PROTOSTIGMARIA, A NEW PLANT ORGAN FROM THE LOWER MISSISSIPPIAN OF VIRGINIA

by JAMES R. JENNINGS

ABSTRACT. A lycopod underground system from the Price Formation (Lower Mississippian) of Virginia is described as *Protostigmaria eggertiana*. The material consists of impressions that occur in shale and clay underneath a coal in the upper part of the Price Formation. The zone containing the fossil plants resembles the stigmarian underclays that underlie coals of Upper Mississippian and Pennsylvanian age. The plant organ is corm-like, and has short downward extensions to which rootlets are attached. The point of attachment is marked by a circular scar. The remainder of the surface is coarsely rugose. Comparison is made with other lycopod underground parts.

THE abundance of stigmarian remains in the Upper Mississippian and Pennsylvanian is not paralleled by a similar abundance of remains of the underground portions of the arborescent lycopods of the Devonian and Lower Mississippian. The voluminous literature on aerial stems from the Devonian and Lower Mississippian, particularly casts and impressions, contrasts with the current dearth of information concerning the underground parts of these lycopods. In the Devonian lycopod *Lepidosigillaria*, rootlets were borne directly on the rounded base of the plant (White 1907). Another Devonian lycopod, *Cyclostigma*, divided into two short axes at the base and the rootlets were borne on the blunt ends of these. The position of attachment of the rootlets is marked by a circular scar in both of these genera. Neither of these genera had any elongate structure at the base that might resemble a stigmarian axis. This paper describes a lycopod underground system from the Price Formation (Lower Mississippian) of Virginia which adds to the diversity of such structures. Some of the specimens described as *Stigmaria* by Dawson (1873) from the Lower Carboniferous of Canada may represent the same or similar plants.

The material occurs in a roadcut along U.S. 460 at Coal Bank Hollow north of Blacksburg, Virginia, in clay and shale underneath a coal in the upper part of the Price Formation. Because of the abundance of rootlets in this bed, it resembles a stigmarian underclay. A careful search shows, however, that there are no remains of the genus *Stigmaria* in this bed, but instead the material described in this paper. The bed is believed to have formed, like stigmarian underclays, by the disturbance of existing sediment from the penetration of invading rootlets of the lycopods growing in the coal swamp. The evidence for this is: the remains are all oriented in life position rather than inverted, the rootlets are preserved at very high angles to the bedding, the remains of this underground system occur almost exclusively in the strata immediately underneath the coal, and the abundance of the rootlets decreases with increasing depth below the coal.

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SYSTEMATIC DESCRIPTION

Division LYCOPHYTA

Genus PROTOSTIGMARIA gen. nov.

Diagnosis. Form genus for large lycopod underground systems that are corm-like with several short downward extensions to which rootlets are attached, surface rugose, attachment of rootlets marked by circular scar.

Type species. Protostigmaria eggertiana sp. nov.

Protostigmaria eggertiana sp. nov.

Plate 3; text-fig. 1

Diagnosis. Characters of the species as those of the genus; diameter of structure 10–15 cm, downward extensions 1–5 cm, tapering rapidly, rootlet scars 1–7 mm in diameter, furrows present between the extensions with rootlets.

Holotype. Specimen UMMP 60793, in the collections of the University of Michigan Museum of Paleontology (Pl. 3, fig. 1).

Locality. Roadcut along U.S. 460 between the junction with 648 and Coal Bank Hollow about 4·2 km north of Blacksburg, Virginia (Newport 7½′ Quadrangle).

Stratigraphic position. Upper part of the Price Formation.

Age. Lower Mississippian.

Description. The specimens represent the corm-like base and attached rootlets of an arborescent Paleozoic lycopod. This corm-like structure has a coarsely rugose surface (Pl. 3, figs. 1, 2, 4, 5). The ridges and furrows are oriented toward downward extensions to which rootlets are attached. Between these extensions is a somewhat irregular furrow (Pl. 3, figs. 1, 4, 5). It is difficult to determine the exact number of the extensions on any one specimen, since they are preserved as impressions and are, in most cases, incomplete. There are at least three and perhaps four. The diameter of the corm-like structure is approximately 12–15 cm. The downward extensions are approximately 1–5 cm long, tapering rapidly, and bear numerous attached rootlets (Pl. 3, figs. 1, 3) or circular scars that mark their position (Pl. 3, fig. 2). The rootlets are 3–9 mm in diameter. On most specimens it is possible to find some rootlet scars that have been obscured by a rugose surface suggestive of cell proliferation in the

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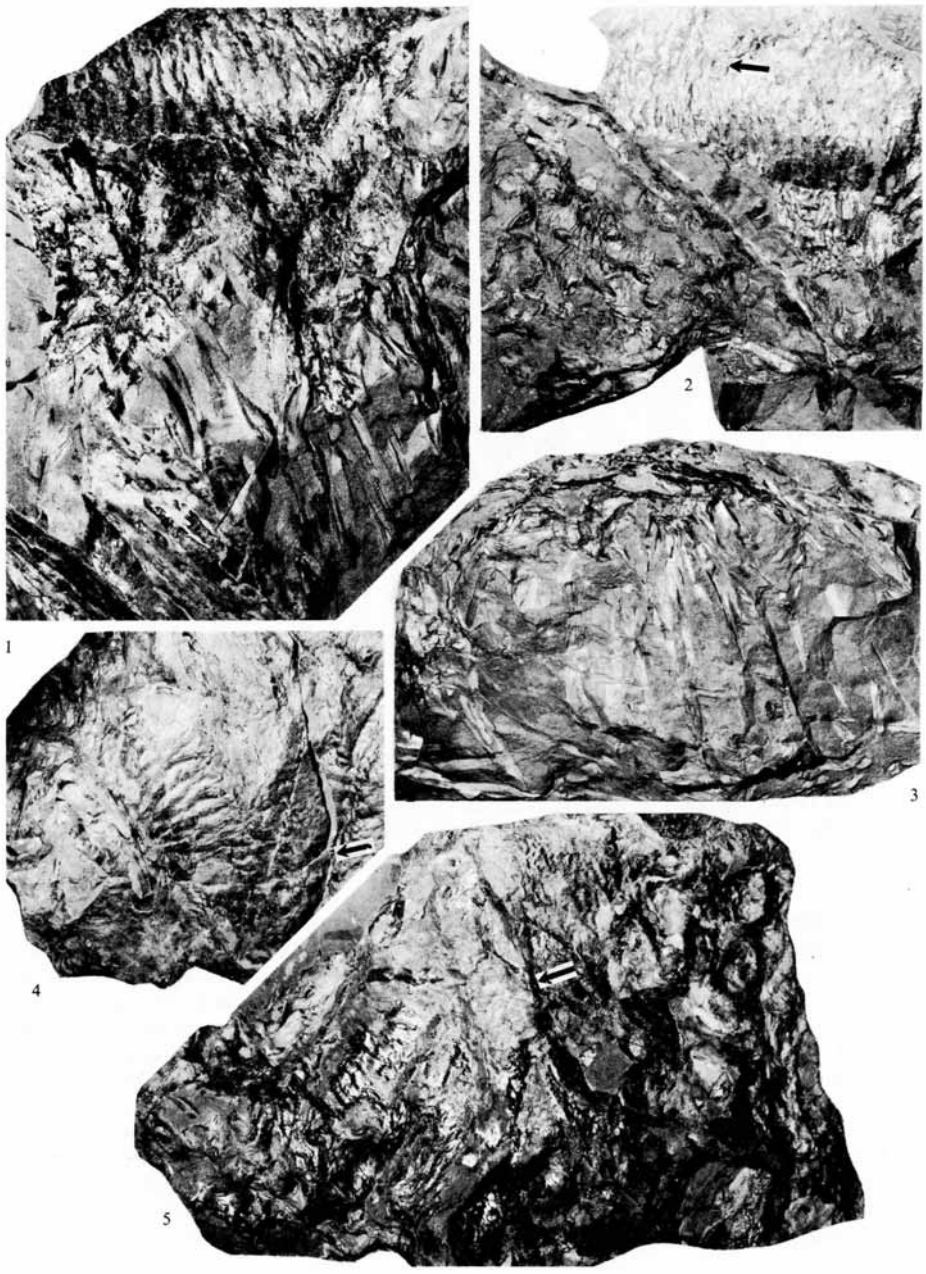
EXPLANATION OF PLATE 3

Figs. 1–5. *Protostigmaria eggertiana* gen. et sp. nov. 1, holotype showing rugose cortex and downward extensions with attached rootlets. UMMP 60793, ×0·8. 2, specimen with detached rootlets which shows the circular rootlet scars. Arrow indicates a rootlet scar that has been nearly obscured by tissue proliferation. UMMP 60794, ×1. 3, specimen showing the rootlets radiating in several directions. UMMP 60795, ×0·35. 4, 5, part and counterpart of a specimen representing the 'corm' which shows its surface and the furrow between the areas where the rootlets are attached (arrow). UMMP 60796*a*, *b*, ×0·75 and 0·7 respectively. UMMP: University of Michigan Museum of Paleontology.



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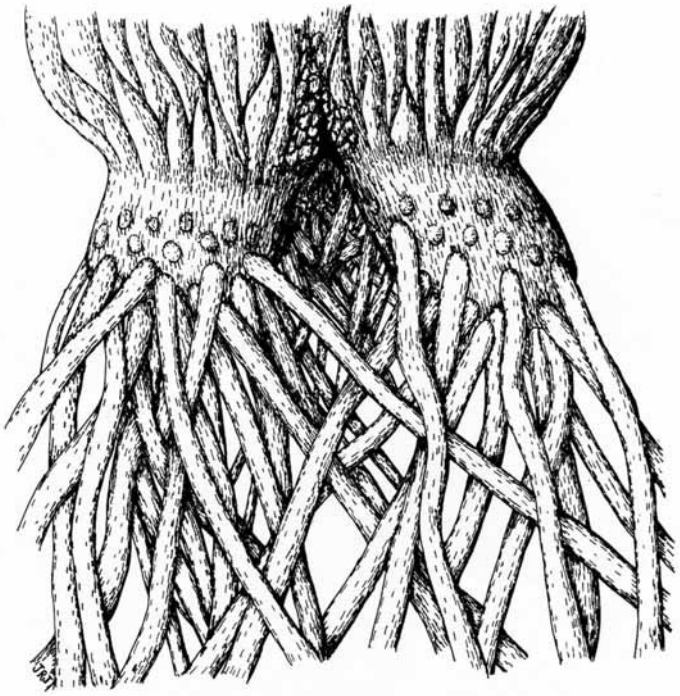

TEXT-FIG. 1. Reconstruction of *Protostigmaria eggertiana*. ×0·5 approximately.

cortex (Pl. 3, fig. 2). The longest attached rootlet is 13 cm long, but is not complete. Text-fig. 1 is a reconstruction showing the various features of this plant.

DISCUSSION

A comparison of *Protostigmaria* with the underground parts of *Cyclostigma* and *Lepidosigillaria*, and with *Stigmaria*, indicates clear lycopodiaceous affinities. It shares with the others the circular scars that mark the position of the attachment of the rootlets and, like the base of *Cyclostigma* and *Lepidosigillaria*, was apparently corm-like. The size of the underground system described here suggests that the parent plant had an arborescent habit. It has not been possible, in the absence of physical attachment, to assign *Protostigmaria* to any of the lycopod genera based on aerial stems; however, abundant remains of *Lepidodendropsis* are found in association with it and may have produced this type of underground system. *Protostigmaria* is clearly distinguishable from *Stigmaria*, because in *Stigmaria* rootlets are borne on elongate, dichotomously ramifying axes, while in *Protostigmaria* the rootlets are borne on short downward extensions. *Lepidosigillaria* differs in bearing the rootlets directly on the rounded base of the stem. In *Cyclostigma* the rootlets are borne on each of two

derivatives that result from a bifurcation of the aerial stem. These are much larger in relation to the over-all size of the organ than the structures that bear the rootlets in *Protostigmaria*, and there are only two of them, compared to at least three in *Protostigmaria*. The genus *Stigmariopsis*, known from the late Upper Carboniferous of Europe, differs from *Protostigmaria* in consisting of elongate axes that resemble *Stigmaria* except for their branching pattern.

In various species of *Stigmaria* the circular rootlet scars have been shown to represent an abscission layer present at the base of the rootlets (Frankenberg and Eggert 1969; Eggert 1972; Jennings 1973). That *Protostigmaria*, *Cyclostigma*, and *Lepidosigillaria* show similar rootlet scars may indicate a similarity in structure. The fact that some of the scars are partly obscured by a rugose surface that is suggestive of proliferation in the cortex is evidence in favour of this interpretation.

Although *Protostigmaria* increases knowledge of the diversity of lycopodiaceous underground systems, its evolutionary significance is not established. One possible interpretation is that it represents an evolutionary intermediate between a Devonian lycopod such as *Lepidosigillaria*, and *Stigmaria* which became abundant in the Upper Mississippian. *Protostigmaria* bears rootlets on short extensions. This is a condition that is intermediate between the situation in *Lepidosigillaria*, which bears rootlets directly on a rounded base, and *Stigmaria*, which bears the rootlets on elongate, branched axes that extend from the base of the aerial stem.

The resemblance between *Protostigmaria* and *Isoetes* is interesting. Potonié (1894) and Mägdefrau (1931, 1932) have suggested that *Isoetes* is the end product of a reduction series that began with *Sigillaria*, through *Pleuromeia*, through *Nathorstiana* to *Isoetes*. Structural comparisons of stigmarian rootlets with the roots of *Isoetes* (Stewart 1947) have been used in support of this idea. This is definitely not, however, the only possible evolutionary sequence. There are *Isoetes*-like plants known from the Triassic (Brown 1958; Bock 1962). These are clearly not derived from *Nathorstiana* or *Pleuromeia*. *Paurodendron* from the Pennsylvanian has underground parts (Phillips and Leisman 1966) that are corm-like and resemble a diminutive stigmarian axis, particularly in such features as the presence of appendage (rootlet) gaps and the production of secondary xylem. It is certainly possible to postulate an evolutionary line leading from *Protostigmaria*, through a Pennsylvanian lycopod resembling *Paurodendron*, to the *Isoetes*-like plants that are known from the Triassic onward, rather than regarding the very large and complex organ called *Stigmaria* as the direct precursor of the corm of *Isoetes*. Nevertheless, despite the numerous lycopod genera and species that have been based on stem impressions, there are comparatively few underground systems known, and this is especially true for petrifactions. For this reason it is difficult to delineate evolutionary pathways among either Paleozoic or later lycopods. It is hoped that a recognition of the problems involved in attempting to interpret the fossil record of the lycopods will stimulate field work that will uncover evidence leading to the resolution of existing uncertainties.

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