Bot. Mag. Tokyo **101**: 473-481, 1988

The Botanical Magazine, Tokyo

Two New Fossil Woods of *Acer* and a New Combination of *Prunus* from the Tertiary of Japan

AKIRA TAKAHASHI AND MITSUO SUZUKI

Department of Biology, College of Bio-Medical Technology, Osaka University, Toyonaka, Osaka 560 ; Department of Biology, College of Liberal Arts, Kanazawa University, Kanazawa 920

Two new species of *Acer* fossil woods, *A. momijiyamense* and *A. Watarianum*, are described and a short review of fossil wood of this genus from the Tertiary of Japan is given. In the course of a study on three fossil wood species which have been described as *Acer* and *Acernium* from Japan, it is noticed that *Acernium iwatense* Watari does not belong to *Acer* but to *Prunus* of the Rosaceae, and is therefore transferred into *Prunus* as *Prunus iwatense* comb. nov.

Key words: *Acer* — Fossil wood — Japan — *Prunus*.

The genus *Acer* of the Aceraceae is one of the most diverse and widespread genera in the temperate zone of the Northern Hemisphere in the Tertiary. The wood of this genus is well defined anatomically and easily recognizable among the dicotyledonous woods. Fossil woods with anatomical features comparable to those of *Acer* are sometimes found from the Tertiary sediments in Japan. As a part of an extensive study on fossil woods from the Miocene of Japan, Dr. Watari noticed the occurrence of a new taxon of this genus among many fossil woods from Noto Peninsula, Ishikawa Prefecture. Recently, Dr. Katoh found a fossil trunk from the Oligocene of Yubari, Hokkaido. We studied those two fossil woods and identified them as a new species belonging to *Acer*. To compare our fossils with already described fossil woods of *Acer* and *Acernium* in Japan, we re-inspected the type specimens of the three species and noticed one of them was not *Acernium* but *Prunus*. We transferred it into *Prunus* and gave it a new combination, *Prunus iwatense*.

The holotype specimen of *Acer momijiyamense* is deposited in the Department of Biology, College of Liberal Arts, Kanazawa University, and the isotypes are in the University Museum, University of Tokyo and the National Science Museum, Tokyo. The holotype specimen of *A. Watarianum* is deposited in the University Museum, University of Tokyo, and the isotype is in the Department of Biology, College of Liberal Arts, Kanazawa University. The type specimen of *Prunus iwatense* is deposited in the University Museum, University of Tokyo.

Description of Two New Species of *Acer*

***Acer momijiyamense* Takahashi et M. Suzuki** sp. nov. Figs. 1-7.

Material. A piece of calcified fossil trunk, No. 22002 (Holotype), 11×10 cm in diameter and 20 cm long. The material was collected by Dr. Takayuki Katoh on April 26, 1982 from mudstone of the Poronai Formation (Oligocene), at Momijiyama, Yubari, Hokkaido.

Description. Wood diffuse porous. Growth rings distinct, delineated by several layers of radially flattened elements; width variable, 0.1-1.8 mm. Pores evenly distributed, 20-70 (mean 49.9) in number per square mm; mostly solitary (71%), sometimes 2-5 or up to 8 in multiples, mostly in radial series, occasionally in clusters. Solitary pores mostly round or oval, sometimes angular in outline; decreasing in size very gradually towards margins of the increments, 20-75 μm and 20-90 μm in tangential and radial diameters, respectively; thin walled (about 2 μm). Vessel elements 130-450 (mean 270) μm long; end walls oblique; perforation plates exclusively simple; spiral thickenings fairly distinct. Intervessel pitting alternate; pits polygonal or round in shape, 5-7 μm in diameter.

Fiber-tracheids constitute the ground mass of the wood; thin-walled larger members and thick-walled smaller ones constitute a distinct patch-work pattern; polygonal in cross section, 7-25 μm in diameter.

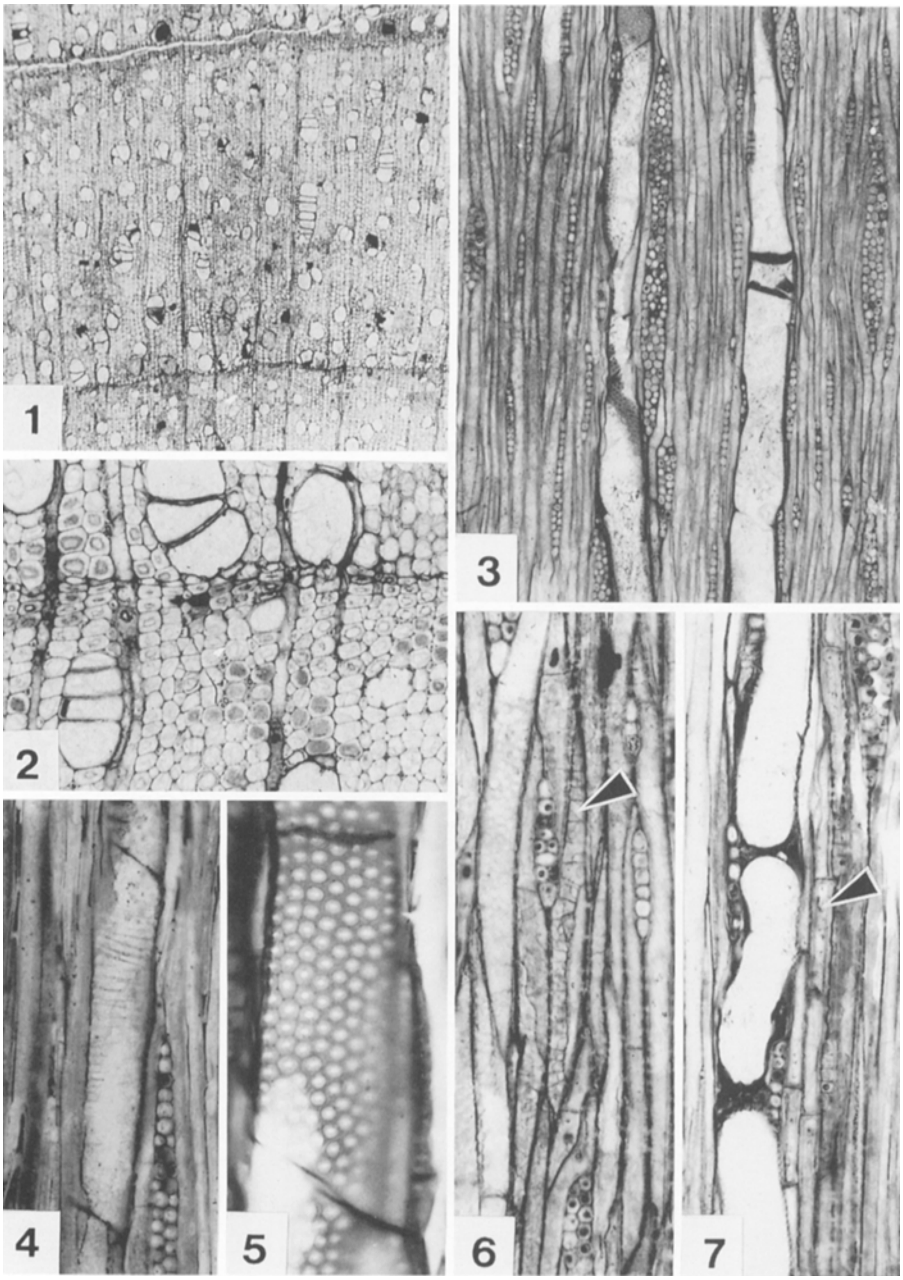
Wood parenchyma rather sparse; terminal in one or two layers and paratracheal scanty; rectangular or polygonal in cross section, 10-20 μm in tangential diameter; crystalliferous elements very rare, usually in vertical series of about 20 elements; each element nearly square or rectangular in tangential section.

Rays unstoried and homogeneous, consisting only of procumbent cells; 6-10 rays per mm width in tangential section; irregular-fusiform in shape in tangential section; usually 1-4(5) cells (8-45 μm) wide; 50-600 μm, up to 750 μm high; crystals invisible. Ray-vessel pits sparsely arranged; round or oval in shape, 3-5 μm in diameter.

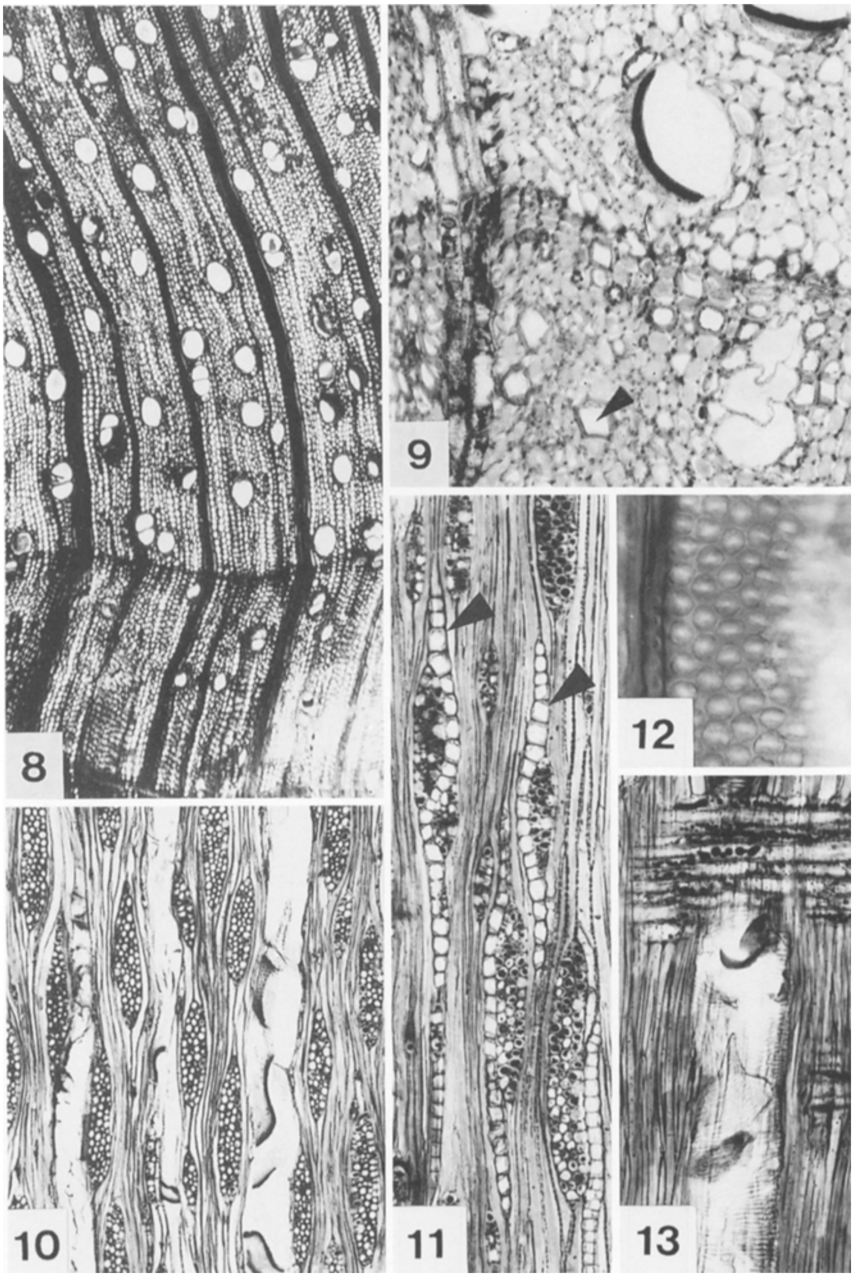
***Acer Watarianum* Takahashi et M. Suzuki** sp. nov. Figs. 8-13.

Material. The holotype, No. 53002, is a small piece of silicified wood obtained by Dr. Shunji Watari in 1965 from a large trunk about 50 cm in diameter. The trunk is displayed as a member of the stone circle, which consists of 33 petrified trunks, in the garden of a famous temple, Sohjiji, for the memorial of the miserable land-slide in 1959 at Monzen-machi, Noto Peninsula, Ishikawa Prefecture. All of the petrified woods were derived from Yanagida Formation (Lower Miocene).

Description. Wood diffuse porous. Growth rings distinct, delineated by several layers of radially flattened elements; width variable, 0.5-5 mm. Pores evenly distributed, 15-35 (mean 23.4) in number per square mm; mostly solitary (80%), sometimes in couples or in triples, rarely up to 6 in multiples, almost in radial series. Solitary pores round or oval in outline; decreasing in size very gradually towards the margins of the increments, 30-90 μm and 30-100 μm in tangential and radial diameters, respectively; thin-walled (about 2 μm). Vessel elements 250-500 (mean 362)



Figs. 1-7. *Acer momijiyamense* sp. nov. (No. 22002). 1 : Cross section (×40) through three growth rings showing diffuse pore distribution and patch-work pattern of fiber-tracheids. 2 : Cross section at a boundary of growth rings (×200). 3 : Tangential section (×100) showing 1-4-seriate homogeneous rays. 4 : Tangential view (×200) of a vessel element with spiral thickenings and oblique end walls, and a biseriate ray. 5 : Tangential view (×370) of a vessel with alternate intervessel pitting. 6 : Tangential section (×200) showing narrow vessels, rays, and crystalliferous elements of wood parenchyma (arrow). 7 : Tangential section (×170) showing a vessel and paratracheal wood parenchyma strands (arrow).



Figs. 8–13. *Acer Watarianum* sp. nov. (No. 53002). 8 : Cross section (×40) through two growth rings showing diffuse pore distribution and indistinct patch-work pattern of fiber-tracheids. 9 : Further magnified cross section (×200) showing solitary and multiple pores and abundant crystalliferous wood parenchyma (arrow). 10 : Tangential section (×60) showing homogeneous rays. 11 : Tangential section (×100) showing rays and abundant crystalliferous elements of wood parenchyma (arrow). 12 : Tangential view (×400) of a vessel with alternate intervessel pitting. 13 : Radial section (×130) showing a homogeneous ray and a vessel with simple perforation plate and spiral thickenings.

μm long; end walls oblique; perforation plates exclusively simple; spiral thickenings fairly distinct. Intervessel pitting alternate; pits polygonal or round in shape, 7-10 μm in diameter.

Fiber-tracheids constitute the ground mass of the wood; thin-walled larger members and thick-walled smaller ones constitute an indistinct patch-work pattern; polygonal in cross section, 10-25 μm in diameter.

Wood parenchyma rather abundant; terminal, diffuse and paratracheal; terminal usually in one layer; diffuse parenchyma sparse; paratracheal scanty; rectangular or polygonal in cross section, 10-40 μm in diameter; crystalliferous elements abundant in the late wood, usually in vertical series of 10-30 or more elements; each element nearly square in tangential view.

Rays unstoried and homogeneous, consisting only of procumbent cells; 6-10 rays per mm width in tangential section; fairly smooth fusiform shape in tangential section; usually 1-5(6) cells (15-60 μm) wide; 70-460 (mostly 120-350) μm high; crystals invisible. Ray-vessel pits sparsely arranged; round or oval in shape, about 3-4 μm in diameter.

Notes. The fossil was found and initially studied by Dr. S. Watari. He noticed that it was a new species of *Acer* but did not describe it. Recently, he kindly allowed us to use the fossil specimen for our study. The specific epithet is dedicated to him.

Affinities of Two New Species of *Acer*

The two fossils described above have distinct anatomical features as follows: 1) evenly distributed diffuse porous wood, 2) small, mostly solitary pores, 3) patch-work pattern of fiber-tracheids, 4) vessels with simple perforation plates, spiral thickenings and alternate intervessel pitting, 5) wood parenchyma in paratracheal and terminal positions, 6) crystalliferous elements in terminal parenchyma, and 7) unstoried homogeneous multiseriate rays. These characters mentioned above agree with those of *Acer* and it is accepted that the fossils are the members of the genus.

There are 14 species of *Acer* and *Acer*-like fossil woods from Cretaceous to Neogene of Europe, North America, Egypt, Madagascar and Japan (Suzuki, 1982). Among the fourteen, the seven species, *Acernium danubiale* Unger (1842, 1847), *A. aegypticum* Schenk (1888), *A. astianum* Pampaloni (1904), *Aceroxylon madagascariense* Loubière (1939), *A.* cf. *palaeosaccharinum* Greguss (see Greguss, 1969), *Acer beckinanum* Prakash et Barghoorn (1961) and *Aceroxylon pennsylvanicum* Prakash (1968), are easily distinguishable from our specimens in having narrower, usually 1-3- or 1-2-seriate rays. Caspary (1888) described two species of *Acer* from the Tertiary(?) of East Prussia. One of the two, *Acer borussicum*, is different from our specimens in having wider pores (up to 142.5 μm in average diameter) and the other, *A. terrae-coeruliae*, also differs from them in having narrower pores (less than 40 μm in average diameter). Furthermore, *Acernium iwatense* Watari (1941) is not *Acer* but *Prunus* and is described later.

The remaining four species are fairly similar to our fossils in having moderately small pores and slightly wide rays. Anatomical comparison among six species includ-

Table 1. Comparision of diagnostic characters

Species Name	Locality age	Patch-work pattern of fiber-tracheid	Pore diam. (μm)
Acer cf. *amoenum* Car. (Watari, 1952)	Yamagata Miocene	indistinct ?	75
Acer olearyi (Prakash and Barghoorn, 1961)	Washington Miocene	distinct	30-80
Acer puratanum (Prakash and Barghoorn, 1961)	Washington Miocene	indistinct	30-72
Acer palmatoxylum (Suzuki, 1982)	Fukuoka Oligocene	distinct	30-80
Acer momijiyamense sp. nov.	Hokkaido Oligocene	distinct	20-75
Acer Watarianum sp. nov.	Ishikawa Miocene	indistinct	30-90

1) I, irregular fusiform; S, smooth fusiform ray shape. See Ogata, 1967.
2) −, absent; (+), rarely present; +, present; ‡, abundantly present.
* no description.

ing these four species and our two materials is presented in Table 1. One of our fossils, *Acer momijiyamense*, is similar to *Acer olearyi* Prakash et Barghoorn (1961) and *A. palmatoxylum* M. Suzuki (1982) in having distinct patch-work pattern of fiber-tracheids. But *A. olearyi* differs from our fossil in having wider (1-7 cells wide) and higher (up to 1050 μm) rays and *A. palmatoxylum* also differs from that in having abundant crystals in wood parenchyma and smooth fusiform rays. On the other hand, the other fossil, *A. Watarianum*, is similar to *A.* cf. *amoenum* (Watari, 1952) and *A. puratanum* Prakash et Barghoorn (1961) in having indistinct patch-work pattern of fiber-tracheids but differs in having abundant crystals in wood parenchyma and smooth fusiform rays. Therefore, our two fossils apparently differ from each other and also from all of the previously reported fossil species, and consequently we regard them as new fossil species of *Acer*, namely, *Acer momijiyamense* and *A. Watarianum*.

In a systematic study of the genus *Acer*, Ogata (1967) noticed that although many wood anatomical characters are quite uniform within the genus, some characters, for example, the shape and width of rays, the occurrence of crystals in wood parenchyma and of starch-storing fibers, are variable within the genus but fairly stable within section and/or species, and consequently those would be very useful as diagnostic characters in section and species levels. He pointed out that the starch grains are easily removable from the fiber-tracheids by treatments such as boiling, and it is impossible that they would be preserved in petrified wood. Therefore, the occurrence of crystals and the shape and width of rays are available for identification of fossils. On the other hand, Yamauchi (1962) studied the wood anatomy of 32 Japanese species of *Acer*. Although her anatomical data sometimes do not coincide with those of Ogata, she also recognized the utility of crystals and ray characters for wood identification. When we compared our fossils with the living species, the characters observed in *Acer momijiyamense* (irregular-fusiform and 1-4(5)-seriate rays and rare among certain fossil woods of *Acer*

Vessel length (μm)	Crystals in wood parenchyma[2)]	Ray shape[1)]	Ray width (cells)	Ray height (μm)
170-550	+	I	1-6(9)	up to 1200
*	—	(S)	1-7	1050
130-350	(+)	S	1-5	560
200-350	#	I	1-5(8)	40-350
130-450	(+)	I	1-4(5)	50-600, 750
250-500	#	S	1-5(6)	70-460

occurrence of crystals) approximately agreed with those of the sections *Macrantha*, *Spicata*, *Rubura* and/or *Campestria*. Among several species in these sections, the fossil is quite similar to *A. Tschonoskii* Maxim. in having the above-mentioned characters and especially in having distinct patch-work pattern and pores often in multiple in radial series, while the living species differs from the fossil in smaller pores, 40-70 μm in tangential diameter (Yamauchi, 1962) and some other characters. Another fossil, *Acer Watarianum* resembles the section *Palmata*, especially *Acer mono* Maxim. in many features but differs in having more abundant crystals and some other characters. Furthermore, based on the reinspection of the holotype specimens, it may be said that *Acer palmatoxylum* shows similarities with *Acer plamatum* Thunb. and *Acer* cf. *amoenum* Carr., and may belong to some species of the section *Palmata*, but to determine the precise affinity is difficult because of the poor state of preservation.

Consequently, it may be said that there are four fossil wood species of *Acer* from the Tertiary of Japan, two from the Oligocene of Hokkaido and Kyushu, and the other two from the Miocene of Honshu. One of the Oligocene woods, *Acer palmatoxylum*, and one of the Miocene woods, *A.* cf. *amoenum*, belong to the same section *Palmata*, while *A. momijiyamense* is closest to the section *Macrantha* and *A. Watarianum* appears to represent the section *Platanoidea*.

Based on the extensive record of fossil leaves and fruits, it has been clarified that *Acer* was widely distributed and fully differentiated in the Tertiary of East Asia (Tanai, 1983). In the Oligocene, *Acer koreanicum* Endo of the section *Macrantha* is known from North Korea, but no representative of the section *Palmata* is known. In the Miocene, three species of the section *Palmata* and five species of the section *Platanoidea* are known (Tanai, 1983). The fact that the sections recognized by the fossil woods imperfectly agree with those of the macrofossils will indicate the occurrence of taxa which are not yet recognized from the macrofossils in the Tertiary of

Japan.

New Combination of *Prunus*

Prunus iwatense **(Watari) Takahashi et M. Suzuki** comb. nov.
Acernium iwatense Watari in Jap. J. Bot. **11**: 431-437 and Fig. 5; 1941.
Acer iwatense (Watari) Watari in J. Fac. Sci., Univ. Tokyo, Sect III (Botany) **6**: 125; 1952.

Specimens. Nos. 31106 (Holotype) and 31122, which were collected from Nesori, Namiuchi-mura, Ninohe-gun, Iwate Prefecture (Lower Miocene) by S. Watari in 1940.

Notes. When we re-inspected the type specimens we noticed that the fossil looked similar to *Acer* in many anatomical features, that is, diffuse pore distribution, vessels with simple perforation plates, distinct spiral thickenings and alternate intervessel pitting. But we found that it was clearly different from *Acer* in having some features as follows: 1) pores are almost exclusively solitary and almost perfectly circular with fairly thick walls (Photo 3B and Fig. 5A in Watari, 1941), 2) there is no tendency to decrease in pore size from the early- to the late-wood within the growth rings (Fhoto 3A), 3) distinct heterogeneous rays consisting of variable cells in shapes and sizes (Fig. 5B, C, E, F). Wood structures of *Acer*, *Prunus* and *Elaeagnus* are fairly similar to each other in having diffuse pore distribution, indistinct wood parenchyma, vessels with simple perforation plates, alternate intervessel pitting and distinct spiral thickenings, and homogeneous or nearly homogeneous multiseriate rays. The wood of *Elaeagnus* is, however, distinguished from the other two in having the nipple-like protrusions on the inner surface of vessels (Warari, 1952), almost solitary pores and often very large and wide homogeneous rays. *Acer* is also distinguished from *Prunus* in having more frequent multiple pores in radial series, somewhat angular pores with thin walls, frequent occurrence of patchwork pattern of fiber-tracheids, terminal wood parenchyma and homogeneous rays. Therefore we regarded *Acernium iwatense* as a member of *Prunus*.

Four species of the fossil woods of *Prunus* are known from the Oligocene of Kyushu in Japan (Suzuki, 1984). The present fossil is easily distinguishable by its even pore distribution, almost solitary and medium-sized pores with beautiful round outlines and with fairly thick walls, and some characters other than those four and also from the other reported species in the world (see Suzuki, 1984). Therefore we gave a new combination for the fossil as *Prunus iwatense*.

Because the original description by Watari is chiefly based on the specimen No. 31106, it will be appropriate to determine the specimen as the lectotype, and the other specimen, No. 31122, which surely belongs to the same taxon as the lectotype.

We are very grateful to Dr. Ex-Prof. Shunji Watari for his gracious proposal to utilize his specimens and notes, and Dr. Steven R. Manchester of Indiana University for his advice and critical reading of the manuscript. Thanks are due to Dr. Takayuki Katoh, Geoscience Co. Ltd. Sapporo Branch, for his kindness in presenting the specimen, to Dr. Hideaki Ohba, Curator of the Department of Botany, University Museum, University of Tokyo, for permission to inspect the fossil specimens, to Mr. Hiroshi Yonemichi, Pacific Consultants Co. Ltd. and Mr. Yoshihiko Goto, Hokkaido University, for their help in collecting the sample, and to Mr. Katsuhisa Sasaki, Geoscience Co. Ltd. Sapporo Branch, for his preparation of beautiful microscopic slides.

References

CASPARY, R. 1888. Einige fossile Hölzer Preussens. Schrift. könig... physil.-ökonom. Gesel. König. **28**: 27-45.

GREGUSS, P. 1969. Tertiary Angiosperm Woods in Hungary. Akadémiai Kiadó, Budapest.

LOUBIÈRE, A. 1939. Anatomie comparée d'un bois de dicotylédone crétacique de Madagascar. Bull. Mus. Hist. Nat. Paris, 2e ser. **11**: 484-486.

OGATA, K. 1967. A systematic study of the genus *Acer*. Bull. Tokyo Univ. Forests **63**: 89-206.

PAMPALONI, L. 1904. Sopra alcuni legni silicizzati del Piemonte. Boll. Soc. Geol. Ital. **22**: 535-548.

PRAKASH, U. AND E.S. BARGHOORN. 1961. Miocene fossil woods from the Columbia basalts of central Washington. J. Arnold Arb. **42**: 165-195.

SCHENK, A. 1888. Fossile Hölzer aus Ostasien und Aegypten. Bihang K. Svensk. Vet. Akad. Handl. XIV, Afd. III, no. 2.

SUZUKI, M. 1982. Some fossil woods from the Palaeogene of northern Kyushu, II. Bot. Mag. Tokyo **95**: 281-294.

————. 1984. Some fossil woods from the Palaeogene of northern Kyushu, III. Bot. Mag. Tokyo **97**: 457-468.

TANAI, T. 1983. Revisions of Tertiary *Acer* from East Asia. J. Fac. Sci., Hokkaido Univ. Ser. IV **20**: 291-390.

UNGER, F. 1842. Über die Untersuchung fossiler Stämme holzartiger Gewächse. Neues Jahrb. Mineral. Geol. Paläont. **1842**: 149-178.

WATARI, S. 1941. Studies on the fossil woods from the Tertiary of Japan. II. Fossil woods from the River Nesori, Namiuti Village, and the River Hiranuka, Kozuya Village, Ninohe District, Iwate Prefecture. Jap. J. Bot. **11**: 417-438.

————. 1952. Dicotyledonous woods from the Miocene along the Japan-Sea side of Honshu. J. Fac. Sci. Univ. Tokyo, Sect. III (Botany) **6**: 97-134.

YAMAUCHI, F. 1962. Anatomical identification of the woods in Japanese *Acer*. Misc. Rep. Res. Inst. Nat. Resour. **58-59**: 3-11.

Accepted June 2, 1988
Received February 22, 1988