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A MISSISSIPPIAN FLORA FROM NORTHEASTERN
UTAH AND ITS FAUNAL AND
STRATIGRAPHIC RELATIONS

BY
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11. A Mississippian Flora from Northeastern Utah and its Faunal and Stratigraphic Relations, by Chester A. Arnold and Walter Sadlick. Pages 241-263, with 2 plates.

A MISSISSIPPIAN FLORA FROM NORTHEASTERN UTAH AND ITS FAUNAL AND STRATIGRAPHIC RELATIONS

BY
CHESTER A. ARNOLD and WALTER SADLICK

CONTENTS

Introduction	241
Locality	241
Occurrence	242
Acknowledgments	242
Stratigraphic relations	244
Lithologic description	244
Invertebrate paleontologic relations	248
Age implications of the flora	253
Systematic descriptions	255
The fauna	255
Phylum Brachiopoda	255
Genus <i>Inflatia</i>	255
The flora	257
Phylum Pteropsida	257
Genus <i>Cardiopteris</i>	257
Genus <i>Rhodea</i>	258
Genus <i>Caulopsis</i>	258
Phylum Sphenopsida	259
Genus <i>Archaeocalamites</i>	259
Phylum Lycopsidea	259
Genus <i>Lepidodendron</i>	259
Literature cited	259
Plates	(after) 261

INTRODUCTION

BECAUSE OF THE RARITY of fossil plants in the Mississippian of western North America, a small flora recently found in the western end of the Uinta Range in northeastern Utah is of special interest. Except for a few spores no plant fossils of Mississippian age have as yet been described from the western half of the continent.

LOCALITY

The flora was discovered by William T. McDougald, who collected a few specimens in 1952 in SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14, T. 2 W., R. 6 E. A larger collection was made by Arnold and Sadlick in 1960 in NE $\frac{1}{4}$ NE $\frac{1}{4}$ of the same section. Both localities are

in Summit County, Utah, on approximately the anticlinal axis of the Uinta Mountains about 2.5 miles east of the western end of the Uinta massif (Fig. 1 and Pl. I, Figs. 2, 3). The localities are reached by an unimproved dirt road that leads north from Beaver Creek along Wide Hollow, about 2 miles east of Kamas.

OCCURRENCE

The flora occurs in the basal beds of a newly named formation, the Soapstone Formation (Figs. 1-5). The exact stratigraphic position of the plant bed is difficult to determine because of the dense vegetational cover and slumping of strata in the area, but it is within an interval 58-69 feet above the base of the Soapstone Formation as determined by the Brunton-pace method.

The plant-bearing bed is a light olive-gray noncalcareous siltstone that shows blocky weathering. This layer pinches out 2-2.5 miles north and south of the collecting sites, hence the flora probably represents streamside vegetation that was brought into an estuary or bay by river currents. The fossil marine coral, *Nichelina*, occurs a few feet above the plant bed.

The plants are fragmentary, consisting of impressions bearing only small amounts of adhering carbon. Throughout the siltstone are minute flecks of black material that evidently represent macerated plant tissue. Five forms, not all of which are determinable to species, constitute the collection. For the most part the plants represent genera that range widely in the Mississippian, so they provide only approximate evidence concerning the age of the bed that contains them. They are, however, in agreement with the Chesterian age indicated by the associated invertebrate fossils. The most abundant plant is a species of *Cardiopteris* which is similar to *C. hirta* White from the Wedington sandstone of Arkansas.

ACKNOWLEDGMENTS

The identification of the plants and the analysis and interpretations of the flora was accomplished by Arnold, senior author. All credit for the stratigraphic treatment, maps, correlations, illustrations of sections, and Plate I belongs to Sadlick and to others who are cited. Financial aid for the text figures was secured by Sadlick through grant No. G-102 of the Research Programs Committee of Idaho State College. A grant from the Cottrell Research Corporation helped defray field expenses as well as the costs of the photographs of the new brachiopod shown on Plate I. Dr. W. P. Kitaj, professor of languages at Idaho State College, verified the grammatical agreement of the name *Inflatia bilobata*. Each author assumes full responsibility for the part he contributed to the manuscript. The manuscript

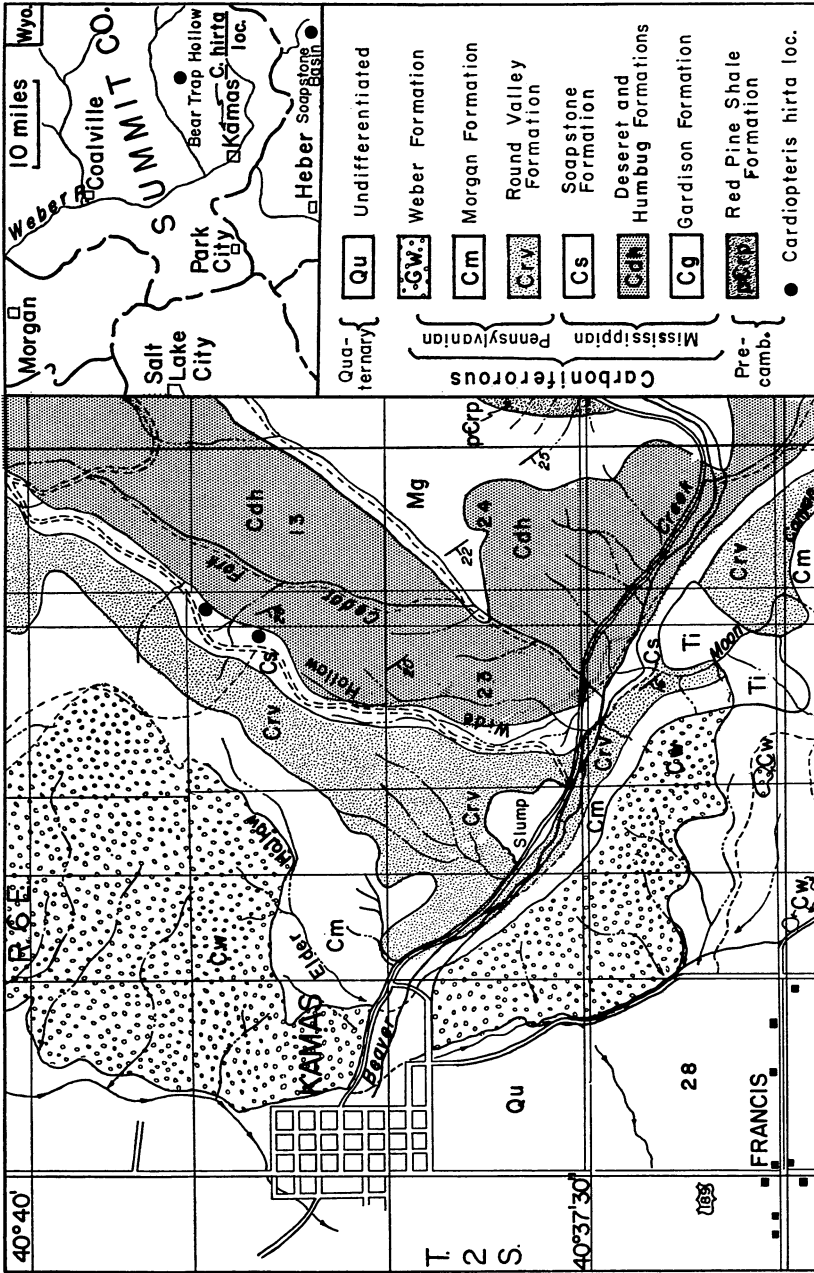


FIG. 1. Geologic map of the western end of the Uinta Mountains, Summit County, Utah, showing localities of the *Cardiopteris* flora.

was read by Dr. L. B. Kellum and Dr. R. V. Kesling, who offered helpful suggestions.

STRATIGRAPHIC RELATIONS

The following partial stratigraphic section of the Soapstone formation was measured near the two floral sites:

LITHOLOGIC DESCRIPTION	Thickness (Feet)	
	Each unit	Above base
Soapstone Formation:		
<i>Unit</i>		
5. Limestone, medium and light olive gray, weathers light yellow brown, earthy, silt grained. Contains <i>Michelina</i> , fragments of <i>Spirifer leidy</i> and <i>pellensis</i> , bellerophontid snails.	5	69-74
4. Siltstone, light olive gray, noncalcareous, contains many specimens of <i>Cardiopteris</i> , blocky weathering.	11	58-69
3. Covered slope, laterally the basal 10 feet is the same as unit 2.	54	4-58
2. Orthoquartzite, moderate brown, fine- to medium-grained, subangular and subrounded grains, ferruginous cement, contains a few clay galls, dense, tough, in one bed.	4	0-4
Paraconformable contact, locally no relief discernable.		
Humbug Formation:		
1. Limestone, olive gray, dense, sublithographic.	6	

The correlation of the lithostratigraphic unit containing the flora has been a controversial subject. Previous views have been published elsewhere by Crittenden (1959, pp. 71-73) who correlated the lithostratigraphic unit with the Doughnut Formation which seemingly is correlative to both the Great Blue and Manning Canyon formations (Fig. 5, central Utah column). Contrarily, Sadlick (1959, p. 80) correlated the unit in question with the Manning Canyon Formation based mainly on lithologic similarity (a dominance of dark gray clayey shale) and on the fact that both the Manning Canyon Formation and the Uinta Mountain "black" shale seemingly were no older than medial Chester.

The main cause for the correlation controversy stems from the fact that generally west of Salt Lake City an unstable basin developed during Carboniferous time, whereas in the vicinity of the Uinta Mountains, shelf conditions prevailed (see index map of Figure 4). Furthermore, geologic investigations in northern Utah have emphasized physical stratigraphy at the expense of fossil systematics; and third, paleontologists realize that

many species range throughout Chester strata, although locally several vertically restricted ecological zones (local range zones) developed.

Hence Sadlick has been investigating a few invertebrate species that seem to have a truly restricted vertical range ("range zone" of the new code of stratigraphic nomenclature). Some of these few taxa are listed in Figures 2 to 5 and their currently known range zones are indicated in Figure 5. As a result of these investigations it is evident that the "black" shale unit in the Uinta Mountains correlates with the Manning Canyon Formation and also with the upper part of the Great Blue Formation (Figures 4 and 5). Furthermore, the Uinta "black" shale unit is lithologically different from the Doughnut Formation just east of Salt Lake City; hence a new name is proposed. According to Crittenden (1958, p. 69) the Doughnut Formation is about 400 feet thick; the basal 100 feet is black fossiliferous shale and the remainder is medium-bedded black fossiliferous limestone with dark chert.

The name Soapstone Formation is here proposed for chiefly Chesterian strata of dominantly dark gray, "black," soft fissile clayey shale with minor amounts of gray limestone (calcisiltite) and siltstone. The average thickness is about 300 feet and the maximum is about 550 feet. The formational name is derived from Soapstone Basin where very representative facies are present. The type locality (Pl. 1, Fig. 1) is in the N $\frac{1}{2}$ sec. 31, T. 3S, R. 9E., Wasatch Co., Utah, in an area mapped by Huddle and McCann (1947). The lithologic nature and fossil content of the type section are illustrated in Figure 3. The nature of a section measured on the northwestern flank of the Uinta Mountains is illustrated in Figure 2. At this locality the Soapstone Formation contains more limestone than is normally found in the formation, and the abundant fossils aid in determining the age of the middle part of the formation. Because the lateral continuity of some of the beds has been traced in the western Uinta Mountains, it is probable that units 34 and 35 of Figure 2 correlate with the lower part of unit 20 and units 16-19 of Figure 3. Additional data on the Soapstone Formation in the Uintas has been presented previously (Sadlick, 1955, pp. 53-54; 1957).

Article 4 of the new code of stratigraphic nomenclature may preclude the recognition of the Soapstone Formation as a valid lithostratigraphic unit. In essence Article 4 states that formations are recognized by physical features and are independent of both inferred geologic history and time concepts. If the correlations shown in Figure 4 are correct, the name Soapstone Formation may be pre-empted by the name Manning Canyon, which is the reason for including both names in the Eastern Utah column in Figure 5.

The lower contact of the Soapstone Formation is interpreted as a para-

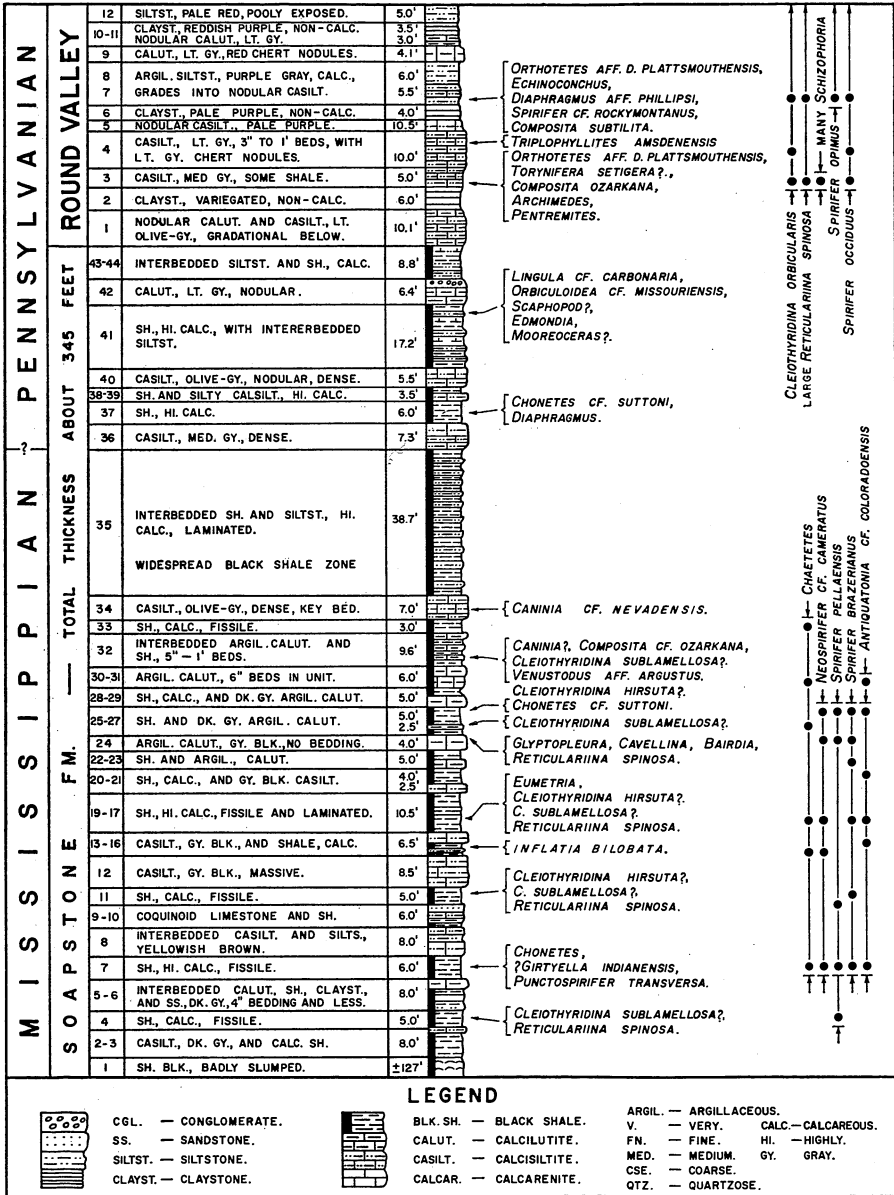


FIG. 2. Lithologic and faunal succession of the Soapstone and lower Round Valley formations, sec. 12, T. 1 S., R. 7 E., Bear Trap Hollow, Summit County, Utah.

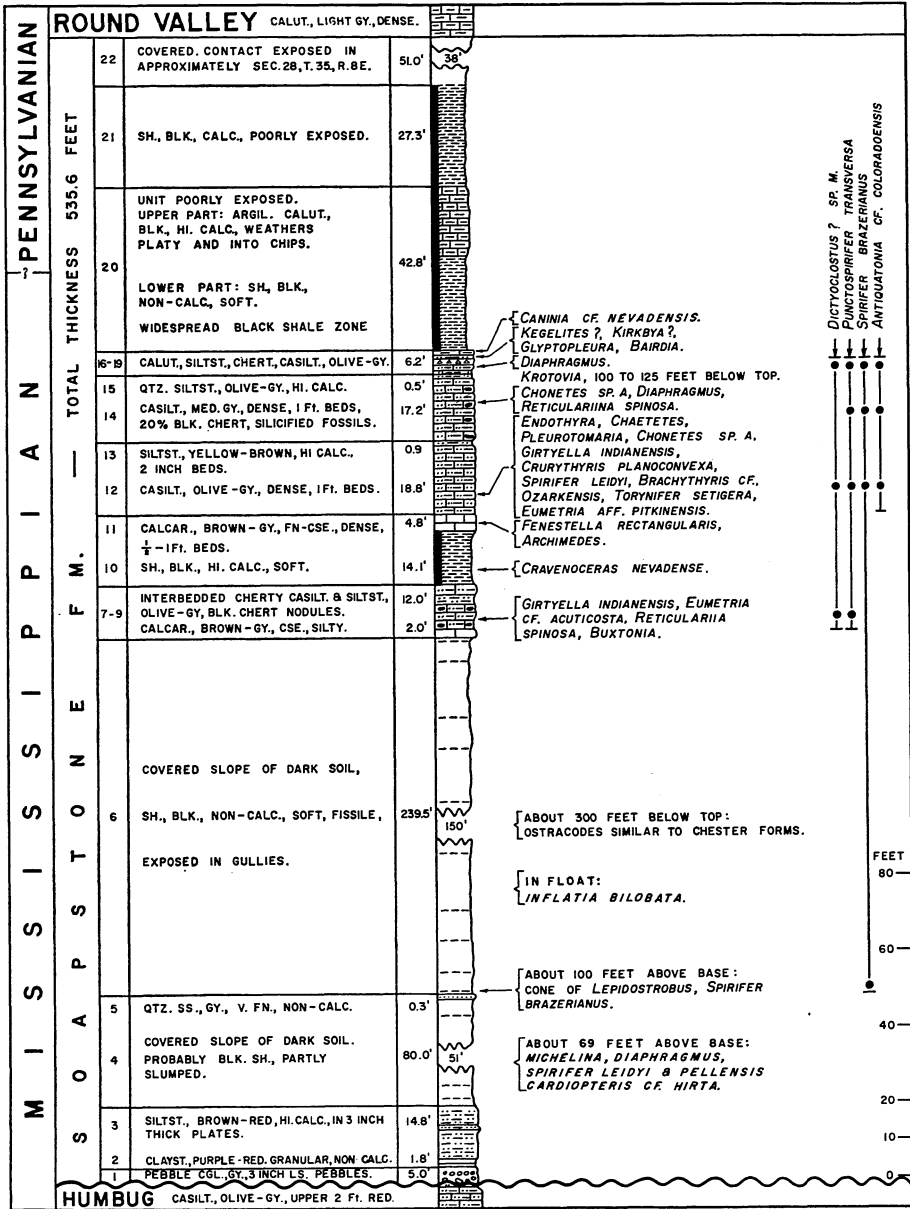


FIG. 3. Lithologic and faunal succession of the type section of the Soapstone Formation, sec. 31, T. 3 S., R. 9 E., Soapstone Basin, Wasatch County, Utah.

conformity. A basal pebble conglomerate is recognized at the type section (Fig. 3, unit 1). Overlying the conglomerate are about 17 feet of reddish brown silty beds that are correlative in part to the lower 125 feet of reddish brown calcareous silty shale southwest of Manila, Utah (Fig. 4). These basal beds are interpreted to be a lateritic regolith that developed on the Humbug Formation while the lower part of the Great Blue Formation was being deposited to the west. The sandstone at the base of the Soapstone Formation at the western end of the Uinta massif probably was deposited by streams that flowed westerly into the "Great Blue Sea." Such a fluvial system could be the source of the pelitic clastics that occur in the lower part of the Great Blue (Morgan section in Fig. 4). Undoubtedly a transgressive sea reworked many of the basal beds so that their original condition is no longer preserved.

The upper contact of the Soapstone Formation is transitional into the overlying Round Valley Formation or occurs in a rhythmic repetition of limestones and shales as demonstrated in Figure 2. In 1957, Sadlick (p. 60) showed that the Soapstone Formation (as the Manning Canyon) extends throughout the Uinta Mountains and southward almost to the Uncompahgre Plateau. Most of this region was part of the continental platform during the Mississippian Period.

INVERTEBRATE PALEONTOLOGIC RELATIONS

In Late Mississippian strata one commonly encounters either brachiopod-bearing beds, as in the type Chester series of Illinois, or strata containing goniatites almost exclusively, as in the "Caney" shale of Oklahoma. Fortunately, goniatites and brachiopods are sometimes associated, as in the Chainman Formation of western Utah and the formations listed under the Arkansas column in Figure 5. Both of these contain brachiopods and goniatites and serve as excellent standards for interbasinal and intercontinental correlations.

TAXONOMIC LEGEND (Figure 4)

Phylum Coelenterata

C, *Caninia*; F, *Faberophyllum*; L, *Lithostrotion*; M, *Michelina*.

Phylum Bryozoa

P, *Paleocoryne*.

Phylum Brachiopoda

Ac, *Antiquatonia* cf. *coloradoensis*; Cs, *Chonetes suttoni*; Fl, *Flexaria*; I, *Inflatia*; Ib, *Inflatia bilobata*; L, *Leiorhynchus*; N, *Neospirifer*; R, *Rhipidomella*; S, *Striatifera*; Sb, *Spirifer brazerianus*.

Phylum Mollusca

Cr, *Cravenoceras*; E, *Eumorphoceras*; G, *Goniatites*; G1, *Glabrocingulum*.

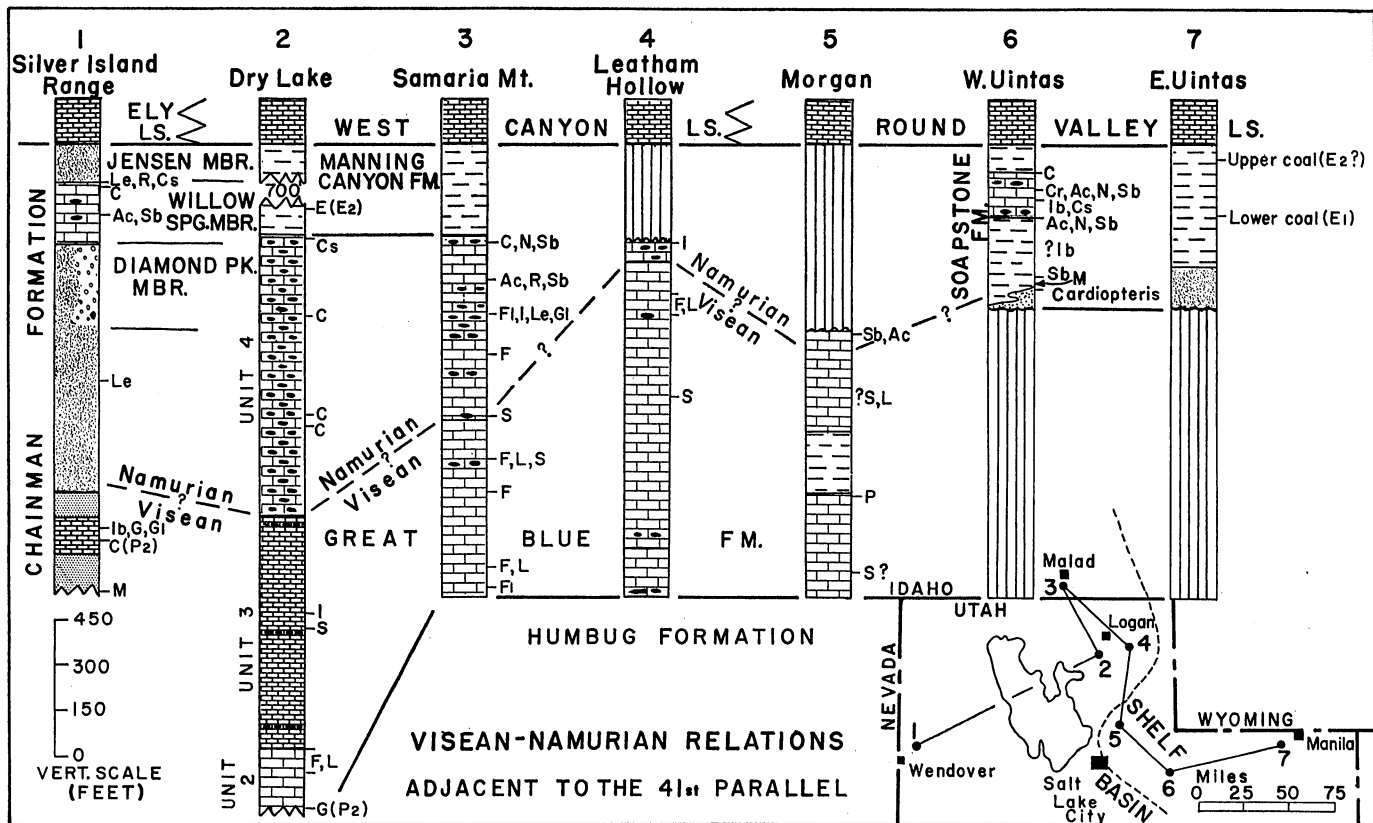


FIG. 4. Probable position of the Visean-Namurian boundary (about medial Chester) across northern Utah.

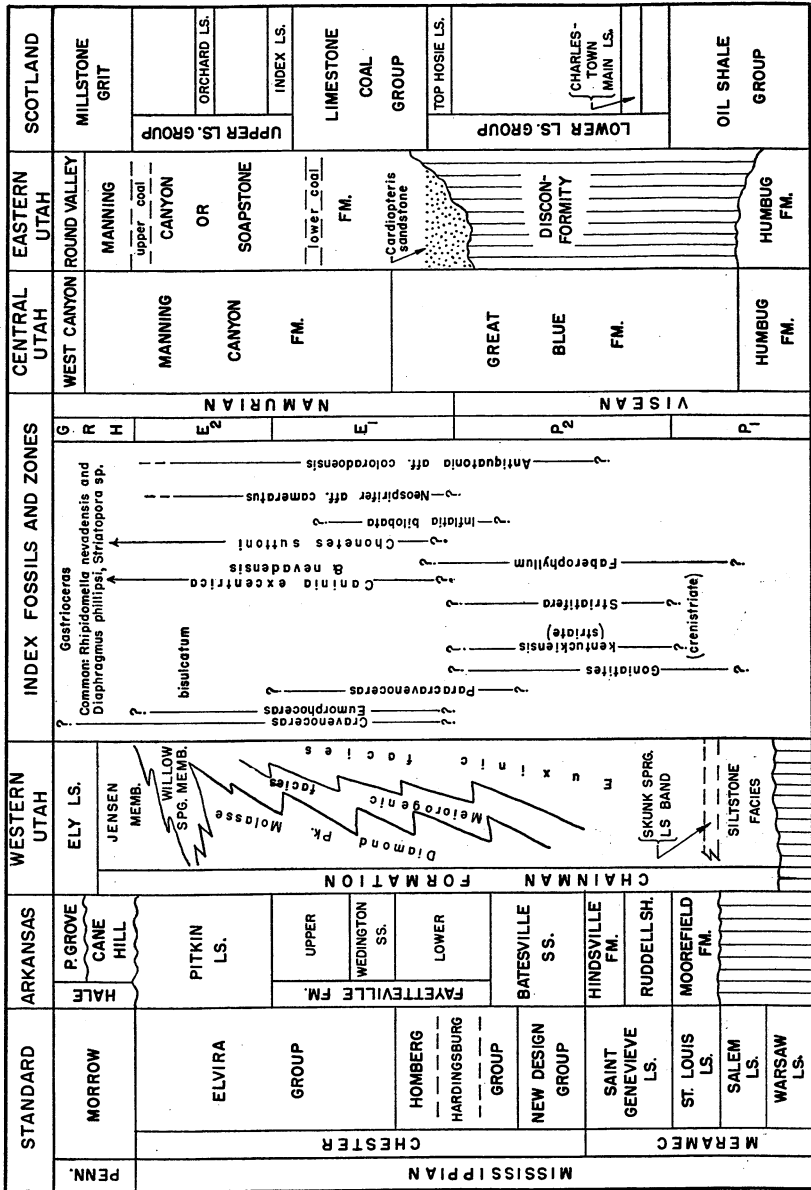


FIG. 5. Correlation chart based primarily on stratigraphic position of goniolites and secondarily on brachiopods.

Late Mississippian goniatites have been described from numerous localities in the world. A recent work summarizing their usefulness in England was presented by Butcher and Hodson (1960, p. 80), who indicated that a rather detailed zonation is possible. In essence, a Late Mississippian sequence of goniatite zones is established on two or three genera, namely, a lower zone of *Goniatites* and an upper zone of *Eumorphoceras*. The latter genus is usually rare, but fortunately representatives of the genus *Cravenoceras* are common in the *Eumorphoceras* zone. In Europe *Goniatites* is common in the British zones designated P_1 and P_2 , and the genus is almost terminated at the Visean-Namurian junction. In general, radially crenistriate forms are indicative of zone P_1 whereas longitudinally lirate ("striate") forms are more representative of zone P_2 . The zone of *Eumorphoceras* is subdivided into zones E_1 and E_2 . Both *Eumorphoceras* and *Cravenoceras* are restricted to the lower part of the Namurian series. These relations are shown in Figure 5.

Currie (1954) has presented a fine cephalopod correlation of some lithostratigraphic units of Scotland with the British goniatite zones. Her correlations are summarized in Figure 5. Gordon (1953, p. 1427) has recognized a comparable sequence in Arkansas and has reported a similar one from the Chainman Formation of western Utah (Gordon, and others, 1957). The Visean limestone of the Chainman Formation (Fig. 4) is at about the stratigraphic position as the beds containing the late Visean goniatites described by Miller and coauthors (1952). In the Dry Lake section (Fig. 4) Sadlick has located the goniatite that Williams and Yolton (1945, p. 1148) described from unit 2 of the Brazer Formation (which is actually the Great Blue Formation). The thin-bedded Visean limestone, which is unit 3 of Williams and Yolton, and also Parks' interval of 300-1000 feet (Parks, 1951, p. 174), contains *Striatifera brazerianus* (Girty) as illustrated by Muir-Wood and Cooper (1960). Incidentally, member 3 is about 700 feet thick, and not 470 feet as Williams and Yolton report it. Unit 4 of the Great Blue is considered Namurian because similar large *Caninia* corals are quite common near the top of the "Willow Spring member" of the Chainman Formation in beds that are seemingly representative of the British zone E_2 . The Jensen and Willow Spring members will be introduced subsequently. Poorly preserved specimens similar to *Eumorphoceras plummeri* occur about 100 feet above the *Chonetes suttoni* bed, and *Rhipidomella nevadensis* occurs in the uppermost few feet of the Manning Canyon Formation (unit 5 of Williams and Yolton).

A perusal of the field evidence as presented in Figure 4 indicates that the following invertebrates appear to indicate Namurian age in the western United States: (1) the large *Caninia* corals, which Dr. Helen Duncan con-

siders similar to *C. nevadensis* (Meek) and *C. excentrica* (Meek), (2) *Antiquatonia* cf. or aff. *coloradoensis* (Girty), which is very rare below the selected Visean-Namurian boundary, (3) *Chonetes suttoni* Branson, 1937, (4) *Neospirifer*, and (5) abundant forms of *Spirifer brazerianus*, and *Cravenoceras* and *Eumorphoceras*. Almost all of these forms occur above the *Cardiopteris* beds in the Soapstone formation.

Visean forms are represented by the genera *Faberophyllum*, *Lithostroton*, *Michelina* (a thin-walled species), *Striatifera*, and *Goniatites*. At Morgan, Utah (Fig. 4), *Paleocoryne* occurs about 330 feet above the base of the Great Blue Formation, and a similar form occurs with *Faberophyllum* in the Great Blue just south of Great Salt Lake.

The same form of a thin-walled *Michelina* occurs in the Visean portion of the Chainman Formation as is found in the limestone immediately above the *Cardiopteris* siltstone of the Soapstone Formation. Likewise, a productid brachiopod, *Inflatia bilobata* Sadlick, sp. nov., is abundant in the high Visean limestones of the Chainman Formation. Its only other occurrence is in strata above the *Cardiopteris* siltstone and about one-third of the distance up from the base of the Soapstone Formation. These two species are the only invertebrates that give any clue regarding the age of the lower part of the Soapstone Formation. Both indicate late Visean age, although the new *Inflatia* is also present in early Namurian strata as indicated by Figures 2-5. Single specimens of *Diaphragmus* sp., *Spirifer leidyi*, and *S. pellenis*, which occur abundantly immediately above the *Cardiopteris* siltstone, indicate Chester age and support a Chester age determination of the flora.

Some as yet unpublished results of studies of spores in two coals in two coal seams in the Soapstone Formation that are shown in column 7 of Figure 4 appear to corroborate the age as indicated by the invertebrates and the flora. Hoffmeister and Stover (private communication) have found a taxonomic similarity between these spores and spores described by Butterworth and Williams (1959) in some Scottish Lower Carboniferous coals. This relationship is similar to that one found to exist between spores of the Limestone Coal group and the Hardinsburg Formation of the type Chester Series as described by Hoffmeister, Staplin, and Malloy (1955). The coals in the Soapstone Formation are considerably higher than the plant megafossils in the *Cardiopteris* bed, being in units 25 and 20 respectively, as shown in Figures 2 and 3. An E_1 early Namurian age seems to be indicated for the lower Soapstone coal, and an E_2 age or younger for the upper coal.

Sohn (in private communication, 1955) identified abundant ostracod specimens of *Kegelites?*, *Kirkbya?*, and *Glyptopleura* from unit 18 of the type section of the Soapstone Formation. Sohn also states that the *Kegel-*

ites? has Pennsylvania affinities, so if the ostracods alone were the basis of age determination, the age would be either Late Mississippian or Early Pennsylvanian.

In the type Chester series the Visean-Namurian boundary is in the Homberg group. In England, Higgins (1961) studied the conodonts in the Namurian *Eumorphoceras* aff. *pseudobilingue* band. It contains *Lonchodina furnishi*, which in Illinois is restricted to the Glen Dean Formation (Rexroad and Collinson, 1961) and which lies at the top of the Homberg group above the Hardinsburg. All evidence indicates that the Visean-Namurian junction is above the *Cardiopteris* bed in the lower part of the Soapstone Formation.

AGE IMPLICATIONS OF THE FLORA

In the *Cardiopteris* siltstone the following plants have been identified:

Cardiopteris sp. (cf. *C. hirta* White)

Rhodea sp. (cf. *R. vespertina* Read)

Cauloopsis punctata Gothan & Hartung

Archaeocalamites scrobiculatus (Schl.) Zeiller

Lepidodendron sp.

The two localities where the plants were collected are shown in Plate II, Figures 2 and 3. Though some of the plants range rather widely in the Mississippian, the assemblage, when considered in its entirety, points to a position in the lower part of the Upper Mississippian. In the Appalachian trough, where the largest North American Mississippian floras are found, White (1913) recognized two, the *Triphylopteris* flora and the *Cardiopteris* flora. The former is the older, and characterizes the Pocono, Price, and other Lower Mississippian floras of Kinderhookian and Osagean age. The *Cardiopteris* flora occurs in the Mauch Chunk formation and is of Chester age. *Triphylopteris* is abundant in the flora that bears this name, and in addition there are numerous lycopods of the *Lepidodendropsis* type. The later flora is characterized by *Cardiopteris* and *Archaeocalamites* and by lycopods that are more closely related to the lepidodendrids of the Pennsylvanian. In the Appalachian trough *Lepidodendropsis* does not extend into the Upper Mississippian and *Archaeocalamites* has not been found in the Lower Mississippian. Thus the presence or absence of either of these plants in representative floras of that area has stratigraphic significance.

Two noteworthy features of the flora are the abundance of *Cardiopteris* and *Archaeocalamites* and the absence of plants resembling *Triphylopteris* and *Lepidodendropsis*. Thus its relationships seem to be with the *Cardiopteris* flora, and with the possible exception of one *Rhodea* fragment, all of

its components would be entirely at home in it. The detached *Cardiopteris* pinnules are of uncertain specific identity, but their stratigraphic value is augmented by the associated plants. The two species of *Cardiopteris* that Read (1955) found in the Pocono flora are different from ours.

The *Rhodea* fragment does bear some resemblance to *R. vespertina* of the Pocono flora. The genus ranges through the whole Mississippian sequence and into the Pennsylvanian. In this instance, however, it hardly outweighs the evidence of Late Mississippian age that is presented by the other plants.

That *Archaeocalamites* did thrive during Early Mississippian time in eastern North America is shown by its occurrence in the Horton group of Nova Scotia (Bell, 1960). Also, in Europe it appears to extend throughout the whole Lower Carboniferous sequence. Unfortunately, we possess little information on its relative abundance in Lower versus Upper Mississippian strata, but from the material Bell selected for illustration (1960, Pl. VII) it is not an abundant species in the Horton group. This plant seems to have been much rarer and its occurrence more localized during Early Mississippian time than later.

Some punctate petiole and rachis fragments are identified as *Caulopsis punctata*. These are portions of fronds that probably represent some member of the Lyginopteridaceae, a family of pteridosperms that became highly developed during Early Pennsylvanian time. These compressions would doubtlessly be identified as *Sphenopteris hoeninghausi* if they were found in the Westphalian of Europe. In fact, White (1926, p. 841) lists *Sphenopteris* of the *S. hoeninghausi* type as one of the components of the Late Mississippian flora.

The fragmentary lycopod remains of the Utah flora are quite different from the Pocono lycopods, and they bear more resemblance to later forms. Those with the broadened foliar scars (Pl. II, figs. 14, 15), though referred to here as *Lepidodendron sp.*, might indeed be more appropriately identified as *Lepidophloios* because the scars are wider than high. Though smaller, the specimens are quite similar to those Bell (1944) identified as *Lepidophloios laricinus* from the Riversdale group of Nova Scotia.

White (1937) concluded that the Wedington sandstone flora was of late Chester age because of several Early Pennsylvanian elements in it, but it is probably slightly older.

The relationships of the flora seem to be with the late Visean or early Namurian, though the former is more in harmony with the invertebrate and lithologic evidence.

SYSTEMATIC DESCRIPTIONS

The Fauna

Phylum BRACHIOPODA Dumeril, 1807

Suborder PRODUCTOIDEA MAILLIEUX, 1940

Superfamily Productacea Waagen, 1883

Family Marginiferidae Stehli, 1954

Subfamily Costispiniferinae Muir-Wood and Cooper, 1960

Genus *Inflatia* Muir-Wood and Cooper, 1960***Inflatia bilobata* Sadlick, sp. nov.**

(Pl. I, Figs. 4-9)

Types.—Holotype No. 143258 U. S. National Museum; paratype No. 143257 U. S. National Museum. Cast of holotype No. 44765, The University of Michigan, Museum of Paleontology, cast of paratype, No. 44765, The University of Michigan, Museum of Paleontology. Casts have also been deposited with the Geological Survey of Canada.

Diagnosis.—*Inflatia* characterized by a subparallel bilobed ventral valve with a median sulcus, a flattened umbonal region, prominent rugae, and protruding, knob-like, highly curved ears.

Description.—Posterior outline subquadrate; ventral outline also subquadrate in a plane just above the ears. Lateral profile consists of a highly curved beak with an arc length of 5 to 7 mm measured along the spiral outline from the beak, followed by about 10 mm of a relatively flat umbonal region with well-developed rugae; remainder of shell outline uniformly curved, uniform curvature beginning at about the last developed ruga. Width of median sulcus slightly less than one-fourth valve width measured from extremities of ears. Ears protruding, knoblike, and highly curved, separated from visceral disc by a shallow sulcus which is well-developed at the last prominent ruga. Ventral view shows the characteristic subparallel bilobed nature of the species. The lobes are separated by a moderately developed median sulcus.

Pedicle valve ornamented by about six spines disposed in a single row at a low angle to the hinge line, and by a few (less than 25) erect, irregularly disposed spines on the ventral visceral disc and trail; spines developed typically on the costae, and the width of the spine bases is commonly equal to the width of the costae. The spines rarely bifurcate on the visceral disc and trail. Rugae prominent, height at least twice that of the costae. Rugae limited to the first 20 mm of the spiral outline measured along the arc-length beginning at the beak.

Dimensions.—Most of the measurements were made in respect to arc-lengths along the spiral curve generated during growth and they begin at

the point of initial shell growth at the beak. The radius of curvature, sometimes referred to as the radius vector, increases gradually during ontogeny. Comparison is made with the figured specimen of *Inflatia inflatia* (McChesney) (Pl. 1, Figs. 10–11).

TABLE 1
MEASUREMENTS OF SPECIES
(In mm)

Character	<i>I. bilobata</i>		<i>I. inflatia</i>
	Holotype	Paratype	
Arc-length	55	50	53
Width including ears	30	27	30
Width just above ears	23	20	24
Median sulcus originates at arc-length	9	9	9
Width of sulcus at arc-length of 30 mm	8	8	8
Arc-length at which last ruga noted	20	18	28
Number of rugae in plane of bilateral symmetry	15+	13+	19
Number of spines along one side of the hinge line	about 6	about 5	8
Number of costae at arc-length of 20 mm	57	58	55
Number of costae at arc-length of 30 mm	60	60	55
Number of costae in 5 mm on crests of lobes at arc-lengths of 20 and 30 mm	5–6	5–6	5–6

Stratigraphic and geographic position.—The holotype was collected from unit 15 (Fig. 2), about 193 feet above the base of the Soapstone Formation in Bear Trap Hollow, Smith and Morehouse Canyon, sec. 12, T. 1 S., R. 7 E., Coalville Quadrangle, Summit County, Utah. The paratype was collected about one-third of the distance above the base of the Soapstone Formation in approximately the SW $\frac{1}{4}$ sec. 32, T. 1 S., R. 6 E., Coalville Quadrangle, Summit County, Utah. Additional specimens were collected in the lower third of the Soapstone Formation south of Beaver Creek narrows, sec. 25, T. 2 S., R. 6 E. (Fig. 1) and from unit 12 of the Chainman Formation in A-1 Canyon in sec. 28, T. 34 N., R. 70 E., unsurveyed, north of Wendover, Nevada (Sadlick, p. 87, Utah Geol. Soc. Guidebook 15, 1960).

Discussion.—Several species of the genus *Inflatia* in collections from Utah and Nevada await description. Although most of these are initially known from strata of Chester age, undoubtedly some species persisted into Early Pennsylvanian time. Of the eight genera currently assigned to the subfamily Costispiniferinae, six are restricted to the Permian, one, *Desmoinesia* Hoare, 1960 (= *Rudinia* Muir-Wood and Cooper, 1960) is first known in the medial Pennsylvania, and all known species of the eighth genus, *Inflatia*, are from the Mississippian. Thus, currently a phylogenetic gap exists between *Inflatia* and *Desmoinesia*, due to either an undescribed genus or to

unknown species of *Inflatia* in the Early Pennsylvanian. Thus, the genus *Inflatia* may ultimately be found in strata above Chester.

Previous to the discovery of *Inflatia bilobata*, the genus *Inflatia* was monotypic. The measurements presented above show the similarity between the generitype and *I. bilobata*. Since *Inflatia bilobata* seemingly is restricted to strata of medial Chester age, it represents some sort of a cryptogenetic offspring of *Inflatia inflatia* which ranges through the entire Chester in the central part of the United States. The only significant mensurable difference is the arc-length at which the last developed ruga is noted—about 20 mm for *Inflatia bilobata* and 28 mm for *I. inflatia*. However, *Inflatia inflatia* is characterized by a nearly uniform spiral lateral profile, flattened ears, poorly developed rugae which are slightly stronger than the costae, and when viewed ventrally, the outline of the visceral disc converges towards the beak. *Inflatia bilobata*, on the other hand, is characterized by a flattened umbonal region when viewed laterally, by prominent rugae, by highly curved ears, and by the subparallel bilobed nature of the ventral visceral disc after which the species is named.

SYSTEMATIC DESCRIPTIONS

The Flora

Phylum PTEROPSIDA

Genus *Cardiopteris* Schimper, 1869¹

Cardiopteris sp. (cf. *C. hirta* White)

(Pl. II, Figs. 6-12)

Detached pinnules of this plant are rather abundant on some of the sandstone slabs. They are small, sessile, rounded, and range from 4 to 14 mm in length. There is no distinct midrib. The veinlets radiate outward from the base with but slight curvature, and terminate at the margin 0.25 to 0.35 mm apart. Several of the largest pinnules, evidently terminal ones, are slightly inequilateral and some of them bear small pinnules partially joined to them at the base. The pinnules appear to have been rather thick, as their upper surfaces are somewhat curved.

White's diagnosis of *Cardiopteris hirta* (1937, p. 19) from the Wedington sandstone of the Fayetteville shale of Arkansas fits these pinnules well. They differ only in the texture of the venation which, to judge from the published figures, is slightly coarser in the Utah specimens. The epidermal hairs, which White says are characteristic of *C. hirta*, do not show in his figures and are not visible on our specimens, but this may be due to the coarseness of the matrix and the extreme carbonization that had taken

¹ Wolfe, J. (*Taxon*, Vol. 11, No. 4, p. 141, 1962) has proposed substitution of *Fryopsis* for *Cardiopteris* Schimper, 1869, which is a homonym of *Cardiopteris* Royle, 1943.

place. The pinnules of *Cardiopteris abbensis* from the Bluefield shale of West Virginia (Read, 1955) are similar but larger.

Genus *Rhodea* Presl, 1838

Rhodea sp. (cf. *R. vespertina* Read)

(Pl. II, Fig. 5)

There is one small specimen in the collection that consists of a portion of a slender rachis slightly less than 5 cm. long to which are attached three wedge-shaped pinnules that are deeply cut into filiform segments. It appears indistinguishable from Read's *Rhodea vespertina* (1955, Pl. 16, Fig. 6) from the upper part of the Pocono and Price formations. It also bears some resemblance to certain Mississippian species of *Diplothemema*, *Sphenopteridium*, and *Sphenopteris*. However, *Rhodea* seems best for its reception.

Read says that *Rhodea vespertina* is the most abundant and widely spread plant species in the Early Mississippian of the Appalachian trough, and if our specimen is the same species, it constitutes the only genuine connecting link between the Utah and Pocono floras.

Genus *Caulopsis* Gothan and Hartung, 1949

Caulopsis punctata Gothan and Hartung

(Pl. II, Figs. 1-3)

Several defoliated axes that range from 5 to 18 mm in width are present in the collection. They are conspicuously ornamented with numerous scattered punctations that are apparently the imprints of spinose or glandulose emergences. Such emergences occur on the small stems, petioles, rachises, and seed cupules of certain members of the Lyginopteridaceae of the Late Mississippian and Early Pennsylvanian.

The largest of these flattened axes are straight, unbranched, and probably represent large petioles of fronds. The smaller ones are branched and slightly flexuose, and are probably rachises from higher portions of fronds. The branches depart at wide angles (Pl. II, Figs. 1, 2).

The imprints of the emergences show best along the midportions of the compressions and are less distinct at the edges. This no doubt is due to the angle of pressure, which was perpendicular to the surface along the middle but increasingly more oblique toward the edges. Because they cannot be seen at the extreme edge, their length is unknown.

Caulopsis is a form genus that was created when it seemed advisable to provide taxonomic status to certain defoliated axes. The type specimens were punctate like those shown here (Gothan, 1949).

Phylum SPHENOPSIDA

Genus *Archaeocalamites* Stur, 1875*Archaeocalamites scrobiculatus* (Schl.) Zeiller

(Pl. II, Fig. 4)

There are several specimens of this typically Early Carboniferous calamite in the collection. The ribbed axes are from 1.0 to 2.2 cm wide with nodes 1.0 to 4.5 cm apart. The ribs, which do not alternate at the nodes, are flat and sometimes not very distinct, and are mostly 2.0 to 2.5 mm wide. It is not clear from the material at hand whether the specimens are much flattened pith casts or replicas of whole stems. They are, in fact, nothing more than imprints covered with a film of carbonaceous substance without appreciable thickness.

The Utah specimens resemble the European species more than any of the four species of *Archaeocalamites* that White (1937) described from the Wedington sandstone. Of these, *A. umbralis* most closely resembles our form.

Phylum LYCOPSIDA

Genus *Lepidodendron* Sternberg, 1820*Lepidodendron* sp.

(Pl. II, Figs. 13-15)

The lycopods in the collection are so fragmentary that precise identification is impossible. They consist of stem impressions, leafy twigs, and detached leaves. Of the various Mississippian lycopods, they bear some resemblance to *Lepidodendron henbesti* from the Wedington sandstone. The leaf cushions, however, are broader, like those of *Lepidophloios*. In the Utah fragments and in *L. henbesti* the cushions stood out prominently on the stem surface and produced deep imprints in the matrix. Detached leaves are about 3 mm wide and more than 20 mm long.

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EXPLANATION OF PLATE I

(All fossil figures $\times 1$)

PAGE

- FIG. 1. View south. Type section of the Soapstone Formation in Soapstone Basin. (a) Humbug Formation, (b) basal reddish-brown beds and (c) cherty limestone beds in upper part of the Soapstone Formation. Round Valley Formation begins with prominent limestone ledges just below the skyline.
- FIG. 2. View showing small excavation in siltstone which contains many specimens of *Cardiopteris* cf. *hirta* White. Location: SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14 T. 2 S., R. 6 E., Summit County, Utah.
- FIG. 3. View northeast. Black line on photograph marks outcrop belt of light olive gray siltstone containing fossil flora described in this report. Location: NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 14, T. 2 S., R. 6 E., Summit County, Utah.

- Inflatia bilobata* Sadlick, sp. nov. 255
- FIGS. 4-5, 9. Paratype. Respectively posterior, ventral, and left lateral views. About one-third above base of Soapstone Formation, SW $\frac{1}{4}$ sec. 32, T. 1 S., R. 6 E., $\frac{1}{2}$ mile east of Hoyt Peak, Summit County, Utah. No. 143257 USNM.
- FIGS. 6-8. Holotype. Respectively left lateral, posterior, and ventral views. Soapstone Formation, unit 15, sec. 12, T. 1 S., R. 7 E., Bear Trap Hollow, Smith and Morehouse Canyon, Summit County, Utah. No. 143258 USNM.
- Inflatia inflatia* (McChesney) 256
- FIGS. 10-11. Respectively ventral and left lateral views of a specimen from the Fayetteville Formation about 5 miles west of Strang, Oklahoma, T. 22 N., R. 20 E., Mayes County. Note the nearly spiral lateral profile (Fig. 11) flattened ears, and the posteriorly divergent nature of the "bilobed" ventral valve (Fig. 10).
- Note the flattened umbo in profile (Figs. 5, 6), the prominent rugae (Figs. 7, 8), the rounded ears, and the subparallel "bilobed" ventral valve (Figs. 10, 11).

PLATE I

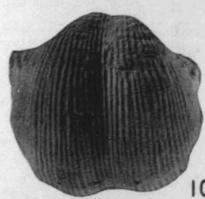
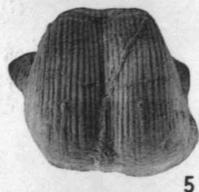
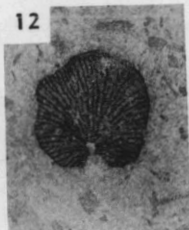
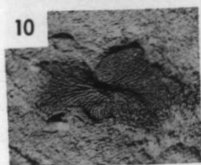
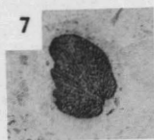
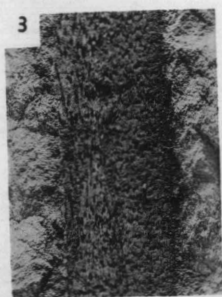
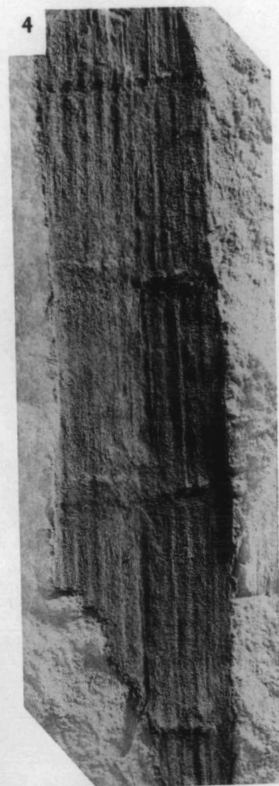


PLATE II



EXPLANATION OF PLATE II

(All figures natural size unless otherwise indicated)

	PAGE
FIGS. 1-2. <i>Caulopsis punctata</i> Gothan and Hartung. UMMP 44445	258
FIG. 3. <i>Caulopsis punctata</i> Gothan and Hartung. $\times 2$	258
FIG. 4. <i>Archaeocalamites scrobiculatus</i> (Schl.) Zeiller. UMMP 44446.	259
FIG. 5. <i>Rhodea</i> sp. (cf. <i>R. vespertina</i> Read). UMMP 44447.	258
FIGS. 6-12. <i>Cardiopteris</i> sp. (cf. <i>C. hirta</i> White). Fig. 12, $\times 2$. UMMP 44448. . .	257
FIGS. 13-15. <i>Lepidodendron</i> sp. Fig. 15, $\times 2$. UMMP 44449.	259

