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ON THE LOBED OAK LEAVES FROM THE MIOCENE KOBE GROUP, WESTERN HONSHU, JAPAN

by

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(with 3 text-figures and 2 plates)

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Abstract

In this paper we described the deeply-lobed leaves of oak from the middle Miocene Kobe Group in western Honshu, and established a new name, *Quercus kobatakei*. These leaves belong apparently to the white oak group; they are closely similar to leaves of the modern *Q. alba* Linnaeus and *Q. lyrata* Walt. living in the eastern United States, and also to *Q. gambelii* Nutt. growing in the low Rocky Mountain region. There are no living or fossil oaks in East Asia related to *Q. kobatakei*. A phytogeographic discussion was done for the occurrence of *Q. kobatakei*.

Introduction

It has been long known that well-preserved plants occur from the Middle Miocene Kobe Group distributed in the western part of Kobe City, Hyogo Prefecture. These plant fossils have been studied by several workers, but no detailed paleobotanical study has been yet published. The first report was done by Morita (1933) on the leaves of *Aralia*. Then, on the basis of plant fossils collected through his geological investigation, Shikama (1938) described the floristic composition in detail, illustrating several characteristic fossils, though he gave no systematic descriptions. Kobatake, N. has investigated the Miocene flora of the Kobe Group during many years, and he published a preliminary report with a systematic list and a short note of many characteristic species (in Ikebe *et al.*, 1961). Though this flora is important for the Miocene phytogeography of Japan, including a number of characteristic species, it has been not yet fully investigated.

Recently the junior author, Yokoyama, collected a number of plant fossils from the Kobe Group, and has studied them. Some of these specimens were sent to the senior author for a detailed investigation. Of this collection the

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authors could find many characteristic deeply-lobed leaves of oak, which are very interesting for the Tertiary vegetation of Japan. This paper dealt the occurrence of lobed oak from Japan with a systematic description and discussion.

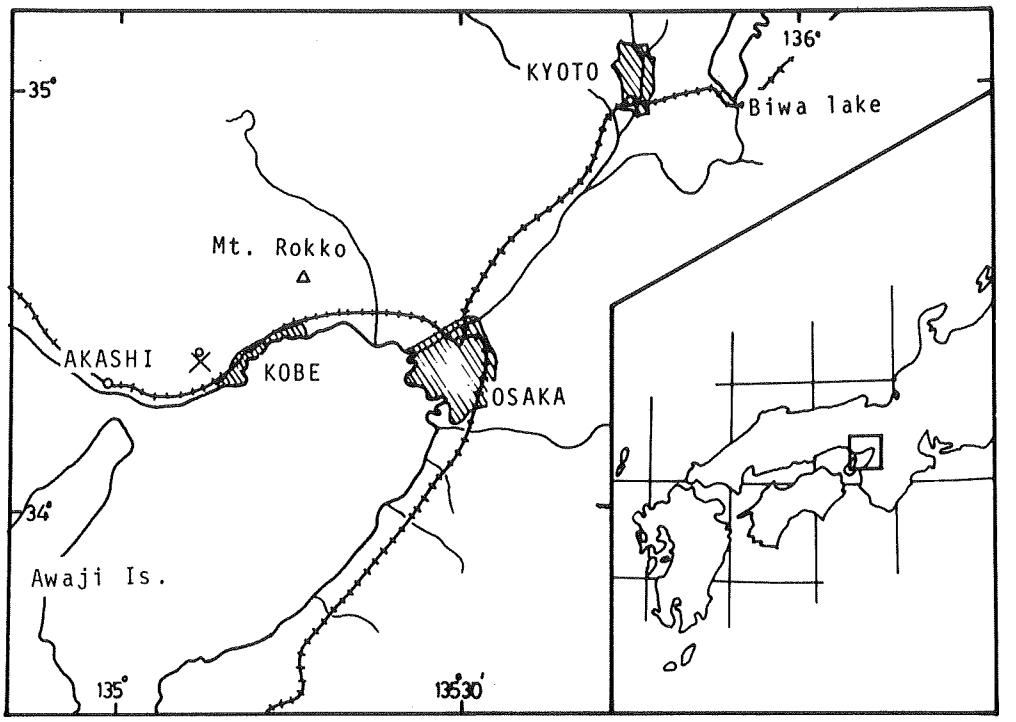
The authors wish to express their great appreciation to Dr. Nobuo Kobatake, who offered a specimen collected by him for their comparison. The senior author is also indebted to Dr. Herman F. Becker, the New York Botanical Garden, for his kind suggestion and offering the modern leaves of North American oaks for comparison. Thanks are also to Mr. Kenichi Matsumoto for his kind permission of investigating his collection.

Geologic Occurrence

In the western margin of the Rokko mountains is distributed the Miocene Kobe Group, which is composed mainly of terrestrial sediments except the marine basal part. Tertiary stratigraphy of these sediments was first investigated by Ueji (1937) and Shikama (1938), and was recently summarized by Huzita *et al.* (in Ikebe *et al.*, 1961). The Kobe Group is subdivided into three formations: the Tainohata, the Shirakawa and the Aina in the ascending order. The Tainohata formation is composed largely of alternation of sandstone and siltstone, including lenticularly conglomerates. The lower part contains several molluscan fossils, which are of marine origin.

The Shirakawa formation is somewhat variable in lateral lithology, but the lower and middle parts are composed largely of sandstone, intercalated by conglomerate. The upper part consists of thick alternation of rhyolitic tuff and conglomerate; these tuff beds contain a number of well-preserved plants in many localities. According to Kobatake (1961), these plants consist principally of the Fagaceae, Hamamelidaceae, Magnoliaceae, Lauraceae and Aceraceae including palms (*Trachycarpus* or *Livistona*). The Shirakawa flora shows typically a warm-temperate aspect in composition, and is considered to be of Middle Miocene age. The Shirakawa formation is covered by the Aina formation, which is composed of siltstone, sandstone, conglomerate and tuff.

The oak leaves described here, were collected from the white tuff of the upper Shirakawa formation in Ochiai, Suma-ku, Kobe City as shown in Text-figure 1. The plant-bearing rock is laminated, fine-grained tuff; the fossil leaves somewhat curled or are slightly disturbed in preservation, but the fine venation is rather well preserved.



Text-figure 1. Showing the fossil locality.

Description of the Species

Family Fagaceae

Quercus kobatakei Tanai et Yokoyama, sp. nov.

(Pl.1, figs.1,3; pl.2, fig.2)

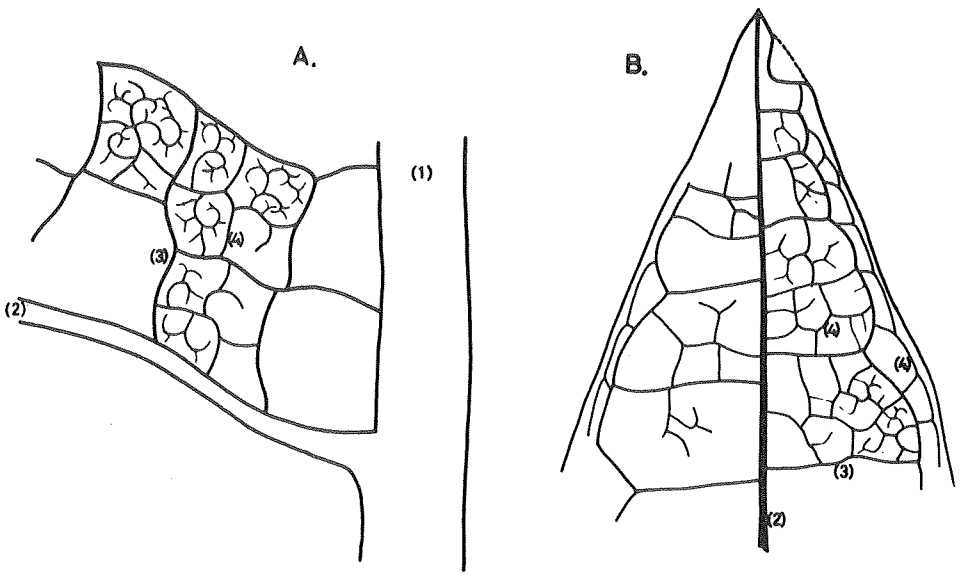
1938 *Quercus alba* Linnaeus, Shikama. Jour. Geol. Soc. Tokyo, v. 45, pl.19, fig.3.

1961 *Quercus japonoalba* Kobatake. nom. nud. Explanatory Text of Geol. & Mineral Resources Map of Hyogo Pref. p. 85, pl.3, fig.21.

Description: Leaves ovate to ovate-oblong in general outline, 8.5 to 15.3 cm. long and 6.5 to 10.8 cm. wide, obtuse of obliquely truncate at base, sinuate-pinnatifid with 9 to 15 lobes; central lobe ovate and mostly weakly 3-lobed, with acute or slightly acuminate apex; lateral lobes narrow, lanceolate to ovate in shape, usually acute at apex, with bluntly pointed tips, usually entire at margin but rarely weakly toothed near apical part; sinuses generally narrow but deep toward the midrib, asymmetrically rounded at the bottom; midrib thick, somewhat arcuate; secondary veins opposite to subopposite, diverging at angles of 40 to 70 degrees from the midrib, frequently arcuate

outward, ending at the tip of each lobe; tertiary veins from the secondaries distinct, numerous, diverging at various angles ranging from 50 to 90 degrees, camptodromous to the margin, making distinct loops near the margin; fourth-order veins within marginal area forming smaller loops outside of the tertiary loops, another fourth-order veins among the tertiary loops making quadrangular networks with fifth-order veins, including more than twice branched veinlets (Text-figure 2); texture subfirm; petiole thick, more than 1 cm. long.

Discussion: These specimens doubtlessly belong to the white oak group by their shape and marginal characters. They are closely similar to leaves produced by the modern *Quercus alba* Linnaeus, *Q. macrocarpa* Michx. and *Q. lyrata* Walt., which are living in the eastern United States. Though the fossil leaves are very variable in general outline and lobation as much as in leaves of these three living species, they are most close to those of *Q. alba* in shape of lobes. Our specimens are, however, different from *Q. alba* by broad base of leaves and somewhat pointed tip of each lobe. Our leaves are also similar to *Q. lyrata* in having pointed tips of each lobe.



Text-figure 2. Showing the fine venation characters of *Quercus kobatakei* Tanai et Yokoyama.
A) Basal part (X 15) B) Lateral lobe (X 6.5)
(1) Primary vein (2) Secondary veins (3) Tertiary veins (4) Fourth-order veins

Several white oak species similar to our specimens can be also found in the western United States, such as *Q. garryana* Dougl., *Q. gambelii* Nutt. and *Q. lobata* Nees. Leaves of these three species closely resemble our specimens in pointed tip of each lobe. Thus our specimens belong apparently to the white oak group, but there is no living species which closely matches with our fossils in all morphologic characters. All of our specimens are identifiable with *Q. japonoalba* Kobatake, and actually one of them (pl.1, fig.1) is an original specimen illustrated by Kobatake (1961). However, the epithet *"japonoalba"* is unfortunately "nomen nudum" because of no description or diagnosis (International Code of Botanical Nomenclature, Article 38). We prefer to give a new name, *Q. kobatakei,* to our specimens in the honour of Dr. Kobatake.

A number of lobed oak leaves have been described from the Tertiary of the western United States, and various name have been proposed by many workers. Chaney and Axelrod (1959) discussed the synonymy of Miocene lobed oaks, and distinguished four species: *Q. pseudolyrate* Lesquereux, *Q. merriami* Knowlton, *Q. prelobata* Condit. and *Q. eoprinus* H.V. Smith. The former two species* belong to the black oak group, and the latter two to the white oak group. *Q. kobatakei* somewhat resembles *Q. praelobata* from the Miocene and Pliocene of California and Oregon (Condit, 1944; Chaney and Axelrod, 1959), but differs in generally narrower lobes and broad base. Leaves described under the name of *Q. pseudolyrata* include various shape and size, and some of them may belong to the white oak group; for instance, two leaves from Stinking Water, Oregon (Chaney and Axelrod, 1959) and two leaves from Tipton, Oregon (Brown, 1937). These four specimens seem similar to *Q. kobatakei* in general outline and lacking a bristle tip of each lobe.

The lobed oak leaves have been known not always abundantly from the Tertiary of Europe as in the present forest of Europe. Straus (1956) reported *Q. praeerucifolia* Straus from the Pliocene Willershausen flora near Hartz. It somewhat resembles *Q. kobatakei* in general outline and lobation, but differs in rather obtuse tip of each lobe and generally less number of lobes.

Occurrence: Ochiai, Suma-ku Kobe City, Hyogo Prefecture. Shirakawa Formation (Middle Miocene).

Collection: Holotype UHMP no. 25969, paratype no. 25970.

Phytogeographic Consideration

The modern oaks with deeply-lobed leaves are divided into two groups, the white oak and the black oak. The latter leaves are characterized by bristle-tipped lobes, while the formers mostly lack a bristle at the end of each lobe. These two groups are widely distributed in North America, and partly

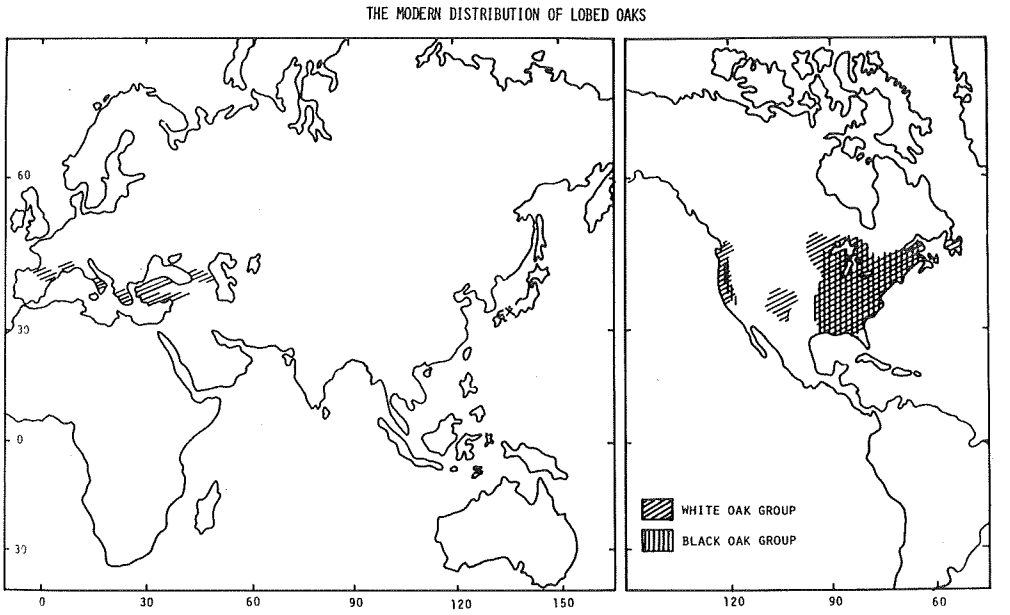
* These two species were synonymized by Wolfe (1964).

extend into Mexico (Text-figure 3). The deeply-lobed oaks are also living in Europe, extending into western Asia and northern Africa, but all of them belong to the white oak group. The black oak has never lived in the past and present in Europe. On the one hand, no oak with the deeply-lobed leaves is living in East Asia. There are living, of course, several living oaks in East Asia allied to American or European white oaks: they are *Quercus mongolica* Fischer, *Q. aliena* Blume and *Q. dentata* Thunb., but all leaves of these species are shallowly lobed.

The middle Tertiary vegetations around the northern Pacific show a close relationships with a number of common genera, even of closely similar species, represented by many relict genera such as *Liquidambar, Sassafras, Liriodendron, Cercis, Catalpa, Nyssa* and others. Such relationship of Miocene floras between East Asia and western North America was once virtually summarized by Chaney (1967), although his description includes some inconsistency on the geofloral concept. Such similarity is now further represented by a close relationships of the modern forestes between East Asia and eastern North America, as already pointed out by many botanists such as Li (1952), Hara (1952, 1956), Wang (1961) and others. Actually we can find a number of the Japanese Miocene analogues in the modern forests of the eastern United States; for instance, they are *Comptonia peregrina* (Linn.) Coult., *Carya ovata* (Mill.) K. Koch., *Carpinus caroliniana* Walt., *Liriodendron tulipifera* Linn., *Sassafras albidum* (Nutt.) Nees, *Acer saccharum* Marsh., *Acer saccharinum* Linn., *Acer negundo* Linn. and others. (Tanai, 1961; Tanai and N. Suzuki, 1963). However, the deeply-lobed oak leaves have never attracted the attention in the Tertiary floras of Japan. Actually these fossil leaves have been not found in the Miocene of central and northern Japan up to the present, though a number of detailed studies on Miocene floras have been published by many authors.

The first record of the deeply-lobed oak leaves from Japan was reported by Shikama (1938) from the Kobe Group under the name of *Quercus alba* Linnaeus. Then Kobatake (1961) reported an lobed oak leaf from the same locality: he established a new species, *Quercus japonoalba.* These two reports have, however, attracted no attention from the paleobotanists, because they were written in Japanese with no paleobotanical description or discussion. The senior author has kept this occurrence in mind for long years, and has expected to collect deeply-lobed oak leaves from the Tertiary of Japan.

The white oak, *Q. alba,* which is allied to *Q. kobatakei,* is one of the most common oaks in the eastern United States, especially distributed in the Atlantic states and the Mississippi basin (Little, 1971). It grows both in rich uplands and river bottoms, where it is not too moist. *Q. alba* is associated



Text-figure 3. Showing the distribution of the modern oaks with deeply-lobed leaves.

commonly with beech and maples in the Mixed Mesophytic Forest region, while it is accompanied by several evergreens such as *Magnolia* and other oaks in the Southeastern Evergreen Forest region. The overcup oak, *Q. lyrata,* is rather confined its distribution to swamps and low wet bottom land. It is associated with *Quercus nigra* Linn., *Q. laurifolia* Michx., *Nyssa sylvatica* March., *N. aquatica* Linn., *Ptelea trifolia* Linn., *Taxodium distichum* (Linn.) Richard. and others. *Quercus gambelii* is most close to *Q. kobatakei* among the western North American oaks. It is commonly distributed in the low Rocky Mountain forest, and grows on dry foot-hills and canyon walls: for instance, in the Oak Creek Canyon south of Flagstaff *Q. gambelii* grows luxuriantly with *Ostrya knowltoni* Conville, *Platanus racemosa* Nutt., *Cypressus* spp. and *Populus tremuloides* Michx. var.

Considering the floristic composition of the Shirakawa flora, *Q. kobatakei* seems to have been neither a particularly water-loving nor a dry-habitat tree. Many living analogues of the Shirakawa plants are found in the Mixed Mesophytic Forest of the eastern United States, especially in the Oak-Chestnut or the Oak-Pine Forest developed west or southwest of the Appalachian Region: they are *Carya* app. *Cornus florida* Linn., *Acer rubrum* Linn., *Liriodendron tulipifera* Linn., *Liquidambar styraciflua* Linn., *Cercis canadensis* Linn., *Sassafras albidum* (Nutt.) Nees, and *Castanea dentata* (Marsh.) Borkh.

Thus it seems probable that *Q. kobatakei* is related with the living *Q. alba* in the habitat condition, along with the morphological features.

As already stated, in East Asia there is no living oak related to *Q. kobatakei*. East Asiatic oaks such as *Q. aliena, Q. mongolica* and *Q. dentata* are always shallowly lobed in their leaves, and their ancestral fossils such as *Q. miocrispula* Huzioka and *Q. protodentata* Tanai et Onoe have been known from the middle or lower Miocene of Japan. Accordingly, *Q. kobatakei* is not a direct progenitor of East Asiatic oaks with lobed leaves. It is an important problem to investigate in future the migrating route through which the oak with deeply-lobed leaves had entered East Asia.

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Postscript: After the manuscript was submitted, the senior author received a paper published by A. G. Ablaev and P. G. Gorovoi (1974). They described two species of the lobed oaks from the Miocene of Rettikhovka, Primorye, USSR. Of these two oaks, *Quercus sichotensis* Ablaev et Gorovoi is generally similar to our new species, *Q. kobatakei,* but differs in having larger dentation on the upper lobes. It is very interesting that the deeply lobed oaks were widely distributed in East Asia during Miocene time.

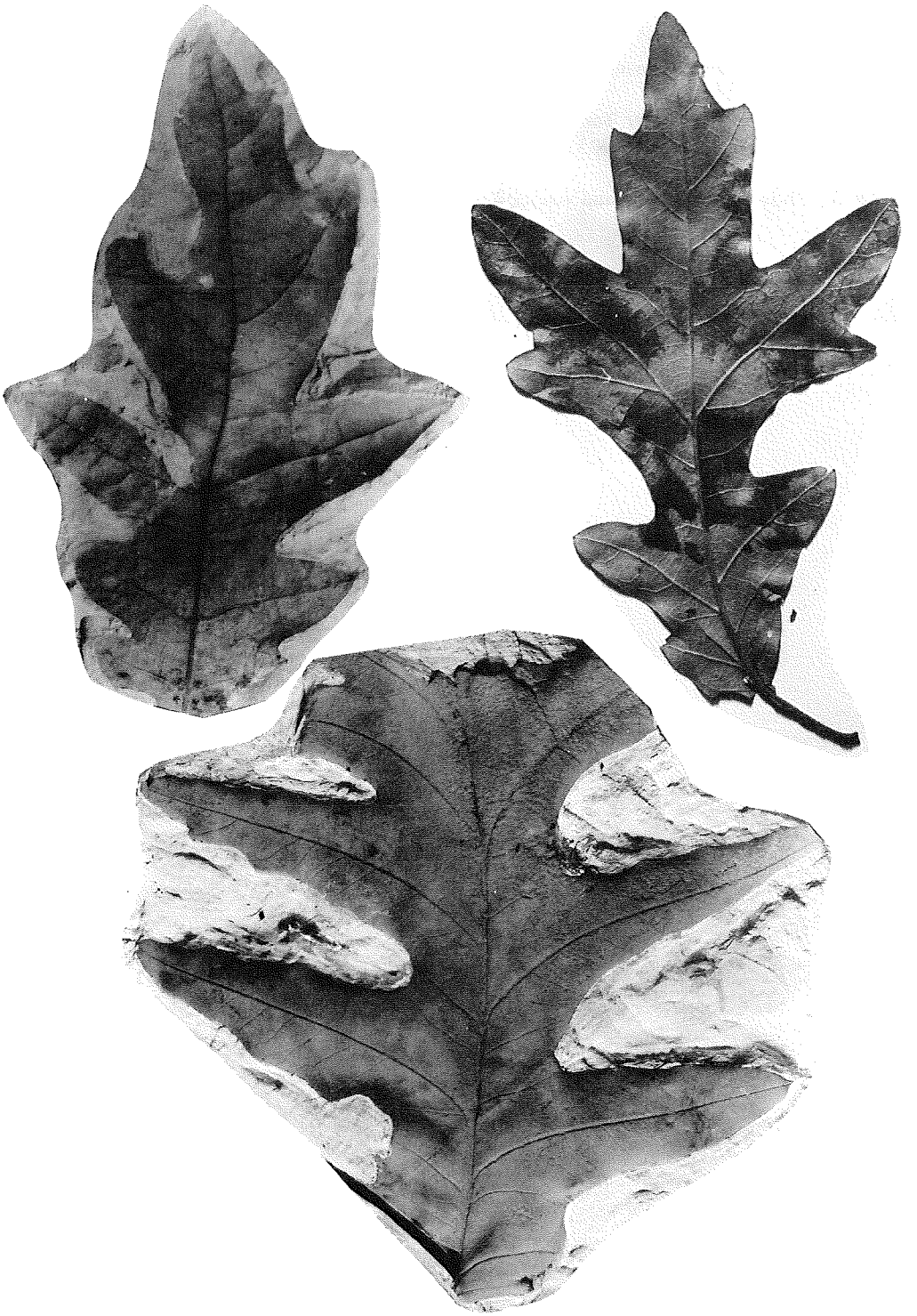
Ablaev, A. G. and P. G. Gorovoi, 1974. Fossil oaks of Primorye, USSR, and the origin of oak forests. Lethaia, 7 (2):163-169.

Explanation of Plate 1
(All natural size)

Fig. 1. *Quercus kobatakei* Tanai et Yokoyama, sp. nov. Ochiai, Suma-ku, Kobe City. Holotype, H.U.M.P. no. 25969

Fig. 2. *Quercus lyrata* Walt. The living leaf for comparison.

Fig. 3. *Quercus kobatakei* Tanai et Yokoyama, sp. nov. Ochiai, Suma-ku, Kobe City. Paratype, H. U. M. P. no. 25970.



Explanation of Plate 2

Fig. 1. *Quercus alba* Linnaeus. x1 The living leaf for comparison.

Fig. 2. *Quercus kobatakei* Tanai et Yokoyama, sp. nov. x 1 Ochiai, Suma-ku, Kobe City. (collected by Matsumoto, K.)

Fig. 3. Showing apical part and venation of lateral lobes (plate 1, fig. 3). x 3.5