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FOSSIL PLANTS FROM THE BEDS OF VOLCANIC ASH NEAR MISSOULA, WESTERN MONTANA.

By O. E. Jennings.

(Plates XXII–XXXIII)

Introductory.

This paper deals with some fossil plants obtained by Mr. Earl Douglass from the beds of volcanic ash in the vicinity of Missoula, Montana, and with a smaller collection made by him near Winston, Montana. The specimens are now in the Carnegie Museum.

The fossils from near Missoula were collected by Mr. Douglass from two places. One of these places is termed on the labels "Locality 165" and is stated to be about one and one-half miles north of Missoula, the collections having been made September 26–30, 1903. These beds are noted as being "Several hundred feet thick and are composed of volcanic ash, sandstone, conglomerate, etc. There are several seams of coal." Another label from the same place says: "In beds of volcanic ash. Coal above and below." The other station from near Missoula, and from which the better part of the material came, is evidently near "Locality 165" and is called on the labels "Locality 196." The collection from Winston was made on September 23, 1902, on the north side of Beaver Creek, northeast of Winston, Montana. This latter collection is a small one, containing but two or possibly three species.

The Missoula collections, with which this paper is mainly concerned, were taken by Douglass from beds which he believed to be of Oligocene age.[1] He states that they "appear in the main to represent the Titanotherium and Oreodon beds of South Dakota." This horizon, as understood by most American paleontologists, includes approximately the lower half of the White River formation.[2] The fossil plants in these deposits consist of impressions of leaves and of leafy twigs, there being also a few impressions of fruits and leafless twigs. The Missoula specimens are in a very light colored, grayish-white, soft and friable rock, consisting of a fine-grained volcanic ash, which was evidently more or less stratified and laminated.[3-4] It is generally believed that the dust was wind-borne and that it was mainly deposited in freshwater lakes or other shallow basins. Douglass states that "It does not appear that the water was as a rule very deep. There are undoubtedly not only lake but marsh and river deposits. . . . We find nearly everywhere evidences of shallow water, such as ripple marks, bird tracks, plant remains, shallow water mollusca, etc." Rowe[5] also states his belief that the ash fell in freshwater lakes.

The Missoula specimens mostly preserve in considerable detail even the finer venation of the leaf surfaces, and in a number of instances the outline of the whole leaf is plainly evident. The Winston specimens are, however, in a harder, light gray rock, which has slickenside surfaces developed at various angles and directions and presents every appearance of having once been a slumping mass of very fine-grained mud. In this material the fossils are unsatisfactory, the hardness of the rock and its irregularity of fracture resulting in fragmentary specimens.

I have undertaken the study of these various collections more as a student of modern systematic botany and ecology than as a paleobotanist, and it is barely possible that my conclusions may in some instances differ from what might have been those of a paleobotanist, trained as a stratigrapher. However, no sharp line of distinction can now be drawn between the work of a paleobotanist on the one hand and that of the student of modern botany and ecology on the other, and it is plainly evident that each of these fields of study may yet receive many valuable and enlightening contributions from the other.

In the preparation of the illustrations accompanying this article I have had the able assistance of my wife, Grace K. Jennings, and to her is due quite largely

[1] Douglass, Earl. New Vertebrates from the Montana Territory. Annals Carnegie Museum, II, 1903, 145–199.

[2] Willis, Bailey. Index to the Stratigraphy of North America. U. S. Geol. Surv., Prof. Paper LXXI, 1912, p. 770.

[3] Rowe, J. P. Some Volcanic Ash Beds of Montana. Univ. Montana Bull., XVII, 1903.

[4] *Op. cit.*, p. 146.

[5] *Op. cit.*, p. 12.

the excellence of many of the photographic reproductions. The photographs were made with an ordinary 5 × 7-inch bellows camera, the specimens being usually placed in direct sunlight at a low angle of incidence in order to give sharper contrast and to show better the features of relief on the impressions. The photographs showing parts of the specimens enlarged were made by supplementing the ordinary lens of the camera with an enlarging lens which fits over the front of the regular lens like a cap. To give greater contrast in these enlargements ordinary daylight was supplemented with a rather strong desk dissecting lamp fitted with "daylight" glass and by proper manipulation of this light the inequalities on the surface of the leaf impressions were shown as highlight and shadow.

In the publication just referred to Rowe gives a short list of the plants collected from beds of volcanic ash near Missoula, the list being as follows:

1. *Sequoia Langsdorfii.*
2. *Sequoia,* probably new species.
3. *Glyptostrobus europæus.*
4. *Alnus.*
5. *Carpinus,* probably new species.
6. *Cornus* or *Viburnum.*
7. *Populus balsamoides* (?)
8. Fruit near *Chinchonidium.*
9. *Taxodium occidentalis.*
10. *Taxodium.*

Accompanying Rowe's report are three plates illustrating some of the fossil plants from these beds. Plants shown on these plates are evidently the same as some of those described in the present paper, as follows: Plate VI shows at the left upper margin what is probably a piece of a leaf of *Alnus Hollandiana* Jennings, a specimen of *Populus Zaddachi* Heer being shown in the middle of the plate, while both Plates VI and VII show leaves of what I have described as a new species, *Betula multinervis.* The *Taxodium*-like sprays in Plate VIII are evidently the same as the sprays in our material which I believe to represent one of the various types of *Sequoia Haydenii* (Lesquereux) Cockerell.

The *Glyptostrobus* mentioned in Rowe's list is probably the same as the specimens in our collections which I believe belong to *Sequoia Haydenii.* The *Carpinus* is evidently the same as my *Betula multinervis*; the *Populus balsamoides* (?) I take to be *Populus Zaddachi* Heer and the *Taxodium,* like that shown in his Plate VIII, at least, is probably *Sequoia Haydenii.*

II. Relations of the Fossil Flora from Missoula to the Nearest Eocene and Miocene Floras of the West.

The specimens collected by Mr. Douglass from near Winston appear to represent but two, or possibly three, species, as follows:

Equisetum insculptum Jennings
Equisetum sp. Vegetative buds
Aralia longipetiolata Jennings

These species appear not to be represented in collections described from other localities and this fact, in connection with the wide geological ranges of the genera *Equisetum* and *Aralia,* makes the collection of little value as a means of correlating this flora with other ancient floras.

The specimens from the Missoula district represent at least twenty species, ten of which I have described as new and one of which requires a new name. These twenty-one species are enumerated in the following list, the numbers in parentheses indicating from which of Douglass' localities the specimens came:

Sequoia Haydenii (Lesquereux) Cockerell. (165, 196)
Sequoia oblongifolia Jennings. (196)
Thuyopsis gracilis Heer. (196)
Sabina linguæfolia (Lesquereux) Cockerell. (196)
Typha Lesquereuxii Cockerell. (196)
Cyperacites sp. (196)
Populus smilacifolia Newberry. (165)
Populus Zaddachi Heer. (165, 196)
Juglans pentagona Jennings. (165)
Betula multinervis Jennings. (165, 196)
Alnus microdontoides Jennings. (165, 196)
Alnus Hollandiana Jennings. (196)
Quercus approximata Jennings. (196)
Quercus flexuosa Newberry. (165)
Quercus laurisimulans Jennings. (196)
Ficus (?) *prunifolia* Jennings. (196)
Ilex furcinervis Jennings. (196)
Celastrus parvifolius Jennings. (196)
Acer oregonianum Knowlton. (165)
Vaccinium palæocorymbosum Jennings. (196)

The flora represented in the Missoula collections appears closely related to that reported for the Florissant basin of Colorado.[6] Of the fifteen genera repre-

[6] Among the more important titles consulted with reference to the Florissant flora were the following:
Kirchner. Trans. St. Louis Acad. Sci., VIII, 1898, pp. 161–198, Pls. 11–15.
Cockerell. Univ. Colorado Studies, III, No. 3, 1906, 157–176. Bull. Am. Mus. Nat. Hist., XXIV, 1908, pp. 71–110, Pls. 6–10. Amer. Nat., XLIV, 1910, pp. 31–47.
Knowlton. Proc. U. S. Nat. Mus., LI, 1916, pp. 241–297, Pls. 12–27.

sented in the Missoula flora all but two are also represented in the Florissant. Three species, *Sequoia Haydenii*, *Typha Lesquereuxii*, and *Sabina linguæfolia*, apparently occur in both floras and there are other species which a further study of more complete and more abundant material might prove to be identical. Further comparisons show that to a large extent the genera having more than one species each in the two floras were largely the same. In the Missoula flora *Sequoia*, *Populus*, *Alnus*, and *Quercus* were each represented by more than one species.

One of the fossils in the Missoula collection apparently represents the species described by Knowlton from the Mascall beds of the John Day Basin, Oregon, and in a number of respects the Missoula flora seems to be rather closely allied to the Mascall flora. Eleven of the Missoula genera occur in the Mascall and, while, with the exception of the maple, perhaps none of the corresponding forms in the two floras are identical, some of them are rather closely similar. Of the genera reported as having two or more species each, the Mascall flora has *Sequoia* (with 2 or 3), *Quercus* (5 or 6), *Celastrus* (2), and *Acer* (8), as against *Sequoia* (2), *Populus* (2), *Alnus* (2), and *Quercus* (3) in the fossil flora at Missoula.

Another of the floras of the John Day Basin reported by Knowlton[7] and of interest with reference to the Missoula collections is that from what are regarded as upper Eocene[8] beds at Bridge Creek, Oregon. Comparing the Missoula flora with that of Bridge Creek it appears that seven of the fifteen genera of the former are represented also in the latter. Of the genera of the Bridge Creek flora represented by more than one species there are *Sequoia* (with 2 species), *Juglans* (3), *Betula* (4), *Alnus* (4), *Quercus* (8), *Ficus* (1), *Acer* (1). The Missoula flora has *Sequoia* (2), *Populus* (2), *Alnus* (2), and *Quercus* (3), so that, considering the relative percentage of species represented by the leading genera together with the number of genera common to the two floras, it would appear that the flora from Missoula is about as closely related to the Bridge Creek flora as to that of the Mascall beds.

Knowlton[9] has reported eighteen genera of plants among the fossils collected in the Payette formation (regarded by Knowlton as Upper Eocene)[10] from the

[7] Knowlton. Fossil Flora of the John Day Basin. U. S. Geol. Surv. Bull., CCIV, 1902, pp. 19, 89–93, 106–108, 113. *Op. cit.*, pp. 17, 89–93, 103–105, 113.

[8] Merriam, J. C. Significant Features in the History of Life on the Pacific Coast, in Nature and Science on the Pacific Coast, 1915, pp. 88–103. See also A Contribution to the Geology of the John Day Basin. Bull. Dept. Geol., Univ. Cal., II, 1901, 269–314, 285–287, 290–299; also Merriam, J. C., and Sinclair, W. J. Tertiary Faunas of the John Day Basin. Bull. Dept. Geol., Univ. Cal., V, 1907, p. 173.

[9] Knowlton. The Fossil Plants of the Payette Formation. U. S. Geol. Surv. Ann. Rpt., XVIII, Part III, 1898, pp. 721–736, Pls. 99–102.

[10] Knowlton. Succession and Range of Mesozoic and Tertiary Floras, in Willis and Salisbury, Outlines of Geologic History, Chapter X, 1910, pp. 200–211.

fossil lake beds of the Snake River in western Idaho. Eight of these genera are common to the Payette and Missoula collections. Of the Payette genera five are represented by more than one species each (*Sequoia*, *Myrica*, *Populus*, *Betula*, and *Quercus*) as against four such genera in the Missoula collections (*Sequoia*, *Populus*, *Alnus*, and *Quercus*). While not identical in the two floras a number of species are here also represented by similar forms.

The Lamar flora described by Knowlton[11] from the Yellowstone National Park has listed for its lower member ("Fossil forest *a*") eight of the fifteen genera which I have recognized in the Missoula collections, and there are at least five or six species closely similar in these two floras.

From what he regards as the true Green River formation "excluding Florissant and Elko Station," Cockerell[12] has compiled a list of the plant genera represented. A comparison of this list with the list of Missoula genera shows nine genera to be common to the two floras.

The following table presents in a more compact form a list of the plant genera represented in the Missoula collections together with the occurrences of the genera in the other floras discussed in the preceding pages:

TABLE OF THE GENERA REPRESENTED IN THE COLLECTIONS OF FOSSIL PLANTS FROM THE BEDS OF VOLCANIC ASH NEAR MISSOULA, MONTANA, SHOWING ALSO THE OCCURRENCE OF THESE GENERA IN A NUMBER OF OTHER FOSSIL FLORAS.

	Regarded as Upper Eocene.				Middle Miocene.	
White River. Missoula, Mont.	Lamar. Yellowstone National Park.	Green River. Wyoming and Utah.	Payette. Snake River, West Idaho.	Bridge Creek. Oregon.	Mascall. Oregon.	Florissant. Colorado.
Sequoia......	x	x	x	x	x	x
Thuyopsis....						
Sabina.......					(x)	x
Typha.......		x				x
Cyperacites...	x	x			x	
Populus......	x		x		x	x
Juglans......	x	x	x	x	x	x
Betula.......			x	x	x	x
Alnus........		x		x	x	x
Quercus......	x	x	x	x	x	x
Ficus........	x	x	x	x	x	x
Ilex.........		x				x
Celastrus.....	x		x		x	x
Acer.........	x	x	x	x	x	x
Vaccinium...						x

[11] Knowlton. Fossil Flora of the Yellowstone National Park. U. S. Geol. Surv., Monograph XXXII, Part II, Chapter XIV, 1899, pp. 651–791.

[12] Cockerell. The Fossil Flora of Florissant, Colorado. Bull. Amer. Mus. Nat. Hist., XXIV, 1908, p. 44.

It is obviously unsafe in questions of comparison or correlation between rather closely related floras to place much reliance on such evidence as may be furnished by a small collection of fossil plants consisting mainly of leaf-impressions. Conditions of deposition and fossilization are probably very rarely effective in preserving a representative sample of a flora, unless the fossils collected are in large numbers. As far as the indications go, it appears that the Missoula specimens represent much the same kind of a flora as was preserved in the Florissant beds. Yet differences between the Missoula flora and the Green River flora, as referred to above, and generally regarded as Upper Eocene[13] in age, is by no means great. The Florissant beds are now regarded as Miocene[14], Cockerell even advancing both the Mascall and Florissant floras to middle Miocene.[15]

As far as the genera are concerned collectively there has been comparatively little change in the flora of the temperate regions of the United States since Florissant times, and, allowing for a probably gradual cooling and a decrease in moisture during the period between the Green River (Eocene) and the Florissant (Middle Miocene), it appears that the changes in genera in this latter period were likewise not great. Cockerell, comparing the Intermediate and Lamar floras on the one hand and the plants "said to occur elsewhere or in the Eocene" on the other, shows that these Yellowstone floras have "twenty-six plants specifically identical with those of the basal Eocene" and, further, "The conclusion seems to be legitimate that the Yellowstone Intermediate and Lamar floræ are Upper Eocene, or at least older than Miocene." In his discussion of the records furnished by fossils as to the distribution of the various floras through the different periods of time, Clements says[16] that "the flora of the Oligocene was essentially that of the Eocene somewhat reduced by deformation, and the plants of the Pliocene are practically those of the Miocene, but with a striking reduction," the reduction mentioned being due in part to the reduction in the area in which sedimentation and fossilization were taking place.

Of the floras referred to in the above discussion and in the table, the Bridge Creek, Lamar, Payette, and Green River are now probably best regarded as late

[13] Willis. Index to the Stratigraphy of North America. U. S. Geol. Surv., Prof. Paper LXXI, 1912, pp. 676, 758–760, 765.

[14] Knowlton. A Review of the Fossil Plants in the United States National Museum from the Florissant Lake Beds of Florissant, Colorado, With Descriptions of New Species and Lists of Type Specimens. Proc. U. S. Nat. Mus., LI, 1916, pp. 241–297, Pls. 12–27.

[15] Cockerell. The Miocene Trees of the Rocky Mountains. Am. Nat., XLIV, 1910, pp. 31–47; Some American Fossil Insects. Proc. U. S. Nat. Mus., LI, 1916, pp. 81–106.

[16] Clements, F. E. Plant Succession. Carnegie Inst. Wash., Publ. CCXLII, 1916, p. 352.

Eocene, the Mascall and Florissant as middle Miocene. Assuming this to be the case it is interesting to group together the four upper Eocene floras for purposes of comparison with the two Miocene floras. Upon doing this it appears that of the fifteen genera in our Missoula flora twelve occur also in the combined upper Eocene floras and fourteen in the combined middle Miocene floras. This comparison does not show any great preponderance in favor of the Miocene, and it is quite possible that climatic and other ecological conditions may have brought about similar groupings in the Missoula and Florissant floras somewhat out of proportion to the actual systematic relationships of the floras existing at the time these fossils were formed.

The Missoula flora probably occupied the shores and surrounding slopes of a high mountain lake. Douglass says, however: "There is doubt that the mountains were as high during the White River epoch as at the present time."[17] Cockerell and other writers have referred to Lake Florissant as a mountain lake and some of the differences between the Mascall and Florissant floras are thought by Cockerell to be possibly due to the differences between a lowland flora, like that of the Mascall, and one around a mountain lake, such as that of the Florissant.[18] I am inclined to believe that the similarity of habitat has brought about a similarity in the fossil floras from Missoula and Florissant that may have obscured to a considerable degree the actual difference of the two floras in point of time.

Two of the plants represented in the Missoula collections (*Thuyopsis gracilis* Heer, and *Populus Zaddachi* Heer) appear to be the species described and reported by Heer from the Atane beds of Greenland. These beds were regarded by Heer[19] and some other authors[20] as Miocene, but they are more likely Cretaceous or early Eocene.[21–22] A considerable number of plants described from the arctic regions by Heer and others from beds thought at that time to be Miocene appear farther south during early and middle Tertiary times. This southward shifting of floral zones is to be ascribed to corresponding climatic changes. Clements notes[23] that 'A distinct cooling is indicated by the flora of the early Eocene, and the usual accom-

[17] Douglass. New Vertebrates from the Montana Territory. Annals Carnegie Museum, II, 1903, p. 149.

[18] Cockerell. The Miocene Trees of the Rocky Mountains. Am. Nat., XLIV, 1910, p. 37.

[19] Heer, O. Flora Fossilis Arctica I, 1868, pp. 98–99, and various other pages in this and other volumes of the series.

[20] Schuchert, C. Climates of Geologic Time. In Huntington's The Climatic Factor. Carnegie Inst. Wash., Publ. CXCII, 265. 1914.

[21] Willis, Bailey. Index to the Stratigraphy of North America. U. S. Geol. Surv., Prof. Paper LXXI, 1912, pp. 705 and 838.

[22] Clements, F. E. Plant Succession. Carnegie Inst. Wash., Publ. CCXLII, 1916, p. 242.

paniment of aridity is shown by the salt and gypsum beds of the Texas formations of the period. The earliest Eocene flora, that described by Heer from Belgium, indicates a temperate climate, characterized by *Quercus, Castanea, Salix, Laurus, Hedera,* etc. Similar horizons are found in the lower Eocene of France and England. At a later stage, palms, bananas, figs, cinnamons, etc., became dominant, indicating a return to tropical conditions.' With the period of "mountain making and vulcanism" in the Oligocene there came another change to a cooler and drier climate.[23] Clements further notes[24] that the evidence indicates "that the Oligo-Miocene cycle was marked by a general climate cooler and drier than that of the Eocene, and hence by a differentiation of climates approaching that of today." And, further, "So far as dominants are concerned there appears to be little difference between the floras of the Eocene and Miocene. The dominant tree genera appear to have been about equally represented in both, and this is largely true of shrubs. . . . Thus, while the flora remained largely the same, it must have undergone marked differentiation and shifting as a result of the deformation and cooling which initiated the cycle. The northerly climax zones must have been broadened as well as pushed to the south. . . . Before the climatic effect of Oligocene deformation had disappeared the deformation cycle of late Miocene and Pliocene had begun to culminate in the Ice Age. Thus the shifting of the climatic zones took place only to the southward, as well as downwards on the mountains." The cooling during the Oligo-Miocene cycle "from a tropical or subtropical climate to a warm temperate one over much of the continent was permanent."

Assuming, then, that during the period from the late Eocene up into the Miocene there was, in general, a cooling and drying of the climate and a differentiation of climatic regions and zones and, further, that during this time there was a migration of northern plants southwards as well as down from the higher and cooler habitats to the lowlands, it seems to me not unreasonable to believe that the mountains of western Montana during the Oligocene would have been populated by the northern flora long before a similar region in central Colorado at a latitude of about six hundred miles farther south. The Missoula region would likely have been invaded by this northern flora long before the Mascall region lying to the southwest in Oregon and probably on lowlands separated but little from the western ocean either by distance or elevation. Unless exception might be made in the case of the Payette flora, I feel fairly certain that the Florissant was the only one of the fossil floras discussed which approximated very closely the Missoula flora as to the

[23] Schuchert. *Op. cit.*

[24] Clements. *Op. cit.,* pp. 364–366.

ecological conditions involved. I think that the similarity of the Missoula and Florissant floras may actually be regarded as indicating a considerable time interval during which similar stages in a southward migration of northern plants were reached in the two floras. During the corresponding disappearance of the southern plants the Missoula region would, of course, lose them before they would disappear from the Florissant and, in this connection it is interesting to note that of the southern element Florissant had *Sapindus, Diospyros, Persea, Leucœna, Annona, Ficus,* and others, while only one such species, which I doubtfully determined as *Ficus,* appears in the Missoula collection. All this leads me to believe that the collections from Missoula represent an earlier period than do the Florissant collections, a period somewhere between the late Eocene and middle Miocene, and I see no reasons for not accepting Douglass' claim that the beds belong to the White River formation and are of Oligocene age.

If we may accept the claim that there had come about a differentiation of climates it would not be unreasonable to expect a considerable difference between the flora of the Missoula White River and the Oligocene flora of the lower southeastern part of the United States, much as is the case today with the modern floras. Berry has this to say with reference to the tropical character of the Oligocene flora of the Catahoula sandstone of the Gulf Coastal Plain[25]: "Finally, the facies of the flora as a whole is that of the abundant floras found in the early Oligocene of southern Europe, notably in Provence, France, in Tryol, and in Dalmatia and Styria. Not only does it exhibit this parallelism with these European early Oligocene floras, but when the genera are considered separately it appears that almost without exception they have not been found in what are now temperate latitudes in any beds younger than Oligocene." In general this was a tropical flora and the climate along the Gulf Coast at that time was evidently much more tropical than now.[26–27] There was later a general cooling, possibly also a shifting of ocean currents bringing about a change from subtropical to cold-water conditions, with evidently somewhat corresponding changes in the flora of the adjacent coasts. Berry has shown by a study of the flora of the Calvert formation from Virginia and the District of Columbia that by the time of the middle Miocene the climate in this region

[25] Berry, E. W. The Flora of the Catahoula Sandstone. U. S. Geol. Surv., Prof. Paper XCVIII–M, 1916, pp. 227–243, Pls. 55–60.

[26] Berry, E. W. A Study of the Tertiary Floras of the Atlantic and Gulf Coastal Plain. Proc. Amer. Phil. Soc., L, 1911, 311–315.

[27] Dall, W. H. Contributions to the Tertiary Fauna of Florida, Part VI. Trans. Wagner Free Inst., III, 1903, p. 1594.

was cooler, probably only warm-temperate.[28] "The Calvert flora was a coastal flora of strikingly warm-temperate affinities, comparable with the existing coastal floras of South Carolina and Georgia along the south Atlantic coast or with those along the coast of the Gulf of Mexico from western Florida to eastern Texas. The climate of the Chesapeake Miocene epoch, cooler undoubtedly than that of the Apalachicola or preceding epochs, was neither cold nor cool temperate."

It is evident that the Oligocene and middle Miocene floras of the middle and southeastern Atlantic Coastal Plains were related ecologically, and, especially as to the climatic aspect, were related to the Oligocene and middle Miocene floras of the West in very much the same manner as are the modern floras of those regions. I can see nothing in either the character or ecological relationships of the old southeastern floras that might serve as an argument against our belief in the Oligocene age of the Missoula flora.

III. Ecological Conditions Indicated by the Fossil Flora from Missoula.

As to the ecological relationships of the flora around the old Missoula basin, it is interesting to compare the fossil flora with that, which in the case of a shower of volcanic ash we might suppose would be represented by plant materials imbedded under conditions likely to lead to fossilization in the basins of some of the lakes now to be found in western Montana and Idaho. The plants preserved in the Missoula fossil collections were practically all woody plants, evidently mostly trees, and I have found particularly useful for the purposes of this comparison the biological reconnoissances of Flathead Lake and several other smaller lakes in western Montana by Elrod,[29] and the more detailed studies of the forests of the Flathead Valley by Whitford.[30] To a considerable extent, also, I have relied upon first-hand information gained during two weeks in the summer of 1915 which my wife and I spent in botanizing around Lake Newman, along the Washington-Idaho state boundary line about one hundred and sixty miles west of Missoula.

Whitford's classification of the vegetation in the Flathead Valley, western Montana, in the midst of rugged mountains, shows it to consist of five main divisions, as follows: I. Meadow (hydrophytic); II. Englemann Spruce Forest (meso-

[28] Berry, E. W., Physical Conditions indicated by the Flora of the the Calvert Formation. U. S. Geol. Surv., Prof. Paper XCVIII-F, 1916, p. 66.

[29] Elrod, M. J. A Biological Reconnoissance in the Vicinity of Flathead Lake. Univ. Mont. Bull., X, 1902, pp. 91-182, Pls. 18-46. (Biological Series III.)

[30] Whitford, H. N. The Forests of the Flathead Valley, Montana. Bot. Gaz., XXXIX, 1905, pp. 99-122, 194-218, 276-296.

hydrophytic); III. Western Larch—Douglas Spruce Forest (mesophytic); IV. Douglas Spruce—Bull Pine Forest (meso-xerophytic); and V. Prairie (xerophytic).

Numbers I, II, III, and V of Whitford's divisions contain more or less abundantly species corresponding to those represented in the Oligocene flora of Missoula. The Meadow (I) is usually along the end or border of a lake or else in a wet swampy depression, and such a meadow with subsequent filling or draining will tend to be invaded and eventually succeeded by Spruce Forest (II).

From the articles cited I gain that most of the meadows have, on the hummocks or as a bordering thicket, the advance guard of the spruce forest in the form of willows (*Salix*) and alders (*Alnus*). The thickets formed by these plants are eventually entered by spruce (*Picea Engelmanni*) accompanied by poplars (*Populus angustifolia* and *P. tremuloides*), birches (*Betula papyrifera*), and sometimes *Echinopanax horridum, Rhamnus alnifolia,* and *Cornus stolonifera.* For the purposes of the present discussion, the wet meadow and spruce forest will be treated as one unit. They are both situated close to the water or are in the central part of a wet depression and, often the shore of the lake may be so dry that there is no meadow, the spruce forest bordering the shore directly, with perhaps but a narrow fringe of alders, willows, and a few other plants.

Three of the genera mentioned in the above paragraph were present also in the Oligocene flora of Missoula, these three genera including five of the fossil species. Added to these five, should be the fossil species of *Typha, Cyperacites, Vaccinium,* and *Ficus,* which must have occupied either the wet meadow, its invading and surrounding thickets, or the adjacent wet woods. Thus considered, the meadow or its immediate borders or adjacent wet woods in the Flathead Valley would be quite likely to contribute to the waters of the nearby lake leaves of representatives of at least five of the genera found in the Oligocene fossil flora from Missoula, while, considered from the standpoint of systematic and ecological equivalents, similar habitats around a lake in the Missoula district in Oligocene times might easily have contributed at least nine of the twenty-one species found among the Missoula fossils.

Whitford's third class, the one having the habitat next drier than the spruce forest and thus usually the one next higher on the slope from the lake basin, is the Western Larch-Douglas Spruce forest. Characterizing this forest are the larch (*Larix occidentalis*), Douglas Spruce (*Pseudotsuga mucronata*), and accompanying them are the Lodge-pole Pine (*Pinus Murrayana*), Lowland Fir (*Abies grandis*), White Pine (*Pinus monticola*), Engelmann Spruce (*Picea Engelmanni*), White Cedar (*Thuya plicata*), and occasionally *Abies lasiocarpa, Pinus ponderosa, Tsuga heterophylla,* and some other chiefly deciduous trees and shrubs.

With gentle slopes rising from the lake basins this forest will usually be found at some little distance from the open water, but on higher, drier, well-drained soil on steeper slopes or benches along the lake shore, such forests occur close to the open water. At Newman Lake near the Idaho-Washington boundary line patches of this association occupy soil not over fifteen feet from open water and extending down upon levels not over three feet above lake-level. Such a forest might easily become a strong competitor with the meadow-spruce forest in contributing leaves and other materials to a bed of volcanic dust accumulating in the lake close by. The old ecological equivalent of this habitat probably furnished for fossilization in the Oligocene lake-bed at Missoula the two species of *Sequoia*, the *Thuyopsis* (represented in our Northwest now by *Thuya*), the maple (*Acer*), the walnut (*Juglans*), and perhaps some of the oaks (*Quercus*).

On sandy or rocky habitats or on dry uplands and slopes, where not too cold, the next drier habitat to that occupied by the Larch-Douglas Spruce forest is that of the Douglas Spruce-Bull Pine forest. On rocky or dry sandy soils around Newman Lake this forest comes down practically to the water's edge. Whitford[30a] notes that: "If the outcrop is near a large body of water like Flathead Lake, *Juniperus scopulorum* is one of the first trees." The forest is mainly composed of the Yellow Pine or Bull Pine (*Pinus ponderosa*) and Douglas Spruce. Such a forest around an Oligocene lake-basin at Missoula could thus have contributed readily from a rocky cliff or promontory twigs of the Juniper (*Sabina*) or with the somewhat warmer conditions indicated by the presence of the oaks and possibly a fig, the Juniper might have come from a sandy shore or from sand dunes such as are now so characteristically covered with the Red Cedar (*Juniperus virginiana*) along the shores of Lake Erie and the lower end of Lake Michigan.

Assuming that the climate in the Oligocene lake basin at Missoula was warmer and probably drier (*see* p. 394) than that now prevailing in the Flathead Valley, it appears probable that the habitat occupied by the Oligocene equivalent of the Douglas Spruce-Bull Pine forest occupied a larger area, or at least crowded more closely the more moist areas around the basin. I believe that this habitat is the one which probably furnished the oaks, or at least most of them, and possibly also the Holly (*Ilex*) and *Celastrus*, although modern species of both of these genera also occur in more moist habitats. The Oligocene oaks were apparently xerophytic, as indicated by the nature of the leaf impressions, and I take them to have been comparable to the modern live-oaks, chestnut-oaks, and shingle-oaks so characteristic of moderately xerophytic habitats in the eastern, southeastern, and southwestern parts of the United States.

[30a] *Op. cit.*, p. 216.

As indicated in the preceding discussion, the fossils in the volcanic beds at Missoula might readily have been contributed to the waters of an Oligocene lake, in a climate somewhat warmer than now prevails in that region, by a series of vegetational associations ranging from wet meadow to moderately xerophytic oak-forests on rocky or sandy shores, all of these vegetational associations in close proximity, at least here and there, to the waters of the lake.

IV. Remarks on the Fossil Flora from Winston, Montana

The collections from the consolidated mud from Winston apparently belong to the same general age as the Missoula collections. As noted earlier in this paper- there are but two species represented, a small *Equisetum* and a plant which I have referred to *Aralia*. Neither of these plants offer much basis for correlation with other fossil floras. *Equisetum* occurs in all of the late Eocene and middle Miocene floras listed in the preceding table, excepting only Bridge Creek, and it, or the forms referred to *Equisetites*, range from the Paleozoic up to modern times, so that its presence means little as to the time relations of the beds in which it occurs. *Aralia* occurs in the Lamar and Green River floras (late Eocene) and in the Florissant (middle Miocene). Its range from the upper part of the lower Cretaceous up to modern times makes it, too, of little use for purposes of correlation. If there is other evidence, as for instance, from animal fossils, for believing that these plants were of Oligocene age I can see no objection to such a view from any evidence to be furnished by the plant fossils. Ecologically the *Equisetum* and *Aralia* might readily have been a part of the vegetation believed to have grown around the Oligocene lake at Missoula; the *Equisetum* in shallow water with sandy bottom, the *Aralia* in the thickets invading the wet meadow or in the moist woods.

V. Descriptions of the Species in the Oligocene Flora of Missoula, Montana, and of a few Species from Winston, Montana.

1. **Equisetum insculptum** Jennings, sp. nov. (Plate XXII, Fig. 2.)

The specimen consists of a mould of a piece of stem about 3 cm. long, this mould being mainly filled with the corresponding cast. The mould and cast reproduce in great detail the minute features of the outside of the stem. The stem was about 3 mm. in diameter but was compressed in fossilization to about 4 mm. and it had eighteen ridges about 0.5 mm. apart, these being quite prominent and each having two distinct rows of papilla-like tubercles. In the rather deep and rounded furrows there are fine but distinct and closely set silex ridges running crosswise and there are longitudinal lines indicating the position of two rows of stomata. The character of the impression suggests a species with a rather firm and strong stem-wall, such as is the case in the living *Equisetum hyemale* Linnæus.

The one specimen upon which this record is based comes from "Locality 139," near Winston. So far as I have been able to discover among the various publications relating to fossil *Equisetaceæ,* there have been no fossil species described in which the markings have been so beautifully preserved as in this specimen. The most nearly related species are, perhaps, *Equisetum wyomingense,* described by Lesquereux from the Green River group of Wyoming, and the *Equisetum* studied by Knowlton from the Payette of Idaho, both probably Eocene in age. Among living species, *Equisetum variegatum* var. *Jesupi* A. A. Eaton, which is probably a hybrid between *E. variegatum* and *E. hyemale*[31] is very closely similar, having the double row of carinal tubercles, small stem, and cross-bands of silex in the furrows.

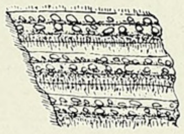


FIG. 1. *Equisetum insculptum* Jennings. Sketch to show details of markings on the stem shown in Plate XXII, fig. 2. Enlarged about fifteen diameters.

The genus *Equisetum,* or *Equisetites,* as most of its older representatives have been called, is recorded from at least as far back as the Paleozoic. Excepting possibly for a considerable diminution in size, these plants have changed but little up to the present time and the various species are of relatively little stratigraphic value.

As the Winston species seems not to be the same as any of the species before described, I am designating it as new, the specific name *insculptum* being used for it on account of the unusually distinct and bold markings on the outer surface of the stem.

2. **Equisetum** sp. (PLATE XXII, FIG. 1.)

This is a poorly preserved specimen from the Winston locality representing a piece of a stem, about 17 mm. long and 3 mm. wide, at the apex of which is indicated a cluster of three branches, only two of which are preserved with any degree of distinctness. The most perfect of the branches consists of a short stem about 1 mm. in diameter and 11 mm. long. This probably is a bud from the basal part of a plant, just as may be found on some of the Equisetums of today, and such as have been described several times in paleobotanical literature.

The specimen may represent a plant of the species to which I have given the name *Equisetum insculptum,* found at the same place, but aside from a probable similarity in size and the mere fact that they were taken from the same locality there is no basis for such an assumption.

[31] Holden, Ruth. The Anatomy of a Hybrid *Equisetum.* Am. Journ. Bot., II, 1915, pp. 225–237.

3. **Sequoia oblongifolia** Jennings, sp. nov. (Plate XXIII, Figs. 1 and 1*a*.)

Among the various fossils representing *Sequoia* in the White River material from Douglass' "Locality 196", near Missoula, Montana, there are three specimens showing fragments of leafy twigs, which can not be satisfactorily referred to any of the various kinds of leafy twigs of *Sequoia Haydenii*, but apparently resemble rather closely the specimens from Greenland described and figured by Heer as *Sequoia brevifolia*, as follows:[32]" S. foliis oblongis, basi angustatis, adnato decurrentibus, confertis, patentibus, planis, distichis, apice obtusis, infimis squamæformibus, adpressis."

As shown by Heer's figures and later by Lesquereux[33] and by Knowlton,[34] the leaves of the White River plant were more strictly oblong, with straight sides, and the base more abruptly rounded, while the leaf-blades were about one-half longer and wider. The White River specimens show the leaves about 7–10 mm. long by 2–2.8 mm. wide, oblong, the apex rounded and apiculate. The midrib is fairly strong, there being also faint furrows on each side of it and there are also faint indications of numerous fine longitudinal striæ. The leaves were evidently quite thick and stiff and the impressions show irregular cross-furrows and ridges, such as are evident in dried specimens of many living species of *Sequoia*, *Taxus*, *Podocarpus*, etc., having thick leaves. The base of the leaf is strongly decurrent, while the leaves apparently spread distichously and at a wide angle, the blade often curving enough to place the apex of the leaf at almost a right angle with the branch.

In general outline the leaves resemble some of the fossils described as *Taxites* and *Taxodium*, but the quite strongly decurrent leaf base would appear to relate it to *Sequoia*. It is also similar, possibly very close to some of the specimens referred by some authors to *Sequoia Langsdorfii*, but I have preferred to refer the Missoula specimens to a distinct species on account of the more decidedly oblong leaves with the apex blunter than seems to be the case in *S. Langsdorfii*.

4. **Sequoia Haydenii** (Lesquereux) Cockerell. (Plate XXIII, Figs. 3, 4, 6; Plate XXIV, Figs. 1, 2, 3; and Plate XXII, Figs. 3, 3a, 4, and 5.)

Hypnum Haydenii Lesquereux, Bull. U. S. Geol. and Geogr. Surv. Terr., I, 1875, p. 383; Rept. U. S. Geol. Surv. Terr., VII, 1878, p. 44, Pl. 5, figs. 14, 14*b*.

[32] Heer. Flora Fossilis Arctica, I, 1868, pp. 92 and 93, Pl. 2, figs. 23 and 23*b*.

[33] Lesquereux, Tertiary Flora, U. S. Geol. Surv. Terr., VII, 1878, p. 78, Pl. 61, figs. 25–27.

[34] Knowlton. Flora of the Montana Formation. U. S. Geol. Surv., Bull. CLXIII, 1900, p. 27, Pl. 4, figs. 1–4.

Sequoia affinis LESQUEREUX, U. S. Geol. and Geogr. Surv. Terr., Bull. I, 1875, p. 384 (1876); Tertiary Flora, Rept. U. S. Geol. Surv. Terr., VII, 1878, p. 75, Pl. 7; figs. 3–5 and Pl. 65, figs. 1–4.

Glyptostrobus Ungeri? HEER. LESQUEREUX, Cretaceous and Tertiary Floras, Rept. U. S. Geol. Surv. Terr., VIII, 1883, p. 139, Pl. XXII, figs. 1–6a.

Sequoia Haydenii (LESQUEREUX) COCKERELL, Science, XXVI, 1907, p. 447; Pop. Sci. Monthly, LXXIII, 1908, p. 122, text-fig.; Bull. Amer. Mus. Nat. Hist., XXIV, 1908, p. 78; Amer. Nat. XLIV, 1910, p. 32, fig. 3, p. 36.

The most abundant conifer in the material studied is a *Sequoia* which seems to present a remarkable amount of variation in both size and form of leaf. After much study I have decided to pursue the course adopted by Cockerell and Knowlton with respect to the similar series of Sequoias found in the Florissant beds and to regard these all as belonging to the plant described by Lesquereux as *Sequoia affinis* and *Hypnum Haydenii.*

One common type of twig among these specimens is small and densely leafy, the largest of this type (Plate XXII, figs. 3 and 3*a*) being about 7 cm. long, irregularly pinnately branched, the leaves being mainly lanceolate or elliptic-oval, ranging up to a size of about 3 to 4 mm. long by 1 mm. wide, tapering into a decurrent base about half as wide, and tapering above into an acute or somewhat obtuse apex. The midrib is not prominent, often not showing at all. The leaves spread at an angle of about 45°, being mostly somewhat recurved and being quite uniform in size throughout the length of the twigs. These specimens match quite closely the descriptions and figures of *Sequoia Couttsiæ* Heer,[35] but the leaves from the Montana collections are scarcely or not at all falcate and they are more spreading than the Bovey Tracy specimens, as shown by Heer's plates. Twigs of this type are represented in material from Douglass' "Locality 196" at Missoula, but not from Winston. This is evidently also the same plant as that occurring in some of the Tertiary rocks of the Western United States and referred in the past to *Glyptostrobus europæus.*

In association with the leafy twigs, but not attached to them, is a short twig (Plate XXIII, fig. 4) at the apex of which are three cones, at least one of which, and probably all three, belong to the twig. The cones are oblong, about 6 mm. thick by 8 mm. long, rounded at the ends, the scales being 3–4 mm. long, with their shank 4-angled, or perhaps some of them 3-angled, widening to about one and one-half mm. at the apex, where they are capped by a thin flattened shield about

[35] Heer. Fossil Flora of Bovey Tracy, Trans. Royal Soc. London, CLII, 1862, pp. 1051–1055, Pl. 59, figs. 1–19, Pl. 60, figs. 1–45, and Pl. 61.

2–2.5 mm. wide. The scales are loosely placed on the axis of the cone, the peltate tops being only rarely in contact with each other and they are little or not at all mucronate. These cones agree fairly well with the figures given by Saporta[36] for *Sequoia Couttsiæ*, but, as was also the case in the comparison of them with the figures of the Bovey Tracy specimens, the Missoula cones are somewhat smaller and are distinctly oblong.

In the Missoula material there is a small leafy shoot (Plate XXII. fig. 5) about 12 mm. long, but with a rather thick central axis and clothed with leaves, which range from scale-like organs less than 2 mm. long at the base to ascending lanceolate bracts at the apex about 4–5 mm. long. The upper bracts apparently form a cup or campanulate structure resembling the arrangement of the perigonial bracts at the apex of a vigorous *Polytrichum* shoot. Indeed, the fossil suggests at once a vigorous moss shoot. It appears, however, to be of the same nature as the fossil described rather doubtfully by Lesquereux (*l.c.*) under the name of *Hypnum Haydenii*. Lesquereux's specimen has occasioned considerable discussion, Mrs. E. G. Britton and Dr. Arthur Hollick having referred it[37] to some conifer resembling *Juniperus communis* L., to young growing branchlets of which the fossil shows considerable resemblance; while Cockerell (*ll.cc.*, above) refers the specimen to *Sequoia affinis* Lesquereux; and Knowlton, still later,[38] publishes it as *Juniperus? Haydenii* (Lesquereux) Knowlton.

The Missoula specimen is found to resemble very closely the short branchlets which constitute the pedicels of the cones of *Sequoia sempervirens* Endlicher. As compared with such branchlets on specimens of the Redwood in the Carnegie Museum (*Jennings*, Mill Creek Valley above Muir's Woods, Cal., 1915) the fossil is found to have about the same size, the bases are similarly blunt and clothed with short, thick, scale-like leaves, the apex having longer, more slenderly tipped bracts arranged in campanulate fashion. In view of these similarities I am following Cockerell in referring the moss-like twig to Lesquereux's *Sequoia affinis*, which, however, is required to be known as *Sequoia Haydenii* on account, unfortunately, of the prior publication of the supposed moss.

The third type of specimen, which I am including under the name *Sequoia Haydenii*, consists of rather densely complanately leaved twigs up to 12 cm. long (Plate XXIII, fig. 6) and with leaves spreading collectively to a width of 7–30 mm. The leaves become abruptly much shorter for a distance of 5 cm. or more at the base

[36] Saporta. Annales des Sciences Naturelles, 5 Series, IV, 1865, Pl. 2, figs. 2*a* and 2*d*.

[37] Britton, E. G. & Hollick, A. Bull. Torrey Botanical Club, XXXIV, 1907, pp. 139–140.

[38] Knowlton, F. Proc. U. S. National Museum, LI, 1916, pp. 249–250.

of the twigs. The median leaves are linear-lanceolate to narrowly linear-oblong; varying on different twigs from 5–17 mm. in length and from 1–2 mm. in width; somewhat falcate, spreading at an angle of 50–70°. The apex of the leaf is usually rather acute, sometimes more acuminate, while the base tapers to an oblique, somewhat thickened, and rather widely decurrent insertion. This latter character forms perhaps the most easily observable distinction between this and the somewhat smaller-leaved *Taxodium dubium* (Sternberg) Heer, to which there is a fairly close resemblance in general aspect. Heer[39] figures another character which apparently distinguished *Sequoia* from *Taxodium*. In *Sequoia* there are strong cell-walls running from the midvein to the margin of the leaf and their course is often marked by faint cross-lines on the outer surface of the leaf. In some of the Missoula fossils these markings show quite distinctly. There is also a close resemblance to plates and descriptions of *Sequoia Langsdorfii* (Brongniart) Heer which is a rather characteristic Miocene species of Europe and has been reported from a number of localities in the western part of the United States. It would seem not at all improbable that some of the Western specimens reported as *Sequoia Langsdorfii* may belong to the same species as do ours from Missoula.

Specimens of the complanately leaved type occur in the material from both of Douglass' localities 196 and 165.

5. **Thuyopsis gracilis** Heer. (Plate XXIII, Fig. 5.)

Thuyopsis gracilis Heer, Flora Fossilis Arctica, VII, p. 59, Pl. XX, fig. 16; Schenck, Palæophytologie, Zittel's Handbuch der Palæontologie, II, 1890, pp. 322–323, fig. 223.

The specimens which I have referred to this species consist of three small leafy twigs, the longest of which is less than a centimeter in length. This longest twig, shown in figure 5, matches so closely the figure of Heer's species as to leave little doubt as to the identity of the two plants. In our plants the leaves are appressed, thick, smooth, evidently shining, those on the upper face of the twig being 3–4 mm. long, 2–2.5 mm. wide, the lower two-thirds of only the margins being covered by the overlapping edges of the adjacent pair of lateral leaves, the back of the leaf having a median ridge about one millimeter wide and bordered on each side by a slight furrow, which extends uniformly the whole visible length of the leaf. The apex of the leaf is rather blunt, thick, and incurved. The lateral leaves are apparently inserted a little lower on the twig, being about the same length as the others, but somewhat narrower, the apex thickened and incurved. This approxi-

[39] Flora Fossilis Arctica, I, 1868, Pl. 2.

mation of the leaves into groups, almost whorls, gives the twig a peculiar jointed appearance.

Cockerell has identified a fossil from the Florissant[40] as *Heyderia coloradensis* Cockerell, comparing it to the modern *Libocedrus decurrens* Torrey (*Heyderia decurrens* Koch). This plant is evidently very similar to the plant from Missoula, which I have called *Thuyopsis gracilis* Heer, but the specimens from Missoula show strongly flattened shoots with short and wide leaves, the lateral leaves spreading rather widely, and, so far as leafy twigs of such conifers can be taken to indicate relationships, I think the evidence shows that they are *Thuyopsis* rather than *Libocedrus*.

Thuyopsis gracilis was described by Heer from Greenland, from beds which he regarded as Miocene, but which are now regarded as being older, perhaps Eocene or even Cretaceous. The modern representatives of the genus consist of one species native to Japan (*Thuyopsis dolobrata* Siebold & Zuccarini) and the variety *nana* Siebold & Zuccarini (*T. lætevirens* Lindley) native to China. So far as I know, *Thuyopsis gracilis* has not before been reported on the North American continent. The Montana specimens came from only one locality, Douglass' "Locality 196" at Missoula.

6. **Sabina linguæfolia** (Lesquereux) Cockerell. (PLATE XXIII, FIG. 2.)

Glyptostrobus europæus HEER. LESQUEREUX, Tertiary Flora. Rept. U. S. Geol. Surv. Terr., VII, 1878, p. 74, Pl. 7, figs. 1 and 2.

Widdringtonia linguæfolia LESQUEREUX, Cretaceous and Tertiary Floras, Rept. U. S. Geol. Surv. Terr., VIII, 1883, p. 139, Pl. 21, figs. 14 and 14*a*.

Sabina linguæfolia (LESQUEREUX) COCKERELL, Univ. Col. Studies, III, 1906, p. 175; KNOWLTON, Proc. U. S. Nat. Mus., LI, 1916, p. 249, Pl. 14.

These specimens consist of several fragments of leafy twigs, mostly less than a centimeter long, some of them irregularly and closely pinnately branched. The leaves are 4-ranked, thick, with a rather prominent dorsal ridge, which is especially sharp at the apex. The branches are evidently complanately flattened, but the smaller twigs appear almost as thick as wide. The facial leaves on the larger twigs are about 1–1.5 mm. long, the lower half overlapped on the margins by the lateral leaves, the exposed portion of the leaf rhomboid, almost as wide as long, the apex acute and closely appressed, thick, with a sharp dorsal ridge. On these larger twigs the lateral leaves are about the same size or perhaps a little longer, their lower margins meeting over and below the lower part of the facial leaf for a

[40] Cockerell. Bull. Amer. Mus. Nat. Hist., XXIV, 1908, p. 78.

distance often half that of the length of the exposed part of the facial leaf. These lateral leaves are thick, ovate, somewhat bluntly acute, the tips spreading at an angle of about forty-five degrees. On the larger twigs the successive pairs of lateral leaves do not reach the next higher ones, this giving the twigs a jointed appearance, but on the smallest twigs both the facial and lateral leaves are imbricate throughout. On these smaller twigs the leaves are mostly less than 1 mm. long, scale-like, thick, rather sharply dorsally carinate, there being some indication of a gland at about the middle, the apex acutish, or on the lateral leaves often rather obtuse.

The specimens only occur in material from Douglass' "Locality 196," Missoula, and they are all in mixture with detached *Sequoia* leaves and unidentifiable fragments of wood, bark, etc., a general mixture of small floating fragments, such as can often be seen stranded along more or less protected shores and banks during quiet weather, or more rarely water-logged and forming a layer on the bottom of a quiet pool.

The similarity of the foliage on these twigs to that of *Chamæcyparis Ehrenswardi* Heer is such that confusion might readily occur in attempting to state the geological range of the two genera. *Sabina linguæfolia* is now known to occur in the Florissant beds of Colorado, middle Miocene, and I would have little hesitation in referring to the same species, or at least a very closely related one, the fragment described and figured by Knowlton from Van Horn's ranch, John Day basin, Oregon, middle Miocene.[41] The fossils from the White River beds differ scarcely at all from impressions such as would be formed by the modern Rocky Mountain Juniper, *Sabina scopulorum* (Sargent) Rydberg, occurring on foothills and bluffs throughout the Rocky Mountains.

7. **Typha Lesquereuxi** Cockerell. (PLATE XXIX, FIG. 4).

Typha latissima LESQUEREUX, The Cretaceous and Tertiary Floras U. S. Geol. Surv. Territories, VIII, 1883, p. 141, Pl. 23, figs. 4, 4*a*. Not *T. latissima* Al. Braun.

Typha Lesquereuxi Cockerell, Fossil Plants from Florissant, Colorado, Bulletin of the Torrey Botanical Club, XXXIII, 1906, p. 307; *idem*, The Fossil Flora of Florissant, Colorado, Bulletin of the American Museum of Natural History, XXIV, 1908, pp. 77–110, Pls. 6–10.

The specimen consists of an impression of a leaf fragment about 1.5 cm. long by 1.1 cm. wide, marked with fine longitudinal parallel veins about 1 mm. apart.

[41] Knowlton. Fossil Flora of the John Day Basin, Oregon. U. S. Geol. Surv., Bull. CCIV, 1902, p. 26, Pl. 1, fig. 3.

Between these fine veins are traces of much finer veinlets, while the surface is marked somewhat more strongly by fine transverse lines running from one vein to the next. The leaf appears to have been fairly thick and smooth. Impressions on the same piece of rock are probably those of stems but are indistinct and indefinite.

According to the reports *Typha* appears first in the eastern United States in the middle Cretaceous (Raritan and Magothy), next in the Eocene in Canada (Paskapoo) and in Europe, then in the Oligocene of Europe and the Miocene of Florida and Europe. The genus now contains about nine species well distributed in fresh-water swamps in temperate and tropical regions.

Our specimen appears to be the same species as that figured by Lesquereux (*l.c.*) and by Cockerell from the Florissant (*l.c.*), and, judging from the wide distribution of some of the modern species, it is not unlikely that this species had a wide distribution in the Oligocene and mid-Tertiary swamps of western temperate America.

8. **Cyperacites.** (Plate XXIX, Fig. 3.)

There has been referred to *Cyperacites* a piece of a leaf measuring about 4 cm. long by 4 mm. wide. The midrib is narrow and prominent, and there are indications of a less prominent vein on each side of it, as well as faint indications of other longitudinal markings. The impression is practically uniform in width throughout its length, and the indications are that the leaf was a leathery one with a glossy surface, such as might be the case with coniferous leaves, as, for example, *Podocarpus* or *Taxites Olriki*, or with some of the species of the *Cyperaceæ* of the present period, when growing in more or less xerophytic habitats. However, in the absence of stems, flowers, or fruits, the identification of such a fragmentary specimen must remain very uncertain. The specimen might with almost equal propriety be regarded as representing a species of *Podocarpus*.

The specimen is from "Locality 196," Missoula.

9. **Populus Zaddachi** Heer. (Plate XXV, Figs. 1, 2; Plate XXVI, Figs. 1, 1*a*, 2, 3, 5, 6, and Plate XXIV, Fig. 6.)

Populus Zaddachi Heer, Flora Fossilis Arctica, I, 1868, pp. 98–99, Pls. VI, figs. 1–4, and XV, fig. 1*b*; Lesquereux, The Tertiary Flora, U. S. Geological Survey of the Territories, VII, 1878, p. 176, Pl. XXII, fig. 13; *idem*, The Cretaceous and Tertiary Floras, U. S. Geological Survey of the Territories, VIII, 1883, p. 158, Pl. 31, fig. 8.

The leaves are large, the blades being 5.5–16 cm. long, by 3–12 cm. wide, ovate to broadly ovate, or the smallest ones more narrowly ovate, the base broadly rounded to a rather narrow and shallow cordate sinus, the insertion of the petiole having two well-marked glands at each side, or even with a glandular or thickened rim on the outer side, as in some modern species of *Populus*, the upper part of the leaf being somewhat acuminate with a rather obtuse apex. The leaves are seven- to five-ribbed, the lowest pair of ribs weak and short, swinging back into the broadly rounded basal curves, these, as well as all ribs, looping in camptodrome fashion; the next upper pair in the seven-ribbed leaves leaving the insertion at about right angles and extending well out to the margin of the blade in a broad upturned curve; the pair next to the midrib are stronger, ascending at an angle of about 45–35 degrees, approaching the margin at about two-thirds the distance from base to apex of the leaf, and during the upper half or two-thirds of their course throwing off from their lower side widely diverging and rather strong branches, which, swinging around and forking, loop together in camptodrome fashion within 2–5 mm. of the leaf-margin. The veinlets from these latter loops usually also form a series of much smaller loops from which faint veinlets run out to the small crenate teeth. The uppermost pair of ribs is only about half as wide as is the midrib, having thus about the same thickness as the lateral veins from the midrib itself. The midrib is strong, about 1 mm. wide, sending out four to seven pairs of widely spreading, upwardly curving veins, either approximately opposite or alternate, the strongest of these veins usually arising at about the middle of the leaf or slightly below. Other fainter veins are thrown off at wide angles, some of the finest of them at practically right angles, especially from the lower half of the midrib. As compared with most broad leaves, the ultimate meshwork is rather coarse. The texture of the leaves appears to have been rather thick and leathery and the surface smooth, the larger nerves being deeply impressed on the upper surface of the leaf and rounded but fairly prominent below.

In general shape the larger of these leaves resemble very closely those described by Newberry as *Catalpa crassifolia*[42] or later as *Aristolochia cordifolia*[43]. The character of the teeth and the glandular insertion of the petiole can leave little doubt, however, as to the propriety of placing these specimens in the genus *Populus*. Berry[44] in connection with the description of *Grewiopsis tennesseensis* from specimens from the Wilcox beds of Texas and Tennessee, calls attention to their resemblance to "the numerous forms from Greenland, Europe, and western North

[42] Newberry. Annual Report, New York Lyceum of Natural History, IX, 1868, p. 56.

[43] Newberry. Illustrations of Cretaceous and Tertiary Plants, U. S. Geological Survey, IX, 1878, Pl. 25, fig. 7; U. S. Geological Survey, Monograph, XXXV, 1898, p. 90, Pl. 39; Pl. 40, fig. 7; and Pl. 60, fig. 4.

[44] Berry. The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, p. 286.

America that are commonly referred to the genus *Populus*, as *Populus arctica* Heer, *Populus Zaddachi* Heer, *Populus cuneata* Newberry (a variable and common form of the Fort Union Eocene), *Populus genetrix* Newberry, *Populus paleomelas* Saporta, or *Populus glandulifera* Heer." He appears to doubt that these various species belong to *Populus* and notes that "it is singular that the Arctic and early American forms are palmately and not pinnately veined, like the modern species, and present in a varying degree other distinctive features." In connection with this opinion attention should be called to the distinctly palmate ribbing of our common modern *Populus deltoides*, certainly just as distinctly five-ribbed as are the five-ribbed leaves of the fossils at hand. In addition to the agreement in venation, the presence of glands on the crenulations and at the insertion of the petiole are further arguments for referring at least the Missoula fossils to *Populus*. Sinnott and Bailey[45] conclude among other things that "The primitive angiosperm leaf was palmate in type, probably lobed, and was provided with three main bundles which arose separately at the node;" and "This conclusion is based on evidence from paleobotany, that the palmate leaf was more frequent in the Cretaceous and Tertiary than at present."

The petiole, when preserved, is slender, but apparently rather stiff and woody, and distinctly enlarged at its base. The length of the petiole was 5.7 cm. in a leaf with a blade about 12 cm. long. Another specimen, in which the blade of the leaf was about 13 cm. long, had a petiole 6.2 cm. long.

The genus *Populus* is comparatively a very old one, its oldest known species probably being *Populus primæva* Heer, from the Kome beds of western Greenland, which are presumably of Potomac age[46] (upper part of the Lower Cretaceous). From this time on the number of species reported increases up towards the Eocene, from which period there are perhaps forty species already reported from the United States alone, many of these species resembling very closely some of the living species. The range of *Populus*, beginning in the far north in the Cretaceous, extended during the latter part of the Cretaceous and in the Tertiary quite generally over the temperate regions of the northern hemisphere. In western North America there have been described from the Fort Union beds alone about as many species (25) as there are now of living species of poplars in the whole world.

The range of *Populus Zaddachi* Heer is wide, the species having been reported

[45] Sinnott and Bailey. Investigations on the Phylogeny of the Angiosperms, 5, American Journal of Botany, II, 1915, pp. 1–23.

[46] White and Schuchert. Cretaceous Series of the West Coast of Greenland, Bulletin of the Geological Society of America, IX, 1898, pp. 365–367.

from eastern Germany and western Greenland[47] and, in North America proper, from Alaska, California, Colorado, Wyoming, Montana, and Dakota, from beds variously ranging from the lowest part of the Eocene up to the Miocene.

The smallest of the leaves among the specimens are very likely those at the apex of rapidly growing shoots, and they are much more narrowly ovate to even lance-ovate than are the larger leaves, exactly as may be observed in *Populus balsamifera* and other living species. Among the Missoula specimens is an impression of a leaf-blade about 4 cm. long and 2 cm. wide (Plate XXVI, fig. 6) which matches so closely one of the figures of Newberry's *Populus cuneata*[48] that Newberry's figure might easily serve to illustrate. it It is not unlikely that immature leaves of a number of species of poplars, especially if preserved as fossils, would be impossible or at least extremely difficult to refer to the proper species. It is not at all improbable that some of the numerous fossil species of poplars represent such immature leaves, especially where the species have been described from scanty material.

10. **Populus smilacifolia** Newberry. (Plate XXVI, Fig. 4.)

Populus smilacifolia Newberry, Annals of the New York Lyceum of Natural History, IX, 1868, p. 66; *idem*, Illustrations of Cretaceous and Tertiary Plants, U. S. Geological Survey of the Territories, 1878, Pl. 14, fig. 5; *idem*, Later Extinct Floras of North America, U. S. Geological Survey, Monograph 35, 1898, pp. 53–54, Pl. 29, fig. 5.

The specimen is from "Locality 165," Missoula, and, although somewhat incomplete at the apex, it agrees very closely with Newberry's *Populus smilacifolia*, from the Fort Union group of North Dakota.

The single specimen shows a rounded-ovate leaf from the cordate base of which arise the midrib and two pairs of lateral veins, from the bases of the veins of the lower pair of these arising, however, a much fainter and very short pair, so that the leaf might be regarded as having three pairs of lateral veins. The lowermost strong pair of veins spreads widely from the base of the leaf, curving upwards to the margin at about half-way to the apex and sending off from the proximal side a few widely spreading veinlets which curve upwards towards the margin. The uppermost pair of veins, those next to the midrib, arise at a narrow angle with the midrib and, curving slightly forwards, reach the margin but slightly below the apex. In their upper two-thirds these veins give off short lateral branches, which curve out

[47] Heer, O. Flora Fossilis Arctica, I, 1868, p. 98.

[48] Newberry. The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, Pl. 29, fig. 7.

and up towards the leaf-margin. So far as can be determined, the leaf-margin appears to be but very slightly serrulate.

Populus smilacifolia as described and figured by Newberry does not have the lowermost (third) pair of short and fine veins, as in the Missoula specimens, and it may be possible that the latter represent only a form of the common *Populus Zaddachi* Heer, the apex being but poorly preserved. The resemblance to *Populus smilacifolia* is so close, however, that the specimen has been provisionally referred to that species.

11. **Juglans pentagona** Jennings, sp. nov. (Plate XXIX, Figs. 1, 1*a*, 2, 2*a*.)

This species is based on the impression of a nearly complete leaflet about 6 cm. long by 4 cm. wide, broadly ovate, rather abruptly rounded to a bluntly acute apex, the base being apparently broadly rounded. The midvein is fairly strong; secondary veins, about thirteen pairs, varying from alternate to opposite, the lowermost arising from the midvein at a rather acute angle and then curving quickly outward to a course at almost right angles to the midvein, then curving upward toward the margin, the median and upper veins spreading from the midrib at an angle of 25–30° and curving gradually upward towards the margin. All the veins unite in wide camptodrome loops with the lower tertiaries from the next upper vein, these loops usually running to within a millimeter or two of the leaf-margin and giving off in turn finer loops reaching practically to the margin. The tertiaries from the median and upper secondaries, especially, leave the secondaries at right angles at distances of 2–4 mm. apart, forking and meeting in an alternate manner about midway between the secondary veins, so as to form approximately pentagonal areas. Within these meshes the finer veinlets form rather distinct polygonal meshes mainly about 0.3–0.7 mm. wide. The margin of the leaf is entire, but slightly undulate. The lowermost secondaries are considerably closer together than are the median and upper ones.

In another fragment of rock from this same locality is a leaflet which I take to represent the same species as that described above. It is 8 cm. long by 2.2 cm. wide, lanceolate, the base unequal, being rounded on the one side and tapering in almost a straight line on the other side, the apex being rather slenderly acuminate. The leaf-margin is entire. The midvein is strong, the secondaries being in about seventeen pairs, the lowermost leaving at an acute angle, then curving more widely, then again curving forwards towards the margin where they become camptodrome with tertiaries from the next upper secondary. The median and upper secondaries spread quite widely and towards the margin send off proximally strong tertiaries, or they sometimes fork. Between these median and upper secondaries there are a few intermediate shorter secondaries, which sometimes curve around and loop with the main adjacent secondary at perhaps one-half to two-thirds of the distance from the midvein to the margin.

The wider impression, the first of the fossils just described, is taken as the type of the species, the specific name having been suggested by the more or less distinctly pentagonal areas formed by the tertiary veins. The specimens are from Douglass' "Locality 165," Missoula, and are associated in the same blocks with *Populus Zaddachi* Heer, *Betula multinervis* Jennings, *Sequoia Haydenii* (Lesquereux) Cockerell, and *Alnus Hollandiana* Jennings.

The genus *Juglans* has about twelve living species ranging from southeastern Europe to eastern Asia, and in North America from the temperate regions south to Mexico. The genus also occurs in the Andes of South America. About forty fossil species have been referred to the genus, beginning rather early in the cretaceous (Dakota, Magothy, Raritan beds), the number of species increasing to between twenty and thirty in the Eocene, a few in the Oligocene, about forty reported for the Miocene, and about thirty in the Pliocene. The genus was widely distributed over the northern hemisphere, especially during the Eocene, ranging from the southeastern part of the United States to the middle and northwestern United States, British Columbia, and Alaska. The distribution during the Miocene was apparently more southern (Florida, California, Brandon beds of Vermont, John Day beds of Oregon), no occurrences having been noted farther north in America than Oregon and Vermont.

Juglans pentagona is perhaps most nearly related among fossil plants to *Juglans crassifolia* Knowlton, common in the uppermost John Day beds[49] and regarded as probably Oligocene, and to *J. rugosa* Lesquereux, reported from the Laramie and Montana formations (Cretaceous) and, more recently by Knowlton[50] from the Eocene (Raton Formation) of Colorado and New Mexico.

12. **Betula multinervis** Jennings, sp. nov. (PLATE XXIV, FIG. 4; PLATE XXVII, FIGS. 1, 1*a*, 1*b*, 1*c*, 2; PLATE XXVIII, FIG. 2.)

The leaf-blades vary from 4–9 cm. long to 2.5–5 cm. wide, being lance-ovate to ovate-oblong or widely ovate, the petiole slender, about 1 cm. long, the leaf-base

[49] Knowlton. Fossil Flora of the John Day Basin, Oregon, U. S. Geological Survey, Bulletin CCIV, 1902, p. 36, Pl. 4, fig. 3.

[50] Knowlton. Fossil Floras of the Vermejo and Raton Formations of Colorado and New Mexico, U. S. Geological Survey, Professional Paper CI, 1917, p. 293, Pl. 112, fig. 4.

rounded or faintly subcordate, occasionally somewhat inequilateral, the apex slenderly acute to long acuminate, and the margin of the leaf sharply doubly serrate almost to the base. The tooth at the apex of each secondary vein appears larger than the intermediate teeth, because the leaf-margin slopes inward and backward from this tooth to a rather deep acute sinus in front of the next main tooth, the intermediate teeth being not much smaller than the main tooth, but situated successively lower down on the slope from it to the main sinus. The midrib and veins are deeply impressed on the dorsal surface of the leaf, the veins being usually in 15–16 pairs (13–18), close, almost straight, parallel; in the wider leaves giving off toward the margin from one to four strong branches, which swing down and run out into the intermediate teeth. The tertiary veins are rather prominent, mainly running straight across from one secondary vein to the other and forming nearly right angles with them, sometimes forking or irregularly anastomosing about halfway between them. On the upper surface of the leaf the deeply impressed character of the venation resembles the somewhat rugose surface, which occurs in some of the living species of *Ulmus*.

The fruits associated with the leaves and probably belonging to the same species, although not attached to the same twig with any of the leaves, occur only in "Locality 165," at Missoula. They are evidently narrowly oblong-cylindrical, about 5 mm. thick by 1.5 cm. long, the scales being about 4 mm. long, their three obtuse lobes reaching to about an equal height, the outer lobes about 0.8 mm. wide, ascending at an angle of about 40° from a rounded sinus, the median lobe being narrower. The main outline of the scale is basally rounded and then narrows rapidly to an acuminate tapering portion about 1 mm. long.

The puzzling similarity between the leaves of species of *Carpinus*, *Ostrya*, and *Betula* cannot but cause some uncertainty as to the generic position of the material. It is quite generally stated that the teeth of *Ostrya* are simple and somewhat smaller than are the more or less serrate teeth of *Carpinus*. The specimens show rather fine teeth, which, as far as could be determined from the specimens from Missoula can not be said to be serrate. Further, in the modern species of these genera *Carpinus* has little or no indication of branches running out from the lower side of the veins to form the secondary serrations, but this is quite characteristically the case in our modern *Ostrya virginiana*. The specimens from Missoula agree in this respect with *Ostrya*, rather than with *Carpinus*. However, this method of branching is also quite characteristic of some of the species of *Betula*, such as *Betula lenta* of eastern North America, and a careful comparison of the specimens before me with leaves of *Ostrya* and *Betula* reveals no diagnostic character by which the fossil plant might be referred to one of these genera and not to the other. The disposition of the species under *Betula* practically rests only upon the fact that there were associated with the leaves some specimens of cones, which can be none other than those of *Betula*, and as there are no leaves of other species among the fossils which can be referred to *Betula*, it is assumed that the cones belong to the species, the leaves of which are so abundant in the rocks at that place.

Impressions of these leaves occur abundantly in the collections from both of the localities at Missoula, the most complete specimens being from "Locality 196." The fruits are represented only from "Locality 165."

The genus *Betula* is reported first in North America from the Dakota group in the Cretaceous, thence extending through the Montana and the Laramie into the Eocene, where it is represented by more than a dozen species. In the North American Miocene there are reported about a half-dozen species.

13. **Alnus Hollandiana** Jennings, sp. nov. (Plate XXV, Fig. 3; Plate XXIV, Fig. 8; Plate XXVIII, Fig. 1; Plate XXX, Figs. 1, 1*a*, Type; fig. 3, Cones.)

The leaves are variable in size, the blades of the largest being about 12 cm. long by 5.5 cm. wide, elliptic to oval-elliptic, the apex being rather widely acute, the base acuminately narrowed into a slender petiole, which in one specimen reaches a length of 3.5 cm. The leaf-margins have small, low, somewhat crenate teeth, which are tipped with a glandular or at least a thickened point, the teeth disappearing along the basal 1–2 cm. of the margin. The midrib is rather strong, sending off from nine to twelve somewhat upwardly curved parallel veins, the uppermost of these more or less directly running out into the teeth, the greater number of them, however, curving a little and with branches looping in camptodrome fashion quite close to the margin and sending off minute branches which themselves terminate in the teeth. Usually the base of the secondary vein bends down slightly where it joins the midrib, thus forming a more acute angle. The tooth into which the vein runs, especially in the upper part of the blade, or which most closely approaches the vein in the lower part of the blade, is somewhat larger than the intermediate teeth, it having a height of 1–1.5 mm. There are three to five of these intermediate teeth between each pair of the main teeth. The veinlets (tertiaries), running across from one vein to the next, do so at about right angles to the veins and are rather far apart (about 2–4 mm.), the enclosed areas thus being approximately rectangular, and about two to three times as long as wide. The ultimate meshwork is relatively quite fine, most of the veinlets visibly having their ends free. The leaves appear to have been rather thin but yet stiff, leathery, and especially on the lower side quite smooth and, perhaps, shining. The venation is impressed on the upper surface of the leaf, even the finest meshwork showing on some of the impressions. On the lower side of the leaf the venation is decidedly prominent, even to the finest meshwork.

In some of the specimens the veins in the upper part of the leaf run almost directly to the tooth, although sending off camptodromous branches towards the margin, the tip of the vein which runs out into the tooth often being reduced to a slender nervule not much stronger than those which run out into the intermediate teeth. In general shape and also in venation there is considerable resemblance to the terminal leaflet of some of the species of *Hicoria* and *Juglans*, but the resemblance to *Alnus*, such as *Alnus rhombifolia* Nuttall, of California, or even of some of the more acute leaves of forms of *Alnus rugosa* (DuRoi) Sprengel is closer. In size and in the acute outline of the base and apex the leaves are likewise very similar to those of the Mexican *Alnus glabrata* Fernald (*See* Pringle's *No. 8022*, from Tizapan, Mexico, 1899.)

The Missoula species is closely related to *Alnus carpinoides* Lesquereux from Bridge Creek, Oregon, (Upper Eocene), but differs in that the leaves are more oblong and less ovate than in the Oregon species. Practically the same characters distinguish the Missoula species from *Alnus serrulata fossilis* Newberry, also occurring in the deposits of Bridge Creek, Oregon. The lower part of the leaf in the Missoula specimens begins to narrow from about the middle of the blade and finally tapers quite accuminately to the petiole.

There is a fine series of leaf impressions of this species from Mr. Douglass' "Locality No. 196" and a few from "Locality 165," many of them fragmentary, but representing various sizes and considerable variation, principally with regard to the apex, this occasionally becoming blunter, especially among the smaller leaves. Among these smaller leaves it sometimes becomes difficult to make a satisfactory distinction between this species and the most acute forms among the larger leaves of *Alnus microdontoides* with which latter species *Alnus Hollandiana* is frequently associated in the same pieces of rock. Nevertheless, the majority of the specimens of the two species show clearly as much difference as would be found in a similar association of specimens of leaves from different species of living alders.

This fine species is named in honor of Dr. William J. Holland, Director of the Carnegie Museum, at whose request the study of the fossil plants from the Oligocene beds of volcanic dust at Missoula was undertaken and which has led to the preparation of this paper.

14. **Alnus microdontoides** Jennings, sp. nov. (Plate XXIV, Fig. 7; Plate XXX, Figs. 2 and 2*a*, Type.)

The leaves are 3.5–8 cm. long, and 2–3 cm. wide, widest somewhat above the middle, the blade being narrowly obovate to broadly oblong-elliptic or even somewhat ovate, narrowed acutely to acuminately at the base, petioles slender, up to 13 mm. long, the apex widely rounded, the tip itself usually somewhat retuse varying to obtuse or rarely acutish. The midrib is strong and deeply impressed dorsally, ventrally standing out sharply and prominently. The secondaries are also impressed dorsally and prominent ventrally, springing from the midrib at an angle of about 45°, there being eight to eleven pairs, either alternate or opposite, evenly spaced, parallel and straight to near the margin, then curving slightly forward and usually ending in a tooth, but before doing so, branching and becoming very slender, the branches being few, springing from the lower side of the vein and curving out to the margin and there ending in teeth or variously anastomosing. The tertiaries are spaced about 1–3 mm. apart, rather strong, distinctly impressed above and prominent ventrally, springing from the secondaries at a wide angle and curving slightly outward and running across to the next secondary, or forking and joining with the forks of the adjacent secondary, the final meshwork being fine and indistinct. The margin of the leaf is minutely serrate, there being from two to four slightly smaller teeth between each pair of those teeth which terminate the secondary veins. The teeth are sharply glandular- or callus-tipped and are rather prominently directed forward.

In general appearance the leaves resemble rather closely the form of *Alnus rugosa* known as variety *serrulata* (Aiton) Winkel (*Alnus serrulata* Willdenow). They seem to bear much the same relation to this modern American plant that the similar and approximately contemporaneous *Alnus microdonta* Saporta, from the Armissan of southeastern France, bears to the modern Mediterranean *Alnus glutinosa* var. *denticulata* (Meyer) Ledebour (*Alnus oblonga* Willdenow). In the leaves of *Alnus microdontoides* the serrulations extend along the margins of the leaves to within a centimeter or less above the the base, considerably farther than Saporta figures for *Alnus microdonta*.[51]

As has been pointed out in Gray's Manual of Botany[52] there is considerable intergradation, in the northern part of the range of *Alnus rugosa*, between forms of that species and the equally variable *Alnus incana*, of somewhat more northern

[51] Saporta, G. Études sur la Végétation du Sud-est de la France a l'Epoque Tertiaire, Annales des Sciences Naturelles, Botanique, Ser. 5, IV, 1865, p. 110, Pl. 6, fig. 3.

[52] Gray, Asa. New Manual of Botany, Seventh Edition, 1908, p. 337.

range. Specimens referable to *Alnus rugosa* show a greater variability than is shown in the numerous leaf-impressions from the Missoula beds which I have referred to *Alnus microdontoides.* During the first part of my studies on these specimens the attempt was made to differentiate two species, one with a fairly evenly serrate oblong-elliptic leaf, with a blunt or retuse apex and an acuminately narrowed base, the other with a more plainly doubly serrate leaf, relatively wider, more acute at the apex and less acuminately narrowed at the base. Further studies of material later found in another box with a large number of intermediate specimens disclosed the fact that no separation of these extremes could be made other than in a purely arbitrary manner.

Beginning in the upper Cretaceous, the genus *Alnus* attained in the Miocene a general distribution through the arctic and northern North American and Eurasian regions. Altogether there have been described about forty fossil species, mostly from the Miocene, although in the western part of the United States a number of species have been reported from the Eocene, particularly from the Fort Union beds. There are now recognized about thirty living species, these ranging well over the northern hemisphere, and in America extending south to Peru.

15. **Quercus laurosimulans** Jennings, nom. nov. (Plate XXVIII, Fig. 3; Plate XXXI, Figs. 3 and 3*a*.)

Quercus laurifolia Newberry, Proceedings of the United States National Museum, V, 1883, p. 505; *idem*, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 76, Pl. 59, Figs, 4 and 60, and Pl. 60, fig. 3. Not *Quercus laurifolia* Michaux, Histoire des Chênes de l'Amérique, 1801, No. 10, Pl. 17.

Newberry's original description is as follows:

"Leaves petioled, lanceolate, 6 inches in length by 1½ inches in width, equally narrowed to the point and petiole; margins entire or faintly toothed or undulate; nervation regular; midrib strong, straight, lateral branches, about ten pairs, arching gently upward, terminating in the margins".

The leaf-blade in the best Missoula specimen is between 10 and 11 cm. long, by 4 cm. wide, elliptic lanceolate, rather slenderly acuminate at both base and apex, and with a slender channeled petiole at least 2.5 cm. long, probably even longer. The midrib is strong, rather wide (about 1 mm.), flat, sunken in the dorsal surface of the leaf and sending off at wide angles about twelve pairs of slender but prominent veins, which curve upwards towards the margin where the attenuate ends run almost parallel to it and apparently form loops with the short branches from the next upper vein. Between the main veins the midrib gives off also short but prominent intermediate veins forming practically right angles with it, these short veins forking and disappearing at a distance of 4–6 cm. from the midrib. The veinlets from the secondary veins are irregularly placed and form wide angles with the secondary veins and finally anastomose to form a rather coarse meshwork with irregular angles. The lowermost veins, even those in the attenuate base, leave the midrib at about the same wide angle as those in the middle of the leaf, running quickly out to the apparently slightly revolute margin. The margin is entire but slightly undulate in places. The venation is mostly rather deeply impressed on the dorsal surface of the leaf and prominent on the under surface. The extreme apex of the leaf is broken off in the fossils at hand.

The name *Quercus laurifolia* having been used at an earlier date by Michaux for the well-known Laurel Oak of the southeastern United States, it becomes necessary to rename Newberry's Tertiary species. The names *laurina, laurifolia, laurophylla, lauriformis* and *lauroides* having been used for various species of fossil or living oaks with leaves resembling those of some of the *Lauraceæ*, I have chosen the name *laurosimulans* in order to preserve as nearly as possible the meaning of the name used by Newberry for the fossil species.

The specimen first studied was referred to *Laurus* but further study led to a decision in favor of *Quercus*. My reasons for referring the specimen to *Quercus* rather than to *Laurus* are as follows: The rather numerous and prominent but *short* veins given off from the midrib between the larger main veins and at approximately right angles to the midrib; the rather strong branching and camptodromous looping of the outer ends of the veins; the veins in the attenuate base of the leaf leaving the midrib at practically the same angle as those in the middle and upper parts of the leaf; the impressed, but rather flat, dorsal surface of the midrib; and the slenderer petiole.

The general outline of the leaf is very close, indeed, to that of *Laurus princeps* Lesquereux, as figured from Corral Hollow, California. The resemblance to other species of the *Lauraceæ*, such as *Nectandra*, is striking, as is also the resemblance to the leaves of some of the living species of the *Myrsinaceæ*, such as *Ardisia*, *Icacorea*, and *Myrsine*, but in these genera the midrib does not usually give off the short intermediate veins such as appear so prominently in the Missoula specimens, or, if present in the *Myrsinaceæ*, they are not at all prominent and, further, the petioles are almost invariably quite short.

Newberry's *Quercus laurifolia* was described from specimens obtained from "Burned shales over lignite beds, Fort Berthold, Dakota," now regarded as Fort

Union in age[53] (Eocene), thus not more distant from the Oligocene than many other closely related species in the Tertiary.

About two hundred fossil species of oaks have been described, beginning in the Cretaceous, during which period the genus was widely distributed in western Europe, the United States, and in Greenland. In the Tertiary the genus occurred in Australia and quite abundantly in the northern hemisphere, in what are now temperate regions, as well as farther north in Greenland and Alaska. In North America oaks were particularly abundant in the Dakota and up through the Eocene and Miocene, and in Europe they appear to have reached their maximum in the Oligocene and Miocene.

Oaks with entire margins appear from the evidence thus far furnished by fossils to have been relatively more numerous in the Tertiary than at the present time. In the Oligocene and Miocene there have been reported as oaks with entire margins at least the following: *Quercus neriifolia* A. Braun, *Q. elæna* Unger, *Q. Lyelli* Heer, *Q. chlorophylla* Unger, *Q. Daphnes* Unger, *Q. elæomorpha* Saporta, *Q. lauriformis* Saporta, *Q. socia* Saporta, *Q. areolata* Saporta, *Q. elliptica* Saporta, and *Q. simulata* Knowlton.

16. **Quercus flexuosa** Newberry. (Plate XXXI, Figs. 1 and 1*a*.)

Quercus flexuosa Newberry, Boston Journal of Natural History, VII, 1863, p. 521; *idem*, The Later Extinct Floras of North America, U. S. Geological Survey, Monograph XXXV, 1898, p. 74, Pl. 19, figs. 4–6.

The single specimen consists of the impression of part of a leaf, the base and apex being missing. The impression shows the leaf to have been somewhat curved and about 9 cm. long by 3.5 cm. wide, narrowly elliptic oblong, the basal portion evidently narrowing inequilaterally. The margin has a few unequally spaced, sharp, small teeth, these being directed forwards. The midrib is strong, the secondaries fairly so, alternate, spaced about 5–9 mm. apart, arising at a wide angle and swinging forwards, being branched towards the margin of the leaf and these branches anastomosing in camptodrome fashion. Between the secondaries the midrib sends off fine veins which anastomose with fine veins or their branches from the secondaries, the meshes thus formed being polygonal, with the sharper angles and the longest dimension directed at about right angles to the midrib.

The specimen matches Newberry's figures very closely as to size, outline, and venation, although the inequilateral outlines in both Newberry's figures and in

[53] Merrill, G. P. Catalogue of the Type and Figured Specimens of Fossils, Minerals, Rocks, and Ores. Part II. Bulletin of the United States National Museum, LIII, Part II, 1907, p. 283.

the Missoula specimen suggests that the impressions may perhaps represent leaflets of a compound leaf rather than a leaf of *Quercus*.

Newberry's specimens were from near Bellingham, Washington, in rocks of the Puget Sound group, thus possibly Oligocene, so that the species may have had a general range over the region now separated into two floral regions by the Cascade Mountains. The Missoula specimen was from Douglass' "Locality 165" and was accompanied in the same block by *Betula multinervis* and *Sequoia Haydenii.*

17. **Quercus approximata** Jennings, sp. nov. (PLATE XXVII, FIGS. 3 and 3*a*, TYPE.)

The specimen consists of an impression about 6 cm. long from an oblong leaf of a maximum width of 2.8 cm., the basal portion of the leaf being missing. The leaf was pinnately veined, the midrib and secondaries being quite prominent, the secondaries arising from the midrib about 7–11 cm. apart, but forming with the midrib angles of but 20–30 degrees. Some of the veins are a little more widely diverging at the very base, but immediately above this the veins all pursue straight and parallel courses to the margin, where they end in rather low but sharply crenate or forwardly-directed and evidently often slenderly spine-tipped teeth. Along the margin of the leaf, between each pair of the main teeth, are from one to four, usually two or three, similar teeth of about the same size as the main teeth. These intermediate teeth are at the ends of fine tertiaries which swing off from the lower side of the next upper secondary vein. On the specimen at hand one of the secondary veins is strongly but acutely forked at about two-thirds of the distance from the midrib to the margin of the leaf. The leaf was evidently distinctly leathery in texture, the impression showing a smoothish surface on which the tertiary veins are almost indistinguishable, being obscured by the very fine but unusually distinct ultimate meshwork.

The specimen is from "Locality 196," Missoula, associated in the same piece of rock with fragments of two other leaves of probably the same species, and also with *Betula multinervis.*

The species is nearly related to *Quercus furcinervis americana* Knowlton, reported from the Miocene of the Yellowstone National Park (Lamar) and also from the Eocene of the John Day beds of Oregon (Cherry Creek), and is perhaps about as closely related to the following species reported by Heer from Greenland: *Q. Olafseni* Heer, *Q. platania* Heer, *Q. Steenstrupiana* Heer, and *Q. furcinervis* Rossmæssler. The species from Missoula differs from all of these, however, in the much narrower angle between the secondary nerves and the midrib, and also in that its tertiary veins are so much more obscure. The species clearly belongs to the Chestnut-oak group, the straight, parallel, rather closely pinnate secondary nerves, as well as the character of the teeth and the firm reticulate surface of the leaf, all suggesting *Castanea*.

The specific name "*approximata*" has been used for this species because of the short distance between the secondary veins, this feature being due to the relatively narrow angles formed by the secondaries with the midrib.

18. **Ficus** (?) **prunifolia** Jennings, sp. nov. (Plate XXXII, Fig. 1 and 1*a*, Type.)

The specimen consists of the impression from a piece about 7 cm. long from the middle of a leaf about 7 cm. wide, pinnately veined, the secondaries being spaced about 3–13 cm. apart, given off from the midrib at an angle of 50–55° and curving gradually forward, in the outer part giving off strong branches which loop in camptodromous fashion with the curved and attenuate end of the next lower secondary. From the midrib and from the lower side of the secondaries are given off numerous fine but distinct veins, which pursue a course almost at right angles to the midrib, and fork and anastomose to form polygonal, often diamond-shaped, areas, the sharper angles and longest dimension of which lie cross-wise to the leaf. Smaller and weaker camptodromous loops are formed closer to the leaf-margin by branches from the main loops. So far as preserved the leaf-margin appears to be entire, or at the most but slightly undulate. The venation appears to have been rather deeply impressed and in texture the leaf was probably rather thick.

The specimen came from "Locality 196," Missoula, and is on the same piece of rock with impressions of *Betula multinervis* and *Alnus Hollandiana*. The generic position of the species has been the cause of much perplexity. The rather striking crosswise trend of the finer veins and their meshes is suggestive of species of *Ficus, Diospyros, Terminalia*, various genera of the *Ebenaceæ, Lauraceæ*, and other plants, but most of all, perhaps, it is suggestive of some of the larger leaved-species of *Prunus*, such as *P. alabamensis* Mohr. This resemblance to *Prunus*, however, is not so close, when the outermost course of the veins and the character of the leaf-margin are also taken into account, so that the species seems best referred to the genus *Ficus*.

In *Ficus* there have been reported probably between two and three hundred fossil species, beginning well down in the Cretaceous, thirty or more being reported from the Dakota of the western part of the United States. During the Cretaceous the genus was widely distributed, species being reported from Greenland, Europe, North America, Australia, and New Zealand. In the Eocene there are about as many reported, fifty or more; sixty or more from the Oligocene, mainly in western

Europe; while about ninety species are reported for the Miocene, about twenty of these being from the United States, and about twenty are reported from the Pliocene. The range of the genus has been extended by reports of its discovery in Africa from the Oligocene and in Asia from the Miocene.[54]

19. **Ilex furcinervis** Jennings, sp. nov. (Plate XXIV, Fig. 5, and Plate XXXII, Figs. 2, *2a*, and *2b*, Type.)

The extreme apex and base of the leaf is lacking in our specimen. The impression shows the leaf to have been obovate, probably about 8 cm. long, about 4 cm. wide, at the widest point, somewhat above the middle, narrowing rather rapidly towards the base, apparently rounded or at least narrowing very rapidly towards the apex. Margin entire in the lower half of the leaf, serrulate above, the teeth being widely triangular, about 0.5 mm. high, sharply callus-tipped, this tip directed forward and in the fossil showing a reddish-brown color. Midrib prominent, sending off about twelve pairs of rather prominent and mostly alternate veins, which leave at an angle of about 55–60 degrees, rather irregularly spaced, slightly curving upward, forking in their upper two-thirds or three-fourths, these forks themselves forking and their branches meeting to form irregularly diamond-shaped areas extending to within 1–3 mm. of the leaf-margin. From the outer ends of these diamond-shaped areas one or usually two nervules diverge, again forking and looping in camptodromous fashion or disappearing into the minute teeth. Usually it is the upper one of the two nervules leaving the apex of an area which runs out into the tooth. In the middle of the leaf the tertiaries and the minute ultimate meshwork are faint, suggesting that they were embedded in the tissue of a thick leaf and are apparently rather irregular. The leaves were evidently not only thickish but coriaceous and smooth.

In general outline the leaf was not unlike the wider leaves to be found on vigorous shoots of our living southern *Ilex Cassine* Linnæus, and it also resembles to a certain extent *Ilex longifolia* Heer,[55] both in venation and in that the margin is toothed above. The general aspect of the leaf is that of the more obovate leaves of *Quercus imbricaria* Michaux, our modern Shingle-oak, and there are resemblances also to *Quercus furcinervis americana* Knowlton, reported for the Eocene and Miocene.

The genus *Ilex* contains about 275 living species, mostly in North and South America and temperate and tropical Asia, a few occuring also in Africa, Australia,

[54] Berry, E. W. The Lower Eocene Floras of the Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, pp. 82–83.

[55] Heer, O. Flora Fossilis Arctica, I, 1868, p. 124, Pl. 48, figs. 3–6.

and Europe. More than one hundred fossil species have been reported, thirteen or more of these having been accredited to the Upper Cretaceous from North America, Greenland, and western Europe, and about fourteen in the Eocene from the eastern and western United States, Alaska, Greenland, and western Europe. There are twenty or more species reported for the Oligocene and more than fifty for the Miocene.[56] The occurence of *Ilex* in the Oligocene in the region of Missoula is thus rather to be expected than otherwise.

The specimen in the collections of the Carnegie Museum consists of the obverse and reverse impressions of a single leaf and it was found at "Locality 196", Missoula. The specific name *furcinervis* has been chosen to indicate, as in the case of *Quercus furcinervis*, the characteristic strikingly forked branching of the secondary veins.

20. **Celastrus parvifolius** Jennings, sp. nov. (Plate XXXI, Figs. 2 and 2*a*, Type.)

The single specimen shows an oblong-ovate leaf 11 mm. wide and evidently about 3 cm. long, the apex being broken away. The base of the leaf narrows evenly and rather acutely, being apparently sessile, but this latter feature can not be stated definitely. The leaf is pinnately veined, the midrib being fairly strong, the secondary veins being irregularly spaced, about four of them on each side of the midrib, from which they spring at an angle of about 45 degrees. The secondary veins curve gradually forward to near the margin of the leaf where they merge into a series of camptodromous loops with branches from the next upper secondary vein. The finer veins are quite irregular in spacing and direction, thus giving rise to an irregular, although somewhat coarse meshwork. The leaf-margin, with the exception of that of the cuneate base of the leaf, is rather finely serrulate with low teeth, directed somewhat forward, there being usually a fine vein extending into each of these teeth from the marginal camptodromous loops. The shape of the upper part of the specimen suggests a rather slenderly tapering apex.

The specimen is from "Locality 196," Missoula, and it perhaps most nearly resembles *Celastrus fraxinifolius* Lesquereux, from Florissant, Colorado (Miocene), and *C. Lindgreni* Knowlton, from the Payette of Idaho (Upper Eocene), although it is smaller than either of these. The generic position is none too certain, the leaf being suggestive of genera of the *Rosaceæ*, *Leguminosæ*, *Rhamnaceæ*, and *Ericaceæ*. Considering altogether the characters of leaf-margin, outline, and venation, particularly the method of looping and the finer meshwork, it seems best to refer the plant to *Celastrus*.

[56] See Berry, E. W. The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, pp. 104–105.

The genus *Celastrus* now contains over thirty species of shrubs, ranging through southern and eastern Asia to Australia and America, mostly confined to warm climates. The oldest known species (*Celastrus arctica* Heer) is reported from the Cretaceous (Raritan and Magothy of New Jersey and Maryland, and the Patoot of Greenland). About thirty species are reported from the Eocene, ranging over England, the eastern and western United States, Alaska, and Greenland. About the same number are reported from the Oligocene, evidently all European, and fifty or more are reported from the Miocene of the United States (Virginia, Colorado, Idaho, and Oregon), Europe, Asia, and Australia. Perhaps a dozen Pliocene species are known.[57]

It is interesting to note in this connection that no species of *Celastrus* has been reported heretofore from the Oligocene of America and that the geographically nearest locality for the occurence of *Celastrus* in other horizons is that of the nearly related *Celastrus Lindgreni* Knowlton in the Payette formation of western Idaho, probably of late Eocene age.

21. **Acer oregonianum** Knowlton. (Plate XXXII, Fig. 3.)

Acer, fruits of, Lesquereux, Proceedings of the U. S. National Museum, XI, 1888, p. 15, Pl. 6, figs. 2 and 3.

Acer oregonianum Knowlton, Fossil Flora of the John Day Basin, Oregon, U. S. Geological Survey, Bulletin CCIV, 1902, p. 75, Pl. 13, figs. 5–8.

Knowlton, *l.c.*, says of this species: "Fruits long and broad-winged, the axis being evidently very thick and provided with numerous strong veins; nucleus large, round, showing broad truncation where attached to the sister-fruit. . . . They range in length from 3.5–4.5 cm. The wing is unusually broad, being not infrequently 1.75 cm. wide. It is filled with numerous strong veins which are given off from the axis of the fruit in groups or bundles. . . . Abundant in Mascall beds at Van Horn's ranch and vicinity."

The Missoula specimen consists of a part of a fruit, comprising the upper part of the seed and a little more than 2 cm. of the wing. The bundles of strong veins given off from the seed are quite prominent, these opening out into the membrane of the wing at about right angles to the axis of the wing and forking from one to three times. The widest part of the wing is about 14 mm.

This specimen is from "Locality 165," Missoula. As Knowlton has pointed out, the fruit is very close to that of the modern *Acer macrophyllum* Pursh, found

[57] See Berry, E. W. The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, p. 105.

in the coastal region from Alaska to California, and now the only large native maple-tree west of the Rocky Mountain region.

Acer now comprises about one hundred and twenty species, in the northern hemisphere, mainly in temperate regions. Reports of the occurrence of the genus in the Cretaceous are perhaps rather doubtful. More definite are the reports of its occurrence in the Eocene (England), while in the Oligocene various species occurred in widely separated regions: Spitzbergen and southward in Europe to the Mediterranean, Greenland, Alaska, and in the western United States. During the Oligocene and Miocene the species were especially numerous in western and central Europe.

22. **Aralia longipetiolata** Jennings, sp. nov. (Plate XXXIII, Figs. 1, 1*a*, 2, 2*a*, Type.)

The material from "Locality 139," near Winston, Montana, contains numerous fragmentary leaf-impressions, of which a number show the leaf-base and petiole, but none of them show the complete apex. Although quite variable, the impressions apparently all represent a species of *Aralia*.

The leaves were lance-ovate to oblong-ovate, reaching a length of 7 cm. or more, the width being about half that amount. The petioles were slender, the longest ones preserved being about as long as the leaves were wide. The leaf was rather distantly pinnately veined, the secondaries being mostly six to eight on each side of the midrib, the lowest opposite or essentially so, the median and upper usually alternate. The veins form an angle of about 45 degrees with the midrib, then curve gently forward, one occasionally forking in the outer third. The secondaries are usually simple, but well out towards the margin they throw off at wide angles from one to three tertiary veins, which curve around and, like the attenuate tip of the secondary, end in low teeth, which are either sharply directed forward or else are broadly rounded-crenate. The leaf-base was equally or sometimes unequally broadly rounded and shallowly cordate, most of the leaves having one or two pairs of smaller more widely spreading secondary veins crowded into the space below the lowest main pair of secondaries. The appearance is almost that of a sub-peltate leaf, remotely suggesting leaves such as those described at various times under the names of *Credneria*, *Aspidiophyllum*, and *Protophyllum*. The tertiary veins are weak, rather closely spaced, and diverge from the secondaries and from the midrib at almost right angles. They mostly fork and join midway between the secondaries to form roughly pentagonal areas which are one to two times as high as wide. As far as can be determined from the specimens, the apex was acute or perhaps even slenderly acuminate. The impressions indicate that the texture of the leaf was thin, like that of a shade-leaf.

Most of the fossil species of *Aralia* described have been of the type having palmate veins and lobes, or else being palmately compound, but the Winston species so closely resembles the modern *Aralia racemosa* L., that the writer has little hesitation in referring it to the genus *Aralia*.

Broadly rounded crenate teeth, such as occur on the margin of a few of the Winston fossils, are sparingly found in the modern *Aralia racemosa*, which rather regularly has the petiole long and slender, the base unequal, the basal secondary veins peculiarly crowded, and the leaf-blades thin, while the pattern of the venation, too, is much like that of the Winston fossils.

Although I can find no records of fossil Aralias very closely related to the species from the Oligocene of Missoula, yet the present distribution of *Aralia racemosa*, native to eastern North America, and closely allied species, such as *A. cordata* Thunberg of Japan, and *A. cachemirica* Decaisne of the Himalayas, argues for a Tertiary distribution of one or more ancestral forms of that type.

The genus *Aralia* now includes about thirty species of herbs and woody plants ranging through temperate North America and Asia, and south from the latter through the Malay Archipelago and into Australia. Many of the fossil species so reported are perhaps not *Aralia*, but belong to other genera of that family or even to other families. However, taking the reports as they stand at the present time, there are numerous species of *Aralia* described from the Cretaceous, perhaps sixty altogether, beginning in the upper part of the Lower Cretaceous in Portugal (Albian) and the eastern United States, and becoming numerous and practically cosmopolitan in the Upper Cretaceous. From the Eocene about twenty-five species have been described, these being most numerous in the Fort Union of the western United States and in the Paleocene of Belgium, while about an equal number have been described from the Oligocene, all European, and more than half of these are from the Sannoisian of southeastern France. About twenty-five species are recorded from the Miocene, distributed through North America, Eurasia, and Australia.[58]

Various species of *Aralia* having been recorded for the western part of the United States from the Eocene and Miocene, it is to be expected that Oligocene strata would also yield them from that region and, even though no closely related forms may have been recorded from the Eocene or Miocene of the West, yet the present

[58] See Berry, E. W. Aralia in American Paleobotany. Botanical Gazette, XXXVI, 1903, pp. 421–428; *idem*, The Lower Eocene Floras of Southeastern North America, U. S. Geological Survey, Professional Paper XCI, 1916, pp. 122–123.

distribution of *Aralia racemosa* and its allies would indicate that ancestral forms of that species existed in the region, so that their occurrence in the Oligocene of the Missoula district would be quite natural.

As the type specimen upon which this species rests I would designate the specimen shown on Plate XXXIII, figs. 2 and 2*a*.

23. **Vaccinium palæocorymbosum** Jennings, sp. nov. (Plate XXXIII, Figs. 3 and 3*a*, Type, and 4, 4*a*.)

The type specimen consists of an impression of a leaf with the apex broken off. The petiole is about 0.7 mm. in diameter, 4 mm. long, curved, uniform throughout its length. The leaf-blade is ovate-lanceolate, widest at about the middle, where it is 1.8 mm. wide, apparently about 4.5–5 cm. long, rather bluntly tapering towards the petiole, somewhat more narrowly tapering toward the apex; the margins entire, slightly revolute. The midrib is rather strong, tapering above, the secondary veins pinnate in probably about eight approximate pairs (six pairs are preserved in the specimen), these veins spreading at an angle of about 50° with the midrib, curving upward towards the margin and finally looping successively with branches from the lower side of the next vein above. The tertiary venation is fine and rather indistinct, but toward the margin and along the lower side of the lowermost pair of veins forming small narrow loops, while between the veins there are a few tertiaries running across from one vein to the other at almost right angles to them, the final meshes in the interior of the blade being rather small and indistinct. There appears to be a very narrow decurrent flange along each side of the petiole throughout its length.

In size, shape, and venation the specimen almost exactly matches leaves which can be selected from the modern *Vaccinum corymbosum* Linnæus of swamps and low woods from Maine, Quebec, and Minnesota to Virginia and Louisiana, about the only noticeable difference being the somewhat larger angle of divergence of the veins in the fossil specimen. In length of petiole, number and spacing of the veins, narrow loops on the lower side of the lowest pair of veins, revolute margin, margined petiole, etc., the resemblance is too close to be ignored. At first glance the fossil suggests *Quercus cinereoides* Lesquereux[59] but in that species the base is more rounded, the venation does not match that of the Missoula specimen very closely, and there is little basis for believing that an oak would have such a margined petiole.

[59] Lesquereux, Leo. The Tertiary Flora, U. S. Geological Survey of the Territories, VII, 1878, p. 152, Pl. 21, fig. 6.

The genus *Vaccinium* now contains about 130 species and it ranges from the Arctic Circle to the mountains of the tropics, having its greatest development in the Himalaya Mountains and in North America. Considerable doubt has been expressed as to the correct identification of some of the fossil forms reported, but it seems fairly certain that the genus is correctly ascribed to the Eocene, with three or four species from Alaska and Colorado, while in western Europe in the Oligocene and, especially, in the Miocene, the genus was represented by a number of species, so that the occurrence of *Vaccinium* in the Missoula region in the Oligocene would not be unexpected.

EXPLANATION OF PLATE XXII.

Fig. 1. Buds of *Equisetum* sp. Enlarged two and one-half diameters.

Fig. 2. *Equisetum insculptum* Jennings. Type. Enlarged two and one-half diameters.

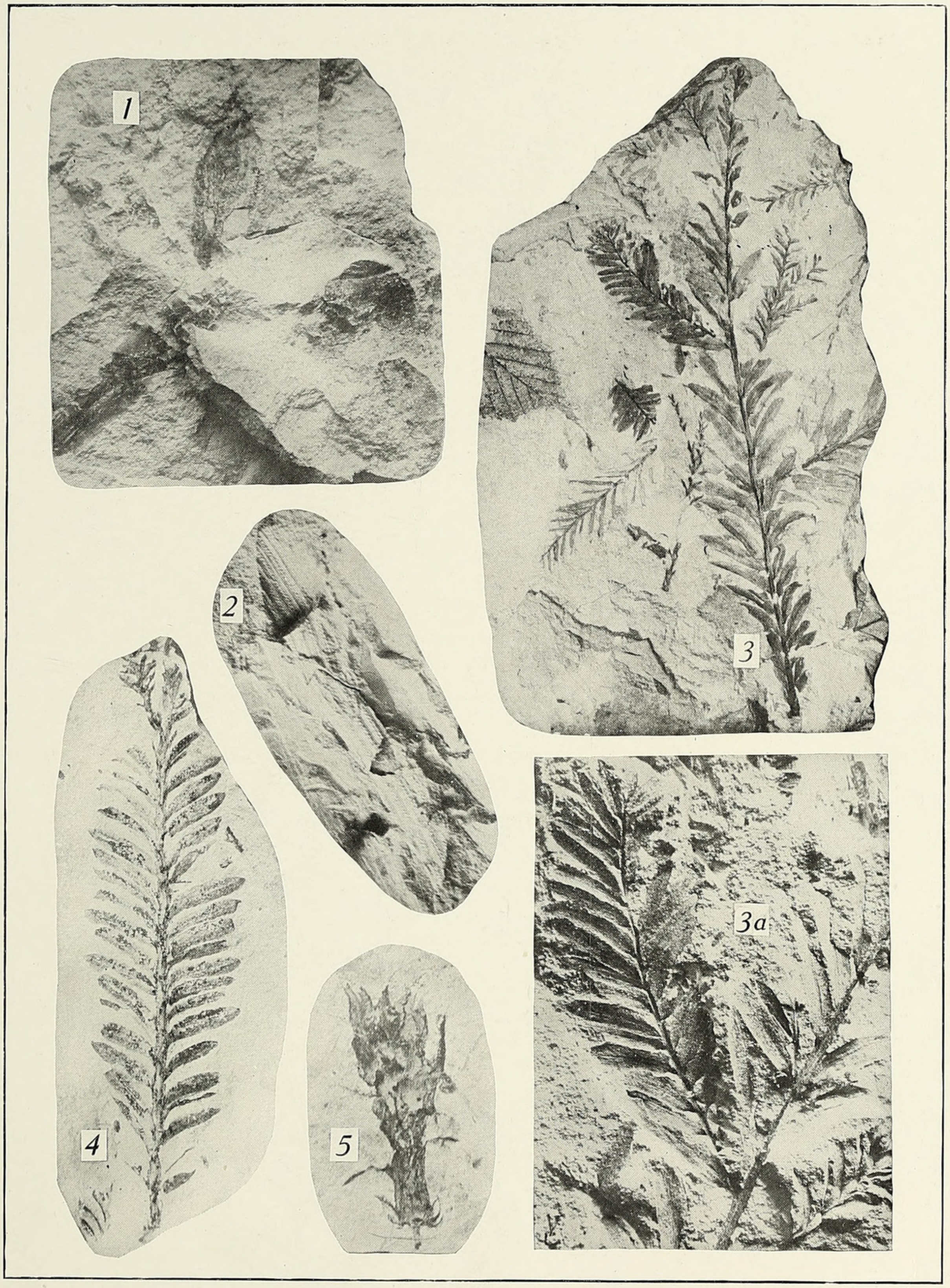
Fig. 3. *Sequoia Haydenii* (Lesquereux) Cockerell. Natural size.

Fig. 3*a*. The upper part of the same specimen, enlarged two and one-half diameters.

Fig. 4. *Sequoia Haydenii* (Lesquereux) Cockerell. Enlarged about two diameters.

Fig. 5. *Sequoia Haydenii* (Lesquereux) Cockerell. A young shoot enlarged three and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass from Montana. Figs. 1 and 2 from "Locality 139," Winston; Figs. 3–5 from "Locality 196," near Missoula, Montana.



Equisetum and *Sequoia*.

(For explanation see opposite page.)

EXPLANATION OF PLATE XXIII.

FIG. 1. *Sequoia oblongifolia* Jennings. Type, enlarged about one and three-fourths diameter.

FIG. 1*a*. Part of same branch, enlarged two and one-half diameters.

FIG. 2. *Sabina linguæfolia* (Lesquereux) Cockerell. Enlarged about two and one-half diameters.

FIG. 3. *Sequoia Haydenii* (Lesquereux) Cockerell. Enlarged two and one-half diameters.

FIG. 4. *Sequoia Haydenii* (Lesquereux) Cockerell. Cones, enlarged about three and one-half diameters.

FIG. 5. *Thuyopsis gracilis* Heer. Enlarged about three and one-half diameters.

FIG. 6. *Sequoia Haydenii* (Lesquereux) Cockerell. Natural size.

Photographed from specimens in the Carnegie Museum collected by Earl Douglass from "Locality 196," Missoula, Montana.

Sequoia, *Sabina*, and *Thuyopsis*.

(For explanation see opposite page.)

EXPLANATION OF PLATE XXIV.

FIGS. 1, 2, AND 3. *Sequoia Haydenii* (Lesquereux) Cockerell. Different types of leaves of the same species.

FIG. 4. *Betula multinervis* Jennings.

FIG. 5. *Ilex furcinervis* Jennings.

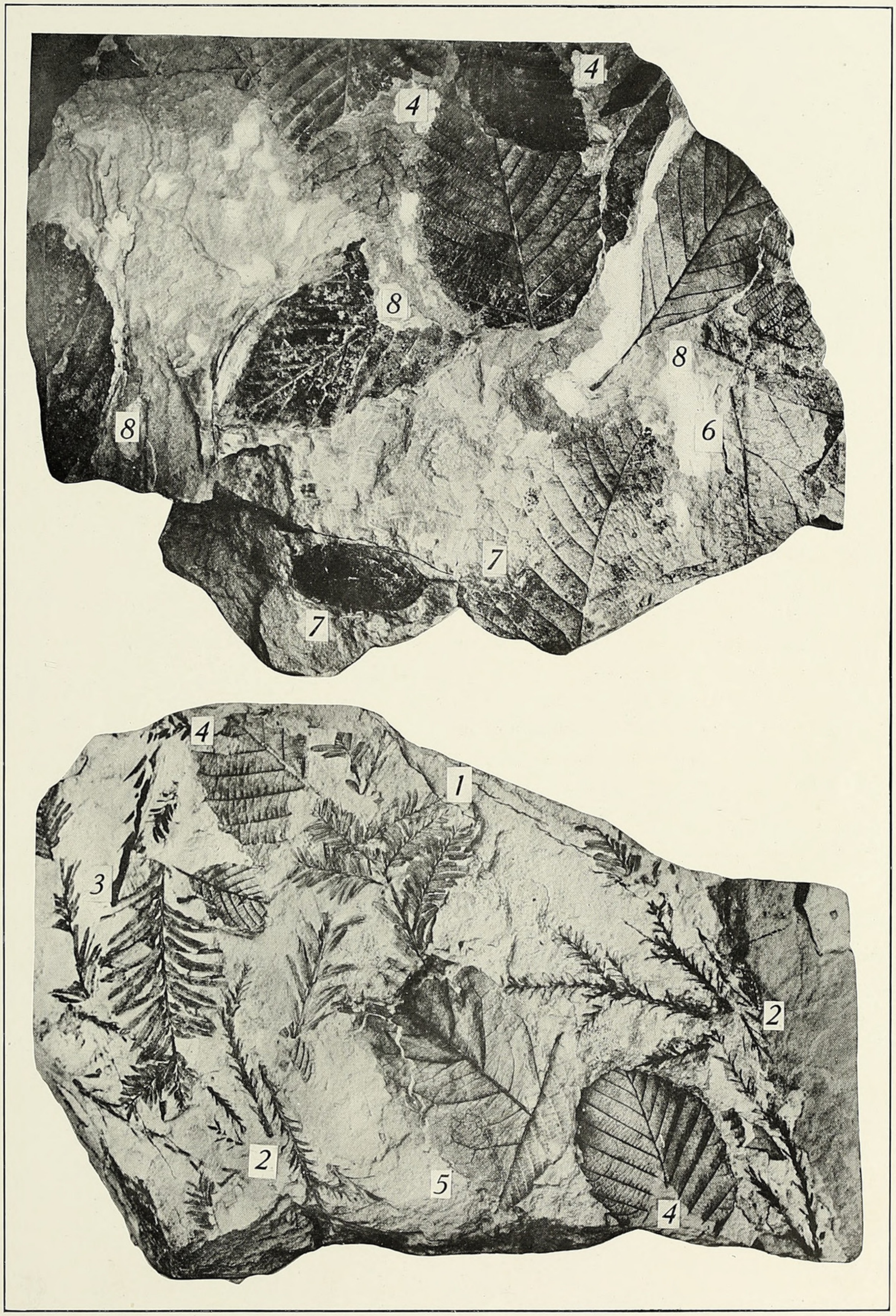
Photographed from a specimen in the Carnegie Museum collected at Missoula, Montana, from "Locality 196". About seven-eighths diameter.

FIG. 6. *Populus Zaddachi* Heer.

FIG. 7. *Alnus microdontoides* Jennings.

FIG. 8. *Alnus Hollandiana* Jennings.

Photographed from a specimen in the Carnegie Museum, collected at "Locality 196," Missoula, Montana, by Earl Douglass. About four-fifths diameter.



Sequoia, *Betula*, *Ilex*, *Populus*, and *Alnus*.

(For explanation see opposite page.)

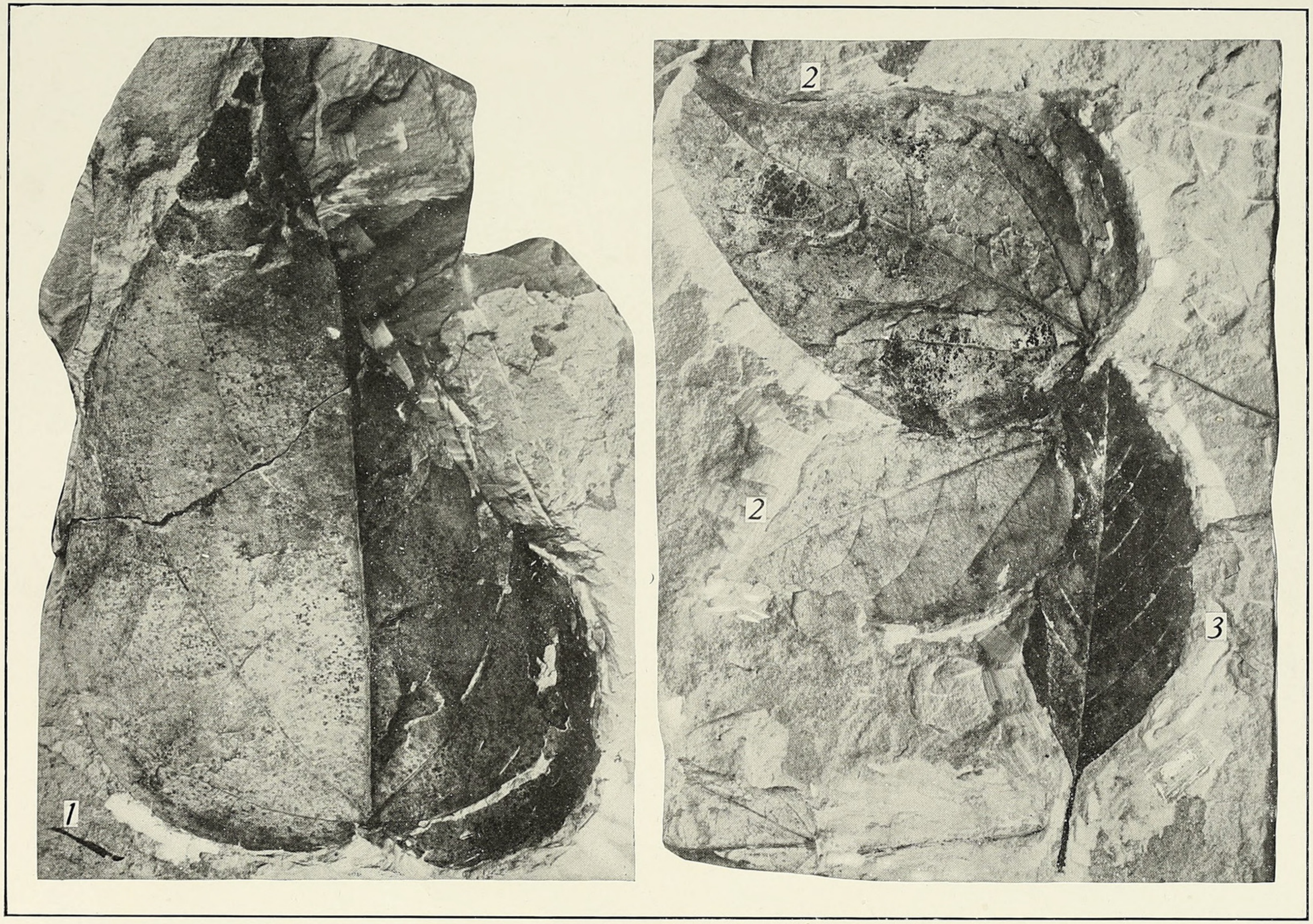
EXPLANATION OF PLATE XXV.

Fig. 1. *Populus Zaddachi* Heer. Natural size.

Fig. 2. *Populus Zaddachi* Heer. About seven-eighths diameter.

Fig. 3. *Alnus Hollandiana* Jennings. Type. About seven-eighths diameter.

Photographed from specimens in the Carnegie Museum, collected at "Locality 196," Missoula, Montana, by Earl Douglass.



Populus and *Alnus*.

(For explanation see opposite page.)

EXPLANATION OF PLATE XXVI.

FIG. 1. *Populus Zaddachi* Heer. Natural size.

FIG. 1*a*. Middle left-hand margin of same specimen, enlarged two and one-half diameters.

FIG. 2. *Populus Zaddachi* Heer. Natural size.

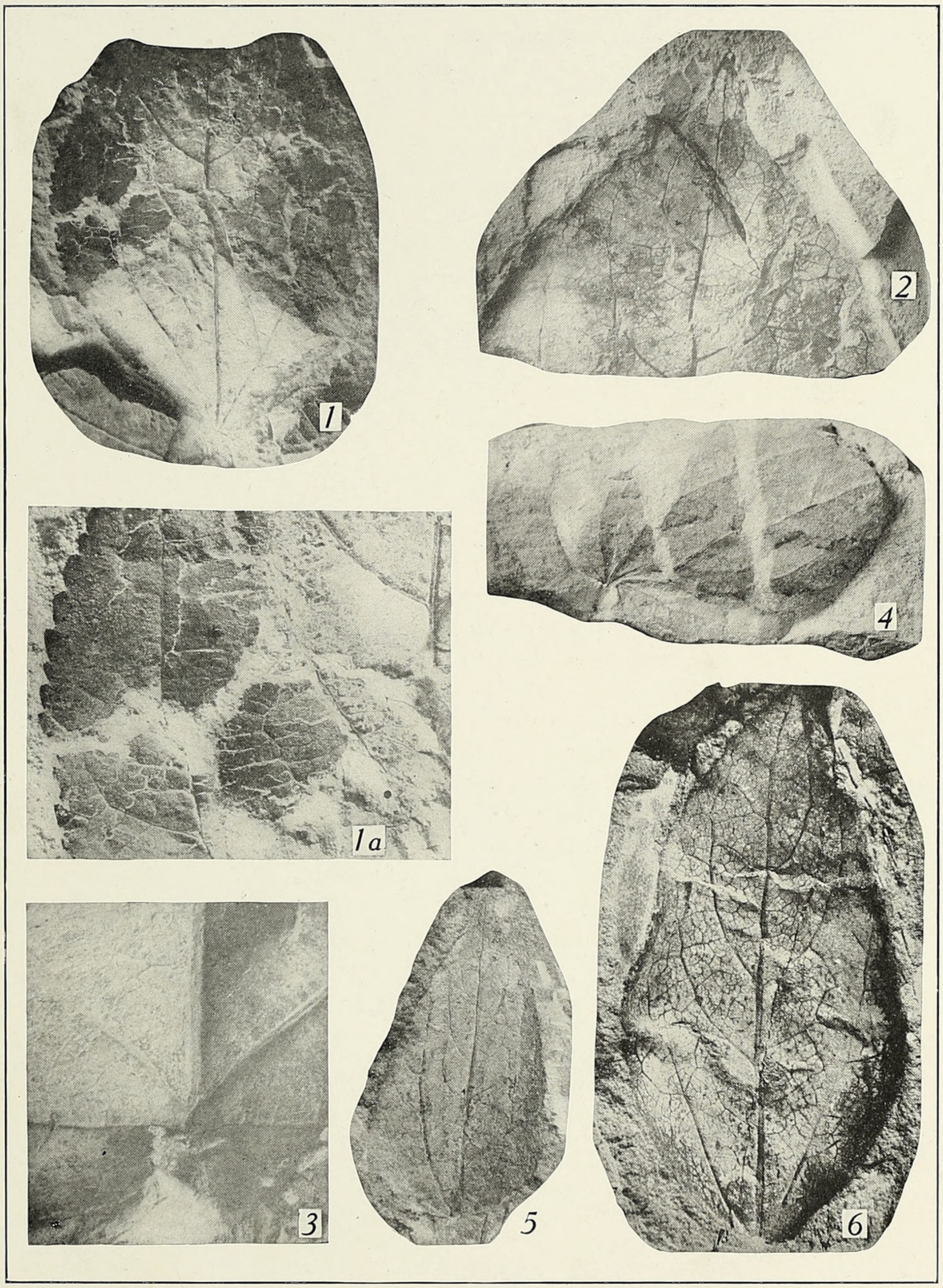
FIG. 3. *Populus Zaddachi* Heer. Base of leaf shown in Plate XXV, Fig. 1, enlarged two and one-half diameters.

FIG. 4. *Populus smilacifolia* Newberry. Natural size.

FIG. 5. *Populus Zaddachi* Heer. Natural size.

FIG. 6. *Populus Zaddachi* Heer. Another leaf enlarged two and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass at Missoula, Montana.—Figs. 1, 2, and 3 from "Locality 196;" Figs. 4, 5, and 6 from "Locality 165."



Populus Zaddachi and *P. smilacifolia*.

(For explanation see opposite page.)

EXPLANATION OF PLATE XXVII.

FIG. 1. *Betula multinervis* Jennings. About three-fifths diameter.

FIG. 1*a*. Same specimen, natural size. Type.

FIG. 1*b*. Part of "1*a*," enlarged two and one-half diameters.

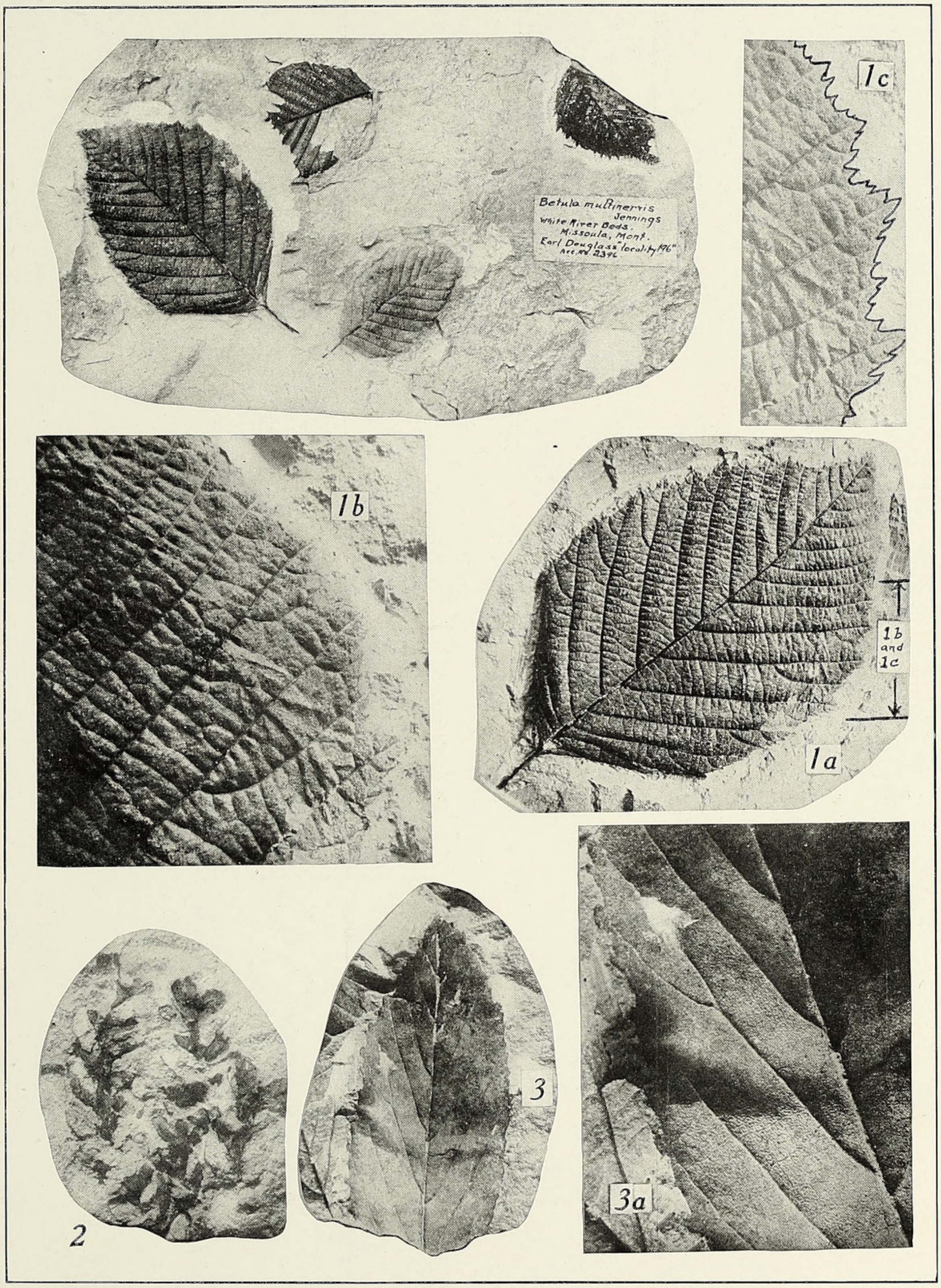
FIG. 1*c*. Same as "1*b*," with the margin of the leaf drawn in.

FIG. 2. *Betula multinervis* Jennings. Cones, enlarged about two and one-half diameters.

FIG. 3. *Quercus approximata* Jennings. Type. Natural size.

FIG. 3*a*. Part of the same specimen, enlarged about two and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass at Missoula, Montana. Figs. 1 and 3 from "Locality 196;" fig. 2 from "Locality 165."



Betula and *Quercus*.

(For explanation see opposite page.)

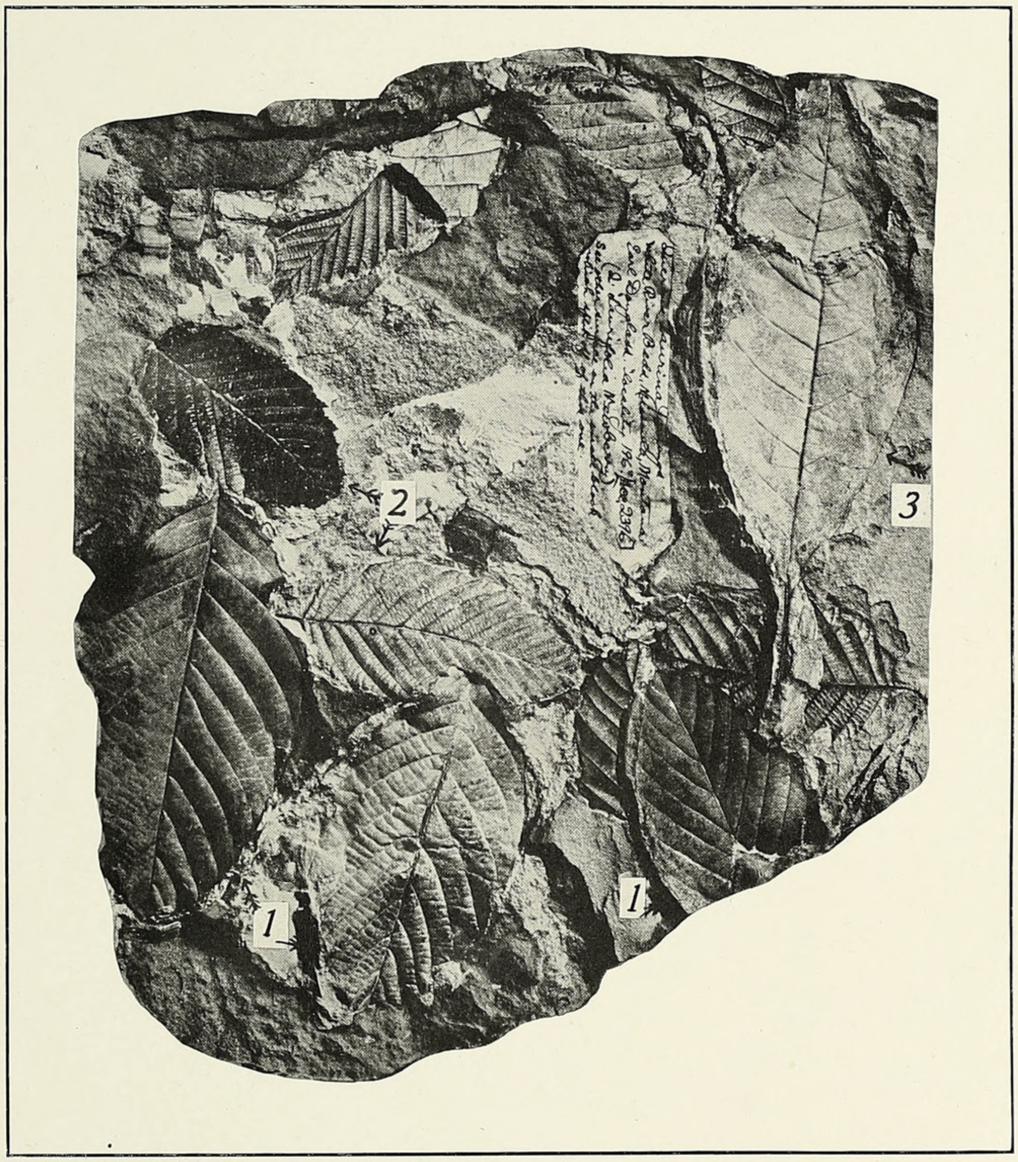
EXPLANATION OF PLATE XXVIII.

FIG. 1. *Alnus Hollandiana* Jennings.

FIG. 2. *Betula multinervis* Jennings.

FIG. 3. *Quercus laurosimulans* Jennings.

About two-thirds diameter. Photographed from a specimen in the Carnegie Museum, collected by Earl Douglass at "Locality 196," Missoula, Montana.



Alnus, *Betula* and *Quercus*.

(For explanation see opposite page.)

EXPLANATION OF PLATE XXIX.

FIG. 1. *Juglans pentagona* Jennings. Type. Natural size.

FIG. 1*a*. Part of same specimen, enlarged about two and one-half diameters.

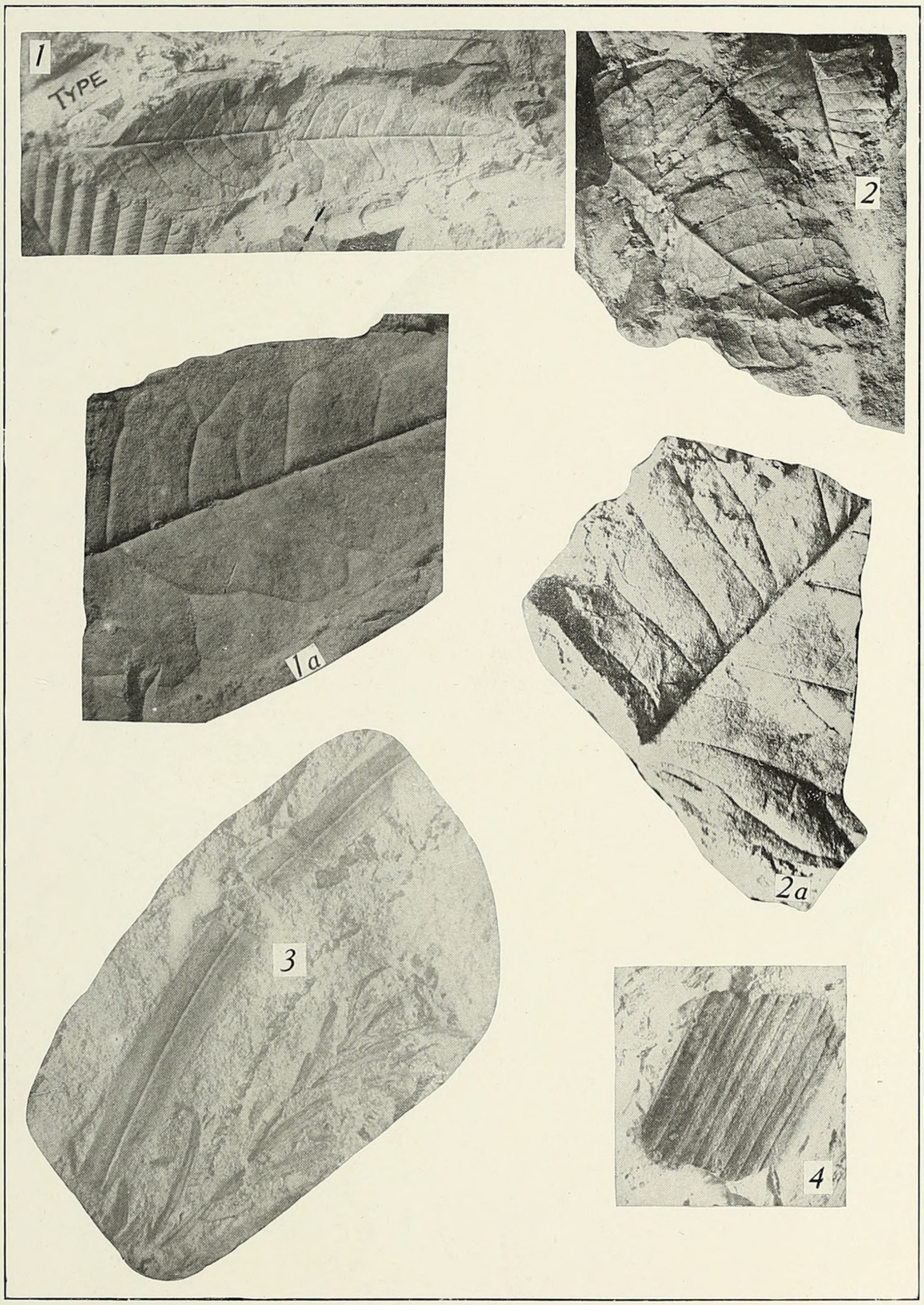
FIG. 2. *Juglans pentagona* Jennings. Natural size.

FIG. 2*a*. Part of the same specimen, enlarged about two and one-half diameters.

FIG. 3. *Cyperacites* sp. Enlarged two and one-half diameters.

FIG. 4. *Typha Lesquereuxi* Cockerell. Enlarged two and one-half diameters.

Photographed from specimens in the Carnegie Museum collected by Earl Douglass from Missoula, Montana. Figs. 1, 1*a*, 2 and 2*a* from "Locality 165;" figs. 3 and 4 from "Locality 196."



Juglans, *Cyperacites*, and *Typha*.
(For explanation see opposite page.)

EXPLANATION OF PLATE XXX.

FIG. 1. *Alnus Hollandiana* Jennings. Type. Natural size.

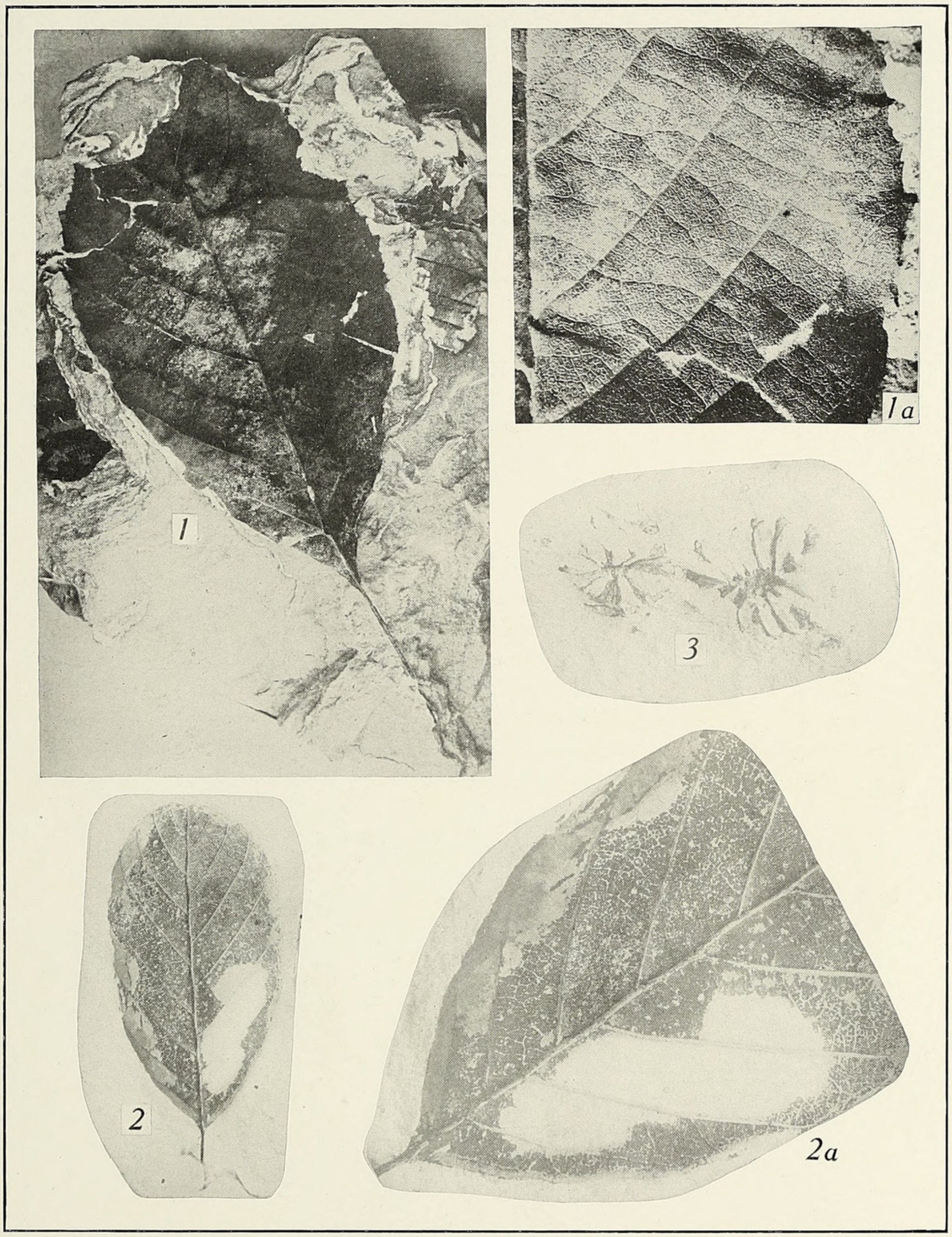
FIG. 1*a*. Middle right-hand margin of same, enlarged two and one-half diameters.

FIG. 2. *Alnus microdontoides* Jennings. Type. Natural size.

FIG. 2*a*. Lower part of same specimen, enlarged two and one-half diameters.

FIG. 3. *Alnus* cones. Enlarged about two and one-half diameters.

Photographed from specimens in the Carnegie Museum collected at "Locality 196," Missoula, Montana, by Earl Douglass.



Alnus Hollandiana and *A. microdontoides*.

(For explanation see opposite page.)

EXPLANATION OF PLATE XXXI.

FIG. 1. *Quercus flexuosa* Newberry. Natural size.

FIG. 1*a*. Part of the same specimen, enlarged about two and one-half diameters.

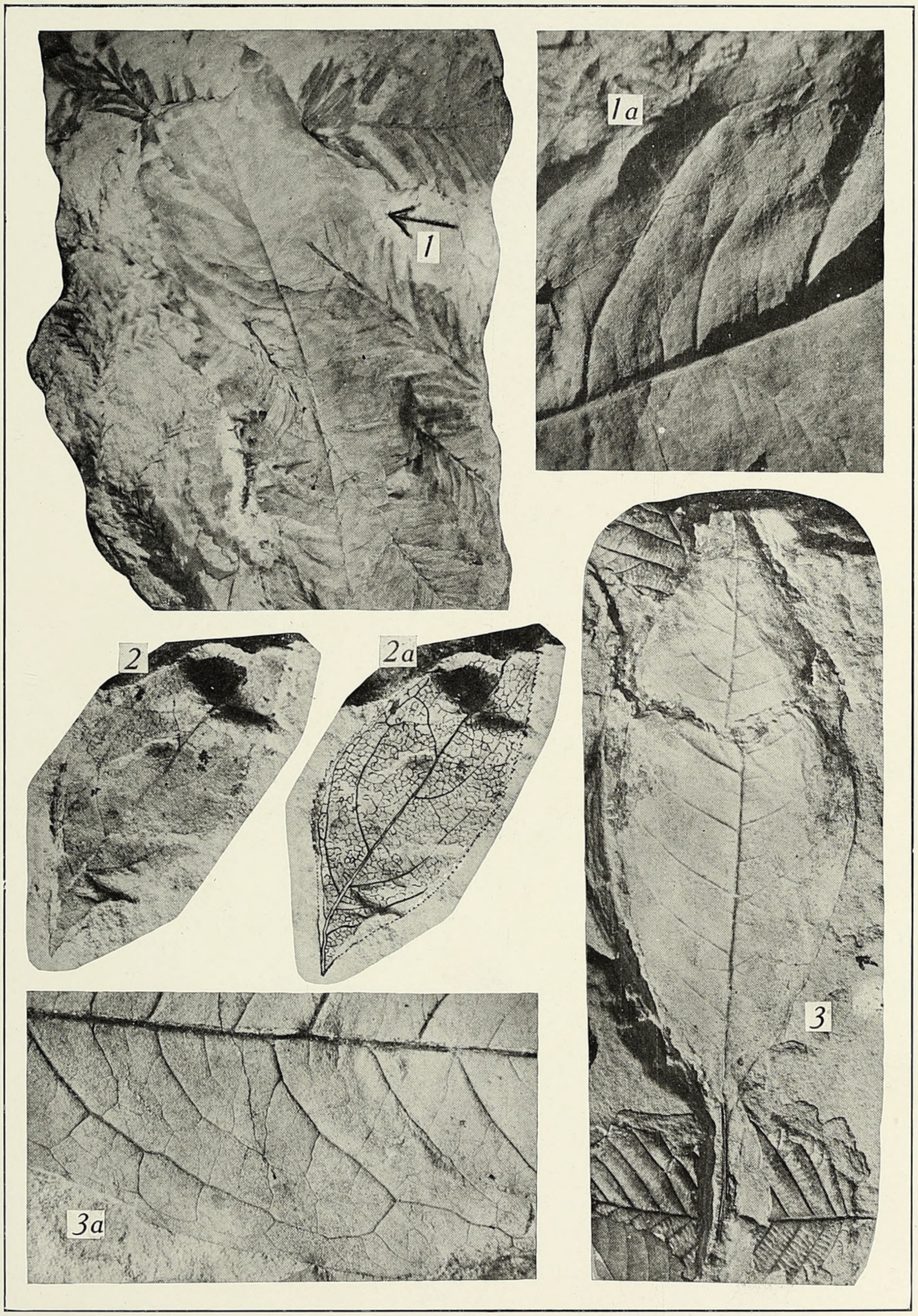
FIG. 2. *Celastrus parvifolius* Jennings. Type. Enlarged about two and one-half diameters.

FIG. 2*a*. Same with the venation inked in.

FIG. 3. *Quercus laurosimulans* Jennings. Natural size.

FIG. 3*a*. Part of another leaf from the same place, enlarged about two and one-half diameters.

All photographed from specimens in the Carnegie Museum collected by Earl Douglass at Missoula, Montana. Fig. 1 from "Locality 165"; figs. 2 and 3 from "Locality 196".



Quercus and *Celastrus*.

(For explanation see opposite page.)

EXPLANATION OF PLATE XXXII.

Fig. 1. *Ficus* (?) *prunifolia* Jennings. Type. Natural size.

Fig. 1*a*. Part of same specimen, enlarged about two and one-half diameters.

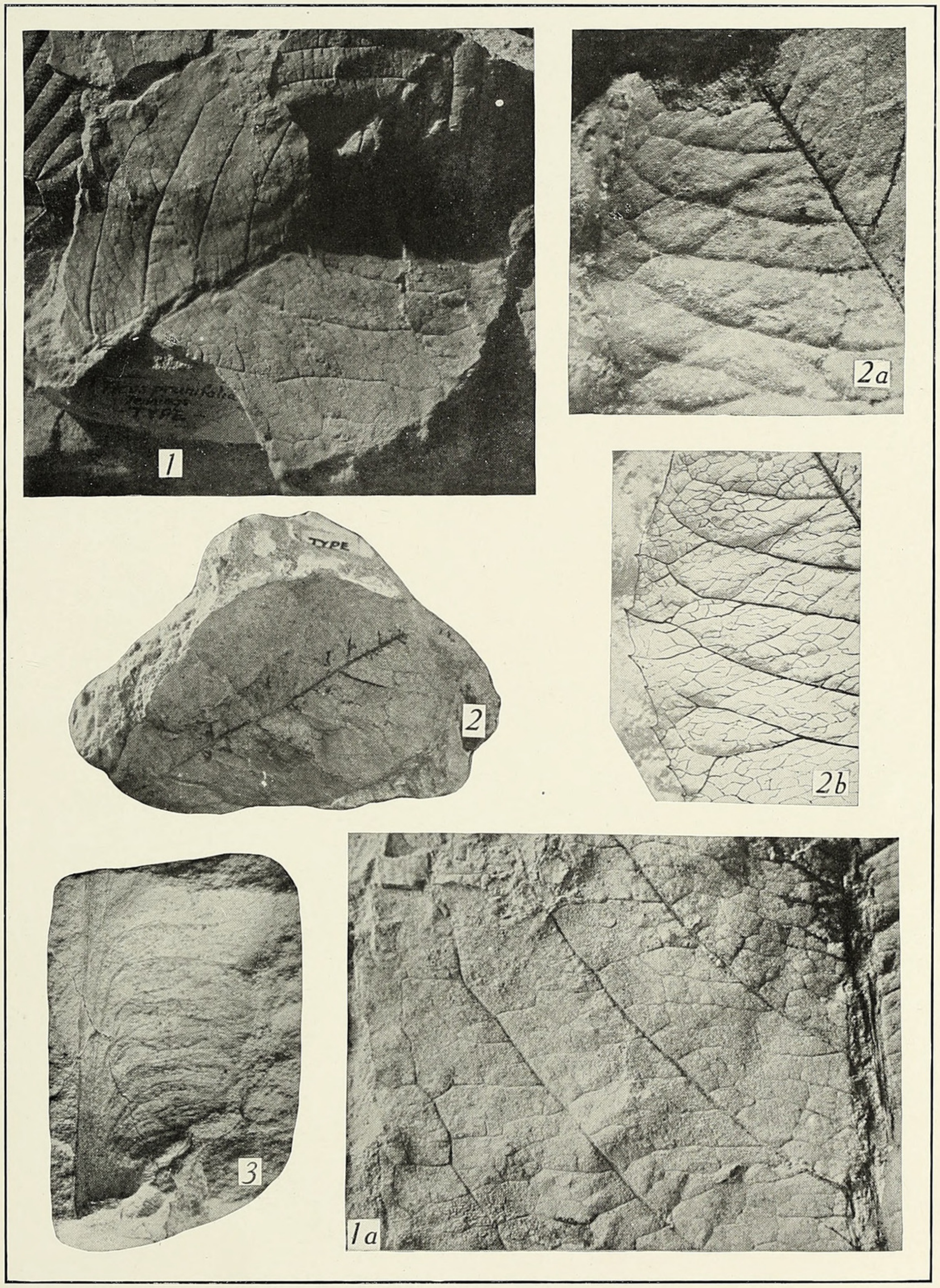
Fig. 2. *Ilex furcinervis* Jennings. Type. Natural size.

Fig. 2*a*. Upper part of same specimen, enlarged about two and one-half diameters.

Fig. 2*b*. Same as 2*a*, but with the margin inked in.

Fig. 3. *Acer oregonianum* Knowlton. Enlarged about two and one-half diameters.

Photographed from specimens in the Carnegie Museum collected at Missoula, Montana, by Earl Douglass; figs. 1 and 2 from "Locality 196", fig. 3 from "Locality 165".



Ficus, Ilex, and *Acer.*

(For explanation see opposite page.)

EXPLANATION OF PLATE XXXIII.

FIG. 1. *Aralia longipetiolata* Jennings. Natural size.

FIG. 1*a*. Same, but with the venation inked in.

FIG. 2. *Aralia longipetiolata* Jennings. Base of a larger leaf, natural size. Type.

FIG. 2*a*. Same, with the venation inked in.

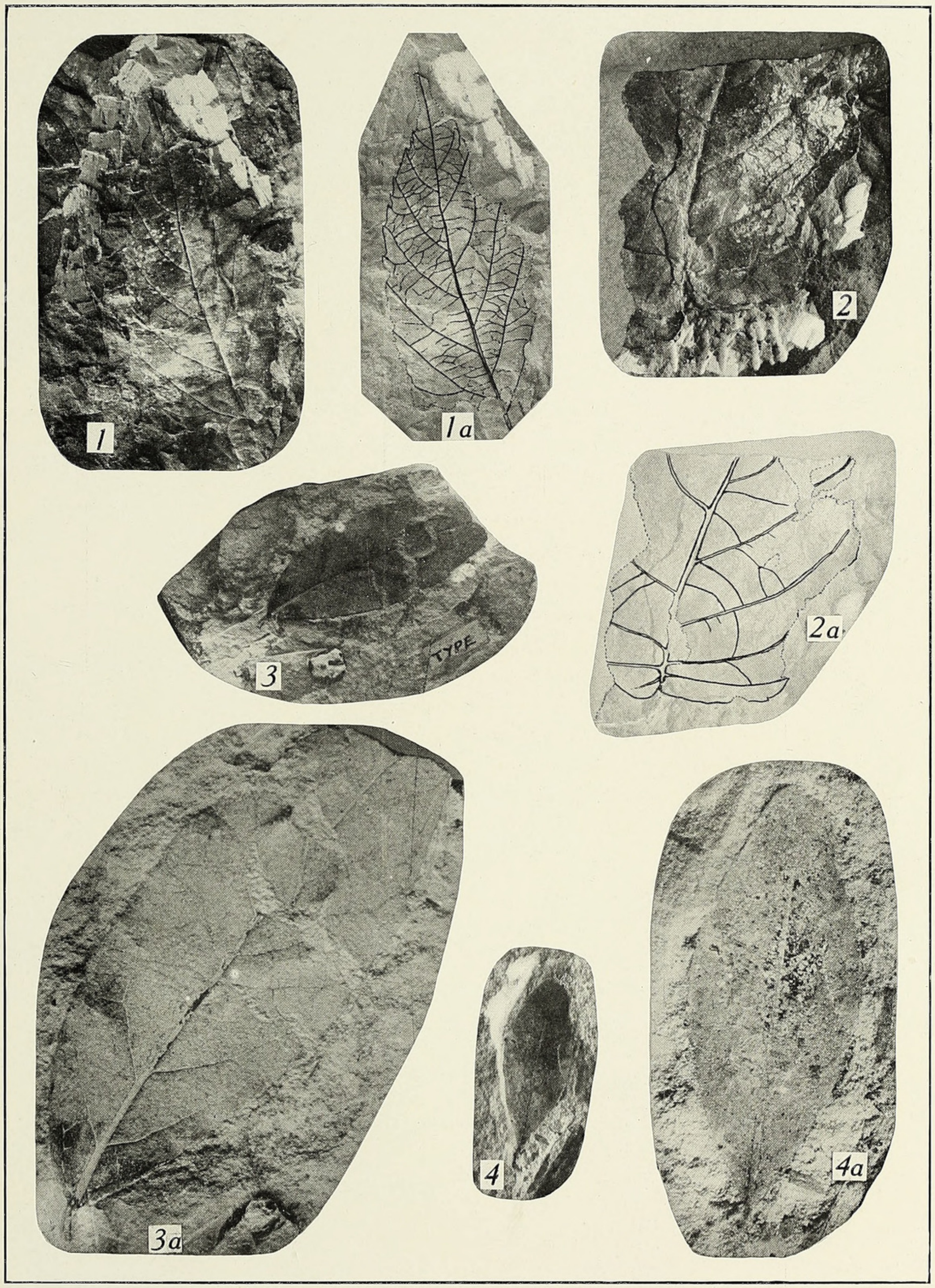
FIG. 3. *Vaccinium palæocorymbosum* Jennings. Type. Natural size.

FIG. 3*a*. Same, enlarged about two and one-half diameters.

FIG. 4. *Vaccinium palæocorymbosum* Jennings. Natural size.

FIG. 4*a*. Same, enlarged about two and one-half diameters.

All photographed from specimens in the Carnegie Museum, collected by Earl Douglass. Figs. 1 and 2 from "Locality 139", Winston, Montana; figs. 3 and 4 from "Locality 196", Missoula, Montana.



Aralia and *Vaccinium*.

(For explanation see opposite page.)