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THE FLORA OF THE WOODBINE SAND AT ARTHURS BLUFF, TEXAS.

By EDWARD WILBER BERRY.

INTRODUCTION.

The presence of fossil plants in the Cretaceous strata of Lamar County, Tex., has been known for over half a century, as is shown by a letter from Dr. B. F. Shumard dated October 2, 1860, read before the Academy of Science of St. Louis at its session of November 5, 1860.[1] Dr. Shumard, at that time State geologist of Texas, states that his brother, Dr. G. G. Shumard, discovered in the Cretaceous yellowish sandstones of Lamar County near Red River numerous dicotyledonous leaves resembling the modern leaves of *Salix*, *Ilex*, *Laurus*, etc. These fossils were undoubtedly from the locality now known as Arthurs Bluff (fig. 11, p. 180), which has furnished most of the subsequent collections. Dr. Shumard further states that these plants were sent to Leo Lesquereux for determination, but if sent they were apparently lost in transit.[2]

When R. T. Hill took up the study of the Texas Cretaceous, new collections were made between 1880 and 1885 at Arthurs Bluff and at Denison, the latter a locality originally discovered by Dr. Shumard. These collections were, according to Hill, sent to the United States National Museum and lost in storage. Finally, in Hill's great work on the Texas Cretaceous,[3] F. H. Knowlton furnished a report on collections of fossil plants from the Woodbine sand at Arthurs Bluff, Lamar County; Woodbine, Cooke County; and Denison, Grayson County. The largest of these collections is the one from Arthurs Bluff, which was made in 1894 by T. Wayland Vaughan. The plants are preserved in a fragmentary state in a yellowish ferruginous sandy clay or loose sandstone. Knowlton identified the following species from this locality:

Aralia wellingtoniana vaughanii Knowlton.
Benzoin venustum (Lesquereux) Knowlton.
Diospyros primaeva Heer.
Ficus glascoeana Lesquereux?
Liriodendron pinnatifidum Lesquereux?
Myrica longa (Heer) Heer.
Phyllites rhomboideus Lesquereux.
Platanus primaeva Lesquereux.
Sapindus morrisoni Heer?
Salix deleta Lesquereux.
Viburnum robustum Lesquereux.

The collection from Woodbine was made by G. H. Ragsdale and is reported as containing these species:

Andromeda pfaffiana Heer.
Cinnamomum ellipsoideum Saporta and Marion.
Cinnamomum sp.?
Diospyros primaeva Heer.
Eugenia primaeva Lesquereux.
Phyllites aristolochiaeformis Lesquereux?

The collection from Denison was made by T. V. Munson from two outcrops on Munson Hill, from which Knowlton was unable to identify any forms specifically, and Rhamey Hill, from which the following are recorded:

Cinnamomum heerii Lesquereux.
Diospyros steenstrupi Heer.
Inga cretacea Lesquereux.
Laurus proteaefolium Lesquereux.
Liquidambar integrifolium Lesquereux.
Magnolia boulayana Lesquereux.
Magnolia speciosa Heer.
Populus sp.?
Salix sp.?

In 1911 T. W. Stanton and L. W. Stephenson visited Arthurs Bluff and made a collection of fossil plants which were sent to me. I made a report on these plants the next year,[4] the following species having been recognized:

Andromeda novae-caesareae Hollick.
Andromeda snowii Lesquereux.
Aralia wellingtoniana Lesquereux.
Benzoin venustum (Lesquereux) Knowlton?
Brachyphyllum macrocarpum formosum Berry.
Cinnamomum membranaceum (Lesquereux) Hollick.
Colutea primordialis Heer.
Cornophyllum vetustum Newberry.

[1] Acad. Sci. St. Louis Trans., vol. 2, p. 140, 1868.

[2] Lesquereux, Leo, Cretaceous flora: U. S. Geol. Survey Terr. Rept., vol. 6, p. 11, 1874.

[3] Hill, R. T., Geography and geology of the Black and Grand prairies, Tex.: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, pp. 314–318, pl. 39, 1901.

[4] Berry, E. W., Contributions to the Mesozoic flora of the Atlantic Coastal Plain—VIII, Texas: Torrey Bot. Club Bull., vol. 39, pp. 387–406, pls. 30–32, 1912.

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Eucalyptus geinitzi (Heer) Heer.
Ficus daphnogenoides (Heer) Berry.
Laurophyllum minus Newberry.
Laurus plutonia Heer.
Liriodendron quercifolium Newberry.
Magnolia speciosa Heer.
Malapoenna falcifolia (Lesquereux) Knowlton?
Myrica emarginata Heer.
Oreodaphneala bamensis Berry.
Palaeocassia laurinea Lesquereux.
Podozamites lanceolatus (Lindley and Hutton) Braun.
Populus harkeriana Lesquereux.
Rhamnus tenax Lesquereux.
Rhus redditiformis Berry.
Sapindus morrisoni Heer.
Sterculia lugubris Lesquereux?
Tricalycites papyraceus Newberry.
Viburnum robustum Lesquereux?
Zizyphus lamarensis Berry.

It was deemed desirable, in connection with the problem of the age of the Dakota sandstone and the relation between the Upper Cretaceous formations of the Coastal Plain and those of the Western Interior, that the flora of the Woodbine sand should be critically reviewed.

Consequently all the material in the United States National Museum from Arthurs Bluff was sent to me and constitutes the basis of the present report. I have never visited the region, nor have I seen the collections from Cooke and Grayson counties, hence recorded forms from these localities are ignored unless they are present in the collections studied. The total number of species in the Arthurs Bluff material amounts to 43, and it is probable that detailed explorations would double or treble the number of known forms. Hence the present report must be regarded entirely as a preliminary contribution.

Fortunately the conclusions to be derived from a study of this small flora are so complete and decisive as regards the age and relationship of the deposits that no subsequent additions to the flora can change the general conclusions, and this fact must be the excuse for calling an account of but 43 species from a single locality the flora of the Woodbine formation.

THE WOODBINE SAND.

NAME.

The name Woodbine formation was proposed by Hill[5] in 1901 from the town of Woodbine, in the northeastern part of Cooke County, Tex. On account of the predominance of unconsolidated sand the formation is now called the Woodbine sand. These beds have a somewhat complicated nomenclatorial history. Hill some years earlier[6] called them the "Timber Creek group" or "Lower Cross Timbers formation." In still earlier years they had usually been considered of Tertiary age. They were originally described by G. G. Shumard as the "arenaceous and marly clay or Red River group" and referred to the Tertiary. His brother, who was the first to record fossil plants from these strata, placed them in various positions in the sections of Texas formations which he published at different times.

Hill clearly recognized their equivalence with the Dakota sandstone but quite rightly objected to the indiscriminate use of that term and fortunately decided to apply the local name.

CHARACTER OF MATERIALS.

The Woodbine materials are largely current-bedded sands, generally white and friable where nonferruginous, in places brownish and consolidated by iron oxide, containing extensive to small lenses of more or less carbonaceous laminated clays with some interbedded layers of lignite or lignitic clay. They give rise to sandy soils strewn with fragments of ferruginous sandstone and siliceous ironstone.

The limits of the Woodbine are uncertain. It is said to be unconformable with the underlying Denison formation of the Washita group and to pass without a break into the overlying Eagle Ford formation. Taff[7] described the formation under the name Dakota sand and divided it into Timber Creek beds, Dexter sand, and basal clay. Hill combined the lower two divisions under the name Dexter sands and renamed the upper division the Lewisville beds because Timber Creek was preoccupied. The fossil plants described in the present report are said to come from Hill's Dexter sand member, the overlying Lewisville member, which makes up from 50 to 100 feet of the several hundred feet of total thickness of the Woodbine, being marine and so far as known lacking determinable fossil plants.

The Woodbine sediments from a maximum thickness of 300 to 500 feet in the Red River

[5] Hill, R. T., op. cit., p. 294.

[6] Am. Jour. Sci., 3d ser., vol. 33, pp. 291–303, 1887.

[7] Taff, J. A., Texas Geol. Survey Fourth Ann. Rept., p. 285, 1892.

valley thin toward the south or are replaced by different lithologic facies which have received other names and whose equivalence has not been determined. No representative of the Woodbine has been recognized in central Texas, where, according to Stephenson,[8] its age equivalent is absent or "lies in the relatively thin sediments that compose the Buda limestone, a supposition which seems highly improbable and which has no basis of known facts." A third alternative which I regard as more probable than the two advanced by Stephenson is that the leaf-bearing sands of Red River which are referred to the lower Woodbine are the time equivalent of what is called Eagle Ford in the Austin section. Either Woodbine time is represented there by the Buda limestone, which Stephenson states is highly improbable, or it is represented by a break in sedimentation, which seems to me equally improbable, or it is represented by the lower part of the Eagle Ford of that section.

FAUNA.

The fauna of the Woodbine, which comes from the upper part, or the Lewisville marine member, is not extensive, but certain species are individually abundant at some localities. It comprises an almost unique assemblage of shallow-water forms as identified by Cragin, including the following:

Arca galliennei var. tramatensis Cragin.
Ostrea soleniscus Meek.
Modiola filisculpta Cragin.
Aguileria cumminsi White.
Cytherea leveretti Cragin.
Trigonarca siouxensis (Hall and Meek).
Turritella renauxiana D'Orbigny.
Cerithium tramatensis Cragin.
Cerithium interlineatum Cragin.
Pteria salinensis White?
Natica humilis Cragin.

It contains also a considerable number of additional forms including ammonites, not yet determined. It is unfortunate that no adequate study of the Woodbine fauna has ever been made.

FLORA.

The flora of the Woodbine sand described in the following pages amounts to only 43 species. It is hence inadequate for a correct estimate of its botanic facies, and the absence of forms normally present in beds of equivalent age may, with much probability, be attributed to their lack of discovery in the Woodbine, for as far as it goes it is a perfectly normal assemblage of forms such as would be expected at this horizon. There are no known ferns or lower plants present, presumably because of the coarseness of the sediments and the trituration to which most of the plants have evidently been subjected.

Only two gymnosperms are represented, a *Podozamites* and a *Brachyphyllum*. In this respect the Woodbine flora is more like the Dakota flora than it is like the corresponding floras of the Atlantic Coastal Plain, in which conifers are usually abundant individually and varied specifically. No monocotyledonous angiosperms have been recognized in the Woodbine, and this lack, like that of the ferns, is probably to be attributed to macerating and triturating water action.

The dicotyledons, which comprise 41 of the 43 identified forms, represent 31 genera in 21 families and 15 orders. They are well scattered among the families usually represented in Upper Cretaceous floras. Elements that are conspicuous by their absence when the Woodbine flora is compared with the Tuscaloosa flora of the eastern Gulf area, for example, are the numerous species of figs and magnolias, for there are only two of each of these types in the Woodbine, and one of the figs is a Dakota sandstone species and not a Coastal Plain species. Other notable absentees are *Menispermites*, *Bauhinia*, *Liriodendropsis*, *Leguminosites*, *Celastrophyllum*, *Grewiopsis*, *Pterospermites*, *Sapotacites*, and other less significant genera. The genus *Celastrophyllum* is especially abundant in the Tuscaloosa, in which 12 species have been recognized, and it is almost equally abundant in the Raritan formation.

No genus is represented in the Woodbine by more than two species except the form genus *Carpolithus*. The largest family is the Lauraceae, with eight species; no other family has more than three species, and only two families, the Salicaceae and Magnoliaceae, reach that number. Similarly the largest order is the Thymeleales, with eight species, and the only order that approaches it in size is the Ranales, with five species.

[8] Stephenson, L. W., U. S. Geol. Survey Prof. Paper 120, p. 145, 1918.

The flora, as at present known, is inadequate to indicate the environment in which the plants lived, but it clearly contains no unusual features, and I can see no reasons for supposing that the physical conditions were different from those which have been predicated from the much larger floras of the Tuscaloosa, Raritan, and Magothy formations, which have been discussed at length in various publications. A systematic list of the Woodbine flora at Arthurs Bluff follows:

Gymnospermae:
- Podozamites lanceolatus (Lindley and Hutton) F. Braun.
- Brachyphyllum macrocarpum formosum Berry.

Dicotyledonae:
- Myricales:
  - Myricaceae:
    - Myrica emarginata Heer.
    - Myrica longa (Heer) Heer.
- Salicales:
  - Salicaceae:
    - Salix lesquereuxii Berry.
    - Salix deleta Lesquereux?
    - Populus harkeriana Lesquereux.
- Urticales:
  - Moraceae:
    - Ficus daphnogenoides (Heer) Berry.
    - Ficus glascoeana Lesquereux.
- Platanales:
  - Platanaceae:
    - Platanus latior (Lesquereux) Knowlton.
- Ranales:
  - Magnoliaceae:
    - Magnolia speciosa Heer.
    - Magnolia lacoeana Lesquereux.
    - Liriodendron quercifolium Newberry.
  - Trochodendraceae:
    - Trochodendroides rhomboideus (Lesquereux) Berry.
  - Ranunculaceae?
    - Dewalquea insigniformis Berry.
- Rosales:
  - Caesalpiniaceae:
    - Palaeocassia laurinea Lesquereux.
  - Papilionaceae:
    - Colutea primordialis Heer.
- Sapindales:
  - Sapindaceae:
    - Sapindus morrisoni Heer.
  - Anacardiaceae:
    - Rhus redditiformis Berry.
- Rhamnales:
  - Rhamnaceae:
    - Rhamnus tenax Lesquereux.
    - Zizyphus lamarensis Berry.
  - Vitaceae:
    - Cissites formosus Heer.

Dicotyledonae—Continued.
- Malvales:
  - Sterculiaceae:
    - Sterculia lugubris Lesquereux.
- Thymeleales:
  - Lauraceae:
    - Benzoin venustum (Lesquereux) Knowlton.
    - Malapoenna falcifolia (Lesquereux) Knowlton.
    - Oreodaphne alabamensis Berry.
    - Cinnamomum newberryi Berry.
    - Cinnamomum membranaceum (Lesquereux) Hollick.
    - Laurus plutonia Heer.
    - Laurus antecedens Lesquereux.
    - Laurophyllum minus Newberry.
- Myrtales:
  - Myrtaceae:
    - Myrtonium geinitzi (Heer).
- Umbellales:
  - Araliaceae:
    - Aralia wellingtoniana Lesquereux.
    - Aralia saportana Lesquereux.
  - Cornaceae:
    - Cornophyllum vetustum Newberry.
- Ericales?:
  - Andromeda novaecaesareae Hollick.
  - Andromeda snowii Lesquereux.
- Ebenales:
  - Ebenaceae:
    - Diospyros primaeva Heer.
- Rubiales:
  - Caprifoliaceae:
    - Viburnum robustum Lesquereux.
- Position uncertain:
  - Tricalycites papyraceus Newberry.
  - Carpolithus sp. 1.
  - Carpolithus sp. 2.
  - Carpolithus sp. 3.

AGE OF THE FLORA.

RELATION TO THE FLORAS OF OTHER UPPER CRETACEOUS FORMATIONS OF THE COASTAL PLAIN.

Relation to the Bingen sand flora.—The geographically nearest flora to that of the Woodbine sand is that found in the Bingen sand of Arkansas. The Bingen is generally recognized as being, in part, at least, the equivalent of the Woodbine and also as representing all the Upper Cretaceous of Arkansas below the *Exogyra ponderosa* zone. The latter fact is of especial importance in the final determination of the age of the Woodbine, for if the Bingen in its easternmost exposures represents the whole of the interval represented in northern Texas by the Woodbine and Eagle Ford formations there is no apparent reason why a part of the

Woodbine may not also represent the Eagle Ford. Such a conclusion would be in accord with the evidence of the fossil plants.

The flora of the Bingen sand is known only from a small collection made by H. D. Miser in Pike and Howard counties, Ark.[9] It comprises but 27 named forms, and these are not all from one level; hence comparisons between it and that of the Woodbine are limited. In spite of this the Woodbine contains nine species that are common to the Bingen sand, including the *Dewalquea*, which is common in the upper Bingen and is confined to these two formations.

The upper Bingen was considered by me as the equivalent of the upper part of the Tuscaloosa and the Eutaw formation of the eastern Gulf area, and the lower Bingen as the equivalent of the lower Tuscaloosa and the Raritan formation.

Unfortunately for ease of correlation and intelligible discussion all the Upper Cretaceous formations of the Coastal Plain have been based upon lithologic differences instead of upon their contained faunas and floras, and as they overlap and intergrade laterally the limits of the same formation are not chronologically equivalent from locality to locality, so that precision in correlation must await the discovery and study of much more extensive paleontologic materials than are available at the present time.

Although the Bingen has been separated by Miser into upper and lower members, the known flora was found near the top of the lower member and near the base of the upper member and hence could not be expected to be as decisive as if it represented both earlier and later Bingen time. The present Woodbine flora comes from a single horizon and locality, and what the other 300 to 500 feet of the Woodbine would show if the flora were known in its entirety can only be surmised. Hence, inasmuch as names must be used in any discussion, it must be borne in mind that when I speak of the Woodbine flora or Woodbine sand my data are derived entirely from the single horizon represented at Arthurs Bluff on Red River. I can therefore only state the well-known fact that the Woodbine and Bingen formations are at least partly contemporaneous. I am of the opinion, which is based on the range of the Woodbine plants in other formations, that Arthurs Bluff is approximately on the boundary between the lower and upper members of the Bingen as recognized by Miser in Arkansas in the specific area where he collected the fossil plants.

Relation to Tuscaloosa flora.—The flora of the Tuscaloosa formation is extensive, comprising 151 described species, recently monographed.[10] The Tuscaloosa occupies the same stratigraphic position with respect to the Eutaw formation of the eastern Gulf area that the Woodbine does with respect to the Eagle Ford formation of the western Gulf area, and both the Eutaw and the Eagle Ford contain comparable marine faunal elements. The Tuscaloosa formation has been shown to be progressively younger when traced northward from western central Alabama, and in the report just cited I have shown its delta character and probable chronologic equivalence with a part of the marine Eutaw formation.

I suspect that the Woodbine might also be interpreted as made up of continental, delta, and marginal deposits, with similar relations to the marine Eagle Ford, but I have no basis for this inference except the writings of others. This would afford an excellent subject for field study. The Woodbine and Tuscaloosa floras have 22 species in common, so that it seems clear that the Woodbine and Tuscaloosa formations are equivalent, at least in part. Whether the Tuscaloosa elements that are conspicuously absent in the Woodbine represent real or only apparent differences can not be determined. I incline to the opinion that these differences are only apparent.

Relation to floras of other formations of the Coastal Plain.—The relation or degree of resemblance between the Woodbine flora and that of geographically more remote formations of the Atlantic Coastal Plain is well shown in the accompanying table of distribution. The Woodbine contains 20 species common to the Raritan, 18 common to the Magothy of the New Jersey-Maryland region, and 25 common to the two combined, thus emphasizing a well-known floral similarity seen throughout the Coastal Plain. This may mean that the Woodbine is equivalent to the upper Raritan and the Magothy, or simply that it is equivalent to the

[9] Berry, E. W., Torrey Bot. Club Bull., vol. 44, pp. 167–190, pl. 7, 1917.

[10] Berry, E. W., U. S. Geol. Survey Prof. Paper 112, 1919.

Magothy, as a great many upper Raritan species survived into Magothy time. There are nine species common to the Woodbine and Black Creek formations, but six of these are widespread and long-lived forms without especial significance. Five of the Woodbine species are common to the Eutaw flora, and one extends as high as the Ripley formation of the eastern Gulf area.

RELATION TO THE FLORA OF THE DAKOTA SANDSTONE.

The flora of the Dakota sandstone is very large, embracing over 400 described species. It is also very obviously not all of the same age, but outside of certain areas in Kansas and Nebraska no data are available for determining what part of Dakota flora came from beds that merit that term and what part came from beds since discovered or suspected to be different.

Of the 43 Woodbine plants 30 are species of the Dakota sandstone flora. The community of facies is thus very great, and it is significant that of these 30 common species all but 10 are forms which their range in other formations proves to represent what for want of a better term might be termed the true Dakota flora, and three of these 10 are only doubtfully determined from the Morrison formation in Colorado [11] and these three occur definitely in the Tuscaloosa, Raritan, and Magothy formations, so that really 23 of the Woodbine plants are true Dakota forms. I regard the Woodbine as synchronous with this undelimited Dakota sandstone, which I regard as bearing the same relation to the Benton as the Woodbine does to the Eagle Ford and the Tuscaloosa does to the Eutaw.

RELATION TO THE FLORA OF THE CHEYENNE SANDSTONE.

The relations between the Woodbine flora and that of the Mentor formation of central Kansas are unknown and will remain so until the Mentor flora is carefully collected and studied. The Cheyenne sandstone of southern Kansas contains a considerable flora, recently studied by me, but there is not a single species common to the Woodbine and Cheyenne. Although both floras consist largely of so-called Dakota forms, some of these in the Cheyenne sandstone are forms that may have come originally from the unrecognized Cheyenne sandstone or the supposed equivalent Mentor formation, and not from the true Dakota sandstone. The majority lack an outside distribution.

The Woodbine plants, on the other hand, as shown by the comparisons in the preceding sections, are nearly all well-known species of formations of known age of the Coastal Plain. There can not be the slightest doubt that the Woodbine sand is younger than the Cheyenne sandstone and synchronous with the true Dakota sandstone of the Western Interior. The Woodbine is also certainly younger than those beds in the West formerly confused with the Dakota and now known as the Purgatoire formation.

RELATION OF THE WOODBINE FLORA TO FLORAS OF OTHER AREAS.

None of the Woodbine species have been identified in the formations of the Montana group. Eight of the Woodbine species are found in the Atane beds and six in the Patoot beds of western Greenland.

The similarities of the flora to European Upper Cretaceous floras are reasonably close, but these similarities naturally seldom extend to the identical species, and where they do the particular forms are wide-ranging and long-lived species of slight value in precise correlation, as might be expected. The Woodbine contains five species common to European beds referred to the Cenomanian and three additional that are tentatively recognized at this European horizon. Similarly two species are identical with forms that occur in the European Turonian. None of the species are known in the Emscherian of Europe, although *Dewalquea insigniformis* of the Woodbine is, as its name indicates, very close to the European Senonian species *Dewalquea insignis* Debey.

The intrinsic character of the Woodbine flora necessitates considering it as either Cenomanian or Turonian when judged according to European standards. From its relationship with other more extensive formations of the Coastal Plain such as the Tuscaloosa and Magothy, in which the evidence is clearer, I would be inclined to consider the Woodbine flora as of Turonian age.

[11] Knowlton, F. H., Am. Jour. Sci., 4th ser., vol. 49, pp. 189–194, 1920.

Outside distribution of Woodbine flora.

	Dakota sandstone.	Tuscaloosa formation.	Bingen sand.	Raritan formation.	Magothy formation.	Black Creek formation.	Eutaw formation.	Ripley formation.	Atane beds.	Patoot beds.	Morrison formation.	Cenomanian.	Turonian.
Podozamites lanceolatus	×			×	×							×	
Brachyphyllum macrocarpum formosum		×			×	×	×					?	
Myrica emarginata	×	×		×					×				
Myrica longa	×	×	×		×				×	×			×
Salix lesquereuxii	×	×	×	×	×	×	×				?	×	
Salix deleta?	×												
Populus harkeriana	×			×									
Ficus daphnogenoides	×	×	×	×	×	×					?		
Ficus glascoeana	×												
Platanus latior	×	×											
Magnolia speciosa	×	×		×	×						?	×	
Magnolia lacoeana	×	×		×	×								
Liriodendron quercifolium			×	×									
Trichodendroides rhomboideus	×												
Dewalquea insigniformis			×										
Palaeocassia laurinea	×	×											
Colutea primordialis	×		×	×	×				×				
Sapindus morrisoni	×	×	×	?	×	×			×	×			
Rhus redditiformis													
Rhamnus tenax	×	×										?	
Zizyphus lamarensis		×											
Cissites formosus	×	×		×						×			
Sterculia lugubris	×												
Benzoin venustum	×												
Malapoenna falcifolia	×	×			×								
Oreodaphne alabamensis		×											
Cinnamomum newberryi	×	×	×	×	×	×	×	×	×	×		?	
Cinnamomum membranaceum	×				×								
Laurus plutonia	×	×		×	×	×	×		×	×		?	
Laurus antecedens?	×				×								
Laurophyllum minus?				×									
Myrtonium geinitzi	×	×		×	×	×			×			×	×
Aralia wellingtoniana	×			×									
Aralia saportana?	×												
Cornophyllum vetustum		×		×									
Andromeda novae-caesareae		×	×	×	×	×							
Andromeda snowii	×												
Diospyros primaeva	×	×		×	×	×	×		×	×		×	
Viburnum robustum	×												
Tricalycites papyraceus		×		×	×								

SYSTEMATIC ACCOUNT OF THE FLORA.

Phylum CYCADOPHYTA.

Genus PODOZAMITES F. Braun.

Podozamites lanceolatus (Lindley and Hutton) F. Braun.

Plate XXXVI, figure 2.

Podozamites lanceolatus (Lindley and Hutton) F. Braun, in Münster, Beiträge zur Petrefactenkunde, vol. 2, pt. 6, p. 53, 1843.

Dawson, Roy. Soc. Canada Trans., vol. 3, sec. 4, p. 6, pl. 1, fig. 3, 1886.

Lesquereux, U. S. Geol. Survey Mon. 17, p. 28, pl. 1, figs. 5, 6, 1892.

Newberry, U. S. Geol. Survey Mon. 26, p. 44, pl. 13, fig. 2 [not figs. 1, 3, 4], 1896.

Penhallow, Canada Geol. Survey Summary Rept. 1904, p. 9, [1905].

Fontaine, in Ward, U. S. Geol. Survey Mon. 48, p. 110, pl. 24, figs. 17–20, 1905; U. S. Geol. Survey Twentieth Ann. Rept., pt. 2, p. 360, pl. 63, fig. 4; pl. 66, fig. 4; pl. 67, figs. 3, 4, 1900.

Knowlton, Smithsonian Misc. Coll., vol. 50, p. 120, 1907; U. S. Geol. Survey Prof. Paper 85, p. 52, 1914.

Hollick, U. S. Geol. Survey Mon. 50, p. 35, pl. 2, fig. 1, 1907; New York Bot. Garden Bull., vol. 8, p. 155, pl. 162; pl. 163, figs. 2, 3, 1912.

Berry, Torrey Bot. Club Bull., vol. 39, p. 391, 1913; Maryland Geol. Survey, Lower Cretaceous, p. 341, pl. 53, figs. 5, 6, 1911; Torrey Bot. Club Bull., vol. 38, p. 410, 1911; Maryland Geol. Survey, Upper Cretaceous, p. 772, 1916.

Pinnis distantibus, alternis oppositisve, elongatis, basi sensim angustatis, inferioribus lanceolato-linearibus, superioribus elongato-ellipticis; nervis crebris.—Schimper, 1870.

This is a species of great geologic range, being recorded from the Jurassic to the Upper Cretaceous. The geographic range is equally extensive, embracing two continents, North America and Europe. It is quite probable that the species is composite, but no certain grounds for segregation are apparent.

Some students may doubt the wisom of correlating both Lower and Upper Cretaceous forms with a species which is essentially a Jurassic type, but specific differentiation founded merely upon stratigraphy has gone astray so often that in cases like the present synthesis may well precede analysis, and it might be added that this was the view taken by Hollick[12] with reference to material from Glen Cove, Long Island, and by Velenovsky [13] in studying the Cenomanian flora of Bohemia.

Forms indistinguishable from the type of this species occur in both the Patuxent and Patapsco formations of the Potomac group, as well as in the Kootenai, Dakota, Black Creek, Raritan, and Magothy formations.

Phylum CONIFEROPHYTA.

Genus BRACHYPHYLLUM Brongniart.

Brachyphyllum macrocarpum formosum Berry.

Plate XXXVI, figure 1.

Brachyphyllum macrocarpum Berry, Torrey Bot. Club Bull., vol. 38, p. 183, 1910 (not Newberry, 1896); vol. 38, p. 420, 1911.

Brachyphyllum macrocarpum formosum Berry, idem, vol. 39, p. 392, pl. 30, 1912; U. S. Geol. Survey Prof. Paper 84, p. 106, 1904; Prof. Paper 112, p. 59, pl. 5, fig. 9, 1919.

Slender elongated twigs, pinnately branched, covered with medium-sized crowded, appressed leaves, spirally arranged. Leaves bluntly pointed, smooth, thick.

In the consideration of the various specimens which have been referred to *Brachyphyllum macrocarpum*, a very considerable variation within certain fixed limits is at once obvious. This variation is usually one of size, the more slender specimens being at the same time smoother. This characteristic has been frequently noted by me and is commented upon in print by Knowlton,[14] who in discussing the younger forms from Wyoming suggests that the species on the verge of extinction became smaller in its proportions. In studying the material from the South Atlantic and Gulf States a constant difference in size was noticed. This may reflect a slight difference in climatic conditions, and all the forms may be interpreted as the variations of a single species—in fact, the specimen from the Raritan formation in New Jersey illustrated in Newberry's figure 7 [15] is approximately of the same size as the forms from the Montana group of the West and is associated with the normal stout, club-shaped type. That the variety has no particular stratigraphic significance is indicated by its abundance at a horizon as low as the basal part of the Tuscaloosa of Alabama and its presence in the Woodbine sand of Lamar County, Tex. In general the present variety occurs in later and more southern beds than the type, a difference which might be ascribed to the fact that only the slender terminal twigs are preserved. This explanation is regarded as improbable, however, for the same reasoning should hold good for the areas where only thicker twigs have been found.

The remains are usually much macerated and broken, and the immediate cause for the recognition of a new variety was the discovery of a relatively large specimen from the Magothy formation of Maryland, which showed such striking unlikeness to the type that separation was demanded and specific differentiation was even considered. In view, however, of the occurrence of both forms in association in Maryland and the well-known variation not only of the type but of coniferous foliage in general, it seemed wiser to consider the present form as a variety of the type, which as time progressed supplanted it to a large extent if not altogether.

The new specimen from Maryland showed the terminal part of two approximately parallel and curved twigs about 12 centimeters in length, united proximad. These in their largest portion are only 6 millimeters in diameter. At intervals of 3 to 5 millimeters subopposite lateral branches are given off in a pinnate manner. These are relatively much elongated, curved, and slender, averaging about 4 centimeters in length by 2 millimeters

[12] Hollick, Arthur, U. S. Geol. Survey Mon. 50, p. 35, 1906.

[13] Velenovsky, Josef, Die Gymnospermen der böhmischen Kreideformation, p. 11, pl. 2, figs. 11–19, 24, 1885.

[14] Knowlton, F. H., U. S. Geol. Survey Bull. 163, p. 29, pl. 4, figs. 5, 6, 1900.

[15] Newberry, J. S., U. S. Geol. Survey Mon. 25, pl. 7, figs. 1–7, 1896.

in diameter, bluntly pointed, and not tapering to any appreciable extent. A few of these lateral branches fork pseudodichotomously, and some of them give off toward their distal ends tiny lateral branchlets less than 1 centimeter in length and about 1 millimeter in diameter.

The general proportions are thus decidedly different from those of the supposed parent type. The leaves are slightly smaller and smoother and relatively somewhat more elongated, at the same time lacking the apical papilla and the convergent striae. The form is much more graceful in appearance than the type and in its general aspect suggests the Lower Cretaceous genus *Arthrotaxopsis* of Fontaine.

While tiny species of *Brachyphyllum* like *Brachyphyllum microcladum* Saporta, of the Neo-Jurassic, have been described, the new variety is even more slender than *Brachyphyllum gracile* Brongniart, of the Jurassic. The most closely allied form known appears to be one from the Albian of Buarcos, in Portugal, described by Saporta [16] as *Brachyphyllum obesiforme elongatum*. The present form also shows considerable resemblance to *Brachyphyllum crassicaule* Fontaine, of the Patapsco formation in Maryland and Virginia.

This variety is abundant throughout the Tuscaloosa formation and in the basal part of the Eutaw formation in Alabama and western Georgia and occurs also in the Woodbine sand of Texas but is known in Maryland only from a single locality. It is also confined to a single locality in North Carolina, where it is not at all uncommon but is not especially well preserved.

Phylum ANGIOSPERMOPHYTA.

Class DICOTYLEDONAE.

Order MYRICALES.

Family MYRICACEAE.

Genus MYRICA De Candolle.

Myrica emarginata Heer.

Myrica emarginata Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 66, pl. 41, fig. 2, 1882.
Lesquereux, The flora of the Dakota group, p. 67, pl. 12, fig. 1, 1892.
Newberry, The flora of the Amboy clays, p. 62, pl. 41, figs. 10, 11, 1896.
Berry, New Jersey Geol. Survey Bull. 3, p. 104, pl. 10, fig. 5, 1911; U. S. Geol. Survey Prof. Paper 112, p. 73, pl. 13, fig. 4, 1920.

[16] Saporta, Gaston de, Contributions à la flore fossile du Portugal, p. 176, pl. 31, fig. 14, 1894.

Heer's description, published in 1882, is as follows:

M. foliis oblongis, integerrimis, apice emarginatis, basi attenuatis, nervis secundariis subtilissimis.

This species, which was described from specimens collected in the Atane beds of Greenland, has been recorded from the Raritan and Tuscaloosa formations of the Atlantic Coastal Plain and from the Dakota sandstone of the Western Interior. It is somewhat variable in form but may be characterized as follows:

Leaves obovate, widest at the rounded, truncate, and more or less emarginate apex, with entire margins narrowing to the cuneate base. Midrib mediumly stout. Secondaries, five thin pairs, subopposite, diverging from the midrib at angles of about 45°, camptodrome.

The reference of this species to the genus *Myrica* is entirely problematic. It is astonishingly close to a form from Niederschoena, Saxony, described by Engelhardt [17] as *Mimusops ballotaevides*.

Myrica longa (Heer) Heer.

Plate XXXIX, figure 5.

Proteoides longus Heer, Flora fossilis arctica, vol. 3, Abt. 2, p. 110, pl. 29, fig. 8b; pl. 31, figs. 4, 5, 1874.
Dawson, Roy. Soc. Canada Trans., vol. 1, sec. 4, p. 22, pl. 2, fig. 8, 1883.
Frič, Archiv naturw. Landes. Böhmen, vol. 4, No. 1, pp. 18, 94, 1878.
Myrica longa (Heer) Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 65, pl. 18, fig. 9b; pl. 29, figs. 15–17; pl. 33, fig. 10; pl. 41, fig. 4d, 1882; vol. 7, p. 21, 1883.
Lesquereux, U. S. Geol. Survey Mon. 17, p. 67, pl. 3, figs. 1–6, 1892.
Bartsch, Iowa Univ. Lab. Nat. Hist. Bull., vol. 3, p. 180, 1896.
Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 314, pl. 39, fig. 7, 1901.
Berry, Torrey Bot. Club Bull., vol. 33, p. 170, 1906; Maryland Geol. Survey, Upper Cretaceous, p. 812, pl. 57, figs. 1–3, 1916; Torrey Bot. Club Bull., vol. 44, p. 175, 1917; U. S. Geol. Survey Prof. Paper 112, p. 74, 1919.

Leaves of various sizes, linear to lanceolate, with a stout midrib, numerous thin, ascending, camptodrome secondaries, entire margins, obtusely pointed apex, narrowly decurrent base, and long, stout petiole.

This species, which Heer described as a *Proteoides* and subsequently transferred to the genus *Myrica*, has a particularly wide

[17] Engelhardt, Hermann, Naturwiss. Gesell. Isis in Dresden Abh. 7. Jahrg. 1891, p. 98, pl. 2, fig. 13, 1892.

distribution. It occurs in both the Atane and Patoot beds of western Greenland, in the Dakota sandstone of the West, in the Magothy formation of Maryland, and in the Bingen sand of Arkansas and is very common in the Tuscaloosa formation in western central Alabama. Abroad it has been recorded from the lower Turonian of Bohemia. Dawson recorded it from Peace River in Northwest Territory.

It occurs in the Dakota sandstone in Woodbury County, Iowa, in Ellsworth County, Kans., and near Lander, Wyo. It is thus a member of the true Dakota sandstone flora. This is also emphasized by its distribution in the Upper Cretaceous of the Atlantic Coastal Plain.

Although abundant this species lacks good diagnostic characters, and its botanical affinity is therefore uncertain. Its relation to *Myrica* is extremely doubtful.

Order SALICALES.

Family SALICACEAE.

Genus SALIX Linné.

Salix lesquereuxii Berry.

Salix lesquereuxii Berry, Torrey Bot. Club Bull., vol. 36, p. 252, 1909; vol. 37, pp. 21, 194, 1910; New Jersey Geol. Survey Bull. 3, p. 114, 1911; U. S. Geol. Survey Prof. Paper 84, pp. 33, 109, pl. 7, figs. 11–13, 1914; Maryland Geol. Survey, Upper Cretaceous, p. 814, pl. 58, figs. 5–8, 1916; Torrey Bot. Club Bull., vol. 44, p. 176, 1917; U. S. Geol. Survey Prof. Paper 112, p. 76, 1919.

Salix proteaefolia Lesquereux, Am. Jour. Sci., 2d ser., vol. 46, p. 94, 1868 (not Forbes); The Cretaceous flora, p. 60, pl. 5, figs. 1–4, 1874; The Cretaceous and Tertiary floras, p. 42, pl. 1, figs. 14–16, pl. 16, fig. 3, 1883; The flora of the Dakota group, p. 49, 1892.

Newberry, The flora of the Amboy clays, p. 66, pl. 18, figs. 3, 4, 1896.

Kurtz, Mus. La Plata Rev., vol. 10, p. 51, 1902.

Berry, New Jersey Geol. Survey Ann. Rept. for 1905, p. 139, 1906; Torrey Bot. Club Bull., vol. 33, p. 171, pl. 7, fig. 2, 1906; Johns Hopkins Univ. Circ., new ser., No. 7, p. 81, 1907.

Salix proteaefolia longifolia Lesquereux, The flora of the Dakota group, p. 50, pl. 44, fig. 9, 1892.

Bartsch, Iowa Univ. Lab. Nat. Hist. Bull., vol. 3, p. 179, 1896.

Proteoides daphnogeoides Heer. Newberry, The flora of the Amboy clays, p. 72 (part), pl. 32, fig. 11, 1896.

Dewalquea groenlandica Heer. Newberry, The flora of the Amboy clays, p. 129 (part), pl. 41, fig. 12, 1896.

Leaves ovate-lanceolate, somewhat more acuminate above than below, variable in size, ranging from 6 to 12 centimeters in length and from 1.1 to 2.2 centimeters in greatest width, which is usually slightly below the middle. Petiole stout, much longer than in *Salix flexuosa*, having a maximum length of 1.2 centimeters. Midrib stout below, tapering above. Secondaries numerous, in some specimens as many as 20 pairs; they branch from the midrib at angles of about 45° and are subparallel and camptodrome.

This species is exceedingly variable, as might be expected in a *Salix*, and Lesquereux established several varieties, of which at least one, *linearifolia*, is referable to *Salix flexuosa* Newberry. Some of Lesquereux's forms are distinguishable with difficulty from *Salix flexuosa*, and this is especially shown in the leaves which he figures on Plate I of his "Cretaceous and Tertiary floras." They are, however, larger and somewhat more robust, of a thicker texture and broadest near the base, from which they taper upward to an exceedingly acuminate tip. In general *Salix lesquereuxii* is a relatively much broader, more ovate form, with more numerous and better seen secondaries and a longer petiole.

This species is an exceedingly abundant Upper Cretaceous type in both the East and the West, ranging chronologically in the Coastal Plain from the base of the Raritan formation to the top of the Tuscaloosa formation, and possibly through the Eutaw formation as well. It is abundant in the Magothy and Black Creek formations, including the Middendorf arkose member of the Black Creek. It is widespread from the bottom to the top of the Tuscaloosa formation in Alabama and occurs in the Bingen sand of Arkansas. In the West it is a member of the Dakota sandstone flora and is not present in the older Cheyenne sandstone flora, nor is it known from beds younger than the Dakota sandstone in that region. It is one of the forms recorded by Kurtz from the Upper Cretaceous of Argentina, indicating, if the identification is correct, which is doubtful, a very considerable migration during early Upper Cretaceous time.

Recently Knowlton[18] has tentatively identified this species from the type section of the Morrison formation in Colorado.

[18] Knowlton, F. H., Am. Jour. Sci., 4th ser., vol. 49, p. 190, 1920.

Salix deleta Lesquereux.

Salix deleta Lesquereux, U. S. Geol. Survey Mon. 17, p. 49, pl. 3, fig. 8, 1891 [1892].

Leaves ovate-lanceolate and subfalcate, widest below the middle and tapering gradually upward to the bluntly pointed tip and downward to the cuneate inequilateral base. Margins entire. Texture subcoriaceous. Length about 8.5 centimeters, maximum width about 2.7 centimeters. Midrib stout and prominent. Secondaries numerous, diverging from the midrib at angles of about 50°, subparallel, camptodrome. Areolation quadrangular.

This species was described originally by Lesquereux from Pipe Creek, Cloud County, Kans., and so far as known is confined to the Dakota sandstone and the Woodbine sand. Its relationship to the genus *Salix* is extremely problematic and, in my judgment, is far from demonstrated. The leaf has the appearance of a leaflet of some member of the Sapindaceae, but the amount of material available for study is insufficient to warrant final conclusions.

Genus POPULUS Linné.

Populus harkeriana Lesquereux.

Populus harkeriana Lesquereux, U. S. Geol. Survey Mon. 17, p. 44, pl. 46, fig. 4, 1891 [1892].

Hollick, New York Acad. Sci. Annals, vol. 2, p. 419, pl. 36, fig. 8, 1898; U. S. Geol. Survey Mon. 50, p. 49, pl. 7, fig. 31, 1906.

Berry, Torrey Bot. Club Bull., vol. 39, p. 394, 1912.

This species was described by Lesquereux from material collected in the Dakota sandstone at Fort Harker, Kans., and was subsequently recorded by Hollick from the Cretaceous material (Raritan or Magothy) in the terminal moraine near Tottenville, Staten Island. The collection from Arthurs Bluff, Tex., contains a single specimen and its counterpart, showing half of a large typical leaf of this species. There is also an undeterminable species of the *Populus* type in the collection.

Order URTICALES.

Family MORACEAE.

Genus FICUS Linné.

Ficus daphnogenoides (Heer) Berry.

Plate XXXIX, figure 1.

Proteoides daphnogenoides Heer, Phyllites crétacées du Nebraska, p. 17, pl. 4, figs. 9, 10, 1866.

Lesquereux, The Cretaceous flora, p. 85, pl. 15, figs. 1, 2, 1874; The flora of the Dakota group, p. 90, 1892.

Hollick, New York Acad. Sci. Trans. vol. 11, p. 98, pl. 3, figs. 1, 2, 1892; vol. 12, p. 36, pl. 2, figs. 4, 9, 13, 1893; Torrey Bot. Club Bull., vol. 21, p. 52, pl. 177, fig. 1, 1894; The Cretaceous flora of southern New York and New England, p. 59, pl. 12, figs. 1–5, 1906.

Smith, On the geology of the Coastal Plain of Alabama, p. 348, 1894 (determined by Ward).

Newberry, The flora of the Amboy clays, p. 72, pl. 17, figs. 8, 9; pl. 32, figs. 11, 13, 14; pl. 33, fig. 3; pl. 41, fig. 15, 1896.

Berry, New York Bot. Garden Bull., vol. 3, p. 74, pl. 51, figs. 6–9, 1903.

Ficus daphnogenoides (Heer) Berry, Torrey Bot. Club Bull., vol. 32, p. 327, pl. 21, 1905; vol. 33, p. 173, pl. 7, fig. 5, 1906; vol. 34, p. 194, pl. 11, figs. 10, 11, 1907; New Jersey Geol. Survey Bull. 3, p. 122, pl. 12, fig. 4, 1911; Torrey Bot. Club Bull., vol. 39, p. 394, 1912; vol. 44, p. 177, 1917; Maryland Geol. Survey, Upper Cretaceous, p. 818, pl. 58, fig. 3, 1916; U. S. Geol. Survey Prof. Paper 112, p. 80, pl. 13, figs. 6, 7, 1919.

Ficus proteoides Lesquereux, The flora of the Dakota group, p. 77, pl. 12, fig. 2, 1892.

Eucalyptus? attenuata Newberry, The flora of the Amboy clays, pl. 16, fig. 5 (not figs. 2, 3), 1896.

Heer's description, published in 1866, is as follows:

Les feuilles sont coriaces, à la base atténuées, entières; la nervure médiane est forte; elle porte deux nervures secondaires faibles, acrodromes, qui sont presque parallèles au limbe; mais elles ne sont pas opposées, comme chez les *Daphnogene* et *Cinnamomum*.

This species was described by Heer from very incomplete material found in the Dakota sandstone of Nebraska. His specimens have some long ascending secondaries, but Lesquereux's more complete specimens from the same formation and region show that these secondaries were not acrodrome but camptodrome. The species in this feature and also in other respects differs from *Protea* and its allies, which are more coriaceous and have the secondaries branching at acute angles and massed toward the generally apetiolate base. It closely resembles a number of different existing species of *Ficus* from such widely separated localities as Central and South America and Celebes. Especially among the Mexican and Central American forms are very similar leaves seen—for example, *Ficus fasciculata* Watson, *Ficus lancifolia* Hooker and Arnott, *Ficus ligustrina* Kunth and Bouché, and especially *Ficus sapida* Miquel, which has much the same outline and consistency, the same prominent midrib, and the same venation. When the fossil forms are placed in

the genus *Ficus*, where they properly belong, they find their affinity in the group which includes, among others, such fossil species as *Ficus elongata* Hosius, *Ficus berthoudi* Lesquereux, *Ficus suspecta* Velenovsky, and *Ficus krausiana* Heer.

This species has been found to be variable in size, ranging in length from 11 to 22 centimeters and in width from 1.9 to 3.7 centimeters. It is usually widest in the lower half of the leaf, although in some specimens the base is narrow and the widest part is toward the middle. In all unequivocal material the upper half of the leaf is narrow and is produced as a long, slender, commonly recurved tip, which is one of the characteristic features of the species. This tip is strictly comparable with the "dripping points" developed on various modern leaves in the regions where precipitation is heavy.

Ficus daphnogenoides is a widespread and common form, ranging from Marthas Vineyard to Alabama, Arkansas, and Texas in the Atlantic Coastal Plain and from the Northwest Territory to Kansas and Nebraska in the Western Interior region.

It is a member of the Dakota sandstone flora and does not occur in the older Cheyenne sandstone so far as my observations go. It was reported by Ward from the Cheyenne sandstone at Chatman Creek, Kans., but Ward's material, which I have before me, is not this species but a leaflet of *Sapindopsis*. Knowlton[19] has recently tentatively identified this form from the type section of the Morrison formation at Morrison, Colo. The species is not uncommon in the Woodbine sand at Arthurs Bluff, Tex.

Ficus glascoeana Lesquereux.

Ficus glascoeana Lesquereux, U. S. Geol. Survey Terr. Rept., vol. 8 (Cretaceous and Tertiary floras), p. 48, 1883; U. S. Geol. Survey Mon. 17, p. 76, pl. 13, figs. 1, 2, 1891 [1892].

Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 317, 1901.

Leaves large, oblong-ovate in general outline, with an obtusely pointed apex and a broadly rounded or cuneate, ultimately slightly decurrent base. Length from 18 to 20 centimeters; maximum width, at or below the middle, 6.5 to 7.5 centimeters. Margins entire. Texture coriaceous. Surface polished. Petiole missing. Midrib very stout and prominent on the under surface of the leaf. Secondaries numerous, thin, diverging from the midrib at wide angles, subparallel, straight, ascending, joining one another by abrupt curves subparallel with and close to the margins.

This species, which is of the same general type as *Ficus atavina* Heer,[20] was described by Lesquereux from material collected 2½ miles south of Glascoe, Kans. So far as known it is confined to the Dakota sandstone and to the Woodbine sand at Arthurs Bluff, Tex., and the remains were usually much broken before fossilization. *Ficus atavina*, which is closely related to it, was also a stiff form, usually found in a broken condition. It has an extensive range, occurring in the Atane and Patoot beds of Greenland, the Magothy formation and the Middendorf arkose member of the Black Creek formation in the Atlantic Coastal Plain, the Turonian of Bohemia, and the Gosau beds of Tyrol. It seems very probable that *Ficus glascoeana* is genetically related to the more widely distributed *Ficus atavina*.

Order PLATANALES.

Family PLATANACEAE.

Genus PLATANUS Linné.

Platanus latior (Lesquereux) Knowlton.

Platanus aceroides? Goeppert var. *latior* Lesquereux, Am. Jour. Sci., 2d ser., vol. 46, p. 97, 1868.

Platanus latior (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 170, 1898; U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 314, 1901.

Berry, U. S. Geol. Survey Prof. Paper 112, p. 84, 1920.

Platanus primaeva Lesquereux, The Cretaceous flora, p. 69, pl. 7, fig. 2; pl. 26, fig. 2, 1874; The flora of the Dakota group, p. 72, pl. 8, figs. 7, 8b; pl. 10, fig. 1, 1892.

Leaves large, palmately trilobate, broadly rhomboidal. Length about 17 centimeters; maximum width about 15 centimeters. Margins somewhat irregularly dentate, entire at the broadly cuneate base. Lateral lobes short; intervening sinuses scarcely differentiated. Petiole long and stout. Primaries stout, three in number, diverging at or near the base in the material from Alabama but commonly suprabasilar in the forms from the Dakota sandstone. Venation strictly platanoid. Texture coriaceous.

[19] Knowlton, F. H., Am. Jour. Sci., 4th ser., vol. 49, p. 190, 1920.

[20] Heer, Oswald, Flora fossilis arctica, vol. 6, Abt. 2, p. 69, pl. 11, figs. 5b, 7b, 8b; pl. 17, fig. 8b; pl. 19, fig. 1b; pl. 20, figs. 1, 2, 1882.

This fine large species is very abundant in the Dakota sandstone of Kansas, Nebraska, and Minnesota, and Lesquereux differentiated three varieties, *integrifolia*, *subintegrifolia*, and *grandidentata*.

Order **RANALES.**

Family **MAGNOLIACEAE.**

Genus **MAGNOLIA** Linné.

Magnolia speciosa Heer.

Plate XL, figure 6.

Magnolia speciosa Heer, Allg. schweiz. Gesell. gesammt. Naturwiss. Bern Neue Denskchr., Band 23, p. 20, pl. 6, fig. 1; pl. 9, fig. 2; pl. 10, fig. 1, 1869.

Lesquereux, The Cretaceous and Tertiary floras, p. 72, 1874; The flora of the Dakota group, p. 202, pl. 60, figs. 3, 4, 1892.

Hollick, New York Acad. Sci. Trans., vol. 12, p. 234, pl. 7, fig. 4, 1893; Torrey Bot. Club Bull., vol. 21, p. 60, pl. 178, fig. 5, 1894; Geol. Soc. America Bull., vol. 7, p. 13, 1895; The Cretaceous flora of southern New York and New England, p. 64, pl. 19, figs. 1–4, 1906.

Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 318, 1901.

Smith, On the geology of the Coastal Plain of Alabama, p. 348, 1894.

Berry, Torrey Bot. Club Bull., vol. 31, p. 76, pl. 3, fig. 10, 1904; vol. 32, p. 46, pl. 2, figs. 4, 5, 1905; New Jersey Geol. Survey Bull. 3, p. 129, pl. 14, fig. 3, 1911; Torrey Bot. Club Bull., vol. 39, p. 395, 1912; U. S. Geol. Survey Prof. Paper 112, p. 88, pl. 18, figs. 3, 4, 1919.

Magnolia auriculata Newberry, The flora of the Amboy clays, p. 75 (part), pl. 41, fig. 13; pl. 58, fig. 10, 1896.

Heer's description, published in 1869, is as follows:

M. foliis maximis, coriaceis, ovato-ellipticis, apice longe attenuatis, valde acuminatis, basi in petiolum validum attenuatis, nervo primario crasso, nervis secundariis valde curvatis, camptodromis.

This species is somewhat variable in size. The American material, which is somewhat smaller than the type material from Moletein, Moravia, ranges in length from 8.5 to 19 centimeters and in maximum width from 4 to 7.5 centimeters. It is ovate-elliptical, with the apex more or less produced and the base decurrent. The midrib and petiole are stout. The secondaries are well marked, camptodrome; they number seven to nine pairs and are subopposite, branching from the midrib at angles of about 45° and curving upward. The texture is coriaceous.

This species, which was described originally from specimens collected in the Cenomanian of Moravia, has a wide range in America. Typical leaves occur in the Dakota sandstone. It is present on Marthas Vineyard and Long Island and in the Raritan and Magothy formations of New Jersey. It is present at Arthurs Bluff, Tex., and was recorded by Knowlton from the Woodbine at Rhamey Hill, Denison, Tex.

Magnolia lacoeana Lesquereux.

Magnolia lacoeana Lesquereux, The flora of the Dakota group, p. 201, pl. 60, fig. 1, 1892.

Newberry, The flora of the Amboy clays, p. 73, pl. 55, figs. 1, 2, 1896.

Hollick, The Cretaceous flora of southern New York and New England, p. 65, pl. 17, fig. 2, 1906.

Berry, Torrey Bot. Club Bull., vol. 37, p. 23, 1910; New Jersey Geol. Survey Bull. 3, p. 134, pl. 16, fig. 2, 1911; Maryland Geol. Survey, Upper Cretaceous, p. 832, pl. 70, figs. 1, 2, 1916; U. S. Geol. Survey Prof. Paper 112, p. 91, pl. 17, fig. 9, 1919.

Leaves broadly oval to almost orbicular, obtuse or abruptly pointed above and rounded to a somewhat cuneate base below, 10 to 12 centimeters in length by 8.5 to 9.5 centimeters in maximum width. Midrib stout, somewhat flexuous. Secondaries numerous, camptodrome, rather stout, 10 to 12 pairs; they branch from the midrib at acute angles, immediately curving outward, forming festoons near the margin, which is somewhat undulate in one specimen that Newberry referred to this species.

This species differs from its contemporaries, especially in its nearly round outline. Lesquereux finds a resemblance to *Magnolia inglefieldi* Heer, from Greenland, and it also suggests some of the Arctic forms which have been referred to *Magnolia capellinii* Heer.

Although this species is reported from points so widely separated as Marthas Vineyard and Kansas, it is nowhere abundant and is usually poorly preserved, suggesting that the leaves were readily macerated. It also occurs in the Magothy formation of New Jersey and Maryland and the Tuscaloosa formation of Alabama. The type locality was Ellsworth County, Kans., and the range elsewhere of this species would indicate that this locality was in the true Dakota sandstone.

Genus LIRIODENDRON Linné.

Liriodendron quercifolium Newberry.

Plate XXXVI, figure 3.

Liriodendron quercifolium Newberry, Torrey Bot. Club Bull., vol. 14, p. 6, pl. 62, fig. 1, 1887; U. S. Geol. Survey Mon. 26, p. 81, pl. 51, figs. 1–6, 1896.
Berry, New Jersey Geol. Survey Bull. 3, p. 138, pl. 17, fig. 1, 1911; Torrey Bot. Club Bull., vol. 39, p. 395, 1912; vol. 44, p. 182, 1917.
Liriodendron pinnatifidum? Knowlton (not Lesquereux), U. S. Geol. Survey Twenty-first Ann. Rept. pt. 7, p. 317, 1901.
Liriodendron snowii Knowlton (not Lesquereux), idem.

Leaves oblong, large, pinnately divided by narrow sinuses into two to four lateral lobes. Apex emarginate. Base truncate to somewhat cordate. Length along the midrib 7 to 9 centimeters and probably considerably more in some specimens, as one fragment measures 12 centimeters in width. Width in perfect specimens about 9 centimeters. Lateral lobes ovate, with very acute tips, some narrowed proximad, giving them an almost obovate outline; intervening lateral sinuses narrow and deeply cut, some reaching nearly to the midrib, rounded. Some specimens have only two main lobes developed on each side and are then very similar to the typical modern leaf of *Liriodendron tulipifera*. In these specimens, however, the upper lobes are divided by a shallow sinus into two acute lobules. Other specimens show three lobes of equal magnitude on each side, and one of the best specimens from the Woodbine sand has four nearly equal lobes on each side, the basal and apical pairs being somewhat shorter than the medial pairs. This form of leaf is very suggestive of some species of *Quercus*, but its variations, as well as its venation, show that it is related to *Liriodendron*. The petiole is preserved for a considerable length and is very stout, as is the midrib. There is one main secondary traversing each lobe and running directly to its apical point. In addition there are one or more camptodrome secondaries in each lobe which anastomose with branches from the main secondary, their number being dependent upon the relative width of the lobe; they branch from the midrib at angles of about 60°.

At first sight this species appears to differ considerably from *Liriodendron oblongifolium* and from the modern form, but this difference is not nearly as great as it seems, and it is probable that *Liriodendron quercifolium* is simply a variation from the common ancestor of the two species in the direction of *Liriodendron pinnatifidum* Lesquereux. Numerous leaves of the modern tree can be found with an incipient lobation suggesting *Liriodendron quercifolium*. In these leaves, however, the sinus is comparatively shallow and rounded, so that the general appearance of the two is not markedly similar.

Knowlton recorded *Liriodendron pinnatifidum* and *Liriodendron snowii* from the Woodbine sand, but both of these prove to be fragments of this species.

Family TROCHODENDRACEAE.

Genus TROCHODENDROIDES Berry, n. gen.

This genus is proposed as a form genus for fossil leaves that appear to be referable to the family Trochodendraceae. It is perhaps best, for the present, not to attempt a definition. Attention is called in a recent publication[21] to the possibility that certain Mesozoic forms of dicotyledons commonly referred to *Celastrophyllum*, *Populus*, and *Populophyllum* represented ancestral forms of *Tetracentron*, *Trochodendron*, and *Cercidophyllum*. A great many Cretaceous plant species have been referred to the existing genus *Populus*, and the evidence for such a relationship is very slight in a number of forms, particularly among the older ones. The plant from the Dakota sandstone described by Lesquereux as *Phyllites rhomboideus*, which is present in the Woodbine sand, is here considered the type of the genus and is for the present the only species definitely assigned to it. A critical survey of the late Lower Cretaceous and early Upper Cretaceous dicotyledons would result in transferring a number of forms to *Trochodendroides*, which may serve for the reception of any fossil species of the family.

Trochodendroides rhomboideus (Lesquereux) Berry.

Plate XXXVI, figure 5.

Ficus? rhomboideus Lesquereux, Am. Jour. Sci., 2d ser., vol. 46, p. 96, 1868.
Phyllites rhomboideus Lesquereux, Cretaceous flora, p. 112, pl. 6, fig. 7, 1874.
Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 317, 1901.

This species was described by Lesquereux from material found in the Dakota sandstone at Decatur, Nebr. He at first referred it with a query to *Ficus*, which it obviously does not represent. Subsequently he transferred it to

[21] Berry, E. W., Am. Jour. Sci., 4th ser., vol. 50, p. 49, 1920.

Phyllites, and in his account of 1874 he suggested comparisons with *Smilax*, *Paliurus*, and *Populus*. It has no characters which ally it to *Smilax* or *Paliurus*, but it is much like a variety of species that have been referred to *Populus*, the majority of which do not present clear evidence to warrant such a reference.

The species may be described as follows: Leaves rhomboidal to orbicular, with a rounded or cuneate decurrent base, presumably varying to more or less cordate. Apex broadly rounded. Margins entire in their lower halves, undulate toothed in their distal halves. Texture subcoriaceous. Length about 4.5 to 6 centimeters; maximum width, midway between the apex and the base, 5 to 6.5 centimeters. Petiole stout, curved, 2 centimeters in length in the smaller leaves, not preserved in the larger. Venation five-palmate from the base, the midrib no stouter than the lateral primaries; they diverge at acute angles and arch near the upper margin to join branches from the short camptodrome secondaries. Areolation obsolete.

In form and venation the fossil is much like the modern leaves of both *Tetracentron* and *Cercidophyllum*, especially seedling leaves; it is less like *Trochodendron* but is approached by seedling leaves of that genus. If, as some botanists believe, these somewhat anomalous vesselless dicotyledons are primitive in their features and not reduced, they should be present among the earlier fossil angiosperms and should show considerable abundance and diversity. The abundance of comparable fossil forms, as I have pointed out, masquerading under various names and widespread and abundant in the closing days of the Lower Cretaceous, in a measure substantiates the first of these assumptions.

Family RANUNCULACEAE?

Genus DEWALQUEA Saporta and Marion.

Dewalquea insigniformis Berry.

Dewalquea insigniformis Berry, Torrey Bot. Club Bull., vol. 44, p. 179, pl. 7, figs. 6, 7, 1917.

Leaves digitate, of probably five leaflets. Leaflets linear-acuminate, with prominently serrate margins. Length about 12 centimeters; maximum width mostly 1 to 1.25 centimeters, at or slightly above the middle. Base very gradually narrowed and with entire margins for a distance of about 2 centimeters. Midrib stout, prominent on the under surface of the leaflets. Secondaries numerous, diverging from the midrib at angles of 30° to 40°, long ascending and eventually camptodrome, sending off small outwardly directed branches to the marginal teeth. Texture coriaceous.

This characteristic species with its coriaceous texture must have had rather stiff, strict leaves in life. It adds to our flora another form of the curious genus *Dewalquea*, which is so striking an element in the Upper Cretaceous and lower Eocene. The only known American species that resembles this form in any respect is *Dewalquea smithi* Berry,[22] of the Tuscaloosa and Black Creek formations. *D. smithi* is much larger, with relatively broader leaflets, which have less prominently serrate margins and partly craspedodrome venation.

Dewalquea insigniformis is, however, as its name indicates, very much like *Dewalquea insignis* Hosius and Von der Marck,[23] a prominent species in the Campanian and Maestrichtian substages of Europe. *D. insignis* has relatively broader, less prominently toothed leaflets, in some specimens as many as seven, and the venation is said to be craspedodrome. The venation is, however, a character of slight value, for entire and toothed leaflets generally occur together, and I imagine that *Dewalquea insignis* is merely a serrate form of the associated *Dewalquea haldemiana* Saporta and Marion. If the latter had prominent serrate teeth added it would be identical with *Dewalquea insigniformis*.

Dewalquea insigniformis was described from a large number of fragmentary specimens obtained in the upper part of the Bingen sand in Pike County, Ark. A characteristic leaflet is present in the early collections from the Woodbine sand at Arthurs Bluff, Tex.

Order ROSALES.

Family CAESALPINIACEAE.

Genus PALEOCASSIA Ettingshausen.

Paleocassia laurinea Lesquereux.

Plate XL, figure 8.

Paleocassia laurinea Lesquereux, The flora of the Dakota group, p. 147, pl. 64, fig. 12, 1892.

Berry, Torrey Bot. Club Bull., vol. 39, p. 396, 1912; U. S. Geol. Survey Prof. Paper 112, p. 100, pl. 23, fig. 1, 1919.

Leaflets ovate-lanceolate, subinequilateral, with a pointed apex and a cuneate base. Length

[22] Berry, E. W., Torreya, vol. 10, pp. 34–38, fig. 1, 1910.

[23] Hosius, A., and Von der Marck, W., Palaeontographica, vol. 26, p. 172, pl. 32, figs. 111–113; pl. 33, fig. 109; pl. 34, fig. 110; pl. 35, fig. 123, 1880.

from 3 to 6 centimeters; maximum width, at or below the middle, about 2 centimeters. Margins entire, somewhat irregular. Petiolule short, curved, gradually enlarged proximad, about 5 millimeters in length. Midrib of medium size, curved. Secondaries thin, camptodrome.

This species was described from specimens collected in the Dakota sandstone of Kansas and is present in the lower part of the Tuscaloosa formation in Alabama. As interpreted by Lesquereux, its describer, the remains represented leaflets of a *Cassia*-like plant, although so far as I know all have been detached, the only basis for considering them leaflets rather than leaves being their slight inequilateral form.

A single entire leaflet is contained in the collection from Arthurs Bluff, Tex. It is identical with the type material from Kansas in size, outline, and venation, with the exception that it is slightly wider (2 to 5 millimeters), with a consequently somewhat fuller and more rounded base.

Family PAPILIONACEAE.

Genus COLUTEA Linné.

Colutea primordialis Heer.

Colutea primordialis Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 99, pl. 27, figs. 7–11; pl. 63, figs. 7, 8, 1882.
Lesquereux, U. S. Geol. Survey Mon. 17, p. 148, pl. 13, figs. 8, 9, 1891 [1892].
Newberry, U. S. Geol. Survey Mon. 26, p. 97, pl. 19, figs. 4, 5, 1896.
Hollick, U. S. Geol. Survey Mon. 50, p. 84, pl. 32, figs. 14, 15, 1906.
Berry, Torrey Bot. Club Bull., vol. 37, p. 24, 1910; vol. 38, p. 407, 1911; vol. 39, p. 396, 1912; New Jersey Geol. Survey Bull. 3, p. 156, pl. 20, fig. 4, 1911; Maryland Geol. Survey, Upper Cretaceous, p. 845, pl. 75, fig. 3, 1916; Torrey Bot. Club Bull., vol. 44, p. 184, 1917.

This species was described from material found in the Atane beds of western Greenland and was subsequently recorded from the Dakota sandstone near Delphos, Kans., the Raritan formation of New Jersey, and the Magothy formation of Marthas Vineyard, Long Island, and Maryland. It is represented by a single specimen in the collection from the upper member of the Bingen sand, and by a single complete and in every way typical leaflet from Arthurs Bluff, Tex.

The reference of this and other American Upper Cretaceous species to the Old World genus *Colutea* may well be questioned, and it is probable that they represent some other leguminous genus with similar foliage.

Order SAPINDALES.

Family SAPINDACEAE.

Genus SAPINDUS Linné.

Sapindus morrisoni Heer.

Sapindus morrisoni Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 896, pl. 40, fig. 1; pl. 41, fig. 3; pl. 43, figs. 1a, b; pl. 44, figs. 7, 8, 1882.
Lesquereux, U. S. Geol. Survey Terr. Rept., vol. 8 (Cretaceous and Tertiary floras), p. 83, pl. 16, figs. 1, 2, 1883; U. S. Geol. Survey Mon. 17, p. 158, pl. 35, figs. 1, 2, 1892.
Hollick, New York Acad. Sci. Annals, vol. 11, p. 422, pl. 36, fig. 4, 1898; U. S. Geol. Survey Mon. 50, p. 90, pl. 33, figs. 16–20, 1906.
Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 317, 1901.
Berry, New York Bot. Garden Bull., vol. 3, p. 83, pl. 47, figs. 2, 3, 1903; Torrey Bot. Club Bull., vol. 31 p. 78, 1904; vol. 39, p. 396, 1912; vol. 44, p. 186, 1917; New Jersey Geol. Survey Ann. Rept., 1905, p. 138, 1906; U. S. Geol. Survey Prof. Paper 84, p. 49, pl. 9, fig. 6, 1914; Prof. Paper 112, p. 112, 1919.

Leaflets of variable, usually large size, lanceolate and more or less inequilateral, with a broadly cuneate or rounded base and a pointed apex. Petiolulate. Texture subcoriaceous. Margins entire. Midrib stout, curved. Secondaries numerous, camptodrome.

The present species was described originally as from the Atane beds of western Greenland by Heer, to whom it must be credited, although it was based on Lesquereux's manuscript, which appeared in print the following year. It is common in the Dakota sandstone at a number of widely scattered localities and in the Magothy formation of the northern Atlantic Coastal Plain and the Tuscaloosa formation of the eastern Gulf area. It is not uncommon in both the lower and upper members of the Bingen sand of Arkansas, and fragmentary specimens occur in both the earlier and later collections from Arthurs Bluff, Tex.

Family ANACARDIACEAE.

Genus RHUS Linné.

Rhus redditiformis Berry.

Plate XXXVII, fig. 2.

Rhus redditiformis Berry, Torrey Bot. Club Bull., vol. 39, p. 397, pl. 31, fig. 2, 1912.

Leaves compound, probably trilobate. Leaflets petiolate, ovate, with bluntly pointed tips, cuneate bases, and entire or undulate margins forming a few distal shallow, broadly rounded lobules separated by broad, shallow sinuses. Terminal leaflet nearly equilateral, about one-third larger than the lateral leaflets, about 4 centimeters in length by 2 centimeters in maximum width, which is about midway between the apex and the base; petiole 5 millimeters long; midrib stout, prominent; secondaries thin, five or six alternate pairs, branching from the midrib at angles of about 50°, curving slightly upward, anastomosing close to the entire margin. Lateral leaflets inequilateral, the outer limb of the lamina being slightly wider and fuller than the inner limb; petioles shorter than that of the terminal leaflet, 2 to 3 millimeters in length, diverging from the latter at angles of about 70°; in outline and venation similar to the terminal leaflet, but smaller and showing a tendency to develop slight irregularities in the margin, especially toward their tips.

This species was named from its rather striking resemblance to the European early Tertiary species *Rhus reddita* Saporta,[24] from Aix, in southeastern France. Several Cretaceous species of *Rhus* have been described from specimens found in beds as old as the Woodbine, the Dakota sandstone of Kansas having furnished three supposed species with pinnate leaves, one of which, *Rhus uddeni* Lesquereux,[25] was erroneously reported by Ward from the Cheyenne sandstone at Belvidere, Kans. The Cheyenne form proves to be a species of *Sapindopsis*, and this may also be the botanic affinity of the type material of *Rhus uddeni*.

A small-toothed species from the Cenomanian sandstone of Bohemia has been described by Velenovsky[26] as *Rhus cretacea*, although this name was already in use for a very different Cretaceous species described by Heer[27] from material obtained in the Senonian at Quedlinburg, in Saxony, and recorded by Hollick[28] from the Upper Cretaceous of Long Island. The Woodbine species is readily distinguishable from all the foregoing and adds a well-marked and probably trifoliate Cretaceous form to this genus, which was so largely developed during Tertiary time. In the existing flora *Rhus* is a prominent element with more than 150 species, most of which are natives of warm temperate and tropical regions.

A modern species with almost identical foliage is the South African *Rhus villosa* Linné.

Order RHAMNALES.

Family RHAMNACEAE.

Genus RHAMNUS Linné.

Rhamnus tenax Lesquereux.

Plate XL, figure 7.

Rhamnus tenax Lesquereux, Am. Jour. Sci., 2d ser., vol. 46, p. 101, 1868; The Cretaceous flora, p. 109, pl. 21, fig. 4, 1874; The flora of the Dakota group, p. 170, pl. 38, fig. 6, 1892.

Engelhardt, Naturwiss. Gesell. Isis in Dresden Abh. 7, Jahrg. 1891, p. 101, 1892.

Bartsch, Iowa Univ. Lab. Nat. Hist. Bull., vol. 3, p. 181, 1896.

Berry, Torrey Bot. Club Bull., vol. 39, p. 398, 1912; U. S. Geol. Survey Prof. Paper 112, p. 114, pl. 25, figs. 1, 2, 1919.

Leaves ovate-lanceolate, acuminate, slightly equilateral. Length about 8 centimeters; maximum width about 2 centimeters in the lower half of the leaf. The dimensions of these leaves are remarkably uniform in all the specimens from the Dakota sandstone of the West, as well as in those from the Tuscaloosa formation in Alabama. Margins entire, curving inward somewhat abruptly to the petiole, which is stout, more or less curved, and about 1 centimeter or slightly more in length. Midrib stout, curved, becoming thin in the acuminate tip. Secondaries numerous, thin, approximately parallel, 12 to 14 subopposite to alternate pairs, branching from the midrib at angles of about 45° to 50°, curving slightly upward, camptodrome.

This species, which was described many years ago by Lesquereux from material col-

[24] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire, tome 1, p. 124, pl. 13, figs. 2, a, b, 1862.

[25] Lesquereux, Leo, U. S. Geol. Survey Mon. 17, p. 154, pl. 57, fig. 2, 1892.

[26] Velenovsky, Josef, Die Flora der böhmische Kreideformation, pt. 4, p. 7, pl. 4, figs. 7–12, 1885.

[27] Heer, Oswald, Zur Kreideflora von Quedlinburg, p. 14, pl. 3, fig. 11, 1872.

[28] Hollick, Arthur, U. S. Geol. Survey Mon. 50, p. 87, pl. 33, fig. 2, 1907.

lected in the Dakota sandstone of southern Kansas and subsequently recorded by Bartsch from the same formation in Iowa, is represented in the lower beds of the Tuscaloosa formation of western Alabama and in the Woodbine sand at Arthurs Bluff, Tex., by leaves which are identical in all their characters with the type material and which seem to be closely allied to the Tertiary and modern forms of *Rhamnus*. It has been reported by Engelhardt from the Cenomanian of Niederschoena, Saxony, but this record may well be considered doubtful.

Genus ZIZYPHUS Adanson.

Zizyphus lamarensis Berry.

Plate XXXVI, figure 4.

Zizyphus lamarensis Berry, Torrey Bot. Club Bull., vol. 39, p. 398, pl. 31, fig. 1, 1912; U. S. Geol. Survey Prof. Paper 112, p. 112, 1919.

Leaves elliptical, 4.5 to 5 centimeters in length by 3 centimeters in maximum width, about midway between the apex and the base, though slightly nearer the base; base full and rounded; lateral margins full and rounded; apex rounded, slightly less full than the base; margin with regular but shallow crenate teeth, becoming less prominent toward the base. Midrib slender but prominent, straight. Lateral primaries one on each side, diverging from the midrib at its extreme base at an acute angle (about 10°), thin, slightly curved inward above the middle, joining a secondary in the apical part of the leaf. Secondaries from the midrib two or three alternate thin pairs in the apical region, camptodrome; secondaries from the lateral primaries five or six in number, on the outside, curved, camptodrome; the lowest secondary is longest and branches at the most acute angle (about 10°) and from the extreme base; each successively higher secondary subtending a slightly larger angle and following a somewhat shorter course. Internal tertiaries more or less percurrent, marginal ones similar to the secondaries from the primaries in their arrangement and course, thin and camptodrome.

This handsome species of an undoubted *Zizyphus* was described recently from very scanty material obtained in the Woodbine sand of Texas. It is entirely distinct from any previously described Cretaceous species and is much closer to some of the Tertiary and still existing forms.

Zizyphus has not yet been discovered in the European Cretaceous, but it is represented in the Western Hemisphere by four or five well-marked types. The nearest to the present species is *Z. groenlandicus* Heer,[29] which occurs in the Magothy formation on Marthas Vineyard and in the Patoot beds of western Greenland. It is of about the same size but relatively wider than the Texas form and has a somewhat different venation and much coarser teeth. The species from the Magothy of New Jersey, *Z. cliffwoodensis* Berry,[30] is a larger, lanceolate, entire-margined form. The two species from the Cretaceous of Long Island, *Z. elegans* [31] and *Z. oblongus*,[32] described by Hollick, are much smaller, entire-margined forms, and Hollick's *Z. lewisiana*,[33] another Cretaceous species from the same locality, is a small lanceolate leaf of doubtful affinity.

The existing species of *Zizyphus* number about 40 and are largely indigenous in the Indo-Malayan region, although the genus is represented in subtropical or tropical America, Africa, and Australia. One modern species, *Zizyphus vulgaris* Lamarck, an oriental form, has foliage almost identical with *Z. lamarensis*, the outline, margin, and venation being the same.

Family VITACEAE.

Genus CISSITES Heer.

Cissites formosus Heer.

Plate XL, figure 5.

Cissites formosus Heer, Flora fossilis arctica, vol. 6, pt. 2, p. 85, pl. 21, figs. 5–8, 1882.

Lesquereux, The flora of the Dakota group, p. 161, pl. 21, fig. 5, 1892.

?Hollick, Torrey Bot. Club Bull., vol. 21, p. 57, pl. 174, fig. 6, 1894; The Cretaceous flora of southern New York and New England, p. 94, pl. 37, fig. 7, 1906.

Newberry, The flora of the Amboy clays, p. 107, pl. 47, figs. 1–8, 1896.

Berry, New Jersey Geol. Survey Bull. 3, p. 185, 1911; U. S. Geol. Survey Prof. Paper 112, p. 115, 1919.

Heer's description, published in 1882, is as follows:

C. foliis palmatis, profunde trilobatis, lobo medio basi contracto, trilobato, lobis obtusis.

[29] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 42, pl. 62, fig. 20, 1883.

[30] Berry, E. W., Johns Hopkins Univ. Circ., new ser., No. 7, p. 88, fig. 5, 1907.

[31] Hollick, Arthur, Torrey Bot. Club. Bull., vol. 21, pl. 176, fig. 9, 1894.

[32] Hollick, Arthur, The Cretaceous flora of southern New York and New England: U. S. Geol. Survey Mon. 50, p. 92, pl. 34, figs. 9, 10, 1907.

[33] Hollick, Arthur, Torrey Bot. Club Bull., vol. 21, p. 58, pl. 180, fig. 13, 1894.

This description was based upon very fragmentary material from the Atane beds of Greenland, from which, nevertheless, Heer reconstructed the supposed outline of the perfect leaf. To judge by the specimens referred to this species by Lesquereux and Newberry it was an exceedingly variable form. In plan it is trilobate, but the subsidiary lobes developed upon both the median and the lateral lobes in some specimens obscure this trilobate character and suggest *Cissites parvifolius* Berry, of the Albian of America and Europe; *Cissites dentatolobatus* Lesquereux, of the Dakota sandstone; *Cissites panduratus* Knowlton, of the Vermejo, Mesaverde, and Ripley formations; or *Cissus vitifolia* Velenovsky, of the Cenomanian of Bohemia.

The primaries are stout and three in number; they may diverge from the top of the stout petiole or be suprabasilar; in many specimens the branches of the laterals approach so near the base that the leaves have the appearance of being palmately 5-veined.

This species is common but fragmentary in the Raritan formation; it ranges from 7 to 10 centimeters in length and from 6 to 12 centimeters between the tips of the main lateral lobes. The sinuses are all rounded, and the main ones may be deep or shallow. The fragment from Long Island referred to this species by Hollick is, as he remarks, exceedingly unsatisfactory and doubtful. The species occurs also in the Dakota sandstone of Kansas, and a closely related variety has been found in the Magothy formation of Maryland. Typical material is present in the Tuscaloosa formation of Alabama. It is represented by a scanty amount of incomplete material at Arthurs Bluffs, Tex.

The genus *Cissites* was erected by Heer in 1866 for the species *Cissites insignis*, from the Dakota sandstone of Nebraska, which presented points of affinity with the genus *Cissus* of Linné. It is a largely developed type in the upper half of the Cretaceous system but was replaced after Eocene time by forms which are definitely referable to modern allied genera such as *Cissus* and *Vitis*.

Order MALVALES.

Family STERCULIACEAE.

Genus STERCULIA Linné.

Sterculia lugubris Lesquereux?

Plate XXXVI, figure 6.

Sterculia lugubris Lesquereux, The Cretaceous and Tertiary floras, p. 81, pl. 6, figs. 1–3, 1883.
Berry, Torrey Bot. Club Bull., vol. 39, p. 399, pl. 31, fig. 2, 1912.

Leaves variable in size, often large, deeply palmately trilobate. Length from 12 to 24 centimeters. Texture coriaceous. Margins entire. Base cuneate, decurrent. Lobes narrow linear-lanceolate, acuminate. Primaries three, stout, prominent, diverging from the top of the thick petiole at acute angles. Secondaries thin, camptodrome, mostly immersed in the thick substance of the leaf.

This striking species was described from specimens collected in the so-called Dakota sandstone near Golden, Colo. It is very similar to *Sterculia cliffwoodensis* Berry,[34] of the Magothy formation of New Jersey and Delaware.

This species is apparently represented at Arthurs Bluff, Tex., by the single specimen figured, which agrees very well with the Dakota sandstone forms of *Sterculia lugubris*. The reference is queried, as the specimen may represent an exceedingly slender, elongated, almost parallel-margined form of *Aralia wellingtoniana* Lesquereux, which is so common at this locality.

Order THYMELEALES.

Family LAURACEAE.

Genus BENZOIN Fabricius.

Benzoin venustum (Lesquereux) Knowlton.

Plate XXXVIII, figure 2.

Lindera venusta Lesquereux, U. S. Geol. Survey Mon. 17, p. 95, pl. 16, figs. 1, 2, 1892.
Benzoin venustum (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 47, 1898.
Berry, Torrey Bot. Club Bull., vol. 39, p. 399, 1912.

Leaves of variable size, trilobate, separated by narrow ultimately rounded sinuses about

[34] Berry, E. W., New York Bot. Garden Bull., vol. 3, p. 88, pl. 43, fig. 5, 1903.

halfway to the base into three ovate erect lobes, which are rather bluntly or conically pointed. The median lobe is largest and most expanded medianly. The margins are entire, and the lower lateral margins are full and rounded. The base is more or less decurrent. The leaf substance is thin. Length from 4 to 10 centimeters; maximum width, about halfway between the apex and the base, from 3.5 to 9 centimeters. Petiole missing in all the known material. Midrib stout, normally straight. A single stout lateral primary diverges from the midrib at an acute angle at its extreme base on either side and terminates at the tip of the lateral lobe. The secondaries are thin, numerous, ascending, and camptodrome, the basal lateral secondaries being especially long and ascending, the others being subparallel. Tertiaries mostly percurrent, open.

This species, which shows considerable resemblance to some of the Upper Cretaceous forms that have been referred to the genus *Sassafras*, was described from material collected in the Dakota sandstone of Ellsworth County, Kans. Small leaves are abundant in the characteristic concretionary specimens, which I believe represent the true Dakota sandstone rather than older beds in that area. The species is not abundant in the Woodbine sand, but there are several specimens in the relatively small collections from that formation, to which and the Dakota this form appears to be confined.

Genus MALAPOENNA Adanson.

Malapoenna falcifolia (Lesquereux) Knowlton.

Litsea falcifolia Lesquereux, The flora of the Dakota group, p. 97, pl. 11, fig. 5, 1892.

Malapoenna falcifolia (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 142, 1898.

Berry, Torrey Bot. Club Bull., vol. 33, p. 180, 1906; New Jersey Geol. Survey Ann. Rept. for 1905, p. 139, 1906; Torrey Bot. Club Bull., vol. 39, p. 399, 1912; U. S. Geol. Survey Prof. Paper 112, p. 122, pl. 21, fig. 5, 1919.

Leaves of relatively small size, lanceolate, falcate. Length about 5 to 6 centimeters; maximum width, about halfway between the apex and the base, if anything slightly nearer the base, about 1.7 centimeters; from this point the blade narrows to the lanceolate base and gradually tapers to the extended acuminate tip. Petiole not preserved. Midrib much curved, thin distad. Secondaries three or four pairs; the lower suprabasilar and subopposite pair should possibly be termed lateral primaries, as Lesquereux called them. These lower secondaries are thin and branch from the midrib at angles of 45° or less, sweeping upward in a long curve, at length camptodrome. Upper secondaries somewhat irregularly spaced, camptodrome. Tertiaries very fine and more or less obsolete. Texture coriaceous but not thick.

This attractive species is easily distinguished from other lauraceous forms, particularly from species of *Cinnamomum*, with which Lesquereux originally compared it, by its slight inequilaterality and marked falcate form, as well as by the lack of definiteness in the triple venation, the suprabasilar position of the so-called primaries, and the character of the tertiary venation. It was described originally from material found in the Dakota sandstone near Delphos, Kans., and subsequently was discovered by me in the Magothy formation of New Jersey. Some of the specimens from the lower part of the Tuscaloosa formation of Alabama, though the material is not extensive, are complete and are entirely characteristic, as is the single specimen discovered at Arthurs Bluff, Tex. It may readily be distinguished from *Malapoenna horrellensis* Berry,[35] of the Upper Cretaceous Black Creek, Eutaw, and Ripley formations, by its suprabasilar primaries and cuneate base.

Genus OREODAPHNE Nees.

Oreodaphne alabamensis Berry.

Plate XXXVII, figure 1.

Oreodaphne alabamensis Berry, Torrey Bot. Club Bull., vol. 39, p. 400, pl. 32, 1912; U. S. Geol. Survey Prof. Paper 112, p. 119, pl. 19, figs. 3–5, 1919.

Leaves of large size, ovate, from 13 to 20 cubic centimeters in length and from 4.75 to 7 cubic centimeters in maximum width, which is at a point midway between the apex and the base. From the point of greatest width the margins curve, both distad and proximad, in a very full curve, narrowing rather abruptly to the acuminate tip and also to the more or less decurrent base. Midrib stout, curved. Lateral primaries opposite, one on each side, branching from the midrib at an acute angle a considerable distance above its base, rather

[35] Berry, E. W., Torrey Bot. Club Bull., vol. 37, p. 198, pl. 24, figs. 1–9, 1910.

straight in their course, thinner than the midrib. Above the primaries there is an interval, and then about six pairs of thin, curved, approximately parallel camptodrome secondaries branch from the midrib at acute angles. The lateral primaries give off on the outside numerous regularly spaced and approximately parallel curved camptodrome secondaries, the latter feature serving to distinguish this species from other fossil species of this genus and from *Cinnamomum*, *Cocculus*, or other genera having somewhat similar leaves, with which it might be compared. Texture coriaceous.

This fine large species is represented at Arthurs Bluff, Tex., by fragmentary but characteristic specimens. The description was largely drawn up from abundant and complete material from the Tuscaloosa formation of western Alabama. The specimens show considerable variation in size and some in outline, the leaf being widest either nearer to or farther from the base. In the latter form the distal part is more fully rounded and abruptly contracted to the acuminate tip, while the base is more gradually narrowed and finally cuneate rather than decurrent. In the former the apical part is more gradually narrowed and the base is full and rounded abruptly, decurring to the petiole.

This species is markedly different from other described fossil forms but may be matched by several modern tropical American species of *Oreodaphne*. The genus *Oreodaphne* of Nees, which is exclusively American in the existing flora, is made a subgenus of *Ocotea* Aublet by Pax in Engler and Prantl's "Die natürlichen Pflanzenfamilien." The genus *Ocotea*, which for paleobotanic purposes may be considered as composite, has about two hundred modern species occurring chiefly in the American Tropics and ranging from southern Florida to Brazil and Peru but having some representatives (subgenus *Mespilodaphne* Nees) in the Canary Islands, South Africa, Madagascar, and the Mascarene Islands.

The single existing American species reaching the United States whose habit and environment may be taken as typical for the whole genus is found in Florida, southward from Capes Canaveral and Romano, along the shores and islands, except on some of the western keys, making its best growth in the rich, moist hammock lands near the coast.

Genus CINNAMOMUM Blume.

Cinnamomum newberryi Berry.

Plate XXXIX, figure 3.

Cinnamomum sezannense Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 77, pl. 19, fig. 8; pl. 33, figs. 11, 12, 1882 (not Watelet); vol. 7, p. 30, pl. 41, fig. 1a, 1883.
Lesquereux, The flora of the Dakota group, p. 107, pl. 12, fig. 7, 1892 (not fig. 6).
Dawson, Roy. Soc. Canada Trans., 1st ser., vol. 2, sec. 4, p. 64, pl. 13, fig. 58, 1894.
Hollick, Torrey Bot. Club Bull., vol. 21, p. 53, pl. 180, figs. 5, 7, 1894.
Penhallow, Roy. Soc. Canada Trans., 2d ser., vol. 8, sec. 4, p. 46, 1902.
Hollick, New York State Mus. Fifty-fifth Ann. Rept., for 1901, p. r50, 1903.

Cinnamomum intermedium Newberry. Smith, On the geology of the Coastal Plain of Alabama, p. 348, 1894 (nomen nudum) (not Ettingshausen).
Newberry, The flora of the Amboy clays, p. 89, pl. 29, figs. 1–8, 1896.
Berry, NewJ ersey Geol. Survey Ann. Rept. for 1905, p. 139, pl. 20, figs. 2–6, 1906; Torrey Bot. Club Bull., vol. 33, p. 179, pl. 7, figs. 3, 4; vol. 37, p. 27, 1910.
Hollick, The Cretaceous flora of southern New York and New England, p. 74, pl. 29, fig. 7; pl. 30, figs. 1, 2, 1906.

Cinnamomum newberryi Berry, Torrey Bot. Club Bull., vol. 38, p. 423, 1911; New Jersey Geol. Survey Bull. 3, p. 150, pl. 16, fig. 3, 1911; U. S. Geol. Survey Prof. Paper 84, pp. 54, 117, pl. 9, figs. 12, 13; pl. 21, figs. 9–11, 1914; Maryland Geol. Survey, Upper Cretaceous, p. 860, pl. 71, fig. 6, 1916; U. S. Geol. Survey Prof. Paper 112, p. 118, pl. 21, figs. 6–9, 1919.

Cinnamomum n. sp.? Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 317, 1901.

Leaves subcoriaceous, lanceolate to ovate-lanceolate, differing greatly in size and consequently in appearance. Apex short-pointed or more or less narrowly extended; base broad, narrowed to the petiole. Primaries three, usually suprabasilar.

This species is primarily distinguished from *Cinnamomum heerii* Lesquereux, which Knowlton [36] recorded from the Woodbine sand of Cooke County, Tex., by its relatively narrower form and acute base. The present species, as revised according to the foregoing citations, has a remarkable range in the Upper Cretaceous. It is recorded from the Raritan formation of New Jersey, the oldest formation in which it has been found. Above the Raritan it occurs in the Atane and Patoot beds of Greenland, in the Magothy formation from Long

[36] Knowlton, F. H., in Hill, R. T., Geography and geology of the Black and Grand prairies, p. 318, 1901.

Island to Maryland, in the Black Creek formation of North Carolina, in the Middendorf arkose member of the Black Creek formation of South Carolina, in the Bingen sand of Arkansas, in the Tuscaloosa formation of Georgia and Alabama, in the Eutaw formation of Georgia, in the Ripley formation of Tennessee, and in the Dakota sandstone of Kansas. It appears to be present in the Upper Cretaceous of the Pacific coast on Vancouver Island and to be represented in Texas by the remains of *Cinnamomum* recorded by Knowlton [37] from the Woodbine sand in Cooke County. Although not known from Europe, the forms from the Cenomanian of Bohemia which Velenovsky [38] described as *Aralia daphnophyllum* are very similar to the American species.

The specimens found in the Dakota sandstone came from Ellsworth County, Kans., and the range elsewhere of this species seems to prove that the formation was the true Dakota sandstone rather than some older sandstone.

It seems obvious that the range of this form represents more than a single botanic species, as no question of correlation is involved in the eastern Gulf section from Tuscaloosa to Ripley, but the only criteria for segregation are stratigraphic. The leaves of *Cinnamomum*, both living and fossil, are notoriously variable, so that the problem appears insoluble.

The species is not abundant in the Woodbine material from Arthurs Bluff, Tex., but I regard this scarcity as merely an accident of preservation or discovery.

Cinnamomum membranaceum (Lesquereux) Hollick.

Paliurus membranaceus Lesquereux, Am. Jour. Sci., 2d ser., vol. 46, 1868, p. 101; U. S. Geol. Survey Terr. Rept., vol. 6 (Cretaceous flora), p. 108, pl. 20, fig. 6, 1874; U. S. Geol. Survey Mon. 17, p. 167, pl. 35, fig. 5, 1891 [1892].

Cinnamomum membranaceum Hollick, U. S. Geol. Survey Mon. 50, p. 75, pl. 29, figs. 5, 6, 1906.

Berry, Torrey Bot. Club Bull., vol. 39, p. 401, 1912.

This species, which Lesquereux referred to the genus *Paliurus*, was described originally from specimens collected at Decatur, Nebr., and Pipe Creek, Kans. It occurs in the northward extension of the Magothy formation at Gay Head, Marthas Vineyard, Mass., and in the Woodbine sand at Arthurs Bluff, Tex. I think that Hollick was entirely justified in removing this form from *Paliurus*, but I am not sure that it is a *Cinnamomum*, although it appears to be a lauraceous form. If a *Cinnamomum*, as is perfectly possible, it should probably be regarded as a variant of the contemporaneous *Cinnamomum newberryi*, from which it differs merely in its irregularity of outline.

[37] Knowlton, F. H., idem.

[38] Velenovsky, Josef, Die Flora der böhmische Kreideformation, pt. 2, p. 10, pl. 7, figs. 5–8, 1882.

Genus LAURUS of authors.

Laurus plutonia Heer.

Plate XXXVIII, figure 5.

Laurus plutonia Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 75, pl. 19, figs. 1d, 2–4; pl. 20, figs. 3a, 4, 5; pl. 24, fig. 6b; pl. 28, figs. 10, 11; pl. 42, fig. 4b, 1882; vol. 7, p. 30, pl. 58, fig. 2; pl. 62, fig. 1a, 1883.

?Velenovsky, Die Flora der böhmische Kreideformation, pt. 3, p. 1, pl. 4, figs. 2–4, 1884.

Lesquereux, U. S. Geol. Survey Mon. 17, p. 91, pl. 13, figs. 5, 6; pl. 22, fig. 5, 1892; Minnesota Geol. and Nat. Hist. Survey, vol. 3, pt. 1, p. 14, pl. A, fig. 6; pl. B, fig. 5, 1895.

Newberry, U. S. Geol. Survey Mon. 26, p. 85, pl. 16, figs. 10, 11, 1896.

?Frič and Bayer, Naturw. Landes. Böhmen Archiv, vol. 11, No. 2, p. 130, fig. 94, 1901.

Berry, New York Bot. Garden Bull., vol. 3, p. 79, pl. 1, figs. 9–11, 1903; Torrey Bot. Club Bull., vol. 31, p. 77, pl. 3, fig. 1, 1904; vol. 33, p. 178, 1906; vol. 39, p. 401, 1912; New Jersey Geol. Survey Ann. Rept. for 1905, pp. 138, 139, 1906; U. S. Geol. Survey Prof. Paper 84, p. 52, pl. 11, fig. 2; pl. 12, fig. 6, 1914; Maryland Geol. Survey, Upper Cretaceous, p. 861, pl. 71, fig. 5, 1916; U. S. Geol. Survey Prof. Paper 112, p. 123, 1919.

Hollick, U. S. Geol. Survey Mon. 50, p. 80, pl. 27, figs. 9, 10, 1906; New York Bot. Garden Bull., vol. 8, p. 162, pl. 169, figs. 3–5, 1912.

Leaves lanceolate, usually tapering almost equally in both directions but some specimens less acute at the base. Length, 7 to 11 centimeters; greatest width, 1.5 to 2.5 centimeters. Midrib fairly stout. Petiole short and stout, 6 to 15 millimeters in length. Secondaries slender, eight or more alternate pairs, camptodrome.

This species was described by Heer from material collected in the Atane beds of western Greenland, and a large number of somewhat variable and fragmentary specimens were figured. Subsequently it was recorded from a very large number of Cretaceous plant beds, so that its range both geographic and geologic is rather extensive. A number of these records are not entirely above suspicion, and this

appears to be especially true of the forms from the Cenomanian of Bohemia identified by Velenovsky.

Laurus plutonia is uncommon in the Raritan formation, and I have found it only near the top. It is abundant in the overlying Magothy formation from New Jersey to Maryland. In the southern Coastal Plain it occurs in the Middendorf arkose member of the Black Creek formation of South Carolina and ranges from the base of the Tuscaloosa formation upward into the Eutaw formation in the Alabama area. It was identified by Ward from the Cheyenne sandstone of Chatman Creek, Kans., but his material, which I have studied, is not this species but represents leaflets of *Sapindopsis*.

A single complete and characteristic leaf and several fragments are contained in the collections from Arthurs Bluff, Tex.

Laurus antecedens Lesquereux?

Laurus antecedens Lesquereux, U. S. Geol. Survey Mon. 17, p. 92, pl. 11, fig. 3, 1891 [1892].
Hollick, U. S. Geol. Survey Mon. 50, p. 80, pl. 28, figs. 9, 10, 1906.

This species, the type locality of which is simply "Dakota sandstone of Kansas (Lacoe collection)," is at best of doubtful validity. It was described by Lesquereux as follows:

> Leaf membraneous, lanceolate, gradually tapering to the apex, narrowed to the base, not decurrent, somewhat curved to one side, entire, irregularly undulate; median nerve thick; secondaries oblique, curved, parallel, but of unequal thickness and distance, camptodrome. The leaf is 11 centimeters long, 2.5 centimeters broad below the middle, slightly inequilateral by the partial contraction of the borders on one side, and is not gradually narrowed to the petiole but somewhat rounded in narrowing to it. Its precise relation is not satisfactorily ascertained.

The Texas material is fragmentary and of doubtful identity.

Genus LAUROPHYLLUM Goeppert.

Laurophyllum minus Newberry.

Laurophyllum minus Newberry, U. S. Geol. Survey Mon. 26, p. 87, pl. 17, figs. 7–9, 1895 [1896].
Berry, N. J. Geol. Survey Bull. 3, p. 149, 1911; Torrey Bot. Club Bull., vol. 39, p. 402, 1912.

This species, which is of doubtful validity, was described from material collected in the Raritan formation of New Jersey, and I have found it only in the upper part of that formation. In the absence of venation characters in both the type and later collected material its identification is always more or less uncertain; and it may represent a variety of *Laurus plutonia* Heer or some of the forms that have been referred to *Myrica longa* Heer, although in general it is wider than the latter and more elongated and less symmetrical than the former. A single specimen is present in the collection from Arthurs Bluff, Tex.

Order MYRTALES.

Family MYRTACEAE.

Genus MYRTONIUM Ettingshausen.

Myrtonium geinitzi (Heer) Berry.

Myrtophyllum geinitzi Heer, Kreideflora von Moletein in Mähren, p. 22, pl. 11, figs. 3, 4, 1872; Flora fossilis arctica, vol. 3, Abt. 2, p. 116, pl. 32, figs. 14–17, 1874.
Frič, Naturw. Landes. Böhmen Archiv, vol. 4, No. 1, pp. 18, 94, 1878.
Hollick, New York Acad. Sci. Trans., vol. 12, p. 236, pl. 6, fig. 2, 1893.
Myrtophyllum warderi Lesquereux, U. S. Geol. Survey Mon. 17, p. 136, pl. 53, fig. 10, 1892.
Hollick, U. S. Geol. Survey Mon. 50, p. 97, pl. 35, fig. 13, 1906.
Eucalyptus? angustifolia Newberry, U. S. Geol. Survey Mon. 26, p. 111, pl. 32, figs. 1, 6, 7, 1896.
Hollick, New York Bot. Garden Bull., vol. 3, p. 408, pl. 70, figs. 8, 9, 1894; U. S. Geol. Survey Mon. 50, p. 95, pl. 35, figs. 9, 14, 15, 1906.
Eucalyptus geinitzi Heer, Flora fossilis arctica, vol. 6, Abt. 2, p. 93, pl. 19, fig. 1c; pl. 45, figs. 4–9; pl. 46, figs. 12c, d, 13, 1882.
Engelhardt, Naturwiss. Gesell. Isis in Dresden Abh. 7, p. 102, 1891.
Lesquereux, U. S. Geol. Survey Mon. 17, p. 138, pl. 37, fig. 20, 1892.
Newberry, U. S. Geol. Survey Mon. 26, p. 110, pl. 32, figs. 2, 12, 15, 16, 1896.
Krasser, Beiträge zur Kenntniss der fossilen Kreideflora von Kunstadt in Mähren, p. 22, 1896.
Frič and Bayer, Naturw. Landes. Böhmen Archiv, vol. 11, No. 2, p. 142, fig. 110, 1901.
Berry, New York Bot. Garden Bull., vol. 3, p. 87, pl. pl. fig. 3, 1903; Torrey Bot. Club Bull., vol. 31, p. 78, pl. 4, fig. 5, 1904; vol. 33, p. 180, 1906; vol. 34, p. 201, pl. 15, fig. 4, 1907; vol. 37, p. 26, 1910; vol. 39, p. 402, 1912; New Jersey Geol. Survey Ann. Rept. for 1905, p. 138, 1906.
Hollick, U. S. Geol. Survey Mon. 50, p. 96, pl. 35, figs. 1–8, 10–12, 1906.
Hollick, New York Bot. Garden Bull., vol. 8, p. 166, pl. 180, figs. 1, 2, 1912.
Berry, U. S. Geol. Survey Prof. Paper 84, p. 56, pl. 13, figs. 8–12; pl. 14, fig. 1, 1914; New Jersey Geol. Survey Bull. 3, p. 189, 1911; Maryland Geol. Survey, Upper Cretaceous, p. 870, pl. 81, figs. 1–5, 1916; U. S. Geol. Survey Prof. Paper 112, p. 126, pl. 28, fig. 8, 1919.

This widespread and characteristic Upper Cretaceous species is found in this country from the base of the Raritan formation of New Jersey upward into the Black Creek formation of the Carolinas. Abroad it is common in the Cenomanian and ranges upward into the Turonian. The type locality is in the Cenomanian of Moravia, but the species has also been recorded from the Atane beds of western Greenland and from the Dakota sandstone of the West. In the Alabama Cretaceous it has been collected only from the lower part of the Tuscaloosa formation.

Several characteristic specimens are present in the collections from Arthurs Bluff, Tex. This species was recorded by Ward from the Cheyenne sandstone at Chatman Creek, Kans., but the material upon which the record was based is referable to the genus *Sapindopsis*.

Order UMBELLALES.

Family ARALIACEAE.

Genus ARALIA Linné.

Aralia wellingtoniana Lesquereux.

Plate XXXVII, figure 3; Plate XXXVIII, figures 3, 4.

Aralia wellingtoniana Lesquereux, U. S. Geol. Survey Mon. 17, p. 131, pl. 21, fig. 1 (pl. 22, figs. 2, 3, is not this species but *Aralia saportana* Lesquereux), 1891 [1892].

Newberry, U. S. Geol. Survey Mon. 35, p. 114, pl. 26, fig. 1, 1895 [1896].

Berry, New Jersey Geol. Survey Bull. 3, p. 202, pl. 25, fig. 7, 1911; Torrey Bot. Club Bull., vol. 39, p. 402, 1912.

Aralia concinna Newberry, U. S. Geol. Survey Mon. 16, 16, p. 114, 1895 [1896].

Aralia wellingtoniana vaughanii Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 317, 1901.

This handsome species is described by Lesquereux as being palmately three to five lobed, but it certainly seems significant that all the forms from the Raritan formation are three-lobed and that the five-lobed forms from the Dakota sandstone referred by Lesquereux to this species are indistinguishable from his species *Aralia saportana*, which occurs at the same horizon and, in part at least, at the same locality.

This is the most abundant form collected at Arthurs Bluff, Tex., there being 15 specimens in the one small collection made by Stanton and Stephenson and as many more in the old collections made by Hill and Vaughan. These are all trilobate, and the majority have toothed margins and agree exactly with the Raritan leaves of this species and with the trilobate leaves from the Dakota sandstone like the one figured by Lesquereux on his Plate XXI, figure 1.

In the light of our present knowledge *Aralia wellingtonia* may be redescribed in the following terms:

Leaves variable in size, 10 to 20 centimeters in length by 8 to 15 centimeters in maximum width from tip to tip of the lateral lobes; average size about 15 centimeters in length by 11 centimeters in width; coriaceous, palmately deeply trilobate, with a rapidly narrowed and more or less extended decurrent base; lobes long, lanceolate, widest in the middle and narrowing below, somewhat abruptly acuminate, the medium slightly the longest, diverging at an angle of about 30°, separated by sinuses extending more than halfway to the base, narrowly rounded; margins entire below and for varying distances upward, sometimes throughout, generally passing gradually into dentate-serrate teeth, one to each secondary or less, prominent in some specimens, where they are more or less extended and directed upward, separated by wide, shallow sinuses. Primaries stout, suprabasilar, the median slightly larger than the laterals. Secondaries numerous, thin, regular, subparallel, ascending, as the angle of their divergence from the primaries averages about 33°, but slightly curved in their course, ultimately craspedodrome in the distal parts of the leaf, where the margin is toothed, and camptodrome in the basal half of the leaf, where the margin is entire. Areolation indistinct, reticulate, of quadragonal or polygonal meshes. The smaller leaves are relatively shorter and broader, with less extended lobes and more open and less deep sinuses.

The present species was confused by Ward[39] with what was subsequently differentiated as *Aralia cottondalensis* Berry,[40] of the Tuscaloosa formation, which has shorter, more conical lobes, a broadly rounded base, and more crenate marginal teeth.

[39] Ward, L. F., in Smith, E. A., Geology of the Coastal Plain of Alabama, p. 348, 1894.

[40] Berry, E. W., U. S. Geol. Survey Prof. Paper 112, p. 128, pl. 26, figs. 1–3, 1919.

The present species is also very similar to *Aralia decurrens* Velenovsky,[41] from the Cenomanian of Bohemia, which, however, has relatively narrower and more elongated lobes, with coarser teeth, and deeper sinuses.

In reporting on a collection made by Vaughan at Arthurs Bluff, Tex., and now in the United States National Museum, Knowlton[42] mentions *Aralia wellingtoniana vaughanii* n. var. as the most abundant form observed. This variety was distinguished from the type "by its trilobate form, more slender lobes, and entire margins." A study of this material has satisfied me that it is not distinct from the normal *Aralia wellingtoniana*, which shows every gradation in size and ranges from entire to more or less completely toothed margins.

Aralia saportana Lesquereux?

Aralia saportana Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 394, 1875 [1876]; idem, Ann. Rept. for 1874, p. 350, pl. 1, figs. 2, 2a, 1876; U. S. Geol. Survey Terr. Rept., vol. 8 (Cretaceous and Tertiary floras), p. 61, pl. 8, figs. 1, 2; pl. 9, figs. 1, 2, 1883.

Aralia wellingtoniana Lesquereux, Flora of the Dakota group, p. 131 (part), pl. 22, figs. 2, 3 (not pl. 21, fig. 1), 1892.

This species was described by Lesquereux as follows:

Leaves large, subcoriaceous, triple-nerved and five-lobate by division of the lateral nerves, fan-shaped in outline, narrowed in a curve or broadly cuneate, and decurring to a long, slender petiole; lobes narrowly lanceolate or linear-lanceolate, acute or blunt at the apex, equally diverging, distantly dentate from below the middle upward; secondary nerves subcamptodrome.

This beautiful species is known by numerous finely preserved specimens. The leaves, 9 to 20 centimeters long from the top of the petiole to the sumit of the middle lobe, are of the same width between the points of the lower lateral lobes; the petiole is long and comparatively slender, though appearing thick upon one of the specimens, probably enlarged and flattened by compression. The preserved broken part on one of the leaves measures 5 centimeters. The lobes cut down to about two-thirds of the leaves are narrowly lanceolate, slightly narrower near the obtuse sinuses, equally diverging, the lower lateral ones much shorter, curved down, and decurring to the base of the leaves. The leaves, triple-nerved from the division of the primary nerves a little above the base, become five-nerved from the forking of the lateral nerves at a short distance from their base. The secondary veins emerge at an acute angle of 30°, curve in ascending to the borders, and sometimes enter the teeth by their ends; the upper more generally follows close to the borders in festoons, emitting under the teeth short branches which enter them. There are not any intermediate tertiary veins, but the nervilles are strong, often continuous, anastomosing in the middle of the areas and forming by subdivisions a small quadrangular areolation.

The material from Arthurs Bluff, Tex., is scanty and not positively determined.

Family CORNACEAE.

Genus CORNOPHYLLUM Newberry.

Cornophyllum vetustum Newberry.

Cornophyllum vetustum Newberry, The flora of the Amboy clays, p. 119, pl. 19, fig. 10, 1896.

Berry, New Jersey Geol. Survey Bull. 3, p. 196, 1911; Torrey Bot. Club Bull., vol. 39, p. 404, 1912; U. S. Geol. Survey Prof. Paper 112, p. 129, 1919.

Leaves elliptical, 7 to 8 centimeters in length by about 4 centimeters in maximum width, with an acute apex and base, the base slightly decurrent and inequilateral. Margin entire, very slightly and inconspicuously undulate. Midrib slender and straight. Secondaries slender, about seven pairs, opposite or alternate, branching from the midrib at angles of about 45° and strongly curved upward, approximately parallel and camptodrome; they increase in length from the apex to the base, the lower ones sweeping upward in strong arches parallel with the margin and all drawn inward toward the apex.

With the exception of the delicate and somewhat flexuous character of the venation, these leaves are strictly comparable with those of *Cornus*, good species of which, very similar to this species, occur in the Dakota sandstone of the West, in Greenland, and in the Magothy formation of Maryland.

This species is found also in the Raritan formation of New Jersey and the Tuscaloosa formation of Alabama.

Order ERICALES?

Family ERICACEAE?

Genus ANDROMEDA Linné.

Andromeda novaecaesareae Hollick.

Plate XXXVIII, figure 1.

Andromeda novaecaesareae Hollick, in Newberry, The flora of the Amboy clays, p. 121, pl. 42, figs. 9–12, 28–31, 1896.

Smith, On the geology of the Coastal Plain of Alabama, p. 348, 1894.

Berry, Torrey Bot. Club Bull., vol. 33, p. 181, 1906; vol. 34, p. 204, 1907; vol. 37, p. 29, 1910; vol. 39, p. 405, 1912; vol. 43, p. 301, 1916; vol. 44, p. 188, 1917; New Jersey Geol. Survey Bull. 3, p. 204, pl. 25, fig. 6, 1911; U. S. Geol. Survey Prof. Paper 84, p. 58, pl. 14, figs. 5, 6,1914; U. S. Geol. Survey Prof. Paper 112, p. 129 (part), pl. 30, figs. 1, 2, 1919.

[41] Velenovsky, Josef, Die Flora der böhmische Kreideformation, pt. 3, p. 11, pl. 4, figs. 5–7, 1884.

[42] Knowlton, F. H., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, 317, 1901.

Leaves small, thick, and entire, with stout petioles and midribs and obscure secondary venation which is immersed in the thick lamina. Length 2.5 to 5 centimeters; width 0.9 to 1.3 centimeters. Venation, where visible, showing numerous parallel, camptodrome, relatively long and thin secondaries, which branch from the midrib at acute angles. Though the majority of these leaves are equally acuminate at both ends, there is considerable variation in this respect, and a well-marked tendency is shown in many specimens that are relatively broader, especially in the upper half, toward an obtusely rounded apex, the termination of the midrib showing as a small mucronate point. The base in these forms gradually narrows to the stout petiole. The variations in outline of this species are well shown in the figures reproduced in Newberry's monograph.

Typical leaves of this species are not uncommon at Arthurs Bluff, Tex. It was described originally from specimens found in the upper part of the Raritan formation of New Jersey and has subsequently been recognized in the Magothy, Black Creek, and Tuscaloosa formations of the southeastern Atlantic Coastal Plain and in the Bingen sand of Arkansas. Somewhat similar obovate leaves of very coriaceous texture, formerly confused with this species, are somewhat younger and have recently been transferred by me to the genus *Euphorbiophyllum*.

It may well be questioned whether this and the following species of *Andromeda* should be referred to the Ericales. Certainly the present form has numerous points of contact with the leaves of *Eugenia*, which has been positively recognized in the lower Eocene floras of this general region.

Andromeda snowii Lesquereux.

Andromeda snowii Lesquereux, U. S. Geol. Survey Mon. 17, p. 117, pl. 17, fig. 16, 1891 [1892].
Berry, Torrey Bot. Club Bull., vol. 39, p. 405, 1912.

Leaves small, entire, coriaceous, lanceolate, broadest in the middle and equally acute at both ends. Length 4.5 centimeters; maximum width 1.5 centimeters. Midrib stout. Secondaries oblique, regularly spaced, subparallel, camptodrome.

This species, of doubtful distinctness from the preceding, was described originally from material collected in the Dakota sandstone of Ellsworth County, Kans. It is represented by a single specimen from Arthurs Bluff, Tex. It resembles the lanceolate leaves of the preceding species but is broader, with less numerous and much less ascending secondaries.

Order EBENALES.

Family EBENACEAE.

Genus DIOSPYROS Linné.

Diospyros primaeva Heer.

Plate XXXIX, figure 2.

Diospyros primaeva Heer, Phyllites crétacées du Nebraska, p. 19, pl. 1, figs. 6, 7, 1866; Flora fossilis arctica, vol. 6, Abt. 2, p. 80, pl. 18, fig. 11, 1882; vol. 7, p. 31, pl. 51, figs. 5a, b, c, 1883.
Englehardt, Naturwiss. Gesell. Isis in Dresden Abh. 7, Jahrg. 1891, p. 98, 1892.
Lesquereux, The flora of the Dakota group, p. 109, pl. 20, figs. 1–3, 1892.
Smith, On the geology of the Coastal Plain of Alabama, p. 348, 1894.
Newberry, The flora of the Amboy clays, p. 124, pl. 30, figs. 1–5, 1896.
Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 317, pl. 39, fig. 3, 1901.
Berry, Torrey Bot. Club Bull., vol. 32, pl. 2, 1905; vol. 34, p. 204, 1907; vol. 38, p. 417, 1911; New Jersey Geol. Survey Bull. 3, p. 211, pl. 29, fig. 1, 1911.
Hollick, The Cretaceous flora of southern New York and New England, p. 103, pl. 42, figs. 2, 11, 1906.
Berry, Maryland Geol. Survey, Upper Cretaceous, p. 894, pl. 90, fig. 4, 1916; U. S. Geol. Survey Prof. Paper 84, p. 61, pl. 11, fig. 3; pl. 14, figs. 12, 13, 1914; Torrey Bot. Club Bull., vol. 43, p. 303, 1916; U. S. Geol. Survey Prof. Paper 112, p. 134, pl. 30, fig. 3, 1919.

Leaves oblong-ovate, variable according to age, ranging from 3 to 15 centimeters in length by 1.3 to 5 centimeters in greatest width, which is in the middle part of the leaf. Apex acute or obtuse. Base cuneate. Margins entire. Petiole rather long and very stout. Midrib also stout. Secondaries branching from the midrib, generally at acute angles, subopposite to alternate, parallel, camptodrome. Tertiaries forming polygonal areoles, whose relative prominence is one of the features of this species.

This species, which is suggestive of the modern *Diospyros virginiana* Linné, was described by Heer from specimens collected in the Dakota sandstone of Nebraska over half a century ago. It has proved to be a form of very wide range, having been identified at both the Atane and Patoot horizons in Greenland,

from the Cenomanian of Niederschoena in Saxony, and from various localities within the Dakota sandstone; and with the exception of the fragments from Marthas Vineyard and Long Island, which are of questionable identity, it is common in the Raritan and Magothy formations, or their homotaxial equivalents, from New Jersey to Alabama.

Its most marked character is the prominence of its tertiary areolation. It is common at various localities in the lower part of the Tuscaloosa formation of western Alabama and continues upward into those beds in Hale County which have been placed in the basal portion of the Eutaw formation and into the Coffee sand member of that formation in Tennessee. It is undoubtedly present, but not common, in the collections from Arthurs Bluff, Tex.

Order RUBIALES.

Family CAPRIFOLIACEAE.

Genus VIBURNUM Linné.

Viburnum robustum Lesquereux.

Plate XXXIX, figure 4.

Viburnum robustum Lesquereux, U. S. Geol. Survey Mon. 17, p. 120, pl. 20, figs. 4–6, 1891 [1892].
Knowlton, U. S. Geol. Survey Twenty-first Ann. Rept, pt. 7, p. 317, 1901.
Berry, Torrey Bot. Club Bull., vol. 39, p. 405, 1912.

Leaves shortly and broadly ovate, generally widest below the middle, narrowing upward to the obtuse tip. Base cuneate, slightly decurrent to the thick petiole. Margins entire, often somewhat undulate. Texture coriaceous. Length 7 to 10 centimeters; maximum width 5 to 6 centimeters. Petiole long and stout, about 3 centimeters in length. Midrib stout. Secondaries stout, ascending, somewhat irregularly spaced, rather straight, camptodrome or brachydrome.

This species is represented by characteristic specimens from Arthurs Bluff, Tex. It was described originally from material collected in Ellsworth County, Kans., and is not known from other areas.

POSITION UNCERTAIN.

Genus TRICALYCITES Newberry.

Tricalycites papyraceus Hollick.

Plate XL, figure 9.

Tricalycites papyraceus Hollick, Torrey Bot. Club Bull., vol. 21, p. 63, pl. 180, fig. 8, 1894.
Newberry, U. S. Geol. Survey Mon. 26, p. 132, pl. 46, figs. 30–38, 1896.
Hollick, New York Acad. Sci. Annals, vol. 11, p. 423, pl. 37, figs. 1, 2, 1898; New York Bot. Garden Bull., vol. 2, p. 405, pl. 41, fig. 3, 1902; U. S. Geol. Survey Mon. 50, p. 109, pl. 5, figs. 8–12, 1906.
Berry, Torrey Bot. Club Bull., vol. 31, p. 81, pl. 1, fig. 4, 1904; vol. 39, p. 405, 1912; New Jersey Geol. Survey Ann. Rept. for 1905, p. 139, 1906; New Jersey Geol. Survey Bull. 3, p. 221, 1911; U. S. Geol. Survey Prof. Paper 112, p. 137, pl. 28, figs. 1–5, 1919.

This very characteristic tri-alate fossil is abundant in the middle and upper parts of the Raritan formation of New Jersey. It occurs sparingly in the overlying Magothy formation and is very common in the lower part of the Tuscaloosa formation in western Alabama. It is abundant at Arthurs Bluff, Tex., the present collection containing eight typical specimens, some of them complete. They are in exact agreement with the Tuscaloosa forms and demonstrate what is discussed at length in my account of the Tuscaloosa flora, that the approximately parallel longitudinal venation of the wings is really a more or less forked and anastomosing venation, thus allying these fossils in a remote way with such modern genera as *Vatica*, of the Dipterocarpaceae.

This form, despite its uncertain botanic affinity, is an important stratigraphic type, readily and surely recognized at all times. It characterizes the Tuscaloosa, Woodbine, Raritan, and Magothy formations but has never been discovered in the Dakota sandstone.

Genus CARPOLITHUS of authors.

Carpolithus sp. 1.

A coriaceous, ovate, concavo-convex scale or fruit of unknown botanic affinity, represented by a single specimen in the Woodbine sand at Arthurs Bluff, Tex. It is of no value, either geologic or botanic, but is entirely unlike previously described forms.

Carpolithus sp. 2.

Plate XL, figure 1.

A coriaceous valve of a capsule or pod, laterally compressed, oval, and acuminate at both ends. About 1.5 centimeters in length and 8 millimeters in maximum width, in the median region. Represented by a single specimen in the Woodbine sand at Arthurs Bluff, Tex., and of unknown botanic affinity. Suggestive of a valve of some coriaceous, single-seeded leguminous form.

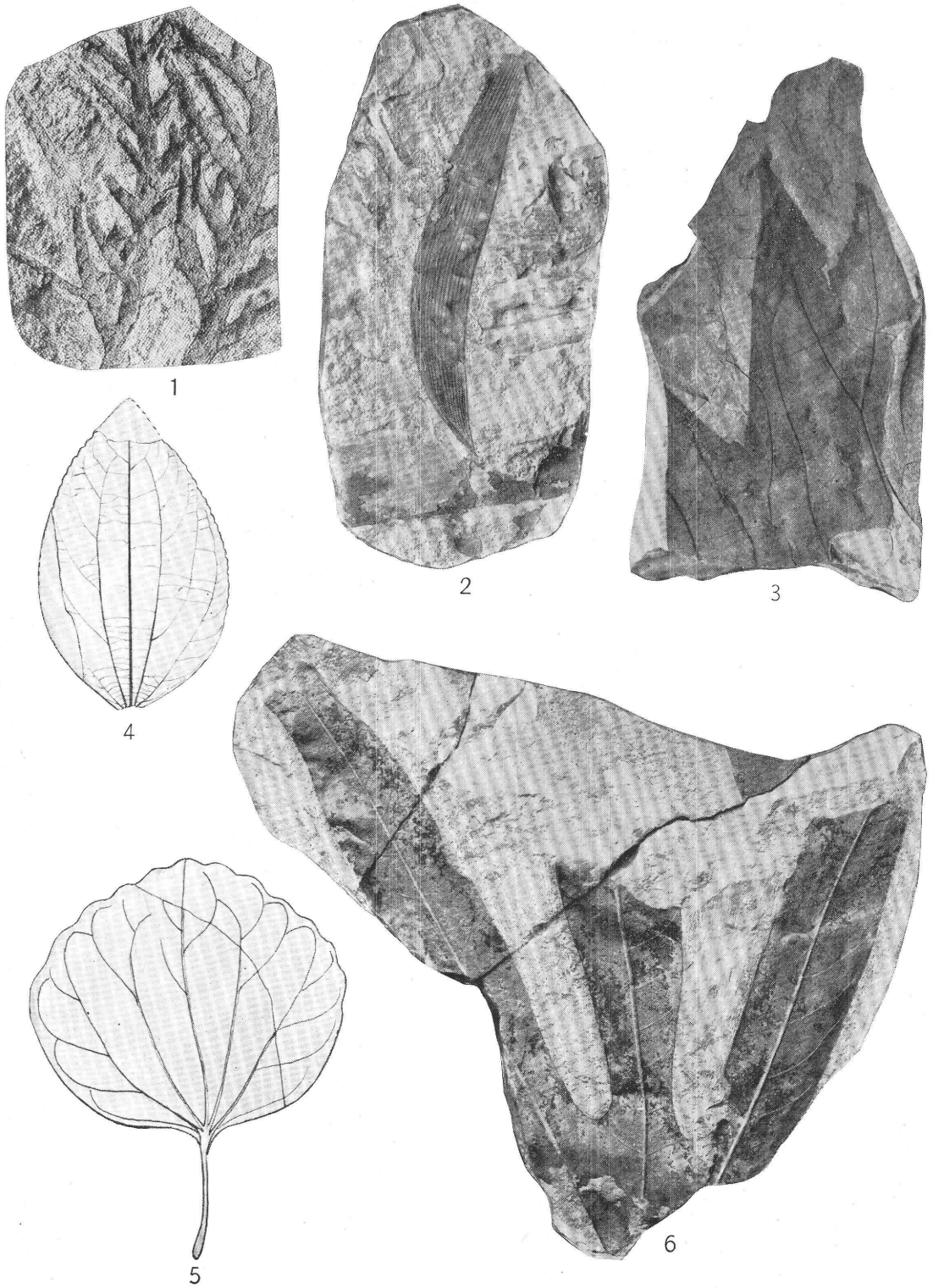
Carpolithus sp. 3.

Plate XL, figures 2–4.

A rhomboidal or obovate object with a somewhat transversely wrinkled, broadly rounded apex and a cuneate base, marked below the transversely striated apical arc by ascending, closely spaced, acutely forking subparallel veins. Of unknown botanic affinity, probably bracteate in character. Represented by three specimens in the Woodbine sand at Arthurs Bluff, Tex.

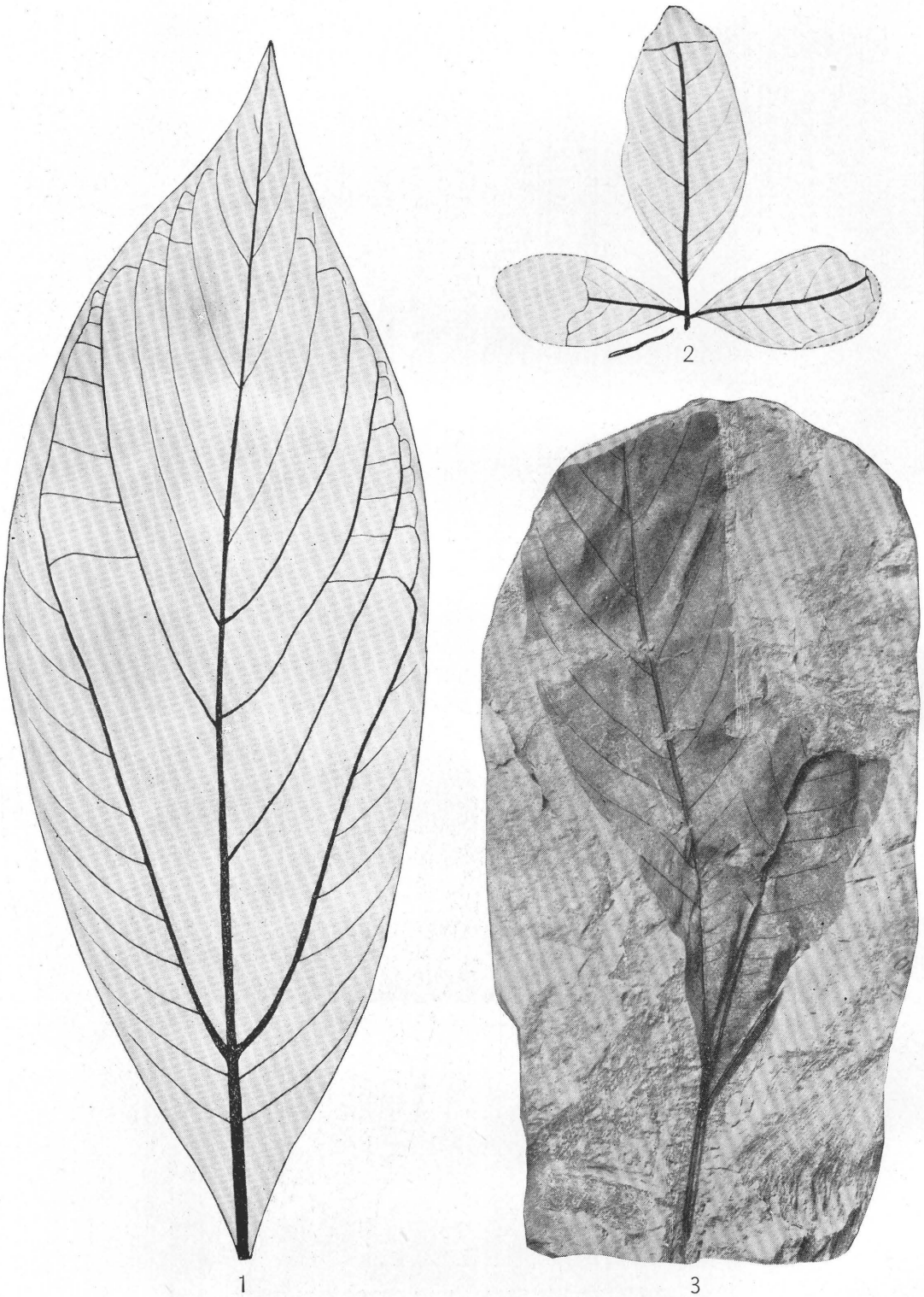
FIGURE 11.—Cut in the Woodbine sand near Arthurs Bluff, Tex.

PLATES XXXVI–XL



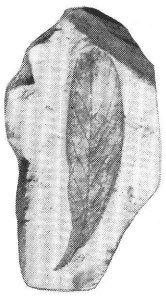
FOSSIL PLANTS FROM THE WOODBINE SAND.

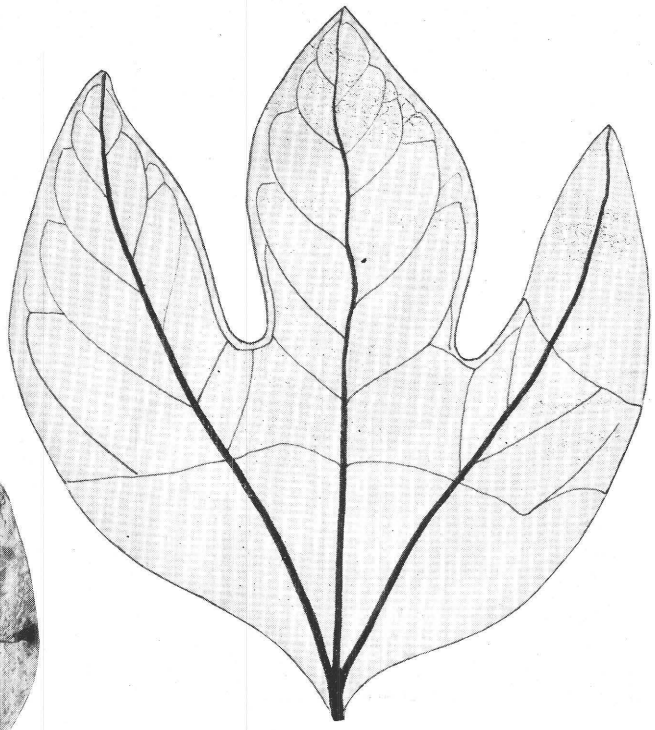
1, Brachyphyllum macrocarpum formosum Berry; 2, Podozamites lanceolatus (Lindley and Hutton) F. Braun; 3, Liriodendron quercifolium Newberry; 4, Zizyphus lamarensis Berry; 5, Trochodendroides rhomboideus Berry; 6, Sterculia lugubris Lesquereux.

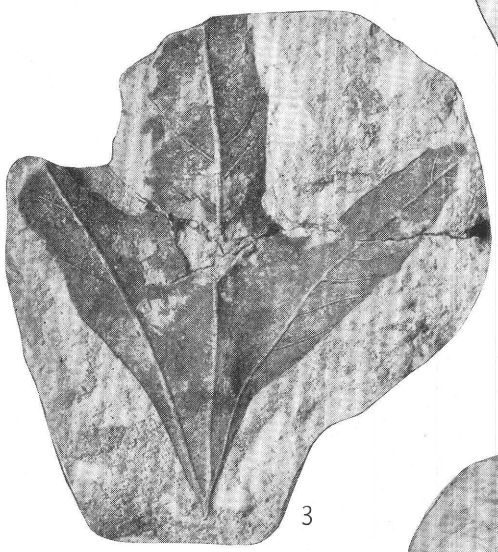


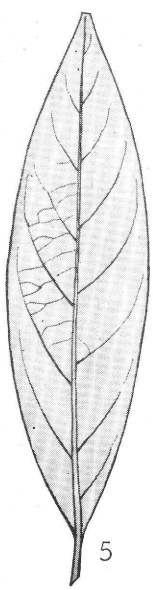
FOSSIL PLANTS FROM THE WOODBINE SAND.

1, Oreodaphne alabamensis Berry; 2, Rhus redditiformis Berry; 3, Aralia wellingtoniana Lesquereux.



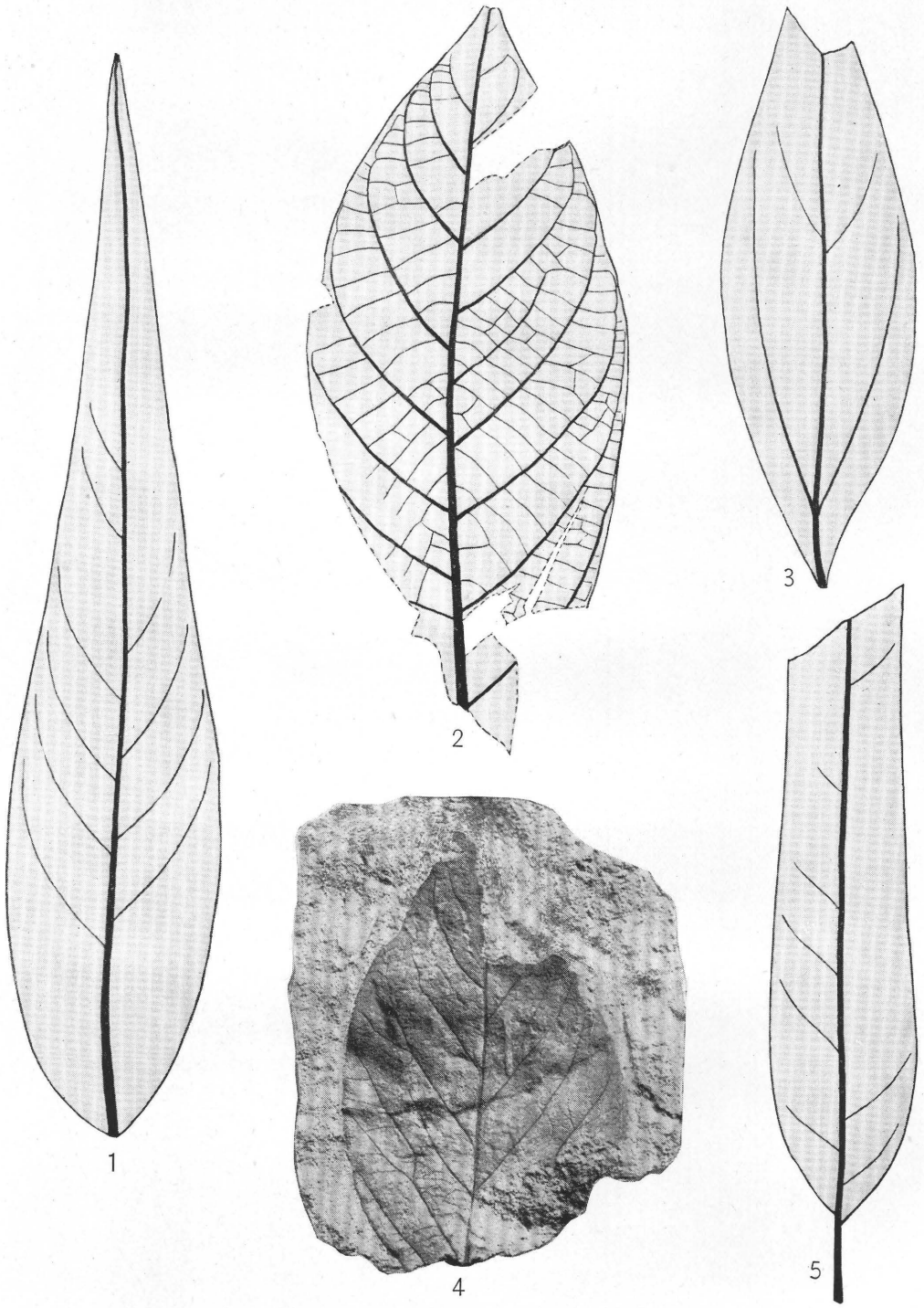






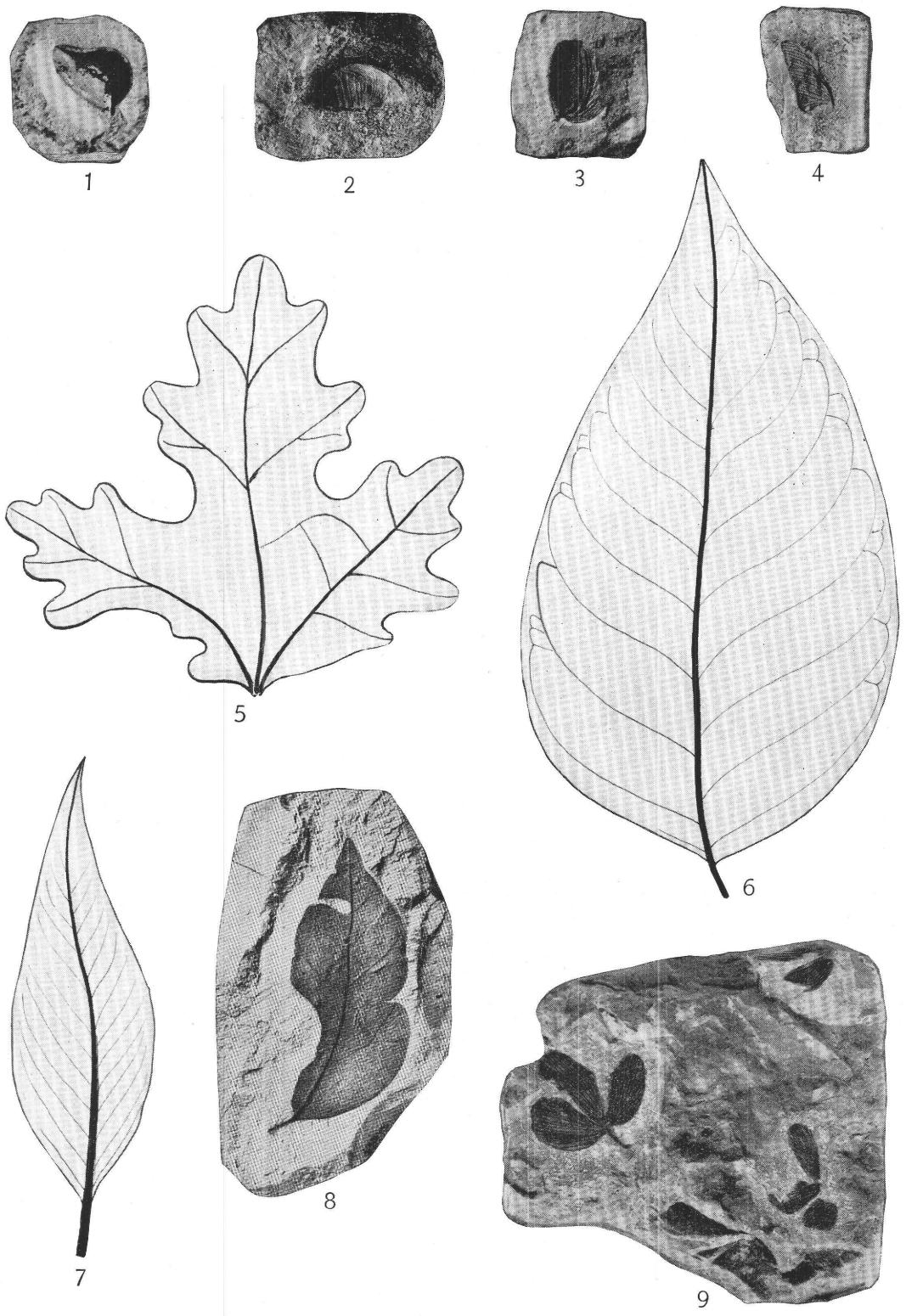
FOSSIL PLANTS FROM THE WOODBINE SAND.

1, Andromeda novaecaesareae Hollick; 2, Benzoin venustum (Lesquereux) Knowlton; 3, 4, Aralia wellingtoniana Lesquereux; 5, Laurus plutonia Heer.



FOSSIL PLANTS FROM THE WOODBINE SAND.

1, Ficus daphnogenoides (Heer) Berry; 2, Diospyros primaeva Heer; 3, Cinnamomum newberryi Berry; 4, Viburnum robustum Lesquereux; 5, Myrica longa (Heer) Heer.



FOSSIL PLANTS FROM THE WOODBINE SAND.

1, Carpolithus sp. 2; 2, 3, 4, Carpolithus sp. 3; 5, Cissites formosus Heer; 6, Magnolia speciosa Heer; 7, Rhamnus tenax Lesquereux, 8, Palaeocassia laurinea Lesquereux; 9, Tricalycites papyraceus Newberry.