DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

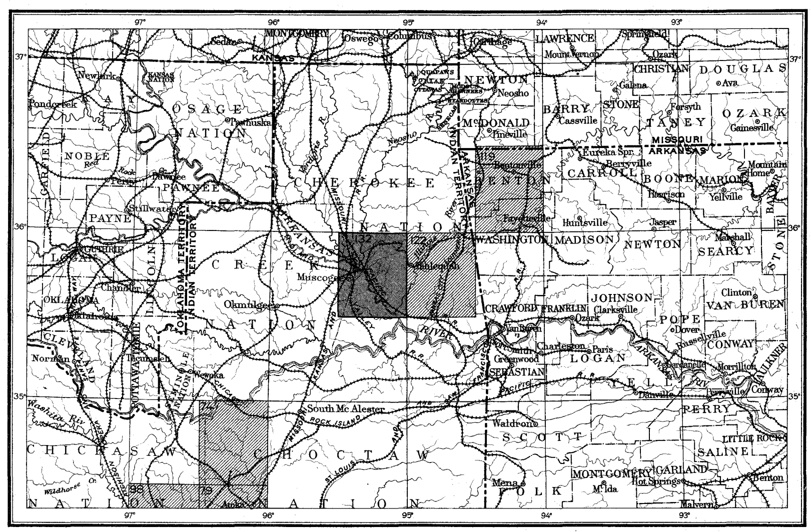
OF THE

UNITED STATES

MUSCOGEE FOLIO

INDIAN TERRITORY

INDEX MAP



SCALE: 40 MILES=1 INCH

MUSCOGEE FOLIO

OTHER PUBLISHED FOLIOS

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

1906

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).

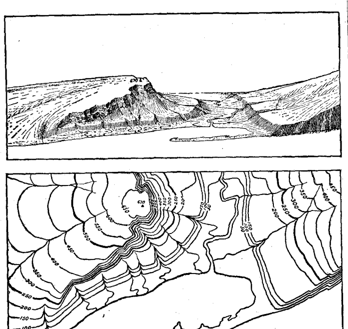


FIG. 1.—Ideal view and corresponding contour map.

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.)

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		Ꞧ	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	Є	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:

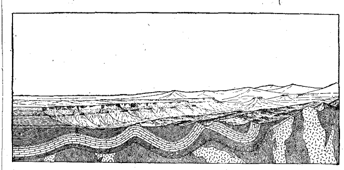


Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

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:

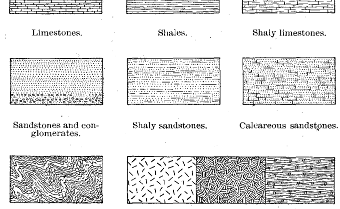


Fig. 3.—Symbols used in sections to represent different kinds of rocks.

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

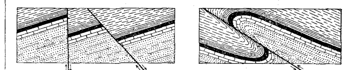


Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

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.

DESCRIPTION OF THE MUSCOGEE QUADRANGLE.

By Joseph A. Taff.

INTRODUCTION.

LOCATION AND AREA.

The Muscogee quadrangle is bounded by parallels of latitude 35° 30′ and 36° and by meridians of longitude 95° and 95° 30′ and contains 968.7 square miles. It is located in the Cherokee and Creek nations, Indian Territory, approximately the eastern two-thirds being in the former, and its southern boundary is within a few miles of the Choctaw Nation. Its name is taken from Muscogee, the principal town in the Creek Nation, which is located near the junction of Verdigris and Neosho rivers with Arkansas River.

PHYSIOGRAPHIC RELATIONS.

The Muscogee quadrangle may be separated, physiographically, into two nearly equal parts, one of which belongs to the physiographic province of the Ozark Plateau, or highland, and the other to that of the Prairie Plains. The two provinces meet in this quadrangle in a broad, shallow basin occupied in part by Neosho and in part by Arkansas River. The Ozark Plateau is low and nearly flat in this, its extreme southwestern part, where it approaches these rivers, and from them the Prairie Plains rise gradually toward the west. Brief descriptions of the salient topographic features of the Ozark Plateau and of the Prairie Plains will assist in making clear the topography of the Muscogee quadrangle.

OZARK MOUNTAIN REGION.

The Ozark region is a broad, relatively flat, dome-shaped, dissected highland. In parts of this region, notably the southern and the eastern, the greater elevations attain considerable prominence and are widely known as the Boston and St. Francis mountains. Elsewhere there are numerous lower elevations, remnants of dissected subordinate plateaus, to which names have been given and which are locally called mountains, although they do not generally deserve recognition as such. In general geography the region is known as the Ozark Mountains, but the name has not been applied to any mountain or definite collection of mountains in the province. Fig. 1 shows the main physical features of the region and the location of the Muscogee quadrangle.

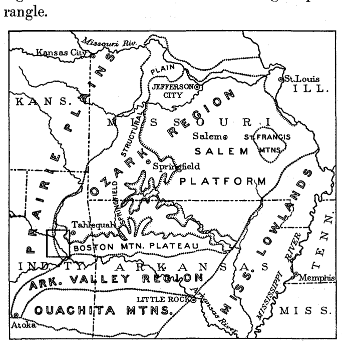


FIG. 1.—Diagram showing relations of Ozark region to surrounding physiographic provinces and principal divisions of the region.

Location of Muscogee quadrangle is indicated by the small rectangle.

Physiographically, the Ozark region is bounded as follows: On the north and west the low, inclined upland grades almost imperceptibly into the Prairie Plains. On the east the Mississippi lowland in southeastern Missouri and Arkansas meets it along a sharp line, near which runs the St. Louis, Iron Mountain and Southern Railway. On the south the upland extends to the southern border of the Boston Mountains. In outline the Ozark Plateau has rudely the form of a quadrilateral whose sides are nearly 225 miles in length.

The Ozark Plateau is limited, approximately, on the north, east, and south sides by Missouri, Mississippi, and Arkansas rivers, respectively. On the west its border is followed closely by Neosho (or Grand) and Arkansas rivers in Indian Territory, and in part by Spring and Osage rivers in Missouri. White, Black, St. Francis, Meramec, and Gasconade rivers have their sources in the plateau near the main watershed and flow out of the plateau through narrow, deep, and crooked valleys.

Considered in a broad sense the Ozark region is made up of three dissected plateaus, the general character as well as the topographic detail of which is dependent upon the kinds and attitudes of the rocks. These plateaus succeed one another concentrically westward from the St. Francis Mountains as a center. They cross the axis of the Ozark uplift and the main divide, which nearly coincide, and are inclined in the general direction of the dip of the strata. The physiography of the Ozark Plateau in Missouri has been clearly described by C. F. Marbut (Physical features of Missouri: Geol. Survey Missouri, vol. 10, 1896). Geologic mapping by the Arkansas Survey disclosed the same features in their southern extension in Arkansas (Arkansas Geol. Survey, vol. 4, 1890).

The first of these plateaus has been termed by the Missouri Survey the Salem platform. It occupies southeastern Missouri and a large part of northeastern Arkansas. The magnesian limestones, cherts, and saccharoidal sandstones of the Cambrian and Ordovician systems underlie this plateau, and slope gently away from the St. Francis Mountains. The edges of these lower deposits form distinct escarpments facing the lowlands surrounding the St. Francis Mountains. Higher formations of limestone and chert crop out in succession farther away, making subordinate platforms and escarpments. The intervening softer saccharoidal sandstone beds occur in the lower back slopes of benches and in the bases of the escarpments. The Salem platform is in general deeply cut by stream erosion and the tops of the higher ridges and hills of its dissected escarpments stand at the same general level. Thus the Salem platform has been developed on the truncated edges of a number of formations.

Back of the Salem platform, surrounding it on the north, west, and south, lies an even structural plain of chert and limestone, named by Marbut the Springfield structural plain, which has been developed on the surface of the Boone formation. Its inner border south of Osage River is marked by a pronounced escarpment—the exposed edge of the Boone formation, which overlooks the Salem platform. The Springfield plain slopes westward at low angles in Missouri and farther south and west, in northern Arkansas, following the dip of the formation. In Missouri, Coal Measure shales succeed the Boone formation, producing lowland. In northeastern Indian Territory and Arkansas alternating formations of limestone, shale, and sandstone occur above the Boone formation in low terraced hills and mountains that stand as remnants above the Springfield structural plain. Such topographic features may be seen at the borders of the Boone formation, in the northeastern part of the Muscogee quadrangle. The Springfield plain is also deeply dissected by the larger streams which flow through it in narrow, crooked valleys. Near the inner border of the Springfield plain the Boone formation has been longer exposed and is deeply corraded, giving the escarpment a tortuous and ragged outline. Hills and buttes, cut off from the escarpments, stand out on the divides between the streams above the Salem platform, their crests marking points in the former extension of the Springfield plain. Between the principal drainage lines lie large tracts of land from which the younger formations have been removed, leaving broad, flat surfaces of deeply weathered chert.

The third plateau is that of the Boston Mountains, which rise back of and above the Springfield plain. These mountains are not well defined, but may be said to extend from the Mississippi lowland, northeast of Little Rock, westward into Indian Territory, ending near the southeast corner of the Muscogee quadrangle.

The Boston Mountains rise above the Springfield plain on the south. They reach higher elevations than any other part of the Ozark highland, but become lower westward from near the Arkansas–Indian Territory line. Viewed from eminences on the Springfield plain the Boston Mountains have the appearance of a bold, even escarpment with a level crest. Actually, however, instead of having an even northward front, this escarpment sends out finger-like ridges and foothills, which descend by steps as successively lower, hard rocks come to the surface. Toward their northern ends many of these foothills are intersected, becoming flat-topped outliers on the Springfield plain.

The rocks that cap the Boston Mountains and extend down the southern slope are the thick sandstones and shales of the Winslow formation. The sandstones, being the more resistant to erosion, form the salient features of the mountains. The beds of hard sandstone near the middle of the formation make the tops of the ridges in the middle and upper courses, but in the southern slopes shaly strata higher in the section occur, so that the Boston plateau is approximately a structural plain. Structurally the mountains are monoclinal, with gradually increasing steepness of dip toward the south.

The Boston Mountains are deeply dissected by streams. Some of these flow down the southern slopes; others have eaten, by headwater erosion, into their northern border. The crests of the numerous ridges, which slope southward from the main divide to the border of the Arkansas Valley, define what may properly be called an inclined plain or sloping dissected plateau.

Near the east end of the Boston Mountains, where the capping sandstone formations are thicker and lie more nearly horizontal and where White River in its deep valley approaches its northern front, the escarpment attains its greatest height. Here high, flat-topped, precipitous ridges, 1000 to 1500 feet high, project northward on a level with the mountain top, making a high and ragged escarpment. Farther west, toward the Arkansas–Indian Territory line, the Winslow formation, especially in its sandstone beds, becomes thinner and more shaly, and in proportion as it changes in thickness and nature the Boston Mountains decrease in elevation and in distinctness of topographic form. Northward, beyond the west end of the mountains, the change in the character of the rocks and in the topography is pronounced. In the Muscogee quadrangle the Winslow formation is 800 to 1000 feet thick and the Boston plateau is not conspicuous, being represented by low, sloping table-lands with northward-facing escarpments. Farther north, on the east side of Neosho River, the Winslow formation gradually decreases in thickness and in hardness of beds until it loses its identity in the northeast corner of Indian Territory. Correspondingly, the topographic form changes from the low, westward-sloping, dissected plateau to the lowland plain bordering the Springfield plain in the southeastern part of Kansas.

ARKANSAS VALLEY REGION.

The physiographic province of the Arkansas Valley approaches the southern border of the Muscogee quadrangle. It is bounded on the north, as has already been stated, by the Boston Mountains; on the south by the Ouachita Mountains of southwestern Arkansas and southeastern Indian Territory; on the east by the Mississippi lowland at Little Rock, Ark.; and on the west by the Prairie Plains across the western part of the Choctaw Nation, Ind. T.

The Arkansas Valley is made up of a great thickness of sandstone and shale formations of the Pennsylvanian series. These beds have been thrown into many folds, which together make a deep structural trough corresponding with the Arkansas Valley and extending from eastern Indian Territory to the Mississippi embayment opposite Little Rock. These folded rocks were beveled off by erosion until their edges formed a peneplain now standing approximately 800 feet above sea level. A few exceptions to this general statement may be noted in some of the broader synclinal folds in the south side of the valley. Protected by massive sandstone strata, whose resistance to erosion was aided by their attitude in the broad, basin-like folds, the rocks in such places remain as conical mountains with crests 900 to 2000 feet above the surrounding plain. Such are Sansbois, Cavanal, Sugar Loaf, and Magazine mountains, whose crests give some idea of the former high level of the whole region. Since the development of this peneplain of the Arkansas Valley the land has been raised and erosion has cut more rapidly into the shaly beds, leaving the sandstones, which make low, narrow, and sharp-crested, but generally level, ridges. In many of the smaller synclinal folds remnants of sandstone beds cap low buttes and hills in the general level of the peneplain. This peneplain extends westward into the region of the Prairie Plains. The crests of the hills in the southern part of the Muscogee quadrangle west of Arkansas River mark levels in this peneplain. The flat valleys of the larger streams and the alluvial lands of Arkansas River are in the lower plain, being developed on the softer rocks.

PRAIRIE PLAINS.

The Prairie Plains include a broad region which rises in a gradual slope from the Ozark Plateau westward across Indian Territory until it merges into the plateaus of the Great Plains. Southwestward it extends across central Texas and northward and eastward through eastern Kansas, northern Missouri, and beyond to the plains of the Great Lakes. In Indian Territory it is a rolling or undulating land interspersed or broken by northeast-southwest ridges and hills. The ridges are characterized by a bench-and-terrace or table-land-and-escarpment form of topography. The escarpments and terraces face eastward and the table-lands and benches slope gently to the bounding plain. The rocks of this region in Indian Territory are chiefly soft shales in which lie beds or formations of hard sandstone, the whole dipping at a low inclination westward, in a direction opposite to the general slope of the plains. The thickness of these sandstone deposits varies, decreasing northward along the outcrops. With the change in thickness there is a gradual diminution of the prominence of the ridges and of the bench and terrace features of the topography. The main drainage channels trend eastward with the slope of the plains, and many of the smaller streams have cut by headwater erosion into the table-lands and benches, giving tortuous outlines to the escarpments. The western half of the Muscogee quadrangle illustrates the Prairie Plains topography in Indian Territory.

TOPOGRAPHY.

The topographic features east and west of Arkansas and Neosho rivers differ markedly, the modified topography of the Ozark highland lying to the east and the various phases of the Prairie Plains to the west. Neosho River and Arkansas River below the mouth of the Neosho have modified the somewhat indefinite boundary between the two provinces by erosion and have masked it with alluvial deposits.

OZARK HIGHLAND.

In the northeastern part of the Muscogee quadrangle there are tracts of gently rolling land. These areas are parts of the Springfield structural plain, which has been developed on the Boone formation in northwestern Arkansas, southwestern Missouri, and northeastern Indian Territory. On this an exceedingly durable surface mantle of disintegrated porous chert has been formed by weathering. Waters falling upon it pass downward and gradually reach the valleys or issue in springs through subterranean solution channels. Thus only valleys of considerable size afford streams of sufficient power to corrade the fresh rock or even to remove the fragmentary chert. The result of these conditions is that broad, level tracts are developed on the surface of the Boone formation.

The hard sandstone beds of the Winslow formation thin out or give place to shales northward in eastern Cherokee Nation. As a result of this change in sediments, erosion has reduced large areas in the northeastern part of the Muscogee quadrangle to wide, shallow valleys having the general level of the Springfield plain. The flat lands in the valleys of Greenleaf Creek east of Braggs, east of Fort Gibson, and on Fourteenmile and Double Spring creeks are in this low plain. In the western part of the Ozark region this plain is generally developed on the Boone formation, but in the northeastern part of this quadrangle it extends also over areas underlain by the Winslow, and may be said to extend to Arkansas and Neosho rivers and to join the Prairie Plains through the valleys of Bayou Manard and Fourteenmile Creek.

It has been stated that the hard sandstone beds of the Winslow formation constitute the salient features of the Boston Mountains and of their lower westward extension, or foothills, in eastern Cherokee Nation. The sandstone beds become thinner and more shaly westward to Arkansas River and thence northward east of Neosho River, and produce correspondingly reduced topographic features. The crest of the Boston Mountain plateau slopes westward from an elevation of 2000 feet near the St. Louis and San Francisco Railroad in Arkansas to 1600 feet near the Arkansas-Indian Territory line and to 900 feet in the southeast corner of the Muscogee quadrangle. The westward extension of the Boston Mountain plateau in the southeastern part of this quadrangle is marked by the crests of the flat-topped ridges and hills which slope southward and westward to the level of the Prairie Plains along Arkansas River. Remnants of the same plateau may be seen in the buttes and broken escarpments along the south side of the valley of Bayou Manard and between Bayou Manard and Fourteenmile Creek. Similar features, less pronounced, occur north of Fourteenmile Creek.

Near the middle of the Winslow formation there are some thick beds of hard sandstone which now cap the higher ridges of the plateau. Where these beds have come to the surface there are small tracts of table-land or flat benches. Similar phases of topography occur where certain beds of hard sandstone, at the base of the Winslow formation, cap the buttes and hills of limestone in the underlying formation. These topographic details may be noted in the detached hills south of Bayou Manard and Double Spring Creek. The lower sandstone member of the Winslow also makes the bluffy timbered hills facing Arkansas River on the west side of the valley south of Coata Creek. The sandstone beds are thinner and the hills proportionately less prominent along the western border of the Neosho River flood plain. From the bluffs overlooking the valleys of these rivers the surface slopes down with the dip of the strata to the line of the Prairie Plains.

The Morrow, Pitkin, and Fayetteville formations, composed of resistant beds of limestone alternating with soft shale, form the lower northern slopes of the Boston plateau and the outlying hills on the Springfield plain. They produce minor though distinct bench-and-terrace forms of topography, which are not sufficiently large to be represented on a map having 50-foot contour intervals.

Throughout the Boston plateau in Arkansas the northward-facing escarpment is dissected by streams which flow to the north. In Indian Territory, as illustrated in the Muscogee and Tahlequah quadrangles, the entire plateau district is dissected by streams which flow southward and southwestward across it from the Springfield plain. The larger streams have cut relatively deep and narrow valleys or canyons, such as that of the Illinois River in the southeast corner of the quadrangle. The sources of these streams are among the detached hills near the northern edge of the Boston Mountain plateau. The country between them is intricately dissected and the small tributary streams, which flow only during abundant rainfall, descend in steep, sharp valleys.

PRAIRIE PLAINS.

The topography of the Prairie Plains in Indian Territory is typically illustrated in the western half of the Muscogee quadrangle. The country west of Neosho River is an open, undulating prairie. Thin sandstone and limestone beds in the softer shales make low terraces and narrow benches which border the shallow valleys, but these terrace features are not sufficiently prominent to be shown on the topographic map and are scarcely perceptible in a general view of the rolling plain. Here and there a low butte or conical prairie hill is preserved by a capping of harder strata. A typical instance is the conical hill 2 miles west of Wagoner, upon which has been mounted a triangulation station. This rolling prairie is characteristic of large areas of the Prairie Plains in northern Indian Territory north of the Arkansas and west of the Neosho, where relatively few thick beds of hard rock occur in the shales to interrupt the flat features of the land. Farther south, however, along the strike of the rocks, the sandstone formations become thicker and harder. With the change in the sediments sandstone ridges and hills rise higher above the general level of the plain. The broad stretches of rolling prairie immediately south of the Arkansas Valley in the Muscogee and Okmulgee quadrangles decrease gradually in width southward until they become narrow strips between belts of westward-sloping timbered hills. In the Muscogee quadrangle the southward change in the topography is seen west of Arkansas River.

The district 8 to 10 miles in width about Muscogee is an open, undulating prairie. The timbered hills along the Arkansas southeast of Muscogee border it on the east, and eastward-facing, low escarpments and flat-topped buttes bound it on the west, near the border of the quadrangle. Toward the south the river hills and escarpments converge until they approach on each side of Dirty Creek at the southern border of the quadrangle.

Another band of flat prairie land lies parallel to the escarpment of the Rattlesnake Mountains, extending down the wide valley of Butler Creek.

The Rattlesnake Mountains are a typical instance of the table-land and escarpment features of the Prairie Plains in Indian Territory. The eastward-facing escarpment is abrupt, and the table-land, which slopes westward with the general inclination of the rocks to a belt of rolling prairie that crosses the southwest corner of the quadrangle, is broken into lobes by streams that have cut through it by headwater sapping of smaller drainage lines. Thus the harder formations of sandstone determined the location of the table-lands and escarpments, and the shale outcrops coincide with the rolling or flat lands and with the lower slopes of the escarpments.

RIVER VALLEYS.

The principal rivers in the Muscogee quadrangle are the Arkansas, the Verdigris, and the Neosho. They have worn down their valleys to essentially permanent low grades; that is, each river in any one part of its course is not eroding or cutting down its channel more rapidly than in other parts, and each is scarcely more than able to remove the sediments which are being brought down and deposited by the floods. These rivers may be spoken of, therefore, as graded streams. The transported sediments make relatively wide and almost flat plains, and in these surficial deposits the streams meander back and forth, occasionally touching the older rocks at the borders.

A large part of the surficial deposits in the Arkansas Valley is above the river's present flood plain. Numerous local terraces occur in the surficial deposits, the highest of which are above the highest points reached by the river at the present time. The sediments in the lower of these terraces have not been deposited long enough to be appreciably affected by erosion. Some of the high terraces reach altitudes more than 150 feet above the present flood plain of the river, and have had developed on them distinct drainage and topographic features. Erosion of these terraces has advanced so far that large parts of them have been removed and the remnants have been deeply etched by small intermittent streams.

Illinois River has a steeper grade and a narrower valley than the Arkansas. It approaches the latter through the more elevated and hilly country of the Ozark highland, and its valley is canyon-like, typical of the larger streams of that region.

DRAINAGE.

Four rivers drain the Muscogee quadrangle—the Arkansas, Verdigris, Neosho, and Illinois. The largest is the Arkansas, which flows across the central part of the quadrangle in a southeasterly course. From the Prairie Plains it flows eastward, touches the southwestern border of the Ozark highland, and then takes a southeasterly course. South of the southeast corner of the quadrangle the river turns eastward again and continues parallel with the southern boundary of the Ozark region to the Mississippi lowland.

The Verdigris River drainage lies within the Prairie Plains. Rising in Kansas, it flows in a southeasterly direction, joining the Arkansas near the center of the Muscogee quadrangle. Like the Arkansas in the Prairie Plains region, it flows across the strike of the rocks.

Neosho River has its source southeast of the center of Kansas, near that of the Verdigris. Its course is southeasterly until it approaches the border of the Ozark highland, near the northeast corner of Indian Territory. Touching the Ozark highland here, it is deflected southward and follows the highland border until it empties into the Arkansas near the center of the Muscogee quadrangle.

Illinois River collects its waters entirely from the Ozark highland. It rises in the northern foothills of the Boston Mountains, in northeastern Arkansas, and flows northward into the Springfield plain, thence westward and southwestward, with the pitch of the rocks, and enters the Arkansas near the southeast corner of the Muscogee quadrangle.

The eastern part of the Muscogee quadrangle is drained by Fourteenmile, Double Spring, and Greenleaf creeks, Bayou Manard, and Illinois River, besides numerous small tributary streams. The last three streams named flow directly into the Arkansas; Fourteenmile and Double Spring creeks are tributary to the Neosho. All these streams are fed by springs that issue chiefly from the Boone chert and are perennial except in times of extended drought.

The smaller streams in the western half of the quadrangle drain the Coal Measure shales and sandstones and are intermittent, their flow depending on the rainy season. During extended droughts the smaller drainage channels are almost entirely dry and the waters of the larger creeks stand in isolated pools.

DESCRIPTIVE GEOLOGY.

All the rocks exposed in the Muscogee quadrangle are stratified deposits formed in Carboniferous time. They are represented on the columnar section sheet, and their comparison with related rocks in northern Arkansas is shown in the correlation table. The structural relations of the formations to one another and their composition afford some idea of the geologic history of the region. The interpretation of the available parts of this geologic record is given under the heading "Historical geology," page 6. The determination of fossils and the statements concerning the age, classification, and correlations of the formations resulting therefrom are the work of Dr. E. O. Ulrich.

STRATIGRAPHY.

PRE-CARBONIFEROUS ROCKS.

The oldest rocks exposed in the Muscogee quadrangle consist of Carboniferous chert and limestone, though surface exposures show little other than chert, which occurs in a number of areas in the northeastern part of the quadrangle, where much of it has been worn away. In the adjoining Tahlequah quadrangle erosion has gone through these Carboniferous rocks, exposing Devonian, Silurian, and Ordovician strata in parts of the deeper valleys, and the same pre-Carboniferous rocks have been cut through in drilling a deep well at Fort Gibson, near the center of the Muscogee quadrangle.

A brief description of these rocks will probably be of service, especially in view of the active prospecting for oil now being carried on by deep-well drilling in the Muscogee quadrangle. The pre-Carboniferous rocks will be described in the order in which they are encountered in drilling, beginning with the Devonian.

CHATTANOOGA SHALE.

The top of the Devonian is encountered at a depth of 800 feet in the well at Fort Gibson. The rock is a black, slaty shale about 30 feet thick. When dry or powdered it assumes a brownish-black hue. A bed of sandstone or conglomerate occurs in places at the base of the shale in the Tahlequah quadrangle. This local sandstone is of the same age as the shale and is classed as a member of the formation. The formation has been correlated with the Chattanooga black shale of the southern Appalachian region and has been more fully described under this name in the Tahlequah folio.

ST. CLAIR MARBLE.

Beneath the Devonian black shale lies a formation of yellowish-blue and white marble, or limestone, 62 feet thick. It is supposed to be the same as the St. Clair marble, which occurs immediately beneath the Chattanooga formation in the Tahlequah quadrangle. Before the Devonian shale was deposited the rocks beneath it in eastern Indian Territory and northwestern Arkansas were folded and then eroded to a generally flat surface. Near Marble, in the southern part of the Tahlequah quadrangle, the St. Clair marble appears to be not less than 200 feet thick. It is entirely absent, however, from the lower Paleozoic outcrops near Tahlequah, and is generally lacking throughout northwestern Arkansas and southwestern Missouri. Whether the frequent absence of the St. Clair marble is due to original local nondeposition or to removal during periods of erosion preceding the deposition of the Devonian is a problem not yet solved.

The St. Clair marble belongs to the Silurian system. It was first described by the Arkansas Geological Survey in 1890 (Ann. Rept., vol. 1, 1891) and named St. Clair, for St. Clair Springs, north of Batesville, Ark., where it is well exposed.

TYNER FORMATION.

Beneath the St. Clair marble in the Fort Gibson well there is a formation consisting of greenish, bluish, and reddish-gray shale and thin-bedded sandstone, aggregating 116 feet in thickness. This formation apparently corresponds to the Ordovician Tyner formation, described from outcrops on Illinois River east of Tahlequah, where it is found to be essentially the same in character and in thickness as at Fort Gibson. Some variable beds of limestone in the upper part of this formation contain fossils of Trenton age. The formation has received the name Tyner from a small stream near the northern border of the Tahlequah quadrangle, on which it is typically exposed.

BURGEN SANDSTONE.

Beneath the Tyner formation in the Fort Gibson well there is a deposit of light-gray to yellow sand 80 feet thick. This sand corresponds in character and position with the Burgen sandstone, which underlies the Tyner formation east of Tahlequah. It is massive and consists of round, limpid quartz grains loosely cemented together. No fossils have been found in the Burgen sandstone. Its age is inferred from its stratigraphic position. It lies between the Tyner formation, which is of Trenton or late Ordovician age, and the Yellville formation, which is of Canadian or early Ordovician age. A study of the St. Peter or "Saccharoidal" sandstone in northern Arkansas and Missouri, with which the Burgen is correlated by Dr. E. O. Ulrich, causes him to class it as early Ordovician.

YELLVILLE FORMATION.

From the base of the Burgen sand down to the bottom of the Fort Gibson well there are 78 feet of light-blue magnesian limestone. A formation of similar character occurs in northern Arkansas and in Missouri beneath the St. Peter sandstone, to which, as stated above, the Burgen sandstone in the Tahlequah quadrangle is believed to correspond. This formation of magnesian limestone contains fossils that have been classed as earlier Ordovician in age. It has been named from the town of Yellville and described by G. I. Adams in 1904 (Zinc and lead deposits of northern Arkansas: Prof. Paper U. S. Geol. Survey No. 24, 1904, pp. 18–20).

CARBONIFEROUS SYSTEM.

MISSISSIPPIAN SERIES.

BOONE FORMATION.

Character.—Only the upper part, probably 200 feet, of the Boone formation is exposed in the Muscogee quadrangle. The rocks consist, for the most part, of interstratified chert and cherty limestone. At the base of the formation in the adjoining Tahlequah quadrangle thin limestones free from chert occur locally, while at other localities the chert rests on the Chattanooga black shale without intervening limestone beds. This lower limestone is thick enough to be classed as a member of the formation, and although not exposed in this quadrangle, will be briefly described. It consists of fine-textured, even-bedded, and dense, white to pinkish, marble-like limestone and light-colored crinoidal limestone in beds aggregating 10 to 15 feet in thickness. Its position in the formation and its lithologic character strongly indicate that it should be correlated with the basal St. Joe member of the Boone formation in the northern part of the Fayetteville quadrangle and farther east in northern Arkansas. Near the northern boundary of the Tahlequah quadrangle, in the east side of Illinois River Valley, also, there are basal beds which consist of dull-blue, earthy, fossiliferous limestone in the lower part, on which rest beds of thicker and harder limestone, the whole aggregating 6 feet in thickness. These beds contain fossils of Kinderhook age, and according to this classification lie at the base of the Boone formation. They are, however, too thin and limited in exposure to justify separate description and name.

The upper bed of the St. Joe member is a lighter-colored, often pink, and generally crystalline crinoidal limestone, which, together with the lower part of the cherty limestone overlying it, contains a Burlington fauna.

The succeeding cherty limestone constitutes almost the whole of the Boone formation and is the part exposed in this quadrangle. The exposed beds are made up essentially of calcareous chert or flint, with variable bands or beds of limestone. Fresh exposures occur in but few places. They are found in steep bluffs and cliffs where the larger streams meander against the sides of their valleys or, more rarely, in the beds of the smaller streams, in their middle or lower courses, where the grades are sufficiently steep and the volume of water is great enough to induce active erosion. The chert element is so much more abundant than the limestone and is so resistant to the effects of erosion that almost the entire surface rock consists of angular chert bowlders and fragments.

In the deep well at Fort Gibson the Boone formation consists of light- to dark-blue siliceous and argillaceous limestone, with 20 feet of light-gray limestone at the base. The samples of drillings obtained from the well indicate that the character of the surface rock has been produced by the removal of a large part of the original lime by solution and by segregation of the silica as chert.

Fossils.—The cherts in the upper part of the formation are locally very fossiliferous. The foregoing list includes the species most commonly found; their association is decidedly indicative of Keokuk age.

Amplexus fragilis White and St. John.
Glyptopora keyserlingi Prout.
Fenestella multispinosa Ulrich.
Polypora maccoyana Ulrich.
Hemitrypa proutana Ulrich.
Pinnatopora striata Ulrich.
Spirifer logani Hall.
Reticularia pseudolineata Hall.
Productus setigerus Hall.
Orthothetes keokuk Hall.
Capulus equilaterus Hall.

Thickness.—The Boone formation at Fort Gibson is estimated to be 184 feet thick, and probably as much is exposed in the northeastern part of the quadrangle, where the base is not reached. In the Tahlequah quadrangle, where full sections are exposed, its thickness ranges from 100 to 300 feet. Except in a few localities the top and base are separated in outcrop by several miles, and the rocks are so concealed by surface chert débris that determinations of thickness are at best only approximate.

Name.—The formation was named for Boone County, in northern Arkansas, and was first described by Dr. F. W. Simonds in 1888 (Arkansas Geol. Survey, vol. 4, 1889).

FAYETTEVILLE FORMATION.

Character.—The Fayetteville formation consists of dark-blue to black fissile shale, with usually thin limestone beds. The larger part consists of shale, in which the limestones are inclosed as thin lentils or as beds locally variable in thickness. In the Muscogee quadrangle two of these beds of limestone seem to be constantly present. One occurs at or near the base, another near the top of the formation. In many places where the rocks are not well exposed the lower limestone appears to be in contact with the underlying cherty beds of the Boone formation, the bed of shale that in more complete sections underlies the limestone being absent. However, where the contact between the Fayetteville and Boone formations was well exposed the shale was always found to be present in greater or less amount.

The layers making up this lower bed of limestone are mainly fine grained in texture and vary from an inch or two to a foot or more in thickness. Their color varies from light to dark blue, or even black when fresh, but the weathered surface of the rock commonly displays shades of drab or yellowish blue. The thickness of the whole bed ranges from 5 to 15 feet. These extremes were observed in near-by exposures in the northeastern part of the quadrangle.

Fossils.—Fossils are extremely rare in the shale, but the limestone beds generally afford a varied and abundant fauna. The following list includes the names of the principal fossils of the lower limestone bed:

A large undescribed crinoid, related to Eupachycrinus but having uniserial arms. The plates of the calyx, being thick and bulbous, are striking fossils.
Productus unnamed species of the type of P. splendens.
Camarotœchia sp. undet.
Archimedes cf. A. communis Ulrich.
Orthothetes kaskaskiensis McChesney.
Chonetes n. sp. of the type of C. geinitzanus Waagen (rare).
Productus cf. P. cora and P. tenuicostus.
Productus cestriensis Worthen.
Seminula subquadrata Hall.
Cleiothyris sublamellosa Hall.
Spirifer increbescens Hall.
Spirifer of the type of S. pinguis; cf. S. scobina Meek.
Spiriferina transversa McChesney.
Dielasma cf. D. formosum Hall.

Of the above list the first three are very abundant and characteristic.

The upper limestone bed is thin, rarely exceeding 3 or 4 feet, and occurs about 10 feet below the top of the shale. It is argillaceous and more or less ferruginous, and weathers in thin, hackly slabs or plates. Many of the layers are composed principally of fossil shells, which weather unequally with the ferruginous and argillaceous matrix. Such beds disintegrate to lumpy masses or slabs of loosely cohering shells and fragments of fossils. The rock when fresh is bluish in color, but changes to yellowish brown on weathering.

The fossils of the upper limestone are distinguished from those of any part of the formation below by the greater abundance and variety of Bryozoa and by the presence of *Pentremites*. The fauna of this limestone is more closely related to that of the overlying Pitkin limestone than to that of any lower beds, and were it not for the intervening black shale the upper limestone of the Fayetteville formation would be included with the Pitkin.

Pentremites sp. undet. (a large form between P. godoni and P. conoideus).
Septopora cestriensis Prout.
Fenestella sp. nov. (a common Chester form).
Archimedes compactus Ulrich.
Archimedes communis Ulrich.
Archimedes intermedius Ulrich.
Archimedes swallovanus Hall.
Polypora corticosa Ulrich.
Productus cestriensis Worthen.
Productus sp. of the type of P. cora.
Productus sp. of the type of P. punctatus.
Seminula subquadrata Hall.
Reticularia setigera Hall.
Spiriferina spinosa N. & P.

The species of common occurrence in this upper limestone are given in the foregoing list.

Name.—The formation is named for the town of Fayetteville, in Washington County, Ark., and is described in the Fayetteville and Tahlequah folios.

Thickness.—The thickness of the Fayetteville formation is estimated to vary from 20 feet in its southern exposures to 60 feet in the northeastern part of the Muscogee quadrangle. Both the shale and the included limestone beds vary in thickness.

Toward the east the Fayetteville formation changes in character. In the northeastern part of the Tahlequah quadrangle and in the Fayetteville quadrangle the shale in the central and upper part of the formation is lighter in color than it is in the Muscogee quadrangle and includes a thick lentil of sandstone called the Wedington sandstone member. With the change in character eastward goes an increase in the thickness of the formation. In the northeastern part of the Tahlequah quadrangle the thickness is 170 feet and in the Fayetteville quadrangle it probably exceeds 200 feet.

There is apparent perfect conformity in the Muscogee quadrangle between the Fayetteville formation and the contiguous Boone formation and the Pitkin limestone. Toward the east, in the Fayetteville quadrangle and at other places in northwestern Arkansas north of the Boston Mountains, the basal shale is locally separated from the underlying Boone formation by the Batesville sandstone. Where this sandstone is wanting it is considered that the shale rests on a more or less eroded surface of the Boone. In the Muscogee quadrangle the even contact between the Fayetteville formation and the overlying Pitkin limestone appears to be perfectly conformable.

PITKIN LIMESTONE.

The Pitkin limestone consists of light-blue to brown, granular, earthy, slightly oolitic strata interbedded with fine-textured massive layers. The granular and oolitic types of rock are the more common and may be said generally to characterize the formation. The thickness of beds is variable, ranging from thin platy strata to beds 1 or 2 feet thick. The thinner strata are usually more argillaceous, and thin shale layers not uncommonly separate them.

The Pitkin limestone is considered to be the top of the Mississippian series of the Carboniferous. The fossils listed as from the upper limestone of the Fayetteville formation are equally characteristic of the Pitkin.

In thickness the Pitkin limestone in the Muscogee quadrangle varies but little from 50 feet, such slight changes as probably occur being due to erosion of its upper beds prior to the deposition of the overlying formation. Where the shaly bed is concealed the boundary between the Pitkin and Morrow formations is difficult to determine without a careful study of the fossils in the limestones both above and below the contact. In places shale, and in other localities sandy shale as well, may be found above the Pitkin limestone. This represents the Hale sandstone member of the Morrow formation, which is well developed in the Tahlequah quadrangle and farther east in Arkansas.

The Pitkin limestone crops out generally at the bases of hills and in steep slopes, bluffs, and escarpments of the higher Morrow and Winslow formations, the talus from which frequently conceals the contact. Toward the east, beyond the Tahlequah quadrangle, the Pitkin limestone occurs in isolated areas and crops out along the northern foothills of the Boston Mountains in northwestern Arkansas. Typical exposures occur in the north slopes of the Boston Mountains near Pitkin, on the St. Louis and San Francisco Railroad, from which place the name of the limestone has been taken. The formation was described by Dr. F. W. Simonds (Arkansas Geol. Survey, vol. 4, 1889), by whom it was called the Archimedes limestone. Archimedes, the generic name of one of the characteristic fossils, not being an appropriate designation for a formation, a name of geographic significance has been substituted.

PENNSYLVANIAN SERIES.

MORROW FORMATION.

Variations.—The Morrow formation as developed in this region consists of limestone and shale, with local beds of thin sandstone. The limestone greatly predominates in thickness. The shale occurs most abundantly in the upper part of the formation, but is found in places both at the base and near the middle of the main body of limestone. The quantity of lime in the formation decreases toward the east, and in the same direction there is an increase of both shale and sandstone. The shale found locally at the base in the Muscogee quadrangle becomes more sandy as it grows thicker, until, in parts of the Tahlequah and in the Fayetteville quadrangle, it assumes the importance of a separate formation or member. In the Tahlequah and Fayetteville folios it is described as the Hale sandstone member of the Morrow formation. In parts of the Fayetteville and adjoining quadrangles the formation consists almost entirely of shale and sandstone. Still farther east, in the vicinity of Yellville, the limestone, it is reported, is entirely absent. As will be shown in discussing the relations of the Morrow formation to contiguous formations, these local variations in the constituents of the Morrow appear to be attributable chiefly to overlap and to variations in character and amount of sediments according to relative distances from the shore line at which the sediments were deposited.

The main limestone, with its included shale, constituting the lower and larger part of the formation, will be described as limestone of the Morrow formation. The succeeding shale, with its thin limestone and local sandy beds, will be discussed as shale of the Morrow formation.

Limestone of the Morrow formation.—The main limestone of the Morrow formation consists of relatively hard, blue, fine-textured rock. Usually in the middle part a deposit of blue clay shale occurs, interbedded with which here and there are thin sandstone and limestone layers. In places shale also occurs near the top of the member, interbedded with the limestone; in such places there is a gradation from the limestone into the shale above. Again there is an abrupt change upward from limestone into shale.

Some layers of this important limestone member are full of small gasteropods and pelecypods, of species mainly undescribed. Other layers are charged with many kinds of Bryozoa. These, also, are nearly all new to science, but when compared with known species their alliances are in nearly every case nearer Pennsylvanian than Mississippian types. A subramose *Michelinia* (near *eugeneæ* White) is abundant, also another coral comparing rather closely with *Trachypora austini* Worthen. Both of these corals are of service in distinguishing the horizon from the lithologically similar Pitkin limestone. Among the brachiopods, which class is represented by a number of undetermined species, a *Hustedia* (cf. *mormoni* Marcou) affords perhaps the most reliable evidence of the Pennsylvanian rather than the Mississippian age of the Morrow formation. Several very fine species of crinoids occur in the lower limestone, but as they are all new they throw very little light on the age of the bed. The generic types represented occur in late Mississippian rocks and, in part at least, in much later Pennsylvanian deposits. However, so few crinoids are known from the latter series that it is not yet possible to estimate properly their value as evidence of the age of the rocks. *Pentremites rusticus* Hambach is one of the common fossils. It is from this fossil that the old name of the member, Pentremital limestone, described as a formation by the Arkansas Geological Survey, was derived.

The limestone of the Morrow formation is locally variable in thickness. In places some of the upper beds were removed by erosion prior to the deposition of the succeeding Winslow formation, but the variations are not due in all instances to such removal. South of Manard the limestone is 100 to 150 feet thick. The shale that belongs above the limestone was found in this district wherever exposures could be noted. The thickness decreases, though not regularly, toward the northeast. On Neosho River, near the east side of T. 16 N., R. 19 E., the limestone is nearly 100 feet thick. Here the sandstone beds of the succeeding Winslow formation rest on the limestone, the shale that usually intervenes having been removed, it is presumed, prior to the deposition of the Winslow sediments. Near the northeast corner of the quadrangle the thickness of the limestone is reduced to nearly 50 feet. The same conditions occur near the boundary of the quadrangle, farther south, in Tps. 16 and 17 N., R. 22 E.

Shale of the Morrow formation.—The deposits above the main limestone consist of blue and black shale, with thin beds of limestone and sandstone locally developed and more rarely with thin coal in the lower part. The thin limestones and the shales interbedded with them are usually light blue and weather to shades of yellow. They resemble the limestone and associated shale lower in the formation. The shale in the lower part of this upper member is darker in color and that associated with the coal is black, being impregnated with bituminous matter.

The fauna from the upper thin limestone and sandy beds of the Morrow consists for the most part of brachiopods and bryozoans. All the forms observed occur also in the main limestone below. Essentially a single fauna pervades the whole formation.

The shale in the upper part of the Morrow formation is usually concealed by sandstone débris and overwash of soil from the overlying Winslow formation. It crops out near the hilltops or in the sides of valleys near the sources of drainage channels. In consequence of these relations estimates of its thickness can be but roughly approximate. In places the massive sandstone of the Winslow formation rests on the limestone belonging below the shale; at others a belt of sloping clay soil, from which thin ledges of limestone project, ranging from a narrow strip to a slope 40 feet in height, indicates the thickness of the upper shale member of the Morrow formation.

Name.—The Morrow formation is named for the village of Morrow, near which a typical section of the rocks is exposed, in Washington County, Ark., about 5 miles east of the Indian Territory line.

Relations to contiguous formations.—The stratigraphic relations of the bottom and top of the Morrow formation to the underlying Pitkin limestone and the overlying Winslow sandstone, respectively, seem always to be more or less unconformable, without, however, in any case exhibiting any marked discordance of stratification. That the relations are unconformable is generally determinable only through comparisons between the beds on either side of the contacts in separate exposures.

At and south of Fayetteville the Hale sandstone, at the base of the Morrow formation, is an important member. The relatively small amount of siliceous sand it contains in the Muscogee quadrangle and the increasing prevalence of such material in the more easterly and northerly outcrops point to the Ozark region, which at that time was land, as the main source from which the clastic elements of the formation were derived.

The unconformity at the top of the Morrow formation seems to be greater in the Muscogee quadrangle than in the more eastern localities where the contact with the Winslow has been observed. Here the upper Morrow beds, that is, the strata above the main limestone, are locally absent. While the upper shale member ranges from a knife edge to only 40 feet in thickness in the exposures studied in the Muscogee quadrangle, it is not less than 140 feet in the Fayetteville and Winslow quadrangles and at least 275 feet in the southern part of the Yellville quadrangle. Part of this inequality in thickness is doubtless due to the diminution westward of the quantity of the clastic material derived from the Ozark land of the time, but the greater part must be ascribed either to nondeposition or to erosion, or to both. In any event a considerable hiatus between the Morrow and Winslow formations is indicated in the Muscogee quadrangle.

Correlation.—The Morrow formation in the Muscogee quadrangle includes stratigraphic representatives of a group of rocks which were separated into four formations in northwestern Arkansas by the Arkansas Geological Survey (Ann. Rept., vol. 4, 1888). The lowest of these, called the Washington shale and sandstone (a preoccupied name), is described in the Fayetteville and Tahlequah folios as the Hale sandstone member of the Morrow formation. The locally sandy shales occurring at the base of the Morrow formation in the Muscogee quadrangle doubtless are to be correlated with the sandy shale forming the lower part of the Hale sandstone member in its typical exposures. The upper part of that member, however, is always more or less calcareous and locally includes real limestone, and may be provisionally correlated with the lower part of the main limestone of the formation in the Muscogee quadrangle. According to this interpretation, only the upper part of the main limestone is the equivalent of the Pentremital limestone of the Arkansas Survey and the Brentwood member of the Morrow formation, described in the Fayetteville folio. The lower part of the shale, which contains the local coal beds, is the "Coal Bearing shale" of the Arkansas Geological Survey report. The thin limestone in the upper part of the Morrow is to be correlated with the Kesler limestone of the same report.

WINSLOW FORMATION.

Character.—The Winslow formation consists of bluish and blackish clay shale, sandy shale, brown sandstone, and thin beds of coal. The sandstone beds for the most part occur in two groups, one near the base and the other above the middle of the formation.

The rocks near the base and below the lower body of sandstone are interstratified sandstone and shale beds. The sandstones are for the most part thin or shaly, but in places are thick and massive and occur at the base in contact with the limestone of the underlying Morrow formation. Locally they are coarse grained at the base and may contain small rounded pebbles of quartz. This pebbly character increases eastward until, in the northern foothills of the Boston Mountains of northwestern Arkansas, the rocks become conglomeratic. It may be said that these alternating sandstone and shale beds culminate in the thicker sandstone deposits which lie 200 to 400 feet above the base of the formation. These sandstone beds gradually become thinner toward the north, and at the same time the amount of lime in the shale increases, so that parts of it become very calcareous and it contains beds of shaly limestone.

The sandstone deposits have their strongest topographic expression in the southeastern part of the quadrangle, where they are thickest. The beds of heavy sandstone in the upper part of the series cap the local table-lands east of Illinois River and the timbered hills lying along the west side of Arkansas Valley from the southern border of the quadrangle to a point opposite Muscogee. Farther north and east of Arkansas and Neosho rivers and bordering the valley of the latter the topographic features incident to these sandstone beds are less pronounced. The forest also, which is influenced by the occurrence of the sandstone, becomes gradually thinner northward and is interspersed with prairie on the uplands.

On the lower group of sandstone and shaly beds rests a deposit of shale composed chiefly of clay. Locally sandy shale or thin sandstone may occur in this position, but not of sufficient thickness or hardness to become apparent in the surface of the land. The shale dips approximately 2° toward the southwest in the southern part of the quadrangle, and its outcrop is limited to the valley of Dirty Creek. Toward the middle and in the northern part of the quadrangle the dip of the rocks becomes less and the sandstone both above and below decreases in thickness, so that the surface extent of the shale can not be outlined. A thin coal which occurs in the upper part of this shale has been prospected near the source of Spaniard Creek and on Sam Creek south of Muscogee. Thin coal beds, presumably in the same shale, have been prospected 2 miles south of Wagoner. Like the deposits lower in the formation, the shale becomes more limy northward. Limestone beds, probably of local extent, occur in the vicinity of Wagoner, and others are reported to have been penetrated by drills in deep wells at Muscogee.

The upper group of sandstones consists of yellowish-brown beds interstratified with bluish clay shales. These beds are in part ferruginous and are generally soft, except where segregations of iron have locally indurated the rock. The uppermost beds are thickest; these cap the escarpments and low hills that mark the outcrops of the deposits west of Dirty Creek and those at the sources of Spaniard, Sam, and Pecan creeks. The low dip slopes of the uppermost beds extend from the top of the low escarpments down to the wide valley at the base of the Rattlesnake Mountains and to Butler Creek, toward the northwest. The thickness of these sandstone beds, with their included shales, near the southern boundary of the quadrangle is estimated to be more than 100 feet. Toward the northwest the sandstones become thinner and softer and it is believed that they can not be traced north of Arkansas River.

From the top of the upper group of sandstone beds shale continues to the top of the formation. Locally variable shaly sandstone beds and beds of thin coal occur in the shale. Accurate determinations could not be made, but it is estimated that the thickness of this shale does not exceed 100 feet. This shale is the westward continuation of the Akins shale member of the Winslow formation, described in the Tahlequah folio.

Name.—The Winslow formation is named for a town located at the crest of the Boston Mountains on the St. Louis and San Francisco Railroad, in northwestern Arkansas. The greatest development of the formation, especially that of the sandstone deposits in the lower part, occurs in the Boston Mountains. The Boston Mountains are the physiographic expression of the Winslow formation.

Thickness.—The thickness of the Winslow formation in the quadrangle is estimated to be 800 to 1000 feet, but an accurate determination of its thickness is not possible where the rocks are inclined at low angles, where dips are variable, or where the strata in large measure are obscured by soil. Toward the west and north it becomes thinner. Near the Arkansas–Indian Territory boundary, 25 miles east of the Muscogee quadrangle, it is estimated to be not less than 1500 feet thick. Strata equivalent to the Winslow and several higher formations, aggregating several thousand feet in their exposures along Canadian River, decrease in thickness northward until they do not exceed 500 feet at the Indian Territory–Kansas boundary. In the Kansas section the Winslow formation is represented in the lower part of the Cherokee shales.

Correlation.—Southward the Winslow formation descends beneath the surface in the deep trough of the Arkansas Valley, which lies south of the Muscogee quadrangle. Where it rises in the south side of the Arkansas Valley trough and against the Ouachita Mountain region in central Choctaw Nation, the section has increased to an estimated thickness of 8000 feet. Here the stratigraphic representatives of the Winslow are divisible into three formations, named the Atoka formation, the Hartshorne sandstone, and the McAlester formation. These formations have been mapped through their entire extent in the Choctaw Nation and have been described in the Coalgate and Atoka folios and in papers on Indian Territory coal published in the Nineteenth, Twenty-first, and Twenty-second Annual Reports of the United States Geological Survey. The McAlester formation is exposed across the Arkansas Valley trough and is found to be equivalent to the part of the Winslow formation in the Muscogee quadrangle that extends from the top down to the lower group of sandstones 200 to 400 feet above the base. The stratigraphic relations between the lower 200 to 400 feet of the Winslow formation in the Muscogee quadrangle and the Atoka and Hartshorne formations, aggregating more than as many thousand feet, can not be ascertained, because these rocks have not yielded fossils for accurate comparative studies.

The McAlester formation in the Sansbois quadrangle, which adjoins the Muscogee quadrangle, is overlain by the Savanna formation. South of Sansbois Mountain the Savanna is approximately 1000 feet thick. Its thickness becomes gradually less toward the north, until the sandstone beds contained in it are lost to view near the southern boundary of the Muscogee quadrangle. This formation not being distinguishable, the top of the Winslow formation, being stratigraphically the same as the upper boundary of the McAlester, seems to be in contact with the overlying Boggy formation.

BOGGY FORMATION.

Character.—The Boggy formation is composed of bluish clay shale, sandy shale, and gray or brown sandstone. The shale and sandstone occur in alternate strata, and the shale in the aggregate is thicker than the sandstone. There are twelve or more groups of sandstone beds separated by thicker deposits of shale which include thin sandstone and shaly sandstone strata.

In the Muscogee quadrangle only the lowest sandstone and its inclosing shale members are exposed. The basal deposit is a comparatively soft shale, approximately 200 feet thick. The overlying sandstone is a gray to yellowish-brown rock, and occurs for the most part in thick or massive and moderately hard beds. The lower sandstone beds are usually exposed in cliffs and bluffs at the crests of the escarpments which they produce. The upper layers make flat and gently rolling tracts of sandy loam which slope westward from the escarpment of the Rattlesnake Mountains. Toward the northwest this sandstone gradually grows thinner, more shaly, and softer, the decrease in thickness and the change in character being emphasized by the topographic expression of the rock. Near the southern boundary of the quadrangle the sandstone is marked by the strong escarpment and timbered table-land of the Rattlesnake Mountains. Northwestward the escarpment becomes gradually lower and less distinct, until it is lost in the rolling prairie north of Oktaha. The lowest shaly strata, lying above the sandstone, occur in the southwest corner of the quadrangle. A bed of bituminous coal, 2 feet 6 inches thick, occurs in this shale near the base. It should be found to crop out across the southwest corner of the quadrangle.

Name.—The Boggy formation was named for Boggy Creek, in the Choctaw Nation, and has been described in the Coalgate and Atoka folios of the United States Geological Survey. It has large exposures on Boggy Creek in the Coalgate quadrangle and attains there a maximum thickness of over 2000 feet. Only the lower part of the Boggy formation, having an estimated thickness of 500 feet, is exposed in the Muscogee quadrangle.

Correlation.—The greatest development of the sandstone members of the Boggy formation is found along the Canadian River Valley in the Canadian quadrangle, which adjoins the Muscogee quadrangle on the southwest. From the Canadian Valley, both toward the southwest and northeast, there is a gradual thinning of the sandstone beds and of the formation as a whole. In both directions there is an introduction of limy strata in the shale, with thinning of the sandstones. This thinning of the sandstones or their gradation into shaly deposits becomes so pronounced farther north that the formation can not be distinguished north of Arkansas River. Formations lying above the Boggy have been traced from Arkansas River to the Indian Territory–Kansas line, showing that the 2000 feet or more of the Boggy formation in the Canadian River Valley must be correlated with a part of the Cherokee shales of southeastern Kansas.

QUATERNARY SYSTEM.

TERRACE SAND.

At the borders of the immediate valleys of Arkansas and Neosho rivers, above their flood plains, lie surficial deposits of gravel, sand, and silt. Along the Arkansas Valley these deposits consist of fine yellow sand and silt, with small quantities of quartzose gravel locally in the lower part or at the base. The coarser sand is found in the central parts of the areas and in the sides toward the river, and resembles in all respects that now being transported by Arkansas River.

Near the borders of the terrace deposits farthest from the river the sand grades into silt which is scarcely distinguishable from the light sandy loams residual on Carboniferous rocks. These sands and silts are porous, nonindurated deposits and are easily transported, even by the smaller rivulets. As a result the upper, finer sands often conceal by overwash the lower parts of formations and their basal contacts.

The terrace deposits at the border of the Neosho River Valley locally contain chert and sandstone gravels, derived from the Boone chert and the overlying Carboniferous rocks contiguous to the valley of Fourteenmile Creek. Gravel of the same class, with less sand associated, occurs on the north side of Fourteenmile Creek across T. 17 N., R. 20 E., and extends upward from the valley to an elevation of nearly 100 feet above the stream. It occurs as a thin mantle or in local patches spread over the Carboniferous rocks.

These terrace sands and gravels extend from the borders of the river bottoms upward more than 100 feet. The sand between Arkansas and Verdigris rivers occupies the watershed between these streams for over 9 miles. These sands have been deposited a sufficient length of time to have had developed on them a pronounced erosion topography. The larger streams have worn down channels to a depth of 50 to 100 feet and the small tributaries have obliterated the level of the original flat surface.

Sand deposits of the same character have been mapped along Arkansas Valley in the adjoining Sansbois and Sallisaw quadrangles, and similar deposits have been reported by the Arkansas Geological Survey to occur in the same valley in Arkansas. Terrace deposits of the same kind occur in elevated channels along Canadian, Washita, and Red rivers. The sand in the Canadian and Washita valleys is described in the Coalgate and Tishomingo folios. Terrace gravels and sands in Red River Valley continue southeastward, joining extensive deposits of similar nature widely distributed over the Tertiary rocks of eastern Texas and Louisiana. These gravel and sand deposits descend beneath the surface near the base of the Quaternary sediments bordering the Gulf coast. Since these terrace sands in the Muscogee quadrangle are related in both composition and location to the sand transported by the river at the present time, it is concluded that they were laid down by the meandering Arkansas when it flowed at elevations 150 feet and less above its present level.

RIVER ALLUVIUM.

The rivers of the Muscogee quadrangle, and especially the Arkansas, have developed in recent time relatively broad flood plains and second bottoms composed of silt, sand, and gravel. The rivers have deposited the sediment in their flood plains to such depth that they now meander from side to side in them, only occasionally touching the country rock at the sides and beneath the surficial deposits.

The sediments deposited by Arkansas River consist of gravel, yellow sand, silts, and chocolate and red clays. The gravels are found along the river banks near low-water line and in the lower part of the older deposits, marking the beds of the river during earlier stages. The sands are most abundant near the present channel, while the finer silts and chocolate clays have been deposited more abundantly toward the outer limit of the flood plain and in other localities protected from strong currents. The larger part of the Arkansas River deposits was derived from the red strata of the Permian and the more friable Cretaceous, Tertiary, and later surficial sediments of the western plains in Kansas and Colorado, so that they necessarily differ from the alluvium in the flood plains of the Verdigris and the Neosho.

Verdigris River drains the Carboniferous rocks of southeastern Kansas and northern Indian Territory. Its alluvium, especially that of the finer silts deposited near the borders of the flood plain, is scarcely to be distinguished from the residual and local transported soils.

Neosho River receives a large part of its sediment from the cherty strata of the lower Carboniferous in southeastern Kansas and southwestern Missouri. The silts, however, which are more limy than those of Arkansas and Verdigris rivers, resemble closely the local transported soils of the Carboniferous shales in northern Indian Territory.

STRUCTURE.

REGIONAL FEATURES.

GENERAL STATEMENT.

Sedimentary rocks of broad extent, consisting of fine sand, clay, and lime, like those exposed in the Muscogee quadrangle, were originally almost flat, though not necessarily horizontal, being doubtless slightly inclined with the sea bottom on which they were deposited, in a manner similar to the sediments being laid down off the shores of the continent at the present time.

After the Carboniferous period the region was uplifted and the flat strata were tilted, warped into folds, and broken by faults, as they are now found. It is not to be assumed that this tilting, folding, and faulting occurred in a short interval, even of geologic time. Instead, it is most likely that the deformation of the rocks has been going on at various ages since the Carboniferous and that movements have occurred, especially in the eastern part of the quadrangle, in relatively recent time.

Two structural provinces are represented in the Muscogee quadrangle. One of these is the Ozark uplift, corresponding to the physiographic province of the Ozark highland; the other is the Prairie Plains in northern Indian Territory, of monoclinal structure. A brief outline of the Ozark uplift and the monoclinal Prairie Plains will give a better understanding of the structure of the Muscogee quadrangle.

OZARK UPLIFT.

The Ozark uplift comprises southern Missouri, that part of Arkansas included in and lying north of the Boston Mountains and west of the Mississippi lowlands, northeastern Indian Territory east of Grand River, and the southeast corner of Kansas. In fig. 1 are outlined approximately the physiographic divisions of the Ozark province. The boundaries of the uplift can not be clearly defined because of the gradual change in structure to that of the border provinces of the Prairie Plains and that of the Arkansas Valley. The strata incline gradually downward on the north and west beneath the Prairie Plains. The limits are more distinct on the south, owing to the more abrupt change from the monocline of the Boston Mountains to the folded rocks of the Arkansas Valley. On the eastern border of the dome the structure is concealed for the most part by the northern extension of the Tertiary and the recent flat sediments of the Mississippi lowlands. The exposed limit, however, is sharply marked here by the western border of these flat-lying sediments, along which the St. Louis, Iron Mountain and Southern Railway has been built. The eastern boundary crosses Mississippi River near the mouth of the Ohio and curves northward and then westward, including a small district of southwestern Illinois.

The Ozark uplift has the form of an elongated dome whose axis trends approximately S. 70° W., through the St. Francis Mountains in eastern Missouri, toward the northwest corner of Arkansas and the Muscogee quadrangle. The axis is not marked by a definite crest, such as is usually found in distinct smaller upward folds. For long distances across the axial part the strata are flat or but slightly undulating and are locally broken by normal faults. As explained, the formations incline at low angles from the northwest side of the broad dome. Likewise, the strata pitch at a low angle along the axis toward the southwest. Between the axial part of the uplift and the Boston Mountains the structure is undulating and the rocks are locally faulted, resulting in a low slope toward the south. In the southern slopes of the Boston Mountains the tilting is increased by a succession of strong southward-dipping monoclines accompanied by local faulting.

PRAIRIE PLAINS MONOCLINE.

The Prairie Plains constitute a broad and long physiographic province that includes rocks of varied geologic and structural character. In that part of the province, however, in northern Indian Territory, Kansas, and Oklahoma the structure is generally monoclinal. West of the Ozark uplift the rocks are inclined at slightly variable but low angles. Toward the south, in the plains near the eastern boundary, the westward pitch of the strata increases from about 20 feet per mile in eastern Kansas to nearly 100 feet per mile at the southwestern limit of the Ozark region, near Muscogee. Toward the west, in the Prairie Plains, there is, on the contrary, a gradual decrease in the inclination of the strata. Locally there is a slight warping, but it is not known to be sufficient at any place to reverse the westward dip of the rocks.

The greatest variation in structure is found near the western border of the Ozark uplift. Undulations in this uplift extend westward and die out in the Prairie Plains monocline.

STRUCTURE OF THE MUSCOGEE QUADRANGLE.

Divisions.—The Muscogee quadrangle is divided structurally into two nearly equal parts by the Ozark uplift and the Prairie Plains monocline. Arkansas and Neosho rivers follow approximately the line between the two structural divisions. When viewed broadly the rocks in the quadrangle are seen to be tilted southwestward. In the eastern half the average inclination is less than 20 feet per mile. Near Arkansas and Neosho rivers the monoclinal tilting is increased to 100 feet or more per mile, and this inclination continues to and beyond the southwest corner of the quadrangle.

Structure sections and maps.—To aid in giving an understanding of the structure of the quadrangle a structure sheet has been prepared, showing the geology of two sections, one drawn across the strike in a southwesterly direction, and the other across the folded and faulted strata. These structure sections show approximately the altitude of the formations beneath the surface, though the scale is too small to show the minor undulations and details of folding. The sections show the structure only near the line along which they have been drawn, but will aid materially in the interpretation of the structure of the quadrangle as a whole.

Folds and faults.—The rocks in the eastern half of the quadrangle, more particularly east of Arkansas and Neosho rivers, have been thrown into relatively wide and shallow, unsymmetrical, depressed folds, which trend northeast and southwest. These synclinal folds are separated or interrupted by normal faults associated with incipient anticlinal folds or by unsymmetrical anticlines that in general strike with and extend beyond the end of the faults. Where the folds and faults are associated it is necessary to describe them together.

The faults may be classified into two series or groups—one in which the associated folds are more or less pronounced and one in which the folds are not pronounced or are incidental to the faulting.

Those of the first group occur in the central part of the folded and faulted district. Here, between Greenleaf and Fourteenmile creeks and included in their valleys, are three broad and shallow synclines whose northern limbs are wide and undulating and nearly flat and whose southern limbs are broken and displaced downward toward the north by faults that extend generally parallel with and near the axes of the folds. The rocks on the downthrown side are strongly flexed upward toward the faults—seemingly as a result of drag produced by the faulting. The axes of the anticlines lie near at hand south of the main faults.

The fault south of Greenleaf Creek ends east of Garfield. As it dies out the slight folding with which it is associated increases and in the strike of the fault there is a strong northward deflection in the rocks. This structure continues in the strike of the fault southwest to Arkansas River.

A second broad syncline and associated fault of this series occurs in and near the valley of Bayou Manard. This fault is also in the steep and narrow southern limb of the fold and the rocks are steeply upturned on the northern or downthrown side. The northern limb of the syncline is broad and locally warped and is broken by three small faults that trend parallel with the larger structures. Their downward displacements are toward the north, as in the larger folds, but the local folding or warping of the associated strata is apparently due to the faulting. These local faults belong properly with the second class, in which the folding seems to be incidental to the faulting.

The third large fold of this series of faulted folds is in the valley of Double Spring Creek. The southern limb is narrow and faulted, as in the folds of Greenleaf Creek and Bayou Manard. The rocks are strongly flexed upward against the fault on the north as the result of the drag.

To the second series belong several smaller folds. A very shallow syncline bears northeastward from Arkansas River Valley at the mouths of Greenleaf and Cedar creeks. Near the boundary of the quadrangle this fold is broken by three faults which trend northeastward into the Tahlequah quadrangle. The rocks between the two southernmost faults have dropped down with respect to the strata on the north and south, and a third fault crosses the quadrangle boundary a mile north of the downthrown block. It is the west end of a fracture that extends 12 to 15 miles into the Tahlequah quadrangle. In this instance the downthrow is toward the north, resulting in a narrow, elevated, westward-pitching fault block near the center of the main fold. In the strike of the most southerly fault, extending southwestward from its end to Arkansas River, there is a distinct anticline. In this fold the rocks in the southern limb are more steeply tilted than those in the northern limb, although the rocks near the quadrangle border are thrown downward toward the north. Toward the southeast in this fold the dips of the rocks gradually decrease to the corner of the quadrangle.

A number of faults occur between the valleys of Fourteenmile and Double Spring creeks and the northern boundary of the quadrangle. These are peculiar in respect to their relations both to one another and to the folding of the strata. Two of them, which cross the northwest corner of T. 17 N., R. 20 E., within about half a mile of each other, are curved and are essentially parallel. The downthrow of the more easterly one is toward the southeast, while the displacement of the other is downward in the opposite direction, leaving an elevated block between them. To the east of these faults are two others, which are about a mile apart and nearly parallel. The strata between these have been moved downward with respect to the adjoining rocks. This depressed block abuts against the elevated fault block just mentioned. The faults on the south of each block join in a common fracture, while the one on the north of the downthrown area cuts across the faults bounding the elevated block.

Two other faults occur farther west, near Arkansas River, and bear toward the southwest in the general direction of the dip. The larger and more easterly of the two has thrown the rocks down toward the east, while the downthrow of the other is in the opposite direction. The general inclination of the strata is toward the south, and the folding of the rocks, except in one small area to be considered later, is, locally, apparently due to the drag of the beds along the lines of faulting. Where these faults have an east-west bearing and the downthrow is toward the north there is an interruption of the southward dips and locally variable folding is produced. Where the downthrow is in the opposite direction there is simply an increase in the dip southward near the fault contact.

In the eastern part of the quadrangle there are three peculiarly sharp local upward folds. The largest of these is near the mouth of Fourteenmile Creek. Its axial trend is nearly north and south, in the direction of the general dip of the strata. The fold is sharp and the dips are greater on the east than on the west side. Of the two other local folds, one on Illinois River, in the southeast corner of T. 14 N., R. 21 E., is a small and sharp elliptical dome, whose axis cuts across the trend of a larger faulted fold. The other, a small dome-like uplift, lies 3 miles north of Melvin and within 2 miles of the northern border of the quadrangle. Its axial trend is in the direction of the general inclination of the strata. It is situated near one fault and in the strike of another, but apparently is not related to either or to the warping of the strata produced by them.

Relations of folding and faulting.—As has already been explained, all the broader folds of the Ozark uplift are related to the faults, but the general causes producing them can not be determined at the present time. That the folding in some instances has been accentuated by the faulting is evident, and that they occurred about the same time is probable. An example of the close relation and interdependence of the folding and the faulting may be noted in the faulted basin southeast of Crittenden, near the northeast corner of the quadrangle. In this instance the basin is apparently bisected by the fault. If folding had preceded the faulting or had been independent of it evidence of folding of the rocks should appear on both sides of the fault, but the rocks are essentially flat on the southeast side of the fault, opposite the greatest displacement and the deepest part of the trough. The stresses producing the fold were evidently relieved on the southeast side of the fault by the fracturing of the strata. Similar phenomena of structure will be found in the eastward extension of the faults and folds in the Tahlequah quadrangle and are illustrated in the Tahlequah folio (No. 122) by a view of a model showing the deformed surface of the Boone formation.

Geologic distribution of faulting.—The faults in the Muscogee quadrangle affect only the Mississippian and the lower part of the Pennsylvanian rocks. Both the faulting and the folding decrease westward, and the former is not known to occur west of Arkansas and Neosho rivers. The anticlinal folds pitch toward the southwest and, with the synclines, grow gradually flatter and more indistinct until they are lost in the undulating monoclinal structure of the Prairie Plains region, in the western half of the quadrangle. The local variations in structure west of Arkansas and Neosho rivers are not expressed in the mapping of the Winslow formation. Could certain sandstone beds near the middle of the formation be mapped their outcrops would mark wavy lines in a north-south direction near Muscogee, showing the westward dying away of the folds of the Ozark uplift. When the succeeding Boggy formation is reached, however, little effect of folding can be discerned, the irregularities of the contact at the base of the formation being due to the surface configuration of the land. Local variations of the dip of the rock occur, but as a whole the inclination of the strata is toward the west at approximately 100 feet per mile.

HISTORICAL GEOLOGY.

The rocks of the Muscogee quadrangle were deposited in water as sediments from the waste of neighboring lands and from the remains of animals and plants which lived in or near the borders of the seas when the sediments were being laid down. These rocks are limestones, shales, and sandstones, and when they were deposited consisted of limy ooze, mud, and sand, respectively.

The character of these rocks when traced and studied over a wide field tells the story, though not the complete story, of the manner of their formation. As successive formations were deposited the forms of animal and vegetable life changed or migrated and were succeeded by other forms. At certain stages in the sedimentation gaps in the life record, accompanied by discordance in the character and structure of the rocks, show oscillations of the land and sea. The variations in the coarseness, composition, and thickness of the formations give evidence as to the depth of the water in which they were deposited and the nature of the contiguous lands. The fossil remains not only show the relative ages of the successive strata, but aid in identifying and correlating formations which come to the surface in separated localities.

Stratigraphically below the lowest rocks at the surface in the Muscogee quadrangle lie dolomites, limestones, sandstones, cherts, shales, etc., of Ordovician, Silurian, and Devonian age. These deposits, with rocks of Cambrian age, appear around the older igneous rocks of the axial part of the Ozark uplift in southeastern Missouri. They make large areas in southern Missouri and northern Arkansas, and occur in several small tracts in the adjoining Tahlequah quadrangle. They reveal a record of sedimentation which is not essential to the geologic history of the Muscogee quadrangle and deserves but brief mention. That a large part of the region underwent numerous oscillations of level above and below the sea is recorded by the alternation of formations of saccharoidal sandstone, dolomite, limestone, and shale, and by the occurrence of conglomerate. Some of these formations have been deposited unconformably upon others, showing intervals of erosion.

After the deposition of the St. Clair marble, the only Silurian formation in the southwestern part of the Ozark region, there was a break in the sedimentary record, corresponding to the closing portion of Silurian and to early Devonian time. In this long interval the rocks were folded into low undulations and uplifted into land. Probably while the folding was in progress, and certainly after it had occurred, the land was reduced by erosion to a low and nearly level surface. This land was submerged in late Devonian time. These conditions prevailed not only in the vicinity of the Muscogee quadrangle, as shown in the adjoining Tahlequah quadrangle and at many localities in Missouri and northern Arkansas, but seem to have extended over nearly the whole of the marginal part of the Ozark uplift. The record of this submergence is found in the Chattanooga black shale, which was deposited over a very broad extent of country on the south and east sides of the Ozark uplift, and in the other middle to late Devonian deposits lying on the northern flanks of the uplift. These Devonian rocks are such as would be formed in broad, shallow seas.

That the land had been nearly base-leveled is shown by the fact that the Devonian sediments rest on the eroded surfaces and slightly beveled edges of many older formations, ranging in age from early Ordovician to middle Silurian and consisting of sandstones, shales, limestones, and dolomites; and that the submergence was comparatively rapid is indicated by the fact that the remaining minor hollows and channels were filled with quickly accumulated land wash, consisting largely of rounded quartz grains, before the more evenly spread shales and shaly limestones were laid down. These initial deposits of this Devonian submergence make up the unequally distributed Sylamore sandstone, the local member of the Chattanooga formation, a full description of which can be found in the Fayetteville folio. The general evenness of the old land surface and the rapidity of the submergence are further indicated by the total absence of any but the finest of clastic material in the overlapping Devonian beds that lie upon the Sylamore sandstone, although several of the exposed older formations, as for instance the Tyner shale and the Burgen sandstone of the Tahlequah quadrangle, are friable rocks. Recognizable débris from the latter occurs only in the initial deposit, that is, in the Sylamore sandstone.

After the deposition of the Chattanooga shale submergence of the region continued well into Mississippian time until the Boone limestone and chert were formed. The broad extent of this submergence is shown by the fact that patches of the Boone formation occur almost up to the crest of the Ozark dome. In later Mississippian time the sea bottom was elevated and a part, at least, of the Ozark region became land. Oscillations of land and sea, however, occurred until the completion of the Mississippian series, as is shown by the presence of locally variable formations of sand, clay, and limestone.

In mid-Carboniferous time the sea withdrew, leaving the Ozark region as land beyond the boundary marked by the exposed top of the Mississippian sediments. The existence of a broad land at this time is shown by the erosion of the highest Mississippian formations where the Pennsylvanian rocks come into contact with them. In the south and southwest sides of the uplift, notably in the Muscogee quadrangle, the unconformity is not great, but farther up, toward the crest of the dome, higher rocks of the Pennsylvanian series rest upon successively lower beds of the Mississippian. In southwestern Missouri, on the western slope of the uplift, the Boone formation shows evidence of mid-Carboniferous erosion, and the depressions in its surface contain remnants of Pennsylvanian conglomerates and shales. In central Missouri, on the northern slope of the Ozarks, Coal Measure shales and coal occur in sinkhole-like depressions in what are probably Ordovician strata. Thus it is seen that after the elevation of the Ozark region in mid-Carboniferous time it was again submerged, but to what extent is not known, since so large a part of the formations of Pennsylvanian age has been removed from the uplift. The waters in which the Winslow and later formations of the Pennsylvanian series were deposited were shallow; the bottoms of the seas frequently rose to the surface, and the lands were low, as is attested by the alternating and irregularly bedded deposits of shale and sand. The lands extended beyond the confines of the Ozark uplift. The Pennsylvanian sediments grow thicker and contain a greater quantity of coarse material toward the south and east, indicating the direction of the land from which the great abundance of sand especially was derived. Additional evidence of this is the fact that the later beds of the Pennsylvanian deposits which overlap the old rocks of the Ozark dome decrease in thickness northward and contain little coarse sediment.

After the close of the Carboniferous the whole region was raised above the sea and there is no record of sedimentation to indicate that it has since been submerged. The features of the Ozark region and the occurrence of later rocks on its eastern border show that the surface has oscillated and that the rocks have been locally deformed, but these are records of physiographic and structural history, and are described elsewhere.

MINERAL RESOURCES.

The Muscogee quadrangle contains coal, oil, gas, building stone, limestone, road material, and clay. To these resources may be added water, soil, and the forests, which deserve careful attention. The ores of zinc and lead may possibly be found in small quantities in the Boone formation, particularly near lines of faulting, as this formation yields the lead and zinc ores of southwestern Missouri and of parts of northern Arkansas. The structural conditions in all these areas are very similar; that is, the rocks are essentially horizontal and are broken by normal faults. However, no zinc ores are known to occur in commercial quantity in the Muscogee quadrangle.

COAL.

Bituminous coal of good quality occurs in the Muscogee quadrangle, but has not been found in beds of sufficient thickness to be profitably mined except for local consumption. Coal has been prospected and mined by stripping to a small extent at eight localities. The locations of these prospects are shown on the map by the usual conventional signs.

A coal bed has been mined by a single opening in the eastern part of sec. 2, T. 17 N., R. 20 E. The mining or stripping is in the flat valley of Fourteenmile Creek 3 miles north of the St. Louis and San Francisco Railroad. The coal occurs in a black shale, 30 feet or more in thickness, that lies above the thick limestone of the Morrow formation and beneath certain sandstone beds of the Winslow formation. The coal is presumed to be in the Winslow formation and is the lowest known to occur in Indian Territory. The rocks in the immediate vicinity are approximately flat and the coal lies near the surface, so that it can be mined by stripping off the surface rock. The bed is 22 inches thick and contains no shale or other apparent impurities. The coal has been mined only at intervals and for local consumption, and no analyses or tests of it have been made.

Several thin coal beds have been located and prospected in the northwestern part of the quadrangle, south and west of Wagoner; also in the southwestern part, 4 and 7 miles south of Muscogee. These beds occur in the shale near the central and upper parts of the Winslow formation and in all cases lie approximately flat. The coal is bituminous, but so far as known the beds are too thin to be mined with profit. A coal bed has been prospected and mined by stripping near the southwest corner of sec. 7 and in the northeast corner of sec. 18, T. 12 N., R. 19 E. This bed is near the top of the Winslow formation, in the horizon of the coal mined at Starvilla and at Stigler, in the adjoining Sansbois quadrangle. The coal beds at all these localities correspond stratigraphically with the McAlester coal, in the southern part of the Indian Territory coal field. The beds in the Muscogee quadrangle are inclined 2° toward the southwest. The coal is of good bituminous grade, clean, and from 18 inches to 2 feet thick. A considerable quantity has been stripped near the railroad in the NE. $\frac{1}{4}$ sec. 18. The development near the southwest corner of sec. 7 is recent, and the output is used for local consumption.

A coal bed is mined on Elk Creek 2 miles south of the point where the Creek-Cherokee line approaches the southern boundary of the quadrangle. Its outcrop, extended northwestward, should cross the southwest corner of the quadrangle. It is a good grade of bituminous coal 2 feet 6 inches thick, and is being mined for local consumption.

OIL.

The production of oil in the Muscogee quadrangle is limited to the immediate vicinity of Muscogee. The productive territory at the time of investigation, in July, 1904, was located in the southeastern part of the town, on a strip of land one-fourth of a mile wide and a mile long, extending from northeast to southwest. This land is not all oil bearing, however, for a group of six wells drilled near its center proved to be barren, and a few wells drilled near the border of the town site, on the north, east, south, and west sides, did not yield oil in paying quantity. Other unprofitable wells have been drilled a few miles southwest of Muscogee, at Fort Gibson, and at Wagoner, each to a depth reaching or passing beneath the geologic horizon of the oil-bearing sand of the Muscogee field.

The discovery of oil at Muscogee was made in 1894, when two wells were drilled. In one of these a sand was encountered at 665 feet which yielded 12 barrels of oil a day. Another sand, penetrated at 1100 feet, produced 60 barrels of oil a day. Active drilling for oil began in February, 1904, and during the year more than 30 productive wells had been drilled. Their combined capacity was estimated at 1000 barrels a day.

The Muscogee oil is greenish in color, turning to a reddish hue in transmitted light. It is of much higher grade than any other oil produced in Indian Territory, having a specific gravity of 42° Baumé. The Muscogee oil has a paraffine base, while the residuum from the other oils in Indian Territory is a bitumen or so-called asphaltum.

The oil-bearing rock at Muscogee is a fine-textured, moderately hard, gray sandstone 12 to 18 feet thick. The texture of the rock is too fine to permit a rapid flow of oil through it, and in order to obtain a larger volume the sand is shattered by high-power explosives, a larger surface being thus gained for the passage of the oil. The oil-bearing sand was encountered at depths ranging from a little more than 1000 feet in the north end to about 1100 feet in the south end of the field, the difference in the depth being due chiefly to the general southward inclination of the strata. The surface of the land is generally undulating and a little lower in altitude at the south than at the north end of the field.

The wells at Muscogee were put down by several drilling companies and the same oil-bearing sand was penetrated by each. The succession of shale, sandstone, and limestone was not interpreted alike by each driller. The logs of the wells, however, accord generally in showing that shales and sandstones, with thinner strata of limestone, make the rock section from the surface down to about 700 feet. At this depth thick limestones were generally encountered and there was greater resistance to the drill. Limestone, shale, and sandstone in alternating succession continue, according to reports, down to the oil-bearing sand. On comparing this general record with the section determined by detailed geologic mapping east of Neosho River, it is found that the top of the limestone occurs 100 to 200 feet above the top of the Mississippian series. In this region the thickness of the Mississippian is found to range from 200 to 300 feet. According to this interpretation of the well records the Muscogee oil sand is interbedded with or lies immediately beneath the Mississippian strata.

A well recently drilled to a depth of 1167 feet at Fort Gibson furnished 65 samples of various kinds of rock penetrated, from which a reasonably accurate section of the rocks is obtained. From this material the fact is developed that the cherty Boone formation of the Mississippian series that is exposed at the surface in eastern Cherokee Nation is a dark-colored siliceous limestone where it reaches depths below the level of weathering. The Boone formation makes a large part of the Mississippian series in the Cherokee Nation and is the only part of the Mississippian known to the well driller. This cherty limestone was believed to be the horizon beneath which oil was not known to occur in the Indian Territory field.

NATURAL GAS.

Beds of sandstone occur in the Muscogee oil field at depths of 800 to 840 feet which yield, locally, salt water and gas. They are referred to by the driller as "salt sands." Several of the wells have yielded considerable quantities of gas from this horizon, but the supply not being large in most cases, drilling was continued down to the oil sand. A gas flow was encountered at a depth of 825 feet in a well near the center of the west side of the oil-producing area. The capacity of this well was estimated to be 1,000,000 cubic feet a day. The gas was utilized as fuel for some time, but later it was ignored and drilling was continued to the oil sand, where a profitable flow of oil was obtained. Another well, at the north end of the area, yielded an estimated flow of more than 1,000,000 cubic feet of gas daily, but it became flooded by a strong flow of salt water and had to be abandoned.

BUILDING STONE.

Near the base of the Fayetteville formation there are certain beds of dense, evenly stratified limestone that may be utilized for building purposes. The strata vary from a few inches to a foot or more in thickness. As a whole the section of these beds varies from place to place, aggregating a maximum of about 15 feet. The fresh rock varies from dark to light blue, but on weathering it changes to drab and yellowish blue.

Deposits of limestone similar in color and hardness to the limestone of the Fayetteville formation occur in the Pitkin and Morrow formations. These limestones vary from thin layers to beds nearly 2 feet thick. There is also variation from bed to bed as to purity and hardness. Certain layers are dense, fine textured, and crystalline; others are more earthy and shaly. All are more or less fossiliferous, and the fossils, particularly where abundant, will lower the quality of the stone. The quantity of this limestone is practically unlimited, and its occurrence is shown on the geologic maps by the boundaries of the Pitkin and Morrow formations.

The Winslow formation contains many beds of sandstone, some of which is adapted to certain uses in building construction. Large quantities of stone may be obtained for foundations, fencing, and other ordinary farm improvements. Many sandstone beds are exposed or lie near the surface in the hills west of the Arkansas between Muscogee and Webbers Falls, and on both sides of the Neosho. The same beds occur at the surface in the hills east of these rivers. Many of these beds are of workable dimensions, separated by thin layers of shale that permit more easy quarrying of the stone. Sandstone beds that produce building stone occur also above the middle of the formation. Some of these outcrop in the escarpment west of Dirty Creek and at the heads of Spaniard, Sam, Coata, and Pecan creeks. Large areas of the sandstone beds crop out or lie beneath the soil on the gentle westward slopes of the hills.

A group of sandstone beds 30 to 40 feet thick occurs in the vicinity of Muscogee and crops out from that point westward to the boundary of the quadrangle. This stone caps local table-lands in the center of sec. 23, T. 15 N., R. 18 E., and extends on the lower ridge to the Mission. They also cap the hill in sec. 20, T. 15 N., R. 18 E., and the table-land east of Pecan Creek. This rock occurs in both massive and thin beds, the thicker strata being usually in the central part of the sandstone group. The unweathered rock is of gray or bluish tint and in certain beds has an even, fine texture and is moderately hard, furnishing freestone of a fair quality. Certain beds in the lower part of this group cap the small table-land at the northern edge of the city of Muscogee, and the rock is quarried and used successfully in large building construction. In 1902 massive beds about 8 feet thick near the middle of the exposure were being quarried. On weathering stratification planes develop, separating the beds into dimension layers, and these planes are utilized in quarrying the stone. The weathered stone assumes durable shades of yellow and brown.

Large areas of sandstone are exposed in the table-land of the Rattlesnake Mountains and in the hilly district east of Oktaha. Some of the beds occur in layers suitable for quarrying and doubtless will be utilized as agriculture develops in the contiguous districts of fertile land.

LIMESTONE.

Certain beds of limestone in the formations referred to as containing building stone may be utilized in the manufacture of lime. These limestones occur near the base of the Fayetteville and in the Pitkin and Morrow formations. The beds differ in purity or in percentage of carbonate of lime. Some of them, however, may produce a commercially valuable lime.

A branch of the St. Louis and San Francisco Railroad has recently been built across the quadrangle and is conveniently situated for the development of lime industries between Fort Gibson and Tahlequah. The Kansas City Southern Railroad also approaches limestone outcrops south of Fort Gibson and between Braggs and Campbell.

ROAD MATERIAL.

The various classes of rocks enumerated in the discussion of building stone may be used as material for road construction. Among those suitable for this purpose are certain siliceous limestones of the Morrow and Pitkin formations and the more indurated and thinly-bedded sandstones found in various parts of the Winslow formation. The residual chert of the Boone formation, however, in the northeastern part of the quadrangle, surpasses all of these in quality as road metal. On weathering the Boone formation has left a deep and, for the most part, loose mantle of angular chert that can be removed with comparative ease. This chert when crushed produces a durable roadbed and with use becomes consolidated and cemented into a compact mass. Broad areas of the Boone chert occur in the northeastern part of the quadrangle and are accessible to wide tracts of country underlain by Coal Measure shales and to river-bottom lands where good roads will be in demand. This chert is also accessible by railroad to Muscogee and Wagoner and should be in demand for street improvements in these cities.

CLAY.

Clay shales occur in abundance in the Fayetteville, Morrow, and Winslow formations. All of them vary in their different parts in percentage of lime, sand, and iron.

The shales of the Morrow formation occur in its middle and upper parts. Those in the middle lie between beds of limestone and probably contain a considerable percentage of lime. Those in the upper part are thicker, but are more variable in proportion of lime and sand. There are beds of even-textured shale, however, in this formation which may produce brick clay.

More than half of the Winslow formation consists of shales. These occur chiefly in the upper part, though many beds are interstratified with the sandstones in the lower part. They range from very sandy deposits to purer shales which may be utilized in the production of brick. The purer shales occur in the central and upper parts of the formation, and they are believed to be almost free from lime.

The clay shales of the same formation are found in the vicinity of Van Buren, near the Arkansas-Indian Territory line, where some of them have proved to be high-class brick clays. To be utilized they require to be crushed or ground. They are moderately soft, however, and their reduction may be accomplished with comparative ease. These shales disintegrate readily, forming clay soils, and are not usually exposed.

WATER RESOURCES.

The ground-water supply of the Muscogee quadrangle is limited almost entirely to the area of the Boone formation. The higher rocks, consisting chiefly of sandstone and shales, are practically impervious to water and afford only a few springs of weak flow.

Springs.—The Boone formation, although originally an impervious deposit of limestone and chert, is permeated with underground solution channels both across and along the bedding of the rocks. Many of these underground channels come to the surface in the valleys and their waters issue as springs. Others rise, the water issuing from joint fissures or faults in the rocks. A number of large springs issue from the fault that extends down Double Spring Creek from the northeast corner of the quadrangle. Others issue from the fault near the sources of Greenleaf Creek and Bayou Manard. A group of saline springs of small flow issue from the limestone and chert formations in the southeast corner of T. 14 N., R. 21 E. The rocks here are steeply upturned and the waters appear to come up through the bedding planes of the chert and limestone of the Boone and Morrow formations. Springs of small flow issue from the thicker sandstone beds of the Winslow formation at favorable situations, where the beds are considerably tilted and where erosion has cut deeply into them across the strike of the rocks. One of the most noted of these springs flows from the sandstone in the western slope of the hill 7 miles southeast of Muscogee, on the Muscogee-Braggs road.

A number of springs issue also from the base of the terrace-sand deposits southwest of Braggs and between Arkansas and Verdigris rivers. These sands are not consolidated, and a large part of the water that falls on them ultimately issues at points where they are in contact with the impervious Carboniferous strata.

Wells.—It is practicable to obtain water in wells at almost any place in the Muscogee quadrangle, but the flow and quality of the water depend on the position of the well and the kind of rock penetrated. Abundance of water of good quality may be obtained from the Boone formation and from the thicker sandstone beds of the Winslow and Boggy formations. Wells driven into the surficial sands of the terrace or river-bottom deposits yield an abundant supply of water.

Water from the Boone cherty limestone contains a considerable percentage of lime and is commonly classed as "hard," while that from the sandstone and surficial sand deposits may contain an appreciable amount of iron as a carbonate or sulphate. In many instances, however, it is almost pure.

Water in wells in the Winslow formation a few hundred feet in depth, located in the immediate valleys of Double Spring and Fourteenmile creeks and of Bayou Manard, may rise nearly to the surface or may overflow, but the volume is not likely to be great nor the flow to be strong. The sandstone beds that contain circulating water are usually of fine texture and do not permit water to flow freely through them. Water obtained in the shales is usually in weak flows and almost invariably contains alkaline salts in solution. Deep wells sunk at Wagoner and Muscogee to depths of 1000 to 1800 feet in search of oil and gas show that potable waters are probably not obtainable by deep-well drilling in the Muscogee quadrangle.

Surface water.—Four rivers, besides a number of smaller streams, flow through the Muscogee quadrangle. Two of these, Arkansas and Verdigris rivers, carry a relatively large amount of silt in suspension, and the Arkansas, especially during the summer season or at times of low water, contains an appreciable amount of salts in solution. The waters of these rivers are not considered wholesome for drinking purposes during low stages or in the summer season.

With Neosho and Illinois rivers, however, the conditions are different. These streams are fed by many springs from the Ozark region, their volume is more regular, and their waters are usually clear. Many of the smaller streams east of Arkansas and Neosho rivers are perennial, being fed by springs. Those west of these rivers, however, which have their sources in the Carboniferous shales, are intermittent in flow, and during dry seasons the water stagnates in pools.

SOIL.

Except for tracts of bottom land of transported soil distributed along the river valleys, the soils of the Muscogee quadrangle are formed in place by the weathering of the rocks beneath them. The river deposits are mapped as river alluvium and terrace sands and are treated as formations. In view of the fact that the soils, with these exceptions, are residual, the geologic map may be considered as a soil map also.

The Boone formation produces a cherty soil. On weathering the chert breaks into angular blocks and fragments and, because of its great durability, forms a surface layer. The soil it produces is fertile, but is carried downward and away by the rains, or where left in place is mixed with a residuum of weathered chert. Thus over a large part of the Boone formation, especially in the more hilly districts, the soil is too thin, or at too great a depth beneath the weathered material, or too stony, to be of value for agricultural purposes. The soil under these conditions can be of service only to the forest, which seemingly thrives in accumulations of loose stone. In certain localities where the surface has remained flat for a long time the soil is sufficiently thick to be cultivated, as in the fertile lands about Crittenden and in other smaller tracts in the northeastern part of the quadrangle.

The limestone near the base of the Fayetteville formation assists in giving fertility to its soil, as do the limestone beds in the upper part, and with the addition of wash from the overlying Pitkin and Morrow limestones a considerable part of the Fayetteville formation produces good agricultural lands. Where the surface is flat, however, and is underlain by shales of the central part of the formation, the soil is not highly productive.

The Pitkin and Morrow formations produce the most fertile soils in the region, but usually occur on steep slopes, where much of the rock is exposed. The fertility of these soils is attested by the luxuriance of the forest and the occurrence of walnut, locust, and other trees that grow, naturally, on fertile soils.

The Winslow formation produces a varied soil. East of Arkansas and Neosho rivers a large part of the formation is too rugged and stony to be utilized for agricultural purposes. In more level upland tracts, where there is a mixture of sand and clay, the result is a loamy soil well adapted to the growth of vegetables and fruits as well as of cereals. In the western part of the quadrangle soil of the same class is found on the westward-sloping hills and ridges. In this region relatively wide tracts of sandstone approach the surface. The shale in the upper part of the Winslow formation, together with included thin limestone, sandstone, and limy strata, naturally has produced grassy, open uplands. Until recently these lands were given over for the most part to native grasses and were utilized as grazing and meadow lands. Now, however, since the lands have been allotted to the citizens, they are being rapidly opened to the cultivation of corn and cotton.

The soils of the terrace sands and river-bottom lands consist of loamy sands, loams, and silty clays. A very large part of the terrace sands and much of the Arkansas River bottom lands within the flood plains contain deep, loamy sand of but moderate fertility. The larger part of the Arkansas and Verdigris alluvium, however, consists of highly fertile silts and silty clays. The alluvial deposits of the Neosho and the limited bottom lands of the Illinois and of smaller streams in the eastern part of the quadrangle contain a larger percentage of limy material and are very fertile.

FORESTS.

The forests of the Muscogee quadrangle consist entirely of the hard woods common to this latitude in the western part of the Mississippi Valley. They include many species of oak and hickory, besides ash, walnut, cherry, locust, sycamore, and cottonwood. Many varieties of wild grape abound on both high and low lands.

Originally all bottom lands were thickly forested with large trees. Now almost this entire forest is destroyed in those parts where the land is tillable.

The areas of sandstone and limestone, which include almost all the country east of Arkansas and Neosho rivers, contain a forest of variable density and luxuriance. The part occupied by the Morrow and Boone formations contains a sparse forest of oak, hickory, walnut, locust, etc., especially on the northern slopes of hills. On southward-facing slopes the trees are less abundant and smaller, and here much open land is found. The Winslow formation bears a forest consisting chiefly of oak and hickory of only moderate size except on the northern slopes, where the trees attain larger growth. On southern slopes of hills and on tracts of shaly soil the forest is more open, being interspersed with small areas of prairie land.

The western slopes of the hills lying along the east sides of Arkansas and Neosho rivers are forested, while the opposite sides are covered by growths of stunted trees and thorny shrubs interspersed with patches of prairie.

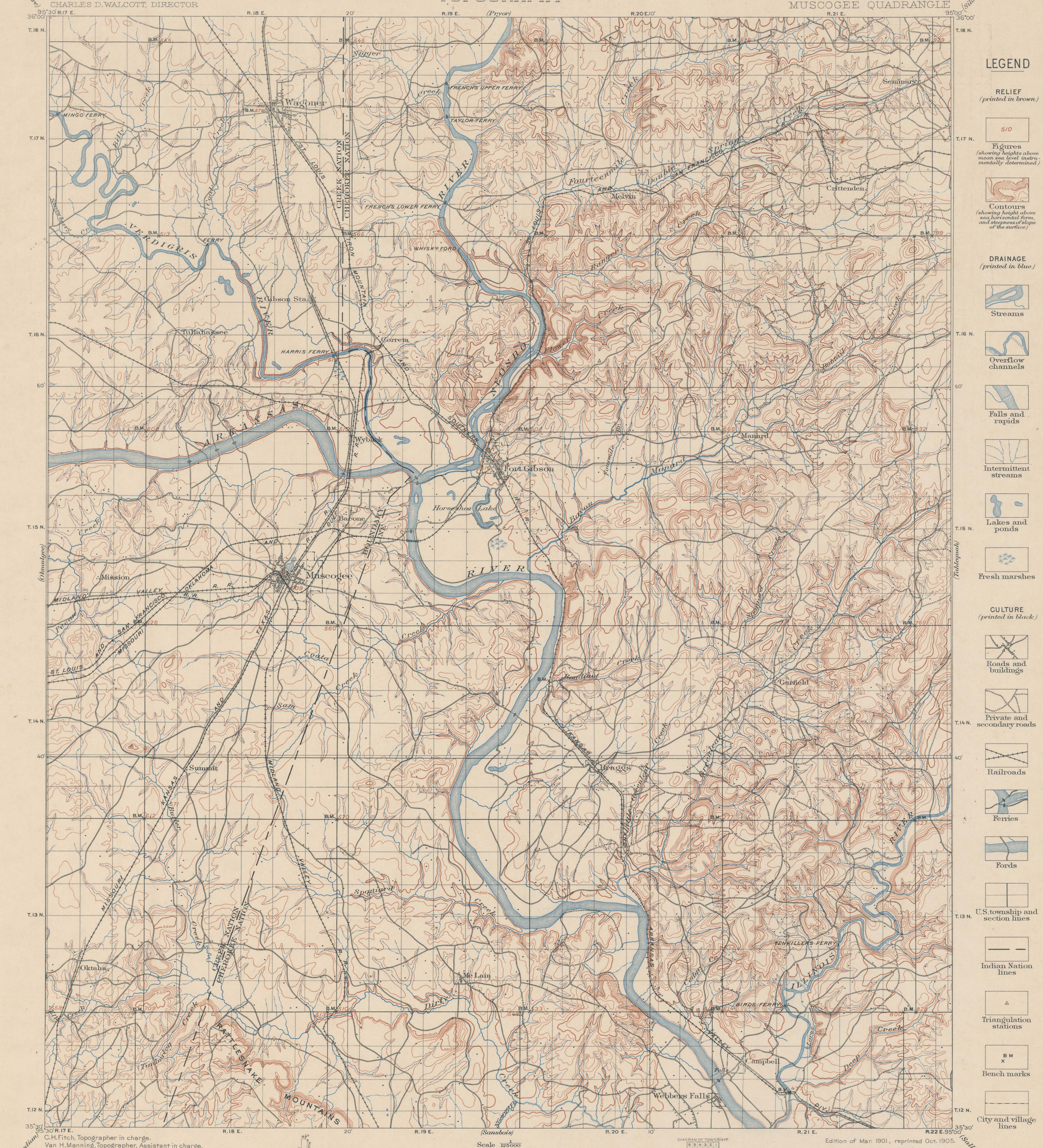
The western half of the quadrangle is almost treeless except along the immediate valleys of the streams and within a few limited areas of thick sandstone outcrops. A small forest tract of stunted oaks occurs on the sandstone highland bordering Pecan Creek on the east. The table-land of the Rattlesnake Mountains bears a similar forest. Small tracts of oak forest also occur on the sandstone divides east of Butler Creek. Scattering trees are found on the prairie uplands, and forest trees transplanted into the same areas have prospered, showing that it is feasible to extend the forest.

May, 1905.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

TOPOGRAPHY

INDIAN TERRITORY
MUSCOGEE QUADRANGLE



C.H. Fitch, Topographer in charge.
Van H. Manning, Topographer, Assistant in charge.
Triangulation by C.F. Urquhart.
Topography by R.H. Mc Kee, Van H. Manning, and J. Ahern.
Surveyed in 1896-98.

TRUE NORTH
MAGNETIC NORTH
$8\frac{1}{2}°$
APPROXIMATE MEAN DECLINATION 1896.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 50 feet.

Datum is mean sea level.

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

Edition of Mar. 1901, reprinted Oct. 1905.

U.S. GEOLOGICAL SURVEY
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AREAL GEOLOGY

INDIAN TERRITORY
MUSCOGEE QUADRANGLE

LEGEND

SEDIMENTARY ROCKS

(Areas of subaqueous deposits are shown by patterns of parallel lines; subaerial deposits by patterns of dots and circles)

QUATERNARY

Recent — Qal — River alluvium *(fine yellow sand and silt)*

Pleistocene — Qts — Terrace sand *(unconsolidated sand and gravel above present river deposits)*

CARBONIFEROUS

Pennsylvanian — Cb — Boggy formation *(brown sandstone, shaly sandstone, and shale, with beds of coal)*

Cwl — Winslow formation *(shale and shaly sandstone, with variable, thick and thin sandstone beds and thin coals)*

UNCONFORMITY

Cmr — Morrow formation *(light-blue limestone, blue clay shale, and local thin sandstones and coal beds)*

UNCONFORMITY

Mississippian — Cp — Pitkin limestone *(light-blue to brown limestone)*

Cf — Fayetteville formation *(black to dark-blue clay shale with thin limestone beds near top and base)*

UNCONFORMITY

Cbn — Boone formation *(chert and cherty limestone)*

Faults

Strike and dip of stratified rocks
X *Coal prospects*

Sections

C.H. Fitch, Topographer in charge.
Van H. Manning, Topographer, Assistant in charge.
Triangulation by C.F. Urquhart.
Topography by R.H. Mc Kee, Van H. Manning, and J. Ahern.
Surveyed in 1896-98.

APPROXIMATE MEAN DECLINATION 1896.

Scale $\frac{1}{125000}$

Contour interval 50 feet.
Datum is mean sea level.

Edition of Dec. 1905.

DIAGRAM OF TOWNSHIP

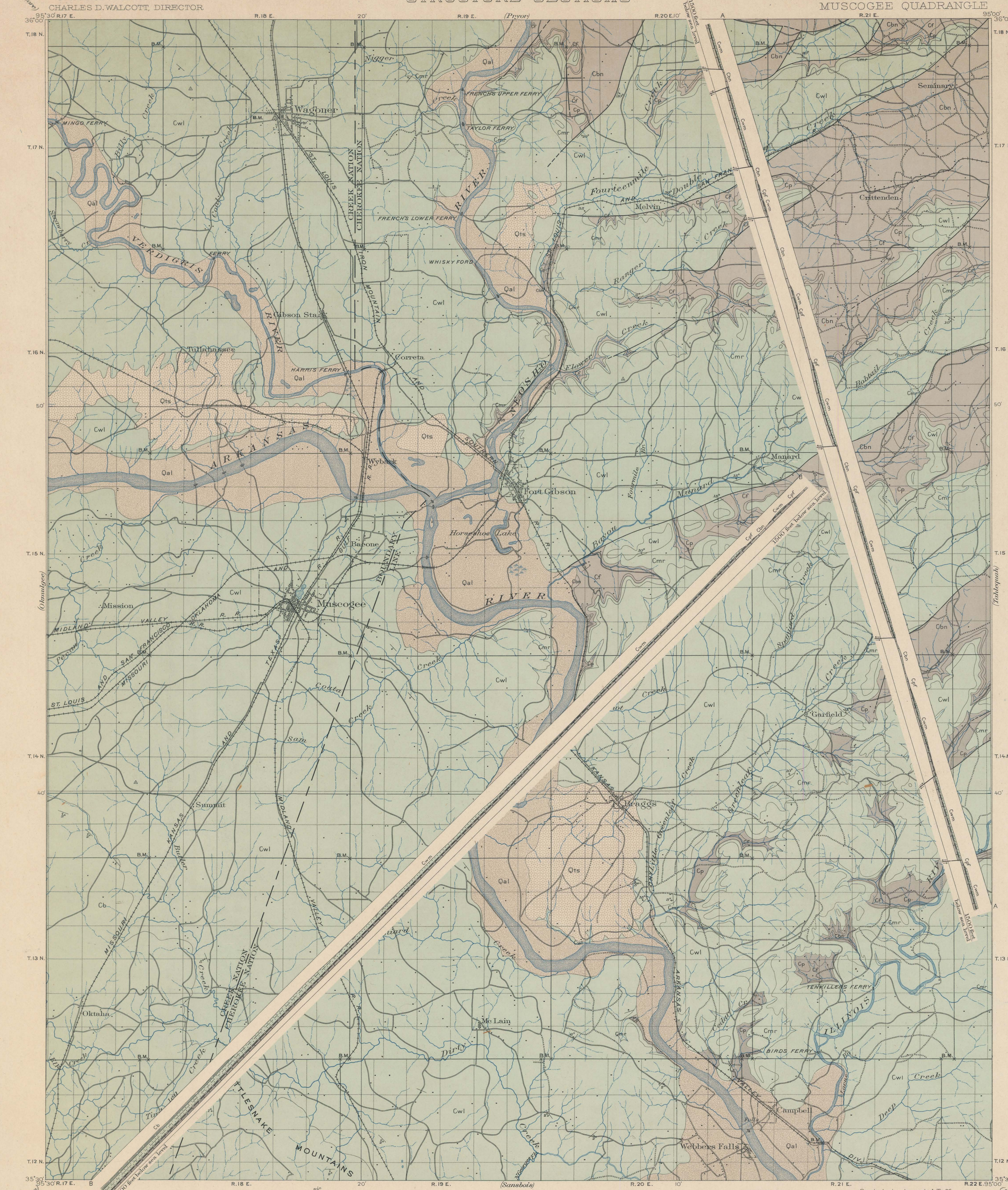
6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Geology by Joseph A. Taff,
assisted by S.W. Beyer and J.W. Beede.
Surveyed in 1902.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

STRUCTURE SECTIONS

INDIAN TERRITORY
MUSCOGEE QUADRANGLE



LEGEND

SEDIMENTARY ROCKS

	Sheet symbol	Section symbol		
Recent	Qal		River alluvium (fine yellow sand and silt)	QUATERNARY
Pleistocene	Qts		Terrace sand (unconsolidated sand and gravel above present river deposits)	QUATERNARY
Pennsylvanian	Cb	Cb	Boggy formation (brown sandstone, shaly sandstone, and shale, with beds of coal)	CARBONIFEROUS
Pennsylvanian	Cwl	Cwm	Winslow formation (shale and shaly sandstone, with variable, thick and thin sandstone beds and thin coals)	CARBONIFEROUS
	UNCONFORMITY			
Pennsylvanian	Cmr	Combined with Winslow formation on sections	Morrow formation (light-blue limestone, blue clay shale, and local thin sandstones and coal beds)	CARBONIFEROUS
	UNCONFORMITY			
Mississippian	Cp	Cpf	Pitkin limestone (light-blue to brown limestone)	CARBONIFEROUS
Mississippian	Cf	Combined with Pitkin limestone on sections	Fayetteville formation (black to dark-blue clay shale with thin limestone beds near top and base)	CARBONIFEROUS
	UNCONFORMITY			
Mississippian	Cbn	Cbn	Boone formation (chert and cherty limestone)	CARBONIFEROUS

Faults

Strike and dip of stratified rocks

C.H. Fitch, Topographer in charge.
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APPROXIMATE MEAN DECLINATION 1896.

Scale $\frac{1}{125000}$

Edition of Dec. 1905

DIAGRAM OF TOWNSHIP

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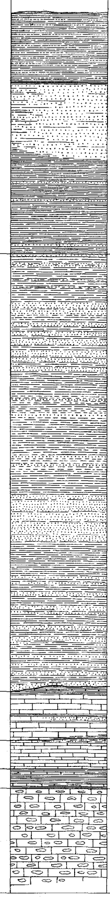
Surveyed in 1902.

COLUMNAR SECTION

GENERALIZED SECTION OF THE MUSCOGEE QUADRANGLE.
SCALE: 1 INCH = 200 FEET.

System.	Series.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography.
CARBONIFEROUS	PENNSYLVANIAN	Boggy formation.	Cb		500+	Sandy gray shale with 30-inch coal bed in basal part.	Gently rolling prairie upland with bluffs and escarpments.
						Gray to yellowish-brown sandstone, massive and moderately hard.	
						Soft gray and black shale with some sandy shale.	
		Winslow formation.	Cwl		800–1000	Shale and shaly sandstone with thin coal beds locally.	
						Brownish sandstone beds interstratified with bluish clay shale.	Rolling prairie land.
						Chiefly clay shale with a thin coal bed in upper part.	
						Heavy sandstone beds.	Local table-lands and hilly country.
						Alternating beds of shale and sandstone, usually thin bedded.	Rolling prairie land.
		UNCONFORMITY					
		Morrow formation.	Cmr		100–120	Blue to white limestone, light-blue to greenish clay shale, and local thin sandstone beds, with blue to black shale and thin limestone at the top where not removed by erosion.	Generally steep hill slopes, bluffs, and cliffs.
		UNCONFORMITY					
	MISSISSIPPIAN	Pitkin limestone.	Cp		60±	Blue and brown limestone, locally siliceous and ferruginous.	Valleys and lower slopes of hills.
		Fayetteville formation.	Cf		20–60	Black to dark-blue, fissile, clay shale with thin limestone lentils.	Valleys and bases of hills.
		Boone formation.	Cbn		200+	Cherty limestone and beds of chert.	Rolling plains of small extent and cherty hills.

JOSEPH A. TAFF,
Geologist.

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