BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES

Volume 21, Part 3 — October 1974

CONTENTS

Brigham Young University Geology Studies

Volume 21, Part 3 — October 1974

Contents

A publication of the
Department of Geology
Brigham Young University
Provo, Utah 84602

Brigham Young University Geology Studies is published semiannually by the department. *Geology Studies* consists of graduate-student and staff research in the department and occasional papers from other contributors. *Studies for Students* supplements the regular issues and is intended as a series of short papers of general interest which may serve as guides to the geology of Utah for beginning students and laymen.

Distributed October 31, 1974

Price $5.00

(Subject to change without notice)

Flora of the Manning Canyon Shale
Part II: Lepidodendrales

WILLIAM D. TIDWELL[1], DAVID A. MEDLYN[1], AND A. DANIEL SIMPER[2]
[1]*Department of Botany and Range Science, Brigham Young University*
[2]*Department of Botany, University of California, Davis, California 95616*

ABSTRACT.—The Manning Canyon Shale, a time-transgressive formation in central Utah, contains a diversified compressional flora with many species assignable to the Lycopodophyta. This flora also includes calamitean, fern, fernlike foliage, pteridosperm and cordaitalean genera (Tidwell, 1967). Lycopod specimens consist of stem remains, leaves, strobili, sporophyllis, and twigs. These are fairly common and include the genera *Lepidodendron, Lepidophloios, Sigillaria, Knorria, Stigmaria, Lepidophylloides* (=*Lepidophyllum*), *Cyperites, Lepidostrobus, Lepidocarpon, and Sigillariostrobus.*

CONTENTS

ACKNOWLEDGMENTS

The authors wish to express their appreciation to J. K. Rigby of the Department of Geology and S. R. Rushforth of the Department of Botany and Range Science for reviewing the manuscript. They wish to acknowledge Mr. Al Davis of Orem High School and his students for their donation of specimens and their continued interest in the study of the Manning Canyon Shale flora. Special thanks are due to Naomi Hebbert, Blaine Furniss and Paul Smith for their assistance with the illustrations and to Greg F. Thayne for his aid in collecting.

INTRODUCTION

Collections made since the previous report on the Manning Canyon Shale flora (Tidwell, 1967) contain abundant bark and leafy shoots of *Lepidoden-*

dron, Lepidophloios and *Sigillaria,* as well as other lepidodendralean plant remains. The fossilized remains are impressions and unfortunately do not show detailed anatomical features. Spores were unobtainable from the strobili, thus leaving their exact affinities problematical.

The relatively large number of genera and species of the Lycopodophyta in this flora suggests that an abundance of arborescent lycopods were growing in and near the swamps which formed in the deltaic sequence of the Manning Canyon Shale Formation. *Lepidodendron* is the most commonly encountered lycopod genus, whereas *Lepidocarpon, Lepidostrobophyllum, Lepidophylloides,* and *Cyperites* are relatively abundant.

Previous Work

Carboniferous lepidodendrids have been described from various areas in the western United States. Read (1934) reported a new species of *Lepidostrobus* and specimens of *Stigmaria* from the Lower Pennsylvanian Mosquito Range flora near Leadville, Colorado. Arnold (1940) described *Lepidodendron johnsoni,* a petrified stem, from near Trout Creek Pass in central Colorado. He mentioned the presence of a large number of arborescent lycopod stems, which suggests they were a dominant element in the Pennsylvanian flora of that area. He further reported numerous shale fragments bearing characteristic imprints of *Lepidodendron* and *Lepidophloios* occurring in association with the petrified material. He did not assign them to species but considered the possibility of the lepidodendrons' being *L. simile* and *L. scutatum* and the *Lepidophloios*' being *L. larcinus.*

Mamay and Read (1956) reported a lepidodendrid branchlet from the Lower Pennsylvanian Spotted Ridge flora of central Oregon.

Arnold and Sadlick (1962) collected from the Mississippian of northeastern Utah specimens of a *Lepidodendron* that were later referred to *L. volkmannianum* (Lacey and Eggert, 1964).

Tidwell (1967) reported *Lepidodendron aculeatum, Lepidodendron obovatum, Lepidodendron volkmannianum, Lepidostrobus variabilis, Lepidostrobus obovatus, Lepidocarpon linearifolium, Lepidostrobophyllum majus, Lepidophyllum longifolium, Lepidophyllum* sp. and *Stigmaria ficoides* from the Manning Canyon Shale flora.

Pfefferkorn (1972) discussed *Stigmaria wedingtonensis* from the Upper Mississippian Indian Springs Formation in Arrow Canyon, Nevada. He also noted the occurrence of *Stigmaria ficoides* with *S. wedingtonensis* in the Mississippian Battleship Wash Formation in Nevada.

Lepidodendron aculeatum has been observed by the authors from the Pennsylvanian Illipah Formation near Ely, Nevada, and from strata near Forest Grove, Montana. This suggests a wide geographic distribution for this species in the western United States.

Stratigraphy and Collecting Localities

The Manning Canyon Shale spans the Mississippian and Pennsylvanian boundary (Tidwell, 1967). Stratigraphically, the exact location of this boundary within the formation is uncertain.

In the Uinta Mountains of northeastern Utah, Arnold and Sadlick (1962) subdivided the Manning Canyon Shale Formation and proposed the Soapstone Formation for the chiefly Chesterian strata of dominately "dark gray, black,

soft fissile clayey shale with minor amounts of gray limestone (calcisiltite) and siltstone," which would be equivalent to the Mississippian portion of the Manning Canyon Shale. Sadlick (1957) demonstrated that the Manning Canyon Shale extends throughout the Uinta Mountains and southward almost to the Uncompahgre Plateau.

Darrah (1969) considers the lepidodendrids to have little stratigraphic value within the limits of our present knowledge. He subsequently directed his discussions of the group towards their botanical significance. However, the lycopods in the Manning Canyon Shale Formation, with the exception of the predominately Mississippian species *Lepidodendron volkmannianum* and the ubiquitous *Stigmaria ficoides,* are generally Pennsylvanian forms. The stratigraphic ranges of these lycopods, in combination with the other plant types previously described (Tidwell, 1967), add considerable evidence that the flora, and thus the upper part of the Manning Canyon Shale, are Lower Pennsylvanian (Namurian B) in age.

The specimens were collected from essentially the same clay pits in the formation as previously described by Tidwell (1967) on Lake Mountain, in the Traverse Mountains, and in the Five Mile Pass area south of the Oquirrh Mountains, Utah.

SYSTEMATIC PALEOBOTANY

Order LEPIDODENDRALES
Family LEPIDODENDRACEAE
Genus LEPIDODENDRON Sternberg
Lepidodendron aculeatum Sternberg

Pl. 1, fig. 3.

Lepidodendron obovatum Sternberg, 1820, "Versuch" pp. 20, 23, pl. 6, fig. 1; pl. 8, figs. 1A, a, b.

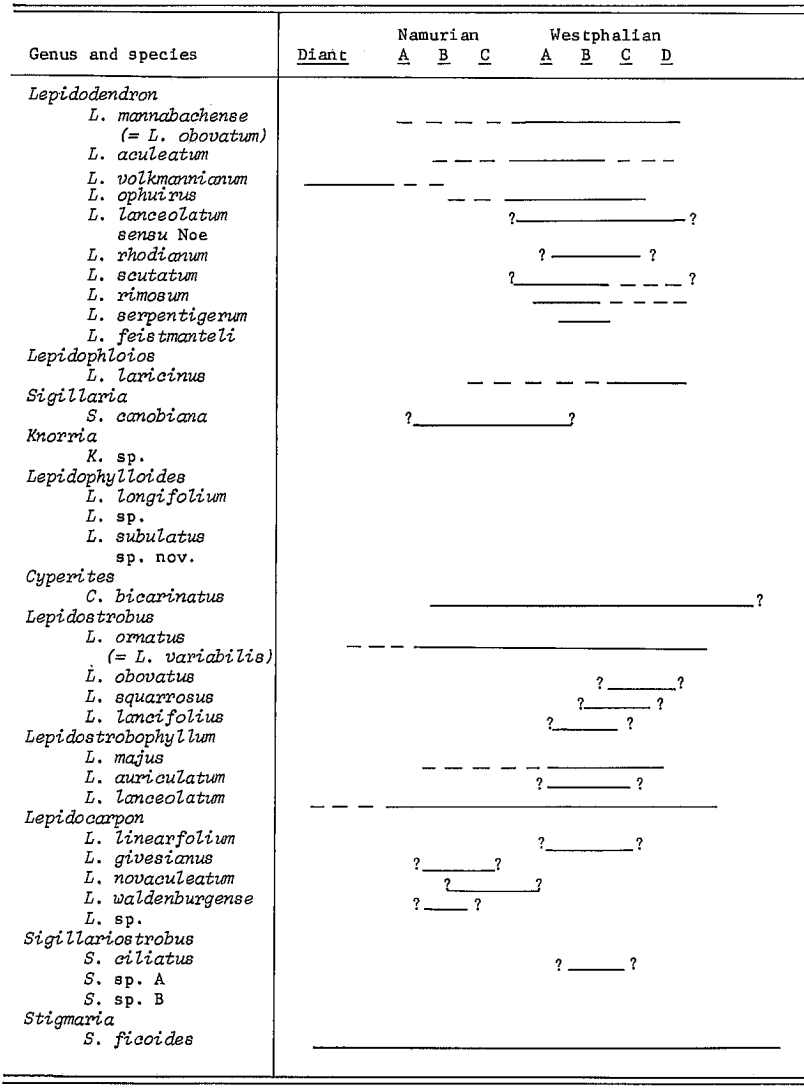
Lepidodendron aculeatum, Sternberg, 1820, "Versuch" pp. 20, 23, pl. 6, fig. 2; pl. 8, figs. 1B, a, b; Zeiller, 1886, Etudes Gîtes Min. France, p. 435, pl. 65, figs. 1-7; Neméjc *pars,* 1947, Acta Musei Nationalis Pragae, p. 49; Arnold, 1949, Univ. Mich., Contr. Mus. Paleont., pp. 160, 161, pl. 2, figs. 1, 3-4; Crookall, 1964, Mem. Geol. Surv. Gr. Brit., Palaeont., p. 233, pl. 60, fig. 6; text-fig. 77a; Tidwell, 1967, Brigham Young Univ. Geol. Studies, v. 14, p. 19, pl. 1, fig. 5; text-fig. 1a; Thomas, 1970, Palaeont., v. 13 (1), pp. 146, 147, 149, 151, pl. 29; pl. 30, fig. 1; pl. 31, figs. 1-3; text-figs. 2, 3.

Discussion.— *Lepidodendron aculeatum* has been previously reported from the Manning Canyon Shale (Tidwell, 1967). Our figured specimen shows a somewhat different shape but still retains the diagnostic characters of *L. aculeatum.* It is similar to those figured by Arnold (1949, pl. 2, figs. 3, 4) and Thomas (1970, pl. 31, fig. 3). Although Thomas's specimen shows a rimosum condition (separation of cushions), it is probably a result of the lateral expansion of the stem. Our specimen is more fusiform than those typically figured, having a ratio of 5:1 or 6:1 (25-30 mm long, 5 mm wide) as opposed to 3:1 or 4:1.

The figured specimen has fusiform bolsters with rounded lateral angles. The apices and bases of the cushion are sharp and slightly inflected and appear to insinuate themselves between adjacent cushions, uniting with the cushions above and below. The leaf scar is more or less diamond shaped, with three foliar prints. The bundle scar, and occasionally the parichnos, are visi-

TABLE 1

SPECIES OF LEPIDODENDRALES REPORTED FROM THE MANNING CANYON SHALE AND THEIR KNOWN STRATIGRAPHIC RANGES



ble. The arenchyma scars are conspicuously present situated below the rounded lateral angles of the leaf scar. There is a well-marked upper and lower keel with four or five well-defined transverse notches on the lower keel.

There are several long, incomplete leaves attached. These leaves are similar to the form genus *Cyperites*.

Figured Specimen.—BYU 2190.

Lepidodendron mannabachense Presl

Lepidodendron mannabachense Presl, 1838, in Sternberg, p. 178, pl. 8, fig. 6; Thomas, 1970 Palaeont., v. 13, p. 157, pl. 30, figs. 3, 4; pl. 32; pl. 24, figs. 1, 2, 7, 8; text-figs. 7, 8. *Lepidodendron obovatum,* Tidwell, 1967, Brigham Young Univ. Geol. Studies, v. 14, p. 19, pl. 2, fig. 6; text-fig. 16.

Discussion.—Thomas (1970), in redefining some *Lepidodendron* species based upon cuticular studies, concluded that the type specimen of *L. obovatum* Sternberg was actually a specimen of *L. aculeatum* Sternberg. However, specimens described by other researchers as *L. obovatum* are forms different from the type specimen and closely related to the one illustrated as *L. obovatum* by Presl. Presl's figured specimen is unlike the type. Thomas (1970) regarded *L. obovatum* as a confused name and reduced it to a synonym of the more commonly used *L. aculeatum.* He considered *L. mannabachense* as being identical to the presently accepted form of *L. obovatum* and therefore used the former name for those reported specimens closely paralleling *L. obovatum* as figured by Presl.

The specimens described as *Lepidodendron obovatum* from the Manning Canyon Shale Flora (Tidwell, 1967) are therefore transferred to *L. mannabachense.*

Lepidodendron rhodianum Sternberg
Pl. 2, fig. 2; Pl. 5, fig. 5

Lepidodendron rhodeanum Sternberg, 1825, "Versuch," p. 11; Arnold, 1949, Univ. Mich. Contr. Mus. Paleont., v. 7, p. 171, pl. 4, fig. 4; pl. 6, fig. 1. Thomas, 1970, Palaeont., v. 13, p. 168, text-fig. 12.

Discussion.— The leaf bolsters of *L. rhodianum* are nearly symmetrical and are vertically aligned. The upper margin is rounded and entire and not continuous with the bolster above. In contrast to the rounded upper margin, the lower margins are concave due to the crowding of the bolsters on either side. The bolsters are small, 3 mm by 6 mm in width and length respectively, as compared with 12 mm wide by 17 mm long described by Arnold (1949). The domed upper portion occupies about half the length of the bolster.

Because of slight decortication, only the lower margin of the leaf scar is visible, and the ligule pit is not observable. However, the specimens from the Manning Canyon Shale are similar to those described by Arnold (1949).

The leaf-scar form and the relatively strict vertical alignment of the bolsters are similar to those of *Lepidodendron volkmannianum,* a form to which *L. rhodianum* is possibly related. The basic difference "lies in the confluence of the cushions in vertical series in the former species" (Arnold, 1949, p. 172).

Lepidodendron rhodianum differs from the similar species *L. mannabachense* (=*L. obovatum* Presl) by forming a vertical rather than a spiral series of bolsters. The upper margins of the bolsters in *L. rhodianum* are slightly convex, whereas they are very convex in *L. mannabachense.* In *L. rhodianum,* the leaf scar occupies nearly the entire width and is near the top of the bolster. However, in *L. mannabachense* the scar is placed two-thirds to three-fourths of the distance up the bolster and occupies only about one-half its width.

Thomas (1970) changed the spelling of *Lepidodendron rhodeanum* to *L. rhodianum* referring back to Sternberg's original descriptions and spelling.

Range.—*Lepidodendron rhodianum* is a rare species. Crookall (1964) reported it from the Calciferous Sandstone Series and Carboniferous Limestone Series of Great Britain and also from the "Millstone Grit" of Ireland. The Michigan Coal flora in which it was reported (Arnold, 1949) is considered to be late Westphalian A or B in age.

Figured Specimen.—BYU 2191, 2192.

Lepidodendron rimosum Sternberg
Pl. 2, fig. 1, Pl. 5, fig. 6

Lepidodendron rimosum Sternberg, 1820, "Versuch," v. 1 (1), pp. 21, 23, pl. 10. fig. 1; Brongniart, 1828, Prodome, pp. 86, 174; Zeiller, 1886, Études Gîtes Min. France, p. 449 (1888); Atlas (1886), pl. 68, figs. 4, 5; Kidston, 1901, Trans. Nat. Hist. Soc. Glasgow, v. 6 (N.S.), p. 45, text-fig. 5; Jongmans, 1936, Fossilium Catalogus 2, Plantae *pars* 21, p. 1935; Bell, 1944, Mem. Geol. Surv. Canada 238, p. 90, pl. 46, fig. 2; Němejc, 1947, Acta Musei Nationalis Pragae, v. 3B (2), p. 62; Crookall, 1964, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4) p. 248, pl. 80, figs. 1-6, text-fig. 81.

(Cf.) *Lepidodendron rimosum* var. *retocorticatum,* D. White, 1889, U.S. Geol. Surv. Mon. 37, p. 196, pl. 54, figs. 3, 4.

(?) *Lepidodendron rimosum,* Berry, 1922, John Hopkins Univ. Studies Geol., No. 4, p. 24, pl. 8, fig. 1-3.

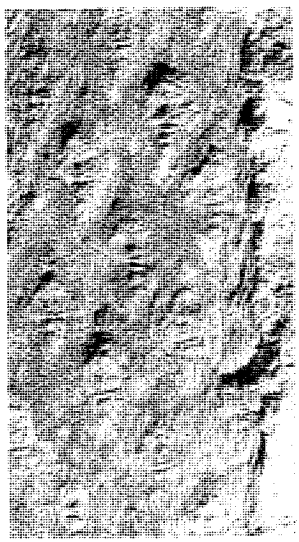
Discussion.— *Lepidodendron rimosum* has fusiform to rhomboidal leaf bolsters which are slightly convex with rounded lateral angles. These leaf bolsters are much higher than wide. The length/width ratio of our specimen is 5:1. Rhomboidal leaf scars occur about two-thirds of the distance up the bolster. Bolsters are separated by wide bands of cortex that have more or less deep parallel ridges. These ridges form discontinuous lines that run more or less parallel to the bolster margins. The distance between the bolsters is 2 mm. They are rather short, with sharply pointed apices and bases. These bolsters are straight and independent of neighboring bolsters. The keel is very faintly marked with a few transverse markings. The parichnos, vascular strand, and ligule scars are not observable.

Lepidodendron rimosum is similar to *L. fusiforme* Corda and *L. lanceolatum.* A character pointed out by Crookall (1964) that seems to distinguish them is the contraction above the leaf scar that occurs in the lateral margins of *L. rimosum* bolsters but is absent in the other two.

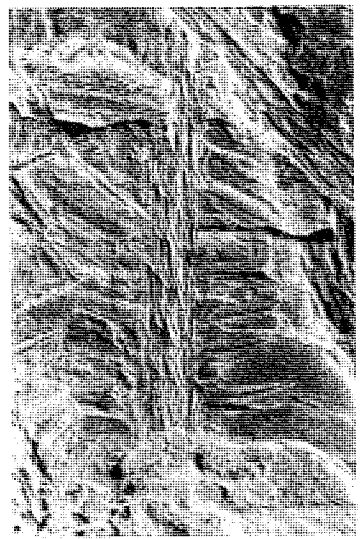
Range.—Bell (1944) reported *L. rimosum* from the Cumberland Group of Lower Westphalian B. Age. Crookall (1964) reported it as common in Westphalian A, frequent in Westphalian B, and rare in Westphalian C.

EXPLANATION OF PLATE 1
LEPIDODENDRON

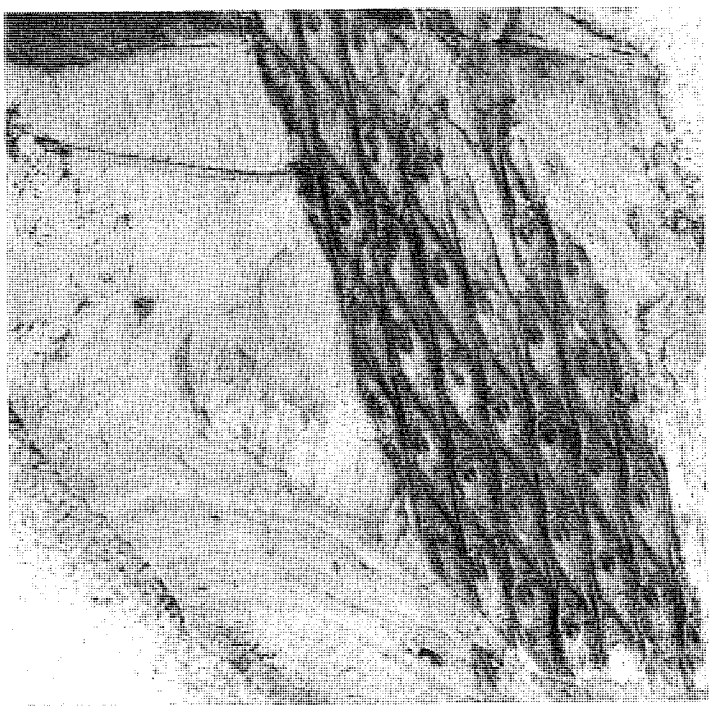
Fig. 1.—*Lepidodendron serpentigerum* Koenig (1X) BYU 2195.
Fig. 2.—*Lepidodendron ophiurus* Brongniart (1X) BYU 2196.
Fig. 3.—*Lepidodendron aculeatum* Sternberg (1X) BYU 2190.



1



2



3

PLATE 1

Figured Specimen.—BYU 2193.

Lepidodendron lanceolatum Lesquereux *sensu* Noé
Pl. 4, fig. 2

Lepidodendron fusiforme Kidston (*non* Corda), 1903 Trans. Roy. Soc. Edin., v. 11, p. 809, pl. 2, figs. 17, 18; Crookall, 1929, Coal Measure Plants, pl. 6, fig. c.

Lepidodendron lanceolatum sensu Noé, 1925, Illinois State Geol. Surv. Bull. No. 52, p. 14, pl. 7, fig. 2; Crookall, 1964, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4), p. 257, pl. 61, fig. 3; Jongmans *pars,* 1922, Fossilium Catalogus 2, Plantae, *pars* 15, p. 201; Crookall, 1929, Coal Measure Plants, p. 24, pl. 3, fig. b; pl. 4, fig. b; pl. 20, fig. a.

Discussion.—*Lepidodendron lanceolatum* as described by Janssen (1940) has a long, narrow leaf cushion or bolster. Crookall (1964) mentioned a 5:1 ratio of length to width for these bolsters (26 to 33 mm long and 5 to 7 mm wide). Generally these bolsters have somewhat the same proportions as *L. aculeatum,* except they are straighter vertically. The leaf scar of *L. lanceolatum* is narrower than that of *L. aculeatum,* although the scar for the former species is fairly large as compared with the overall size of the bolster. It is about as broad as long (3 mm wide to 4 mm long). Lateral angles of the leaf scar often give rise to two short, descending lines. No keel occurs above the leaf scar and only a slight keel below. Janssen (1940) stated that transverse markings are lacking on the lower keel, whereas Crookall (1964) mentioned that a few short, transverse notches may be present.

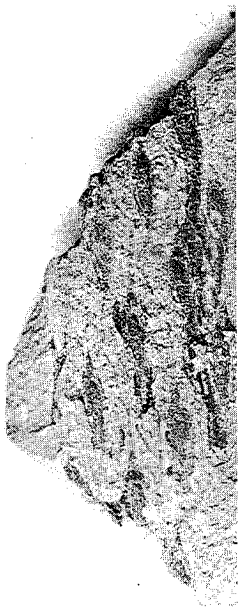
The specimens from the Manning Canyon Shale flora are similar to those illustrated by Kidston (1903) as *Lepidodendron fusiforme* Corda but are unlike Corda's species and subsequently were placed in synonymy with *L. lanceolatum* Lesquereux sensu Noé by Jongmans (1929). Kidston's illustrated specimens bear transverse markings and lack a distinct lower keel. Jongmans (1929) pointed out that Kidston's illustrations of *L. fusiforme* lack the leaf-cushion margins, have little or no keel, and have a central leaf-scar—all characteristics similar to those of *L. lanceolautm.*

Basing his conclusions on three criteria, Jongmans placed *L. fusiforme* as intermediate between *L. rimosum* Sternberg and *L. lanceolatum* Lesquereux *sensu Noé.* These criteria are:

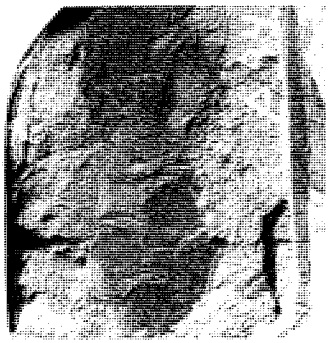
1. Degree of separation of the bolsters. The separation is definite in *L. rimosum,* slight in *L. fusiforme* and nonexistent in *L. lanceolatum.*

EXPLANATION OF PLATE 2
LEPIDODENDRON, LEPIDOCARPON, LEPIDOSTROBUS, CYPERITES

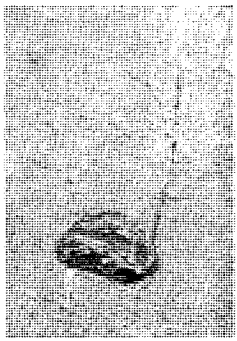
Fig. 1.—*Lepidodendron rimosum* Sternberg (1X) BYU 2193.
Fig. 2.—*Lepidodendron rhodianum* Sternberg (1X) BYU 2191.
Fig. 3.—*Lepidocarpon novaculeatum* (Bassler) Schopf (1.5X) BYU 2206.
Fig. 4.—*Lepidostrobus squarrosus* Kidston (1X) BYU 2202.
Fig. 5.—*Lepidocarpon givesianus* (Stockmans and Williere) Chaloner (2X) BYU 2208.
Fig. 6.—*Lepidostrobus squarrosus* Kidston (1X) BYU 2203.
Fig. 7.—*Cyperites bicarinatus* Lindley and Hutton (1X) BYU 2216.



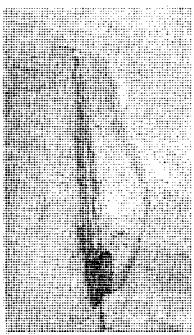
1



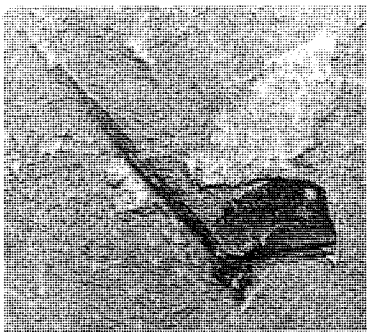
2



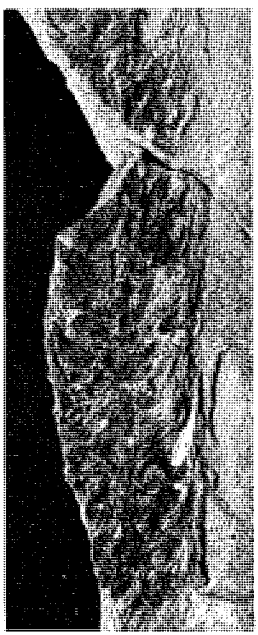
3



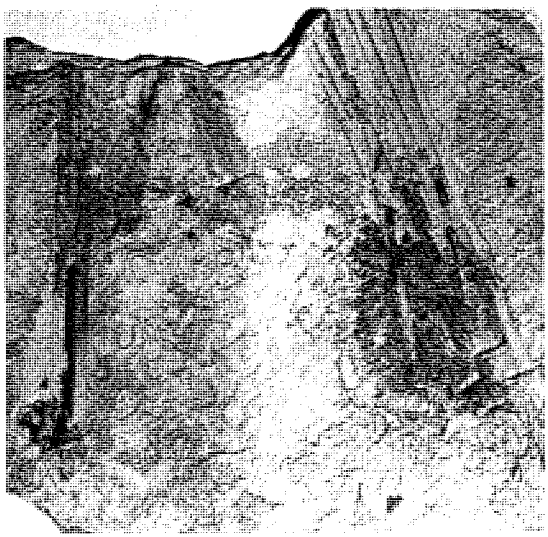
4



5



6



7

PLATE 2

2. Position of the leaf scar on the bolster. The leaf scar occurs two-thirds the distance up the bolster in *L. rimosum,* one-half the distance in *L. fusiforme,* and one-half to two-thirds in *L. lanceolatum.*
3. Keel development. There is a definite keel in *L. rimosum* and only a slight one in *L. lanceolatum.* The keel is variable in *L. fusiforme.* It is weak in some specimens and fairly strong in others.

Crookall (1964) did not consider the last two characteristics consistent enough to be valid at all times. Basing his conclusions upon an illustration in the Pennsylvanian flora of Illinois by Noé (1925), Crookall (1964) distinguished *L. lanceolatum* Lesquereux *sensu* Noé.

Because of the confusing status relative to *Lepidodendron lanceolatum,* Arnold (1949) and Bell (1944) preferred to retain it as a species until satisfactorily distinguished from *L. lycopodioides* and *L. ophiurus* (= *L. simile*).
Figured Specimen.—BYU 2194.

Lepidodendron serpentigerum Koenig
Pl. 1, fig. 1

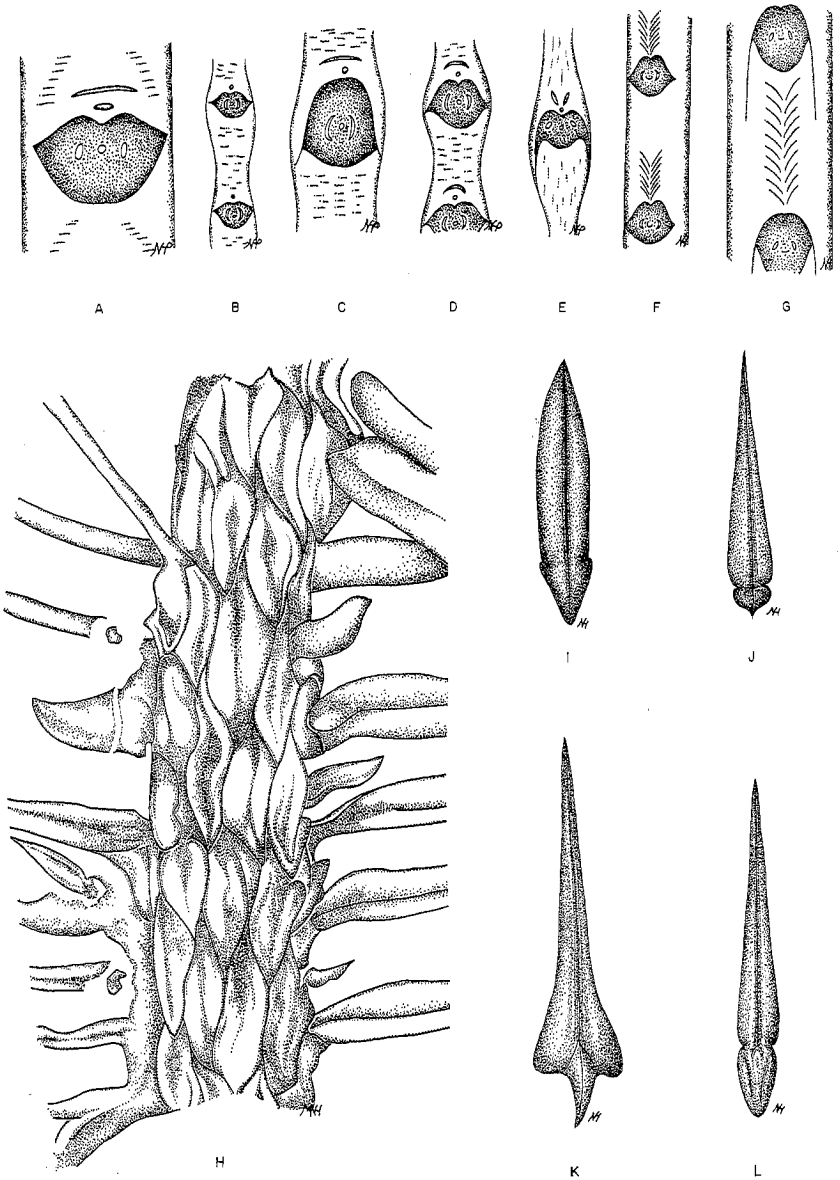
Lepidodendron serpentigerum Koenig, 1825, Icones Fossilium Sectiles, pl. 16, fig. 195; Hirmer, 1927, Hand. der Palaeobot., pp. 200, 204; text-fig. 237; Crookall, 1964, Mem. Geol. Surv. Gr. Brit., Palaeont., p. 260, pl. 61, fig. 5; text-fig. 83; Thomas, 1970, Palaeont., v. 13 (1), pp. 151, 152, 153, pl. 31, fig. 4; pl. 34, fig. 6; text-fig. 4.

Discussion.—Our specimen, although somewhat poorly preserved, demonstrates the delineating characteristics of *Lepidodendron serpentigerum.* The bolsters are widely separated by areas of wrinkled bark. They are approximately 20 mm long and 6 mm wide (3.5:1). The cushions have strongly inflexed extensions of the sharp apical and basal angles that connect with the cushions above and below. The lateral angles of the bolster are rounded. The leaf scar is situated one-half to two-thirds of the way up the cushion. The scar is raised, showing three foliar prints with the ligule trace in the upper angle. There are two depressions on each side of the keel corresponding to the arenchyma scars. The most diagnostic feature is the deep transverse grooves on the lower keel.

There are several similar forms that have cushions separated by undulated, longitudinal bark. Němejc (1947) pointed out that *Lepidodendron aculeatum,* as well as *L. obovatum* Presl. non Sternberg (= *L. serpentigerum* Presl.) Thomas, shows this rimosum type in more mature stages of bark growth. However, Thomas (1970) separated *L. serpentigerum* from the above on growth form, the latter being more S-shaped and on epidermal peels. He also considered *L. zeilleri* Zalessky (1904, p. 91, pl. 4, fig. 1, 1a) a synonym of *L. serpentigerum.*
Figured Specimen.—BYU 2195.

Lepidodendron ophiurus Brongniart
Pl. 1, fig. 2; Text-fig. 1H.

Lepidodendron ophiurus Brongniart, 1828, Prodome, p. 85; Zeiller, 1886, Etudes Gîtes Min. France, p. 458 (1888); Atlas (1886), pl. 68, figs. 1-6; Kidston, 1891, pt. 2, Trans. Roy. Soc. Edin., v. 36, p. 81; Kidston, 1892, Trans. Yorks. Nat. Union, pt. 18, p. 76; Kidston, 1893, Trans. Roy. Soc.



TEXT-FIGURE 1.—Diagrammatic representation of leaf scars of some species of *Sigillaria, Lepidodendron, Lepidophylloides, Lepidostrobophyllum, Lepidostrobus,* and *Sigillariostrobus.* All are approximately natural size. A.—*Sigillaria sol* Kidston. B.—*Sigillaria canobiana* Kidston. C.—*Sigilaria scutellata* Brongniart. D.—*Sigillaria polyploca* Boulay. E.—*Sigillaria youngiana* Kidston. F.—*Sigillaria Communis* Koehne. G.—*Sigillaria Schlotheimiana* Brongniart. H.—*Lepidodendron ophiurus* Brongniart. I.—*Lepidostrobophyllum auricultatum* (Lesquereux) Tidwell. J.—*Lepidophylloides subulatus* Tidwell. K.—*Sigillariostrobus* sp. A. L.—*Lepidostrobus squarrosus* Kidston.

Edin., v. 37, pl. 334; Jongmans *pars,* 1929, Fossilium Catalogus 2, Plantae, *pars* 15, p. 247; Crookall, 1929, Coal Measure Plants, p. 24, pl. 3, fig. d; pl. 4, fig. c; pl. 20, fig. c; Němějc *pars,* 1947, Acta Musei Nationalis Pragae, v. 3B (2), p. 63, pl. 4, figs. 4-6; pl. 2, figs. 1, 2; Crookall, 1964, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4) p. 287, pl. 61, figs. 4, 9, text-fig. 93.

Lepidodendron simile Kidston in Jongmans, 1909, Meded. Rijks Ops. Deif. no. 2, p. 174, 215.

Discussion.—This species, as described by Crookall (1964), has rhomboidal to fusiform bolsters (leaf cushions). These are contiguous in younger stems. The bolster varies from 3 to 17 mm in length and is 2 to 5 mm wide, thus exhibiting a ratio of 2:1 to 4:1. Some, however, may be as wide as tall. Bases and apices of the bolsters are usually sharp and straight, although the Manning Canyon Shale specimens have straight apices with slightly flexed bases. Generally the upper and lower keels are distinct. The upper keel may be ornamented, whereas the lower may have only rare transverse markings. Leaves are generally persistent on the branches. Where the leaves have fallen, the leaf scar is usually angular and narrow. Leaves are broad near their base and have sharply pointed apices. Leaves on the Manning Canyon Shale specimens are 11 mm to 2 cm long and 3 mm wide, although specimens with leaves as long as 5 cm have been reported (Crookall, 1964). The taxonomy of the related species of *Lepidodendron* (*L. ophiurus, L. lycopodioides, L. simile, L. fusiforme, L. lanceolatum, L. pictoense and L. ophiuroides*) and their relationship to one another are very confusing.

Bell (1962) considered Lesquereux's illustrations and descriptions of *Lepidodendron lanceolatum* (non-sensu Noé) to be conspecific with Dawson's species *L. pictoense* and used the latter species name although Dawson's figures and descriptions were inadequate.

Němějc (1947) placed *Lepidodendron lanceolatum* Lesquereux with *L. acutum* Presl. Using leaf length and width as his criteria, he differentiated between *L. acutum* and the similar *L. simile* Kidston. The leaves of the former are broader, reaching lengths of 3 to 7 cm, as compared with 1.2 to 2 cm for *L. simile.* Bell (1962) mentioned that leaves of *L. pictoense* are 1 to 2.5 cm long and 1.5 to 3 mm broad, which would place it in *L. simile* as defined by Němějc Crookall (1964) combined *L. simile* into *L. ophiurus,* with which we are in agreement. Bell (1962) pointed out that Arnold's (1949) specimens of *L. lanceolatum* Lesquereux from Grand Ledge, Michigan, would be *L. acutum* based upon leaf length. One problem that arises when leaf length is used for species determination is the placement of specimens having similar bolster configuration as *Lepidodendron acutum* and *L. ophiurus* but lacking attached leaves.

Arnold (1949) reviewed the nomenclatural problem and proposed the new species *Lepidodendron ophiurioides* for specimens from the Michigan coalfields related to *L. ophiurus* and *L. lycopioides.* This was done because of the poor illustrations and descriptions and because of the confusion surrounding the latter two species.

Renier and Stockmans (1938) stated that a cone they named *Ulostrobus squarrosus* belongs to *Lepidodendron ophriurus.* However, Kidston (1914) had previously separated a similar cone he had found attached to a branch with *Lepidodendron ophiurus*-type foliage from *Lepidostrobus squarrosus* based upon the disposition of bracts and the cone size of the latter.

Wagner (1960) stated that *Lepidodendron simile* Kidston and *Lepidodendron lycopodioides* Sternberg differ from *L. ophiurus* by the latter possessing a more prominent leaf scar situated about one-third down the leaf bolster. He further stated this difference also separates *L. simile* from *L. acutum* in which the leaf-scar occurs halfway down the bolster.

Range.—*Lepidodendron ophiurus* generally occurs in Westphalian strata.

Figured Specimen.—BYU 2196.

Lepidodendron feistmanteli Zalessky
Pl. 3, figs. 1, 5

Lepidodendron feistmanteli Zalessky, 1904, Trudy Geol. Kom. N. S., p. 93, pl. 4, figs. 6, 10; Thomas, 1970, Palaeont., v. 13 (1), p. 155, 156, 157, pl. 33, fig. 3; text-fig. 6.

Lepidodendron jaraczewski Zeiller, Bureau, 1914, Etudes Gîtes Min. France, p. 113, Atlas (LC) (1913), pl. 40, figs. 1, 1a; Bell, 1944, Mem. Geol. Surv. Canada 238, p. 89, pl. 51, figs. 1, 2.

Discussion.—Leaf cushions are rhomboidal in shape, with the length equal to the width. The cushion size varies only slightly in figured specimens (4-5 mm by 4-5 mm), but is constant within a given specimen. The upper and lower keel is prominent and unmarked. The lateral angles of the scar are raised, giving the overall appearance of a four-pointed star. Although the scar is distinct, the foliar prints of the centrally located scar are obscure.

Previous workers recognized similarities between *Lepidodendron feistmanteli* and *L. dichotomum*. Fischer (1904) combined the former into *L. dichtomum* while Hirmer (1927) thought them to be related. Although their cushions are similarly shaped, they have leaf scars that are specifically distinct. *L. dichotomum* does not have a leaf scar centrally located or elevated; its scar is closer to the top of the cushion and shows little relief. Thomas (1970), in his epidermal studies of the Lepidodendraceae, further delineated between them by showing that *L. feistmanteli* has larger epidermal cells and stomata that are generally the same over the whole cushion.

Thomas (1970) included in his synonymy of *L. feistmanteli* two specimens described as *L. jaraczewski* Zeiller, one by Bureau (1914, pl. 40, figs. 1, 1a) and another by Bell (1944, pl. 51, figs. 1, 2). Both these specimens have raised scars and lateral angles, but their cushions are two to three times longer than wide. Their scars are similar to *L. feistmanteli* and may represent a more mature growth form.

Figured Specimen.—BYU 2197, 2198.

Lepidodendron scutatum Lesquereux
Pl. 3, fig. 9

Lepidodendron scutatum Lesquereux, 1879-80, Coal Flora, p. 369, pl. 43; White. 1899, U.S. Geol. Surv., Mon. 37, pl. 45, fig. 4.

Discussion.—Specimens of this taxon from the Manning Canyon Shale are slightly distorted due to preservation, but the characters are sufficient to place them in *Lepidodendron scutatum*. Our specimens closely resemble those figured and described by White (1899) on plate 45, figure 4. Bolsters of our specimens are 2.5 mm wide and 4 mm long. Their lateral angles are rounded

with the leaf scar in the upper portion of the bolster. The upper angle of the bolster is obtuse, and its lower angle is acute.

White (1899), in discussing *Lepidodendron dichotomum* and *L. scutatum,* stated that *L. scutatum* should be combined with *L. dichotomum.* However, the specimens of *L. dichotomum* as illustrated by Němejc (1946) do not appear closely related to *L. scutatum.*

Abbott (1968) redescribed *Lepidodendron scutatum* based in Lesquereux's type specimen and additional specimens collected from Lesquereux's locality and other localities in Henry County, Missouri; Kimberly, Ohio; and Wheatland, Indiana. She emphasized the distinction between *L. scutatum* and *L. mannabachense* (=*L. obovatum* Sternberg) and thought *L. scutatum* should not be included in synonymy with *L. mannabachense* as indicated in the bibliography of *Fossilum Catalogus.* The distinction was based upon the differences of the leaf scar, proportionate area of the leaf scar in the bolster, and the lack of ornamentation in *L. scutatum* that is present in *L. mannabachense.*

Range.—*Lepidodendron scutatum* has been reported from the uppermost Allegheny.

Figured Specimen.—BYU 2199.

Genus LEPIDOPHLOIOS Sternberg
Lepidophloios laricinus Sternberg
Pl. 3, fig. 2

Lepidodendron laricinus Sternberg, 1820, "Versuch," v. 1 (1), p. 21, 22, 23, pl. 11, figs. 2-4.

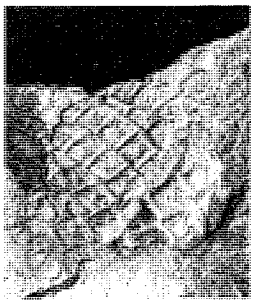
Lepidofloyos laricinum Sternberg, op. cit., vol. (4) p. 13.

Lepidophloios laricinus, Zeiller, 1886, Etudes Gîtes Min. France, p. 471 (1888); Atlas (1886), pl. 72, figs. 1-3; Kidston, 1894, Trans. Roy. Soc. Glasgow, v. 6, N.S., p. 58 (footnote); Bureau *pars,* 1914, Etudes Gîtes Min. France, Text (1914), p. 168; Atlas (1913), pl. 41, fig. 2; Kidston, 1914, pt. 3, Trans. Roy. Soc. Edin., v. 1, p. 137; Scott, 1920, Studies in Fossil Botany (3d ed.), v. 1, p. 154; Crookall, 1929, Coal Measure Plants, p. 26, pl. 3, fig. k; pl. 22, fig. 1; Bell, 1938, Mem. Geol. Surv. Canada 215, p. 102, pl. 101, fig. 4; 1944, Mem. Geol. Surv. Canada 238, p. 93, pl. 1, fig. 1; pl. 56, fig. 1; pl. 52, fig. 4; pl. 53, figs. 1, 3, 4; pl. 60, fig. 5; pl. 61, fig. 1; Němejc 1947, Acta Musei Nationalis Pragae, v. 3B (2), p. 75.

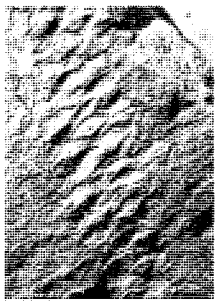
EXPLANATION OF PLATE 3

LEPIDOPHLOIOS, LEPIDOSTROBUS, LEPIDOSTROBOPHYLLUM, LEPIDODENDRON, LEPIDOPHYLLOIDES, SIGILLARIOSTROBUS, AND KNORRIA

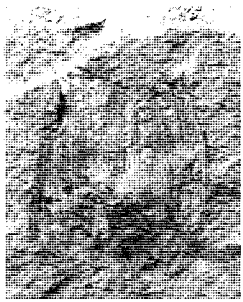
Fig. 1.—*Lepidodendron feistmanteli* Zalessky (.75X) BYU 2197.
Fig. 2.—*Lepidophloios laricinus* Sternberg (1X) BYU 2200.
Fig. 3.—*Lepidostrobus lancifolius* Lesquereux (1X) BYU 2201.
Fig. 4.—*Lepidostrobophyllum auriculatum* (Lesquereux) (1X) BYU 2204.
Fig. 5.—*Lepidodendron feistmanteli* Zalessky (1X) BYU 2198.
Fig. 6.—*Lepidophylloides subulatus* sp. nov. (1X) BYU 2215.
Fig. 7.—*Sigillariostrobus* sp. A (1X) BYU 2211.
Fig. 8.—*Knorria* sp. (1X) BYU 2213.
Fig. 9.—*Lepidodendron scutatum* Lesquereux (1X) BYU 2199.



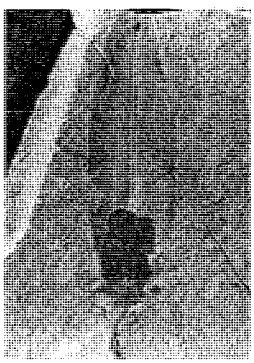
1



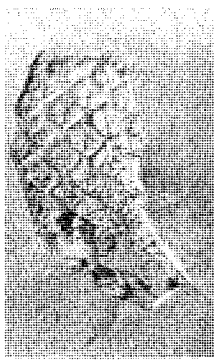
2



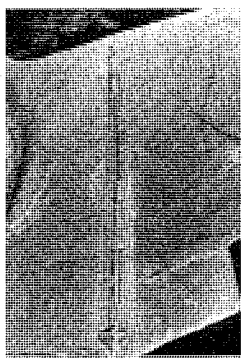
3



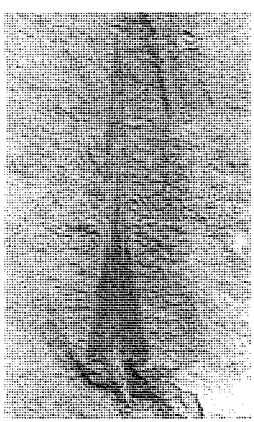
4



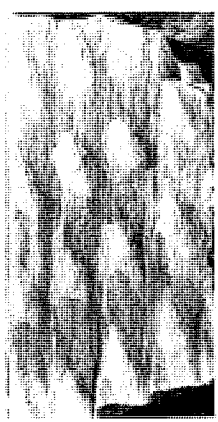
5



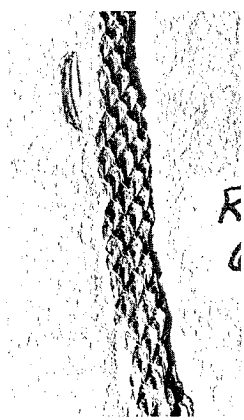
6



7



8



9

PLATE 3

Discussion.—Bolsters of *Lepidophloios laricinus* from the Manning Canyon Shale are small for this species, being only 4.5 mm wide by 2 mm long. Most described specimens have larger bolsters (6.5 mm wide by 4 mm long). The bolsters are separated by slightly more than 1 mm. Leaf scars, which are only faintly visible, are 2 mm wide by 1 mm tall and are located in the lower angle of the bolster. No foliar points are evident. The lateral angles are acute, while the upper and lower angles are rounded.

Our specimen is a small branch 13 mm wide and 55 mm long. This specimen was collected from a locality different from that of the other lycopods of this flora. It came from a clay pit in the Manning Canyon Shale near Fairfield, Utah, in the Five Mile Pass Area.

Lepidophloios laricinus is similar to *L. acerosus*. They differ in that the bolsters of *L. laricinus* are 2 to 3 times wider than high, whereas they are slightly wider than high in *L. acerosus*. In addition, a keel often present in *L. acerosus* is lacking in *L. laricinus*. Keels are absent in our specimen.

Range.—This species is rare in the Manning Canyon Shale flora, but has a wide stratigraphic range. It occurs from the Upper Namurian to the uppermost Westphalian.

Figured Specimen.—BYU 2200.

Genus LEPIDOSTROBUS Brogniart

Lepidostrobus lancifolius Lesquereux

Pl. 3, fig. 3

Lepidostrobus lancifolius Lesquereux, 1870, Illinois Geol. Surv., v. 4 (2), p. 422, pl. 31, figs. 7, 7b; Lesquereux, 1879, Coal Flora, Text, v. 2 (1880), p. 436; Atlas (1879), pl. 69, figs. 30, 30a; Janssen, 1940, Illinois State Museum Sci. Papers, v. 1, p. 34, pl. 9, fig. 2; Crookall, 1966, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4), p. 514, pl. 101, fig. 13, text-fig. 145j.

Discussion.—This species is represented in the Manning Canyon Shale flora by a single incomplete specimen. This cone is 2.1 cm wide and 1.3 cm long. This is somewhat wider than the diameter of 1.5 cm for the cone described by Crookall (1966). The sporophylls are similar to those mentioned in Lesquereux's original description (Janssen, 1940). They are wider near their middle, their bases have small diverging auricles, while their apices are acute. The pedicel is triangular in shape, whereas the sporophyll lamina is more or less lanceolate. These laminae are 2.5 mm long and terminate in acuminate tips. The midvein is well marked.

Janssen (1940), in his restudy of Lesquereux's types, concluded that this species represents a strobilus with a distinct sporophyll form and should be retained as a valid species.

Crookall (1966) stated that there is some resemblance of *Lepidostrobus lancifolius* to *L. hastatus* Lesquereux, but the pedicel of the former is shorter and its blade appears longer and narrower.

Figured Specimen.—BYU 2201.

Lepidostrobus squarrosus Kidston

Pl. 2, figs. 4, 6; Text-fig. 1L

Lepidostrobus variabilis Zeiller *pars,* 1886, Etudes Gîtes Min. France, Text (1888), p. 499; Atlas (1886), pl. 76, figs. 3a (*non* fig. 4).

Lepidostrobus squarrosus Kidston, 1893, Trans. Roy. Soc. Edin., v. 37, p. 342, pl. 4, figs. 13, 13a, 14; Jongmans, 1930, Fossilium Catalogus 2, Plantae, *pars* 16, p. 512; Crookall, 1966, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4) p. 496, pl. 101, fig. 1; text-fig. 145b.

Discussion.—*Lepidostrobus squarrosus* is known from the Manning Canyon Shale flora as a single, incomplete cone and several isolated sporophylls. The sporophylls are close to those reconstructed by Kidston (1893) for his *L.* squarrosus. The laminae of these sporophylls are generally 37 mm long and taper to the apex from the base width of 5 mm. The pedicle is 11.5 cm long by 4 cm wide, and sporangia may be observed on some. The midvein is well marked. The detached sporophylls are fairly common in the flora.

Lepidostrobus squarrosus has been considered conspecific with *L. ornatus* (Arber, 1922), which also occurs in the Manning Canyon Shale.

Arber considered the two criteria of its relatively larger size and more spreading bracts as insufficient to separate the two. Crookall (1966) regarded this as being possibly true for the size but thought it still convenient to separate cones with spreading bracts from those with more appressed bracts such as the numerous specimens of *L. ornatus.* The sporophylls assigned to *L. squarrosus* have not been observed on *L. ornatus* or associated with it.

Range.—*Lepidostrobus squarrosus* has been reported by Crookall (1966) to be rare in the Westphalian B of Great Britain and from the Namurian of Belgium by Stockmans and Williere (1953) under the name *Ulostrobus squarrosus.*

Figured Specimen.—BYU 2202, 2203.

Lepidostrobus ornatus Brongniart

Lepidostrobus ornatus Brongniart, 1828, Prodome I, p. 87, 174; Crookall, 1966, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4), p. 493, pl. 101, figs. 2-5.

Lepidostrobus variabilis Lindley & Hutton, 1831, Fossil Flora Gr. Brit., v. 1, pls. 10, 11; Tidwell, 1967, Brigham Young Univ. Geol. Studies, v. 14, p. 20; pl. 2, fig. 8.

Discussion.—Arber (1922) grouped several species of *Lepidostrobus* into the single species *L. ornatus.* This resulted in a rather large and, according to Němejc (1954, p. 14), "an utterly artificial and collective species." Němejc (1954) pointed out that Kidston has indicated that there are not means by which true *L. ornatus* and true *L. variabilis* can be distinguished, because they are very similar in size and shape. Němejc further stated that different types of preservation of the type specimens may have given an impression of distinguishing characters that are not actually present. *L. variabilis* represents mere impressions, whereas *L. ornatus* is an incrustation in an ironstone concretion. This resulted in different dimensions; otherwise, they look the same. Němejc (1954) considered the thin and elongated strobili (which other authors had placed with *L. variabilis*) under *L. ornatus.* Wider *Lepidostrobus* species he assigned to *L. kidstoni* Zalessky, and the bigger cones he termed *L. geinitzi* Schimper.

Crookall (1966) stated that *Lepidostrobus ornatus* and *L. variabilis* are synonymous and that *L. ornatus* has priority. He further stated (p. 495), "This is not a species but a designation for similar cones many of which would, no doubt, be separable in the petrified condition." He accepted Arbers (1922) broad definition of the species with the exclusion of *L. squarrosus* Kidston. Arber (1922) and Crookall (1966) also included *L. geinitz,* which, Arber stated, was larger than but otherwise indistinguishable from *L. ornatus.*

Because of this generally accepted combination, the specimen described as *Lepidostrobus variabilis* from the Manning Canyon Shale (Tidwell, 1967) is hereby transferred to *L. ornatus.*

Genus LEPIDOSTROBOPHYLLUM Hirmer

Lepidostrobophyllum was proposed by Hirmer (1927) for isolated sporophylls with or without attached sporangia to separate them from *Lepidostrobus,* which was instituted by Brongniart (1828) for detached cones of *Lepidodendron, Lepidophloios,* and *Bothrodendron.* However, Crookall (1966) uses *Lepidostrobus* in the broader sense to include isolated sporophylls and assembled cones. He points out that it is often difficult to determine whether the sporangia has become detached from the sporophyll or is just a vegetative leaf. We prefer *Lepidostrobophyllum* so as to avoid the confusion of referring to detached sporophylls of undetermined affinity as cones.

Lepidostrobophyllum auriculatum (Lesquereux) Tidwell, comb. nov.
Pl. 3, fig. 4; Text-fig 1i

Lepidophyllum auriculatum Bureau, 1914, Etudes Gîtes Min. France, Text (1914), p. 180, Atlas (1913), 74, fig. 4.

Discussion.—Janssen (1940) combined *L. auriculatum* Lesquereux into *L. majus* Humes because he considered the small auricles at the base of the lamina to be due to a fracture in the shale. However, Bureau (1914) illustrated a specimen that he assigned to *L. auriculatum* that distinctly shows the auricles. The specimens from the Manning Canyon Shale also clearly demonstrate these small basal auricles. On these specimens the sporophyll is widest near the middle (11 mm), and although the extreme tip is missing on the specimen figured (Pl. 3, fig. 3), it is 40 mm long and 7 mm wide at the base. Its apex tapers quickly to a rather sharp point.

This species is rare in the Manning Canyon Shale flora but well preserved, showing the midvein and the lateral stomatal grooves.

Figured Specimen.—BYU 2204.

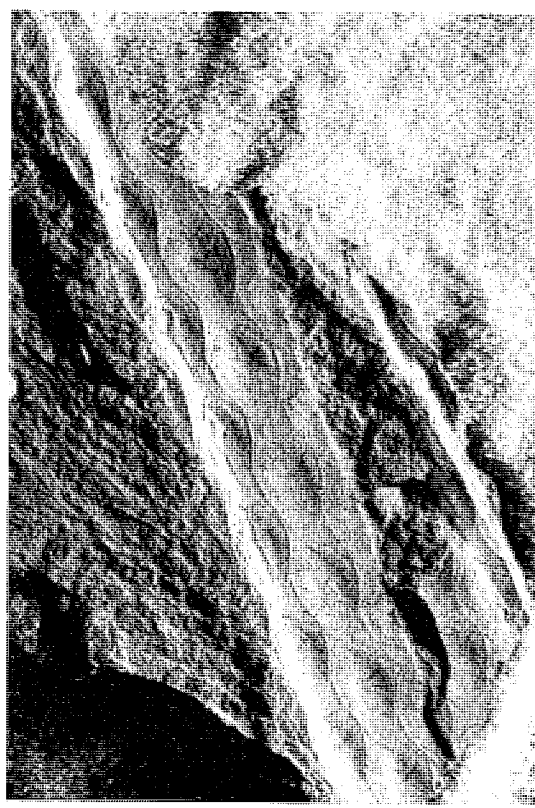
Lepidostrobophyllum lanceolatum (Lindley and Hutton) Bell
Pl. 5, fig. 1

Lepidostrobophyllum lanceolatum (Lindley and Hutton) Bell, 1938, Mem. Geol. Surv. Canada 215, p. 97, pl. 98, fig. 10; Bell, 1940, ibid., No. 225, p. 127, pl. 7, fig. 3; pl. 8, figs. 5, 6; Boureau, 1967, Traite Paleobotanique, II , pp. 593-595.

Lepidophyllum lanceolatum Lindley and Hutton, 1831, Fossil Flora Gr. Brit., v. 1, p. 28, pl. 7, figs. 3, 4; Zeiller, 1886, Etudes Gîtes Min. France, Text

1

2



3

4

EXPLANATION OF PLATE 4
KNORRIA, LEPIDODENDRON, AND SIGILLARIA

Fig. 1.—*Knorria* sp. (1X) BYU 2214.
Fig. 2.—*Lepidodendron lanceolatum* Lesquereux *sensu* Noé (1X) BYU 2194.
Figs. 3, 4.—*Sigillaria canobiana* Kidston (1X) BYU 2209.

(1888), p. 505, Atlas (1886), pl. 77, figs. 7, 8; Jongmans *pars*, 1936, Fossilium Catalogus 2, Plantae, *pars* 16 p. 1044.

Lepidostrobus lanceolatus (Lindley and Hutton) Goeppert in Brown, 1848, Index Palaeont., p. 632; Crookall, 1966, Mem. Geol. Surv. Gr. Brit., Palaeont. v. 4 (4), p. 503-505, pl. 102, fig. 2; text-fig. 145E.

Discussion.—This is the only sporophyll of *Lepidostrobophyllum lanceolatum* collected from the Manning Canyon Shale. The sporophyll is 3 cm long and 0.5 cm broad at its widest point. The lamina is lanceolate, tapering from the midpoint toward the apex and the base. The smooth tapering margins form an acute apex. The pedicel and the lamina are approximately the same shape with the pedicel being 1 cm long and 0.3 cm wide with a prominent midvein that tapers towards the tip.

Lepidostrobophyllum lanceolatum is smaller than *L. intermedius* Lindley and Hutton, which is intermediate between *L. major* Brongniart and *L. lanceolatum*. These three species are separated arbitrarily by size. Our specimen falls within the variability of *L. lanceolatum* and the lower limits of *L. intermedius* (3-9 cm long, 3-9 mm broad).

Range.—*L. lanceolatum* has been reported from both the Lower and Upper Carboniferous (Crookall, 1966).

Figured Specimen.—BYU 2205.

Family LEPIDOCARPACEAE
Genus LEPIDOCARPON Scott
Lepidocarpon novaculeatum (Bassler) Schopf
Pl. 2, fig. 3

Cantheliophorus novaculatus Bassler, 1919, Bot. Gaz., v. 68, p. 99.

Lepidocarpon novaculeatum Schopf, 1941, Amer. Midl. Nat., v. 25 (3), p. 561.

Discussion.—Strobili were not collected in the Manning Canyon Shale. Only isolated megasporophylls with sporangia are present. The megasporangia are about 19 mm long and 5 mm high. The extent of attachment of the pedicel to the megasporangia is not clear, owing to a prominent enclosure of the distal end of the sporangium by the base of the distal lamina. The pedicel descends slightly more than 90° from the axis, and extends 8 mm from axis to the upturn of the distal lamina. The distal lamina extends approximately 17 mm from tip to point of upturn. There is a faint evidence that the distal lamina was 4 to 5 mm longer. The pedicel extends below, forming a ventral keel. The keel region either is absent on some specimens, perhaps due to preservation, or is notched on others with a distal portion extending into a narrow distal pouch. The lateral lamina extends above the sporangium enclosing it. A ligule is not visible. The vascular bundle appears to come directly from the axis and extends through the pedicel into the distal lamina. The characteristic feature of this species, as outlined by Bassler (1919), is that the linear blade reduplicates only near the base and is flexed forward into a position nearly parallel to that of the cone axis. The keel is never wide and appears to have been rather "frail," because often it is missing.

Lepidocarpon novaculeatum is similar to *L. waldenburgense* (Potonie) Schopf. The latter differs from the former by having a distinctly different lamina, showing great expansion from the keel where it narrows to the distal extremity of the pedicel and terminates rather abruptly (Bassler, 1919).

Range.—Lepidocarpon novaculeatum is known from the post-Pottsville Allegheny Formation (Bassler, 1919).

Figured Specimen.—BYU 2206.

Lepidocarpon waldenburgense (Potonie) Schopf
Pl. 5, Fig. 2

Lepidophyllum waldenburgense Potonie, 1899, Lehrbuch der Pflanzenpalaeon., p. 272-273, fig. 350.

Cantheliophorus waldenburgense, Bassler, 1919, Bot. Gaz. v. 68, p. 101, pl. 10, figs. 19, 20, 21; Stockmans and Williere, 1953, Assoc. Etude Paléont. Strat. Houill. 13, Text (1953), p. 153-154; Atlas (1952), pl. 36, fig. 4; pl. 53, fig. 5.

Lepidocarpon waldenburgense (Potonie) Schopf, 1941, Illinois Geol. Surv. Circ. 73, p. 561.

Discussion.—Lepidocarpon waldenburgense is one of the smaller described species of *Lepidocarpon.* The main delineating characteristic is the marked expansion of the heel, which is wide at the distal end and tapering towards the proximal end of the pedicel.

The figured specimen is small, with the 8 mm long and 4 mm high sporangium being somewhat rounded. The distal lamina is 2.0 cm in length, with a reflexed, relatively thin, distal lamina tapering to a fine point.

Lepidocarpon waldenburgense has a short geological range, having been reported only from Lower Pennsylvanian strata.

Figured Specimen.—BYU 2207.

Lepidocarpon givesianus (Stockmans and Williere) Chaloner
Pl. 2, fig. 5

Cantheliophorus givesianus Stockmans and Williere, 1953, Assoc. Étude Paléont. Strat. Houill. 13, p. 152-153.

Lepidocarpon givesianus (Stockmans and Williere) Chaloner, *in* Boureau, 1967, Traité de Paléobot., II, p. 607.

Discussion.—The specimens from the Manning Canyon Shale assigned to this species are slightly larger than those defined by Stockmans and Williere (1953). These forms are similar to *Lepidocarpon waldenburgense,* but they are much larger than the latter species.

Range.—Lepidocarpon givesianus has been reported from various localities in the Namurian of Belgium.

Figured Specimen.—BYU 2208.

Lepidocarpon sp.
Pl. 5, fig. 7

Discussion.—This compression is an incomplete specimen, lacking a portion of the distal lamina. The rectangular megasporangium is 14 mm long and 5.5 mm high, containing four megaspores. A single mature megaspore, 5.5 mm long and 3 mm broad, occurs near the proximal end, and three aborted megaspores can be observed at the distal end of the megasporangium. The pedicel is 14 mm

long and tapers slightly toward a well-defined heel, which is 3.5 mm deep. Although the distal lamina is incomplete, it appears to be 20 to 25 mm long and 1.5 mm at its widest point. The lamina is straight with no indication of reflexion.

The specimen closely resembles *Lepidocarpon waltoni* Chaloner in the shape and size of the megasporangium. The length of the distal lamina is within the range of variation of *Lepidocarpon waltoni,* up to 35 mm, but the width is smaller, *Lepidocarpon waltoni* being 4 mm wide. Our specimen has a well-defined heel, which *Lepidocarpon waltoni* lacks. Chaloner (1952) described a rhomboidal splinter of axis tissue about 1.8 mm long that commonly occurs at the end of the pedicel, but he did not consider it a heel.

Figured Specimen—BYU 2217

Family SIGILLARIACEAE
Genus SIGILLARIA Brongniart
Sigillaria canobiana Kidston

Pl. 4, figs. 3, 4; Text-fig. 1B

Sigillaria canobiana Kidston, 1903, Trans. Roy. Soc. Edin., v. 11, p. 765, pl. 3, fig. 26; pl. 4, figs. 29-35, pl. 5, figs. 45-47; Crookall, 1966, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4), p. 371, pl. 74, figs. 1-4; text-figs. 139.

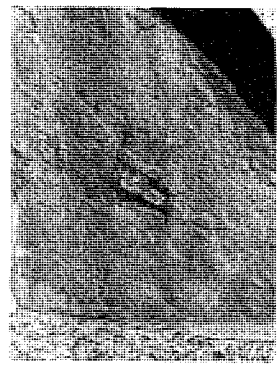
Discussion.—This species has a rhomboidal leaf scar with a distinctly notched upper margin and a rounded lower margin. The lateral angles are prominent. Leaf scars occupy the whole width of the rib, which widens at this point. This rib varies from 5.5 mm wide between scars to 9 mm wide where the rib is inflated around the scar. Leaf scars are 12 mm apart, and the individual scars measure 7.5 mm broad by 5.5 mm tall, occupying almost the whole width of the rib. The foliar points are slightly above the center of the scar. The ligule scar is situated in the notch of the upper margin. Because of slight decortication, the transverse wrinkling mentioned by Kidston is missing.

Sigillaria canobiana is similar to *S. scutellata* Brongniart. The scar of *S. scutellata* (Text-fig. 1C) is almost pear shaped, and furrows occur from the lateral angles to the rib margin. The scars of *S. polyploca* Boulay (Text-fig. 1D) are situated higher in the rib in relation to the inflated portion. Additionally, the lower portion of the scar is very shallow, and furrows extend downward from the lateral angles. The ribs of *S. communis* Koehne (Text-fig. 1F) are nearly straight, and there is a plumelike marking above the ligule pit.

EXPLANATION OF PLATE 5
LEPIDOSTROBOPHYLLUM, LEPIDOCARPON, SIGILLARIOSTROBUS, AND LEPIDODENDRON

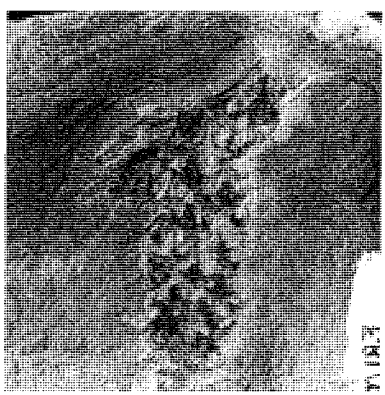
Fig. 1.—*Lepidostrobophyllum lanceolatum* (Lindley and Hutton) Bell (1X) BYU 2205.
Fig. 2.—*Lepidocarpon waldenburgense* (Potonie) Schopf (1X) BYU 2207.
Fig. 3.—*Sigillariostrobus ciliatus* Kidston (1X) BYU 2210.
Fig. 4.—*Sigillariostrobus* sp. B (1X) BYU 2212.
Fig. 5.—*Lepidodendron rhodianum* Sternberg (1X) BYU 2192.
Fig. 6.—*Lepidodendron rimosum* Sternberg (1X) BYU 2193.
Fig. 7.—*Lepidocarpon* sp. (1X) BYU 2217.

1

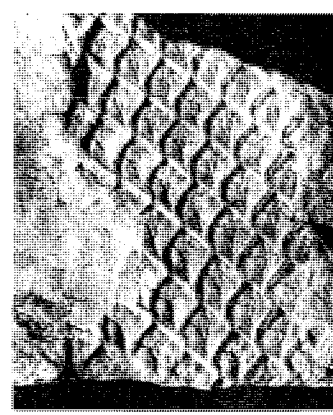


2

3



4



5

6

7

PLATE 5

Sigillaria youngiana Kidston (Text-fig. 1E) a Namurian form, is similar to *S. canobiana* but differs from the latter mainly by the longer distance between scars, which is about 3.3 cm (as compared with 1.2 mm for the Manning Canyon Shale specimens). Kidston (1903, p. 767) differentiated between these two species "by the form and position of the leaf-scar which is placed about the centre of the inflation, and by the delicate short lines, mostly upright, with which the surface of the interfoliar cortex is ornamented." Another Namurian species, *S. schlotheiminiana* Brongniart (Text-fig. 1G) has a characteristic plumule above the leaf scar, and its ribs are generally straighter than those of *S. canobiana.*

Range.—*Sigillaria* is predominately an Upper Carboniferous genus, reaching its maximum development in Westphalian A, B, and (lower) C. It is rare in older Carboniferous rocks, although *S. youngiana* has been recorded from the Namurian. *S. canobiana* is known from two Carboniferous localities in Great Britain, but the exact age of the localities is unknown (Crookall, 1966). Chaloner (1967) placed it questionably in the Namurian and definitely in the Upper Carboniferous.

Figured Specimen.—BYU 2209.

Genus SIGILLARIOSTROBUS Schimper

The genus was established by Schimper in 1870. It includes assembled and detached sporophylls. The heterosporus cones are large, some being upwards of 20 cm long. They are peduncled, cylindrical, and occasionally dichotomously branched. The sporophylls are caducous, entire or with ciliate margins, rhomboidal, and acute or lanceolate with an expanded rhomboidal base. The sporophylls possess a single central vein.

Crookall (1966) states that the genus *Sigillariostrobus* is rare in Great Britain and occurs only in strata of Westphalian A, B, and C age.

Sigillariostrobus ciliatus Kidston

Pl. 5, fig. 3

Sigillariostrobus ciliatus Kidston, 1897, Trans. Roy. Soc. Edin., v. 39, p. 53, pl. 2, figs. 2-9; Crookall, 1966, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4, p. 541-542, pl. 103, figs. 7, 8.

Discussion.—The figured specimen is an isolated sporophyll. It is lanceolate 1.5 cm long with somewhat concave margins expanding at the widest point, located basal from the midpoint to 4 mm. The sporophyll is ciliated, although the preservation is poor and the ciliation is not observable in the photograph. Crookall (1966) mentions a single central vein which, because of the method of preservation, is not apparent in the figured specimen. The peduncle is preserved.

Figured Specimen.—BYU 2210.

Sigillariostrobus sp. A

Pl. 3, fig. 7; Text-fig. 1K

Discussion.—The specimens of *Sigillariostrobus* sp. A from the Manning Canyon Shale are detached, caducous, lanceolate sporophylls that have relatively broad bases. The sporophylls are abruptly contracted (concave) near

their middle and narrow to a very prolonged, acute apex. Their margins are smooth. These sporophylls are larger than other species of *Sigillariostrobus*. They are 45 mm long and 10 mm wide at their widest part, in contrast to the sporophylls of *S. nobilis* Zeiller, which are 1.5 mm long by 1 mm wide.

Our specimens are assigned to *Sigillariostrobus* with some reservation. The laminar margins of *Sigillariostrobus* sporophylls appear to be generally, if not always, concave, whereas those of *Lepidostrobus* are usually convex (Crookall, 1966). This is the basis for the placement of these specimens from the Manning Canyon Shale Formation.

Figured Specimen.—BYU 2211.

Sigillariostrobus sp. B
Pl. 5, fig. 4

Discussion.—The specimen is a small cone, approximately 3.5 cm long and 1.5 cm in diameter. The sporophylls are spirally arranged, not oppressed. They are broadly wedge shaped with more or less rounded lateral angles being 4 mm in total length from the lower pedicel angle to the apex of the distal lamina. The affinities of the figured specimen are uncertain. The sporophylls most closely resemble those of *Sigillariostrobus* and, more specifically, those of *S. nobilis* Zeiller and *S. rhombibracteaus* Kidston. However, they are decidedly smaller than the sporophylls of the latter species. The margins of the distal lamina are straight, which is not compatible with the concave conditions of *Sigillariostrobus*. However, *S. goldbergi* Feistmantel, as illustrated by Zeiller (1884; pl. 12, fig. 4), has relatively straight margins. The bases of the bracts of the specimen from the Manning Canyon Shale are broader than those of *S. goldbergi*. Sigillarian cones may have their sporophylls either spirally or vertically arranged (Felix, 1954). They are also pedunculate, while *Lepidostrobus* is born on an ordinary leafy shoot (Schopf, 1941), a condition which cannot be determined in our specimen.

Figured Specimen.—BYU 2212.

LEPIDODENDRALES INCERTAE SEDIS
Genus KNORRIA Sternberg
Knorria sp.
Pl. 3, fig. 8; Pl. 4, fig. 1

Discussion.—*Knorria* was erected for stems related to the Lepidodendraceae exhibiting a degree of preservation with vertically oriented, but spirally arranged depressions or impressions that were once leaf traces. Different stages of decortication in the stems of lepidodendrids are assigned to various form genera. If the epidermal layers and periderm are present, they are *Lepidodendron, Sigillaria,* etc.; but when these layers are lost, the stem remains are placed in *Bergeria*. If the next layer down to the middle cortex is removed, the genus *Aspidiaria* is applied. The latter condition is generally represented by cast or mold impressions (Basson, 1968). The genus *Knorria* constitutes specimens with outer stem surfaces removed, leaving only the inner cortex.

Knorria may represent stem remains of *Lepidophloios, Lepidodendron, Bothrodendron* and some sigillarian forms. Preservation of these specimens is such that they cannot be generically identified with the above, except that sometimes *Lepidodendron* and sigillarian forms can be so identified (Darrah, 1969). These specimens are of little stratigraphic or botanical value.

A form to that illustrated in Plate 4, figure 1 was described by Lesquereux (1890) as *Lepidodendron crusiatum.* This was later combined with *Asolanus camptotaenia* Wood by Janssen (1940). The specimen illustrated by Janssen appears similar to an *Aspidiaria* or *Knorria* type. Basson (1968), however, discussed a possible relationship between the two.
Figured Specimen.—BYU 2213, 2214.

Genus LEPIDOPHYLLOIDES Snigirevskaya

The generic name *Lepidophylloides* was proposed to replace the older term *Lepidophyllum,* which previously had been applied to a living South American flowering plant (Snigirevskaya, 1958). Originally, *Lepidophyllum* was used for detached sterile and fertile leaves (sporophylls) of *Lepidodendron* and *Lepidophloios.* However, Hirmer (1927) proposed the genus *Lepidostrobophyllum* for sporophylls, leaving the sterile leaves for *Lepidophyllum,* now *Lepidophylloides.* According to Crookall (1966), *Lepidophylloides* is rarely more than a few centimeters in length, whereas *Cyperites,* which contains the leaves of *Sigillaria,* may be much longer. In other words, the differentiation between the two genera is based upon their length. Crookall (1966) included both sterile and fertile leaves under *Lepidophylloides.*

Lepidophylloides subulatus Tidwell, sp. nov.
Pl. 3, fig. 6; Text-fig. 1J

Description.—Sterile, linear leaves, 3.8 cm long by 5 mm wide at their bases, gradually tapering to an acuminate apex, base of the leaf rather pointed, base 4 mm wide, 3 mm high. Single vein extends the length of leaf paralleled on each side by stomatal grooves.

Discussion.—Leaves of this type are relatively common in the Manning Canyon Shale flora. The leaf is shorter and broader than *Lepidophyllum* sp. reported by Tidwell (1967). The latter species should probably be considered under *Cyperites.* A specimen similar to *Lepidophylloides subulatus* is illustrated in Stockmans and Williere (1953; Pl. 36, fig. 4) associated with *Lepidocarpon* (*Cantheliophorus*) *waldenburgensis* (Potonie) Schopf.

Holotype.—BYU 2215.

Genus CYPERITES Lindley and Hutton

Cyperites was proposed for detached sterile leaves that originally were considered under *Sigillariophyllum.* These are long, grasslike leaves, pointed at the apex and enlarged and thickened at the base. They are not necessarily sigillarian forms, as some may be borne on *Lepidodendron* and *Asolanus* species and possibly other aborescent lycopod genera (Crookall, 1966). Some species of *Cyperites* have double veins and are considered to be only sigillarian types.

Cyperites bicarinatus Lindley and Hutton
Pl. 2, fig. 7

Cyperites bicarinatus Lindley and Hutton, 1831, Fossil flora Gr. Brit., v. 1, p. 123, pl. 13, figs. 1, 2; Jongmans, 1930, Fossilium Catalogus 2, Plantae, *Pars* 16, p. 359; Crookall, 1966, Mem. Geol. Surv. Gr. Brit., Palaeont., v. 4 (4), p. 534, pl. 105, fig. 7; text-fig. 153.

Sigillariophyllum bicarinatum Crookall, 1929, Coal Measure Plants, p. 31, pl. 35, fig. 6.

Discussion.—Leaves assignable to this genus are isolated and are about 10 cm in length with pointed apices. Some have *Lepidodendron* leaf bolsters still attached. A single vein with parallel stomatal grooves extend to the apex. Their margins are entire.

These leaves are fairly common in the flora. Crookall (1966) reported that several species of *Sigillaria* and *Lepidodendron* possibly bore leaves of the *Cyperites bicarinatus* type. Among these is *Lepidodendron aculeatum* Sternberg, which occurs in the Manning Canyon Shale.

Figured Specimen.—BYU 2216.

REFERENCES CITED

Abbot, M. L., 1968, Lycopsid stems and roots and sphenopsid fructifications and stems from the Upper Freeport Coal of southeastern Ohio: Paleontogr. Amer., 6(38):5-25, pls. 1-18.

Arber, E. A. N., 1922, Critical studies of Coal Measure plant impressions: J. Linn. Soc. Botany, 46:171-217.

Arnold, C. A., 1940, *Lepidodendron johnsonii,* sp. nov., from the Lower Pennsylvanian of central Colorado: Contr. Mich. Univ. Mus. Paleont., 6(2):21-52, pls. 1-11.

———, 1949, Fossil Flora of the Michigan coal basin: Contr. Mich. Univ. Mus. Palaeont., 7 (9):131-269, pls. 8-15.

———, 1953, Fossil plants of early Pennsylvanian type from central Oregon: Palaeontogr., 93B:61-68.

———, and Sadlick, W., 1962, A Mississippian flora from northeastern Utah and its floral and stratigraphic relations: Contr. Mich. Univ. Mus. Paleont. 17 (11): 241-63, pls. 1-2.

Bassler, H. 1919, A sporangiophoric lepidophyte from the Carboniferous: Bot. Gaz., 68(2):73-108, pls. 9-11.

Basson, P. W., 1968, The fossil flora of the Drywood Formation: Univ. Missouri Press, 170 p., Columbia.

Bell, W. A., 1938, Fossil Flora of Sydney coalfield, Nova Scotia: Geol. Surv. Canada, Mem. 215, p. 1-115, pls. 1-107.

———, 1940, The Pictou coalfield, Nova Scotia: Geol. Surv. Canada, Mem. 225, 1-141, pls. 1-10.

———, 1944, Carboniferous rocks and fossil floras of northern Nova Scotia: Geol. Surv. Canada, Mem. 238, 1-119, pls. 1-79.

———, 1962, Flora of Pennsylvania Pictou Group of New Brunswick: Geol. Surv. Canada, Bull., 87: 1-71, pls. 1-56.

Brongniart, A., 1828, Prodome d' une Histoires des Veg. foss., 223 p.

Bureau, M. E., 1914, Bassin de la Basse Loire, II. Description des flores fossiles: Études Gîtes Min. France fasc. II, 417 p., 80 pls.

Chaloner, W. G., 1967, Lycophyta: *in* Boureau, Traite de Paleobotanique part II, Paris.

Crookall, R., 1964, Fossil plants of the Carboniferous rocks of Great Britain. (Second section): Mem. Geol. Surv. Gr. Brit., Palaeont., 4(3):217-354, pls. 59-81.

———, 1966, Fossil plants of the Carboniferous rocks of Great Britain. (Second section): Mem. Geol. Surv. Gr. Brit., Palaeont., 4(4):355-572; pls. 82-106.

Darrah, W. C., 1969, A critical review of the Upper Pennsylvanian floras of eastern United States with notes on the Mazon Creek flora of Illinois: 220 p., pls. 1-80.

Felix, C. J., 1954, A study of the arborescent lycopods of southeastern Kansas: Ann. Miss. Bot. Gard., 39:263-88.

Fischer, F., 1904, Zur nomenclatur von *Lepidodendron* und zur Artkritik dieser gattung. Abhandl. K. Preuss. Geol. Landesanst., N.F., 39:1-80.

Hirmer, M., 1927, Handbuch der palaeobotanik, 708 p. Munich.

Janssen, R., 1940, Some fossil plant types from Illinois: Illinois St. Mus. Sci. Papers, 1:1-124.

Kidston, R., 1893, On the fossil flora of the South Wales coal field and the relationship of its strata to the Somerset and Bristol coal fields: Trans. Roy. Soc. Edinb., 37(3):565-614.
———, 1903, The fossil plants of the Carboniferous rocks of Canonbie, Dumfrieshire, and of parts of Cumberland and Northumberland: Trans. Roy. Soc. Edinb. 40 (4):741-834, pls. 1-5.
———, 1914, On the fossil flora of the Staffordshire Coalfield: Trans. Roy. Soc. Edinb., 115:6-78, pl. 1.
Lesquereux, L., 1879-1884, Descriptions of the Coal Flora of the Carboniferous formation in Pennsylvania and throughout the United States: Dept. Prog. P. 2nd. Geol. Surv. Pennsylvania.
Mamay, S. H., and Read, C. B., 1956, Additions to the flora of the Spotted Ridge Formation in central Oregon: U.S. Geol. Surv. Prof. Pap., 274I: 211-26, pls. 34-37.
Němejc, F., 1946, Further critical remarks on Sternberg's *Lepidodendron dichotomum* and its relations to the cones of *Sporangiostrobus* Bode: Bull. Intern. de l'Academie Tcheque des Sci., 47 (7):1-8.
———, 1947, The Lepidodendraceae of the coal districts of central Bohemia: Acta Musei Nat. Pragae, 3B:45-87, pls. 1-3.
———, 1954, Taxonomial studies on the strobili of the Lepidodendraceae of the coal districts of central Bohemia. Acta Musei Nat. Pragae, 10B(5):3-83, pls. 1-12.
Noé, A. C., 1925, Pennsylvanian flora of northern Illinois: Illinois Geol. Surv. Bull., 52:1-113, pls. 1-45.
Pfefferkorn, H. W., 1972, Distribution of *Stigmaria wedingtonensis* (Lycopsida) in the Chesterian (Upper Mississippian) of North America: Amer. Midl. Nat., 88: 225-31.
Read, C. B., 1934, A flora of Pottsville Age from the Mosquito Range, Colorado: U. S. Geol. Surv. Prof. Pap. 185D: 79-96.
Renier, A., and Stockmans, F., 1938, Flore houillières de la Belgique, in Renier, A. et. al., Flore et Faune houillières de la Belgique Edit. Patrimonie: Mus. Roy. Hist. Nat. Belg., Brussels, 2nd part, p. 35-99.
Sadlick, W., 1957, Regional relations of Carboniferous rocks of northeastern Utah: Intermt. Assoc. Petrol. Geol. Guidebook 8th Ann. Field Corp., Guidebook to the geology of the Uinta Basin, p. 56-77.
Schimper, W., 1869-1874, Traité de Paléontologie Végétale: v. 2, v. 3 (1874), v. 8 (Atlas [1870-72]).
Schopf, J. M., 1941, Notes on the Lepidocarpaceae: Amer. Midl. Nat., 25:548-63 (Ill. State Geol. Surv. Circ. 73).
Snigirevaskaya, N. S., 1958, Anatomical investigation of fossil leaves (phylloids) of certain Lycopsida in coal balls of the Donetz coalfields: Bot. Zhurnal, S.S.S.R., 43(1):106-12, pls. 1-4.
Stockmans, F., and Williere, Y., 1953, Végétaux Namuriens de la Belgique: Assoc. Etude Paléont. Stratigraph. Houilliéres, 13:1-382, pls. 1-57.
Thomas, B. A., 1970, Epidermal studies in the interpretation of *Lepidodendron* species: Palaeont. 13:145-73, pls. 29-34.
Tidwell, W. D., 1967, Flora of Manning Canyon Shale Part I: A lowermost Pennsylvanian flora from the Manning Canyon Shale, Utah, and its Stratigraphic Significance: Brigham Young Univ. Geol. Studies, 14:3-66.
Wagner, R. H., 1960, Middle Westphalian floras from northern Palencia (Spain): Estud. Geol., 16:55-92.
White, D., 1899, Fossil flora of the lower Coal Measures of Missouri: U.S. Geol. Surv. Mon., 37:1-467.
Wood, J. M., 1963, The Stanley Cemetery flora (Early Pennsylvanian) of Greene County, Indiana: Indiana Dept. Conserv. Geol. Surv. Bull., 29:1-75.
Zalessky, M. D., 1904, Végétaux fossiles du Terrain Carbonifère du Bassin du Donetz, I, Lycopodiales: Mem. Comité Geol. St. Petersbourg, N.S., 13:1-126, pls. 1-14.
Zeiller, M. R., 1884, Cones de fructification de Sigillaires: Ann. Sci. Nat., 6 Ser. Bot., 19:256-80, pls. 11-12.