FOSSIL PLANTS FROM THE LATE TERTIARY OF OKLAHOMA.

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The following short paper is based upon materials collected by Prof. E. C. Case, of the University of Michigan, and presented by him through the writer to the United States National Museum. These collections were incidental in the exploration of the red beds of Oklahoma in search for Permian vertebrates, under the auspices of the Carnegie Institution. They were made from an outcrop of chalk-like clay on the south side of Beaver Creek, near the since abandoned post office of Alpine, about 10 miles east of Beaver City. The matrix is a light-colored fluffy clay which appears to be largely a volcanic ash. No vertebrates were found associated with the plants except a few undeterminable fishbones. A small undetermined crustacean was also found in the clay.

Darton[1] in 1899 divided the Loup Fork of the central Great Plains into the Arikaree and the Ogallala formations, regarding the former as Miocene and the latter as possibly Pliocene in age. Various local subordinate divisions have been recognized by the field geologists in Kansas and Nebraska. Materials corresponding in a general way to those of the Ogallala formation of Kansas and Nebraska are widespread in western Oklahoma. These are clays, sands, and gravels of exceedingly variable character and proportions. They probably once covered the entire "panhandle" but are now preserved chiefly on the uplands where the argillaceous cliffs of these materials are locally known as "mortar beds" or "chalk." The thickness varies from place to place and ranges in Beaver County from thin remnants to upwards of 300 feet. These deposits are, in the latter region, usually underlain by the red beds of the

[1] Darton, N. H., U. S. Geological Survey 19th Ann. Rept., pt. 4, p. 734, 1899; Professional Paper 32, p. 176, 1905.

Permian, although locally traces of the Lower Cretaceous may be intercalated.

According to our present knowledge of the genesis of the continental Tertiary deposits it can not be expected that similarity of lithologic composition has any definite bearing upon correlation, and it must be understood that the conclusions of the present paper refer only to the fossiliferous outcrop which is discussed.

The florule collected from this outcrop represents but six determinable species, of which four are new, and three additional forms that are generically but not specifically recognizable. It includes two grass or sedge-like plants which are fragmentary and of no botanical value beyond indicating the presence of such plants in this region at that time. Willow leaves are present, but not specifically determinable. The most abundant forms are the *Platanus* and the *Sapindus*. The *Gymnocladus*, *Rhamnus*, *Bumelia*, and *Diospyros* are all represented by a scanty amount of material, but as the collection is a small one the individual abundance of the different species is probably without significance.

All of the forms appear to have been alluvial species of river bottoms, and most of them have their genera still represented in the valleys of the principal streams that enter eastern Oklahoma from the Coastal Plain of the Gulf States. This statement is true of *Platanus*, *Gymnocladus*, *Sapindus*, *Rhamnus*, *Bumelia*, and *Diospyros*. All these genera are normal constituents of the rich alluvial deciduous forests of the southeastern United States, and the presence of fossil representatives in western Oklahoma shows that climatic conditions in that region were more mesophytic toward the close of the Miocene than they are at the present time, with the stream valleys covered with a mixed deciduous forest, which may also have covered more or less of the interstream areas.

Regarding the age indicated by this florule, it may be said that the *Cyperacites*, *Caulinites*, and *Salix* are without significance. Only one of the nine forms—namely, *Rhamnus lesquereuxi*—is limited to a single outside horizon, and this species occurs in the late Miocene of Florissant, Colorado. *Platanus aceroides* and *Diospyros brachysepala* are recorded throughout the Tertiary in both this country and Europe, and while both are probably composite species, it is impossible to segregate them in the present state of knowledge. Both are, however, typically Miocene forms, the *Platanus* being found in the John Day Basin on the west coast and in the Calvert Miocene of the Atlantic coast, and indistinguishable leaves of the *Diospyros* occur at Florissant, Colorado. Moreover, the new species of *Sapindus* approaches closely to *Sapindus lancifolius* Lesquereux, another Floris-

sant species. From this it would seem that the Oklahoma plants were of somewhat similar age to those of Florissant, the different physical conditions combined with the much less effective methods of preservation accounting for the sparseness of the flora recognized from Oklahoma. I believe that this is substantially true, and I am inclined to regard the Oklahoma outcrop as of upper Miocene age, although there is no conclusive evidence in existence that such a valley flora may not have continued in this region during the early Pliocene, there being no considerable American Pliocene floras, except that of the Gulf coast,[1] with which to make comparisons.

Subclass MONOCOTYLEDONAE.

Order GRAMINALES.

Genus CYPERACITES Schimper.

CYPERACITES, species.

Fragments of the foliage of an undeterminable species of a grass or sedge are not uncommon in the collection. Similar remains are not uncommon at many Upper Cretaceous and Tertiary outcrops and are without significance beyond indicating the presence of this order of plants.

Genus CAULINITES Brongniart.

CAULINITES, species.

Fragments of the impression of a rhizome of a grass or sedge are present in the collection. The impressions are 8 mm. in diameter, with nodes about 4 cm. apart, and indicate a grass or sedge of considerable size. Similar remains are not uncommon throughout the Tertiary.

Subclass DICOTYLEDONAE.

Order SALICALES.

Family SALICACEAE.

Genus SALIX Linnaeus.

SALIX, species.

Several fragments of an undeterminable species of willow are contained in the collection. These represent a form with entire leaves

[1] Berry, E. W., U. S. Geological Survey Prof. Paper 98 L, pp. 193–208, pls. 44–47, 1916.

and about the size and shape of those of the existing *Salix nigra* Marsh.

Order PLATANALES.

Family PLATANACEAE.

Genus PLATANUS Linnaeus.

PLATANUS ACEROIDES Goeppert.

Plate 94, fig. 3; plate 95, fig. 5.

Platanus accroides GOEPPERT, Zeits. Deutsch, Geol. Gesell., vol. 4, 1852, p. 492.

There is no need for me to redescribe this exceedingly well-known species. It is the most abundant form in the present collection where it is represented by counterparts of both small and large leaves beside numerous fragments showing petioles, tips, and lobes, so that collectively all parts of the leaf are well represented. Both the large and the small leaves are identical in proportions, lobation, marginal and basal characters with Goeppert's types[1] and with the leaves of this species figured by Heer[2] from the Tortonian of Oeningen, Baden.

This species has been identified from such a variety of horizons and localities that it would be fruitless to endeavor to make comparisons with all of the forms that stand in the literature as *Platanus aceroides*. Undoubtedly some of these represent distinct species, but it is impossible to make any rational segregation at the present time. As the records stand it has a range from the basal Eocene to the Pleistocene in this country, and from the Oligocene through the Pliocene in Europe.

Its typical development, however, is in the middle and upper Miocene, and although it has not been discovered in the deposits of the Miocene lake basin at Florissant, Colorado, it is present in the John Day Miocene of Oregon and in the Calvert Miocene of Virginia. A very similar form, questionably distinct, is *Platanus dissecta* Lesquereux[3] from the California Miocene which is said to be a larger and more coriaceous form.

Plesiotypes.—Cat. Nos. 35283, 35284, U.S.N.M.

[1] Goeppert, H. R., Tertairflora von Schossnitz, 1855, p. 21, pl. 9, figs. 1–3.
[2] Heer, O., Fl. Tert. Helv., vol. 2, 1856, p. 71, pl. 87; pl. 88, figs. 5–12, 15.
[3] Lesquereux, L., Mus. Comp. Zoöl., Memoirs, vol. 6, 1878, p. 13, pl. 7, fig. 12; pl. 10, figs. 4, 5.

Order ROSALES.

Family CAESALPINIACEAE.

Genus GYMNOCLADUS Lamarck.

GYMNOCLADUS CASEI, new species.

Plate 94, fig. 2.

Leaflets sessile, relatively small in size, somewhat inequilateral ovate in general outline, with a short acuminate tip and a rounded base. Margins entire. Texture subcoriaceous. Length 3.5 cm. Maximum width, below the middle of the leaflet, 1.7 cm. Midrib stout, prominent, slightly curved. Secondaries comprising about four subopposite to alternate pairs, camptodrome; they diverge from the midrib at angles of about 45 degrees and curve regularly upward subparallel with the lower lateral margins. The character of the matrix has obliterated the areolation.

The present material is clearly to be affiliated with the leaflets of the existing *Gymnocladus dioicus* Koch, the Kentucky Coffee tree, differing from the latter principally in the slightly smaller size of the fossil leaflets. *Gymnocladus* has but two existing species, the one just mentioned and a second in southern China. This distribution in itself and from the analogy furnished by other genera such as *Magnolia*, *Liriodendron*, *Sassafras*, and *Liquidambar*, likewise found in eastern North America and eastern Asia, and with more or less of their geological history known, is conclusive evidence that *Gymnocladus* had a Tertiary history during which it occupied intervening areas. However, with the exception of the species just described and some rather doubtful European records [1] no fossil remains have thus far been discovered.

Gymnocladus dioicus (*G. canadensis* Lamarck), the existing American species, is a member of the mixed deciduous forests of southeastern North America, ranging from central New York and western Pennsylvania and Maryland through southern Ontario and southern Michigan to the valley of the Minnesota River and to the bottoms of the larger rivers in eastern Nebraska, eastern Kansas, and eastern Oklahoma. It is distinctly an alluvial species throughout its range and while plant geographers record it and other species of like habitat as invaders into the prairie region from the east it is certain that they or their immediate ancestors had a much more extensive range in the late Tertiary in what is now the prairie country.

Holotype.—Cat. No. 35285. U.S.N.M.

[1] Heer, O., Fl. Tert. Helv., vol. 3, 1859, p. 103, pl. 134, figs. 9–12. Squinabol, S., La Flore de Novale, 1901, p. 71, pl. 4, fig. 15.

Order SAPINDALES.

Family SAPINDACEAE.

Genus SAPINDUS Linnaeus.

SAPINUS OKLAHOMENSIS, new species.

Plate 95, figures 1, 2.

Leaflets inequilateral, relatively large, sessile or subsessile, ovate-lanceolate and more or less falcate in outline. Apex and base about equally acuminate but the former more extended and the greatest width of the leaflets below the middle. Margins entire. Substance of the leaflets of medium consistency but hardly deserving the term subcoriaceous. Length 9.5 cm. to 13 cm. Maximum width 2.5 cm. to 3 cm. Midrib stout, fairly prominent, curved. Secondaries numerous, thin but prominent where the preservation is good; they diverge from the midrib at angles around 50 degrees at regular intervals of from 3 mm. to 5 mm., are indifferently opposite to alternate, rather straight and subparallel in their courses and camptodrome. The tertiary areolation, which was well marked in life and rather fine consisted of transversely or obliquely elongated polygonal meshes, and is shown in occasional patches on the specimens but is generally entirely obliterated by the character of the matrix.

This species next to *Platanus aceroides* is the most common form in the collection and indicates a vigorous and fairly large-sized tree. There are a number of described fossil species that approach it very closely. Thus *Sapindus lancifolius* Lesquereux[1] a common Florissant form, while prevailingly smaller, occasionally approaches it in size, as for example in figure 9 cited. The base is, however, more obtuse and the secondaries are somewhat less ascending. *Sapindus affinis* Newberry[2] which is a very common Eocene species, has been identified by Knowlton[3] from the Miocene of Yellowstone Park. The latter specimens are very similar to the Oklahoma species differing merely in their less extended form and fewer secondaries. The widespread European *Sapindus falcifolius* Al. Braun[4] is also very similar but generally smaller and relatively narrower, and the middle Miocene *Sapindus densifolius* Heer[5] of Europe is also very similar.

The geological record of *Sapindus* is a full one, many species having been described from the Upper Cretaceous onward. The genus

[1] Lesquereux, L., Cret. and Tert. Flora, 1883, p. 182, pl. 32, figs. 3–6; pl. 37, fig. 9.
[2] Newberry, J. S., U. S. Geol Survey Mon., vol. 35, 1898, p. 116, pl. 30, fig. 1; pl. 40, fig. 2.
[3] Knowlton, F. H., Idem, vol. 32, 1899, p. 736, pl. 102, figs. 1–3.
[4] Heer, O., Fl. Tert. Helv., vol. 3, 1859, p. 61, pl. 119; pl. 120, figs. 2–8; pl. 121, figs. 1, 2. figs. 1, 2.
[5] Heer, O., Idem, p. 62, pl. 120, fig. 1.

is particularly prominent in the Miocene, no less than 30 species of this age having been described from Europe, Asia, and North America. The genus is present in the Miocene of the United States in Oregon, Colorado, and the Yellowstone Park. The existing species number about two score and are widely distributed throughout the tropics of both hemispheres and are especially abundant in the Asiatic region. Several extend long distances into the North Temperate Zone. Three of these are found in the United States—two in Florida and *Sapindus drummondi* Hooker and Arnott as a considerable tree in moist clayey and dry calcareous soils ranges from western Louisiana to southern Kansas and through Texas to the mountain valleys of southern Arizona and northern Mexico. It occurs in the Wichita Mountains of Oklahoma, but I do not know of its presence in Beaver County, although it may occur there.

Cotypes.—Cat. Nos 35286, 35287, U.S.N.M.

Order RHAMNALES.

Family RHAMNACEAE.

Genus RHAMNUS Linnaeus.

RHAMNUS LESQUEREUXI, new species.

Plate 95, fig. 4.

Rhamnus notatus LESQUEREUX, Cret. and Tert. Flora, p. 189, pl. 38, fig. 15, 1883 (not Saporta, 1867).

Leaves relatively small and very short petioled, ovate in general outline, inclined to be slightly inequilateral. Apex short and obtusely pointed, as is also the base. Margins entire. Texture sub-coriaceous. Length about 3.5 cm. Maximum width, midway between the apex and the base, 2.1 cm. to 2.2 cm. Midrib stout, curved in the material seen, prominent on the lower surface of the leaf. Secondaries six to eight opposite to alternate, mediumly stout and prominent pairs. They diverge from the midrib at angles of over 45 degrees, are subparallel with the lower lateral margins and with one another, and are camptodrome in the maginal region. The areolation is not visible in the Oklahoma specimens. Lesquereux says of the Florissant material, "nervilles oblique, transversely reticulate."

This species was provisionally identified by Lesquereux with a form described by Saporta[1] from the Miocene of southeastern France. The latter is obviously different, being smaller, more coriaceous, subdentate apicad, and with fewer secondaries. It is, however, similar in appearance, and the two are possibly closely related. The material from Oklahoma appears certainly identical with that

[1] Saporta, G. de, Etudes, vol. 3, 1867, p. 108, pl. 11, fig. 5.

from Florissant. It may also be compared with various identifications of *Rhamnus rossmässteri* Unger, as, for example, the leaves figured by Heer[1] from the Miocene of Switzerland. The latter species is rather common in Europe from the Aquitanian to the Pliocene and shows considerable variation. It is, in general, a somewhat larger form than the present species.

Rhamnus is a rather common element in Miocene floras both in this country and abroad. Its known history extends from the Upper Cretaceous to the present, and it is especially abundant in the early Tertiary of the western United States. The existing species number about three score shrubs and small trees widely distributed in all temperate and many tropical parts of the world except Australia and the Pacific islands. There are eight species and three varieties in the existing flora of the United States of which the eastern *Rhamnus caroliniana* Walter, a stream bank and bottomland species, extends westward to eastern Nebraska, Kansas, Oklahoma, and Texas. I do not know of its occurrence in the "panhandle" region, however.

The humid demanding mesophytic species of the Cretaceous and Eocene appear to have given rise to two physiologically divergent lines—one dwellers in bottoms, along streams and as undershrubs in forests—the other becoming inured to scanty water conditions, bright sunlight, high evaporation, etc., and giving rise to the chaparral and montane species of the Rocky Mountains and Pacific coast region.

Lesquereux's material of *Rhamnus lesquereuxi* from Florissant is said to be in the collections of Princeton University. The Oklahoma material is in the United States National Museum.

Holotype.—Cat. No. 35288, U.S.N.M.

Order EBENALES.

Family SAPOTACEAE.

Genus BUMELIA Swartz.

BUMELIA OKLAHOMENSIS, new species.

Plate 94, fig. 1.

Leaves oblong-obovate in outline, with a rounded tip and a narrowly cuneate base. Length about 5 cm. Maximum width, at or slightly above the middle, 1.75 cm. Margins entire. Texture subcoriaceous. Extreme base and petiole missing in the present material. Midrib very stout and prominent, somewhat curved proximad. Secondaries extremely thin, numerous, subparallel; they diverge

[1] Heer, O., Fl. Tert. Helv., vol. 3, 1859, pl. 124, figs. 18–20.

from the midrib at rather regular intervals of about 3 mm. at angles of about 45°, and are camptodrome. Areolation not made out.

These leaves, in both form and venation, are allied to numerous fossil and living species of *Bumelia*, of which many have been described. In the existing flora about a score of species are known—all American, and distributed from the southern United States through the West Indies and Central America to Brazil. The fossil species are known from the Upper Cretaceous onward, and the genus is represented in the Miocene of Europe by seven or eight different forms. It occurs also in the Florissant lake bed.

The present fossil species is very similar to various existing subtropical forms, as for example *Bumelia angustifolia* Nuttall and *Bumelia tenax* Willdenow. It is also very much like the leaves of the existing *Bumelia lanuginosa* Persoon which ranges from Georgia and Florida to Illinois, Missouri, Arkansas, and Texas, and reaches its optimum development in the bottom lands of eastern Texas.

Holotype.—Cat. No. 35289, U.S.N.M.

Family EBENACEAE.

Genus DIOSPYROS Linnaeus.

DIOSPYROS BRACHYSEPALA Al. Braun.

Plate 95, fig. 3.

Diospyros brachysepala Al. Braun, Die Tert. Fl. v. Oeningen, Neues Jahrb., 1845, p. 170.—Heer, Fl. Tert. Helv., vol. 3, 1859, p. 11, pl. 102, figs. 1–4.—Lesquereux, Tert. Fl., 1878, p. 232, pl. 40, figs. 7–10, pl. 63, fig. 6; Cret. and Tert. Fl., 1883, p. 174, pl. 34, figs. 1, 2.—Knowlton, Proc. U. S. Nat. Mus., vol. 51, 1916, p. 285.

Diospyros princetonia Cockerell, Amer. Mus. Nat. Hist. Bull., vol. 24, 1908, p. 105, pl. 10, fig. 36.

This polymorphous species has been recorded from a very large number of localities and horizons. The type material came from both the earliest and the latest Miocene of Switzerland, but subsequently this species has been identified from all stages of the Tertiary of Europe. In America it has been recorded from beds of the late Upper Cretaceous and at different Teritary horizons. It seems incredible that all of these records should represent a single species and probably several are included, but their segregation on other than stratigraphic grounds is impossible at the present time. This being true I can not do otherwise than to refer the Oklahoma material to this species since it appears to be identical with that from Florissant, Colorado, so determined by Lesquereux and Knowlton. At the same time it should be kept in mind that many of the identifications of *Diospyros brachysepala*, of which an extended

bibliography was published by me in 1916,[1] can not be accepted without reservation.

Practically all of the fossil species of *Diospyros* and most of the numerous existing species belong in mesophytic environments. Thus our American *Diospyros virginiana* Linnaeus is a member of the deciduous forest association of the southeastern United States, extending westward a short distance into the prairie States along the bottoms of the principal streams. Some modern species, as for example *Diospyros texana* Scheele of Texas and Mexico, are found under more arid conditions, but like certain existing species of *Rhamnus*, they are believed to indicate relatively modern specialization of habitat in a direction away from the normal habitat of the two genera.

Plesiotype.—Cat. No. 35290, U.S.N.M.

EXPLANATION OF PLATES.

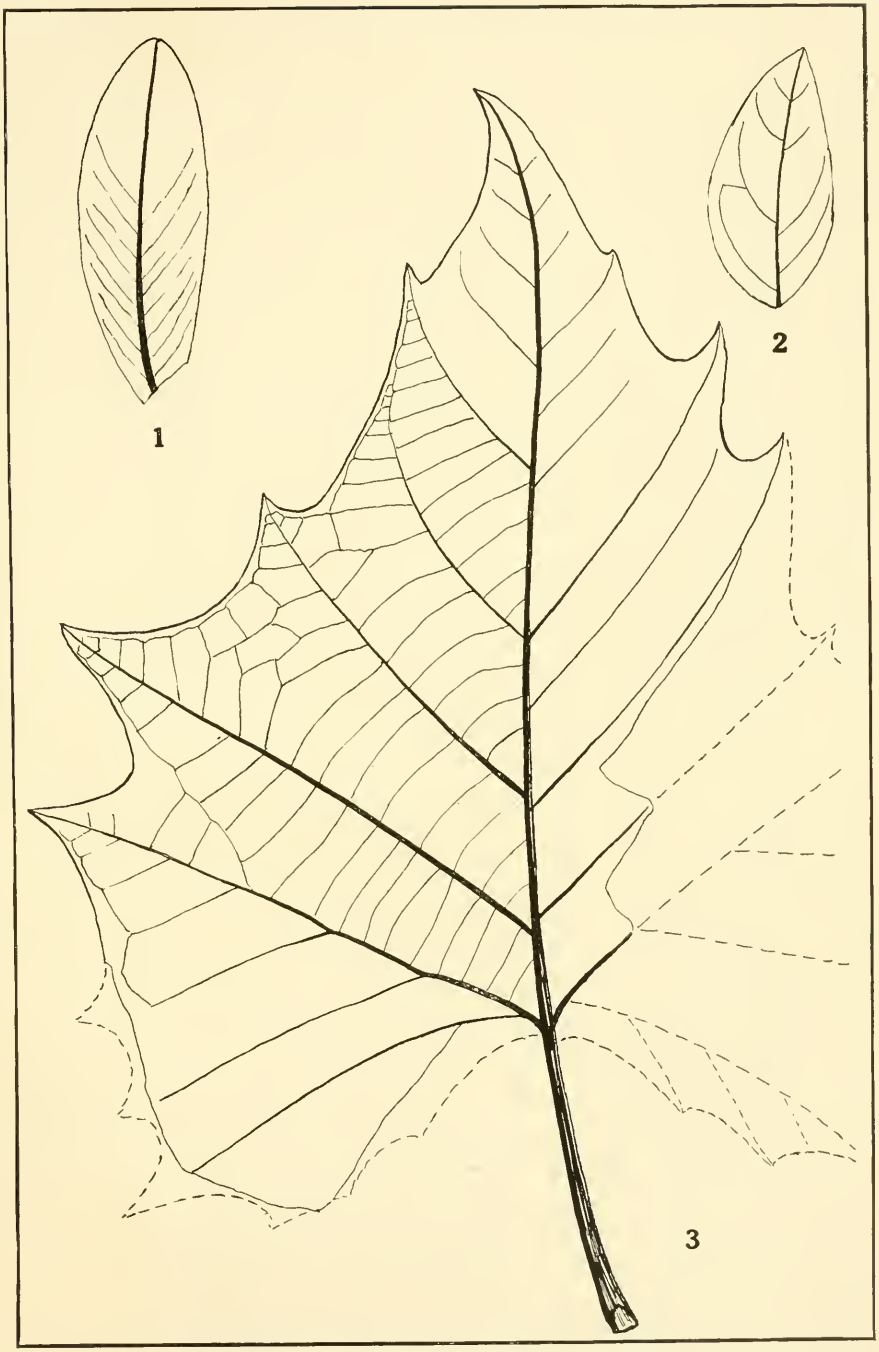
PLATE 94.

FIG. 1. *Bumelia oklahomensis*, new species.
2. *Gymnocladus casei*, new species.
3. *Platanus aceroides* Goeppert.

PLATE 95.

FIGS. 1, 2. *Sapinus oklahomensis*, new species.
3. *Diospyros brachysepala* Al. Braun.
4. *Rhamnus lesquereuxi*, new species.
5. *Platanus aceroides* Goeppert.

[1] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, 1916, p. 333.



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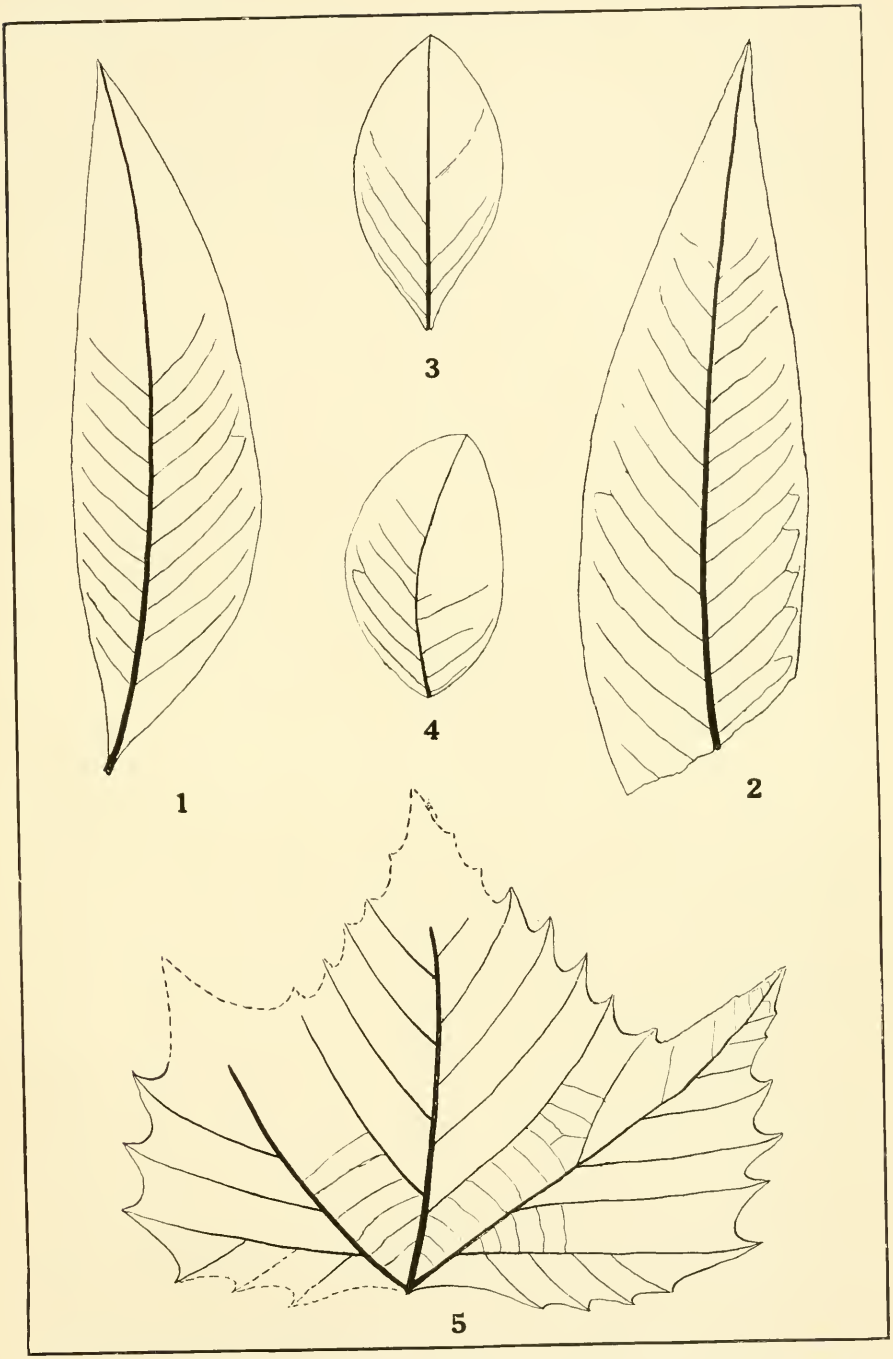

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