CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

UNIVERSITY OF MICHIGAN

VOL. VIII, No. 5, pp. 59–111 (18 pls.) JUNE 2, 1950

MEGASPORES FROM THE MICHIGAN COAL BASIN

BY

CHESTER A. ARNOLD

UNIVERSITY OF MICHIGAN PRESS
ANN ARBOR

CONTRIBUTIONS FROM THE MUSEUM OF PALEONTOLOGY

UNIVERSITY OF MICHIGAN

Director: LEWIS B. KELLUM

The series of contributions from the Museum of Paleontology is a medium for the publication of papers based entirely or principally upon the collections in the Museum. When the number of pages issued is sufficient to make a volume, a title page and a table of contents will be sent to libraries on the mailing list, and also to individuals upon request. Correspondence should be directed to the University of Michigan Press. A list of the separate papers in Volumes II–VII will be sent upon request.

VOL. I. The Stratigraphy and Fauna of the Hackberry Stage of the Upper Devonian, by C. L. Fenton and M. A. Fenton. Pages xi+260. Cloth. $2.75.

VOL. II. Fourteen papers. Pages ix+240. Cloth. $3.00. Parts sold separately in paper covers.

VOL. III. Thirteen papers. Pages viii+275. Cloth. $3.50. Parts sold separately in paper covers.

VOL. IV. Eighteen papers. Pages viii+295. Cloth. $3.50. Parts sold separately in paper covers.

VOL. V. Twelve papers. Pages viii+318. Cloth. $3.50. Parts sold separately in paper covers.

VOL. VI. Ten papers. Pages viii+336. Paper covers. $3.00. Parts sold separately.

VOL. VII. Ten numbers sold separately.

(Continued on inside back cover)

VOL. VIII, No. 5, pp. 59–111 (18 pls.) JUNE 2, 1950

MEGASPORES FROM THE MICHIGAN COAL BASIN*

By

CHESTER A. ARNOLD

CONTENTS

INTRODUCTION

SYSTEMATIC studies of isolated fossil spores constitute a relatively new phase of paleobotanical research. Although the basis of the subject was established by Reinsch in 1884 (15) and by Bennie and Kidston in 1886 (6), the bulk of the literature dates only from 1929, the year of publication of Bartlett's paper (4) on spores in coal pebbles from the glacial drift. Many of the accounts published between 1884 and 1929 of petrified plants occurring in coal balls contain descriptions of spores in fructifications, but the thin sections from

* The photographs illustrating this paper were made with equipment secured by a grant from the Faculty Research Fund of the University of Michigan, Project No. 715.

which the studies were made seldom show the whole bodies of the spores or reveal adequately their shape and surface features. Coal petrographers have long realized that spores are important constituents of coal. Photomicrographs of thin sections of coal (Thiessen, 20; Thiessen and authors, 21) show flattened spores but as in the coal balls only parts of spores are revealed.

Although no systematic studies were reported between 1886 and 1929, isolated Paleozoic spores were designated with binomials in a few instances. An example is the name *"Triletes diabolicus"* given by R. Scott (19). Mrs. Scott made no effort, however, to develop a system of spore nomenclature, so when she identified the plant that produced this particular spore, the use of the name was discontinued.

In the first of two papers published in 1929 Bartlett (4) gave impetus to the practice of assigning binomials to spores by describing three new species of *Triletes,* a name that had been coined by Reinsch but not used by him in a generic sense. Soon after the appearance of Bartlett's paper other investigators began using binomials to designate spores, and outstanding contributions were made during the next decade by Ibrahim (11), Potonié (14), Loose (14), Schopf (17), Wicher (22, 23), Zerndt (27–32), and others. Schopf and Zerndt were the only ones among these to base their nomenclature on the system of Bennie and Kidston. The rest followed independently developed systems.

In a second paper in 1929 Bartlett (5) reviewed the much neglected work of Reinsch and brought out the fact that, although Reinsch had been mistaken about the nature of the microfossils he had described and figured, his work constituted an accurate record of extensive observations and could be made the starting point of a stable system of spore nomenclature.

Within recent years an increasing amount of attention has been devoted to spores isolated by maceration from coals from the eastern United States, but publications on the subject are not numerous. The only illustrated account demonstrating the occurrence of spores as low in the Pennsylvanian column as the Pottsville series is by Cross (9), who listed and figured sixty forms from strata that range from the Kanawha through the Monongahela. The spores described by

Bartlett are from an unknown source. The supposition that they are from the Pottsville is based upon the fact that the nearest coal beds either in Michigan or Ohio are known to be of that age.

The spores described in this paper are from coals and shales of the Saginaw and Grand River groups of early Pennsylvanian age. The study is not complete for the whole Saginaw group, because no coals below the Saginaw seam or above the cyclical formations at Grand Ledge have been examined. Some of the coal seams, as the Grand Ledge coal and the Cycle "E" coal, were sampled from top to bottom, but from others only pieces of undetermined position were secured. At some of the abandoned mines the only material obtainable was lumps of coal picked up on the dumps. Because of the random and sporadic nature of some of the sampling, no quantitative spore studies were attempted. The aim of this paper is to describe and illustrate the megaspores that have been found, in order to facilitate the identification of spores of comparable age in near-by coal fields.

LOCALITIES

The spores described in this paper are those that were present in coal and shale samples collected from 12 horizons and localities. Information on the localities is given by Kelly (12) and by Arnold (3).

1. Shale of Cycle "A" and the plant bed below it (Kelly, 12; Arnold, 3). Grand Ledge.

Triletes triangulatus Zerndt
T. ramosus Arnold, sp. nov.
T. auritus Zerndt
T. mamillarius Bartlett
T. Fermii Arnold, sp. nov.

2. Grand Ledge coal of Cycle "B" (Kelly, 12; Arnold, 3). Grand Ledge.

Cystosporites varius (Wicher) Dijkstra

3. Coal of Cycle "D" (Kelly, 12). Grand Ledge.

Triletes auritus Zerndt
T. subbrasserti Arnold, sp. nov.
Lagenicula horrida Zerndt
L. saccata Arnold, sp. nov.

4. Coal of Cycle "E" (Kelly, 12). Grand Ledge.

Triletes Brasserti Stach and Zerndt
T. triangulatus Zerndt

5. Coal of Cycle "F" (Kelly, 12; Arnold, 3)[1]. Grand Ledge.

Lagenicula rugosa (Loose), comb. nov.
Cystosporites giganteus (Zerndt) Schopf, Wilson, and Bentall

6. Cycle "H" (Eaton sandstone, Kelly, 12). Grand River group. Grand Ledge.

Triletes Brasserti Stach and Zerndt
T. subbrasserti Arnold, sp. nov.

7. Strip mine in Section 14 (Kelly, 12). Eaton County.

Lagenicula rugosa (Loose), comb. nov.
L. horrida Zerndt
Cystosporites giganteus (Zerndt) Schopf, Wilson, and Bentall

8. Quarry of the New Corunna Brick Company in Section 22 (Kelly, 12). Shiawassee County. North end of quarry just beneath glacial drift.

Triletes triangulatus Zerndt
T. auritus Zerndt

9. Saginaw coal. St. Charles-Garfield Mine (Arnold, 3). Eastwood.

Triletes triangulatus Zerndt
T. auritus Zerndt

10. Shale from the Big Chief No. 8 Mine (Arnold, 3). St. Charles.

Triletes triangulatus Zerndt
T. ramosus Arnold, sp. nov.
T. auritus Zerndt
T. mamillarius Bartlett
T. fulgens Zerndt
T. globosus Arnold, sp. nov.
Lagenicula rugosa (Loose), comb. nov.
L. saccata Arnold, sp. nov.
L. horrida Zerndt
Cystosporites giganteus (Zerndt) Schopf, Wilson, and Bentall

11. Black shale of the Woodville Mine (Arnold, 3). Jackson. Winchell Collection.

Triletes triangulatus Zerndt

12. Williamston spore coal (Bergquist, 7). Williamston.

Triletes subbrasserti Arnold, sp. nov.
T. triangulatus Zerndt
T. ramosus Arnold, sp. nov.
T. auritus Zerndt
Cystosporites varius (Wicher) Dijkstra
Sporites michiganensis Arnold, sp. nov.

[1] The exact position of this coal seam is uncertain. Recent excavations at Grand Ledge indicate that the plant bed originally assigned to Cycle "F" may belong to the lower part of Cycle "E" or to an intermediate cycle between cycles "D" and "E."

TECHNIQUE

The coal was softened by prolonged soaking in dilute (about 10 per cent) nitric acid. The exact concentration of the acid is not important, the object of the treatment being to remove the calcium held in combination with the humic substances. The process is slow and requires several weeks. Longer soaking is not harmful and some of the coal samples were left in the dilute acid for more than two years before they were examined. The time required for this method has compensating advantages because the mild treatment is not so destructive to the delicate appendages on some of the spores as are the more drastic processes usually employed for coal maceration. When the acid is removed it is replaced with dilute potassium hydroxide solution which is allowed to act for about twenty-four hours. The highly humified coals break down into a coarse black mud in the alkali. In coals with more free carbon or in those in which silica is present as a cementing agent, disintegration is less thorough.

After maceration the material was washed on a coarse sieve with four openings to the linear inch. The part that passed through this was then washed on a fine sieve with twenty-five openings to the inch. The residue caught on the fine sieve was examined in small quantities with a low-power binocular microscope and the spores picked out. Then the spores were treated individually or in small numbers with Schulze's reagent until they became light-brown or yellow. Finally, they were transferred to water in watch glasses to which a few drops of 5 per cent ammonium hydroxide had been added. Extreme care has to be exercised not to allow the Schulze's reagent to act too long or to have the ammonia solution too strong. Excessive treatment causes the spore extines to become gelatinous and swell, and ultimately to dissolve completely. Spores to be examined by reflected light were dried and stored in gelatin capsules; those to be examined by transmitted light were mounted in diaphane under cover glasses.

With one exception (Pl. VII, Fig. 2) all of the spores illustrated in this paper were photographed with transmitted light. Some of the thick dark-colored individuals presented special problems, but it is believed that in the majority of instances the results were better with transmitted light than with reflected. Surface configuration is often revealed more distinctly with reflected light, but it is impossible with most photomicrographic equipment to have the whole spore in sharp focus at one time. There are also great differences in the high lights and shadows, and the dirt particles, which cannot always be removed, are distracting and sometimes cannot be distinguished from the essential features. Furthermore, transmitted light is almost essential for revealing minute details under high magnification.

CLASSIFICATION OF SPORES

Several systems of spore classification have been proposed, but none has been universally adopted. The classical system of Bennie and Kidston (6) has been the most used, but its success is mainly because it was the first one to be proposed and because it remained without any competing system for about half a century. This system had a complete monopoly on the field of spore literature for so long that different systems have been slow to be accepted.

The reason for the diversity of opinion on the subject of spore classification is that all systems so far proposed have been essentially artificial. Information is lacking on the affinities of many Paleozoic fossil spores. Some are known or believed to be lycopsid, sphenopsid, or pteropsid spores (or pollen), but only a relatively few of the described types can be assigned to some particular plant form with complete assurance. Unfortunately, in the excellent and analytical accounts of the anatomy of plants from the Carboniferous of Great Britain and Continental Europe, rather little information has been given on the form of the spores that were frequently encountered in the petrified fructifications. This lack is due to the fact that the petrifactions were studied from thin sections in which whole spores are seldom seen. If the spores in these petrifactions were better known, many isolated specimens in coal might be assigned with more certainty.

The question of whether it will ever be possible to formulate a usable natural classification of fossil spores must be considered. If such a classification could be made, the further question would remain of whether a natural system would be more suitable than an artificial one for the purposes for which it was desired. If every fossil spore that has been named could be identified with the plant that bore it, a separate classification of spores would not be necessary, because it would mean no more than would a separate classification of the spores and pollen of living plants. But the mere fact that this ideal has never been attained (and it is not expected that it ever will be) makes an independent classification necessary. Isolated spores of unknown affinities have little biologic significance, but they are assuming an increasing importance in stratigraphic studies. For purposes of correlation of rock units a system of classification based upon the obvious external features of spores would be more favored by stratigraphers, the ones expected to use it, than would a natural system in which seemingly unlike spores were grouped together into the same categories just because they were genetically related. Furthermore, an acceptable artificial system is more within the realm of possibility than one based upon affinities.

Systems of spore classification have been primarily of two types. In one the forms are distinguished by letters and numerals. Such designations are not provided for in the rules governing botanical nomenclature. In the other type generic and specific names are used. Numeral systems have been widely developed and used for microspores in British coals and have been employed in part (though independently) by Zerndt and others for megaspores. The type of system in which spores are designated by binomials (and in some instances trinomials) has involved various modifications of the system of Bennie and Kidston and the development of independent systems by Potonié, Ibrahim, and others. The merits of the various systems are difficult to evaluate. Modifications of the system of Bennie and Kidston seem to be preferred by North American paleobotanists, probably as a result of the impetus given it by Bartlett (4) and its partial adoption by Schopf (16, 17). Bennie and Kidston (6) set up two groups of spores, the *Triletes* group (the name attributed to Reinsch), in which the individuals are spherical or nearly so, and the *Lagenicula* (a new group), in which are included flaskshaped forms. *Triletes* was divided into three subgroups: the Laevigati (smooth), the Apiculati (apiculate), and the Zonales (with an equatorial rim). This system was adopted by Zerndt to supersede his original plan of assigning numbers.

Schopf, in his modification of the system of Bennie and Kidston (17), enlarged *Triletes* to embrace *Lagenicula,* which he made one of four sections of the genus, the other three being Aphanozonati, Auriculati, and Triangulati. Instead of using simple characters Schopf endeavored to utilize groups or combinations of characters which he believed were more indicative of natural relationships. These characters include shape, presence or absence of zonal appendages, form of the tetrad scar, and thickness and structure of the spore coat. In the utilization of groups of characters in place of single ones, this system is an advance over previous ones. Natural affinities are better expressed in this way, although in this particular instance usage alone will determine whether Schopf's system will supplant the older one. Unfortunately, it suffers in places from lack of clarity. In the section Triangulati, for example, the spore body is given as usually round or oval, the triangular appearance being produced only by having the zonal appendage wider opposite the "trilete" rays. But members of the Triangulati that have no zonal appendage seem, therefore, only vaguely distinguished from the Aphanozonati. Schopf is inclined to minimize the importance of the zonal appendage as an essential character in classification on the grounds that it may be present on spores of some plants but absent from those of closely related species. The appendage, however, is often so conspicuous that it is questionable whether it should be ignored as a major feature. At any rate its presence cannot be lightly considered. Dijkstra (10), in his work on Carboniferous spores, accepts the groups Aphanozonati, Lagenicula, and Triangulati of Schopf, but omits the Auriculati, which he merges with the Aphanozonati. The spores of the *Triletes superbus* and *T. rotatus* types, along with other large spores with pronounced zonal appendages, are removed from the Triangulati and retained in Bennie and Kidston's Zonales. The Triangulati, as Dijkstra restricts it, contains smaller spores resembling those of the Recent heterosporous lycopods and others that have been assigned to *Selaginellites.*

A system of spore and pollen classification was proposed by Naumova (13), in which spores are divided into the groups Rimales and Irrimales. The spores in the latter lack dehiscence slits. The Rimales include the Monoletes, those with one slit, and the Triletes, those with three. Triletes is in turn subdivided into the Azonotriletes, without zonal appendages, and the Zonotriletes, with them. Azonotriletes is broken up into nine genera on the basis of the surface features of the extine; Zonotriletes into ten genera that are distinguished from each other by the character of the margin.

A disadvantage of Naumova's system is that so few characters are used that spores with obvious and striking differences are sometimes brought together, and others which are very similar are kept apart. For example, such widely different spores as *Triletes fulgens, Lagenicula rugosa,* and *Cystosporites giganteus* would all belong to Naumova's genus *Leiotriletes,* but *Lagenicula rugosa* and *L. horrida,* which are almost identical except for the long spines on the latter, would belong to different genera. Except for containing more genera this system has few advantages over any of the others.

The most serious drawback to Naumova's system of spore classification is that no types are designated, and it is quite unlikely that any two investigators working with identical sets of spores would assign all of them to the same genera. It is essential in diagnosing generic groups that reference be made to a representative species. Another undesirable feature is its cumbersomeness. A set of generic names like *Trematozonotriletes, Trilobozonotriletes,* and *Diatomozonotriletes,* which are among those proposed, is sufficient to deter future investigators from paleobotanical research!

Naumova's system does circumvent one of the chief shortcomings of previous systems, that is the tendency to recognize too few generic groups. Ibrahim (11) endeavored to overcome this deficiency, but his system also is cumbersome because of the compound terms used to designate genera. As Schopf, Zerndt, and Dijkstra conceived the genus *Triletes* it contains too many diverse forms. If Schopf's sections could be more clearly defined they would probably merit generic rank. In keeping with this supposition *Lagenicula* is treated in the present work as a genus, on the grounds that if it can be satisfactorily delimited as a section it can be regarded as a genus in its own right.

Present deficiencies in the knowledge of the affinities of detached spores make it necessary to classify megaspores and microspores separately, and they will probably continue to be thus classified as long as utilitarian motives dominate their study. Some megaspores of the *Lagenicula* and *Cystosporites* groups present special problems, because in certain forms one megaspore of the tetrad developed at the expense of the other three, and these matured members may show diameters several times that of the immature ones and thus appear quite different. Unless it is possible, as it rarely is, to find specimens in which the matured and aborted members are still in contact, the two may be mistaken for spores of different plants. In the Michigan coals it has been possible to identify the matured and aborted members of *Cystosporites varius* by means of the characteristic tufted apical crest.

TERMINOLOGY OF SPORES

Terms for the surface features of spores have been proposed and defined by several authors (Schopf, 16; Dijkstra, 10). Wodehouse (26) divided the features exhibited by spores into two categories, emphytic and haptotypic. The emphytic features are the characteristics that are specifically inherited and include the texture of the extine, the character of its surface, and the presence of zonal appendages. These features are mainly on the distal parts. They have high diagnostic value. The haptotypic features are those that result from contact and other relations between neighboring spores, and they vary according to circumstances. In this paper the haptotypic features of the spores discussed are regarded as those caused by contact between or to size differences among the members of the same tetrad.

The terminology in current use for haptotypic features of the *Triletes* and *Lagenicula* types is not entirely satisfactory, partly from a confusion concerning the meaning of some of the terms and partly in other instances from an unfortunate choice of terms. Such terms as "trilete markings" and "trilete rays" are based upon the assumption that when Reinsch coined the word "Triletes" he had reference to the three radiating lines which are a conspicuous feature of some spores. But Reinsch was not referring specifically to this feature but to something entirely apart from the morphology of the spore, although members of the group to which he applied the name do bear the three lines. In the interests of accuracy in the formulation of descriptive terms some other designation should be used in place of "trilete" for the three-rayed tetrad scar. "Triradiate marking" is probably a better term to apply to the set of three lines, but the designation "suture lines" is used in the present work. Although this does not designate the number of lines of the set, no confusion can result from its use. A suture line includes the suture (which may be shorter than the suture line) and the lips that flank it.

The entire set of haptotypic features which results from contact between tetrad members may appropriately be termed the "tetrad scar," even though the scar may occupy the whole proximal half of the spore. The flattened areas (three in number in the spores under consideration) produced by contact between the four tetrad members, are here called the "contact faces." The use of "pyramic" in "pyramic surface" or "pyramic segment" (terms that have been introduced for these areas) is from the etymologic standpoint most undesirable, for it implies something very different from the intended meaning.

Throughout this paper the term "apical prominence" is applied to the necklike projection that characterizes the *Lagenicula* group of spores. This is used instead of "vestibule," which was proposed by Schopf (17). Schopf defined the vestibule as "consisting of the elongated and upraised apical portions of the three pyramic segments." In his description of *Triletes translucens,* however, he said that it had no suggestion of one, although in his figures (Pl. 1, Fig. 12 and Pl. 5, Fig. 4) something that can hardly be interpreted as other than a vestibule is clearly shown. If *T. translucens* does not have a vestibule, it is not clear from his definition which spores do have it, so it seems best to omit the term and substitute "apical prominence." The term apical prominence as used here does not apply to the small blunt prolongation at the apex of such spores as *Triletes splendens* or *T. globosus* (described on page 80), but to a structure resulting from separate upgrowths of the contact faces.

SPECIFIC DESCRIPTIONS

Triletes Brasserti Stach and Zerndt

(Pl. I; Pl. II, Fig. 1; Pl. III, Fig. 1)

This spectacular and highly characteristic spore was present in several coal samples but because of the readiness with which the appendages become detached complete specimens were difficult to isolate.

Triletes Brasserti is similar to *T. superbus* (Bartlett, 4) but is smaller. Bartlett gives the mean diameter of *T. superbus* as near 2.25 mm., whereas that of *T. Brasserti* averages about 1375 microns. The cylindriform processes (not the zonal appendage)) ornamenting the body of some specimens of *T. superbus* are 70 microns long; on most examples of *T. Brasserti* they rarely exceed 25 microns and on many specimens are absent. In surface view the body of *Triletes Brasserti* is disc-shaped to subtriangular (Pl. I; Pl. II, Fig. 1).

It is likely that more than one species of plant bore spores of the *Triletes Brasserti* type, but no combination of characters occurs with sufficient constancy to render separation possible. Many of the Michigan specimens have smooth extines, but others have scattered processes segregated mostly on the contact faces. On some these processes extend as small papillae. In specimens in which they are lacking they may have been lost during maceration, so their presence or absence cannot be used as a specific character. On some of the specimens the sutures stop short of the equatorial flange, but on others the suture line (though not necessarily the actual slit) continues to the outer edge of the flange. Out of fifty-four spores that were selected for measurement twelve do not show the suture lines extending to the edge of the body. The twelve spores average 1518 microns in diameter, which is 143 microns larger than the average diameter of the lot, but less than the minimum diameter of 1700 microns given by Bartlett for *T. superbus*. Instead of assuming that the larger spores with the short suture lines are a different species from the smaller ones, it is concluded here that in spores of maximum size the suture line does not continue to the extreme edge during the final stages of expansion. Thirty-two of the fifty-four spores measured (or nearly 80 per cent) range from 1200 to 1500 microns in diameter, exclusive of the flange. There is no evident correlation between length of suture lines and presence of surface papillae.

The spore body is a deep brown that bleaches to reddish brown and ultimately to yellow if maceration is prolonged. Maceration sufficient to render the spore body transparent is quite destructive to the substance composing it. With prolonged treatment with Schulze's reagent the extine swells and in dilute ammonia it dissolves completely. Of all the spore forms encountered, this one is the most difficult to prepare for microscopic examination.

In Michigan, *Triletes Brasserti* is often accompanied by microspores of similar appearance which are 20 to 35 microns in diameter. Specimens of this small spore are often present in large numbers in the folds of the flange of the large spores. They resemble the *Cirratriradites* type of Wilson and Coe (25).

Triletes Brasserti, T. subbrasserti, T. superbus, T. circumtextus, T. saturnoides, and a few others constitute a series of similar spores characterized by the flattened ruffled equatorial flange of cylindriform processes joined in varying degrees. They constitute a distinct group of spores that probably merits generic recognition. The flange is not a mere prolongation of the extine substance as it readily becomes detached.

Triletes Brasserti belongs to the section Zonales of Bennie and Kidston (6) and to the Triangulati of Schopf (17).

Occurrence.—Upper third of the coal of Cycle "E" and the Eaton sandstone (Cycle "H") at Grand Ledge. It has not been found at any of the lower levels in Michigan.

Triletes subbrasserti, sp. nov.

(Pl. II, Figs. 2–3)

Diagnosis.—Spore body round, 725 to 900 microns in diameter; extine yellowish to light-brown, smooth but ornamented near the apical part with scattered beaked papillae which are 4 to 7 microns broad, a maximum of 12 microns long, and 40 to 45 microns thick;

equatorial flange thin, radially pleated and broken at margin into a system of anatomosing rami, 150 to 200 microns wide; suture lines extending to margin of flange; suture 280 to 360 microns long; lips thin, membranaceous, 45 to 50 microns high.

Triletes subbrasserti is distinguished from *T. Brasserti* by its smaller size and lighter-colored extine. It lacks the surface reticulations of T. triangulatus and has a narrower wing than *T. circumtextus.*

This spore is rare in the Michigan Coal Basin. Only a few specimens of it have been found, but they are so much alike and so distinct from associated spores that specific identity seems certain. Structurally, the spore is like *Triletes Brasserti,* the similarities extending to the character of the equatorial flange, the suture lines, and the surface papillae.

Every specimen of *Triletes subbrasserti* examined had a delicate fold in the extine that encircles the apex at one-half to two-thirds the distance between the apex and the margin. This fold is evidently the result of pressure during fossilization but reflects some structural characteristic of the spore wall. It is not accidental because it is always present.

When first discovered this spore was supposed to be a small or aborted form of *Triletes Brasserti,* but the uniformity in size of the specimens combined with the lighter color of the spore coat, and the fact that they are not always associated with *T. Brasserti,* leads to the conclusion that the two were borne on different though closely related plants. There is some resemblance to *T. laxomarginalis* (Zerndt, 32), but the account of that species is insufficient to make exact comparisons possible.

Occurrence.—Eaton sandstone (Cycle "H") and coal of Cycle "D" at Grand Ledge, and the Williamston spore coal.

Triletes ramosus, sp. nov.

(Pl. III, Fig. 2; Pls. IV–V)

Diagnosis.—Spore body round to subtriangular in apical view, 580 to 1744 microns in diameter, averaging 1036 microns; extine dark reddish-brown, with dull or matte surface, about 50 microns thick; suture lines extending to proximal boundary of appendaged zone; lips sinuous or straight, and raised 50 to 100 microns above surface of contact faces; equatorial region and, in most specimens, most of the distal surface invested by a growth of slender stalklike appendages which are branched toward the apex and fused into a network that usually has the appearance of a marginal rim; branches terminating beyond the rim as short processes with rounded or slightly swollen tips; appendages around equatorial plane about one-half as long as diameter of spore body, becoming progressively shorter distally.

Triletes ramosus is one of the chief constituents of the Williamston spore coal described by Bergquist (7). Most of the smooth spores that make up the bulk of the coal appear to be specimens of this species that have lost their appendages.

This spore is almost identical with *Triletes rotatus;* the only difference of any consequence is size. Of the 115 spores measured, only about 1 per cent fell within the size limits, 700 to 750 microns, given for *T. rotatus* by Bartlett (4). Eighty-five per cent of them range from 900 to 1180 microns, with the mean 1036 microns. Bartlett does not give the number of specimens upon which the size range of his species was based, but six are figured on his Plate IX. It therefore seems impossible that the spores which Bartlett described were merely small specimens of *T. ramosus;* the chance of his finding six that agreed in size with only 1 per cent of the Williamston spores is extremely remote. The conclusion reached is that the spores were borne by two different plants. Zerndt's (29, 30) studies extended the size limits of *T. rotatus* to 998 microns, but even that is still below the average for *T. ramosus*. There may be some question whether the Polish spores described by Zerndt are identical with those from Michigan.

Partial loss of the appendage complement in different specimens of *Triletes ramosus* produces a variety of appearances. In complete specimens the appendages are not limited to the equatorial region but cover the distal surface as well. The appendages are longest around the equatorial zone and shortest at the distal pole opposite the apex. The distal surface is often bare, but close examination usually reveals the minute scars where appendages were formerly attached. Bartlett referred only to the "equatorial appendage" of *T. rotatus,* but the distribution of the processes is probably the same as in *T. ramosus.*

The spores from Poland that Zerndt (29, 30) assigned to *Triletes rotatus* differ from those of *T. ramosus* in size and in the character of the appendages. Zerndt compared his spores to a wheel with the body as the hub and the terminally joined prolongations as the spokes and the rim. None of the specimens in Zerndt's figures have such a dense and copious appendage growth as is present on the Williamston spores (Pl. III). In almost all of the specimens figured by him the appendage complement consists of a single row of columnar processes which are equatorially arranged and broaden and fuse at the apex into a continuous rim. At many places or on many spores two or more adjacent processes fuse for part or all of their length. In the Michigan material the processes cover the distal surface, although in many specimens (as explained above) this surface may be bare. Instead of forming a simple rim the processes unite laterally to some extent to produce a two-dimensional network, which in the compressed condition often simulates a rim. Beyond the network short branches extend which terminate in rounded or slightly swollen tips (Pl. IV, Fig. 2; Pl. V, Fig. 2).

Differences between the Polish and the Michigan spores may be the result of preservation. Practically all of Zerndt's figures are of incomplete specimens and some only of fragments. Spores of this kind can be interpreted satisfactorily only when available in large numbers; the Williamston coal is a rare instance of such abundance.

Triletes ramosus is evidently a lepidodendraceous spore, but the plant upon which it was borne is unknown. The species belongs to the section Zonales of Bennie and Kidston (6) and to the Triangulati of Schopf (17).

Occurrence.—Abundant in the Williamston spore coal. A few specimens came from the shale below Cycle "A" at Grand Ledge and from the Big Chief No. 8 Mine at St. Charles.

Triletes triangulatus Zerndt

(Pl. VI, Figs. 1–2, 4.)

The flattened body of this spore is a circular or subtriangular disc, encircled by a narrow, membranaceous, and unbroken flange of nearly uniform width. The flange may be flat, undulate, or pleated. Average specimens range from 500 to 600 microns in diameter (exclusive of the flange). The surface of the spore is ornamented with a system of raised reticulations which outline areas 25 to 50 microns in diameter. These areas often appear like rounded thin places in the spore wall (Pl. VI, Figs. 1, 4). The suture lines extend to the margin of the rim. They are flanked by raised ruffed lips which in places have a maximum height of 60 microns. In addition to being smaller than *Triletes Brasserti* and *T. subbrasserti, T. triangulatus* differs from both in the solid membranaceous flange and reticulated surface pattern.

The variations attributed to *Triletes triangulatus* by Zerndt and other authors were not seen in the Michigan specimens, which are quite uniform in size and appearance. In size they vary but little, 580 microns being the diameter of the body in most of the typical specimens. The surface reticulations, which are due to delicate folds on the surface, occur on the distal part. The proximal surface encompassed entirely within the tetrad scar does not show them. At the periphery of the flattened discs many specimens have surface folds extending across the breadth of the wing and forming radial pleats which are spaced about as far apart as the diameter of the areas outlined on the surface. The contact-face surfaces are finely granular and under high magnification the faces in some specimens show a dense growth of minute bristle-like papillae. Some of the papillae range from 2 to 5 microns in width by 10 microns in length, but they are usually much smaller. Most of the papillae do not exceed 2 microns in length, and they grade down in size to minute granulations.

Occurrence.—Woodville Mine, Jackson; Big Chief No. 8 Mine, St. Charles; the plant bed below Cycle "A" and the coal of Cycle "E" at Grand Ledge; the Williamston spore coal; and the New Corunna Brick Company quarry, Shiawassee County.

Triletes auritus Zerndt

(Pl. VI, Figs. 3, 5–6)

The normal form of *Triletes auritus* has been found at several places in Michigan, but it occurs in greatest numbers in the plant bed below Cycle "A" at Grand Ledge. Ten spores from this bed range from 824 to 940 microns in diameter, and average 881 microns. In one typical specimen, which measures 900 microns, the length of the radius through the lobes is 50 microns and that between the lobes is 360 microns. The suture lines do not extend beyond the bases of the lobes, and the suture openings are shorter, being only 225 microns. The largest specimen came from St. Charles. It is 1140 microns in diameter, whereas the smallest, from the coal of Cycle "E," is 738 microns in its greatest diameter.

All specimens were nearly opaque when first recovered and rather intensive maceration was necessary to render them suitable for examination with transmitted light. With too strenuous treatment the extines disintegrate, and great care was needed to secure specimens that were not altered in size and shape by chemical action.

The general shape of *Triletes auritus* is triangular, with the corners made blunt by rounding or truncation. The sides between the "ears" are slightly concave. Because the lips and arcuate ridges are prominently elevated the contact faces appear to be slightly depressed. Spores resembling *T. auritus* were noted between the sporophylls of *Lepidostrobus Bartletti* from Grand Ledge (Arnold, 1).

Occurrence.—Most abundant in the plant bed below Cycle "A"; present in smaller numbers in the coal of Cycle "D"; the Big Chief No. 8 Mine at St. Charles; in the Williamston spore coal; and in the New Corunna Brick Company in Section 22, Shiawassee County.

Triletes mamillarius Bartlett

(Pl. VII)

This is a fairly large spore with strongly delimited contact faces; characterized by a warty surface. Individual specimens range from less than 1.5 mm. to slightly more than 2 mm. in diameter. The dark extine has a maximum thickness of 70 microns; the warts, which are about 30 microns broad and 24 microns high, bear a small terminal umbilicus, which in most specimens is usually broken off. The contact faces are free of warts, but they may bear a few surface plications. In the apical angle of each face there is a rather conspicuous raised area which stands out prominently under reflected light (Pl. VII, Fig. 2).

Only fragments of these large thick-walled spores can be examined satisfactorily by transmitted light (Pl. VII, Fig. 1). All specimens are nearly uniform in size and conform to the measurements given by Bartlett (4).

Some of the spores included by Zerndt (28, 29) in his Type 14 may belong to *Triletes mamillarius*. Dijkstra (10) included Zerndt's Types 14 and 15 in this species, but Type 15, according to Zerndt (28), consisted of very large spores that are sometimes 3.7 mm. in diameter.

Schopf's *Triletes brevispiculus* (Schopf, 17) is in all probability identical with *T. mamillarius*. The difference in the shape of the suture, which was cited by Schopf as the main distinguishing feature between *T. mamillarius* and his spores, is seemingly slight and hardly sufficient to indicate a different species.

Triletes mamillarius probably is a sigillarian spore, although Zerndt (31) designated his Type 14 as a megaspore of *Lepidodendron.*

Occurrence.—Plant-bearing shales below Cycle "A" at Grand Ledge and Big Chief No. 8 Mine at St. Charles.

Triletes Fermii, sp. nov.

(Pl. VIII)

Diagnosis.—Spore body spherical, 2 to 3 mm. in diameter; extine dark reddish-brown, about 10 microns thick, granular, and covered with numerous short spines; contact faces distinct, delimited distally by broad, low, moderately arched arcuate ridges, and occupying about one-half of the area of the proximal half of the spore; suture lines 600 to 800 microns long and splitting at one-half to two-thirds of their length to form the triradiate aperture; lips thin; spines of two kinds, those on emphytic parts are 4.7 to 7 microns broad at base and 10 to 21 microns long and those on contact faces are about one-half these dimensions, all tapering to sharp points.

This spore bears such close resemblance to *Triletes mamillarius* that, unless brought together for direct comparison, the two are not easily separated. *T. Fermii* is larger than *T. mamillarius,* has a thinner wall, and the extine prolongations are cone-shaped spines instead of warts or tubercles (Pl. VIII, Fig. 2). These spines have smaller diameters than the warts of *T. mamillarius* and are more numerous. They somewhat resemble those of *Lagenicula saccata,* figured on Plate XV, Figure 2, but are not so conspicuously bulbous at the base. This spore does not belong to *Lagenicula,* however, for it has no apical prolongation. The spines on the contact faces are smaller than those on the distal parts.

Triletes Fermii is similar in size to Zerndt's Type 15, which is commonly regarded as a larger form of the same kind of spore as that embraced by his Type 14. Most authors assume that the spores of Zerndt's Type 14 belong to *T. mamillarius* and Dijkstra (10) has drawn up a long list of synonyms that includes not only Zerndt's Type 14 but Bennie and Kidston's Types V to XIII, Ibrahim's (14) *Sporonites tuberosus,* and others. To judge from Zerndt's (29, Fig. 5, p. 17) drawing of his Type 14, a drawing which can surely be accepted as accurately portraying the essential characters of the spore, it differs from *T. mamillarius* and except for its smaller size is more like *T. Fermii.* Zerndt pictured Type 14 as ornamented with cone-shaped spines on the distal regions and smaller spines on the contact faces and as having the rays of the triradiate cleft about one-half as long as the suture lines, features that are all strikingly like those observed in *T. Fermii.* Although Bartlett gave no measurements of the surface features of *T. mamillarius,* his photomicrographs (4, Pl. XV) as well as his description (p. 21) indicate clearly that the extine projections are of the nature of tubercules or warts, and are not cone-shaped spines. Furthermore, they have the appearance of being larger and less numerous than the spines of *T. Fermii.*

Although it is quite evident when material of the two is compared that *Triletes mamillarius* and *T. Fermii* are distinct, separation cannot always be made on the basis of figures. Ibrahim's drawings of his *Sporonites tuberosus* are for a fairly large spore with coarse warts or spines on the distal surfaces and smaller ones on the contact faces, but there is insufficient detail to identify the spore with precision. Dijkstra's (10) photographs rather strongly suggest that at least two forms have been included under *T. mamillarius.*

The surface ornaments shown on Zerndt's photomicrographs of Type 15 look much like those observed on *Triletes Fermii* (28, Pl. 4, Fig. 13; Pl. 5, Fig. 14). On the assumption that Zerndt's Type 15 differs from his Type 14 and that neither of them is identical with *T. mamillarius,* the large spiny spore described here is designated *Triletes Fermii,* sp. nov., after its collector, Mr. John Ferm.

Triletes Fermii has been found in compressed fragments of small lepidophytic fructifications. Judging from the size of the contact faces the tetrads consisted of four members of equal bulk.

Occurrence.—Plant-bearing shale of Cycle "A," quarry of the Grand Ledge Clay Products Company.

Triletes fulgens Zerndt

(Pl. XII, Figs. 5–6)

Only a few specimens of this small dark-colored spore have been found in Michigan, but the species may be more prevalent than is now realized. *Triletes fulgens* is easily recognized by its shape. Intensive maceration, which tends to gelatinize and swell the extine, is necessary to render the spore coat transparent.

The relatively small spores range from 400 to 930 microns in diameter. The contact faces, which cover at least one-half of the proximal surface, are distinctively outlined by prominent arcuate ridges and raised lips. Although appendages are lacking, the extine has a coarse texture that imparts roughness to the surface.

Triletes fulgens is close to *T. glabratus* and to specimens figured by Schopf (17, Pl. 2, Figs. 2–4) as *T. Reinschi,* but it is smaller than these species and the contact faces cover more of the surface. It is probably a sigillarian spore.

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

Triletes globosus, sp. nov.

(Pl. IX)

Diagnosis.—Spore body round, 390 to 570 microns in diameter, averaging about 480 microns; extine 17 microns thick, ornamented on all surfaces except the contact faces with columnar peglike appendages, which are about 12 microns in diameter and 35 to 50 microns long and bear at the summit two to five short slightly spreading barbs; contact faces smooth, unornamented, distinctly outlined by raised lips and arcuate ridges; suture lines about 180 microns long; lips about 5 microns thick; apex prolonged into a small prominence about 110 microns high.

This rather small spore is characterized by its peglike, terminally branched appendages. Only a few specimens have been recovered. The spores, however, because of their small size could readily have escaped notice by passing through the finest sieve used to separate coarser particles from the sludge. Dimensions given in the diagnosis are based upon ten specimens.

The spines stand 15 to 45 microns apart and constitute a prominent growth over the entire surface except the contact faces. Occasional spines are joined at the base but most of them are separate. they taper only a little, having the apex about as wide as the base. The summit bears two to five short unequal spreading barbs that are 12 microns or less long (Pl. IX, Fig. 5). Occasional spines are simple or have only a shallow terminal cleft.

The contact faces are smooth and free of spines, but careful examination is required to reveal their distribution (Pl. IV, Fig. 1) because with transmitted light the spines on the distal side are visible through both layers.

The small apical prominence is not always preserved and is easily overlooked. In vertically compressed spores the prominence is pressed against the spore apex and as it is very thin the apex is visible through it. On laterally compressed specimens little remains of it, and only on obliquely flattened ones can the outline be clearly discerned. Careful examination is always necessary to determine its presence. The small apical prominence may indicate affinity with the *Lagenicula* group of spores, but it is often so difficult to see that this distinctive spore is tentatively retained in *Triletes.*

Triletes globosus is close to the slightly larger *Triletes tenuispinosus* of Zerndt (29) and to *Sporites hirsutus* of Loose (14). Wicher (22, Pl. 8, Fig. 28) illustrated a specimen of *S. hirsutus* on which some of the spines were branched, but most were simple. The three spores were probably borne by closely related plants.

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

Lagenicula horrida Zerndt

(Pl. X)

At first it was believed that two or more closely related forms might be represented by these fairly large roundish spiny spores with large apical prominences. Close examination, however, led to the conclusion that the variations exhibited by them were not of specific grade. While bodies of the spores appear to have been round, the relatively thin extine invariably has long folds which extend in various directions over the surface and modify the shape (Pl. X, Figs. 1–3). This surface buckling alters the normal relations between the longitudinal and transverse axes, and various degrees of asymmetry result. Because of these alterations the measurements are only approximate.

Approximately one-half of the specimens measured range from 900 to 1300 microns in diameter. This range is slightly larger than that of 830 to 1130 microns given by Zerndt (29, p. 25) for the species. The contact faces are visible on most specimens, but the sutures and suture lines are usually hidden beneath the apical prominence. The contact faces are usually smooth, but on some specimens are adorned with minute excrescences which may extend over the entire spore surface (Pl. X, Fig. 4).

The large awl-like spines which give the spore the appearance of a bur, are 200 microns in maximum length. Some of them taper gradually from the base to the apex; others have slightly swollen bases. As both forms of the large spines are present on many spores, they are of no taxonomic value. The bases range from 36 to 42 microns in diameter. Complete spines bear on the tip a small spherical globule about 20 microns in diameter.

Although the spines are prolongations of the extine, their structure is slightly different. The extine is composed of a structureless yellowish matrix in which are embedded minute flattened granules about 2.5 microns long and 1 micron thick. The presence of the granules extends only into the bases of the spines; throughout most of their length the spines consist only of the structureless material (Pl. X, Fig. 5).

The small excrescences (Pl. X, Fig. 4) that occur among the large spines vary from 10 to 20 microns in length, and the ends are blunt. They are lacking on about 20 per cent of the specimens, but on the remainder are present in varying numbers. On some spores they are so numerous and close together that they render the surface rough, and on some they cover the contact faces.

Lagenicula horrida is similar to *L. crassiaculeata* (Zerndt, 30), but that species is slightly larger and has a higher apical prominence. The differences, however, are only those of degree. *L. horrida* is distinguished from *L. Kidstoni* (*Triletes robertianus* of Schopf, Wilson, and Bentall, 18) by its larger spines.

Occurrence.—Coal of Cycle "D," Big Chief No. 8 Mine at St. Charles, and the abandoned strip mine in Section 14 of Eaton County.

Lagenicula rugosa (Loose), comb. nov.

(Pl. XI; Pl. XII, Figs. 1–4)

Sporonites rugosus Loose, 1932, *Neues Jahrb. Min. Geol., Palaont.*, Beilage-Bd. 67, Abt. B, p. 452, Pl. 20, Fig. 59.

Certain spores from the Michigan Coal Basin ranging between 450 and 1150 microns in diameter are referred here to *Lagenicula rugosa*. These spores were round or nearly round, but the shape in most of the specimens has been altered by creases which are usually directed diagonally or lengthwise. The granular extine measures from 10 to 35 microns in thickness, but in most specimens it is 13 microns. The surface is usually smooth, but in some spores the equatorial region is ornamented by scattered minute papillae which are 5 microns broad and 9 to 10 microns long and have globular tips. In none of the previous descriptions of *L. rugosa* are these papillae mentioned, but their sporadic occurrence does not seem to constitute a basis for specific separation. In some of the specimens the extine is porous. What at first sight appear to be minute granules or dots are seen, when the edge is examined, to be small pores that penetrate the spore coat.

The tetrad scar is best seen on vertically flattened specimens (Pl. XI, Fig. 3), the apical prominence on laterally compressed ones (Pl. XI, Figs. 1–2). The length of the suture lines equals one-half to two-thirds the spore radius. The three contact faces are sharply delimited by the connecting arcuate ridges that arch rather strongly. The apical prominence consists of three upwardly projecting flaps which arise from the contact faces more than half-way between the apex and the distal extremities of the suture lines. These flaps are dark colored in unmacerated spores; with moderate treatment with Schulze's reagent they become translucent so that the spore apex and the lips are visible through them. When the sutures open, the three flaps of the apical prominence also spread apart. Viewed laterally, the prominence is rounded with sloping sides (Pl. XII, Figs. 1, 3) or the three segments may stand slightly apart; it is usually about one-half as high as broad.

The taxonomic limits of *Lagenicula rugosa* have not been well defined, and spores of more than one species of plant have probably been referred to it. The original description by Loose (Potonié, Ibrahim, and Loose, 14) is brief. It is supported by a drawing of a vertically compressed spore that was somewhat deformed so that it shows the suture lines and contact faces but not the apical prominence. Since no reference is made to an apical prominence in the diagnosis, one might question its existence if Ibrahim (11), who was probably familiar with the material on which Loose based his original description, had not shown the prominence on a spore assigned to the same species. Schopf (17) doubtfully assigned a spore from the Herrin coal of Illinois to this species and said that it differed from *Triletes translucens* (also from the Herrin coal) only by its slightly smaller size, thicker extine, coarser surface, and less expanded arcuate ridges. It is evident that *T. translucens* and *L. rugosa* are similar, but whether the differences cited by Schopf are sufficient to designate different species is uncertain. Dijkstra (10) regarded them as one.

Regardless of the inadequacy of the descriptions, the name *Lagenicula rugosa* seems to be the most suitable for the Michigan spores. The alternative would be to describe them under a new name, but the main effect of that would be to complicate the nomenclature. Spores of the *Lagenicula* group are variable, and the difficulties in clearly defining species is evident from the accounts by Zerndt, Schopf, and Dijkstra. Problems arising from the normal variations are increased by the alterations produced by flattening. Specimens laterally flattened might not always be recognized as the same if they are compressed in another direction. The elevation of the apical prominence can be determined only in laterally flattened specimens, but the form of the tetrad scar and the extent of the suture lines can be seen to best advantage on those that have been compressed vertically. These factors of preservation, in addition to normal variations, render specific separation difficult, and lead to the prevalent lumping and splitting of species which is so very prevalent in the literature of spore taxonomy.

Most Michigan specimens agree with the published figures of *Lagenicula rugosa* in the folded and broken extine that seems to be of delicate construction. Specimens that had been pressed flat with a minimum of wrinkling are nearly round except for the large apical prominence. Because the varied appearance of different specimens makes a concise description of the entire lot difficult, a few representative specimens are described briefly.

One spore, discovered in a *Lepidostrobus* fructification (Arnold, 3), is shown on Plate XI, Figure 3. It is nearly round and measures 636 microns in length and breadth, exclusive of the apical prominence which is 248 microns wide and 119 microns high. The suture lines are 160 microns long and the contact faces are delimited distally by arcuate ridges about 7 microns wide. The extine, which is 13 microns thick, is composed of a yellowish-brown matrix in which are embedded minute flattened granules. The contact faces are shorter and smaller in proportion to the size of the spore than in the others assigned to *L. rugosa,* and the arc outlined by each arcuate ridge is less than one-half a circle. This specimen, since it has smaller contact faces and less arched arcuate ridges, may be different from the others which are referred to *L. rugosa,* but it is otherwise so similar that it is tentatively assigned to that species.

A second spore (Pl. XII, Fig. 2) which is vertically compressed is 818 microns in diameter. The three-lobed apical prominence is 284 microns broad and the suture lines are 238 microns long.

A third spore (Pl. XI, Fig. 2) is 1011 microns in diameter. The apical prominence is 568 microns wide and 238 microns high. The extine is 13 microns thick. The contact faces, apparently as a result of imperfect preservation, are not visible. This specimen is larger than the average, but in all other respects is representative.

A fourth spore (Pl. XI, Fig. 1) is 1136 microns in length by 965 microns in breadth, but the shape has been altered by flattening. The apical prominence is 624 microns broad and approximately one-half as high. The wall is 13 microns thick. The suture lines are not visible.

That *Lagenicula rugosa* is a true lepidodendrid spore is demonstrated by its occurrence in *Lepidostrobus.* It is related to *L. horrida,* from which it differs only in the smooth surface and slightly smaller size.

Occurrence.—Big Chief No. 8 Mine at St. Charles; Eaton sandstone; the coal of Cycle "F"; and the abandoned mine in Section 14 in Eaton County.

Lagenicula saccata, sp. nov.

(Pls. XIII–XV)

Diagnosis.—Saclike spore body, round or oval, 2 mm. or slightly more in length; extine granular, about 20 microns thick, and bearing scattered spines about 20 microns broad at the base and 90 microns in maximum length; contact faces obscure; apical prominence slightly less than 0.5 mm. in breadth and in height; surface just below the apical prominence pleated.

About a dozen specimens, some incomplete, of this rather distinctive spore have been found. It is characterized by a large saclike body ornamented with spines similar to those of *Lagenicula horrida* but smaller. In most specimens the spore body appears to have been nearly round but lengthwise folding often has produced an oval outline.

Several of the specimens have material adhering to the distal end that resembles the "wing-like appendage" on the megaspore of *Lepidostrobus majus,* which was described by Bochenski (8). In the Michigan material, however, the appendage is not an extension of the extine, and is readily separable from it (Pl. XIII, Fig. 1; Pl. XIV, Fig. 2).

The spines, although varying considerably in size, all appear to be of the same type. Some are bulbous at the base like those of *Lagenicula horrida* (Pl. XV, Fig. 2).

In the enlargement of the spore body which follows the tetrad stage the contact faces were stretched beyond their original limits so as to render their outlines indistinct. One member of the tetrad developed at the expense of the other three, and in some specimens at least two of the aborted members can be seen attached to the apex of the mature spore (Pl. XIV, Fig. 1).

In all specimens the extine is very dark, and in many it is partly obscured by adhering fragments of carbonaceous material (Pl. XIII, Fig. 2). With prolonged maceration some details of the extine become visible, but it has not been possible to observe the sutures or the suture lines, both of which are hidden by the apical prominence.

Lagenicula saccata is similar to or identical with the large spores of *Lepidostrobus braidwoodensis* (Arnold, 2) from Braidwood, Illinois. In this fructification only one megaspore matured in a megasporangium, although the other tetrad members remained in aborted form. The situation is similar to that of *Cystosporites giganteus,* the megaspore of *Lepidostrobus majus,* and to that of *Lepidostrobus Bodhanowiczii,* both described by Bochenski (8). The only discernable difference between *L. saccata* and the spores of *Lepidostrobus braidwoodensis* is that the latter has spines which are only 24 microns long.

Lagenicula saccata differs from *Cystosporites,* which it resembles in shape and size, in its conspicuous apical prominence and granular (instead of fibrous) extine. The contact faces are visible on well-preserved specimens of *Cystosporites* and not obscure as in this species. When still in position the three aborted tetrad members sometimes bear a superficial resemblance to an apical prominence, but careful examination will reveal the difference.

In the discussion of *Lepidostrobus braidwoodensis* (2, p. 712) it is explained that the production of a single large spore in the megasporangium represents an evolutionary trend among the Paleozoic lycopods which culminated in the seedlike organ of *Lepidocarpon.* While it is not certain that *L. braidwoodensis* and *Lagenicula saccata* were in the direct line of development of *Lepidocarpon,* they at least represent an evolutionary trend in forms which are closely related to it.

Occurrence.—Big Chief No. 8 Mine at St. Charles, and the coal of Cycle "D."

Cystosporites giganteus (Zerndt) Schopf, Wilson, and Bentall

(Pl. XVIII, Fig. 1)

Specimens of this very large megaspore, which have a maximum length of 1 cm., seldom occur whole. Destructibility rather than rarity is probably the reason. Because of the highly characteristic wall structure, however, even small fragments of *Cystosporites giganteus* are easy to recognize.

In Michigan a few small specimens which are almost complete have been recovered. Two of them, one figured in Plate XVIII, Figure 1, measured 4 by 4.75 mm. A specimen 9 mm. long was badly broken. On most specimens the apex had opened along the sutures so that the exact form of the apex is obscure, but it appeared to project out slightly into a broad beak around which the three aborted members of the tetrad were arranged. The obscure contact faces were apparently small. On two specimens two oval bodies, apparently the aborted megaspores, were still in place. They measured 550 and 700 microns in length. The texture of the extine at the apical end of the large megaspore is granular like that in *Triletes* and *Lagen-*

icula, but within less than one-fourth of the distance toward the distal end it is completely transformed into the fibrous texture which is typical of *Cystosporites* (Schopf, 17). This fibrous texture extends through the entire distal part.

Cystosporites giganteus resembles *C. breretonensis* from the Herrin coal of Illinois (Schopf, 17), but *C. breretonensis* is probably closer to *C. varius* than it is to *C. giganteus.* In *C. breretonensis* the apex is flatter than in *C. giganteus* and the extine is coarser textured along the middle part of the spore body. The most pronounced difference between the two is that *C. breretonensis* has a spongy apical tuft which is like that of *C. varius.*

Cystosporites is believed to be one of the large megaspore types retained within the sporangium of the Carboniferous lepidocarps. The fibrous texture is probably an adaptation that facilitated food absorption, and it is especially developed in that part of the spore coat that underwent most stretching after tetrad formation was complete. This texture, so characteristic of the functional megaspores, is obscure or undeveloped in the aborted tetrad members.

Occurence.—Coal of Cycle "F"; the Big Chief No. 8 Mine, St. Charles; and the abandoned mine in Section 14 of Eaton County.

Cystosporites varius (Wicher) Dijkstra

(Pls. XVI–XVII)

Cystosporites varius resembles *C. giganteus* in that one member of the megaspore tetrad matured at the expense of the other three. The mature spore is smaller than the comparable member of *C. giganteus,* and both the mature and aborted ones are provided with a spongelike apical tuft that obscures the apex and most of the tetrad scar.

In Michigan aborted members of the tetrads are abundant in some coal samples, but only a few mature megaspores have been recognized (Pl. XVI, Fig. 1; Pl. XVII, Fig. 1). One of the mature spores recovered (Pl. XVI, Fig. 1) was an oval body 1400 microns in diameter and 2300 microns long. Another (Pl. XVII, Fig. 1) was 1726 microns in diameter and of undeterminable length. Both have the triangular apical crest, which measured 375 and 570 microns in diameter, respectively, in the two specimens. The extine has the meshlike texture typical of *Cystosporites,* but the meshes are smaller than those in *C. giganteus.*

Aborted tetrad members are rounded and baglike (Pl. XVI, Figs. 2–3; Pl. XVII, Figs. 2–3). The largest specimen observed was ovoid or pyriform and 1350 microns in diameter by 1860 microns in length. The average specimen is about 1400 microns in both dimensions. The apical crest is rounded in side view but triangular when seen from above (Pl. XVI, Fig. 3); it ranges from 327 to 550 microns in diameter and slightly less in height. There seems to be no relation between the size of the spore and the size of the crest. Some of the largest spores have the smallest crests.

From the taxonomic standpoint the two spore types here identified as *Cystosporites varius* are difficult to place; it was only through the fortunate discovery of the large specimens bearing the diagnostic apical crests in association with the smaller that it was possible to correlate the mature and aborted forms. Wicher (23) gave the apical tuft as diagnostic of *C. varius* and as the means of distinguishing it from *C. giganteus.*

If only the aborted members had been seen, they probably would have been assigned to *Triletes diabolicus*—the name proposed by R. Scott (19) for tufted megaspores found in British coal balls. After studying many fragments of a large number of specimens, Mrs. Scott concluded that *T. diabolicus* was about 1.5 mm. in diameter and that it had four spores to each sporangium. The spores were in strobili identified as *Lepidostrobus foliaceus.* Some of them were still within the sporangia that produced them and no notable size difference was evident. It is possible that fragments of a larger tetrad member may have been present and passed unrecognized, since the fructifications in all other respects were typical of *Lepidostrobus.* It would be almost unbelievable that had Mrs. Scott observed lepidocarp spores, their identity would have escaped her notice. The likelihood is, that the tufted spores observed in the coal balls were true lepidodendrid spores which were in line with lepidocarp development. Possibly during the evolution of the lepidocarps the peculiar characteristics which they exhibit developed in free-sporing ancestors, at a stage when all members of the tetrad were still developing to an equal extent. In that event *Triletes diabolicus* would represent the ancestral free-sporing stage of the lepidocarp line and *Cystosporites varius* would be a step further along, in which one tetrad member developed at the expense of the others.

As far as size is concerned *Triletes diabolicus* corresponds to an average aborted spore of *Cystosporites varius.* If only the aborted members of *C. varius* had been found the trivial name *diabolicus* would be correct for them. In the Michigan material, however, the true nature of these bodies is revealed by the associated larger specimens and they are all referred to *C. varius.*

In his original description of *Cystosporites varius* in 1934 Wicher (22, p. 173) said that the essential difference between this spore and *C. giganteus* is the three-lobed granular outgrowth which is from 100 to 300 microns in diameter. In another paper published the same year Wicher (23, p. 89, Pl. 6, Figs. 2–4) figured the functional megaspore and compared the condition with that in *Lepidocarpon.* He was sure that the smaller members which measure 0.5 to 1.00 mm. in diameter are aborted forms. He also identified Zerndt's Type 30 with his species.

Schopf (17) described a tufted spore from Illinois, which is similar to *Cystosporites varius,* as *C. breretonensis,* and distinguished two "forma," *abortivus* and *reticulatus.* He says both forms were found in connection with fully developed spores. He does not mention, however, an apical tuft on any of the matured spores which he referred to *C. breretonensis,* nor do any of his figures show this tuft on any of the aborted members still in attachment to mature ones. One might be led to believe from Schopf's account that in *C. breretonensis* the aborted spores are tufted but the functional ones are not, although Schopf does not specifically state this to be the case. Such a difference in spores of one species seems quite improbable and it appears that the functional megaspores described by Schopf are of some other species and that the tufted spores which he attributes to *C. breretonensis* belong to *C. varius.* Schopf, Wilson, and Bentall (18, p. 42) made Wicher's *Sporites varius* a form of *C. giganteus,* but the two appear to be quite distinct. In *C. giganteus* both of the developmental stages lack the characteristic spongelike apical tuft, and the wall is more porous and coarsely fibrous than in *C. varius*. Whether all spores having the tuft, including Scott's *Triletes diabolicus* and Schopf's *C. breretonensis*, should be brought together into one species is impossible to say. If they are conspecific the trivial name *diabolicus* has priority, but since different spores may be represented by *diabolicus* and *breretonensis*, *varius* is the most satisfactory name to apply to forms that exhibit the two stages of development.

Occurrence.—The Williamston spore coal, and the Grand Ledge coal (Cycle "B").

Sporites michiganensis, sp. nov.

(Pl. XVIII, Fig. 2)

Diagnosis.—Spore body spherical, about 1500 microns in diameter; tetrad scar consisting of three narrow sutures, 440 microns long, without raised lips or arcuate ridges; contact faces not different from remainder of surface; extine unornamented, dark, coarsely granular.

The diagnosis is based upon a single specimen from the Williamston spore coal. The shape of the spore is round and there has been no folding or apparent distortion from flattening. The only evidence of its tetrad origin is the three slender radiating sutures that appear as narrow crevices in the extine. There is no apparent thickening of the extine adjacent to the suture or noticeable difference in the structure or composition of the extine in the contact regions. The contact surfaces are unbounded distally and are rounded to conform to the remaining part of the spore surface. Although the thickness of the extine has not been determined, it is obviously not membranaceous. The extine is quite dark, coarsely granular, and probably of rather loose porous texture.

The systematic position of *Sporites michiganensis* is in doubt; hence, it is assigned to the form genus *Sporites*. In some respects the specimen resembles *Calamospora* but it is considerably larger than typical members of that genus and has a heavier, more granular extine. The spore looks more like the original figure of *Sporonites*

Reinschi (Ibrahim, 11, Fig. 28), which Schopf (16) designated as the type species of *Triletes,* than do any of the figures referred to this species by subsequent authors. *Triletes I* of Bennie and Kidston (6), Zerndt's Type 1 (27), and the material from Illinois, which was used in making the revised diagnosis of *T. Reinschi* (Schopf, 16), show distinct contact faces bounded distally by arcuate ridges. Ibrahim does not show contact faces, but does state in his brief description that the spore is like Bennie and Kidston's *Triletes I.* Whether the contact faces were clearly defined or merely imagined is uncertain. In view of the importance of arcuate ridges and well-defined contact faces in spore diagnoses and the omission of any suggestion of them in the figure of the type specimen, it hardly seems feasible to apply the name *Reinschi* to spores that do show them. Dijkstra's (10) choice of *Triletes glabratus* as the type species of *Triletes* seems to be a better one; however, in view of the questionable nature of *T. Reinschi* the two names should not be thrown into synonymy. Although Zerndt (27) did include two forms in his original account of *T. glabratus,* his Figures 1 to 3 on Plate I show the same essential features of the spores identified and illustrated as *T. Reinschi* by Schopf and others.

Occurrence.—Williamston spore coal.

LITERATURE CITED

1. ARNOLD, C. A. 1930. A Petrified Lepidophyte Cone from the Pennsylvanian of Michigan. Amer. Journ. Bot., 17: 1028–32.

2. ——— 1938. Note on a Lepidophyte Strobilus Containing Large Spores, from Braidwood, Illinois. Amer. Midl. Nat., 20: 709–12.

3. ——— 1949. Fossil Flora of the Michigan Coal Basin. Contrib. Mus. Paleontol. Univ. Mich., VII, No. 9: 131–269.

4. BARTLETT, H. H. 1929. Fossils of the Carboniferous Coal Pebbles of the Glacial Drift at Ann Arbor. Papers Mich. Acad., 9: 11–28. 1928.

5. ——— 1929. The genus Triletes, Reinsch. *Ibid.,* pp. 29–38. 1928.

6. BENNIE, J., and R. KIDSTON. 1886. On the Occurrence of Spores in the Carboniferous Formations of Scotland. Proc. Phys. Soc. Edinburgh, 9: 82–117.

7. BERGQUIST, S. G. 1939. The Occurrence of Spore Coal in the Williamston Basin, Michigan. Journ. Sed. Petrol., 9: 14–19.

8. BOCHENSKI, T. 1936. Über Sporophyllstande einiger Lepidophyten aus dem produktiven Karbon Polens. XII Jahrd. Polnischen Geol. Gesell, pp. 193–240.

9. CROSS, A. T. 1947. Spore Floras of the Pennsylvanian of West Virginia and Kentucky. Journ. Geol., 55: 285–308.

10. DIJKSTRA, S. J. 1946. Eine monographische Bearbeitung der karbonischen Megasporen. Mededeel. Geol. Stich. (Holland) C–III–I (I). Maastricht.

11. IBRAHIM, A. C. 1933. Sporenformen des Aegirhorizonts des Ruhr-Reviers. Diss. Tech. Hochschule, Berlin.

12. KELLY, W. A. 1936. The Pennsylvanian System of Michigan. Ann. Rept. Mich. Geol. Surv., Div. Publ., 40, Geol. Ser. 34., Pt. II.

13. NAUMOVA, S. N. 1939. Spores and Pollen of the Coals of the U. S. S. R. Rept. XVII Session Internat. Geol. Congr., 1: 353–64. Moscow.

14. POTONIÉ, R., A. C. IBRAHIM, and F. LOOSE. 1932. Sporenformen aus dem Flozen Ägir und Bismarck des Ruhrgebietes. Neues Jahrb. Min., Geol., Palaont., Beilage-Band, B, 67: 438–54.

15. REINSCH, P. F. 1884. Micro-Palaeophytologia formationis carboniferae. Pts. 1–2.

16. SCHOPF, J. M. 1936. The Paleobotanical Significance of Plant Structures in Coal. Trans., Ill. State Acad. Sci., 28: 106–10.

17. ——— 1938. Spores from the Herrin (No. 6) Coal Bed in Illinois. Rept. Investig. Ill. Geol. Surv., No. 50: 1–55.

18. ——— L. R. WILSON, and R. BENTALL. 1944. An Annotated Synopsis of Paleozoic Fossil Spores and the Definition of Generic Groups. Rept. Investig. Ill. Geol. Surv., 91: 1–66.

19. SCOTT, R. 1906. On the Megaspore of *Lepidostrobus foliaceus*. New Phytol., 5: 116–19.

20. THIESSEN, R. 1920. Structure in Paleozoic Bituminous Coal. U. S. Bur. Mines Bull., 117.

21. ——— G. C. SPRUNK, and H. J. O'DONNELL. 1931. Microscopic Study of Elkhorn Coal Bed at Jenkins, Letcher County, Kentucky. U. S. Bur. Mines Tech. Paper, 506.

22. WICHER, C. A. 1934. Sporenformen der Flammkohle des Ruhrgebietes. Arbeit. Instit. Paläobot. Petr. Brennst., Berlin, 4: 165–212.

23. ——— 1934. Über Abortiverscheinung bei fossilen Sporen und ihre phylogenetische Bedeutung. *Ibid.,* 5: 87–95.

24. WILSON, L. R. 1944. Spores and Pollen as Microfossils. Bot. Rev., 10: 499–523.

25. ——— and E. A. COE. 1940. Descriptions of Some Unassigned Plant Microfossils from the Des Moines Series of Iowa. Amer. Midl. Nat., 23: 182–86.

26. WODEHOUSE, R. P. 1929. The Origin of Symmetry Patterns of Pollen Grains. Bull. Torrey Bot. Club, 56: 285–338.

27. ZERNDT, J. 1930. Megasporen aus einen Flöz in Libiaz (Stephanian). Bull. Internat. Acad. Pol. Sci. et Lett., B, pp. 14–70.

28. ——— 1931. Megasporen als Leitfossilen des produktiven Karbons. *Ibid.*, 165–83.

29. ——— 1934. Les mégaspores du bassin houiller Polonais. I. Acad. Pol. Sci. et Lett. Trav. Géol., I. Krakow.

30. ——— 1937. Les mégaspores du bassin houiller Polonais. II. *Ibid.*, 3. Krakow.

31. ——— 1937. Megasporen aus dem Westfal und Stefan in Böhmen. Bull. Internat. Acad. Polonaise Sci. et Lett., A, pp. 583–99.

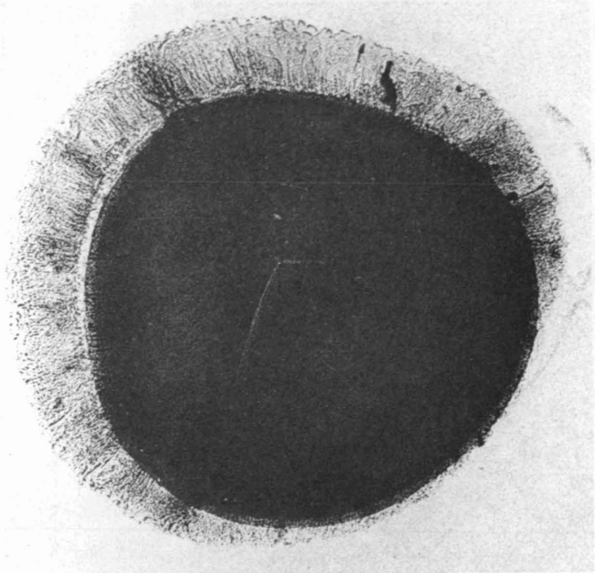
32. ——— 1940. Megasporen des Saarkarbons. Palaeontographica, 84 (B): 133–50.

EXPLANATION OF PLATE I

FIGS. 1–2 *Triletes Brasserti* Stach and Zerndt. Coal of Cycle "E," Grand Ledge. × 50.

PLATE I

1



2

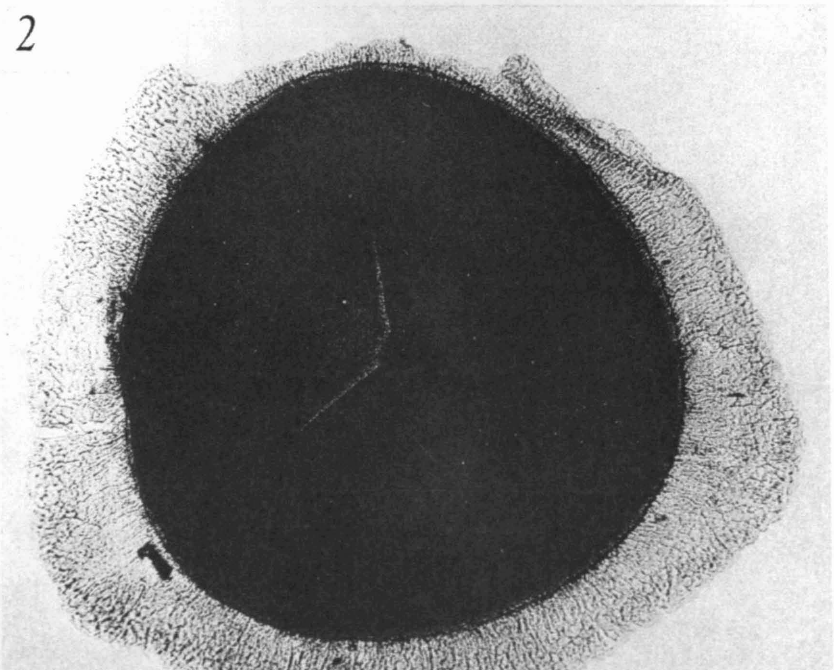
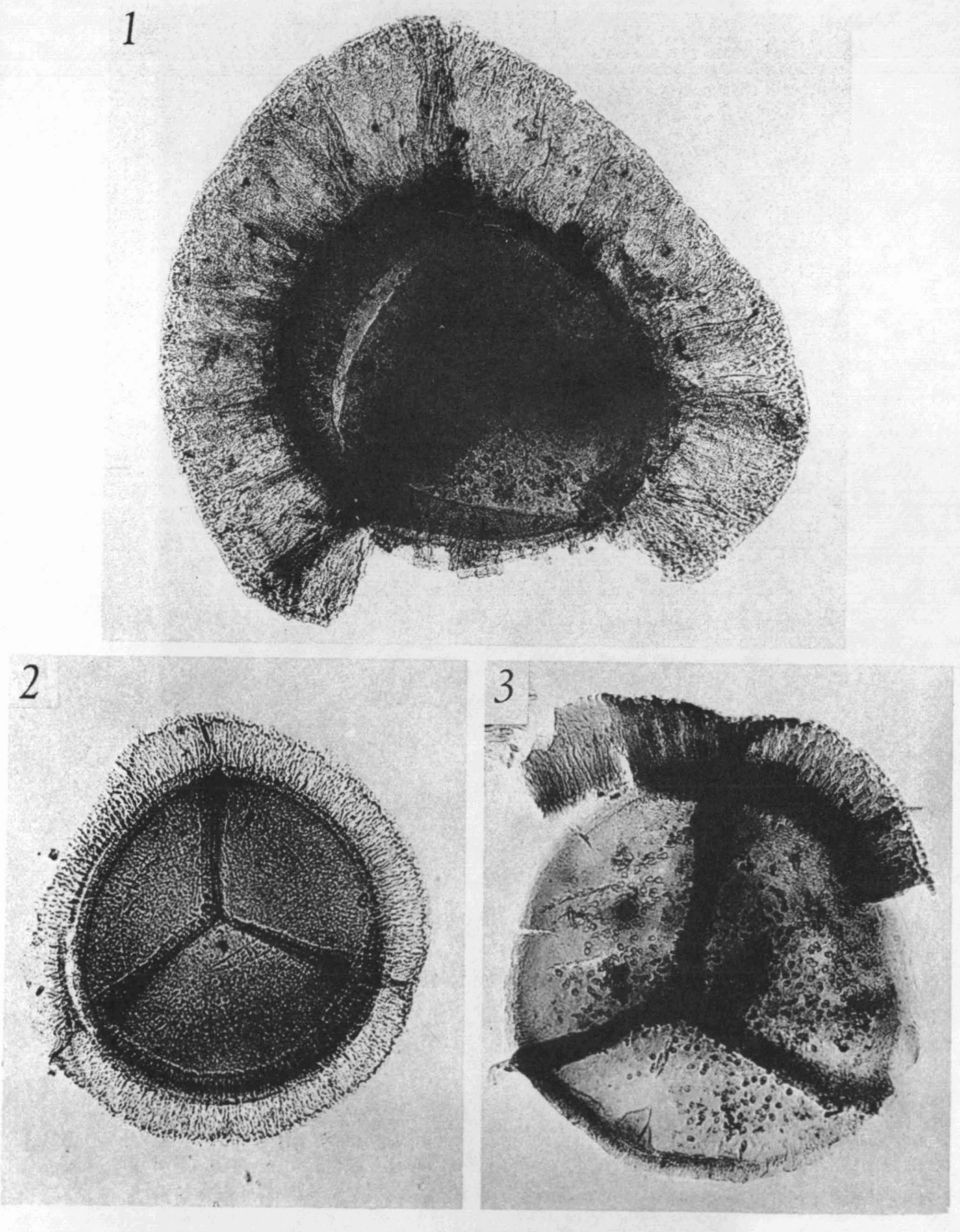


PLATE II



EXPLANATION OF PLATE II

FIG. 1. *Triletes Brasserti* Stach and Zerndt. Coal of Cycle "E," Grand Ledge. × 50.

FIG. 2. *Triletes subbrasserti* Arnold, sp. nov. Coal of Cycle "E," Grand Ledge. × 50.

FIG. 3. *T. subbrasserti* Arnold, sp. nov. Williamston spore coal. × 50.

EXPLANATION OF PLATE III

FIG. 1. *Triletes Brasserti* Stach and Zerndt. Coal of Cycle "H" (Eaton sandstone), Grand Ledge. × 50.

FIG. 2. *Triletes ramosus* Arnold, sp. nov. Williamston spore coal. × 50.

PLATE III

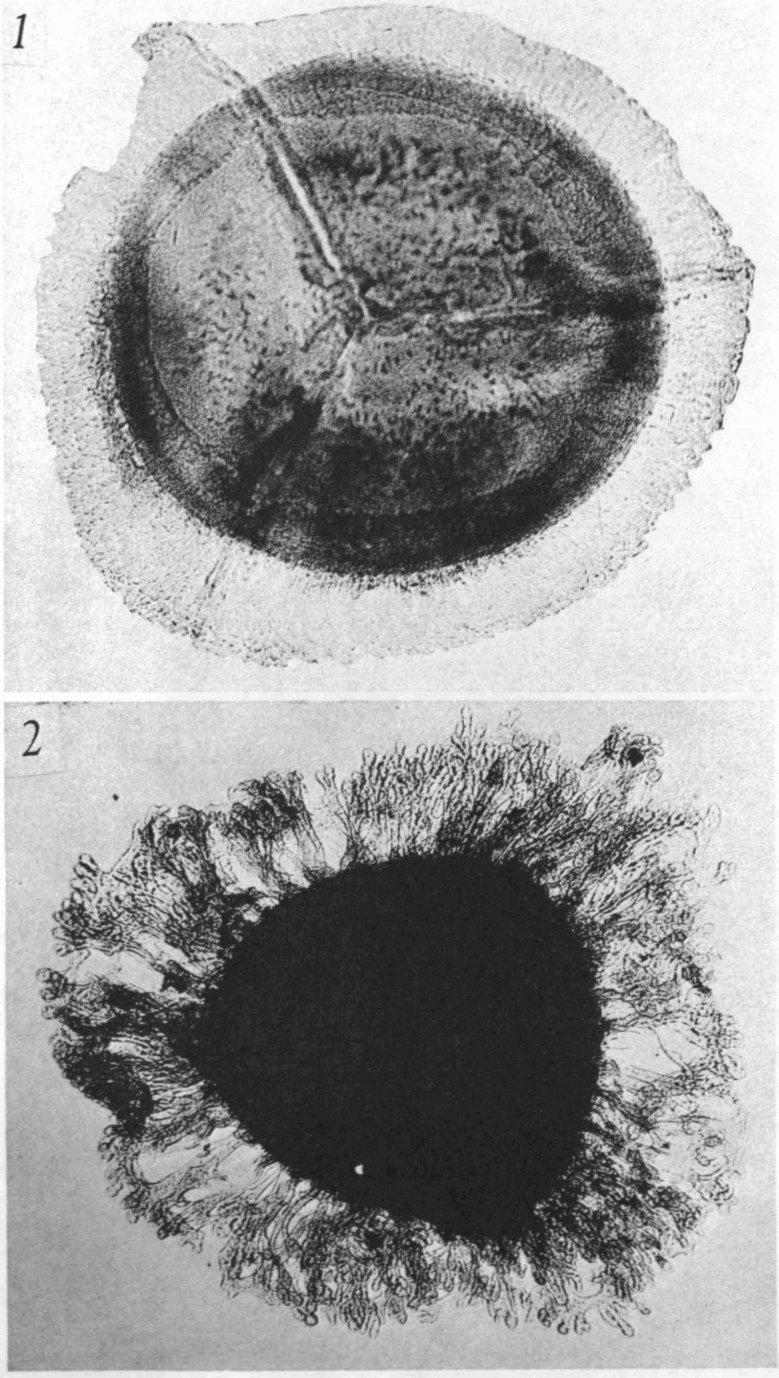
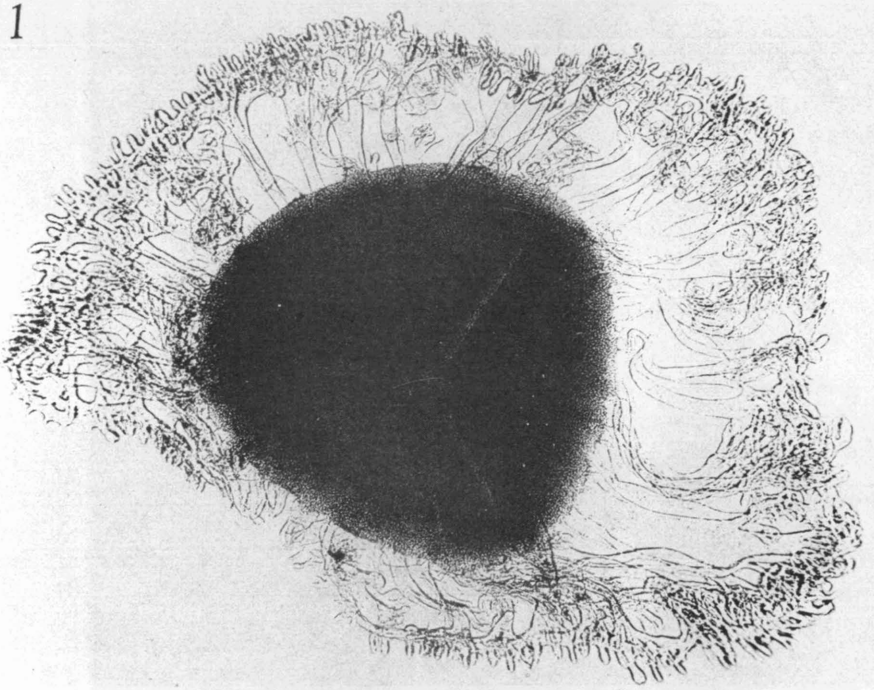
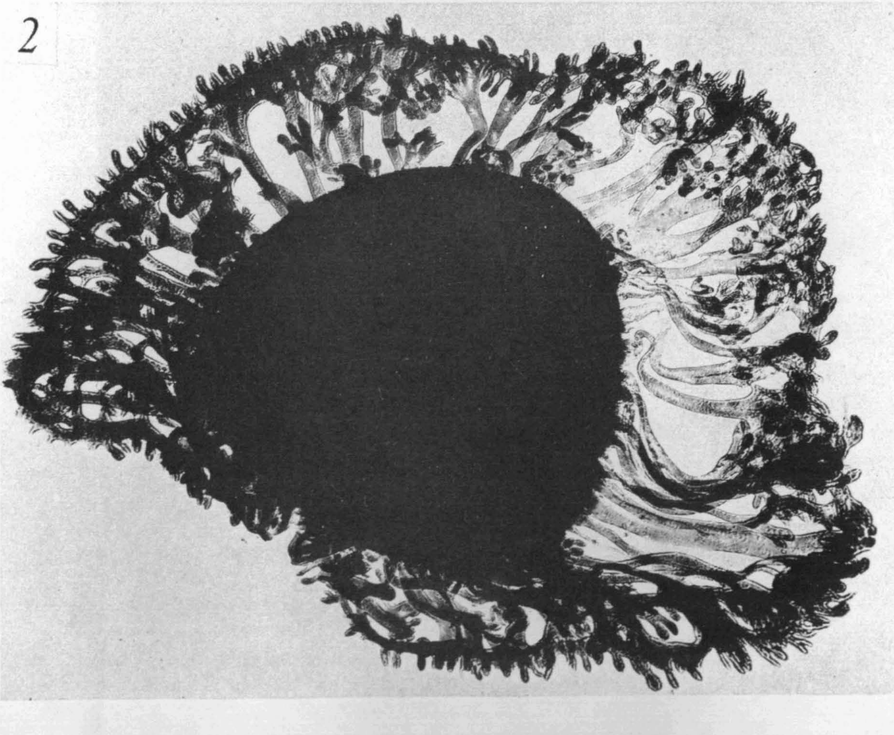


PLATE IV

1



2



EXPLANATION OF PLATE IV

Triletes ramosus Arnold, sp. nov.

FIG. 1. Photographed with red filter to reveal shape of spore body. Williamston spore coal. × 50.

FIG. 2. Same specimen shown in Figure 1, but photographed with a blue filter to emphasize details of the appendage.

EXPLANATION OF PLATE V

Triletes ramosus Arnold, sp. nov. Williamston spore coal.

FIG. 1. Photographed with red filter to show detail of spore body. × 50.

FIG. 2. Spore fragment showing structure of the appendage. × 50.

FIG. 3. Laterally compressed specimen showing apex and membranaceous lips. × 50.

PLATE V

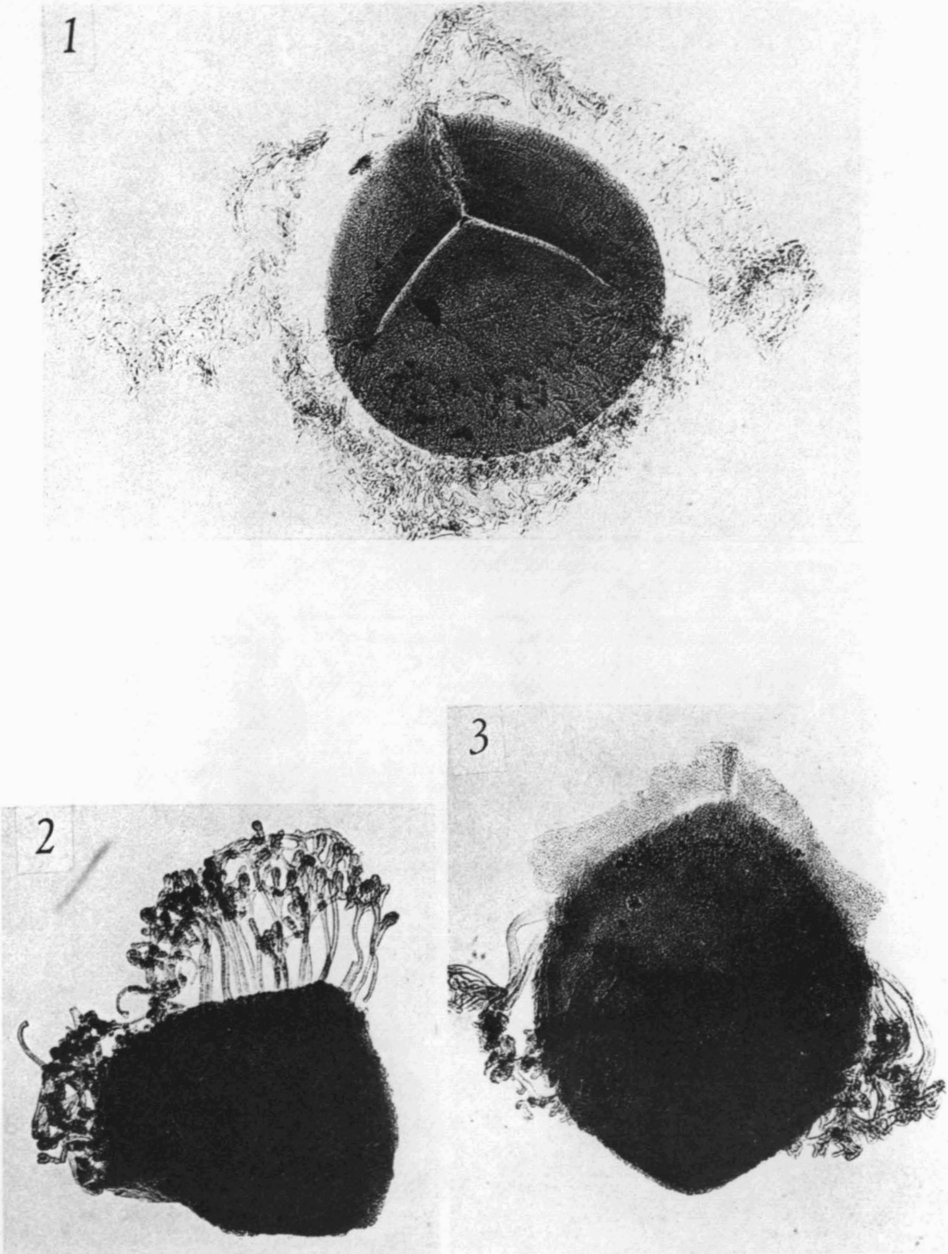
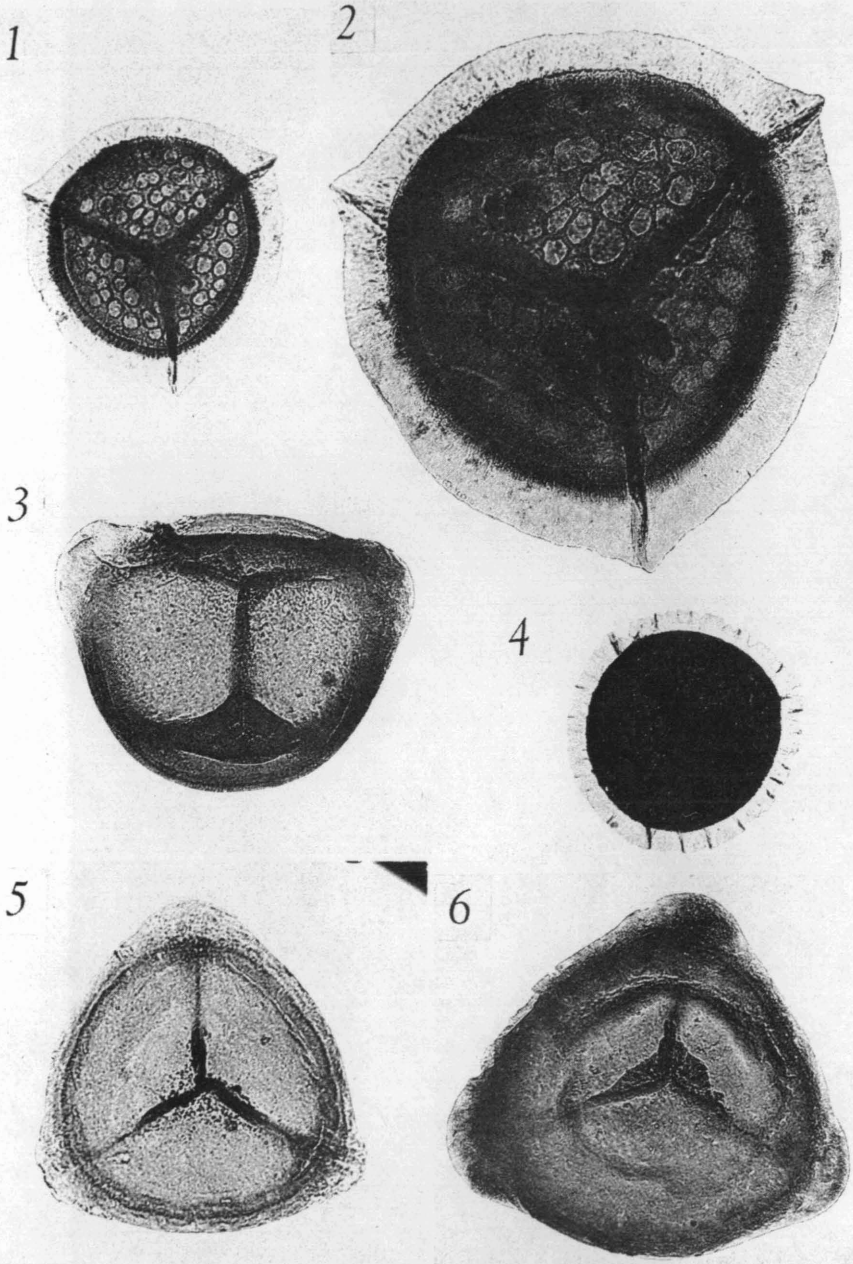


PLATE VI



EXPLANATION OF PLATE VI

FIG. 1. *Triletes triangulatus* Zerndt. Woodville Mine. × 50.

FIG. 2. Same specimen as shown in Figure 1. × 100.

FIG. 3. *Triletes auritus* Zerndt. Plant bed below Cycle "A," Grand Ledge. × 50.

FIG. 4. *T. triangulatus* Zerndt. Specimen showing pleated appendage. Woodville Mine. × 50.

FIGS. 5–6. *T. auritus* Zerndt. Plant bed below Cycle "A," Grand Ledge. × 50.

EXPLANATION OF PLATE VII

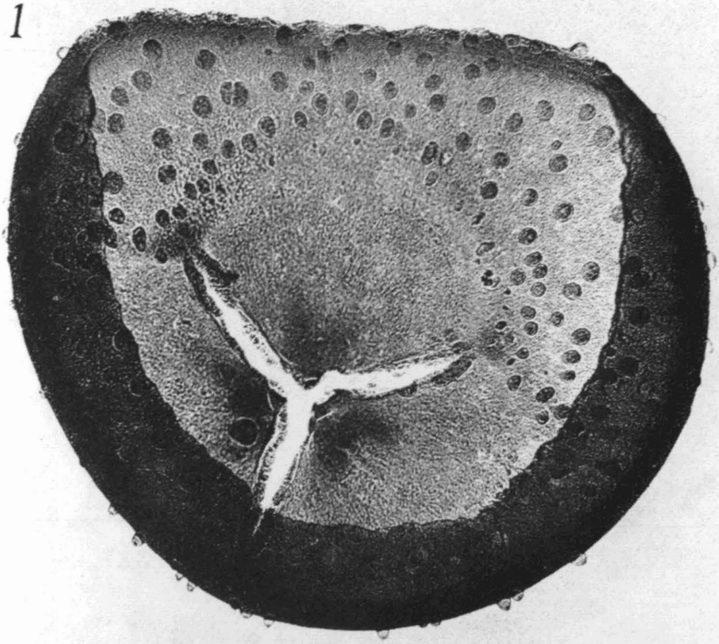
Triletes mamillarius Bartlett.

FIG. 1. Plant bed below Cycle "A," Grand Ledge. × 50.

FIG. 2. Photographed by reflected light. Plant bed below Cycle "A," Grand Ledge. × 50.

PLATE VII

1



2

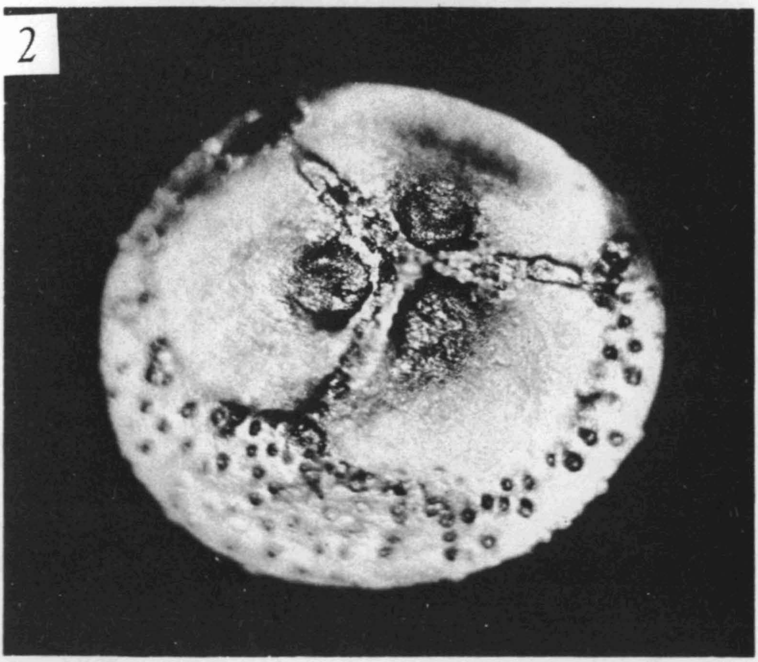
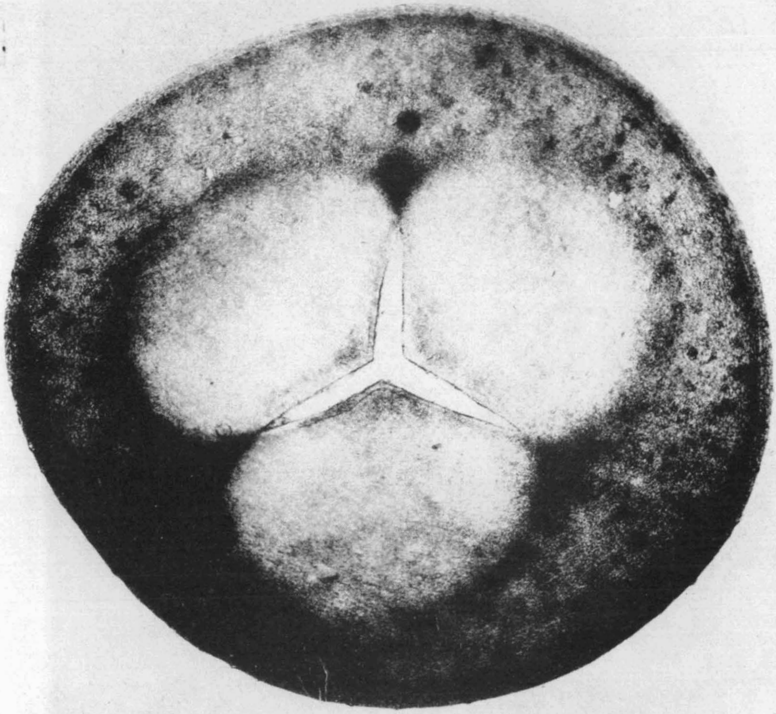
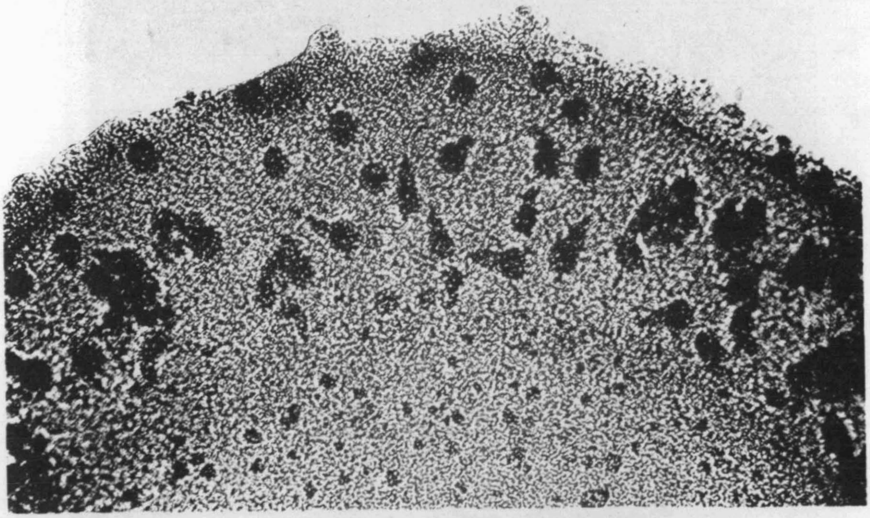


PLATE VIII

1.





EXPLANATION OF PLATE VIII

Triletes Fermii Arnold, sp. nov. Cycle "A," quarry of the Grand Ledge Clay Products Company.

FIG. 1. × 40.

FIG. 2. Highly magnified view to show part of one of the contact faces (below) bearing smaller spines, and the adjoining distal area (above) bearing larger cone-shaped spines. × about 350.

EXPLANATION OF PLATE IX

Triletes globosus Arnold, sp. nov. Big Chief No. 8 Mine, St. Charles.

FIG. 1. × 100.

FIGS. 2–4. × 50.

FIG. 5. Portion of surface of spore body showing details of the spines. × 700.

PLATE IX

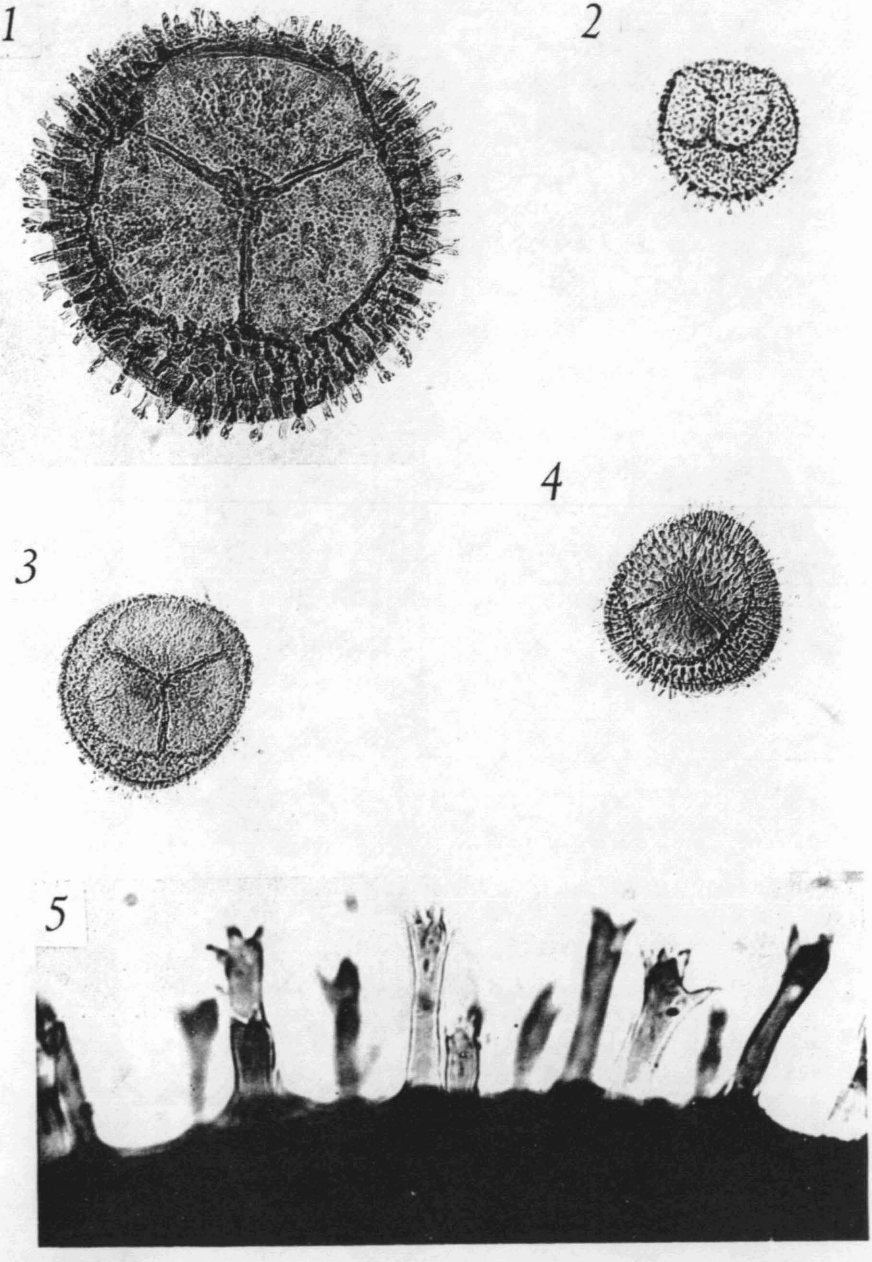
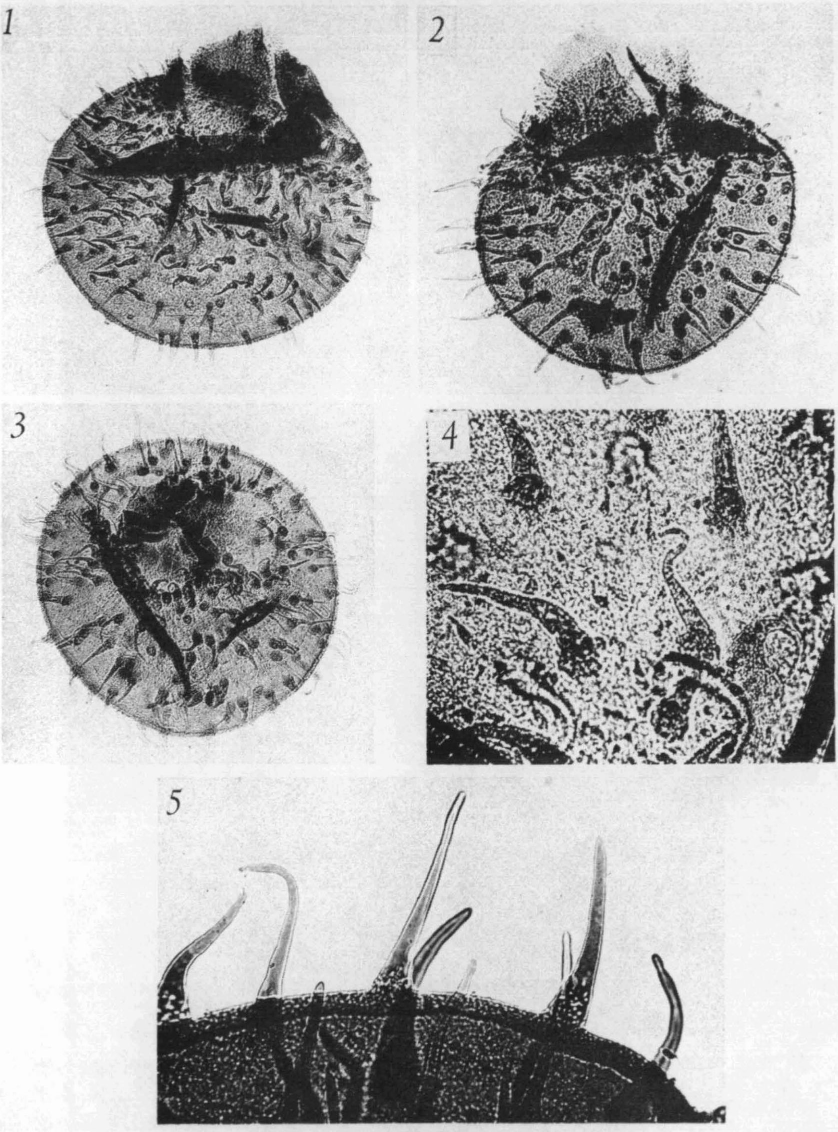


PLATE X



EXPLANATION OF PLATE X

Lagenicula horrida, Zerndt. Coal of Cycle "D," Grand Ledge.

FIGS. 1–3. × 35.

FIG. 4. Portion of extine surface greatly enlarged to show minute spines among the larger ones. × 150.

FIG. 5. Portion of periphery of spore greatly enlarged to show structure of the large spines. × 150.

EXPLANATION OF PLATE XI

Lagenicula rugosa (Loose) Arnold, comb. nov.

FIG. 1. Big Chief No. 8 Mine, St. Charles. × 50.

FIG. 2. Big Chief No. 8 Mine, St. Charles. × 50.

FIG. 3. Coal of Cycle "F," Grand Ledge. × 50.

FIG. 4. Big Chief No. 8 Mine, St. Charles. × 50.

PLATE XI

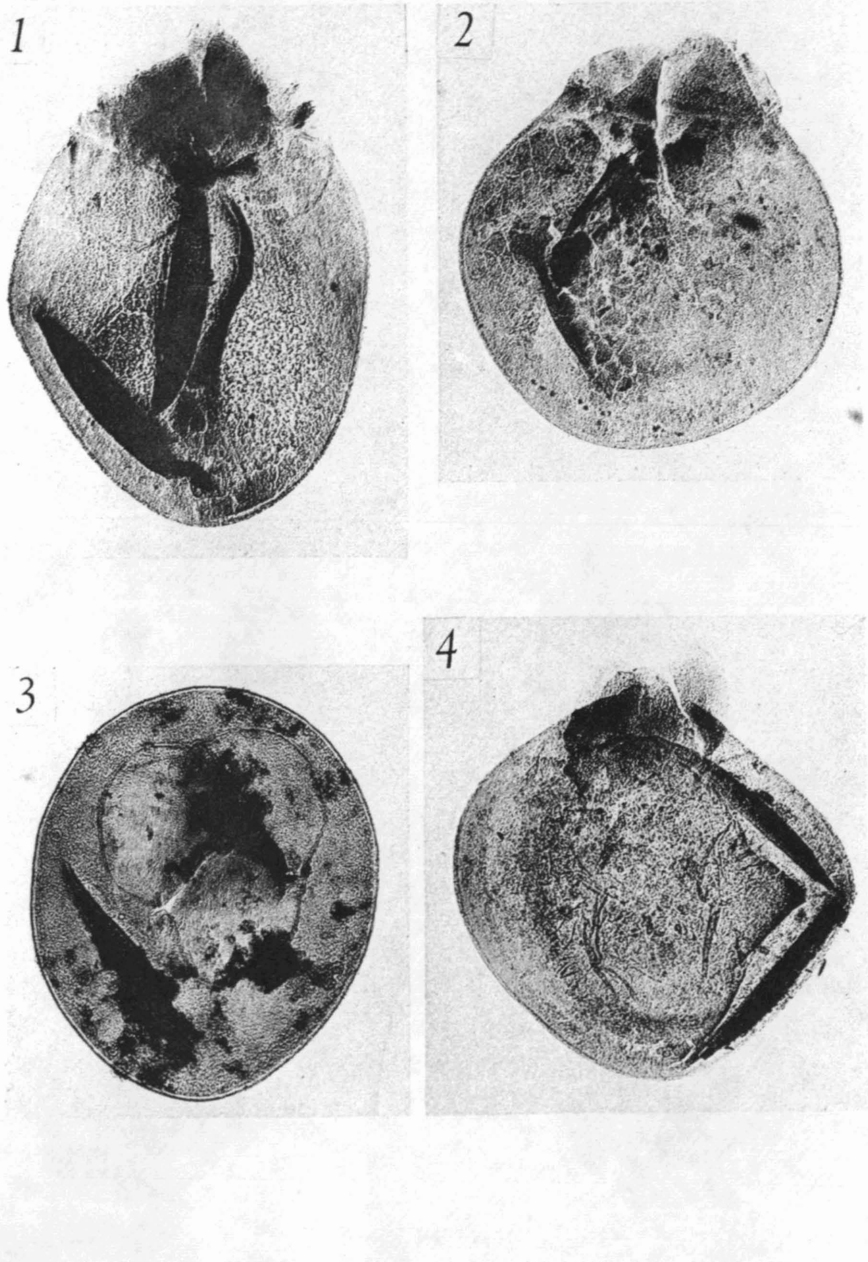
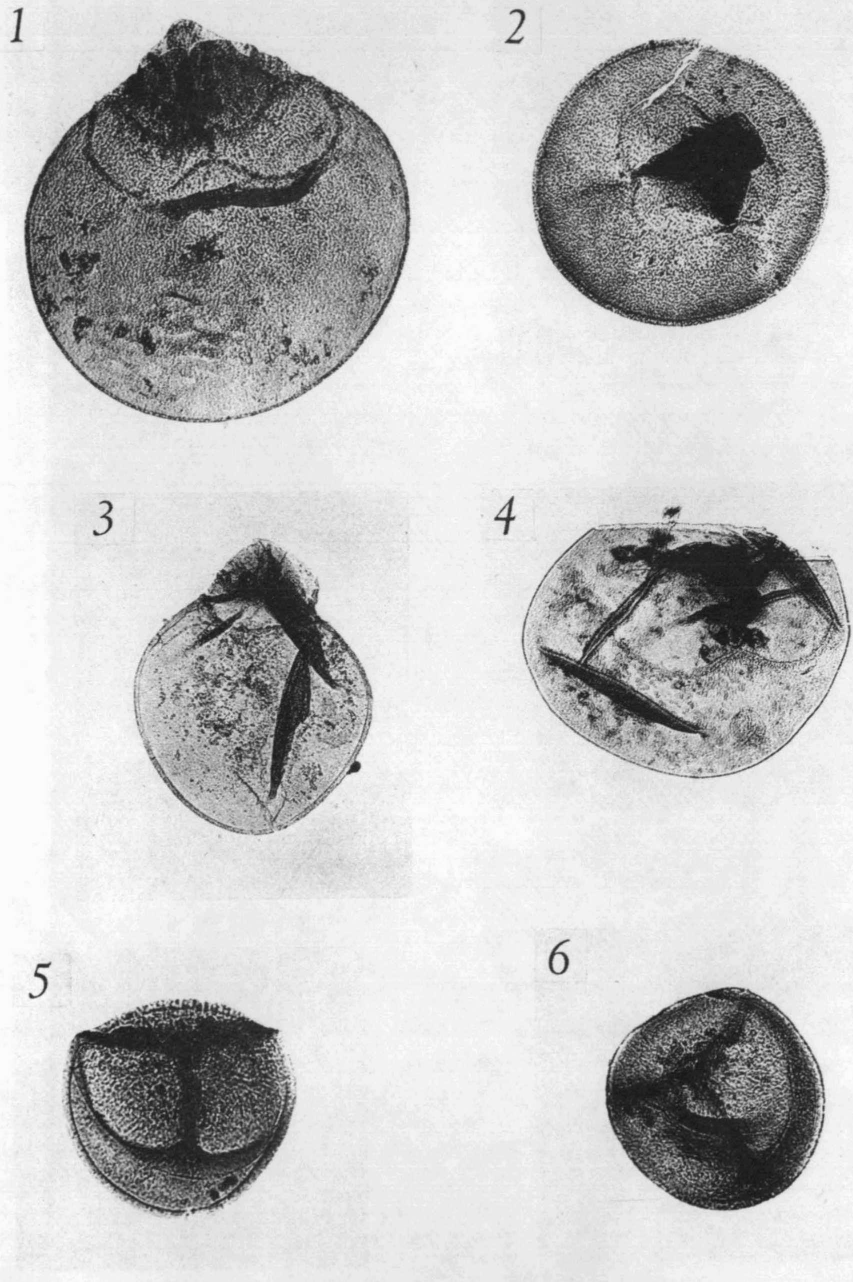


PLATE XII



EXPLANATION OF PLATE XII

FIG. 1. *Lagenicula rugosa* (Loose) Arnold, comb. nov. Coal of Cycle "F," Grand Ledge. × 50.

FIG. 2. *L. rugosa* (Loose) Arnold, comb. nov. Big Chief No. 8 Mine, St. Charles. × 50.

FIG. 3. *L. rugosa* (Loose) Arnold, comb. nov. Cycle "H" (Eaton sandstone), Grand Ledge. × 50.

FIG. 4. *L. rugosa* (Loose) Arnold, comb. nov. Coal of Cycle "F," Grand Ledge. × 50.

FIGS. 5–6. *Triletes fulgens* Zerndt. Big Chief No. 8 Mine, St. Charles. × 50.

EXPLANATION OF PLATE XIII

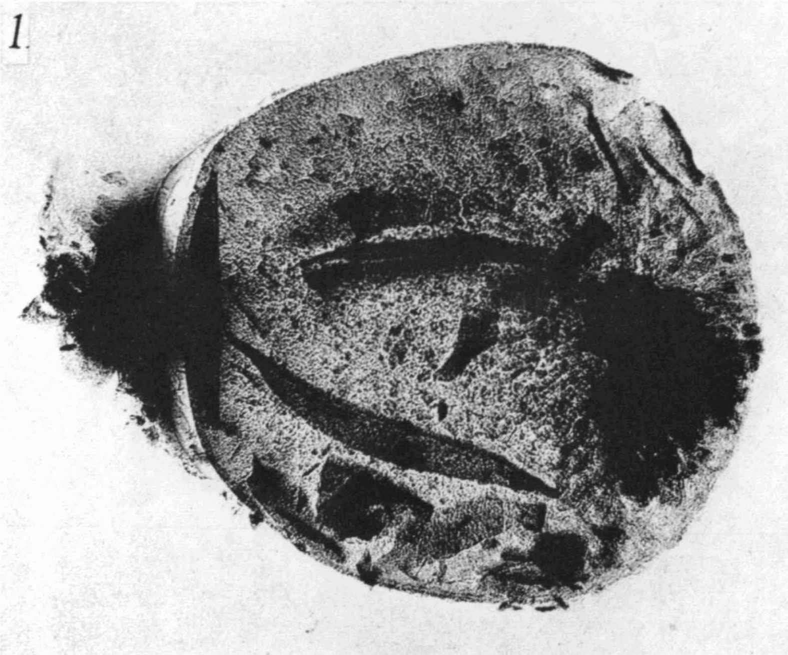
Lagenicula saccata Arnold, sp. nov. Big Chief No. 8 Mine, St. Charles.

FIG. 1. Specimen showing winglike appendage separate from spore body. × 35.

FIG. 2. × 35.

PLATE XIII

1



2

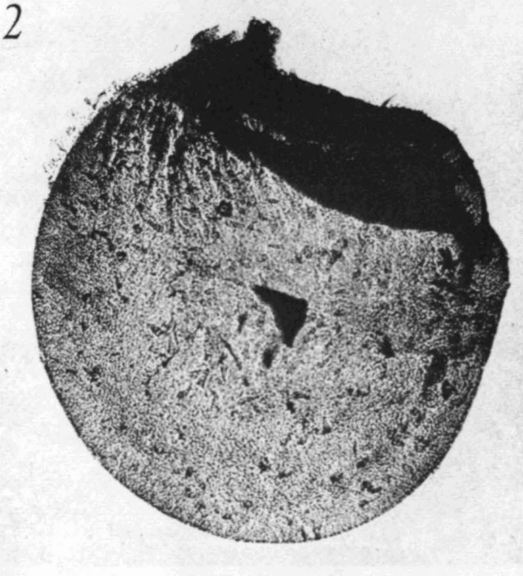
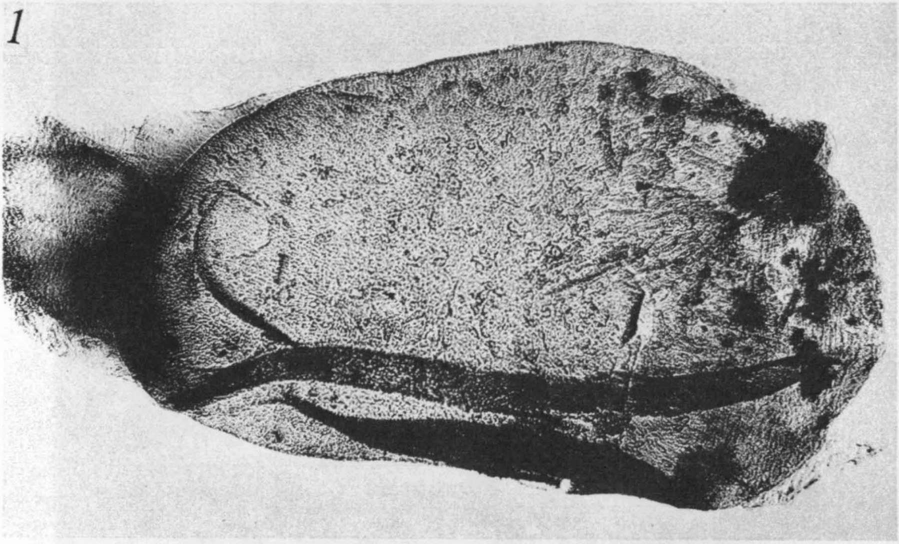
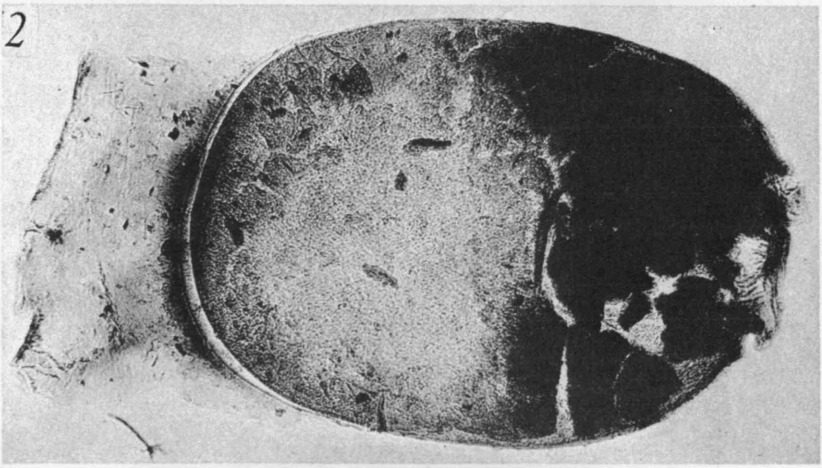


PLATE XIV

1



2



EXPLANATION OF PLATE XIV

Lagenicula saccata Arnold, sp nov. Big Chief No. 8 Mine, St. Charles.

FIGS. 1–2. Specimens showing winglike appendage separate from the spore body. × 35.

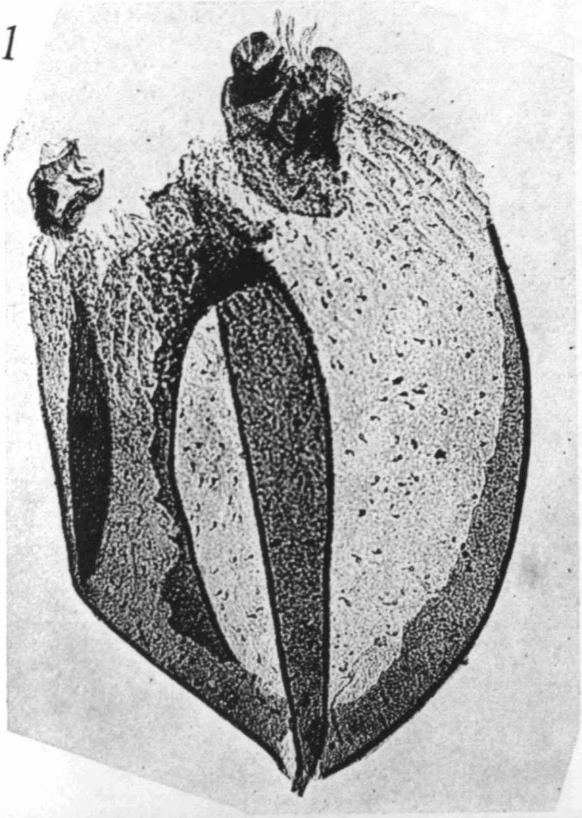
EXPLANATION OF PLATE XV

FIG. 1. *Lagenicula saccata* Arnold, sp. nov. Specimen showing two aborted spores attached at apex. Coal of Cycle "D," Grand Ledge. × 35.

FIG. 2. Part of specimen shown in Figure 2 enlarged to show detail of spines. × 175.

PLATE XV

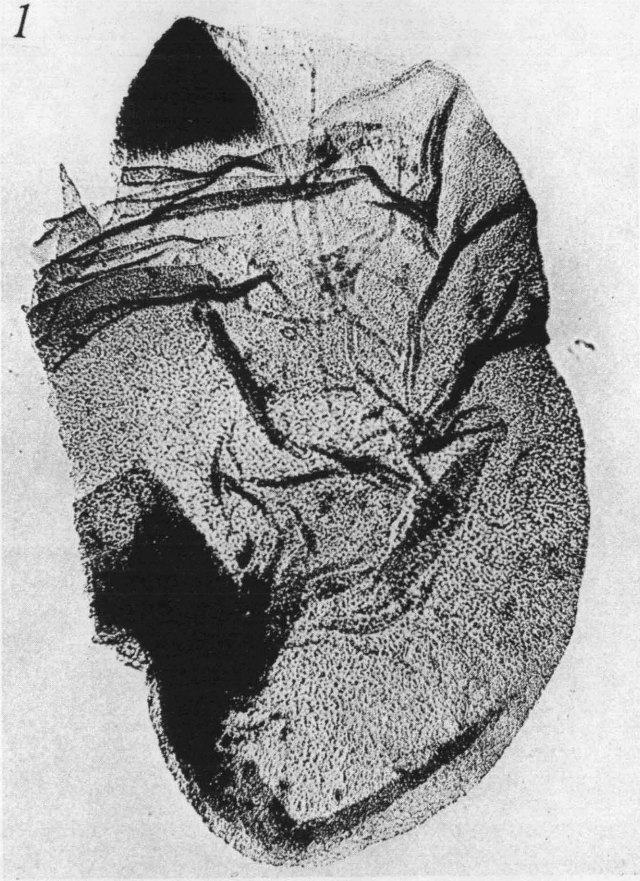
1



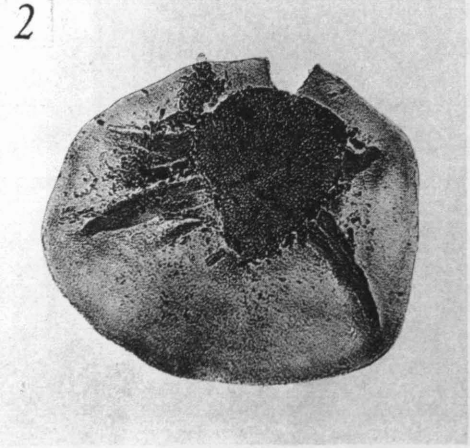
2

PLATE XVI

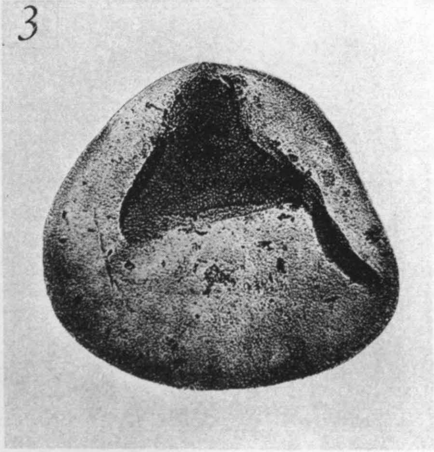
1



2



3



EXPLANATION OF PLATE XVI

Cystosporites varius (Wicher) Dijkstra. Williamston spore coal.

FIG. 1. Mature megaspore showing triangular spongelike crest at apex. × 50.

FIGS. 2–3. Aborted megaspores. × 50.

EXPLANATION OF PLATE XVII

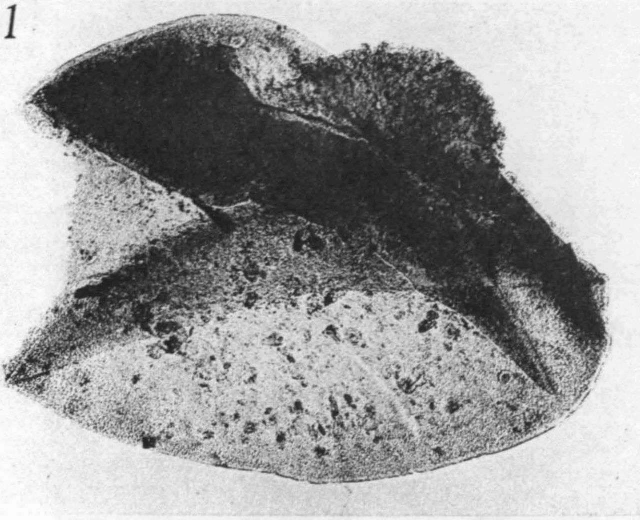
Cystosporites varius (Wicher) Dijkstra. Williamston spore coal.

FIG. 1. Mature megaspore showing apical crest in side view. × 50.

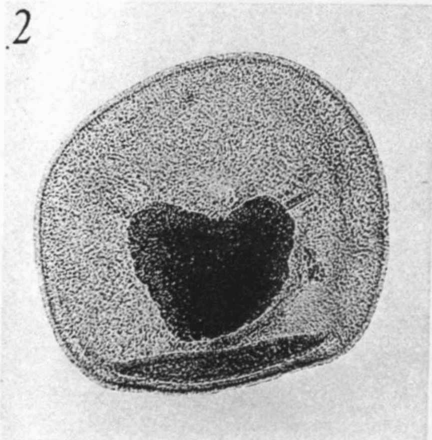
FIGS. 2–3. Aborted megaspores. × 50.

PLATE XVII

1



2



3

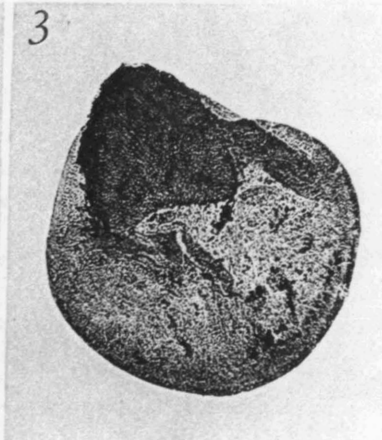
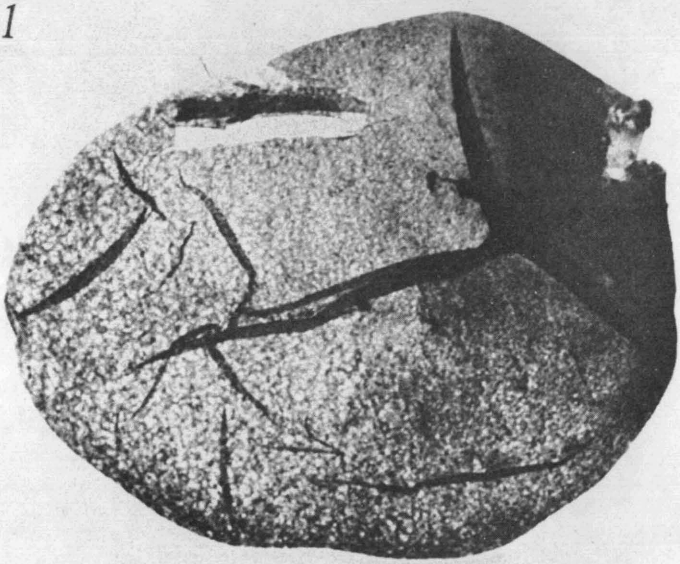
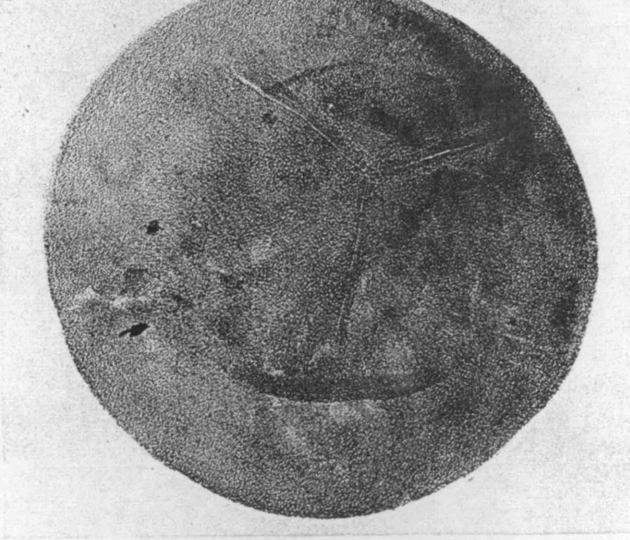


PLATE XVIII

1



2



EXPLANATION OF PLATE XVIII

FIG. 1. *Cystosporites giganteus* (Zerndt) Schopf, Wilson, and Bentall. Big Chief No. 8 Mine, St. Charles. × 20.

FIG. 2. *Sporites michiganensis* Arnold, sp. nov. Williamston spore coal. × 50.

Volume VIII

1. *Pachyphyllum vagabundum,* a New Coral from the Upper Devonian Strata of New York, by George M. Ehlers. Pages 1–6, with 3 plates. Price $.30.

2. Techniques of Collecting Microvertebrate Fossils, by Claude W. Hibbard. Pages 7–19, with 4 plates. Price $.50.

3. Corals of the Devonian Traverse Group of Michigan. Part II, *Cylindrophyllum, Depasophyllum, Disphylllum, Eridophyllum,* and *Synaptophyllum,* by George M. Ehlers and Erwin C. Stumm. Pages 21–41, with 8 plates. Price $.75.

4. A New Testudo from Madison County, Montana, by Thomas M. Oelrich. Pages 43–58, with 1 plate. Price $.50.

5. Megaspores from the Michigan Coal Basin, by Chester A. Arnold. Pages 59–111, with 18 plates. Price $1.50.