GEOLOGIC ATLAS
OF THE
UNITED STATES
EUREKA SPRINGS—HARRISON FOLIO
ARKANSAS—MISSOURI
BY
A.H.PURDUE AND H.D.MISER
WASHINGTON, D.C.
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1916
FIGURE 1—Ideal view and corresponding contour map.

The alluvium represents a river valley between two hills. In the foreground is the sea, a body of water that is partly closed by a hooked sand bar. On each side of the valley is a terrace. The term "terrace" refers to the height above sea level. The vertical distance between two consecutive terraces is called the "height of the terraces." The height of the terraces is usually measured in feet or meters. In the diagram, the terraces are shown as horizontal lines at different elevations.

The contour lines are used to represent the topography of the area. Each contour line represents an equal elevation above sea level. The closer the contour lines are to each other, the steeper the slope. The contour intervals vary depending on the area and can be used to determine the steepness of the slope. In the diagram, the contour intervals are shown as solid lines at different elevations.

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DESCRIPTION OF THE EUREKA SPRINGS AND HARRISON QUADRANGLES.

By A. H. Purdine and Hugh D. Miser.

INTRODUCTION.

GENERAL RELATIONS OF THE QUADRANGLES.

The Eureka Springs and Harrison quadrangles lie between parallels 36° and 36° 30' and meridians 92° and 94° and include an area of about 1,925 square miles. They are in northwestern Arkansas (see fig. 1) and comprise the whole of Plains. For convenience, this northern part of the western boundary may be represented as a nearly straight line drawn, from a point near the southeast corner of Kansas to the sharp bend in Missouri River north of Marshall, Mo.

Topographically the Ozark differs from the adjoining regions in its greater altitude and relief. The Boston Mountains, which form the highest as well as the roughest part of the province, are slightly surmounted in both ruggedness and height by the Ouachita Mountains, but the broad dissected plateau surface of the Ozark region contrasts sharply with the long, narrow, sharp-crested, westward-trending ridges of the Ouachita Mountains and is also very different from the Arkansas Valley, whose nearly westward-trending ridges resemble but are generally lower than those in the Ouachita Mountains.

The Ozark region differs sharply from the Mississippian embayment not only in the character and age of its rocks but in its history and its physiographic development. The rocks of the Ozark region consist chiefly of dolomites, limestones, cherts, sandstones, and shales, ranging in age from Cambrian to Pennsylvanian, and of pre-Cambrian crystalline rocks. The rock beds, though lying nearly flat, have been arched into a broad, low dome. On the other hand, the exposed rocks of the Mississippian embayment, which also are practically horizontal, consist mainly of mud, gravel, and clay and range in age from Cretaceous to Quaternary. The geologic distinction of the Ozark region from the Glaciated Plains and from the Prairie Plains is not marked; some formations are common to all three provinces, and to a large extent their geologic history has been the same. The rocks common to their adjoining parts are practically horizontal and are mainly sandstones and shales of Carboniferous age, which as a rule have not been either partly or completely impregnated with variously westward-trending antlines and synclines which throughout the greater part of the valley have been bent downward into a westward-trending syncline. Although the rocks of the Ouachita Mountains, like those in the Arkansas Valley, are enormously thick, they consist chiefly of cherts, shales, sandstones, and siltstones, which range in age from possible Cambrian to Pennsylvanian. Their structure is that of a westward-trending anticline or fold, the numerous individual folds of which are closely compressed.

REVIEW.

The Ozark region consists of two parts, the northern and larger of which is the Ozark Plateau and the southern and higher the Boston Mountains, whose upper surface is likewise that of a plateau. (See fig. 2.)

The Boston Mountains have an average width north and south of about 25 miles, and they extend east and west a distance of approximately 300 miles, from the valley of Neosho (Grand) River in Oklahoma eastward to the Missis- sippian embayment near Batesville, Ark. The mountains slope from a gently dissected table-land, which rises 2,300 feet above sea level and 1,700 feet or more above the flood plain of Arkansas River, though a few remnants along the north side stand 3,200 to 4,000 feet above sea level. The mountains are rather rugged and have steep slopes and sharp projecting spurs separated by narrow ravines, 200 to 1,400 feet deep. The slopes are broken at many places by vertical or nearly ver-
700 feet, to which the same Boston Mountains escarpment has been said to extend. This escarpment is highest in its back country and gradually falls off westward and westward to the borders of the area. If viewed at a distance from the Ozark Plateau, on the north, this escarpment presents a bold, even, wall-like front and a level crest, but in fact it is very irregular, the plateau being dissected by numerous and deep ravines. (See Fig. 1. A.) Moreover, the arrow points of the mountain area, and numerous knobs and peaks that are isolated from the main upland mass conceal the escarpment and make the boundary between the mountains and the plateau transitional rather than abrupt, in spite of the difference in altitude and of the local steepness of the escarpment.

Many of the spurs and outlying peaks are in the southern parts of the Ozarks, Spring Hill and the Black Rock knobs are mentioned above. A more detailed account of the plateau is given in the chapter on ‘Topography.’

Most of the southern slopes of the mountains are less precipitous and pass off gradually into the broad old fields. Some of the high ridges and hills along its low dissected escarpments stand at the same general level. This dissected upland has been developed on the truncated residuals of a number of formations.

The St. Francis Mountains occupy a small area in southwestern Missouri, and are composed of resistant crystalline rocks and are highest at the highest point, Table Rock Mountain, of 1,750 feet above sea level, or 200 to 600 feet above the surrounding valleys and several hundred feet above the general level of the adjoining portions of the plateau.

DRAINAGE

The Ozark region lies wholly in the basin of the Mississippi River and its tributaries. It is divided into the following drainages:

1. The St. Francis River, which enters the Missouri River near Cape Girardeau, Mo.
2. The Current River, which enters the Mississippi River near Helena, Arkansas.
3. The White River, which enters the Mississippi River near Little Rock, Arkansas.

The streams of the Ozark Plateau in southern Missouri and northern Arkansas are very crooked. This is due to the region's topography, with many streams flowing over flood plains.

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The St. Francis River is the most important stream in the region, and its tributaries drain nearly all the plateau south of Table Rock Mountain. The Current River flows westward to White River, while the White River, which is the largest stream in the region, is formed by the White River and its tributaries. The White River is the longest stream in the region, and it flows from the east to the west. The Current River is the second longest stream in the region, and it flows from the north to the south.

The Ozark Plateau is drained directly by small streams to the Arkansas River, and the White River, which is the longest stream in the region, is formed by the White River and its tributaries. The White River is the largest stream in the region, and it flows from the east to the west. The Current River is the second longest stream in the region, and it flows from the north to the south.

The structure of the region consists of a number of large escarpments, which are composed of resistant crystalline rocks and are highest at the highest point, Table Rock Mountain, of 1,750 feet above sea level, or 200 to 600 feet above the surrounding valleys and several hundred feet above the general level of the adjoining portions of the plateau.

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Continuously recurring slow
warings of the earth’s crust produced changes in the outline
and position of the sea, and the strata laid down upon much
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this alteration, deposition was resumed over such areas, the new
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recently deposited sediments were elevated into land, were
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part of the Eureka Springs quadrangle, following a general northeastward course and leaving the quadrangle near the middle of its north side. About 2 miles of its course farther east in the northeast corner of the quadrangle. In the Eureka Springs quadrangle the principal tributaries of White River are Kings River, which enters the southeast corner; takes a northwesterly course through the quadrangle, exits the northwestern part of the quadrangle, and enters White River in Missouri, and Wolf Creek, which runs northwesterly across the south half of the quadrangle and enters White River just beyond the western margin of the quadrangle. Each of these streams receives numerous small tributaries, among which are Little Catty, Big Catty, and Leatherwood creeks, which enter White River in the northeastern part of the quadrangle, and Big Creek, which enters the southwestern part of the quadrangle, and enters White River in the Fayetteville quadrangle; Dry Fork, Pince, Rockhouse, Keels, and Ogee creeks, which enter Kings River; and Holman and Storms creeks, which enter Wolf Creek. In the Harrison quadrangle the largest tributaries of White River are Long, Bear, and Crooked creeks, and Buffalo Fork of White River. The creeks rise in upland areas to the west of the quadrangle, flow northward, and joins White River in Missouri. Bear Creek also rises near the center part but flows northeastward into White River, in the northeast corner of the quadrangle. Crooked Creek rises south of Harrison in two forks, flows northward, and then continues, and enters White River southeast of Cottar, Ark. Buffalo Fork of White River begins in the Bastion Mountains in the western part of Newton County, enters the southwestern part of the quadrangle, leaves it near the southeast corner after making a sweeping curve near the southern border, and joins White River in a few miles in the southeastern part of the quadrangle. Among the principal tributaries of these streams are Terrapin Creek, Nix Branch, and Dry, Yoom, and Cricket creeks, which enter Long Creek; Chautauqua Creek and Barnen Fork, which enter Bear Creek; Houser Creek, which enters Crooked Creek in the Yellville quadrangle; and Wells Creek, Mill Creek, and Little Buffalo Fork, which enter Buffalo Fork of White River. The two streams that are named are, next, White River, in the largest quadrangle, but they drain only about one-eighth of it. Much of the western part of the quadrangle is drained by Osage and Poyne creeks and by Dry Fork, which joins Kings River in the Eureka Springs quadrangle.

Most of the streams mentioned are perennial, and as they are supplied by springs their sources at low water are clear. They subject to sudden rises after heavy rains, which convert them from clear streams that can be easily fished to dangerous muddy torrents, but these floods last only a few hours after the rains cease. A large amount of mineral matter is at all times carried in solution and suspension by the streams. By the loss of this matter the surface of the region is being constantly though slowly lowered.

The streams in the quadrangle are very crooked. The distance in a straight line from the point where White River enters the Eureka Springs quadrangle on the west side of the price of art it leaves 100 miles and a half, but the distance by the curves of the river is 40 miles. Big and Little Buffalo forks of White River, in the southern part of the Harrison quadrangle, both quadrangles are equally crooked, the curves of the smaller streams have shorter swings than those of the larger ones. The surface on the inside of the curves, except along bluffs produced by occupying them, is the site of houses, and the highest points to the present streams boil. On many such slopes along White River waterworn gravel extends to a height of more than 200 feet above the present stream. On the outside of the banks the descent to the streams is everywhere steep and in many places vertical. These bluffs are prominent features of the topography, many being 200 feet high. The highest bluff, which is on a midslope of Big Fork of White River, 3 miles in a straight line northeast of Ponca, rises 500 feet above this stream. As the valleys are narrow, only small marginal areas are covered by mute, and where faulting or alluvial deposits are more narrow stretch along the streams.

The average fall of White River is about 25 feet, of War Eagle Creek 4 feet, of Kings River 5 feet, and of Buffalo Fork of White River 10 feet to the mile within the quadrangle. All these streams have short, comparatively quiet reaches separated by short riffles, and waterfalls are common along the upper courses of the small streams.

CULTURE

The quadrangles are not densely populated, though all parts of them are inhabited, with large portions of the area devoted to forest land in the quadrangles. The two largest towns, from which the quadrangles are named, are Harrison, the county seat of Boone County, and Eureka Springs, one of the two county seats of Carroll County. Eureka Springs is a prominent health and pleasure resort, which, particularly during the summer, is frequented by many visitors, who enjoy the pleasant climate and healthful climate of the area. The city is located in the northeastern part of the quadrangle, and is the county seat of Carroll County; Huntsville, the county seat of Madison County, and is the county seat of Newton County; and Green Forest, Belleville, Hindsdale, Alpaha Pass, and Oranola.

The Missouri & North Arkansas (formerly the St. Louis, St. Louis and Arkansas) Railroad, which is the principal link between the Eureka Springs quadrangle and the central part of the Harrison quadrangle, passes through the principal towns in these two quadrangles, the Brink and Rollinsville, and the Jefferson City limestone, which occupies the northeast corner of the Eureka Springs quadrangle and the White River section of the Missouri & North Arkansas (formerly the St. Louis, St. Louis and Arkansas) Railroad, is the most important part of the railroad, with a short section that is not well traveled. A few of the main roads, however, are kept in good repair. Apotag is the chief occupation in the quadrangles, which are adapted to general farming, fruit growing, and grazing. More or less lumbering is done. There is a large lumber mill at Eureka Springs and many small mills at other places.

DESCRIPTIVE GEOLOGY.

GENERAL FEATURES

The rocks of the Eureka Springs and Harrison quadrangles are all of sedimentary origin and consist of dolomite, magnesite, and limestone, with a small amount of quartzite. The rocks are considered to be nonconformable. The nonconformable is not generally apparent. The rocks in these regions are graphically represented in the columnar section, given at the end of the text. They belong to seventeen general formations, the highest of which is a thick, almost continuous, 3,200 feet thick. Of these formations only five, the Cotter dolomite of the Ordovician system, the Boone limestone and the Fayetteville shale of the Mississippian series, and the Hall and the Windom formations of the Pennsylvanian series, are everywhere persistent; the other twelve are cut off by unconformities of a larger area. The formation and their stratigraphic positions as determined by the Geological Survey of Arkansas and later retooled by P. J. Adams, E. O. Ulrich, G. H. Hury, David White, J. A. Taff, and the authors are shown in the correlation table on page 31.

ORDOVICIAN SYSTEM

Ordovician strata are exposed in the two north-western quadrangles, one in the northeast corner of each quadrangle. Elsewhere they outcrop as a rule in narrow bands along the larger streams and their tributaries. Except the Cotter dolomite (the oldest) and the Green River limestone, the well-marked eight formations representing this system are wanting over large parts of the area, but they commonly appear southwest in the Harrison quadrangle, and the smaller part of the formation may be seen in a few places in the Arkansas and in some places of Devonian and in some places of Mississippian age.

LOWER ORDOVICIAN SERIES

COTTER DOLOMITE

Definition.—The Cotter dolomite, as the name implies, consists largely of dolomite, but it also contains some sand, chert, and sandstone. The formation is named by E. O. Ulrich from the Cotter, Baxter County, Ark., where it is well exposed. In the report of the Geological Survey of Arkansas it is known simply as "magnesian limestone," and in Missouri it has been included in the "Second Magnesian Limestone." The name Yellville was applied in 1894 and again in 1905 by G. J. Adams and E. O. Ulrich for strata that have since been described as the Cotter dolomite by the Cotter dolomite and the Powell limestone, the limestone overlying the dolomite. In 1911 Ulrich called the Cotter the Jefferson City dolomite, but in 1912 he determined that the beds he called Jefferson City in the Eureka Springs and Harrison quadrangles are younger than this formation at the type locality. This name, therefore, is not applicable to these rocks, and for this reason the formation is called Cotter dolomite.

Distribution.—In the Eureka Springs quadrangle the Cotter dolomite is the surface rock along White River and its tributaries, and the largest exposure is in the northeastern part of that quadrangle. Several beds of this formation are found in the area, and the upper part of the formation is generally well exposed, but the rock containing them belongs to the Cotter dolomite. The other beds consist chiefly of chert, and the remainder being chert and sandstone.

The following table gives the species of fish collected in northern Arkansas, nearly all of which are characteristic of the formation:

<table>
<thead>
<tr>
<th>Species</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. p.</td>
<td>50.5%</td>
</tr>
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<td>S. alpine</td>
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<td>V. alpina</td>
<td>1.2%</td>
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<td>10.6%</td>
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<tr>
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<td>20.5%</td>
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*Present but not determined.

A. Leatherwood switch (north side); B. Leatherwood switch (south side); C.Deposit at Eureka Springs.

Several beds contain chert in the form of angular fragments, their resemblance, breccia, and others contain a good deal of dense gray to dark chert in lenticular and irregularly shaped masses. The nodules near the top of the formation are most pleasant banded with concentric and dark layers. Irregularly banded and massive masses of chert, with the outer or less perfect concentric structure of fine markings abound in two or three beds and are known as Cryptogamaeans. In some places near the surface of the formation, the sandstone beds are 10 to 20 inches in diameter. Some of the chert is calcite, and a good deal of the porous chert, in which the fossils are commonly found, is residual and is apparently produced by unaltered rocks, and in the absence of the all of certain beds of dolomite are exposed to weathering. Sandstone and shale form but a small part of the formation. The sandstone occurs in the dolomite as streaks, most of which are not more than half an inch thick, and as layers, few of which exceed 2 feet in thickness. It is carbonaceous, and the surfaces of both the sandstone and the bedrock layers are generally thinly fissured. The lower surface of the sandstone beds shows the casts of well-developed sand ripples that were formed in the underlying layer of calcareous mud beds and deposits. The shale consists of a few thin green beds, which weather to fine layers.

Fossils and correlation.—Organic remains are not generally distributed through the Cotter dolomite, but in certain beds fossils are found to the mile within the quadrangle. The masses of chert that are known as Cryptogamaeans are common and are everywhere striking. Though they occur in Missouri and farther east in Arkansas, as well as in the quadrangle, the Jefferson City limestone, which is the upper part of the area, and the rock containing them belongs to the Cotter dolomite. The other beds consist chiefly of chert, the remainder being chert and sandstone. The following table gives the species of fish collected in northern Arkansas, nearly all of which are characteristic of the formation:

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A. Leatherwood switch (north side); B. Leatherwood switch (south side); C. Deposit at Eureka Springs.
cover of cherry beds in day. With the exception of one or more beds of cherry stone, the formation consists of finely bedded and well-laminated limestone, containing more or less argillaceous matter. Most of the lime-
stone offshoots rather freely in cold dilute hydrochloric acid, showing beds of lime-filled cavities. The formation is at
least as great in the underlying Cutter dolomite, which is more
nearly a true dolomite. The light-colored, most porous beds are located in the middle of the Cutter dolomite,
but the small amount of chert throughout the formation and
the absence, except in the basal conglomerate, of the cherry
masses makes this limestone sufficiently distinct to distinguish this limestone from the Cutter.
A bed containing much drusy quartz and outcropping as a
sparging, massive dark ledge with a rough surface occurs in
the lower half of the formation in the eastern and southern
core of the Harrisson quadrangle. This bed, which is several
feet thick, is located in the Yellville quadrangle, on the
cast, but none have been found in it in the Harrisson

All these parts are not recorded on Swedes Creek and in Harrison County, about 2 miles south of Compton, but else-
where in the quadrangles one, or two, or all of these divisions may be wanting. The formation ranges in thickness from
a small ledge on a small hill to a great cliff. Throughout the
Harrison quadrangle it is exposed on Little Clifty Creek and its tributaries; on the upper part of Big Clifty Creek, Kossuth Creek, and in Williams Hollow; along Kings River and its tributaries most of the
way from a point a mile south of Williams Springs to the
mouth of Pine Creek; and along Pines Creek. In the Harr-
sisson quadrangle it is exposed along Ogee Creek near the
western border, on the heads of the streams from Francis east-
ward, on Hassar and Crooked creeks on the eastern border,
and along the two Buffalo forks north and northwest of the
mouth of the quadrangles, south of that parallel and east of Kings River.
The thickness of the upper limestone portion of the Evetson
range is generally about 6 feet in these quadrangles, but in
the adjoining Yellville quadrangle the maximum is con-
siderably more. Its thickness is irregular within short dis-
tances and is generally somewhat more to the north than to the
west. In general, it decreases northward and westward. The maximum thickness is found on Crooked Creek near the eastern border of the Harr-
sisson quadrangle, where it is in places 10 feet, at other
places in the same locality it is only 40 feet. Along Ogee
Creek, in the western part of the Harrison quadrangle, its
distribution is more or less uniform. Along Kings River and
its tributaries in the Evetson quadrangle its thickness is
generally 15 feet. On Buffalo Fork of White River and near Willysocken it is from 60 to 75 feet.
The part of the Everett that overflows the Kings River sandstone consists of alternate beds of limestone and sandstone, the calcareous portion comprising 50 to 75 percent of the whole. It is even bedded and the layers range from thin bedded to massive. The prevailing color is somewhat lighter than the underlying limestones, though both are white or light gray. Many of the limestones are made up of hemipelagidal masses from 6 to 8 inches in diameter, convex upward. The structure of these masses is that of concentric shells, and in some beds the layers have been broken out at the base and join those of the surrounding masses. Where such layers are exposed, as in the beds of creaks, the surface is distinctly banded. In the blocks of the limestone member farther east, the edges of the sandstone beds become fluted, and in places the parts of the area the limitation and cross-bedding are conspicuous. At its base the sandstone contains pebbles of quartz, chert, and quartzite, which are obviously of local origin. On the other hand, the underlying rocks there are here called "pipes" and are more fully developed in connection with the St. Peter sandstone, which shows similar phenomena. The exposure of this sandstone in the Eureka Springs quadrangle resembles in its general appearance the overlying rock, but the escarpment and is more closely joined to the Kings River sandstone that it is not easy to distinguish the one from the other.

**Sections—**The best observed section of the Everett limestone, where the Soodles limestone, the Kings River sandstone, and the overlying limestone are present, is given below.

**Section of the Everett Limestone in the Black Hills south of Compton.**

| St. Peter sandstone | Marine lenticular sandstone, forming layer of thin, gray or bluish sandstone, 0.25 foot thick... |
| Everett limestones | Commonly laminated limestones, forming thin, bluish or gray sandstone. |
| Kings River sandstone | Marine sandstone, laminated, forming thin, bluish or gray sandstone. |
| Powell limestones | Marine sandstone, laminated, forming thin, bluish or gray sandstone. |

The following section is exposed on Kings River a mile south of the mouth of Piney Creek, in the Eureka Springs quadrangle, where the Kings River sandstone is well displayed.

**Section of the Everett Limestone on south side of Piney Creek, Kings River sandstone well developed.**

| St. Peter sandstone | Marine lenticular sandstone, forming layer of thin, gray or bluish sandstone. |
| Everett limestones | Commonly laminated limestones, forming thin, bluish or gray sandstone. |
| Kings River sandstone | Marine sandstone, laminated, forming thin, bluish or gray sandstone. |
| Powell limestones | Marine sandstone, laminated, forming thin, bluish or gray sandstone. |

At many places in the Eureka Springs quadrangle the Kings River sandstone is the only representative of the formation, as on Little Cliffy Creek, where the following section was measured.

**Section of the Everett Limestone on Little Cliffy Creek.**

| Chattanooga shale | Black shale, exposed on bench. |
| Sylvania sandstone member | Angular clast fragments in finely grained quartz sandstone. |
| Everett limestones | Kings River sandstone member (marine sandstone). |
| Powell limestones | Marine sandstone. |

**Section on the east side of Kings River half a mile above the mouth.**

| Sylvania sandstone member | In wave-cut terraces consisting of marine sandstone, 1 foot thick. |
| Everett limestones | Marine sandstone. |
| Powell limestones | Marine sandstone. |

**Section on the west side of Wolf Creek half a mile above the mouth.**

| Sylvania sandstone member | In wave-cut terraces consisting of marine sandstone, 1 foot thick. |
| Everett limestones | Marine sandstone. |
| Powell limestones | Marine sandstone. |

**Fossils and correlation—**Organisms in the Soodles limestones have been observed only in the lower part of the core, at two localities in the Yellville quadrangle, which adjoins the Harrison on the east. The following species have been determined as far as the imperfect specimens permit:

- *Plectonema* sp., low spired, 0.003 to 0.004 inch in diameter, often with two or more spirals in a single coil.
- *Lychnoceras* sp., shell about 0.011 millimeters high, but about 0.040 millimeters wide.
- *Heterosiphon* sp. in *ff. gravis.*
- *Ampullaria* sp., free cheeks only.

Most of these species are of the genus *Lychnoceras,* which is known for its large size and is abundant in the lower part of the Soodles limestones. The back-reef localities for fossils are in the eastern part of the Harrison and in the adjoining western half of the Yellville quadrangle. Organic remains, however, are not generally distributed through the beds. As a rule the foraminifera, particularly the Ostracoda, are confined to certain layers in which they are often extremely abundant. The *Lychnoceras* and other foraminifera are very commonly found in great numbers. The pelecypods are more abundant in distribution, but when they occur at all their separated valves are likely to be numerous on one species, which with one or two exceptions are undescribed, have been determined, as follows:

**Monostromys** sp., a peculiar *Monostromys.*

Two or three undescribed *Pleuroceras.*

*Lychnoceras* sp., same as on the lower limestones.

*Lychnoceras* sp., high spired, 0.003 to 0.004 inch in diameter, often with two or more spirals in a single coil.

*Fenestella* sp., small, height less than 0.01 millimeters, var. minima.

*Fenestella* sp., var. subminima.

*Fenestella* sp., var. plana.

*Fenestella* sp., var. plana.

The Ostracoda are all small, not exceeding 0.03 millimeters in length.

No fauna closely resembling this is known from elsewhere. One of the pelecypods is identified with a species collected from the St. Peter sandstone, one of the gastropods is found also in the underlying Soodles limestones, and another can not be distinguished from a species found in the Joplin limestone. The general aspect of the fauna indicates that it might be of pre-Cretaceous age, though it is distinctly younger than the Joplin formation. These relations are in accord with the known fact that the St. Peter sandstone underlies the Stoner River (near Chazy age) in Kentucky. According to the evidence in hand the fossil herein listed from the Everett limestone, the Jashinch limestone, and perhaps the Joplin limestone, seem to give an imperfect conception of the first post-Joplinian fauna in Arkansas.

**Stratigraphic relations—**In some places the basin part of the formation contains fragments of quartz, sandstone, and limestones derived from the older formations; but at other places there is a distinct unconformity. For these reasons the formation is thought to lie unconformably upon the Powell everywhere in the Eureka and the amount of the overlying formation in the Eureka Springs quadrangle occupies the base of the upper limestone member, but in the Harrison quadrangle neither a conglomerate nor any other physiographic feature suggesting a stratigraphic break at this horizon was observed.

Near the mouth of Piney Creek, in the Eureka Springs quadrangle, the Kings River sandstone forms a lens in the bed of Bear Creek in the Harrison quadrangle. This unconformity is a conspicuous feature of
at the most southern outcrop along that stream. On Crooked and Hissor creeks it is 10 to 20 feet thick.

**Characfer.**—The formation is arkosoidal and is composed of well-rounded, medium-sized transparent quartz grains cemented by a small amount of calcium carbonate. Well-developed ripple marks appear in places. The sandstone becomes friable on weathering and shows fine laminations and cross-bedding, and in many places presents fluted surfaces.

A foot of sandy, bluish-gray sandstone in the St. Peter sandstone, 40 feet from its top, is exposed on Little Buffalo Fork, 3 miles northeast of Jasper. It is possible, however, that this sandy limestone is the upper part of the Eocene, and that the underlying 30 feet of massive friable white sandstone that is calcareous in thin layers is the Kings River sandstone member, but no characteristic lenses of the base of the St. Peter has been seen at a few other places in this part of the Harrison quadrangle these beds are referred to the St. Peter.

A peculiar feature of both the St. Peter and the Kings River sandstone is the rod uncommon occurrence in thins of pipes, as shown in figures 7,8, and 9. These pipes are exposed in the upper surface of the Eocene is more even, so that in many places the unconformity is not distinct. The Eocene sandstone is overlain by the upper part of the Sylamore sandstone, except about its northern border in the Harrison quadrangle, where the overlying beds are the Sylamore sandstone, as shown in figure 6. The mass of sandstone shown in the figure is either cave, channel, or sink-hole filling, the upper part of which was removed by erosion. A later submergence of the area brought about the deposition of the Sylamore sandstone.

**St. Peter Sandstone.**

**Definition.**—The St. Peter sandstone is widely distributed in the upper Mississippi Valley and extends as far south as northern Arkansas. It receives its name from the fact that it occurs along the lower course of St. Peter (now known as Minnesota) River, in Minnesota, where it is well developed. In different parts of the Ozark region it has been known as the "Key" sandstone (in the Yellville district in Arkansas), "Burgeon" sandstone (in northeastern Oklahoma), "Sochaoidal" sandstone, "Firtt" sandstone, "Crystal City" sandstone, "Pacific" sandstone, and "Cap-a-Gene" sandstone. Most of these names have been applied to the formation in Missouri. It consists of a massive bed of white quartz firmly cemented, not weathered, by a small amount of calcium carbonate.

**Distribution.**—In the Eureka Springs quadrangle the St. Peter sandstone outcrops along Kings River and its tributaries south of the Buffalo Fork post office and at one locality on War Eagle Creek northeast of Hindsville; in the Harrison quadrangle it outcrops on Osage Creek near the western border, on Crooked and Hissor creeks in the eastern part, and on Buffalo Fork of White River and its tributaries in the southern part. In these parts of the quadrangles that lie north of the area where the St. Peter sandstone is mapped numerous large isolated masses of arkosoidal sandstone stand up conspicuously on the hill slopes. Some of these are cave deposits; others are sink-hole deposits and have been described under the Powell limestone; but still others rest on top of the Powell and Eocene limestones, and they are interpreted as remnants of the St. Peter sandstone, left after the long interval of erosion that followed the close of Ordovician sedimentation in the Ozark region.

The St. Peter sandstone along much of its outcrop produces an evaporite which in many places is a precipitated bluish. The much weathered vertical face of this bluish is tinted here and there, and along the edges in most places more or less rounded. These bluish form a conspicuous feature of the slopes, especially along Buffalo Fork of White River north and northwest of Jasper, where the formation ranges in thickness from 75 to 150 feet. (See figs. 1, 2, 3, and 4.)

**Thick ness.**—The maximum observed thickness of the formation is 150 feet, as is at a point on Buffalo Fork of White River south of Compton. From that point the sandstone becomes thinner northward and disappears about the middle of the quadrangles. It also becomes thinner outcrop, and near Yeadle it is 10 feet thick. Along Kings River its thickness ranges from 10 to 70 feet. On Osage Creek its thickness is generally about 30 feet, but it ranges 100 feet

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**Eocene Limestone.**

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**Definition.**—The Joachim limestone consists of medium to coarse sandstone and greater or less mass of arkosoidal sandstone. Besides being widely exposed on the southern border of the Ozark region in Arkansas, the formation is found along the eastern border of this region in Missouri, where it was named by Arthur Winslow. In the Missouri section it is also known as the "First Magnesium" limestone and the "Follett" limestone. In Arkansas east of the quadrangles herein treated the
Joachim limestone represents the lower part of the Izard limestone. The thickness of the formation is 90 feet and more, and 95 feet in the southeastern part of the Izard quadrangle. Its thickness diminishes abruptly northwestward and is absent in the extreme northwest part of the quadrangle.

**Distribution.**—The Joachim limestone outcrops along Buffalo Fork of White River and its tributaries in the Izard quadrangle, but it does not outcrop in the Eureka Springs quadrangle. It is exposed in the Arkansas Valley and generally occurring on steep slopes just above the escarpment usually produced by the underlying St. Peter sandstone.

**Character.**—The formation consists mainly of compact, dark-colored, finely crystalline magnesite limestone, the greater part of which contains a large quantity of quartz sand. The limestone is generally friable and is usually exposed on the surface without any limestones below as lichen-beds. Layers of hard calcaceous sandstone several feet thick are intercalated with the limestone. These layers become feeble on weathering and are not unlike the weathered exposures of the underlying St. Peter sandstone.

Good sections of the formation, one of which is given on page 6, are exposed at many places in the Harrison quadrangle.

**Fossils and correlation.**—As a rule fossils occur rather sparingly in the Joachim limestone. At some places, however, in the vicinity of Jasper and at a point about 4 miles southwest of Yardsell, certain layers are crowded with shells of various kinds. The fauna so far collected comprises the following species:

- *Gyraulus sp.* (large, shellfish, sp. like in thickness, 0.25 inch).
- *Bivalvia sp.* (6) (inches about 1 sulfurea in diameter, Pseudoceras sp.?, short, bifurcated in outline, Delightia sp.?, short, pointed in outline, Delightia sp.?, short, pointed in outline, Delightia sp.?, short, pointed in outline).

As stated above, the Joachim limestone has herefore been called the Izard limestone. Prior to the discovery and study of the foregoing fossils it was supposed to correspond to the upper or the flat limestone of the Izard. But the fossils show that it does not, for none of them is found in either the upper or the lower limestone of which the flat limestone is the base of the Geological Survey of Arkansas based its composite formation. In the typical outcrop the Izard consists of a lower, middle, and upper limestone, corresponding with the Joachim limestone and an upper fine-grained pure dolomite limestone that corresponds to the Platte limestone of Missouri. The typical outcrop evidently belongs in the time of the two divisions of the typical Izard. It overlies the Joachim and, judging by its fossils, it is almost certainly younger in age than that of the carboniferous.
its bulk of the formation, consisting of 20 feet of fosil-free sandstone and 5 feet of boulders, which are thrown in great masses to the sea. This area is also surrounded by a large body of salt water, which is thrown over the rocks by the waves of the sea. The area is very extensive, and the salt water is thrown over the rocks in a very irregular manner, which makes it difficult to determine the exact extent of the area.

**Roleau and correlation.**—The Formation is divided into two main parts: the Upper Devonian and the Lower Devonian. The Upper Devonian is characterized by the presence of fossiliferous sandstone, which is rich in plant and animal remains. The Lower Devonian, on the other hand, is characterized by the presence of fossiliferous limestone, which is rich in fossil remains. The two parts are separated by a prominent unconformity, which is known as the Devonian-Permian unconformity. The Upper Devonian is further divided into the Ecca and the Karoo formations, which are characterized by the presence of fossiliferous sandstone and limestone, respectively.

**Middle Devonian Series.**

**Clyde Limestone.**

Deposition and distribution.—The Clyde Limestone is named from the Clyde River, in the Ecca Springs quadrangle, where, within an area not exceeding half a square mile, all its known exposures are found. The formation is a bed of limestone that is nowhere more than 25 feet thick.

Character.—The best observed section of the formation is at the head of a large ravine on the north side of the stream, on the west side of the SW 1/4 sec. 17, T. 39 N., R. 27 W., where it occurs in its maximum thickness. The lower 1 foot is gray compact laminated and cross-bedded limestone containing a few fossils and a large amount of quartz sand, the grains of which are rounded and transverse. The upper 12 inches is compact light grayish-limestone, which has a combed fracture and contains a considerable amount of sand that is finer than the sandstone. The upper bed was observed only for about 100 yards along the slope of the large ravine indicated above, where the following section was measured:

**Section of Clyde Limestone at Head of Little Clyde Creek in the SW 1/4 sec. 17, T. 39 N., R. 27 W.,**

<table>
<thead>
<tr>
<th>Havana</th>
<th>T. E.</th>
<th>B.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Sandstone</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pale Sandstone</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clydesdale Sandstone Member</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Clydesdale Limestone Member</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Fossil and correlation.**—The bed 18 inches of the Clydesdale limestone at the only locality in northern Arkansas at which rocks of this age have been found contains a small but highly characteristic Middle Devonian fauna. The fossils and the faunas are therefore somewhat difficult to prepare for determination. Amongst some 10 or 12 species are represented. Of these Spiriferiformes, the Lower and Middle Devonian Conodonta, Theriaceae, and Hemitrichia are positively identified, and Hemitrichia dolomii Green are positively identified, and Spirifer and Spiriferiformes. Cribellum and the Hyolithidae are identified with some doubt. The remaining species are belemnoids and gastropods that resemble forms commonly found in association with the fossils named; at least several species are represented, some of which are known to be characteristic of the genus and others that are found in Arkansas. On the evidence afforded by these fossils the Clydesdale Limestone is therefore confidently assigned to the age of the Mission shale of the New York section. More exactly correlated is it of the age of the Selivee Formation of Illinois.

**Stratigraphic relations.**—The Clydesdale Limestone rests upon the Upper Devonian of the Kings River sandstone member, but the two are separated by a break that represents a period of erosion lasting probably through middle and late Devonian and Silurian.

It is overlain by the Sylva sandstone member, from which it is separated by a stratigraphic break. There is, however, no marked physical evidence of a break between these two members, except that afforded by the overlap of the Sylva upon the Kings River member.

**Upper Devonian Series.**

**Huntsville Sandstone.**

**Definition.**—The Huntsville Sandstone was named by C. W. Hayes from Chatahoochee, Tenn., where it is well developed, but the name was not used in northern Arkansas until 1906, when it was supplied by G. I. Adams and E. O. Ulrich to the Echuca sandstone and shale in the Echuca Springs quadrangle. The formation in the Echuca Springs and Harrison quadrangles, as in the Fayetteville, consists of sandstone and shale known as the Huntsville sandstone, name this formation having been taken by J. C. Bremer from Sylva Creek in Stone County, Ark. The formation has also been called the "Huntsville" sandstone and "Huntsville" shale.

**Distribution and character.**—The Huntsville sandstone occurs in the northern half of the Echuca Springs quadrangle and on the northern border of the southern part of the Harrison quadrangle it overlies the Sylva sandstone, and in the southern and eastern parts of the quadrangle it is not present where the sandstone is exposed. West of Echuca Creek at the western border of the Echuca Springs quadrangle, where 50 feet of it is exposed, without, however, disclosing the lower part of the formation, it is exposed north and east. Its thickness along the northern part of the Echuca Springs quadrangle is 5 to 8 feet. In the northwestern part of the quadrangle and immediately west of Echuca Springs it is 2 to 6 feet thick. It occurs on the north slope of Pinkston Mountain but is absent farther south, along Rockhouse and Fanny creeks and their tributaries. Its outcrop is generally a narrow band on the hill slopes and appears just below the escarpment produced by the St. Joe limestone and above the small bench produced by the Sylva sandstone or possibly by other underlying sandstone beds. It is exposed at many places, but along most of its outcrop it is covered with residual material and debris derived from the overlying bench. Where the slope is thickest the lower and greater part of the Huntersville sandstone is black or dark brown, varying from black to dark gray, with a combed fracture and containing a considerable amount of sand that is fine. Where the lower part is absent and the upper part rests upon the Sylva sandstone the surface of the sandstone is at places much thicker and is thrown over the bench on which the black shale of the Chatahoochee is exposed.

Some of the sandstone mapped as Sylva in parts of the Echuca Springs quadrangle, where it is not overlain by the shale of the Chatahoochee, may possibly be of lower Mississippian age. If it is Mississippian the sandstone in these areas is a fine sandstone with a combed fracture and is overlain by the shale, which is composed of sand picked up from sandy beds that immediately underlie it. Such sand would have been deposited above the erosion surface and would have been underlain by the Mississippian sandstone that is currently continuous with the Sylva, and it is referred to the Sylva.

**The Sylva Sandstone is generally 2 to 5 feet thick, but at some places with a short distance it changes in thickness to 1 inch or less. It consists typically of one or more massive beds, but it is locally thin beded. It is composed of white to yellow in color and consists of matile-brown sand and silt grains.**

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**Definites.**—The Boone limestone consists of chert and limestone varying in amount horizontally as well as vertically, and is well rounded and transomed; in places it contains small particles of limonite derived from pyrite. Oval phosphatic pebbles, some as large as walnuts, are here and there scattered over its surface, and some such pebbles lie in and between the layers of sandstone. The pebbles are yellow to brown on the outside but on fresh surfaces are black. At some places the gray or white sandstone that overlie the limestone contain a small amount of disseminated black phosphatic material. In the Echuca Springs quadrangle the sandstone contains pieces of chert that look like water-worn pebbles, but many of these pieces are so irregularly shaped and transomed that they are not identifiable. Exposed upper surfaces of the sandstone show numerous small pits, and the undersurface of overlapping ledges are similarly pitted, from the dropping out of loose particles. The phosphatic pebbles, conglomerates, and limonite are characteristic of this sandstone, but they are not found at some places, and in these places is it difficult to distinguish the rock from the Mississippian sandstone, upon which it is exposed. Under such conditions it must be identified by its prominent differences, such as those of color, size, grain, and scale of weathering. As a rule, the Sylva sandstone is not so white as the other two sandstones and weathered with more rounded edges. Other differences are the absence of the Sylva from the cross-bedding and fine laminae that are characteristic features of the other sandstones.

The sand of this member was derived mainly from the St. Peter and the Kings River sandstone, though some of it was doubtless derived from sandstone in the Joachin and Jasper formations and in limestones of the Echuca, which overlies the Kings River.

**Foissal and correlation.**—Arid from a small Lepidodendron, which may be distinctly distinguished from L. ephedrus Hall of the Genesee shale of New York and which is much like E. north Hall of the Summory shale of Ohio, and from forms that have minute quadrangular joints and are known as condonites, the Chatahoochee sandstone has yielded no invertebrate fossils. Both the Lepidodendron and the condonites are characteristic fossils of the Chatahoochee sandstone in Tennessee. The only other fossil collected from this formation in Arkansas is an imperfect fish bone about 5 inches long, 2 inches wide, and possibly half an inch thick, which may be one of the mandibles of a species of Dicksonia. The specimen is embedded in a piece of sandstone from the Sylva, found at the base of the member in the adjoining Valley quadrangle, near Dorf, Ark. Bones of apparently the same fish occur in a phosphatic bed at the base of the Chatahoochee shale in Tennessee.

Lithologically the Chatahoochee sandstone agrees very closely with that of the same name in Tennessee and adjoining States. As the evidence furnished by the fossils is in entire accord with the correlation thus suggested, the practice of using the same name for the black shale and the sandstone in Arkansas seems fully warranted. There is some legitimate difference of opinion as to whether the formation should be classed as late Devonian or early Mississippian, but in this folio it is classed as Devonian.

**Stratigraphic relations.**—The Chatahoochee shale is unformable on the chert, appearing upon the eroded surfaces and truncated edges of which it rests, but the contact is only slightly irregular. In the eastern part of the Harrison quadrangle it rests upon the large身体岩, which is the source of the chert that rests upon the Joachin limestone and the Lower Mississippian, but in this folio it is classed as Devonian.

**Carboniferous System.**

**General Remarks.**

The rocks of the Carboniferous system in the area are divided into two series—the Mississippian below and the Pennsylvaniaian ("Coal Measure") above. These names are taken from the Missouri Valley and Pennsylvania, respectively, the regions in which the two series are typically developed. In the Echuca Springs and Harrison quadrangles the Mississippian series includes the Boone limestones, the Echuca sandstone, the Fayetteville shale, and the Pitts limestone, and the Pennsylvaniaian series includes the Hild formation, the Upper Mississippian, and the Marcella formation. Only the lower part of the Pennsylvaniaian series is exposed in the quadrangles, but higher rocks, which are coal bearing over considerable areas, are widely distributed in the Arkansas Valley, farther south.

**MISSISSIPPIAN SERIES.**

**Boone Limestone.**

**Definites.**—The Boone limestone consists of chert and limestone varying in amount horizontally as well as vertically.
It comprises strata of Kinderhook, Osage, and Warsaw age. At the base of the formation there is a persistent and occupies limestone that is mapped and described as the St. Joe member. This member is divided by J. F. C. Smith into several types from St. Joe, Ark., where it is typically exposed and where it was first studied by the Geological Survey of Arkansas.1

The formation is named from Boone County, Ark., most of which is included in the Harrison quadrangle. It is named after a prominent personage in the area.2

The limestone near the top of the formation in the Joplin district has been described by C. E. Sisbenthal as the Short Creek member, and a heavy bed about 300 feet below it as the Grand Falls chert member.3 These two members are probably represented in places in the Eureka Springs and Harrison quadrangles by beds of similar lithology and stratigraphic position, the Short Creek chert member by an oolitic limestone near the top of the formation and the Grand Falls chert member by some part of the chert beds beneath the oolite.

The thickness of the Boone, not including the St. Joe member, is generally 500 to 650 feet, but near Ponca, in the southern part of the Harrison quadrangle, it is about 600 feet.4

Distribution and surface form.—The Boone limestone is the surface rock over a larger area within the quadrangles than is occupied by any other formation. In the Harrison quadrangle it outcrops over a broad, irregular belt that extends northward across the lake of Joplin, and is nearly 3 miles wide, at least.5

The oolitic limestone near the top of the formation in the Joplin district has been described by C. E. Sisbenthal as the Short Creek member, and a heavy bed about 300 feet below it as the Grand Falls chert member. These two members are probably represented in places in the Eureka Springs and Harrison quadrangles by beds of similar lithology and stratigraphic position, the Short Creek chert member by an oolitic limestone near the top of the formation and the Grand Falls chert member by some part of the chert beds beneath the oolite. The thickness of the Boone, not including the St. Joe member, is generally 500 to 650 feet, but near Ponca, in the southern part of the Harrison quadrangle, it is about 600 feet. Distribution and surface form.—The Boone limestone is the surface rock over a larger area within the quadrangles than is occupied by any other formation. In the Harrison quadrangle it outcrops over a broad, irregular belt that extends northward across the lake of Joplin, and is nearly 3 miles wide, at least. In the extreme west of this belt the formation usually outcrops in narrow bands along the streams and at only a few places does it occur as outliers or inliers. It is exposed over considerable areas in the central and northeastern parts of the Eureka Springs quadrangle. Elsewhere in this quadrangle the outcrops are less extensive and lie along the hills in the northern part and in the valleys in the southern part.

The outcrops of the Boone over a large part of the quadrangles are dissected by narrow valleys, most of which are cut-away-like, but in places the larger streams the surface is less broken and is gently rolling, as in Hindsville, Osage Grove, Harrison, Guider, Elwood, and Bellefonte. In the northern part of both quadrangles and in the northeastern part of the Harrison, where the streams have cut out the Boone into underlying rocks, its outcropping edges from a steep slope known as the rim of the basin. This impression is probably most commonly developed on land of Eureka Springs, where it forms a highland rim that practically surrounds the basin-like area in which it is situated; elsewhere it forms a less steeply rising rim, which polymerization is probably most commonly developed on land of Eureka Springs, where it forms a highland rim that practically surrounds the basin-like area in which it is situated; elsewhere it forms a less steeply rising rim, which is usually 200 to 300 feet high. In the extreme west of this belt the formation usually outcrops in narrow bands along the streams and at only a few places does it occur as outliers or inliers. It is exposed over considerable areas in the central and northeastern parts of the Eureka Springs quadrangle. Elsewhere in this quadrangle the outcrops are less extensive and lie along the hills in the northern part and in the valleys in the southern part.

The valleys that have been cut into the Boone were reffered to the level marked by the crests of the highest high of the formation, the result would be a remarkably even straenum plan. Practically the only hills or mountains that would rise above it would be the Boston Mountains and a few hills of circumcreszent make up of formations overlying the Boone. Character.—The Boone limestone, exclusive of the St. Joe member, which can be described under a separate heading, consists of limestone, cherty limestone, and chert, the last two predominating. The relative proportions of chert and lime- stone differ both horizontally and vertically, but as a rule the chert content is 50 feet or more, and thick, that thickness may be

3 Bannister, W. F. The geology of Cincinnati and surrounding area. Cincinnati, 1875, p. 68-69, 163-164.
5 Bannister, W. F. The geology of Cincinnati and surrounding area. Cincinnati, 1875, p. 68-69, 163-164.
6 Bannister, W. F. The geology of Cincinnati and surrounding area. Cincinnati, 1875, p. 68-69, 163-164.
7 Bannister, W. F. The geology of Cincinnati and surrounding area. Cincinnati, 1875, p. 68-69, 163-164.
8 Bannister, W. F. The geology of Cincinnati and surrounding area. Cincinnati, 1875, p. 68-69, 163-164.
9 Bannister, W. F. The geology of Cincinnati and surrounding area. Cincinnati, 1875, p. 68-69, 163-164.
10 Bannister, W. F. The geology of Cincinnati and surrounding area. Cincinnati, 1875, p. 68-69, 163-164.
On Davis Creek a quarter of a mile northwest of Yardelle there is an apparent unconformity which can be confidently identified with the St. Joe member. Over the Precambrian limestones on Davis Creek, on the fourth mile northwest of Yardelle, varies in texture from compact and finely crystalline to coarsely crystalline beds almost without a break. It contains xanthate and shoolspool. The apparent unconformity between the two beds does not represent a long interval of time. It is the result of tectonic adjustment and is the horizontal layer of thin and massive limestones. (See fig. 11.) The lower line of beds exposed is raised above the stream.

Some of the more characteristic species of the St. Joe fauna, which especially show its affinity with the Fern Glen, are as follows:

- Corthyrella minor
- Corthyrella minor
- Cladosina arenacea
- Cladosina arenacea
- Cladosina arenacea
- Cladosina arenacea
- Cladosina arenacea

The foliage does not contain any visible faunas or other species which occur in the lower half of the Ofen and the Kuskokwim species. Some of the common and more significant faunas found in the lower half of the Ofen are listed below:

- Corthyrella arenacea
- Corthyrella minor
- Cladosina arenacea
- Cladosina arenacea
- Cladosina arenacea
- Cladosina arenacea

The fossil faunas listed were found in the upper half of the Fern Glen limestones:

- Triplagnostum arenula
- Triplagnostum arenula
- Triplagnostum arenula
- Triplagnostum arenula
- Triplagnostum arenula
- Triplagnostum arenula

Some novel features of these faunas are the occurrence of two Fern Glen species of Corthyrella at horizons equivalent to the upper horizon of the Fern Glen and the occurrence of faunas apparently belonging to the genus Delphinus practically throughout the Fern Glen at horizons as high as the Kuskokwim, and the occurrence of faunas of the genera Cymathula and Phyllophaga in both of the Fern Glen at horizons as high as the Kuskokwim and at horizons in both of the Fern Glen and the Kuskokwim. The absence of faunas of the genera Cymathula and Phyllophaga in the lower half of the Fern Glen is characteristic of the Kuskokwim and of the Beringian fauna. The absence of faunas of the genera Cymathula and Phyllophaga in the lower half of the Fern Glen is characteristic of the Kuskokwim and of the Beringian fauna. The absence of faunas of the genera Cymathula and Phyllophaga in the lower half of the Fern Glen is characteristic of the Kuskokwim and of the Beringian fauna.

The faunas listed from the upper half of the Fern Glen are:

- Delphinus arenula
- Delphinus arenula
- Delphinus arenula
- Delphinus arenula
- Delphinus arenula
- Delphinus arenula

This faunis differs somewhat from the peculiar assemblage of species found in the Short Creek of the Fern Glen at its localities and the occurrence of the Kuskokwim and the Kuskokwim quadrangle and is believed to be a continuation of this other. A collection made from this faunas at Ocmulgin, in the Kuskokwim quadrangle, contains the following species:

- Dictyotoma arenula
- Dictyotoma arenula
- Dictyotoma arenula
- Dictyotoma arenula
- Dictyotoma arenula
- Dictyotoma arenula

This fauna is essentially identical with those at horizons above the ofen member and is much more common in its aspect than it is in the horizons of the Fern Glen. The ofen member and the Kuskokwim members are characterized in a general way by distinctive faunas, but the faunas appear to change abruptly and they have many species in common with the faunas of the Short Creek and the Kuskokwim quadrangle. The upper horizon of the Fern Glen is probably an advance of the Kuskokwim.
Stratigraphic relations.—In the northern and western parts of the Eureka Springs quadrangle, the outcrop of the Lamar Sandstone is continuous upon the Chattanooga shale. In the central-eastern part of this quadrangle and most of the northern part of the Harrison it rests upon the Sylvania sandstone, the Canyon sandstone, and the Lamar Sandstone, the Joaquin limestone, and the highly cemented sandstone of the Chattanooga. Elsewhere it is continuous with the Chattanooga shale, which is apparently the same formation as the Chattanooga, but the sandstone is less cemented and the shale more argillaceous. In places the two formations are of the same age, as is shown by the fossiliferous beds and the fact that they are both of the same age. However, it is not certain whether the Eureka Springs sandstone is the same formation as the Chattanooga, or whether it is a separate formation.

The facies of the Eureka Springs sandstone is similar to that of the Chattanooga, but the sandstone is less cemented and the shale more argillaceous. In places the two formations are of the same age, as is shown by the fossiliferous beds and the fact that they are both of the same age. However, it is not certain whether the Eureka Springs sandstone is the same formation as the Chattanooga, or whether it is a separate formation.

The Eureka Springs sandstone is a well-marked formation, and is easily distinguished from other formations in the area. It is a fine-grained, well-cemented sandstone, with a thick bed of coal or shale at its base. The sandstone is usually gray or brown, and is often fossiliferous. It is locally thin, but it is generally continuous over the area.

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sandstones of Simonds in his report on Washington County. Simonds also uses this shale, from Mundall, Ark., for the upper shale of the Fayetteville, though the “Marshall” shale at the type locality is the same as the Fayetteville. Distribution.—The Fayetteville is nowhere absent in the Eureka Springs quadrangle and Harrison quadrangles. In the Eureka Springs quadrangle it outcrops on Posy, Posy, Poor, Blansett, and in the mountains in the northwest corner; on Grindall, Pond, Sandown, and Sweeny Mountain in the central part; and on the slopes of the mountains and along the roads in the southern part. In the Harrison quadrangle it is the surface outcrop of the southeast two-thirds of that area, where it is commonly exposed in rather steep slopes. The area where this is the surface rock nearly all remains in forest, though of the slopes above and the poor soil only small tracts have been cleared and put under cultivation. The shale is exposed at the surface at few places, being concealed almost entirely by the surface material in which there are large and small boulders derived from the Pittkin limestones, Hale formation, and Window formation, all of which outcrop higher on the slopes.

Thickness.—In the Eureka Springs and Harrison quadrangles the thickness of the formation ranges from 10 to 400 feet. The minimum thickness observed is in some of the knobs in the northwestern part of the Eureka Springs quadrangle, although in most of those knobs, as well as in those south of Eureka Springs, the formation is from 20 to 30 feet thick. The area of greatest thickness is a northwest-trending belt a few miles wide, extending from the vicinity of Green Forest to that of Baston. The common thickness in this belt is 150 feet. From this belt the formation becomes thinner westward and southwestward, so that in the Harrison quadrangle along the two Buffalo forks west of Jasper and along South Fork of Ouachita Creek, South Fork of Ouachita Creek, Dry Creek, and Swedeb Creek, its ordinary thickness is from 150 to 200 feet. In the Eureka Springs quadrangle, along Kings River, it is from 250 to 300 feet thick. There are one or two small knobs of the Ordovician rocks mentioned as outliers, on which the formation may be from 250 to 300 feet thick. At three localities in the southeastern part of the Harrison quadrangle its thickness changes so greatly in a short distance as to deserve special mention. One is in the valley of the Green Mountain Creek just west of Carrollton on what is called the Carrollton dome, where the formations below the Fayetteville are abruptly domed to the height of 325 feet above sea level. The other is the shale of the Fayetteville shale at the top of the dome is only 40 feet; a mile and a half east of this it is 350 to 400 feet, and at the same distance to the north and west it is 250 to 300 feet. (See section E–E1, structure-section sheet.) The second locality is a small area 2 to 3 miles north of Ouachita post office, where the Fayetteville shale is 25 to 30 feet thick. A mile to the east it is 300 feet thick and 2 miles to the southeast, south, and southwest it is 150 feet thick. The third locality is on the Swedeb Creek dome, along Swedeb Creek and the head of South Fork of Ouachita Creek, southeast of Grindall, where the Fayetteville is only 40 feet thick; but away from the dome its thickness increases in all directions until it is 100 to 250 feet within a distance of 3 miles. (See section F–F1, structure-section sheet.)

Character.—The Fayetteville shale consists chiefly of shale but includes a thin sandstone member, the Wedington, in the upper part and a thin limestone. The lower shale, which is that part between the Wedington sandstone, forms the bulk of the formation. It is black carbonaceous fissile clay shale that weathered to plastic clay of a yellow or red color. Globular concretions of black siderite known as clay ironstone are common in it, and on weathering these shale soiled in concentric shells of yellow limonite. Many of these concretions are cut into a great number of segments by a network of joints, now filled with calcite, which form what are known as septaria. Near the base there are septarian layers of limestone, whose segments are cemented together with white calcite that is blanched in many places by some organic matter. These layers are dark, and when freshly broken to a color that is bluish gray; in some specimens that of petroleum. Locally there occurs at the base a layer of fossiliferous limestone, which is a pale color or only a foot or two thick and commonly is bluish drab to bluish gray; but in the northeastern corner of sec. 15, T. 20 N., R. 28 W., it is a dark gray, coarse textured, somewhat dolomite, and contains numerous blackish to black calcite crystals. Now Batavia this bed is several feet thick.

The upper shale of the Fayetteville—that is to say, the part lying above the line of the maximum number of septaria, is a thin, almost soft as the lower shale of the formation. In the Eureka Springs quadrangle it contains in places thin layers of fossiliferous limestone. A maximum thickness of 70 feet for this part is reached in the southeast quarter of that quadrangle, from which area it thins eastward and northward. It occurs in the southeastern part of southwest of Harviellville,
Stratigraphic relations.—The Pitkin limestone overlies the Fayetteville shale and rests upon beds of different horizons in different parts of the area. Such a relation is suggestive of a stratigraphic break at the base of the Pitkin, but no further evidence indicating such a break has been observed in the area. It rests upon the upper shale of the Fayetteville in places near Wesley, on Drakes Creek, on War Eagle and Whar ton creeks northeast of Huntsville, near Kington, southwest of Guither, west and northwest of Jasper, and on two or three mountains west of Yardsite. On Sulphur, Boat, and Pilot mountains it rests upon the Wooling sandstone member. Possibly in many places where the Wooling is wanting it rests upon the lower shale of the Fayetteville. The Pitkin is unconformably overlain by the Hale formation, the lowest of the Pennsylvanian series. The evidences of this unconformity are a heavy conglomerate in places at the base of the Hale, the upper irregular surface of the Pitkin, its northern thinning, and its eroded northern border. The unconformity rapidly disappears southward, for there is little evidence of it in the southern part of the area herein discussed or in the adjoining area on the west and southwest.

PENNSYLVANIAN SERIES.

Only the lower part of the Pennsylvanian series is represented in the quadrangles. The strata consist of shale, sandstone, and limestone, with some conglomerate, and comprise three formations, of which the lower two constitute the Morrow group.

MORROW GROUP.

Hale formation.

Definition.—The Hale formation was named by J. A. Taff from Hale Mountain, in the western part of the Winfield quadrangle, where it is well developed. The upper beds of the Paleozoic series in Arkansas, other than the upper shale of the Fayetteville, is known as the Washington shales and sandstone. It consists of shale, sandstone, limestones, and conglomerates, all more or less disintegrated and limited in distribution. The character and diversity of the beds are graphically represented by figure 12, which consists of eight sections of the Morrow group. The formation ranges in thickness from 60 to 200 feet, the thinnest exposure being near Compton, in the Harrison quadrangle, and the thickest on Diers Mountain in the Eureka Springs quadrangle.

![Figure 12](image)

**FIGURE 12**—Sections of the Morrow group in the Eureka Springs and Harrison quadrangles.

1. Composite section in order north of Walnut Fork, Arkansas. Composite section 4 miles east of Rocky Ford, Arkansas. 2. Composite section on Table Rock Creek, near Compton, Arkansas. 3. Composite section on Table Rock Creek, near Compton, Arkansas. 4. Composite section on Table Rock Creek, near Compton, Arkansas. 5. Composite section on Table Rock Creek, near Compton, Arkansas. 6. Composite section on Table Rock Creek, near Compton, Arkansas. 7. Composite section on Table Rock Creek, near Compton, Arkansas. 8. Composite section on Table Rock Creek, near Compton, Arkansas.

Distribution.—The formation occupies the surface of considerable areas in the eastern part of the Eureka Springs quadrangle and caps the summits of knobs in the central and northeastern parts. In the Harrison quadrangle it outcrops in the slopes in the southwestern third of the area and on the mountains in the southeastern part. The inter-

and nonconformable. The massive beds, which are 20 feet thick in places, are gray to brown, coarse grained, cross-bedded, and in many parts of the area colorless. Some portions of the sandstone contain numerous limestone lenses and other portions are interbedded with limestone bands of several feet thick. In some places the nonconformable outcrops of this part of the formation produce bluffs, above which are narrow benches, as near Osage post office and Carrolton.

The bluffs appear where the rock is undermined by the weather-

ing of the shale beneath, which cracks and breaks off and falls to the slope below. Weathered surfaces of the sandstone generally show cross-bedding, and owing to the calcarous nature of some of the limestone, which readily weather into pits and lenticular cavities, these surfaces at many places assume a honeycombed or cavernous appearance.

The thickness of the middle part of the formation is irregular and varies from 20 to more than 100 feet. It is least in the Eureka Springs and greatest in the Harrison quadrangle. The thin part of the formation is largely shale, but it contains a good deal of sandstone. Much of the sandstone is hard, gray, thin bedded, and ripple marked; but in places it is soft, brown, cross-bedded, and calcarous. The shale is black, thin-bedded, and contains many thin, shiny plates that are particularly conspicuous in the red clay to which it weathers.

The upper part of the formation closely resembles the lower, except that it is much more calcarous. In the Eureka Springs quadrangle it is from 20 to 150 feet thick, and in most places outcrops in well-rounded hills or smooth hill slopes. In the Harrison quadrangle its thickness is from 5 to 100 feet and it outcrops in steep slopes or escarpments. The differ-

ences in the topography of its outcrop in the two quadrangles are attributed to differences in the proportions of the upper part and of the middle or shaly part of the formation. The sandstone, like much of that in the lower part, is brown, soft, massive, cross-bedded, and calcarous, and on weathering becomes exceedingly cavernous. Thin beds of black shale are common in this upper part.

Limestones as lenses and as more or less distinct beds occurs in all parts of the sandstone, the upper beds of which are distinctly calcarous and at the top grade into limestone. Thin-beded strata of pure white to pink Eureka Springs limestone, except at a few localities along the eastern border south of Kington and near the head of Tate Hollow. Its eastern exposure in the Harrison quadrangle is definitely limited by a line drawn southward through the center of the area, though it is locally absent in the west half of the quadrangle. This limestone is 6 to 10 feet thick and is composed of cross-bedded, coarse crystalline, highly fossiliferous, and of light-gray to rusty-gray color. In places it contains a few feet of compact bluish-gray noncrystalline limestone which at most places its outcrops are in bluffs or steep slopes, and it weathered by exfoliation into thin rusty plates parallel to the bedding.

Beds of limestone and dolomite.—The passage from the Mississippian to the Pennsylvanian is marked in northern Arkansas by a pronounced faunal break. Nevertheless, the earlier Pennsylvanian formations were for a number of years placed in the Mississippian. David White was the first to assign them correctly and correlating them with the Potawatomi. His conclusions were based on the faunal flora of the "coal-bearing" shale of the Geological Survey of Arkansas that lies between the Brentwood and Kosker limestones—a flora which he determined as of late middle or early upper Pennsylvanian age. Later, because the fauna of the Hale formation and of the Brentwood limestone proved to be closely related to the fauna of the Kosker limestone the Hale and the Brentwood also were placed in the Potawatomi. The Hale, Brentwood, and Kosker faunas are all closely related to one another and, though of Pennsylvanian age, they are consistently different from the familiar Pennsylvanian faunas of Kansas, Minnesota, Illinois, and other States, none of which, indeed, are geologically young. Many of the species are undescribed, and for this reason more lists do not give an adequate idea of these faunas. Two collections from the Hale formation contain the following species:
shale, the particular formation underlying it at any place depending upon the amount of erosion that preceded its deposition at that place. Not far south of the serted northern limit of the outcrop of the Pittsburgh limestone the shale is thought to be everywhere conformable with the subjacent rocks.

Where the section is fully represented the shale formation is overlain by the shale group. Where the layer is absent the Winslow formation rests unconformably upon the Hale.

Hale shale.

Definition.—The Hale shale was named by the senior author from the Hale Mountain, south of Emporium, parts of the Warren County, Arka., where it is typified developed. It consists of carbonaceous clay shale, containing two limestones, the Brentwood below and the Kasler above. The relations of these beds are represented in the first section of figure 12.

The Kasler was named by F. W. Simonds from the Kasler Mountain, south of Emporium, Warren County, Arka., and the Brentwood from the Brentwood, Washington County, Arka. In the reports of the Geological Survey of Arkansas the Brentwood is known as the "Pennsylvanian" limestone because the rather striking fossil Procopitella exsanguis is widely distributed in it. In the report of that survey the shale between the two limestones is termed the "Cohocton" shale from the fact that in places in Arkansas west of the quadrangles herein described it contains a thin seam of coal. The shale below the Brentwood is included in the "Winlock sandstone" and that above the Kasler in the "Millstone grit formation".

Distribution.—The Hale shale in the eroded is confined almost wholly to the Eureka Springs quadrangle. It is wanting in place near Kingston and Mayfield and east of Marble. It is exposed on the higher summits north of Drakes Creek and is small near near Mayfield, Huntsville, and Kingston, the outcrops forming narrow belts, generally on upper slopes. These belts are exposed and are covered with debris, though rock exposure is uncommon. It occurs in the southeast corner of the Harrison quadrangle on the heads of Dry and Sweden creeks and west of Buffalo Fork of White River, on the heads of South Fork of Osage and Potosi creeks, and on the north of Sassafras Mountain, at all of which places its outcrop is on the steep upper slopes.

Thickness.—In the Eureka Springs and Harrison quadrangles the formation ranges in thickness from a feather edge to 176 feet, the maximum occurring at the head of War Eagle Creek near the southeast boundary of the Eureka Springs quadrangle. From that locality it becomes thinner toward the west, north, and east. Its maximum thickness in the Harrison quadrangle occurs near Puxon, where it is 70 feet.

Character.—The formation, as already defined, consists of shale and of two limestone members, the Kasler and the Brentwood, the relations of which are shown in figure 12. In these quadrangles the Kasler member lies 10 to 20 feet above the Brentwood, the intervening rock being thinly fossil black shale with thin layers of sandstone near its base. Beneath the Brentwood and extending into the quadrangle from 0 to 10 feet of thinly fossil black clay shale, which is exposed on War Eagle Creek near the southern border of the Eureka Springs quadrangle and also 21 miles northeast of Drakes Creek. Elsewhere in the quadrangles this shale is absent or is not exposed, though it is persistent in the Window quadrangle. Within the area herein treated the shale overlying the Kasler Limestone is the least widely distributed of the beds of the formation. It occurs at many places southeast and southwest of Huntville and south-east of Kingston, but probably not in place in the Harrison quadrangle. It consists of thinly fossil, very black clay shale, which on weathering changes to an unusually plastic yellowish or reddish clay. Thin sandy plates and numerous clay ironstones (colerite) concretions, which commonly weather to limonite, are found in it.

The following sections of the Hale shale show the character and diversity of the formation:

Section of the Hale shale on War Eagle Creek at the mouth of the Eureka Springs quadrangle.

Window formation.

Cross-bedded sandstone in heavy ledge.

Brentwood shale.

Three thinly fossil clay shale containing a good many clay ironstone concretions, which on their surface are partly charged to purple hue.

Inches, highly fossiliferous gray to calcite-brown limestone, conglomerate containing the Kasler limestone member.

Inches, thinly fossil shale clay with thin sandstone layers near its base.

Hale Formation.

Cross-bedded sandstone near Puxon. A thin ledge of the same bed is described as occurring on the headwater of Sassafras Mountain, 2 miles southeast of Mashon, near the mouth of Buffalo River, where it is about 50 feet thick and is broken by a fault of a thin layer of sandstone with thin beds of shale.

The Window formation consists of alternate beds of sandstone and shale. The name is taken from Winslow, Washington County, Ark., at the summit of the Boston Mountain, in the St. Louis and San Francisco Railroad.

The reports of the Geological Survey of Arkansas the Window is known as the Millstone grit formation.

The exposed layer of the window is represented in the areas under discussion, the upper part having been removed by erosion. The thickness of the remaining part ranges from a few feet to the outlying knot, where it is thickest, to at least 200 feet where it is thickest. It is found in greatest thickness in the Eureka Springs quadrangle, where it is the rock in the large area east of Drakes Creek. Its greatest thickness in the Harrison quadrangle is on Taitor Mountain, where it is about 400 feet thick.

Description.—In the Eureka Springs quadrangle the Winslow formation consists of alternate beds of sandstone and shale. The name is taken from Winslow, Washington County, Ark., at the summit of the Boston Mountain, in the St. Louis and San Francisco Railroad.

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exposed farther south in this valley and in the Ouachita Mountains. The Window formation has nowhere yielded sufficient fossils for paleontologic correlation, so that its age has been determined from its stratigraphic relations to the Boyd shale beneath, which is of Pottsville age, and to the overlying and equivalent strata exposed in the deep synclined trough of the Arkansas Valley south of the area herein described, where the Window passes into the basement surface. In southern Oklahoma, where it rises in the south side of the Arkansas Valley and against the Ouachita Mountains, the equivalent section of the Window, according to J. A. Toff, has a thickness estimated at 8,000 feet, and in the Ouachita area in that State the equivalent strata are underlaid by the Wapanucka limestones, which are part of the equivalent, in part a fault of the Morrow group. 1 In that area, according to Toff, the stratigraphic representatives of the Window are divisible into three formations, the Atoka formation, the Harrison sandstone, and the McAlester shale. In the Tidewater quadrangle, which is mainly in Oklahoma, the topmost strata of the Window have been described by Toff 2 as the Akins shale member, which he states represents the upper part, approximately the upper third, of the McAlester shale. In the Window quadrangle, which is mainly in Arkansas and contains the type locality of the Window, this formation, as defined by the senior author, includes strata which in the southern part of this quadrangle have been divided by A. J. Cole 3 into the Atoka formation and the Harrison sandstone and which (according to Collie’s map) include the lower part of the Spadn shale. This shale is the lowest formation of the McAlester group and is overlain in the Arkansas Valley in Arkansas. Neither the Atoka nor the Window has yielded fossils that afford good ground for accurate correlation. The McAlester group, however, is believed by its fossil flora to be in age lower to the Alleghanian formation of the Appalachian trough. David White 4 states that the flora of the Coal Hill coal, which lies in the rocks immediately above the Harrison sandstone and is commonly called the Harrison coal, indicates its basal Alleghanian age but adds that the beds contain some Pottsville forms, particularly Menisporites and Neocystopteris. Probably the lower 1,500 feet or more of the Window in the Window quadrangle, its lower 600 to 800 feet in the Tidewater quadrangle, and 200 to 400 feet of it in the Muskogee quadrangle are the stratigraphic equivalent of the Atoka formation, which in the Arkansas Valley in Arkansas reaches a thickness of 7,000 to 8,000 feet, in Oklahoma a thickness of 6,000 feet, and in the Caddo Gap quadrangle, on the southern border of the Ouachita Mountains, a thickness of 6,000 feet. This part of the Window and its equivalent, the Atoka formation, which lies beneath a basal Alleghanian formation, are doubtless of Pottsville age. In the quadrangles here considered only the basal part of the Window formation has escaped erosion, the higher strata being exposed farther south, and this part probably comprises no rocks of later age than the Atoka formation or the Pottsville epoch.

Structural relations of the Window. The Window formation rests unconformably upon the upper or the lower parts of the Boyd shale or upon the Halle formation, the horizon of its floor at any given place depending upon the unconformity of the area that preceded its formation. At many places in the Harrison quadrangle it rests upon the Halle formation and at others upon the lower part of the Boyd. In the Eureka Springs quadrangle it rests upon different places upon the upper horizons of the Boyd shale, except near Mayfield, east of Maroa, and near Kingston, where its floor is formed by the Halle formation. Where it rests upon the shale in the Boyd formation, the nature of the contact can not be determined, as the lower part of the Window is itself shale, but where it rests upon the Brantwood or the Kessler limestone members or the limestone of the Halle formation the contact is distinct and the surface of the limestone is covered with small irregularities and is places weathered.

STRUCTURE.

INSCRIPTIONAL FEATURES.

Definition.—The strata in the Eureka Springs and Harrison quadrangles, which must have been deposited in a nearly horizontal position, have undergone little deformation. The general doming of the beds in the Ozark region (Fig. 1) is by no means atypical of those of this area a slight dip to the north, which is apparent in the Eureka Springs quadrangle but is largely disregarded in the Harrison quadrangle by minor folding.

Most of the minor folds in the strike, which dip steeply, and the synclinal flexures form small domes, and one axial fold is


Green Forest faults.—West of Green Forest, in the Harrison quadrangle, a fault between 5 and 6 miles in length extends almost along the northeast side of the Ozone anticline. The downward throw on its northern side is about 150 feet above the crest of Broken Mountain, from which point it decreases in both directions. (See section C-C.)

One of the smaller faults is a short fault on Long Creek 23 miles northeast of Denver, in the Harrison quadrangle. The downthrow is small and is on its southwest side. The fault is a steep fault which lies for 3 miles in the eastern part of the Harrison quadrangle and which extends into the Yellville quadrangle on the east. The downthrow is about 100 feet and is on its southeast side.

NORTHEASTERLY FAULTS

Price Mountain faults.—In the Eureka Springs quadrangle, in Walnut Township, Benton County, there is a fault extending from Red Bluff to White River to a point 3 miles to the northwest where it crosses a high point in a bend of White River. The downthrow is about 100 feet and is on its southeast side. This fault was not seen in the bluffs above Lake on the south side of White River but was observed at the head of Pine Creek at the crossing of the roads, in the west part of sec. 33, T. 19 N., R. 28 W. At the mouth of Pine Creek it passes into a syncline. It is described in the Fayetteville and WINDOW WILLOW as the Price Mountain fault and syncline. Its total length in the three quadrangles is 55 miles.

Drakes Creek fault.—The most persistent fault in the two quadrangles, though they are larger and occur in greater number in the Harrison quadrangle. The largest basin extends northeastward through Green Forest, is of irregular shape, and is about 15 miles long.

GEOLOGIC HISTORY.

GEOLINE RECORD.

The geologic history of the Eureka Springs and Harrison quadrangles is recorded in the numerous layers of rock at and below the surface. The geologic events now to be related have been previously discussed by a study of the topographic features and the rocks. The geologic events date in the geologic record are far too complete, but much of their history may be inferred from studies made in other parts of the Ozark region, for the same processes that operate in these quadrangles have operated also and affected the Ozarks somewhat similarly a large region around them. Much of the history of the smaller area is therefore deduced from the more complete record found in the Ozark region as a whole.

The oldest formation exposed in the quadrangles is the Cotton dolomite. Lower Ordovician age. Still older Ordovician strata are exposed farther east in Arkansas, and older Ordovician and Upper Cambrian beds and pre-Cambrian crystalline rocks are exposed further northeast, in Missouri. It is from the results of studies made in those areas, chiefly by others than the authors, that the earliest geologic events in these quadrangles are inferred.

PALAEOGEOGRAPHIC ERA.

CAMBRIAN AND EARLY ORDOVICIAN DEPOSITS BEFORE COOPER TIME.

At the opening of the Paleozoic era probably all the surface of the Ozark region had been above the sea for a long time and had undergone great erosion, but later in the Cambrian period the region was covered by the sea. The first deposits laid down in the encroaching sea consisted of sand and pebbles, which later formed sandstone and conglomerates, respectively. Then followed an accumulation of silts and clays, and later of siltstones, sandstones, and shales. From time to time more or less sand and shale were delivered to the sea, but the rocks formed from these terrigenous deposits are only a small part of those now exposed. The submergence lasted through the early part of the Ordovician period except during intervals when parts or all of the region became land, as is attested by conglomerates and sand creks.  

ORDOVICIAN DEPOSITION BEFOOD AND AFTER COOPER TIME.

Cooper deposits.—During Cooper time, while some Rockport deposits were being formed in the north-south Appalachian region, the sea was submerged at least in the southern and eastern sides of the Ozark region. If it extended over the whole province the rocks formed in the northern part were subsequently removed. However, the sea occupied much of the upper Mississippi Valley, where it received deposits that formed the Shackopee dolomites, with the lower part of which the Cotton dolomite is correlated. The chief deposits were calcium-magnesium carbonates, which formed dolomite, but some sand and considerable quantities of sand were also mixed with the sediments brought to the sea by the streams that were adjacent to land, and thin sand creks were formed in exposed sand flats and pebbles and other detrital material were carried from the eroded areas into the sea by running water. It is uncertain whether the sea was then the stable
of animals whose shells supplied the large quantity of calcareous material that now forms limestones of this age or whether this material was deposited as a chemical precipitate, probably the limestone was deposited in the basin of an oxygenated and chemically precipitated environment.

Nevertheless, the few fossils present in certain beds show that the sea of this time contained some marine life. A withdrawal of the sea or a reduction in the depth of the lake accompanied by a warming of the rocks into broad, flat folds, brought Cortez deposition during this time. The first deposit of Powell time in the quadrangle consisted of scattered beds of marly sandstone and siltstone, and as far as can be determined at least some of the material at the base of the Powell limestone indicates that it is a residual mantle or deposit in a low-lying or mud flat. The second deposit of Powell time is made up of the so-called Jaspilite and it consists of a calcareous sandstone which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The third deposit of Powell time is made up of the so-called Limestone Member, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The fourth deposit of Powell time is made up of the so-called Upper Limestone Member, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material.

Jasper formation deposits.—The Jasper formation deposits are characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The first deposit of Jasper time is made up of the so-called Lower Jasper Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The second deposit of Jasper time is made up of the so-called Middle Jasper Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The third deposit of Jasper time is made up of the so-called Upper Jasper Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material.

Chapouton deposits.—In the late part of the Devonian time the area was covered by a widespread upland and a low-lying area that was separated by a large body of water. The upland area was characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The low-lying area was characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The first deposit of Chapouton time is made up of the so-called Lower Chapouton Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The second deposit of Chapouton time is made up of the so-called Middle Chapouton Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The third deposit of Chapouton time is made up of the so-called Upper Chapouton Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material.

Carboniferous deposits.—In the Carboniferous time the area was covered by a widespread upland and a low-lying area that was separated by a large body of water. The upland area was characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The low-lying area was characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The first deposit of Carboniferous time is made up of the so-called Lower Carboniferous Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The second deposit of Carboniferous time is made up of the so-called Middle Carboniferous Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The third deposit of Carboniferous time is made up of the so-called Upper Carboniferous Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material.

Mississippian deposits.—In the Mississippian time the area was covered by a widespread upland and a low-lying area that was separated by a large body of water. The upland area was characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The low-lying area was characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The first deposit of Mississippian time is made up of the so-called Lower Mississippian Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The second deposit of Mississippian time is made up of the so-called Middle Mississippian Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material. The third deposit of Mississippian time is made up of the so-called Upper Mississippian Formation, which is characterized by the presence of a great thickness of sandstone beds that are rich in fossil material.
During the Burlington, Kankak, and Warsaw epochs there was an admixture of the lime deposits with siliceous which produced the chalk in the Boone limestone. Marine animals, chiefly crinoids, though rare, are found. Great numbers of brachiopods, bryozoa, and other forms were abundant, and their remains are well preserved at several horizons in the formations. The series continued until the Kankak epoch and into the Warsaw epoch, as shown by the presence of the Boone all along the southern and western flanks of the Cincinnati and other correlative formations along the northern and eastern flanks.

A retreat of the sea at the close of the Boone formation brought up the sea water over the land, and continued until further rises occurred in the Eureka Springs and Harrison quadrangles. These rises did not produce marked irregularities in the surface of the Boone limestone, but in southerly Missouri and northern Arkansas, the rise in the surface was accompanied by underground solutions, the result being the formation of sink holes in which later deposits were laid down.

During the earliest part of the Chester epoch the land comprised in the Eureka Springs quadrangle and most of that of the Harrison quadrangle, besides extensive areas to the west and northwest, undescribed and covered by a shallow limestone-making sea in which the Hinkleville limestone was formed. From time to time more or less quartz sand, which later became sandstone, was washed out over the sea bottom, forming the Bat Cave sandstone, which in the quadrangles is thickest to the northeast and thinnest to the southeast.

The section in this area is composed of some calcareous material, and the combination formed a calcareous sandstone. The general occurrence of cross-holding in the sandstone indicates shallow water. The Bat Cave sandstone, like the Hinkleville limestone, probably marks a slight submergence; for it is absent from considerable areas in the southeast corner of the Eureka Springs quadrangle and further west, in Arkansas and eastern Oklahoma. Certain interbedded marine forms were common while the material of the Hinkleville limestone was undergoing deposition but more rare while that of the overlying sandstone of the Bat Cave formation was being laid down.

Fayetteville deposition.—With the continued advance of the sea on the southern and southeastern borders of the Ozark region during the early Chester epoch a bed of black shale and sandstone, 15 or 20 ft. thick, was laid down, which, on solidifying, formed a shale known as the Fayetteville shale. The deposition of this mud was interrupted by a bed of sandstone, 2 or 3 ft. thick, known as the Hinkleville sandstone. This sand was delivered to the sea probably as the result of an elevation of the land that supplied it. There were also brief periods at near the beginning of Fayetteville time in which during the wave was sufficiently clear to permit limestone to be formed. The oscillations of the land evidently fixed the rocks in parts of the area of deposition, as indicated by the varying thickness in northern Arkansas of both the lower and the upper shales and of the Wellington member. The most prominent features produced, in part, at this time are the Ouachita anticline and the Corrullon and Secces Creek domes. But this anticline, and probably the two domes, had their inception at a much earlier date, between the Ordovician and late Devonian periods.

A short period of erosion may have followed Fayetteville deposition, a probability suggested by the overlapping relations of the Fayetteville limestone, which at some places extends over the upper shale, at others upon the Wellington sandstone member, and at still others possibly upon the lower shale. However, no trace of an unconformity, such as a conglomerate on an irregular surface at this horizon. As has been suggested, the varying thickness of the beds of the Fayetteville appears to be due in large measure to unequal sedimentation over the undulating surface.

Pikin lime-deposition.—During the Bedford time this shale was laid down calcareous deposits were formed over a wide area. Three deposits may be recognized; one of dolomite deposition of detrital material and consequently a time when the sea was at low. It was during this epoch that the Pikin limestone was formed. Mollusks, which at this time were abundant, especially bryozoa, corals, crinoids, and brachiopods, denote Chester age for the limestone, whereas their remains are well preserved.

Mid-Carboniferous erosion and denudation.—The Pikin limestone was the last deposit of Mississippian time, at the close of which probably all the Ozark region that had been submerged became land, except, possibly, small areas along the southern border of the quadrangles and larger areas further south and east. The surface of the top of the Pikin limestone over these southern parts of the quadrangles suggest that little if any erosion took place there, but the Pikin limestone in the northern parts of the counties was removed. The Fayetville shale was truncated by erosion. In southeastern Missouri and toward the center of the Ozark uplift the Boone limestone was not wholly eroded, but evidence of erosion is found in the region, and the depressions in the surface still contain remnants of Pennsylvanian conglomerates and shales. In the region farther north the erosion of the Boone limestone was accompanied by the appearance of the surface of Carboniferous time.

The folds or features which were started earlier were accentuated at this time, as is shown by the absence of the Pikin limestone and the occurrence of beautiful parallel beds in the region. A total conglomerate consisting of rounded pebbles derived from the Pikin limestone was laid down here and there along the advancing shore and was overthrown by sand, silt, and conglomerate, respectively. The matter course grained, cross-bedded conglomerates of this formation, which contains fossil wood and brachiopods and was probably derived from the near-by shore, and the current flows which, and the Searles Creek dome, which are the most conspicuous features in the quadrangles.

Pennsylvanian sedimentation.

During Pennsylvanian time the sea again transgressed upon the land, submerging all of northern Arkansas and parts of southern Missouri, the west, northern, and eastern flanks of the Ozark region and other large areas in the interior of the continent.

Hale formation.—The first rocks formed during the Pennsylvanian epoch constitute the Hale formation, which is the lowest horizon of the system, and the region became land. A total conglomerate consisting of rounded pebbles derived from the Pikin limestone was laid down here and there along the advancing shore and was overthrown by sand, silt, and conglomerate, respectively. Two of the more prominent folds, cross-bedded conglomerates of this formation, which contains fossil wood and brachiopods and was probably derived from the near-by shore, and the current flows which, and the Searles Creek dome, which are the most conspicuous features in the quadrangles.

Bloyd deposition.—The varying conditions of Hale time were followed by the deposition of the Hale epoch, by conditions that were more uniform over the area and resulted in the deposition of mud which on hardening formed the Bloyd shale, but only in the interior of the continent. The alternating layers of sandstone and shale which at these times were present formed the Eagle Bluff and Kosseker limestones. In the time between the deposition of these two limestones swamps existed farther west in Arkansas, where vegetal matter accumulated that was changed to coal.

After the deposition of the Bloyd shale three sandstones and muds of the rest if not all of the northern Ozark region again became land. During the period of erosion thus began the shale was removed from much of the Harrison and from the northern parts of the quadrangles. The condition is now an unconformity there, by which the succeeding Window formation rests in places upon the Hale formation. This unconformity is noted in the northern part of the continent, and the formation is exposed throughout wide areas and has been described.

The Springfield plateau in much of the Eureka Springs quadrangle in northern Arkansas is composed of the Osage formation. The northwestern extension of the erosion surface in southwestern Missouri that has been described as a Cretaceous-Tertiary formation. If the erosion, then, and cutting in the surface of the Springfield plateau was disregarded and only the flat-topped uplands of this plain and the Boone Mountains and their outliers were considered, the old ground surface would be practically reproduced over parts of the quadrangles, but it is not known just how far northward in the quadrangles the Boone Mountain plateau extended during Cretaceous and early Tertiary time. This Cretaceous-Tertiary surface probably corresponds approximately to the upper surface of the Osage limestone, though in the northern part of the Missouri quadrangle, as well as in other areas where the surface of the Boone is relatively low, it may have been developed on higher formations that were afterward removed.

The main drainage lines cut in the southern Ozark region at the time this erosion surface was formed were White River and Arkansas River, from which small tributaries gradually cut back to the divide between the two. Most of the streams doubtless reached grade and developed meandering courses.

Cretaceous and Eocene era.

Had the region not suffered erosion after uplift it would have stood much higher than it stands now and the surface of the quadrangles would have been nearly level, though broken here and there by irregularities due to faulting and slight flexing of the earth's crust. The region became land. At least 1,000 feet of material has been removed from these parts of the country. The erosional surface of the Boone limestone is the surface rock, and 1,400 to 1,700 feet from those parts where the Cotter domes is the surface rock.

During this period of erosion in northern Arkansas three successive plateau in the Boston Mountain plateau, the Springfield plateau, and the Saline plateau were formed. Each of them has an undulating surface that is cut by canyon-like valleys, and above the lower two stands isolated remnants of the next higher slowly vanishing uplifted surface.

The erosion that formed these physiographic features doubtless has not continued at a uniform rate from the time of the emergence of the region to the present but has been at times retarded by a reduction of the area to moderate relief and at other times accelerated by a new surface or new cycle. How many such cycles the region has undergone is not known.

The rather even summits of the Boston Mountains, which form essentially a plateau, suggest that they represent a former peneplain or base-level surface, but the authors of this folio are inclined to the view that their present level does not imply a former base-level but has been determined by the preservation of the resistant beds of the Window formation. As a matter of fact, any existing evidence of a former peneplain would be difficult to recognize in a region that has been originally a nearly level coastal or structural plain. The rock strata are nearly horizontal over much of the Boston Mountain plateau, and as descending they are accompanied by a new surface or new cycle. How many such cycles the region has undergone is not known.

Most of the streams doubtless reached grade and developed meandering courses.

Probably a much wider area than that, perhaps all the rest of the southern Ozark region, including the Eureka Springs and Harrison quadrangles, was raised above water at this time. This elevation, which was affected by increased uplift of the land, which may have raised some submerged parts above the sea, and which was accompanied by the widespread coastal movements which occurred at the close of Carboniferous time.

No record remains that this area was again the seat of sedimentation, except possibly for a brief time when the waters of the Upper Mississippi and Cretaceous sea rose and covered the eastern part of Arkansas and adjacent areas, may have encroached upon its southeastern slope. The forces that elevated the land and formed the plateaus of Arkansas and the Boston Mountains. These forces, however, accentuated some of the old folds, notably the Osage antiline and the Searles Creek dome. The Cotter dome was but little affected. The fracturing of the strata took place near the close of the Carboniferous period and was probably contemporaneous with the flexing.
removed by denudation during the present cycle of the older strata overlying it. Further atmospheric and physiographic study of this interesting problem outside the quadrangles is necessary before it can be explained satisfactorily. At present, the authors, in view of the evidence available in northern Arkansas, where they have studied this physiographic feature, hold to the view that this pleistocene is a structural plain due to resistant strata.

The sluggish meandering streams of Cretaceous and Tertiary time were rejuvenated by the uplift of the region at the close of the Eocene epoch and many streams were cut by cutting their beds downward. At the same time they have shifted laterally by undercutting the outside of their curves, thus greatly changing the original meanders. A slight curve once begun may become a large curve in a vigorous, downward-cutting stream as well as in a weak, depositing one. That the curve of these streams, many of them bold and compressed, have been in large part formed since the Eocene epoch is at once evident from the slopes above the streams, which are long and gradual on the inside and precipitous on the outside. The inside slopes are steeper with more or less terrace gravel; the outside slopes are bluffs that commonly have a height of 300 to 300 feet, though one bluff is 600 feet high. (See PI. I.)

The courses of the streams have been determined partly by the structure. The strata in this area have some major flexures and numerous minor ones. The largest flexures have determined the general courses of some of the streams, and probably the smaller flexures, which are "wobbles," have determined the narrower courses. As more pronounced in the older than in the younger rocks the streams are more and more influenced by them as they lower their beds. As a result of this influence, the lateral sides of the smaller streams flow with the pitch of the hills, several of the larger streams flow in antiformal valleys or synclinal troughs, and many curves and bends in the strata. The small streams in the depressions of the structural wobbles.

Though the structure of the area has determined or affected the minor features of the streams, yet, as may be seen by reference to the contour map of the deformed surface of the Boone limestone, there is no striking relation between the structure and the general direction of the streams. White River, in the northwestern part of the area, follows a syncline, but it flows against instead of with the plunge. The upper part of War Eagle Creek flows across an antiformal instead of following the Dry Creek fault and joining Kings River or Richland Creek. Kings River flows for a part of its course along the strike of a monocline, and Osage Creek, one of its tributaries, flows against the dip. Onge Creek follows the Osage antiformal for a part of its course but flows against the plunge of the anticline at its southeast end. Yocum, Long, Bear, and Crooked creeks and Buffalo Fork of White River follow their courses regardless of structure.

The present drainage is probably the result of numerous captures and other diversions of streams affected which, in the time they flowed over rocks that were long ago removed by erosion, their removal obliterating all clues to that part of the drainage history. It is to be noted, however, that the part of White River in northeastern Arkansas formerly flowed westward into Oklahoma through Illinois River and its tributaries but was captured by a stream working its way back from Missouri. Probably also, the upper part of War Eagle Creek formerly flowed into either Richland Creek or Kings River and was captured by the main stream, and the upper part of Osage Creek formerly flowed either southwestward into Dry Fork or northeastward into Long Creek and was captured by the main stream working its way backward along the axis of the Osage anticline.

MINERAL RESOURCES.

The important mineral resources of the Eureka Springs and Harrison quadrangles consist of building stone, clay, lime, cement, road materials, glass sand, ores of zinc and lead, and bituminous shale.

STRUCTURAL MATERIALS.

Building stone.-The principal building stone in the Eureka Springs quadrangle, building stone is quarried from the Cotter dolomite. It is compact grey magnesian limestone or dolomite, in beds from 2 to 4 feet thick. The best beds afford durable building stone of pleasant color.

In and about Eureka Springs, Harrison, and Jasper, the St. Joe limestone furnishes stone for retaining walls, buildings, and culverts. Usually that portion of the member that comes immediately beneath the road and portion of the member and when put up as under it makes an attractive building of massive appearance.

The stone of the calcareous beds in the Boone limestone above the St. Joe has a pleasing light-gray color, is compact, and is largely crystalline. Much of it would make superior building stone and it would be extensively used at that purpose if a demand existed. The Hindsville limestone member of the Batesville sandstone, in beds, of a pleasing gray color, and would make good building stone. The limestones for the columns at the front entrance of the main building of the University of Arkansas, at Fayetteville, was quarried from this limestone. Others.-Βartlett Springs.

Other formations that afford building stone are the Jasper limestone, the sandstone of the Batesville formation, and the Halo formation. Some of the rock is gravelly and has been utilized for building purposes. It is placed in Green Forest and Harrison and on farms. The thin-bedded sandstone of the Halo formation is used in constructing buildings at Hindsville, Summerdale, and Huntsville and by farmers for granaries and in root cellars.

Clay.-The residual clays in the Boone limestone and in the Cotter dolomite will make good common bricks if properly worked. Some of the clays near the edge of the ledge at the northern end of the Panama road are worked for building purposes.

Glass.-Limestone suitable for making Portland cement can be obtained near Silver Springs and for this purpose from the Chocotano, the Fayetteville, and the Floyd shales and the Halo and Winfield formations.

ROAD MATERIALS.

The chert of the Boone formation is left in large quantity on the surface as a residual product. Under climatic influences it is broken up into small fragments that make admirable road material. In many places the fragments have collected in enormous quantities as talus at the base of the slopes, where the material could be easily loaded on wagons with a steam shovel.

OTHER NONMETALLIC MINERALS.

Much of the St. Peter sandstone and of the Kings River sandstone is sandcrushed and fragile and is composed of practically pure silica. It is well suited for the manufacture of plate glass.

The shales of the Chocotano and the Sylamore sandstone member are in places phosiphatic, but probably no part of these beds in the areas here considered is rich enough in phosphates to be of value for making fertilizers.

Geologically, the area is less prominent in northern Arkansas in rhinolite wells with the hope of finding oil or gas, but neither has yet been found in commercial quantity north of Cotter. It is to be noted, however, that the part of White River in northeastern Arkansas formerly flowed westward into Oklahoma through Illinois River and its tributaries but was captured by a stream working its way back from Missouri. Probably also, the upper part of War Eagle Creek formerly flowed into either Richland Creek or Kings River and was captured by the main stream, and the upper part of Osage Creek formerly flowed either southwestward into Dry Fork or northeastward into Long Creek and was captured by the main stream working its way backward along the axis of the Osage anticline.

WATER RESOURCES.

Ground water.-Springs are common in all parts of the quadrangle and their water is widely distributed by streams, most of which furnish a constant supply of excellent quality. The chief water-bearing formations are the Cotter dolomite, the Batesville sandstone, the Purdy limestone, the Coon Formation, and the Winfield formation, the Brookville carrying the most water and the Winfield the least. The water of the Cotter dolomite is clear and cold, and is usually uncontaminated, as the region is sparsely populated. The water from the Cotter dolomite and the Pittkin limestone is hard. That from the Boone, the Batesville, and the Halo, though hard, does not contain so much lime as that from the Pittkin and the Cotter, because of the greater proportion of chert in the Boone and sandstone in the Batesville and the Halo. The water from the Winfield, which comes from sandstone, is soft.

Strong springs are not uncommon where the Cotter dolomite is the surface rock, though they are not nearly so abundant as in the Boone limestone where spring water is not available from the Cotter a good supply of water at moderate depth can be obtained from wells.

The Boone limestone is an excellent water-bearing formation, for it is thick, bears a great deal of cht vesinits on its surface, which causes the run-off, and is much fractured and jointed. Springs of strong, sparkling springs issue from it, especially at its base. Water from this formation supplies the springs at Eureka Springs, which, as in other places where the Chattanooga shales are present, the springs emerge at the top of the shale and the base of the St. Joe limestone member. When the shale is absent, however, they emerge at the top of the Sylamore sandstone member. Where the Boone limestone is the surface rock over rather level areas, such as those around Spring Valley, Hindsville, and Oark Cree and at places along the railroads, springs are rare and water must be procured by means of wells, which as a rule need not be dug or drilled to a depth exceeding 75 feet. In much of the northern half of the area, where the Boone lies high above the streams, it is not practicable to dig wells or usually to drill them, because of the great depth to ground water from the crists of the hills.

Where the Batesville sandstone is the surface rock it is an important water-bearing formation because the calcium carbonate that makes it compact and impervious in other places has been washed out. Small springs issue from it here and there along the hill slopes, but over the more level and areas outside of its outcrop, the largest of which is around Green Forest, a sufficient supply of water for general farm and domestic use can be obtained from wells.

The Buffalo shoal, on which the Pittkin limestone rests, prevents the water from passing downward from the limestone, through which it moves along joints in small underground streams and from which it issues here and there along the hill sides in strong springs.

The sandstone of the Halo formation, having been generally made of sand or gravel by the breaking down of the calcium carbonate, when it is exposed it forms an excellent water reservoir, along whose outcrop many fine springs issue in the southern part of the quadrangle. Where the sandstone is the surface rock over considerable areas water is obtained from it by shallow wells.

The springs that emerge from the Winfield formation are few and small. The sandstone of the formation, however, furnishes abundant water to wells of moderate depth, even on the summits of the highest mountains. The inhabitants of the areas in which this is the surface rock rely almost wholly on wells for their domestic supply.

Water power.—The fall on White River from Junction Ford to the State line in Carroll County, 20 miles along the stream, is 96 feet, equivalent to an average fall of only 0.5 feet to the mile. But the fall from Hubbard, Washington County, Ark., to the State line, 12 miles along the stream, is 369 feet, equivalent to an average fall of 0.021 feet to the mile. The water power available in this stretch of the stream can be utilized by building dams 10 to 12 feet high at intervals of 5 or 6 miles and installing at each dam suitable hydroelectric generators.

The fall on Buffalo Fork of White River from Boxley. Less than a mile more than a mile south of the Harrison quadrangle, to the mouth of Little Buffalo Fork, a distance of 32 miles, is 2265 feet, equivalent to an average fall of about 10 feet per mile. Measurements made July 20, 1910, in sec. 8, T. 16 N., R. 30 W., on Buffalo Fork of White River above the mouth of Little Buffalo, gave a flow of 65 cusecs of water per second. The fall of 323 feet in the part of the stream considered show that there was available in that stretch about 2,500 horsepower.


2 Idem, p. 11.
Streams that are dammed at several places in the quadrangles furnish power for small grist and other mills. Water from a few of the larger springs and that at some of the low waterfalls is used for generating power.

**SOILS.**

The surface of large parts of the quadrangles is rough, and much of the soil in such parts is unfit for cultivation. This is especially true of the southern part of the area. Practically all the soils of the region are residuary. The stream valleys are narrow and contain but little alluvium. Even along White River, the largest stream in the area, there are no large floodplain deposits. Where the Boone limestone is exposed over local areas, as about Hindsville, in the Ezra Springs quadrangle, and in the west-central part of the Harrison quadrangle, it makes a good soil, but where the surface is rough the soil derived from that formation is thin and unproductive, because most of it is removed by erosion. For the same reason the soil over most of the area in which the Ordovician rocks are exposed is unsuitable. The Batavia sandstone, at the largest exposures of which are in the Harrison quadrangle, forms a moderately good soil. The considerable areas of the Hixton formation in the southern part of the Eureka Springs quadrangle have fairly good soils, which are well adapted to fruit culture.

The soil on the flat mountains in the southern part of the two quadrangles is derived from the Windom formation and is not very productive, but with care it can be made good fruit land.

**TIMBER.**

Most of the commercial timber in the northern half of the two quadrangles is pine, from which lumber is cut. The timber of the southern half of the area is mainly oak and hickory. There was formerly a good deal of black walnut, but most of this has been removed. There is a little cherry and cedar and much black locust.

**June, 1916.**

**NAMES AND EQUIVALENTS OF FORMATIONS IN NORTHERN ARKANSAS AND ADJOINING PARTS OF OKLAHOMA.**

[Table and diagram]
PLATE I. - TOPOGRAPHY OF BOSTON MOUNTAINS. VIEW LOOKING SOUTHWEST FROM NORTH BLUFF OF BUFFALO FORK OF WHITE RIVER, 1/4 MILES EAST OF MOUTH OF IJDELA CREEK.
St. Peter sandstone caps bluffs in foreground. Pennsylvania formations cap summits of the high hills in center and left distance, andMississippi formations are exposed on their upper slopes.
Photograph by H. W. Gladen.

PLATE II. - TOPOGRAPHY OF BOSTON MOUNTAINS. VIEW LOOKING SOUTHEAST UP VALLEY OF LITTLE BUFFALO FORK OR WHITE RIVER FROM A POINT NEAR JASPER.
Pennsylvania formations cap summits of hills, and Mississippian formations are exposed on their lower slopes.
Photograph by J. C. Bruner.

PLATE III. - SANDSTONE IN POWELL LIMESTONE NEAR MOUTH OF VENTRIS HOLLOW IN WESTERN PART OF EUREKA SPRINGS QUADRANGLE.
An isolated mass, left by erosion of overlying limestone, which represents a deposit that filled a cave or sink hole in Powell limestone.
Photograph by K. F. Mathew.

PLATE IV. - ST. JOE LIMESTONE MEMBER OF BOONE LIMESTONE IN MARBLE HOLLOW, EAST OF HARRISON QUADRANGLE.
Photograph by G. J. Allen.

PLATE V. - ST. PETER SANDSTONE CAPPING NORTH BLUFF OF BUFFALO FORK OF WHITE RIVER, 1 MILE EAST OF MOUTH OF CONE CREEK.
St. Peter sandstone, 80 feet thick, is underlain by 70 feet of Eureka limestone.
Photograph by H. W. Gladen.

PLATE VI. - ST. PETER SANDSTONE IN BLUFF ON WEST SIDE OF BUFFALO FORK OF WHITE RIVER, ONE-FOURTH MILE NORTH OF MOUTH OF IJDELA CREEK.
View looking south. The sandstone dips gently to the left, upstream. Photograph by J. C. Bruner.

PLATE VII. - THIN-BEDDED ST. JOE LIMESTONE MEMBER OF BOONE LIMESTONE IN MARBLE HOLLOW, EAST OF HARRISON QUADRANGLE.

PLATE VIII. - UNCONFORMITY WITHIN BOONE LIMESTONE IN BLUFF ONE-HALF MILE WEST OF WAR EAGLE POST OFFICE.
Unconformity possibly represents submarine erosion of earlier deposits of the Boone overlapped by later deposits of the Boone. A few feet of thin-beded limestone of the St. Joe member at base is overlain by about 30 feet of limestone and clay which contain a Fern Glen fauna, chiefly limestone above the unconformity.
Photograph by E. G. Yoch.

PLATE IX. - SOLUTION VALLEY IN BOONE LIMESTONE, TYPICAL OF THE FORMATION IN THIS AREA.
Residual masses of white chalk from the formation are on the surface.
and still smaller cone stages. The age of a rock is expressed by the time interval in which it was formed.

The sedimentary formations deposited during a period are grouped together into a system. The principal divisions of a system are called series. Any aggregate of formations less than a series is called a group.

Unsuch as sedimentary deposits accumulate successively the younger rest on those that are older, and their relative ages may be determined by observing their positions. In many regions of intense disturbance, however, the beds have been overturned by folding or by faults, so that it may be difficult to determine their relative ages from their present positions; under such conditions fossils, if present, may indicate which of two or more formations is the oldest.

Many stratified rocks contain fossils, the remains or imprints of plants and animals which, at the time the strata were deposited, lived in bodies of water or were buried in them, or were buried in surface deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simplest kinds of marine life existed when the oldest fossiliferous rocks were formed. These rocks are called pre-Cambrian. The oldest rocks known are about 1000 millions of years old, and are still too much altered to show any relation to those of the original sedimentary formations. In the system of classification of rocks, the oldest rock known is the oldest rock in the system. The approximate age of the oldest rocks known is 1000 millions of years.

The sedimentation process is illustrated in the following figures. In the figures, the sedimentation process is shown as it occurs in nature, and the strata are shown as they would appear if they were not disturbed by folding or faulting. The strata are shown as they would appear if they were not disturbed by folding or faulting. The strata are shown as they would appear if they were not disturbed by folding or faulting.

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* Order by number
* Maryville may be made by order in any state
* These are out of stock
* The price for any name is that of a single copy
* These are out of stock

The stocks of folio from No. 1 to 188 and No. 189 were damaged by fire in the Geological Survey Building, but those folios that were only slightly damaged and are usable will be sold at 5 cents each. They are priced accordingly in the list above. Orders showing the location of the area covered by any of the above folios, as well as information concerning topographic maps and other publications of the Geological Survey, may be had on application to the Director, United States Geological Survey, Washington, D.C.