THE MILL CREEK FLORA, ROCA SHALE, WABAUNSEE COUNTY, KANSAS

by

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CONTENTS

TEXT

ILLUSTRATIONS

Plates

THE MILL CREEK FLORA, ROCA SHALE, WABAUNSEE COUNTY, KANSAS

INTRODUCTION

Kansas is richly endowed with fossil plant remains. Since the mid-1800's, amateur rock collectors, natural scientists, geologists and paleobotanists have recognized this wealth of material and have come to the state to collect. The majority of the collections made have been from outcrops of Tertiary, Cretaceous, Permian and Pennsylvanian rocks. This work has revealed a great taxonomic diversity of plants through geologic time and has provided data linking Kansas fossil floras with similar floras in other regions of North America and the rest of the world.

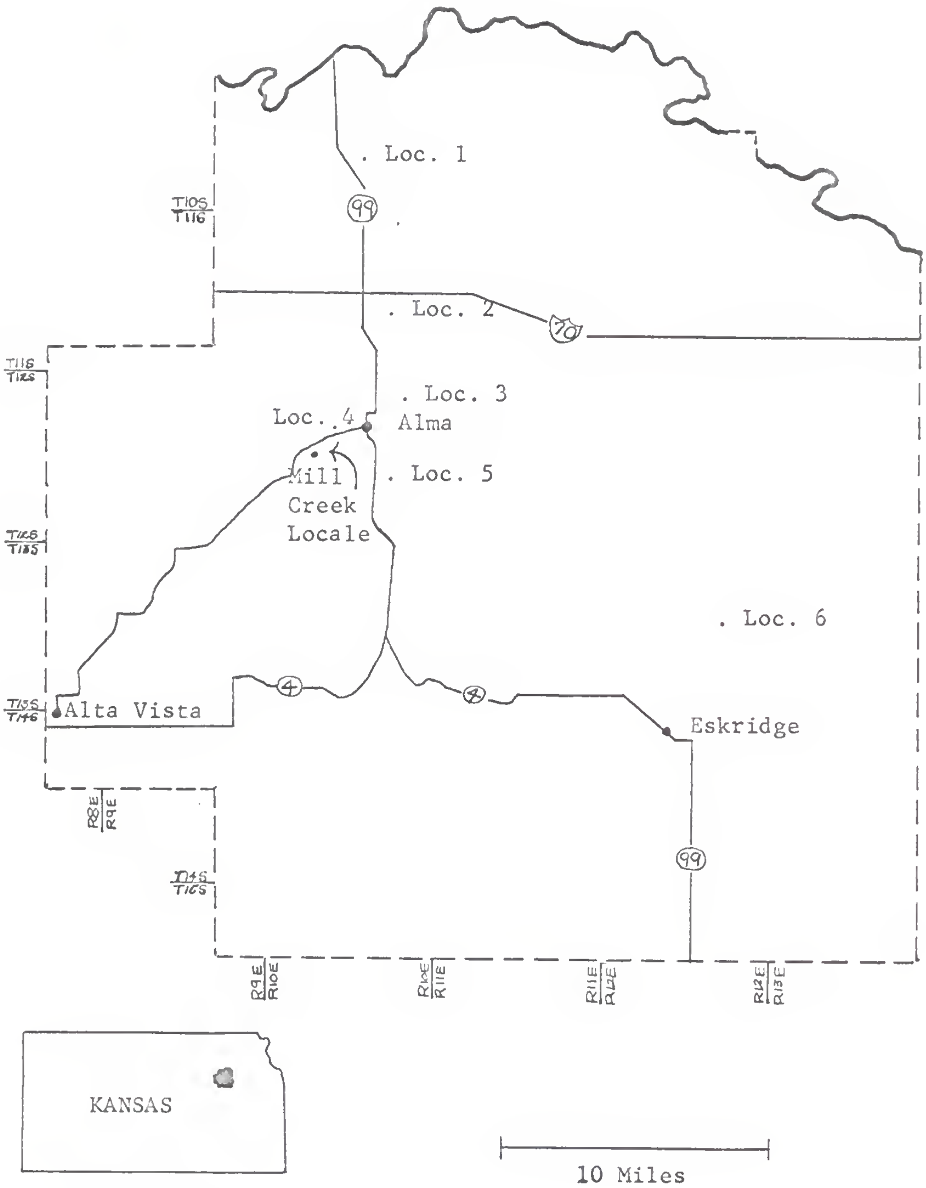
These fossil floras display a wide range of preservational types. Plant fossils of the state have been preserved as petrifications (mostly in coal balls), compressions, impressions, casts and molds. Most recent studies on the fossil plants of the state have been concentrated on the material in coal balls. These irregular masses of petrified plant remains occur in rocks of the Pennsylvanian System in southeastern Kansas (Andrews, 1946). The attention focused upon these petrifactions is certainly justified as excellent anatomical studies have been completed by many workers. Utilizing this material, paleobotanists have pieced together morphological and evolutionary stories which could not have been so clearly elucidated with fossils of other preservational types. The only disappointing aspect of this work has been an almost total lack of interest in plant fossils of other preservational types.

In this thesis, a compression flora occurring in a limestone lentil of the Roca Shale Formation, Council Grove Croup, Gearyan Stage, Lower Permian Series, Permian System is described. The fossil-bearing limestone crops out in a small area of the NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 29, T. 12 S., R. 10 E., Wabaunsee County, Kansas. The site is on the Ray Dieball farm, 3.6 miles southwest of the west city limits sign of Alma, Kansas, on Mill Creek Scenic Drive. The fossil-bearing unit is on a northwest-facing stream cut on the south bank of Mill Creek and is south of the Chicago, Rock Island and Pacific Railroad tracks (Plate 1). The outcrop is approximately 70 miles south of the northern border of the state and 100 miles west of the state's eastern border and is near the eastern border of the exposed Permian rocks of east-central Kansas (Plate 2). Although this flora contains few species, it is important because paleobotanical reports and detailed descriptions of plant fossils from the Kansas Permian System are few. The flora also provides some evidence for cyclic ecological conditions in the Upper Paleozoic of the state as postulated by Elias (Moore, Elias & Newell, 1936). This fossil plant assemblage also provided a comparison with the compressional flora from the Pennsylvanian rocks of the state as studied by Cridland, Morris & Baxter, 1963.

EXPLANATION OF PLATE I

Map of Wabaunsee County showing Mill Creek Locale and locations of field checks on the Roca Shale.

PLATE I

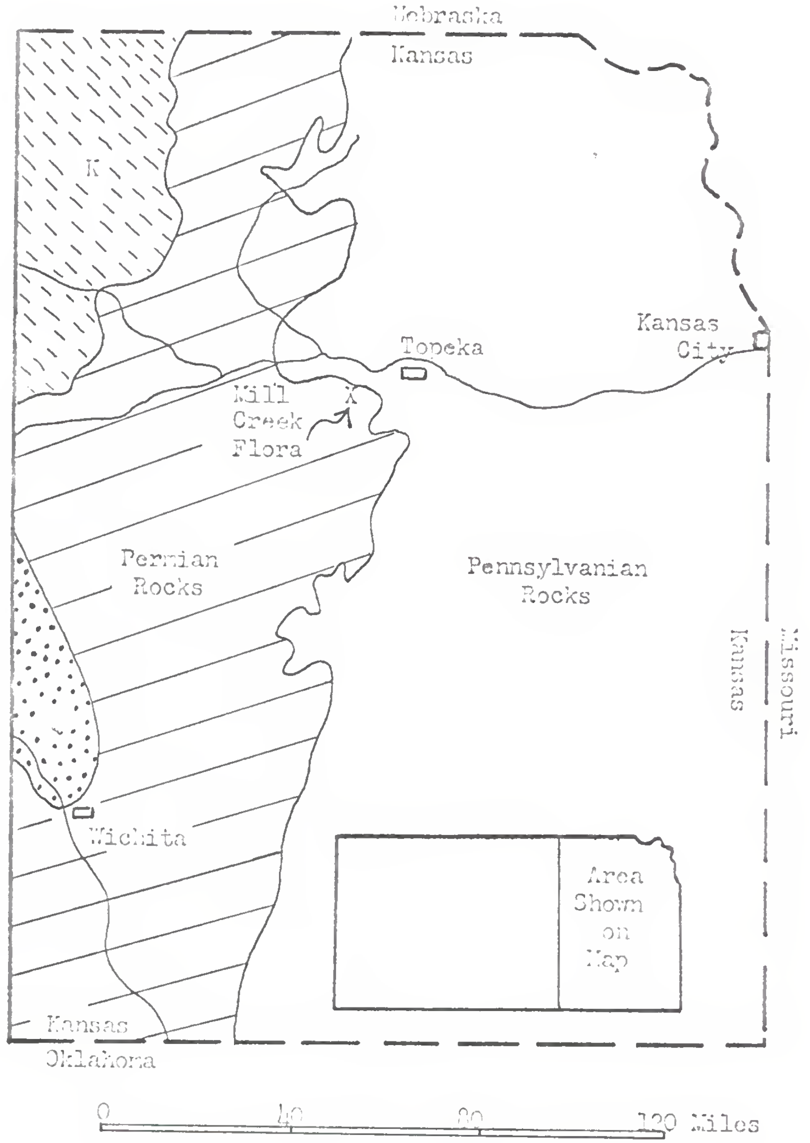


Index Map

EXPLANATION OF PLATE II

Geologic sketch map showing location of Mill Creek Flora.

PLATE II


Nebraska
Kansas
K
Topeka
Kansas City
Mill Creek Flora
Permian Rocks
Pennsylvanian Rocks
Kansas
Missouri
Wichita
Area Shown on Map
Kansas
Oklahoma
0
40
80
120 Miles

PREVIOUS WORK FROM THE KANSAS PERMIAN

Earliest works of a comprehensive nature on the floras from the Kansas Permian were by E. H. Sellards and David White in the early 1900's. Sellards' most significant contribution was in compiling previous work on plant fossils from the Kansas Permian (1908). Most of Sellards' own work was done on compression fossils occurring in younger Permian units than those considered here. White identified fossils found by other workers; these fossils were from a great many stratigraphic units and a great taxonomic diversity of plants is represented. One of White's works (1903) included a flora of comparable age to the Mill Creek Flora. A more detailed examination of both of these workers contributions will be given in a later section of this thesis.

Many records of plant fossils from the Permian do not include the proper stratigraphic designations and many fossils are misidentified. Where it has been possible, an attempt to establish the true identity of the fossils and the unit in which they occurred has been made; this method is certainly not free from error.

ACKNOWLEDGEMENTS

Dr. P. C. Twiss, Geology Department, Kansas State University headed the thesis committee and advised the author on the geologic aspects of the problem and his aid is greatly appreciated. The author is grateful to Dr. T. M. Barkley, Division of Biology, Kansas State University, who provided access to previous collections of fossils from the site, assisted in making new collections, read the manuscript of the thesis, and acted as a committee member. Dr. H. V. Beck, Department of Geology, Kansas State University, served also as a committee member and his general knowledge of the geology of the area provided the author with an instant source of information. Dr. T. Delevoryas, Yale University, provided the author with manuscripts dealing with the identification of the fossils themselves and without this material, identifications would have been very difficult. The author is indebted to landowner Ray Dieball for his hospitality, courtesy and cooperation. T. J. Hansen, Geology Department, Kansas State University helped the author immensely with field work and was always available to discuss any problems which the author encountered. The author wishes to acknowledge the assistance of the Kansas Academy of Science research grant that partly supported this program.

Special thanks must go to my wife, Ann Beth, who read the manuscript, suggested refinements and spent hours making the plates.

GEOLOGY

The geology of Kansas and of Wabaunsee County has been described by Merriam (1963) and Mudge and Burton (1959). If the reader is not familiar with the general geologic setting of the state or county, these two works are excellent sources.

The flora is in a limestone lentil of the Roca Shale which is in the lower one-third of the Council Grove Group, Gearyan Stage. The Roca Shale is part of a sequence of alternating (cyclothemic) limestones and shales which have been regarded as being typical marine sediments. The Roca Shale was originally named by Prosser in 1902 (Mudge and Burton, 1959). Prosser included the shale as a member of the Elmdale Formation which he defined as, "Yellowish to bluish shales, with thin beds of alternating limestones including 2 or 3 thicker ones. Thickness 130 feet. Underlies Neva Limestone and overlies the Americus Limestone." (Plate 3).

In 1927, G. E. Condra first referred to the unit as the Roca Shale, described it also as a member of the Elmdale Formation and stated that this formation was of Pennsylvanian age. Condra described it as "a bluish-gray, olive-green and reddish argillaceous shale with thin seams of fossiliferous limestone in the upper part. It overlies the Howe Limestone member and underlies the Neva Limestone." (Plate 3). The fossils that were described from the limestones in the Roca Shale were incidentally invertebrates and not plant fossils. The unit was named for the city of Roca in Lancaster County, Nebraska.

EXPLANATION OF PLATE III

Stratigraphic Nomenclature

Neva Limestone Member, Grenola Limestone through Americus Limestone Member, Foraker Limestone

	Prosser, 1902	Condra, 1927	Condra, 1935			Moore, 1936	
PENNSYLVANIAN SYSTEM	Neva Ls.	Neva Ls.	Grenola Ls.	Neva Ls.	PERMIAN SYSTEM	Grenola Ls.	Neva Ls.
	Elmdale Fm.	Roca Sh.		Salem Point Sh.			Salem Point Sh.
				Burr Ls.			Burr Ls.
				Legion Sh.			Legion Sh.
				Sallyards Ls.			Sallyards Ls.
			Roca Sh.			Roca Sh.	
		Howe Ls.	Red Eagle Ls.	Howe Ls.		Red Eagle Ls.	Howe Ls.
		Bennett Sh.		Bennett Sh.			Bennett Sh.
		Glenrock Ls.		Glenrock Ls.			Glenrock Ls.
		Johnson Sh.	Johnson Sh.			Johnson Sh.	
		Long Creek Ls.	Foraker Ls.	Long Creek Ls.		Foraker Ls.	Long Creek Ls.
		Hughes Creek Sh.		Hughes Creek Sh.			Hughes Creek Sh.
	Americus Ls.	Americus Ls.		Americus Ls.			Americus Ls.

The next major revision of the stratigraphic terminology was in 1935 when Condra elevated the Roca to a formation and said that it was separated from the Neva Limestone by the Salem Point Shale, the Burr Limestone, the Legion Shale and the Sallyards Limestone. At this time the unit was still placed in the Pennsylvanian System. In 1935 R. C. Moore, revising the systematic boundary between the Permian and the Pennsylvanian in Kansas, transferred the Roca Shale to the Permian System. This last change brings the unit to its present status of being a component of the Permian System and stratigraphically being between the Sallyards Limestone and the Howe Limestone (Plate 3).

In Kansas, Mudge (1962) described the Roca Shale as a gray, gray-green and green silty to clayey shale that contains thin beds of purple and maroon shale. The maroon beds of shale thicken toward the south and the unit consists largely of these red beds in Oklahoma. Mudge also noted that the limestone units, which are of great importance to this thesis, occur only in the northern part of Kansas and that they are generally argillaceous but are in places dense beds of limestone.

In Wabaunsee County, the Roca Shale has been field-checked by the author at the locations shown on Plate 1. Using these checks and the measured stratigraphic sections of others the unit can be considered as being composed of gray to gray-green beds of shale. Locally, lenses of red to yellow shale are in the middle of the unit. Throughout the county one or two lentils of limestone occur in the upper part of the Roca Shale. In areas where the limestone lenses out, it is replaced by white, highly calcareous beds of shale. These limestone lentils do not contain the abundance of invertebrate fossils that were reported in other parts of the state.

In the outcrop on Mill Creek only the upper part of the Roca Shale is exposed (Plate 4). Contrary to the other outcrops of Roca Shale in the immediate area, there are two lentils of limestone in the upper part of the unit. The uppermost limestone lentil in the outcrop at Mill Creek seems to correspond in stratigraphic position to the single lentil seen in other outcrops studied. This seemingly implies that it is the lower limestone lentil which is unique to the Mill Creek locale. It is at the base of this lower limestone lentil that the plant fossils are found. The limestone is very argillaceous and is not as dense as the overlying lentil. The lower six inches of this limestone contains the greatest abundance of plant remains and there are two levels of remains found in the unit. The upper layer of plant material is very fragmental in nature and was not largely useful in this thesis. The lower layer of plant material is at the contact between the limestone and an underlying bed of yellow-green shale and this is the level where the best plant fossils are found. The best fossils come from a zone in the limestone that is not more than two inches in thickness. The limestone is difficult to quarry in large slabs as it is highly jointed and the fossil occurrence is only about 30 feet.

EXPLANATION OF PLATE IV

Measured section from the Burr Limestone Member of the Grenola Limestone into the Roca Shale exposed in a stream cut in the $NW\frac{1}{4}$ $SW\frac{1}{4}$ sec. 29 T. 12 S, R. 10 S.

PLATE IV

Grenola Limestone:

Burr Limestone Member:

	Feet
Limestone, hard, gray to tan: thick-bedded------------	2.9
Shale, clayey, dark-gray; brachiopods common----------	1.5
Limestone, hard, gray to tan; thick-bedded------------	2.5
Thickness	6.9

Legion Shale Member:

Shale, clayey, dark-gray to buff; non-fossiliferous-------------------------------------	5.1
Thickness	5.1

Sallyards Limestone Member:

Limestone, dense, white to buff; thick-bedded; abundant crinoid columnals, gastropods, pelecypods, and fragments of other fossils---	1.0
Thickness	1.0

Roca Shale:

Shale, clayey, tan to buff------------------------------	1.8
Limestone, argillaceous, soft, gray; iron oxide stained; plant fragments common-----------------------	1.1
Shale, clayey, tan to gray------------------------------	0.5
Limestone, soft, gray to white; iron oxide stained; plant fossils common at base--------------------------	1.0
Shale, clayey, yellow-green to light-gray---------------	3.4
Base Covered:	
Thickness	7.8
Total Thickness	20.8

Samples were taken from the units in the outcrop on Mill Creek (Plate 4) to see if any significant differences between the clay mineral content of the units containing abundant marine fossils, such as the Sallyards Limestone and the plant fossil-bearing unit occurs. X-ray diffraction analyses showed no significant differences in the clay mineral suites in the units. This datum is thus not useful in the determination of a possible site of deposition for the plant material. The fine-grained nature of the sediments has allowed the delicate features of the plants to be preserved.

CHARACTER OF THE "MILL CREEK FLORA"

The fossil locale on Mill Creek has been known to staff members of the Botany Department, Kansas State University, for many years. It has been a regular field trip stop for paleobotany classes and literally hundreds of pounds of material have been collected from the site and many of these fossils are stored on the campus. The systematic description of the fossils presented here is based on a study of both fossils in these collections as well as those in new collections made by the author. The fossils described are stored in the thesis collections of the Geology Department, Kansas State University. They are classified by specimen number given in the description.

A brief statement is deemed necessary about the techniques used in the identification of the specimens included in this thesis. The lack of anatomical detail in compression fossils as well as their fragmentary nature makes it necessary to use form genera in the naming process. The specific differences between form genera are not always definite and the accuracy of the identifications may suffer for this reason. The naming of the specimens in this thesis was done by comparing the specimens to specimens from other localities that have been previously collected and identified, by asking the opinion of paleobotanists having experience identifying similar fossils, and by comparing the specimens with photographs and drawings from previous published reports.

Approximately four hundred specimens were studied for this thesis and the percentages given with the systematic descriptions reflect relative abundance of each species computed on this basis.

SYSTEMATIC DESCRIPTION OF THE FLORA

Division Pteropsida

Class Filicineae

Order Marattiales

Pecopteris (Brongniart) Sternberg
Tentamen, p. xvii., 1825, Leipsic and Prague

Pecopteris arborescens (Schlotheim) Brongniart Specimen 1. Plate 5, Fig. 1

This species makes up roughly five percent of the plant fossils found at the Mill Creek locale. The "better" specimens found lack organic matter and are thus impressional fossils rather than compressional in nature. All of the specimens are fragmentary with segments of fronds predominating.

This form genus is used for marattiaceous tree-fern foliage and this particular species is well-known from the Upper Pennsylvanian and Permian floras of Kansas.

The Mill Creek specimens have the pinnae arising from the main rachis at right angles with the individual pinnules being nearly at right angles to the pinna midrib. The individual pinnules touch each other at their mutual borders or are only slightly separated. Some specimens have pinnules which are united at their bases. The pinnules reach an average length of 3 mm. The midvein of the pinnules is straight or only slightly arched and extends the entire length of the pinnule. Lateral veins depart from the midvein at nearly a forty-five degree angle and are unbranched and only slightly arched as they extend to the margin of the pinnules. Generally, only five or six lateral veins are on either side of the midvein.

These specimens compare favorably with illustrations of the same species in Remy & Remy (1959), Gothan & Remy (1957), and Sellards (1908). Sellards apparently had a much larger specimen of the species and was able to describe the configuartion of the entire frond. He stated that the fronds are tripinnate and have a strong rachis which reaches a diameter of 2 cm or more. The primary pinnae of Sellards' specimen were reportedly 40 to 50 cm in length and had a width of 10 to 20 cm.

The geologic range of the species in Kansas was described by Sellards (1908) as being from the Chanute Shale (Pennsylvanian) through the Wellington Formation (Permian). Cridland, Morris & Baxter (1963) have clarified Sellards' comment as they stated that the species is in the following Pennsylvanian units; the Scranton Shale, the Tecumseh Shale, the Lawrence Shale, the Stranger Formation and the Chanute Shale. The species has also been reported from the following Permian units; the Three Mile Limestone (Mamay, written communication, 1968), the Winfield Limestone (Sellards, 1908), and the Wellington Shale (Sellards, 1908).

Pecopteris hemiteloides Brongniart   Specimen 2

No photographs of this species are available; it occurs only as very fragmentary remains of fronds and isolated pinnules in the flora. It makes up only one percent of the Mill Creek assemblage.

The specimens from the Mill Creek locale are very similar in branching and venation pattern to that of Pecopteris arborescens. The two species differ in that Pecopteris hemiteloides has a greater number of lateral veins in the pinnules than does Pecopteris arborescens. Where P. arborescens has only five or six lateral veins on either side of the midvein, P. hemiteloides has eight to ten on either side of the midvein.

These specimens show similarities with specimens given the same name by Sellards (1908) and illustrated by Remy & Remy (1959).

The species has not been reported from the Pennsylvanian System of Kansas but it has been reported from the following Permian units; the Elmdale Shale (White, 1903) and the Wellington Shale (Sellards, 1908). The Elmdale Shale was a very general term encompassing those units from the base of the Neva Limestone to the top of the Americus Limestone. This stratigraphic interval includes the unit now known as the Roca Shale (Plate 3). Unfortunately, the general stratigraphic description of the flora from the "Elmdale Shale" does not allow correlation with present stratigraphic terminology.

Pecopteris cyathea (Schlotheim) Brongniart Specimen 3. Plate 5, Fig. 2

Only one specimen assignable to this species has been found at the Mill Creek site. The specimen found is only a segment of a frond and unfortunately, the venation is seen in only a few pinnules as the specimen is only fairly well preserved.

The specimen found in this flora gives the appearance that this foliage genus was perhaps more filmy than those specimens of Pecopteris already described. The configuration of the branching differs only slightly from that of P. arborescens in that individual pinnules depart the pinna midrib at slightly more than ninety degrees. The pinnules of this specimen are more elongated than in other species. The midvein of the pinnules is straight or only slightly arched and does not extend the entire length of the pinnule. The lateral veins come off of the midvein at nearly a forty-five degree angle and they dichotomise at least once as they extend to the margins of the pinnule.

The specimen compares favorably with illustrations of the same species in Remy & Remy (1959) and Gothan & Remy (1957). Sellards (1908) expressed doubt that P. arborescens and P. cyathea should be regarded as distinct species. Cridland, Morris & Baxter (1963) chose not to separate the two species as they could not see any appreciable difference in the venation pattern of the specimens that they had for study. The author believes that enough difference in the venation pattern does exist to be a distinguishing feature between the two species.

The geologic range of this species is uncertain because many specimens assignable to the species have been included with P. arborescens. Sellards (1908) reported this species in the Scranton Shale of the Pennsylvanian System and the Wellington Shale of the Permian System. This thesis establishes the occurrence of the species in the Roca Shale.

Asterotheca Presl
K. Bohmische Gesell. Wiss., Prag, Abh., Band 4, p. 261-379, 1847

Asterotheca sp. Specimen 4 Plate 5, Fig. 3

Several specimens of this genus have been found at the fossil site; they compose nearly five percent of the flora. The specimens have been largely replaced by limonite and are so poorly preserved that no specific determination could be made. The form genus is applied to the sporangia-bearing foliage of Pecopteris. Because of the shape and configuration of the pinnules, these specimens resemble Asterotheca hemiteloides.

Division Spermopsida

Class Pteridospermaceae

Order Medullosales

Alethopteris Sternberg
Tentamen, p. i-vlii, 1825, Leipsic and Prague

Alethopteris grandini (Brongniart) Goeppert Specimen 5, Plate 6, Fig. 1.

This species, the dominant component of the Mill Creek Flora, makes up some forty-five percent of the flora. The specimens collected include isolated pinnules, pinnae and some nearly entire fronds. Much organic matter remains in many specimens while others are mere impressions. The great abundance of specimens has allowed identification of the species.

This form genus was erected for the foliage of the medullosan seed ferns and this particular species of the foliage is common

EXPLANATION OF PLATE V

Fig. 1. — *Pecopteris arborescens* x 3/4

Fig. 2. — *Pecopteris cyathea* x 3/4

Fig. 3. — *Asterotheca* sp. x 3/4

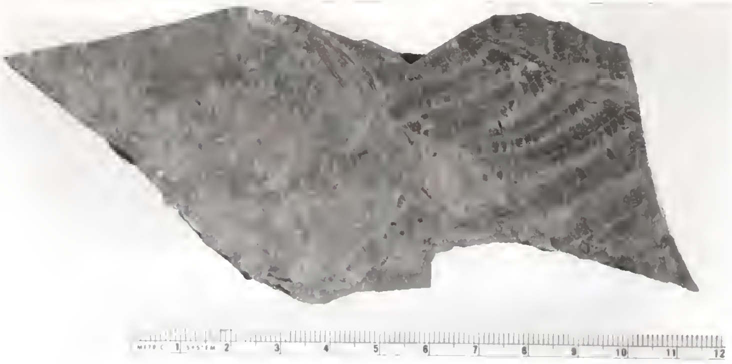


Figure 1

Figure 2

Figure 3

throughout the Pennsylvanian System of Kansas, but is not a well-known component of the Permian floras of the State.

The specimens from this flora reveal that the fronds of *Alethopteris grandini* are quite large and are usually several times pinnate at their base. The rachis of the fronds found at the site are very strong as some of them reach up to 3 cm in diameter. Some workers have noticed longitudinal striations on the rachis but such striations are not apparent on the material found at Mill Creek. The largest fronds reach a length of 60 to 75 cm and a width of 20 to 30 cm. The primary pinnae of these fronds depart the rachis at nearly right angles and secondary pinnae are at right angles to them. The individual pinnules depart the pinna midrib at an acute angle. The pinnules do not usually touch along their mutual borders except at the area near the base of the pinnules. In many of the Mill Creek specimens, the venation of the pinnules is clearly seen and they show that the midvein of the pinnules is very distinct and that it continues to the apex of the pinnules. The lateral veins depart the midvein at nearly a right angle and they branch once before reaching the border of the pinnule. A study of the several specimens assignable to the species from this flora reveals that some specimens (5a, for example) show a pronounced dimorphism in the foliage pattern as pinnae bearing several individual pinnules (as in *Pecopteris*) occur near the base of the pinna midrib while near the tip of the pinna these are replaced by single elongated pinnules. An excellent photograph of this dimorphism is given in Sellards (1908). Two specimens from the flora exhibit the "fiddlehead" (specimen 5b) so typical of ferns showing that the seed ferns also had circinate vernation.

The genus Alethopteris has often been closely associated taxonomically with the form genus Callipteris or Callipteridium. Leisman (1960) stated that Alethopteris pinnules have a prominent midvein which extends to the apex and lateral veins which are disposed almost at right angles to it. He describes Callipteridium as having pinnules in which the midvein dissolves before reaching the apex and lateral veins leaving it at a low angle. The author is still not certain that there is a generic difference between the two species but Leisman (oral communication) has concurred that the specimens collected from Mill Creek belong to the genus Alethopteris.

Alethopteris grandini has not been reported from any other Permian unit and no other species of this genus has been reported from the Permian either. One possible reason for this may be that the Permian boundary in Europe is paleobotanically regarded as that point where the genus Callipteris first appears. This may have caused some to use the term Callipteris in preference to Alethopteris when questionable specimens were found in "Permian" rocks. This point illustrates the fact that the paleontological boundary between two systems does not necessarily correspond to the boundary chosen for stratigraphic convenience. This species has been reported by Cridland, Morris & Baxter (1963) from the following Pennsylvanian units of the state; the Cabaniss Formation, the Chanute Shale, the Bonner Springs Shale, the Weston Shale, the Stranger Formation, the Lawrence Shale, the Scranton Shale, and the Root Shale.

Dolerotheca Halle
K. Svenska vetensk. akda. Handl., band 12, p. 1-103 pls. 1-15, 1933

Dolerotheca sp. Specimen 6 Plate 6, Fig. 2

The assemblage from the Mill Creek site is rather unusual in that it contains many well-preserved specimens assignable to this species. The species makes up some ten percent of the flora.

This form genus was established to include the microsporangiate bodies which were subsequently found attached to foliage of the medullosan pteriodosperms. The definitive study on this form genus was by Halle (1933) in which he dealt with compression fossils and devised an embedding technique which enable him to make specific determinations on the restorations which he constructed. Such a technique is necessary to ascertain the arrangement of the individual sporangia in the specimen. Only by using such restorations can accurate specific determinations be made. The author attempted to conduct some of these transfers and was unsuccessful. Other workers have assigned specific names to compressions of Dolerotheca, but the author believes that without the restorations described above specific determinations should not be attempted. Using this reasoning, specimens from Mill Creek are referred to as Dolerotheca sp. The specimens range in size from 2 to 5 cm in diameter and only a hint of the individual sporangia can be seen.

<u>Holcospermum</u> Nathorst
Zur Fossilen Flora der Polarlander; 110 p., 15 pls., Stockholm, 1914

<u>Holcospermum</u> sp. Specimen 7. Plate 6, Fig. 3

This genus makes up only five percent of the Mill Creek Flora but these specimens are the most spectacular of the assemblage.

The form genus was constructed for compression fossils of the megasporangiate bodies of the medullosan pteriodosperms; they are the so-called "seeds" of the seed ferns. The genus probably corresponds to the genus <u>Triganocarpon</u> found as petrifactions, casts, and molds, but some uncertainty has led to placement of the specimens in another form genus. An excellent photograph of the genus <u>Holcospermum</u> is in Gillespie, Latimer & Clendening (1966) and from this illustration the identification of the Mill Creek specimens was made. The discovery of seeds like this attached to fern-like foliage led to the seed fern concept.

The specimens at the Mill Creek site are roughly oblate and are about 5 cm long and 3.5 cm wide. The external ribbing pattern, best shown in casts and molds of these "seeds", is very apparent in specimens from the fossil site.

EXPLANATION OF PLATE VI

Fig. 1. — *Alethopteris grandini* x 3/4

Fig. 2. — *Dolerotheca* sp. x 3/4

Fig. 3. — *Holcospermum* sp. x 3/4

PLATE VI

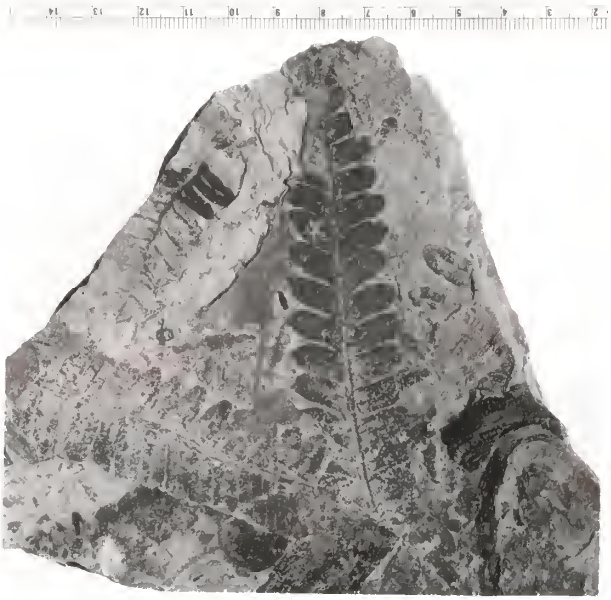


Figure 1

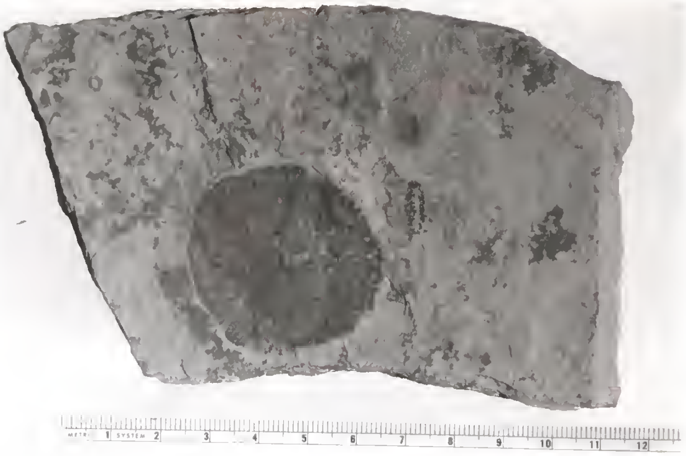


Figure 2

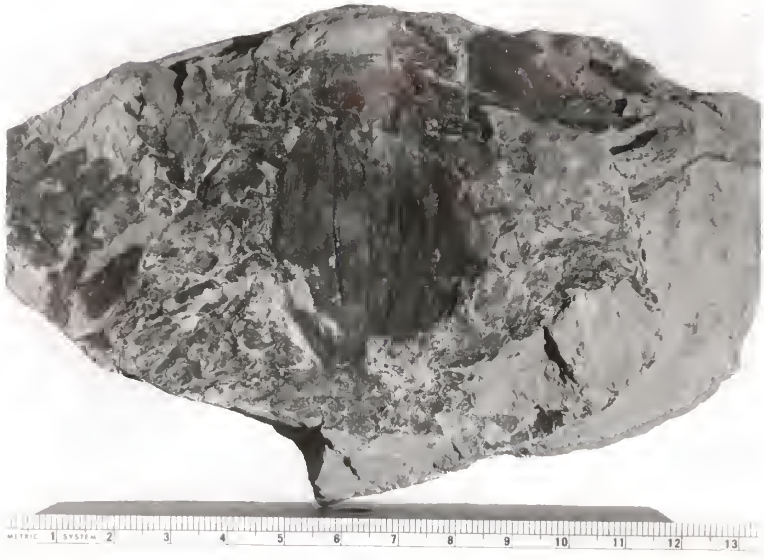


Figure 3

Medullosa Cotta
Die Dendrolithen in Beziehung auf ihren inneren Bau:
89 p., 18 pls., Dresden and Leipzig, 1832

Medullosa sp. (?) Specimen 8

This genus is questionably present as rather large carbonized compressions which compose twenty-five percent of the flora. This form genus is used for the stems of the medullosan seed ferns. The size of the stems and their great abundance in the flora suggest an association with the foliage, *Alethopteris*, which is also very abundant. No foliage has been found attached to these stems. Because the stems show no external ornamentation no specific identification of them is possible. The largest specimen was 40 cm in diameter.

Stewart and Delevoryas (1956) illustrated their reconstruction of the seed fern *Medullosa* as being 12 to 15 feet tall tree with large drooping fronds of the *Alethopteris* or *Neuropteris* type. They stated that in many cases pinnules were replaced by seeds or microsporangiate bodies. Thus the genera *Medullosa*, *Alethopteris*, *Dolerotheca* and *Holcospermum* can presumably be regarded as different parts of one plant. None of these single parts has ever been found attached to another in the Mill Creek assemblage.

Order Lyginopteridales

<u>Sphenopteris</u> (Brongniart) Sternberg
Tentamen, p. i-viii, 1825, Leipsic and Prague

<u>Sphenopteris</u> sp. Specimen 9

Only fragmentary remains of this seed fern foliage have been found; these specimens make up a mere one percent of the Mill Creek Flora. Unfortunately, the remains are not complete enough to allow a specific identification. The isolated pinnules of the species are lobate and the veins of the pinnules dichotomise twice through the length of the pinnule. Such specimens seem to be assignable to the genus <u>Sphenopteris</u> as illustrated by Sellards (1908) and others. This is the only form genus assignable to the Lyginopteridales in this fossil assemblage.

Division Sphenopsida

Class Calamarieae

<u>Calamites</u> Schlotheim
Die Petrefactenkunde auf ihrem jetzig Standpunkte durch die Beschreibung seiner Sammlung versteinerter und fossiler Uberreste des Thier und Pflanzenreichs der Vordwelt erlauter; lxii, 437 p., Gotha, 1832

<u>Calamites</u> sp. Specimen 10. Plate 7, Fig. 1

Only two specimens assignable to this species have been found at the Mill Creek site. This form genus was constructed for fossil specimens of jointed stems typical of the Division Sphenopsida. Specific identifications in the genus have historically been accomplished by comparisons of the nodal anatomy of the specimens. Unfortunately, the specimens studied here are not well enough preserved to allow such description. These stems are characteristically jointed and ribbed longitudinally and the larger of the two specimens is 3 cm in diameter.

Asterophyllites Brongniart
Mus. histoire nat. Paris Mem., tome 8, p. 203-348

Asterophyllites equisetiformis (Schlotheim) Brongniart   Specimen 11

A few generally well-preserved specimens of this species have been found at the locale and they form about two percent of the total flora. The best specimen of the species at Mill Creek (Specimen 11) was from a previous collection and was unfortunately coated with lacquer making photographing of the specimen impossible.

The specimens from Mill Creek all have rather robust main branches that average 0.5 cm in diameter. On the branches are found whorls of leaves which characterize the foliage of the Division Sphenopsida. The Mill Creek specimens show whorls of six or seven leaves which are borne regularly along the branches. The individual leaves are spike-like and extend upward almost to the node above; the average leaf is nearly 2 cm long. These specimens are well-preserved as there is no curling shown in any of the leaves. One specimen (11a) is remarkable because it shows the areal part of the plant as well as the underground rhizome. The specimen has three areal branches originating from the rhizome and the specimen must have been washed free from its substrate and carried in an aqueous environment until it was preserved.

Cridland, Morris & Baxter (1963) stated that the species is in the following Pennsylvanian units of Kansas; the Cabaniss Formation, the Stranger Formation, the Lawrence Shale, the Kanwaka Shale, the Scranton Shale, and the Root Shale. The only previous report of the species from the Permian System of Kansas was by White (1903) in his study of the Elmdale Shale.

Annularia Sternberg
Versuch einer Geognostischen Botanischen Darstellung der Flora der Vorwelt; Band 1, Teil 2, p. 1-33, 1822

Annularia stellata (Schlotheim) Brongniart Specimen 12. Plate 7, Fig. 2

This is not a common species in the flora; it makes up only one percent of the assemblage. The specimens are well-preserved and are easily identified. This other form genus for calamarian foliage differs from *Asterophyllites* in that the leaves in the individual whorls are more nearly at right angles to the main branch. In *Asterophyllites*, the leaves extend upward from the node to overlap the node above. The flattened aspect of the whorls is shown on Plate 7, Fig. 2.

The specimens at Mill Creek have robust stems that reach 0.5 cm in diameter. The whorls of leaves are evenly spaced along the branch and seem farther apart than the leaf whorls in *Aster-ophyllites* because the leaves do not overlap the node above them. The individual leaves differ also from those of *Asterophyllites* in being blade-shaped and there are usually more leaves per whorl than in *Asterophyllites*. The specimens of *Annularia* have from

EXPLANATION OF PLATE VII

Fig. 1. — _Calamites_ sp. x 3/4

Fig. 2. — _Annularia_ _stellata_ x 3/4

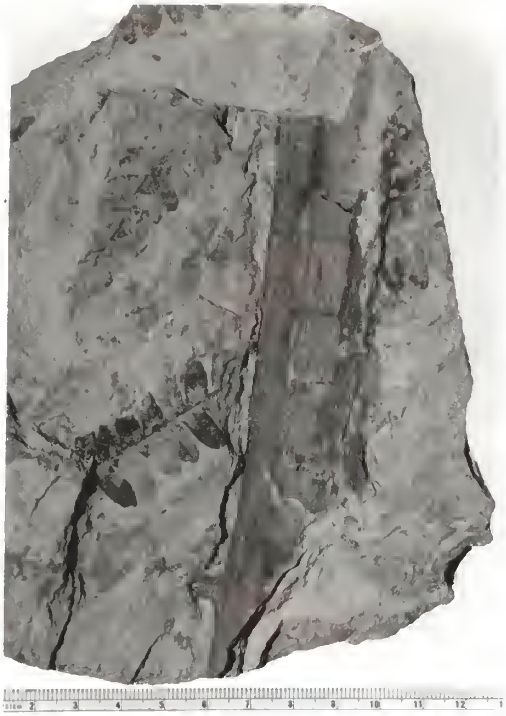


Figure 1

Figure 2

9 to 12 leaves per whorl and the leaves are somewhat shorter than those of Asterophyllites.

The species has not previously been reported from the Permian System of Kansas, but Cridland, Morris & Baxter (1963) have reported the species in the following Pennsylvanian units; Cabaniss Formation, Labette Shale, Chanute Shale, Stranger Formation, Lawrence Shale, and Tecumseh Shale.

OTHER FOSSILS ASSOCIATED WITH THE FLORA

Mascerations of the fossil-bearing limestone have yielded a rich microflora of palynomorphs which the author has been unable to identify.

A closer examination of all specimens of the stem genera in the flora has revealed a great number of coiled worm cases of the Spirorbis type (See Plate 6, Fig. 1 and Specimen 8). The worm cases are completely lacking in the matrix material and on any other plant element of the flora.

Mamay (1966) and other workers have cited many examples of Spirorbis attached to stems and foliage of fossil plants. Most of these workers have reported a selectivity in the choice of attachment of these worm cases and have attempted to explain this selectivity in different ways. As an example, Mamay (1966) found Spirorbis selectively attached to the foliage of seed ferns from Texas and suggested two explanations. The foliage may have dangled into a surrounding body of water and emitted oxygen through stomata thereby creating a micro-climatic environment favorable for the growth and development of *Spirorbis* larvae. Similar reasoning was used to explain the presence of worm cases in parichnos scars of stems of *Lepidodendron*. Mamay also explained the selectivity as simply due to the decay process of organic matter; *Spirorbis* could favor the more bulky plant parts that would emit the greatest quantity of gaseous decay products.

Because the worm cases are on the stem genera of the Mill Creek plants and because these stems do not have parichnos scars or other similar features, the author believes that the selectivity was caused by the greatest quantity of decay products being produced by the stems.

SIGNIFICANCE OF THE FLORA

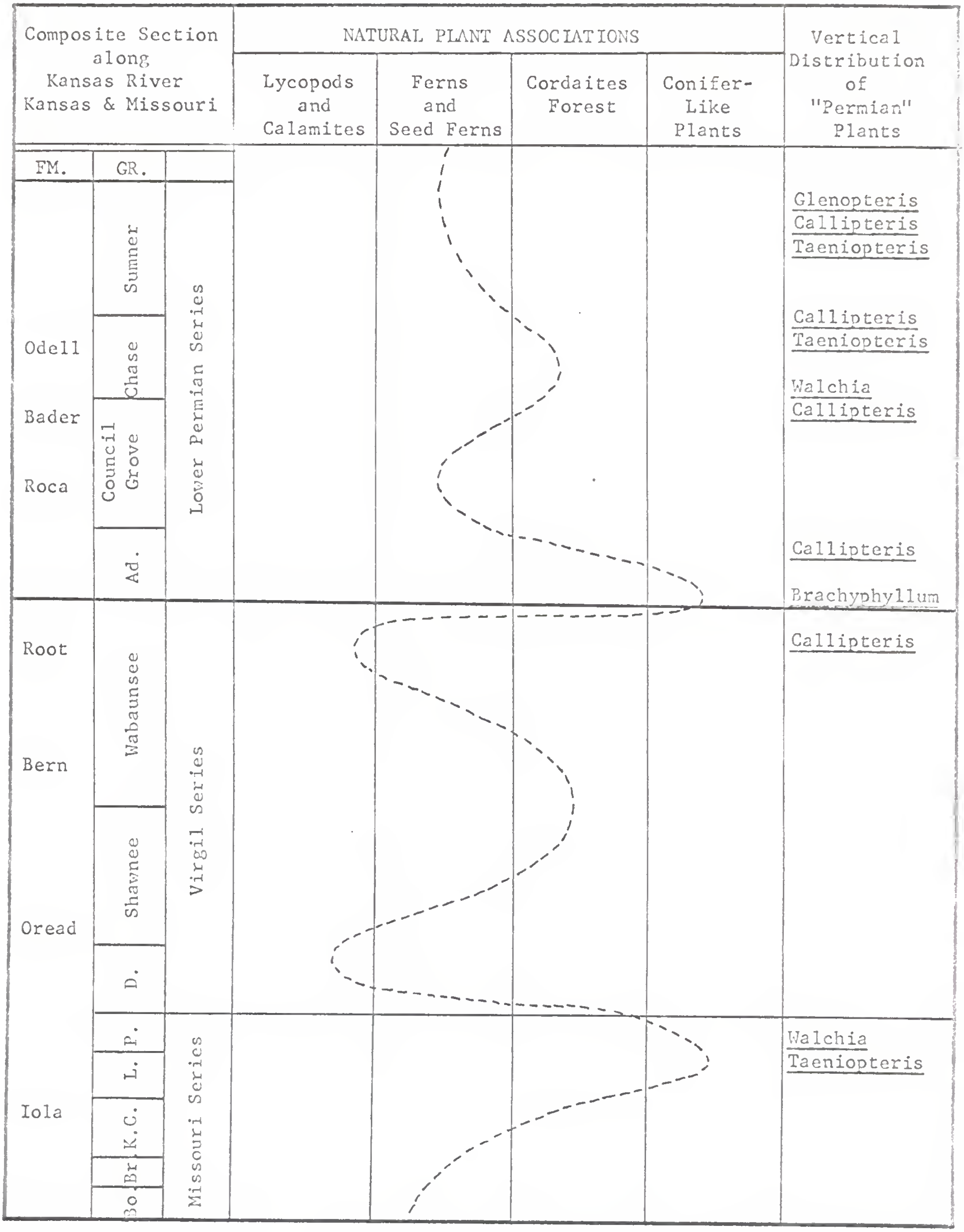
It is evident from the ranges of occurrence given with the systematic descriptions that this flora cannot be classified, without qualification, as being typically Permian. Indeed, many of the species are in no other Permian unit. This illustrates that circular reasoning often has been used with geologic dating techniques. For example, rocks of Permian age, are so designated because they contain fossils which another worker has found in "Permian" rocks. Inversely, certain fossils are considered Permian because a worker has reported them from rocks that have been designated Permian by other techniques. Such a situation was discussed in the use of the genus Callipteris as a factor in establishing a boundary between the Pennsylvanian and Permian systems. Workers have not considered use of the genus outside of the Permian System in the United States because Callipteris does not occur in other than Permian rocks in Europe. This discussion is certainly pertinent to Kansas because the stratigraphic boundary between the Pennsylvanian and Permian of Kansas has been changed often over the past 70 years. A better comparison of this flora with other Permian and Pennsylvanian floras is afforded by comparing it with floras listed by Cridland, Morris & Baxter (1963) and Sellards (1900, 1908).

A comparison of the floras reveals that the Mill Creek Flora with its calamarians, ferns, and seed ferns is closely aligned with floras of Pennsylvanian and Early Permian age but shows rather definite contrasts with the Late Permian floras which are dominated by conifer-like plants. This change in floral content may have been caused by the evolution of these conifer-like plants from the seed ferns or the change may have come about by changing ecological conditions.

The Pennsylvanian and Lower Permian floras reflect a hot, very humid environment and most of the plants could be considered hydrophytes. The Mill Creek assemblage, a representative hydrophytic assemblage, could certainly not have tolerated long periods of aridity. In contrast, the floras of the Upper Permian reflect much more arid conditions as they are composed of more xerophytic plants such as conifer-like species and species of hydrophytic genera which show a reduction in the size of leaves that is commonly associated with xerophytic plants. The stratigraphic sequence of the time periods gives similar climatic testimony. Pennsylvanian and Lower Permian strata are composed largely of sediments deposited in a marine environment (Mudge, 1962) pointing to humid conditions during the time of deposition. The stratigraphic contrast of the Upper Permian is as striking as the floristic one as these units are dominantly red, highly oxidized units which contain evaporite deposits such as salt and gypsum. These deposits tell of very arid climatic conditions.

This suggestion of moist climates in the Pennsylvanian - Lower Permian and arid conditions in the Upper Permian is not quite that simple as floras with xerophytic elements have been reported from the Pennsylvanian (Moore, Elias & Newell, 1936) and hydrophytic plants are known high up in the Permian. Stratigraphically, some complications arise when it is considered that intermingled with marine deposits of the Upper Pennsylvanian and Lower Permian are stringers of coal. With these factors in mind, Elias (1936) postulated cyclic environmental conditions in the Pennsylvanian and Permian of Kansas and these changes were not considered to be seasonal changes but were envisioned as alternation of long periods of warm, moist conditions with periods of more arid conditions. His evidence was based solely on the contents of floras from both ages of rocks. The author believes that the coal stringers may point to brief periods of aridity when the seas retreated and plants were able to occupy greater areas and produce that quantity of vegetation necessary for the formation of coal. Elias constructed a chart showing the results of his investigation and his proposed environmental fluctuations (Plate 8). The Mill Creek flora seems to fit Elias' general scheme well as one can see by noting the relationship between the stratigraphic position of the Roca Shale and the corresponding postulated climatic conditions on Plate 8. The chart shows that the time the Roca Shale was deposited was in a humid cycle and this fits well with the floral content. However, Elias' hypothesis is not the only explanation that fits the data; differences between "lowland" (hydrophytic) plants and "upland" (xerophytic) vegetation might explain the floral difference. The hydrophytic floras, occurring in the lowlands, would be the most prevalent in the fossil records because they

PLATE VIII


Composite Section along Kansas River Kansas & Missouri
NATURAL PLANT ASSOCIATIONS
Lycopods and Calamites
Ferns and Seed Ferns
Cordaites Forest
Conifer-Like Plants
Vertical Distribution of "Permian" Plants
FM.
GR.
Odell
Bader
Roca
Root
Bern
Oread
Iola
Sumner
Chase
Council Grove
Ad.
Wabaunsee
Shawnee
D.
P.
L.
K.C.
Br.
Bo
Lower Permian Series
Virgil Series
Missouri Series
Glenopteris
Callipteris
Taeniopteris
Callipteris
Taeniopteris
Walchia
Callipteris
Callipteris
Brachyphyllum
Callipteris
Walchia
Taeniopteris

have the best chance of being preserved. The upland floras would be far less abundant because their remains would be far more vulnerable to erosion. Thus we should recognize that we may be getting a very prejudiced view of the floras of the past. In other words, we could be dealing with paleogeographical differences instead of paleoclimatic fluctuations.

All these paleoecological studies have a common weakness in that none of the plants occurring in the Pennsylvanian and Permian floras are living today. We have no real knowledge of the exact ecological requirements of the fossil genera and only educated guesses can be made about such requirements by comparing them with similar modern plants having known ecological needs.

DEPOSITIONAL ENVIRONMENT

The specimens from the Mill Creek Flora are generally well-preserved and intact; almost entire fronds of some genera and even fragile pecopterid foliage occur. Little mechanical abrasion, pre-depositional decay, and curling of individual pinnules and leaves is observable. These factors all point to little transport of the material from its site of growth to the depositional site. Some have used the genus Spirorbis as an indicator of the salinity of the water but recent work demonstrates that Spirorbis could tolerate marine, brackish, and fresh water conditions making it useless as an indicator. The author speculates that this plant assemblage of the "lowland" type, grew in a swamp environment which was near either an arm of the Permian sea, an estuary leading into the sea, or a lagoonal area. Because abrasion of the material is minimal, it may have been covered by an advancing sea and the vegetative remains covered by fine sediments. Mamay (written communication, 1968) stated aptly about a similar flora, "they were probably transported only a short distance from their site of growth in a coastal swamp into an estuarine or lagoonal situation a short distance offshore."

SUMMARY

The Mill Creek Flora occurs in the Roca Shale, Council Grove Group, Gearyan Stage, Lower Permian System. It is a representative of the Pennsylvanian-Lower Permian swamp flora. The flora presumably grew in a lowland environment near the depositional basin during a warm, humid climatic interval of the Permian System.

REFERENCES

Andrews, H. N., 1946, Coal balls - a key to the past: Scientific Monthly v. 46, p. 1-12.

______, 1955, Index of generic names of fossil plants 1820-1850: U.S. Geol. Survey Bull. 1013, 262 p.

______, 1961, Studies in Paleobotany: John Wiley and Sons, Inc., New York, New York, 487 p.

Crevecoeur, F. F., 1902, List of fossil plants collected in the vicinity of Onaga, Kansas: Trans. Kansas Acad. Science, v. 18, p. 124-128.

Cridland, A. A., Morris, J. E., and Baxter, R. W., 1963, The Pennsylvanian plants of Kansas and their stratigraphic significance: Palaeontographican Abt. B, 112, Liefg. 1-3, p. 58-92.

Delevoryas, T., 1963, Morphology and Evolution of Fossil Plants: Holt, Rinehart and Winston, New York, New York, 189 p.

Fenneman, N. W., 1931, Physiography of the Western United States: McGraw-Hill Inc., New York, New York, 534 p.

Gillespie, W. H., Latimer, I. S., and Clendening, J. H., 1966, Plant Fossils of West Virginia: West Virginia Geological and Economic Survey, Education Series, Morgantown, West Virginia, 131 p.

Gothan, W., and Remy, W., 1957, Steinkohenflanzen: Essen, 248 p.

Jewett, J. M., 1959, Graphic Column and Classification of Rocks in Kansas: Kansas Geol. Survey, chart.

Leisman, G. A., 1960, The Morphology and anatomy of Callipteridium sullivanti: Amer. Jour. Bot. v. 47, p. 281-287.

Krumbien, W. C., and Sloss, L. L., 1963, Stratigraphy and Sedimentation: W. H. Freeman and Company, San Francisco, California, 487 p.

Mamay, S. H., 1966, Tinsleva, a new genus of seed-bearing callipterid plant from the Permian of north-central Texas: U.S. Geol. Survey Prof. Paper, 523-E, p. 1-15.

Merriam, D. F., 1963, The Geologic History of Kansas: Kansas Geol. Survey Bull., 162, 317 p.

Moore, R. C., Elias, M. K., and Newell, N. D., 1936, A "Permian" flora from the Pennsylvanian rocks of Kansas: Jour. Geol., v. 44, p. 1-31.

_____, Frye, J. C., Jewett, J. M., Lee, W., and O'Connor, H. G., 1951, The Kansas Rock Column: Kansas Geol. Survey Bull., 89, 132 p.

Mudge, M. R., 1967, Central mid-continent region, p. 93-124, in Paleotectonic Investigations of the Permian System in the United States: U. S. Geol. Survey Prof. Paper, 323,

_____, and Burton, R. H., 1959, Geology of Wabaunsee County, Kansas: U. S. Geol. Survey Bull., 1068, 210 p.

_____, and Yochelson, E. L., 1962, Stratigraphy and paleontology of the uppermost Pennsylvanian and lowermost Permian rocks in Kansas: U. S. Geol. Survey Prof. Paper, 323, 207 p.

Read, C. B., 1957, Paleobotanical zones in the Upper Paleozoic rocks: New Mexico Geol. Soc. Guidebook. 8th Field Conf. p. 257-258.

Remy, W., and Remy, R., 1959, Pflanzenfossilien: Berlin, 285 p.

Schoewe, W. H., 1949, The geography of Kansas: Trans. Kansas Acad. Science, V. 52, p. 261-333.

Sellards, E. H., 1900, Fossil plants in the Permian of Kansas: Trans. Kansas Acad. Science, v. 17, p. 208-209.

_____, 1908, Fossil plants of the Upper Paleozoic of Kansas: University Geol. Survey Kansas, 9 (special report on oil and gas), p. 386-480, pl. 44-69.

Shattuck, G. H., 1903, A fossil forest in Jackson County: Trans. Kansas Acad. Science, v. 19, p. 107-109.

Stewart, W. N. and Delevoryas, T., 1956, The medullosan pteridosperms: The Botanical Review, v. 22, p. 45-80.

White, D., 1903, Summary of the fossil plants recorded from the Upper Carboniferous rocks and Permian Formations of Kansas: p. 85-117 of Adams, Girty and White, 1903.

_____, 1904, Permian elements in the Dunkard Flora (abstract): Geol. Soc. America Bull., v. 14, p. 539-542.

_____, 1910, Permian floras in the western "red beds": Science n. s., v. 32, p. 223.

Wilmarth, M. G., 1957, Lexicon of geologic names of the United States: U.S. Geol. Survey Bull., 896, 2396 p.

THE MILL CREEK FLORA, ROCA SHALE,
WABAUNSEE COUNTY, KANSAS

by

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

A compression flora occurring in a limestone lentil of the Roca Shale, Council Grove Group, Gearyan Stage, Lower Permian Series, Permian System is described. The Roca Shale is a varicolored red-to-green unit which contains one or two lentils of limestone in the upper part. The flora is found only in the NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 29, T. 12 S., R. 10 E., Wabaunsee County, Kansas. It is composed of calamarians, ferns and seed ferns and thus may be regarded as a typical representative of the Late Pennsylvanian - Early Permian swamp flora. The assemblage lends support to Elias' postulated climatic fluctuations between moist and arid conditions in the Pennsylvanian and Permian systems of Kansas. The flora also provides additional data to the sketchy knowledge of Permian floras of the State. The lack of mechanical abrasion and pre-depositional decay presumably indicates that the material was transported only a short distance from its site of growth.