A NEW PERMINERALIZED MARATTIALEAN FERN FROM THE PENNSYLVANIAN OF ILLINOIS

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ABSTRACT. Ironstone nodules from a Middle Pennsylvanian locality near Carterville (Illinois) have yielded both fertile and sterile foliage of a new species of *Scolecopteris*. Permineralized specimens were studied utilizing polished surfaces and a modified liquid peel technique. *Scolecopteris macrospora* sp. nov. has ovate-elongate pinnules measuring 2–9 mm long and 2–5 mm wide, with a strong midvein that produces seldom-branched laterals that meet the margin at a 60° angle. Synangia are borne abaxially in a single row on each side of the midrib on pinnules with dissected margins. Synangia are composed of four to five radially arranged, closely appressed sporangia with acute apices. The outer-facing sporangial walls are one to two cells in thickness basally and become progressively thicker distally, spores range from 42 to 66 μm in diameter and possess a prominent trilete suture and papillate sculpturing. The new species appears similar to *S. elegans* and *S. minor*, but differs in the greater amount of sterile tissue present centrally in the synangium, in foliage type, and in spore morphology.

ALMOST all species of the fossil marattialean genus *Scolecopteris* have been described from calcareous or siliceous petrifactions. A few examples of well-preserved compression or partial petrifaction specimens are recorded in the literature; however, these specimens seldom have preserved the anatomical information necessary for adequate characterization of species of *Scolecopteris*. Compression specimens do provide the valuable information on marattialean foliage morphology that is difficult to obtain from the generally fragmentary remains present in petrifactions. The present report describes fertile and sterile marattialean foliage from 'ironstone nodules' that are, in part, sufficiently well preserved anatomically to assign confidently to the genus *Scolecopteris*. Furthermore, the investigation of this fertile foliage has revealed all the features necessary to distinguish it from previously described species in this genus.

The specimens studied are present in ironstone (sideritic) nodules in which the fertile pinnules have been infiltrated with calcite whereas the sterile foliage is preserved as compression or impression. These nodules were obtained from the Anna Shale Member of the Carbondale Formation (Willman *et al.* 1975), which directly overlies the Herrin (Illinois No. 6) Coal, of Middle Pennsylvanian age (Kosanke *et al.* 1960). The shale is exposed in an abandoned strip coal mine in Sec. 4, T. 9 S, R. 1 E., Williamson Co., Illinois (Herrin 15 ft Quadrangle), about half a mile (0·8 km) from Carterville, Illinois.

Frond morphology was first studied on split-nodule surfaces which were subsequently glued back together. The nodules were then ground to expose the specimen, which was then polished and photographed (Pl. 77, fig. 4; Pl. 78, fig. 1). Polished surfaces were etched with 3% hydrochloric acid, dried, and covered with a solution of cellulose acetate and Duco cement (® Dupont Co.) dissolved in butyl acetate and acetone. This modification of the liquid peel technique was necessary because the organic material would not adhere adequately to cellulose acetate or nitrocellulose peels produced in the conventional manner.

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SYSTEMATIC DESCRIPTION

Order MARATTIALES
Genus SCOLECOPTERIS Zenker
Scolecopteris macrospora sp. nov.

Plate 77, figs. 1–4; Plate 78, figs. 1–6

Diagnosis. Radially symmetrical, pedicellate synangia consisting of four to five elongate sporangia, each laterally attached for entire length prior to dehiscence, becoming separate after dehiscence, distally to the central cellular area in the synangial base; synangia up to 1·5 mm wide and 1·8 mm long; pedicel composed of thick-walled parenchyma, tissue of pedicel continuous between the bases of the sporangia centrally in lower quarter of synangium; outward-facing sporangial walls one to two cells thick basally becoming much thicker in distal half of synangium; inward-facing sporangial walls uniseriate, of empty elongate cells; sporangial apices acute, solid, and cellular. Synangia abaxial in a single row flanking pinnule midrib; pinnules dimorphic, fertile pinnules with down-turned incised margin, 4–10 mm long by 3–5 mm wide, pinnule spacing 5 mm; sterile pinnules with entire margins, 2–9 mm long by 2–5 mm wide, ovate-elongate, borne at an angle to pinna, with constricted base or occasionally with decurrent trailing margin, midvein strong, giving rise to laterals alternately at 0·4 mm intervals, lateral veins occasionally divided and meeting margin at 60° angle; ultimate pinnae spacing 12 mm on same side of penultimate pinna. Spores radial, spherical, measuring 42–66 μm in diameter, trilete suture extends nearly to spore amb, lasurae thin, ornamentation of uniformly spaced papillae which occasionally coalesce laterally; exine 1·5 μm thick.

Holotype. Specimen No. 63082 in the University of Michigan Museum of Paleontology type and figured collection (Pl. 77, figs. 3, 4; Pl. 78, figs. 1–6).

Stratigraphic occurrence. Anna Shale above the Herrin (Illinois No. 6) Coal, Carbondale Formation, Kewanee Group, Middle Pennsylvanian.

Description. The new species *Scolecopteris macrospora* is based on five specimens in ironstone nodules which are partly or entirely fertile. The most complete specimen (Pl. 77, fig. 1) is primarily sterile and is useful in showing the wide pinna spacing and the morphology of the terminal pinnules. Sterile pinnules vary somewhat in size along the pinna axis, ranging from 2 to 9 mm long and 2 to 5 mm wide. Fertile pinnules may occur in groups or singly among the sterile pinnules (Pl. 77, fig. 1 arrows), and tend to be larger, measuring 4–10 mm long. Sterile pinnules are elongate-oval in

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EXPLANATION OF PLATE 77

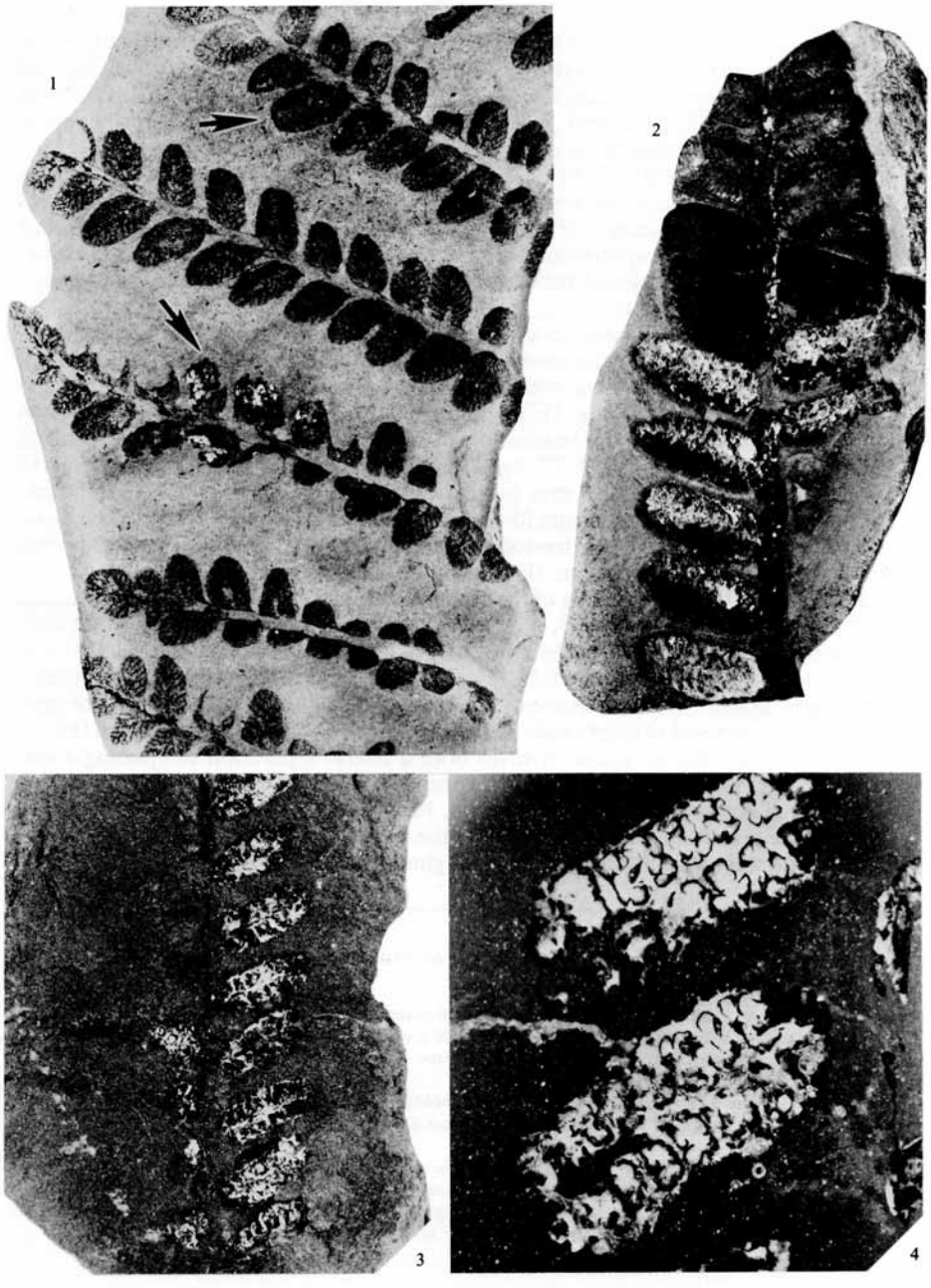
Scolecopteris macrospora sp. nov.

Fig. 1. Predominantly sterile specimen showing pinnule venation. Note fertile areas (at arrows). UMMP no. 63080, ×2.

Fig. 2. Pinna exhibiting basal fertile area. UMMP no. 63081, ×3.

Fig. 3. Well-preserved specimen from which the illustrated anatomical preparations were obtained. UMMP no. 63082, ×2.

Fig. 4. Paradermal section of pinnule pair exposed on polished and etched surface of nodule. Synangia are sectioned transversely at various levels. UMMP no. 63082. ×7.



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outline with a constricted base (Pl. 77, fig. 2), although a number of pinnules are decurrent on their trailing margins (Pl. 77, fig. 1). Pinnules are borne at an angle of 60° on the pinna and have a spacing of 4–6 mm. The pinnules have a straight midvein which extends to the apex and produces laterals with a spacing of approximately 0·4 mm. The lateral veins form an angle of 60° with respect to the midvein and may occasionally fork once (Pl. 77, figs. 1, 2). Apart from their larger size and the presence of synangia, the lamina of the fertile pinnules differs from that of the sterile pinnules in having a dissected margin (Pl. 78, fig. 1). The dissections occur opposite each synangium and extend approximately to synangium midlevels. The laminar extensions therefore are positioned between synangia and extend to the synangial apices (Pl. 77, fig. 4; Pl. 78, fig. 1).

Although little histological detail of the pinnules is preserved, the cellular construction of the synangia was readily determined. The synangia are composed of four to five elongate sporangia, which are closely appressed throughout their length prior to dehiscence (Pl. 78, fig. 1). The synangia are radially symmetrical, although numerous specimens give the impression of slight bilateral symmetry as a result of preservational phenomena (Pl. 77, fig. 4; Pl. 78, figs. 4–6). Synangia measure up to 1·8 mm long and average 1·5 mm in diameter. The sporangial cavities are largest towards the base of the synangium (0·4 mm in diameter) and taper distally. The distal third of each sporangium is extended into a solid, cellular, acute apex that appears triangular in transverse sections (Pl. 78, fig. 1). The sporangia surround a central cellular mass in the basal quarter of the synangium (Pl. 78, fig. 4), and enclose a central cavity distally (Pl. 78, figs. 1, 5, 6). The outward-facing sporangial walls are only one to two cells in thickness in the lower half of the synangium (Pl. 78, figs. 4, 5), but rapidly increase in thickness distally (Pl. 78, fig. 6) culminating in the solid cellular sporangial apices. When preserved the inward-facing sporangial walls are uniseriate and composed of empty cells which appear square in transverse section (Pl. 78, fig. 5, at arrow). Spore release involves both a lateral separation of sporangia and rupture along the inner midline of each sporangium.

Synangial pedicels are poorly preserved, but have the same cellular composition as the tissue present in the basal quarter of the synangium (Pl. 78, fig. 2). No vascular tissue was observed in the pedicel or synangium base.

EXPLANATION OF PLATE 78

Scolecopteris macrospora sp. nov.

Fig. 1. Polished and etched surface of fertile pinnule in paradermal section. Synangial apices in transverse section alternate with extensions of dissected pinnule margin (arrows). UMMP no. 63082, ×10.

Fig. 2. Oblique section of synangium with *in situ* spores. Arrows indicate portion of pedicel and central tissue of synangium. UMMP no. 63082, ×30.

Fig. 3. Trilete spore with papillate ornamentation. UMMP no. 63082, ×1000.

Fig. 4. Transverse section of several synangia near base showing central parenchymatous tissue. UMMP no. 63082, ×30.

Fig. 5. Transverse section near synangium midlevels where outward-facing sporangial walls are thin. Arrow indicates cells of inward-facing sporangial wall. UMMP no. 63082, ×30.

Fig. 6. Transverse section distal to that of previous figure showing thicker sporangial walls. Little of the inward-facing sporangial wall is preserved. UMMP no. 63082, ×30.


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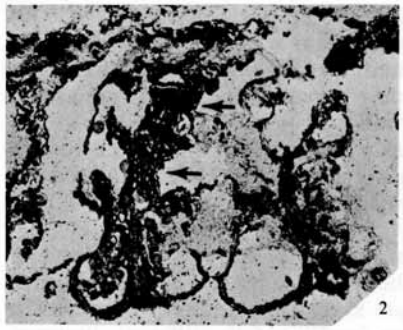
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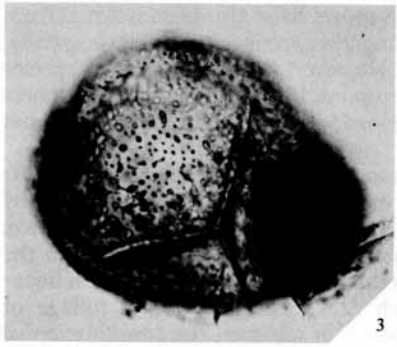
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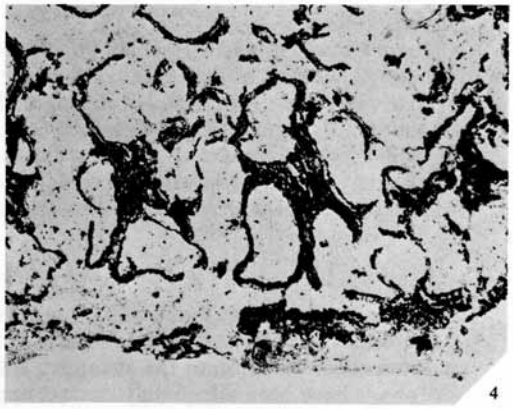
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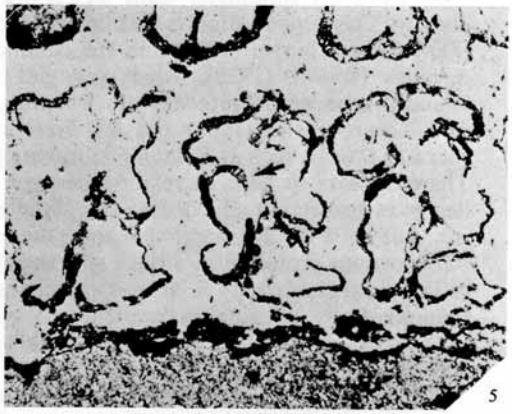
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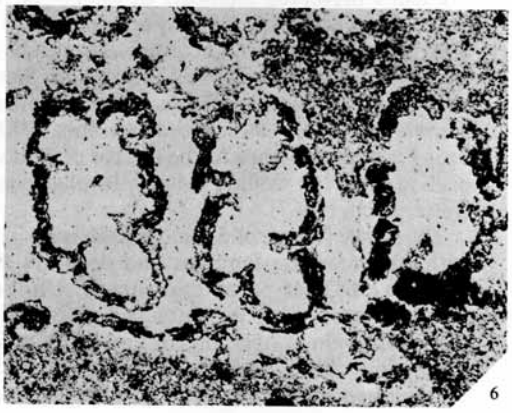
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The spores of *S. macrospora* are spherical and measure 42–66 μm (av. 52 μm) in diameter. The arms of the trilete suture extend nearly to the spore margins as seen in polar view, and average 18 μm in length (Pl. 78, fig. 3). The lasurae are very thin, and the exine is approximately 1·5 μm in thickness. The spore ornamentation consists of papillae which are 0·5–1·0 μm in diameter and may be 0·5–1·0 μm in height. Papillae may be round topped or taper slightly apically. There are occasional examples of lateral fusion of sculptural elements resulting in short chains.

DISCUSSION

The genus *Scolecopteris* Zenker (1837) at present includes approximately nine species of anatomically preserved fertile foliage. The diagnostic feature of the genus is the anatomical construction of the synangia, since in most instances neither the spores nor foliage have been adequately characterized. In *S. macrospora* the synangia have outward-facing sporangial walls which are thin basally and become quite thick distally. This organization is identical to the situation in the generitype *S. elegans* (Zenker) Strasburger (1874) and the common North American (coal ball) species *S. minor* Hoskins (1926). Other synangial types found in species of *Scolecopteris* include those with uniformly thick outward-facing sporangial walls as seen in *S. illinoensis* Ewart (1961) and *S. oliveri* Scott (1932), and forms with very thin sporangial walls such as *S. latifolia* Graham (1934) and *S. incisifolia* Mamay (1950). There appears to be a correlation between synangium wall construction and the degree of protection afforded by the pinnule margins (Millay 1976). *S. macrospora* is consistent with this suggestion since the exposed areas of the synangium are the only portions protected by a thick sporangial wall.

The synangial base in *S. macrospora* contains a large amount of parenchymatous tissue centrally, a feature not present in *S. elegans* or *S. minor*. The central cavity in the synangium, delimited by the sporangial apices, is a characteristic feature of most species of *Scolecopteris*.

The spores of *S. macrospora* are larger than those known from most other anatomically preserved members of the genus. The spores of both *S. iowensis* Mamay and *S. major* Mamay (1950) average over 40 μm in diameter and are spherical with a large trilete suture. These scolecopterids are fundamentally different, however, because they have thick-walled synangia. Large spores have also been isolated from various fertile pecopterid foliage forms including *Pecopteris lobulata*, *P. longifolia*, *P. miltoni*, and *P. oreinervosa* (Laveine 1970). However, these compression species bear little resemblance to the foliage of *S. macrospora*. If found dispersed the spores of *S. macrospora* would probably be placed in *Verrucosisporites* (Ibrahim) Smith and Butterworth (1967).

The sterile foliage of *S. macrospora* is not conspecific with any species of *Pecopteris* with which we are familiar, and does not fit into any of the groups proposed by Corsin (1951) for pecopterid foliage. Unlike *S. macrospora*, most pecopterids are characterized by broadly attached pinnules, arcuate lateral veins that intersect the pinnule margin at right angles, and by pinnules that are not greatly different in linear dimensions from adjacent pinnules. Although each character of the foliage of *S. macrospora* is known for one pecopterid species or another, the combination of

these features in one specimen has not been reported previously. The general aspect of the pinnules of *P. polymorpha* Brongniart is reminiscent of *S. macrospora* in having obliquely orientated pinnules with a narrow base, and in the orientation of the lateral veins. However, the straight, unbranched lateral veins of *S. macrospora* contrast with the arcuate, branched lateral veins of *P. polymorpha*.

This new species of fertile marattialean foliage has been assigned to *Scolecopteris* because we believe that it is well-enough preserved to characterize adequately and document that it is specifically distinct. For cases in which it is not possible to determine the anatomy of the synangial walls, the specimen is best assigned to the form genus *Asterotheca* Presl (*in* Corda 1845) or simply referred to as fertile *Pecopteris*. There has been some discussion in the literature regarding whether there is a structural basis to the generic boundaries between *Asterotheca* and *Scolecopteris* or whether the two genera are simply preservation types of the same fertile foliage (Andrews 1943; Barthel 1975; Hirmer 1927; Radforth 1942; Stur 1883). Present evidence weighs heavily in favour of the interpretation that the genera represent preservation types (Mamay 1950; Millay 1976, 1977). As the number of species of *Scolecopteris* increases it becomes progressively more important to characterize each species adequately.

In a recent paper by Barthel (1975) some silicified marattialean foliage is named as a new species of *Scolecopteris* based mainly on its foliage form (*P. lepidorachis* Brong.). While considering the distinctness of *S. lepidorachis* Barthel, it should be noted that the foliage form is known for only a few other species of *Scolecopteris* (Millay 1976). Among these, a majority had foliage of the *P. arborescens* type (*S. elegans*, *S. illinoensis*, *S. minor*, *S. minor* var. *parvifolia* Mamay). From this it would appear that foliage form by itself is not ultimately diagnostic in the recognition of species of *Scolecopteris*.

As more members of this fern order are described the remarkable heterogeneity becomes more clearly evident and underscores the necessity for more complete descriptions. The present study illustrates the quality of preservation sometimes present in 'ironstone nodules' which may provide the means for the identification of taxa usually recognized only in other preservational modes.

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