OKLAHOMA GEOLOGICAL SURVEY
Chas. N. Gould, Director

Bulletin No. 44

Age Relations of the Carboniferous Rocks of the Ouachita Mountains of Oklahoma and Arkansas*

By
Hugh D. Miser
Geologist of the United States Geological Survey
and
C. W. Honess
Formerly Chief Geologist of the Oklahoma Geological Survey

NORMAN
NOVEMBER, 1927

*Published by permission of the Director of the United States Geological Survey.

CONTENTS

ILLUSTRATIONS

AGE RELATIONS OF THE CARBONIFEROUS ROCKS OF THE OUACHITA MOUNTAINS OF OKLAHOMA AND ARKANSAS*

ABSTRACT

Differences of opinion provail among geologists about the age of certain thick beds of shale and sandstone in the Ouachita Mountains of Oklahoma and Arkansas. The aggregate thickness of the beds in question is about 12,000 feet over much of the Ouachita Mountains of Oklahoma and Arkansas, and measures as much as 16,000 feet at some places. Some geologists hold that the age of these rocks is Mississippian and others believe they are Pennsylvanian. The rocks have been grouped into the following formations with the oldest named first: Hot Springs sandstone, Stanley shale, Jackfork sandstone, and Caney shale.

Fossils in these formations are few; none have been found in the Hot Springs sandstone; meagre collections of fragmentary fossil plants and a few specimens of invertebrates have been obtained from the Stanley shale; a few indeterminable fossil plants and invertebrates have been obtained from the Jackfork sandstone; and fairly good collections of invertebrate fossils and some plants are available from the Caney shale. The fossils have been studied by several geologists including David White, C. S. Prosser, G. H. Girty, Charles Schuchert, E. O. Ulrich, C. R. Eastman, and C. W. Honess.

Due to the meagre fossil evidence the conclusions of the present authors are tentative. They are that the Caney shale contains beds of both Pennsylvanian and Mississippian age, and that the Jackfork, Stanley, and Hot Springs formations are of Mississippian age.

STUDIES BY PRESENT AUTHORS AND ACKNOWLEDGMENTS

The purpose of the present paper is to outline briefly the stratigraphic relations of the Carboniferous rocks, and to give the opinions of different geologists who have studied fossils from the Caney, Jackfork, and Stanley formations. Most of the fossil collections from the Jackfork and Stanley were obtained by Miser and Honess in recent years in the course of their structural and stratigraphic studies in the Ouachita Mountains. H. D. Miser, in cooperation with the late A. H. Purdue, spent many years beginning in 1907 in the Ouachita Mountains of Arkansas for the United States Geological Survey, and C. W. Honess spent many years beginning in 1916 in the Ouachita Mountains of Oklahoma for the Oklahoma Geological Survey. In 1923, Miser and Honess reviewed together the geology of parts of the region in both

* The writing of this paper was finished in February, 1927. Since then the senior author has spent three months in the Ouachita Mountains of Oklahoma, studying, among other things, the ages of the rocks that are discussed in the present paper. Several conferences—some in the field—have been held with many geologists on the ages of the rocks. Much new information has been obtained and will be fully presented in a future paper on the region. The available results of the recent field work corroborate the conclusions of the authors as given in the present paper.

H. D. M.

Oklahoma and Arkansas for the purpose of clarifying, if possible, some of the problems, especially those with reference to the age of the Carboniferous rocks.

The results of the studies of the various geologists who have worked in Oklahoma and Arkansas have been presented in several reports, the most important of which are as follows:

Griswold, L. S., Whetstones and the novaculites of Arkansas: Arkansas Geol. Survey Ann Rept. for 1890, vol. 3, 1892.

Drake, N. F., A geological reconnaissance of the coal fields of the Indian Territory: Amer. Philos. Soc, Proc., vol. 36, pp. 326-419, 1897.

Ashley, G. H., Geology of the Paleozoic area of Arkansas south of the novaculite region: Amer. Philos. Soc. Proc., vol. 36, pp. 217-318, 1897.

Taff, J. A., U. S. Geol. Survey, Geol. Atlas Atoka folio (No. 79), 1902.

Taff, J. A., Grahamite deposits of southeastern Oklahoma: U. S. Geol. Survey Bull. 380, pp. 286-297, 1909.

Girty, G. H., Fauna of the Caney shale of Oklahoma: U. S. Geol. Survey Bull. 377, 1909.

Purdue, A. H., The slates of Arkansas: Arkansas Geol. Survey, 1909. U. S. Geol. Survey Bull. 430, pp. 317-334, 1910.

Wallis, B. F., The geology and economic value of the Wapanucka limestone of Oklahoma: Okla. Geol. Survey Bull. 23, 1915.

Miser, H. D., Manganese deposits of the Caddo Gap and De Queen quadrangles, Arkansas: U. S. Geol. Survey Bull. 660, pp. 59-122, 1917.

Miser, H. D, Geology and topographic features of Arkansas: Chapter in "Outlines of the geology, soils and minerals of the State of Arkansas," by Jim G. Ferguson, pp. 21-42, 1920. Also chapter in "Minerals in Arkansas," by Jim G. Ferguson, pp. 11-34, 1922

Miser, H. D., Llanoria, the Paleozoic land area in Louisiana and eastern Texas: Amer. Jour. Sci., 5th ser., vol. 2, pp. 61-89, 1921.

Honess, C. W., The Stanley shale of Oklahoma: Amer. Jour. Sci., 5th ser., vol. 1, pp. 63-80, 1921.

Honess, C. W., Geology of the southern Ouachita Mountains, Okla.: Oklahoma Geol. Survey Bull. 32, 1923.

Purdue, A. H. and Miser, H. D., U. S. Geol. Survey Geol. Atlas, Hot Springs folio (No. 215), 1923.

Honess, C. W., Geology of southern LeFlore and northwestern McCurtain counties, Okla.: Circular 3, Bureau of Geology, Norman, Okla., 1924.

Gould, C. N., Index to the stratigraphy of Oklahoma: Oklahoma Geol. Survey Bull. 35, 1925.

Miser, H. D., Geologic map of Oklahoma: U. S. Geol Survey, 1926.

In the present paper there is brought together published as well as unpublished material from different sources.

To J. A. Taff the writers are especially indebted for the assistance they have obtained from his unpublished geologic maps of the McAlester, Windingstair, Tuskahoma, Antlers, and Alikchi quadrangles in Oklahoma. Taff spent many years in these quadrangles for the United States Geological Survey, and has mapped all the rock formations in great detail, but the reports on the quadrangles were not completed by him. H. D. Miser plans to review the geology of the quadrangles in the near future and to prepare reports on them.

DISTRIBUTION AND AGE RELATIONS OF THE CARBONIFEROUS AND ASSOCIATED ROCKS

GENERAL FEATURES

Rocks of Carboniferous age are widely exposed in the Ouachita Mountains of Arkansas and Oklahoma, the belts of outcrop extending from the east end of the mountains to the west end—a distance of 200 miles, and extending from the south side to the north side—a distance of 50 to 60 miles. On the east and south borders of the mountains the Carboniferous rocks pass beneath the Cretaceous, Tertiary, and Quaternary deposits underlying the Gulf Coastal Plain, but on the north border, they extend into the Arkansas Valley and beyond. The rocks of this age in the Ouachita Mountains are between 15,000 and 20,000 feet thick in most parts of the region, and they together with the rocks of Cambrian, Ordovician, Silurian, and Devonian age were faulted and closely folded, presumably late in Pennsylvanian time. They have been subdivided into several formations which are listed in the accompanying table of formations of the Ouachita Mountains and the adjoining Arkansas Valley. The distribution of the rocks is shown on the accompanying small-scale generalized map (Fig. 1).

Only the Wapanucka limestone and Caney shale contain abundant faunas that have been known for many years.

There is unanimity of opinion among geologists for the Pennsylvanian age of the Wapanucka, Atoka, Hartshorne, McAlester, Savanna, and Boggy formations. There has been, however, and still is a difference of opinion with reference to the Hot Springs, Stanley, Jackfork, and Caney formations. Some geologists maintain that they are Mississippian and others that they are Pennsylvanian in age.

ARKANSAS NOVACULITE AND EQUIVALENT ROCKS

The Stanley shale is underlain by the Arkansas novaculite in Arkansas and in McCurtain County, Oklahoma, though in and near the city of Hot Springs, Arkansas, the Hot Springs sandstone intervenes between the shale and the novaculite. The shale is underlain by the Talihina chert in Oklahoma northwest of McCurtain County. The topmost beds of the chert have been observed by the authors to have the same lithology as the upper part of the Arkansas novaculite; they have the same stratigraphic position as this part of the novaculite; and they are apparently of the same age. They also have been observed by the authors to have the same lithology as the Woodford chert, and are believed by them to be of the same age as the Woodford.

Composite section of exposed rocks of Carboniferous age in the Ouachita Mountains and Arkansas Valley, in Oklahoma and Arkansas.

Age		Formation	Thickness In Feet	Remarks On Occurrence
CARBONIFEROUS	PENNSYLVANIAN	Boggy shale	2,000-3,000	Present in Arkansas Valley in Arkansas and Oklahoma.
		Savanna sandstone	750-1,500	
		McAlester shale	1,150-2,500	
		Hartshorne sandstone	100-300	
		Atoka formation	3,000-7,800	Present in Arkansas Valley and Ouachita region of Arkansas and Oklahoma.
		Wapanucka limestone	0-800	Exposed near boundary between Arkansas Valley and Ouachita region in Oklahoma; absent in Arkansas.
	MISS.-PENN.	Caney shale	0-1,500	Exposed in Ouachita region in Oklahoma; absent in Arkansas.
	MISSISSIPPIAN	Jackfork sandstone	0-6,600	Exposed in Ouachita region in Oklahoma and in Arkansas Valley and Ouachita region in Arkansas; absent along north side of Ouachita region in Oklahoma.
		Stanley shale	0-10,000	Exposed in Ouachita region in Oklahoma and Arkansas; absent along north side of Ouachita region in Oklahoma.
		Hot Springs sandstone	0-200	Exposed in places at and near Hot Springs, Ark., but absent at most places in Arkansas; not present in Oklahoma.

The age designations are those that are used by the United States Geological Survey.

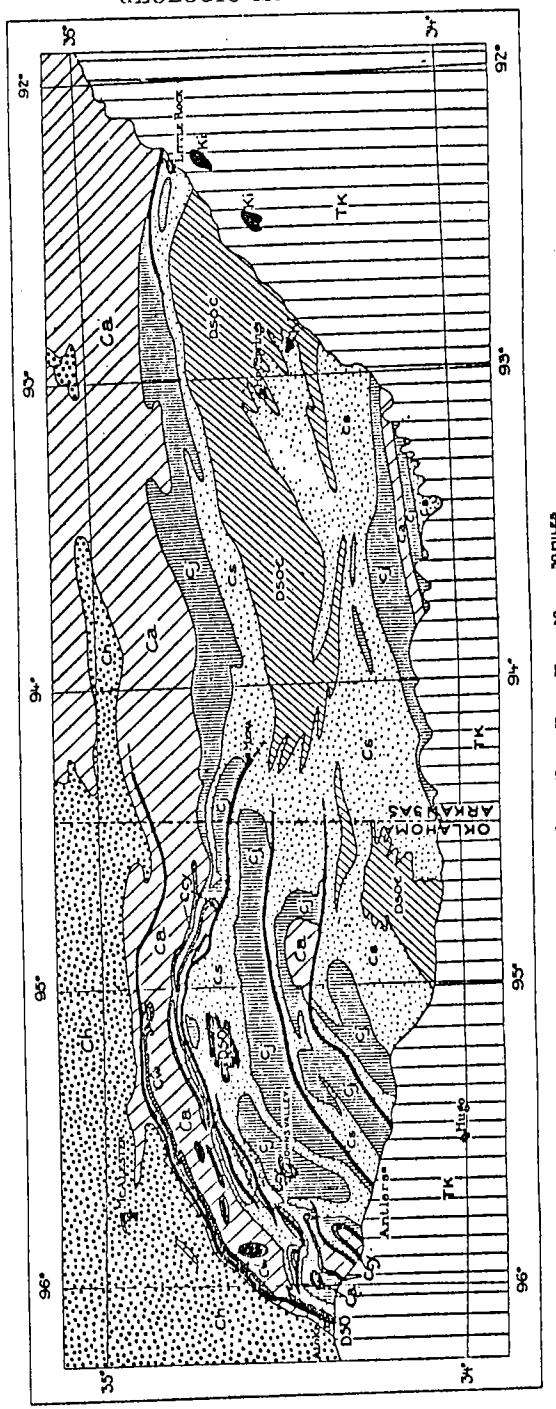


Fig. 1. Generalized geologic map of the Ouachita Mountains, Arkansas and Oklahoma.

Cretaceous, Tertiary, and later rocks. **TK**.

Carboniferous.

Ch, Hartshorne sandstone and younger Carboniferous rocks.

Ca, Atoka formation.

Cw, Wapanucka limestone.

Ccy, Caney shale.

Cj, Jackfork sandstone; may include some areas of Atoka formation.

Cs, Stanley shale and Hot Springs sandstone.

Devonian, Silurian, and Ordovician.

DSO, Talihina chert; the topmost beds of the Talihina chert are of the same age as the Woodford chert and the upper portion of the Arkansas novaculite; they are classed as Devonian (?) in age.

Devonian, Silurian, Ordovician, and Cambrian.

DSOC, Arkansas novaculite and older rocks; the upper portion of the Arkansas novaculite is classed as Devonian (?) in age.

Igneous rocks of Cretaceous age, **Ki**.

The only fossils thus far found in the Arkansas novaculite in Arkansas comprise silicified wood and a single collection of many conodonts from a minutely pebbled conglomerate, and of conodonts, small linguloids, and sporangites in associated shale. These have been obtained from the middle division of the formation. The wood was found at two localities near Glenwood. The other fossils were procured at Caddo Gap, and upon them E. O. Ulrich bases the opinion that the middle and perhaps also the upper division of the formation are to be correlated with the Woodford chert in the Arbuckle Mountains and with the Chattanooga shale. He, however, believes a small part of the middle division is of the same age as the Genesee shale of the Appalachian region. He assigns the Woodford chert and the Chattanooga to the Mississippian series, and he accordingly assigns to this series these two divisons of the Arkansas novaculate, with the exception of the part of Genesee age; but the United States Geological Survey classifies the Woodford chert and the Chattanooga shale as Devonian (?). As the whole of the Arknasas novaculite is still treated as a unit, the lower part of which is shown by fossil evidence discovered by C. W. Honess[1] to be Devonian, its middle and upper divisions are also tentatively assigned to that age.

HOT SPRINGS SANDSTONE

The Hot Springs sandstone rests unconformably upon the Arkansas novaculite, as is indicated by a thick conglomerate at the base of the sandstone and the varying thicknesses of the topmost beds of the novaculite. All the known exposures of the sandstone occur in and near the city of Hot Springs, Arkansas. The sandstone is absent at most places in Arkansas and is not present in Oklahoma.

STANLEY AND JACKFORK FORMATIONS

The Stanley shale and Jackfork sandstone are the two most widely exposed formations of the Ouachita Mountains. The extent of their distribution, as indicated by the exposures, is apparently the same for the two formations. They are present everywhere in the mountains except along their northwest border in Oklahoma, as is shown in three small areas in northern Atoka and southern Pittsburg counties, where the Caney shale rests upon chert of the same age as the Woodford chert. Also the Stanley and Jackfork are absent in the Arbuckle Mountains to the west of the Ouachita Mountains. There the Caney rests directly upon the Woodford chert (Devonian?) or is separated from it by a thin limestone (Sycamore limestone) of Mississippian age.

An unconformity probably separates the Stanley shale and the Arkansas novaculite at all places where the Hot Springs sandstone does not lie between them. It is indicated not only by a widely distributed conglomerate at the base of the Stanley but also by the absence of the novaculite in a few places in Arkansas.

1. Honess, C. W., Geology of the southern Ouachita Mountains, Okla.: Oklahoma Geol. Survey Bull. 32, pp. 116-117, 1923.

The Stanley shale contains, near its base, one extensive bed, about 90 feet thick, and several local, thin layers of volcanic ash or tuff. These crop out widely in McCurtain County, Oklahoma and in Polk County, Arkansas, but have not been recognized outside of this general locality. The main bed of this ash has been named by H. D. Miser[2] the Hatton tuff lentil, the name being taken from the village of Hatton, Ark., where typical exposures occur.

In the middle of the Stanley shale occurs a bed of black chert, about 25 feet in thickness, which crops out in northern McCurtain and southern Le Flore counties, Oklahoma, and which has up till now always been referred to simply as the black chert of the Stanley shale. Since this horizon in the Stanley is of first importance in mapping the local structure and in calculating thicknesses of adjacent beds it should be given a name, and C. W. Honess here proposes the name Smithville chert lentil for this rock, naming it from the village of Smithville east of which, in T. 1 S., R. 26 E., Oklahoma, there are typical exposures[3].

The fossils from the Stanley and Jackfork formations and their age indications are fully discussed on pages 14-24.

CANEY SHALE

The Caney shale is widely exposed in the Arbuckle Mountains and in the northwest part of the Ouachita Mountains, but disappears toward the southeast and is absent in the southern part of the Ouachitas of Oklahoma and at all places in Arkansas. The formation at its type locality—Johns Valley (formerly called Caney Basin or Cove), in upper Cane Creek Valley, 6 miles north of Eubanks, Pushmataha County, Oklahoma—rests upon the Jackfork sandstone. This relation holds in a fairly large part of the Ouachita Mountains of Oklahoma, but the Caney seems to overlap progressively both the Jackfork and Stanley toward the northwest, as is indicated by the presence of the Caney upon chert of the same age as the Woodford at three localities in northern Atoka and southern Pittsburg counties. (See Fig. 2-A). Also the Caney rests at places upon the Woodford chert (Devonian ?) in the Arbuckle Mountains and at other places upon the Sycamore limestone.

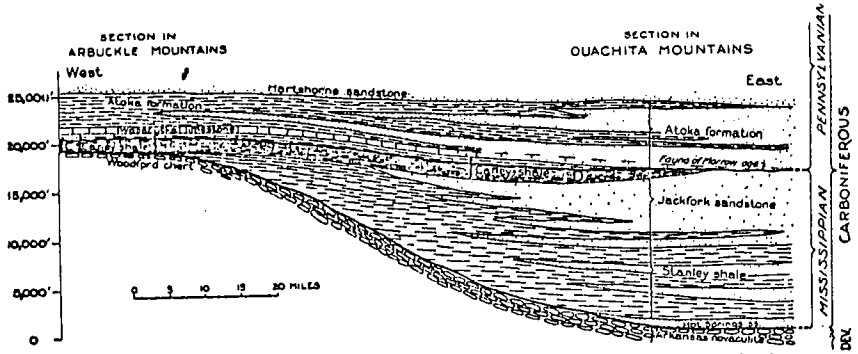
If the Caney does not overlap successively the Stanley and Jackfork in this manner, it is possible, as suggested by Honess, that the Stanley and Jackfork are beds equivalent to parts of the Caney. (See Fig 2-B). In this case, instead of the Caney overlapping the Stanley and Jackfork, these two last-named formations wedge into it—the wedges of sandstone having their broad, thick bases lodged against the ancient land, Llanoria, and their thin edges projected northwestward,

2. Miser, H. D., Mississippian tuff in the Ouachita Mountain region (Abstract): Bull. Geol. Soc. of America, vol. 31, no. 1, pp. 125-126, Mar. 31, 1920.
3. The black chert referred to here has been mapped and is shown on Plate 1, Circular No. 3, of the Bureau of Geology as "Stanley black chert." Descriptions of it are given in Oklahoma Geol. Survey Bull. No. 32, pp. 152-156 and p. 192, 1923.

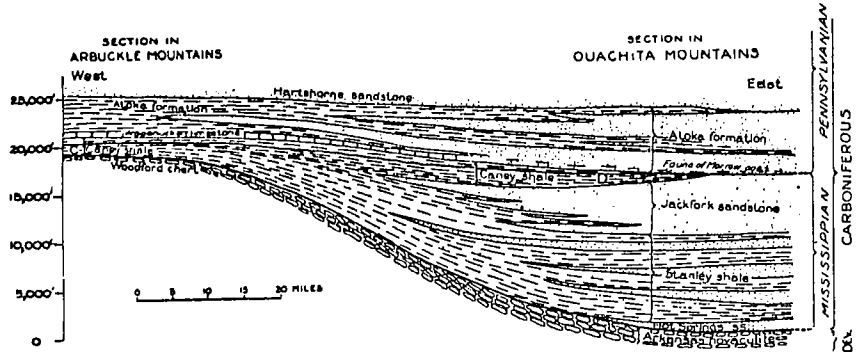
interbedded in shale and finally, far out, giving place to shale entirely—the Caney shale. According to this interpretation the Jackfork and Stanley are composed of northward thinning beds of sandstone and southward thinning beds of shale. The typical Caney shale that rests upon the Jackfork sandstone may simply be one of these beds of shale.

Whether the Caney overlaps the Stanley and Jackfork or whether it is a shaly northwesterly development of the same age as the Stanley and Jackfork will probably be discovered in time. At present there are these two working hypotheses.

The fossils and age of the Caney are fully discussed on pages 23-27.



A. Section illustrating the hypothesis that the Caney progressively overlaps the Jackfork and Stanley formations toward the Arbuckle Mountains where it comes into contact with the Woodford chert.



B. Section illustrating the hypothesis that the Caney contains beds of the same age as the Stanley and Jackfork formations.

Figure 2. Restored diagrammatic west to east sections illustrating hypothetical relations of some of the formations in the Arbuckle and Ouachita Mountains at the beginning of Hartshorne time. The points C in the two drawings represent localities where a Caney fauna of Mississippian age may be obtained from shale on top of the Woodford chert. The points D in the two drawings represent localities where a Caney fauna of Mississippian age may be obtained from shale on top of the Jackfork sandstone.

WAPANUCKA LIMESTONE

The Wapanucka limestone occurs along the north side of the Ouachita Mountains in Oklahoma but does not extend as far toward the southeast as the Caney shale. It is present westward, and is widespread in the eastern part of the Arbuckle Mountains, where it overlies the Caney shale.

Girty[4], Mather[5], and Morgan[6], who have studied the fauna of the Wapanucka limestone, point out the close similarity of the Wapanucka fauna to that of the Morrow group of Pottsville age in the southern Ozark region. From the fossils the conclusion is that the Morrow and Wapanucka are at least partially equivalent.

ATOKA FORMATION

The Atoka formation rests upon the Wapanucka limestone along the north border of the Ouachita Mountains in Oklahoma, upon the older Caney shale farther southeast, and upon the still older Jackfork sandstone beyond the margin of the Caney. The Atoka overlies the Jackfork everywhere in the Arkansas Valley and the Ouachita Mountains in Arkansas. Equivalent beds (the Upper Jackfork of Honess) rest upon the Jackfork in eastern Pushmataha and northern McCurtain counties. The Atoka rests not only upon older and older rocks toward the southeast but thickens in this direction from about 3,000 feet in the coal fields of eastern Oklahoma to thicknesses of 6,000 to 7,800 feet toward the east and southeast.

Mather[7], who has identified 42 species of fossils from the lower part of the Atoka near Clarita, Oklahoma, says, "The evidence is quite conclusive that this fossiliferous portion of the Atoka formation cannot be much, if any, younger than the upper beds of the Morrow group." Morgan[8], who has studied two small collections of fossils from the Atoka in the western part of the Coalgate quadrangle says, "It seems probable that at least the lower part of the Atoka is of Pottsville age."

The Atoka is succeeded in the Arkansas Valley coal fields of Oklahoma and Arkansas by the Hartshorne sandstone and this in turn by the McAlester shale, Savanna sandstone, and Boggy shale, in the order named with the oldest first.

4. Girty, G. H., The relations of some Carboniferous faunas: Wash. Acad. Sciences, Proc., vol. 7, p. 10, 1905.
5. Mather, K. F., The fauna of the Morrow group of Arkansas and Oklahoma: Scientific Laboratories Denison Univ., Bull. vol. 18, p. 83, 1915. Pottsville formations and faunas of Arkansas and Oklahoma: Amer. Jour. Sci., 4th ser., vol. 43, pp. 134-135, 1917.
6. Morgan, G. D., Geology of the Stonewall quadrangle, Oklahoma: Bureau of Geology, Bull. 2, pp. 56-62, 1924.
7. Mather, K. F., Pottsville formations and faunas of Arkansas and Oklahoma, Amer. Jour. Sci., 4th ser., vol. 43, pp. 135-137, 1917.
8. Morgan, G. D., Geology of the Stonewall quadrangle, Oklahoma: Bureau of Geology, Bull. 2, pp. 62-65, 1924.

CARBONIFEROUS ROCKS YOUNGER THAN THE ATOKA

The McAlester formation is known from its flora to correspond in age to the lower portion of the Allegheny formation in the Appalachian trough[9]. Concerning the flora associated with the Coal Hill which lies in the rocks immediately above the Hartshorne sandstone and at the base of the McAlester shale and which is commonly called the Hartshorne coal, David White[10] states that it indicates basal Allegheny age, but contains a few traces of Pottsville development, illustrated particularly in *Mariopteris* and *Neuropteris*. It thus seems probable that the Atoka formation, which reaches an estimated thickness of 7,000 to 7,800 feet in the Arkansas Valley in Arkansas, 6,000 to 7,000 feet in this valley in Oklahoma, and 6,000 feet in the Caddo Gap quadrangle, is of Pottsville age, and the formation is so classified by White.

DAVID WHITE ON FOSSIL PLANTS FROM CANEY, JACKFORK, AND STANLEY FORMATIONS

David White furnishes the following statements concerning a number of plant collections from the Caney, Jackfork, and Stanley formations in Oklahoma:

Most of the collections are designated by the lot numbers used in the paleobotanic work of the Survey at the National Museum.

3911, Impure limestone fragments collected by Taff and others from Caney shale.

Lepidodendron sp. suggestive of L. brownii.

3952, Caney shale. Vermicular traces of algae or borings, probably of no present value.

3910, Ramentum, possibly of Psaronius, associated with very small seeds, probably Trigonocarpum.

3911, SW. ¼ sec. 2, T. 1 S., R. 16 E., Antlers quadrangle: Black shale in valley of Caney Creek.

Calamitean stem base of pre-Pottsville aspect.

3912, Tributary of Ellen Creek just north of Ti post office, northeast corner of sec. 20, T. 3 N., R. 16 E.

Asterocalamites, probably A. radiatus.

6240, Eight miles east of Atoka. Collected by White. Jackfork ? (probably Stanley).

Asterocalamites, probably A. radiatus.
Stigmaria with small scars.
Lepidophloios ? decorticated, indeterminable twigs.

These fragments have a lower Carboniferous aspect, but the evidence is inconclusive.

5669, East-northeast of Tuskahoma, foot of Kiamichi Mountain.

Lepidodendron sp., indeterminable.
Lepidodendron veltheimianum, as described from the Carboniferous limestone by earlier authors.

9. White, David, Report on fossil plants from the Coal Measures of Arkansas: U. S. Geol. Survey Bull. 326, pp. 24-31, 1907.
10. Idem.

Sphenophyllum sp. (probably), indeterminable.
Sphenopteris sp., indeterminable.
Asterocalamites scrobiculatus (equals radiatus).

5508, NE. ¼ NE. ¼ sec. 32, T. 2 N., R. 20 E., lower part of heavy black shale, in creek bed. Stanley (?).

Asterocalamites scrobiculatus.
Asterophyllites ?
Sphenopteris cf. S. larischii.
Fern stem (Aneimites ?).
Lygenopteris sp. ?.
Trigonocarpum sp.
Sphenopteris sp., Mississippian aspect, indeterminable.

A collection of plants was obtained by H. D. Miser in 1914 and 1923 from the upper part of the Stanley shale in the Whitley railroad cut 2½ miles by wagon road south of Gillham, and 1 mile southwest of King, Ark. This collection was also examined by David White and is said by him to contain the best fossil plants that have come to his attention from the Stanley and Jackfork formations. He has supplied the following statement and list of species:

Sphenopteris cf. S. schimperiana.
Sphenopteris cf. S. quercifolia.
Sphenopteris cf. S. goepperti.
Sphenopteris cf. S. sphyropteris.
Sphenopteris cf. S. vespertinus or bifida.
Aneimites ? stem.
Neuropteris antecedens ?
Asterocalamites scrobiculatus.
Calamites sp. with wide ribs.
Sphenophyllum cf. S. tenerrimum, with very small leaves.
Lycopod stem, obscure, phyllotaxy verticillate in aspect.
Carpolithes, very small, species probably new.
Carpolithes cf. C. siliqua.
Trigonocarpum, small, coronate, same as at other localities.
Trigonocarpum cf. T. parkinsoni ?
Rhacopteris ? sp., fragment possibly from the basal portion of a leaf of this genus.

"The fossils in this collection have been subjected to wave attrition and have been reduced to very small fragments, most of which are somewhat macerated, as well as torn.

"Asterocalamites scrobiculatus and another calamarian stem comparable to Calamites roemeri are most numerous in the collection. With these are plant fragments, better described as ragged scraps, including Sphenopteris, probably S. goepperti, or possibly S. refracta (which may be identical with goepperti); Rhacopteris? or Adiantites; a Rhodea or Rhacopteris, probably identical with R. moravica; Sphenopteris cf. S. schimperiana and Sphenopteris cf. S. quercifolia, together with another Sphenopteris, possibly S. Bifida. The Trigonocarpums are comparable to T. conchaeforme and a new species found in the Floyd shale of Alabama. Carpolithes siliqua is of doubtful systematic value and is best known from the Pocono. Neuropteris antecedens is probably present. Sphenophyllum cf. S. tenerrimum as here identified is a more rigid and simpler type than that in the Pottsville.

"On the whole the plant material, consisting mainly of minute fragments, though in part closely related to species known from the Pottsville, appears to find a closer relation, and some specific identities in the floras described from the Carboniferous limestone, probably of Chester age, in the Old World. The **Lepidodendron** quoted as **L. veltheimianum** is identical with one from the Chester of Alabama, in which it is associated with a similar phase of **Asterocalamites scrobiculatus.**

"The discovery of better material will doubtless necessitate revision of some of the tentative (specific) identificatons. Possibly such material will show that the beds are Pennsylvanian, but the aspect of the plant fragments and the apparent relations of the beds strongly suggest that they are Mississippian. Accordingly, I am inclined to regard them as Mississippian and to suggest that they are of Chester age, but the paleobotanic data available are insufficient to justify their conclusive reference to the Mississippian.

"The examination suggests the possibility, of the deposition of a great thickness of sandstone and shale derived from the north Texas land mass on the south during the period of Mississippian uplift and deformation and the concomitant early stages of Pennsylvanian subsidence. Further, it is to be noted that marine conditions appear to have been absent in the Stanley-Jackfork region during most, if not all, of the time of deposition of this great thickness of beds."

C. S. PROSSER ON FOSSIL PLANTS FROM STANLEY SHALE.

C. S. Prosser, who collected some fragments of fossil plants from the Stanley shale in Hot Springs, made the following statement concerning them:

"On one of the olive pieces of shale is a fern pinnule, which is similar to those of **Sphenopteris.** It resembles somewhat the pinnules of **Sphenopteris decomposita** Kidston from the Calciferous sandstone (lower Carboniferous) of Scotland, but nothing could be stated positively of such a fragment. Other fragments resemble **Cordaites.**"[11]

CHARLES SCHUCHERT ON INVERTEBRATE FOSSILS FROM STANLEY SHALE.

A few invertebrate fossils have been found in the Stanley shale by Honess in McCurtain County, Oklahoma. The following statement from his report[12] gives the opinion of Charles Schuchert concerning them:

"With regard to the small marine fauna found on the banks of Little River (specimens 943 and 944) and the inarticulate brachiopods from the base of the Stanley (specimens 1015 and 1016) Professor Schuchert writes as follows:

11. Prosser, C. S., Notes on Lower Carboniferous plants from the Ouachita uplift: Arkansas Geol. Survey, Ann. Rept. for 1890, vol. 3, pp. 423-424, 1922.
12. Honess, C. W., Geology of the southern Ouachita Mountains of Oklahoma: Oklahoma Geol. Survey Bull. 32, pp. 177-178, 1923.

"It seems to me fairly certain that these specimens cannot be other than Mississippian or Pennsylvanian. As you got an undoubted **Lepidodendron** oven beneath lots 943 and 944 and as the specimen appears to me like a Pennsylvanian form, it seems that the whole of the Stanley and Jackfork may be Pennsylvanian in age rather than Mississippian. The marine fossils do not indicate anything to the contrary. Your marine fossils are as follows:

Orbiculoidea nitida Phillips. Loc. 1015 and 1016. I cannot distinguish the specimens from Coal Measures forms.

Crinoid columnals. Loc. 943 and 944. Common. At least two species.

Cystodictya, sp. undet. Loc. 943 and 944.

Rhombopora, sp. undet. Loc. 944.

Fenestella, sp. undet. Loc. 944.

Bryozoa, undet. Common, Loc. 944.

Productus suggesting Pustula nebraskensis, Loc. 943 and 944.

Chonetes, sp. undet. Loc. 943. (Very fragmentary. Finely striate form).

Fish bone. Loc. 943,"

E. O. ULRICH ON INVERTEBRATE FOSSILS FROM STANLEY AND JACKFORK

The same fossils as those submitted to C. Schuchert were also submitted to E. O. Ulrich, who reports in part as follows[13]:

"The invertebrate part of the evidence by itself would not be inclusive either way. The trend of the evidence is toward the Pennsylvanian rather than the Mississippian (either early or late). Again there is nothing in the collection that may be justly cited as definitely opposed to correlation of the Stanley with lower Pottsville or basal Morrow, which conclusion I reached in my 'Revision' mainly on physical and diastrophic considerations.

"The fossils observed by me in the Jackfork seemed decidedly corroborative of my convictions respecting the post-Chester age of the Stanley. So far as I can see, your new evidence leaves the problem just about where I left it in 1911—that is, with the probabilities favoring assignment of the Stanley to the earlier Pennsylvanian."

GEO. D. MORGAN ON CANEY FAUNAS IN ARBUCKLE MOUNTAINS.

G. D. Morgan[14] has recently made a study of the Caney shale including its fauna in the northern part of the Arbuckle Mountains of Oklahoma. He says:

13. Idem.
14. Morgan, G. D., Geology of the Stonewall quadrangle, Oklahoma: Bureau of Geology, Bull. 2, p. 56, Norman, Okla., 1924.

"From the evidence afforded by the fossils the conclusion is here drawn that the upper part of the Caney is of Pennsylvanian age and partially equivalent to the Morrow formation and that the lower part is late Mississippian, approximately equivalent to the Moorefield, Fayetteville, and Batesville formations of Arkansas."

C. R. EASTMAN ON FISH REMAINS FROM CANEY SHALE

C. R. Eastman[15], who studied brain structures of fossil fishes that were found in concretions in the Caney shale in Oklahoma, stated that the character of the fish remains tends to support the upper Mississippian age of the Caney.

INVERTEBRATE FOSSILS FROM JACKFORK SANDSTONE

Some fragmentary casts of shells were found in the De Queen quadrangle in a bed of dark greenish-gray millstone grit at the base of the Jackfork sandstone about one-eighth of a mile south of an abandoned sawmill site, which is near the north line of sec. 34, T. 7 S., R. 30 W., Ark. A collection from the locality was submitted for examination to G. H. Girty, whose report follows:

The material contains little besides crinoid segments which are in considerable abundance. Mr. Frank Springer has kindly examined some of these crinoid fragments for me and writes as follows regarding them: 'It is impossible even to guess at the geologic age of the crinoid stem fragments you have sent me. I have seen some joints in somewhat similar condition in highly metamorphic Carboniferous material in New Mexico, but so far as the crinoid fragments show it might belong anywhere from the Silurian to the Trias or Jura.

Among other forms are fragments of a finely costate shell which is probably some species of Productus. Another fragment suggests a species of Myalina, but it may not belong to that genus. A third and last type is a tiny fragment of some lunarium-bearing bryozoan suggesting Fistulipora, Meekopora, or less probably Cystodictya. The age of this collection is probably Carboniferous, but more than this it is impossible to say.

MORROW FAUNA FROM McCURTAIN COUNTY, OKLAHOMA.

A large fauna was obtained by C. W. Honess from two localities in the northwest corner of McCurtain County, Okla., from a thick succession of sandstone which he calls the Jackfork sandstone. The fauna is described[16] by him as a Morrow fauna and is composed of the following species as indentified by him:

15. Eastman, C. R., Brain structures of fossil fishes from the Caney shales: Bull. Geol. Soc. America, vol. 24, pp. 119-120, 1913.

16. Honess, C. W., Geology of southern Leflore and northwestern McCurtain counties, Oklahoma: Bureau of Geology, Circular No. 3, Norman, Okla.,

Morrow fauna obtained by Honess in northwestern McCurtain Co., Oklahoma

Zaphrentis gibsoni
Aulopora angularis n. sp.
Aulopora magna n. sp.
Aulopora gracilis
Polypora sp.
Rhombopora sp.
Many undeterminable bryozoa
Chonetes arkansanus
Chonetes sp.
Productus cf. gallatinensis
Productus sp. (1)
Productus sp. (2)
Productus sp. (3)
Pustula punctata
Pustula moorei n. sp.
Avonia sp.
Marginifera splendens
Squamularia transversa
Rhipidomella pecosi
Rhipidomella sp.
Schizophoria resupinoides (?)
Girtyella cf. emarginata
Spiriferina transversa
Spiriferina spinosa
Spirifer rockymontanus
Reticularia cf. setigera
Brachythyris laticosta
Hustedia brentwoodensis
Hustedia miseri
Composita subtilita
Composita wasatchensis
Composita cf. gibbosa
Edmondia sp.
Nucula anadontoides
Nucula parva
Nucula sp.
Leda bellistriata
Leda rugosa n. sp.
Parallelodon obsoletus
Parallelodon tenuistriatus
Leiopteria jackforkensis n. sp.
Leiopteria sp.
Conocardium parrishi
Myalina orthonota
Schizodus wheeleri
Aviculopecten cf. hertzi.
Aviculopecten halensis
Aviculopecten sp. (1)
Aviculopecten sp. (2)
Allorisma cf. goinitzi
Pleurophorus oblongus
Cypricardella oblonga
Cypricardella n. sp.
Astartella n. sp. (1)
Astartella n. sp. (2)
Plagioglypta annulistriata
Pharkidonotus percarinatus
Euphemus carbonarius
Phanerotrema grayvillense
Worthenia (?) tabulata
Worthenia sp.
Euconospira arkansana
Trepospira depressa
Euomphalus catilloides
Strophostylus cf. subovatus
Platyceres parvum
Zygopleura rugosa
Meekospira peracuta var. choctawensis
Meekospira sp.
Sphaerodoma intercalaris
Sphaerodoma primigenia
Orestes nodosus
Conularia crustula
Orthoceras sp.
Metacoceras cornutum
Gastrioceras excelsum
Gastrioceras sp.
Griffithides sp.
Eupachycrinus cf. magister
Eupachycrinus sp.
Crinoid stems and plates of doubtful genus
Fragments of wood
Shark spine

When the above list of fossils was published, Honess[17] commented in part as follows regarding the fauna:

The fauna is regarded as definitely Morrow and equivalent to the Wapanucka.

The Morrow fauna * * * occurs about midway in the sandstone series which forms Boktukola syncline. The sandstone series overlies the Stanley shale in normal sequence and is 13,618 feet thick, * * * The questions arising are: (1) Is the whole sec-

17. Idem.

tion Jackfork sandstone, or is only the lower portion Jackfork, and the upper part something else? (2) How much of the sandstone series may be regarded as Morrow? (3) Where is the Caney shale?

From the point of view of the lithology there is no difference between that part of the formation which lies below the fauna and that part which lies above it. There is no large body of shales intervening any place in the section to form a basis of division, and no part of this vast series looks like or resembles in any way the Caney shale or the Atoka formation. The Wapanucka limestone is wanting and in its stead there are fine-grained ferruginous sandstones. The entire series (13,618 feet thick) is one continuous and uniform whole, and this being a fact, the writer does not see fit to do otherwise than to speak of a Lower Jackfork (that portion which lies below the Morrow fauna) and an Upper Jackfork (that part which lies above it). * * *

The question of the exact limits of the true Morrow is one which cannot be answered at the present time. We shall have to await the discovery of other fossiliferous horizons, lower in the series. As to the Upper Jackfork, it is all Pennsylvanian, of course, by the law of superposition, and is, apparently, a sandy shoreward phase of the Atoka formation of more northerly latitudes.

Not having discovered the Caney shale in the Jackfork sandstone series, it must be much thinner in its southerly development, or possibly wanting entirely in the Boktukola syncline. Whether its position is represented by some one or more of the thin shaly bands in the Lower Jackfork, or to some part of the Stanley, if it may be permitted to go that far, is also an unsolved problem. It is hoped that some time, somewhere the Caney fauna may be discovered in the section beneath the Morrow horizon.

Correlating then, the Wapanucka of the Arbuckle region with the Morrow of the Ouachita region, a portion, at least, of the Upper Jackfork should be equivalent to the Atoka formation; and the Caney of the Arbuckles either pinches out to eastward and southward or wedges into the lower Jackfork or older sediments somewhere beneath the Morrow. The Woodford of the Arbuckle region is regarded as pre-Stanley and probably equivalent to the middle division of the Arkansas novaculite as Dr. Ulrich has pointed out.

PRESENT CONCLUSIONS OF AUTHORS ON MORROW FAUNA FROM McCURTAIN COUNTY, OKLAHOMA.

The Caney shale is apparently absent in the localities where the above-listed fossils of Morrow age were obtained, but it is present farther north and west in the Ouachita Mountains of Oklahoma, as is shown by J. A. Taff's manuscript maps of the McAlester, Antlers, Tuskahoma, and Windingstair quadrangles. As all these maps were used in the preparation of the recently issued geologic map of Oklahoma the belts of outcrop of the Caney shale are indicated on that map. The belts in a much generalized form are also indicated on the accompanying map (Fig. 1).

In the most southerly belts the Caney rests upon the Jackfork sandstone, but exposures at three localities in the Ouachita Mountains in southern Pittsburg and northern Atoka counties show it to rest upon chert beds of the same age as the Woodford chert.

The Caney is overlain by the Wapanucka limestone and this in turn by the Atoka formation in parts of the Ouachita Mountains of Oklahoma. But the Caney is overlain directly by the Atoka in parts of these mountains in Oklahoma. Both the Caney and the Wapanucka appear to be absent in the Ouachita Mountains of Arkansas; in the exposures in that State the Atoka rests upon the Jackfork.

The fauna from the Jackfork sandstone of Honess is appropriately designated by him as a Morrow fauna and the beds containing the fauna are correlated by him with the Wapanucka limestone. The part of the Jackfork above the fossiliferous beds has been termed Upper Jackfork by Honess and is regareded by him to be a probable phase of the Atoka formation.

When this correlation, and also the similarity of the "Upper Jackfork sandstone" with the "Lower Jackfork sandstone", are considered we may then raise the question; "Shall we follow time equivalency or lithologic character in the use of formation names?" Lithologic character is certainly to be followed in the definition and correlation of rock formations, but fossil evidence and the age relations indicated by fossils should also be considered.

For several reasons (enumerated below) the present writers believe that the "Upper Jackfork" sandstone should be given the name Atoka sandstone and the "Lower Jackfork" is the same as the true Jackfork sandstone. The reasons for the classification of the Upper Jackfork as Atoka and the Lower Jackfork as Jackfork are as follows:

1. The beds that contain the Morrow fauna in McCurtain County are correlated by Honess with the Wapanucka limestone.

2. These fossiliferous beds underlie the "Upper Jackfork" sandstone just as the Wapanucka underlies the Atoka.

3. The "Upper Jackfork", 6,000 feet thick, has a thickness similar to that of the Atoka in nearby areas to the north in Oklahoma where the thickness is between 6,000 and 7,000 feet and also similar to that in Arkansas where the thickness ranges from 6,000 to 7,800 feet.

4. The "Lower Jackfork" has not only the same lithology as the true Jackfork in nearby areas, but also the same thickness.

5. The "Lower Jackfork" is underlain by the Stanley shale just as the true Jackfork is underlain by the Stanley.

The type locality of the Jackfork sandstone is Jackfork Mountain, a long ridge trending in a northeast direction from northeastern Atoka

County into and across the adjacent corners of Pittsburg and Pushmataha counties, i. e., from T. 1 N., R. 15 E., into T. 3 N., R. 18 E.

The ridge-making sandstone of Jackfork Mountain is mapped by Taff as Jackfork sandstone. It is bordered on the north by the Stanley shale which underlies the sandstone and is also bordered by the Stanley on the south face of the mountain, though the Stanley on the south face of the mountain has been thrust northward against and upon the Jackfork sandstone along a thrust fault that separates the two formations here. No exposures of Caney shale have been observed and mapped on Jackfork Mountain by Taff, but belts of the Caney have been mapped several miles away from the mountain, both to the northwest and southeast. Taff's mapping in the McAlester quadrangle shows three belts—all in the Ouachita Mountains south of the Choctaw fault—where the Caney rests upon a chert formation of the same age as the Woodford chert.

The area of the Caney shale that is southeast of Jackfork Mountain is the type area of this shale. It is in Johns Valley (formerly called Caney Basin or Cove), six miles north of Eubanks in Pushmataha County. There the Caney shale rests upon the Jackfork sandstone several thousand feet thick—apparently about 6,000 feet. The type Caney contains a fauna which is regarded by most, if not all, paleontologists, who have studied the fossils, as being of the same age as the fauna of the lower part of the Caney in the three areas where the Caney rests upon chert of the same age as the Woodford chert. This fauna and also the fauna of the lower part of the Caney to the northwest are, however, regarded by some geologists as Mississippian and by others as Pennsylvanian. Those who hold the latter view prefer to think of the Caney fauna as a black mud fauna of Mississippian types, living intact through the Mississippian-Pennsylvanian transition and actually holding over into Pennsylvanian time."[a]

17-a. Since the writing of this paper E. O. Ulrich presented at Tulsa, Okla., in March, 1927, a paper that was based on extensive field investigations by him in 1908 and previous years and also on recent office studies of fossils. In his paper he expresses the opinion that the fauna in the black shale (his Johns Valley shale) on top of the Jackfork sandstone is not in place but has been transported from exposures of Mississippian Caney shale and that the fauna is now really embedded in a black shale of Pennsylvanian age. After the presentation of Mr. Ulrich's paper I spent three months making a special field study of the age relations of the Carboniferous rocks in the Ouachita Mountains of Oklahoma. Among the things I did was to examine carefully the Caney shale at its type locality which is now known as Johns Valley. This locality is also the type locality of the Johns Valley shale of Mr. Ulrich.

The shale in Johns Valley lies on top of the Jackfork sandstone in a broad long synclinal basin. In the lower 50 to 100 feet of the shale there are numerous ice-borne boulders and blocks of many kinds of rock including limestone, flint, and sandstone. The limestone masses which are more numerous than the other kinds range in size from small particles an inch or less in diameter to blocks measuring 30 feet across, though I observed one block measuring 200 feet in length, another measuring 110 by 195 feet, and a third about 50 by 369 feet. Fossils which have been obtained from many of the masses have been studied by Mr. Ulrich and his conclusions concerning them are that the represented faunas range in age from that of the Arbuckle limestone (lower Ordovician) to that of the Sycamore limestone (Kinderhook).

(Continued on bottom page 23).

The Upper and Lower Jackfork sandstones of Honess are designated Atoka and Jackfork, respectively, by Miser on the new geologic map of Oklahoma. This designation was made with the approval of Honess and also is made on the accompanying map. (Fig. 1).

The sandstone containing the fauna of Morrow age in McCurtain County is relatively thin, being not more than 10 feet thick, and is difficult to trace. Since the Atoka formation contains a fauna[18] similar to the Morrow farther north the fossiliferous sandstone is here included in the Atoka formation. The sandstone has been so classified on the recent geologic map of Oklahoma and also on the accompanying map (Fig. 1).

G. H. GIRTY ON AGE OF CANEY, JACKFORK AND STANLEY FORMATIONS

The following statement with reference to the age of the Caney, Jackfork, and Stanley formations has been written by G. H. Girty for this report:

> The Caney shale contains two very unlike faunas, of which the upper is Pottsville in age, and the lower, it is believed, Mississippian. The lower fauna, which is the only one that at present concerns this discussion, ranges through about 500 feet, beginning at the basal contact with the Jackfork sandstone. It is abundant in individuals, especially those belonging to a few species, and presents a fair variety of forms, of which 42 were recognized when the fauna was originally described. Though in these respects the evidence is favorable for purposes of correlation, it is rendered somewhat ambiguous by the fact that the Caney fauna is peculiar and very unlike any of the well-known faunas of Carboniferous age, Mississippian as well as Pennsylvanian. The faunas of northern Arkansas and northeastern Oklahoma are, however, intermediate in character, as they are intermediate in position between

17-a continued.

The boulder-bed just mentioned is apparently overlain by a black platy hard shale perhaps, several hundred feet in thickness. In several fresh clean exposures of the shale there are hundreds of small phosphate nodules,—most of them nearly spherical—like toy marbles,—and many concretionary masses of limestone. The limestone concretions all lie parallel with the bedding of the shale and the phosphate nodules are rather uniformly disseminated through portions of the shale. The nodules and the limestone concretions contain fossils, all of which belong to the fauna of the Mississippian Caney shale. Every feature of the shale, as revealed in the exposures, can be matched with exposures of the Caney shale in the areas where it rests upon the Woodford chert. The lithology of the shales in the two different stratigraphic positions—one on the Jackfork and the other on the Woodford—is the same. The character and arrangement of the limestone concretions are the same, and also the character and distribution of the phosphate nodules are the same. To me, as well as to several other geologists who accompanied me to Johns Valley in June, 1927, the conclusion which we reached while looking at the field relations, was obvious that the fauna as represented in the phosphate nodules and limestone concretions lived, died, and was buried where it is now found. If the fauna had been transported by floating ice, as is believed by Mr. Ulrich, there would surely have been some admixing of the Caney fossils with those of pre-Caney age and also there would surely have been an admixture of rocks of pre-Caney age. The excellent exposures of the Caney that were examined by me and by my geologist companions do not reveal a single pre-Caney fossil nor a single specimen of rock of pre-Caney age.

Oct. 5, 1927 H. D. MISER.

18. Mather, K. F., Pottsville formations and faunas of Arkansas and Oklahoma: Amer. Jour. Sci., 4th Ser., vol. 43, pp. 135-137, 1917.

the region which saw the development of the typical Mississippian faunas and that in which the Caney fauna lived. In this intermediate region are found many species that are identical with or closely related to those of the Caney shale, and at the same time others that are characteristic of the Chester faunas of the upper Mississippi valley, the two groups of species occurring either directly associated or in distinct but interfingering beds. The rocks in Arkansas containing such intermediate faunas have been classified as the Moorefield shale, the Batesville sandstone, and the Fayetteville shale and are recognized by all as of Mississippian age. These facts are not open to dispute—the three formations of northern Arkansas are of Chester age or possibly in part of pre-Chester Mississippian age, and the Caney fauna is more or less closely related to those Mississippian faunas, but is not at all closely related to any American fauna of known Pennsylvanian age. On these grounds the Caney shale was in 1909 correlated with the Moorefield-Fayetteville interval in the geologic sequence of northern Arkansas and identified as Mississippian.

In the intervening years much evidence has accumulated bearing upon this question, and it has accumulated all upon one pan of the balance. Faunas in a general way related to the Caney fauna prove to have had a wide dispersion on the North American continent and to have been confined to Mississippian time wherever the facts of paleontology and stratigraphy permitted this to be determined. On the other hand, or perhaps in other words, no fauna whose age could be determined as Pennsylvanian has been found that is in any sense comparable to the fauna of the Caney shale. As a more confined statement, many hundred collections of invertebrate fossils have been examined from areas in Oklahoma and Arkansas continuous with that in which the Caney shale occurs. In these collections a profound faunal change is shown between those that came from the Morrow group, which is of Pennsylvanian (Pottsville) age, and those that came from the underlying Mississippian formations. Without exception, wherever faunas of the Mississippian type were obtained, they occurred stratigraphically below faunas of the Morrow type.

In this region then, where the evidence is so pertinent and so abundant, its bearing is perfectly plain. The faunal succession is the same in the region where the Caney, Jackfork, and Stanley are developed. The higher fauna of the Caney shale is entirely different from the lower fauna and is closely related to that of the overlying Wapanucka limestone being without much question of Pottsville age and belonging in the general horizon of the Morrow group.

If the Wapanucka and the upper part of the Caney correlate with the Morrow group, the lower part of the Caney occupies the same position in the geologic sequence as the Mississippian beds that underlie the Morrow. Not only so, but its fauna, as already pointed out, is rather closely related to the faunas of those Mississippian formations, whereas no rocks belonging to the Morrow, much less any of those that overlie the Morrow, have furnished anything even remotely comparable to it.

COMPARISON OF CANEY FAUNA IN DIFFERENT AREAS

The Caney shale, as mapped by Taff and as shown on the new geologic map of Oklahoma, occupies two contrasting stratigraphic positions. In the Arbuckle Mountains it rests upon the Woodford chert (Devonian ?) or upon the Sycamore limestone (Carboniferous). Also it rests upon beds of Woodford age along the northwest border of the Ouachita Mountains of Oklahoma. But the Stanley shale and Jackfork sandstone both lie between the Caney and beds of Woodford age in a large area in the mountains in that state.

Because the Stanley and Jackfork attain an aggregate thickness of 12,000 feet or more and because they appear to wedge in toward the southeast and attain this thickness within a distance of a few miles we may properly raise the question; "Is the shale that is on the Jackfork of the same age as that on the Woodford chert and on the Sycamore limestone?"[19]

The apparent short distance in which the Stanley and Jackfork attain such a thickness is doubtless due in part to the shortening of the earth's crust in this part of the Ouachita Mountains. The amount of the shortening is not known but is certainly many miles and it has been brought about by both folding and thrust faulting.

The fauna from the lower part of the Caney, as described by Girty in Bulletin 377 of the United States Geological Survey, is made up of collections from the different areas where the contrasting stratigraphic relations obtain. The localities of the collections given on pages 73-75 of the above bulletin have been compared with J. A. Taff's maps, published and unpublished, and it appears that 20 collections were obtained from the Caney where it is on the Woodford or Sycamore and that 11 collections were obtained from the Caney where it is on the Jackfork sandstone.

The accompanying table, compiled from the list of Caney fossils on pages 9 and 10 of Bulletin 377, indicates the number of collections in which the species are represented in the Caney shale in the two contrasting stratigraphic relations.

Distribution of the Caney Fauna

The figures in the two columns are the number of collections in which the species are represented in the Caney shale in the areas where it occupies the two indicated stratigraphic positions.

A. Areas where Caney shale is on Woodford chert or Sycamore limestone; and B. Areas where Caney shale is on Jackfork sandstone.

	A	*B*
Lingula paracletus	2	0
*Lingula albapinensis	1	2
*Lingulidiscina newberryi, var. caneyana	3	2
*Lingulidiscina newberryi var. ovata	2	2
*Lingulidiscina batesvillensis	1	0
Chonetes planumbonus var. choctawensis	2	0

(Continued on page 26)

19. The field work by Miser in 1927 shows that the Caney in the two contrasting stratigraphic relations has many common lithologic features. H. D. M.

Distribution of the Caney fauna (cont'd.)

	A	B
*Productella hirsutiformis	3	0
*Productus pileiformis	1	0
*Liorhynchus aff. mesicostale	1	0
*Liorhynchus aff. laura	1	1
*Spirifer sp.	1	0
*Martinia sp.	2	0
*Composita ? sp.	2	0
Deltopecten ? caneyanus	2	0
*Caneyella wapanuckensis	4	3
*Caneyella vaughani	6	0
*Caneyella nasuta	0	2
*Caneyella percostata	3	0
Caneyella richardsoni	3	0
Parallelodon multiliratus	2	0
Conocardium sp.	1	0
Idiotheca rugosa	1	0
Laevidentalium venustum	2	1
Pleurotomaria ? sp.	1	0
Naticopsis sp.	1	0
Macrocheilus ? micula	1	0
Macrocheilus ? sp.	2	0
Orthoceras wapanuckense	2	2
Orthoceras caneyanum	3	2
Orthoceras crebriliratum	3	1
*Orthoceras choctawense	2	0
Orthoceras indianum	1	0
Orthoceras sp.	0	1
Cyclocerus ballianum	1	0
Actinoceras vaughaninanum	2	0
Cyrtorhizoceras ? hyattianum	1	0
Coelonautilus gratiosus	1	0
Bactrites ? quadrilineatus	1	0
Bactrites ? smithianus	4	0
Gastrioceras richardsonianum	6	5
*Gastrioceras caneyanum	5	2
Goniatites sp. a	0	1
Goniatites sp. b	1	0
*Goniatites choctawensis	5	2
Goniatites newsomi	0	1
*Adelphoceras meslerianum	2	1
*Eumorphoceras bisulcatum	4	4
Trizonoceras lepidum	4	1
Trizonoceras typicale	0	1
Entomis unicornis	1	0
Cytherella aff. benniei	1	0

* Indicates identical or nearly identical species occurring in the Moorefield shale, the Batesville sandstone, and the Fayetteville shale of Arkansas.

The table has been examined by G. H. Girty, who comments as follows concerning the comparison of the two lists:

> The Caney-on-Jackfork list is made up from 11 collections; the Caney-on-Woodford-Sycamore list is made up from nearly twice as many—20 collections. Other things being equal, the larger group of collections would be expected to yield the larger number of species. This proves to be the case and the Caney-on-Woodford-Sycamore list contains 46 species as against 20 species in the Caney-on-Jackfork list. As it chances, the ratio between the species does not vary far from the ratio between the collections.

If the Caney is the same in both of the areas under consideration, the two faunas should be essentially the same;—in explicit terms, most of the species going to make up the smaller fauna should occur also in the larger, and most of the common species in the larger fauna should occur also in the smaller. As regards the first point the lists show that of the 20 species composing the Caney-on-Jackfork fauna, 15, (or 75 per cent), occur in the Caney-on-Woodford-Sycamore fauna.

Before discussing the other point it is necessary to consider what is meant by the expression "common species". Although the Caney-on-Woodford-Sycamore fauna is made up from 20 collections, no one of the 46 species was identified in more than 6 collections. In fact, only two species were identified in as many as 6; only two others in as many as 5; and only 4 others in as many as 4. These facts illustrate the very scattered nature of the specific representation in the Caney shale. For the purpose of this comparison I have classed as 'common' any species that was identified in two or more collections. A larger number would probably make the comparison fairer but if that number was made larger by only two or three species the field of comparison would be reduced to only four or five species. If 'common' is defined as abve, there are 27 common species in the Caney-on-Woodford-Sycamore fauna, and of these 13 occur also in the Caney-on-Jackfork fauna. There is, however, another factor that ought to be considered in any definition of 'common', namely, the number of individuals as well as the number of localities. For instance, a species of the Caney-on-Woodford-Sycamore fauna recorded in 3 collections might be represented in each collection by one or two specimens, or by 100 or 200, but nevertheless the record would be the same. In a broad way a species is likely to be found in proportion as it is abundant or rare and one might think that the species abundant in individuals was more likely to be found in the Caney-on-Jackfork area than the species represented by but few individuals. For the same reason, however, it would be more likely to be found at many localities in the Caney-on-Woodford-Sycamore area, and as we have seen, no one species has been found at many localities in the Caney shale. There are other angles to this question.

The most notable of the "common" Caney-on-Woodford-Sycamore species that were **not** found in the Caney-on-Jackfork region are several species of **Caneyella** which are cited from 4, 6, 3, and 3 collections. From these records the representation of the **Caneyellas** would appear to be distinctly regional. On the ther hand, the most notable of the 'common' Caney-on-Woodford-Sycamore species that were found in the Caney-on-Jackfork area are the **Goniatites**, which are generally regarded as having been migratory and as being especially valuable in correlation. On the whole, the two lists appear to satisfy the requirements that might reasonably be predicated for two essentially contemporaneous faunas developed in adjacent areas like the Caney fauna of the Caney-on-Woodford-Sycamore, and the Caney-on-Jackfork areas.

CONCLUSIONS OF PRESENT AUTHORS.

The authors' conclusions, which are based on the available fossil evidence and stratigraphic evidence, are tentative and are thus subject to modification if future field studies bring to light new interpretations of the stratigraphic relations of the rocks and new and extensive faunas

and floras to augment the present meagre collections from the Stanley shale and Jackfork sandstone.

The identifications and conclusions from the fossils that have been studied and also the present interpretation of the stratigraphic relations of the rocks have been given in the preceding pages.

The authors' conclusions on the age of the rocks are that the Caney shale contains beds of both Pennsylvanian and Mississippian age, and that the Jackfork, Stanley, and Hot Springs formations are of Mississippian age.