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(*Continuation of Contributions from the Museum of Geology*)
UNIVERSITY OF MICHIGAN

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A PRELIMINARY STUDY OF THE FOSSIL FLORA OF THE MICHIGAN COAL BASIN

BY
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THE purpose of this paper is to illustrate and describe briefly some of the fossil plants of the Pennsylvanian formation of Michigan. Only those forms which have been determined with a reasonable degree of certainty are included, and the remainder, of which there are a considerable number of species, will be reserved for a later report.

The Michigan Coal Basin (Map 1) occupies the central part of the Lower Peninsula. The entire area is deeply covered with glacial drift, and at only a few places, such as along the Grand River at Grand Ledge and the Rifle River north of Saginaw Bay, can naturally exposed strata be seen. The extent of the coal basin has been determined mostly by borings. At Grand Ledge, Williamston, Corunna, and a few other places in the vicinity of Jackson the drift is thin enough for quarrying operations to be practicable. Possibly a few quarries can be found elsewhere, but those at the places mentioned above are the only ones of any considerable importance.

The Michigan Coal Basin has been described in some detail by Lane (12, 13) and by Smith (19). More recently a detailed study of the stratigraphy in the vicinity of Grand Ledge has been completed by Kelly (11).

The coal formation of Michigan rests upon a saucer-shaped base of Mississippian (Grand Rapids) age. Immediately underlying the coal is the much-eroded surface of the Maxville Limestone, in the troughs of which the coal swamps existed. The Mississippian beds dip gently from the outside toward the center, but the coal formation does not follow this trend. Unlike the

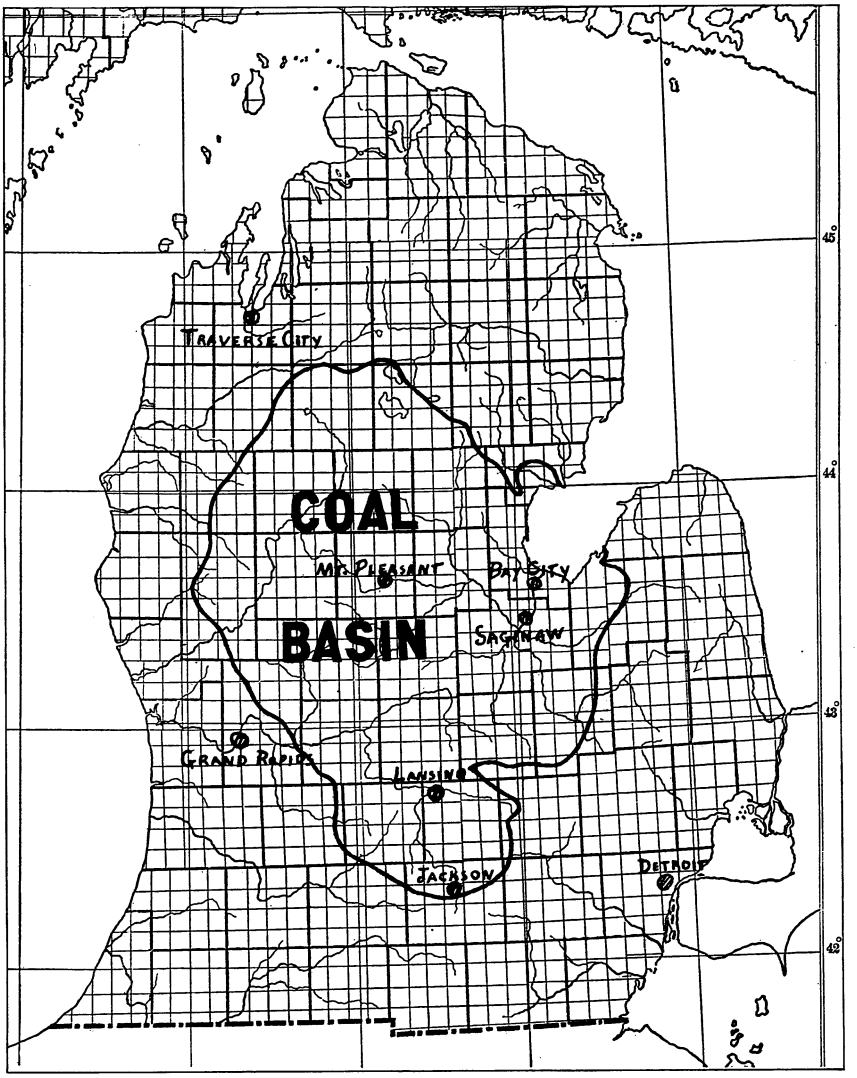
coal beds of Ohio and Illinois, none of the Michigan seams has a great horizontal extent. An instance is on record in which a drill struck a vein four feet thick, but two hundred feet away no coal could be found. A similar abrupt pinching out of coal and shale layers can be observed in the quarries at Grand Ledge. The explanation of this seems to be that the coal-forming swamps, instead of covering large areas, occupied the smaller depressions of the much-dissected and eroded Mississippian land surface. At many places within the coal basin and especially within the central part no coal has been found. This localization of the beds and the suddenness with which a bed may pinch out and be replaced by another of totally different character, together with the comparatively few localities where the formations can be studied, renders the understanding of the stratigraphy of the coal basin a particularly difficult problem.

The Pennsylvanian system of Michigan can be divided into three parts, of which the Parma Conglomerate (Pottsville) is the basal member (Lane, 13). Above this is the Saginaw Formation (also Pottsville), which is the coal-bearing series. Fourteen coal horizons have been recognized within the Saginaw (Lane, 13, p. 89). Over the Saginaw Formation is the Woodville Sandstone which, because of lithologic characters, has been regarded as possibly Permo-Carboniferous. It is doubtful whether the contained flora supports this conclusion.

Plant Remains

Plants have been found in several localities. However, in many places the material consists merely of casts of *Calamites* or *Artisia*, or impressions of *Cordaites* leaves in coarse sandstone, in which identification is impossible. A considerable quantity of such material from numerous sources had accumulated in the old geological collection of the University of Michigan. Numerous impressions on black shale which bear the catalogue numbers of the Michigan Geological Survey are preserved in the general collection, but most of these specimens are too poorly preserved and fragmentary for accurate identification.

The most useful material is that collected during the past four



MAP 1. The Michigan Coal Basin

years by Dr. W. A. Kelly, of Michigan State College, and the present author. During the course of stratigraphical studies in the quarries near Corunna and Grand Ledge Dr. Kelly was able to make a considerable collection of fragmentary though well-preserved material. With the assistance of information kindly given by Dr. Kelly the present author supplemented his collections.

In addition to material found *in situ* a few fragments, mostly of *Stigmaria*, have been collected in the glacial drift in the vicinity of Ann Arbor and Jackson. The occurrence of spores in the Carboniferous coal pebbles of this drift has been reported by Bartlett (3).

The fragmentary nature of the fossils renders identification of much of the material difficult and some of it impossible. In spite of this condition the preservation of many small fragments is excellent, and for this reason the size of the specimens rather than the state of preservation is generally the chief difficulty encountered. Preservation in the red ironstone nodules at Grand Ledge is often such as to reveal clearly the most minute details, but the tendency of these nodules to break into irregular lumps instead of splitting along a definite plane results in partial destruction of otherwise well-preserved material. Another difficulty is brought about by the readiness with which the shale weathers. Some of the most fossiliferous shales disintegrate into a mass of mud after two months of exposure to the weather.

Previous reference to fossil plants from the Michigan Coal Basin is limited to two lists made by Lane (12, 13) of species determined by David White. They are merely tabulations, with no accompanying descriptions. Altogether forty-five forms are listed from eleven localities, but many of the identifications are followed by an interrogation mark or are merely determined to genus. White states (as quoted by Lane, 12, p. 44) that this meager flora indicated a place high up in the Pottsville. Although the present study is too limited in scope to point out anything conclusive, it appears that the forms represent a place no lower than the upper Pottsville, and it becomes evident upon comparing our species with those of the Yorkian flora of Great Britain (Crookall, 6) that a similar flora exists there.

In assigning the species to their respective horizons reference is made to the sedimentation cycles as defined by Kelly (11). This applies only to the material from Grand Ledge, since the cyclical determinations of the sediments have not been made in the other localities. For much of the other material only the localities are known, and in these instances assignment to cycles is not made.

Determination of the Material

In determining the material the specimens were first compared with the figures and descriptions in Lesquereux's *Coal Flora* (14) and White's monograph, *Fossil Flora of the Lower Coal Measures of Missouri* (20). The *Coal Flora* is old and needs revision, but even now it is the most comprehensive work dealing with the American Carboniferous. White's monograph is more recent and is illustrated with photographs, but it is somewhat more limited in scope. Noé's *Pennsylvanian Flora of Northern Illinois* (16), though without descriptive material, is the most recent work on any American Carboniferous flora, and with its excellent illustrations it serves a useful purpose.

In attempting to identify the fossil plants of the Michigan Coal Basin it soon becomes apparent that the American literature on the subject is not wholly adequate. Since the publication of the *Coal Flora* many American forms have been described and given new specific names, but they are so vaguely diagnosed and illustrated that new material cannot be assigned to them with confidence. When material could not be identified with species described in one or more of the three works mentioned above the present author has considered it advisable to refer it to forms described by the better-known European authors, as Zeiller, Renier, Gothan, and several others. Zeiller's *Flora fossile du Bassin Houiller de Valenciennes* (21), although rather old, is superbly illustrated and is comprehensive in the number of forms included. Renier's *Documents pour l'étudie de la paléontologie du Terrain Houiller* (17) is more recent than Zeiller's monograph and constitutes an excellent supplement to it. Kidston's extensive investigations of the Carboniferous floras of Great Britain are

summarized in Crookall's *Coal Measure Plants* (5). It is not intended here to mention all of even the most outstanding European works on the subject, but those named above are among the most useful in dealing with the Michigan fossils.

CLASSIFICATION OF THE MATERIAL

ARTICULATALES
- Sphenophyllineae
  - Sphenophyllum emarginatum Brong.
  - Sphenophyllum myriophyllum Crépin
  - Sphenophyllum majus Bronn
  - Sphenophyllum cuneifolium Sternb.
  - Sphenophyllum saxifragaefolium Sternb.
- Calamitineae
  - Calamites suckowi Brong.
  - Calamites undulatus Sternb.
  - Asterophyllites equisetiformis (Schl.) Brong.
  - Annularia sphenophylloides (Zenker) Unger
  - Annularia radiata Brong.
  - Annularia sp.
  - Calamites sp. (fructification)

LYCOPODIALES
- Lepidoderdraceae
  - Lepidodendron aculeatum Sternb.
  - Lepidodendron obovatum Sternb.
  - Bothrodendron minutifolium Boulay
  - Asolanus camptotaena (Wood) Wood
  - Lepidostrobus Bartletti Arnold
  - Lepidocystis fraxiniformis (Goepp.) Lesq.
  - Triletes Reinsch
- Sigillariaceae
  - Sigillaria scutellata Brong.
  - Stigmaria ficoides Brong.

FILICALES AND PTERIDOSPERMAE
- Neuropteridae
  - Neuropteris tenuifolia (Schl.) Zeiller
  - Neuropteris sp.
  - Neuropteris rarinervis Bunbury
  - Neuropteris dilatata (L. & H.) Lesq.
  - Neuropteris (Cyclopteris) sp.
  - Odontopteris sp.
- Alethopteridae
  - Alethopteris decurrens Artis
- Megalopteridae
  - Megalopteris dawsoni Hartt
  - Megalopteris Southwellii Lesq.
  - Megalopteris kellyi Arnold, sp. nov.

Sphenopteridae
Sphenopteris obtusiloba Brong.
Sphenopteris artemisiaefolioides Crépin
Mariopteris muricata (Schl.) Zeiller

CORDAITALES
Cordaites michiganensis Arnold
Cordaites (Artisia) sp.

PALEOZOIC GYMNOSPERMOUS SEEDS
Trigonocarpus sp.
Rhabdocarpus multistriatus (Presl) Lesq.
Rhabdocarpus mamillaris Lesq.
Samaropsis Newberryi (Andrews) Seward

DESCRIPTION OF FORMS AND SPECIES

ARTICULATALES

The term "Articulatales" is used as an inclusive designation for all pteridophytes, both living and fossil, with jointed stems and whorls of leaves at the joints (nodes). The only present genus belonging to this group is *Equisetum* (the horsetail or scouring rush), which has about twenty-five species. During Paleozoic times this group was one of the dominant elements of the flora and was represented by several genera, of which *Sphenophyllum* and *Calamites* are the best known.

Sphenophyllum emarginatum Brong.

(Plate II, Fig. 9)

Fragments of the well-known species *Sphenophyllum emarginatum* Brong. occur in the quarries at Grand Ledge and probably at other places also.

This species is readily distinguished from the others described in this paper by the wedge-shaped leaves, which are practically as broad at the apex as they are long. Their sides are straight, or nearly so, in contrast to the concave margin of *S. cuneifolium* and *S. saxifragaefolium*. At the apex there are several small teeth, which are rounded rather than pointed.

Quarry of the Grand Ledge Face Brick Company, Cycle "F." No. 14783 U.M.

Sphenophyllum myriophyllum Crépin
(Plate VI, Fig. 5; Plate VII, Fig. 11)

Material referable to this species occurs at Grand Ledge. The leaves, which are twelve to fifteen millimeters long, are divided by a cleft that extends almost to the base in such a way as to present a deceptive appearance of an *Annularia* split along the midrib.

Quarry of the Grand Ledge Face Brick Company, Cycle "F."
No. 14782 U.M.

Sphenophyllum majus Bronn

A single leaf fifteen millimeters long appears to belong to this species. It is divided into two equal lobes by a cleft which extends nearly to the base. Each lobe is then subdivided by a cleft extending nearly halfway down. Each ultimate lobe bears three or four pointed teeth.

Quarry of the American Vitrified Products Company, Grand Ledge.
No. 14790 U.M.

Sphenophyllum cuneifolium Sternb.
(Plate II, Fig. 4; Plate IV, Fig. 6)

The available material agrees well with published figures of this species in showing the concave margin and the pointed teeth at the apex of the leaves. Most of the leaves are divided by a cleft which extends one third of the way down. Surmounting each lobe are three or four sharp teeth.

Big Chief No. 8 Mine, St. Charles.
No. 14789 U.M.

Sphenophyllum saxifragaefolium Sternb.
(Plate II, Fig. 2; Plate III, Fig. 6; Plate IV, Fig. 3)

Along with *S. cuneifolium* there are rather abundant remains of a form with more deeply notched leaves. Each leaf of *S. saxifragaefolium* is strongly bifurcated by a cleft which extends about one third of the way down. Each lobe thus formed is in

turn divided by a smaller notch, so that the leaf is terminated by four sharp pronglike teeth, which bend outward in such a manner as to produce a strongly concave margin.

There are gradations between *S. cuneifolium* and *S. saxifragaefolium*, and Gothan (9) maintains that it is unnecessary to retain the separate specific designations. However, in our material the two types are easily recognizable; hence it is considered advisable to retain both names.

This material also resembles figures of *S. bifurcatum* (*Coal Flora*, Atlas, Pl. II, Fig. 10), which is little known and seems to resemble *S. saxifragaefolium* closely.

Big. Chief No. 8 Mine, St. Charles.

No. 14784 U.M.

Calamites suckowi Brong.

(Plate II, Fig. 6; Plate V, Fig. 1)

The most abundant remains of *Calamites* are the casts of the pith. These fossils were formed by the filling in of the pith cavity with sediment (the pith of the stem broke down when the plant was young), which hardened as the surrounding stem tissues decayed or altered into coal. The longitudinal ridges characteristic of these casts are the counterparts of the furrows at the inner margin of the wood which extend from one node to the next. The nodes represent the point of attachment of the leaves and branches, and, as will be noted, an alternation of the furrows usually occurs there.

Pith casts of *Calamites* are abundant in the Pennsylvanian rocks of Michigan, especially in the Woodville Sandstone along the Grand River west of Grand Ledge and in the quarries near that place. They are also abundant in the mines near St. Charles. The specific determinations of these fossils are difficult and uncertain. This is partly because of our unsatisfactory knowledge of American species of *Calamites* and partly because of the fragmentary nature of the material. The figures of *Calamites* in Lesquereux's *Coal Flora* are entirely inadequate, and no other American author has attempted to figure many forms.

Like *Stigmaria ficoides*, the casts of *Calamites suckowi* are dis-

tributed throughout the extent of the Coal Measures and are likely to occur in almost any fossiliferous stratum. For this reason their stratigraphic value is not great.

Quarry of the Grand Ledge Face Brick Co., Cycle "F."
Flushing, Genesee County.
Nos. 12201 and 14806 U.M.

Calamites undulatus Sternb.
(Plate III, Fig. 4)

In this species the furrows on the pith casts are sometimes wavy instead of straight.

Standard Mine, Saginaw.
No. 14772 U.M.

Asterophyllites equisetiformis (Schl.) Brong.
(Plate I, Fig. 3; Plate III, Fig. 3)

As yet only a few specimens of this form of calamitean foliage have been observed in the Michigan Coal Basin. The various species of *Asterophyllites* are difficult to distinguish in the barren condition, and it is quite probable that any one so-called species bore more than one type of fructification. *A. equisetiformis* has whorls of spreading needle-shaped leaves, which are sharply pointed.

The specimen figured in Plate I, Figure 3, has eight leaf whorls along six and one-half centimeters of stem. The leaves are about fifteen millimeters long, and there are about fifteen to a whorl.

Quarry of the Grand Ledge Face Brick Company. Cycle "A."
Big Chief No. 8 Mine, St. Charles.
Nos. 15430 and 14768 U.M.

Annularia sphenophylloides (Zenker) Unger
(Plate VII, Fig. 7)

This rather characteristic species has small leaves, from three to ten millimeters long, which broaden gradually toward the apex, then narrow rapidly to a point. It is a very common leaf fossil in both American and foreign Carboniferous strata. Though it is supposed to represent calamitean foliage, it has never been found in connection with the stem on which it was borne.

Quarry of the Grand Ledge Face Brick Company, Cycle "F." No. 14802 U.M.

Annularia radiata Brong.

(Plate I, Fig. 1)

A single leaf whorl apparently belonging to this species came from Grand Ledge. The leaves of our specimen are somewhat smaller than are typical for this species, but in many respects the similarity is close. It would be necessary to find material of this type in connection with larger leaves to establish its identity beyond all doubt. It differs from *A. sphenophylloides* principally in being larger and in having leaves with more taper-pointed apices.

Quarry of the American Vitrified Products Company, Grand Ledge.

No. 14795 U.M.

Annularia sp. (small form)

(Plate I, Figs. 2, 4)

A few specimens of small-leaved forms of *Annularia* resembling those variously described as *A. minuta*, *A. spicata*, *A. microphylla*, and *A. galioides* were found at several localities. Different authors have at times united some or all of them, but without the opportunity to examine authentically identified material it is difficult to refer our material to any of these species with certainty. A number of our specimens might bear some resemblance to *Asterophyllites acicularis* Dawson, and Renier (17) figures a small form of *Annularia radiata*, with which some of our material seems to correspond closely.

Quarry of the American Vitrified Products Company, Grand Ledge.

Big Chief No. 8 Mine, St. Charles.

Standard Mine, Saginaw.

Nos. 14799 and 14800 U.M.

Calamites sp. (fructification)

(Plate VI, Fig. 2)

The strobilus of *Calamites* consists of a slender axis bearing alternate whorls of peltate sporangiophores and sterile bracts which are united basally. In the *Calamostachys* type the sporangiophores are on the axis midway between two adjacent whorls of sterile bracts. In the *Paleostachya* type the sporangiophores are in the axils of the sterile bracts. In either one the jointed structure so evident in the stem shows here, although the internodes may be considerably shorter.

The specimen under consideration is a large one, measuring two by eleven and one-half centimeters, but is incomplete. The successive whorls of bracts are five millimeters apart.

Grand Ledge, Cycle "F."

No. 15429 U.M.

A similar but smaller strobilus, probably of *Calamites*, came from the quarry of the Grand Ledge Face Brick Company (Plate II, Fig. 8). It measures one by six centimeters, with whorls of bracts two millimeters apart. The position of the sporangiophores is indeterminable, since preservation is poor, but the articulate structure of the axis indicates the fructification typical of *Sphenophyllum* or *Calamites*.

Quarry of the Grand Ledge Face Brick Company, Cycle "F."

No. 14774 U.M.

LYCOPODIALES

Lepidodendron aculeatum Sternb.

(Plate VI, Fig. 6)

This widely known species has leaf cushions on which the foliar scars are somewhat above the middle. The most characteristic feature is that the upper and the lower extremities of the cushions are inflected. In many respects the species resembles *L. obovatum*, but both the cushions and the scars are longer in proportion to their width. Also the keels above the foliar scars are more distinct.

Quarry of the American Vitrified Products Company, Grand Ledge.

No. 14777 U.M.

Lepidodendron obovatum Sternb.

(Plate VI, Fig. 1)

A very fine imprint in sandstone of this species was collected several years ago from a ledge in a brook that joins Grand River just above Grand Ledge. The leaf cushions measure two and one-half by four and one-half centimeters, and their form is perfectly preserved. This species is probably rather abundant in the Michigan Coal Basin.

Woodville Sandstone, Grand Ledge.

No. 13981 U.M.

Bothrodendron minutifolium Boulay

(Plate VI, Fig. 3)

Leaf-bearing twigs of this species were found at Grand Ledge in association with *Sigillaria scutellata.* Several other forms as *Lycopodites carbonaceus, L. Meeki,* and *Lepidodendron selaginoides* are very similar to this and are frequently confused with it. The identification of this material is based principally upon figures of *L. carbonaceus* which, according to Jongmans (10), represent this species.

Quarry of the Grand Ledge Face Brick Company, Cycle "E."

No. 14792 U.M.

Asolanus camptotaena (Wood) Wood

This form is not common in the Michigan Coal Basin, but is occasionally seen. Formerly thought to be related to *Sigillaria,* it is now considered closer to *Lepidodendron* or *Bothrodendron,* since the leaf scars are spirally arranged.

Quarry of the Grand Ledge Face Brick Company, Cycle "F."

Big Chief No. 8 Mine, St. Charles.

No. 14771 U.M.

Lepidostrobus Bartletti Arnold

This specimen, upon which this species was founded, was described in a previous paper (1). It is a partly petrified hetero-

sporous strobilus measuring two and one-half by eleven and one-half centimeters.

Woodville Sandstone, Grand Ledge.

No. 14779 U.M.

Lepidocystis fraxiniformis (Goepp.) Lesq.

A specimen from the Big Chief Mine No. 8 appears to be identical with specimens in the museum collection which were derived from the Intraconglomerate at Pittston, Pennsylvania. Lesquereux (*Coal Flora*, text, p. 457) describes this form as follows: "Sporanges inflated or bladder-like, oblong in outline, rounded or truncate at both ends." Our specimen is a small capsule-like structure which measures six by thirteen centimeters. It tapers slightly, both ends are somewhat rounded, and there are no recognizable surface markings. Lesquereux regarded these objects as the probably detached sporangia of Lepidodendraceae. There is no question concerning the identity of our specimen and the Pennsylvania material, but since this type of sporangium may be produced by several species it has but slight biologic or stratigraphic significance.

Big Chief No. 8 Mine, St. Charles.

No. 14764 U.M.

Triletes Reinsch

The designation *Triletes* is frequently used for isolated lycopodiaceous spores which cannot be associated with the vegetative phase of the life-history. Three types from the coal pebbles of the glacial drift at Ann Arbor, *T. superbus*, *T. rotatus*, and *T. mamillaris*, have been described by Bartlett (3).

The parts of the spores preserved in these forms are the cutinized exines, which are quite resistant to decay, and the attached appendages, which are merely extensions or prolongations of the exine. The function of the appendages was to assist the dispersal of the spores by the wind. The source of the coal pebbles which yielded the spores is unknown, since they occur east of the supposed eastern margin of the Michigan Coal Basin and since the glacial drift at Ann Arbor is thought to have been derived from the opposite direction.

Sigillaria scutellata Brong.

(Plate IV, Fig. 1)

A fine specimen closely resembling figures of this species by Zeiller (21), Deltenre (8), Renier (17), Crookall (6), and others came from the quarry of the Grand Ledge Face Brick Company.

In this specimen the rounded ridges, which are separated by slightly undulating furrows, are approximately 11 to 13 millimeters broad. The foliar scars are about 25 millimeters apart and are about equal in height and breadth. The lateral angles of the scars are prolonged to a point, and from each a decurrent line passes downward for a short distance. The lower half of the scar is more rounded than the upper part, which has a trapezoidal outline. The print of the vascular bundle is a small dot located midway and just above the line of the two lateral angles. The prints of the parichnos strands are oval, about one millimeter long, and extend slightly above the vascular strand print. Where preservation is sufficiently good the ligule pit is visible immediately above the leaf scar. Above this is a transverse arc, which extends across the rib and has a length about equal to the diameter of the scar. Occupying the space between the scars on the top of the ribs is a series of fine irregular transverse wrinkles, which are shorter than the width of the scars and the transverse bars above them.

Most authors mention the variability shown by this species. The scars may be almost contiguous on the ribs, resembling those of *S. mamillaris*, or they may be vertically elongated, so that they resemble those of *S. elongata*. In some specimens the furrows are distinctly wavy, recalling those of *S. polyploca*. In our specimen, which appears to represent the middle part of the trunk, the scars are distantly placed and have about equal transverse and vertical diameters. The furrows are slightly wavy.

So far this is the best preserved *Sigillaria* specimen which has been found in the Michigan Coal Basin. Less well preserved material has been gathered in Cycle "F," which is slightly higher than the horizon bearing this species.

Quarry of Grand Ledge Face Brick Company, Cycle "E."

No. 14794 U.M.

Stigmaria ficoides Brong.

(Plate V, Figs. 2, 5)

Stigmaria, the rootlike organ of *Lepidodendron* and *Sigillaria*, is the most common plant fossil in the Carboniferous rocks. Specimens are often present in considerable numbers in the clay beneath coal seams, and the assumption is frequently made that these clays are the old soil which supported the vegetation that occupied the coal swamp.

Stigmariae are abundant at Grand Ledge, where specimens several feet long may sometimes be seen in the exposed strata below the coal seams in the quarry walls.

Several species are known, but the form commonly assigned to *S. ficoides* is by far the most abundant and most widespread.

The exact nature of these rootlike organs has never been explained. Functionally they were probably roots, but anatomically and morphologically they appear to have been different.

Pieces of *Stigmaria* with lateral "rootlets" attached have been found in the glacial drift at Ann Arbor and at Jackson.

Nos. 14807 and 14808 U.M.

FILICALES AND PTERIDOSPERMAE

These two great groups of Paleozoic plants are here treated together because of the impracticability of attempting to distinguish them by leaf characters alone. The designation "Age of Ferns" is no longer applied to the Carboniferous period, as it was in former times, and after the discovery of the Pteridospermae or the "seed ferns" some investigators even went so far as to suggest that ferns did not then exist at all. The study of petrified remains, principally from coal balls, has demonstrated that both plant types existed then, but they cannot be distinguished from each other by the mere impressions of the leaves such as are commonly found in coal mines and quarries. Consequently the so-called genera, as *Neuropteris*, *Alethopteris*, and others, are not genera in the natural sense, but are merely convenient designations to include forms having similar external morphology. The discovery of seeds in connection with certain of these leaf types has enabled

investigators to place some of them in their proper divisions in the plant kingdom.

Neuropteris tenuifolia (Schl.) Zeiller

(Plate VI, Fig. 4)

A single rather incomplete specimen is referred to this species after some hesitation. It is a fragment of a single large pinna from which the terminal part is missing. The pinnules range from two and one-half to three and one-half centimeters in length, are one centimeter or more broad at the base, and taper gradually to the rounded apex. The midrib is distinct for about two thirds of the length of the pinnules. The veins leave the midrib at a steep angle and then bend gradually outward toward the margin, with the curve increasing as the margin is approached.

Grand Ledge.

No. 15428 U.M.

Neuropteris sp.

(Plate VII, Fig. 2)

A fragment of *Neuropteris* consisting of a terminal pinnule and five adjacent lateral pinnules came from the ironstone nodules at Grand Ledge. Although the lateral pinnules are constricted at the base, some of the veins enter directly from the rachis, to which the pinnules are attached, after the manner of *Odontopteris*. Whether this condition is characteristic or whether the pinnules become neuropteroid farther down on the rachis cannot be determined from the specimen at hand.

Quarry of the American Vitrified Products Company, Grand Ledge, Cycle "A."

No. 14796 U.M.

Neuropteris rarinervis Bunbury

(Plate III, Figs. 1, 2, 5, 7)

In Cycle "F" and in some of the other lower horizons at Grand Ledge this is the most common plant fossil. Large specimens are never found, but parts near the apices of the pinnae occur in quantity.

This species is distinguished by the lateral veins, which are

few and well separated, and by the rather strongly marked midrib.

Quarries of the American Vitrified Products Company and the Grand Ledge Face Brick Company, Cycle "F."

Nos. 14780 and 14781 U.M.

Neuropteris dilatata (L. & H.) Lesq.

(Plate V, Fig. 4)

A single large incomplete specimen closely resembles material described by Lesquereux (14) and by White (20) from Clinton, Missouri. It shows the base expanded into large auricles, which overlap around the point of attachment to the rachis. It is eight centimeters broad along its greatest dimension, but the margin is indistinct and it is broken along one side.

Big Chief No. 8 Mine, St. Charles.

No. 14791 U.M.

Neuropteris (*Cyclopteris*) *sp.*

(Plate V, Fig. 3)

Among the numerous unattached neuropteroid pinnules is a single large specimen worthy of special mention. It measures three by four centimeters, is broadly oval, and is without a distinct midrib. The veins, which dichotomize several times, radiate outward from the point of attachment at the base.

This specimen closely resembles the large orbicular basal pinnules of some of the neuropteroid fronds, originally designated as *Cyclopteris*. There is considerable variation among these basal pinnules even within a species, and since in this specimen preservation is inadequate to show the finer details of the venation and the surface characters, its exact identification is uncertain.

Big Chief No. 8 Mine, St. Charles.

No. 14765 U.M.

Odontopteris sp.

(Plate II, Fig. 5)

A single specimen from the red ironstone nodules at Grand Ledge is referable to this genus. It consists of a small part of a frond, with the terminal pinnula and a few lateral pinnules. The

latter show the venation characteristic of this leaf type. It is suggestive of *Odontopteris Wortheni*, although it is too incomplete to permit specific identification.

In this genus the pinnules are attached by their full width at the base, and the veins pass into them from the rachis instead of branching off from the midrib. If a midrib is present it is usually obscure.

Quarry of the American Vitrified Products Company, Grand Ledge, Cycle "A."

No. 14778 U.M.

Alethopteris decurrens Artis

(Plate II, Figs. 1, 3, 7)

Alethopteris decurrens is represented by several small pieces of terminal parts of pinnae. They agree closely with figures by Zeiller, Renier, and other European authors.

This species, which is not so abundant in the Coal Measures of North America, has long narrow pinnules, often rather distantly placed. The margins are parallel and converge very gradually from the middle to the tip. The midrib is distinct, and the lateral veins arise from it at an acute angle, but they immediately bend outward and pass to the margin at right angles to it.

Big Chief No. 8 Mine, St. Charles.

Quarry of the Grand Ledge Face Brick Company, Cycle "F."

Nos. 14792, 14793, and 14809 U.M.

Megalopteris dawsoni Hartt

(Plate VII, Figs. 1, 10)

The genus *Megalopteris* was instituted by Dawson (7) to include certain fossils with simple pinnate fronds, irregularly branched and with long straplike, decurrent pinnules. With the exception of a single doubtful specimen from Devon, this form is unknown outside North America, where it has been reported from several localities. Because of the large size of the fronds they are usually found only as fragments, and consequently our knowledge of these magnificent Carboniferous plants is very incomplete. The decurrent pinnules recall *Alethopteris*, whereas

the venation is more of the *Neuropteris* type, and in this way *Megalopteris* combines the characters of the two forms. Its distinctive feature, however, is its large size. Seeds of the *Samaropsis* type are commonly found in association with it.

At least two forms are present in the red ironstone nodules in the quarries south of the river at Grand Ledge. Remains are also abundant at Corunna, and a single specimen came from the Uncle Henry Mine east of Saginaw. At Grand Ledge and at Corunna material is abundant, but owing to the character of the inclosing rock large pieces cannot be secured. Nevertheless preservation is good, and the finer details are clear.

Specimens from the quarries at Grand Ledge so closely resemble Dawson's figure (7, Fig. 191) of this species that no doubt remains concerning their identity. One very fine specimen is fifteen centimeters long (Plate VII, Fig. 1). Distally it is five centimeters broad and narrows to two centimeters toward the base, although neither the apex nor the base is present in the specimen. Another fragment from near the middle of a pinnule is six centimeters broad (Plate VII, Fig. 10). The midrib in both specimens is prominent and is about five millimeters broad. The veins are fine and close and depart from the midrib at an acute angle, but gradually bend outward and pass to the margin at an angle of about 45 degrees from the vertical. This angle varies somewhat in different places.

One feature of the venation heretofore unobserved in this form is a tendency for several veins to leave the midrib near together. It is possible that they arise as a single vein which branches several times in a short distance and before it has swung away from the midrib for any perceptible distance. The upper branches of one of these units pass upward at a steep angle and bend outward just below the lower branches of the next unit above in such a way that the arrangement is not apparent except upon close examination.

Quarry of the American Vitrified Products Company, Grand Ledge, Cycle "A."

No. 14766 U.M.

Megalopteris Southwellii Lesq.

(Plate I, Fig. 5)

A fragment appears to resemble Lesquereux's figures and description of this species. The specimen is well preserved as an impression in a very fine black shale, in which the veins show clearly. The veins bend outward from the midrib and pass to the margin at an angle of about ten or fifteen degrees from the horizontal. Just before reaching the margin they bend slightly upward. About three divisions occur, the first one just as the veins leave the midrib and the last one about one quarter of the way out to the margin. Occasional branching may occur farther out.

Uncle Henry Mine No. 2, Saginaw.

No. 14767 U.M.

Megalopteris kellyi, sp. nov.

(Plate I, Fig. 6; Plate VII, Fig. 3)

Associated with material of *M. dawsoni* at Grand Ledge are abundant fragments of a large branched type of frond in which the lateral veins, after leaving the midrib at an acute angle, pass to the margin at right angles to it. The ribbon-like segments of the frond are large, many of them being four or five centimeters broad, and they must have attained a length of at least half a meter. The general habit was much like that of *M. Southwellii.*

The midrib is two or three millimeters thick, and the veins fork immediately after leaving it. Each branch then bends sharply outward and divides once or twice more during its horizontal course to the margin.

Quarry of the American Vitrified Products Company, Grand Ledge, Cycle "A."

No. 14805 U.M.

Sphenopteris obtusiloba Brong.

(Plate VII, Figs. 4–5)

The material which appears to belong to this species consists of a few fragments from the Marquette Mine. This type of

frond is subject to so much variation that identification of small parts is difficult. However, the similarity of these fragments to figures of this species by Zeiller (21, Pl. 3, Fig. 4) and Brongniart (4, I, Pl. 53, Fig. 2) is close.

Marquette Mine.

No. 14770 U.M.

Sphenopteris artemisiaefolioides Crépin

(Plate VII, Figs. 8–9)

Among the material from the Marquette Mine are a few fragments which appear referable to this species. The deeply dissected wedge-shaped pinnules are alternately arranged upon a slightly zigzag rachis. In this respect there is considerable resemblance to *Diplotmema furcatum*, although in general the pinnule lobes are too broad for this species. It resembles figures of *S. artemisiaefolioides* in that the pinnules are cut mainly into three lobes, with the lowermost abaxial one more strongly developed and somewhat lower than the corresponding lobe on the opposite side of the pinnule. Other points of agreement are the size of the pinnules and the angle at which they spread out from the rachis.

Eremopteris Cheathami Lesq. bears some resemblance to this material, but the pinnules of this form appear to be smaller and less deeply cut, and the segments are broader and more rounded.

Our form is somewhat larger than *Sphenopteris spinosa*. There is but little evidence that any of the pinnules are terminated by a long point.

Marquette Mine.

Nos. 14769 and 14801 U.M.

Mariopteris muricata (Schl.) Zeiller

(Plate VII, Fig. 6)

Material referable to this species consists of a few fragments which show the pinnule form and the venation with a fair degree of certainty. The pinnules are attached by their full width at the base and taper to an acute point. The veins are rather strongly marked and are arched; some of them arise directly from the

rachis. The midrib becomes indistinct before it reaches the apex of the pinnule.

Because of the fragmentary nature of the material its identification remains somewhat in doubt. Some authors recognize two species, *M. muricata* and *M. nervosa*, which, according to Crookall (4), are frequently confused. Previous authors (Zeiller, 21; Renier, 17) recognized *M. nervosa* as a variety of *M. muricata*. Our material is clearly the *M. muricata* of Zeiller and Renier if the species is considered in the broad sense, but the varietal identity is uncertain. Only the tips of the pinnae are preserved here.

Big Chief No. 8 Mine, St. Charles.

No. 14764 U.M.

CORDAITALES

The Cordaitales were Paleozoic gymnosperms of arborescent habit. The most common fossil remains are the impressions of the long strap-shaped leaves which, before their connection with the stem was known, were supposed to belong to *Typha* (the common cat-tail), a monocotyledon. These leaves were ordinarily an inch or two wide and sometimes as much as a yard long. Some of the ironstone nodules in Cycle "A" in the quarry of the American Vitrified Products Company consist almost entirely of matted masses of these leaves.

Petrified wood of the Cordaitales has been described under various generic designations, of which *Cordaites*, *Cordaioxylon*, *Dadoxylon*, and *Mesoxylon* are a few. Casts of the large septate pith have been referred to as *Artisia* and *Sternbergia* and the strobili as *Cordaianthus*.

Cordaites michiganensis Arnold

A complete account of this form has been given elsewhere recently (2), so that mere mention will be made of it here. The specimen, which measures four by sixteen centimeters, is a part of a stem with cell structure preserved. In the center there is a large pith, two centimeters wide, surrounded by the woody cylinder, which is infiltrated with calcium carbonate and iron pyrites. It came from one of the quarries at Grand Ledge.

Nos. 12405 and 14709 U.M.

Cordaites (Artisia) sp.

(Plate IV, Figs. 2, 4; Plate VI, Fig. 7)

"Artisia" is a term used for the pith casts of the Cordaitales. The young stems of some of these forms had a large pith, which became ruptured at intervals owing to growth in length of the stem. The pith diaphragms thus produced later broke down and formed a continuous pith cavity, with remnants of the diaphragms surrounding it. The transverse constrictions which mark these casts represent the remnants of the original pith diaphragms. Although numerous attempts have been made to assign these casts to species, their size and markings have no specific value. Neither do these fossils have any general stratigraphic importance, since they occur throughout the extent of the Carboniferous.

These casts are common in the Woodville Sandstone. They vary from two to four centimeters in diameter, and the constrictions are about one millimeter apart. They occur with casts of *Calamites* and fragments of charred wood.

Nos. 14773, 14803, 14804 U.M.

PALEOZOIC GYMNOSPERMOUS SEEDS

Isolated seeds belonging to the Cordaitales and the Pteridospermae are abundant in the red ironstone nodules at Grand Ledge and Corunna. None were found in organic connection with other plant parts, so that their identification is impossible other than their assignment to the various artificial genera designed to accommodate such isolated specimens.

Trigonocarpus sp.

This type of seed is represented by a small nucellar cast which bears the three characteristic ridges. The cast is two centimeters long and eight millimeters wide. At the pointed apex the ridges form three sharp crests, which become less conspicuous farther down, although they can be traced to the chalaza. Our specimen is somewhat unusual in being cylindrical instead of ovate or subspherical.

Quarry of the Vitrified Products Company, Grand Ledge, Cycle "A."

No. 14776 U.M.

Rhabdocarpus multistriatus (Presl) Lesq.
(Plate VI, Figs. 8–9)

In the red ironstone nodules at Grand Ledge occasional large ovate seeds are preserved as sphalerite casts of the nucellar part inclosed within a hard testa. In one very fine specimen (Pl. VII, Fig. 8), which measures four and one-half centimeters in length, the outer part of the testa is broken away, so that it shows the course of the vascular bundles as they pass upward from the base. Six of them radiate outward from the point of attachment at the base, but they soon divide, so that twelve bundles extend upward along the exposed inner part of the testa. In another specimen, which is somewhat smaller (Plate VI, Fig. 9), the outer surface of the seed is partly exposed. At no place on the surface can the ribs be counted, but it seems altogether probable that they correspond to the twelve vascular strands.

The lower part of these seeds is oval, but the apical part is prolonged into a columnar snout. In some specimens this snout tapers slightly.

These seeds bear considerable resemblance to those of a specimen which Lesquereux refers with some hesitation to this species (*Coal Flora, Atlas,* Pl. 85, Fig. 22) and to *Rhabdocarpus carinatus* Newberry (15, Pl. XLIV, Fig. 3), but, to judge from the published figures, there seems to be little difference between the two forms.

At Grand Ledge this form is associated with *Samaropsis Newberryi, Megalopteris dawsoni,* and *M. kellyi.*

Quarry of the American Vitrified Products Company, Grand Ledge, Cycle "A."

No. 14775 U.M.

Rhabdocarpus mamillaris Lesq.

Closely resembling Lesquereux's figures of this species (*Coal Flora, Atlas,* Pl. 85, Fig. 33) are two specimens, one from Grand Ledge and one from Corunna. Each one measures a little more than one centimeter in length and is bluntly oval. There traverses each seed from base to apex a series of fine longitudinal ridges.

Quarries of the American Vitrified Products Company, Grand Ledge, Cycle "A," and the New Corunna Brick Company.

No. 14775 U.M.

Samaropsis Newberryi (Andrews) Seward

(Plate IV, Figs. 5, 7)

Several specimens from the red ironstone nodules at Grand Ledge appear identical with a figure of this species reproduced by Seward (18, Vol. 3, Fig. 402k) from a specimen sent from Ohio by Claypole to Kidston. Part of the winglike border is present on some of the specimens, but not enough to show its entire extent. The nucellar part is broader than deep, and in one specimen it measures approximately 2.6 by 2 cm., which is slightly smaller than the one figured by Seward. Other specimens are slightly smaller.

Quarry of the American Vitrified Products Company, Grand Ledge, Cycle "A."

No. 14797 U.M.

LITERATURE CITED

1. Arnold, C. A. A Petrified Lepidophyte Cone from the Pennsylvanian of Michigan. Am. Journ. Bot., Vol. 17, pp. 1028–1032 (1930).
2. —— Cordaitean Wood from the Pennsylvanian of Michigan and Ohio. Bot. Gaz., Vol. 91, pp. 77–87 (1931).
3. Bartlett, H. H. Fossils from the Carboniferous Coal Pebbles of the Glacial Drift at Ann Arbor. Pap. Mich. Acad. Sci., Arts and Letters, Vol. 9 (1928), pp. 11–28 (1929).
4. Brongniart, Adolphe. Histoire des végétaux fossiles ou recherches botaniques et géologiques sur les végétaux renfermés dans les diverses couches du globe. Texte et Atlas. Paris, 1837.
5. Crookall, R. Coal Measure Plants. London, 1929.
6. —— The Relative Value of Fossil Plants in the Stratigraphy of the Coal Measures. Mem. and Proc. Manchester Lit. and Phil. Soc., Vol. 76, pp. 91–122 (1932).
7. Dawson, J. W. The Fossil Plants of the Devonian and Upper Silurian Formations of Canada. Canada Geol. Surv. 1871 (1872).
8. Deltenre, H. Les Sigillaires des charbonnages de Mariemont (Mémoire posthume publié par Jean de Dorlodot). Mém. de l'Inst. Géol. de l'Université de Louvain, Vol. 3, pp. 1–116 (1924–27).

9. GOTHAN, W. In G. Güruch, Leitfossilen, 3. Berlin, 1923.

10. JONGMANS, W. Fossilium catalogus II: Plantae. Lycopodiales III. Berlin, 1930.

11. KELLY, W. A. Pennsylvanian Stratigraphy near Grand Ledge, Michigan. Journ. Geol., Vol. 41, pp. 77–88 (1933).

12. LANE, A. C. Coal of Michigan, Its Mode of Occurrence and Quality. Geol. Surv. Mich., Vol. 8, pt. 2 (1902).

13. —— Geol. Surv. Mich., Ann. Rep. for 1908 (1909).

14. LESQUEREUX, L. Description of the Coal Flora of Carboniferous Formation in Pennsylvania and throughout the United States. Second Geol. Surv. Pennsylvania, Rep. of Progress P, Text 1880, Atlas 1879. Harrisburg.

15. NEWBERRY, J. S. Descriptions of Fossil Plants from the Coal Measures of Ohio, Rep. Geol. Surv. Ohio, Vol. 1, pt. 2, sect. 3 (1873).

16. NOÉ, A. C. Pennsylvanian Flora of Northern Illinois. Bull. 52, State of Illinois, Department of Registration and Education, Division of the State Geol. Surv. (1925).

17. RENIER, A. Documents pour l'étudie de la paléontologie du Terrain Houiller. Liège. 1910.

18. SEWARD, A. C. Fossil Plants, Vol. 3. Cambridge, 1917.

19. SMITH, R. A. Michigan Coal. Mich. Geol. and Biol. Surv., Publ. 8, Geol. Ser. 6, pp. 257–333 (1911).

20. WHITE, D. Fossil Flora of the Lower Coal Measures of Missouri. U. S. Geol. Surv., Mon. 37 (1899).

21. ZEILLER, R. Flore fossile du Bassin Houiller de Valenciennes. Étude des gîtes mineraux de la France. Atlas, Paris, 1886; Texte, Paris, 1888.

EXPLANATION OF PLATE I

FIG. 1. *Annularia radiata* Brong. Single leaf whorl. Grand Ledge. No. 14795 U.M.

FIG. 2. *Annularia sp.* (small form). Grand Ledge. No. 14799 U.M.

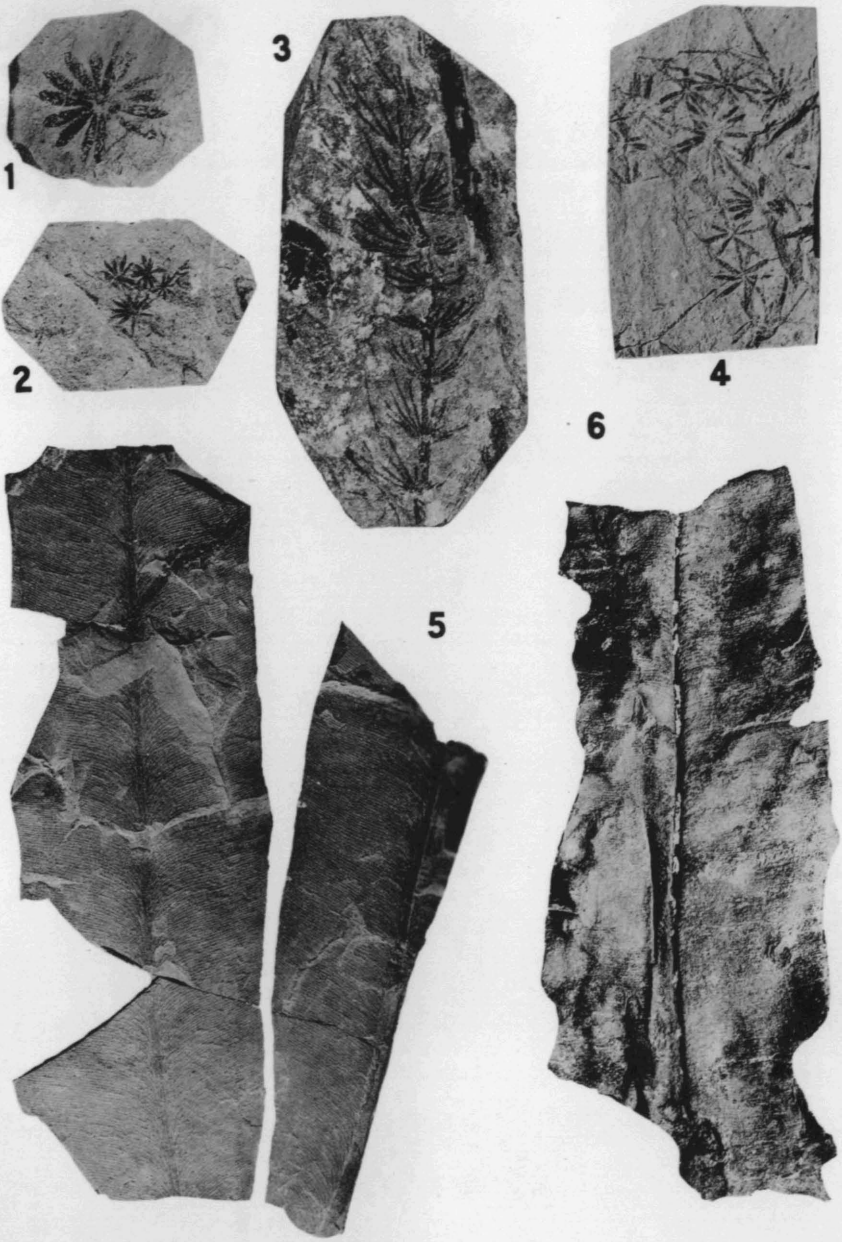
FIG. 3. *Asterophyllites equisetiformis* (Schl.) Brong. Part of stem bearing several whorls of leaves. Grand Ledge, Cycle "A." No. 15430 U.M.

FIG. 4. *Annularia sp.* (small form). Grand Ledge. No. 14800 U.M.

FIG. 5. *Megalopteris Southwellii* Lesq. Uncle Henry Mine No. 2, Saginaw. No. 14767 U.M.

FIG. 6. *Megalopteris kellyi* Arnold, sp. nov. Part of frond showing distinct midrib and veins that pass at right angles to the margin. Grand Ledge, Cycle "A." No. 14805 U.M. Cotype.

PLATE I



EXPLANATION OF PLATE II

FIG. 1. *Alethopteris decurrens* Artis. Part of pinna showing pinnules characteristic of this species. St. Charles. No. 14792 U.M.

FIG. 2. *Sphenophyllum saxifragaefolium* Sternb. Part of stem bearing deeply notched leaves. St. Charles. No. 14784 U.M.

FIG. 3. *Alethopteris decurrens* Artis. Data as for Figure 1. No. 14793 U.M.

FIG. 4. *Sphenophyllum cuneifolium* Sternb. Leaf whorl showing characteristic notching of leaves. St. Charles. No. 14789 U.M.

FIG. 5. *Odontopteris sp.* Tip of pinna showing characteristic venation in lateral pinnules. Grand Ledge, Cycle "A." No. 14778 U.M.

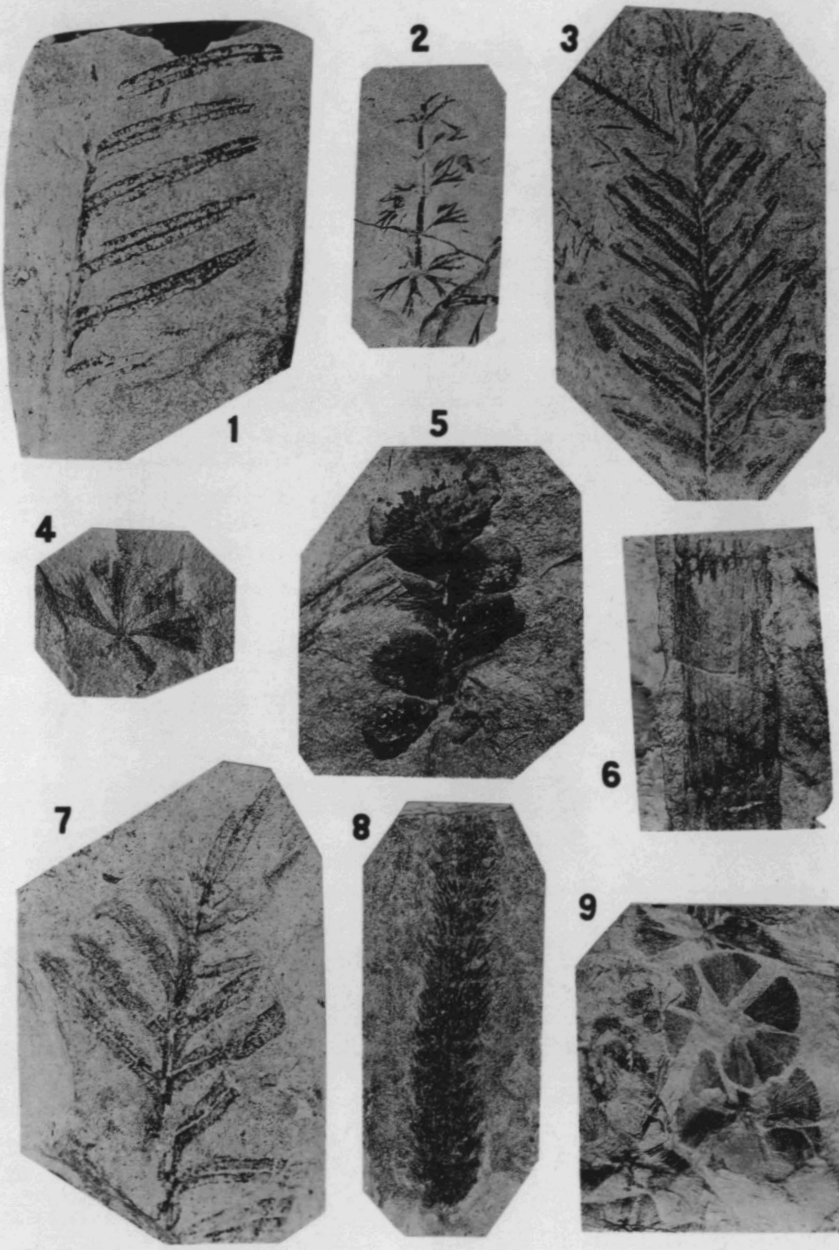
FIG. 6. *Calamites suckowi* Brong. Small flattened pith cast bearing two nodes. Grand Ledge, Cycle "F." No. 14806 U.M.

FIG. 7. *Alethopteris decurrens* Artis. Part of frond showing terminal pinnule. Grand Ledge, Cycle "F." No. 14809 U.M.

FIG. 8. *Calamites sp.* (fructification). Grand Ledge, Cycle "F." No. 14774 U.M.

FIG. 9. *Sphenophyllum emarginatum* Brong. Leaf whorls. Grand Ledge, Cycle "F." No. 14783 U.M.

PLATE II



EXPLANATION OF PLATE III

FIG. 1. *Neuropteris rarinervis* Bunbury. Terminal part of pinna. Grand Ledge. No. 14781 U.M.

FIG. 2. *Neuropteris rarinervis* Bunbury. Data as for Figure 1.

FIG. 3. *Asterophyllites equisetiformis* (Schl.) Brong. Part of calamitean stem bearing whorls of leaves. St. Charles. No. 14768 U.M.

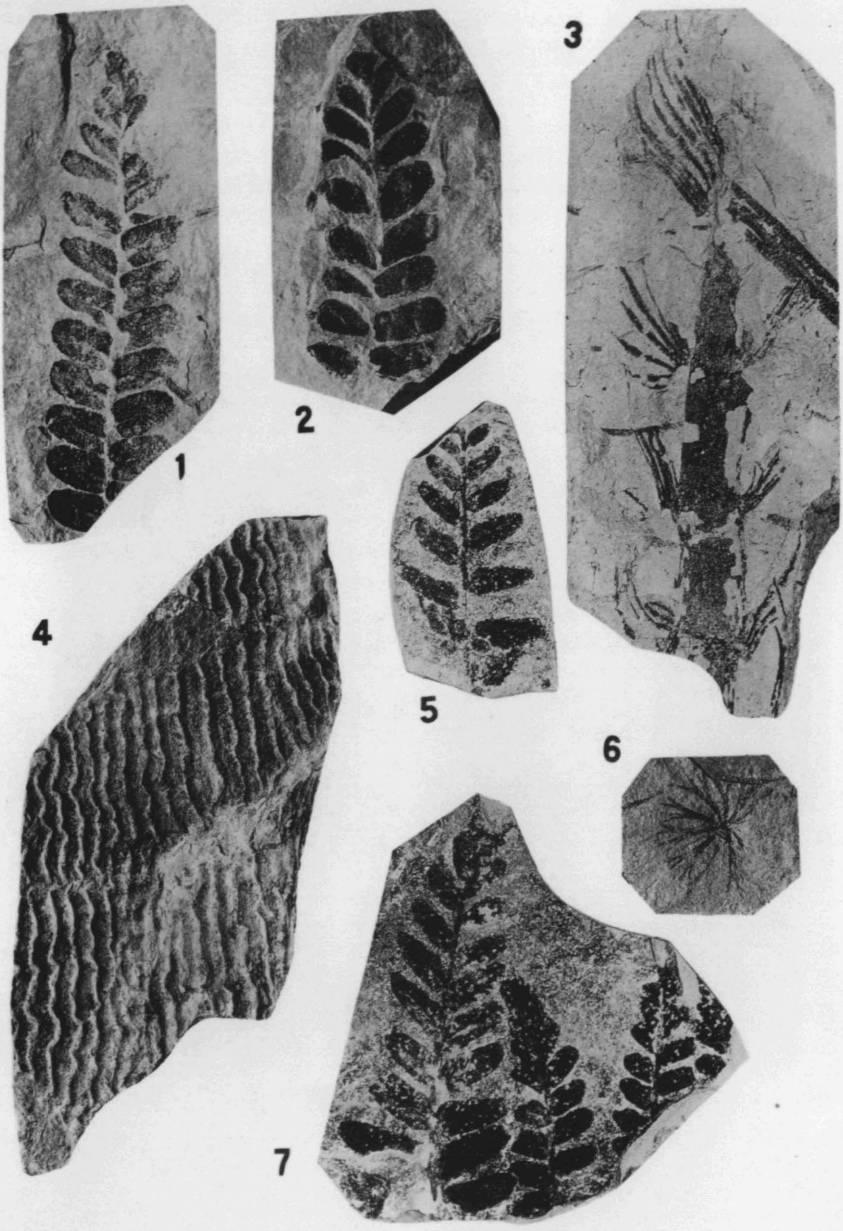
FIG. 4. *Calamites undulatus* Sternb. Part of outer surface of pith cast showing undulating furrows. Standard Mine, Saginaw. No. 14772 U.M.

FIG. 5. *Neuropteris rarinervis* Bunbury. Data as for Figure 1.

FIG. 6. *Sphenophyllum saxifragaefolium* Sternb. Single leaf whorl. St. Charles. No. 14784 U.M.

FIG. 7. *Neuropteris rarinervis* Bunbury. Data as for Figure 1.

PLATE III



EXPLANATION OF PLATE IV

FIG. 1. *Sigillaria scutellata* Brong. Part of trunk surface showing three ribs and their leaf scars. Grand Ledge, Cycle "E." No. 14794 U.M.

FIG. 2. *Cordaites* (*Artisia*) *sp.* Part of pith cast showing the transverse markings corresponding to the diaphragms of the pith. Grand Ledge, Woodville Sandstone. No. 14773 U.M.

FIG. 3. *Sphenophyllum saxifragaefolium* Sternb. Stem bearing whorls of leaves. St. Charles. No. 14784 U.M.

FIG. 4. *Cordaites* (*Artisia*) *sp.* Part of flattened pith cast. No. 14804 U.M.

FIG. 5. *Samaropsis Newberryi* (Andrews) Seward. Nucellar portion of seed. Grand Ledge, Cycle "A." No. 14797 U.M.

FIG. 6. *Sphenophyllum cuneifolium* Sternb. St. Charles. No. 14789 U.M.

FIG. 7. *Samaropsis Newberryi* (Andrews) Seward. Nucellus of seed and part of the surrounding wing. Data as for Figure 5.

PLATE IV

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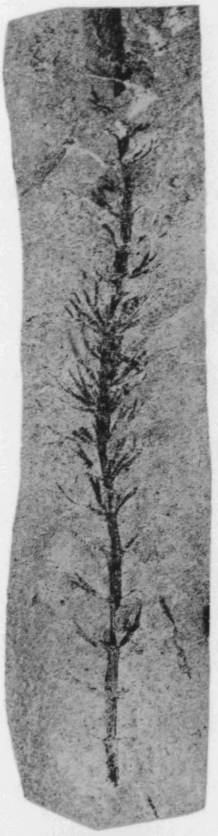

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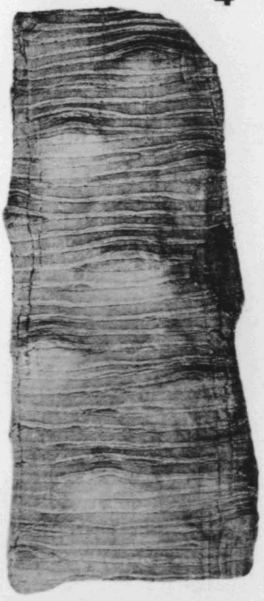

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EXPLANATION OF PLATE V

FIG. 1. *Calamites suckowi* Brong. Part of a large pith cast showing the broad flat-topped ribs and short internodes. Flushing, Genesee County. No. 12201 U.M.

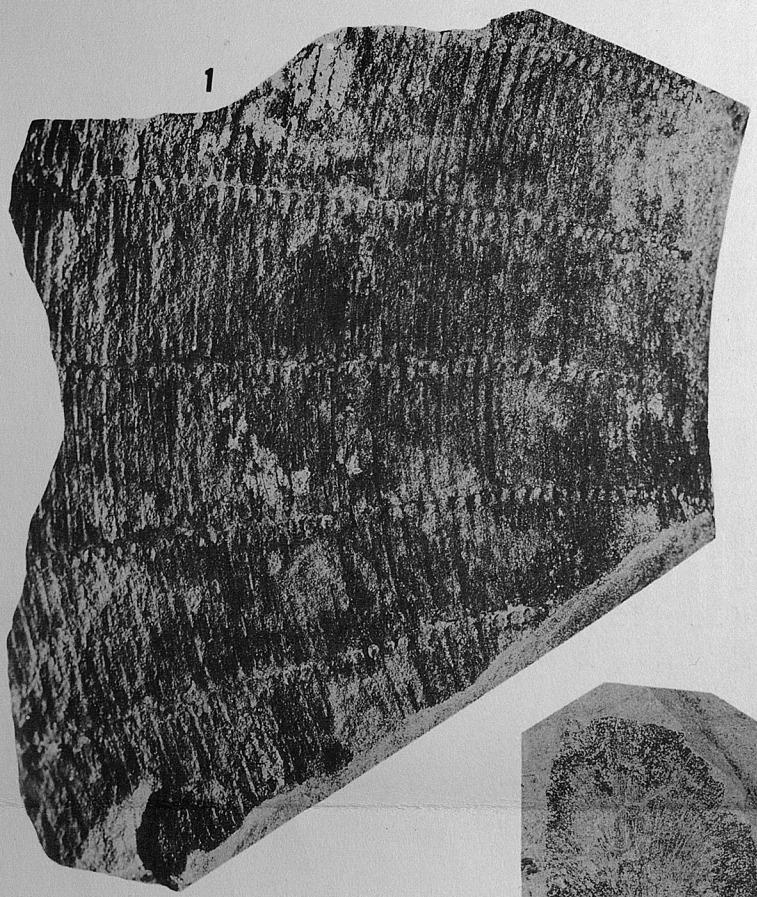
FIG. 2. *Stigmaria ficoides* Brong. Part of main axis bearing lateral "rootlets." Glacial drift, Jackson. No. 14808 U.M.

FIG. 3. *Neuropteris* (*Cyclopteris*) *sp.* Large cyclopteroid pinnule. St. Charles. No. 14765 U.M.

FIG. 4. *Neuropteris dilatata* (L. & H.) Lesq. Very large cyclopteroid form. St. Charles. No. 14791 U.M.

FIG. 5. *Stigmaria ficoides* Brong. Part of main axis showing "rootlet" scars. No. 14807 U.M.

PLATE V



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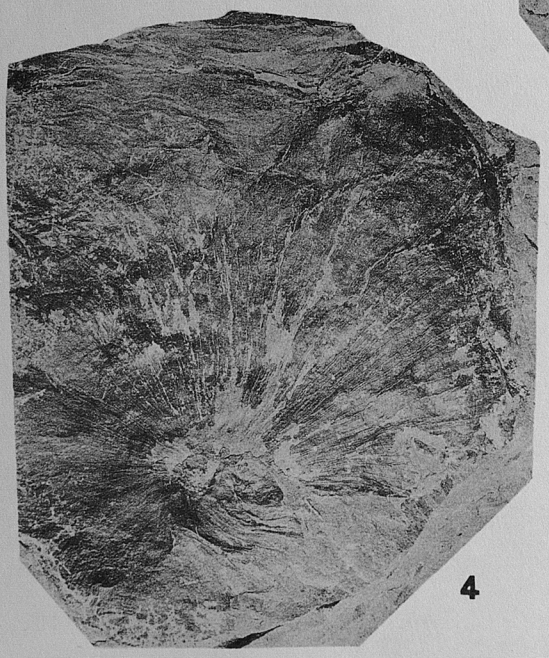

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EXPLANATION OF PLATE VI

FIG. 1. *Lepidodendron obovatum* Sternb. Part of trunk surface showing very large and characteristic leaf cushions. Woodville Sandstone, Grand Ledge. No. 13981 U.M.

FIG. 2. *Calamites sp.* (fructification). Flattened strobilus showing the articulate axis, the whorls of bracts, and the position of the crushed sporangiophores between. Grand Ledge, Cycle "F." No. 15429 U.M.

FIG. 3. *Bothrodendron minutifolium* Boulay. Leafy twigs. Grand Ledge, Cycle "E." No. 14792 U.M.

FIG. 4. *Neuropteris tenuifolia* (Schl.) Zeiller. Grand Ledge. No. 15428 U.M.

FIG. 5. *Sphenophyllum myriophyllum* Crépin. Scattered leaf whorls showing the leaves incised almost to the base. Grand Ledge, Cycle "F." No. 14782 U.M.

FIG. 6. *Lepidodendron aculeatum* Sternb. Imprint of bark surface showing characteristic leaf cushions. Grand Ledge. No. 14777 U.M.

FIG. 7. *Cordaites* (*Artisia*) *sp.* Part of pith cast, with the characteristic transverse furrows and partly inclosed within the bituminized remains of the woody cylinder. No. 14803 U.M.

FIG. 8. *Rhabdocarpus multistriatus* (Presl) Lesq. Base of nucellar cast showing four of the six vascular bundles which pass upward from the chalaza. Grand Ledge, Cycle "A." No. 14775 U.M.

FIG. 9. *Rhabdocarpus multistriatus* (Presl) Lesq. Exterior of seed showing. Other data as for Figure 8.

PLATE VI

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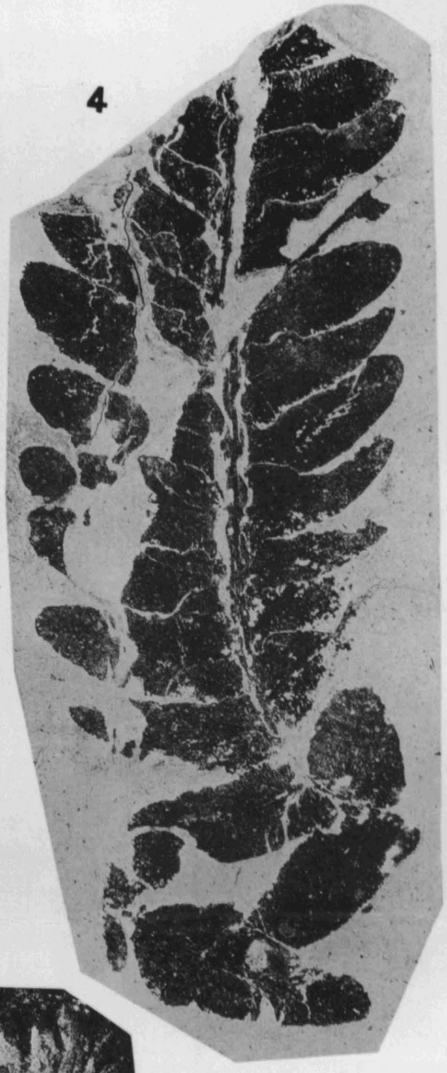

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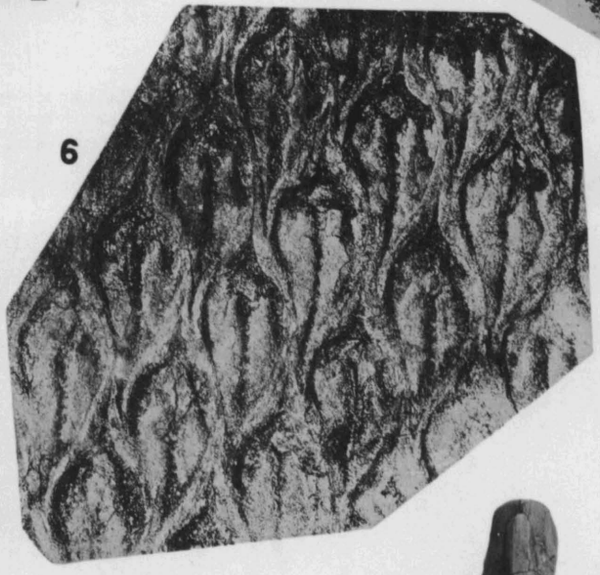

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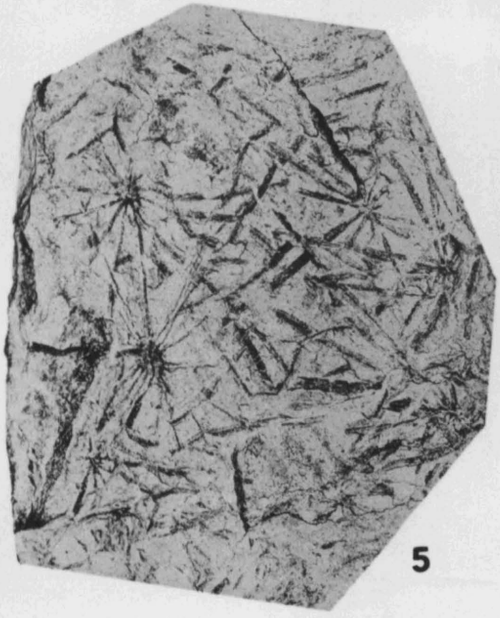

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EXPLANATION OF PLATE VII

FIG. 1. *Megalopteris dawsoni* Hartt. Part of leaf showing the strong midrib and arched veins. Grand Ledge, Cycle "A." No. 14766 U.M.

FIG. 2. *Neuropteris sp.* Grand Ledge, Cycle "A." No. 14796 U.M.

FIG. 3. *Megalopteris kellyi* Arnold, sp. nov. Part of branched frond. Grand Ledge, Cycle "A." No. 14805 U.M. Cotype.

FIG. 4. *Sphenopteris obtusiloba* Brong. Marquette Mine. No. 14770 U.M.

FIG. 5. *Sphenopteris obtusiloba* Brong. Data as for Figure 4.

FIG. 6. *Mariopteris muricata* (Schl.) Zeiller. St. Charles. No. 14764 U.M.

FIG. 7. *Annularia sphenophylloides* (Zenker) Unger. Grand Ledge, Cycle "F." No. 14802 U.M.

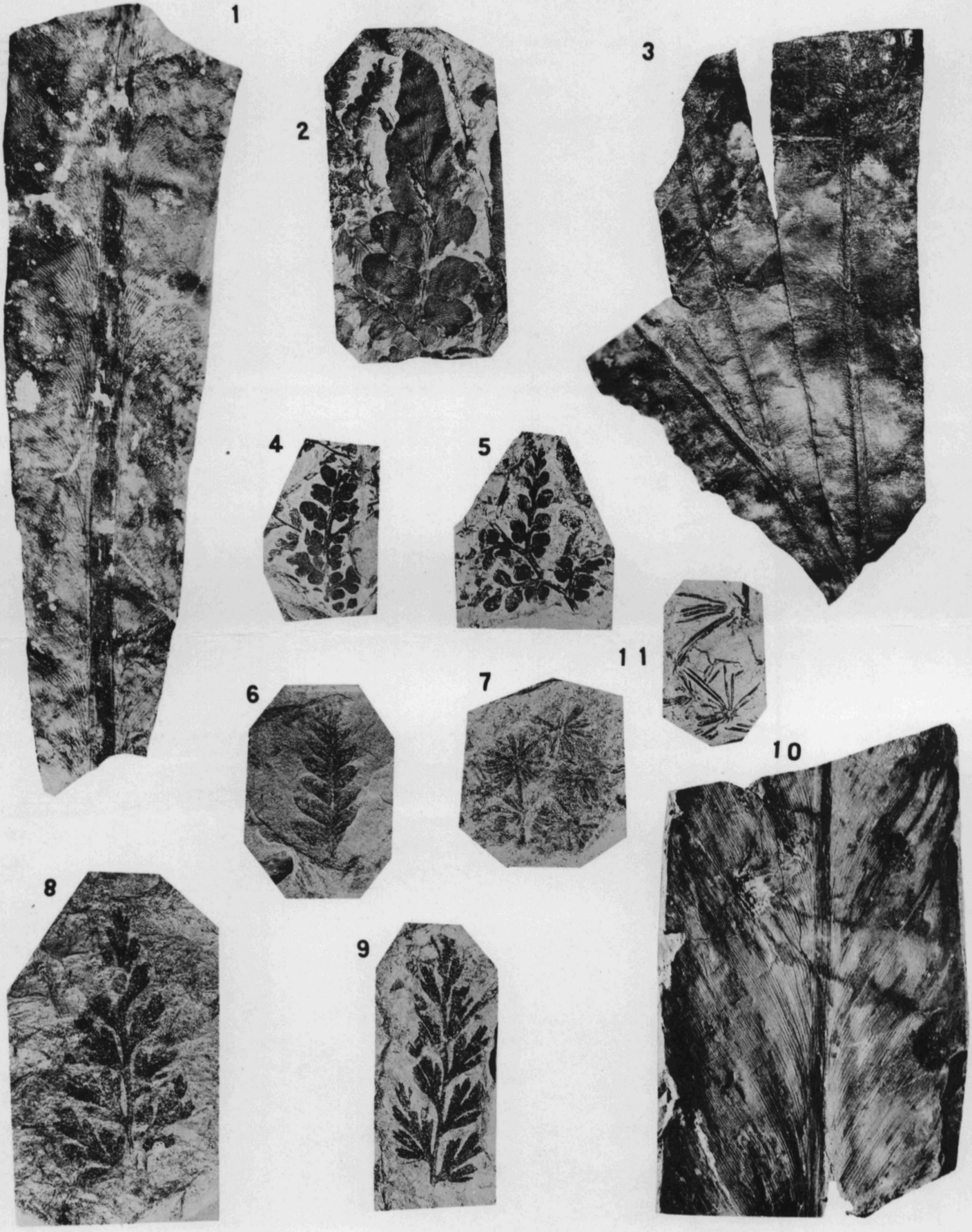
FIG. 8. *Sphenopteris artemisiaefolioides* Crépin. Marquette Mine. No. 14769 U.M.

FIG. 9. *Sphenopteris artemisiaefolioides* Crépin. Marquette Mine. No. 14801 U.M.

FIG. 10. *Megalopteris dawsoni* Hartt. Part of very large leaf. Grand Ledge, Cycle "A." No. 14766 U.M.

FIG. 11. *Sphenophyllum myriophyllum* Crépin. Data as for Plate VI, Figure 5.

PLATE VII



(*Continued from inside of front cover*)

of Michigan, by G. M. Ehlers and T. E. White. Pages 93–100, with 5 plates. Price, $.20.

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