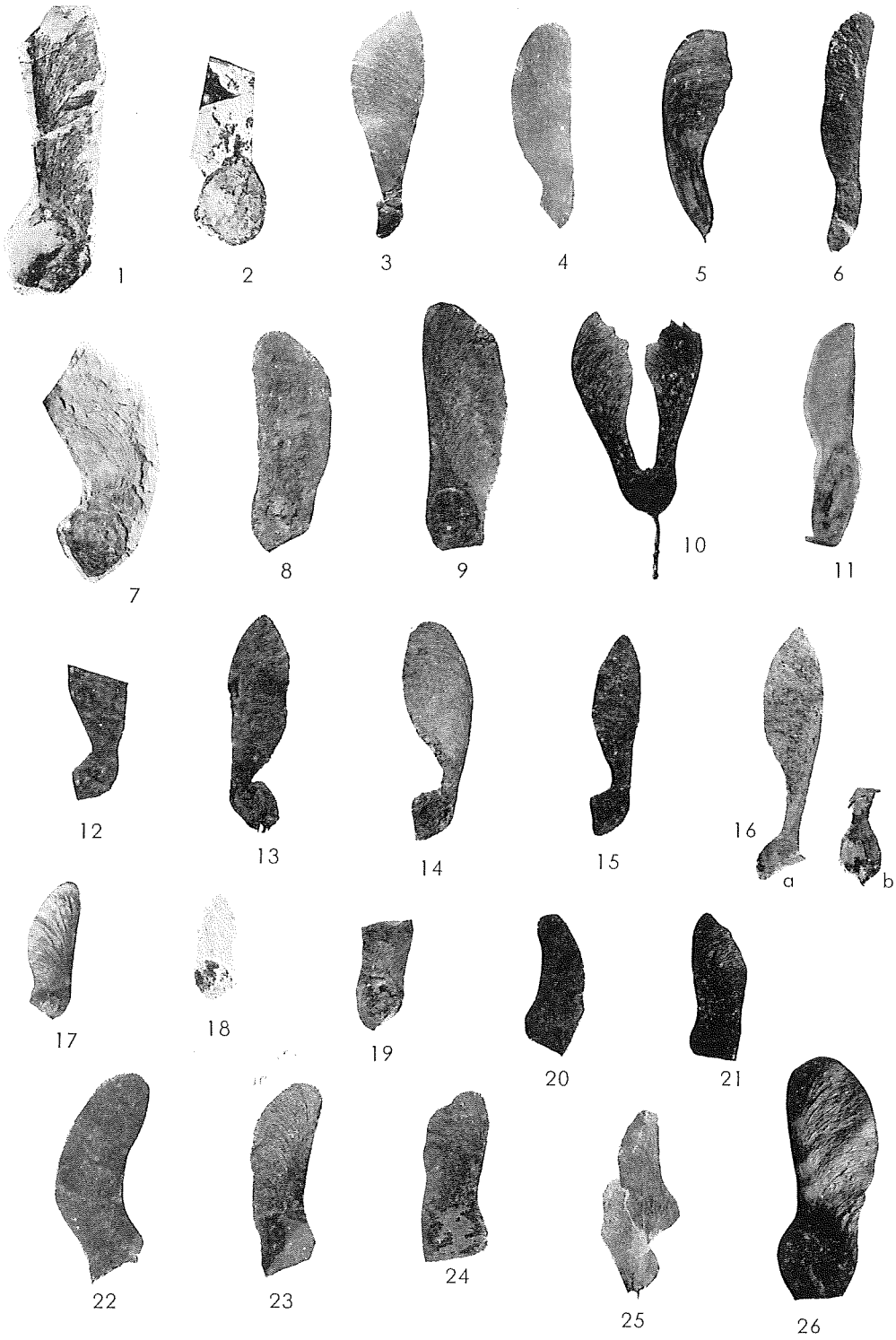
Figs. 16a, 16b. *Acer pseudoginnala* TANAI et ONOE: U. H. Reg. Nos. 15045, 15046 (Yoshioka).

Fig. 17. *Acer japonicum* THUNB.: the living samara for comparison, collected from Nukabira-lake side, Nakagawa-Gun, Hokkaidô, by T. TANAI.

Figs. 18-19. *Acer protojaponicum* TANAI et ONOE: 18). U. H. Reg. No. 15038 (Setana). 19). No. 15039 (Yoshioka).

Figs. 20-25. *Acer ezoanum* OISHI et HUZIOKA: U. H. Reg. Nos. 15015, 15016, 15017, 15018, 15019, 15020 (Yoshioka).

Fig. 26. *Acer Miyabei* MAXIM.: the living samara for comparison, collected from the botanical garden of Hokkaido Universiy, Sapporo, by T. TANAI.



T. TANAI and N. SUZUKI Photo.