MISSISSIPPI STATE GEOLOGICAL SURVEY

E. N. LOWE
DIRECTOR

BULLETIN No. 23

Paleozoic Rocks

By
WILLIAM CLIFFORD MORSE, Ph. D.
1930

TO

PAUL FRANKLIN MORSE

1897-1929

SON GEOLOGIST SCHOLAR MAN PAL

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STATE GEOLOGICAL COMMISSION

GEOLOGICAL SURVEY STAFF

LETTER OF TRANSMITTAL

Office of the State Geological Survey,
University, Mississippi,
September 16, 1930

To His Excellency, Gov. Theo. G. Bilbo, **Chairman**, and Members of the Geological Commission.

Gentlemen:—I herewith present for your approval the manuscript of this Report on the Paleozoic Rocks of Mississippi, by Dr. William Clifford Morse, to be published as Bulletin No. 23 of the Mississippi Geological Survey.

This Report, together with a report on the Coastal Plain Stratigraphy of Mississippi, by several authors, will constitute a complete presentation of the stratigraphic geology of the state.

Respectfully submitted,

E. N. LOWE, Director.

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PALEOZOIC ROCKS*

BY WILLIAM CLIFFORD MORSE PH.D.

I INTRODUCTION

INTEREST

The Paleozoic beds are the oldest rocks in Mississippi. They are very interesting in that they constitute the extreme southwestern corner of the Paleozoic area of the eastern half of the United States. Beyond this place they are covered by great thicknesses of Mesozoic and Cenozoic sediments of the Mississippi embayment, which reached to the mouth of the Ohio; and then crop out next in Arkansas and Texas, on the opposite side of the embayment. They form, therefore, the connecting area between the better known Paleozoic strata of northeastern United States and the Upper Mississippi Valley, on the one hand, and Paleozoic beds of the southwest, on the other hand. Their interest, accordingly, reaches beyond the confines of the State.

***Submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy from the Massachusetts Institute of Technology, 1927.**

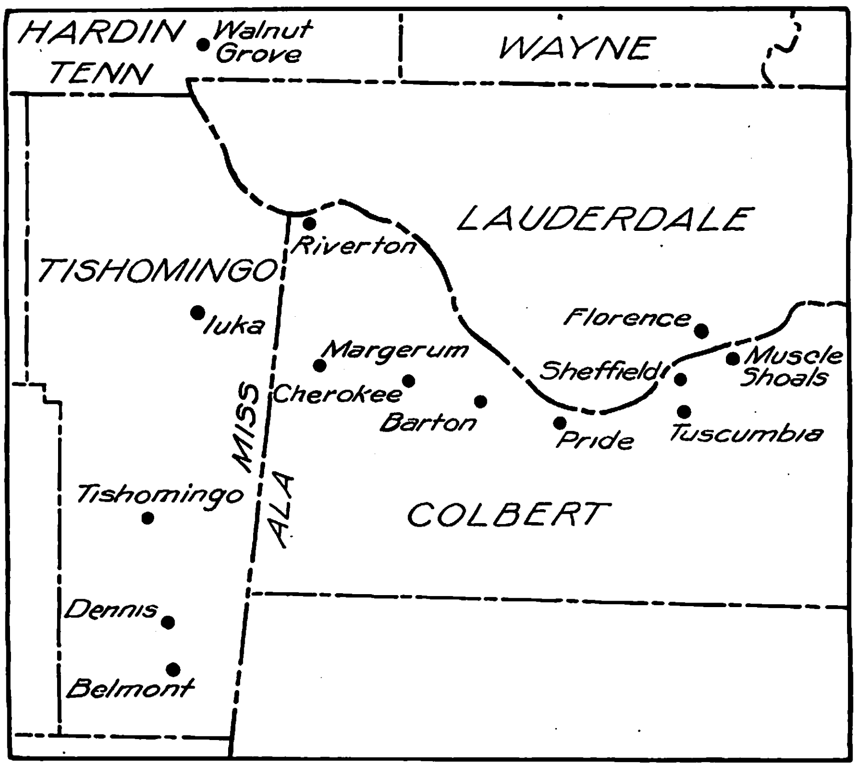

Figure 1.—Key Map of the Mississippi, Alabama, and Tennessee Region.

DISTRIBUTION

For more than twenty years the Paleozoic beds have been depicted on the maps of the Federal and State surveys as extending entirely across Tishomingo County, cutting the southeastern corner of Prentiss, and extending almost completely across Itawamba[1]. Many statements and quotations concerning their distribution have been to the same general effect. As a matter of fact, the Paleozoic beds are confined almost to, or quite within, the limits of Tishomingo County, their outcrops extending for the most part along the stream courses (Plate 1).

[1]United States Geological Survey, Water Supply Paper 159, p. 4, 1906, and Bulletin 283, p. 6, 1906; Mississippi State Geological Survey, A provisional Geologic and Topographic map of Mississippi.

PLATE 1

Distribution of the Paleozoic rocks in Mississippi, which are confined to the stream courses of Tishomingo County. Beyond the limits of the Iuka quadrangle outcrop stations are shown by means of small circles.

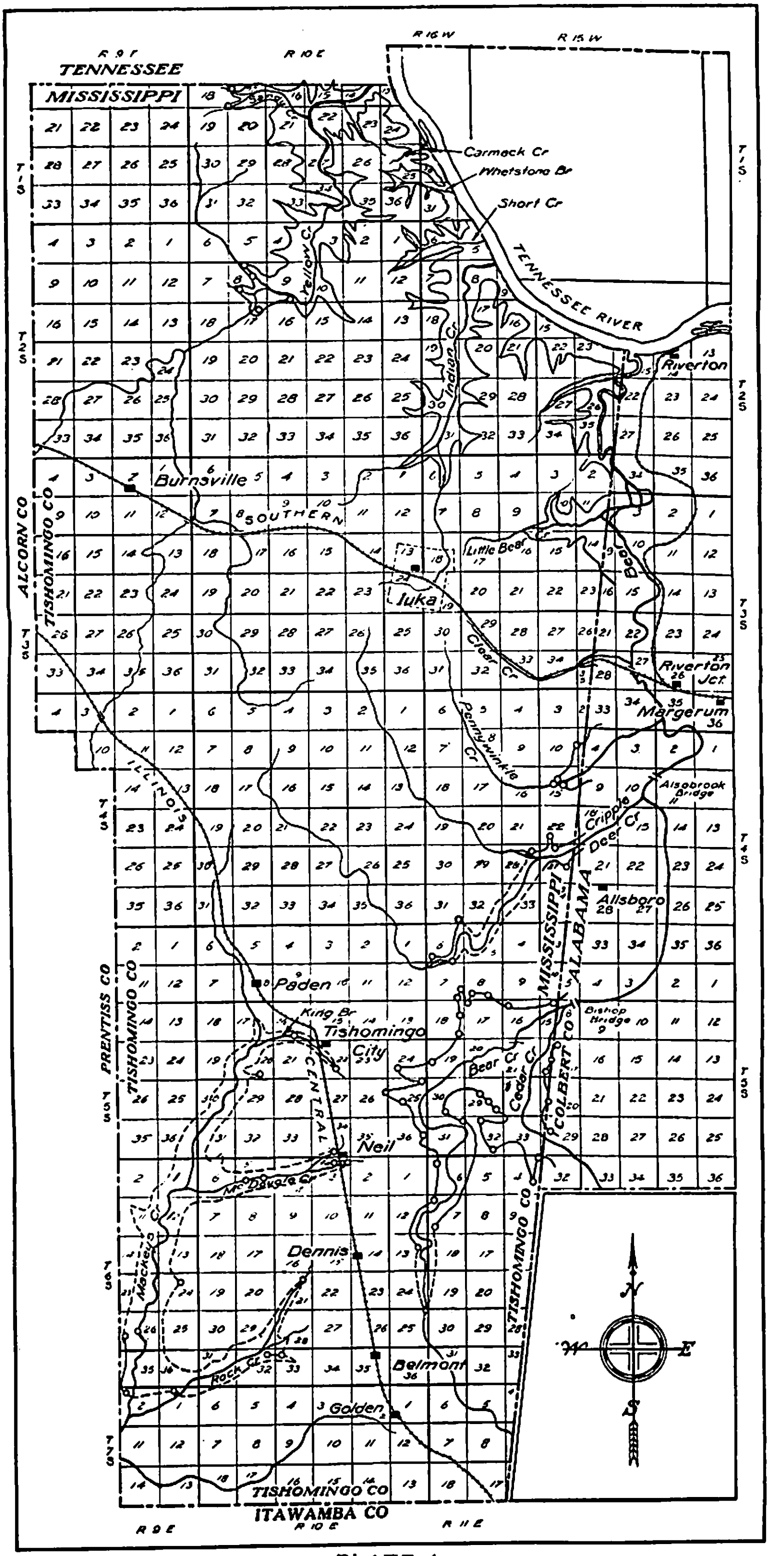
TENNESSEE
MISSISSIPPI
R 9 E
R 10 E
R 16 W
R 15 W
R 11 E
T 1 S
T 2 S
T 3 S
T 4 S
T 5 S
T 6 S
T 7 S
Carmack Cr
Whetstone Br
Short Cr
TENNESSEE RIVER
Yellow Cr
Indian Cr
Riverton
Burnsville
SOUTHERN
Iuka
Little Bear Cr
Bear Cr
Clear Cr
Riverton Jct.
Margerum
Pennywinkle Cr
Alsobrook Bridge
Cripple Deer Cr
ILLINOIS
ALCORN CO
TISHOMINGO CO
PRENTISS CO
MISSISSIPPI
ALABAMA
Allsboro
Paden
King Br
Tishomingo City
CENTRAL
Bishop Bridge
Bear Cr
Cedar Cr
COLBERT CO
Neil
McDougle Cr
Dennis
Mackeys Cr
Rock Cr
Belmont
Golden
ITAWAMBA CO
N
E
S

PLATE 1

RANGE

For a similar length of time the Paleozoic beds have been known to range from the New Scotland, near the base of the Devonian system, to the Chester, at the top of the Mississippian system. Detailed work, however, has shown the systems to be much fuller than was revealed by the early reconnaissance surveys. During that time also, a four fold division has been recognized, which since 1915 has been designated as follows:

MISSISSIPPIAN SYSTEM:

Hartselle
Tuscumbia
Lauderdale

DEVONIAN SYSTEM:

Yellow Creek

The present survey recognizes the following formations:

MISSISSIPPIAN SYSTEM:

Forest Grove formation
Southward Bridge formation
Southward Spring formation
Southward Pond formation
Allsboro sandstone
Alsobrook formation
Iuka formation
Carmack Creek limestone

DEVONIAN SYSTEM:

Whetstone Branch shales
Island Hill formation
New Scotland limestone

II LITERATURE OF THE AREA

MISSISSIPPI STATE GEOLOGICAL SURVEY:

1857—Preliminary report on the geology and agriculture of the State of Mississippi by L. H. Harper.

1860—Report on the geology and agriculture of the State of Mississippi by Eugene W. Hilgard.

UNITED STATES GEOLOGICAL SURVEY:

1906—Geology and mineral resources of Mississippi by A. F. Crider. Preliminary geologic map of the State of Mississippi by E. C. Eckel and A. F. Crider, Bulletin 283.

1906—Summary of the underground-water resources of Mississippi by A. F. Crider and L. C. Johnson. Water-Supply and Irrigation Paper 159.

MISSISSIPPI STATE GEOLOGICAL SURVEY:

1907—Cement and Portland cement materials of Mississippi by A. F. Crider, Bulletin No. 1.

1907—Brick clays and clay industry of northern Mississippi by William N. Logan, Bulletin No. 2.

1907—The lignite of Mississippi by Calvin S. Brown, Bulletin No. 3.

1909—The pottery clays of Mississippi by William N. Logan, Bulletin No. 6.

1911—A preliminary study of the soils of Mississippi by E. N. Lowe, Bulletin No. 8.

1911—The structural materials of Mississippi by William N Logan, Bulletin No. 9.

1915—Mississippi, its geology, geography, soils and mineral resources by E. N. Lowe, Bulletin No. 12.

1916—Preliminary report on the marls and limestone of Mississippi by William N. Logan, Bulletin No. 13.

1919—Mississippi, its geology, geography, soil, and mineral resources by E. N. Lowe, Bulletin No. 14.

1919—Oil and gas prospecting in Mississippi by E. N. Lowe, Bulletin No. 15.

1920—Road making materials of Mississippi by E. N. Lowe, Bulletin No. 16.

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, BULLETIN:

1923—Petroleum prospecting in Mississippi by Paul Franklin Morse, Vol. 7, No. 6, pp. 684-695.

MISSISSIPPI STATE GEOLOGICAL SURVEY:

1923—The bauxite deposits of Mississippi by Paul Franklin Morse, Bulletin No. 19.

1923—Petroleum prospecting in Mississippi by E. N. Lowe, Ninth Biennial Report, 1921-1923.

1925—Geology and mineral resources of Mississippi by E. N. Lowe, Bulletin No. 20.

III REVIEW OF THE LITERATURE

HARPER REPORT

In the Harper report, which followed Wailes's or the first state report, the Paleozoic beds were mentioned for the first time and were discussed in a number of places. They were shown on the chart and were described in the text as covering, besides a part of Itawamba County, the eastern third of Tishomingo, but Tishomingo of that date included nearly the whole of the present Alcorn and Prentiss as well, so that the eastern third covered practically the whole of Tishomingo County of today. Unfortunately, too, the most southern outcrop was given as Section 6, T. 11S., R. 9E., almost the southern border of Itawamba County, although this limit was somewhat qualified in note 9 on page 266 and again on pages 338 and 339.

As conceived the range of the beds was stated in the following words: "The oldest formation of the State is the lower part of the Carboniferous, consisting of a portion of the Mountain (Mississippian) limestone, which extends into Mississippi from the State of Alabama" (p. 34). Concerning the lithological make up of the Lower Carboniferous beds, the author had a fairly correct conception, for he described limestone, sandstone, hornstone (chert), and slaty clay (shale), practically all the different rocks of the system. Concerning the origin of the beds, his conceptions were likewise fairly correct, for he recognized the marine source of most of them. The various kinds of beds at the surface, largely the result of dip, baffled him, however, and led him far afield, as the following excerpt illustrates: "The examples above quoted, have, I believe, sufficiently shown that the Carboniferous formation, or rather its lowest member, the Mountain limestone, does not only consist of limestone, but also of sandstone, hornstone, and a soft schistose clay slate, and that these different rocks are not subordinate to each other, but co-ordinate, and occur in juxtaposition." (p. 47). Inasmuch as no suggestion was made of faulting, it is difficult to understand how such a conception of the relationship (juxtaposition) of beds, likewise expressed in diagrams, could have been entertained by one having otherwise a rather clear understanding as to the origin of such beds. Truly a marvelous admixture of correct and incorrect interpretation. The pulverulent silica of the chert beds was referred to the Tertiary (pp. 55, 56), for the author did not have the artificial openings to show that the silica is overlaid by beds of chert which have not been reworked. It is interesting to note that his assistant, Dr. Hilgard, recorded the presence of bitumen in the limestone at Southward (or Cypress) Pond (p. 46), and that it was nearly 70 years later before this same asphaltic limestone was first worked for road material in the adjacent parts of Alabama.

It is unnecessary to take up in detail the errors concerning the geographic distribution of the Paleozoic beds in this report or to call attention to the mistakes in correlation, etc. Suffice it to say that for a state-wide report based on a few years of reconnaissance work, it ranks well with the average of its day.

HILGARD REPORT

Dr Hilgard served as an assistant on the Second Survey. Much of the material of his field notes relating to the northwestern[1] part of the State, seemingly, was used in the Harper report without credit. It was somewhat natural, at the outset of his ascendancy as State Geologist, that he should state in the opening paragraph of his report it "is intended to embrace the observations and results heretofore obtained in connection with the Geological and Agricultural Survey of the State," but, of course with due credit. And so, among others he treated the Paleozoic beds. They were usually referred to as the Carboniferous. The fossil identification seems to have been performed largely or wholly by Professor W. D. Moore, of the University of Mississippi (pp. XII, 47). "The fossils thus far collected * * * place the greater portion of the outcrops within the limits of the Warsaw and Keokuk limestones of the Iowa Report * * * and it seems likely that lower and perhaps even higher groups of the sub-Carboniferous series may hereafter be found to be represented" (p. 47).

The shaly limestone of Yellow Creek and Tennessee River valleys as far east as Eastport was commonly referred to as "black calcareous slate," "black slate," etc. (pp. 3, 47). This was unfortunate. It was liable to lead the reader unfamiliar with the beds to the conclusion that the black carbonaceous shale of Devonian or Mississippian age was being considered.

From the dip of the beds, observed at least in a few places, Dr. Hilgard recognized the possibility of folds extending from Alabama and Tennessee into this part of Mississippi. He thus escaped

[1]No doubt Dr. Hilgard meant the northeastern part of the state.

the error of Harper in concluding that different kinds of beds lie in juxtaposition to one another. Unfortunately Hilgard did not clearly recognize the full import of the folded structure at a number of places, as along Yellow Creek and at Southward (or Cypress) Pond (pp. 48, 50), and accordingly erroneously concluded that one kind of beds was the equivalent of another kind, etc. As previously stated, it is not within the province of the present report, however, to call attention to all the errors of these early reports, such as incorrect correlation, mistaken locations, and the like.

Above the Carboniferous, Dr. Hilgard placed the Eutaw group, referring the underlying Tuscaloosa sand and gravel to the so-called surface deposit of "Orange Sand" (Plate I, Fig. 1, p. 3), which was given the most prominent place in the report. The present State Geologist, Dr. Lowe, has, on the other hand, pointed out clearly that where the underlying formation consists of sand and gravel the "Orange sand formation" is well developed, and where the underlying beds are chalk and clay, there is no "Orange sand formation." Clearly much, if not almost the whole, of the "Orange sand" (Lafayette) is the weathered surface exposures of various sand and gravel strata. Though far afield on the "Orange sand," Dr. Hilgard's report still stands as a classic on the interrelation of geology, soil, and vegetation.

BULLETIN 283

On the geologic map of Mississippi by Eckel and Crider, the Paleozoic beds extend across Tishomingo County, cut the southeastern corner of Prentiss, and extend nearly the full length of Itawamba; and in the text (p. 11) the southernmost outcrop of the same beds was placed on Bull Mountain Creek near the northern edge of Monroe County (south of Itawamba). It is unfortunate that, in response to demands, reports have to be issued on insufficient data; for the distribution of the Paleozoic beds, as given in this report is too great, the beds being confined almost to or quite within the limits of Tishomingo County. To Crider's credit it should be added, however, that in 1926 after search failed to reveal any Paleozoic rocks in Itawamba County, he stated, in reply to a telegraphic request for specific places of exposure, that probably no Paleozoic beds outcrop in Itawamba County.

Fossils collected by Crider from the limestone outcropping along Yellow Creek, and sent to Schuchert and Kindle for identification, proved to be New Scotland in age. The known range of the Paleozoic beds in Mississippi was accordingly extended downward from the Mississippian almost to the very base of the Devonian. To the Devonian were referred likewise all the other beds lying beneath "the Chert."

The younger beds of Mississippian age were divided in ascending order into the following formations: Tullahoma (Lauderdale chert), St. Louis limestone, and Chester, largely after the Alabama report by McCalley. The section of the Mississippian beds at the bridge (Southward) across Bear Creek near Mingo and the remarks concerning the sandstones are somewhat erroneous; and the section of Mississippian and Devonian beds on Whetstone Branch was badly confused, as the present report shows. All townships are given as North instead of South of the base line.

BULLETIN No. 12

All the other reports listed, save Bulletin No. 12, contain little if anything new about the Paleozoic beds, although they have incorporated in them many of the errors of distribution, succession, correlation, and the like of the earlier reports, particularly of Bulletin 283, as this early report has the errors of the still earlier reports. In Bulletin No. 12 the name Yellow Creek was introduced by Dr. Lowe to cover all the beds in Mississippi lying beneath "the Chert," and these beds were referred to the Devonian, after the manner of Bulletin 283.

IV PRESENT RESEARCHES

The writer's introduction to the geology of the Paleozoic beds of Mississippi came late in 1919, when he was engaged in making a commercial survey of that section. Further opportunity to study these most interesting beds was afforded by the Mississippi State Geological Survey, through the courtesy of Dr. E. N. Lowe, State Geologist. Under the auspices of the survey, part of the summer of 1920, part of the summer of 1921, and the whole summer of 1926 were spent in the field.

During the first season Paul Franklin Morse served as an assistant; during the second, T. B. Fatherree and Julian Patrick; during a part of the last, F. E. Vestal, F. N. Geddes, L. H. Shropshire, and E. H. Toney. All were deeply interested and shared most efficiently in the pleasure of determining for the first time the history of these somewhat elusive beds.

More than 120 collections of fossils were made and shipped to the Department of Geology of Massachusetts Institute of Technology, where they were studied during 1926-1927 under the most helpful supervision of Professor Hervey W. Shimer. At this Institution, too, was the report prepared.

The writer would be ungrateful, also, if he did not add a further word of acknowledgment. Except for instruction to connect the beds of Mississippi with those of adjacent Alabama and Tennessee, Dr. Lowe gave no orders other than to produce. Whatever value the report may have, therefore, is largly due to this unhampered policy; whatever its short-comings, they must be charged directly to the author. From its inception, that most public spirited citizen and venerable educator and physician, Dr. F. T. Carmack (who is at heart a geologist) has shown the greatest enthusiasm and most helpful interest in the study. Mr. Leatherwood, veteran proprietor of the Leatherwood Hotel, and scores of others, in one way or another, have assisted materially in the prosecution of the work.

V PHYSIOGRAPHY

The drainage of the region is into two great river systems, that of the Tennessee on the north and that of the Tombigbee on the south. The Tennessee River forms the northeast boundary of Tishomingo County for ten miles and of the state for an equal distance. Bear Creek, its largest tributary, flows northward along the eastern border of the county; in some places its valley is wholly within Mississippi; in others within Alabama, and in still others partly in each state. A number of tributaries flow east into Bear Creek, the most important of which are Cripple Deer Creek, Pennywinkle Creek, Clear Creek, Little Bear Creek, and Eastport Branch. Likewise a number of tributaries flow into the Tennessee, the larger being Indian Creek, Short Creek, Whetstone Branch, and Carmack Creek. Yellow Creek, draining the northwest quarter of the county, flows northward to within two miles of the Tennessee, where it turns due east around Island Hill, reaching the river just beyond the Tennessee line. Mackeys Creek, draining the southwest quarter of the county, flows south into the Tombigbee. Two of its tributaries are McDougle Creek and Rock Creek.

Although Bear Creek valley in its lower reaches is a mile in width, its walls are commonly steep to precipitous, reaching 100 to 200 feet above the valley flat. The Tennessee Valley is likewise a mile in width and has mostly precipitous walls, commonly 200 feet in height. All the minor tributary valleys of both these valleys are short, steep sided without valley flats. Two small tributaries, Carmack Creek and an unnamed stream, north of Whetstone Branch even have falls 60 feet in height, due to foreshortening of their valleys by lateral planation of the Tennessee River and the inability of their small streams subsequently to keep pace with the master stream. These small valleys form a wild rugged beauty probably unsurpassed anywhere in the state. Yellow Creek valley has a steep to precipitous east wall, reaching a maximum of 200 feet above the stream, and a wide valley floor in its lower stretches to Island Hill, below which the valley contracts sharply. All these tributary valleys which pass headward beyond the confines of the Paleozoic beds, have more open valleys of gently slopes in the unconsolidated Tuscaloosa or higher deposits. In the southern part of the county in the sandstone region, Bear Creek has a deep precipitous gorge or canyon-like valley, also strikingly beautiful. Where the two tributary valleys of Mackeys Creek unite at Bay Springs they are cut into the same cliff-forming sandstone, forming a delightful section, so readily accessible to motor travel, as to warrant its conversion into a state park.

VI DESCRIPTIVE GEOLOGY

GENERAL STATEMENT

As previously stated the Paleozoic beds of Mississippi are confined almost or quite to Tishomingo County, the northeast county of the state. Their surface distribution is shown in some detail on the outline map of this county (Plate I). The isolated exposures (indicated on the map), especially at the headwaters of Mackeys Creek and its eastern tributaries, have been connected by means of broken lines on the map for the reason that between these places probably the beds lie but slightly buried beneath unconsolidated Tuscaloosa sand and gravel. The same statement is applicable to a lesser degree to the exposures of the southern tributaries of Cripple Deer Creek, and even less to the exposures of Bear Creek near the southern limits of the county. The covering of unconsolidated sand and gravel may be so thin in fact that a slight shifting or deepening of the streams may expose Paleozoic beds here and there at any time. On the other hand, even though the beds have been most carefully traced, it is not unlikely that a few small isolated exposures may have escaped detection, largely because of the irregular coating of sand and gravel. Subsequent to the mapping along Bear Creek in its upper stretches in Tishomingo County, it was reported that there is a small exposure in that stream a mile or so above the most southern one of the map, but there was no opportunity to visit the region again. Any such exposures as may have escaped will undoubtedly be few in number and small in extent. The distribution shown on the map is essentially correct.

In their exposures, the Paleozoic beds are confined to the stream courses, so that in tracing them from place to place the streams which are not limited to the meets and bounds of state lines, must be followed, though they lead without the State, a condition clearly forecasted by Dr. Hilgard more than 60 years ago. In spite of the numerous minor dips of the rocks in diverse directions, their general inclination is toward the south. Because the beds rise toward the north and the deeper parts of the valleys are in the same direction, the oldest beds would be expected likewise in this direction. Such is the case, and the oldest beds are exposed in the lower reaches of Yellow Creek and some smaller tributaries of the Tennessee close at hand, whereas the younger beds are exposed along the stream courses in the southern part of the county.

CLASSIFICATION AND NAMES

A number of formations new to the science of the state have been discovered, and, therefore, require names. Some of the terms adopted from other states have been applied to the wrong formation, through mistaken correlation, and will have to be supplanted. In still other cases some of the older names themselves, were applied early or originally to terranes of different range at different places. Possibly most confusing of all has been the radical restriction recently of the limits of old established terms, until it is now necessary to explain what is meant by the use of such names. For all these reasons the introduction of new terms becomes inevitable. All the names of fomations and smaller divisions used in the present survey are, therefore, new ones, with a single exception.

The revised classification of the Paleozoic beds of Mississippi is as follows:

MISSISSIPPIAN SYSTEM:

- Chester series
  - Forest Grove formation
    - Highland Church sandstone (member)
    - Shale and sandstone
  - Southward Bridge formation
    - Limestone, upper
    - Shale and sandstone
    - Limestone, lower
    - Shale
  - Southward Spring sandstone
  - Southward Pond formation
    - Pond limestone "C"
    - Shale
    - Pond limestone "B"
    - Shale
    - Pond limestone "A"
    - Shale
  - Allsboro sandstone
  - Alsobrook formation
    - Cripple Deer sandstone (member)
    - Hargett sandstone (or shale member)
    - Limestone
- Lower (Iowa) series
  - Iuka terrane (chert)
  - Carmack limestone

DEVONIAN SYSTEM:

- Upper series
  - Whetstone Branch shale
- Oriskanian series
  - Island Hill formation
- Helderbergian series
  - New Scotland limestone

To aid the reader at the outset, this classification is correlated with the classification used in the earlier reports, so far as such correlation can be represented in tabular form. McCalley's classification of the Tennessee Valley Region (1896) has been added, because it served largely as a basis for the early Mississippi work. Attention should be called to the fact, that the base of Crider's Tullahoma includes a part of the top of McCalley's Lauderdale, and that the base of Morse's Alsobrook includes a small part of the top of McCalley's Tuscumbia.

Correlation table of the Devonian and Mississippian formations recognized by the different surveys of the notheast part of the state.

Morse 1927	Lowe 1915	Crider 1906	McCalley 1896 (Alabama)	Hilgard 1860	Harper 1857
Forest Grove S'ward Bridge S'ward Spring S'ward Pond Allsboro Alsobrook	Hartselle	Chester	Hartselle	Warsaw	Mt. limestone
Iuka	Tuscumbia Lauderdale	St. Louis Tullahoma	Tuscumbia		
Carmack			Lauderdale		
Whetstone Br. Island Hill New Scotland	Yellow Creek	New Scotland	Black Shale	Keokuk	

To further aid the reader the present classification is correlated with that of Alabama and of the standard section of the United States, so far as any section can be said to be standard. The Chester divisions of the standard section are those given by Weller in Volume 4 of the Kentucky Geological Survey (1921).

Though fully discussed in the text, attention should be directed to some features perhaps not clearly illustrated in the table. The Whetstone Branch formation is equivalent to most of the Chattanooga shale. The Carmack formation may include at the top some beds of Burlington age. The contact between the Lauderdale and Tuscumbia may have been drawn at slightly different stratigraphic positions in different localities. Both the Tuscumbia and the Iuka may or may not include some Ste. Genevieve at their top.

Correlation table of the Devonian and Mississippian formations of the different states.

Standard Weller 1921	Mississippi Morse 1927	Alabama McCalley 1896
Hardinsburg Golconda Cypress Paint Creek Bethel Renault	Forest Grove Southward Bridge Southward Spring Southward Pond Allsboro Alsobrook	Hartselle
Ste. Genevieve St. Louis Salem Warsaw Keokuk Burlington	? Iuka	? Tuscumbia (St. Louis)
Kinderhook Chattanooga	Carmack Whetstone Branch	Lauderdale (Keokuk) Black shale
Oriskany New Scotland	Island Hill New Scotland	

DEVONIAN SYSTEM

GENERAL

The Devonian system, consisting of the New Scotland limestone, the Island Hill formation, and the Whetstone Branch shale, lies at flood plain level of Yellow Creek at a point (Location 90, S. E. corner Sec. 27, T. 15S, R. 10E) four miles above its mouth. From this place these beds are exposed northward along the east wall of the valley to Island Hill, thence on both sides of the valley eastward toward its mouth near which the local east dip carries them beneath drainage. Here or beneath the lower talus slope of the west wall of the Tennessee they lie, with one exception, for two miles up the river. From this point to Whetstone Branch, another stretch of one and one-half miles, at least parts of them are exposed in the small tributaries of the Tennessee. Southward from Whetstone Branch they are concealed beneath the present flood plain deposits.

Though confined to a few square miles, these Devonian beds, for a number of reasons, require detailed study to read their complicated history. They dip in divers directions at different places; they are lens-shaped or rather wedge-shaped, as a result of their unconformable relations; and they are commonly exposed only in a fragmentary manner.

NEW SCOTLAND LIMESTONE

NAME AND GENERAL DESCRIPTION

The name New Scotland, the only surviving Paleozoic formation name in Mississippi, was adopted from the New York survey by Crider. This followed the identification by Schuchert and Kindle of the fossils, which Crider collected from the limestone, as New Scotland in age. The limestone and all the overlying sandstone, shale, and limestone, reaching to the base of "The Chert" (Iuka), was referred to the Devonian by Crider, withont any upper limit of the New Scotland being established.

Inasmuch as the New Scotland is the oldest terrane in the state, it is not known whether the whole formation or but a part of it is represented. In any event the exposed part is about 40 feet in thickness and consist entirely of limestone. It is in very massive layers, the lower half of which is extremely fossiliferous whereas the upper half is largely barren of fossil forms.

DISTRIBUTION AND DESCRIPTION

The New Scotland limestone, as in the case with the overlying beds, is beautifully exposed in the Cliff section (85) on the east side of Yellow Creek, some three miles above its mouth. Here as elsewhere the most marked feature distinguishing it from the other formations of the State is its massive character. It is also hard, and its upper portion is very compact. The lower part is gray in color, and the upper part is a bluish gray or more commonly blue.

Here as well as at some other localities, perhaps no less distinctive is its wonderful array of beautifully preserved fossils, lists of which are appended to the columnar sections. Filling the top layer of the lowest 10-foot interval of the Cliff section is *Leptaena rhomboidalis,* easily recognized by its marked concentric wrinkles. A larger, flatter form having faint concentric wrinkles, *Stropheodonta beckii,* is even more abundant in this interval, so much so in fact that it is impossible to break one from the limestone matrix without destroying several others.

Filling the top layer of the next higher (12-foot) interval is the small cone-shaped *Tentaculites gyracanthus.* Even more abundant is this form in a layer five feet lower. Similarly *Spirifer cyclopterus* is very abundant in a layer five feet above the base of the interval. Not so conspicuous, but perhaps as numerous as any forms save *Tentaculites gyracanthus* is the small *Anoplotheca con-*

cava. More striking than all others, perhaps, are the large tail shields of the Trilobite, *Dalmanites pleuroptyx,* both in this interval and the lower one.

Strangely enough the uppermost (17.5-foot) of the New Scotland beds yielded only two or three fossils so poorly preserved that but one form was recognized doubtfully as a *Meristella.*

Section of the Cliff on the east side of Yellow Creek valley some three miles above its mouth (Location 85, SE¼, Sec. 22, T. 1S., R. 10E.)

Tuscaloosa formation[1] total		30.0
Gravel, consisting for the most part of rather large to small pebbles of chert; all more or less rounded	30.0	
Carmack Creek limestone, total		81.5
Limestone, thin-bedded to shaly brownish-gray. Fossils are rare, but they are most abundant at the top of the interval. (Collection 14)	22.0	
Limestone, thin-bedded to shaly brownish-gray. It contains a few small Brachiopods. (Collection 15)	32.0	
Limestone, thin-bedded, similar to that above, but it contains more fossils, including both *Productella* and *Productus.* (Collection 16)	1.0	
Limestone, massive resistant layer	1.0	
Limestone, thin-bedded to shaly brownish-gray, which is much darker in the basal 5 or 10 feet. The lowest half-foot is covered. The limestone contains a few fossils. (Collection 17)	25.5	
Island Hill (?) formation, total		3.0
Limestone, massive hard gray, and some chert. No fossils. It is a question as to which formation this limestone belongs	3.0	
New Scotland limestone, total		39.5
Limestone, massive hard gray and bluish-gray, which is very compact and slightly sandy. Only two or three fossils were found in this interval. (Collection 18)	17.5	
Limestone, massive gray, which is very hard and very fossiliferous. *Tentaculites gyracanthus* is found at the top; 5 feet lower is a layer just filled with Trilobites and other fossils, including another *Tentaculites gyracanthus* bed; and 5 feet above the base is a *Spirifer* bed. (Collection 13)	12.0	
Limestone, massive, hard, which is very fossiliferous. *Leptaena rhomboidalis* bed at the top. (Collection 12). To water level of Yellow Creek about 380 feet above sea level	10.0	

[1]Since this report was written the boundary line between the Tuscaloosa and Eutaw has been shifted toward the east, so that Cretaceous beds west of Indian Creek itself are shown as Eutaw (U. S. Geol. Survey, Water-Supply Paper 576, Plate 2). Nevertheless, the few basal feet of the Cretaceous gravels in the sections west of that creek are probably correctly referred to the Tuscaloosa in the present report.

PLATE 2

New Scotland limestone fossils

Figs. 1, 2. *Atrypa reticularis.* ×1. Fig. 1 is a pedicle valve; Fig. 2, a brachial valve. Collection 12.

Fig. 3. *Eatonia sp., cf. peculiaris.* ×1. Brachial valve. Collection 13.

Figs. 4, 5. *Leptaena rhomboidalis.* ×1. Fig 4 is a pedicle valve, partly exfoliated; Fig. 5, a pedicle valve. This species is very common in a bed at the top of the basal 10 feet of the New Scotland. Collection 12.

Fig. 6. *Meristella princeps.* ×1. Brachial view, showing pedicle opening in the opposite valve. Collection 13.

Fig. 7. *Spirifer cyclopterus.* ×1. Pedicle valve. Collection 11.

Fig. 8. *Stropheodonta beckii.* ×1. Pedicle valve. Collection 12.

Fig. 9. *Stropheodonta planulata.* ×1. Valve attached to matrix. Collection 11.

Collection 11 is from a loose block from the lower half of the New Scotland;

Collection 12 is from the basal 10 feet of the New Scotland; and

Collection 13 is from the second interval (12 feet) of the New Scotland; all from the Cliff section (Location 85, SE¼, Sec. 22, T. 1S., R. 10E.) on the east side of Yellow Creek valley some three miles above its mouth, Miss.

Note: Although the photographs of the fossils of Plates 2 to 22 were all taken to exact scale and the scale indicated as natural size (× 1) or as twice natural size (× 2) in the description of the plates and on the plates themselves, unwarranted reductions were made in the making of the halftones. All were reduced approximately five per cent.

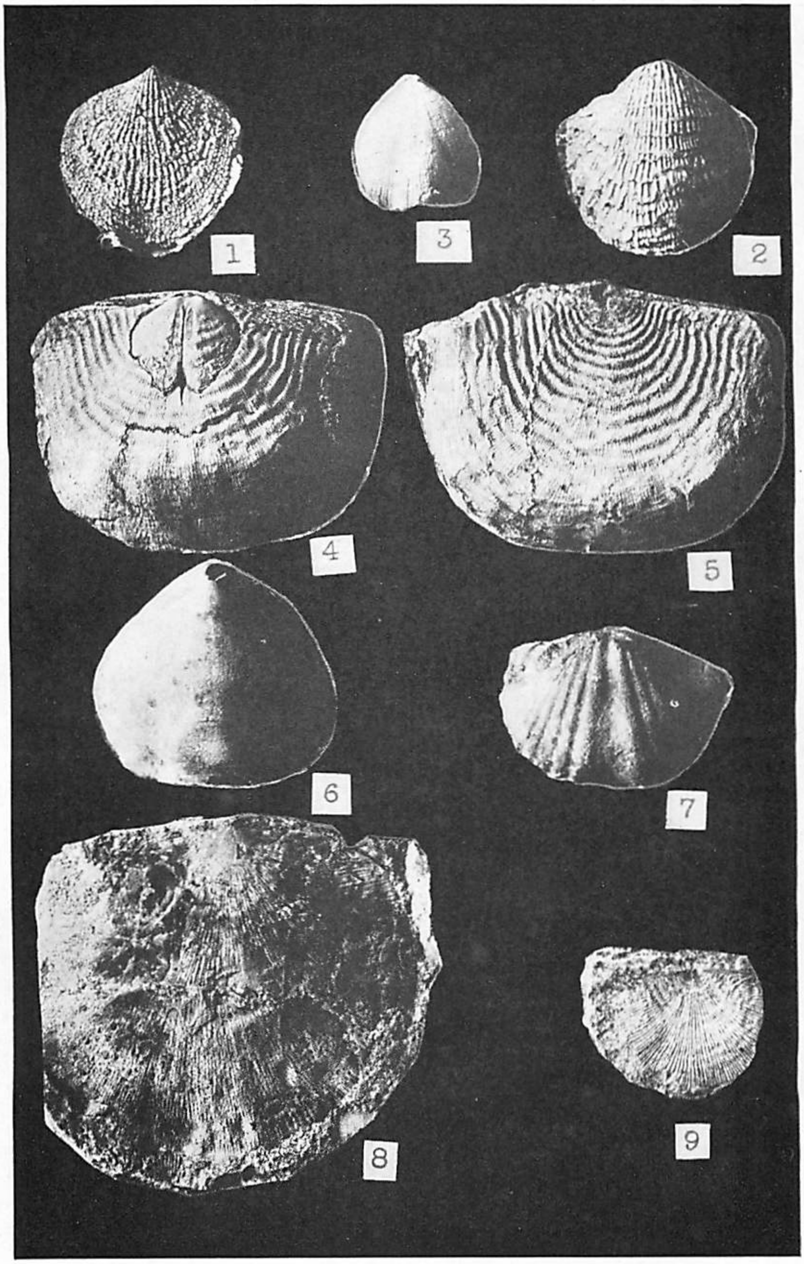

PLATE 2

List of fossils collected in the Cliff section (85)

CARMACK LIMESTONE:
- Collection 14:
  - Anthozoa
    - Cup Coral
  - Brachiopoda
    - Anoplia (?) sp.
    - Chonetes sp.
    - Liorhynchus sp., cf. laura
    - Lingula albapinensis
    - Lingula sp.
    - Productus (?) sp.
- Collection 15:
  - Brachiopoda
    - Anoplia (?) sp.
    - Chonopectus fisheri
    - Liorhynchus sp., cf. laura
    - Lingula albapinensis
    - Orbiculoidea sp.
- Collection 16:
  - Brachiopoda
    - Liorhynchus sp.
    - Productella hirsutiformis (?)
    - Productus sp., cf. ovatus
    - Reticularia sp., cf. pseudolineata or prematura
  - Gastropoda
    - Bellerophon sp.
- Collection 17:
  - Brachiopoda
    - Anoplia (?) sp.
    - Liorhynchus sp.
    - Orbiculoidea sp.

NEW SCOTLAND LIMESTONE:
- Collection 18:
  - Brachiopoda
    - Meristella (?) sp.
- Collection 13:
  - Crinoidea
    - Stems
  - Bryozoa
    - Fenestella
  - Brachiopoda
    - Anaplotheca concava
    - Chonostrophia sp., cf. helderbergiae
    - Eatonia sp., cf. peculiaris
    - Leptaena rhomboidalis
    - Meristella princeps
    - Spirifer cyclopterus
    - Spirifer perlamellosus (?)
    - Spirifer sp., cf. vanuxemi
    - Stropheodonta beckii
    - Stropheodonta planulata
    - Stropheodonta varistriata
  - Pelecypoda
    - Actinopteria textilis
    - Aviculopecten teneuilamellatus
    - Megambonia lamellosa (?)

Gastropoda
- Conularia huntiana
- Platyceras sp.
- Tentaculites gyracanthus

Crustacea
- Dalmanites pleuroptyx
- Phacops logani

Collection 12:

Crinoidea
- Edriocrinus pocilliformis (?)

Bryozoa
- Fenestella sp., cf. altidorsata

Brachiopoda
- Atrypa reticularis
- Chonostrophia helderbergiae
- Leptaena rhomboidalis
- Rhipidomella oblata
- Spirifer cyclopterus
- Stropheodonta beckii
- Stropheodonta planulata
- Strophcnella punctulifera
- Uncinulus mutabilis
- Uncinulus nucleolatus

Pelecypoda
- Actinopteria communis

Gastropoda
- Conularia sp., cf. pyramidalis
- Tentaculites elongatus
- Tentaculites gyracanthus

Crustacea
- Dalmanites pleuroptyx

PLATE 3

New Scotland limestone fossils

Fig 1. *Tentaculites gyracanthus.* ×1. A slab filled with the longitudinally crushed slender cones of this species and three or four specimens of a *Spirifer. Tentaculites gyracanthus* is abundant at the top and five feet below the top of the second interval (12 feet) of the New Scotland limestone. Collection 13.

Collection 13 is from the second interval (12 feet) of the New Scotland limestone in the Cliff section (Location 85, SE¼, Sec. 22, T. 1S., R. 10E.) on the east side of Yellow Creek valley some three miles above its mouth, Miss.

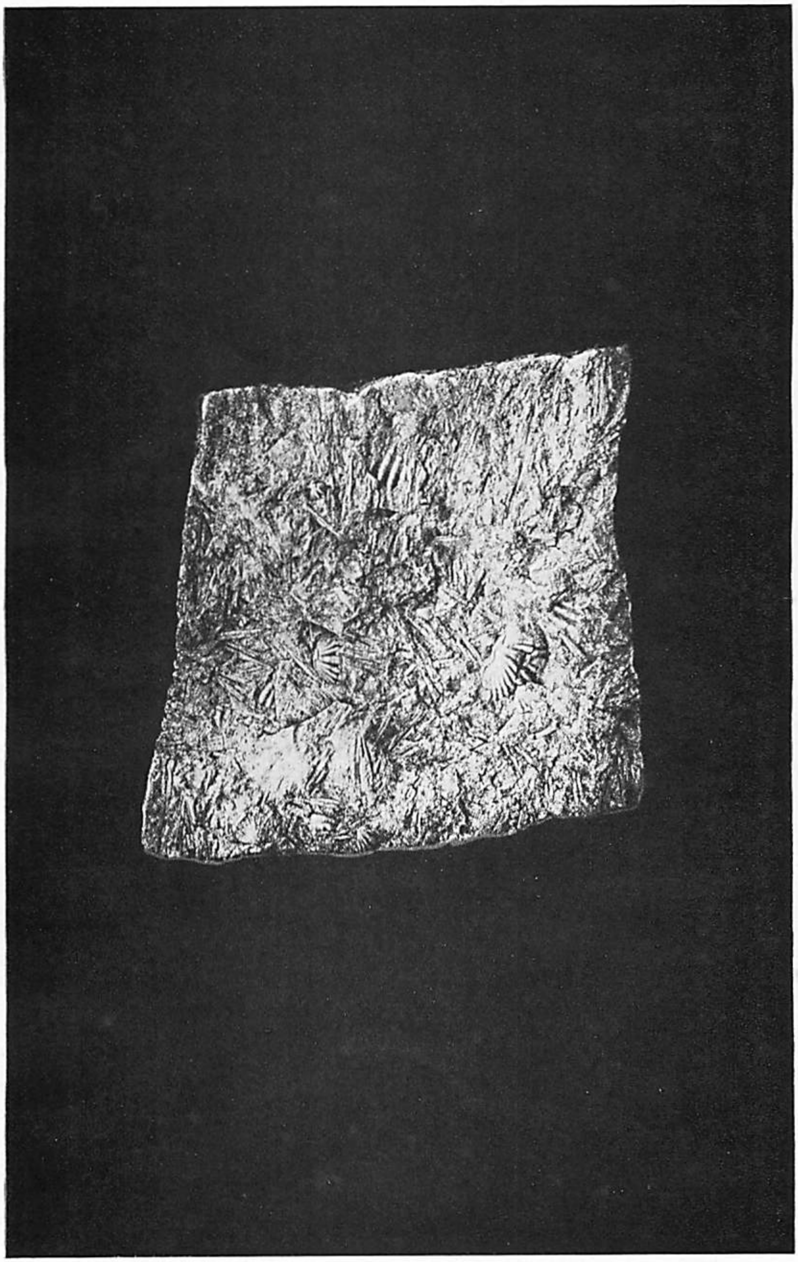

PLATE 3

PLATE 4

New Scotland limestone fossils

Figs. 1, 2. *Dalmanites pleuroptyx.* ×1. Exterior and interior views, respectively, of two tails (pygidia). The slab contains also other fragments of Trilobites. Collection 11.

Fig. 3. *Phacops logani.* ×2. The head (cephalon) of an individual showing the eyes and the faint tubercles on the glabella. Collection 11.

Collection 11 is from a loose block of limestone of the lower half of the New Scotland limestone in the Cliff section (Location 85, SE¼, Sec. 22, T. 1S., R. 10E.) on the east side of Yellow Creek Valley some three miles above its mouth, Miss.

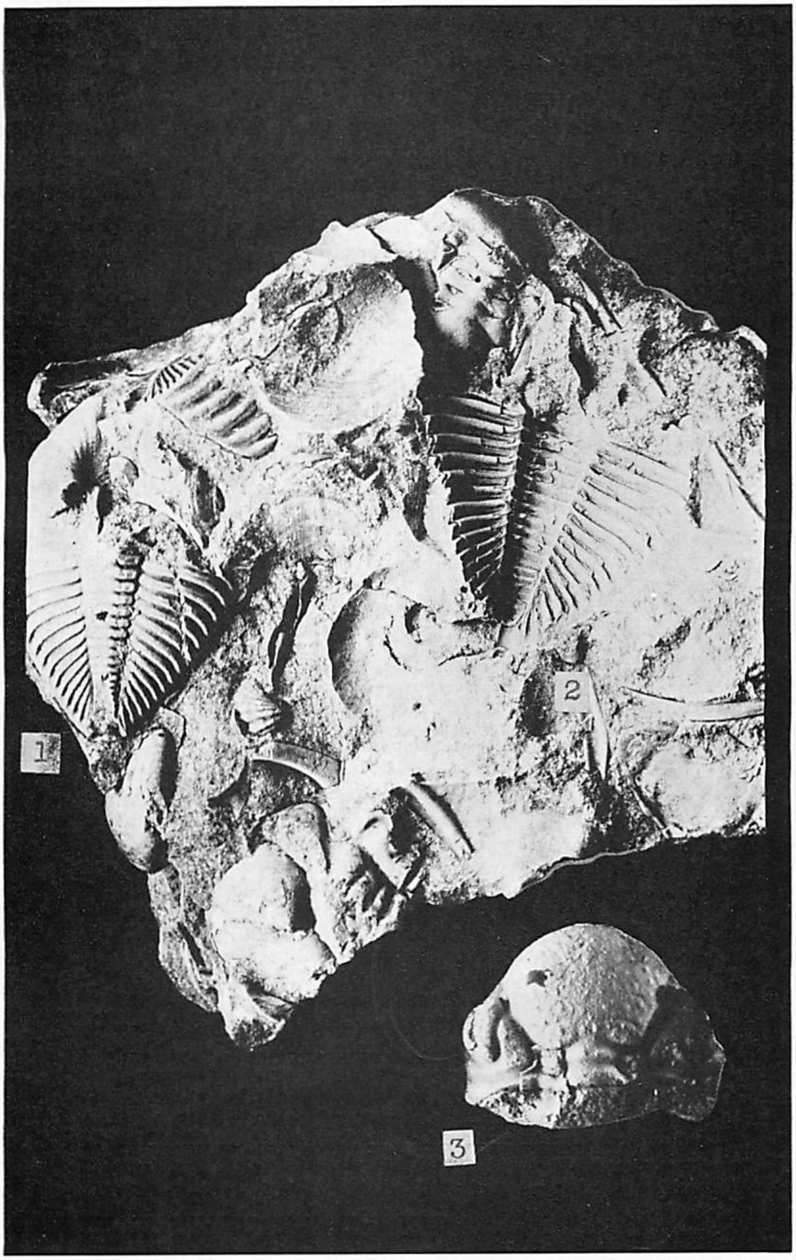

PLATE 4

The New Scotland limestone is well exposed on the south side of Island Hill (Section 127), where the beds dip 5° almost straight east, thus exposing lower layers down stream for a short distance, toward the west. Approximately at the base is a 2-foot layer of peculiarly crystalline limestone from which *Meristella sp.* protrudes conspicuously. The list of fossils (25) collected from the basal part of the exposure at this place five years before the section was measured, shows a few of the many species at the Cliff section (85).

Most, if not all, of the remaining upper portion of 37 feet is a massive compact, blue limestone, seemingly destitute of fossils. Some of it is inconspicuously bedded, some irregularly or wavy bedded, and some cross-bedded. The whole is more or less finely arenaceous, so that in weathered outcrops the stone has the general appearance rather of a sandstone than of a limestone.

Section of the south side of Island Hill on Yellow Creek (Location 127, NW¼, Sec. 22, T. 1S., R. 10E.)

Carmack limestone, total		53.0
Limestone, thin to shaly bedded brownish-gray, which breaks into thin layers, but which maintains its color and freshness. Partly covered	53.0	
Whetstone Branch formation, total		1.5
Sandstone, massive compact blue, no doubt somewhat calcareous. The top is filled with worm borings or plant markings. The basal part contains chert pebbles and water worn bone fragments. Here the contact is unconformable. Collection 63)	1.5+	
Island Hill formation, total		3.0
Limestone, layer of largely siliceous or cherty, from whose surface *Meristella sp.* and *Schuchertella becraftensis* project conspicuously (Collection 28)	1.0	
Interval consists of: a thin bottom layer of fragmentally crystalline and fragmentally fossiliferous limestone, containing Crinoid stems and other fossils; a thin top layer of more compact limestone, filled with *Meristella lata* and two or three species of *Dalmanites;* and interstratified layers; the whole being more or less cherty and more or less covered. A block of limestone from one of these layers is a coarse breccia or conglomerate and, no doubt, represents a basal conglomerate and, therefore, an unconformity. (Collection 27-A) (Collection 26 is from loose blocks of chert, all of which probably came from this 2-foot interval and the 1-foot layer above)	2.0	
New Scotland limestone, total		39.0
Limestone, massive; some inconspicuously bedded; some slightly cross-bedded or wavy bedded; all hard, compact blue and more or less finely arenaceous, seemingly without fossils	12.0	
Limestone, massive irregularly and cross-bedded, compact blue finely arenaceous. Dip 5° S. 85° E. Measured down stream and up dip	22.0	
Limestone, poorly exposed, but seemingly compact blue	3.0	
Limestone, peculiarly crystalline, from which *Meristella sp* protrudes conspicuously. (Collection 25 was secured, five years before the section was made, from the basal part of the limestone at this place). The beds extend about 50 feet farther west, and possibly 5 feet additional are exposed	2.0	

List of fossils from the Island Hill section (127)

WHETSTONE BRANCH FORMATION:
- Collection 63:
  - Brachiopoda
    - Strophomenoid form
  - Gastropoda
    - Tentaculites sp., cf. spiculus
  - Vertebrata
    - Fish plates

ISLAND HILL FORMATION:
- Collection 28:
  - Brachiopoda
    - Meristella sp.
    - Schuchertella becraftensis
  - Crustacea
    - Trilobite pygidium
- Collection 27-A:
  - Brachiopoda
    - Meristella lata
    - Schuchertella becraftensis
    - Stropheodonta sp., cf. magnifica
  - Crustacea
    - Dalmanites micrurus
    - Dalmanites multianulatus
    - Dalmanites stemmatus
- Collection 26:
  - Crinoidea
    - Stems
  - Bryozoa
    - Fenestelloid
  - Brachiopoda
    - Anoplotheca concava
    - Chonostrophia complanata
    - Meristella lata
    - Meristella sp.
    - Rhipidomella assimilis
    - Rhipidomella marylandica
    - Rhipidomella musculosa
    - Rhipidomella subcarinata
    - Schuchertella becraftensis
    - Spirifer sp. (S. murchisoni muscular impressions)
  - Pelecypoda
    - Specimen, undetermined
  - Gastropoda
    - Platyceras sp.
    - Tentaculites gyracanthus
  - Crustacea
    - Dalmanites pleuroptyx
    - Specimen No. 1
    - Specimen No. 2

NEW SCOTLAND LIMESTONE:
- Collection 25:
  - Brachiopoda
    - Meristella princeps
    - Stropheodonta beckii
  - Crustacea
    - Dalmanites pleuroptyx
    - Phacops logani

The New Scotland limestone is fairly well exposed in the highway just north of the Yellow Creek iron bridge (Section 130). The basal part of the 47 feet is here unweathered; it is a hard, compact blue limestone, similar to what is found in other nearby sections at this horizon. The upper part has weathered to a yellowish mass which is decidedly sandy or at least siliceous.

Section in the highway north of Yellow Creek iron bridge (Location 130, South Central, Sec. 15, T. 1S., R. 10E.)

Tuscaloosa formation, total		5.0
Gravel, medium, and sand, red	5.0	
Carmack limestone, total		41.0
Limestone, thin to shaly bedded, which splits into thin shaly layers, but which retains its hardness and brownish gray color. In the sloping surface at the highway it has weathered to a yellowish-buff and whitish residue, after the leaching of the calcium carbonate	41.0	
Whetstone Branch formation, total		2.0
Sandstone, position of. In the immediate vicinity of the highway the sandstone dips 16 feet N. 45° E., in 400 feet	2.0	
Island Hill formation, total		3.0
Limestone, contains much banded chert. Both limestone and chert are extremely fossiliferous. (Collection 30) (Collection 30—duplicate from loose blocks)	3.0	
New Scotland limestone, total		47.0
Limestone, hard, compact, blue at the base, where it is fresh. Higher in the highway, it is weathered to a yellowish mass, which is decidedly sandy or at least siliceous. The upper part is much weathered and mostly covered. Base of exposure about flood plain level	47.0	

List of fossils collected in the highway section (130)

ISLAND HILL FORMATION:

- Collection 30:
  - Crinoidea
    - Stems
  - Brachiopoda
    - Leptaena rhomboidalis
    - Meristella sp.
    - Rhipidomella musculosa
    - Rhipidomella oblata
    - Schuchertella becraftensis
    - Spirifer sp., cf. murchisoni
    - Stropheodonta magnifica
  - Crustacea
    - Dalmanites stemmatus
    - Dalmanites sp.
- Collection 30—Duplicate:
  - Anthozoa
    - Favosites helderbergiae
  - Crinoidea
    - Stems
  - Brachiopoda

Meristella lata
Rhipidomella musculosa
Rhipidomella oblata
Schuchertella becraftensis
Spirifer sp., cf. murchisoni
Stropheodonta magnifica
Pelecypoda
Specimen incomplete
Crustacea
Dalmanites sp.

Inasmuch as the beds dip east down Yellow Creek at a greater inclination than the slope of the valley, more and more of basal part of the New Scotland disappears in this direction, leaving less and less of the top above the creek bed. In fact outcrops of the New Scotland are confined largely to the banks of the channel from the mouth of Big Branch (Section 134) to a point about one-half mile lower (Section 172) and to a point about one-fourth mile still lower (Section 136), where the limestone passes beneath drainage. For this reason the limestone is plastered very commonly with mud and sand, and therefore, it is not exposed clearly in these sections.

Section of Yellow Creek at the mouth of Big Branch (Location 134, SW¼, Sec. 14, T. 1S., R. 10E.)

Whetstone Branch formation, total		5.5
Sandstone, massive layer; poorly exposed	4.0	
Sandstone, thin bedded, and shales, some of which are black and carbonaceous	1.5	
Undetermined		4.0
Interval covered	4.0	
New Scotland limestone, total		11.0
Limestone, sandy; poorly exposed	2.5	
Limestone layer, the top and bottom of which are sandy and the middle of which is spongy siliceous and calcareous material. Filled with Crinoid stems, *Tentaculites gyrancanthus* and *Spirifer cyclopterus* which constitute the whole of Collection 66	2.0	
Limestone, massive, compact blue sandy. *Leptaena rhomboidalis*	6.5	

Section of Yellow Creek about one-half mile below Big Branch (Location 172, SW¼, Sec. 14, T. 1S, R. 10E.)

Carmack limestone		00.0
Limestone, thin bedded to shaly, exposed in the cliffs, but the basal part has slumped over the Whetstone Branch formation. Farther up stream exposures of the two formations reach within 5 or 6 feet of each other so that either formation can not be increased more than this amount	00.0	
Whetstone Branch formation, total		6.5
Sandstone, massive layer of gray. The top is covered with worm markings and is undulating; the base contains black fish bones or concretions	3.5	

Sandstone, layer of probably calcareous, above and below which are shales, some of which are sandy and some of which are black, carbonaceous, and fissile. The sandstone is marked with worm trails	3.0	
New Scotland limestone, total		4.0
Limestone, massive indefinitely bedded sandy mostly gray. The top is covered with worm marks, seems more sandy than the rest and may have been reworked slightly, but the whole is indistinct in that it is more or less plastered with Yellow Creek mud and sand. Otherwise the stone has all the appearance of the upper compact sandy limestone of this formation at the Island Hill (127) and Cliff (85) sections. Dip 2° N. 90° E. To water level of Yellow Creek	4.0	

In the same cliff, but in a slightly separated exposure, the massive sandstone (3.5 feet) seems to be split into two parts by a black carbonaceous shale wedge, as follows:

WHETSTONE BRANCH FORMATION:	
Sandstone, gray	1.0
Shale, black, carbonaceous	0.6
Sandstone, compact bluish gray	1.0

Section of Yellow Creek about three-fourth mile below Big Branch (Location 136, SE¼, Sec. 14, T. 1S., R. 10E.)

Iuka chert, total		50.0
Chert, fragmental blocks	50.0	
Carmack limestone, total		90.0
Limestone, thin bedded to shaly, brownish-gray. The basal part has slumped slightly over the beds below, so that the contact is not sharp. Flood plain of Yellow Creek	90.0	
Whetstone Branch formation		4.5
Sandstone, massive layer of bluish-gray. The top is covered with *Taonurus*-like markings; the base contains black bone fragments or concretions and flat pebbles. (Collection 65, which has the same basal conglomerate and plant or animal markings as Collection 63)	4.5	
Undetermined		5.0
Medium layers of blue sandy and probably calcareous material; the upper part is covered with worm markings or mud cracks. At least one of the layers contains a *Spirifer* and other forms as determined in 1921, but the whole is badly covered with creek mud. Probably mostly New Scotland but the top may have been slightly reworked. To water levels	5.0	

Although the section (139) one mile above the mouth of Yellow Creek and the one (142) two miles above the same stream, both contain Devonian beds, they do not extend deeply enough to expose the New Scotland limestone. The next tributary (143) two and one-half miles above Yellow Creek does, however, show 8-feet of New Scotland limestone at about the level of the flood plain of the Tennessee, where a wet weather spring or an underground stream has removed the overlying debris. The stone is slightly crinoidal, but, otherwise, it is the typical massive limestone of that bed.

(Since this report was written, however, a loose block of Island Hill chert was found at this Spring.)

Section of eroded byway extending up the west wall of the Tennessee, one mile above the mouth of Yellow Creek (Location 139, NW¼, Sec. 24, T. 1S., R. 10E.)

Tuscaloosa formation, total		70.0
Gravel; some chert blocks far up	70.0	
Iuka chert, total		30.0
Chert, blocks	30.0	
Carmack limestone, total		96.0
Interval, covered, but it seems to be all shaly limestone float	10.0	
Limestone, thin-bedded to shaly brownish-gray. Recent cutting in the by-way has reevaled its more massive character where fresh. The basal part contains an occasional chert nodule	40.0	
Limestone, thin bedded to shaly brownish-gray, which is somewhat weathered	46.0	
Undetermined		8.0
Interval, covered	8.0	
Whetstone Branch formation, total		26.0
Sandstone, thin layers interstratified with shales, some of which are badly weathered clayey and sandy and some of which are black carbonaceous. The basal layer is a sandstone, 0.4 foot in thickness, which contains *Lingula sp.* The interval is partly covered	26.0	
Undetermined		11.0
Interval covered to the flood plain of Tennessee River	11.0	

No section was made at this place either in 1920 or 1921. The rains previous to the 1926 visit seem to have exposed the lower part of the section, especially that of the Whetstone Branch formation, which has been brought above flood plain level by the slight local rise of the beds toward the southeast. Neither the erosion nor the inclination of the beds, however, was sufficient to expose the New Scotland limestone.

Section of Carmack Creek, small tributary of the Tennessee, two miles above Yellow Creek (Location 142, NE¼, Sec. 25, T. 1S., R. 10E.)

Tuscaloosa formation, total		15.0
Gravel 10 to	15.0	
Iuka chert, total		75.00
Chert, loose blocks	75.0	
Carmack limestone, total		100.0
Limestone, brown shaly. Dip 5°, S. 65° W. To brink of falls	40.0	

Limestone, brown shaly. To base of falls	60.0	
Whetstone Branch formation, total		31.5
Sandstone, massive layer, containing concretions in the base. Possibly the prominent layer on Yellow Creek	2.0	
Interval, mostly covered, partly sandy shales	2.0	
Shales, black carbonaceous fissile. Dip 4.5° S. 65° W.	3.5	
Interval, partly covered, partly black carbonaceous shale and partly slightly sandy gray shales	3.5	
Interval, covered	5.5	
Shales, sandy, and shales, black carbonaceous. Base of exposure near the falls	5.0	
Interval, covered	7.0	
Sandstone, layer, fine grained, which is exposed near the mouth of the valley. Dip 5.5°, N. 90° W., therefore, the intervals are too thin	1.0	
Sandstone, thin layers, and shales, black carbonaceous, some of which are beneath the sandstone	2.0	
Undetermined		10.0
Interval, covered, to the flood plain of the Tennessee	10.0	

The next tributary up the Tennessee about one-half mile, also has a 60-foot water fall in it, the basal 10 feet of which exposes black carbonaceous Whetstone Branch shales, but the lower part of the formation is rather badly covered. At the mouth of the valley is an 8-foot exposure of New Scotland limestone, which lies just above the Tennessee flocd-plain and which contains a small cave.

Even though the Carmack brown shaly limestone lies at water level at the mouth of Whetstone Branch, the lower New Scotland limestone is exposed farther up stream, 1,500 feet and more, because the beds rise in this direction at a greater angle than that of the stream. Of the New Scotland limestone the upper part of the 3.5-foot basal interval is very fossiliferous (Collection 36), but the limestone is so coarsely crystalline as nearly, in the process of crystallization, to have destroyed the fossil forms. It is accordingly possible to identify them generically only, save in the case of a single individual, more completely preserved. The middle 13-foot interval of the New Scotland limestone has the typical structure, texture, etc., of this formation, being a hard, compact massive slightly cross-bedded somewhat sandy blue limestone. The uppermost interval of 3 feet is a slightly cherty limestone, which seems to be fossiliferous in few places only; or the fossiliferous portion may have been swept away by erosion in Devonian, Mississippian, or recent times.

The list of fossils from the upper interval includes but few forms (Collection 35). The number of species represented in this decidedly fossiliferous part is not only fewer by far than the number from the New Scotland limestone in the Cliff section (85) on Yellow Creek, but the individual specimens belong largely to the Trilobite identified as *Dalmanites stemmatus*, an Oriskany form. The Trilobite is represented by pygidia (tails) and incomplete cephala (heads) alone, no complete form having been found. Typically the pygidia of *D. pleuroptyx* have 11 to 13 lateral ribs, which are longitudinally grooved, whereas those of *D. stemmatus* have 9 to 10 ribs without grooves. The pygidia from this interval have 15 lateral ribs as in *D. pleuroptyx* all which are without grooves as in *D. stemmatus* except one which has faintly grooved ribs. Agreeing in size with the large pygidia are the large cephala, save one, which have huge frontal lobes on the glabellae, and which have the first, second, and even third lateral lobes fused at the distal end as in *D. stemmatus*. The forms seem to be *D. pleuroptyx* changing into *D. stemmatus*. However, for lack of more complete evidence, this top interval of 3 feet is left in the New Scotland formation rather than being referred to the Island Hill formation, the next youngest terrane.

Section of Whetstone Branch of the Tennessee (Location 157, Sec. 36 and Sec. 31, T. 1S., R. 10E., and R. 11E.)

Tuscaloosa formation, total		55.0
Sand, red, and gravel	55.0	
Iuka chert, total		70.0
Chert, mostly angular blocks, and porous siliceous rock. In some places the chert is in beds, showing that the rock enclosing it has been leached away. *Productus sp.* was found near the top of the formation on the south side of the valley, in the highway leading south in the NE¼, Sec. 36; otherwise the chert seems rather barren of fossils	70.0	
Carmack limestone, total		79.0
Limestone, brown shaly. The top portion consists of 5 or 6 feet, in the road branching to the south in the NE¼, Sec. 36, has been weathered to a clay shale, possibly in pre-Iuka times	78.0	
Rock, hard, dark blue, containing marcasite nodules or concretions, somewhat sandy. The basal conglomerate of this formation	1.0	
Whetstone Branch shale, total		23.5
Shales, black carbonaceous (Collection 31)	0.8	
Sandy and calcareous layer containing pyrite	0.2	
Shales, black carbonaceous, fissile interstratified with thin layers of limy and pyritiferous sandstone. The shales are broken by two systems of joints; one trends N. 40° E., the other, N. 50°-70° W. The basal contact resembles an unconformity	4.0	
Shales, black carbonaceous, interstratified with limy and pyritiferous sandstone; both are concretionary, cross-bedded, or contorted, or all of these. The sandstone is ripple-marked. (Collection 32 from basal part)	6.0	

Shales, black carbonaceous irregularly-bedded. They contain thin lenses or concretions of limy and pyritiferous sandstones	4.3	
Interval, covered	0.7	
Shales, black carbonaceous; a little limy or pyritiferous sandstone interstratified (Collection 33)	3.5	
Sandstone, yellow calcareous (Collection 34)	0.8	
Shales, black carbonaceous, and sandstone, thin, limy, and pyritiferous	2.0	
Interval, covered	1.2	
New Scotland limestone, total		19.5
Limestone and chert, very fossiliferous; seemingly absent in places; the fossil evidence as to their age is not entirely conclusive. (Collection 35)	3.0	
Limestone, hard compact massive slightly cross-bedded and sandy blue	13.0	
Limestone, the top of which is so coarsely crystalline as almost to destroy the fossil forms (Collection 36). To water level	3.5	

At this end of the section the base of the Carmack limestone is 43 feet above the stream, whereas 1,500 feet down stream at the mouth of the branch the limestone of the same Carmack formation, probably the basal part, lies in the water. The bed dips down stream, therefore, 43 feet more than the gradient of the stream. This structure exposes both the Whetstone Branch formation and the New Scotland limestone in the branch, but no doubt the failure to recognize this feature led to the confusion of the earlier workers.

List of fossils collected on Whetstone Branch (157)

WHETSTONE BRANCH FORMATION:

- Collection 31:
  - Conodonts
    - Teeth
- Collection 32:
  - Brachiopoda
    - Lingula sp. (Intermediate between L. spatulata and L. melie)
  - Conodonts
    - Teeth
- Collection 33:
  - Brachiopoda
    - Lingula sp. (L. spatulata-L. melie)
  - Conodonts
    - Hindeodella sp.
    - Polygnathus (?) sp.
- Collection 34:
  - Brachiopoda
    - Lingula sp.

NEW SCOTLAND FORMATION:

- Collection 35:
  - Crinoidea
    - Stems abundant

Brachiopoda
- Spirifer sp.
- Stropheodonta (Leptostrophia) oriskania

Gastropoda
- Platyceras sp.
- Tentaculites gyracanthus

Crustacea
- Dalmanites stemmatus

Collection 36:

Anthozoa
- Cup coral

Crinoidea
- Stems

Brachiopoda
- Meristella sp.
- Spirifer sp.
- Stropheodonta sp.
- Uncinulus nucleolatus

Summarizing, the New Scotland limestone, as best exposed in the Cliff section (85) on Yellow Creek, is about 40 feet in thickness, all more or less massive, but roughly divisible into a lower and upper half. The lower half is profusely fossiliferous; the upper, so sparingly so as scarcely to be called fossiliferous at all. The lower part is rather pure limestone; the upper, is somewhat sandy. The lower half is fairly regularly bedded; the upper unevenly bedded and cross-bedded. The upper part, thus in contrast to the lower, seems to indicate retreating sea conditions during deposition.

FAUNA AND CORRELATION

The New Scotland faunal table shows that a few species range through the Helderbergian and into the Oriskanian. Nearly all of them, however, are confined to the Helderbergian. Some of the Helderbergian forms range through the Coeymans and New Scotland; some, through the Coeymans, New Scotland, and Becraft; and some, through the New Scotland and Becraft. The most characteristic fossil each of the Coeymans and of the Becraft is entirely absent. Even though the most characteristic northern Appalachian New Scotland form, *Spirifer macropleurus,* likewise is not present here, nevertheless the range of the forms in the table points strongly to the New Scotland age of the limestone.

New Scotland Faunal Table (1)	Maryland						New York				
	Keyser	Coeymans	New Scotland	Becraft	Shriver-Orisk	Ridgely-Orisk	Coeymans	New Scotland	Becraft	L. Oriskany	U. Oriskany
Crinoidea											
Edriocrinus pocilliformis (?)			X	X				X			
Bryozoa											
Fenestella sp., cf. altidorsata	X										
Brachiopoda											
Anaplotheca concava			X	X				X		X	
Atrypa reticularis	X	X	X			X	X	X	X		
Chonostrophia helderbergiae			X				X				
Eatonia sp., cf. peculiaris			X	X		X		X		X	X
Leptaena rhomboidalis	X	X	X	X			X	X	X	X	X
Meristella princeps								X	X		
Rhipidomella oblata		X	X				X	X	X	X	
Spirifer cyclopterus		X	X					X	X		
Spirifer perlamellosus (?)			X				X	X			
Spirifer sp. cf. vanuxemi	X										
Stropheodonta beckii			X					X	X		
Stropheodonta planulata		X	X	X			X		X		
Stropheodonta varistriata							X				
Strophonella punctulifera		X	X				X	X	X		
Uncinulus mutabilis							X				
Uncinulus nucleolatus	X							X			
Pelecypoda											
Actinopteria communis	X	X	X			X		X		X	
Actinopteria textilis			X					X			
Aviculopecten tenuilamellatus	X							X			
Megambonia lamellosa (?)						X				X	X
Gastropoda											
Conularia huntiana								X			
Conularia sp. cf. pyramidalis								X			
Platyceras sp.											
Tentaculites elongatus		X	X		X			X	X	X	X
Tentaculites gyracanthus	X										
Crustacea											
Dalmanites pleuroptyx		X	X				X	X	X		
Phacops logani			X					X			

(1) Range according to the Devonian Reports of the Maryland Geological Survey.

ISLAND HILL FORMATION

DISTRIBUTION AND DESCRIPTION

The Island Hill formation is named from the beautiful round isolated hill which a tributary and Yellow Creek, about two miles above its mouth, almost if not completely surround at flood time. The formation is limited largely to this hill and to the opposite wall of Yellow Creek toward the north.

Perhaps this formation, new to the science in Mississippi, is best exposed on the south side of Island Hill in a small gully emptying into Yellow Creek where the creek waters first meet the hill (Section 127). Here and elsewhere the most conspicuous feature is the cherty upper layer, one foot in thickness, from whose weathered surface fossils project prominently. Originally the layer was undoubtedly a limestone. Two of the most abundant fossils are Brachiopods, *Meristella sp.* and *Schuchertella becraftensis.* Beneath is an interval of two feet which consists of: a thin top layer of somewhat compact limestone, filled with *Meristella lata* and two or three species of *Dalmanites;* a thin bottom layer of fragmentally crystalline and fragmentally fossiliferous limestone, containing Crinoid stems and other forms; and intermediate layers; the whole being more or less cherty, and at this place more or less concealed by soil. Most fortunately under these conditions, a block of coarsely brecciated or conglomeratic limestone was found weathered out from this two-foot interval, thus revealing its basal conglomerate nature and the unconformable relation of the three-foot Island Hill formation to the underlying New Scotland limestone.

On the opposite side of Yellow Creek valley to the north of the hill of the type locality, the Island Hill formation lies at the surface where it is chiefly in the form of loose blocks of extremely fossiliferous chert. In the highway north of the Yellow Creek iron bridge (Section 130), it is poorly exposed as a limestone containing much banded chert. The whole formation is about three feet in thickness and, as usual, is very fossiliferous.

Aside from the three-foot, slightly cherty, unfossiliferous limestone in the Cliff section (85) doubtfully referred to this formation, the Island Hill formation is known only in the hill at the type locality and on the opposite side of Yellow Creek valley in the immediate vicinity to the north. Such is the case in spite of its position being above drainage farther down Yellow Creek and in the middle stretches of Whetstone Branch. In the known area it is directly

PLATE 5

Island Hill formation fossils

Fig. 1. *Schuchertella becraftensis.* ×1. A slab which is largely filled with small, intermediate, and large specimens of this species. but which contains a *Spirifer* and one or two other forms. Collection 30-duplicate.

Collection 30—duplicate came from the cherty limestone stratum, 3 feet thick, of the Island Hill in the highway north of the Yellow Creek iron bridge (Location 130, South Central, Sec. 15, T. 1S, R. 10E.), Mississippi.

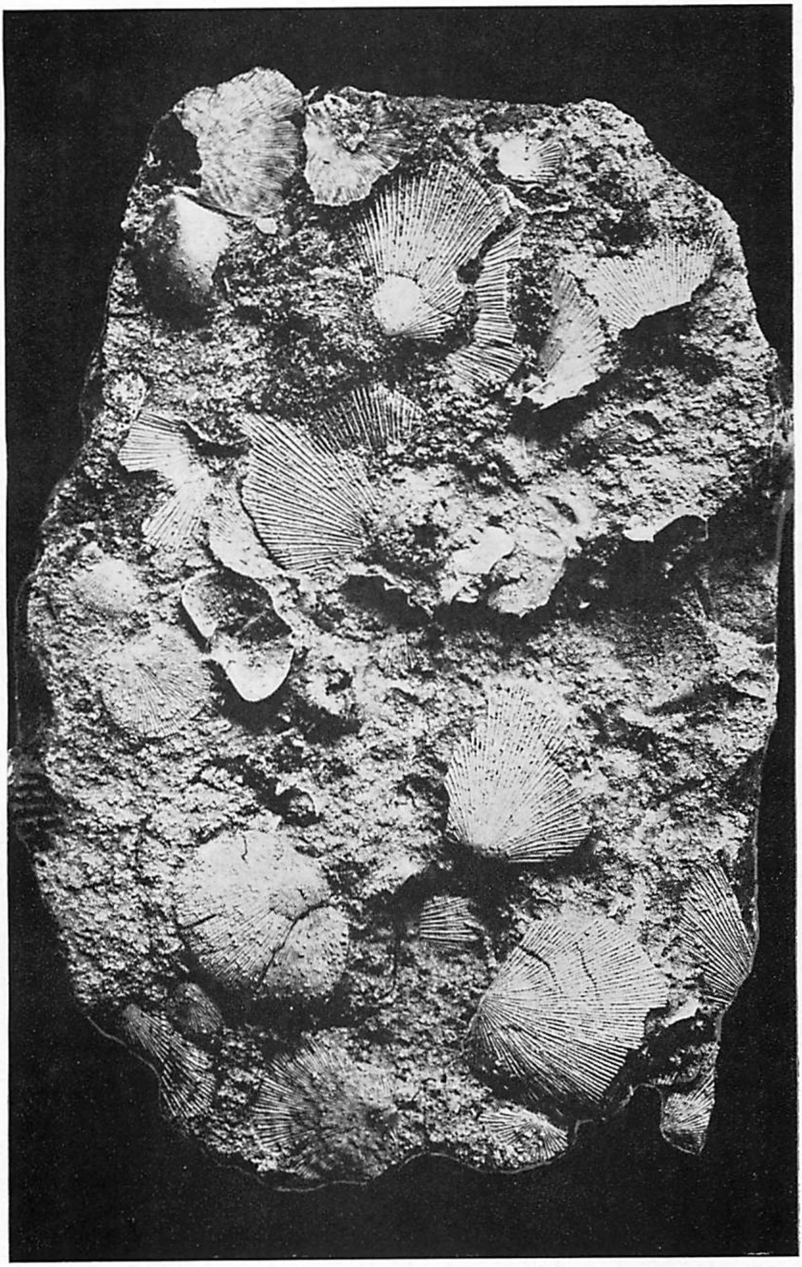

PLATE 5

PLATE 6

Island Hill formation fossils

Fig. 1. *Schuchertella becraftensis.* ×1. A slab of large specimens of this species. Collection 30-duplicate.

Fig. 2. *Stropheodonta magnifica.* ×1. The interior of the pedicle valve showing the large muscle impressions, which have passed those of the New Scotland forms, but which have not completely attained the sturdiness of those of the typical or late Oriskany forms. Collection 30.

Collection 30—duplicate and **Collection 30** came from chert and limestone of the 3-foot stratum of Island Hill in the highway north of the Yellow Creek iron bridge (Location 130, South Central, Sec. 15, T. 1S, R. 10E.), Miss.

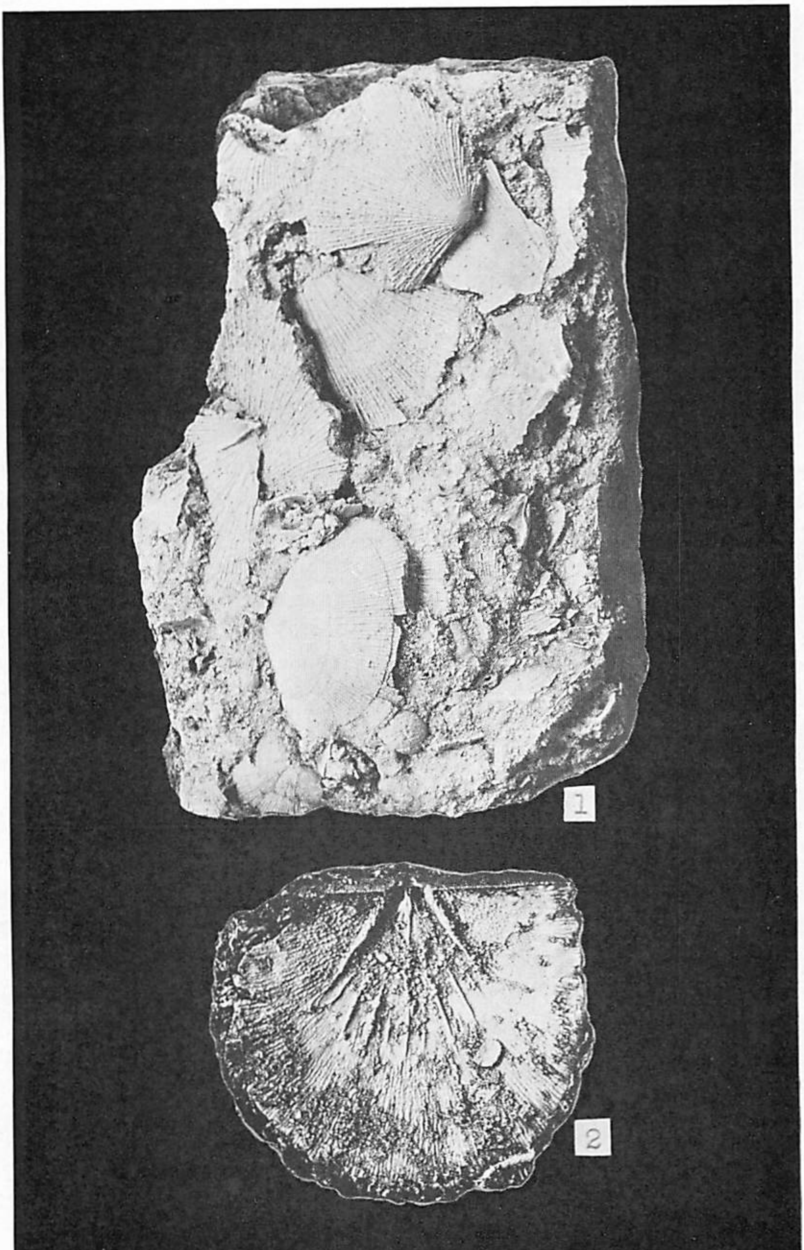

PLATE 6

overlain unconformably by a sandstone, presently to be described. Elsewhere it seems to have been worn away completely by the erosion preceding the deposition of the superjacent sandstone.

FAUNA AND CORRELATION

As shown in the faunal table by the range of its fossils, the Island Hill fauna is closely related to the New Scotland fauna and no doubt was a more or less direct outgrowth of it. On the other hand, many of the Island Hill forms had evolved notably, some acquiring the sturdy aspect of the hardy Oriskany forms, if, in fact, they had not already developed completely into those forms. In proportion to the size of its shell, *Spirifer cyclopterus* or its descendants had developed huge adductor muscles, so characteristic a feature of Oriskany *Spirifers.* Similar had been the development of *Rhipidomella oblata* into *R. musculosa* and of an older *Stropheodonta* into *S. magnifica.* Not only had the internal organs thus begun their change to meet the adverse conditions developing with the Oriskany, but the size of some individuals had been notably increased, as, for example, *Stropheodonta magnifica* and the *Dalmanites* trilobites. In addition, in forms identified as *Dalmanites stemmatus* the second and third pairs of lateral glabella lobes as well as the first and second pairs had become completely fused distally. Sufficient time for this development is recorded in the upper 20 feet of the New Scotland limestone, during the deposition of which few forms left their record; and in the unconformity at the base of the Island Hill, during the formation of which the region slowly rose from beneath the shallow sea to a land surface, was slowly eroded, and then slowly sank back beneath the sea when it received the Island Hill deposits. Although part of the evidence suggests the possibility of the Island Hill fauna being Becraft in age, the stronger part of the evidence points toward Oriskany as the time of its development, and, when the rather close proximity of the true upper Oriskany fauna in the Quall limestone at Walnut Grove in southern Tennessee is considered, the Island Hill fauna shall have to be referred to the early rather than to the late Oriskany.

Island Hill Faunal Table (1)	Maryland						New York				
	Keyser	Coeymans	New Scotland	Becraft	Shriver-Orisk	Ridgely-Orisk	Coeymans	New Scotland	Becraft	L. Oriskany	U. Oriskany
Anthozoa											
Favosites helderbergiae	....	X	X	....	....	....	X	X	....	....	....
Brachiopoda											
Anoplotheca concava	....	....	X	X	....	....	....	X	....	X	....
Chonostrophia complanata	....	....	....	....	....	X	....	....	....	X	X
Leptaena rhomboidalis	X	X	X	X	....	....	X	X	X	X	X
Meristella lata	....	....	....	X	....	X	....	....	....	X	X
Meristella sp.	....	....	....	....	....	....	....	....	....	....	....
Rhipidomella assimilis	....	....	....	X	....	....	....	X	X	....	....
Rhipidomella marylandica	....	....	....	....	....	X	....	....	....	....	....
Rhipidomella musculosa	....	....	....	....	....	X	....	....	....	....	X
Rhipidomella oblata	....	X	X	....	....	....	X	X	X	X	....
Rhipidomella subcarinata	....	....	....	....	....	....	....	X	....	....	....
Schuchertella becraftensis	....	....	....	....	X	X	....	....	....	X	....
Spirifer sp., cf. murchisoni	....	....	....	....	....	X	....	....	....	X	X
Stropheodonta magnifica	....	....	....	....	....	X	....	....	....	X	X
Gastropoda											
Platyceras sp.	....	....	....	....	....	....	....	....	....	....	....
Tentaculites gyracanthus	X	....	....	....	....	....	....	....	....	....	....
Crustacea											
Dalmanites micrurus	....	....	....	....	....	X	X	X	....	....	....
Dalmanites multianulatus	....	....	....	....	....	X	....	....	....	....	....
Dalmanites pleuroptyx	....	X	X	....	....	....	X	X	X	....	....
Dalmanites stemmatus	....	....	....	....	....	X	....	....	....	X	....

(1)Range according to the Devonian Reports of the Maryland Geological Survey.

PLATE 7

Island Hill formation fossils

Figs. 1-4. *Spirifer sp., cf. murchisoni.* ×2. Figs. 1 and 2 are exterior views of two pedicle valves; Figs. 3 and 4 interior views of two pedicle valves. Although these specimens have not attained the large size of typical Oriskany specimens, yet the muscle scars are relatively as sturdy as those of the Oriskany. Collection 30.

Collection 30 is from the 3-foot, cherty, limestone stratum of the Island Hill in the highway north of the Yellow Creek iron bridge (Location 130, South Central, Sec. 15, T. 1S., R. 10E.), Miss.

Iuka (Keokuk) terrane fossils

Fig. 5. *Orthotetes keokuk.* ×1. Brachial valve of this large Brachiopod, typical of the Keokuk limestone. Collection 4.

Collection 4 is from a loose block of chert in the lower part of the Iuka terrane on the east side of Indian Creek, two miles north of Iuka (Location 59, NE¼, Sec. 6, T. 3S., R. 11E.), Miss.

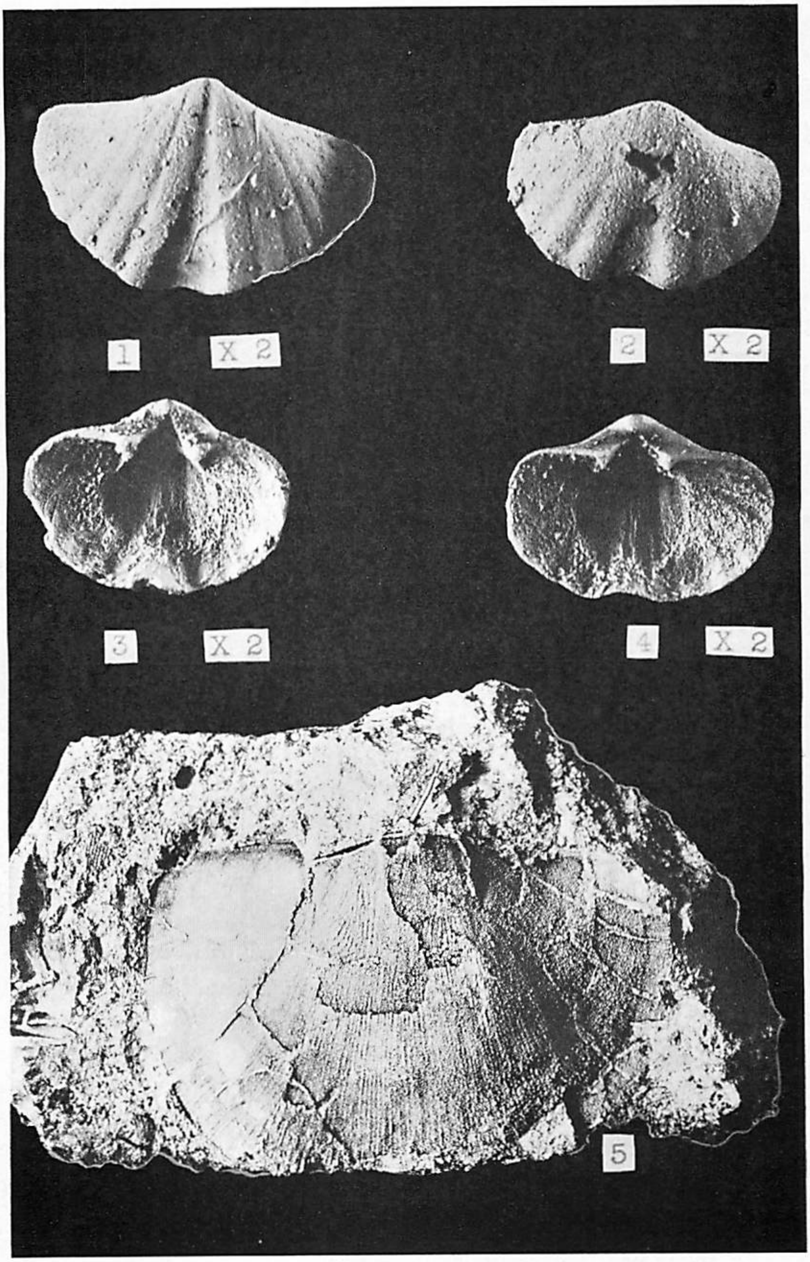

PLATE 7

WHETSTONE BRANCH FORMATION

DISTRIBUTION AND DESCRIPTION

The type locality of the Whetstone Branch formation, the second formation new to the science of the state, is the mid portion of the stream of that name, which enters the Tennessee River about three and one-half miles above the Tennessee State line and the mouth of Yellow Creek. The formation is the "Black shale," famous for the controversies which it has provoked, and otherwise a most interesting terrane. It is well exposed in the type locality along this beautiful little valley, where it consists chiefly of black carbonaceous shales and thin interbedded sandstones, but its basal relationships are better shown along Yellow Creek.

On the south side of Island Hill (Section 127), the Whetstone Branch formation directly overlies the Island Hill formation, and consists of a single layer of sandstone, which varies from 1.5 to 2.5 feet in thickness. This massive layer is a compact blue somewhat calcareous sandstone, the top of which is filled with worm borings or other worm or plant markings. The basal part contains chert pebbles and water worn bone fragments and is hence a basal conglomerate at this place. In addition to the worn fish plates and worm or plant markings, the sandstone contains an imperfect Brachiopod and some *Tentaculites,* the last of which did not survive Devonian times. The presence of the basal conglomerate thus proves the formation's uncomfortable relation to the subjacent Island Hill formation; and the inclosed *Tentaculites* thus apparently limits at least this part of the formation to the Devonian age. Evidence further supporting both of these conclusions will be presented later in the discussion.

The Whetstone Branch layer of sandstone is scarcely discernible in the highway just north of Yellow Creek iron bridge (Section 130), but a more or less continuous series of blocks of it lie approximately in position on both sides of the highway. These blocks dip 16 feet N. 45° E. in a horizontal distance of 400 feet. Better exposures might reveal the dip to be nearly straight east, however, as is the case of other beds at near by places. In any event, toward the east the sandstone dips beneath the flood plain on the north side of Yellow Creek within a half mile. On the south side the deeper stream channel exposed it for a distance of more than a mile

At the mouth of Big Branch (Section 134), in a poor exposure, the Whetstone Branch formation consists of the same layer of sandstone, 4 feet thick, and a foot and a half interval of underlying shaly sandstones and shales, some of which are black carbonaceous shales. A half mile farther east (Section 172), the layer of sandstone, 3.5 feet thick, contains the same worm or plant markings, and basal black fish plates or concretions as it does on the south side of Island Hill. Here, too, in places, the layer has been split into two parts, each a foot thick, by an intermediate bed of black carbonaceous shale, a half-foot in thickness. The interval of underlying sandstone and sandy and carbonaceous shales has increased to three feet. One-fourth mile still farther east (Section 136), the layer of sandstone is 4.3 feet thick, is covered with the same worm or plant markings, and the base seems to contain the same fish plate pebbles. The thin interval of sandy shales and black carbonaceous shales, lying beneath it, separates the layer of sandstone from any formation older than the "Black shale." Likewise, the 6-inch bed of black carbonaceous shales lying between the two halves of the layer of sandstone, proves it to be older than the superjacent brownish-gray shaly limestones of the Carmack formation. Where present alone, as on Island Hill, the layer of sandstone, therefore, can not be assigned to the base of the Carmack limestone, as a basal conglomerate. Because of all these conditions, the presence of *Tentaculites* in the layer at Island Hill takes on new significance.

One mile above the mouth of Yellow Creek, in an eroded by-way leading up the west wall of the Tennessee (Section 139), the Whetstone Branch formation in whole or in part is somewhat exposed for a vertical distance of 26 feet. At the base of the interval is a 0.4-foot layer of sandstone, which contains *Lingula sp.* Above this layer are other thinner layers interstratified with thin beds of shales, some of which are clayey and sandy and badly weathered and some are black and carbonaceous. A long mile farther up the Tennessee, in the beautiful little valley of Carmack Creek containing the picturesque falls, having a drop of 60 feet (Section 142), the Whetstone Branch formation is partly exposed from the base of the falls to the mouth of the small valley. Though difficult to determine, both because of the separation of the exposures and of the dip of the layers, the thickness of the formation is at least 31.5 feet. A large part of the formation consists of shales, sandy and carbonaceous, of which the black shales seem to predominate. Near the base is a layer of sandstone, one foot thick, and near or at the top is another layer of sandstone, two feet thick. The top sandstone is mostly concealed at the falls, but blocks of it, farther down stream, seem to contain concretions in the basal part possibly correlating it with the massive layer on Yellow Creek. One-fourth mile still farther up the Tennessee, in another beautiful little valley likewise having picturesque falls of 60 feet drop (143), the Whetstone Branch formation is partly exposed under almost the same conditions as in Carmack Creek for a vertical distance of 22 or 25 feet. Here, however, the black carbonaceous shales form the lower 10 feet of the falls, but the top sandstone is covered.

Figure 2.—The upper half (15 feet) of the Whetstone Branch shale on Whetstone Branch, the type locality; and the entire thickness (78 feet between the two men) of the Carmack limestone.

In the type locality (Section 157 and Fig. 2), the Whetstone Branch formation consists chiefly of black carbonaceous shales, some of which are somewhat sandy, and subordinately of thin sandstones or rather sandy shales. The total thickness of the constituent intervals is 23.5 feet, which is probably within 5 feet of the total thickness of the formation at this place. The massive layer of sandstone, such a conspicuous feature of the formation on Yellow Creek, is not typically developed in the mid portion of Whetstone Branch, the thickest of any of the layers being only 0.8 foot. In the steep wall of the valley farther down the branch, above a 3-foot interval of black carbonaceous shales and shaly sandstones and probably in the lower part of the formation, is a layer of sandstone which is separated by a parting into a lower part 0.3 foot thick and an upper part 0.7 foot thick, as on Yellow Creek (Section 172). The basal part contains, furthermore, at least some small black fish bones. The collection from the lowest beds (See Section 157) yielded *Lingula sp.* only; the next two collections, *Lingula sp.* and fragmental *Conodonts;* and collection from the top *Conodont* fragments only. The *Lingula sp.* is intermediate in form between the Genesee *Lingula spatulata* and the Mississippian *Lingula melie.* More significant than the fossil content is the structure of the stone; for instance, the sandstone basal conglomerate above the 3-foot interval of black shales; the sandy nature of shales interstratified with the black carbonaceous shales, which are commonly clayey; and the middle 10 feet of concretionary, cross-bedded, and contorted carbonaceous shales and shaly sandstone; and especially the ripple marks of the sandstone of the upper half of this mid 10-foot bed and the contemporaneous erosional contact or unconformable contact at the top of it; all point to extremely shallow water conditions of accumulation, and intervals of emergence and erosion, followed by resubmergence and deposition.

Figure 3.—Longitudinal section of the south bank of Whetstone Branch and cross section of a tributary valley, showing the unconformable contact of the Whetstone Branch shale and the overlying Carmack limestone.

Still more significant yet is the structure intimately associated with the top contact of the formation, perhaps most freshly exposed in the 12-foot falls of Whetstone Branch (Section 157 in part). Here the upper limit is fixed by the basal conglomerate of the overlying Carmack limestone. The conglomerate layer, one foot in thickness, differs from all others thus far described, in that many of the pebbles are long flat shale-like pieces imbedded in a dark matrix of oolitic and green sand texture. Less freshly exposed, but even more significant, is the structure at the road-stream crossing, 200 yards down stream from and east of the falls (Fig 3). A small tributary stream enters from the south in such a manner as to have removed most of the steep south valley wall of Whetstone Branch. From the isolated patchy exposures in the remnant, it seems evident that the upper 12-foot interval of black shale at the falls dips down stream 200 yards, till its top lies at water level at the crossing, and that down stream from the crossing a reverse dip causes the interval to rise a like amount in 100 feet. Not only does the overlying Carmack limestone seem not to be involved in the folding which produced this small syncline in the black shale, but small patches of limestone, which escaped erosion and the prospector's pick, lie horizontally on the shale even at stream level, thus accentuating the angular unconformity between the two formations. From the extremely shallow water conditions of deposition, the contemporaneous erosion surfaces or unconformities, as the case may be, in the underlying black shale may, and probably do, represent only minor breaks in the process of deposition and hence minor time intervals. The unconformity between the Carmack limestone and the Whetstone Branch shale at the crossing, on the other hand, marks a great time interval, during which the shale was folded, elevated, and eroded, before it sank to a position again beneath the sea to receive the limestone deposits upon it. That this unconformity at the top of the Whetstone Branch shale and at the base of the Carmack formation is of great magnitude is further substantiated by the different beds on which the Carmack lies in different places, as on the Island Hill or older formation in the Cliff section (85), on the Whetstone Branch sandstone layer in the Island Hill section (127), and on the Whetstone Branch shale in the Whetstone Branch section (157), to mention the most striking examples.

Section in detail at the Falls in Whetstone Branch (Location 157—in part)

Carmack limestone, total		10.5
Limestone, thin-bedded to shaly, brownish-gray. To brink of falls	9.5	
Conglomerate, basal, consisting of long flat pebbles in a dark matrix of oolitic and green sand texture. Some of the larger rounded masses may be concretions instead of pebbles, and some of them give the test for phosphate. The layer seems to be in irregular places in the underlying black shale. (Collection 67 contains *Lingula sp.* and fish scale only)	1.0	
Whetstone Branch shale, total		1.6
Layer of limestone and siderite in which is some marcasite	0.1	
Shale, hard blue clay	0.5	
Shale, black carbonaceous, typical, which extends beneath the pool at the base of the falls	1.0	

FAUNA AND CORRELATION

The Whetstone Branch formation contains a meager fauna. The massive layer of sandstone bears plant or worm markings nearly everywhere and worn fish plates as basal pebbles in many places. Other thinner sandstones or sandy shales are marked similarly in some localities. In addition to these organisms and a *Strophomenoid*-like Brachiopod, the massive layer of sandstone contains a few *Tentaculites* at Island Hill. Along the Tennessee, a thin layer of sandstone bears *Lingula sp.* On Whetstone Branch a thin sandstone contains the same *Lingula,* as does the overlying black shale. In addition the black shale contains Conodont teeth, but unfortunately only fragments.

The Lingulas, like most Lingulas, are not diagnostic, seeming to be intermediate in form between *Lingula spatulata* of the Genesee shale and *Lingula melie* of the lower Mississippian formations. *Tentaculites* is clearly Devonian in age, none of the species being known to have survived that period. Among a few other forms, the overlying Carmack limestone contains species of both *Productella* and *Productus,* the association of which is so characteristic of the early Kinderhook faunas, next succeeding the Devonian. The lower part of the Whetstone Branch formation is undoubtedly Devonian in age. There is no evidence either of a sufficiently important stratigraphic break or of a faunal hiatus in the formation, by means of which the upper part can be referred to the Mississippian. To so place the upper part of the Whetstone Branch formation would be to refer the great unconformity at the base of the Carmack limestone to an intraformational unconformity of mid-Kinderhook times, a procedure unwarranted from the evidence at hand.

Although such correlation may be contrary, possibly, to the prevalent opinion concerning the "Black shale" problem, the Whetstone Branch shale, although a "Black shale" formation, can be rather definitely correlated with even smaller sub-divisions. To substantiate this statement, it will be necessary first to review briefly some of the earlier work, in order to show how each stratigraphic unit has been correlated, and the basis for such correlation.

Correlation table of upper Devonian and lower Mississippian formations

Mississippi Valley	Mississippi	Tennessee Eastern	Ohio
Ste. Genevieve			
St. Louis			
Salem		Bangor	
Warsaw	Iuka		
Keokuk		Fort Payne	Logan
Burlington, Upper			Black Hand
Burlington, Lower			Cuyahoga, Upper
		Glendale	Cuyahoga, Lower
Kinderhook	Carmack		Sunbury
			Berea
		Chattanooga	
			Bedford
			Ohio { Cleveland
Devonian	Whetstone Br.		Ohio { Huron-Chagrin

In 1908 the Ohio shale and a part of the superjacent Waverly series, consisting of the Bedford, Berea, Sunbury, Cuyahoga (Black Hand), and Logan formations, were traced from the Ohio River at Vanceburg southwestward 70 miles to the Kentucky River at Irvine, by Morse and Foerste[1] with the result that certain radical changes in the formations were discovered. At Vanceburg, Lewis County, the Ohio shale (not the Cleveland shale), consisting of the typical black carbonaceous shale, is 300 feet thick. The Bedford, commonly a shale formation, contains a thick lentil of sandstone in the middle portion and has a total thickness of 96 feet. The Berea, consisting of typical sandstones, is 22 feet thick. The Sunbury, a black carbonaceous shale like the Ohio, is 15 feet thick.

At Elk Lick, Lewis County, 13 miles south, the Bedford and Berea have a total thickness of 75 feet as compared with 118 feet at Vanceburg. At Petersville, Lewis County, 5 miles farther south, the Bedford-Berea interval is only 46 feet, and both formations have lost practically all their sandstones and have chiefly clay shales left. At Rockville, Rowan County, the Bedford-Berea is only 19 feet thick; at Jeffersonville, Montgomery County, only 4 feet. At Indian Fields,

[1]Morse, W. C. and Foerste, A. F. The Waverly formations of east-central Kentucky, Jour. Geol. XVII: 164-177, 1909.

Clarke County, the Bedford-Berea shales although but one-fourth foot thick, are fossiliferous. At Stanton, Powell County, the Bedford-Berea terrane is one-half foot thick. At Irvine, Estill County, the Bedford-Berea is 1.5 feet thick and fossiliferous, and the Sunbury is 3 feet thick.

Not only has careful tracing from point to point clearly demonstrated the thinning out of the Bedford and Berea formations in these 70 miles, but the fauna at Indian Fields and especially the fauna at Irvine,[1] being the same as the fauna in the basal Bedford shale at Columbus, Ohio, corroborate the stratigraphic work, should any corroboration be needed. South of Bath County the Sunbury black shale, except for the thin shale interval representing the Bedford and Berea, rests directly on the Ohio black shale; the whole seeming to be one black shale formation. At Irvine, among other places it was so considered, and was called the "Black shale" and the Ohio shale in the Kentucky reports and the Chattanooga shale in the United States reports. For this region, therefore, the name "Black shale" or Ohio shale or Chattanooga shale connoted in addition to Ohio shale, which it was supposed to signify, the Bedford, Berea, and Sunbury time intervals if not formations.

From Berea near Cleveland to Lithopolis in central Ohio the Berea sandstone is separated from the Bedford shale by a marked unconformity. It is not recalled that Hyde records such an unconformity in southern Ohio. In fact he is inclined to recognize the Berea of this region as a phase or top member of the Bedford.[1] In the area of great change between Vanceburg and Petersville where the Bedford and Berea lose their sandstones, it seems impossible to separate the two formations; certainly no such separation is possible south of Petersville. At Harrison Chapel in the Vanceburg-Petersville area, the Berea sandstone is more massive than it is nearer Vanceburg. In the mid-portion of this area small folds seem to affect the Berea, the Bedford, and the exposed top of the Ohio, but not the Sunbury.[2] Would the conception that pre-Sunbury fold-

[1]Foerste, A. F., The Bedford fauna at Indian Fields and Irvine, Kentucky. Ohio Naturalist, IX: 515-523, 1909.

[1]Hyde, Jesse E., The ripple marks of the Bedford and Berea formations of central and southern Ohio, with notes on the paleogeography of the epoch. Jour. Geol. XIX: 257, 1911.

[2]Morse, W. C. and Foerste, A. F., The Waverlian formations of east central Kentucky and their economic values. Kentucky Geol. Survey Bull. 16, p. 22, 1912.

Note: In the change from the galley to the page form, the numbers assigned the foot-notes on some of the following pages were not changed to a consecutive order. Although such is, unfortunately, the case, the references seem, nevertheless, clear.

ing of the sea floor so shallowed the waters as to stop the transportation of sand toward the south and strongly curtail the amount of finer clay sediment in the same direction, do greater violence to the facts, than the post Bedford-pre-Sunbury erosion idea, supporting which there is no field evidence other than the thinness of the clay and the absence of the sand? Then, too, the withholding of the sand is a fact to be explained regardless of which hypothesis is accepted. It is difficult to conceive how a transgressing Sunbury sea could extend itself for a distance of 50 or 60 miles without leaving any evidence of coarser basal sediments. Likewise it is difficult to understand how pre-Sunbury peneplanation or base leveling could reduce a soft clay shale stratum to a mere feather edge of a few inches or even of a few feet, without completely removing it somewhere in the area; or how such erosion could leave at Indian Fields and at Irvine, respectively, 3 inches and 18 inches of clay and calcareous shales filled with fossil forms in a perfectly fresh condition.

Attacking the "Black shale" problem in a similar manner, Swartz spent five months during 1921 and 1922 in eastern, central, and western Tennessee, publishing the results of his work in an excellent paper of about the same number of pages.[1] At Apison, 16 miles east of Chattanooga, he measured the following section and collected the fossils named therein:

Section at Apison, Tennessee, by Joel H. Swartz

	Ft.	In.
Ft. Payne Chert (Keokuk-Logan)	----	----
Glendale shale, separated from the chert (lower Cuyahoga)	2	11
Shale, hard gray full of concretions, becoming much darker toward the base. From 4 to 6 inches above the base are found *Lingula melie* abundant.		
Sunbury shale	2	10½
Shale, black. *Lingula melie.*		
Bedford-Berea	1	10
Shale, light to somewhat dark gray clay, containing, about 6 inches above the base, *Lingula irvinensis* (Bedford-Berea, Irvine, Ky.), *Orbiculoidea ovata* var. *transversa*, *Schuchertella sp. Rhipidomella sp. Chonetes acutiliratus.* (Last two in Bedford, Ohio).		
Cleveland shale	10	8
Shales, black.		
Undetermined	0	4
Sandstone, very argillaceous.		
Rockwood formation	----	
Shale, gray, greenish, and buff arenaceous, and sandstone, argillaceous.		

[1]Swartz, Joel H., The age of the Chattanooga shale of Tennessee. Am. Jour. Sci. (5) VII: 24-30, 1924.

The same Bedford-Berea clay shale (and fauna) lies between the same Cleveland and Sunbury black shales at La Follette, 110 miles northeast of Chattanooga, and the same three shales are in Cumberland Gap, near the corner of Kentucky, 30 miles farther northeast. A short distance southeast of Chattanooga no Bedford-Berea shale was present, but abundant *Lingula melie* in the upper 8 or 10 inches of the black shale proved the Sunbury age of that small part of it.

From all this evidence in general and from that of Apison and southeast of Chattanooga in particular, Swartz, without fossils, interpreted the section at the type locality as follows, and, no doubt, correctly so.

Section at Chattanooga, by Joel H. Swartz

	Ft.	In.
Ft. Payne chert (Keokuk-Logan)	----	----
Glendale shale, separated from the chert (Lower Cuyahoga)	2	4
Shale, hard gray, containing some concretions toward the base.		
Sunbury shale	0	0⅝
Shale, black.		
Bedford-Berea, absent to	0	9
Shale, mottled brown and gray.		
Cleveland shale	8	0
Shale, black.		
Concealed	----	----

After showing that the Bedford, Berea, and Sunbury formations vary from a minimum thickness of less than one-half inch to a maximum of less than ten inches, Swartz states that, "The main mass of shale at the type locality is thus of Cleveland age" (p. 26). The black shale in central and western Tennessee he believes to be entirely Cleveland in age. Fortunately for Swartz he does not reach the conclusion he is stated to have reached on page 161 of Special Report No. 14, Geology of Alabama.

In his work in eastern, central, and western Tennessee, Swartz has made one of the real contributions to the "Black shale" problem. To refer, however, the main mass of the Chattanooga shale to the Cleveland rather than to the Ohio is practically equivalent to correlating the Cleveland shale of northern Ohio with the top of the Ohio shale in southern Ohio, an added burden to the present stage of the "Black shale" problem.

With all due respect to the many distinguished geologists who hold to the overlap theory, the writer, while desirous of being counted among the faithful, nevertheless craves the privilege of sounding a note of warning against the tendency to destroy such an excellent hypothesis by making it a panacea for so many geologic ills. He should like to question the propriety of appealing to it *exclusively* as a solution to *all* the "Black shale" problem. That transgressive overlap was the chief means of extending the basal and greater part of the "Black shale," there is abundance of field evidence, which perhaps no one doubts. But to have the Sunbury sea transgress 250 or 300 miles and spread a thin blanket of sediment, of approximately uniformly fine texture and but a few feet or a few inches in thickness, just at the proper time, seems more improbable than continuous but unequal accumulation in different places, for this portion of the "Black shale" at least.

So much for the "Black shale" in the Appalachian trough. It is now necessary to turn to the "Black shale" of the West Tennessee-Mississippi area,where the writer was assigned for the second time a task unexpectedly involving, again through no choice of his own, this most fascinating problem.

Here in northeast Mississippi, physical conditions of deposition, instead of remaining constant for greater or less intervals of time as in the east, repeatedly changed throughout the Whetstone Branch age, as recorded in the formation itself. From the base to the top of the 23.5-foot formation in the type locality (Section 157), thin intervals of black carbonaceous shale and thin layers of sandstone are interstratified. In some of the intervals both shales and sandstones are concretionary, cross-bedded, and contorted, and some of the sandstones ripple-marked. At one or more vertical positions contacts of two intervals resemble contemporaneous erosion or unconformable surfaces. All these differences in texture, structure, and the like are records of the repeated changes in shallow water conditions of deposition.

Exclusive of these records, the prominent sandstone layer having basal pebbles of fish plates and other material would most certainly have to be considered as conclusive evidence of an unconformity everywhere present. With the records, it can on the whole be assigned no greater value than evidence of a minor erosion or contemporaneous erosion interval. Ignoring the records, the sandstone layer still could not be assigned to a basal conglomerate position of the "Black shale," for it is underlain by black shales at the mouth of Big Branch on Yellow Creek (Section 134), at the exposure one-half mile farther down Yellow Creek (Section 172), probably in Carmack Creek, the lower valley having a 60-foot fall

(Section 142), in the lower part of Whetstone Branch (Section 157), and at Dry Creek School near Walnut Grove, Tennessee, even though it does occupy a basal position in near by places. It seems far more probable that during the general period of deposition, sediments of certain portions of the shallow water basin suffered erosion, during which time about the only large material available, namely the Devonian fish bones lying yet unincorporated on the bottom, were worn to pebble fragments and incorporated in the sand to form the layer of sandstone. In further keeping with this conception is the change in thickness, splitting into halves, intercalation of black carbonaceous material, and other changes of the layer itself, from place to place.

Recognizing the importance of the discovery by Bassler of worn silicified fossils of Ordovician, Silurian, and Devonian age associated with fish teeth and Conodonts in the Hardin sandstone member of the Chattanooga shale in northern Tennessee,[1] it is still difficult to conceive how in the Whetstone Branch sandstone on Island Hill, such minute organisms as *Tentaculites* could be preserved in rather coarse sediment from extraneous forms being incorporated in the new sediment itself. So also is it difficult to conceive how such a fragile Strophomenoid valve could have escaped some comminution. The material, furthermore, has been examined by Professor Shimer, who agrees with the writer in considering the forms indigenous to the sandstone. As already stated, even should this massive layer be referred to the early Mississippian, by the same act the few feet (possibly the whole 29.5 feet in Section 142) of underlying shale would be referred automatically to the Devonian. When all the evidence is considered, especially in connection with the significance of the overlying huge unconformity, it seems best to refer the whole Whetstone Branch formation to the Devonian. The record furnished by the superjacent Carmack shaly limestone, yet to be described, will not only confirm that decision, but prove the Whetstone Branch formation to be of the same age as that of the main mass of the Chattanooga shale at the type locality, namely pre-Bedford.

In a report of this kind, obviously it is impossible to review even a small part of the notable contributions to the "Black shale" problem. No discussion of this problem would be complete, however, without reference to the work of that venerable geologist,

[1]Bassler, Ray S., The Waverlyan period of Tennessee. U. S. Nat. Mus. Proc. 41: 214 and 216, 1911.

Dr. Ulrich, who, by association with the younger geologist, has maintained such an open mind to progress that his new ideas keep most of us in a helpful though vigorous state of activity in our efforts to follow him, and, thereby, either to confirm or disprove his conclusions.

In U. S. Geological Survey Bulletin 769 (page 77) he is reported as holding that the Bedford shale is of Kinderhook age. Evidence presently to be presented, it is believed, will corroborate that opinion. This extension of his Kinderhookian downward to include the Bedford, automatically limits his Chattanoogan to the Cleveland (or Ohio) shale. Subsequently in his report with Bassler in 1926 (U. S. Nat. Mus. Proc. 68: 3), instead of Cleveland he has used the term Ohio in expressing his conclusions concerning the post-Devonian age of the Chattanooga and Ohio shales. Save for the upper fraction of a foot of the shale at Chattanooga, as shown in the two papers recently reviewed, he seems to be correct in the general equivalency of the Chattanooga and Ohio. The post-Devonian age of the main mass of the Chattanooga shale and of the Ohio shale was determined by a process of elimination in which one type of fossils, namely Conodonts, is used. None of the Conodonts largely if not exclusively from the basal 10 inches of the 12-feet of Rhinestreet shale (Portage) exposed near Buffalo, New York, was found to be the same as any of those from the thin basal Hardin sandstone of the Chattanooga at Mount Pleasant, Tennessee. Hence the correct conclusion that the two formations are not the same in age. But it does not follow necessarily as a correct form of logic, that the Hardin member of the Chattanooga is post-Devonian in age, for the member could be upper Rhinestreet shale, Angola shale, Hanover shale, Dunkirk shale, Gardeau flags, Nunda sandstone, or Wiscoy shale of the Portage or any bed of Chemung in age, and still be different (younger). When the equivalency of the Conodonts of the Hardin sandstone member of the Chattanooga shale to those of the Cleveland (or Ohio) shale was determined by the same author, he seems to have established the Chemung age of the younger Conodonts, for Prosser showed, by careful tracing of the beds from the type locality of one formation to that of the other, that the Huron and Chagrin dovetail into each other, that is, they were deposited synchronously,[1] the Che-

[1]Prosser, Charles S., The Devonian and Mississippian formations of northeastern Ohio. Geol. Survey Ohio, Bull. 15: 515, 1912. The Huron and Cleveland shales of northern Ohio, Jour. Geol. XXI: 361, 362, 1913.

mung age of the Chagrin already being an established fact. Prosser's results are corroborated by the studies of Kindle who concluded that the Huron shale and the basal part of the Cleveland shale are contemporaneous with the Chagrin formation.[2] The Huron-Chagrin and Cleveland shales, more or less completely extend from Lake Erie entirely across the state to the Ohio River as the Ohio shale.

DEVONIAN IN ADJACENT TENNESSEE

As previously stated, all the Devonian beds dip beneath Yellow Creek about one mile above its mouth, leaving only the sparsely fossiliferous Carmack limestone and the Iuka chert. On the opposite side of the Tennessee Valley even these two formations are practically covered with loose chert. To connect the beds of Mississippi with those of Tennessee, as instructed, was not, therefore, an easy task.

Dunbar in his excellent work on the Devonian of western Tennessee[1] experienced some difficulty in correlating and placing a few of the beds on Dry Creek, Walnut Grove, at the southern border of the state, because of insufficient exposures of the patchy angular-unconformable beds. His results are given in the following two paragraphs and a section, which, unfortunately for comparative purpose, is a composite section.

"The Oriskany limestone outcrops at the roadside between the house and barn on Mr. Jim Quall's place, onehalf mile east of Paulk's store at Walnut Grove. About a half mile north of this place the Linden limestone forms the low bluff of Dry Creek where it is succeeded by the same Oriskany limestone. The same distance east of Mr. Quall's house is Dry Creek schoolhouse, and the ford crossing the stream. The schoolhouse is situated in the mouth of a deep, narrow, V-shape tributary valley which intersects the bluff at this point. Linden limestone forms the lower portion of the bluff, dipping westward at an angle of 5 or 6 degrees. The Ridgetop (Mississippian) shale lies nearly horizontal, beveling across the Linden. As a result, the lower strata exposed in the east bluff dip below the surface west of the schoolhouse, while the heavy limestone of the west bluff is truncated and does not appear east of the schoolhouse. The information afforded by these exposures is combined in the following section for the vicinity of Dry Creek schoolhouse:"

[2]Kindle, E. M., The stratigraphic relations of the Devonian shales of northern Ohio. Am. Jour. Sci. (4) XXXIV: 209, 1912.

[1]Dunbar, Carl O., Stratigraphy and correlation of the Devonian of western Tennessee. Tenn. State Geol. Survey, Bull. 21: 1-127, 1919.

Dry Creek Section, by Carl O. Dunbar

MISSISSIPPIAN:
Fort Payne chert
Ridge top shale
Disconformity

DEVONIAN:
Chautauquan (series)
Chattanooga formation
Hardin sandstone member
Sandstone massive, compact layer of fine-grained gray, with a 6-inch layer of conglomerate at the base. Pebbles mostly subangular, chiefly composed of black and gray chert. Associated with the pebbles are numerous pieces of flat fish bones 3
Unconformity. Angular discordance of 5 or 6 degrees.

Oriskany (series):
Quall limestone
Limestone, heavy-bedded dense light gray siliceous, weathering to porous, rotten yellow chert and yellow clay. Characterized by *Edriocrinus cf. becraftensis*, which is very common. Also *Spirifer murchisoni*, *S. perdewi*, *Beachia suessana*, etc. .... 10+
Contact. Not observed. In the best exposure, one-half mile north of Mr. Quall's house, there is a small unexposed interval at this level. The beds seem to be accordant.

Linden (series)
Flat Gap limestone (?)
Limestone, rather pure coarsely crystalline heavy bedded light gray. Only a few species such as *Rhipidomella oblata* and *Spirifer cycloptera* are moderately common 25+
Unconformity. Contact sharp and irregular. Adjacent beds contrast sharply in lithology. Seen best in bluff one-half mile north of Mr. Quall's house.

Pyburn limestone
Limestone, fine-grained highly siliceous bluish gray. Weathered surface is brownish, appears sandy, and shows small cross-bedding, especially in the middle and upper portions. This last character is best shown one-half mile north of Mr. Quall's house........ 25

Ross limestone
Limestone, impure, fine-grained dark gray, grading into that above.
A 6-inch band of bluish chert at 5 feet and another at 10 feet are replete with the single orthid, *Rhipidomella oblata*. *Camarocrinus* present........ 15
Limestone, more impure siliceous dark thin-bedded, grading into that above. Irregular thin bands and concretions of dark chert. Very sparingly fossiliferous. *Camarocrinus* occurs 40

"It is interesting to find the Decaturville chert present in this locality. Its nearest known exposure is at Grandview, 25 miles to the north. Pieces of chert, crowded with fossils, were found loose on the slope near the top of the Linden and below its contact with the Hardin sandstone east of the schoolhouse. At this point the upper massive crystalline member of the Linden is absent, so that the relation of the chert to the latter could not be positively determined. Where the massive limestone is present west of the schoolhouse its contact on the lower Linden can be seen for some distance, and the chert is not present between them. The same conditions obtain in another section north of Mr. Quall's house. The chert, therefore, very probably succeeds the massive limestone whose upper contact is soil covered in both sections'' (pp. 125-127).

About one-half mile north of Mr. Jim Quall's house, Dry Creek makes a small sharp bend to the east around a small terrace, projecting from the west side of the valley. Limestones are exposed in the bluff at this place, where the following section was measured.

Section of Dry Creek one-half mile north of the Quall home

Hardin sandstone		11.0
Sandstone, massive layer, the top surface covered with *Spyrophyton caudagalli*-like marks	1.5	
Interval, covered, probably Hardin	9.5	
Oriskany—Quall (?) limestone		10.0
Limestone, coarsely crystalline, slightly fossiliferous. Large Crinoid stems at the base	10.0	
Linden—Flat Gap (?) limestone		25.0
Limestone, coarsely crystalline, the basal foot covered	25.0	
Linden—Pyburn (?) limestone		5.0
Limestone, massive compact. *Tentaculites sp.* at the top; fossiliferous below	5.0	

All the limestones dip west. Sufficient fossil material was not collected from the two upper limestones to prove their age, but they are, no doubt, properly named. The lower limestone seems to be the New Scotland of Mississippi. The layer of sandstone is the Whetstone Branch in part.

At the Dry Creek old schoolhouse, one-half mile east of the Quall home, the new schoolhouse being at Walnut Grove, the beds are partly exposed in the east bluff and in the west bluff of the small tributary valley. They are, however, better exposed up the small tributary valley itself, where the following main section was measured. The shorter section is of the west bluff.

Section of the tributary valley at Dry Creek old schoolhouse

Carmack limestone (Ridgetop)		......
Limestone, brown shaly, at the falls (Collection T-7 consists of *Bellerophon sp.* only)	....	
Whetstone Branch formation (Hardin), total		10.0

Sandstone, thin 6-inch layer at the top and thinner ones at intervals below; shales, gray and black fissile carbonaceous; all interstratified	10.0	
New Scotland limestone (Pyburn ?), total		22.5
Interval, covered, except for a 0.7-foot layer of crystalline limestone, containing *Leptaena rhomboidalis*	4.0	
Interval, partly covered, and partly chert and compact blue limestone	3.0	
Chert, one or two layers, very fossiliferous, extremely blue in places (Collection T-11 Loose blocks)	2.0	
Limestone, hard, compact blue slightly fossiliferous; a 4-inch blue chert layer at the base	2.0	
Limestone, hard, massive, compact blue which has cross-bedded bands in it; contains a little chert	7.0	
Limestone, banded slightly shaly compact; containing many *Tentaculites gyracanthus*	1.0	
Limestone, massive, hard, compact blue; filled with *Stropheodonta*, *Spirifer*, and *Dalmanites* specimens	2.0	
Limestone, massive, hard, compact blue. Lowest stratigraphic position in schoolhouse run	1.5	

List of fossils from the tributary valley at Dry Creek old schoolhouse

NEW SCOTLAND:

Collection T-11:

- Brachiopoda
  - Anoplotheca concava
  - Atrypa imbricata
  - Leptaena rhomboidalis
  - Meristella sp.
  - Schuchertella becraftensis
  - Stropheodonta sp.
  - Uncinulus nucleolatus
- Gastropoda
  - Platyceras gebhardi
- Crustacea
  - Dalmanites sp.
  - Phacops sp.

Section of the west bluff at Dry Creek old schoolhouse

Whetstone Branch formation (Hardin)		9.0
Sandstone, massive layer	2.5	
Interval, covered, probably Whetstone Branch	6.5	
Flat Gap (?) limestone		30.0
Limestone, massive crystalline; partly covered	2.5	
Limestone, massive crystalline slightly fossiliferous	27.5	
New Scotland limestone (Pyburn ?)		12.5
Limestone and chert, massive, hard, compact blue fossiliferous (Collection T-9)	2.5	
Limestone, massive, hard, compact blue; cross-bedded bands	5.5	
Limestone; *Tentaculites* bed	1.0	
Limestone, massive, hard blue, fossiliferous	2.0	
Limestone, compact blue. Lowest stratigraphic position in schoolhouse run	1.5	

List of fossils from the west bluff at Dry Creek old schoolhouse

NEW SCOTLAND LIMESTONE:
- Collection T-9:
  - Crinoidea
    - Stem segments
  - Brachiopoda
    - Anoplotheca concava
    - Rhipidomella oblata
    - Stropheodonta planulata
    - Stropheodonta varistriata (?)
  - Crustacea
    - Trilobite fragments

In the last two sections, the three lowest intervals are the same in each section. There seems little doubt that the New Scotland and the Pyburn limestones are more or less the same stratum. It will be noted that Dunbar himself, however, was in doubt as to the correctness of his identification of the Flat Gap limestone in this Dry Creek area. As explained by him, the 30-foot bed of crystalline limestone, questionably so identified, is present in the west bluff by virtue of the strong west dip of the lower beds and the angular unconformity of the upper ones.

One of the most extensive exposures is in the spur ridge at the Quall house. Supplementing it, is another exposure at the cave at the rear of the house.

Section at the Quall house

Tuscaloosa, total		83.0
Gravel, sand, and sandstone to top of hill	83.0	
Iuka chert (Fort Payne) total		55.0
Chert, loose blocks	55.0	
Carmack limestone (Ridgetop member of the Fort Payne), total		77.0
Limestone, thin-bedded to shaly brownish gray	77.0	
Whetstone Branch formation (Hardin) total		9.5
Shales, gray and black for the most part, and thin sandy layers, interstratified. The sandstone at the top ranges from a few inches up to two feet in thickness, and its base is filled with peculiar plant-like markings	9.5	
Oriskany-Quall limestone, total		16.0
Limestone, massive gray, which contains some interstratified chert. Very fossiliferous in places, containing *Spirifer arenosus S. murchisoni*, and other typical upper Oriskany forms (Collection T-2)	7.0	
Chert, fossiliferous rather massive pieces, which probably came from limestone similar to that at the cave. To small branch	9.0	

List of fossils from the section at the Quall house

ORISKANY (QUALL) LIMESTONE:
- Collection T-2:
  - Crinoidea
    - Stem segments

Bryozoa
    Fenestelloid form
Brachiopoda
    Meristella lata
    Rensselaeria ovalis
    Spirifer arenosus
    Spirifer hartleyi
    Spirifer intermedius
    Spirifer murchisoni
    Spirifer tribuarius
    Stropheodonta linckiaeni
    Stropheodonta (Leptostrophia) oriskania
Pelecypoda
    Actinoptera textilis arenaria
Gastropoda
    Platyceras gebhardi
    Platyceras nodosum

Section at the Quall cave

Carmack limestone (Ridge top member of the Fort Payne		7.0
Limestone, brownish-gray shaly	7.0	
Whetstone Branch (Hardin) total		10.0
Sandstone, containing peculiar plant or worm markings; lying at the top of the interval as at the house but much thicker at the house; shales, mostly black fissile (Collection T-1 contains *Lingula sp.* only); and at the base, limestone, banded sandy, having an irregular or concretionary base	5.0	
Shales, gray sandy for the most part, but at intervals black and fissile, like those above	5.0	
Oriskany—Quall Limestone		16.0
Limestone, massive light gray crystalline, containing the same fossils as at the house. To the roof of the mouth of the cave	16.0	

The importance of the sections at the Quall house and at the Quall cave is the presence of the Quall limestone and the complete exposure of the Whetstone Branch formation. The Quall limestone in these two sections is very fossiliferous, containing the large *Spirifer murchisoni*, *S. arenosus* and other large Brachiopods, so characteristic of the upper Oriskany fauna. The Whetstone Branch formation consists of (1) gray sandy shales, (2) black carbonaceous shales, and (3) thin, shaly sandstones, all interstratified. At the cave a sandy layer in the middle and a sandstone layer at the top are thicker and consequently more conspicuous. The middle one has an irregular or concretionary base, the full significance of which may not be manifest in the exposure. At the house the top layer of sandstone varies from a few inches to two feet in thickness and has the peculiar plant-like or worm-like markings. This is the layer of sandstone which alone is exposed in places and which alone is described as the Hardin sandstone member of the Chattanooga in the combined section by Dunbar—one of the sacrifices of brevity in a combined section. In passing, attention should be called to the designation of the Ridgetop shale as a member of the Fort Payne chert, in the combined section, because of the bearing of this reference on the Fort Payne problem soon to be discussed.

In brief, the Dry Creek area introduces two formations not present or at least not recognized in Mississippi: (1) the limestone questionably identified by Dunbar as the Flat Gap, and (2) the Quall limestone, typical upper Oriskany. The Mississippi New Scotland limestone seems to be the general equivalent of the Pyburn limestone of this area, but it may include more or less of the underlying Ross limestone. Though the fauna of the Olive Hill formation (Ross, Pyburn, and Flat Gap limestone in ascending order) is overwhelmingly New Scotland in age, Dunbar refers it to late Coeymans time, because of the lack of some distinctive New Scotland forms found in the overlying Birdsong shale and because of the erosion interval (unconformity) between the Olive Hill and the Birdsong, thus indicating his valuation of unconformities. The thin elusive Decaturville chert, whose nearest known northern exposure is 25 miles away at Grandview, Dunbar believes, succeeds the massive Flat Gap (?) limestone on Dry Creek, whereas it overlies the Birdsong shale unconformably where the two are associated. This Decaturville chert, referred to the Becraft by Dunbar, seems to be the nearest equivalent of the Island Hill chert of Mississippi, referred to the lower Oriskany.

MISSISSIPPIAN SYSTEM-LOWER

GENERAL DISCUSSION

In the Illinois-Iowa-Missouri area of the Mississippi Valley, the lower half of the Mississippian system, in order of their descending position, consists of the following divisions: Ste. Genevieve, St. Louis, Salem, Warsaw, Keokuk, Burlington, and Kinderhook. In the Mississippi-Alabama area most of, if not all, these divisions are recognizable in the combined exposures of one place and another. The enormous amount of chert and silica, set free by the profound disintegration of the surface beds, covers the formations themselves with such a mantle as to make the determination of their limits exceedingly difficult.

In this work only two divisions have been attempted. The lower formation is the Carmack limestone, a definite lithologic unit, limited below and above by unconformities. It is largely Kinderhook, but it may include the lower Burlington. The upper terrane is the Iuka, perhaps largely upper Burlington and Keokuk in some places in Mississippi. In other places and especially in the Cripple Deer Creek area and in northwest Alabama the Iuka also includes most if not all the remaining divisions of the lower Mississippian, namely the Warsaw, Salem, St. Louis, and (possibly) Ste. Genevieve.

The Carmack and Iuka beds form the bluffs of Yellow Creek, the Tennessee River, Bear Creek, and tributary valleys at most places as far south as Cripple Deer Creek. The upper Mississippian beds do form, however, a small upper portion of the cliffs of Bear Creek to the north of Cripple Deer Creek. All exposures of Paleozoic rocks to the south of this creek are exclusively upper Mississippian.

Figure 4.—Falls over the basal 60 feet of the Carmack limestone on Carmack Creek, the type locality.

CARMACK LIMESTONE

DESCRIPTION AND DISTRIBUTION

Following Crider's reference of the limestone now under consideration to the Devonian, Dr. Lowe applied the name Yellow Creek to it and to all the underlying (Devonian) terranes, a most appropriate term had not this uppermost limestone later proved to be Mississippian in age. Obviously, a minor division name can not include two major divisions. For this limestone, therefore, the name Carmack is proposed, which is the name of the little branch, which contains a beautiful 60-foot falls and which enters the Tennessee River near the division line between Ranges 10 and 11 East.

The Carmack formation in Mississippi is dominantly a thin-bedded to shaly limestone. Though in medium layers when fresh, it always tends to break down or rather split up into thinner layers or even into a shaly limestone on exposure. Where fresh the limestone commonly has a bluish gray color, but in most natural exposures this color has changed to a brown or brownish gray, due to weathering. The lower part in some places is a very dark brown or almost black color. The stone, no doubt, contains a considerable quantity of clay, and it is, therefore, almost everywhere a rather compact, dense fine-grained limestone. Save for a little chert in the thin top layer near the mouth of Indian Creek and the least bit of chert in the thin upper part on Bear Creek and a bit at another locality, the limestone is practically free from chert everywhere in Mississippi. Such is not the case, however, in northwest Alabama. In Mississippi where the formation has a maximum thickness of more than 100 feet, the limestone is, therefore, more or less uniform in structure, texture, and color in its geographic as well as its stratigraphic distribution.

The fossil lists show how meagre the Carmack fauna is. Careful search of practically every inch of the 81.5 feet of limestone in the excellent Cliff section (85) on Yellow Creek, by three men, yielded a cup coral, ten Brachiopods, and a Gastropod. The association of *Productella sp.* (cf. *hirsutiformis*) and *Productus sp.* (cf. *ovatus*) is significant. The Anoplia-like form has interior converging hinge teeth. *Chonetes, Lingula* (two), *Liorhynchus,* and *Orbiculoidea,* individually and collectively suggest a "Black shale" fauna. The Devonian aspect is marked, but, of course, the *Productus ovatus* form in association with the other forms makes it early Mississippian.

The basal conglomerate on Whetstone Branch (Section 157 in part) has been described already in the discussion of the Whetstone Branch shale. Briefly, the basal conglomerate is a layer one foot thick, consisting of long flat shale-like pebbles in a dark matrix of oolitic and green sand texture. Some of the larger rounded masses may be concretions instead of pebbles, and some of them give the test for phosphate. Though not clearly exposed the layer seems to rest in irregular places on the Whetstone Branch shale. There is still plenty of other evidence of the unconformable relation of the Carmack limestone to the underlying terrane. At the Cliff section (85) the limestone rests on the Island Hill or an older formation; at Island Hill (127), on the Whetstone Branch sandstone layer; along Whetstone Branch (157), on the Whetstone Branch shale itself. In Tennessee it has been shown to lie on a thick sandstone layer at the top of the Chattanooga (Hardin) shale. Such unconformable relationship has been reported at many other places in Tennessee. The unconformity at the base of the Carmack limestone is, therefore, a marked break in the sequence of deposition, sufficiently large to be of system rank.

The upper contact of the Carmack limestone is marked similarly by an unconformity, probably, however, of less magnitude than its basal unconformity. Because of the profound weathering of the overlying Iuka chert and the resultant mantle of chert fragments, the upper contact is concealed practically everywhere, to a greater or less degree. Fortunately a few fresh natural exposures and artificial cuts have exposed it along Yellow Creek and its tributaries. Even here detailed study was necessary to determine the unconformity, but once established, evidences of its presence could be detected in practically all poorer exposures wherever distributed.

At Scruggs Bridge across Yellow Creek, eight or nine miles above its mouth, the contact of the Carmack limestone and the Iuka chert is exposed in the old abandoned portion of the highway leading up the hill toward the west (Section 108). Although the limestone in the creek bluff at the side of the old roadway has split into thin layers, it is still a hard firm rock, whereas that in the roadway itself is weathered almost beyond recognition. Farther down the hill toward the east uncontrolled erosion in the old roadway has exposed the chert at a lower level. Perhaps all these conditions can be presented best in two columnar sections.

Section of Scruggs Bridge—Yellow Creek bluff (Location 108, SE¼, Sec. 9, T. 2S., R. 10E.)

Tuscaloosa formation, total		11.0
Sand, red clayey to top of hill	11.0	

Iuka chert, total		2.5
Chert, angular	2.5	
Carmack limestone, total		36.5
Limestone, hard brownish thin bedded to shaly, in which one fossil specimen was collected (Collection 20—*Anoplia*-like form only). Dip 8.5° S., 45° E. at the southeast end of the bluff. To water level	36.5	

Section in old roadway at the side of the bluff at Scruggs Bridge (108)

Tuscaloosa formation, total		13.0
Sand, red clayey and a little gravel in pockets; to the top of the same hill	13.0	
Carmack limestone, total		37.0
Limestone, from which the calcium carbonate has been leached; the residue is thin bedded clayey and siliceous material, containing a bit of white chert. At first it was thought to be Iuka chert (Collection 21 contains *Bellerophon sp.* and Crinoid stems only)	12.0	
Interval between road and flood plain covered	12.0	
Interval between flood plain (420 feet above sea level) and water level covered	13.0	

The layers in the upper interval of weathered Carmack limestone in the old roadway dip toward the east at approximately the same rate as the road descends. Ninety feet east of this exposure of limestone, through recent erosion, the Iuka chert is exposed to the level of the flood plain 420 feet above sea level. Whether the chert extends deeper is obviously unknown. Much of the eastern inclination of the Carmack-Iuka contact surface clearly is the result of the dip of the beds themselves, but examination in the field shows the inadequacy of dip to account for the whole of it. Some of it is, therefore, the result of the angularity of the unconformity itself. Corroborating this conclusion is the height of the contact in the high bluffs on the east (opposite) side of Yellow Creek, where the beds, with possibly a single exception, maintain their eastward dip. In the nearest east bluff exposure (Location 102 near the center of Sec. 10), one mile a little north of east, the contact is 20 feet higher, or 440 feet above sea level. These east bluff contacts are especially significant in case of the examples next to be presented.

As stated in the section, the top 12-foot interval of the Carmack limestone has been leached of all or practically all of its calcium carbonate. The residue is a thin bedded clayey and siliceous material, containing a small amount of chert, so unlike the Carmack limestone, that in this section, the first section of the unconformable contact to be studied, it was originally referred to the Iuka chert. Here it might have remained, had not the adjacent bluff section revealed the hard firm nature of the Carmack limestone in the same interval.

Inasmuch as the Carmack limestone is overlain here partly by the Iuka chert and partly by the Tuscaloosa sand and gravel and inasmuch as both upper beds are very pervious the process of weathering or leaching of the limestone could have been operative during different geologic ages. Post-Tuscaloosa waters, descending through the sand and gravel until they came in contact with the rather impervious Carmack limestone, would have been concentrated and would have concentrated their chemical work at this stratigraphic position. Pre-Tuscaloosa erosion, so pronounced in this area, could have accomplished the leaching. Post-Iuka waters, descending through the pervious Iuka chert during its transformation from limestone to chert or subsequent to that time would have been concentrated at the top of the more impervious Carmack limestone and would have performed here its maximum of leaching. Or pre-Iuka erosion which produced the angular unconformity, of necessity would have had to do some leaching. All in all it seems best to refer most if not the whole of the leaching to pre-Iuka erosion period, for in no place where the Tuscaloosa sand and gravel overlies the Carmack limestone above the immediate Carmack-Iuka contact is there any indication of pronounced leaching at the top of the Carmack limestone.

There seems to be a depressed belt of this leached surface of the Carmack limestone extending northward into T. 1S., R. 10E., where the leaching or depression is especially pronounced in the following sections: Southwest and northwest 27, southwest 22, southwest 21, and western 16. Recently excavated cuts in the standard highway in the western half of Section 16, perhaps, reveal the upper leached part of the limestone and the unconformable contact better than any natural exposure. The following columnar and structural sections illustrate the conditions here.

Section of standard highway cut one-half mile south of the Tennessee line (Location 124, SW¼, Sec. 16, T. 1S., R. 10E.)

Tuscaloosa formation, total		7.0
Sand, red, and a little gravel; the sand is cemented at the base	6.0	
Gravel, impure, large pebbles	1.0	
Iuka chert, total		33.0
Chert and silica, pulverulent; both white	19.0	
Chert, white brittle	1.5	
Silica, somewhat pulverulent and a little chert. The calcium carbonate has all been leached out	9.5	
Chert, top and bottom layer white, brittle; leached of its calcium carbonate	3.0	
Carmack limestone, total		15.5

Limestone, leached to white clay and a little yellow clay, to a position 100 feet in the hill	2.0	
Limestone, leached to a yellow slightly siliceous residue	3.5	
Interval, covered to the level of the highway at the W. A. Morris home	10.0	

Section of the east-west spur ridge at the W. A. Morris home, standard highway and Tennessee line (NW¼, Sec. 16, T. 1S., R. 10E.)

Tuscaloosa formation, total		20.0
Interval mostly covered; some sand and gravel; a few rounded pieces of chert; otherwise, no suggestion of the Iuka chert	20.0	
Carmack limestone, total		57.0
Interval, slightly covered; mostly limestone, thin-bedded to shaly, bluish to brownish gray in color. It weathers to a clayey and siliceous yellow residue under the tree roots and along the joints	41.0	
Limestone, in the highway cut, which has weathered to a yellow clayey and siliceous residue	16.0	

Figure 4a.—Leached upper part of the Carmack limestone in contact (at hammer) with the basal Iuka chert. The photograph illustrates how difficult it is to obtain an exposure of the stratification of the chert even in an artificial cut only one year old. Highway cut on Sandy Creek one-half mile south of the Tennessee State line.

The striking feature of these two sections is the leached or weathered condition of the Carmack limestone. In the first of the sections, the leached limestone beneath the overlying Iuka chert extends back into the hill for a distance of 100 feet, along the highway cut. In no manner, therefore, can the leaching be attributed to surface weathering. In the second section the most highly leached portion of the limestone is the basal part of the spur ridge, recently truncated by the highway cut. Here all calcium carbonate seems to have been removed, leaving a residue of yellow clayey and siliceous material. On the southern natural slope of the spur ridge, much of the limestone projecting slightly from the surface, has, to be sure, split into thin or shaly layers, but in all cases the limestone has maintained its hard firm character and its bluish to brownish gray color. On the other hand, some of the same layers extending into the side of the ridge are much more weathered than the outcropping ends, a very perplexing condition.

In the east-west spur ridge at the Morris home, last section, the Carmack limestone extends 57 feet above the common flood plain of Sandy Creek and Yellow Creek, 400 feet above sea level, without reaching the Carmack-Iuka contact. Five hundred feet straight east from the last section is the southern tip of a north-south spur ridge, on which large blocks of chert extend from the flood plain or highway level to the Tuscaloosa gravel, 45 feet higher. Embankments of up-rooted trees within five feet of the highway level show such masses of chert as practically to prove the presence of the Iuka formation, the base of which may extend even lower (Fig .5). Although the Carmack limestone has a dip of 4°, S.65°E., this angle of inclination would not suffice to project the whole 57 feet of limestone in the east-west spur beneath the flood plain and the 45 feet

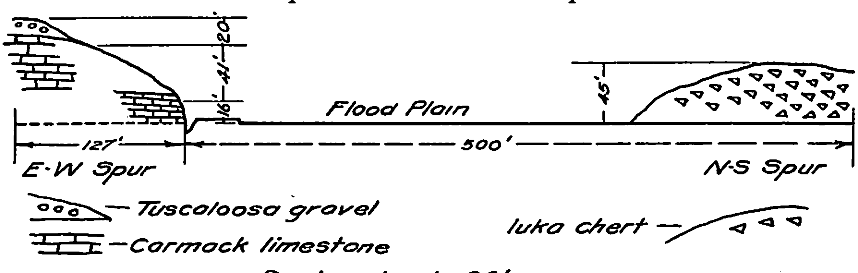

Figure 5.—Section of Sandy Creek at the Tennessee State line illustrating the relation of the Carmack limestone and the overlying Iuka chert.

of chert in the north-south spur, in a horizontal distance of 500 feet. In the absence anywhere in this region of any evidence of a fault the irregular erosional (unconformable) contact of the Carmack and Iuka formations is an inescapable conclusion. Corroborative evidence is found farther east, where the limestone, still maintaining its eastern dip, reaches an elevation of 490 feet in the southeast quarter of Section 15 (Section 130) and 510 feet in the southeast quarter of Section 22. The contact must, therefore, rise 90 to 110 feet in the general direction of dip.

The Carmack limestone forms the bottom portion of the beautiful little valley at Coles Mills (Center Sec. 8, T. 2S., R. 10E.), a few hundred feet west of which is one of the two westernmost exposures of the limestone. Similarly the limestone forms the bed rock of another beautiful little valley, South Fork of Sandy Creek, at the Tennessee State line, the uppermost outcrop of which at the western edge of Sec. 17, T. 1S., R. 10E., constitutes the other most western outcrop of the limestone. The Carmack limestone is exposed down these two tributaries to Yellow Creek, and more or less continuously from Coles Branch down Yellow Creek to its confluence with the Tennessee River. In fact the limestone forms practically the whole east bluff of Yellow Creek, having the maximum thickness as indicated at the following places in T. 1S, R. 10E.: 107 feet at the common corners of Sections 26, 27, 34, and 35, where both contacts are with Paleozoic beds; 112 feet in Columnar Section 83 along the highway in eastern Section 22, where the upper contact is with the Tuscaloosa; 90 feet in Section 136, in the SE¼, Sec. 14, where both contacts are Paleozoic. In Section 83, where the Carmack limestone has its greatest known thickness, it is overlain unconformably by the Tuscaloosa sand and gravel, and must have been subjected to erosion, therefore, in pre-Tuscaloosa times as well as in earlier pre-Iuka times, so that its original thickness must have exceeded 112 feet.

Section along the highway south of the Yellow Creek iron bridge (Location 83—NE¼, Sec. 22, T. 1S., R. 10E.)

Tuscaloosa formation, total		10.0
Gravel and sand, to top of spur	10.0	
Carmack limestone, total		112.0
Limestone, thin bedded to shaly brownish gray, which breaks up into thin shaly layers, but which maintains its freshness and color. It is somewhat weathered at the top. The upper part is sparingly fossiliferous (Collection 9-A and 9-A duplicate), the *Anoplia*-like form being the most common	45.0	
Limestone, thin bedded to shaly brownish gray; slightly covered	22.0	
Limestone, thin bedded to shaly light brownish gray. The lower part is somewhat weathered along the sloping road surface	25.0	
Interval, covered in the road but exposed along the creek bluff, where it consists of the same kind of limestone	20.0	

List of fossils from the highway section (83)

CARMACK LIMESTONE:

Collections 9-A and 9-A duplicate:

Brachiopoda

Anoplia (?) sp.

Chonetes sp.
Chonopectus fischeri
Lingula sp.
Liorhynchus sp.
Orbiculoidea sp.
Paryphorhynchus sp.
Rhynchopora cooperensis
Gastropoda
Conularia sp.
Cephalopoda
Gastrioceras (?) sp.

Similar to conditions on Yellow Creek, are the conditions along the Tennessee where the Carmack limestone forms the lower part of the river bluff practically all the way from Yellow Creek to the mouth of Bear Creek at Eastport. It extends up most of the intermediate tributaries of the Tennessee a short distance, but, owing to a local flexure, it lies at flood plain level at the mouth of the small valley at Iuka Landing (SE¼, Sec. 16, T. 2S., R. 11E.). The limestone extends up Bear Creek about four miles, where 5 feet of it is exposed at low water in the bed of the stream at the ford, one mile above the Alabama line but still on the western side. Perhaps three sections, respectively, at the mouth of Indian Creek, at Eastport, and at the ford, will suffice to show the character of the limestone in this area.

Section of the Tennessee bluff just above Indian Creek (Location 17, NE¼, Sec. 8, T. 2S., R. 11E.)

Iuka chert, total		135.0
Chert, loose blocks	135.0	
Carmack limestone, total		19.0
Limestone, massive layer of brownish gray, containing black flint; slightly fossiliferous (Collections 3 and 3 duplicate), containing *Anoplia*-like form and both *Productella* and *Productus*	2.0	
Limestone, thin bedded to shaly bluish gray to brownish gray slightly fossiliferous. The beds dip north	17.0	
Undetermined		32.0
Interval, covered to the flood plain of the Tennessee River	32.0	

List of fossils from the section of the Tennessee bluff near Indian Creek (17)

CARMACK LIMESTONE:

Collections 3 and 3 duplicate:
Crinoidea
Stems
Brachiopoda
Anoplia (?) sp.
Chonetes sp.
Chonopectus fischeri (?)
Productella hirsutiformis
Productus sp.

Section of the Tennessee bluff at Eastport (Locations 30, 31, 32—SE¼, Sec. 23, T. 2S., R. 11E.)

Tuscaloosa formation		......
Gravel and sand	......	
Iuka chert, total		120.0
Chert, loose blocks	120.0	
Carmack limestone, total		48.0
Limestone, thin bedded to shaly brownish gray; from the Spring to the road	23.0	
Limestone, thin bedded to shaly blue, compact where fresh. The weathered portion is a yellow or buff sandy clay shale, so unlike the fresh limestone as to raise the question as to the correct identification, were some of the weathered part not overlain by fresh limestone. To the flood plain of the Tennessee River (395 feet above sea level)	25.0	

Section just below the ford of Bear Creek near the Alabama line (Location 54—NW¼, Sec. 3, T. 3S., R. 15W.)

Carmack limestone, total		30.0
Limestone, thin bedded to shaly brownish, containing a little bluish black chert. It resembles the material blasted out of the Tennessee at Wilson Dam (Muscle Shoals). Near the top if not the top of the formation	20.0	
Interval, covered from flood plain to low water level. Five feet of it is exposed, however, at the ford, where it is a brown shaly limestone	10.0	

As previously stated, the Carmack limestone, a homogenous unit having an unconformable base and top, is practically free from chert, being quite so in all but a few localities. Attention should be directed to these few places now, however, because of the changes which the formation undergoes in the adjacent part of Alabama. In the Tennessee bluff old roadway one mile above Yellow Creek (Section 139) are rare small chert nodules near the middle of the formation; in the bluff at Indian Creek (Section 17) the top two-foot massive layer contains black flint; and in Bear Creek at the ford (Section 54), the upper part of the limestone contains a little bluish black chert. Perhaps this is the extent of the chert in Mississippi.

CARMACK LIMESTONE IN ADJACENT ALABAMA

DISTRIBUTION AND DESCRIPTION

On the eastern (Alabama) side of Bear Creek, the Carmack limestone seems to be beneath either the flood plain deposits or the Iuka chert mantle; and the same condition obtains on the south side of the Tennessee to a point, some two miles above Riverton, where the bluff meets the Colbert Shoals Canal, about one mile above its mouth. At least the limestone was not found in a traverse of the region mentioned. From this point near the mouth of the canal to Beach Branch at its head, a distance of some six miles, are a series of natural exposures and old quarries, from which rock was taken for the construction of the canal. Fortunately this is true, for here the Carmack limestone undergoes considerable change, as illustrated in the following sections. Perhaps this is the key area to much of the lower Mississippian problem.

Section of the hollow about one mile above the lower end of Colbert Shoals Canal (Location 228—SE ¼, Sec. 12, T. 2 S., R. 15 W.)

Tuscaloosa formation		......
Gravel, to top of hill	......	
Iuka chert, total		115.0
Chert, large loose blocks of white; the upper blocks are fossiliferous; the blocks 90 feet or more above the base are just filled with Crinoid stems and Bryozoa fragments, which make up much of the chert mass and all of Collection 86.	115.0	
Carmack limestone, total		34.5
Clay, white and yellow, and a two-inch layer of chert. This interval is either the base of the upper or the top of the lower formation, and it resembles the one on Yellow Creek. (Collection 87 revealed no organisms)	2.0	
Interval, covered	8.5	
Limestone, compact blue, which is almost flinty in hardness	2.0	
Interval, covered	5.0	
Limestone, compact blue very hard (Collection 88 *Anoplia*-like form)	5.0	
Limestone, hard brownish gray, and a little black chert or flint. Like that above Indian Creek (Section 17)	1.0	
Limestone, brownish gray, which breaks up into thinner layers as the Eastport limestone typically does. The base is 6 feet below the Canal road and about water level	11.0	

Section of old quarry 1½ miles above the mouth of Colbert Shoals Canal (Location 229—SW¼, Sec. 7, T. 2 S., R. 14 W.)

Iuka chert, total		14.5
Silica, pulverulent white, interstratified with two thin layers of chert. To top of quarry	8.5	
Chert, in more or less definite layers interstratified with material from which the calcium carbonate has been leached. Ratio about 1 to 1	6.0	
Carmack limestone, total		41.0
Shales, yellow, buff, and white clayey and siliceous, containing a few small nodules and a little iron. The calcium carbonate is leached out similar to that on Yellow Creek, hence evidence of an unconformity (Collection 89)	6.5	
Shales, brown earthy	0.5	
Limestone, hard, compact blue, and a little black flint; the upper half has the flint covered with iron rust. Like that above Indian Creek	2.0	

Limestone, rather massive bluish or brownish gray, and a little black flint in irregular nodules. It breaks up into thin hard brownish gray limestone shales or shaly limestone on exposure. To Canal road	18.5
Limestone, massive compact bluish or brownish gray and possibly a little chert. It breaks up into a brownish gray shaly limestone on exposure. To water level of the canal	13.5

List of fossils from the quarry one and one-half miles above the mouth of Colbert Shoals Canal (229)

CARMACK LIMESTONE:

Collection 89:

Crinoidea
Stems

Brachiopoda
Anoplia (?) sp.
Productus sp.
Spirifer sp., cf. marionensis

A little east of the last section (229), the beds dip 3.5°, S. 45° E., so that still farther east in the hollow opposite the upper end of Bee Tree Island. two miles above the mouth of the canal, the exposed upper part of the Carmack limestone is reduced to 34 feet, being overlain by 90 feet of the Iuka chert. A foot traverse continued up the Tennessee showed Iuka chert blocks at the base of the bluff to Ross Branch, a mile farther upstream, probably indicating that the dip carried the top of the limestone to near canal level. Such must be the case for at the mouth of Boone Branch, one mile still farther east, an 8 or 10-foot interval of white pulverulent silica of the Iuka chert lies just above canal water level. One and one-half miles above Boone Branch, at the spillway in the lower end of the concrete wall of the canal, which is just above Brush Creek Island, the beds dip in the opposite direction, 2 feet in 120 feet N. 45° W., which reverse dip carries the upper part, 34 feet, of the Carmack limestone above the canal toward the southeast. This portion of the Carmack is massive bluish-gray or brownish-gray limestone containing a little black flint in nodules, particularly the uppermost layer. Save for the flint the limestone is typical Carmack limestone of Mississippi. Here the Iuka chert blocks extend above the limestone for 121 feet and are capped by four feet of limestone having a cherty basal portion and a coarsely crystalline upper part. This 4-foot limestone seems to be in place, although it does carry a Chester fauna (Collection 90). Perhaps this information should be emphasized by placing it in section form.

Section of the bluff at the lower end of canal concrete wall (Location 231—NW¼, Sec. 23, T. 2 S., R. 14 W.)

Alsobrook formation, total		4.0
Limestone; the lower portion is cherty, resembling compact quartzite; the upper part grades into a coarsely crystalline limestone, which is fossiliferous (Collection 90), bearing a Chester fauna. The limestone seems to be in position	4.0	
Iuka chert, total		121.0
Chert and limestone, loose blocks of	121.0	
Carmack limestone, total		34.0
Limestone, massive bluish gray or brownish gray, containing a little black flint in nodules, particularly the uppermost layer. This is typical Carmack limestone of Mississippi. To canal level	34.0	

List of fossils from the section at the lower end of the concrete wall of the canal (231)

ALSOBROOK FORMATION:

Collection 90:

Brachiopoda

Composita trinuclea
Productus (Diaphragmus) elegans
Productus ovatus
Productus sp.
Spirifer leidyi

Section of old quarry about straight west of the swell in the channel of the Tennessee River and about one mile above the spill-way (Location 233—NE¼, Sec. 23, T. 2 S., R. 14 W.)

Iuka chert, total		16.0
Silica, largely pulverulent yellow and a little chert. All inaccessible, but the basal part is probably shaly and probably belongs to the top of the Carmack limestone	16.0	
Carmack limestone, total		69.0
Limestone, massive where fresh, compact bluish gray, and black flint bands, some of which are 0.7 foot thick, and much nodular black flint. In natural outcrops, the limestone becomes shaly hard brownish gray typical Carmack limestone of Mississippi. The chert nodules and irregular layers of chert stand out as irregular projecting masses on weathering, however. The pulverulent silica of the overlying mass proves this 55-foot interval to be Carmack limestone, and the exposure shows conclusively the change from a homogeneous chert-free limestone in Mississippi to a cherty limestone in this short distance up the Tennessee Valley from the state line. To road level	55.0	
Limestone, layer, as above	2.0	
Interval, covered. Across the gully the beds dip toward the south 1.5 feet in 50 feet. To water level of the canal	12.0	

Attention should be called to the thickness of the exposed upper part of the Carmack limestone in the sections thus far presented, and its bearing on the problem of correlation. In order, it is 35, 41, 34, and 69 feet, and represents only the amount of exposure above water level of the Colbert Shoals Canal, which has a lock lift of 25 feet above the river. If this amount be added to the thickness in the different sections 60, 66, 59, and 94 feet are had as something like the total thickness of Carmack limestone above the Tennessee River. In addition, the limestone forms the channel of the stream.

It is not known how many of the quarries were opened or how much of the work on the canal was completed in McCalley's day. Records show that to June 30, 1890, only $62,000 had been spent on the whole 30-mile stretch from Florence to Bee Tree (Colbert) Shoals; and that to June 30, 1895, the amount had reached only $149,000 of the total cost of $2,313,000 of the 8.6 miles of Colbert Shoals Canal, which was not completed and opened until 1911. It seems highly probable, therefore, that very little of the canal work had been done previous to the appearance of McCalley's report in 1896, and that he used the Tennessee River rather than the canal as a datum plane. If so, the Carmack limestone in the sections of the bluff along Colbert Shoals Canal already given and yet to be presented must include most if not actually the whole of McCalley's Lauderdale at this place, for he states that: "They (Lauderdale strata) are most highly exposed in the northeast and northwest corners of the county (Colbert), where their bluffs along the river are frequently from 75 to 100 feet high[1]," though on the same page, he does give their exposed thickness in the county as 200 feet. For years McCalley's report has been the outstanding one of this region and perhaps still is so, but it must be obvious how difficult becomes the problem of correlation when, unfortunately, generalized sections only are published.

Section at Spring Branch, one-half mile above the last section (Location 232, SE¼, Sec. 23, T. 2S., R. 14W.)

Tuscaloosa formation		.....
Gravel	.....	
Iuka chert, total		127.0
Chert, loose blocks, larger toward the top. The basal part seems to be pulverulent silica and possibly shaly. (Collection 91 from the extreme top, where Crinoid stem segments and Bryoza fragments make up much of the chert mass)	127.0	
Carmack limestone, total		57.0
Limestone, compact bluish or brownish gray, and much black flint. It is typical Carmack limestone, changed to a mere compact, more bluish, and more cherty or flinty stone	38.0	

[1]McCalley, Henry, The Tennessee Valley Region, Colbert County, Geol. Surv., Ala. The Valley Region of Alabama, p. 147, 1896.

Limestone, brownish gray, containing a very little black flint. It is more shaly due to weathering, and is almost typical Carmack limestone	5.5
Limestone, compact bluish or brownish gray, containing considerable black flint in irregular masses. Carmack limestone changed to flinty material	8.5
Interval, covered. To canal bank or flood plain level	5.0

List of fossils from the section at Spring Branch (232)

IUKA CHERT:

Collection 91:

Anthozoa
- Cup coral

Crinoidea
- Stem segments abundant

Echinoidea
- Spines

Bryozoa
- Fragments abundant

Brachiopoda
- Cliothyridina sp.
- Spirifer sp.

It seems more than probable that the typical Carmack limestone of Mississippi has changed, in the last section, to a more compact, dense bluish limestone, which contains 20 to 30 per cent. or perhaps more of its total make up in the form of black flint, as it did in the sections down stream. The question then arises, are the overlying, typical loose chert blocks in these sections Lauderdale in part? They seem to represent the cherty phase of the Tuscumbia. In other words, has the Tuscumbia been called such where it is a limestone and has it been called Lauderdale where it is a chert? In any event it is obvious by this time, that the Lauderdale (Iuka) chert of the Mississippi reports included only a part of the Lauderdale of Alabama, and that the upper brownish gray shaly limestone member (Carmack) of the underlying Yellow Creek formation of the Mississippi reports is in part or in whole the Lauderdale of Alabama.

The next section, about three-fourths of a mile above the last section and a like distance below the head of Colbert Shoals Canal, is the last in this region. It begins with the river bluff at the mouth of Beach Branch, continues up the stream one mile, and thence up the high hill to the south. It is presented not so much to extend the area of the Carmack limestone as to show the results of the last strenuous effort to connect this limestone with the overlying Chester formations through intermediate beds of more or less continuous exposures in as short a horizontal distance as possible.

Section of Beach Branch mouth, stream, and hill (Location 234, Sections 25 and 26, T. 2S., R. 14W.)

Tuscaloosa formation, total		35.0
Gravel, to top of hill	35.0	
Chester series, total		93.5
Limestone (Southward Pond "A"), massive, oolitic asphaltic	3.5	
Interval, covered. It probably belongs mostly if not wholly to the Chester series	90.0	
Iuka terrane, total		168.0
Chert, loose blocks, the top filled with large Bryozoa	105.0	
Limestone, massive slightly more compact, and, at least, a thick layer of granular chert (Collection 92)	25.0	
Limestone, massive, granular, gray, fossiliferous (Collection 92, both consist of abundant fragments of Crinoid stems, *Hemitrypa proutana*, and other Bryozoa)	5.5	
Limestone, massive, granular, gray; at base of the G. H. Watkins old quarry	5.5	
Interval, covered; chert blocks up the stream	27.0	
Carmack limestone, total 70.0 to		98.0
Limestone, bluish or brownish gray to nearly white, and dark or black flint, like that at Spring Branch (232), except lighter in color. The limestone of the lower 35 feet or half of the interval projects as a prominent ledge along the Tennessee bluff from Spring Branch to Beach Branch, thence up Beach Branch one-half mile to the road forks. A running line of levels up Beach Branch shows the top of the limestone in the road at 61 feet above the Tennessee flood plain and 4 feet of overlying weathered limestone or shale; a little farther up stream, the top of what appears to be the same limestone is 22 feet higher and is likewise overlain by an interval of weathered limestone or shale; and still farther up stream in the creek opposite the G. H. Watkins house, the top of the limestone is 98 feet above the Tennessee flood plain. Therefore, although in the lower stretches of Beach Branch the limestone is nearly level, in the upper stretches it seems to rise with the stream. To Tennessee flood plain 70 to	98.0	

No attempt was made to trace the lower Mississippian formations from point to point farther up the Tennessee Valley toward the east. The top of the lower Mississippian and the base of the upper Mississippian were followed, however, along the highway at the south of the valley to the Tuscumbia-Sheffield-Muscle Shoals area. In the Tennessee bluff at Sheffield, McCalley[1] reported 65 or 70 feet of Lauderdale chert, but the lack of fresh exposures, fossil forms, and accessible intervals make the study at this place most difficult indeed. Just below Wilson Dam at Muscle Shoals, on the other hand, recent excavations add much to the clearness of the

[1]Op. cit. p. 148.

exposures. Viewed from the north side of the Valley, one mile distant, there appears two or three distinct breaks in the stratigraphic sequence of the beds on the south side of the valley. These breaks merit a more careful consideration than has been given them thus far, even though close examination discloses somewhat conflicting evidence; and the absence of sufficient fossils or diagnostic forms leaves conclusions concerning them unfortunately indefinite.

Section of the south bluff of the Tennessee River at Wilson Dam

Iuka formation, total		96.3
Interval, covered with loose chert	22.0	
Limestone, massive crystalline oolitic slightly fossiliferous. The base is about the place of a change in texture	33.8	
Limestone "C". Gray and bluish gray limestone and some chert. Slightly fossiliferous. The base probably represents an unconformity	26.0	
Limestone "B". Compact limestone, containing Crinoid sections, and chert. The base probably represents an unconformity	14.5	
Carmack limestone, total		59.0
Limestone "A". Compact dark bluish gray limestone and irregular masses of dark gray and black chert. The rock of this interval is practically without bedding planes, that is, is more like a monolithic mass. In some places the inclosed chert is partly in layers, but in most places it is in irregular nodular masses. (Collection 60). The base probably represents an unconformity, the contact varying 6.2 feet in 200 feet	15.0	
Limestone "A"—. Massive bedded compact bluish gray limestone and dark to black chert or flint	23.0	
Interval, covered, but it is certainly limestone because of the limestone and chert in the bed of the river	21.0	

List of fossils from the south bluff of the Tennessee at Wilson Dam

CARMACK LIMESTONE:
- Collection 60:
  - Crinoidea
    - Stem fragments
  - Bryozoa
    - Cystodictya sp.
    - Fenestella sp.
    - Polypora sp.
  - Brachiopoda
    - Productus ovatus
    - Productus sp.

If an attempt be made to divide these limestones into two divisions, Lauderdale chert and Tuscumbia limestone, on the basis of the lower interval of 65 or 70 feet at Sheffield and the lower interval of 75 or 80 to 100 feet at Muscle Shoals being Lauderdale according to McCalley, then the line probably will have to be drawn at the top of Limestone "C" where there appears to be no unconformity. On the other hand, the compact bluish gray limestone containing black chert, which breaks into thin or shaly brownish gray limestone and chert, seems to be without much doubt the upper part of the Carmack limestone of the Colbert Shoals area. The line between the Carmack, and Iuka, therefore, seems to be at the top of Limestone "A," as drawn, though this probably involves an intraformational unconformity in the Carmack, located between "A"— and "A." Granted the uncertainty of this correlation, the fact nevertheless remains that unless some one ventures an opinion concerning the limits of these beds so sparingly fossiliferous, their history never will be known.

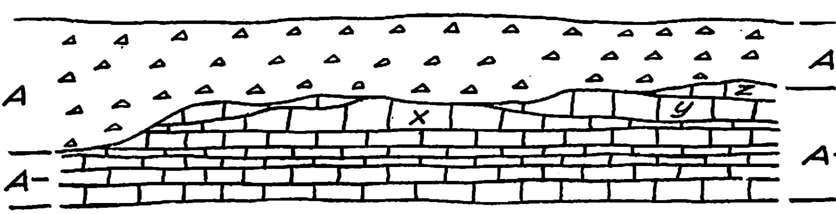

Figure 6.—Intraformational unconformity between beds "A—" and "A" of the Carmack limestone at Wilson Dam, Muscle Shoals.

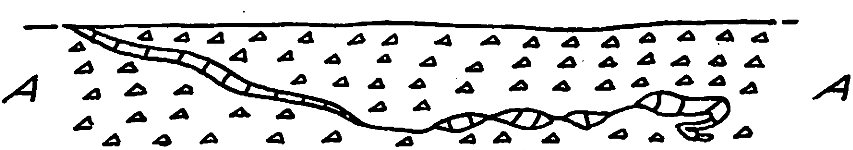

Figure 7.—Contemporaneous erosion unconformity in bed "A" of the Carmack limestone at Wilson Dam, Muscle Shoals.

In Fig. 6, the line between limestone "A"— and limestone "A" seems to be an unconformity, the surface varying vertically 6.2 feet in a horizontal distance of 200 feet. It may be, however, only a contemporaneous erosion surface. The greatest obstacle to a definite solution of the problem is the lenticularity of layers x, y, and z. The next illustration, Fig. 7, is a sketch of limestone "A," farther down stream. It seems to represent a contemporaneous erosion surface upon which limestone accumulated, partly consolidated, and then slumped into the deeper eroded portion. In Fig. 8, the limestones are sketched still farther down stream. There seems little doubt that the surfaces between "A" and "B," and between "B" and "C" represent unconformities; and that the irregularities within "B" itself are contemporaneous erosion surfaces. The greatest lithologic break is most certainly between limestone "A" and limestone "B," as shown in the columnar section.

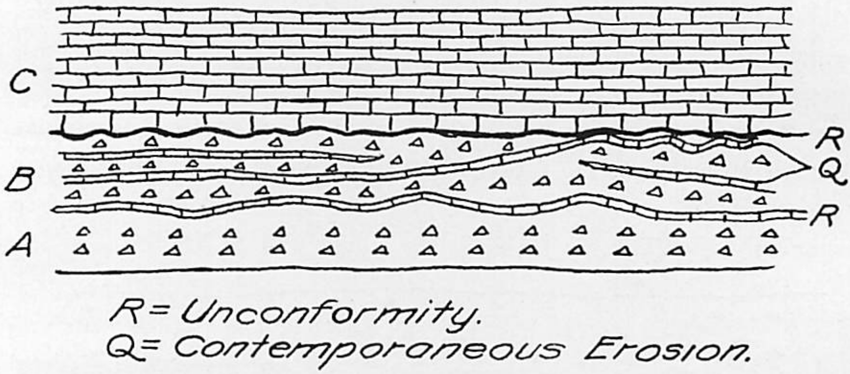

Figure 8.—Unconformity between the Carmack limestone ("A") and the Iuka chert ("B"), and intraformational unconformity between beds "B" and "C" of the chert at Wilson Dam, Muscle Shoals.

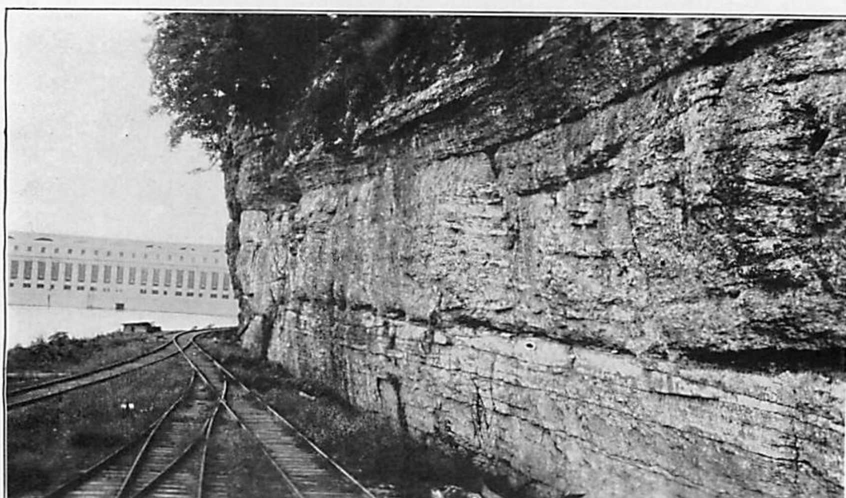

Figure 9.—Lenticular upper layers (marked x, y, and z in the diagram, Figure 6) of bed "A—", and intraformational unconformity between beds "A—" and "A" of the Carmack limestone. In the upper part of the figure is the unconformity between the Carmack and Iuka formations. The photograph also shows the cherty phase of the Carmack limestone. South side of the Tennessee River at Wilson Dam, Muscle Shoals.

CARMACK FAUNA AND CORRELATION

Already attention has been called to the meagerness of the Carmack fauna. Furthermore, all the forms preserved are more or less comminuted and are mostly of species closely resembling other related species. In spite of these handicaps, the following complete list of Carmack fossils shows rather definitely the age of the fauna. Its Devonian affinities are marked. On the other hand, the presence of such species as *Productus ovatus* proves the arrival of Mississippian times, whereas the absence of a pronounced Mississippian assemblage just as definitely proves its earliest Mississippian age.

Complete list of fossils from the Carmack limestone

- Anthozoa
  - Cup coral
- Crinoidea
  - Stem plates
- Bryozoa[1]
  - Cystodictya sp.
  - Fenestella sp.
  - Polypora sp.
- Brachiopoda
  - Anoplia (?) sp.
  - Chonetes sp.
  - Chonopectus fischeri (Kinderhook)
  - Lingula albapinensis (U. Devonian, Caney)
  - Lingula sp.
  - Liorhynchus sp., cf. laura (Marcellus, Hamilton)
  - Orbiculoidea sp.
  - Paryphorhynchus sp.
  - Productella hirsutiformis (U. Devonian, Caney)
  - Productus ovatus (Kinderhook-Chester)
  - Reticularia sp., cf. pseudolineata (Burlington, Keokuk) or prematura (Chemung)
  - Rhynchopora cooperensis (Kinderhook, basal Keokuk)
  - Spirifer sp., cf. marionensis (Kinderhook)
- Gastropoda
  - Bellerophon sp.
  - Conularia sp.
- Cephalopoda
  - Gastrioceras (?) sp.

The stratigraphic evidence corroborates the paleontologic conclusions. There is a pronounced unconformity at the base and another at the top of the Carmack limestone, which in Mississippi is a definite lithologic unit. Part of the overlying Iuka chert, as will be shown later, bears definite Keokuk forms. Dr. Springer in that most excellent summary of the work of early geologists and of himself[1] in Iowa, Missouri, Illinois, Indiana, Kentucky, and Tennes-

[1]Bryozoa from section at Wilson Dam.

[1]Springer, Frank, The Crinoid fauna of the Knobstone formation. U. S. Nat. Mus., Proc. 41: 175-208, 1912.

see, has called attention to the pronounced Crinoid break between the lower Burlington and the upper Burlington, that, in fact, it is far greater than any faunal change between the upper Burlington and Keokuk or between the lower Burlington and Kinderhook. He even suggests the appropriateness of combining the lower Burlington with the upper part, at least, of the Kinderhook formation. Inasmuch as the lower Burlington fauna was found at Whites Creek Springs, 12 miles north of Nashville, separate and distinct from the fauna of the overlying beds, it is possible that the unconformity at the top of the Carmack limestone is intra-Burlington in age. It is at least interesting, if not significant, to glance at the Wilson Dam columnar section and structural sections (Figs. 6, 7, 8, and 9), and then to read from Dr. Springer, who says: "The southern Indiana region especially was one of many changes, and frequent invasions and recessions of the waters, accompanied by much erosion and replacement during the epoch which the Burlington-Keokuk-Warsaw beds represent" (p. 177). Because of all the evidence thus far presented and yet to be offered in the description of the later beds, it is the writer's unqualified opinion that the Carmack limestone represents the whole or practically the whole of Kinderhook times, and, possibly, some of the early Burlington as well.

In the description of the Devonian system in the adjacent part of Tennessee, it was shown that the overlying Carmack limestone in the section at the Quall house at Walnut Grove is the Ridgetop shale member of the Fort Payne chert of Dunbar.[1] Inasmuch as Dunbar traces the underlying Devonian beds entirely across the State of Tennessee, there is no doubt as to his identification of the Ridgetop shale, at least in a general way. Where most fully represented in Mississippi, the Carmack limestone ranges from a little less to a little more than 100 feet in thickness as does the Ridgetop shale at the type locality. At Ridgetop, however, the formation contains more clay shale. From the Ridgetop fauna Winchell recognized numerous Kinderhook species and Bassler in his excellent paper likewise not only referred the formation to the Kinderhook but to the lowest Kinderhook.[1]

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[1]Dunbar, Carl O., Stratigraphy and correlation of the Devonian of western Tennessee. Tenn. State Geol. Surv., Bull. 21: 126, 1919.

[1]Bassler, Ray S., The Waverlyan period of Tennessee, U. S. Nat. Mus., Proc. 41: 216, 217, 223, 1911.

It has been shown that the upper part of the Carmack limestone in the adjacent part of Alabama is more cherty, becoming decidedly more so toward the east; and that in whole or in large part the formation is included in McCalley's Lauderdale chert. Although detailed sections by McCalley are wanting, it seems probable that the upper limit of the Lauderdale was not drawn everywhere at the same stratigraphic position. However that may be, at places the upper limit of his Lauderdale is higher than that of the Carmack limestone, because it includes beds of Keokuk age. For the prior Lauderdale Butts most unfortunately substituted the restricted term Fort Payne,[2] as a geologic name whose limits have been shifted so frequently that it has to be re-defined each time it is used.

IUKA TERRANE

DISTRIBUTION AND DESCRIPTION

The Iuka formation is named from the county seat of Tishomingo County, around which the beds here so designated are more or less exposed. The terrane includes all the beds from the definite unconformity at the top of the Carmack limestone to the base of the overlying Chester series, in other words all the remaining lower Mississippian beds, consisting of the upper Burlington (probably), Keokuk, Warsaw, Salem, St. Louis, and (possibly) Ste. Genevieve. Fossils indicative of most of these beds have been found here and there in the Mississippi-Alabama area, but not in sufficient abundance thus far to effect a separation of the beds from place to place.

In Mississippi (and the small part of Alabama west of Bear Creek) north of Clear Creek or the Southern Railway, weathering or rather the leaching of the calcium carbonate has been so profound that the residual chert of the Iuka breaks into blocks which cover the beds practically everywhere. Nowhere along Yellow Creek, the Tennessee River, the west side of Bear Creek below the Southern Railway, or the tributaries of these streams is the Iuka terrane fully or even largely exposed. In fact at only a few places is there enough of the beds exposed to show the stratified nature of the rock. Elsewhere the terrane is represented by angular blocks of porous chert, which range in size from small pieces up to huge blocks.

[2]Butts, Charles, The Paleozoic rocks. Geol. Surv., Alabama, Special Rept. 14: 162. 1926.

Nearly everywhere the chert bears direct evidence of the tests and other hard parts of organisms of which it was originally composed and about which it formed a protecting mass. Much of the organic material had been more or less comminuted by the time of accumulation; and, since consolidation of the sediments, leaching of the calcium carbonate has been so well nigh complete that only external and internal impression of the organic fragments remain. Although the chert is really fossiliferous nearly everywhere, the fossils are so largely fragmental as to preclude the practical identification of the species in all but a few places. At one of these places on Indian Creek north of Iuka (Collections 1 and 2), the huge Brachiopod, *Orthotetes keokuk,* proves a portion of the terrane to be of Keokuk age.

List of fossils collected on Indian Creek (SW ¼, Sec. 17, T. 2S., R. 11E.)

IUKA TERRANE:

- Collection 1:
  - Bryozoa
    - Hemitrypa proutana
    - Proutella discoidea (?)
    - Polypora (?) sp.
  - Brachiopoda
    - Camarotoechia mutata
    - Orthotetes keokuk
    - Productus altonensis
    - Productus scitulus
    - Reticularia setigera
    - Spirifer bifurcatus
    - Streptorhynchus ruginosum
  - Pelecypoda
    - Aviculopecten sp. 1
    - Aviculopecten sp. 2
    - Myalina congeneria
  - Crustacea
    - Griffithides sp.
- Collection 2:
  - Blastoidea
    - Mesoblastus (?) sp.
    - Pentremites conoides
  - Bryozoa
    - Hemitrypa proutana
  - Brachiopoda
    - Spirifer bifurcatus
    - Spirifer latior
    - Spirifer sp., cf. keokuk
    - Spiriferina sp.

Evidence of the universal unconformity at the base of the Iuka terrane has been given in the description of the Carmack limestone. At a few places on the west side of Bear Creek between Clear Creek and Little Bear Creek there is evidence of marked pre-Chester erosion of the Iuka beds, and, therefore, of an unconformity at the top of the terrane. Elsewhere north of the Southern Railway or Clear Creek, Tuscaloosa sand and gravel overlie the terrane unconformably. As is to be expected, the field evidence shows that this pre-Cretaceous erosion cut across the beds, beveling them to a feather edge along the north side of their area.

At Coles Mill near the center of Section 8, T. 2S., R. 10E., the Iuka chert extends beyond the Carmack limestone about one-half mile toward the northwest and a similar distance toward the southwest. Up the south branch of Sandy Creek at the Tennessee line the Iuka chert does not extend so far west as does the Carmack limestone at the western edge of Section 17, T. 1S., R. 10E. On the north side of Sandy Creek proper blocks of Iuka chert extend into Tennessee, at least for a short distance.

In the description of the Carmack limestone a section of the standard highway cut (124), one half mile south of the Tennessee line, showed the bedding of the interstratified chert and pulverulent silica of the basal 33 feet of the Iuka chert. Perhaps the only other place in this whole area where an appreciable amount of the Iuka chert is shown in stratified form, is in the natural exposure a mile South of the cut. Here the following section may be seen.

Section of the small stream at the home of H. L. Smith (Location 118, SE¼, Sec. 21, T. 1S., R. 10E.)

Tuscaloosa formation, total		5.5
Sand and gravel; sand red	5.5	
Iuka chert, total		40.0
Chert, white brittle; mostly in position; some slightly covered. To top of hill opposite the Smith home	12.5	
Chert, white brittle, in layers which are interstratified with more or less pulverulent silica. All exposed in the bed of the stream	25.5	
Chert, two irregular layers between which is the same material as below. It is impossible to determine whether some of this material has been reworked	2.0	
Carmack limestone, total		5.0
Material, white leached, having some nodules somewhat cherty. Possibly this material has been slightly reworked	2.0	
Limestone, leached; residue, fine clayey and siliceous yellow and bluish white, in the bed of the stream. The whole could easily be mistaken for the Tuscaloosa clay, did it not extend back under the chert	3.0	

As loose surface blocks overlying the Carmack limestone practically everywhere, the Iuka chert extends from Coles Mill and from the Tennessee line down the respective tributaries to their mouths; thence down Yellow Creek to its confluence with the Tennessee River; thence up the river to Bear Creek; thence up Bear

Creek to a point one mile north of Clear Creek and the Southern Railway, where its contact with the Chester beds carries the chert below flood plain level. Likewise it extends up the tributaries of the Tennessee and Bear Creek, reaching a point within 1.2 miles of Iuka corporate limits on Indian Creek and a place within 1.6 miles of the corporate limits on Little Bear Creek.

Owing to the uneven (unconformable) basal surface on which it rests and in part to the erosion it suffered in pre-Chester and pre-Cretaceous times, the Iuka chert has a variable thickness. At the mouth of Yellow Creek it is 50 feet thick; in the vicinity of Whetstone Branch, 70 to 110 feet; at the mouth of Short Creek, 160 feet; near Iuka Landing, 157 feet; at Eastport, 120 feet; below the mouth of Little Bear, 169 feet. Farther up Bear Creek less and less of the upper part only is exposed and finally the whole of the chert formation comes to lie at flood plain level near Clear Creek, as already stated.

Yet farther up the west side of Bear Creek and still partly in Alabama and partly in Mississippi, a rise of the basal portion of the Chester series exposes the top part of the Iuka terrane from the mouth of Pennywinkle Creek, 1.5 miles above Clear Creek and the Southern Railway, to some point between Allsboro and Bishop Bridge, a distance of five to seven miles. In this stretch the relation of the Iuka terrane to the overlying Chester series is beautifully shown, but, unfortunately, the relation of the Iuka beds of this area to the Iuka beds of the area just north of the Southern Railway can not be determined except in the most roundabout way. One of the best series of exposures of the Iuka top and the Chester base begins at the Alsobrook Bridge and extends past the Alsobrook homestead and on up the Iuka highway from the forks of the Allsboro and Iuka roads.

Section from the Alsobrook Bridge to the Alsobrook homestead

Alsobrook formation, total		63.0
Interval, covered; contains a few blocks of sandstone let down from a higher level; to top of hill at the barn	44.0	
Shales, greenish clay	11.0	
Limestone, bluish gray crystalline to granular; medium to thin-bedded or shaly at the top; the upper part at least extremely fossiliferous; the whole probably belonging to this formation. The top of this limestone at the school house 1,100 feet N. 75°E., is 10 feet lower than at the barn	8.0	
Iuka terrane, total		58.5
Chert, residual, at the barn	4.0	
Chert, residual	6.5	

Limestone, massive layers of gray, somewhat crystalline, fossiliferous, Bryozoa	11.0
Limestone, gray, in the middle; and mostly chert layers at the top and bottom (Collection 52). Top of exposure at the bridge	6.0
Limestone, two massive layers of gray slightly crystalline, and chert; both fossiliferous	8.0
Limestone, massive indefinite layers of light gray, alternating with nodular layers of chert; stylolites. The limestone is compact like the St. Louis	17.0
Limestone, layer of gray, containing chert in the middle. To water level of Bear Creek	6.0

List of fossils from the Alsobrook Bridge section

IUKA TERRANE:

Collection 52:

- Crinoidea
  - Stem plates
- Echinoidea
  - Plates
- Bryozoa
  - Hemitrypa proutana
- Brachiopoda
  - Eumetria sp.
  - Productus sp.
  - Reticularia setigera
  - Spirifer sp.
- Pelecypoda
  - Winged form

The interval of cherty limestone (10.5 feet) at the top of the Iuka terrane weathers faster than the overlying Alsobrook limestone (8 feet), thus not only freeing the chert, blocks of which cover the surface of the ground, but producing an unstable base for the limestone, huge rectangular slabs of which assume all kinds of tilted positions. A loose block of chert, probably from this top interval of the Iuka terrane, containel a *Lithostrotion* which, though imperfect, resembled *L. proliferum* closer than *L. canadense*. Rather large masses of *L. canadense* from the same bed of loose chert on the south side of Cripple Deer Creek, three miles distant, however, leave no doubt as to the St. Louis age of this part of the Iuka terrane.

The top of the limestone (8 feet) in the basal part of the Alsobrook formation rises 16.4 feet to the forks of the Iuka and Allsboro roads about one-fourth mile S. 55° W., where the following section is clearly exposed, as well as some of the underlying Iuka terrane. Though the portion of the section measured is exclusively Chester, Its presentation at this time is necessary to a clear understanding of the sections lying east of Bear Creek and exclusively in Alabama, soon to be considered.

Section at the forks of the Iuka and Allsboro roads

Southward Pond formation, total		22.0
Limestone A, blocks reaching from the top to the bottom	13.0	
Interval, covered, except for some clay and calcareous shale at the base	9.0	
Allsboro sandstone, total		5.5
Sandstone, massive brown coarse, at the base; thin bedded at the top	5.5	
Alsobrook formation, total		80.0
Shales, calcareous, green clay, containing a little carbonaceous material	29.0	
Sandstone, layer of yellow brown, which breaks into blocks about one-foot square	1.0	
Shales, calcareous, green clay	42.0	
Limestone, measured at Alsobrook barn in the last section	8.0	

The Iuka beds (or their upper contact surface) in the Alsobrook locality continue their northward dip to the mouth of Pennywinkle Creek, where on the north side of the stream an interval of something like ten feet of the top of the terrane is exposed. The north dip is continued beyond this place also, as will be shown in the description of the Chester series. In the opposite direction, the Iuka beds are exposed on Cripple Deer Creek, where on the south side of the valley, about east of Allsboro, a large mass, one foot in diameter, of *Lithostrotion canadense* was found in the loose chert blocks of the upper part of his terrane. Up Cripple Deer Creek at the state line the exposed top portion of the Iuka terrane is about 50 feet thick. Blocks of Iuka chert and limestone extend on up Cripple Deer for two miles, and possibly the Paleozoic rocks exposed three miles still farther up the stream contain a little of the top of the Iuka at their base. Though not traced along Bear Creek itself south of Cripple Deer Creek, the top of the Iuka terrane passes beneath the flood plain somewhere between Cripple Deer Creek and Bishop Bridge.

IUKA TERRANE IN ADJACENT ALABAMA

DESCRIPTION AND DISTRIBUTION

Attention has been directed already to the dip of the Iuka beds (or of their upper contact surface on the west side of Bear Creek) from the Alsobrook locality northward to the mouth of Pennywinkle, and to their position beneath the flood plain deposits for a stretch of two miles from Pennywinkle Creek to the point a mile north of Clear Creek and the Southern Railway. Small railway cuts at the mouth of Clear Creek, subsequently illustrated in the description of the Chester series, show sharp transverse folds in these upper strata. On the east side of Bear Creek, an interval of about 25 feet of the Iuka limestone and chert forms the east abutment of the new highway bridge across Bear Creek at Stemeni Ford, about half way between Pennywinkle and Clear creeks. On the north side of Buzzard Roost Creek in its lower stretches, the Iuka beds dip west, reaching flood plain level at the junction of this valley and that of Bear Creek. One mile north of the highway bridge, Southward Pond limestone "A" is exposed in an old slough 12 to 14 feet below Bear Creek flood plain; the Iuka beds, therefore, are buried more than 100 feet.

In keeping with these irregularities and in spite of the new Alabama map in Special Report No. 14 to the contrary, no Paleozoic beds were found exposed beneath the Tuscaloosa gravel along the east wall of Bear Creek for two miles below Buzzard Roost Creek or Chester beds for two additional miles, though many traverses were made in a strenuous effort to connect the Iuka beds of the area north of the Southern Railway with Iuka beds and Chester series in the area south of the railway. Accordingly the Iuka beds were traced down Bear Creek and up the Tennessee ten miles to near the head of Colbert Shoals Canal, where exposures along Beach Branch could be connected at least poorly with the Chester series in the top of the high hill on the south side of that stream (Section 234).

Figure 10.—Interstratified pulverulent silica and chert of the Iuka formation in the railway cut at Free Bridge, Alabama. Leaching of the original calcium carbonate has resulted in the unequal settling of the layers and hence their present wavy condition.

From the crossing of the Southern (Riverton Branch) Railway and highway, two miles below Buzzard Roost Creek, along the tracks and highway to the old Cary School, 1.2 miles straight north of the crossing, the Iuka chert is exposed perhaps best of any place in the whole Mississippi-Alabama area, and to a maximum height of 70 feet. Rather the Iuka consists of thin beds of pulverulent silica interstratified with thin layers of chert, both of which in the excellent railway cut exposures are wavy, commonly in rolls two to three feet high, more rarely in rolls five to six feet high. This wavy condition, no doubt, is the result of the leaching of the calcium (perhaps of some magnesium) carbonate or the replacement of the carbonate by silica, the depressions representing places of greatest thicknesses of carbonate and hence greatest leaching and settling. Because of this condition the beds dip in diverse directions, the reading of which inclination is of no significance save over larger areas.

Nowhere in the great eastward expansion of Bear Creek Valley, the significance of which expansion is still unknown, are even blocks of Iuka chert visible below the Tuscaloosa gravel, from the old Cary school to the branch railway-highway crossing, two miles to the north. Two traverses of the divide to the east, likewise, failed to reveal anything but Tuscaloosa sand and gravel.

Beginning at the last mentioned crossing, which is three miles from the Tennessee Valley, the Iuka terrane or chert, almost exclusively in the form of loose chert blocks, extends down Bear Creek, thence up the Tennessee ten miles, and thence up Beach Branch to the high hill capped by Chester beds. Along Bear Creek the top of the terrane reaches to 40 and 50 feet above the flood plain. Up the Tennessee the top is 65 feet above the flood plain at Riverton, and 90 feet above the Colbert Shoals Canal near its lower and. Beyond this point the Iuka terrane has already been described in the sections presented in the discussion of the Carmack limestone. In some of these it has the following thicknesses: 115 feet in section 228; 121 feet in 231; 127 feet in 232; and 168 feet in 234.

Aside from the loose blocks of limestone (the source of which could be the overlying Alsobrook formation) mixed with the loose blocks of chert in the 121 feet of the Iuka terrane in the section (231) at the lower end of the concrete wall of Colbert Shoals Canal, all the Iuka beds along Bear Creek and the Tennessee River from the exposures north of the Southern Railway to the mouth of Beach

Branch are exclusively chert or chert and some interstratified pulverulent silica, as they are in Mississippi (and in Alabama west of Bear Creek) north of the Southern Railway. Such is not the case beyond Beach Branch in Alabama.

In Section 234 on the south side of the valley of Beach Branch and on the adjacent side of the high hill, the Iuka terrane seems to be about 168 feet in thickness. Besides the lower 27 feet and the upper 105 feet, both of loose chert blocks, there is a median interval 36 feet in thickness, of massive granular limestone, which contains at least one bed of chert. A part of this limestone, having been quarried, for use in the construction of the Colbert Shoals Canal, is fairly well exposed. Although the limestone is slightly fossiliferous, the forms collected are so fragmentary as to preclude identification save for a Bryozoan, *Hemitrypa proutana,* which, unfortunately, ranges from the Keokuk to the St. Louis. Of course, it can not be affirmed that the basal and top intervals, respectively, 27 and 105 feet, are exclusively chert, though the loose blocks thus seem to indicate. Whereas the Iuka terrane has about the average maximum thickness of the terrane in Mississippi, it is interesting to note in passing, that here in Alabama about one-fourth of that interval consists of a limestone, and that near the base of the terrane.

On the opposite of Beach Branch Hill are a series of small exposures which have a very important bearing on the interpretation of the section on the north side of the hill, already presented in the description of the Carmack limestone. These exposures have been connected in the following section:

Section of the south side of Beach Branch Hill (Location 234 cont'd, SW¼, Sec. 26, T. 2S., R. 14W.)

Tuscaloosa formation, total		40.0
Interval, covered, except for gravel and conglomerate at the top	40.0	
Chester series, total		93.0
Limestone (Southward Pond "A"); large blocks of typical oolitic and asphaltic limestone, some of which have badly slumped, 3 to 4 feet thick	4.0	
Interval, mostly covered, except for a few loose blocks of sandstone and a little green clay shale wash 65 to	84.0	
Limestone, blocks 5 feet thick about in place on top of a little knoll on the side of the larger hill, which knoll is about 19 feet higher than what seems to be the position of the blocks directly below Limestone "A." Still farther west about 100 yards the limestone is about 11 feet higher	5.0	
Iuka formation		.....

Chert, large blocks of white, associated with and directly underneath the limestone. Large Bryozoa like those at Alsobrook Bridge. Collections 93 and 95 were secured from loose blocks of chert and some loose blocks of limestone. Inasmuch as the exact origin of the fossils is unknown and the fossils themselves present nothing new, perhaps it is best not to list them........................ ......

The different elevations of the blocks of 5-foot limestone seem to indicate a rather strong east dip of this basal Chester limestone, although they may represent deposition upon an eastward sloping erosion surface, or merely slumping. In spite of the uncertainty of the position of this limestone here and in Section 231, it is still worth while to note that here the limestone rests on 168 feet of Iuka beds, whereas in that section it rests on only 121 feet of Iuka beds. The compact quartz-like cherty lower portion of the limestone in Section 231 is also worthy of note. The presence of this limestone, of the green shale wash, of the blocks of sandstone, of the oolitic and asphaltic Southward Pond limestone "A;" and the normal interval between the two limestones; all taken together leave no doubt whatsoever as to the correctness of the correlation of these beds with those paleontologically known to be Chester in age, even though the new Alabama map shows no Chester beds closer than four miles to the south.

On the southwest and west sides of Beach Branch Hill, limestone in the Iuka terrane is somewhat more prominent than it is on the north side where, with the exception of the 36 feet of limestone near the lower part, the terrane seems to be chert. Thus far it has been impossible to ascertain how much of this difference may be apparent and how much may be real; and, if real, how much of it is the irregular results of the processes which produced the unconformities known but undelimited in the Iuka terrane, and how much of it is due to the simple chemical processes of leaching and replacement. This much is certain, however, that isolated exposures of small portions of the Iuka terrane yield fossils which definitely establish the age of this formation here and of that formation there, until most of the lower Mississippian divisions above the Kinderhook have been recognized.

Perhaps the most instructive exposures in this respect are those beginning at Cherokee, straight south of Beach Branch Hill, and extending in a westerly direction down Buzzard Roost Creek and its tributaries to Bear Creek, thus making a complete circuit of the Alabama sections.

At the southwest corner of Cherokee corporate limits (Location 237) in the highway and at its side are large flat blocks of limestone, angular blocks of chert, and the upper surface of a limestone, all projecting in places from the soil. From this admixture the fossils in the next list (Collection 97) were gathered. *Lithostrotion proliferum* was found in both limestone and chert and *L. canadense* was found in chert above. The large flat blocks of limestone was filled with *Productus inflatus* and contained a few specimens of other forms. The whole collection seemed to come from the same bed, seemingly not much more than two feet in thickness. Such is not the case. *Lithostrotion proliferum* in the limestone may represent late Salem or St. Louis time. *L. proliferum* and *L. canadense* in the chert are St. Louis in age. *Productus inflatus* and four or five other forms in the flat blocks of limestone are Chester. From a detailed study of other sections it is known that these fragments and their fossils, represent the top of Iuka terrane, here St. Louis in age, and the basal limestone of the overlying Alsobrook formation, Chester in age. This interpretation is confirmed stratigraphically by the presence of green shales and blocks of sandstone just east of the limestone and chert.

List of fossils from the southwest corporate limits of Cherokee (237)

CHESTER AND IUKA TERRANES:

- Collection 97:
  - Anthozoa
    - Lithostrotion canadense
    - Lithostrotion proliferum
  - Brachiopoda
    - Composita trinuclea
    - Eumetria vera
    - Productus (Diaphragmus) elegans
    - Productus inflatus
    - Productus ovatus
    - Productus (Echinoconchus) sp.
    - Productus sp. 1
    - Productus sp. 2
    - Productus sp. 3
    - Spirifer sp.
  - Crustacea
    - Trilobite pygidium

Here in the Mississippi-Alabama area as well as in Illinois, the Chester series consists of alternate beds of sandstone, shale, and limestone. Strangely enough in many places the basal member of the Chester is a limestone, resting directly on the limestone or chert top of the Iuka terrane; whether conformably or unconformably it has not been possible thus far definitely to determine stratigraphically, for in most places the underlying Iuka consists of irregular masses of

PLATE 8

Iuka (St. Louis) terrane fossils

Fig. 1. *Lithostrotion proliferum.* X1. A limestone slab of well spaced individual corallites, most of which have the cylindrical outline so characteristic of this species. Collection 97.

Collection 97 came from large flat blocks of limestone, angular blocks of chert, and the upper surface of a limestone, all projecting in places from the soil at the southwest corner of Cherokee corporate limits (Location 237), Ala. Identification of the fossils of this collection shows the admixture to be from both the Iuka and Alsobrook terranes. *L proliferum* was found (1) in the limestone and (2) in the chert associated with *L. canadense*, thus demonstrating the St. Louis age of the upper part of the Iuka terrane at this place.

L. proliferum forms a reef-like mass in the base of a layer near the top of the Iuka terrane in the John A. Denie Sons Company Quarry (Location 191, NW¼, Sec. 31, T. 3S., R. 14W), one mile east of Margerum, Ala., and a small fragment of this coral was found in the chert at the Alsobrook locality, Alabama.

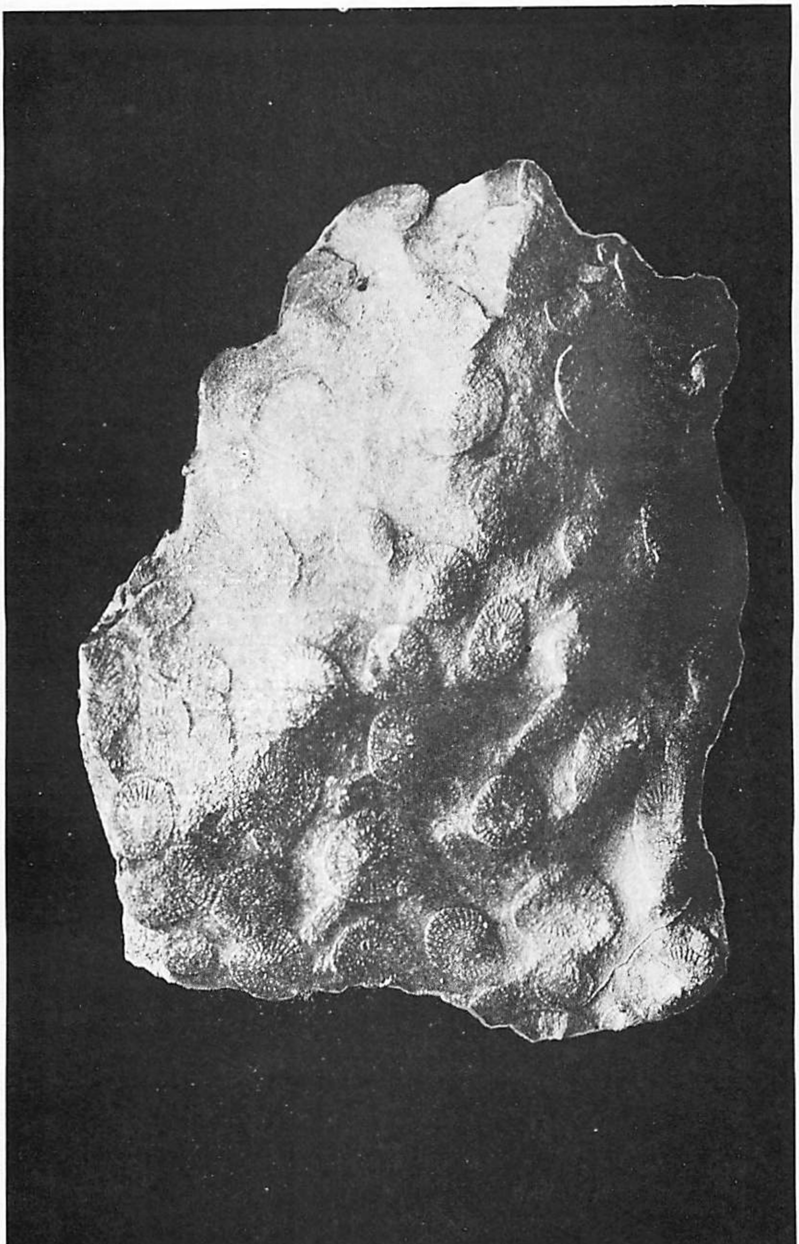

PLATE 8

PLATE 9

Iuka (St. Louis) terrane fossils

Fig. 1. *Lithostrotion canadense.* ×1. A chert block filled with individuals all in contact with each other, in such a way as to impart to the individual corallites the polygonal outline so characteristic of this species. Collection 97-duplicate.

Collection 97-duplicate and Collection 97 came from the admixture of Iuka terrane and Alsobrook formation materials at the southwest corner of Cherokee corporate limits (Location 237), Ala. Here *L. proliferum* and *L. canadense* are associated in the chert at the top of the Iuka terrane, thus proving the St. Louis age of this part of the Iuka.

A huge mass of cherty *L. canadense* was found at the juncture of Cripple Deer and Bear valleys, east of Allsboro; and a mass of the coral, which lies in the front yard of Dr. Harris on the south side of Cripple Deer Creek, was collected in the field across the road from his house.

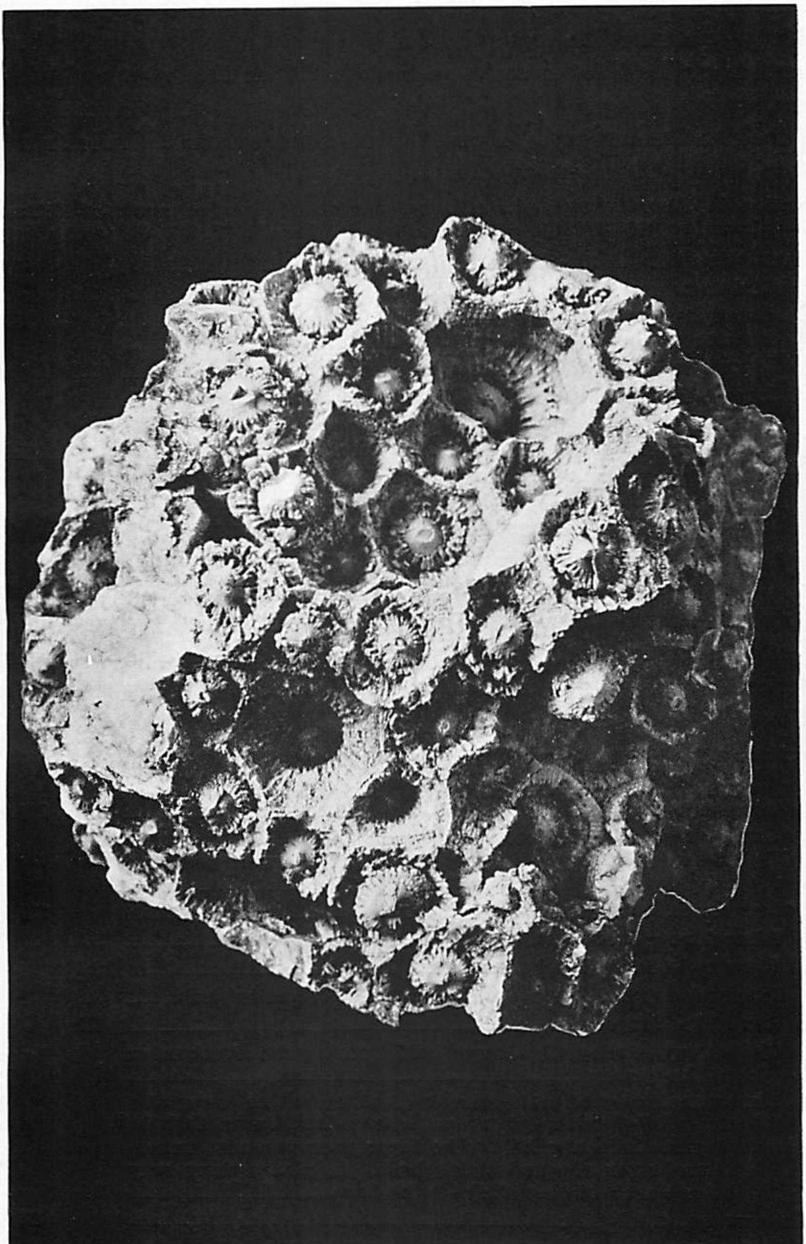

PLATE 9

chert and the overlying Chester of huge flat blocks of limestone, tilted in many directions. Of special significance, therefore, is the cherty quartzite-like lower part of the limestone forming the basal member of the Chester series in Section 231 at the lower end of the concrete wall in the Colbert Shoals Canal. Of still greater import is the relationship revealed in the following section, 2.4 miles northwest of the Cherokee exposures.

Section in the highway, old railway spur cut, 1½ miles north of Dickson (Location 196—Middle of the south side, Sec. 21, T. 3S., R. 14W.)

Recent total		2.0
Soil to top of hill	2.0	
Alsobrook formation, total		8.0
Shales, green clay, slightly covered	6.0	
Limestone, layer of hard compact gray	1.7	
Layer of calcareous material filled with angular chert, which seems to represent a basal breccia. The base is uneven	0.3	
Iuka terrane, total		5.5
Limestone, massive layers of crystalline; a little chert at the top	3.5	
Limestone and chert, mostly chert; both vary much in a short distance	2.0	

The old lime kilns and quarries of the John A. Denie Sons Company are located on the south side of Buzzard Roost Valley, 4 miles west of Cherokee and 1½ miles east of Bear Creek. The interesting section of the quarry and of the high hill to the south of it is as follows:

Section of the John A Denie Sons Company quarry and hill (Location 191, NW¼, Sec. 31, T. 3S., R. 14W.)

Tuscaloosa formation, total		225.0
Conglomerate, ferruginous, at the top of the hill; the rest is covered practically except for some gravel; probably all belongs to this formation	225.0	
Chester series, total		115.0
Limestone (Southward Pond "A") massive oolitic	3.5	
Limestone, loose blocks	29.5	
Interval, covered, except for 2 or 3 feet of green shale	33.0	
Sandstone, layer	1.0	
Shales, green clay, the lower half forming the overburden of the quarry	45.0	
Limestone, layer of bluish gray crystalline, in the lower portion; filled with *Productus inflatus* and large Crinoid stems (Collection 81). The layer seems to rest unconformably on the underlying beds. In places there may be one inch of clay shale at the base	3.0	
Iuka terrane, total		23.0
Limestone, two or more layers, containing chert, fossiliferous; usually chert blocks after leaching. In places largely chert. (Collection 78.)	1.5	

(A visit after the report was written revealed ripple marks and other features suggesting the Chester age of this interval.)

Limestone, massive, seemingly in two layers, but the stratification is indistinct. It is crystalline and crinoidal at the top. The base of the upper layer is filled with *Lithostrotion proliferum* (Collection 78). In places the chert in this interval is more fully developed.......... 9.0

Basal part of the quarry is covered in most places with shale wash and dump 12.5

List of fossils from the Denie quarry (191)

CHESTER SERIES:
- Collection 81:
  - Anthozoa
    - Cup corals
  - Crinoidea
    - Stem plates
  - Bryozoa
    - Fragments
  - Brachiopoda
    - Productus inflatus

IUKA TERRANE:
- Collection 78:
  - Anthozoa
    - Lithostrotion proliferum
    - Zaphrentis sp.
  - Bryozoa
    - Hemitrypa proutana
    - Polypora biseriata
  - Brachiopoda
    - Camarotoechia mutata
    - Eumetria verneuiliana
    - Productus ovatus.
    - Reticularia salemensis
    - Spirifer bifurcatus
    - Spirifer tenuicostatus
  - Pelecypoda
    - Myalina sp.
    - Pinna maxvillensis
    - Pleurophorus monroensis (?)
  - Gastropoda
    - Anomphalus rotuliformis
  - Crustacea
    - Trilobite fragment

The presence of the great coral mass of *Lithostrotion proliferum* is of the utmost significance. It proves that at least a part of the upper portion (23 feet) of the Iuka terrane at this place is as late as Salem or St. Louis in age, with the odds much in favor of St. Louis. In connection with the presence of *L. canadense* and *L. proliferum* at Cherokee and of the Salem fauna in the section next to be described, the limestone must be considered St. Louis in age.

As early as 1896 McCalley[1] reported in the geology of Colbert County the presence of *Lithostrotion canadense,* at Cherokee. Regardless of this definite location, Butts,[2] thirty years later, makes the following statements: "No evidence of its (St. Louis) presence west of Decatur was found by the writer, but McCalley cites the occurrence of *Lithostrotion* over a very small area in the vicinity of Cherokee, Colbert County. As will be shown farther on, it is certain that the St. Louis here is of small areal extent and of little thickness. Probably it was a reef-like deposit in a shallow lagoon on the Warsaw limestone. The writer has traversed the Tuscumbia limestone area between Decatur and the Mississippi state line quite extensively and was at all times on the lookout for *Lithostrotion* but found none, although chert, in which rock it invariably occurs, is everywhere abundant. Furthermore, it is established, from continuous exposures through the Warsaw into overlying formations in this region, that the St. Louis is absent."—whatever such conflicting statements may mean. Of course Butts should not be held too strictly accountable, for he had a large portion of Alabama to cover, yet he should not emphasize his extensive Decatur-Mississpipi state line traverses so much.

In review, a large mass of *Lithostrotion canadense* was found in the chert at the juncture of Cripple Deer and Bear Creek valleys east of Allsboro. Another mass of it, picked up in the field opposite his home, lies in the front yard of Dr. Harris on the south side of Cripple Deer Creek. A small fragment of *Lithostrotion proliferum* was discovered in the chert at the Alsobrook locality. A large amount of the same coral is present in the Denie quarry on Buzzard Roost Creek. *Lithostrotion canadense* and *Lithostrotion proliferum* have been collected for years in the highway at Cherokee. But why enumerate place after place where such prosaic fossils as *Lithostrotions* may be found, when the chert here and there contains such interesting forms as Bryozoa? Every paleontologist knows with what facility fragmentary impressions of Bryozoa may be identified as the particular species needed to confirm a pet theory.

Before passing to the consideration of the next section, attention should be directed to the stratigraphic relation of the Iuka terrane to the Chester series. Most everywhere myriads of *Productus in-*

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[1]McCalley, Henry, The Tennessee Valley Region, Geol. Surv. Alabama, pp. 152-153, 1896.

[2]Butts, Charles, The Paleozoic rocks, Geol. Surv. Alabama, Special Report, No. 14: 175, 1926.

flatus and a few other Chester forms mark the thin basal limestone of the Chester, so that its age is definitely known. Nevertheless this limestone resting directly on the Iuka limestone and forming the thin basal limestone member of the Chester shale series, seems to constitute the integral top part of the Iuka limetone, so much so in fact that it is most difficult to place one's hand on the unconformable contact known to exist.

The (three-foot) basal limestone of the Chester series in the Denie quarry seems to be harder and less soluble than the underlying limestone, though the difference is slight. Solution of the underlying pure crystalline limestone along a vertical joint plane in one place in the quarry has permitted blocks of the overlying less soluble Chester limestone to settle into the joint to a depth almost below the top of the underlying Iuka limestone. Immediately beneath the layer of Chester limestone are two or more thin layers of limestone containing considerable chert. Even with the protective over burden of clay shale, in some places in the quarry, either pre-Chester erosion or post-Chester leaching along these horizontal beds has removed the bond of calcareous material, thus freeing the chert. One or the other or both of these processes, no doubt, account for the tilted position of the basal limestone layer of the Chester series in so many places, and one's inability to see a sharp unconformable contact of the two terranes.

Three-fourths of a mile to the north of the Denie quarry is the obtuse spur ridge between Buzzard Roost Creek and its tributary, Mill Creek, where the following interesting section was obtained. The lower part is exposed just above the creeks and the upper part above the col in the ridge.

Section of the spur ridge between Buzzard Roost Creek and Mill Creek (Locations 199 and 200, SW¼, Sec. 30, T. 3S., R. 14W.)

Chester series, total		109.0
Limestone (Southward Pond "A"), loose blocks at the top, the rest covered	22.0	
Sandstone, rather poorly cemented	10.0	
Interval, covered, except for a few green shale; to the level of the col	55.0	
Interval, covered	20.0	
Limestone, filled with *Productus*	2.0	
Iuka terrane, total		116.0
Limestone and chert blocks, to the top of the bluff	73.0	
Limestone, gray crystalline	4.0	
Limestone, layer, and chert; the chert makes about one-third of the whole of the fresh rock and about three-fourths of the weathered rock	2.0	

Limestone, crystalline light gray to white irregularly bedded. Fossiliferous (Collection 83)	6.0
Chert and a layer of limestone between; the chert contains a large Bryozan, *Hemitrypa proutana,* similar to those in the top of the Iuka chert at most places. (Collection 84)	2.0
Limestone, coarsely crystalline, and a little chert; massive irregular beds which have been quarried to a slight extent	11.0
Limestone, crystalline, in three or four wavy layers and interbedded chert. The base of the lowest layer is stylolitic and otherwise decidedly uneven, and it may represent an unconformity	6.5
Limestone, hard gray, which contains irregular amounts of chert. It is without bedding planes, weathers in vertical faces, and thus seems to differ from that above....	6.0
Interval, covered, to flood plain of Buzzard Roost Creek........	5.5

List of fossils from the spur ridge between Buzzard Roost and Mill Creeks (199 and 200)

IUKA TERRANE:

Collection 83:
- Anthozoa
  - Zaphrentis compressa
  - Cup coral
- Bryozoa
  - Fragments
- Brachiopoda
  - Camarotoechia mutata
  - Productus (Echinoconchus) biseriatus
  - Productus sp.
  - Spirifer bifurcatus
  - Strophomenoid form
- Crustacea
  - Trilobite fragment

Collection 84:
- Crinoidea
  - Stem plates
- Bryozoa
  - Hemitrypa proutana
- Brachiopoda
  - Reticularia sp.

All the fossils in Collection 83, the specific identification of which is possible, belong exclusively to the Salem formation. Some of them are very characteristic of that formation. With the exception of the medium *Spirifer bifurcatus* and the Strophomenoid shell, all the fossils are small forms like the Salem dwarfs at Spergen Hill and other places in Indiana. There seems to be no reason, therefore, to doubt the Salem age at least of a part of the limestone in this section. Granting the Salem age at least of the six feet of limestone from which the fossils came, there remains above 79 feet of Iuka beds, the upper interval of 73 feet of which is represented only by blocks of chert and limestone, perhaps an adequate amount to be assigned to later Salem or to the St. Louis.

Before giving a summary of the fauna of the Iuka terrane, perhaps three sections, at Pride, at the Keller quarry, and at Tuscumbia, will suffice to show the great development of the limestone phase of the terrane and the nature of the Tuscumbia member at the type locality.

Section of the south bluff of the Tennessee at Pride (NE, Cor., Sec. 8, T. 4S., R. 12W.)

Interval, covered to top of hill	16.5	
Tuscaloosa formation, total		22.0
Gravel and sand, exposed in old gravel pit	22.0	
Alsobrook formation, total		54.0
Interval covered	11.0	
Shales, bluish to yellowish or greenish partly covered	35.0	
Limestone, gray crystalline tabular, containing *Productus inflatus* (Collection 59) at the top. Probably all of the interval belongs to this formation	8.0	
Iuka terrane, total		136.5
Limestone, gray, somewhat granular, crystalline, which breaks up into cubical blocks and which contains fragments of fossils. There is considerable chert in the float which seems to come from two beds	35.5	
Limestone, mostly compact, and compact chert, both gray in color. They extend upwards to the top of cliff	21.5	
Interval, partly covered; in the ravine are some gray limestone and chert	5.7	
Limestone, gray fragmentally crystalline and fossiliferous, which contains a small amount of chert. The stone is decidedly cliff-making and breaks up into cubical blocks	22.8	
Limestone, gray granular crystalline; a few nodular-like chert masses in the lower 10 feet; and a little chert in the top 10 feet; and a little asphalt in the basal part. It forms the slope to the water's edge and breaks up into irregular tabular slabs, which are fragmentally fossiliferous. To low water of Tennessee River	51.0	

List of fossils from the Tennessee bluff at Pride

Alsobrook formation:

- Collection 59:
  - Crinoidea
    - Agassizocrinus sp.
  - Bryozoa
    - Specimen incomplete
  - Brachiopoda
    - Chonetes chesterensis
    - Productus inflatus
    - Fragments, two

Aside from a single specimen of each of a Crinoid and of a Bryozan and two fragments of Brachiopods, all the collection belongs to the two genera and species of Brachiopods. There are 106 specimens of *Productus inflatus* and 225 specimens *Chonetes chesterensis,* thus revealing the myriads of these two forms which lived in the early Chester sea.

Section of the Keller (Bowser) quarry in the south bluff of the Tennessee (SW¼, Sec. 1, T. 4S., R. 12W.)

Iuka terrane, total		70.0
Limestone, massive. It has few bedding planes, is somewhat cross-bedded, and is oolitic or foraminiferal in texture, and contains fragments of fossils	70.0	
Undetermined		28.5
Interval, covered, to the level of the Tennessee	28.5	

This limestone was quarried by the Federal Government for use in the construction of locks in the Muscle Shoals Canal and in the Colbert Shoals Canal years ago. Blocks of the quarried stone, 4 feet by 4 feet and larger, still remain in piles on the river bank. The stone is practically free from chert, and, as McCalley said, it is one of the best of the building stones.

Intentionally or otherwise, McCalley referred the stone to the Lauderdale.[1] Butts, on the other hand, identifies it as Warsaw[2] (McCalley's Tuscumbia in part). It has the texture and structure of the famous Salem building stone of Indiana, rather than of the Warsaw limestone at the type locality in Illinois. The present report has just shown the Salem limestone to be present on Buzzard Roost Creek, 15 miles to the west. Whether or not the limestone in the Keller quarry is Warsaw or Salem, enough fossils may be found some day to determine.

Section at Big Springs in Tuscumbia (238)

Iuka terrane, total		44.0
Chert, angular pieces, and red clay from the disintegrated limestone (Collections 99 and 99 duplicate)	25.0	
Limestone, massive crystalline crinoidal	6.0	
Interval, covered	7.0	
Limestone, massive bluish gray, and some chert. To water level at the dam, which may submerge 5 or 6 feet of limestone	6.0	

List of fossils from Big Springs (238)

IUKA TERRANE:

Collections 99 and 99 duplicate:
- Anthozoa
  - Cup coral
  - Monilopora beecheri
- Blastoidea
  - Mesoblastus sp.
  - Pentremites conoideus
- Crinoidea
  - Stem segments
- Bryozoa
  - Hemitrypa proutana
- Brachiopoda

[1]McCalley, Henry, The Tennessee Valley Region, Geol. Surv., Alabama, p. 148, 1896.

[2]Butts, Charles, The Paleozoic rocks. Geol. Surv., Alabama, Special Report, No. 14, p. 169 and pl. 55, 1926.

Camarotoechia sp., cf. grosvenori
Chonetes (?) sp.
Eumetria sp.
Orthotetes sp., cf. kaskaskiensis
Productus altonensis
Productus ovatus
Productus scitulus
Productus (Echinoconchus) sp.
Productus sp. 1
Productus sp. 2
Reticularia setigera
Schizophoria sp.
Spirifer incertus
Spirifer (Brachythyris) subcardiiformis
Spirifer (Spiriferella) neglecta
Spiriferina sp.

Gastropoda
Platyceras sp.

Obviously the Tuscumbia member in the type locality is but partly exposed and that part very poorly so. The damming of Big Springs to form the municipal lake has flooded only a small part of the limestone. Furthermore the old quarry on Spring Creek just below Big Springs adds but a few feet to the springs exposure.

The fossils in Collections 99 and 99 duplicate came from loose blocks of chert in the red residual clay at Big Springs and at the cut in the street one block east of the springs. They are preponderatingly Salem forms, though one is Burlington, one is Keokuk, and two or three are St. Louis; and *Orthotetes sp.* has plications like *O. kaskaskiensis* of the Ste. Genevieve-Chester.

Two and one-half miles southwest of Big Springs, just beyond the forks of the road (Location 239—NE¼, Sec. 19, T. 4S., R. 11W.), the top of the Iuka terrane is something like 100 feet higher than the top of the exposure at the springs and is overlain by green clay shales of the Alsobrook formation. The few fossils in Collection 100 came from the bedded chert, 5 to 10 feet below the top of the Iuka terrane. Unfortunately they are few in number and poorly preserved, the only form fully identified being *Spirifer bifurcatus* of the Salem; but, of course, this one form does not prove the beds to be of that age. If the beds of this vicinity are level or dip to the south as they commonly do, then an interval of 100 feet, more or less, is to be added to the limestone and chert at Big Springs, enough perhaps to take care of the St. Louis, should fossils yet to be collected prove the presence of that formation somewhere in this locality.

List of fossils from the road forks, 2.5 miles southwest of Big Springs (239)

IUKA TERRANE:
- Collection 100:
  - Crinoidea
    - Stem segments
  - Bryozoa
    - Fragments
  - Brachiopoda
    - Eumetria sp.
    - Productus sp.
    - Spirifer bifurcatus
  - Pelecypoda
    - Aviculopecten sp.

IUKA FAUNA AND CORRELATION

As previously stated, the Iuka chert bears evidence nearly everywhere of the tests and other hard parts of organisms of which it was originally composed. Nearly all these are more or less comminuted, and the calcium carbonate has been replaced by silica, both to such an extent as to preclude the specific identification of the forms at most places. In Mississippi north of the Southern Railway, there are a few exceptions to this general condition; and in Alabama, the terrane contains much more limestone, in some parts of which the fossils are better preserved.

The forms in Collections 1 and 2, obtained from loose blocks of Iuka chert on Indian Creek to the north of Iuka, seem to indicate a mixed fauna, largely due no doubt to the mixture of the chert blocks. The presence, however, of such a typical Keokuk form as the huge Brachiopod, *Orthotetes keokuk,* leaves little doubt that at least a part of the chert is Keokuk in age.

It is not recalled that any members of the Carmack fauna (save the long ranged *Productus ovatus*) survived the break in continuity of deposition at the close of that time. At least this it true of any outstanding forms. To these statements, however, there is one exception of one form at one place. A loose block of chert (Collection 68) found above the Carmack limestone in the spur between the two forks of Short Creek, contained besides three or four mere fragments and two or three Crinoid stem segments, nothing except great numbers of the Anoplia-like form, elsewhere confined to the Carmack limestone. In fact the block of chert, which is unlike all other Iuka chert, is a mere mass of this small Brachiopod shell.

Nearly eighty feet below the top of the Iuka terrane in the spur between Buzzard Roost Creek and Mill Creek, a Salem fauna proves the Salem age at least of a portion of the terrane.

On the opposite side of the creek in the Denie quarry, the large reefs of *Lithostrotion proliferum* prove the late Salem or St. Louis age of the upper part of the Iuka terrane. *Lithostrotion proliferum* and *L. canadense* at Cherokee determined the St. Louis age of the top of the Iuka at that place. Likewise one or the other of these corals proves the St. Louis age of the Iuka at Alsobrook homestead and on the south side of Cripple Deer Creek.

Still other faunas are at least suggested by the fossils from the loose blocks of chert or the bedded stone. From the range of the definitely established faunas, it seems highly probable that most if not all the beds, Burlington, Keokuk, Warsaw, Salem, St. Louis, and Ste. Genevieve of the Mississippian above the Kinderhook are represented in the Iuka terrane in the Mississippi-Alabama area.

MISSISSIPPIAN SYSTEM-UPPER (CHESTER)

GENERAL DISCUSSION

As in the Illinois district, so in the Mississippi-Alabama area, the Chester consists of a succession of a three-fold series of sandstone, shale, and limestone. To be sure the Chester in the southern area has not receivd the profound study that Dr. Weller has given the same series in Illinois and Kentucky. But even so, it perhaps is too much to expect a detailed correlation of beds, representing such continually shifting conditions of deposition, in two so widely separated areas. Although all are desirous of obviating the multiplication of stratigraphic terms, it is necessary, however, to name the beds under consideration, in order to be able to describe them adequately. Perhaps the advantage of new completely defined names over old indefinite, undelimited, confusing terms will mitigate in some measure any multiplication of terms.

The names of the divisions in the Mississippi-Alabama region now recognized are given in the following classification:

CHESTER SERIES:
- Forest Grove formation
  - Highland Church sandstone member
  - Shale and sandstone
- Southward Bridge formation
  - Limestone, upper
  - Shale and sandstone
  - Limestone, lower
  - Shale
- Southward Spring sandstone
- Southward Pond formation
  - Pond limestone "C"
  - Shale
  - Pond limestone "B"

Shale
Pond limestone "A"
Shale
Allsboro sandstone
Alsobrook formation
Cripple Deer sandstone
Shale
Limestone

ALSOBROOK, ALLSBORO, SOUTHWARD POND AND SOUTHWARD SPRING FORMATIONS

NAMES AND GENERAL DESCRIPTION

The members of the Alsobrook and Southward Pond formations are most delightfully and alluringly elusive, in this wonderfully picturesque region lying on the borderland between the consolidated Paleozoic rocks and the unconsolidated Tuscaloosa gravel. The frayed edge of the gravel blanket exposes here and there fragments of the various members in a most baffling manner. Days of search were necessary to piece together bit by bit the fragments here and there, when the whole history became so clear. For these reasons, therefore, perhaps the story can best be told by giving a brief description of each of the three formations followed by a fuller description as the fragments are traced from place to place.

Figure 11.—The basal limestone member and the overlying shale member of the Alsobrook formation at the Alsobrook homestead, the type locality, Alabama.

The Alsobrook formation is fully and beautifully exposed in the very interesting type locality at Alsobrook Bridge and Homestead. Here as practically everywhere the basal member is a thin limestone, seemingly the top part of the underlying limestone and chert, though its abundant fossils, particularly the host of *Productus inflatus*, immediately distinguish it from the older beds. Because of its unstable chert block support, the limestone nearly everywhere breaks into large flat slabs which may assume any angle and any direction of inclination as has been already explained in the description of the Iuka terrane. Above the basal eight feet of limestone at the Iuka and Allsboro road forks in the type locality is an interval of 72 feet consisting exclusively of green clay shale except for a layer of yellowish brown sandstone, which lies just above the middle of the interval and which is one foot thick and which breaks into striking blocks of about one cubic foot. The formation is thus 80 feet in thickness.

The Allsboro sandstone takes its name from the village near the Mississippi-Alabama state line. It is well exposed both north and south of the village. At Bishop Bridge across Bear Creek south of Allsboro, it is a projecting ledge of coarse-grained sandstone which, in places, is decidedly contorted, thereby differing from most other sandstones of the region. It contains a few fossils, and a part of it contains a little asphaltic material. Its relation to the underlying formation has been shown in the section at the forks of the Allsboro and Iuka roads, and to the overlying formation is shown in the following section at Bishop Bridge.

Section of the bluff and highway at Bishop Bridge

Southward Pond formation, total		16.2
Pond limestone "A". Limestone exposed	4.0	
Interval, covered	5.7	
Shale, calcareous slightly sandy clay	6.5	
Allsboro sandstone, total		8.0
Sandstone, massive coarse-grained, very contorted in places. It contains a few fossils and is partly asphaltic	8.0	
Undetermined		22.0
Interval, covered, to flood plain	5.0	
Interval, covered, to water level of Bear Creek	17.0	

The Southward (pronounced Suthard) Pond formation is named after Southward (or Cypress) Pond at the Southward homestead. The formation, perhaps 80 or 90 feet in maximum thickness, consists of three limestones, designated Pond limestones "A," "B," and "C." Each limestone is underlain by less resistant clay and calcareous

Figure 12.—Southward Pond limestone "A" in the Alabama Rock Asphalt Company's quarry near Margerum, Alabama.

shale, which is commonly covered. Limestone "A" is oolitic or foraminiferal in texture and is asphaltic everywhere, being completely saturated in some places—so much so in fact that it is being quarried for road asphalt. Not only are its texture and asphaltic content distinctive, but likewise its prominence as a ledge, 5 to 15 feet in thickness. Twenty-five feet above it is Limestone "B," a thin very fossiliferous crystalline limestone; and ten feet higher is Limestone "C," somewhat cross bedded in structure.

The Southward Spring sandstone is well exposed at the spring south of the pond. It consists of irregularly bedded sandy shales and shaly sandstones exclusively, though they may be slightly calcareous in places. Fifteen feet is the greatest exposed interval, but perhaps twice this amount more nearly represents the thickness of the formation.

Section at the north end of Southward Pond

Southward Pond formation, total		48.0
Pond limestone "C". A layer of limestone 3 to 6 feet thick, which breaks up because of cross bedding	3.0	
Interval, covered	10.0	
Pond limestone "B". A layer of very fossiliferous bluish gray crystalline limestone. *Productus sp.* and Bryozoa are abundant (Collection 50)	1.0	
Interval, covered	25.0	
Pond limestone "A". A massive layer of slightly reddish gray oolitic or foraminiferal asphaltic limestone. It contains small fragments of many fossils especially of		

Crinoidea, Bryozoa, and Brachiopoda. (Collection 49 consists of the fragmental forms mentioned). A good building stone	9.0	
Undetermined		23.8
Interval, covered, belongs in part to the formation above. To water level of the pond	23.8	

List of fossils from the north end of Southward Pond

SOUTHWARD POND LIMESTONE "B":

Collection 50:
- Anthozoa
  - Zaphrentis sp.
- Crinoidea
  - Stem segments
- Bryozoa
  - Fenestella cestriensis
  - Fenestella tenax (?)
  - Lyropora ranosculum
  - Lyropora sp. 1
  - Lyropora sp. 2
- Brachiopoda
  - Chonetes chesterensis
  - Composita subquadrata
  - Productus inflatus
  - Productus lowei
  - Productus sp.
  - Spirifer leidyi
  - Spiriferina spinosa
  - Spiriferina transversa
- Crustacea
  - Phillipsia sp.

DISTRIBUTION AND DESCRIPTION

So far as observed, there is, with one exception, no limestone either within the Iuka terrane itself or above it, in Mississippi north of Little Bear Creek. About three-fourths of a mile south of Eastport in the west bluff of Bear Creek and 20 feet above its flood plain is a block of crystalline limestone, the exact source of which is not known. From the relation of limestone blocks farther up Bear Creek, it seems probably, however, that the block slumped from a higher position, perhaps from the lowest Chester limestone, though no fossils were found in it by means of which its position could be determined.

Where the highway crosses the small tributary at flood plain level on the north side of Little Bear Creek (Location 50) 2.3 miles above its mouth, are massive blocks of oolitic, foraminiferal, or crinoidal limestone, so coarsely crystalline as to look like brown sugar and as to destroy the fossil organisms. On the opposite side of the main valley are smaller blocks of the same kind of limestone, which probably belong on top the few blocks of Iuka chert. On the north side of the valley at the home of G. T. Anderson (Location 51), one-fourth mile below the last locality, are blocks of the same kind of oolitic limestone. Four-tenths of a mile up the large tributary (Location 189) which enters Little Bear Creek six-tenths of a mile below the Anderson home, is another block of the same kind of limestone. The limestone blocks at these four places on Little Bear probably belong to the Chester series, although there is no fossil evidence to prove the supposition.

Beginning just south of Little Bear Creek, on the other hand, the limestones on the west side of Bear Creek valley can be rather definitely assigned to some formation of the Chester series. Such is certainly true in most places, in spite of their fragmentary condition, for the limestones are fossiliferous. The first of these places is at the J. W. Wimbish home, about one-half mile south of Little Bear Creek, where in spite of the Chester age of their fossils, the distribution of the limestone blocks largely resisted and baffled efforts to place them in their proper stratigraphic position. The problem can be presented best, perhaps, by a series of columnar sections: the first, across the ravine to the north of the house; the second, about two hundred feet south of the first and in front of the house; and the third about 200 feet still farther south and still virtually in front of the house.

Section across the ravine from the J. W. Wimbish home (Location 61, NW¼, Sec. 14, T. 3S., R. 11E.)

Tuscaloosa formation		.....
Gravel and sand	.....	
Iuka terrane, total		82.5
Chert, large angular blocks, which probably have weathered out and only slumped some. The upper part is fragmentally fossiliferous, containing Bryozoa and Brachiopoda. To approximately the flood plain of Bear Creek	82.5	

Section at the J. W. Wimbish home (Location 62), 200 feet south of the preceding section

Alsobrook formation		1.5
Limestone, loose blocks, filled with *Productus inflatus* (Collection 5)	1.5	
Iuka terrane, total		25.3
Layer of ferruginous and cherty material, which may belong to the upper formation	0.3	
Chert, angular blocks, the top of which is fossiliferous. To approximately the flood plain of Bear Creek	25.0	

Section at the J. W. Wimbish home (Location 62), 200 feet still farther south.

Alsobrook formation		1.5
Limestone, loose blocks, filled with *Productus inflatus* (Collection 5)	1.5	
Iuka terrane		45.3
Layer of ferruginous and cherty material, which may belong to the upper formation	0.3	
Chert, angular blocks, the top fossiliferous. To approximately the flood plain of Bear Creek	45.0	

List of fossils from the J. W. Wimbish locality

ALSOBROOK FORMATION:

Collection 5:

- Crinoidea
  - Basal plates
  - Stem segments
- Brachiopoda
  - Chonetes chesterensis
  - Cliothyridina sp.
  - Composita subquadrata
  - Dielasma shumardanum
  - Eumetria verneuiliana
  - Orthotetes sp. (between O. keokuk and O. kaskaskiensis)
  - Productus sp., cf. altonensis
  - Productus sp., cf. elegans
  - Productus inflatus
  - Productus (Echinoconchus) sp.
  - Productus ovatus
  - Productus sp.
  - Reticularia setigera
  - Reticularia sp.
  - Spirifer pellaensis
- Pelecypoda
  - Parallelodon multiliratus

That the limestone blocks belong to the Chester, there can be no doubt, for the fossils from them (Collection 5) are clearly Chester in age. That the chert blocks belong to the Iuka terrane, likewise, there can be no doubt. Concerning the relation of the limestone blocks to the chert there can be much doubt.

Granted that the relation of the limestone blocks to the chert blocks is an unconformable one, as it is in other places, and that the limestone blocks are approximately in position in the last two sections and that the Iuka layers are approximately level, then, the erosion surface lies 82.5 feet, 25.3 feet, and 45.3 feet, respectively, above the same datum, the flood plain of Bear Creek. In other words, the structure represents an old erosion valley.

Granted that the limestone blocks in the respective sections are approximately in position and that the chert layers are not horizontal, then the structure could represent a synclinal fold, in addition to a minor unconformity.

Granted that the blocks of limestone in the respective sections have slumped, as the smaller ones and the green shales are known to have done, even down to the tributary flood plain, within 10 feet of Bear Creek flood plain and datum plain, then slumping alone will suffice to explain the relationship. Still further in favor of this view, are the series of seemingly land slide scars farther up Bear Creek valley. The whole terrane-like mass, an acre or so in extent, on which the Wimbish home is located, could then represent an enormous slump. Of course the green shale could partly or wholly underlie the limestone, though green shale overlies the limestone in all the clearly exposed sections, and would thus materially aid in the slumping process.

Faulting is still another possibility. However, no evidence of faulting has been discovered either in Mississippi or adjacent Alabama.

With unconformities, folding, and slumping known to affect the two terranes concerned in the area under consideration, it is hazardous even to express an opinion. Nevertheless a pronounced unconformity, modified by some slumping seems to be the most plausible interpretation.

Across the small tributary from the J. W. Wimbish home and one-fourth mile farther up Bear Creek, the Iuka chert is approximately in position 10 to 15 feet above the valley flat. Just above it are blocks of Alsobrook limestone, which are about five feet thick and fossiliferous, bearing especially *Productus inflatus.* Extending from the limestone still farther up the side of the valley are small pieces of thin-bedded fine-grained sandstone from the Alsobrook or other Chester formations.

On the side of the valley at the state line, more than one-half mile farther south, the Iuka chert extends 40 to 45 feet above the valley flat of Bear Creek. Here, also, it is overlain with large blocks of Alsobrook limestone, containing *Productus inflatus* and other Chester forms. Associated with the blocks of limestone and below the highest blocks is a bluish green shale, the presence of which, if below the limestone, would facilitate the slumping of the limestone blocks. However, by means of a small pit, a careful examination of the shale, which is on an alluvial fan, revealed four thin beds of yellow shale underlain by four thin beds of bluish green shale, none of which is in the original stratification. It seems highly probable that the weathered shale represents stream shifted material during excessive rains, and that it originally lay above the limestone, as it does in all sections which are sufficiently well exposed to show the relationship of the limestone and shale.

As previously stated the block of limestone three-fourths of a mile south of Eastport probably slumped from the Chester. From their position at the top of the Iuka chert, the blocks of limestone at the four places on Little Bear Creek probably belong to the basal limestone member of the Alsobrook formation. Beginning at the Wimbish home just south of Little Bear Creek and extending for a mile to the state line, the blocks of limestone exposed here and there along the west side of Bear Valley, no doubt, belong to the basal member of the Alsobrook formation; and the shales, to the same formation.

To the south along the big curve of the valley wall around the prominent terrace and on the terrace itself, consisting of 40 or 50 feet of Iuka chert, there seem to be no Chester limestone blocks. For much of the next half mile to the south, or half the distance to Clear Creek, there seem to be no exposures other than the Tuscaloosa gravel, not even of Iuka chert blocks. Here outcrop, in about the same position in the side of the valley as that occupied by the Iuka chert and superjacent Alsobrook basal limestone, large blocks of sandstone; and a half mile still farther south, in the same position, large blocks of sandstone and limestone, in a most perplexing manner. The determination of the stratigraphic position of the sandstone and limestone at this place is impossible, but from other exposures the sandstone is known to be Allsboro and the limestone, Pond limestone "A" of the Southward Pond formation.

From this point, one-half mile north of Clear Creek, blocks of Allsboro sandstone cover here and there the side of Bear Creek valley, thence the side of Clear Creek Valley for more than a mile, and thence the south side back almost to its mouth. Blocks of Pond limestone "A," oolitic and slightly asphaltic, lie five feet above the highest blocks of Allsboro sandstone in the spur on the north side of Clear Creek valley at its mouth. It is interesting to note, in passing, that about three-fourths of a mile east in the slough on the east side of the stream and about the middle of Bear Valley, mentioned in the description of the Iuka terrane, the Pond limestone "A" lies below flood plain level, and, consequently, the top of the Iuka terrane is 100 feet below even that level. Such statements could not be made with so great finality, were it not for the few artificial exposures of the region, similar to the one next described.

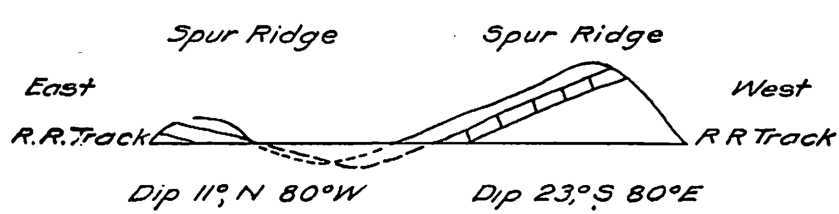

Figure 13.—Structure section of a synclinal fold in Southward Pond limestone "A" in the Southern Railway cuts at the mouth of Clear Creek.

On the south side of Clear Creek valley at its mouth the Southern Railway clips the ends of two minor spur ridges, where the following columnar and structure sections (Fig. 13) were made.

Section of the west cut of the Southern Railway at the mouth of Clear Creek (Location 79, NW¼, Sec. 27, T. 3S., R. 15W.)

Tuscaloosa formation		12.0
Gravel, partly cemented, to a point 54 feet above the track and 70 feet above the flood plain	12.0	
Southward Pond formation: Pond limestone "A"		16.5
Limestone, massive oolitic or foraminiferal steel gray, containing Crinoid stems; the upper part is slightly asphaltic. The top unconformable contact is 47 feet above the tracks and 63 feet above the flood plain	7.0	
Limestone, medium layers of compact gray, which breaks into blocks and which weathers much faster than that both above and below. Fossiliferous	7.0	
Limestone, bluish gray compact, containing Crinoid stems. All these beds dip 23° S. 80° E, in this cut	2.5	

As shown in the structure section (Fig. 13), Pond limestone "A" dips 23°, S. 80° E., in the west limb of the syncline in the west cut and 11°, N. 80° W., in the east limb in the east cut; that is, in almost east and west directions. Along the railway at the state line, one-half mile west of the cuts, Chester shales dip 11°, S. 90° W. Some such western dip must prevail, otherwise the western limb of the syncline would bring up older beds, which would then be exposed in the lower stretch of Clear Creek, rather than the Allsboro sandstone. For similar reasons, the beds east of the east cut must reverse their inclination and dip toward the east. Such an east dip would account for the Pond limestone "A" lying 12 to 14 feet below the flood plain of Bear Creek in the slough about three-fourths of a mile east of the exposures of this limestone at the north and south sides of the mouth of Clear Valley. On the other hand, there is a possibility that the low position of the limestone in the slough may be due in part to a transverse (east-west) fold.

About three-fourths of a mile south of the Southern Railway and on the west side of Bear Valley, huge blocks of Pond limestone "A," which are both oolitic and asphaltic, lie as high as 43 feet above the valley flat. Twelve feet still higher are large blocks of limestone, filled with a small *Productus,* which seem to be Pond limestone "B." Associated with or below the limestone blocks are green shales. Blocks of limestone cover the side of the valley, as they do between the last place and this, and owe their distribution in part clearly to slumping and in part, perhaps, to the inclination of the beds, as in the railway cuts. Similar limestone is exposed about one-half mile still farther south, but this seems to belong to Pond limestone "B."

On the north side of Pennywinkle at its mouth, from the flood plain of Bear Creek to 18 feet above it, are exposed massive layers of limestone and nodular layers of chert. The upper part is the typical basal limestone of the Alsobrook formation. Perhaps the lower part belongs to the top of the Iuka terrane, although this point was not determined in the field. If so, then this is the first place on the west side of Bear Valley to the south of the Southern Railway that the Iuka terrane is exposed.

More than two-thirds of the way up the same bluff, which extends 77 feet above the top of the Alsobrook limestone, are loose blocks of massive coarse-grained sandstone, which may belong to the Allsboro. About opposite on the south side of Pennywinkle Valley, is a layer, 7 feet in thickness, of typical coarse-grained contorted Allsboro sandstone. It dips northwest at the rate of one to two feet in a hundred.

On the north side of Pennywinkle somewhat more than one-fourth mile above its mouth, are large flat blocks of limestone which, no doubt, have slumped from somewhere in the Southward Pond formation, perhaps from just above or just below Pond Limestone "A." A short distance farther up stream on the same side of the valley the following excellent section is exposed.

Section of the north side of Pennywinkle Creek about one-half mile above its mouth (Location 81, SW¼, Sec. 34, T. 3S., R. 15W.)

Southward Pond formation, total		40.5
Pond limestone "A." Massive gray oolitic or foraminiferal limestone	8.5	
Limestone, shaly, interstratified with limy shales, which are travertine-like and yellow at the top, as they are between Bishop and Bishop Bridge. The limestone and shale are extremely fossiliferous, containing many Pentremites as well as other forms (Collection 56)	11.0	
Shale, green clay	21.0	
Allsboro sandstone, total		9.0
Sandstone, massive, brownish gray, which dips N. 45° W., 3 feet in 100 feet	9.0	
Undetermined		3.7
Interval, covered, to the flood plain of Pennywinkle Creek	3.7	

This is one of the best fossil collecting places, if not the best place in the Mississippi-Alabama region. The forms are set free by the disintegration of the shaly limestone and limy shales. Something of the biologic range of the fossils may be gained from the following list of species. The Corals and Bryozoans are abundant; the Blastoids (*Pentremites*) and one Brachiopod (*Composita*) are present by the hundreds,

List of fossils collected near the mouth of Pennywinkle Creek (Location 81)

SOUTHWARD POND FORMATION BELOW LIMESTONE "A":

Collection 56:

- Anthozoa
    - Zaphrentis spinulosum
- Blastoidea
    - Pentremites sp., cf. gemmiformis
    - Pentremites godoni
    - Pentremites sp., cf. pulchellus
    - Dichocrinus sp. 1
    - Dichocrinus sp. 2
- Crinoidea
    - Eupachycrinus sp., cf. asperatus
    - Eupachycrinus sp., cf. boydi
    - Eupachycrinus sp., cf. monroensis
    - Poteriocrinus sp.
- Echinoidea
    - Fragment
- Bryozoa
    - Fenestella tenax
    - Glyptopora punctipora
- Brachiopoda
    - Cliothyridina sublamellosa
    - Composita subquadrata
    - Composita trinuclea
    - Dielasma illinoisensis
    - Eumetria vera
    - Lingulipora sp.
    - Orthotetes kaskaskiensis
    - Reticularia setigera
    - Productus (Diaphragmus) elegans
    - Productus ovatus
    - Spirifer increbescens
    - Spirifer leidyi
    - Spiriferina spinosa
    - Spiriferina transversa
- Pelecypoda
    - Two specimens
- Gastropoda
    - Bellerophon chesterensis (?)
    - Pleurotomaria chesterensis

Because of its massive beds, oolitic texture, and asphaltic impregnation, Southward Pond limestone "A" is exposed in most places and is easily identified nearly everywhere. Southward Pond limestones "B" and "C," on the other hand, are not so massive and have no such outstanding characteristics. Accordingly they are not so commonly exposed or so readily recognized. The following section of the north side of Pennywinkle Creek on the Mississippi side of the state line is one of the exceptions to the general rule.

Section of the north side of Pennywinkle Creek on the Mississippi side of the state line (Location 161—Middle Sec. 10-11 line, T. 4S., R. 11E.)

Southward Pond formation, total		73.9
Shales, green clay, filled with large *Chonetes chesterensis* (Collection 57). The beds of the interval are mostly covered, however, except for the shale fragments. To the top of "Cemetery hill"	12.0	
Limestone "C." Gray crystalline fossiliferous limestone, only the top foot of which is exposed	1.0	
Interval, covered	10.4	
Limestone "B." Crystalline fossiliferous limestone, filled with small *Productus sp.* Only the top foot is exposed	1.0	
Interval, covered	27.5	
Limestone "A." Massive oolitic gray fossiliferous limestone	12.0	
Interval, covered	5.0	
Shales, gray clayey fossiliferous, containing many Crinoid bases, *Agassizocrinus dissimilis*, and a few Blastoids (Collection 58)	5.0	
Undetermined		38.0
Interval, covered, to the flood plain of Pennywinkle Creek	38.0	

List of fossils from Pennywinkle Creek at the Alabama line (Location 161)

SOUTHWARD POND FORMATION ABOVE LIMESTONE "C":

Collection 57:
- Crinoidea
  - Stem segments
- Brachiopoda
  - Chonetes chesterensis
  - Cliothyridina sublamellosa
  - Orthotetes kaskaskiensis
  - Productus inflatus
  - Rhipidomella sp.
  - Schuchertella costatula
  - Spiriferina transversa

SOUTHWARD POND FORMATION BELOW LIMESTONE "A":

Collection 58:
- Anthozoa
  - Zaphrentis spinulosum
- Blastoidea
  - Pentremites sp.
- Crinoidea
  - Agassizocrinus dissimilis
- Bryozoa
  - Archimedes compactus
  - Archimedes communis
  - Glyptopora sp.
  - Lyropora ranosculum
  - Lyropora quincuncialis
- Brachiopoda
  - Chonetes chesterensis
  - Orthotetes kaskaskiensis (?)
  - Productus inflatus
  - Productus lowei
  - Spirifer increbescens
  - Spirifer sp., cf. leidyi
  - Spiriferina spinosa
  - Spiriferina transversa
- Gastropoda
  - Bellerophon (Euphemus) randolphensis
  - Pleurotomaria chesterensis

Nearby in a small stream and in a position lower than Southward Pond limestone "A" of the section is a sandstone belonging either to the Allsboro or Cripple Deer sandstone. Toward the southwest, Southward Pond limestone "A" extends up Pennywinkle and its tributaries for more than a mile to the central portion of Section 15, T. 4S., R. 11E. In places, as was just stated, it is underlain by a sandstone and at others it is overlain, likewise, by a sandstone, which is 70 feet above the limestone and which is perhaps the Southward Spring sandstone belonging above limestone "C." Section 15 is the farthest place up Pennywinkle Creek that the Paleozoic beds have been traced, but they may be exposed in small areas slightly farther up stream.

Returning to Bear Creek and continuing up that valley, the traverse leads past the type locality of the Alsobrook formation. Something like a mile farther up stream, the Allsboro road begins its descent from the J. O. Malone home into Cripple Deer Valley, where the following instructive and interesting section was made.

Section along the highway on the north side of Cripple Deer Valley

Southward Pond formation, total		30.0
Limestone "A." Massive layers of oolitic dark colored slightly asphaltic limestone	14.0	
Limestone "A." Limestone blocks, which may have slumped	7.5	
Interval, covered, except for a little green shale	8.5	
Allsboro sandstone, total		3.0
Sandstone, coarse dark gray, impregnated with petroleum residue and containing limestone nodules inside	3.0	
Alsobrook formation, total		85.0
Shales, greenish, clay	4.5	
Cripple Deer sandstone member. Thin-bedded sandstone to sandy shale, which is ripple-marked and which has wavy deposition lines. Much of it is impregnated with petroleum residue (asphalt)	36.5	
Interval, mostly covered, partly green clay shales	44.0	
Limestone, top of	......	

This is the type locality of the Cripple Deer sandstone member of the Alsobrook formation. A few hundred yards to the east, vertical joints have permitted huge masses of it to topple over, so that cliffs of the sandstone, 26 feet in height, are clearly exposed at the mouth of Cripple Deer Valley. Here all the sandstone except the upper four or five feet is impregnated more or less with asphalt.

It will be recalled that the section of the Alsobrook formation at the type locality was presented in the description of the Iuka terrane. At that place the thin basal part, eight feet in thickness, is limestone; the whole remaining portion of the formation, 72 feet in thickness, consists of calcareous, green clay shale, save for a foot layer of sandstone above the middle. Here at Cripple Deer Creek the shale interval is 85 feet thick and nearly the whole upper half of it is a sandstone. Granted the force of a preconception, yet it is difficult to understand how the Alsobrook formation, exclusively a calcareous, clay shale (lime carbonate less than 10 per cent) and sandstone except for a thin basal limestone, could be called a marl by Butts.[1]

Up Cripple Deer Creek at the state line, the top of the Iuka terrane and the basal Alsobrook formation, having a combined thickness of 57 feet in the south wall just above the flood plain, consist of limestone, the Iuka seemingly much freer from chert than at most places in Alabama. To correct numerous statements in the Mississippi reports concerning the value of the Tuscumbia limestone, it should be mentioned in passing, perhaps, that this is the only locality in Mississippi where any limestone in the Iuka terrane has escaped complete destruction or transformation by leaching. Elsewhere the old "Tuscumbia limestone" most certainly does not exist.

Here and there on both sides of Cripple Deer Valley for one and one-half miles above the state line, are blocks of Iuka chert; blocks of limestone (and limestone at one place), perhaps basal Alsobrook; and blocks of sandstone, Alsobrook, Allsboro, or younger in age. With more detailed study and a contour map, it may be possible to separate these various elements in a general way, though their blocks are badly mixed. At the up stream limits indicated, the Paleozoic beds are buried beneath the Tuscaloosa sand and gravel.

After skipping some two miles in the Cripple Deer traverse, one finds isolated exposures from the old Millford Mill site up the creek and its tributaries a mile or more to the western side of Range 11 East. On the south side of the stream is a low ledge of limestone without fossils, seemingly overlain by green shale. On a tributary on the north side of the stream and in the spring at the home of T. A. and C. J. Millford (SE¼, Sec. 31, T. 4S., R. 11E.) are small exposures of similar limestone. The limestone at these various places may belong to the top Iuka and basal Alsobrook formations or to limestone "A" of the Southward Pond formation. On the north side of Cripple Deer at the range line, are shales and limestone beds which most assuredly belong to the Chester, perhaps to that part of the Southward Pond formation above limestone "A."

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[1]Butts, Charles, The Paleozoic rocks. Geol. Surv., Alabama, Special Report, No. 14, p. 182, 1926.

Along Bear Creek Valley or rather the highway parallel to it on the west, the traverse from Cripple Deer Creek runs south through Allsboro and Bishop to Bishop Bridge across Bear Creek. Along the highway are a number of good exposures where the following sections were measured.

Section of ravine and highway in the north end of Allsboro

Tuscaloosa formation, total		55.0
Gravel and one or two pudding stone layers; to top of hill	55.0	
Southward Pond formation		60.0
Shale, green clay, slightly covered	17.0	
Interval, mostly covered, some green clay shale at the base	10.0	
Interval, partly covered; probably all thin shaly limestone and clay shale; fossiliferous	8.5	
Limestone "A." Massive oolitic fossiliferous limestone, impregnated with petroleum residue	9.0	
Shale, clayey, and limestone, shelly; both are fossiliferous and travertine-like in texture. The top is slightly covered	11.0	
Limestone, shaly and shale, clayey, interbedded. Blastoidea, Bryozoa, etc., are abundant	4.5	
Allsboro sandstone, total		5.0
Sandstone, massive and contorted, and bluish gray shale between	5.0	

Attention should be called to the fact that Southward Pond limestone "B" seems to be undeveloped in this section. Southward Pond limestone "C," on the other hand, could have been eroded before the deposition of the Tuscaloosa, or merely covered by the gravel of that formation during deposition or later slumping.

Section of highway one-half mile south of Bishop

Southward Pond formation, total		34.5
Limestone "A." Massive dark gray limestone	9.0	
Interval, covered	19.0	
Shale, gray	1.0	
Limestone, sandy fossiliferous	0.5	
Sandstone, shaly	1.0	
Shale, clayey olive	3.0	
Interval, covered	1.0	
Allsboro sandstone, total		1.0
Sandstone, blocks, about one foot thick (Shale below)	1.0	

Section of highway one-fourth mile north of Bishop Bridge

Southward Pond formation, total		20.0
Limestone "A." Massive layer or two of oolitic gray fossiliferous limestone	10.0	
Travertine-like float similar to that in the section north of Allsboro. The material is very fossiliferous (Collection 54)	10.0	

List of fossils collected along the highway one-fourth mile north of Bishop Bridge.

SOUTHWARD POND FORMATION:

- Collection 54:
  - Anthozoa
    - Cup coral
  - Blastoidea
    - Pentremites sp., cf. pulchellus
  - Crinoidea
    - Stem segments
    - Crown
  - Bryozoa
    - Fenestella tenax
  - Brachiopoda
    - Cliothyridina sublamellosa
    - Orthotetes kaskaskiensis
    - Productus inflatus
  - Pelecypoda
    - Nucula randolphensis

In the sections north of Allsboro, one-half mile south of Bishop one-fourth mile north of Bishop Bridge, and at the bridge, there is some variation in the thickness and character of the Allsboro sandstone. Similarly, there is some variation in the thickness and composition of the interval between the Allsboro sandstone and Southward Pond limestone "A." Perhaps the variations of the two intervals are somewhat complementary.

The last three sections named, which are 650 and 610 feet apart respectively, reveal a pronounced inclination of Southward Pond limestone "A." From the north section to the middle, the dip is 18 feet S. 45° W.; and from the middle section to the bridge section, the dip is 16 feet in the same direction; or a total of 34 feet in 1,260 feet. It will be recalled that the limestone is 12 to 14 feet below the flood plain of Bear Creek in the slough north of the Southern Railway, and that it is high above the flood plain of Bear Creek round about Allsboro. The dip toward the southwest at Bishop Bridge carries it beneath the valley flat at the northeast corner of Southward Pond, next to be described.

From Bishop Bridge, Bear Creek maintains a southwest-northeast course for five miles up stream to the southwest to a point one mile beyond Southward Bridge, but its western valley wall extends nearly due west for three miles to the northwest "corner" of Southward Pond, which the valley embraces, perhaps as an old meander. From that place the wall stretches south past Southward homestead and Southward Spring, near Southward Bridge. Because of various dips of the beds and because of the lack of exposures at the northeast and southwest "corners," the Southward Pond region, like the Southern Railway-Bear Creek region, was rather baffling at first.

About 200 or 300 yards west of Bishop Bridge in a very poor exposure, the top of Southward Pond limestone "A" was determined to be 18 feet above the top of the Allsboro sandstone. Such determination was not possible, however, until the stratigraphic sequence of the two beds had been determined elsewhere. In fact, the correct sequence was not suspected, for an east dip along the north wall of Southward Pond not only carried limestone "A" from a position 24 feet above to one beneath the valley flat but limestone "C" likewise to that level; and there were no exposures farther east which revealed a reverse dip and therefore a rise of the beds toward the northeast. Of course, a continuation of the east dip would have carried Southward Pond limestone "A," "B," and "C" far below the Allsboro sandstone, where the work down-streamward thus far seemed to place them, though incorrectly so.

By turning back to the section of Southward Pond limestones "A," "B," and "C" at the north end of Southward Pond, it will be seen that limestone "A" lies 23.8 feet above water level. Coarse-grained sandstone blocks lying in this interval possibly came from the covered Allsboro sandstone, though this can not be affirmed. It is not definitely known, therefore, whether the fossils from the loose block of sandstone (Collection 51) belong to the Allsboro or to a higher sandstone.

List of fossils from the north end of Southward Pond

Allsboro sandstone or a higher sandstone (Loose block):
- Collection 51:
  - Bryozoa
    - Fenestella sp.
  - Brachiopoda
    - Dielasma shumardanum
    - Dielasma sp.
    - Eumetria vera
    - Orthotetes kaskaskiensis
    - Productus (Echinoconchus) alternatus
    - Productus inflatus
    - Reticularia setigera
  - Pelecypoda
    - Allorisma sp., cf. neglectum

At the northeast "corner" of Southward Pond is a poor exposure of sandy shale and shaly sandstone, at least 26 feet in thickness, the base of the exposure of which extends within 5.5 feet of the top of Pond limestone "C." The sandstone is irregularly bedded;

and the upper part is slightly calcareous and fossiliferous. Perhaps the fossils of Collection 48 which were secured from blocks at the northeast "corner," came from the top of this sandstone interval or from a layer within the sandstone itself. In any event the sandstone of this interval is the Southward Spring sandstone which caps the Southward Pond formation and which is better exposed at the southwest "corner" of the pond and at Southward Spring.

List of fossils from the north end of Southward Pond

SOUTHWARD SPRING SANDSTONE, FLOAT FROM:

Collection 48:
- Crinoidea
  - Stem segments
- Bryozoa
  - Fenestella sp.
- Brachiopoda
  - Composita trinuclea
  - Dielasma shumardanum
  - Productus inflatus
  - Productus ovatus
  - Productus (Diaphragmus) mississippiensis
  - Orbiculoidea sp.
  - Orthotetes kaskaskiensis
  - Reticularia setigera
  - Spirifer leidyi
  - Spirifer (Brachythyris) chesterensis
  - Spirifer (Brachythyris) suborbicularis
- Pelecypoda
  - Deltopecten batesvillensis

From a north dip at the northwest "corner" of Southward Pond, the inclination of the beds changes to a south dip southward along the west wall. Before this south dip carries Pond limestone "A" below the surface of the pond toward the southwest "corner," however, a measured interval of 40 or 41 feet from the top of Pond limestone "A" to the base of the Southward Spring sandstone shows the sandstone to rest directly on Pond limestone "C."

Section at the southwest "corner" of Southward Pond

Southward Spring formation, total		12.8
Sandstone, shaly and shale, sandy; both irregularly bedded yellowish buff sandy material, having irregular yellow and dark brown iron stains. The lower foot has some blue clay shale. No fossils were found	12.8	
Southward Pond formation		3.4
Pond limestone "C." Hard bluish gray coarsely crystalline fossiliferous limestone. To the base of the exposure at the south end of Southward pond	3.4	

At Southward Spring the Southward Spring sandstone, disregarding the dip, measures 15 feet in thickness, without either the top or the base being exposed. Its actual thickness, therefore, is unknown,

PLATE 10

Alsobrook formation fossils

Figs. 1-6. *Productus inflatus.* ×1. Fig. 1 is an anterior view of a shell; Fig. 2, an interior view of the pedicle valve of another specimen; Fig. 3, the brachial valve of still another shell; Figs. 4, 5, and 6 are views of the pedicle valve of three other specimens. Collection 59.

Collection 59 came from the basal limestone member of the Alsobrook formation at Pride, Ala. Beginning with the Alsobrook formation, the basal formation of the Chester series, fossils are abundant at certain horizons. In the basal Alsobrook limestone member and the base of the overlying shale member, *Productus inflatus* is so abundant that specimens of it may be collected by the hundreds.

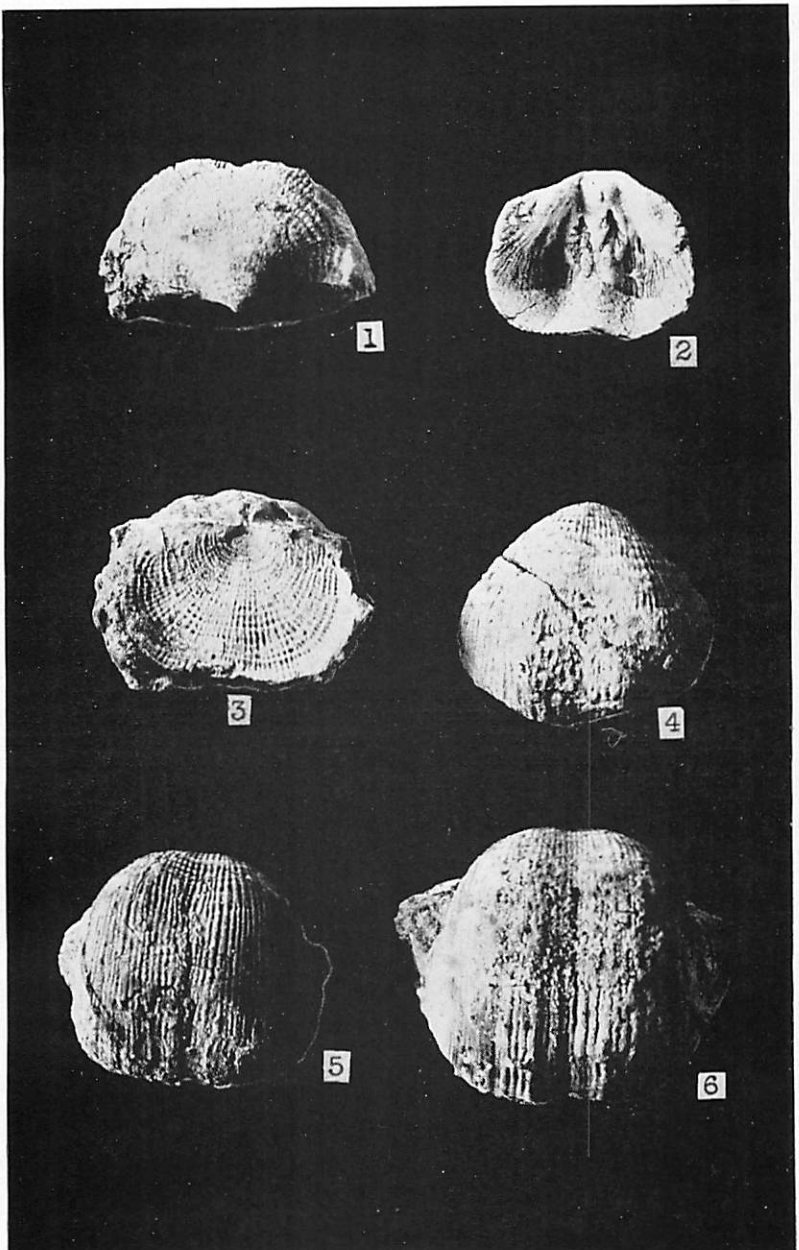

PLATE 10

PLATE 11

Alsobrook formation fossils

Figs. 1-8. *Chonetes chesterensis.* ×2. Figs. 1, 3, 5, and 7 are ventral or pedicle valves; Figs. 2, 4, 6, and 8, dorsal or brachial valves; all of different specimens, showing something of their range in size. Collection 59.

Collection 59 is from the basal limestone member and the very base of the overlying shale member of the Alsobrook formation at Pride, Ala. Like *Productus inflatus*, *Chonetes chesterensis* is present literally by the hundreds in these beds of the Alsobrook formation, and reveals their Chester age.

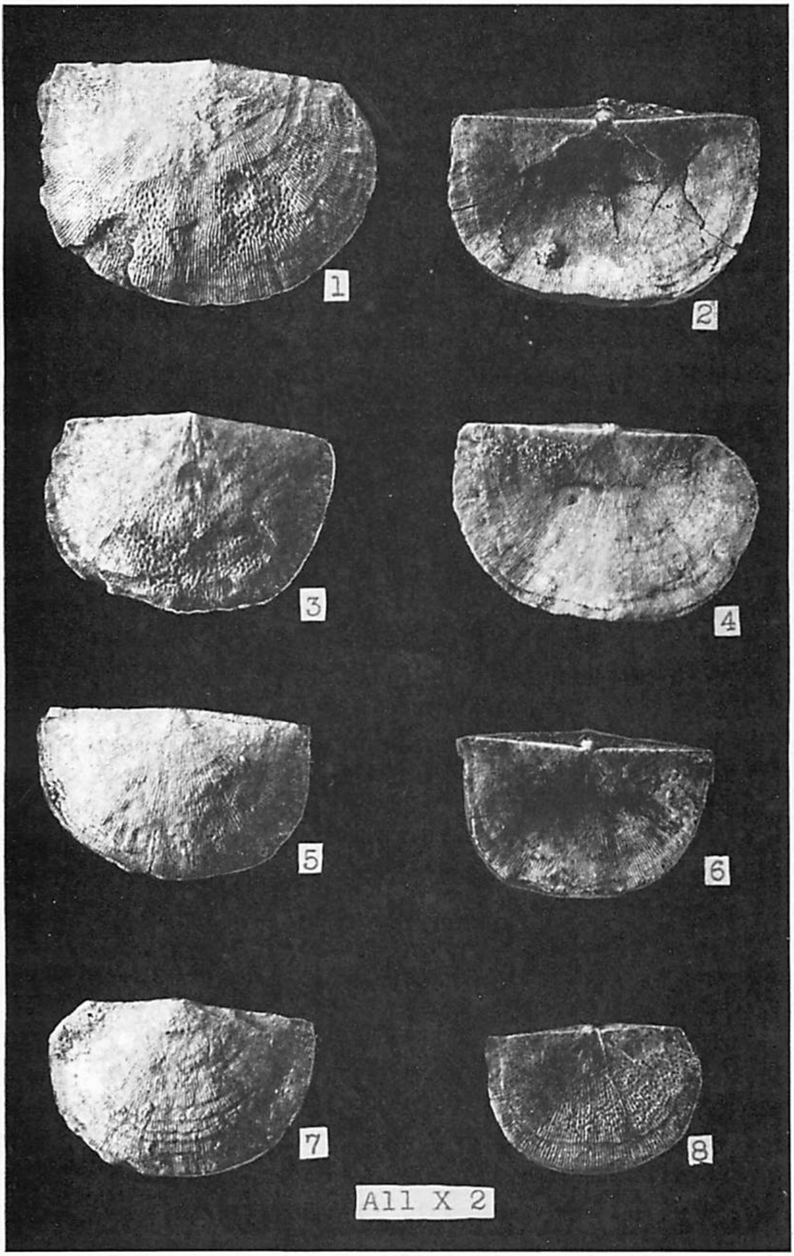

PLATE 11

but it could readily be twice that amount, for the sandy shale and shaly sandstone at the northeast "corner" of the pond are 26 feet thick. The sandstone is harder and more indurated at the spring, perhaps, because of its exposure to the air and sun. The sandstone continues west for one-half mile or farther, dipping gently in this direction to near the end of the exposure where it rises slightly toward the west. At the west end it is overlain by, or rather the top consists of, two or three feet of calcareous material, which could easily lead to confounding its top with one or another of the thin associated limestones.

Southward Spring is one-fourth mile south of Southward Pond, and Bear Creek ford, a short distance above Southward Bridge, is one-half mile southeast of the spring. The base of the exposure of Southward Spring sandstone at the spring is 26 feet lower than the actual basal contact of the sandstone in the south end of Southward Pond. At the ford the top of the calcareous layer, forming the cap of the sandstone, is 25.5 feet lower than the top of the exposure of sandstone at the spring. The top of the two foot calcareous cap is four feet above low water at the ford, and 100 yards farther southeast—here down stream because of a small bend in the channel—it lies at water level. At Southward Bridge, 200 to 300 yards still farther southeast, the top of the Southward Spring sandstone, therefore, lies but a few feet below water level, which is the lower limit of the next higher terrane, the Southward Bridge formation.

ALSOBROOK, ALLSBORO, SOUTHWARD POND, AND SOUTHWARD SPRING FAUNAS AND CORRELATION

The faunas of the Alsobrook, Allsboro, Southward Pond, and Southward Spring formations, particularly of the Alsobrook basal limestone and of the Southward Pond formation, have been given with the stratigraphic sections. The basal limestone member of the Alsobrook formation in many places is filled with myriads of *Productus inflatus*. In addition to this form, the limestone member at Pride, Alabama, contains hundreds of *Chonetes chesterensis*, but some of them may have been freed from the very basal part of the overlying clay shale (List 59). At least in one place, three miles north of Cherokee, Alabama, the hosts of *Productus inflatus* weather from the clay shales, 10 to 15 feet above their base (List 96). Elsewhere the whole Alsobrook formation above the basal limestone member seems to be barren of fossils or largely so.

List of fossils collected three miles north of Cherokee (Location 236, SE¼, Sec 10, T. 3S., R. 14W.)

ALSOBROOK FORMATION SHALES 10 TO 15 FEET ABOVE THE BASAL LIMESTONE MEMBER:

Collection 96:

Crinoidea
- Stem segments

Bryozoa
- Fenestella sp.
- Glyptopora punctipora (?)
- Glyptopora sp.

Brachiopoda
- Composita subquadrata
- Crania chesterensis
- Productus inflatus
- Spiriferina transversa

It is not certain that the loose block of sandstone at Southward Pond which yielded the few fossil forms came from the Allsboro sandstone, though such seem to be the case (List 51). The limestones, particularly Limestones "B" and "C," of the Southward Pond formation are very fossiliferous. Especially so are the interstratified clay shales and shaly limestones and marl-like or travertine-like beds, which travertine-like material in part is due, perhaps, to the action of the ground water in its concentrated flow below the limestones and above the more nearly impervious clay shales.

In the Southward Pond formation near the mouth of Pennywinkle Creek, the shales, 10 feet in thickness, lying just below Pond limestone "A" are very prolific in fossil forms (List 56). *Eumetria vera* is common; *Zaphrentis spinulosum* and *Composita trinuclea* are very abundant; and two or more species of *Pentremites* are represented by literally hundreds of specimens. The shales of the lower half of approximately this same interval farther up stream at the Alabama-Mississippi line are likewise very fossiliferous (List 58). Here, on the other hand, *Productus lowei* is common and the fused basal plates of *Agassizocrinus dissimilis* are very abundant, whereas *Eumetria vera* and *Composita trinuclea* are not represented at all and the hundreds of *Pentremites sp.* scarcely so. The outstanding differences of the fossil forms of the two places are the hundreds of *Pentremites* at the one and of scores of *Agassizocrinus* at the other. This discrepancy is not completely explained by the limited bed from which the forms were secured at the state line. Inasmuch as all the forms at both places are dwarfs and are found in clay shales, perhaps the difference in the faunas can best be explained by postulating somewhat restricted basins in the shallow sea.

PLATE 12

Southward Pond formation; fossils from the bed below Limestone "A"

Figs. 1-3. *Zaphrentis spinulosum.* ×2. Three specimens; the one in Fig. 3 is slightly exfoliated. Collection 56.

Collection 56 came from the basal shale, just below Limestone "A" of the Southward Pond formation near the mouth of Pennywinkle Creek, Ala. *Zaphrentis spinulosum* is one of the abundant forms of the basal part of the Southward Pond formation.

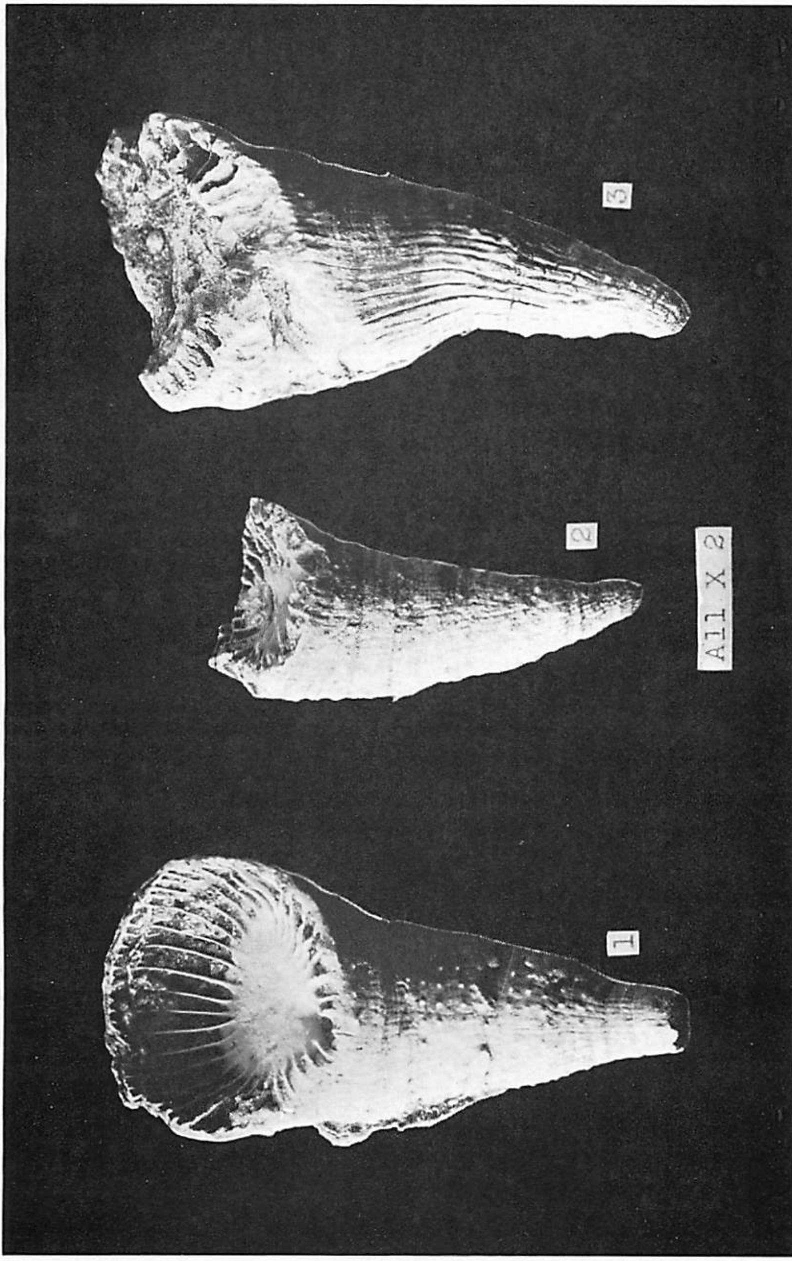

PLATE 12

PLATE 13

Southward Pond formation; fossils from the bed below Limestone "A"

Figs. 1-2. *Pentremites godoni.* ×2. Fig. 1 is a side view of a small specimen; and Fig. 2 is a top or oral view of an intermediate specimen. Collection 56.

Figs. 3-6. *Pentremites sp., cf. pulchellus.* ×2. Lateral views of four specimens of slightly different outline, all of which are doubtfully referred to *P. pulchellus.* Collection 56.

Collection 56 is from the basal shales and shaly limestones, beneath Limestone "A" of the Southward Pond formation near the mouth of Pennywinkle Creek, Ala. These two Blastoids (*Pentremites*) are beautifully preserved, are completely freed from the shaly limestone matrix, and are obtainable by the hundreds.

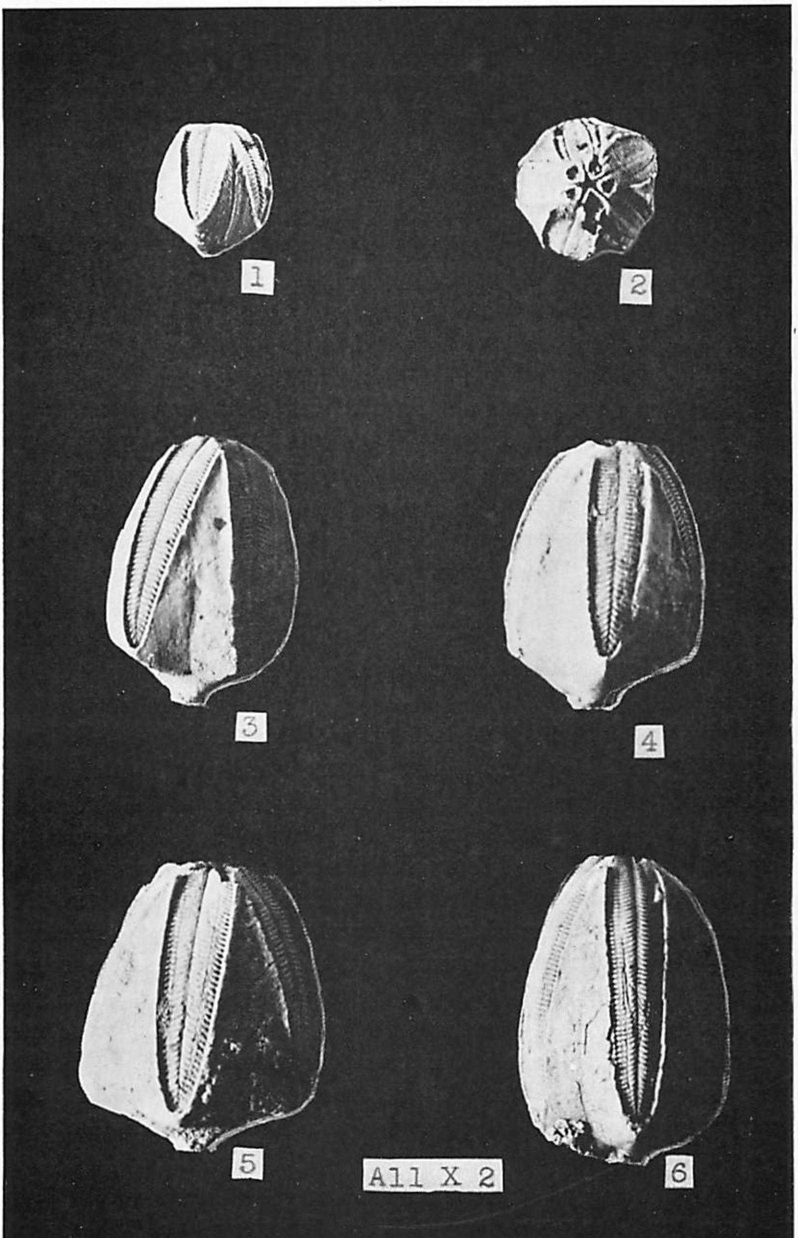

PLATE 13

Of the forms from Limestone "B" of the Southward Pond formation on the north side of Southward Pond, *Lyropora ranosculum* is common, and *Productus lowei* is very abundant (List 50). On the whole all the forms are much larger than the forms in the shales on Pennywinkle. Perhaps the calcareous sea bottom upon which Pond limestone "B" accumulated was more conducive to the development of robust forms.

In the shales of the Southward Pond formation lying just above Pond limestone "C" on Pennywinkle Creek near the state line, *Chonetes chesterensis* is represented by hundreds of shells (List 57). As is the case in the shales below Pond limstone "A", the forms in the shales above Pond limestone "C" are largely dwarfs. Before leaving the Southward Pond faunas attention should be called, in passing, to the large number of Paint Creek forms represented.

The peculiar feature of the fauna from the Southward Spring sandstone on the north side of Southward Pond is the presence of *Spirifer* (*Brachythyris*) *chesterensis* (closely related to *subcardiiformis* and of forms referred to *Spirifer* (*Brachythyris*) *Suborbicularis* (List 48). These forms are largely or exclusively limited, respectively, to beds no younger than the Salem and Keokuk. For a sandstone fauna many of the forms are robust, but the sea bottom was partly calcareous as shown by the calcareous material in the sandstone.

In the description of the Iuka terrane, it was shown that Butts' Warsaw west of Decatur, Alabama, includes beds in part Salem and in part St. Louis in age, for example: (1) in the highway at Cherokee, (2) in the Denie quarry on Buzzard Roost Creek, (3) in the spur between Mill and Buzzard Roost Creeks, (4) near the road at Alsobrook homestead, and (5) in the field east of Allsboro.[1] That some of the limestone or chert directly beneath the basal *Productus inflatus*—bearing limestone member of the Alsobrook formation in places is Ste. Genevieve in age is evidently possible. To affirm, however, that the basal *Productus inflatus*—bearing limestone member and the overlying shale and sandstone member of the Alsobrook formation are Ste. Genevieve in age seems to be as far afield as it is to call such beds as (1) calcareous, clay shale, (2) sandy shale, and (3) sandstone a marl.[2]

Productus inflatus and *Chonetes chesterensis* are typical Chester forms and not Ste. Genevieve. These two forms and the rest of

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[1]Page 108 and Op. Cit. p. 175.
[2]Page 128 and Op. Cit. p. 182.

the collection from the basal 1.5-foot limestone member of the Alsobrook formation at the J. W. Wimbish home (Section 62 and Collection 5) show how overwhelmingly the basal limestone fauna is Chester in age. Such is the case in still other localities.

Furthermore, at the type locality, the Ste. Genevieve is a limestone stratum, so lithologically similar to the St. Louis limestone, which underlies it, that, for years, the two formations were called the St. Louis limestone, even after the Ste. Genevieve had been differentiated. To refer the Alsobrook formation, which, save the foot to eight or ten feet basal limestone member is (1) a calcareous clay shale and (2) a sandstone (70 or 80 feet thick), to the Ste. Genevieve on lithologic grounds is as unwarranted as it is on paleontologic evidence. Just as the dominantly calcareous early Mississippian sea gave way to the dominantly clastic Chester sea in the Iowa-Missouri-Illinois region, so also did the dominantly calcareous early Mississippian sea give way to the dominantly clastic Chester sea in the Mississippi-Alabama region.

The Allsboro sandstone is the formation, or at least one of the formations, which Butts correlates with the Bethel sandstone of Kentucky.[1] That the commercial asphalt sandstone south of Cherokee is the Allsboro sandstone is somewhat doubtful. The asphalt rock may be, at least in part, the Cripple Deer sandstone phase of the Alsobrook formation, for in the type locality where it directly underlies the Allsboro sandstone, the Cripple Deer sandstone is more impregnated than in the Allsboro sandstone at most places. The evidence bearing on this question will be presented more in detail in the description of the economic beds.

The basal part of the Southward Pond formation is nearly the same as the basal part of the formation which Butts correlates with the Gasper formation of Kentucky, which (Gasper formation) he believes to be the equivalent of the Renault, Yankeetown, and Paint Creek of Illinois and Missouri.[1] It is thought that the present paper has clearly shown the Chester rather than the Ste. Genevieve age of the very basal limestone member of the Alsobrook formation. The fauna of the basal part of the Southward Pond formation is strongly Paint Creek in its relationship. The Alsobrook, Allsboro, and Southward Pond formations seem, therefore, to correlate with the Renault, Yankeetown, and Paint Creek formations of the upper Mississippi Valley, without any juggling whatsoever.

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[1]Op. cit. pp. 184, 185.
[1]Op. cit. pp. 185, 186, 189.

PLATE 14

Southward Pond formation; fossils from the bed below Limestone "A"

Figs. 1-4. *Agassizocrinus dissimilis.* ×2. Fig. 1 is a basal view; and Figs. 2-4 are top views of the fused basal plates; all of different specimens. Collection 58.

Figs. 5, 6. *Composita trinuclea.* ×2. Fig. 5 is a lateral view of a specimen and Fig. 6 is a view of the pedicle valve of another specimen. Collection 56.

Collection 58 is from the basal shales, below Limestone "A" of the Southward Pond formation on Pennywinkle Creek on the Mississippi side of the Mississippi-Alabama line; and

Collection 56 is from the basal shales and shaly limestone, beneath Limestone "A" of the Southward Pond formation near the mouth of Pennywinkle Creek, Ala. *Agassizocrinus dissimilis* is very abundant at the State Line and *Composita trinuclea* is abundant near the mouth of Pennywinkle Creek.

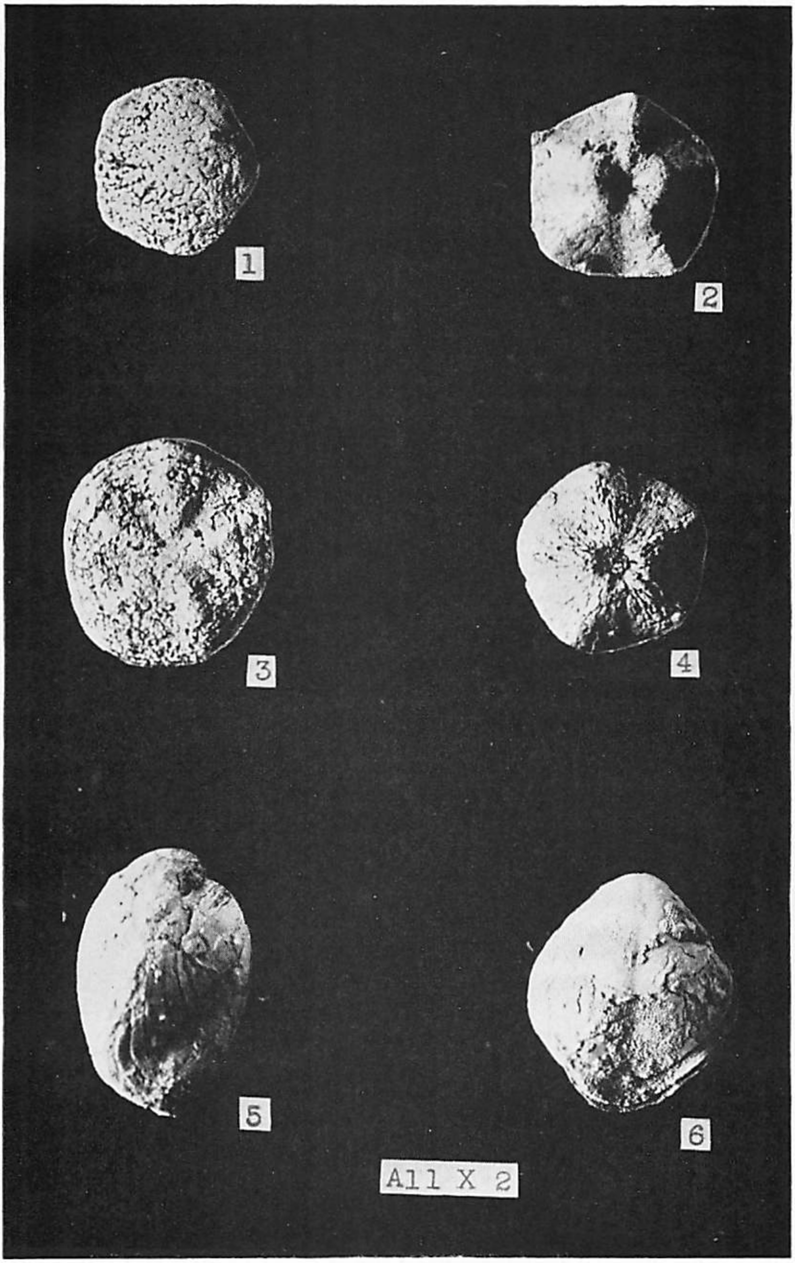

PLATE 14

PLATE 15

Southward Pond formation; fossils from the bed below Limestone "A"

Figs. 1-6. *Productus lowei*. New Species. ×2. (All cotypes. See also Plate 17, Figs. 1-6). Fig. 1 is a view of a pedicle valve; Fig. 2, an interior view of the pedicle valve of another specimen; Figs. 3 and 4 are anterior views of two other specimens; and Figs. 5 and 6, views of the pedicle valves of still two other specimens.

As Productids go, the shell is small, decidedly concavo-convex, and has a hinge line but slightly longer than the greatest width of the shell. The striking features are the plumpness of the shell and the inconspicuous ribs, both of which features give such a beautiful and finished appearance to the individuals.

The pedicle valve is rotund, has commonly small inconspicuous ears and a mesial sinus, the development of which varies somewhat in different shells. An interior view shows that the muscle scar is well developed. The surface is marked by inconspicuous ribs, and, in some specimens, by a few slightly developed concentric wrinkles about the posterior end.

The brachial valve is rather uniformly concave, although it becomes somewhat flattened in the extensions into the ears. The surface is, perhaps, less conspicuously marked with radiating ribs than is that of the opposite valve.

P. lowei is characterized by its primness, its inconspicuous radiating ribs, and its deep, narrow, mesial sinus. Accordingly it seems to differ from all illustrated and described Productids, and must, therefore, be given a new name. Collection 58.

This species is named in honor of Dr. E. N. Lowe, State Geologist of Mississippi.

Collection 58 is from the basal shales, below Limestone "A" of the Southward Pond formation on Pennywinkle Creek on the Mississippi side of the Mississippi-Alabama line.

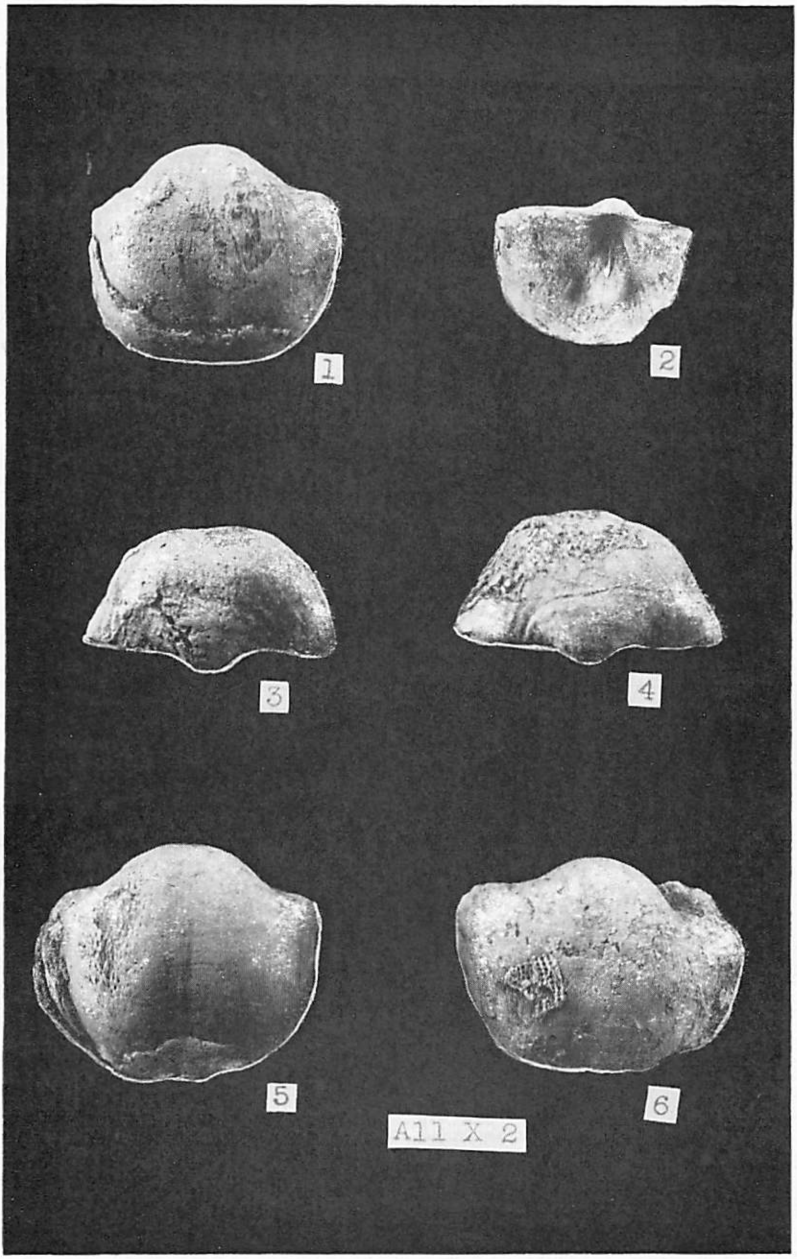

PLATE 15

As a median wedge, separating the Bangor limestone, ranging from the top of the St. Louis throughout the Chester series, into a lower and upper division was the original Hartselle sandstone.[2] Later McCalley extended the lower limit of the Hartselle until it included the whole lower half of the Bangor limestone.[1] As thus defined by McCalley, the term was adopted for Mississippi bv Dr. Lowe.[2] Now its limit has been shifted again by Butts.[3] As used by McCalley and by Lowe, the term embraced all the Chester series in Mississippi described in the present report, save the basal limestone member of the Alsobrook formation.

SOUTHWARD BRIDGE AND FOREST GROVE FORMATIONS

NAMES AND GENERAL DESCRIPTION

The Southward Bridge formation is typically exposed at Southward Bridge near the old village of Mingo located at the confluence of Bear Creek and Cedar Creek valleys, or according to Alabama usage at the confluence of Big Bear and Little Bear valleys. The formation consists of the following divisions or members, arranged in the order of their position:

Limestone, upper
Shale and sandstone
Limestone, lower
Shale

Stated in another way, the formation consists of two limestone members, below each of which is a shale member or a shale and sandstone member. The formation has a total thickness of 85 feet or even more.

The Forest Grove formation is named after the school which is located on top of the formation near old Mingo Village and Southward Bridge. Since the top member forms typical sandstone cliffs about Highland Church, likewise located above the formation but near Tishomingo City, it is proposed to name the member after this Church. The Forest Grove formation consists of two divisions:

Highland Church sandstone member
Shale and shaly sandstone member

Nowhere is the lower member completely exposed. In fact only a few feet of the different parts of the member outcrop here and

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[2]Chart to accompany Geological Map of Alabama (1894), Geol. Surv., Alabama.

[1]McCalley, Henry, The Tennessee Valley Region, Geol. Surv., Alabama, pp. 40-43, 154-177, 1896.

[2]Lowe, E. N., Mississippi, Its Geology, Geography, Soil and Mineral Resources. Miss. State Geol. Surv., Bull. 14, pp. 54, 55, 1919.

[3]Butts, Charles, The Paleozoic Rocks. Geol. Surv., Alabama, Special Report, No. 14, p. 80, 1926.

there. By piecing these together at least the exposed part of the member was found to be largely shale and shaly sandstone. It has a thickness of 90 feet, or more. As the name suggests, the Highland Church member is exclusively sandstone, a typical cliff forming stone having a thickness of 25 feet or more.

The top of the Southward Spring sandstone was seen to dip beneath the waters of Bear Creek at Southward Bridge. From this point toward the south up Bear Creek and its tributaries the Paleozoic beds belong exclusively to the Southward Bridge formation and to the Forest Grove formation. The same condition obtains along Mackeys Creek and tributaries, which discharge south into the Tombigbee River.

DISTRIBUTION AND DESCRIPTION

The Southward Bridge formation is beautifully exposed at Southward Bridge where the waters of Bear Creek striking against the valley side have removed the covering of mantle rock and where higher up the valley wall beyond the reach of Bear Creek small gulleys have laid bare the shales and shaly sandstones. At this place the following section was measured:

Section at Southward Bridge

Southward Bridge formation, total		82.7
"Upper limestone," position of	——	
Shale, sandy, to shaly sandstone, irregularly bedded at the hillside spring	8.0	
Interval, covered	13.0	
Shale, blue clay, containing a little very fine sand. Slightly fossiliferous (Collection 46 contains fragments of Brachiopods and Pelecypods only). The upper part, 11 feet, is partly covered	26.0	
"Lower limestone." Massive layer of bluish gray crystalline fossiliferous limestone. The fossil forms are white and are, therefore, very conspicuous	4.0	
Shale, bluish black clay, or black carbonaceous, and a few thin layers of impure limestone and nodules of siderite	22.0	
Limestone hard blue lenticular, which is filled with one or two species of Brachiopoda (Collection 47)	0.7	
Shale, bluish black clay, or rather black carbonaceous	7.0	
Interval, covered, to water level of Bear Creek	2.0	

List of fossils collected at Southward Bridge

SOUTHWARD BRIDGE FORMATION:
Collection 47

Bryozoa
- Fenestella sp.

Brachiopoda
- Camarotoechia purduei
- Composita sp.
- Eumetria verneuiliana

Liorhynchus carboniferum
Productus inflatus
Pelecypoda
Deltopecten batesvillensis
Leptodesma spergenensis robustum
Myalina illinoisensis
Schizodus arkansanus (?)
Schizodus depressus abruptus
Gastropoda
Bellerophon sp.
Cephalopoda
Gastrioceras caneyanum

Although the "Upper limestone" is not exposed in the Southward Bridge section its position is, nevertheless. definitely known. From sections farther up Bear Creek where both limestones are exposed, 45 to 50 feet apart vertically, one or both of them can be traced by the scarps themselves or by their topographic equivalents almost to the bridge section. Directly across the low ridge from the section, the "Upper limestone," 5.5 feet in thickness, lies in a small stream 36.5 feet above the "Lower limestone," or 10.5 feet below the position assigned to it in the section. It was shown in the description of the Southward Spring sandstone that this sandstone dips below water level into the bank at Southward Bridge. A continuation of the dip 200 to 300 yards to the small stream where the "Upper limestone" is exposed would account for its position 10.5 feet lower than indicated in the section.

Fortunately the Highland Church sandstone member of the Forest Grove formation outcrops around Forest Grove School, near at hand. The vertical distance from the "Upper limestone" to the base of the Highland Church sandstone can be determined from the exposure of the "Upper limestone" in the small stream or from exposures of the limestone farther up Bear Creek valley.

Skeleton section at Forest Grove School

Forest Grove formation, total		100.0
Highland Church sandstone. Massive cliff-forming coarse sandstone	11.0	
Interval, covered	89.0	
Southward Bridge formation, total		5.5
"Upper limestone." Crystalline blue limestone exposed in the small stream	5.5	

Blocks of the coarse Highland Church sandstone have a way of breaking off and creeping down the hillside until they occupy positions somewhat difficult to explain, especially in those places where the whole intervening section between the sandstone and the "Upper limestone" has been carried away by the natural processes of erosion.

Blocks of coarse sandstone, seemingly from the Highland Church sandstone, are present in the Southward Bridge section. Perhaps these blocks and also the lack of good exposures led Crider to place 20 feet of heavy bedded coarse grained sandstone directly upon the "Lower limestone" in his section at Southward Bridge.[1] The matter should be passed over were it not for its bearing on economic problems, for on the same page he states: "The sandstone continues along the creek to the south and becomes coarser in texture * * * * It attains a thickness of at least 100 feet and perhaps much more." As a matter of fact the coarse grained cliff-forming sandstone, suitable for high grade building purposes, exceeds 25 feet in thickness at few places. It is thick enough for economic development, but not on a scale of 100 feet or more.

Composite sections are excellent means of conveying to the reader a general conception of the beds of a region or of summarizing a series of shorter sections. But as a working instrument for those that follow they become a thorn in the flesh, pricking more deeply the more serious the need of detailed information. In spite of this fact, recourse must now be had to such presentation, because of indefinite geographic points of location.

Composite section of Bear Creek valley from a terrace above Southward Bridge to a point about opposite Highland Church fish trap

Tuscaloosa formation, total		22.0
Gravel, mostly coarse, and pudding stone conglomerate, which (conglomerate) ranges from a fraction of a foot to 15 feet in thickness	22.0	
Forest Grove formation, total		117.0
Highland Church sandstone member. Massive gray and yellow sandstone without bedding planes and forming cliffs at many places along the top of the valley wall	25.0	
Interval, practically all covered. On the west side of the valley at Highland Church fish trap about 35 feet above the base is an interval of two or three feet of thin bedded sandstone and sandy shales; and near the top are loose blocks of fossiliferous sandstone (Collection 37) consists of *Orthoceras sp.* and numerous impressions of Pelecypods and Gastropods. Huge blocks of the Highland Church sandstone cover especially the upper part of the interval	92.0	
Southward Bridge formation, total		69.5
"Upper limestone." The upper part, 2.0 feet thick, is crystalline and fossiliferous and weathers to thin beds; the lower part, 3.5 feet thick, is crystalline and fossiliferous and constitutes a massive layer which stands out as a cliff-forming limestone. (Collection 45). At the lower end of the section this "Upper limestone" forms the top of a terrace, on top of which are many loose blocks of Highland Church sandstone	5.5	

[1]Crider, A. F., Geology and Mineral Resources of Mississippi, U. S. Geological Survey, Bull. 283: 11, 1906.

PLATE 16

Southward Pond formation; fossils from the bed below Limestone "A"

Figs. 1-4. *Spirifer leidyi.* ×2. Figs. 1-3 are brachial valves of three specimens and Fig. 4 is a pedicle valve of another specimen. Collection 56.

Figs. 5-8. *Spiriferina spinosa.* ×2. Figs. 5-6 are brachial valves, Fig. 7 is a posterior view of another specimen, and Fig. 8 is a pedicle valve. Collection 56.

Collection 56 is from the basal shales, beneath Limestone "A" of the Southward Pond formation near the mouth of Pennywinkle Creek, Alabama.

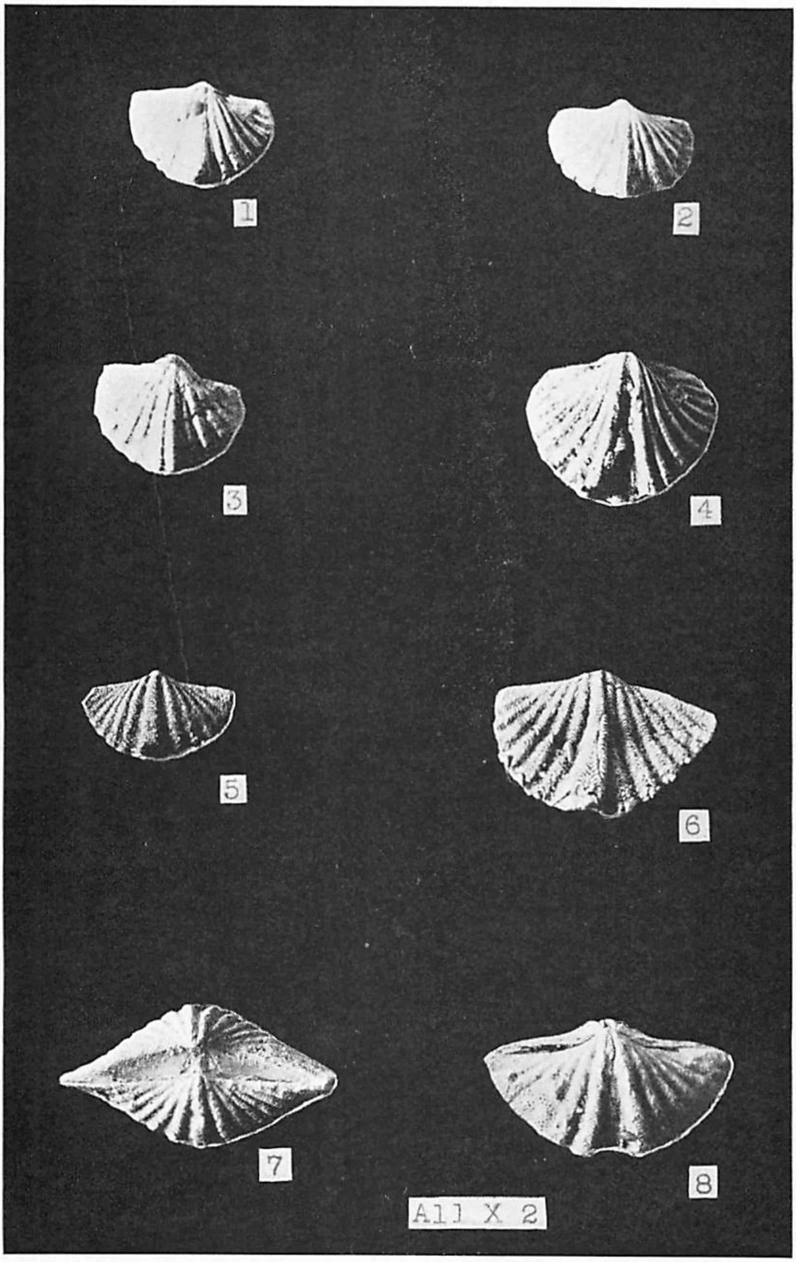

PLATE 16

PLATE 17

Southward Pond formation; fossils from Limestone "B"

Figs. 1-6. *Productus lowei.* New species. ×2. (Cotypes of those of Plate 15, Figs. 1-6). Figs. 1 and 2 are dorsal (brachial) views of two specimens; Figs. 2 and 3, posterior views of two other specimens; and Figs. 5 and 6, ventral (Pedicle) views of still two other specimens. Collection 50.

Collection 50 came from the middle bed, Limestone "B" of the Southward Pond formation at the north end of Southward Pond, Miss. At this place *P. lowei* is abundant.

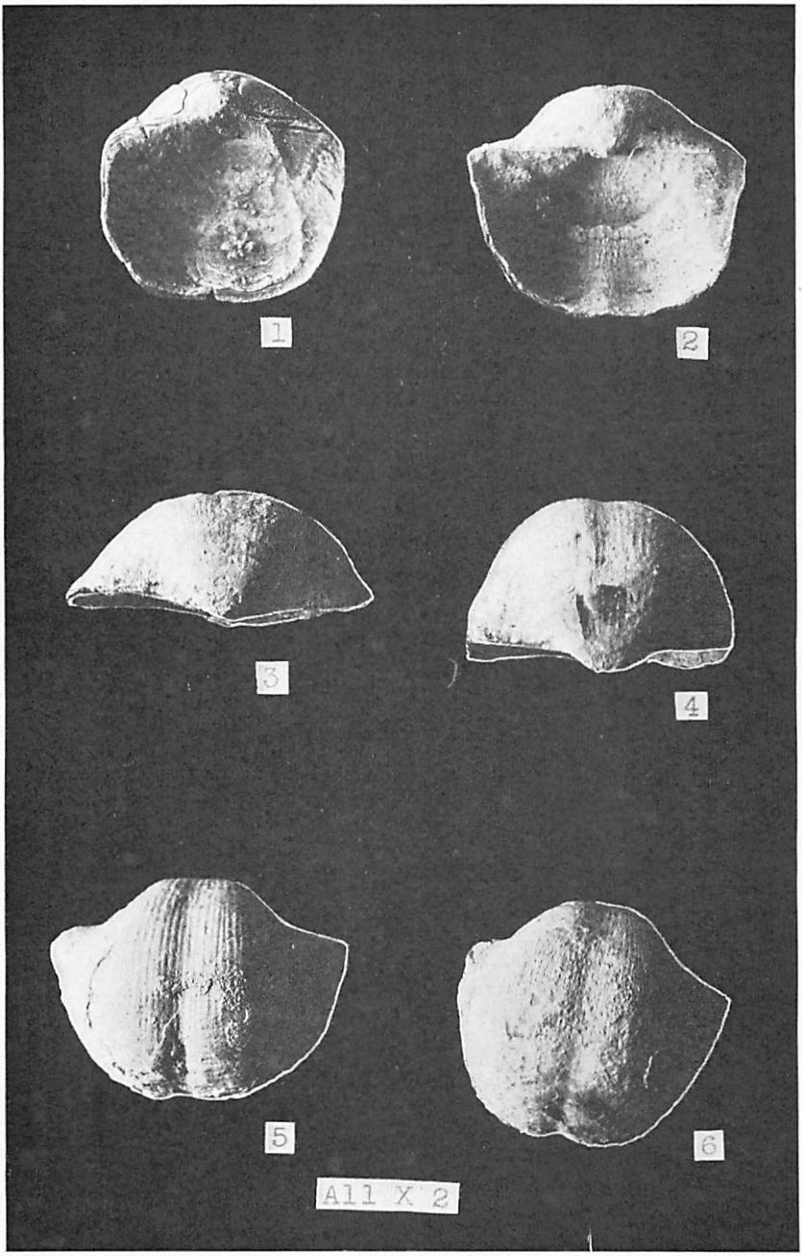

PLATE 17

PLATE 18

Southward Pond formation; fossils from Limestone "B"

Figs. 1, 2. *Lyropora ranosculum.* A slab containing (Fig. 1) a large lyre like support of a Bryozoan belonging to this species, and (Fig. 2) a smaller support of a specimen belonging to the same genus and doubtfully referred to the same species. Collection 50.

Collection 50 is from the middle bed, Limestone "B" of the Southward Pond formation at the north end of Southward Pond, Miss.

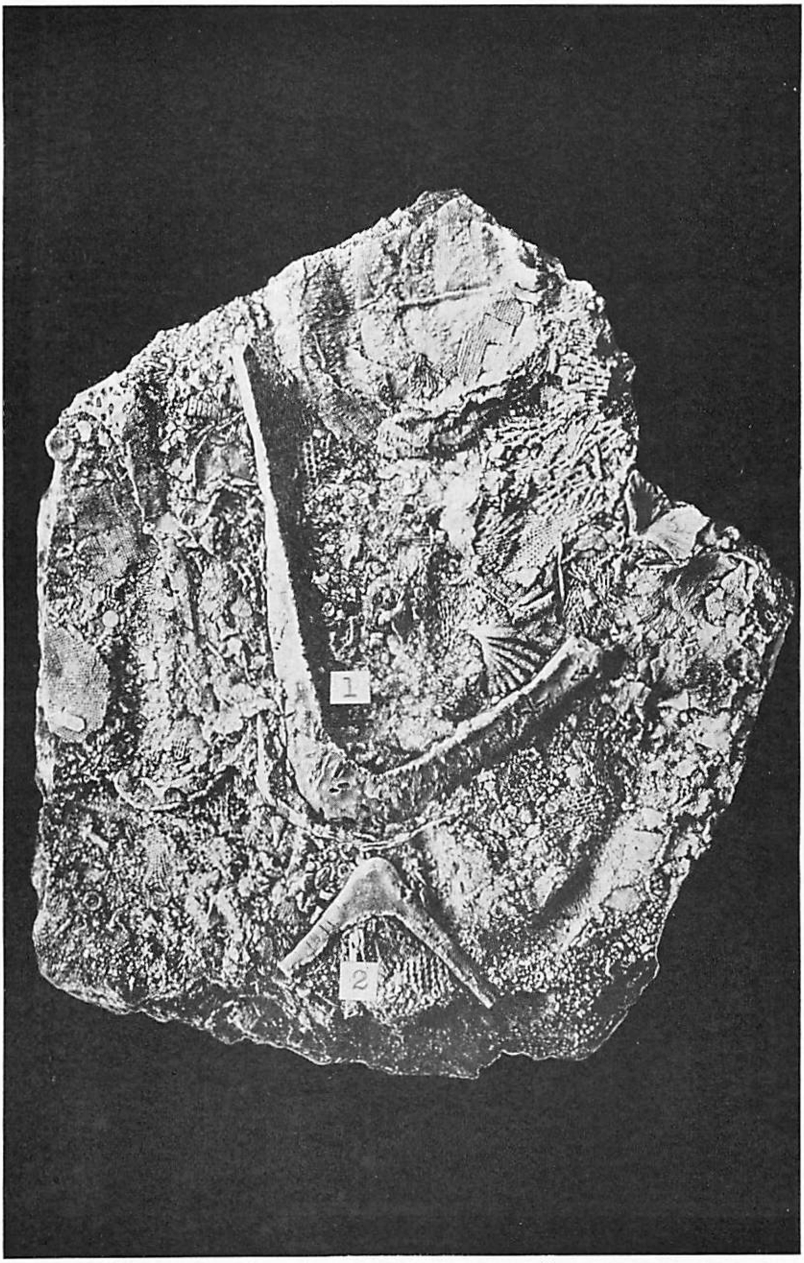

PLATE 18

PLATE 19

Southward Pond formation; fossils from shales above Limestone "C"

Figs. 1-8. *Chonetes chesterensis.* ×2. Fig. 1 is a dorsal view of a specimen; Fig. 2, a ventral view of another; Fig. 3, a dorsal view of another; and Figs. 4-8 are ventral views of still other specimens; all arranged in the order of their size. Collection 57.

Collection 57 is from the shaly topmost member just above Limestone "C" of the Southward Pond formation on Pennywinkle Creek on the Mississippi side of the Miss.-Ala. line. The shales are filled with *Chonetes chesterensis*, which separate from the shales in excellent condition.

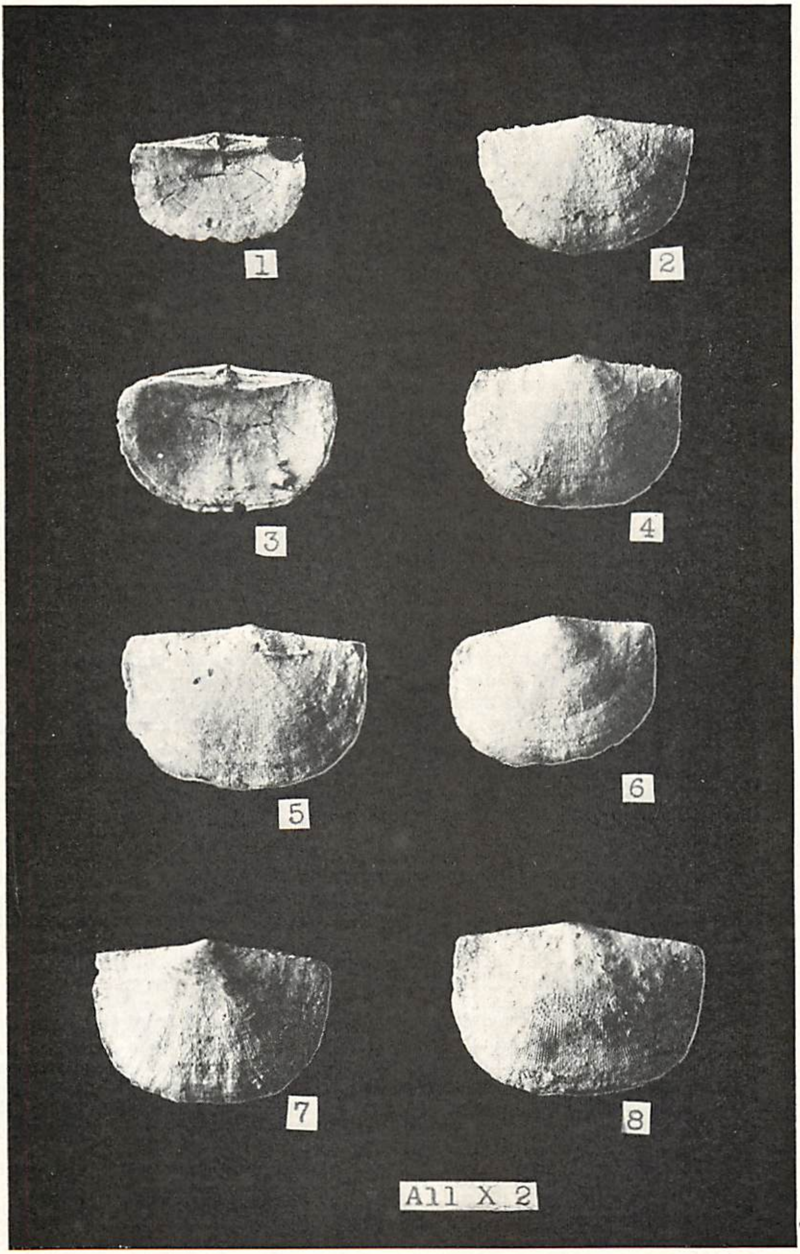

PLATE 19

PLATE 20

Southward Pond formation; fossils from shales above Limestone "C"

Figs. 1, 2. *Spiriferina transversa.* ×2. Fig. 1 shows a brachial valve of a specimen; and Fig. 2, a ventral (pedicle) view of another shell. Collection 57.

Collection 57 is from the shaly topmost member, above Limestone "C" of the Southward Pond formation on Pennywinkle Creek on the Mississippi side of the Miss.-Ala. line.

Southward Spring sandstone fossils

Figs. 3-6. *Productus* (*Diaphragmus*) *mississippiensis*. New Species. ×2. Fig. 3 is an interior view of a brachial valve; Fig. 4, a view of a somewhat compressed pedicle valve of another specimen; Fig. 5, an interior view of a brachial valve at the plane where the pedicle valve so commonly fractures; Fig. 6, a view of the somewhat deformed pedicle valve or still another specimen.

The individuals of this Productid are medium in size and more or less quadrate in outline. As the illustrations show, the characteristic features of this species are the conspicuous radiating ribs (costae) on a somewhat quadrate medium-sized Productid.

The pedicle valve expands very gradually from the beak toward the anterior end in a fairly uniform curve. It is divided into two lateral parts by a medium but definite median groove or sinus, which is uniformly developed from a point near the beak to the anterior end. It has small ears which protrude conspicuously as a result of their abrupt departure from the main curvature of the shell. The valve is completely covered with appropriately developed radiating ribs which are nevertheless prominent. Across the beak, it has a few indistinct concentric wrinkles which are more fully developed on the sides next to the ears.

The brachial valve is known only from interior views. It is only slightly concave in the posterior half, but it bends abruptly forward in the anterior half to conform to the outline of the opposite valve. It is, as the pedicle valve, covered with prominent radiating ribs, which increase in number by both bifurcation and intercalation. It has, on the anterior half, concentric wrinkles more fully developed than those on the pedicle valve.

Although not so evident in the deformed specimens illustrated, *P. mississippiensis* approaches Girty's *P. gallatinensis* in size. outline, and primness, but differs from it in having a deep, narrow, well defined sinus. So far as known, the shell thus differs from all illustrated and described Productids, and must, accordingly, be given a new name. Collection 48.

Collection 48 came from blocks of sandstone float from the Southward Spring formation at the north end of Southward Pond, Miss.

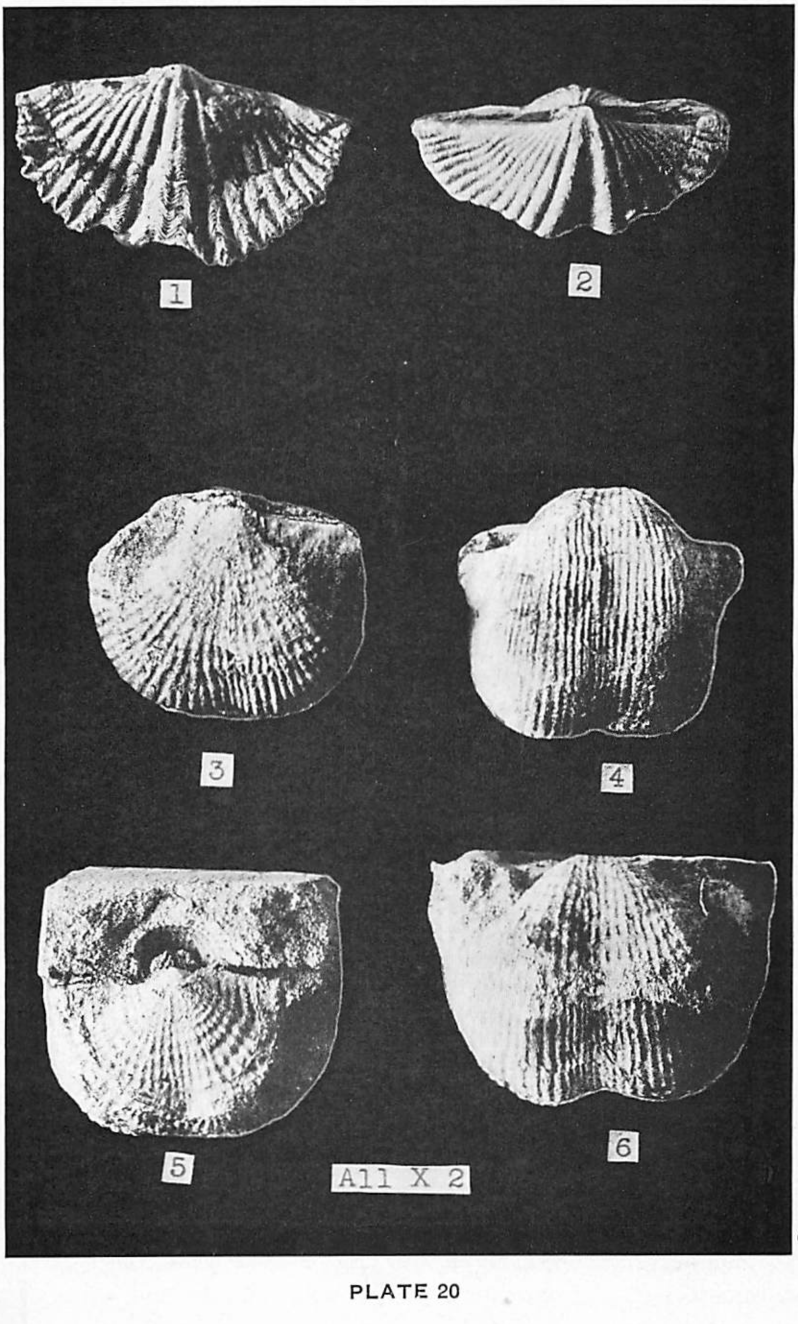

PLATE 20

Interval	47.0
"Lower limestone." Massive layer of crystalline and fossiliferous limestone, which is finer than the "Upper limestone" (Collection 44)	2.0
Interval, covered, to the water level of Bear Creek at the base of the terrace	15.0

List of fossils collected at the terrace on Bear Creek a mile or so above Southward Bridge

SOUTHWARD BRIDGE FORMATION, "UPPER LIMESTONE":

Collection 45:

Crinoidea
- Stem segments

Bryozoa
- Fenestella tenax

Brachiopoda
- Camarophoria explanata
- Orthotetes kaskaskiensis
- Productus inflatus
- Productus ovatus
- Spirifer (Brachythyris) chesterensis
- Spirifer increbescens
- Spirifer leidyi

Vertebrata
- Fish teeth

SOUTHWARD BRIDGE FORMATION, "LOWER LIMESTONE":

Collection 44:

Bryozoa
- Fenestella sp.

Brachiopoda
- Cliothyridina sublamellosa
- Orthotetes kaskaskiensis
- Productus ovatus
- Productus sp., cf. inflatus
- Spirifer increbescens
- Spirifer leidyi

Pelecypoda
- Myalina congeneris

Arthropoda
- Phillipsia sp.

The last exposure of the Southward Bridge formation in Bear Creek is near the up-stream limit of the composite section where the "Upper limestone" lies 15 feet above the flood plain. The Highland Church sandstone varies from 2.5 to 25.0 feet in thickness along these stretches of Bear Creek. Perhaps this variation in thickness has resulted largely from the erosion of the top portion of the member. Farther up the valley the variation in thickness is due in part to the lenticularity of the sandstone itself.

The lower member of the Forest Grove formation has a thickness of something like 90 to 100 feet. Thus far no description of this member has been given, for the reason that there are no exposures of it. Up-stream from the composite section are a series of short sections in different ones of which different parts of the member are exposed. By presenting these some idea of the constitution of the member may be gained.

Section of Bear Creek valley just above the J. Hugh Taylor home

Tuscaloosa formation		......
Sand and gravel	......	
Forest Grove formation, total		43.1
Highland Church sandstone member. Massive buff quartzose sandstone, which forms the prominent cliffs of Bear Creek	21.0	
Interval, covered	8.0	
Shale, sandy. To top of small falls	3.1	
Sandstone, shaly brownish gray, which contains a few fossils	6.5	
Sandstone, shaly, or in one layer	1.0	
Shale blue clay, which weathers beneath the beds above. Fossiliferous. (Collection 41 consists of impressions of Brachiopods and Pelecypods). To base of small falls	3.5	

Section of Bear Creek valley about one-half mile above the J. Hugh Taylor home and just below the Fish Camp house

Tuscaloosa formation, total		38.0
Gravel, coarse and pudding stone	38.0	
Forest Grove formation, total		92.7
Highland Church sandstone member. Massive buff quartzose cliff-forming sandstone, the base of which is extremely fossiliferous (Collection 42, basal two feet)	27.0	
Shale, sandy, to shaly sandstone, which is slightly wavy and gray to yellow in color	9.7	
Sandstone layer of yellowish brown (Collection 43, contains one winged Pelecypod)	1.0	
Interval, covered; to water level of Bear Creek	55.0	

List of fossils from Bear Creek about one-half mile above the J. Hugh Taylor home

HIGHLAND CHURCH SANDSTONE MEMBER:

Collection 42:

- Crinoidea
  - Stem segments
- Bryozoa
  - Fenestella (?) sp.
- Brachiopoda
  - Composita subquadrata
  - Impressions of other forms
- Pelecypoda
  - Deltopecten (?) sp.
  - Leda nucleiformis
  - Impressions of many others
- Gastropoda
  - Impressions of many

Section of Bear Creek valley at the Fish Camp house

Forest Grove formation, total		105.5
Highland Church sandstone member. Massive buff quartzose sandstone; practically one layer of cliff-forming stone	29.0	

PLATE 21

Southward Spring sandstone fossils

Fig. 1. *Spirifer (Brachythyris) chesterensis.* ×2. An internal impression of a brachial valve of a specimen belonging to this beautiful species. Collection 48.

Collection 48 is from a block of sandstone float from the Southward Spring sandstone at the north end of Southward Pond.

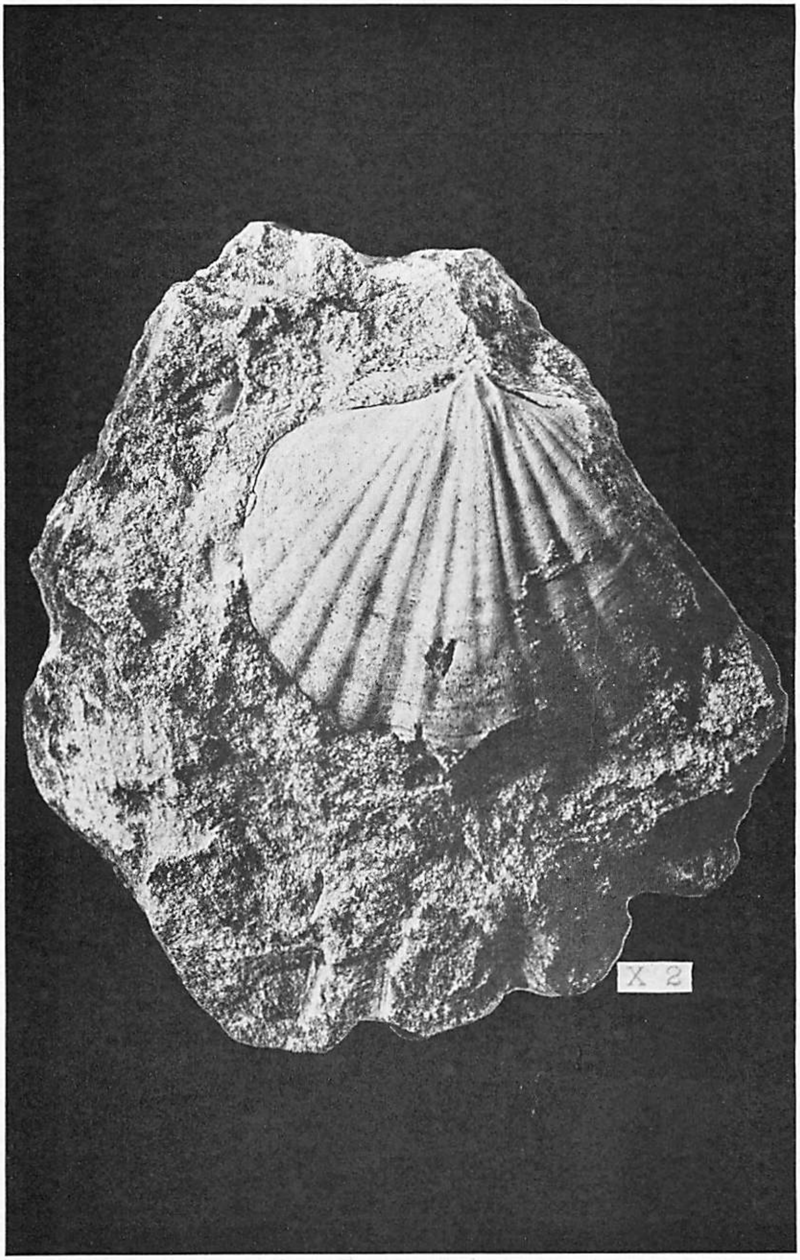

PLATE 21

Interval, covered	15.0
Sandstone, medium to shaly bedded brownish gray, some layers of which are cross bedded or rather cross laminated; the cross bedding planes being marked by yellow iron stains	7.5
Interval, covered; to water level of Bear Creek	54.0

By combining the last three sections, the upper fourth (22.5 feet) of the lower member of the Forest Grove formation, is seen to consist largely of clay shales, sandy shales, and shaly sandstones, though there is one layer of sandstone one foot in thickness and possibly a second layer of the same thickness. Judging from the nature of the topography, the remaining interval of 65 or 70 feet probably consists of the same kind of material. Certainly there is no evidence of a massive cliff-forming sandstone like the Highland Church sandstone member. When the cliff scarps of the Highland Church sandstone and of the "Upper limestones" are jointly considered the conclusion is almost inevitable that there is no thick-bedded sandstone in the lower member of the Forest Grove formation.

The great bends or intrenched meanders of Bear Creek directly above Highland Church were not followed entirely, but both walls of the valley were visited at a sufficient number of places to show that the Highland Church sandstone constitutes the top vertical cliffs of the gorge or canyon-like valley throughout these stretches. At the Fish Camp the Highland Church sandstone member, as shown in the section of that place, is 29 feet thick. Farther upstream at a point approximately two and one-fourth miles below the Dennis Bridge, it is 19 feet thick; and about one and three-fourths miles below the bridge, it is 15.5 feet thick and still maintains its vertical cliffs. The sandstone continues to decrease in thickness as one follows it up-stream. About one and one-half miles below the Dennis Bridge it is only 11 feet thick, and above a covered interval of 25.5 feet is another sandstone, two feet in thickness. About one mile below the bridge the sandstone seems to be only four feet in thickness, perhaps less, as illustrated by the following section:

Section of the small stream about one mile below Dennis Bridge (SW¼, Sec. 7, T. 6S., R. 11E.).

Tuscaloosa formation, total		15.0
Gravel	15.0	
Forest Grove formation, total		38.1

Sandstone. Layer of massive resistant yellowish white or buff pure quartz sandstone, which contains peculiar fucoid-like markings arranged in a series of sub-conical, slightly embracing units (Collection 38 contains plant impressions only)	2.0
Interval, covered	20.0
Highland Church sandstone. Massive resistant sandstone which splits into two or three layers and which is ripple marked and fossiliferous (Collection 39 contains *Productus sp.*, *Sulcatipinna arkansana* and impressions of other forms. Its base lies below the stream where the highway crosses over it. At the crossing the layer is 1.3 feet thick; near the mouth of the stream where blocks of it have slumped into Bear Creek it is 4.0 feet thick and fossiliferous. The layer dips down the small stream toward Bear Creek. Thickness from 1.3 feet to	4.0
Interval, covered at Bear Creek. At the road crossing a water pit had been sunk into the upper 4.5 feet of the interval. Though the pit was filled with water, the dump showed the material to be largely bluish black clay shale and subordinately shaly sandstone. Total thickness	8.0
Sandstone, hard laminated	0.3
Shale, blue clay, and a few thin layers of sandstone	2.4
Sandstone, thin bedded hard bluish gray; to water level of Bear Creek	1.4

The Highland Church sandstone member thus seems to decrease until it is only 1.3 to 4.0 feet in thickness at the place where it is last seen above the flood plain of Bear Creek. The two most plausible causes of this decrease in thickness up-streamward are: (1) lenticular deposition of the sand, that is, less here than farther down stream; and (2) deposition of finer sediments here while coarse sand was accumulating farther down stream. In the latter case some of the clay shale, sandy shale, and shaly sandstone of the lower interval of 12.1 feet was being deposited at the same time as the sandstone farther down stream, and, therefore would constitute a true part of the Highland Church member. Unfortunately the exposures are not sufficiently clear to determine the actual history. Inasmuch as the two-foot layer of sandstone bearing the fucoid markings is the youngest bed and is connected with the Highland Church sandstone member only by a covered interval of 20 feet, both the layer of sandstone and the covered interval are provisionally referred to the Forest Grove formation.

The upper layer (two feet) of sandstone lies at flood plain level and blocks of it lie in the channel of Bear Creek directly below the Dennis Bridge. At the upper side of the Bridge the layer is 13.4 feet above water level, that is, about flood plain level. Beyond the bridge for some distance there are no exposures of Paleozoic rocks.

The stratigraphic sequence of the Southward Bridge and Forest Grove formations was determined largely on the east side of Bear Creek between Southward Bridge and Dennis Bridge. The formations have a similar distribution on the west side. In fact the Highland Church sandstone member is excellently developed about Highland Church east of Tishomingo City. On the west side, too, the Forest Grove sandstone is exposed farther up stream than on the east side. For example, a small interval of sandstone (two feet) is exposed on the T. N. McNutt farm (SE¼, Sec. 13, T. 6S., R. 10E.) and large blocks of sandstone (two or three feet) on the Robert Epps farm (NE¼, Sec. 25, T. 6S., R. 10E.), a maximum distance of more than a mile above the Dennis Bridge. An unverified report places the Paleozoic outcrop a mile still farther up stream.

On Cedar Creek (Little Bear of the Alabama reports) and its tributaries the Forest Grove formation does not extend so far south, the southernmost point being at the S. L. Russell saw mill (SE Corner W½ NE¼, Sec. 4, T. 6S., R. 11E.) on Spring Branch about 1.5 miles above its mouth. From the mill the line of exposures extends north one-half mile to the Alabama line. Along both branches of Holly Branch the Highland Church sandstone particularly forms beautiful cliffs for a distance of 1.5 miles above its mouth. These exposures connect in a broad curve with the outcrops on Bear Creek. At the highway crossing of Holly Branch near its mouth the Forest Grove sandstone beneath the Highland Church sandstone member is very fossiliferous (Collection 62), *Deltopecten batesvillensis* being especially abundant.

List of fossils from Holly Branch of Cedar Creek

FOREST GROVE FORMATION:
- Collection 62:
  - Bryozoa
    - Lyropora divergens
  - Brachiopoda
    - Crania chesterensis
    - Composita subquadrata
    - Eumetria verneuiliana
    - Productus sp.
    - Spirifer increbescens
    - Spiriferina spinosa
    - Spiriferina transversa
  - Pelecypoda
    - Deltopecten batesvillensis
    - Leda sp.
    - Schizodus depressus
  - Gastropoda
    - Impressions

On the east side of Cedar Creek, cliffs of the Highland Church sandstone extend northward from the Alabama line and Cedar Creek valley intersection (Sec. 34, T. 5S., R. 11E.). At the state line about one mile north of this place the valley is sufficiently deep to expose one of the Southward Bridge limestones beneath the sandstones of the Forest Grove formation. At various places along the state line sandstone and limestone of these two formations and possibly of the Southward Spring sandstone are exposed to the point of intersection of the state line and the east side of Cedar Creek valley, just above the stream's confluence with Bear Creek, thus completing the distribution of the Paleozoic rocks in the Tennessee River drainage systems.

The remaining exposures of the Paleozoic beds, consisting of the Southward Bridge and Forest Grove formations, are confined to the southwest quarter of Tishomingo County where they extend along Mackeys Creek and tributaries, which drain into the Tombigbee River and thence into the Gulf. The northernmost two of these exposures are in the vicinity of Tishomingo City. On the J. H. Bickerstaff land (SE¼, Sec. 22, T. 5S., R. 10E.), about one-half mile south of the town, is a small ledge of sandstone, 1.5 feet in thickness, which probably belongs to the Highland Church sandstone member of the Forest Grove formation. At the site of the old King water mill (SE¼, Sec. 16, T. 5S., R. 10E.) on King Branch of Mackeys Creek, about one mile north of west of the town, is an interval of four feet of Forest Grove sandstone, which outcrops along the branch for about one-fourth mile. About one mile to the southwest of the old mill site in the channel of a small branch of Mackeys Creek on the William C. Butler farm (SE¼, Sec. 20, T. 5S., R. 10E.) are blocks of Forest Grove sandstone practically in position.

The two prongs of McDougle Creek, tributary of Mackeys Creek, cross the Illinois Central Railway on each side of Neil Station. The Highland Church sandstone outcrops on the west side of the tracks at both prongs and also just east of the tracks on the south prong, where it measures nine feet in thickness and dips directly east five feet in 100 feet. The exposure just west of the tracks at the south prong has the following section.

Section of the headwaters of McDougle Creek, tributary of Mackeys Creek, at the Illinois Central Railway just south of Neil (Sec. 3, T. 6S., R. 10E.)

Tuscaloosa formation		15.0
Interval covered to track level	8.5	

PLATE 22

Southward Bridge formation fossils

Figs. 1, 2. *Camarotoechia purduei.* ×2. Fig. 1 is a view of a pedicle valve; and Fig. 2, a view of a brachial valve and the pedicle opening in the beak of the pedicle valve of still another specimen. Collection 47.

Figs. 3-6. *Liorhynchus carboniferum.* ×2. Figs. 3 and 4 are internal casts of two pedicle valves; Fig. 5 is a lateral view of another specimen; and Fig. 6, a dorsal (brachial) view of still another specimen. Collection 47.

Collection 47 is from the thin, 0.7 foot, lens of limestone in the basal part of the Southward Bridge formation at Southward Bridge, Miss. Casts of *Camarotoechia purduei, Liorhynchus carboniferum,* and especially of a species of *Composita* are preserved by the hundreds or even hundreds of thousands in this thin lens of limestone, stained red by a small amount of iron oxide.

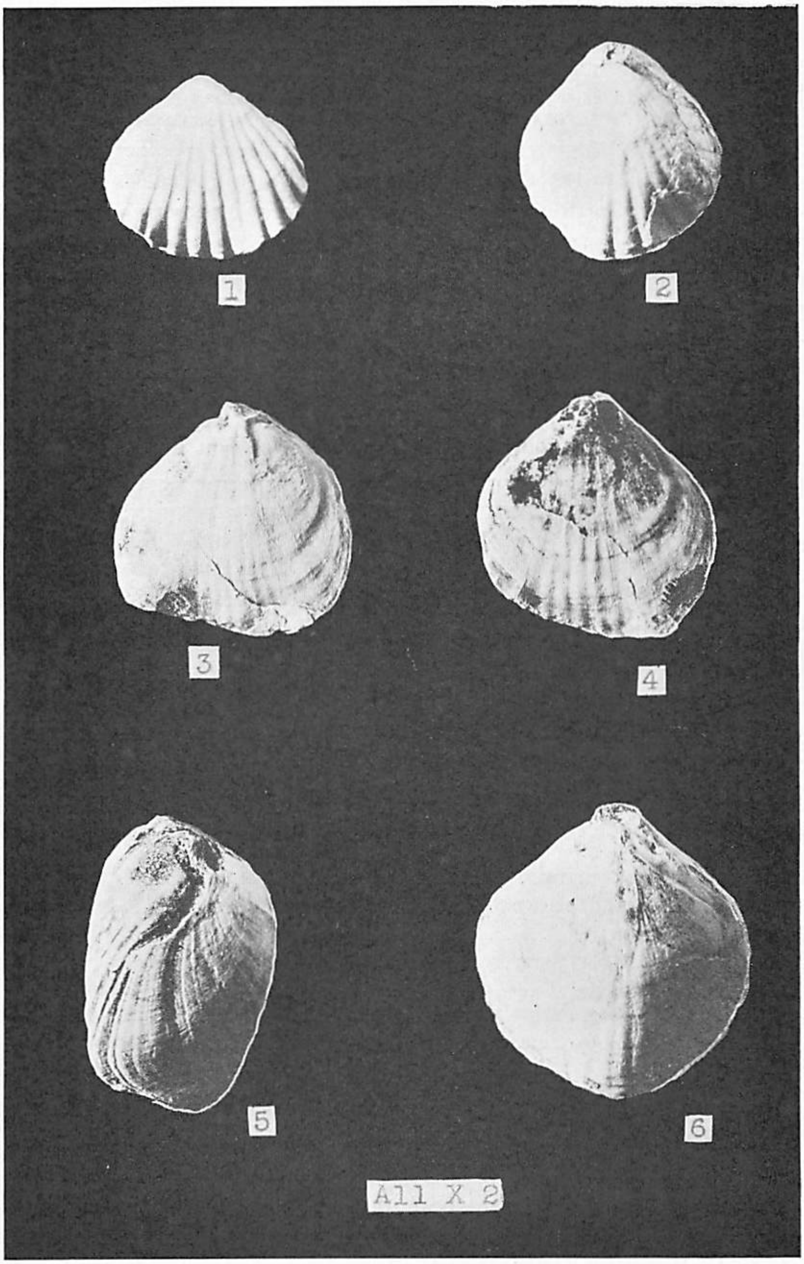

PLATE 22

Sandstone, irregular highly ferruginous yellow brown to black, which contains a few pebbles. Though unconformable it seems to conform in outline to the rounded weathered blocks of sandstone below	6.5	
Highland Church sandstone member		2.0
Sandstone, massive regular bedded medium grained white and buff. Across the tracks 9.0 feet of this sandstone is exposed	2.0	

Two to 2.5 miles west and down McDougle Creek, where the two following sections were measured, are exposures of Southward Bridge limestone, the only place in the Mackeys Creek drainage systems where beds other than the Forest Grove sandstone were found.

Section of McDougle Creek one-half mile east of the Underwood Bridge

Southward Bridge formation, total		7.0
Limestone, massive crystalline; contains Bryozoa and *Pentremites*	3.0	
Sandstone, thin to shaly bedded; dips down stream	4.0	
Undetermined		2.0
Interval, covered	2.0	

As stated in the section, the beds dip down stream so that the limestone lies at water level in the Underwood Bridge section, next to be presented. About 80 feet above the limestone is a place on the Horton property where Mr. L. E. Crowley indicated he obtained blocks of sandstone for a barn foundation, but no blocks were found in the present survey. The relative position of the two beds points to the blocks of sandstone as belonging to the Highland Church sandstone and to the limestone as belonging to the upper limestone of the Southward Bridge formation.

Section of McDougle Creek at the Underwood Bridge (NW¼, Sec. 5, T. 6S., R. 10E.)

Tuscaloosa formation, total		63.0
Sand, yellow and brown; slightly stratified at the base	63.0	
Paleozoic beds, total		36.0
Shales, green clay, partly exposed; they probably belong to this group	16.5	
Interval, covered with sand and gravel	16.5	
Southward Bridge limestone. Brown crystalline limestone, containing Crinoid stems; to water level	3.0	

Some three or four miles farther down stream is the next known exposure of the Paleozoic beds. Here on the George Harris farm (SW¼, Sec. 24, T. 6S., R. 9E.) the Highland Church sandstone forms a cliff about 20 feet high on the east side of Mackeys Creek about one-fourth mile from the stream. The cliff of sandstone can be followed down stream for more than a mile to Bay Springs, where the following section was measured.

Section of the east bank of Mackeys Creek at the Bay Springs Bridge (Center, Sec. 26, T. 6S., R. 9E.)

Recent, total		12.0
Overburden of mantle rock, which varies from a few inches to 10 or 12 feet	12.0	
Highland Church sandstone, total		25.0
Sandstone; massive medium-grained buff. A good building stone	6.0	
Sandstone, massive medium-grained buff. It is broken by two prominent joint systems; one, N 45° W.; and one, N. 45° E. A good building stone	19.0	
Undetermined		12.0
Interval covered to water level of Mackeys Creek	12.0	

Beginning a short distance above the Bay Springs Bridge, both branches of Mackeys Creek flow through a gorge of Highland Church sandstone, which stands in vertical cliffs on each side of the branches. At the bridge the united waters continue their flow between even higher cliffs of sandstone for a quarter of a mile or more. The two smaller gorges uniting to form the larger gorge constitute one of the most beautiful and picturesque spots in the State of Mississippi, which ought to be set aside forever as a State Park.

The Highland Church sandstone reaches a maximum thickness of 30.5 feet on the west side of the gorge. A short distance below the bridge, the top of the sandstone on the east side dips one foot in 110 feet S. 10° W., thus preparing for the final plunge beneath younger beds about 1.5 miles farther south. About this place the sandstone is exposed in the channel of a small stream on the east side of Mackeys Creek. A little farther south it is similarly exposed in the channel of a small gulley on the west side of Mackeys Creek and in the creek itself (NW¼, Sec. 2, T. 7S., R. 9E.), within a quarter of a mile of the Prentiss County line.

Rock Creek empties into Mackeys Creek near the Prentiss County line and near the southwest corner of Tishomingo County. As the name suggests, consolidated rock outcrops along Rock Creek, and along its tributaries as well. Near the Oscar Hughes home (NE¼, Sec. 21, T. 6S., R. 10E.), about 1.5 miles southwest of Dennis, the Highland Church sandstone is exposed in a number of places and has been quarried to a slight extent at two or three of them. Down stream to the south some two miles from the Hughes home, the sandstone outcrops in the roadway where it crosses a branch of Rock Creek; and a short distance farther down stream, it outcrops at the Trollinger old mill site in Rock Creek itself. The following sections were measured at these two places.

Section in the roadway where it crosses a branch of Rock Creek on the Ambrus Vinson farm (NW¼, Sec. 33, T. 6S., R. 10E.)

Tuscaloosa formation		......
Gravel and sand	......	
Highland Church sandstone member, total		6.5
Sandstone, thin to shaly bedded	2.0	
Sandstone, massive layer of medium-grained gray	1.5	
Sandstone, medium-grained buff to yellow thin bedded	3.0	
Undetermined		5.5
Interval covered to flood plain level	5.5	

Section of the east side of Rock Creek at the A. J. Trollinger old mill site (near the last section.)

Tuscaloosa formation		......
Gravel and sand	......	
Highland Church sandstone member, total		25.0
Sandstone, thick bedded medium-grained gray and buff	4.0	
Interval covered	3.0	
Sandstone, massive bedded medium grained gray and buff	5.0	
Sandstone, medium to thin bedded gray	4.0	
Sandstone, massive layers of medium-grained hard; the surface is rippled marked. To water level at dam site	9.0	

Some of the Highland Church sandstone was blasted out in the construction of the dam. From general appearance there is little doubt that it would make an excellent building stone.

Some two miles farther down stream the sandstone outcrops in rather prominent cliffs for a stretch of a mile or more along Rock Creek and its tributaries. Huge blocks break loose, thus forming another rugged and beautiful section after which the stream was named. At the mouth of one of the tributaries of Rock Creek in this stretch was measured the following section, the last one of the area.

Section at the mouth of Tynes Branch of Rock Creek on the John Hood farm (NW¼, Sec. 1, T. 7S., R. 9E.)

Tuscaloosa formation		......
Gravel and sand	......	
Highland Church sandstone member, total		34.0
Sandstone, massive medium-grained gray	6.5	
Sandstone, massive bedded medium-grained gray, which forms prominent cliffs. It has been used for grindstones, chimneys, house foundations, and similar purposes	22.0	
Sandstone, medium-grained and medium bedded. To branch level	5.5	

SOUTHWARD BRIDGE AND FOREST GROVE FAUNAS AND CORRELATION

The Southward Bridge formation is fossiliferous; the shales are sparingly so, whereas the limestones are exceedingly fossiliferous. Although the exposed part of the Forest Grove formation is exclusively sandstone and shale, it is contrary to prevalent opinion, fossiliferous. Certain layers are a mass of small Gastropods and Pelecypods. Unfortunately all the fossils are in the form of external and internal impressions, so that specific identification is well nigh impossible in most cases.

The lenticular layer, less than one foot in thickness, near the base of the Southward Bridge formation at the type locality is literally filled with Brachiopod shells, most of which separate from the stone as internal molds. *Camarotoechia purduei* and *Liorhynchus carboniferum* are abundant. Still more so is the form identified as *Composita sp.,* hundreds of whose internal molds can be obtained in a few minutes. A number of species of Pelecypods are represented, though by only a few individuals. None of the forms of the "Lower limestone" and of the "Upper limestone" of the same formation merit special attention, save *Spirifer* (*Brachythyris*) *chesterensis,* a form closely related to *S. subcardiiformis,* which in the Mississippi Valley is largely or exclusively restricted to beds no younger than the Salem limestone. Likewise no special mention need be made of the Forest Grove forms.

The fauna of the thin lenticular layer of limestone in the basal part of the Southward Bridge formation is closely related to the faunas of the Moorefield shale and Batesville sandstone in Arkansas, located on the other side of the Mississippi embayment. The same relationship has been observed in other Mississippian faunas of the two regions. The faunas of the remaining part of the Southward Bridge formation and of the Forest Grove formation have no outstanding characteristics other than that they are strongly Chester in the main.

VII SUMMARY

The Paleozoic rocks of Mississippi were recognized as such by the second (Harper) State Geological Survey. In the report, dated 1857, they were referred to "the lower part of the Carboniferous, consisting of a portion of the Mountain (Mississippian) limestone, which extends into Mississippi from the State of Alabama" (p. 34). By means of their fossils the third (Hilgard) survey placed "the greater portion of the outcrops within the limits of the Warsaw and Keokuk limestones of the Iowa Report" and recognized the possibility "that lower and perhaps even higher groups of the sub-Carboniferous series may hereafter be found to be represented" (1860, p. 47). Also by means of fossils, which were sent east for identification, the next survey (Crider) recognized Devonian beds of New Scotland age. Beginning with "the chert" the beds, as listed in Bulletin 283 of the U. S. Geological Survey (1906, pp. 7-12), were divided into the Tullahoma (Lauderdale chert), St. Louis limestone, and Chester, largely after McCalley's Alabama report. In Bulletin 12 of the State Geological Survey (1915) all the older beds were named Yellow Creek, and the three younger divisions were called Lauderdale chert, Tuscumbia limestone, and Hartselle sandstone (pp. 29, 51-55), as in the Alabama report. In these various reports and on their maps the distribution of the Paleozoic beds was reported to cover parts of Tishomingo, Prentiss and Itawamba counties.

As a result of the present survey the following divisions of the Paleozoic rocks are recognized and the beds are shown to be confined exclusively to Tishomingo County—Plate 1. Except for New Scotland, all the formation and member names are new.

MISSISSIPPIAN SYSTEM:
- **Chester series**
  - **Forest Grove formation**
    - **Highland Church sandstone (member)**
    - **Shale and sandstone**
  - **Southward Bridge formation**
    - **Limestone, upper**
    - **Shale and sandstone**
    - **Limestone, lower**
    - **Shale**
  - **Southward Spring sandstone**
  - **Southward Pond formation**
    - **Pond limestone "C"**
    - **Shale**
    - **Pond limestone "B"**
    - **Shale**
    - **Pond limestone "A"**

Shale
Allsboro sandstone
Alsobrook formation
Cripple Deer sandstone (member)
Shale
Limestone
Lower (Iowa) series
Iuka formation (chert)
Carmack limestone

DEVONIAN SYSTEM:
Upper series
Whetstone Branch shale
Oriskanian series
Island Hill formation
Helderbergian series
New Scotland limestone

The exposed part of the New Scotland, named after the New York formation, is about 40 feet in thickness and consists entirely of massive limestone. The lower half of the formation is filled with beautifully preserved fossils; the upper half is largely barren of fossil forms. In the lower half, *Tentaculites gyracanthus* is, perhaps, the most abundant form, followed closely by *Anoplotheca concava*. Scarcely less rare is *Stropheodonta beckii*. *Leptaena rhomboidalis* is very common. Perhaps most striking are the numerous tail shields of *Dalmanites pleuroptyx*. Although the forms in the various lists of the formation in the report proper are not confined to the New Scotland formation and even though its most characteristic fossil, *Spirifer macropleurus*, is not present, nevertheless, the formation is referred without question to the New Scotland. This corroborates the conclusions of earlier workers.

The Island Hill formation is named from the beautiful rounded isolated hill on Yellow Creek, about three miles above its mouth. The formation, which is confined largely to the type locality, consists of a thin basal limestone conglomerate and a few layers of more or less cherty and siliceous limestone, having a total thickness of only three feet. Perhaps the most conspicuous feature is the cherty upper layer, from whose weathered surface *Meristella sp.* and *Schuchertella becraftensis*, as well as other forms protrude. The formation contains *Meristella lata*, *Stropheodonta magnifica*, *Dalmanites micrurus*, *D. multiannulatus*, *D. stemmatus* and other forms. Though the fauna is closely related to the New Scotland fauna, still the Island Hill forms had evolved notably, some acquiring the sturdy aspect of the hardy Oriskany forms, if, in fact, they had not already completely developed into those forms. In proportion to the size of its shell, *Spirifer cyclopterus* or its descendants had developed huge adductor muscles, so characteristic a feature of the Oriskany Spirifers. Similar had been the development of *Rhipodomella oblata* into *R. musculosa* and of an older *Stropheodonta* into *S. magnifica.* For these reasons the Island Hill formation is referred to the lower Oriskany.

The Whetstone Branch formation, named from the picturesque tributary of the Tennessee, is largely a black shale, though it does contain sandy shales and a few, mostly thin, sandstones. In a number of places the formation is represented only by a rather prominent sandstone layer, which has a conglomeratic base, and in such places rests unconformably on older formations. In other places typical black shales underlie and overlie it in such relations as to show that the layer of sandstone is separated from the underlying shales by a contemporaneous erosion surface rather than by a true unconformity. Of course the lowest part of the Whetstone Branch formation at every place in the area rests unconformably on older beds. Likewise it is separated from the overlying beds by a pronounced unconformity. Among a few other fossils are *Lingula sp.* and *Tentaculites sp.,* the latter form not being known in beds younger than the Devonian. Because of the fossils and especially because of its unconformable relation to other beds of more definite age, the Whetstone Branch formation is referred to the Devonian. It belongs, therefore, to the lower and greater part of the Chattanooga shale of the type locality. In additional support of this correlation is the work of Morse and Foerste who showed that the Bedford and Berea formations thin southward from the Ohio River, thus allowing the overlying Sunbury black carbonaceous shale to rest almost directly on the underlying Ohio black carbonaceous shale at Irvine, Kentucky. In the older reports, the Ohio shale or the Chattanooga shale of this place consists, therefore, of the Ohio, Bedford, Berea, and Sunbury formations. Swartz, the younger, has, in a similar manner, traced the beds still farther south in Tennessee, and finds that at Chattanooga nearly the whole of the black shale belongs to the Cleveland (Ohio) and the thin upper part to the Bedford, Berea, and Sunbury formations. He finds also that the black shale of central and western Tennessee is older than Bedford. Thus the work of Morse and Foerste, of Swartz, and of the present writer mutually support one another and the conclusions reached as to the age of the Whetstone Branch shale.

The Carmack limestone is named from a small stream (containing a 60 foot fall) tributary to the Tennessee River north of Whetstone Branch. The formation is a uniformly thin bedded brownish or bluish gray limestone, which breaks into thin shaly layers on exposure to the elements. It has a maximum thickness of more than 100 feet. As stated above, it is separated from the underlying formations by a pronounced unconformity. It is also separated from the overlying beds by a great unconformity. Toward the east in Alabama it becomes more cherty and grades into the chert of the Lauderdale formation of that state. From its meager fauna, particularly the association of *Productella* and *Productus* in the absence of a strong Carboniferous phase, the Carmack limestone is known to be Kinderhook early Mississippian, in age. It has, therefore, been taken from the Devonian and referred to the Mississippian, in which series it is completely included in the Lauderdale formation of the Alabama report. Unlike that formation, however, it does not extend so high. As stated, it is separated from the overlying formation by a great unconformity, and it is in itself a complete stratigraphic unit.

The Iuka terrane is named from the county seat of Tishomingo County. It has a wide distribution in this county along the Tennessee Valley and its tributaries. In Mississippi it is almost exclusively chert and pulverulent silica, largely the result of limestone leaching and silica replacement. Practically everywhere blocks of chert in great numbers are set free by weathering, thus concealing the stratified nature of the beds. At one or two places in Mississippi and at a number of places in Alabama it contains limestone as well as chert. Huge *Orthotetes keokuk* in places in Mississippi and *Lithostrotion canadense* in places in Alabama, as well as other forms prove respectively the Keokuk and St. Louis age of portions of the Iuka terrane at such localities. In a similar manner other fossils at other places prove the Salem age of a part of it. From all such evidence, it is more than probable that the terrane extends almost from the Burlington, through the Keokuk, Warsaw, Salem, and St. Louis to the Ste. Genevieve. Like the other divisions thus far considered, it is separated from the overlying beds by a large unconformity.

The Alsobrook formation takes its name from the Alsobrook homestead and Alsobrook Bridge about which it is excellently exposed. The lower part, varying from a foot or so to eight or ten feet in thickness, is a limestone member, which seems more closely related lithologically to the underlying formation than it does to the rest of the formation to which its fossils show it to belong. The upper part of the formation (70 or 80 feet thick) at the type locality is a clay shale save for a thin layer of sandstone near the middle. A short distance south on Cripple Deer Creek, the upper third of the formation has changed to a sandstone, the Cripple Deer sandstone member. The sandstone is impregnated with a petroleum residue, and is, perhaps, the sandstone which is worked for asphalt in at least one of the quarries farther east in Alabama. In most regions the basal limestone member is filled with *Productus inflatus;* in some places, with *Chonetes chesterensis* as well. In still other localities it contains yet other forms, by all of which its Chester age, rather than its Ste. Genevieve age as maintained by Butts, is established. The remaining portion of the formation is largely barren of fossil forms.

The Allsboro sandstone is named from the small village in Alabama near the Mississippi line. The sandstone is well exposed in many places in the type locality, especially at Bishop Bridge across Bear Creek to the south of the village. Here the formation, 8 feet in thickness, forms a projecting ledge of coarse grained sandstone. In places it is decidedly contorted, thereby differing from most other sandstones of the region. In a few localities it contains a little asphaltic material, and it is, perhaps, one of the sandstones worked for asphaltic road material farther toward the east in Alabama. If the fossiliferous block of sandstone at the north end of Southward Pond came from this formation, then the sandstone contains a few forms among which *Dielasma shumardanum, Productus (Echinoconchus) alternatus,* and *P. inflatus* are rather robust specimens for a sandy environment.

The Southward Pond formation is exposed around the bluffs of Southward or Cypress Pond, which is, perhaps, an old meander of Bear Creek. The formation consists of three beds of limestone designated Pond limestone "A," Pond limestone "B," and Pond limestone "C," in the order of their age. Each limestone is underlain and overlain by an interval of shale or shaly limestone. The shale weathers faster than do the limestones, thus causing the limestone to protrude from the surface where the rest of the formation is covered with mantle rock. Especially is this true of the lower limestone, Pond limestone "A." Another conspicuous feature is its oolitic texture; and still another one, at many places, is its asphaltic content. The lower limestone commonly has a thickness of five to fifteen feet; the others, a foot or so.

The whole formation of limestones and shales, 80 to 100 feet in thickness, is extremely fossiliferous, except for Pond limestone "A," whose forms are mostly comminuted beyond the stage of identification. At many places the shallow sea bottom upon which the basal clay and calcareous sediments of the formation accumulated was a veritable flower garden of Blastoids and Crinoids, amongst which Brachiopods lived in large numbers. The most abundant Blastoids were the *Pentremites*, two or three species of which are represented by hundreds of individuals; and the most abundant Crinoid was *Agassizocrinus dissimilis*. *Zaphrentis spinulosum* and *Composita trinuclea* were also abundant. The conspicuous forms of Pond limestone "B" fauna are the harp-like Bryozoans, *Lyropora ranosculum*, and the plump medium-sized Brachiopod, *Productus lowei*. The uppermost shale is filled with hundreds of large *Chonetes chesterensis*. The fauna on the whole is closely related to the Paint Creek fauna of the Illinois-Kentucky region, which strongly supports the correlation of the Allsboro sandstone with the Bethel sandstone, and of the Alsobrook formation with the Renault, and likewise the drawing of the base of the true Chester at the base of the *Productus inflatus* limestone member of the Alsobrook formation.

A part of the Southward Spring sandstone is excellently exposed at Southward Spring, the type locality, where it is 15 feet in thickness. Perhaps twice this amount more nearly represents its complete thickness. It is an impure shaly sandstone, somewhat calcareous, which breaks down rather readily. The peculiar feature of the fauna, collected from blocks of sandstone occupying the position of the Southward Spring sandstone on the north side of Southward Pond, is the presence of *Spirifer* (*Brachythyris*) *chesterensis* (closely related to *S. subcardiiformis*) and of forms referred to *S. suborbicularis*. These forms are largely or exclusively limited to beds no younger, respectively, than the Salem and Keokuk farther to the north. For a sandstone fauna the forms are robust, but the sea bottom was partly calcareous as is shown by the calcareous material in the sandstone.

The Southward Bridge formation is well exposed in the bluffs of Bear Creek at the type locality, southeast of Southward Spring. The formation consists of a "Lower limestone" and an "Upper limestone" each of which is underlain by a thick interval of shale. It is more than 80 feet in thickness. Near its base is a lens of limestone, less than one foot thick, which is literally filled with internal molds of a few Brachiopods. Among these are *Camarotoechia purduei*, *Composita sp.*, and *Liorhynchus carboniferum*. These Brachiopods, several Pelecypods, and still other forms are so closely related to Mississippian faunas in Arkansas as to warrant the conclusion that the two regions were then united, although they are now separated by the sediments of the Mississippi embayment. None of the fossils of the "Lower limestone" and of the "Upper limestone" of the same formation merit special attention, except *Spirifer* (*Brachythyris*) *chesterensis,* a form closely related to *S. subcardiiformis,* which in the Mississippi Valley is largely or exclusively restricted to beds no younger than the Salem limestone.

The Forest Grove formation is named after the school which is located on top of the terrane near old Mingo Village and Southward Bridge. Since the top member forms typical sandstone cliffs about Highland Church, located east of Tishomingo City, it is proposed to name the member after this church. Nowhere is the other member completely exposed. From the nature of the small outcrops here and there and from the manner of slumping of the huge blocks of the overlying Highland Church sandstone, it is perfectly reasonable to suppose that practically the whole of the lower member, 90 feet in thickness, is composed of clay and sandy shales and shaly sandstones. The Highland Church sandstone member is massive, 25 feet in thickness, and is a typical cliff-forming sandstone. Contrary to prevalent opinion, some of the sandstones and shales of the Forest Grove formation are fossiliferous. Certain layers are a mass of small Gastropods and Pelecypods, all, unfortunately, in the form of external and internal impressions, so that specific identification is well nigh impossible. On Holly Branch of Cedar Creek, however, enough calcareous material has remained to preserve the forms in better condition. Of these *Deltopecten batesvillensis* is extremely abundant. This Pelecypod and other forms show the close relation of this fauna to faunas of the Mississippian beds in Arkansas, on the other side of the embayment. Otherwise the Forest Grove faunas warrant no further consideration except a notice of their strong Chester development.

Briefly the results of the present survey may be summarized in the form of two correlation tables. In the first table the various formational names of the Mississippi (and adjacent Alabama) region are correlated in so far as this can be done in a table. In the second table a correlation of the beds of more widely separated areas has been attempted.

Correlation table of the Devonian and Mississippian formations recognized by the different surveys of the northeast part of the state

Morse 1927	Lowe 1915	Crider 1906	McCalley 1896 (Alabama)	Hilgard 1860	Harper 1857
Forest Grove S'ward Bridge S'ward Spring S'ward Pond Allsboro Alsobrook	Hartselle	Chester	Hartselle	Warsaw	Mt. limestone
Iuka	Tuscumbia Lauderdale	St. Louis Tullahoma	Tuscumbia		
Carmack Whetstone Br. Island Hill New Scotland	Yellow Creek	New Scotland	Lauderdale Black shale	Keokuk	

Correlation table of the Devonian and Mississippian formations of the different states

Standard Weller 1921	Mississippi Morse 1927	Alabama McCalley 1896
Hardinsburg Golconda Cypress Paint Creek Bethel Renault	Forest Grove Southward Bridge Southward Spring Southward Pond Allsboro Alsobrook	Hartselle
Ste. Genevieve St. Louis Salem Warsaw Keokuk Burlington	? Iuka	? Tuscumbia (St. Louis)
Kinderhook Chattanooga	Carmack Whetstone Branch	Lauderdale (Keokuk) Black shale
Oriskany New Scotland	Island Hill New Scotland	

VIII ECONOMIC GEOLOGY*

INTRODUCTORY STATEMENT

Although largely pure science, the foregoing pages are not without their economic value. In them the stratigraphic sequence of the beds and their geographic distribution, which were definitely determined in the field and in the laboratory for the first time, have been fully set forth. Such determination, one phase of the value of which is shown by requests from different petroleum corporations for reprints of an abstract of these pages, constitutes the very foundation for the more specific economic discussion which is now to follow.

Limestone, suitable for agricultural lime and for cement; chert, suitable for road metal and for railway ballast; and silica, suitable for scouring powder and other purposes, are abundant in the region. Bitumen-bearing limestone and sandstone, suitable for asphaltic road and street pavement, exists in small areas; and the presence of such petroleum residue shows rather conclusively that down-dip away from the region of outcrops, these beds will be productive of oil or gas, provided a favorable structure in the form of an anticline or dome existed to entrap the hydrocarbons. Sandstone suitable for high grade building stone is present in sufficient thickness and over great areas.

A thin bed of phosphatic material exists at the contact of the Whetstone Branch black shale and the Carmack limestone, but the topography of the area is too rugged to permit of profitable extraction of this material. Although not tested, the bed of black carbonaceous shale (Whetstone Branch) itself is, no doubt, sufficiently pure to yield oil on distillation, but here also the topography is unfavorable for the stripping necessary to lay bare this material.

LIMESTONE FOR AGRICULTURE

Perhaps the most valuable material of the Paleozoic rocks of Mississippi is limestone for agricultural purposes, and, perhaps, the most difficult problem in exploitation will be the task of inducing its use for such purposes, at least in any considerable quantities.

An interval of only 40 feet of the New Scotland limestone is exposed in the area, principally along the lower stretches of Yellow Creek and along Whetstone Branch. Without recourse to chemical analysis, it can be positively stated that this limestone, because of

*Prepared March, 1928.

its purity, will make an excellent agricultural fertilizer. Though not favorably located for a large industry, it should nevertheless find profitable use in the local community.

The Carmack limestone varies in thickness from a few feet to more than 100 feet; as a result of the different erosions to which it has been subjected. Its distribution is shown in detail in the first part of this report. It forms an almost continuous belt of outcrop along the bluffs of the Tennessee and along the lower stretches of all the tributaries of the river. It is not so nearly pure as the New Scotland limestone, but is sufficiently free from impurities to warrant its general use as an agricultural fertilizer. Though it is in sufficient abundance to supply a greater area, its use will have to be confined to local demands, because of its unfavorable geographic location.

Except for some 40 or 50 feet of Iuka limestone on Cripple Deer Creek at the Alabama line just west of Allsboro, all the limestones consist of a few thin beds, each commonly not more than one to four feet thick, that belong to the Chester series. One to several tons of limestone from these thin beds could be gathered at any one of many places here and there along the line of exposure to the south of the Southern Railway. At no place, however, would the material be in sufficient quantities to warrant installation of costly crushing machinery. Portable crushers would, no doubt, suffice.

LIMESTONE FOR CEMENT

Besides the Iuka limestone on Cripple Deer Creek at the Alabama line just west of Allsboro, where it is practically inaccessible, there are only two limestones, the New Scotland and the Carmack, that are of sufficient thickness for use in the manufacture of Portland cement. The New Scotland is 40 feet in thickness, but it is confined largely to Island Hill on Yellow Creek, two miles above its mouth. The Carmack limestone has a thickness ranging from a few feet to more than 100 feet, and outcrops in an almost continuous belt extending along the Tennessee bluffs and along the lower stretches of the tributary valleys. Though the exact geologic and geographic position of the samples collected by Hilgard and Crider is not definitely stated, certainly one of the four samples analysed by these two geologists* came from the Carmack limestone; and

*Hilgard, Eug. W., Report on the Geology and Agriculture of Mississippi. Miss. Geol. Survey, pp. 53-55, 1860.
Crider, Albert F., Cement and Portland Cement Materials of Mississippi. Miss. State Geol. Survey, Bull. No. 1, pp. 37, 38, 1907.

the analysis shows the limestone to be sufficiently low in magnesia for cement purposes. No doubt the New Scotland limestone is also suitable for cement. Unfortunately both the New Scotland and Carmack limestones are so situated as to preclude their use for cement, at least under the present conditions of transportation.

LIMESTONE FOR BUILDING PURPOSES

With the exception of the New Scotland limestone on Island Hill and the Iuka limestone on Cripple Deer Creek at the Alabama line, both of which occupy inaccessible positions, there is no limestone of Paleozoic age in Mississippi suitable for building purposes, the many statements to the contrary notwithstanding. The Carmack limestone, though having a maximum thickness of more than 100 feet, breaks when exposed to the elements, into thin shaly layers, unsuited for building stone. With the exception just mentioned, the Iuka terrane (largely Tuscumbia of McCalley) is almost, if not entirely, chert in Mississippi. The beds of limestone in the Chester series are all too thin for building stone except the Pond limestone A member of the Alsobrook formation which has a prohibitive overburden nearly everywhere exposed. Sufficient limestone for local use may be had here and there, but not in quantities great enough for a first class building stone quarry.

CHERT AND SILICA

In Mississippi the Iuka terrane, with perhaps one exception, consists almost or wholly of chert and pulverulent silica. It extends from the Tennessee line along the Tennessee River and tributaries to the Alabama line at its intersection with Bear Creek, a mile below the mouth of Little Bear. At practically all places the Iuka is a mantle of angular blocks and smaller pieces of chert, so distributed as to reveal a thickness commonly of 40 to 60 feet and in some places of more than 100 feet. Practically inexhaustible quantities of this material are present, therefore. It is suitable for railway ballast and for the lower course in highway construction, provided it is kept completely covered by an upper course of other material; otherwise the sharp angular edges and points, which are harder than steel, cut up rubber tires in a very short time. Crushed sufficiently fine it will make a satisfactory upper course stone only in the event that some binder, as bitumen for example, is used. In the absence of such binders, it is quickly swept aside by the shove of the wheels, so as to expose the angular lower course stone. The chert is, of course, available for local roads; and, should the construction of another Tennessee River dam or the improvement of

Bear Creek-Cripple Deer Creek waterway be made, then, perhaps, the chert could compete as road metal with chert imported from Illinois, if not with the abundant Tuscaloosa gravel, so extensively produced in the pits along the Southern Railway just east of Iuka.

In some places a part of the Iuka terrane is in the form of a very white nearly pure pulverulent silica. At one such place, about one mile southwest of Eastport at the confluence of Bear and Tennessee Valleys, is an old mine where silica was produced some years ago. It was transported by tram down a small tributary valley, across Bear Creek and the Alabama line, to the plant on the Riverton Branch of the Southern Railway, where it was ground and prepared for market. It is reported that the business prospered until the workmen one after another in quick succession were stricken with tuberculosis, induced by the action of the angular silica dust on the lungs. Wet mining and wet grinding, as now practiced in the Joplin Zinc District of Missouri, Kansas, and Oklahoma, would, of course, eliminate that difficulty.

The mine, a section of which follows, consists of a main entry or drift extending S. 7° E. some 350 feet, and two parallel side entries, all connected by numerous cut-offs. Though it has been abandoned for many years, the walls and roof are nearly as white and fresh as during operation; and the roof is free from any caving whatsoever.

Section of Silica Mine near Eastport (Location 45, SW¼, Sec. 26, T. 2S., R. 11E.)

Iuka terrane		.....
Top of mine at entrance	.....	
Roof		2.0
Chert and silica, left as roof	2.0	
Mine		13.7
Silica, pure white pulverulent, approximately free from chert	4.0	
Chert, ranging from 0.3 to 0.5 foot	0.3	
Silica, pulverulent	2.0	
Chert	0.1	
Silica, pulverulent	1.5	
Chert	0.1	
Silica, pulverulent	1.0	
Chert	0.2	
Silica, pulverulent	3.0	
Mine floor near the middle of the entry	.....	
Silica, pulverulent	1.0	
Chert and silica	0.5	
Mine floor near the mouth of the entry and at the mouth of test pit	.....	

Test pit in bottom of mine		9.1
Chert and silica	1.0	
Silica, pulverulent	2.0	
Chert	0.5	
Silica, pulverulent	2.0	
Chert	0.2	
Silica, pulverulent	1.0	
Chert and silica	2.4	
Bottom of test pit	.....	

(Chert and silica mixed extend 12.0 ft. above the top of the mine.)

Some conception of the enormous amount of pulverulent silica present may be gained from a glance at the section. That it may be mined cheaply is fully demonstrated by the perfect condition of the entries and cut-offs, even after years of disuse. The silica mine should be put in operation again and, if need be, others opened. It would be well, furthermore, to manufacture the silica into scouring powder and other finished products, within the state, in so far as this is possible.

SANDROCK AND LIMEROCK ASPHALT

In the adjacent parts of northeastern Mississippi and northwestern Alabama exposures of the lower sandstones and limestones of the Chester series, belonging to (1) the Hargett sandstone member and (2) the Cripple Deer sandstone member of the Alsobrook formation, (3) the Allsboro sandstone formation, (4) the Pond limestone "A" member of the Southward Pond formation, and (5) the Southward Spring sandstone formation, contain varying amounts of bitumen, the residue of the hydrocarbons after the more volatile parts have escaped. At several places in Alabama the bitumen is sufficiently concentrated to be worked for highway asphalt, as, for example, (1) near Margerum, (2) near Cherokee, and (3) at Colrock. A study of the deposits at these places will show something of the possibilities in Mississippi provided the beds are exposed in places in Tishomingo County where the overburden is not prohibitive.

Section of the Alabama Rock Asphalt Company's quarry south of Margerum

Southward Pond formation		.....
Undifferentiated (practically no other overburden)		2.5
Limestone, thin layer	1.2	
Shales, blue clay	1.3	
Pond limestone A		14.0
Limestone, two or three layers of oolitic asphaltic limestone, which is mined for asphalt	14.0	

The company, of which Mr. C. W. Ashcraft is President and Mr. Tyler Calhoun is Vice-President, own 700 acres. According to Mr. Calhoun, the output in 1926 was three to four car loads a day, and the asphalt content ranged from six to nine per cent. It was the intention at that time to install an up-to-date crushing plant.

The next place that asphalt is being produced is south of Cherokee, where two quarries, the Hargett and the O'Reeilly, are being operated by the Cherokee Rock Asphalt Company. The Hargett quarry is nearly two miles south of Cherokee, and the O'Reeilly is about one and one-half miles farther south. Both are located on the plain at the top of the lower (Iowa) series of the Mississippian system, where it extends as a reentrant angle into Little Mountain. The overburden at both quarries is, therefore, light. Their topographic location, however, makes the stratigraphic position of the bitumen-bearing beds difficult to determine.

Section of the Cherokee Rock Asphalt Company's Hargett Quarry south of Cherokee

Recent		5.5
Overburden in the form of mantle rock	5.5	
Alsobrook formation		7.0
Sandstone, medium to thick bedded, somewhat banded. Most of it is impregnated with bitumen, but some of the bands are not. It is said the bitumen content ranges from 4 per cent to 12 per cent. The sandstone varies from 0.8 foot at the south end to 7.0 feet at the north end, and drill holes are said to have penetrated 19 feet more to the bottom of the sandstone, or a total of 26 feet	7.0	

The southern or southwestern end of the quarry and a drainage ditch, both 900 feet south of the last section, expose beds beneath the quarry stone; and a nearby water well penetrated, it is said, an underlying limestone. If the report of the presence of this limestone is correct, the position of the bitumen-bearing sandstone can be fairly definitely established.

Section of the southwest end of Hargett Quarry and of the drainage ditch of the quarry

Alsobrook formation		34.8
Sandstone, medium layers of coarse grained gray asphaltic	6.5	
Shales, mostly gray clay, and a few thin sandstones. Base at top of quarry	15.6	
Sandstone, bitumen-bearing which thickens to 7.0 feet in the quarry proper; the "quarry rock"	0.8	
Shales, green clayey, and shales, sandy asphaltic	1.9	
Sandstone, layer, asphaltic	0.8	
Shales, clayey and sandy	1.0	
Sandstone, layer, asphaltic, ranges from 0.6 to 3.6 feet	3.6	
Shales, bluish gray, clayey	4.6	

The mouth of the water well mentioned is on a level with the base of the lowermost sandstone (ranging from 0.6 foot to 3.6 feet in thickness) in the last section. It is said, the upper 6.5 feet of the well passed through mantle rock and that the lower 3.5 feet penetrated a crystalline limestone, which must be either the lowest (limestone) member of the Alsobrook formation or this limestone member and a part of the underlying Iuka limestone. If the well log is correctly reported, therefore, the base of the last section (shales, 4.6 feet) lies but 1.9 feet above the limestone. The base of the sandstones, accordingly, lies 6.5 feet above the limestone; and the top of the sandstones 14.6 feet above the same limestone; or where the bitumen-bearing sandstone is 7.0 feet thick instead of 0.8 foot, the top of this sandstone member of the Alsobrook formation lies 20.8 feet above the limestone. This sandstone member cannot, therefore, be the Cripple Deer sandstone member of the Alsobrook formation. Its position is below the Cripple Deer and above the limestone member. It can be appropriately named, therefore, the Hargett member of the Alsobrook formation, and its position indicated in tabular form:

Alsobrook formation:
- Cripple Deer sandstone member
- Hargett sandstone member
- Limestone member

Further substantiating its assignment to this position is the statement that the Pond limestone A member of the Southward Pond formation lies fully 40 feet above the sand asphalt.

Section of the Cherokee Rock Asphalt Company's O'Reeilly Quarry, 1½ miles southeast of Hargett

Recent	4.0	
Overburden, consisting of mantle rock	4.0	
Alsobrook formation		7.0
Sandstone, massive, medium grained; it is richly impregnated with bitumen, said to range from 8 per cent to 17 per cent. The sandstone is lenticular in outline; and this particular lens is said to be about 1000 feet long and 200 to 300 feet wide	7.0	

Because the quarry is located in a plain, the stratigraphic position of the lens is difficult to determine. From the following section the sandstone is seen to be 23.0 feet below the Pond limestone A member of the Southward Pond formation. It seems best, therefore, to refer it to the Cripple Deer member of the Alsobrook formation rather than to the Allsboro sandstone formation.

Section just southwest of the O'Reeilly Quarry

Southward Pond formation		......
Pond limestone A		12.5
Limestone, medium to massive bedded; some dark asphaltic and oolitic, some dense and yellow	12.5	
Undetermined		23.0
Interval covered	23.0	
Undetermined		2.0
Sandstone, bluish gray, weathers to yellow-brown; the same stone as worked in the O'Reeilly Quarry for asphalt. It probably belongs to the Cripple Deer sandstone member of the Alsobrook formation	2.0	

In 1926 the Hargett Quarry was equipped with two Erie steam shovels, each having a ¾ yard bucket, and two air drills. The O'Reeily Quarry was equipped with an Erie steam shovel, ¾ yard bucket; an Ingersoll Rand Compressor; and two Ingersoll Rand air drills. At that time 15 tons of the rich asphalt was being produced daily at the O'Reeilly Quarry and transported 1.5 miles in three one-ton Chevrolet trucks to the Hargett Quarry where it was mixed with the leaner bitumen of that quarry to form a product having a minimum of 7.5 per cent asphalt. From the Hargett Quarry all the rock asphalt was hauled on a standard gauge railroad 2.5 miles to the plant lccated on the Southern Railway in Cherokee. This plant is adequately equipped and is modern in every respect. Especial credit is due Mr. A. L. Kenyon, President, for the splendid condition in which the grounds, plant, tracks, and quarries were kept. Mr. Kenyon, Mr. Ivie, Secretary, and Mr. Craddock, Superintendent, extended every aid and courtesy possible to advance the work of the survey.

About two miles east of Cherokee are the plant and quarry of the Colbert Lime-rock Asphalt Company. They are located on the end of a spur about three-fourths of a mile long, branching from the Southern Railway at Colrock Stop.

Section of the Colbert Lime-rock Asphalt Company's Quarry and of the adjacent beds

Southward Pond formation		
Overburden		17.7
Limestone, thin, irregularly bedded, highly crystalline, fossiliferous, bluish-gray; weathers readily	9.0	
Shales, bluish-black, clay; probably mother formation	8.7	
Pond limestone A		21.5
Limestone, two layers, hard compact, very heavy; usually a part of the overburden	2.1	

PLATE 23

A Block of cross-bedded asphaltic sandstone from the Cripple Deer sandstone member of the Alsobrook formation in the O'Reeilly Quarry of the Cherokee Rock Asphalt Company, near Cherokee, Alabama. It shows in a most striking manner the control of petroleum impregnation by the degree of cementation of the sandstone. Where cementation was complete impregnation failed entirely.

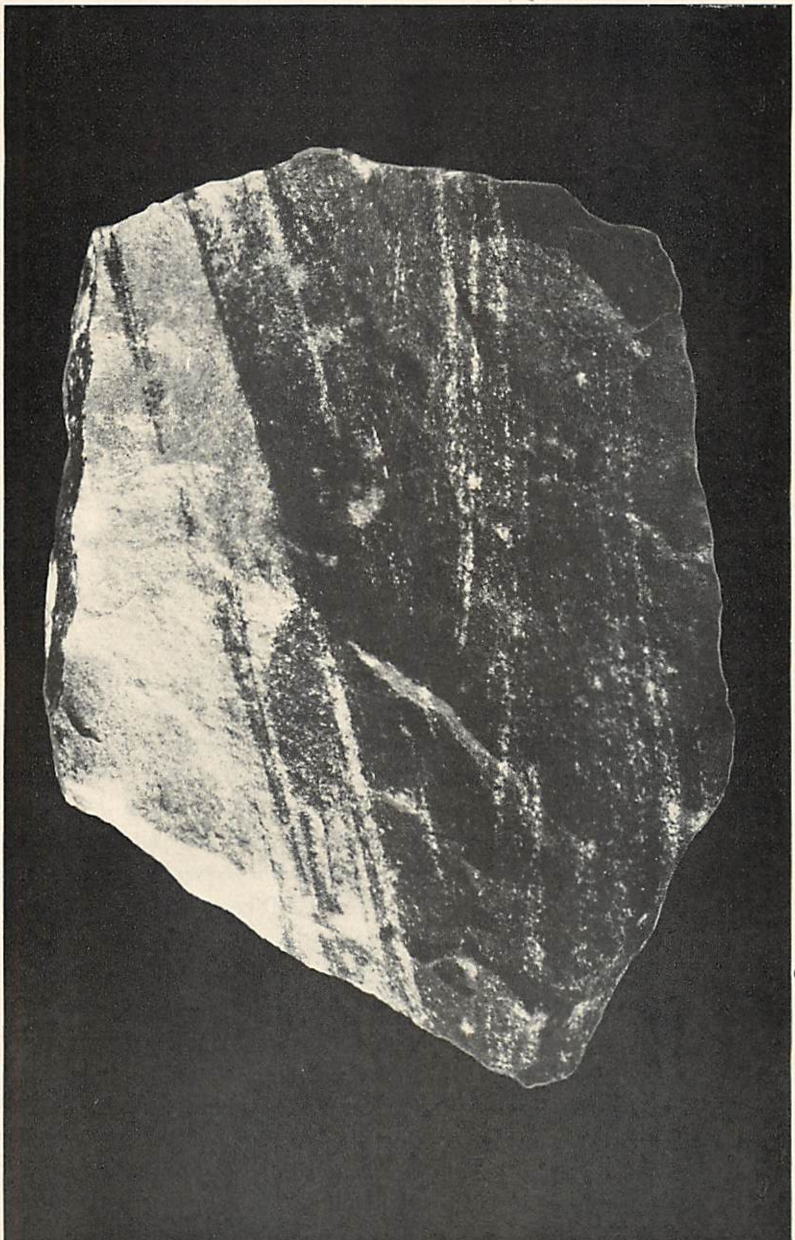

PLATE 23

Limestone, massive layer of oolitic or foraminiferal, asphaltic; quarried. It is said the base and top each contains 3 to 4 per cent asphalt and the middle 4 to 8 per cent. Base of quarry	7.0
Limestone, bluish gray, compact	1.3
Interval, covered	2.4
Limestone, bluish gray, fossiliferous	8.7

The property of the company, of which Mr. Walker Stansell is President and Mr. T. C. Littlejohn is General Superintendent, consisted originally of 260 acres, to which 160 acres and 16 2/3 acres have been added subsequently. About 100,000 tons of asphalt have been mined, and 500,000 tons have been proved.

In 1926 the quarry equipment consisted of an Erie 20-B steam shovel, having a ¾ yard dipper and a caterpillar base; a Sullivan air compressor; and two compressed air drills. The overburden of 19.8 feet was removed with the steam shovel and hauled away in Russell Dump Wagons, holding 1½ yards each. The asphaltic limestone was transported to the plant in Coppel all metal 1¾-ton cars drawn by a Shay 10-ton locomotive. The plant, though not large, maintains a continuous output.

Unfortunately, no physical tests were made to determine the relative value of the limerock and sandrock asphalts; hence no statement can be made in answer to the question as to which type is the better. After three extensive geologic field trips in automobiles, covering 17,000 miles, the writer feels the problem to be not so much a question as to relative value of the two types of asphalt, as it is a question between an asphaltic surface on the one hand and some other kind of surface on the other. Surely most traffic routes of the future will have some type of bitumen surface.

Because of the bitumen impregnation, the Hargett sandstone member and the Cripple Deer sandstone member of the Alsobrook formation and the Pond limestone A member of the Southward Pond formation constitute valuable deposits that are being actively worked at three places in Alabama for highway asphalt. Without a further consideration of the deposits in bordering Alabama, which have been rather thoroughly explored by Mr. J. W. Adams, Prospector, Sheffield, Alabama, it may be stated that similar impregnation of the same beds and others in Mississippi should likewise constitute valuable deposits, provided, of course, the beds have an equally favorable geographic position for shipment and an equally favorable topographic position for stripping.

The Pond limestone A member of the Southward Pond formation, the bed quarried south of Margerum and east of Cherokee, extends westward up Pennywinkle Creek and its tributaries for more than a mile from the Alabama line. Careful search might show the limestone to be sufficiently impregnated and favorably exposed to yield at least a limited amount of asphaltic material.

Perhaps the Southward Pond limestone A member is more highly impregnated with bitumen, is more nearly continuous, and is better exposed topographically in the type locality than elsewhere. It outcrops at Bishop Bridge, just east of the Alabama line, thence west here and there to the northwest side of Southward (Cypress) Pond, and thence southward along the western side of the pond until the southern dip carries it below the surface of the water. At some of these places, at least a part of the limestone is more or less impregnated.

The Southward Spring sandstone at the type locality just south of Southward Pond is at least 15 feet thick. At the spring and especially at the ford just above Southward Bridge, it contains some bitumen. Should tests show it sufficiently impregnated to be of commercial importance, it could readily be quarried for the reason that the bed outcrops westward for one-half mile under rather favorable topographic conditions. It is most unfortunate that sufficient time was not available to the survey to determine rather accurately the bitumen content of all these beds, but it was deemed more important to determine first the proper stratigraphic sequence of all the beds as a solid foundation on which to base all economic estimates.

PETROLEUM AND NATURAL GAS

INTRODUCTORY STATEMENT

In the adjacent parts of Mississippi and Alabama, as already stated, the lower sandstones and a limestone of the Chester series, belonging to (1) the Hargett sandstone member and (2) the Cripple Deer sandstone member of the Alsobrook formation; (3) the Allsboro sandstone formation; (4) the Pond limestone A member of the Southward Pond formation; and (5) the Southward Spring sandstone formation, contain, where exposed, varying amounts of bitumen, the residue after the more volatile parts of the hydrocarbons have escaped. It is entirely possible, in fact highly probable, that down dip from the outcrops of these beds, they will contain either petroleum or natural gas, or even both, in commercial quantities, provided some favorable structure, such as anticlinal fold, a dome, or a terrace, was present to act as a trap and thus prevent the escape of the entire amount of these valuable products. The place to search for such favorable structures is, of course, some distance to the west, southwest, and south of the outcrops in Tishomingo County. Unfortunately the discovery of the favorable structures is going to be extremely difficult for the reason that, back from the belt of outcrop, the Paleozoic beds are covered with a mantle of Tuscaloosa and later sand, gravel, and shale. The chances of obtaining petroleum or natural gas are, however, sufficiently promising to warrant a rather careful search for some evidence even in the overlying shales (or sands), of folds in the underlying Chester and older Paleozoic beds.

Within the area of outcrop of the Devonian and Mississippian beds, petroleum or natural gas would have to come, of course, from older Paleozoic beds: Silurian, Ordovician, or Cambrian in age. A study of the surface Devonian and Mississippian beds reveals the presence of a few favorable structures, and perhaps a more detailed study might disclose still other favorable structures.

One such favorable structure at Southward (Cypress) Pond was briefly described on pages 19 and 20 of Bulletin 15 of the state survey by Dr. Lowe. Through the courtesy of the same gentleman, the writer had an opportunity to make a detailed map of the Southward Pond structure and a reconnaissance survey that revealed another favorable structure crossing Whetstone Branch in the northeastern part of Tishomingo County. Inasmuch as the commercial report of these two structures was rendered in January, 1920, sufficient time has elapsed, perhaps, to make admissible the incorporation of a part of that report in the present bulletin, without a violation of professional ethics.

SOUTHWARD (CYPRESS) POND DOME

A detailed plane-table survey of the Southward Pond area reveals a much more pronounced structure than is at first apparent. From the plane-table structure contour map, Fig. 14, it will be seen that the key bed, Pond limestone "C," rises from the east toward the west, and from the south toward the north through a vertical distance of 80 to 100 feet. Toward the west there are no exposures to show its inclination in that direction, but, inasmuch as the general inclination of the beds of the region is toward the west and south, the key bed must dip away toward the west at a greater or shorter distance. Toward the north the beds are exposed only a short distance, so that the total inclination in this

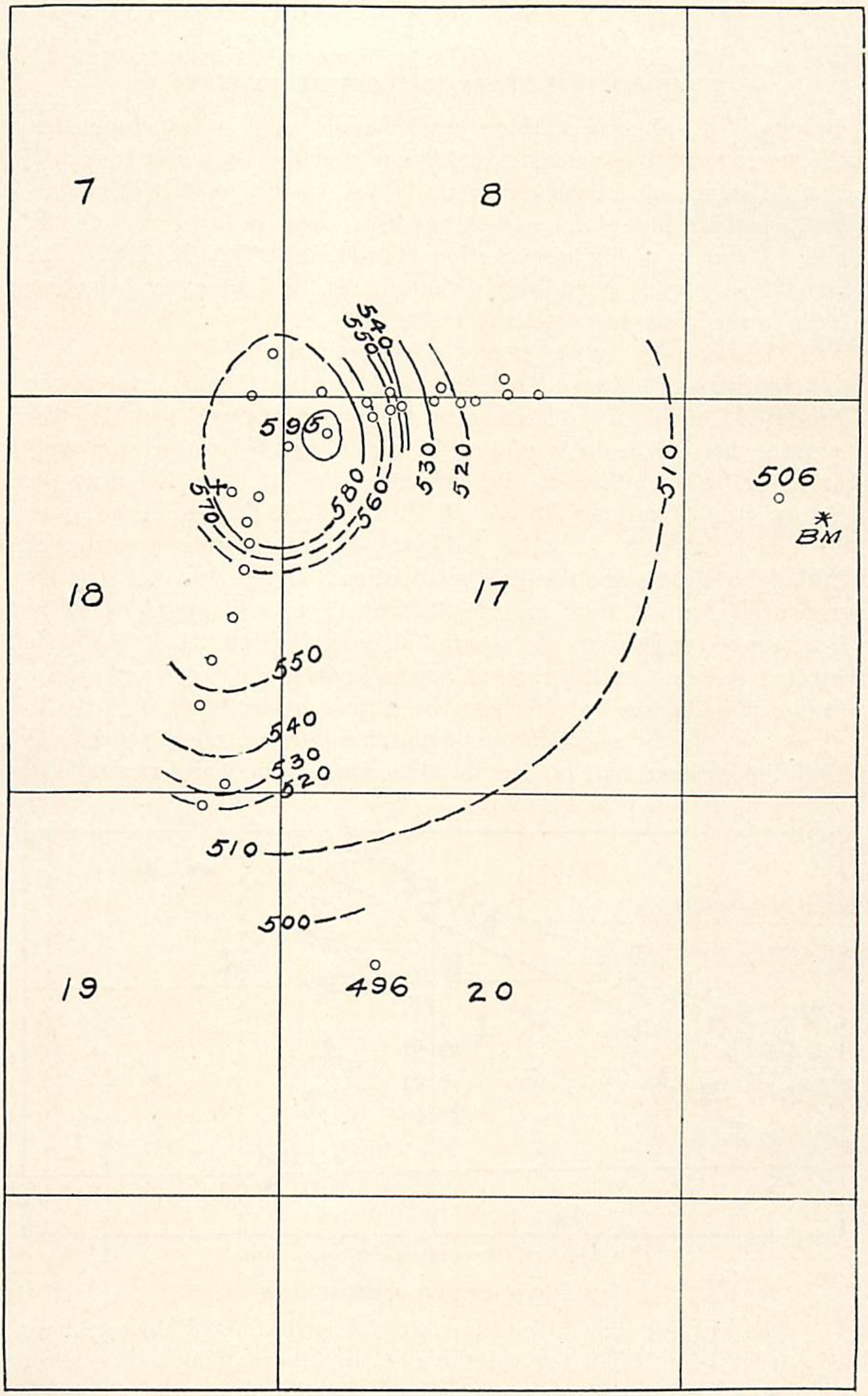

Figure 14.—Structure contour map of Southward (Cypress) Pond Dome by Morse and Morse.

Legend: * B. M. 500.0 feet assumed—blaze on tree 5.0 feet above waters of Bear Creek.

o Elevations or computed elevations on Southward Pond limestone "C."

direction is unknown. However, it seems safe to conclude that the northward inclination is sufficient, for the reason that in the short distance of exposure, the dip is toward the north. The structure seems to be a dome, which covers at least most of Sections 17 and 18 and probably also Sections 7 and 8, T. 5S., R. 11E. The structure may be even larger than indicated and extend farther both toward the west and the north.

WHETSTONE BRANCH FOLD

Lying, as the area does, so much nearer to the axis of the Nashville-Cincinnati arch than to the Ouachita-Ozark uplift, the general dip of the beds of the region should be toward the west or toward the southwest. Perhaps the east dip (Fig. 15) near the Tennessee in Sections 30 and 31, T. 1S., R. 11E., and in Sections 5, 6, and 7, T. 2S., R. 11E., indicates, therefore, a reverse dip or fold. On Whetstone Branch, in Section 31, the east dip can be measured for 500 feet and is 32 feet in this distance. On the next small stream to the south, also in Section 31, the dip is toward the east at the rate of approximately 7.5 feet to the hundred for a distance of 950 feet, or a total of 70 feet. The reconnaissance survey seems to indicate, therefore, a north-south fold near the western half of Section 31, having a vertical magnitude of at least 70 feet, possibly more.

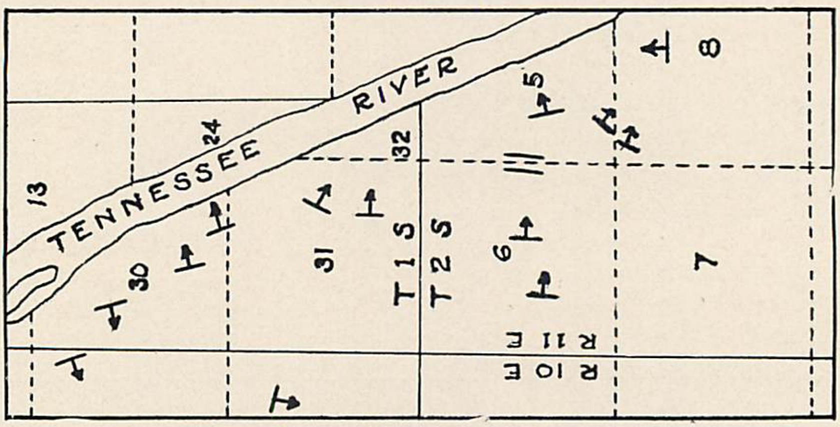

Figure 15.—Whetstone Branch fold.

YELLOW CREEK MONOCLINE

The present survey for the state shows that the Paleozoic beds dip from Island Hill toward the east and down Yellow Creek for two miles to the Tennessee Valley. Inasmuch as the Carmack overlies more than 40 feet of older beds at Island Hill and lies at stream level near the mouth of Yellow Creek, the total dip is more than 40 feet toward the east. Somewhere west of Island Hill, therefore, the Paleozoic beds should begin their dip in the opposite direction or toward the west. The dip down Yellow Creek seems to indicate the east flank of what is perhaps the largest favorable structure thus far described. Some of the most difficult part of the work, however, remains to be done in the region blanketed by the gravels, sands, and clays of the Mesozoic formations.

STATE LINE ARCH

Attention has already been directed to the fact that the Pond limestone A member of the Southward Pond formation lies below the level of Bear Creek flood plain just east of Southward Pond; that it rises in the belt along and to the east of the Alabama line, especially in the vicinity of Allsboro; and that it lies below the flood plain level of Bear Creek just below the Southern Railway and to the east of the two Clear Creek folds (page 215), which are, perhaps, too small to be of commercial importance. In smaller streams having steep headwater gradients, some or all of the differences in elevations of Pond limestone A could be accounted for by the concave longitudinal profile of the stream or valley floor itself; but, in the present case, this part of Bear Creek has a sufficiently flat profile to warrant the conclusion that the differences are due to a large arch in the beds. Inasmuch as but two of the nine or ten miles of the region under consideration are covered by a topographic map, or, for that matter, by a detailed map of any kind, a plane-table survey of the region is most desirable.

PETROLEUM PROSPECTING

Due to the untimely death of Mr. George F. Ramsey, Railroad and Levee Contractor of Memphis, Tennessee, for whom the commercial survey of the Southward (Cypress) Pond dome and Whetstone Branch fold was made, the property passed into other hands, the Mississippi Oil & Refining Company, by whom a test well, Southward No. 1, was drilled (1923-24) in the NE¼ of Section 18, T. 5S., R. 11E., near the center of the Southward Pond dome. It was stated that the drill encountered crevices or small caves at certain depths, and that some so-called "dead" oil was obtained. The well was abandoned at 2472 feet. Cuttings from 150 to 735 feet and from 1002 to 1855 feet, at least, were sent to the state survey and were examined by the Director. Except for the Lauderdale chert and the Devonian black shale, no formational correlation was attempted.[1] A more or less complete set of samples was sent, on the other hand, to the National survey, and was examined by Mr. Bramlett, who presented the results of his study in the form of a graphical columnar section.[2]

Another well, although started just to the west of the Paleozoic area in Cretaceous beds, is the Jordan No. 1, drilled (1921-22) by the Iuka Development Corporation, in the SW¼ of Section 9, T. 4S., R. 11E., to a depth of 1900 or 1902 feet. Some of the samples were passed on by Ulrich;[1] the complete log was obtained by the state from the National Survey;[2] and the results of an examination of a more or less complete set of cuttings from beds below 450 feet were presented in the form of a graphic columnar section.[3] Slight indications of oil were observed at several horizons, though the well is not on a favorable structure.

A third well in the area under consideration was drilled about 1903 or 1904 in the NE¼ of Section 26, T. 2S., R. 11E., at the edge of Eastport and within one mile of the northeast corner of the state. It is reported to be 750 feet deep and to have had a show of oil. There is no indication of a favorable structure at this place.

CONCLUSIONS

As reported, the drill on the Southward Pond dome encountered crevices or cavities in the subsurface beds, which, perhaps, served as passage ways for the escaping oil, for only a thick, dead residue remained behind. Whether or not deeper drilling would disclose other reservoirs containing oil in greater and paying quantities is still an unanswered question. However that may be, individuals and corporations will continue the search for oil, and the more favorable structures already described should be tested first. From the bitumen residue in the five outcopping Chester beds and also from the natural gas production in the Carter well (SE¼,

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[1]Lowe, Dr. E. N., Petroleum Prospecting in Mississippi. Miss. State Geol. Survey, Ninth Biennial Report, 1921-1923, pp. 157, 177.

[2]Bramlette, M. N., Paleozoic formations penetrated by wells in Tishomingo County, northeastern Mississippi. U. S. Geological Survey, Bulletin 781-A, Plate I, 1925.

[1]Morse, P. F., Petroleum Prospecting in Mississippi. American Association Petroleum Geologists, Vol. VII, p. 690. 1923.

[2]Lowe, Dr. E. N., Petroleum Prospecting in Mississippi. Miss. State Geol. Survey, Ninth Biennial Report, 1921-1923, pp. 154, 157.

[3]Bramlette, M. N., Paleozoic formations penetrated by wells in Tishomingo County northeastern Mississippi. U. S. Geological Survey, Bull. 781-A, Plate I. 1925.

Section 7, T. 13S., R. 17W.) and in the Rye well* (Section 22, T. 15S., R. 17W.), both located in Monroe County, it would seem that, perhaps, a better chance to obtain production would be to test these five sands down dip (toward the west and southwest) from their outcrops, provided careful field work reveals favorable structural traps.

SANDSTONE FOR BUILDING PURPOSES

The Highland Church sandstone member of the Forest Grove formation is the cliff-forming stone of Bear, Cedar, and Mackey valleys and their tributaries, in the southern third of Tishomingo County. Vertical cliffs of this sandstone surmounting in places 100 feet of other beds in the valley walls of Bear Creek produce the most rugged and at the same time the most picturesque scenery, perhaps, in the entire state. Though Mackey's Creek at Bay Springs has not cut such a deep trench, the region is, nevertheless, so delightfully beautiful as to warrant the setting aside of a considerable tract here for a state park.

That the Highland Church sandstone is an excellent building stone is attested by its cliff-forming habit. It is developed over broad areas in sufficiently great (25 feet) and uniform thickness to warrant installation of modern quarrying equipment and the construction of modern plants. Over broad areas, too, the ledge is overlain by a medium amount of overburden. Without doubt, therefore the Highland Church sandstone is a great potential building stone.

Between Bear and Cedar Creeks are considerable areas where the sandstone is approximately 25 feet thick and overlain by a medium amount of mantle rock. On the west side of Bear Creek, between the stream and the Illinois Central Railroad are broad areas where the stone has a similar thickness and is overlain by a medium amount of overburden. Perhaps one of the best locations for a modern quarry is near the bluffs of Bear Creek, east or southeast of Tishomingo, for the stone here is fully developed, is overlain by a small amount of overburden, and is located within 1.5 to 2.5 miles of the railroad. At still other places on this side of Bear Creek, quarry locations would also require not more than 1.5 to 2.5 miles of spur track. At many places along Mackeys Creek and tributaries excellent sandstone could be obtained for local consumption; and should the Bear-Cripple Deer-Mackey Creek waterway be developed, the stone would be available for a wider market.

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*The producing sand in these wells has been correlated with beds ranging in age from the Trenton (Ordovician) to Pennsylvanian. Perhaps the most nearly correct reference is that of the Paleontologists of some of the oil corporations to the Mississippian (Chester). If the producing sand is not Mississippian, then, of course, the discussion above is not pertinent.

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