

A NEW SPORANGIUM FROM THE AMERICAN CARBONIFEROUS

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INTRODUCTION

THE present study reports a rather large aggregation of sporangia found in a coal ball petrification from Illinois in the U.S.A. The sporangia and their spores, which were mature or very nearly so at the time of fossilization, present characters which are distinct from those of any previously reported spore-bearing organ; the well-preserved spores are especially striking. It seems possible that the sporangial aggregate constitutes a major portion of a unit fructification similar to those reported for *Botryopteris globosa* Darrah and *Biscalitheca musata* Mamay of the Coenopteridales. However, it is by no means certain that our fossil is properly assigned to that group; it may be the sporangial portion of the cone of some other pteridophytic group. It is, at any rate, distinct from any previously reported fossil and is given the binomial *Eopteridangium dictyosporum*, new genus and species.

DESCRIPTION

A portion of the sporangial aggregate, as it was revealed in the original saw cut, is shown in Plate 1, Fig. 1. Several other cuts were made to determine the extent of the spore mass and approximately 250 peel preparations were made. The entire aggregate was found to extend through a distance of about 75 mm.; at one end it is roughly elliptical in outline and for the first 8 or 10 mm. the number of sporangia appearing in a section varies between 80 and 90; through the next 20 mm. the number decreases gradually to about 50; the aggregate then forks into two masses which taper through another 45 mm. to a point where only 8 or 10 sporangia appear.

We estimate the total number of sporangia to be approximately 1900. This figure was determined by taking the average number of sporangia per peel in each block and multiplying by half the thickness of the block in mm. This is assuming that the

sporangia (2.0-2.5 mm. long) are longitudinally aligned through the aggregate; actually they are rather irregularly oriented so that the figure gives a minimum number. It may also be noted that for more than half its length the spore mass is exposed along an outer surface of the coal ball; thus the part preserved may be only a portion of the original aggregate.

It was difficult to gain a clear understanding of the sporangium wall structure from peel preparations; the walls appear uniformly thin (PL. 1, FIGS 1, 2) in whatever direction the sporangia happen to have been sectioned, there being no conspicuous bulge that might represent an annulus. In an attempt to isolate whole sporangia one of the blocks, with several dozen sporangia exposed on the surface, was immersed in very dilute HCl for several days (the gentler action of formic acid would probably have been more suitable). This treatment partially liberated some of the sporangia from the matrix and with the aid of a fine brush they were removed to a slide. Two essentially whole sporangia were thus obtained as well as numerous fragments; such specimens are extremely fragile and proved very difficult to handle, for study and photography, without shattering.

The sporangia are ovoid to cylindrical, 2.0-2.5 mm. long and 1 mm. in diameter. A representative portion of the entire aggregate appears in Plate 1, Fig. 1, while a single sporangium in nearly median longitudinally section is shown in Plate 1, Fig. 2 and an isolated whole one in Plate 1, Fig. 6. Based on this evidence as well as studies of numerous fragments of isolated sporangia there is no indication of an annulus or at least one in which the cells are at all conspicuous. As preserved, the sporangium wall consists of a single layer of uniform, longitudinally elongate cells. The dark band running lengthwise of the sporangium in Plate 2, Fig. 6 presumably is the natural line of dehiscence.

The sporangia are nearly filled with spores which present a highly distinctive type of

sculpturing. They are nearly spherical with an overall diameter of $80\ \mu$; a triradiate commissure is present, the rays of which measure $25\text{--}30\ \mu$. A very conspicuous ornamentation extends out from the exine in the form of a few large muri which constitute a coarse reticulum of polygonal lumina. The muri average $11\ \mu$ in height and $2\text{--}3\ \mu$ in thickness. This unique sculpturing is shown in Figs. 4 and 5; in the latter the spores have been brought into focus to show most of the surface of one hemisphere just short of the equator, while Fig. 4 is through the equatorial zone. Using the method of Radforth (1939) for ascertaining the spore number we have determined that a sporangium $2.5\ \text{mm.}$ long and $1\ \text{mm.}$ in diameter contained well over 3000 spores.

DIAGNOSIS

Eopteridangium dictyosporum Andrews and Agashe (gen. et sp. nov.). Sporangia ovoid to cylindrical, approximately $2.5\ \text{mm.}$ long and $1\ \text{mm.}$ in diameter; found in a massive aggregate of nearly 2000, the morphology of the fructification as a whole being unknown. Sporangium wall of uniformly long, narrow cells aligned parallel to the long axis; no evident annulus. Spores nearly spherical, about $80\ \mu$ in diameter, with a coarse mural reticulum of polygonal lumina; muri $11\ \mu$ in height and $2\text{--}3\ \mu$ thick.

Locality — Stream bed exposure of coal seam on the Ralph Brian farm, Berryville, Lawrence County, Illinois, U.S.A.

Horizon and Age — Calhoun coal ball horizon; McLeansboro group, Upper Pennsylvanian.

Type Specimen — Coal ball No. 1000, paleobotanical collections, Henry Shaw School of Botany, Washington University, St. Louis, Missouri, U.S.A.

DISCUSSION

It is pertinent first to consider the significance of the occurrence of these sporangia in the massive aggregation of 2000 or more. It is unlikely that this represents a chance accumulation of sporangia from a single plant species, a more probable explanation being that it is a portion of a unit fructification in which the appendages or branching system to which the sporangia were attached have been lost through decay.

Certain fossils that have been assigned to the Coenopteridales are characterized by

having several thousands of sporangia borne in a massive aggregate. In *Botryopteris globosa* Darrah the aggregate may be $5\ \text{cm.}$ in diameter, the sporangia being borne in terminal clusters at the tips of a profusely divided branch system. The more recently discovered *Biscalitheca musata* Mamay is known from a sporangial aggregate some $10 \times 5 \times 2\ \text{cm.}$; this is also tentatively assigned to the coenopterids although the annulus structure is very different from that of *B. globosa*. Such aggregates are also reported for *Botryopteris forensis* Renault. If *Eopteridangium* should ultimately be correlated with some of the known vegetative remains of coenopterid ferns (there are several from the Berryville locality in which sporangia are as yet unreported) it would add appreciably to the already heavy "taxonomic strain" on that group in the variety of sporangia referred to it; in *Botryopteris globosa* an annulus covers a large part of the sporangium while in *Biscalitheca musata* there are two distinct annuli and the sporangium wall is otherwise complex.

It has been called to our attention that there is a similarity to *Waldenburgia corynepterooides* described by Gothan (1950) from Silesia. The sporangia of *Waldenburgia* and *Eopteridangium* are similar in size and shape although the former appear to be somewhat more slender and they display a cellular differentiation at the apex which suggests a primitive annulus. The spore structure, however, is quite different; it may be that the spores of *Waldenburgia* were immature at the time of fossilization, but they do not display the strongly developed muri that are so prominent a feature of *Eopteridangium*.

The distinctive spore morphology has of course led us to search in that direction for clues to the affinities of *Eopteridangium*. Among the *sporae dispersae* the closest comparison seems to lie with *Reticulatisporites*; our spores probably fall within the range of this genus, there being a close comparison with *R. muricatus* Kosanke and *R. reticulatus* Ibrahim (see POTONIÉ & KREMP, 1955); judging from the published descriptions and figures it seems likely to us that these two may be identical. As described by Kosanke (1950) *R. muricatus* is based on spores $84\text{--}91\ \mu$ in diameter, with muri $8\text{--}10\ \mu$ high and $2\ \mu$ broad; the muri are not quite as high or as broad as in *Eopteridangium* and the lumina (polygonal areas formed by the muri) are larger in the latter. *Reticulatisporites*

muricatus is reported as being a fairly abundant upper McLeansboro spore.

It has been suggested that some species of *Reticulatisporites* may be of sphenophyllalean affinities. In their monographic study of *Bowmanites* Hoskins and Cross (1943) record several species in which the spores are coarsely ridged but usually appear spinose due perhaps to partial decay of the exine; some species of *Bowmanites* do not have this type of spore morphology and in quite a few the spore structure is unknown. *Litostrobis iowensis* Mamay contains spores 65-100 μ in diameter which have a fine reticulum of ridges some of which are more conspicuous; there is some resemblance to *Eopteridangium* but not a close one. In the somewhat problematical *Sphenostrobus thompsonii* Levittan and Barghoorn the spores are 85-110 μ in diameter and have a fine net-like reticulum of the exine; however, the muri are not as strongly developed nor are the net areas as large as in our fossil. While the possibility that *Eopteridangium* is a sphenophyll cone may not be ruled out, it does not seem likely that the cone axis, bracts and sporangio-phores would have decayed away, leaving no trace, while the sporangia remain in such a good state of preservation.

Of the modern fern families that are known to have existed during the Upper Carboniferous, namely the Gleicheniaceae, Schizaeaceae and Marattiaceae, there is no close comparison with the sporangia of the first two; the mode of fossilization does not suggest the Marattiaceae, these being usually found with the sporangia (or synangia) and pinnules intact.

That *Eopteridangium* does represent a new and quite distinct type of pteridophytic organ seems evident from the massive aggregation of sporangia, the morphology of the latter and particularly the spore ornamentation. The latter are so striking that they should ultimately serve as guide to the exact affinities of the fossil.

ACKNOWLEDGEMENTS

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REFERENCES

- DARRAH, W. C. (1939). The fossil flora of Iowa coal balls. II. The fructification of *Botryopteris*. *Harvard Univ. Bot. Mus. Leaflets* 7: 157-168.
- GOTHAN, W. (1950). Über eine neue Farnfruktifikation (*Waldenburgia corynepteroides* nov. gen. et sp.) des Niederschlesischen Karbons. *Bot. Archiv* 1: 349-353.
- HOSKINS, J. H. & CROSS, A. T. (1943). Monograph of the Paleozoic cone genus *Bowmanites* (Sphenophyllales). *Amer. Midl. Nat.* 30: 113-163.
- KOSANKE, R. M. (1950). Pennsylvanian spores of Illinois and their use in correlation. *Illinois State Geol. Surv. Bull.* 74: 1-128.
- MAMAY, S. H. (1957). *Biscalitheca*, a new genus of Pennsylvanian coenopterids, based on its fructification. *Amer. Journ. Bot.* 44: 229-239.
- POTONIÉ, ROBERT & GREMP, G. (1955). Die sporee *dispersae* des Ruhrkarbons. *Palaeontographica* 98B: 1-136.
- RADFORTH, N. W. (1939). Further contributions to our knowledge of the fossil Schizaeaceae; genus *Senftenbergia*. *Trans. Roy. Soc. Edinburgh* 59: 745-761.
- SCHOPF, J. M., WILSON, L. R. & BENTALL, R. (1944). An annotated synopsis of Paleozoic fossil spores and the definition of generic groups. *Illinois State Geol. Surv. Rep. Investig.* 91: 1-66.

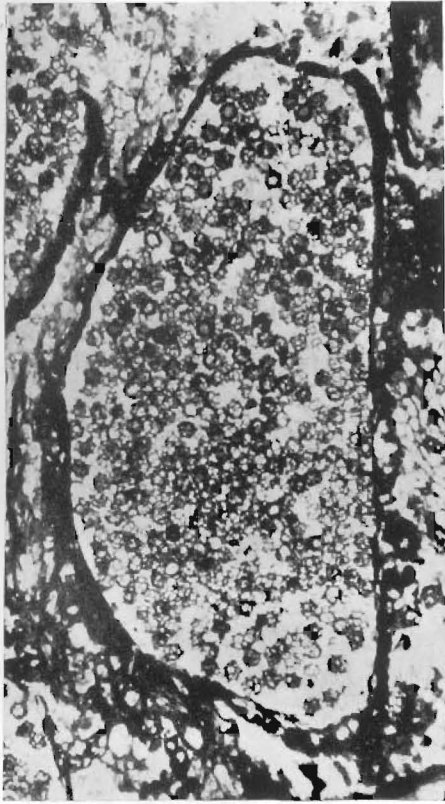
EXPLANATION OF PLATES

PLATE 1

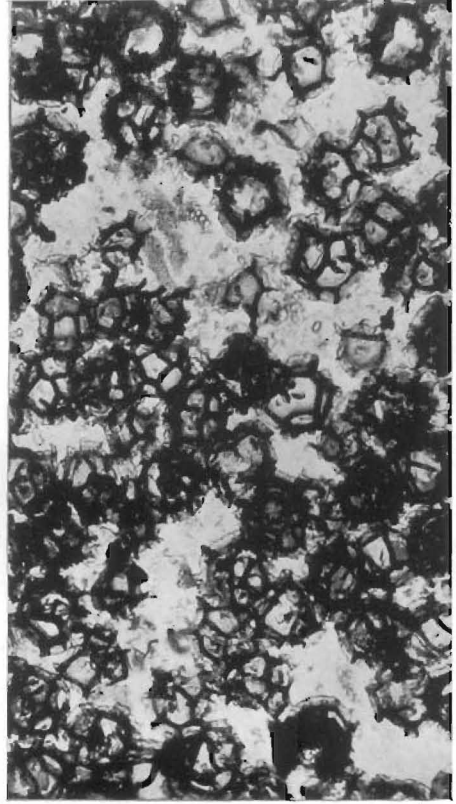
1. A representative portion of the sporangial aggregate; peel 1000B'-b22. \times 12.
2. A single sporangium in nearly median longitudinal section; peel 1000C-t16. \times 45.
3. Spores shown at a magnification of about \times 160.

PLATE 2

4. Spores focused on the equatorial region; peel 1000C-t16, \times 560.
5. Spores focused to show the very conspicuous net areas formed by the large muri; peel 1000C-t16. \times 560.
6. A single sporangium isolated by maceration. \times ca. 40.



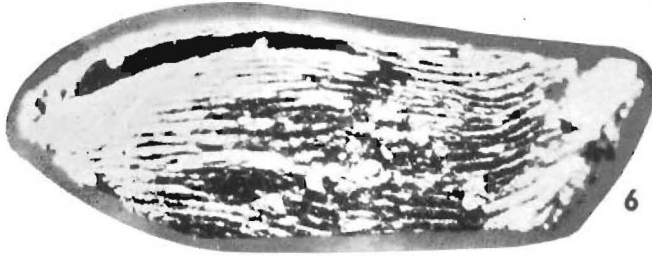
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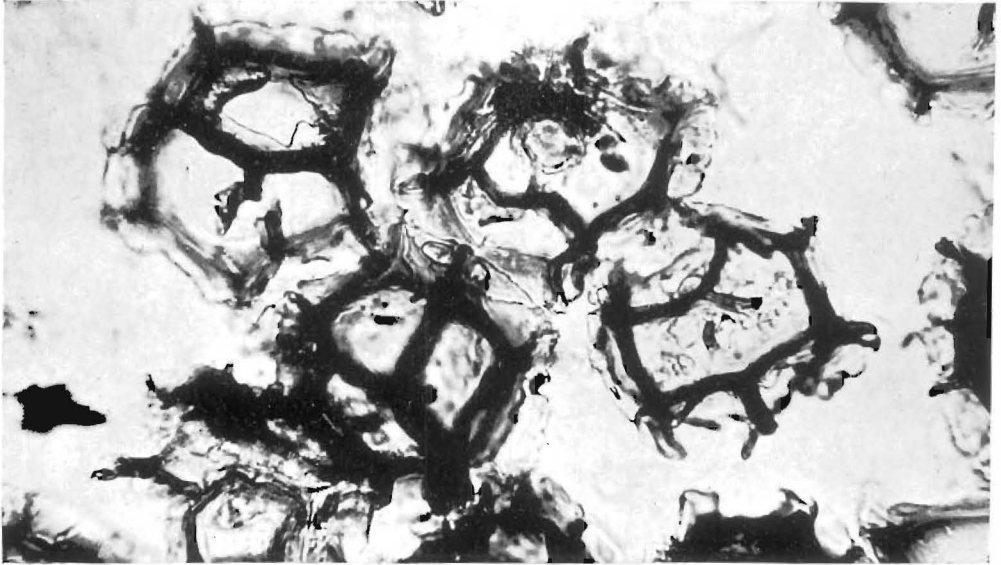
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1



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