DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

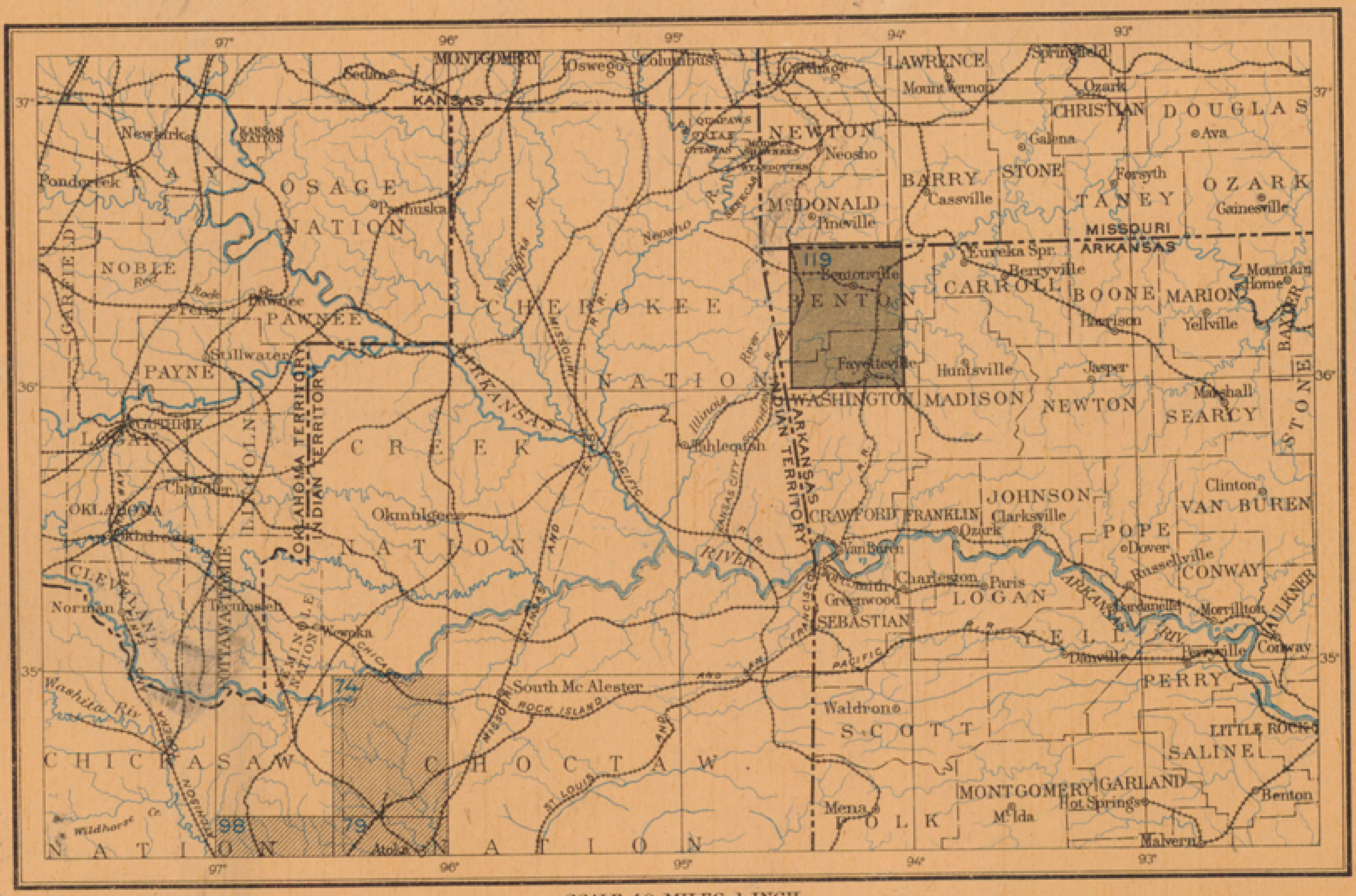
OF THE

UNITED STATES

FAYETTEVILLE FOLIO

ARKANSAS – MISSOURI

INDEX MAP



SCALE 40 MILES=1 INCH

FAYETTEVILLE FOLIO

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FAYETTEVILLE FOLIO
NO. 119

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GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS   S. J. KUBEL, CHIEF ENGRAVER

1905

GEOLOGIC AND TOPOGRAPHIC ATLAS OF UNITED STATES.

The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio includes a topographic map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the altitudinal interval represented by the space between lines being the same throughout each map. These lines are called *contours*, and the uniform altitudinal space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map (fig. 1).

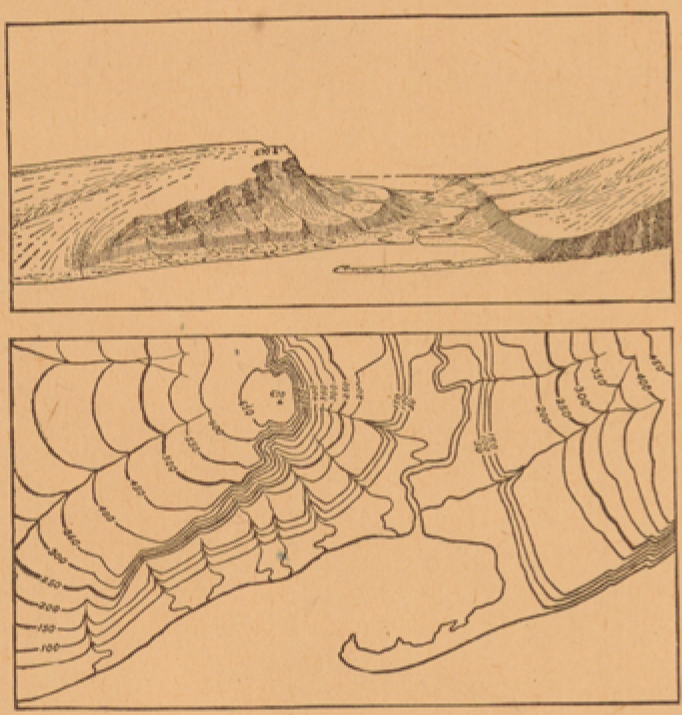

Fig. 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply, forming a precipice. Contrasted with this precipice is the gentle slope from its top toward the left. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above sea; along the contour at 200 feet, all points that are 200 feet above sea; and so on. In the space between any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the accentuating and numbering of certain of them—say every fifth one—suffice, for the heights of others may be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. These relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The altitudinal space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is serviceable for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If a stream flows the entire year the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, are printed in black.

Scales.—The area of the United States (excluding Alaska and island possessions) is about 3,025,000 square miles. A map representing this area, drawn to the scale of 1 mile to the inch, would cover 3,025,000 square inches of paper, and to accommodate the map the paper would need to measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the *scale* of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale $\frac{1}{125,000}$, about 4 square miles; and on the scale $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles in English inches, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree—i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-fourth of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles.

The atlas sheets, being only parts of one map of the United States, disregard political boundary lines, such as those of States, counties, and townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic map.—On the topographic map are delineated the relief, drainage, and culture of the quadrangle represented. It should portray to the observer every characteristic feature of the landscape. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property; save the engineer preliminary surveys in locating roads, railways, and irrigation reservoirs and ditches; provide educational material for schools and homes; and be useful as a map for local reference.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land, and the structure sections show their underground relations, as far as known and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. On the geologic map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—These are rocks which have cooled and consolidated from a state of fusion. Through rocks of all ages molten material has from time to time been forced upward in fissures or channels of various shapes and sizes, to or nearly to the surface. Rocks formed by the consolidation of the molten mass within these channels—that is, below the surface—are called *intrusive*. When the rock occupies a fissure with approximately parallel walls the mass is called a *dike*; when it fills a large and irregular conduit the mass is termed a *stock*. When the conduits for molten magmas traverse stratified rocks they often send off branches parallel to the bedding planes; the rock masses filling such fissures are called *sills* or *sheets* when comparatively thin, and *laccoliths* when occupying larger chambers produced by the force propelling the magmas upward. Within rock inclosures molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. When the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks thus formed upon the surface are called *extrusive*. Lavas cool rapidly in the air, and acquire a glassy or, more often, a partially crystalline condition in their outer parts, but are more fully crystalline in their inner portions. The outer parts of lava flows are usually more or less porous. Explosive action often accompanies volcanic eruptions, causing ejections of dust, ash, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs. Volcanic ejecta may fall in bodies of water or may be carried into lakes or seas and form sedimentary rocks.

Sedimentary rocks.—These rocks are composed of the materials of older rocks which have been broken up and the fragments of which have been carried to a different place and deposited.

The chief agent of transportation of rock débris is water in motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. In smaller portion the materials are carried in solution, and the deposits are then called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Another transporting agent is air in motion, or wind; and a third is ice in motion, or glaciers. The most characteristic of the wind-borne or eolian deposits is loess, a fine-grained earth; the most characteristic of glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks, with reference to the sea, over wide expanses; and as it rises or subsides the shore lines of the ocean are changed. As a result of the rising of the surface, marine sedimentary rocks may become part of the land, and extensive land areas are in fact occupied by such rocks.

Rocks exposed at the surface of the land are acted upon by air, water, ice, animals, and plants. They are gradually broken into fragments, and the more soluble parts are leached out, leaving the less soluble as a *residual* layer. Water washes residual material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of standing water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it is called *alluvium*. Alluvial deposits, glacial deposits (collectively known as *drift*), and eolian deposits belong to the *surficial* class, and the residual layer is commonly included with them. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by a variety of processes, rocks may become greatly changed in composition and in texture. When the newly acquired characteristics are more pronounced than the old ones such rocks are called *metamorphic*. In the process of metamorphism the substances of which a rock is composed may enter into new combinations, certain substances may be lost, or new substances may be added. There is often a complete gradation from the primary to the metamorphic form within a single rock mass. Such changes transform sandstone into quartzite, limestone into marble, and modify other rocks in various ways.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried and later have been raised to the surface. In this process, through the agencies of pressure, movement, and chemical action, their original structure may be entirely lost and new structures appear. Often there is developed a system of division planes along which the rocks split easily, and these planes may cross the strata at any angle. This structure is called *cleavage*. Sometimes crystals of mica or other foliaceous minerals are developed with their laminæ approximately parallel; in such cases the structure is said to be schistose, or characterized by *schistosity*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are important exceptions.

FORMATIONS.

For purposes of geologic mapping rocks of all the kinds above described are divided into *formations*. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, a rapid alternation of shale and limestone. When the passage from one kind of rocks to another is gradual it is sometimes necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils. An igneous formation is constituted of one or more bodies either containing the same kind of igneous rock or having the same mode of occurrence. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics.

When for scientific or economic reasons it is desirable to recognize and map one or more specially developed parts of a varied formation, such parts are called *members*, or by some other appropriate term, as *lentils*.

AGES OF ROCKS.

Geologic time.—The time during which the rocks were made is divided into several *periods*. Smaller time divisions are called *epochs*, and still smaller ones *stages*. The age of a rock is expressed by naming the time interval in which it was formed, when known.

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*.

(Continued on third page of cover.)

DESCRIPTION OF THE FAYETTEVILLE QUADRANGLE.

By George I. Adams and E. O. Ulrich.

INTRODUCTION.

PHYSIOGRAPHY OF OZARK REGION.

General features.—Broadly defined, the Ozark region embraces the southern half of Missouri, a very small corner of southeastern Kansas, the northeastern part of Indian Territory, and the northern part of Arkansas. On its borders are the cities of St. Louis, Jefferson, Marshall, Sedalia, and Joplin in Missouri, Galena in Kansas, Wagoner in Indian Territory, Fort Smith and Batesville in Arkansas, and Poplar Bluff in southeastern Missouri. In a general way Mississippi and Missouri rivers bound it on the northeast and north, Spring, Grand, and Arkansas rivers approximately limit it on the west and south, while the upper portions of St. Francis and Black rivers mark its southeastern margin.

Fig. 1 illustrates the relations of the Ozark region to the surrounding physiographic provinces, and also indicates the divisions of the region.

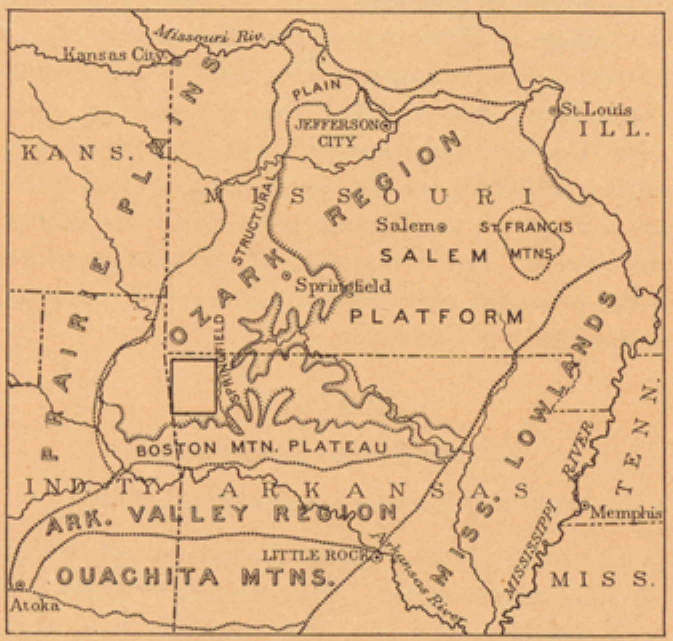

FIG. 1.—Diagram showing relations of Ozark region to surrounding physiographic provinces; also the principal divisions of the Ozark region.

In its northern portion the region is to a large extent a simple rolling plain; in its southern and more rugged part the broken character is evidently the result of erosion by streams which have deeply dissected a generally even surface. As compared with the Mississippi Valley, the region is an elevated one. To the north and west of it lie the Prairie Plains and to the east and southeast are the Gulf Plains. To the south is the Arkansas Valley region, and beyond it the Ouachita Mountain region, both with different types of structure.

Considered in its broader relations the geologic history of the Ozark region is complex. At the close of the Paleozoic era a thick mass of sediments which had accumulated over southern Missouri, Arkansas, and parts of Indian Territory and Kansas was lifted above the level of the sea, producing an elevated region which in its southern part has a folded structure. The force which caused the folding was compressive. The elevation may have been a coincident or a later effect. In central Arkansas and eastern Indian Territory the compression resulted in the Ouachita Mountain structure, which is characterized by close folding and faulting. To the north of this it produced the wide and open folds which are exhibited in the Arkansas Valley. Farther north is the Ozark region, in which the forces developed a less complex structure. The Boston Mountains, on its southern border, are of a monoclinal type, while the plateau portion, or northern part, has the form of a low dome with local faulting and minor undulations. The structure produced during this mountain-making period gradually dies out to the west and north, where the formations are inclined at low angles, dipping away from the Ozark Plateau, and the topography is characterized by step or escarpment features, such as are usually found in nearly horizontal rocks. To this region, which extends around the northern and northwestern border of the Ozark Plateau, the name Prairie Plains has been given. In Cretaceous time there was a subsidence in the Gulf region, and sediments were deposited which concealed the southern border of the Ouachita Mountains. A later oscillation caused the eastern extension of that mountain range to be buried under sediments of Tertiary age. This region, which is covered by Cretaceous and Tertiary sediments, is in general low lying, and is known as the Gulf Plains. Just how these oscillations affected the Ozark region is not readily determined. There were undoubtedly warpings of the strata as the sea in the Gulf region retreated, advanced, and again retreated, but the structure which was developed at these intervals has not yet been differentiated from that produced by the previous faulting and folding. The generally even sky line of the plateau portion indicates a time during which the area was worn down to a lowland. This was probably the condition in late Tertiary time. Since then the region has been elevated and the streams have carved deep valleys. Remnants of the old lowlands now constitute uplands, and along the stream narrow lowlands are being developed.

Divisions of Ozark Region.

BOSTON MOUNTAINS.

The Ozark region may be considered as consisting of two divisions, the Boston Mountains and the Ozark Plateau. The Boston Mountains occupy the southern portion. Their northern border forms an irregular escarpment overlooking the plateau, above which they rise from 500 to 700 feet. They may be described as constituting a highland having in general a monoclinal structure. The dip of the rocks is to the south, and the southern slope of the mountains blends with the Arkansas Valley. The trend of the Boston Mountains is approximately east and west from Batesville, Ark., to within a few miles of Wagoner, in Indian Territory. The formations which constitute them are principally sandstones and shales, and the resultant topography is largely of the terrace and escarpment type. The area is very broken as a result of dissection by the streams.

OZARK PLATEAU.

The plateau portion of the Ozark region is deeply dissected in its central and eastern parts, and in places the topography is rugged, but the elevations rise to approximately the same general horizon, so that, viewed in its entirety, it has the shape of a low elliptical dome, ranging in elevation between 1000 and 1500 feet above sea level.

In the southeastern part of Missouri, in the vicinity of Pilot Knob and Iron Mountain, the surface features of the plateau are of an exceptional character. Within an area approximately 70 miles square, known as the Iron Mountain country, there is a group of peaks, to which the name St. Francis Mountains has been applied. The rocks which form them are crystalline, and erosion has developed a type of topography different from that which prevails generally over the plateau.

The drainage of the Ozark Plateau is believed to be consequent, the arrangement of the streams being radial—that is, down the slopes of the dome. While this is true of the higher portions of the region, along its borders there are seeming departures from this arrangement. One of the most conspicuous examples of what might appear to be a modified phase of drainage is given by White River. This is formed by a number of streams which rise along the northern slope of the Boston Mountains, and is joined by others which flow southward from the higher parts of the Ozark Plateau in Missouri. This flows northward, then northeastward, and finally southeastward, its course evidently having been determined by the Boston escarpment, which in former periods occupied a position farther north. Since the establishment of this stream, erosion has removed a great thickness of the rocks which were the equivalents of those in the northern slope of the Boston Mountains, and the river now lies within a narrow gorge in the lower rocks.

The valleys of the streams exhibit two phases of development, both of which are represented along many of the larger streams, and which grade into each other without sharp distinction. The older and simpler phase is an open trough bordered by hills and without rocky ledges adjacent to the stream. This condition is usually exhibited in the upper portions of the streams. The valley is generally covered with residual cherts and the stream bed is floored with them. The channel is not occupied by water, except during the time of protracted rain, and it is not bordered by bottom lands. The other phase, found in the lower portion of the streams, is the canyon phase, and where this prevails there are many tributary springs and there is usually sufficient water to render the streams perennial. In this part of their course some of the streams have developed flood plains, and furnish rich, although usually narrow, bottom lands. The best example of this condition is found in White River, which lies from 250 to 500 feet below the general surface of the upland. Tributary to the canyons are numerous short stream valleys, which owe their depth to the grade of the larger stream. They are formed by sapping back from the main channel and have little headwater drainage. Along the main valleys numerous smaller streams have dissected the plateau, and the country is broken by narrow points extending out from the general area of the upland surface. These form a complicated series of hills and ridges, over which the soil is shallow.

On the general surface of the plateau, where broad undissected areas exist, there is a peculiar form of drainage that is without definite channels. It exists in areas known as "flatwoods," and also in untimbered areas where the water largely disappears under residual cherts and in sinks and underground channels.

DIVISIONS OF THE OZARK PLATEAU.

The Ozark Plateau is divided into the Salem platform and the Springfield structural plain by the Burlington escarpment. This escarpment is the border of the Mississippian limestones, which constitute the country rock of the western part of the plateau. The escarpment limits the Cambro-Ordovician area to the west, and in crossing it there is a noticeable rise, although the increased elevation is not maintained, since the dip of the rocks is away from it. That the Mississippian limestones have been eroded from over a large part of the Salem platform is shown by the small residual areas of those rocks and the accumulation of cherts derived from them by weathering and erosion. The escarpment, where well defined, has an altitude of from 250 to 300 feet. To the east of Springfield, near Cedar Gap, it stands at a greater elevation than in any other part of the region, inasmuch as at this point it is farthest up on the divide of the Ozark Plateau. In Arkansas, White River and its tributaries have cut a wide embayment into it. It extends in its southern portion in an approximately east-west line parallel with the northern escarpment of the Boston Mountains.

Salem platform.—The eastern portion of the Ozark Plateau is the Salem platform. Its surface is that of a general plain interrupted by the valleys which have been cut into it and by occasional hills rising above it. The streams flow in steep-sided, narrow valleys, some of which reach a depth of 250 feet or more. Where the country is not dissected it is an undulating upland; but along the lower portion of White River and its tributaries, and along some of the other large streams, dissection has gone so far that the plain is scarcely recognizable, except as indicated by the general elevation of the higher points. The hills which rise above the plateau are of two kinds—those which protrude through the strata forming the upland surface, and those which are remnants of higher formations. Of the former type are the hills and peaks of crystalline rock which are found in the southeastern part of Missouri and form the St. Francis Mountains. The second group are residual areas of the rocks which originally overlay the surface, but which have been largely carried away by erosion. They are outliers from the main area of Mississippian limestones farther west.

Springfield structural plain.—This is essentially a structural plain developed on the surface of the Mississippian limestones. The drainage of the upland in its broader part, namely, in southwestern Missouri and in Indian Territory, is in general in the same direction as the dip of the rocks—westward and southwestward. The larger streams begin near the eastern border of the area and have their upper courses in shallow, trough-like valleys; they cut deeper as they flow farther down the slope, and in some places expose the underlying Ordovician rocks, which rise in anticlines and low domes. Adjacent to Grand River the border of this area is very much dissected by numberless short streams whose valleys are deep in proportion to their length. The streams that flow eastward and pass through the Burlington escarpment have but a small portion of their course on the Springfield upland. They have deep channels, due to the fact that they pass over the edges of the Mississippian limestones, in which they have cut a ragged fringe.

The Springfield structural plain extends into Indian Territory westward to Spring River and Grand River. Along Illinois River it forms, in the area of Pennsylvanian rocks, an embayment which, as a result of the dip of the strata, has the peculiarity of extending down the stream. In southeastern Kansas and in the western part of Missouri it grades off into a lowland country, approximately along the contact of the Pennsylvanian formations.

Illinois River, in northwestern Arkansas, rises on the northern base of the Boston Mountains and flows northward, then westward, then southwestward. In its northern course it flows away from the Boston Mountains into the border of the Springfield plain, while in its southwestward course it cuts through the Boston escarpment. It flows in a deep, well-defined valley, and, judging from its course with respect to the Boston escarpment and its relation to outlying areas and headlands of the Carboniferous sandstones and shales, it formerly stood at a much higher level.

The northern part of the Springfield plain is crossed by Osage River, which has a very tortuous course, probably due to meanders which were developed before it eroded its channel into the Mississippian limestones. The western border of the Springfield plain is indefinite, especially where it is coincident with the outcrop of the soft Coal Measures shales and sandstones which form a lowland in Missouri and Kansas. In Indian Territory its border follows the valley of Illinois River to the Boston escarpment. Beyond that point the lowland continues along Arkansas River, where it forms the southern border of the Boston Mountains and becomes coincident with the lowland of the Arkansas Valley region.

Physiographic Relations of Fayetteville Quadrangle.

The Fayetteville quadrangle, in northwestern Arkansas, lies principally in the Springfield plain. The mountains and hills which near its southern border rise above the general level of the country are the northern fringe of the Boston Mountains. The narrow lowland in the valley of White River, along the eastern border of the quadrangle, is an arm of the Salem platform.

GENERAL GEOLOGY OF OZARK REGION.

The formations represented in the Ozark region, when grouped for the purpose of general discussion, correspond closely with the physiographic features. They have a somewhat concentric distribution. The oldest rocks are found in the St. Francis Mountains, while those younger and geologically higher occur successively farther southwest.

Igneous rocks.—The igneous rocks constitute but a small factor in the geology of the region. There are but three areas in which they are known to occur. The most important of these is the St. Francis Mountains, in southeastern Missouri. The exposures have the form of rounded bosses and domes which protrude through the sedimentary series and constitute a scattered group embraced within an area about 70 miles square. The rocks are granites and porphyries with several varieties of basic rocks that occur as dikes. The exposure represents but a small portion of the great mass which forms the basal member over a large area. The age assigned to these rocks is pre-Cambrian, since they are overlain by sedimentary rocks of Cambrian age and there is no sign of contact metamorphism.

The second area of igneous origin is found in the northeastern part of Indian Territory, near the mouth of Spavinaw Creek, where there is a granitic dike about one-fourth of a mile long. The third is a dike consisting of graphic granite or pegmatite, having an actual exposure of only a few square yards. It is located in the southern border of Camden County, Mo. The rocks of the second and third areas are intrusions probably of post-Carboniferous age.

Cambrian and Ordovician.—The great mass of magnesian limestones, dolomites, and interbedded sandstones forming the floor of the Salem platform belongs partly to the Cambrian system and partly to the Canadian series of the Ordovician. As at present defined these two systems can not be separated satisfactorily in the Ozark Plateau. The lowest formations surround the pre-Cambrian area and are exposed on the flanks of the St. Francis Mountains. In general they dip away from these mountains, their margins therefore being buried by later rocks. Younger Ordovician pure limestones and shales, corresponding in age to the Trenton limestone of New York and the Richmond formation of Ohio and Indiana, are found rather generally along the eastern border of the plateau and more locally on its southern margin. The contact of these late Ordovician deposits with the older magnesian rocks is always unconformable.

Silurian.—Rocks of this age occur in very limited exposures on the northeastern and again on the southern and southwestern flanks of the Ozark Plateau. In the latter area they consist almost entirely of a single formation composed of crystalline limestone, to which the name St. Clair marble has been applied.

Devonian. — Formations referred to the Devonian have a limited outcrop along Mississippi and Missouri rivers, but sediments of this age are apparently wanting in a large part of the remaining portion of the region. There are, however, numerous small areas in northern Arkansas. In these the Devonian rocks consist of the black Chattanooga shale and of the Sylamore sandstone member, which usually underlies the shale.

Carboniferous.—The rocks of the Springfield structural plain are principally limestones with interbedded cherts belonging to the Boone formation of the Mississippian series.

The rocks which outcrop in the north escarpment of the Boston Mountains and constitute this division of the Ozark region consist of shales and sandstones with unimportant interbedded limestones, and may be conveniently grouped in accordance with their prevalent lithologic character. They include in their basal portion Mississippian formations and extend up into the Pennsylvanian series. They are in sharp contrast with the rocks of the Springfield upland, both in the character of the sediments which constitute them and in the position which they occupy. They rise above the structural plain of the Mississippian limestones and constitute a deeply dissected highland.

Geologic Relations of Fayetteville Quadrangle.

The larger portion of the Fayetteville quadrangle, which is essentially a plain, is developed on the surface of the Mississippian limestones. This series is in places cut through by erosion, exposing the underlying Ordovician rocks; for instance, along the valley of White River. In the southern border of the quadrangle Pennsylvanian shales and sandstones are found in the hills and mountains constituting the northern edge of the Boston Mountains.

GEOGRAPHY.

Location and general relations.—The Fayetteville quadrangle lies between parallels 36° and 36° 30′ north latitude and meridians 94° and 94° 30′ west longitude, and embraces, therefore, a quarter of a square degree. It measures approximately 34 miles from north to south and 28 miles from east to west. It is situated in the extreme northwest corner of Arkansas. The Missouri–Arkansas boundary, as established, falls just south of the 36° 30′ parallel, so that a strip of Missouri approximately one-fifth of a mile wide is included in the quadrangle.

That portion of the Arkansas–Indian Territory boundary line which lies to the west of the quadrangle has a west of north direction. The southwest corner of the quadrangle approaches within 1½ miles of Indian Territory, while the northwest corner is 7½ miles east of it. Accordingly, a small triangular portion of the State lies to the west of the quadrangle.

Drainage.—The quadrangle lies on the divide of the Ozark Plateau. This watershed crosses the southern border of the quadrangle at Kessler Mountain and trends northward past Fayetteville, Springdale, Rogers, and Avoca, where it turns eastward and passes over the border on the narrow ridge between Little Sugar Creek and White River. The principal streams of the quadrangle are White River and Illinois River, which in their upper courses flow northward from the Boston Mountains on either side of the above-mentioned divide. Illinois River, after a course of about 11 miles in a northward direction, turns to the west and leaves the quadrangle, beyond which its course is around the western end of the Boston Mountains to its confluence with Arkansas River. White River, which flows northward in a very tortuous course along the eastern border, leaves the quadrangle east of Rogers. Its course farther on has a broad curve northward, thence southeastward and around the eastern end of the Boston Mountains to its confluence with Arkansas River. The remaining important streams of the quadrangle are Spavinaw Creek, which flows westward to Grand River in Indian Territory, and Butler Creek and Little Sugar Creek, which flow northward into Missouri, where they are tributary to Elk River, which is an affluent of Grand River. The country is well watered. These streams have numerous tributary springs, and are perennial, except in their upper portions. The valleys of the main streams dissect the plateau and the short streams have a dendritic arrangement which gives a rugged character to the country, especially near the larger valleys.

In that portion of the quadrangle which is semimountainous and is considered as belonging to the Boston Mountains the streams have tortuous courses and the smaller tributaries an irregular arrangement between the isolated hills. In the plateau portion the streams have in their upper parts a shallow trough phase, and in their lower courses, especially along the larger streams, there is developed a canyon phase. These two phases grade into each other.

Springs.—A very noticeable feature of the quadrangle is the large number of springs which are found well distributed. In the vicinity of Fayetteville, in the area which consists principally of sandstones and shales, the springs issue from under beds of interstratified limestones, the joints and bedding planes of which furnish channels for the circulation of the water. In the limestone country, where the streams have cut below the upland, springs issue from between the heavy beds of limestone, and some of them have a large flow. Along Illinois River, Little Sugar Creek, and Butler Creek, where erosion has cut through the limestone and exposed the underlying Devonian shales, a number of springs are found just above the shale bed, which acts as an impervious stratum. The springs issue at the contact of the St. Joe limestone member with the Chattanooga shale, where the dip is such as to bring the circulating water to the point of outcrop. Where there is a surface covering of detrital material these springs are sometimes concealed for short distances and issue at a lower level. There are a number of shallow caves formed at the base of the limestone by the solution of the rock along the joint planes and by the shelving down of the beds along the underground watercourses.

At Sulphur Springs there are springs which are noted for their medicinal qualities. They issue at a lower horizon than those heretofore described; viz, from the Ordovician limestones. At Electric Springs, just east of Rogers, water issues from the Boone limestone at a number of places. There are, no doubt, many other springs within the quadrangle which have similar properties, but the picturesque location of the above-mentioned springs and the facility with which they can be reached have contributed to their popularity.

Caves.—There are, as is usual in a limestone country, numerous caves and sink holes. None are of great extent, but many can be entered and explored for short distances. Those which occur in the upland often have their entrances on spurs between small ravines. Such caves are above the level of ground water and are dry. They contain dead leaves which have been blown in, and the floor is strewn with rocks which have fallen from the roof. Usually they contain dirty stalactitic and stalagmitic growths which form botryoidal surfaces on the limestone. In some places clean calcite and dolomite crystals are found. The floor usually slopes at a low angle, and the caves appear to have originated by solution along the joint planes of the rocks and by the breaking down of the roof. The lower point of outlet can not usually be discovered.

Another class of caves consists of those from which springs issue. They occur in the valleys and are not much above the level of the water in the streams. Some of them are high enough to be entered, and the streams of water are occasionally of sufficient volume to be available for water power. In a few cases there are sinks above the place of outlet which indicate the course of the underground streams. Low, shallow caves occur in the valleys of Butler Creek and Little Sugar Creek, at the contact of the limestones with the shales, at which horizon springs also issue. They are formed by solution and breaking down of the limestone where the ground water flows over the impervious shale. They sometimes extend upward along joint planes as a result of the widening of the fissure by solution.

Relief.—The northern portion of the quadrangle has the general appearance of a plain dissected by deep stream valleys, while the southern portion is semimountainous. The northern or more level part is a structural plain developed on the surface of the limestone formation. On the divides the altitude ranges between 1250 and 1450 feet above tide. The valleys of the larger streams are about 250 feet lower. The lowest points are where the principal streams leave the quadrangle, and are approximately as follows: Illinois River, 950 feet; White River, 1050 feet; Little Sugar Creek, 950 feet; Butler Creek, 900 feet; and Spavinaw Creek, 1000 feet.

In the semimountainous parts the higher points rise from 250 to 500 feet above the structural plain. They constitute a part of outlying areas of the Boston Mountains. Elkhorn Mountain, in the northeast corner of the quadrangle, and Callahan, French, Webber, Price, Fitzgerald, and Twin Mountains, are conspicuous because of their isolation, although they are not over 250 feet above the general level of the surrounding country. The highest points in the quadrangle have elevations approximately as follows: Kessler Mountain, 1750 feet; Round and East mountains, 1700 feet; Robinson Mountain, 1800 feet.

Timber.—The country is covered generally with a growth of oak over that portion which is level, but along the borders of the streams and on the benches of the mountains there are a large number of other hard-wood forest trees. Near the Missouri border in the vicinity of Sulphur Springs there are a few scattered pine trees. The hard wood is cut extensively to supply the demand for railway ties. In the more level portions of the quadrangle there are natural prairies of considerable extent.

Agriculture.—The principal industry of the country is farming and fruit growing. The farm products usually grown are corn, wheat, and oats. The forage plants, clover and grasses, grow luxuriantly. Orchards are a common feature of the landscape, and the growing of apples and small fruits is carried on to a very large extent. The cherty-limestone soil is well adapted to grape growing and a large number of vineyards are successfully cultivated.

Culture.—Portions of two counties are embraced in the quadrangle. The northern two-thirds belongs to Benton County, while the southern third is a portion of Washington County. The county seat of Washington County is Fayetteville, and that of Benton is Bentonville. Along the line of the St. Louis and San Francisco Railroad, which passes through Fayetteville, are the towns of Johnson, Springdale, Lowell, Rogers, Avoca, and Brightwater. The St. Paul branch of the St. Louis and San Francisco Railroad runs eastward from Fayetteville through Baldwin and Harris, while the Bentonville branch, formerly the Arkansas and Oklahoma Railroad, extends westward from Rogers through Bentonville and Gravette and into Indian Territory. Another branch of the Frisco System extends southwestward from Fayetteville to Tahlequah, Ind. T., passing through the village of Farmington and thence out of the Fayetteville quadrangle. The Kansas City Southern Railway runs through Sulphur Springs, Gravette, Decatur, and Gentry. The country is well settled, especially in the level portions, and there are numerous small country towns, post-offices, and mills. The University of Arkansas, which is the principal educational institution of the State, is situated at Fayetteville.

GEOLOGY.

DESCRIPTION OF FORMATIONS.

GENERAL RECORD OF SEDIMENTATION.

The rocks of the Fayetteville quadrangle are all of sedimentary origin. They are nearly horizontal beds which, except in a few localities, have been but slightly disturbed since their deposition. The complete series can not be seen at any one locality, but from the sections which are exposed their sequence has been learned and the general section established. This is shown graphically on the columnar section sheet.

During the progress of deposition there were many important changes in the life of the sea in which the sediments were deposited. Some of the shells of the animals which existed at the time the formations were laid down have been preserved as fossils in the rocks. Since each period of the earth's history has been characterized by certain forms of life, their fossil remains afford a means of determining the age of the formations. According to such evidence the rocks belong to the Ordovician, Devonian, and Carboniferous periods of the Paleozoic era. During the whole of the Silurian period and the early part of the Devonian no sediments were deposited, or if they were they were eroded before the later Devonian and Carboniferous rocks were laid down.

Varying conditions of deposition have given rise to several lithologic units. The rocks which constitute these units either are uniform in character between their upper and lower limits or, when changeable, consist of beds which are uniformly varied in character. The units are called "formations," and their extent is shown on the map by different-colored patterns. The subdivisions of the formations which can not be distinguished throughout the field are discussed as members. Some of them, however, which are important and are well defined, have been mapped as lentils within the formations in which they occur.

Ordovician Rocks.

The oldest rocks which are found within the quadrangle are of Ordovician age. They are more or less cherty magnesian limestones and are to be seen only in valleys which have been cut deeply into the upland. The areas in which they occur have usually a low anticlinal structure. The streams have eroded the higher formations, uncovering Ordovician rocks, and to these facts the exposures are due. Such outcrops are found on White River and on Illinois River.

YELLVILLE FORMATION.

This formation, of which only the upper part is exposed in the Fayetteville quadrangle, consists of magnesian limestone and dolomite, in rather evenly bedded layers varying in thickness from a few inches to several feet. These layers exhibit some variation in composition, and more in physical characters. The beds containing much lime and little silica weather with an even surface and have a soft gray color. The more siliceous varieties are of a darker, leaden color, have uneven bedding planes, and generally exhibit angular faces and close jointing. Strata in which the silica is irregularly segregated weather with a pitted surface. Many layers after long exposure to atmospheric agencies have the superficial appearance of sandstone, the surface being made of small grains of dolomite partially freed by the solution and removal of some of the more soluble components of the rock. Layers containing numerous small rounded grains of quartz frequently occur. Traced laterally in one direction, the grains in such a layer may become so abundant as to constitute a calcareous sandstone, while in the opposite direction they may soon fail entirely. As a rule these quartz grains are associated with oolitic granules. Thin, irregular beds of oolite, now almost invariably silicified, abound in the upper part of the formation as represented in this quadrangle.

Chert is much more abundant in the upper than in the lower part of the formation as here exposed. As a rule it is very hard and compact, of a dark-gray color, and occurs in the form of irregular masses and concretions. The masses are frequently brecciated or conglomeratic, and in this respect correspond with many of the limestone layers associated with them, from which they were formed by replacement. The part of the formation containing the lenses and irregular beds of oolite are usually fossiliferous. The fossils, while not uncommon, are rarely in a satisfactory state of preservation. They consist almost entirely of small coiled Gasteropoda, generally less than one-half inch in diameter.

This formation occurs principally in two areas; the larger is 5 miles east of Rogers, on Prairie Creek and White River, where the latter stream leaves the eastern border of the quadrangle; the smaller is on Butler Creek near Sulphur Springs. The base of the limestone is not exposed within the quadrangle, and the total thickness is not known. The vertical section of the formation south of Prairie Creek is estimated at 100 feet. The best exposures are in ledges and bluffs along White River, and present vertical sections of 20 to 50 feet. North of Sulphur Springs, along the railway, there are ledges which aggregate 50 feet in thickness. In the immediate valley of Little Sugar Creek there are two small areas in which limited exposures of this formation may be seen.

The top of the Yellville limestone forms an unconformable contact with the succeeding formation. In this area the rock usually overlying the Yellville is the Sylamore sandstone member of the Chattanooga formation of the Devonian system. Locally, however, this sandstone is wanting, in which case the black-shale portion of the Chattanooga rests on the Yellville. The stratigraphic hiatus indicated by the unconformity therefore represents the time in which the later Ordovician, all of the Silurian, and the early Devonian deposits were elsewhere laid down. During much of the time not represented by deposits in this quadrangle the surface of the earlier Ordovician rocks was being subjected to erosion and removal. In consequence the top of the Yellville is uneven, and exhibits considerable local variations. For instance, in the vicinity of Sulphur Springs, situated near the northwest corner of the quadrangle, it is estimated that during this time at least 100 feet of Yellville rocks were removed from the top of the formation.

Devonian Rocks.

The Devonian system is represented in this quadrangle by the Chattanooga formation. This formation has a very wide geographic distribution, being traceable or recognizable from Lake Erie to northern Alabama and thence westward to Indian Territory. In this quadrangle it consists of a persistent bed of black shale, generally underlain by a more or less phosphatic, conglomeratic sandstone. Locally this basal member attains considerable thickness, and in such cases it has been distinguished as a mappable lithologic unit under the name Sylamore sandstone.

CHATTANOOGA FORMATION.

As stated above, this formation consists of a persistent black shale generally underlain by a variable bed of sandstone, known as the Sylamore sandstone member.

The name of the formation is derived from Chattanooga, Tenn. From this point it has been traced northward through Kentucky and Ohio. In these States the formation is much thicker than in Tennessee, and is known as the Ohio shale. Westward from Chattanooga the formation extends as a continuous band around the truncated dome of middle Tennessee, and finally dips out of sight under the later deposits occupying the Mississippi embayment. On the west side of the embayment it comes to the surface again in northern Arkansas. Here it forms an intermittent band around the southwestern slope of the Ozark uplift. Wherever the formation has been recognized it retains very strictly the same lithologic character. In western middle Tennessee a more or less highly phosphatic sandstone and conglomerate, corresponding at least in position to the Sylamore member of the formation in Arkansas, occurs very commonly at the base of the formation.

Sylamore sandstone member.—This is a friable sandstone, and when struck with a hammer or crushed it often falls into a loose sand, as a result of the small amount of cementing material present. Because of its white and sugary appearance, and since it nearly always rests upon the Yellville limestone, it is often mistaken for the upper "saccharoidal sandstone" of the Missouri geologists. The true saccharoidal, or St. Peter, sandstone, however, is much older, being Ordovician in age, and seems to have been entirely removed in this quadrangle by erosion prior to the deposition of the Sylamore. It appears highly probable that the Sylamore sandstone is largely derived from the detritus of the older sandstone.

Though the color of the Sylamore sandstone is usually white, its surface is often brown, from a staining of iron. The constituent grains of quartz are translucent and nearly always rounded. Very commonly the rock includes variable quantities of light-gray or black pebbles that on examination prove to be more or less phosphatic. These phosphatic pebbles range from less than one-eighth of an inch to several inches in diameter. Locally the sandstone contains numerous large and small, rounded or angular pieces of chert. These chert pebbles and bowlders were derived from the wash of the underlying Yellville limestone, which, for a long time preceding and during the deposition of the Sylamore sandstone, was raised above sea level and subjected to subaerial decomposition and erosion. This condition is clearly shown in the vicinity of Sulphur Springs, where the chert pebbles are often decomposed, leaving cavities whose thin walls are formed by the siliceous sand that filled the interstices between the pebbles. The rock in such cases has a honeycombed or cavernous appearance that may falsely suggest the cutting of the rocks by a network of quartz seams.

The Sylamore sandstone is very clearly unconformable on the Yellville limestone, its bulk having locally sufficed to only partially fill the inequalities of the old land surface that was submerged beneath the Devonian sea. In consequence its thickness varies greatly, and sometimes very abruptly. Along the north bank of Prairie Creek it is practically wanting in places, or is represented by a conglomerate only a foot or so in thickness. The same is true in the vicinity of Sulphur Springs, where the variations in thickness are sometimes so abrupt as to suggest that the deposition of the sandstone was at least locally confined to channels.

On account of the unfavorable character of the rock, fossils, especially of invertebrates, are difficult to find in the Sylamore. Fragmentary bones of large fishes, chiefly of the genus *Dinichthys*, however, are not uncommon, and may, if not always, at least usually, be found where the member is reduced to a thin conglomerate.

The name of the member was proposed by the geologists of the Arkansas Survey. It is derived from Sylamore Creek, in Stone County, Ark., where it is well developed.

During the course of work in the Fayetteville, Eureka Springs, and Yellville quadrangles this sandstone was at first erroneously considered as the equivalent of the Ordovician upper or "First saccharoidal sandstone" of Missouri. The older sandstone is described under the name Key sandstone in Professional Paper No. 24 of the United States Geological Survey, published in 1904, but as the sandstone at the localities in this quadrangle from which the name Key sandstone was derived proves on examination by Mr. Ulrich to be Devonian in age, and identical with the Sylamore sandstone, the name Key sandstone must be abandoned.

The Sylamore sandstone occurs at numerous points in northern Arkansas and in neighboring parts of adjoining States, but it does not appear to have been laid down as a continuous sheet. There can be, however, no reasonable doubt that the isolated outcrops are practically contemporaneous. In some places the phosphatic constituent occurs in sufficient quantity to make the rock commercially valuable. It is essentially the same horizon that affords the valuable deposits of Devonian phosphate rock in middle Tennessee.

The greatest thickness measured was nearly 75 feet. This occurs in the bluff on the south side of White River just east of the mouth of Hickory Creek. Here the lower beds are massive and the upper ones thin and somewhat laminated. The exposures in the bed of Hickory Creek are of the latter class. Small and not very well exposed areas of Sylamore sandstone occur along Illinois River, on Clear Creek, and on the small stream southwest of Decatur. A small development of the member is indicated also on Little Sugar Creek by loose bowlders of sandstone lying on ledges of Yellville limestone, which outcrops along this stream.

Black shale.—The most common phase of the Chattanooga formation is a bed of black carbonaceous, often fissile shale, varying in thickness from 30 to 70 feet and averaging about 50 feet. At the top there are usually a few inches to a foot of green shale. The outcrops are in slopes and under ledges, and the shale is consequently largely covered by detrital material, so that it is to be seen only where erosion is active. It is argillaceous, and has a jointed structure and a tendency to break up into prismatic blocks. It contains considerable iron pyrite in certain localities, and this weathers out as nodules and concretions, and although of no value has attracted considerable attention because of its yellow metallic appearance. The shale has a fetid odor, and has been thought by some to contain oil. It has been passed through in both shallow and deep wells in many places, but no oil has been found in it. The occurrences of the shale which are most often seen are those where wagon roads pass over and wear down into it. The black color has suggested to some that coal might be associated with it, but this assumption is wholly unwarranted. The shale is very uniform in character, and, being impervious, forms a lower limit to the circulation of the ground water. Its upper surface is accordingly the horizon of many springs, where the dip of the rock is such as to cause the water to flow to the place of outcrop.

Fossils are always rare in the Chattanooga shale. Occasionally a layer may be found containing linguloid shells and perhaps minute teeth and plates of the type known as conodonts. Pieces of fossil wood (of the genus *Dadoxylon*) are probably the most conspicuous of the organic remains.

The principal outcrop of Chattanooga shale in this quadrangle occurs near the northwest corner, in the valley of Butler Creek. It is especially well exposed near the mouth of the valley at Noel, Mo., which lies just north of the border of the quadrangle. When the survey was made the black shale at Noel was believed to be the same as the Eureka shale of the Arkansas geologists. The name Eureka being preoccupied, it was proposed to substitute the new name Noel for Eureka, and it is under this name that the early Carboniferous shale at Eureka Springs and elsewhere in northern Arkansas is described in Professional Paper No. 24 of the United States Geological Survey. On a recent visit to Noel, Mr. Ulrich procured evidence demonstrating the Devonian age of the black shale, and proving its distinctness from the greenish shale at Eureka Springs, with which it had been correlated.

Where the basal sandstone member is wanting, as at a number of points in the vicinity of Sulphur Springs, the Chattanooga shale rests directly upon the eroded surface of the Yellville limestone. The usual absence in this region of at least the lower members of the Kinderhook group suggests an occasional and probably always inconspicuous unconformity also at the top of the shale.

Carboniferous Rocks.

The lowest formation of Carboniferous age is a bed of limestone followed by siliceous limestones interbedded with cherts. These rocks constitute the Boone formation, which forms the upland over a large part of the quadrangle. They lie nearly horizontal, and on their upper surface is developed a generally even plain. They are succeeded by sandstones and shales in the southeast corner of the quadrangle, where the country has a semi-mountainous character. The Boone formation, Batesville sandstone, Fayetteville formation, and Pitkin limestone represent the Mississippian series. The Morrow formation and the Winslow formation belong to the overlying Pennsylvanian series.

BOONE FORMATION.

This formation consists of limestone, cherty limestone, and beds of chert. The lower portion consists of even-bedded limestone, distinguished as the St. Joe limestone member.

St. Joe member.—The limestone forming this member succeeds the Chattanooga shale. It is even bedded, quite free from chert, and usually outcrops in a distinct ledge. Its thickness ranges from 20 to 50 feet, with an average of 30 feet. The limestone has a soft gray color, and when freshly quarried shows a bluish cast where broken. The upper beds are often full of crinoid stems, which weather out on exposed surfaces. In places there are small nodules of pyrite disseminated through the lower, thinner beds. The contact between the underlying Chattanooga shale and the limestone is usually marked by a few inches of greenish-gray shales or soft calcareous beds. The St. Joe limestone member forms a conspicuous horizon, since the weathering and erosion of the shale which lies below it cause it to jut out in a prominent ledge. Occasionally the ledge breaks down into large slabs and blocks, which are found lying on the slope below. Its occurrence is thus favorable for quarrying, and its even beds and jointing make it a convenient building stone. Underneath the jutting ledges there are low caves caused by the breaking down of the limestone along underground water channels, and these often extend upward along joint planes which have been widened by solution.

The upper limit of this member is defined by the presence of chert in the superjacent beds and is not marked by any decided variation in color or change in the texture of the limestone; evidently there was no interruption in the sedimentation at this horizon.

Cherty limestones.—The upper part of the Boone formation consists of cherty limestone, beds of chert, and thin and massive bedded limestone, which vary in character in their lateral extent and are not sharply differentiated in vertical section. The thickness of this portion of the formation, according to the records of deep wells and the measured section, is about 325 feet. These are the most widespread rocks in the quadrangle, their area of outcrop covering fully five-sixths of it. They are distinguished by the presence of chert, which is seen in the exposures or, on the weathering of the rocks, is left upon the surface. As a result of this slow disintegration the cherts cover the slopes and floors of the valleys of the minor streams. In the perpendicular bluffs are the only outcrops which are not more or less disguised by this residual material.

The chert when first exposed is compact, and usually has a light-gray color. On weathering it becomes yellowish brown from staining by iron, and the fragments are often very light and porous. It has many diverse colors, such as black, green, and drab, and the more siliceous varieties retain their compact texture and, being easily fractured, disintegrate into small angular fragments. The chert, which is frequently fossiliferous, occurs as concretions in the limestone strata, as lenses interbedded with the limestone, and as massive beds. There is much silica distributed through certain of the limestone beds, and on removal of the lime by solution the rock has a porous texture. The term "cotton rock" is used locally to designate this variety. As its disintegration progresses such a rock will crumble into a white, chalky bed, such as may be seen in the railroad-cut east of Gravette. "Tripoli" rock, so called, which is quarried and sawed for filters, is obtained from similar siliceous beds from which the lime has been removed by solution, thus rendering the rock porous. To be of commercial value the rock must be free from flint concretions or nodules, which would prevent its being cut and dressed easily.

The limestones of the Boone formation are often free from siliceous matter and occur both as thin and as massive beds. They are coarsely crystalline and usually have a light-gray color on weathered surfaces. In places they are charged with bituminous matter, and when struck give off a fetid odor. Usually the limestone is fossiliferous, and there are some beds which contain numerous crinoid stems. The rock breaks with a conchoidal fracture and is very tenacious. The more even beds furnish a good quarry stone and the purer varieties are burned for lime.

BATESVILLE SANDSTONE.

The Boone formation is succeeded by rocks which are more or less arenaceous. In certain localities there are sandstones and shales interstratified with limestones. The sandstone beds are yellowish and generally are rather soft. The more argillaceous ones have a greenish-gray color. The outcrops occur in small areas widely scattered over the quadrangle and are only remnants which have been left by erosion. The best section of the formation is found on the northern slope of Elkhorn Mountain, where it aggregates 90 feet in thickness and consists of alternating beds of shales, sandstones, and limestones. At this place it is capped by higher formations.

The small patches in which sandstones and arenaceous beds are found over the area of the widely distributed Boone formation have been referred to the Batesville from their relation to the underlying rocks. One of these just west of Bentonville, which has a maximum thickness of 25 feet, contains flaggy layers from 3 to 6 inches thick and some impure interstratified limestones. The rocks are of a greenish-gray color and have been quarried for flagstones.

Along the bases of Callahan, Fitzgerald, and Webber mountains, near the town of Springdale, exposures of the Batesville sandstone have been observed resting on Boone chert and overlain by the Fayetteville shale. The sandstone is but 2½ to 3 feet thick in these exposures, and as it has not been found in Price Mountain nor to the southeast of this series of residual mounds it is possible that the bed thins and disappears in this direction.

Near Fayetteville the sandstone which has been referred to this formation is a soft, yellowish, coarse-grained, and often calcareous sandstone a few feet thick. There are no limestones interbedded with it. It overlies the Boone formation and is overlain by the Fayetteville shale. The formation thins and disappears also westward from Fayetteville, being absent in the adjoining quadrangles in Indian Territory.

Near the post-office of Wyman it is of a nature similar to that of the sandstone near Fayetteville and occupies the same relative position. Its occurrence in such widely separated localities and its varying character make it a somewhat problematic formation. Being an overlapping formation it may not have been deposited at all in certain localities. If, however, the Batesville originally covered the whole quadrangle it must have been entirely eroded over considerable areas before the deposition of the Fayetteville shale. Recent erosion has removed it in still other localities, and now small patches only are to be found. Those in which the best sections are to be seen are the ones which were not reduced by the first period of denudation and now remain covered by higher formations, or those from which the overlying beds have only recently been removed.

Fossils occur locally in considerable numbers, especially in the more calcareous layers. The fauna indicates that the formation is to be correlated with the early formations of the Chester group in the Mississippi Valley.

The name is derived from Batesville, Ark., where the formation attains much greater thickness. The Wyman sandstone of Symonds (Rept. on Washington County, Arkansas Geol. Survey, vol. 2, 1888) is the same formation, the Batesville sandstone of this author being the Wedington sandstone member of the Fayetteville formation as described in this folio. Symonds's erroneous identification of these sandstones arose from the mistaken view that the Batesville was underlain by the Fayetteville.

FAYETTEVILLE FORMATION.

This formation consists principally of a bed of black or dark-gray carbonaceous shale, which is usually thinly laminated. As a rule a more or less definite bed of hard, dark-gray or blue, fossiliferous limestone occurs at or a few feet above the base of the formation. Frequently also there are some highly fossiliferous thin layers of limestone near the top. The shales making up the middle part of the formation are perhaps always lighter colored than those constituting the lower third or half of the thickness. Commonly the color of this middle part varies from gray to yellow, while its lithologic character ranges, according to the proportion of siliceous matter contained in it, from a shale to a true sandstone. Where the latter phase predominates this portion of the formation is distinguished as the Wedington sandstone member.

The Fayetteville formation has a wide occurrence in the southeast corner of the quadrangle. Here its maximum thickness probably exceeds 200 feet, approximately one-half of the thickness being made up by the Wedington sandstone. The black color of much of the shale has suggested to some the possibility that it might contain coal, but none has ever been found in the formation. In some localities the shale contains gypsum, which occurs as individual crystals or as a coating of calcareous concretions.

Fossils occur rather generally in the limestone layers included in the formation. In the sandy beds, however, their distribution seems to be much more local, though, as at the north end of the railroad cut at Fayetteville, they are sometimes extremely numerous, both in species and in individuals. Excepting the upper limestone bands, which abound in fossil bryozoa and brachiopods closely simulating those in the Pitkin limestone, the fauna of the Fayetteville consists preeminently of mollusks.

There is perhaps no unconformity at the base of the Fayetteville when it rests upon the Batesville sandstone. This sandstone, however, is frequently wanting, and in these cases the shale rests upon the more or less eroded surface of the Boone formation. The occasional unconformity at the top of the formation has been mentioned. In a few localities where the Pitkin limestone is absent the Morrow formation rests on the Fayetteville. It is not decided whether the absence of the Pitkin in these cases is due to nondeposition, because of local land conditions, or is the result of erosion subsequent to its deposition and prior to the laying down of the Morrow formation. The latter explanation, however, seems at present to be the more reasonable.

Wedington sandstone member.—Typically this member consists largely of heavy sandstones, the bed ranging from 50 to 150 feet in thickness. But northwest of the White River fault it grades apparently from the base upward into sandy shales, the arenaceous constituent growing gradually less, until finally no trace of the sandstone remains. The sandstone is found capping Wedington Mountain, which is the type locality, Elkhorn Mountain, and the mountains east of Springdale. In the area east and southeast of Fayetteville it forms the lower bench of the mountains. In some localities the top of the sandstone is defined by the Pitkin limestone, which in these cases lies unconformably above it. In other localities, especially near and beyond the south border of the quadrangle, a bed of shale, ranging in thickness from a few feet to over 60 feet, intervenes between the Wedington sandstone and the Pitkin limestone. This shale is regarded as the upper member of the Fayetteville formation. It is rarely so dark as the lower member, and is commonly of a gray or slightly buff color.

PITKIN LIMESTONE.

This formation is usually a light-gray limestone varying in thickness from a few inches to 40 feet, and is rather highly fossiliferous. The limestone, when of any considerable thickness, is conspicuous in contrast with the shales and sandstones. Its outcrop, when traced, is found to follow the benches of the mountains. It is not mapped continuously, because it is not persistent, or, if so, is concealed by the débris of sandstones and shales. It is the highest formation of the Mississippian series, according to paleontologic evidence. The conspicuous fossil of this formation is the bryozoan *Archimedes swallovanus*, the screw-like solid axes of which can be seen on the weathered surfaces of the limestone. Other, but generally smaller, species of the same genus occur, generally very sparingly, in the underlying Fayetteville formation and Batesville sandstone.

MORROW FORMATION.

This name is applied to a succession of sandstone and shale beds in which there are some limestone lentils. The beds aggregate 400 feet, but the variation in the individual members is considerable, and the vertical section is not uniform in character or in thickness. In this quadrangle the full section is found only in the higher mountains, such as Round, East, and Kessler mountains. The interstratified limestones are mapped as members or lentils, since they are of minor importance and are not persistent throughout the formation as definite beds. They are not of special economic importance, and probably only the Brentwood can be followed any great distance.

The name is derived from the post-office of Morrow, in Washington County, Ark., just south of which a high hill affords a nearly complete section of the formation. The formation is of considerable scientific interest, because it contains one of the best representations of an early Pennsylvanian invertebrate fauna known in America. The Brentwood limestone member in particular is highly fossiliferous. The Pennsylvanian age of this bed is indicated by the presence of the brachiopod genus *Hustedia* and by numerous gasteropods and pelecypods closely allied to later Carboniferous species.

The contact of the base of the Morrow with the top of the formation next beneath is probably always unconformable. The unconformity, however, is never conspicuous, and often difficult to see, but its probable occurrence is convincingly indicated by the variation in the beds at the base of the Morrow and at the top of the underlying formation, shown in different sections. In a few localities pre-Pennsylvanian erosion seems to have entirely removed the Pitkin limestone.

Hale sandstone member.—This, the basal portion, consists of sandstones with some shale. This portion is not separately mapped, but its upper limit is the Brentwood limestone. The strata which compose the Hale sandstone are usually soft, thick-bedded, yellowish-brown sandstone and flaggy layers, with more or less carbonaceous and light-colored shales. On weathering, especially in bluffs, the Hale sandstone generally presents a characteristic honeycombed appearance. The soil found on this lower sandstone is often red, from the large amount of iron present, and this feature is in some places an index to the occurrence of the member.

Brentwood limestone member.—This is a gray crystalline limestone, and usually is conspicuously exposed. It abounds in fossils, a common one being *Pentremites rusticus*. The member is sometimes separated into two divisions by the intercalation of sandstone and shale, and where this occurs the thickness may aggregate 80 feet. In the more prominent mountains it forms a conspicuous ledge and has a marked influence on the topography. It is important as indicating the base of the coal-bearing shale, and furnishes a reference horizon in locating the coal bed, the latter lying from 15 to 30 feet above it when present.

Above the Brentwood limestone are shales, more or less carbonaceous and approximately 100 feet thick. They are sometimes decidedly arenaceous, and where their upper limit is not marked by the Kessler limestone they grade into the superjacent sandstones. They contain the coal bed above referred to. The coal has been discovered at many places, but is not very important. It is mined to a small extent for local trade, but inasmuch as it nowhere exceeds 14 inches in thickness it can not become of any great commercial importance. The shales occur in the higher mountains, well up the slope, and in the hill in the north part of Fayetteville. Their occurrence at a lower elevation 7 miles northeast of Fayetteville is due to flexing and faulting. Likewise, the outcrop in North College avenue in Fayetteville, near the ravine, and in the block northeast of the St. Louis and San Francisco station are the result of local disturbances.

Kessler limestone lentil.—This name is applied to a zone in the upper part of the Morrow formation containing from one to four thin beds of generally dark, argillaceous, and frequently somewhat ferruginous limestones. The beds are separated by variable intervals made up of dark-gray or black shales. The limestones generally weather out on the slopes of the mountains in large slabs, which are found at a lower elevation than the ledges from which they are derived. The ledges are difficult to trace, because they occur on steep slopes of the mountains and are usually covered with sandstone débris. The maximum thickness of the zone may be as much as 70 feet, but the individual bands rarely exceed 4 or 5 feet in thickness.

The highest beds of the Morrow formation are usually sandy and carbonaceous shales, which have a maximum thickness of 50 feet. These lie between the Kessler limestone lentil and the Winslow formation, but since they occur high in the slopes of the mountain they are not usually well exposed.

WINSLOW FORMATION.

The base of this formation is characterized by the occurrence of conspicuous quartz grains and small quartz pebbles in the sandstones. Because of this fact the formation has been referred to as the Millstone grit. The beds of which the formation is composed vary in lateral extent, and it does not everywhere carry quartz pebbles. It is found only on the tops of the higher mountains, except some small patches about 6 miles northeast of Fayetteville, in which only the basal portion of the formation is represented. A fuller section is found in the Winslow quadrangle, near the town of Winslow, from which place the name is derived.

There appears to be an unconformity between the Winslow and the underlying formation, but it is not well marked. In the absence of the Kessler limestone it is difficult to determine the base of the Winslow, but in this quadrangle it is usually a heavy sandstone forming a ledge.

HISTORY OF PHYSICAL CHANGES.

The rocks which outcrop in the quadrangle were laid down as beds of sand, mud, and ooze on the sea bottom, and later, under the pressure of superincumbent deposits, and through chemical action, were solidified into sandstones, shales, and limestones. The earliest record we have of these processes within the quadrangle is toward the close of the earlier half of Ordovician time. The condition which prevailed during the deposition of the lowest beds was that of a widespread submergence. The lowest deposit was a limy ooze, which is now the Yellville limestone. Following this a great bed of white "saccharoidal" sand was spread by the action of the water. This is not now present in any of the outcrops of Ordovician deposits within the borders of the Fayetteville quadrangle, but some of it remains in certain quadrangles farther east. Its removal here occurred prior to the deposition of the Devonian beds, and it doubtless furnished the greater part of the material that constitutes the very similar basal sandstone of the Chattanooga formation. The additional beds, if any, which were deposited in the Ordovician sea are not known, for during a subsequent emergence the rocks were subjected to erosion. This is shown by the uneven upper surface of the Yellville limestone and by the abrupt variations in thickness, or the total absence in certain localities, of the Sylamore sandstone. Where present this Devonian sandstone is the first deposit following the Yellville limestone, and its stratigraphic relations to the latter show clearly that it served to fill considerable hollows in the limestone, and thus paved the way for the more evenly spread Devonian shale. There is no record preserved within the quadrangle of sedimentation in the Silurian period, nor in the earlier parts of the Devonian period, and it is probable that the Ordovician rocks during that time formed the surface of a great land area in the Ozark region and were wasted away under atmospheric agencies.

Toward the close of the Devonian period the sea gradually encroached upon the land, and a bed of mud, preceded by an uneven bed of sand, was deposited. These beds are now known as the Chattanooga shale and the Sylamore sandstone member.

The Carboniferous period began with a comparatively brief, and perhaps local, recession of the sea. This is indicated by the general absence of deposits representing the earlier stages of the Kinderhook group. However, before the close of the Kinderhook, the land to the north was again submerged. In consequence of this advance, and the deepening of the sea occasioned thereby, the distance from this area to the shore was increased, and sedimentation changed from mud to limy deposits. This condition prevailed for a long time, and the sediments form what is known as the Boone formation. The beds first laid down were nearly pure lime, and now constitute the St. Joe limestone member. After this there was an admixture of silica, which gave rise to the cherts of the upper part of the Boone formation.

After the deposition of the Boone formation the sea retreated once more. This retreat is indicated by the restriction of the next following deposit, the Moorefield shale, to areas south and east of the Fayetteville quadrangle. The sea retreated at this time also from a large part of the Mississippi Valley, the erosion of the correspondingly increased land being indicated nearly everywhere by the absence of certain deposits and by the unconformable contact formed between the old land surface and the first deposits resulting from the next submergence. In this area, presumably, land conditions prevailed during the whole of the epoch, submergence and sedimentation being resumed only about the beginning of the Chester epoch—the Batesville sandstone, which rests on the Boone, being of the latter age. It seems probable, however, that this sandstone marks merely the beginning of the submergence of this area, and that it was not laid down over the whole of it. With the continued advance of the sea came a bed of black mud, which on solidifying formed a shale known as the Fayetteville shale. During the course of the deposition of this shale slight movements of the earth probably occurred, causing elevation and the production of the coarser siliceous material that now constitutes the Wedington sandstone member of the Fayetteville formation.

Evidently an erosion interval followed the deposition of the Fayetteville formation, since the upper part of the Fayetteville is locally absent in this and adjoining quadrangles. This emergence and consequent erosion probably resulted from comparatively local warpings and oscillations, which first contracted and elevated at least the borders of the basins, and later caused them to sink again beneath the waters of the sea. As the sediments that were accumulated during this later submergence consisted chiefly of the calcareous matter now forming the greater part of the Pitkin limestone, it is presumed that the oscillations occasioned sufficient changes in the relief and drainage of the adjacent land to cause the comparatively quiet- and clear-water conditions that must have prevailed during the deposition of limestone. And this seems to have been true despite the fact that the north shore of the Pitkin sea, as is indicated by the general thinning and local absence of the limestone in that direction and by the wider distribution of the preceding shale formation, was located nearer this quadrangle than was the corresponding shore of the Fayetteville sea.

According to the evidence of the fossils the Pitkin formation is the highest of the Mississippian series. Prior to the deposition of the next succeeding strata in this area the Pitkin was elevated above the sea level and subjected to erosion that at certain points sufficed to remove the greater part if not the whole of the limestone. Elevations of land surfaces and corresponding restrictions of water areas like those which introduced this erosion interval in northern Arkansas occurred over a large part of America at this time. In consequence, the contact between the Mississippian and Pennsylvanian formations is nearly everywhere in this country appreciably unconformable.

The Pennsylvanian series is represented in the Fayetteville quadrangle by sandstones and shales with some thin lenses of limestones. The Morrow formation, which is the lowest of this series, exhibits its frequent alternations in the character of its sediments, for at one stage shallow-water conditions prevailed, with local land areas, which permitted the growth of a layer of plant material that is now found in the form of a coal bed. The youngest rocks in the quadrangle are known as the Winslow formation. They consist of sandstones and shales, the lower sandstone beds carrying some quartz pebbles. The close of the record of Paleozoic sedimentation is not preserved within the limits of this area. In the Boston Mountains, farther south, there is a great thickness of rocks which belong to the Winslow, but they have been so eroded that within the Fayetteville quadrangle the lower beds only remain to form the tops of the higher mountains.

Since the Paleozoic era no additional subaqueous formations have been deposited, or if so there are now no evidences of them. The next stage in the history of the area, the record of which can be read with certainty, is in late Tertiary time. Land conditions had evidently prevailed for a long period and the higher formations in the northern part of the quadrangle had been eroded and the surface reduced to a nearly even lowland plain that corresponded in a considerable degree to the upper surface of the Boone formation. On account of their nearly horizontal position and the unusually resistant character of the rocks of the Boone, this plain is partially preserved at the present time and conforms to the generally even horizon of the uplands. The semimountainous portion of the quadrangle was somewhat more extensive than now and stood at a relatively higher elevation.

Subsequent elevation of the Ozark region has transformed the lowland into an upland, and the streams have cut deep valleys which in places expose the Ordovician rocks, so that at the present time the oldest formations are again the scene of geologic activities.

DEFORMATION AND STRUCTURE.

The various formations, as originally deposited, were in nearly horizontal position. The main centers of the disturbances which influenced the Ozark region have been at considerable distances from the area here described, and the oscillations of level resulted in but slight inclination of the strata within the Fayetteville quadrangle. Moreover, the successive elevations and depressions have tended to neutralize one another. The final result is that the rocks have a gently undulating structure, which in places is accentuated into low domes and folds, and where the tension or stress was too great there are fractures and faults accompanied by vertical displacement.

The formation which is of widest extent and affords the best datum for studying the broader structure of the quadrangle is the Boone limestone. It should be taken into consideration, however, that its upper surface has been largely eroded, so that its full thickness is not represented at all places, and that its lower limit is generally exposed in local anticlines. From the geologic map it will be seen that its highest elevation is along the eastern border of the quadrangle, from Springdale to Elkhorn Mountain, and that it dips very slightly toward the west.

In the southeast corner of the quadrangle it lies at a lower elevation than in other parts, as a result of the faulting and displacement which has taken place. The occurrence of the areas of Ordovician rocks indicates local doming and divergent dips, but no definite system of folds can be made out from a study of them. The faults and folds which occur in the southern part of the quadrangle, however, indicate two structural lines; viz, N. 30° to 40° E., and N. 60° to 80° E. The former is the direction of the Chambers Spring syncline and the Price Mountain fault and syncline; the latter, of the White River fault.

Chambers Spring syncline.—The axis of this syncline enters the quadrangle in sec. 21, T. 16 N., R. 33 W. It passes through Cincinnati, which lies just beyond the western border of the quadrangle. It extends through an area of the Fayetteville shale and Wedington sandstone, which is preserved as a result of the structure. The fold is a very shallow one and does not affect the dip of the rocks very far on either side of the axis. It is in evidence near Chambers Spring, where a remnant of the Fayetteville shale occurs. It does not appear to extend to the northeast far beyond this point. Its direction is N. 40° E.

Price Mountain fault and syncline.—Just south of Price Mountain there is a fault which has a direction of N. 40° E. The maximum displacement near Price Mountain is about 300 feet, the downthrow being on the south side. (See fig. 2.) The fault is not in evidence very far to the northeast. To the southwest it follows the contact of the shales and sandstones with the limestone to sec. 20, T. 17 N., R. 29 W. In this portion of the fault the displacement is evidently between 100 and 200 feet, but it can not be measured accurately. Still farther to the southwest the fault has been observed at a number of places in connection with synclinal structure.

The rocks in East Mountain dip to the west slightly, and at Fayetteville, in the hill on which the university stands, there is a low dip to the east. The axis of the faulted syncline passes between these two localities. The disturbance is greatest in the northern part of Fayetteville, in the hill on which the schoolhouse stands, and along the ravine to the north of it. The displacement and deformation are shown by a careful study of the Brentwood limestone and the Winslow sandstone, but can not be fully expressed in the mapping. The sandstones and shales appear with diverse dips and are considerably crushed. There is some local displacement at right angles to the axis of this structure. An example may be seen in the railway cut north of the depot at Fayetteville, at which place the Pitkin limestone abuts against the Fayetteville shale.

In sec. 31, T. 16 N., R. 30 W., at Cato's shop, the Pitkin limestone is seen to have a decided synclinal structure. Southwestward along the old wire road the rocks dip to the southeast conspicuously. The ravine in that vicinity lies in the axis of the syncline.

White River fault.—There is a fault entering the east side of the quadrangle in sec. 18, T. 17 N., R. 28 W. It trends westward with some deviation and crosses White River in sec. 22. In sec. 20, T. 17 N., R. 29 W., where the White River fault crosses the Price Mountain fault, the dips are diverse. Farther westward, on Hamestring Creek, its trend is along the northern limits of the Fayetteville shale area. In the vicinity of Rhea post-office, in the east slope of Wedington Mountain, there is a fault which is on the same strike with the one above described, and is perhaps a continuation of it.

In the intervening distance the faulting is not conspicuous or recognizable, because of its occurrence in the limestone country, where the surface is covered by chert débris. East of White River the downthrow is probably as much as 200 feet on the south side of the fault; near Rhea it is about 100 feet in the same direction. In connection with the development of this fault there is considerable flexing of the strata. In the area of the Fayetteville shale, shown along Anderson Branch and Hamestring Creek, the structure is in the nature of a shallow syncline.

A branch of the White River fault occurs along the ravine in secs. 21 and 22, T. 17 N., R. 29 W. In this case the downthrow is on the north of the line of fracture. The fault dies out in sec. 29. As a result of this structure in connection with the main White River fault, a block has been dropped downward, so that the shales which are coal bearing and small areas of the Winslow are found at a much lower elevation than they otherwise would be. (See fig. 2.)

In the northern part of the quadrangle there is, locally, evidence of folding and displacement, but the structure can not be traced very far owing to the surface covering of chert. At certain places the Batesville sandstone is found at a lower elevation than the Boone limestone of the surrounding area and there are occasional small fault blocks and unusual dips, but in such cases the exposures are not sufficient to allow a satisfactory explanation.

On the head of McKisic Creek there is an outcrop of the Batesville sandstone within which the structure is synclinal, although it is not very definite. Two miles northwest of Pea Ridge post-office there is another small area which exhibits a similar structure. At intermediate points the sandstone occurs below the general elevation of the Boone limestone. On the road just south of Rago post-office a small block of sandstone has been dropped down, so that it abuts against the limestone. This is apparently the result of a dip fault near the axis of the syncline. The direction of the syncline is N. 30° E., which corresponds with the direction of the Chambers Spring and Price Mountain structural lines.

MINERAL RESOURCES.

The Fayetteville quadrangle does not regularly supply any mineral products to the general market. It, however, contains resources which are of local use. They could be more largely developed, but inasmuch as the same materials are found commonly throughout the surrounding region the cost of freight prevents extensive exploitation. These resources are, besides the soil, clay and shale for brick, stone for building and for burning to lime, and a thin bed of coal.

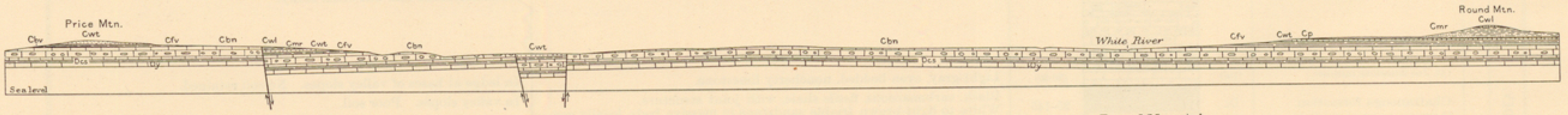

Fig. 2. Northwest-southeast structure section in southeastern part of quadrangle, from Price Mountain to Round Mountain.

Oy, Yellville formation; Dcs, Chattanooga shale and Sylamore sandstone; Cbn, Boone formation; Cbv, Batesville sandstone; Cfv, Fayetteville shale; Cwt, Wedington sandstone; Cp, Pitkin limestone; Cmr, Morrow formation; Cwl, Winslow formation.

Horizontal scale: 1 inch=⅝ mile. Vertical scale the same as the horizontal, or 1 inch=approximately 3500 feet.

Soil.—The upland of the larger part of the quadrangle has a soil which is residual from the decay of the Boone limestone, and contains an admixture of organic matter from the decay of vegetation of the woodlands and prairies which existed before farms were laid out. It is a strong soil, well adapted to the growing of grains and general farm products. The subsoil is usually a red clay which is sticky when wet, and where the drainage is imperfect the ground is apt to be cold and unproductive; but this can be easily modified by ditching and cultivation. In places there is an admixture of sand from the small remnants of the Batesville formation. Along the valleys of the numerous small streams which dissect the upland the surface is largely covered by chert, the soil having been washed away. The transportation of the soil contributes to the enrichment of the valleys, and where they are level enough to be cultivated there are good farms. The valleys of White River and the Illinois, and even of the smaller streams, contain fields which are constantly enriched and renewed by the overwash from the hills. Where the Chattanooga and Fayetteville shales outcrop the soil would be poor and thin if it were not for the addition of material which has been transported from neighboring hills.

In the area of the sandstones of the Morrow formation the soil is usually a light, sandy loam. The presence of the limestone lentils where they form heavy ledges modifies this character considerably, since the washing of the surface water distributes over a considerable belt the soil resulting from the decay of these limestones. In decomposing, the shales, which are interstratified, receive such an admixture of sand from the higher slopes that they do not form a distinct class of soils. The areas of alluvial soil are the richest farming lands, but they are of limited extent, since none of the streams have extensive flood plains. This class of soil is found principally along White and Illinois rivers.

Clay and shale.—Brickkilns have been operated to supply the local trade, but their production has never been large, owing to the facility with which building stone can be procured. Thus far only the surface soil and clay have been used in the kilns. In the southern part of the quadrangle shales are available which could be utilized in making brick and tiling, but the cost of operating is too great considering the present local demand and the condition of the general market.

Building stone.—The St. Joe limestone is an even-bedded stone which is well adapted for walls and heavy masonry. Its occurrence at Sulphur Springs is favorable for quarrying, and it is there conveniently near the railroad, so that it can be shipped. It has been used to a limited extent and quarries are already open. This limestone has also been quarried on Little Sugar Creek, where it forms a conspicuous ledge. At many places there are quarries in other beds of the Boone limestone to supply the local demand. Sandstone is also commonly employed in building, since it is soft and therefore easily dressed and quarried. There is an abundance of it in the southern part of the quadrangle, and in some of the smaller areas of the Batesville formation in the northern part it has been quarried for building blocks and for flagstones because of the facility with which it can be worked.

Lime.—Small limekilns have been operated at many places wherever there has been a demand for the product. Half a mile south of Johnson there is a kiln which is situated on the railway at a point that is convenient for quarrying and shipping. The stone which is used at this place is obtained from the more massive upper beds of the Boone formation, which are here free from chert. Another kiln is in operation at a point about 1½ miles south of Sulphur Springs. This is conveniently situated and the product of the kiln is said to be of excellent quality. The stone used is limestone of Kinderhook age that here forms the basal part of the St. Joe member of the Boone formation.

Coal.—The coal which is mined in secs. 20 and 21, T. 17 N., R. 29 W., in the vicinity of Lemmons bank, is a hard, lustrous, bituminous coal. The bed is only 14 inches thick, and its thinness prevents its being worked on any large scale, but considerable coal is supplied to the local trade. Mines are also operated near the summit of Robinson Mountain, where the same formation occurs, and the coal there is of similar character and thickness. There is little prospect that beds of commercial importance will be developed within the quadrangle.

Prospects, drill holes, and shafts.—Considerable money has been spent in drilling wells, with the hope of finding oil or gas, and a number of shafts have been sunk in prospecting for lead and zinc. The records of the drill holes conform with the general section of the rocks as exposed within the quadrangle, and where the holes reach a considerable depth they penetrate the magnesian limestones of the Ordovician rocks. Oil or gas has, however, not been found. In passing through the Chattanooga shale, which is usually about 50 feet thick, the cuttings of the drill commonly give off a fetid odor, and this has been an encouragement to the prospector. The Chattanooga shale is, however, not known to be oil bearing, and the rocks above and below can not be expected to contain either oil or gas.

The Boone limestone, which is so widely distributed over the quadrangle, is the formation which contains the lead and zinc deposits of southwestern Missouri, and the finding of small quantities of lead and zinc has induced many people to prospect with the hope of finding larger bodies of ore. Thus far no one has met with success. Usually the prospects have not been located with respect to fault lines or fissures. Judging from results obtained in neighboring mineralized regions, it may be worth while to prospect some of the localities in the quadrangle in which the rocks have been disturbed. The conditions which brought about the deposit of lead and zinc in southwestern Missouri do not, however, seem to have prevailed in this quadrangle.

February, 1905.

GENERALIZED SECTION FOR THE FAYETTEVILLE QUADRANGLE.

SCALE: 1 INCH=200 FEET.

System.	Series.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soils.
CARBONIFEROUS	PENNSYLVANIAN	Winslow formation.	Cwl		100+	Brown sandstone and variegated shale; fine quartz pebbles near the base in certain localities.	Mountain tops. Stony and sandy soil.
		(Kessler limestone lentil.)	(Ck)			Gray and yellowish shale, and carbonaceous shale, with thin coal bed and zone of thin lenticular limestones.	
		Morrow formation.	Cmr		200±		Mountain slopes and irregular surfaces. Soil sandy, with small amount of clay.
		(Brentwood limestone lentil.)	(Cbr)			Thin beds of limestone and shale, underlain by sandy shale.	
		UNCONFORMITY					
	MISSISSIPPIAN	Pitkin limestone.	Cp		0–15	Gray fossiliferous limestone of variable texture.	Forms a ledge and contributes lime to soils lower on slopes.
		(Wedington sandstone member.)	(Cwt)			Heavy brown sandstone with thin yellow shale locally at the top.	Tops of low mountains or hills and on mountain benches. Sandy soil.
		Fayetteville formation.	Cfv		20–350	Black, fissile, carbonaceous shale containing calcareous concretions, with thin lenses and beds of dark limestone near the base.	Exposed near the bases of slopes. Soil poor except where covered with overwash.
		Batesville sandstone.	Cbv		0–90	Yellowish and gray thin-bedded sandstone, locally shaly and very calcareous.	At bases of slopes and on small flat areas. Soil sandy.
		UNCONFORMITY					
		Boone formation.	Cbn		325±	Light-gray siliceous limestone, cherty limestone, and beds of chert.	Generally level surface, broken by stream valleys. Good limestone soil, but often stony.
		(St. Joe limestone member.)	(Csj)		(20–30)	Light-gray, even-bedded, noncherty limestone.	In ledge at bases of valley slopes. No soil retained.
DEV.		Chattanooga formation.	Dc		20–145	Black, carbonaceous, fissile shale, with joint structure.	In valley slopes. Poor soil.
		(Sylamore sandstone member.)	(Ds)		(0–75)	White to light-brown friable sandstone in massive beds, locally conglomeratic, with chert, limestone, and phosphatic pebbles.	In valley slopes and floors. Sandy soil.
		UNCONFORMITY					
ORDOVICIAN		Yellville formation.	Oy		100+	Light- to dark-gray magnesian limestone and dolomite, even bedded and locally siliceous or cherty.	In stream valleys, usually as bluffs.

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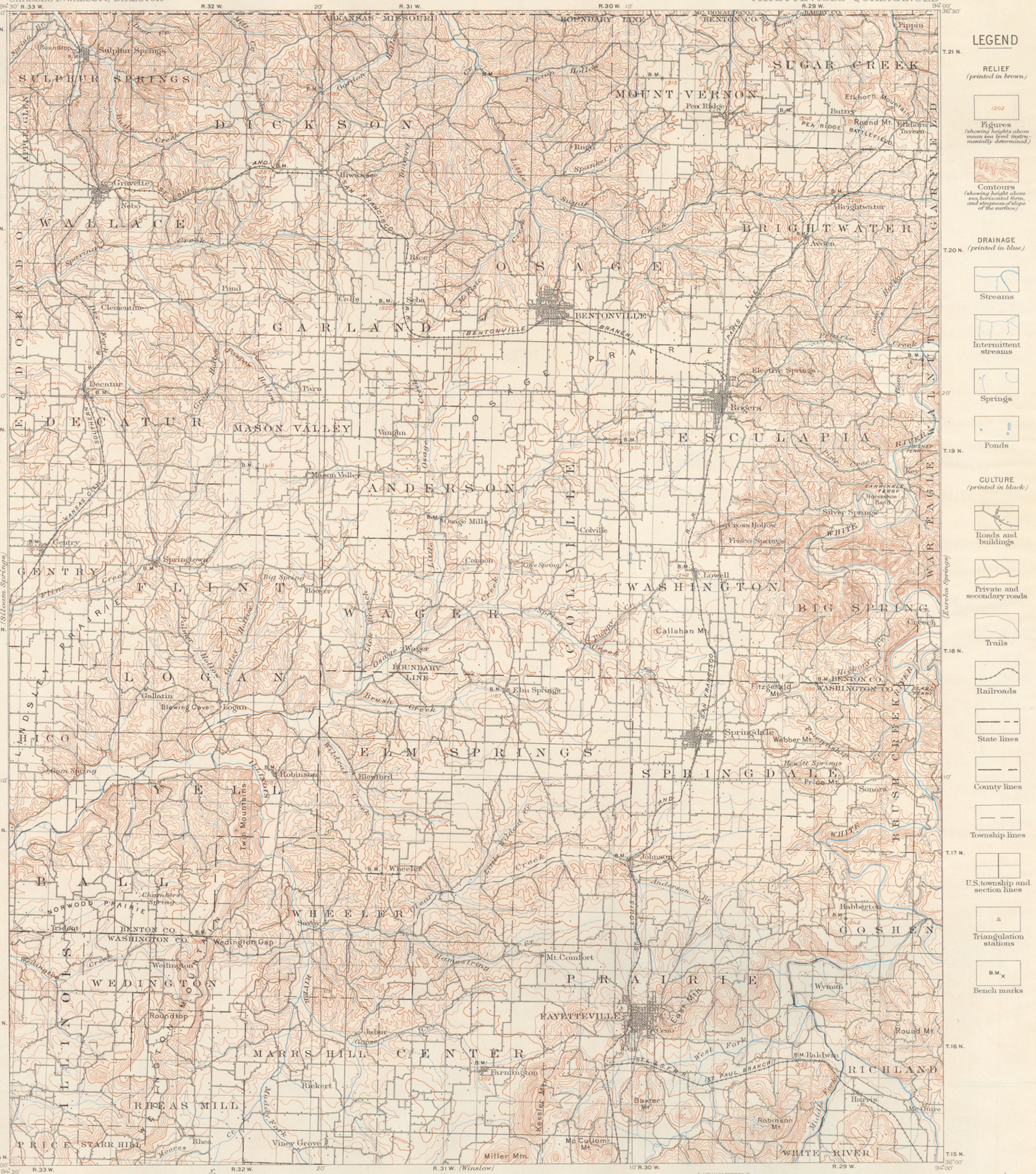
TOPOGRAPHY

ARKANSAS-MISSOURI
FAYETTEVILLE QUADRANGLE



Jno. H. Renshawe, Geographer in charge.
Triangulation by Geo. T. Hawkins.
Topography by H. B. Blair.
Surveyed in 1899.

APPROXIMATE MEAN DECLINATION 1902.

Scale 1/125000

Contour interval 50 feet.
Datum is mean sea level.

Edition of Dec. 1904

U.S. GEOLOGICAL SURVEY
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AREAL GEOLOGY

ARKANSAS-MISSOURI
FAYETTEVILLE QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines)

CARBONIFEROUS

Pennsylvanian

Cwl — **Winslow formation** *(brown sandstone and variegated shale, with fine quartz conglomerate locally near base)*

Cmr, Ck, Cbr — **Morrow formation with Brentwood and Kessler limestone lentils** *(gray and yellowish shale and brown sandstone, with beds of carbonaceous shale, thin coal bed, and limestone lentils)*

UNCONFORMITY

Mississippian

Cp — **Pitkin limestone** *(light-gray fossiliferous limestone of variable thickness, in places sandy)*

Cfv, Cwf — **Fayetteville formation and Wedington sandstone member** *(black, carbonaceous, laminated shale often containing calcareous concretions, with dark-blue limestone at base, and heavy brown sandstone near top with thin yellow shale above)*

Cbv — **Batesville sandstone** *(yellowish and gray sandstones, thin-bedded and arenaceous, with local beds of shale and limestone)*

UNCONFORMITY

Cbn, Csj — **Boone formation with St. Joe limestone member** *(gray limestone, cherty limestone, and beds of chert, with basal member of even-bedded, gray, noncherty limestone)*

DEVONIAN

Dc — **Chattanooga shale** *(black carbonaceous shale, with joint structure and concretions of iron pyrite)*

Member of Chattanooga formation

Ds — **Sylamore sandstone** *(white to light-brown friable sandstone in massive beds; locally conglomeratic and containing chert, limestone, and phosphatic pebbles)*

UNCONFORMITY

ORDOVICIAN

Oy — **Yellville formation** *(light-to dark-gray magnesian limestone and dolomite, even bedded, and locally siliceous or cherty)*

⚒ *Coal mines*

Jno. H. Renshawe, Geographer in charge.
Triangulation by Geo. T. Hawkins.
Topography by H. B. Blair.
Surveyed in 1899.

APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{125000}$

Contour interval 50 feet.
Datum is mean sea level.

Edition of Jan. 1905

DIAGRAM OF TOWNSHIP.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Geology by George I. Adams,
assisted by Ernest F. Burchard and A. H. Purdue.
Surveyed in 1900.

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be determined by observing their positions. This relationship holds except in regions of intense disturbance; in such regions sometimes the beds have been reversed, and it is often difficult to determine their relative ages from their positions; then *fossils*, or the remains and imprints of plants and animals, indicate which of two or more formations is the oldest.

Stratified rocks often contain the remains or imprints of plants and animals which, at the time the strata were deposited, lived in the sea or were washed from the land into lakes or seas, or were buried in surficial 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 simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. When two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains found in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is often difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can sometimes be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it.

Similarly, the time at which metamorphic rocks were formed from the original masses is sometimes shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not of their metamorphism.

Colors and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern, and is labeled by a special letter symbol.

Symbols and colors assigned to the rock systems.

	System.	Series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary...	Recent........ / Pleistocene....	Q	Brownish-yellow.
	Tertiary......	Pliocene....... / Miocene....... / Oligocene...... / Eocene........	T	Yellow ocher.
Mesozoic	Cretaceous....	....	K	Olive-green.
	Jurassic......	....	J	Blue-green.
	Triassic.......	....	Ћ	Peacock-blue.
Paleozoic	Carboniferous.	Permian....... / Pennsylvanian / Mississippian..	C	Blue.
	Devonian.....	....	D	Blue-gray.
	Silurian.......	....	S	Blue-purple.
	Ordovician....	....	O	Red-purple.
	Cambrian.....	Saratogan..... / Acadian....... / Georgian......	€	Brick-red.
	Algonkian....	....	A	Brownish-red.
	Archean......	....	Æ	Gray-brown.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea or in lakes. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin.

The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system. The symbols by which formations are labeled consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters. The names of the systems and recognized series, in proper order (from new to old), with the color and symbol assigned to each system, are given in the preceding table.

SURFACE FORMS.

Hills and valleys and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; sea cliffs are made by the eroding action of waves, and sand spits are built up by waves. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are produced in the making of deposits and are inseparably connected with them. The hooked spit, shown in fig. 1, is an illustration. To this class belong beaches, alluvial plains, lava streams, drumlins (smooth oval hills composed of till), and moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion, and these are, in origin, independent of the associated material. The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and peneplains. In the making of a stream terrace an alluvial plain is first built and afterwards partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and streams carry the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried below sea level, and the sea is therefore called the *base-level* of erosion. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the even surface thus produced is called a *peneplain*. If the tract is afterwards uplifted the peneplain at the top is a record of the former relation of the tract to sea level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—This map shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any colored pattern and its letter symbol the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—This map represents the distribution of useful minerals and rocks, showing their relations to the topographic features and to the geologic formations. The formations which appear on the areal geology map are usually shown on this map by fainter color patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A mine symbol is printed at each mine or quarry, accompanied by the name of the principal mineral mined or stone quarried. For regions where there are important mining industries or where artesian basins exist special maps are prepared, to show these additional economic features.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks, and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface, and can draw sections representing the structure of the earth to a considerable depth. Such a section exhibits what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

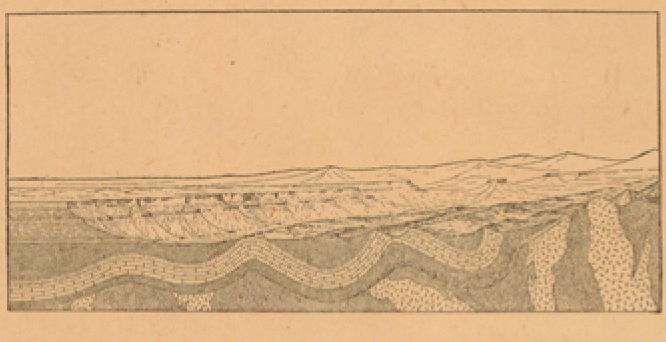

Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

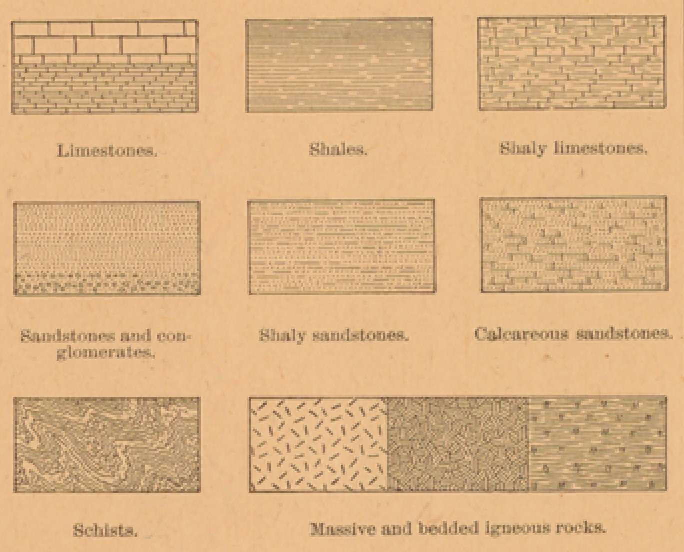

Fig. 3.—Symbols used in sections to represent different kinds of rocks.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction that the intersection of a bed with a horizontal plane will take is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

Strata are frequently curved in troughs and arches, such as are seen in fig. 2. The arches are called *anticlines* and the troughs *synclines*. But the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets; that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in fig. 4.

On the right of the sketch, fig. 2, the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be

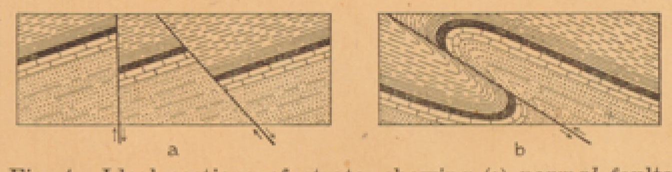

Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

The section in fig. 2 shows three sets of formations, distinguished by their underground relations. The uppermost of these, seen at the left of the section, is a set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been raised from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger rocks thus rest upon an eroded surface of older rocks the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections on the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum which appears in the section may be measured by using the scale of the map.

Columnar section sheet.—This sheet contains a concise description of the sedimentary formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures which state the least and greatest measurements, and the average thickness of each is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest formation at the bottom, the youngest at the top.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

CHARLES D. WALCOTT,

Director.

Revised January, 1904.

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