THE UNIVERSITY OF KANSAS

PALEONTOLOGICAL CONTRIBUTIONS

August 18, 1978 Paper 94

SPHENOPTERIS SELLARDSII, A PROBLEMATICAL PTERIDOSPERM FROM THE PERMIAN OF KANSAS[1]

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ABSTRACT

Sphenopteris sellardsii, a new species of pteridosperm based on fertile foliage from the Elmo Limestone Member of Early Permian age in east-central Kansas, is preserved as deep molds in limestone matrix. It is characterized by thick, fleshy pinnules and by cylindrical adaxial appendages with bilobed apices that resemble young ovules or seeds. The thick revolute pinnules add to similar evidence from specimens of the dominant *Glenopteris* in supporting the concept that these plants were part of a xeric halophytic flora associated with highly saline sediments.

INTRODUCTION

The University of Kansas Fossil Plant Collections contain a rich Lower Permian flora collected and described by Sellards (1908) from the Wellington shales of east-central Kansas. Sellards described 33 species including such typical Permian genera as *Callipteris*, *Taeniopteris*, and *Walchia*, as well as the dominant large fleshy *Glenopteris* frond, which is still unique to Kansas. Most of Sellard's specimens were collected in the vicinity of Banner City (now Elmo), Dickinson County, Kansas. During the early 1920's, various members of the Kansas Geological Survey made additional collections 2.5 miles south of Carlton, Kansas, which is just 4 miles west of Sellard's Banner City locality.

Among the specimens from the Carlton locality, I have recently discovered a hitherto undescribed specimen of a small, pinnately compound, fernlike leaf bearing numerous small cylindrical appendages that may represent seeds.

[1] Manuscript received February 17, 1978; revision received April 5, 1978.

MATERIALS AND METHODS

Determination of the true shape and structure of the specimens was a problem because of their preservation as deep molds. This was especially true of the cylindrical dorsal appendages that are visible solely as deep holes at right angles to the rock surfaces. Photographs of the rock surface (Figs. 1 and 3) show only the position and diameter of the appendages with no hint as to details of their attachment, length, or apical configuration.

To obtain more information, liquid transparent latex plastic was poured into the molds and solidified by low-heat treatment. The resulting flexible casts include three-dimensional replicas of the pinnae. These casts were photographed by a combination of reflected and transmitted light. In this way, almost three-dimensional images of the dorsal surfaces of pinnae, pinnules, and appendages were obtained (Figs. 2 and 4).

SYSTEMATIC DESCRIPTION

Genus SPHENOPTERIS (Brongniart) Sternberg, 1825

SPHENOPTERIS SELLARDSII Baxter, new species

Diagnosis.—Pinnately branched leaf, individual pinnae averaging 4 cm in length with alternately arranged, trilobed, bilobed, and simple pinnules. Larger trilobed pinnules up to 5 mm long by 4 mm wide, wedge shaped, broad at apex and narrowing toward point of attachment to pinna. Simple pinnules (pinnulets) seldom over 2.5 mm in length. Pinnules thick and possibly leathery, with no visible venation on adaxial surface. Pinnule margins revolute. Cylindrical appendages resembling seeds, 2.5 to 1.5 mm long by 1.5 to 1.0 mm wide, with bilobed or simple-conical apices, attached to upper (adaxial) surface of pinnae axis and projecting upward above pinnules at angles of 45 to 90°.

Type Material.—Specimens P-25A and B, in the Sellards (Permian) paleobotanical collections of the University of Kansas, Lawrence. Holotype is shown in Figures 1 and 2.

Occurrence.—Elmo Limestone Member, Wellington Formation, Lower Permian; 2.5 miles south of Carlton, Dickinson County, Kansas.

Etymology.—The species is named for Dr. E. H. Sellards in long overdue recognition of his pioneering work in Kansas paleobotany.

GENERAL MORPHOLOGY

The description is based on a total of six pinnae fragments contained in three rock slabs. In one slab, two pinnae (approximately 4 cm long) are still attached in a pinnate manner to a rachis measuring 5.5 cm in length. The other four pinnae end at the broken edges of rock, but are in a similar parallel alignment, which suggests that they also were attached in a pinnate arrangement to a main rachis.

The pinnae are narrow (6 to 10 mm in width) with wedge-shaped, blunt-tipped, irregularly lobed, small pinnules that seldom exceed 5 mm in length and 4 mm in width. Generally, the pinnules are alternately arranged although the exact pattern is obscured by the presence of numerous smaller unlobed laminar outgrowths similar to what Mamay (1966) described as "pinnulets" in the Permian seed-bearing callipterid *Tinsleya*. The pinnules have revolute margins. The imprint in the rock matrix is of their dorsal (adaxial) surfaces, which form a deep concave mold emphasized by the even deeper cylindrical cavities left by the dorsal (adaxial) appendages. These appendages range from 1.5 to 2.5 mm in length and 1.0 to 1.5 mm in width. They appear to arise from the pinna rachis on the dorsal (adaxial) surface and are consistently cylindrical in shape, frequently bilobed, and extend upward at a 45 to 90° angle from the plane of the pinnules. They are superimposed in an opposite to subopposite arrangement with reference to the base of the pinnules but are clearly not borne on the pinnules themselves. Since they arise from the pinnae axis it might be argued that they are morphologically equivalent to the pinnules; however, their arrangement overlaps and is quite distinct from that of the pinnules, and their attachment is definitely dorsal (adaxial) rather than marginal, as it is in the pinnules.

The strongest evidence that the appendages are seeds or young ovules lies in their notched to obcordate apices. This notched or bilobed appearance, which has been described by Mamay (1976) for the seeds of *Phasmatocycas* from the

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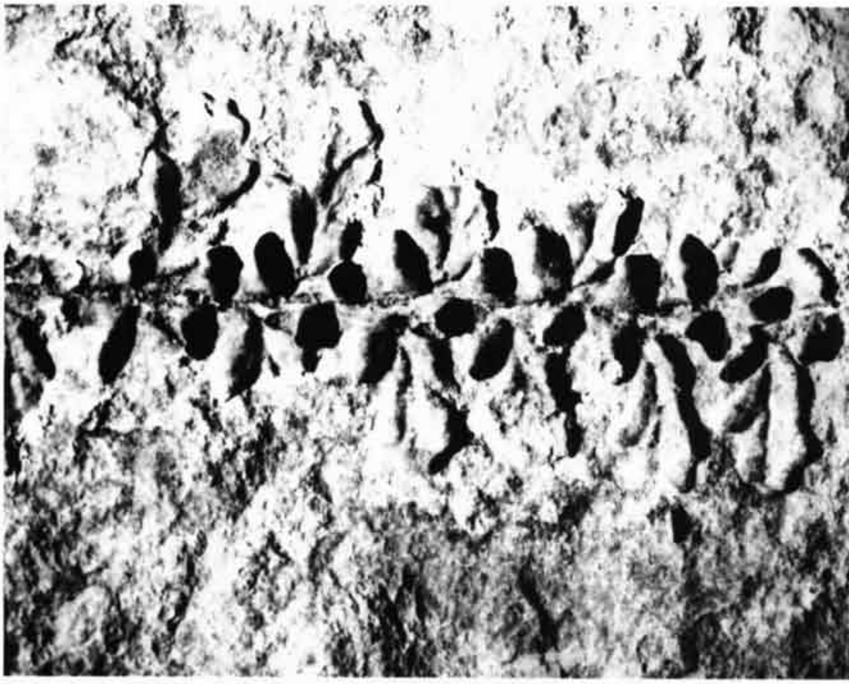
FIGS. 1,2. *Sphenopteris sellardsii* Baxter, n. sp.———1. Mold of the pinnules and "seed" cavities in limestone, photographed in reflected light. Two pinnae are shown with the main rachis visible in upper right. Holotype, P-25A, × 7.8.———2. Plastic cast of portions of the pinnae in Figure 1 showing the adaxial (dorsal) attachment of the "seeds" and the bilobed aspect of their apices. Photographed in transmitted light, × 7.8.



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FIGS. 3,4. *Sphenopteris sellardsii* Baxter, n. sp.——3. Mold of pinna in limestone, photographed in reflected light, P-25B, ×7.——4. Cast of same speecimen as in Figure 3, photographed in transmitted light, ×7. The seed in the lower left corner shows the two concentric patterns that may represent the tip of a central nucellus and surrounding integument.

Lower Permian, and by Cridland and Morris (1960) for *Spermopteris* from the Upper Pennsylvanian, is possibly due to a splitting of the seed integuments in the area of the micropyle as a result of compression during preservation. The more broadly bilobed aspect is also reminiscent of early stages in the ontogeny of *Cycas revoluta* seeds.

Additional evidence that the appendages are true seeds is shown by one cast (Fig. 4), which bears apically the outline of two concentric circles. These are unlike any vegetative anatomy of pinnules, but are strikingly similar to sections through the apical region of many Upper Pennsylvanian pteridosperm seeds in which the inner circle represents the free apical portion of the nucellus and the outer cylinder constitutes the inner integment.

DISCUSSION

Sphenopteris sellardsii is distinctive in its long, unusually narrow pinnae with irregularly lobed small pinnules, simple pinnulets, and adaxial seedlike appendages. The alternately arranged, trilobed, bilobed, and simple pinnules make the pinnae irregular and asymmetrical in gross appearance. Its pinnules, while small, were apparently rather thick and leathery as evidenced by the lack of visible venation on their adaxial surface and the depth and sharpness of their imprint in the limestone matrix. This morphological feature of thick fleshy leaves and deeply buried venation is also a striking characteristic of closely associated large fronds of *Glenopteris,* represented by five species (Sellards, 1908), which is seemingly the dominant component of the fossil flora from the Elmo-Carlton area. Read and Mamay (1964) recognized the "*Glenopteris* Flora" as one of the distinct floral zones of the Permian Period in the United States. The flora is associated with highly saline sediments, which they postulated represent a physiological xeric environment resulting in typical halophytic plants with thick fleshy tissues. Whereas this conclusion was originally based solely on the stout fleshy nature of *Glenopteris,* it is now additionally supported by the similar features of *Sphenopteris sellardsii.* The thick leathery leaves of *S. sellardsii* are unlike those of most species of *Sphenopteris,* although similar structure has been described by Schweitzer (1960), where they also may be an ecological response to specialized conditions.

The increasing evidence of an abundant flora of pteridosperms in the Lower Permian of the central and south-central United States (Mamay, 1960, 1966, 1976; Mamay and Watt, 1971) supports the concept that the cylindrical appendages are young ovules or seeds. At first, their attachment to the upper (adaxial) surface of the pinna rachis seemed to be a point against this interpretation because in the majority of described North American pteridosperms (Cridland and Morris, 1960; Mamay, 1960, 1976), the seeds are borne at the tips of the lateral veins on the abaxial surface or imbedded in the lamina of pinnule margins. In others, the seeds may be at the tips of pinnules (Mamay, 1966; Mamay and Watt, 1971) or rachial and pedicellate (White, 1934).

However, Halle's (1929) classic study of "seed-bearing pteridosperms" from the Permian of China emphasized that the seeds were commonly borne on the adaxial surface of the pinna rachis in a fashion similar to that in *Sphenopteris sellardsii.* In fact, Halle was so impressed with the clear evidence for the seemingly incongruous adaxial position of the seeds that his final discussion was devoted to a lengthy review of the evidence for seed position in the pteridosperms and the factors possibly determining it. His conclusions are particularly well expressed in the following quotation (Halle, 1929, p. 21): "The position of the seed as well as the sporangia is evidently a feature of ecological importance. For the distribution of the spores it may be an advantage that the sporangia should be placed on the lower surface of the leaves. But for seeds destined to receive wind-borne pollen a similar position is obviously very little favorable, the less so the better the lamina is developed. They will be protected from falling pollen as if by an umbrella. The surprising thing in this respect is therefore not that the seeds sometimes seem to be attached to the upper side of the leaves, but that they should ever be on the lower." Because a few of Halle's specimens, *Sphenopteris tenuis* for example, do clearly show attachment of the seeds on the abaxial (lower) side of the leaves, he postulated insect pollination for this species.

Another possible interpretation of the appendages is that they are vegetative reproductive buds. Vegetative bulblike buds are common in a number of extant ferns (*Cystopteris bulbifera, Asplenium bulbiferum;* Bower, 1923). They may be located at various points on the leaf on both the lower and upper surfaces. In *Woodwardia radicans,* they were described as being on the upper surface of the pinnules at points immediately above arrested sori. Pfefferkorn (1973) has described what he interpreted to be reproductive vegetative buds in Carboniferous ferns of the genus *Kankakeea.* These are lobed thalloid structures growing at the tip of a pinna or frond rachis.

I believe the evidence is against this interpretation in the case of *S. sellardsii,* however, and support the seed concept for the following reasons: 1) the biblobed natures of the apices, 2) the apparent concentric pattern of a central nucellus and enclosing integument (Fig. 4), 3) the similarity in seed position with the pteridosperms described by Halle (1929), and 4) the seed-bearing nature of many species assigned to *Sphenopteris.*

With publication of Mamay's (1976) major work on "Paleozoic Origins of the Cycads," which includes several significant specimens from the Permian of Kansas, a brief clarification of place names referred to in the literature is perhaps worthwhile. Mamay (1976, p. 19) correctly recognized that the "Banner" locality collected from by David White in 1909 represents the locality now known as Elmo, Kansas. Unfortunately, however, he did not mention that White should have listed the town name as "Banner City," because in the late 1880's there was a town named "Banner" in Jackson County in northeast Kansas, just a few miles southwest of the present town of Holton. Like "Banner City," the town of "Banner" has disappeared from current maps but is shown on a Rand McNally map copyrighted in 1886 (Baughman, 1961). There are no Permian outcrops in the area of the true Banner, Kansas, and there can be no question that the White collections were made 2.5 miles south of Banner City (now Elmo), Dickinson County. The distinction between Banner City and the Banner in Jackson County is emphasized because they were towns nearly 100 miles apart, and in quite different geological horizons. Sellard's (1908) collecting localities, which without question include the same rock unit as White's collection, are consistently labeled as from Banner City, Dickinson County, Kansas, and *not* Banner, Kansas. It would have eliminated potential confusion if all early collectors had followed Sellard's example and always included the county name on the specimen label.

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