DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

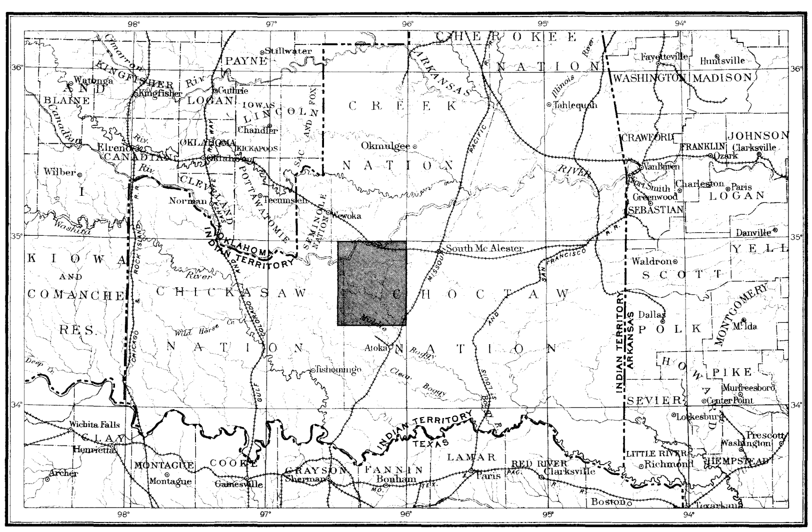
OF THE

UNITED STATES

COALGATE FOLIO

INDIAN TERRITORY

INDEX MAP



SCALE: 40 MILES = 1 INCH

AREA OF THE COALGATE FOLIO

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FOLIO 74 | LIBRARY EDITION | COALGATE

WASHINGTON, D. C.
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GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS | S. J. KUBEL, CHIEF ENGRAVER
1901

EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base 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 horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical 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:

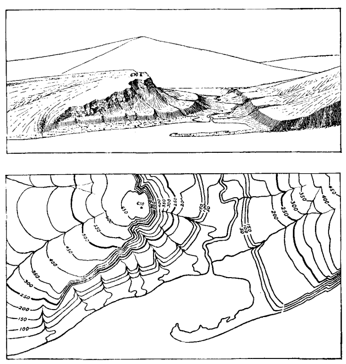


Fig. 1.—Ideal sketch and corresponding contour map.

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 in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. 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 approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea-level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found all 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 nearly all the contours are numbered. Where this is not possible, certain contours—say every fifth one—are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The 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 vertical 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 used 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 the stream flows the year round 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, and artificial details, are printed in black.

Scales.—The area of the United States (excluding Alaska) is about 3,025,000 square miles. On a map with the scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be 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 $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

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 and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$, to about 4 square miles; and on the scale $\frac{1}{250,000}$, to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory 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-quarter 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, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or 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 sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP.

The maps representing areal geology show by colors and conventional signs, on the topographic base map, the distribution of rock formations on the surface of the earth, and the structure-section map shows their underground relations, as far as known, and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of *igneous rocks*, and all other rocks have been derived from them in one way or another.

Atmospheric agencies gradually break up igneous rocks, forming superficial, or *surficial*, deposits of clay, sand, and gravel. Deposits of this class have been formed on land surfaces since the earliest geologic time. Through the transporting agencies of streams the surficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of the waves on the coast, they form *sedimentary rocks*. These are usually hardened into conglomerate, sandstone, shale, and limestone, but they may remain unconsolidated and still be called "rocks" by the geologist, though popularly known as gravel, sand, and clay.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried, consolidated, and raised again above the surface of the water. In these processes, through the agencies of pressure, movement, and chemical action, they are often greatly altered, and in this condition they are called *metamorphic rocks*.

Igneous rocks.—These are rocks which have cooled and consolidated from a liquid state. As has been explained, sedimentary rocks were deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages molten material has from time to time been forced upward to or near the surface, and there consolidated. When the channels or vents into which this molten material is forced do not reach the surface, it either consolidates in cracks or fissures crossing the bedding planes, thus forming dikes, or else spreads out between the strata in large bodies, called sills or laccoliths. Such rocks are called *intrusive*. Within their rock enclosures they cool slowly, and hence are generally of crystalline texture. When the channels reach the surface the lavas often flow out and build up volcanoes. These lavas cool rapidly in the air, acquiring a glassy or, more often, a partially crystalline condition. They are usually more or less porous. The igneous rocks thus formed upon the surface are called *extrusive*. Explosive action often accompanies volcanic eruptions, causing ejections of dust or ash and larger fragments. These materials when consolidated constitute breccias, agglomerates, and tuffs. The ash when carried into lakes or seas may become stratified, so as to have the structure of sedimentary rocks.

The age of an igneous rock is often difficult or impossible to determine. When it cuts across a sedimentary rock, it is younger than that rock, and when a sedimentary rock is deposited over it, the igneous rock is the older.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be changed by the development of planes of division, so that it splits in one direction more easily than in others. Thus a granite may pass into a gneiss, and from that into a mica-schist.

Sedimentary rocks.—These comprise all rocks which have been deposited under water, whether in sea, lake, or stream. They form a very large part of the dry land.

When the materials of which sedimentary rocks are composed are carried as solid particles by water and deposited as gravel, sand, or mud, the deposit is called a mechanical sediment. These may become hardened into conglomerate, sandstone, or shale. When the material is carried in solution by the water and is deposited without the aid of life, it is called a chemical sediment; if deposited with the aid of life, it is called an organic sediment. The more important rocks formed from chemical and organic deposits are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the above sedimentary deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in successive 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 over wide expanses, and as it rises or subsides the shore-lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quartzite, limestone to marble, and modify other rocks according to their composition. A system of parallel division planes is often produced, which may cross the original beds or strata at any angle. Rocks divided by such planes are called slates or schists.

Rocks of any period of the earth's history may be more or less altered, but the younger formations have generally escaped marked metamorphism, and the oldest sediments known, though generally the most altered, in some localities remain essentially unchanged.

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a *formation*, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a *system*. The time taken for the deposition of a formation is called an *epoch*, and the time taken for that of a system, or some larger fraction of a system, a *period*. The rocks are mapped by formations, and the formations are classified into systems. The rocks composing a system and the time taken for its deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

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

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those 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 formations are remote one from the 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 rocks of different areas, provinces, and continents, afford the most important means for combining local histories into a general earth history.

Colors and patterns.—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the color or colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period name.

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations.

Period.	Symbol.	Color.
Pleistocene	P	Any colors.
Neocene { Pliocene / Miocene }	N	Buffs.
Eocene (including Oligocene)	E	Olive-browns.
Cretaceous	K	Olive-greens.
Juratrias { Jurassic / Triassic }	J	Blue-greens.
Carboniferous (including Permian) . .	C	Blues.
Devonian	D	Blue-purples.
Silurian (including Ordovician)	S	Red-purples.
Cambrian	Є	Pinks.
Algonkian	A	Orange-browns.
Archean	Æ	Any colors.

Each formation is furthermore given a letter-symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

The number and extent of surficial formations of the Pleistocene render them so important that, to distinguish them from those of other periods and from the igneous rocks, patterns of dots and circles, printed in any colors, are used.

The origin of the Archean rocks is not fully settled. Many of them are certainly igneous. Whether sedimentary rocks are also included is not determined. The Archean rocks, and all metamorphic rocks of unknown origin, of whatever age, are represented on the maps by patterns consisting of short dashes irregularly placed. These are printed in any color, and may be darker or lighter than the background. If the rock is a schist the dashes or hachures may be arranged in wavy parallel lines. If the rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the metamorphic rock is recognized as having been originally igneous, the hachures may be combined with the igneous pattern.

Known igneous formations are represented by patterns of triangles or rhombs printed in any brilliant color. If the formation is of known age the letter-symbol of the formation is preceded by the capital letter-symbol of the proper period. If the age of the formation is unknown the letter-symbol consists of small letters which suggest the name of the rocks.

THE VARIOUS GEOLOGIC SHEETS.

Historical geology sheet.—This sheet 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 particular colored pattern and its letter-symbol on the map 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 symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet 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 symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

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 name 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 the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting 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:

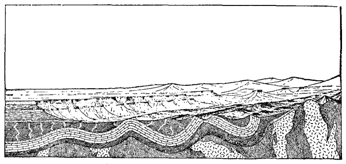


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane that cuts a section so as to show the underground relations of the rocks.

The kinds of rock are indicated in the section 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:

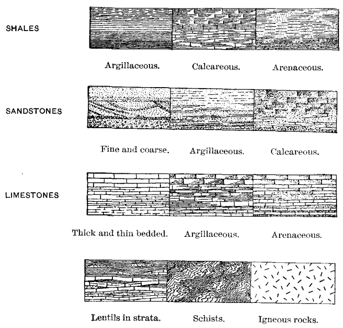


Fig. 3.—Symbols used to represent different kinds of rock.

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 beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shales.

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.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. But these sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones.

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

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the 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 swelled upward 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 strata thus rest upon an eroded surface of older strata 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 this pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that an interval of considerable duration 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, marking a time interval between two periods of rock formation, is another unconformity.

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

Columnar-section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. The diagrams and verbal statements form a summary of the facts relating to the character of the rocks, to the thicknesses of the formations, and to the order of accumulation of successive deposits.

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation 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 is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments may be indicated graphically or by the word "unconformity," printed in the columnar section.

Each formation shown in the columnar section is accompanied by its name, a description of its character, and its letter-symbol as used in the maps and their legends.

CHARLES D. WALCOTT,
Director.

Revised June, 1897.

DESCRIPTION OF THE COALGATE QUADRANGLE.

By Joseph A. Taff.

GEOGRAPHY.

GENERAL RELATIONS.

The Coalgate quadrangle is bounded by the meridians 96° and 96° 30′ and the parallels 34° 30′ and 35°, and thus occupies one-quarter of a square degree of the earth's surface. It is 34.4 miles long north and south and 28.5 miles wide, and contains nearly 980 square miles. The larger part of the quadrangle lies within the bounds of the Choctaw Nation. A strip of land 3 miles in width in the western part of the quadrangle south of Canadian River is in the Chickasaw Nation. The area north of the Canadian, except a narrow band one mile in width along the western border, is in the Creek Nation; this narrow band is in the Seminole Nation.

Extent and location of the quadrangle.

Three physiographic regions or provinces are represented in this quadrangle, each of which possesses distinct geologic conditions which have determined its surface form. These provinces are: the Ouachita Mountain Range, the Arkansas Valley region, and the Prairie Plains. Three other physiographic provinces enter into the geography of Indian Territory, and will be referred to in the general discussion. These are: the Ozark region, whose western end extends into northeastern Indian Territory; the Arbuckle Mountains, which are in the central part of the Chickasaw Nation west of the Ouachita Mountains; and the Red River Plain, which includes the entire southern border of Indian Territory.

Physiographic regions.

The Ouachita Mountain Range, whose ridges cross the southeastern corner of the Coalgate quadrangle, extends from southeastern Choctaw Nation near Atoka to central Arkansas in the vicinity of Little Rock, and is 200 miles long. It is characterized by numerous ridges and mountains, bearing generally east and west. Near the western end, however, they trend southward and decline rather abruptly to the general level of the Red River Plain. The principal mountains and groups of ridges of the Ouachita Range are separated by relatively wide and flat valleys. Those valleys which lead from the mountain range descend gradually to the level of Arkansas Valley and the Red River Plain on either side. Near the western end of the range the crests of the ridges are at an elevation of about 1000 feet above sea and nearly 400 feet above the level of the larger valleys. They rise gradually eastward and near the Arkansas–Indian Territory line attain elevations of 2900 feet above sea and nearly 2000 feet above the valleys of the principal streams. In Arkansas the general elevation of the ridges decreases eastward, until it reaches 500 to 700 feet above sea at the eastern end. Likewise, from the sides toward the center of the range the ridges increase in elevation until they are classed as mountains. Jackfork, Windingstair, Buffalo, Rich, Blackfork, Kiamichi, and Seven Devils are the more prominent mountains of the Ouachita Range in Indian Territory. The northernmost mountain of the western part of the range, known as Pine Mountain, comes to an end in the southeast corner of the Coalgate quadrangle.

Extent and character of the Ouachita Mountain Range.

The Arkansas Valley region lies between the Ouachita Range on the south and the Ozark Mountains on the north, and is characterized, especially in the western part, by narrow and generally level-crested, low ridges and rolling uplands. At the confluence of the Canadian and Arkansas rivers the Arkansas Valley region contracts, bears southwestward, and joins the Red River Plain opposite the west end of the Ouachita Mountain Range. Its low, level ridges and flat valleys cross the southern half of the Coalgate quadrangle. The features of the Arkansas Valley region, especially in the southern part, resemble very much reduced forms of the Ouachita Mountain Range. The ridges of the valley region are nearly parallel with those of the range, but, with the exception of the few isolated mountains which lie in Arkansas Valley, they have low relief.

Features of the Arkansas Valley region.

The Prairie Plains region stretches from the Arkansas Valley and Ozark highland regions northward and westward across northwest Indian Territory into Oklahoma and Kansas. Its plain gradually ascends toward the northwest, and is characterized in Indian Territory by bench and terrace forms of topography—table-lands and escarpments. The benches or table-lands are cut into and traversed by valleys, but maintain their generally level form. The escarpments face eastward and southward, away from the direction of the dip, and have a very tortuous outline. The character of the Prairie Plains geography is admirably illustrated in the north half of the Coalgate quadrangle. An arm of the Prairie Plains extends southward and joins the Red River Plain between the ends of the Ouachita and Arbuckle mountains, separating these two ranges by a space of nearly 50 miles. A second arm, also bearing southward, connects with the Red River Plain between the Arbuckle and Wichita mountains in Oklahoma. The Prairie Plains also join the Arbuckle Mountains on the north.

Character and extent of Prairie Plains region.

Three main river systems—the Arkansas, the Canadian, and the Red—drain the whole area of Indian Territory. Arkansas River flows southeastward from the Rocky Mountains, crosses the Great Plains and the Prairie Plains, and enters the valley between the Ozark and Ouachita mountains near the eastern border of Indian Territory. Canadian River has its source in New Mexico, flows eastward across the Great Plains and Prairie Plains, and joins Arkansas River at the border of the Arkansas Valley region. In its course through the Prairie Plains it enters the northern part of the Coalgate quadrangle. Red River rises in New Mexico, flows eastward through the Great Plains and across the "Panhandle" of Texas, and then forms the entire southern border of Indian Territory. Its northern tributaries in Indian Territory drain a large part of the area south of Canadian River. The watershed between the Canadian and Red, especially in the Chickasaw Nation, lies within a few miles of the banks of the Canadian. Since Canadian River belongs to the Arkansas River system, the Canadian-Red watershed is also a part of the divide between the hydrographic basins of Arkansas and Red rivers. It also here divides the waters which flow into Mississippi River from those which flow directly into the Gulf of Mexico.

River systems.

TOPOGRAPHY OF THE QUADRANGLE.

ORIGIN OF THE TOPOGRAPHIC FORMS.

The various forms of the valleys and hills in this region have been produced by the dissolving and disintegrating action of water and frost, and by the erosion caused by rain and running streams. The shapes of the valleys and hills and their location depend principally upon the degree of erosion and upon the character and structure of the rocks. When the land is uplifted and tilted the streams flow more rapidly and cut deep valleys. They erode the softer rocks more readily than the harder ones, and naturally the softer rocks form valleys and the harder ones hills, ridges, and mountains. On the other hand, when the general surface of the land is nearly level at the beginning of an epoch of erosion, or becomes so by erosion, the streams flow sluggishly and the currents are not able to carry away all of the sediment which is swept from the higher portion of the lands. Under these conditions the channels tend to become choked and the streams meander from side to side and broaden their valleys. When these conditions continue for a long time the valleys become wide and silted, and the hills are gradually reduced to the level of the valleys.

Formation of level plains.

The surface of the Coalgate quadrangle is of low relief, and the topographic features indicate that it has been so for a relatively long period of time. The larger streams have nearly ceased cutting their valleys deeper, and throughout most of their courses are meandering in the deposits of silt and sand which their currents have deposited in times of flood. The relative permanence of the topographic features in this quadrangle depends upon the thickness and hardness of the sandstone and limestone beds and upon their structure. Hardness enables them to withstand more effectively the beating rain and the eroding streams. When the rocks are tilted at a low angle, as in the northern half of the quadrangle, the sandstone beds when once uncovered resist erosion and protect the softer shales beneath, thereby forming table-lands and escarpments. On the other hand, where the beds are steeply uplifted, as in the southern and southeastern parts of the quadrangle, the soft shales on either side of the sandstone are unprotected and are rapidly eroded, leaving the sandstone unsupported and easily broken down.

Formation of table-lands.

THE BROADER TOPOGRAPHIC FEATURES.

Viewed in a broad way, the south half of the Coalgate quadrangle is a nearly level plain. A few eminences rise above the level of 750 feet, and but little of the highland between the main stream valleys falls below the 700-foot level. The valleys are wide and shallow and the streams meander in crooked courses through nearly level flood plains. Beginning about in the middle of the quadrangle, there is a general rise of the land toward the north, from about 750 feet to 950 feet above sea. Elevations between 850 feet and 950 feet are generally maintained over the highland in this part of the quadrangle. On the high plateau in the northeast corner of the quadrangle a few crests are from 1000 to 1100 feet above sea.

Altitudes.

In the northern half of the quadrangle the large streams have deeper and narrower valleys than in the southern half, but they have eroded their channels down to a low grade and are meandering in silted flood plains. The small tributary streams, especially those which flow toward the south and east, descend in narrow, steep channels and are rapidly cutting back into the highland by headwater erosion.

The southern two-thirds of the quadrangle is drained by streams tributary to Red River. The principal tributaries are North Boggy, Muddy Boggy, and Clear Boggy creeks, which flow southwest, south, and southeast respectively. They unite into one stream south of this quadrangle and flow through the wide plain between the Ouachita and Arbuckle mountains. Of these three creeks, Muddy Boggy drains the larger part of the quadrangle. Its source is on the watershed which divides the hydrographic basins of Red and Canadian rivers. The source of one of the small branches of this creek, which is on the divide near Allen, is within a mile of the banks of the Canadian. Muddy Boggy Creek near its source at the west border of the quadrangle is now at a lower level than Canadian River, although the streams are separated by a space of less than 3 miles. From Allen the watershed bears eastward and southeastward across the quadrangle, increasing the space between it and Canadian River.

Drainage.

Canadian River, though a long stream, has a narrow hydrographic basin and a relatively very narrow channel and flood plain. Plateaus and hills, whose crests are at the level of the high table-lands, overlook the river channel through most of its course. The bottom of the channel is filled with fine sand to a depth of many feet, so that at ordinary conditions the stream meanders in rivulets or narrow channels. Indeed, its channel is so choked with sand that the water does not at any stage of the river flow on the country rock. During floods, which usually come in spring from the headwaters of the river, vast quantities of sands are swept down, shifting former shoals and channels. Little River, which is tributary to the Canadian, crosses the northwest corner of the quadrangle in a relatively wide, silted valley. It is a short river and its source does not reach the soft deposits of the Plains from which the Canadian receives its supply of sand.

CLASSIFICATION OF THE TOPOGRAPHIC FEATURES.

The three types of topography belonging to the physiographic provinces or regions which have been briefly outlined under the heading "General relations" occupy the entire area of the Coalgate quadrangle. In describing the topographic features it is necessary to classify them under their respective types: the Ouachita Mountains, the Arkansas Valley, and the Prairie Plains types of topography.

Ouachita Mountains type.—The ridges lying east of North Boggy Creek, in the southeast corner of the quadrangle, belong to the foothills of Pine Mountain, which is a member of the Ouachita Range. They resemble in form many of the ridges of the Arkansas Valley type, which are adjacent on the west, and their separation from the Arkansas Valley topography would seem arbitrary; but they were determined by different structure and are generally more elevated. They become gradually higher southeastward, culminating in the highest ridges of Pine Mountain, the south end of which enters the southeast corner of the quadrangle.

The ridge-making rocks are limestones, cherty sandstones, and sandstones, which are separated by thick beds of friable shale. After being crumpled closely in parallel folds the beds have been worn away and their edges exposed. The softer beds were eroded more rapidly and formed the valleys, while the harder ones stand out in parallel, nearly symmetrical ridges. Many of the hard beds lying between Limestone Ridge and the southeast corner of the quadrangle have been so broken and crushed by faulting that they have not been able to withstand erosion. They occur in low detached hills and ridges, 50 feet and less in height, and can not easily be recognized in the topography as shown on the map. Limestone Ridge, as well as others south of it, is broken off abruptly at its south end by the fault which separates the Ouachita Mountain type of topography and structure from the Arkansas Valley type. A number of ridges of the same class occur in the McAlester quadrangle, which adjoins this quadrangle on the east. These ridges are illustrated by the sketch in fig. 1.

Parallel ridges formed by upturned closely folded rocks.

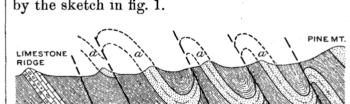


Fig. 1.—Profile section of the ridges in the northern foothills of Pine Mountain. *a*, Sandstone bed.

Arkansas Valley type.—The rocks in which the Arkansas Valley type of topography is developed belong chiefly to the Coal Measures and are in general younger than those of the Ouachita ridges above described. They are composed of a great many beds of sandstone and shale, occurring in alternate strata. The sandstone beds are usually hard, vary in thickness from thin plates to nearly 200 feet, and are separated usually by much thicker beds of shale.

These rocks have been crumpled into folds, but, unlike the Ouachita structure, the folds are

Level-crested ridges formed by open-folded rocks.

wide and open and no faulting of consequence has occurred. The beds of rock which occur in these folds have had their edges planed off by erosion, so that hard and soft layers are alternately exposed through great thicknesses of strata in nearly level-crested ridges and flat valleys. They extend parallel and nearly straight along the folds, or in curves across their axial portions. The whole series of rocks exposed by this folding aggregates a thickness of nearly 7000 feet, and has been divided into five formations. The areas of Caney shale and Wapanucka limestone occurring in this province in the southwestern corner of the quadrangle are too small to be considered in this connection. The lowest to be considered, the Atoka formation, is only partially exposed, being concealed in part by the faults in the southeast and southwest corners of the quadrangle. It is composed chiefly of shale, and, as a result, its surface is generally level.

The Hartshorne sandstone, being composed of many thick beds aggregating nearly 200 feet, makes ridges that lie along the northwestern side of North Boggy Valley and the southern side of Clear Boggy Valley, but is worn down to the level of these valleys in many places.

The McAlester shale, the next succeeding formation, contains but little sandstone and accordingly it forms shallow, wide, and nearly level valleys and plains. The plain southwest of Coalgate is upon this shale. Goose and Clear Boggy creeks flow upon it, and it is almost entirely covered by their flood plains. Two other areas occur in this shale northeast of Coalgate.

Migration of ridges in anticlines.

The Savanna sandstone lies next above McAlester shale. This formation is composed of several sandstone beds separated by thick beds of shale, in all 1100 feet thick. These sandstones dip at a considerable angle, and as a result crop near together, forming low parallel ridges separated by narrow swales. Many streams cross these sandstones, but their persistent low ridges extend to the flood plains of these streams. In the case of anticlinal folds the ridges, formed by the sandstones, gradually migrate from the axis of the fold with the progress of erosion. Fig. 2 illustrates the form of the ridges in an anticlinal fold at successive stages of erosion. It also illustrates a series of cross sections at intervals along a pitching anticline.

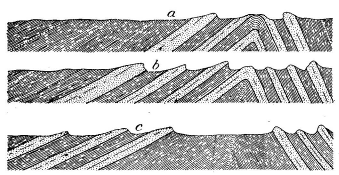


Fig. 2.—Generalized sections across an anticline of the Savanna sandstone at three stages of erosion, illustrating the form and migration of the sandstone ridges.

(*a*) An early stage, where only the highest beds of the Savanna sandstone are exposed.

(*b*) A later stage of erosion, where all the sandstone beds are exposed.

(*c*) A still later stage, where all of the ridges have receded from the axis of the fold and a plain is formed in the center upon the underlying McAlester shale.

Sections at intervals across either the anticline passing through Coalgate or that passing through Savanna in the McAlester quadrangle will illustrate many stages of the erosion of the Savanna sandstone from the time the highest bed is first exposed until all the sandstones are removed from the axial part of the folds.

Migration of ridges in synclines.

In synclinal folds the process is the reverse and the ridges produced by the sandstones gradually approach the axis of the fold as erosion advances. In this way successively lower beds cap the flat ridges and concentric hills. Fig. 3 represents three sections across the north end of the Lehigh Basin, illustrating the forms of the ridges and hills at successive stages of erosion. It also represents a series of cross sections at intervals up the pitch of the syncline.

The Boggy shale succeeds the Savanna sandstone and occupies a relatively large area. It is composed chiefly of shale and thin beds of sandstone interstratified, and has a thickness of nearly 3000 feet. It is only slightly folded, and dips generally toward the northwest. Because of the soft character of these rocks and their flat structure, the surface is a nearly level, undulating plain. Locally some of the sandstone beds become thicker, and, where they are nearly horizontal, form low ridges and mesas. The minor sandstone beds produce very low ridges, or undulations in the plain.

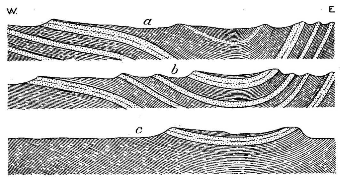


Fig. 3.—Generalized sections across the Lehigh Basin, illustrating the form and migration of ridges in the syncline at three stages of erosion.

(*a*) An early stage, where the sandstone beds form ridges around the basin.

(*b*) A later stage, where the highest sandstone bed makes the central hill.

(*c*) A still later stage, where only the lowest sandstone bed remains, making a hill in a plain of the underlying McAlester shale.

Table-lands and benches tilted to the northwest.

Prairie Plains type.—The rocks in the north half of the quadrangle have a thickness of 2000 feet, and are conglomerates, sandstones, and shales in alternate strata. They have been separated into eight formations. These formations are tilted toward the northwest at low angles, the descent being from 50 to 100 feet per mile. They outcrop in regular order upward from the southeast toward the northwest, and each formation in its occurrence across the quadrangle produces a feature of the Prairie Plains type of topography. The shales are soft and disintegrate readily into small particles which are easily removed by erosion. Shales are found generally on the top of the table-lands near where the next escarpment rises and in the lower slopes of the escarpments below the protecting ledges of harder rocks. The sandstones disintegrate more slowly, breaking into bowlders and coarse fragments, and thereby resist erosion. They produce the benches, the high table-lands, and the steep upper slopes and cliffs in escarpments. Thus table-lands with escarpments are formed by the thick formations of sandstone and shale, and benches with low escarpments by the thinner beds of the same rocks. On going northwest across the country, successive escarpments of nearly equal elevation above sea will be observed, separated by the tilted surfaces of the table-lands and benches.

Since all these formations dip toward the northwest, their edges are exposed toward the southeast. A great number of small rivulets and streams, with their sources in the shales beneath the table-land, are eroding by headwater cutting, thereby undermining the sandstones, which fall away in bowlders and débris, to be broken and disintegrated into pebbles and sand. In this process of erosion the escarpments gradually recede northwestward.

Sandstones of the Thurman, Senora, and Calvin formations become thinner and more shaly toward the southwest, and the topographic features produced by them become smaller in the same direction. The Senora formation, for instance, in the northeastern corner of the quadrangle forms a high plateau, with an escarpment 300 feet high facing the east. In the western part of the quadrangle it is not one-sixth as wide as it is in the northeast corner, and its south-facing escarpment does not exceed 100 feet in height.

Local stream erosion continues to modify these features of the topography, but it will not obliterate them until the country is brought to base-level, where all eminences are reduced to a plain.

Ancient bed of the Canadian River at present a table-land.

Sand plains.—At some remote period of time, yet comparatively recent geologically, a deposit of sand and gravel was formed across the northern part of the Coalgate quadrangle in a general east-west direction. Remnants of this unconsolidated sand, in some instances 40 feet thick, 3 miles wide, and several miles long, occur spread across the edges of the Coal Measures rocks, forming level plains but little lower than the highest land. It extends from the Canadian Valley at the western edge of the quadrangle southeastward across the watershed and into the hydrographic basin of Red River, but near the eastern edge of the quadrangle it returns again to the Canadian hydrographic basin, after passing nearly 10 miles south of the present watershed. From this quadrangle it has been traced northeastward nearly 50 miles to the valley of Canadian River. The separate bodies of this sand are nearly level, but viewed as a whole the deposit has a grade of about 4 feet per mile eastward. Where the sand lies in contact with hard sandstone the floor of the shallow channel or basin in which it was deposited may be observed. The sand is a fresh-water deposit, and was evidently laid down by a river. Judging from its relations to the present Canadian Valley it probably occupied a deserted channel of Canadian River. The width and extent of the deposit indicate that the slope of the country toward the east was less than at present, and that the river flowed sluggishly, meandered in a broad valley, and deposited a large part of its burden of sand.

Since the deposition of this sand the principal streams have cut their channels nearly 100 feet below its level. The branches of Boggy Creek, which flows to Red River, being favored by the structure of the rocks, have by headwater erosion moved northward, capturing tributaries of Canadian River. Caney Boggy Creek, for example, has its source 10 miles north of the old channel in which the sand plain occurs.

GEOLOGY.

BROADER GEOLOGIC RELATIONS.

The rocks found in this quadrangle are conglomerates, sandstones, coal, shale, and limestones of Carboniferous age. They are all of sedimentary origin — that is, they were deposited in water. Gravel, sand, and mud were swept into the seas by rivers and were there sorted and deposited by the waves and currents and later were hardened to conglomerates, sandstones, and shales. Vegetable matter, growing profusely in swamps and marshes near the seashore, accumulated during long successions of seasons and produced peat. The land subsided, and the peat deposit was submerged and covered by sediments brought down from the land. After a long period of time and under the weight of thick sediment, the peat deposit was changed to coal. In other parts of the sea, both in deep and shallow water, where conditions were favorable, the shells and skeletons of sea animals with other lime sediments collected in beds and later were hardened into limestones.

By studying the character of all the rocks occurring at the surface in a region, the record of their formation may usually be interpreted and something may be learned of the physical changes of the land from which the sediments came. In the Coalgate quadrangle a clear record of sedimentation is afforded by the rocks, which are well displayed for study. Very little has been learned, however, of the physical changes of the land from which the sediments originally came, because even its inferred position is remote or concealed by later deposits.

Location of the land area from which the Carboniferous deposits were derived.

Rocks of Silurian age occur in the Ozark, Ouachita, and Arbuckle mountains, northeast, southeast, and southwest, respectively from this quadrangle, but their elevation into mountains and exposure by erosion has occurred chiefly since Carboniferous time and, therefore, after the deposition of the rocks occurring in this quadrangle. The lowest Carboniferous sediments lying upon these older rocks are folded with them and do not contain much coarse material or otherwise indicate that elevated lands were near during their formation. The rocks of this region become thicker toward the east by an increase in the thickness of the sandstone beds, which seems to indicate that the sediments were derived from the east.

At the eastern end of the Arbuckle Mountain uplift, near the southeastern corner of the Coalgate quadrangle, the basal beds of the Carboniferous are thick strata of clay and cherty shales containing limestone and flint segregations and are deposited upon base-leveled Silurian limestones. An extensive lentil of limestone is associated with these sandy, cherty, and shaly beds at the top. Following the limestone deposition conditions of sedimentation changed, and then, with little variation, continued to the end of Carboniferous time. Shales and sandstones followed each other in alternate strata through nearly 10,400 feet of sediments. The shales are laminated and vary from clays to sandy clays and sand. Sandstones are fine grained, with the exception of local conglomerates, in which angular chert pebbles are embedded in fine sand. The sandstones are massive and laminated, cross bedded, and ripple marked. Locally thin beds of sandy fossiliferous limestone occur. The coals usually are found above and near the sandstones, and in one instance shell beds rest upon the coal.

Low shores and extensive marshes during Coal Measures time.

During the formation of this enormous thickness of sediments the sea bottom sank slowly. There may have been temporary elevations and stationary conditions of the sea bottom for considerable spaces of time, but the downward movement prevailed. Where clays were forming, either the water was deep enough to be below the reach of currents, or else only fine sediments were brought in by the streams. Where the sands were accumulating they were sorted and rippled by the waves at the bottom of the shallow sea, and flat shores, and extended over wide stretches. Wide marshes existed along the low shores, and, undisturbed by the sea, the vegetable matter accumulated to depths of many feet, and was then submerged by the sea, as the downward movement of the land recurred, and covered with sediments. Land conditions during the formation of the rocks are further shown by the stems and leaves of plants which occur abundantly in the strata overlying the coal, and by the trunks of trees which are occasionally found and which were buried and preserved by the rapidly accumulating sandy sediments.

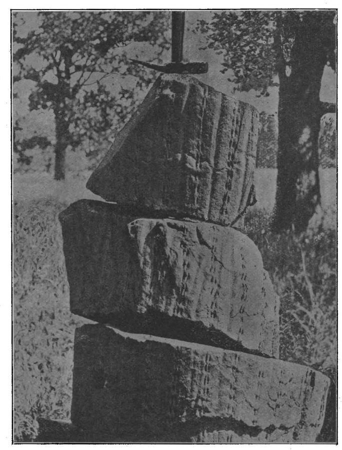


Fig. 4.—Cast of trunk of a coal tree (*Sigillaria*) found in Savanna sandstone 4 miles southwest of Coalgate.

These land areas were, without much doubt, local in extent and of short duration in geologic time. Excepting the local cherty materials occurring in the sandstones, the universally fine texture of the sand and the great thickness of clays would indicate that the land from which they were derived was distant.

DESCRIPTION OF THE ROCKS.

The different formations are here classified according to their age, and in the following description they will be treated in regular order beginning with the oldest, which is the lowest in the undisturbed section. These formations are mapped on the Historical Geology sheet, and the legend in the margin indicates their order of succession and relative ages. On the Columnar Section sheet the formations are graphically represented and briefly described. All the consolidated rocks of this quadrangle belong to the Carboniferous system, and as far as known, to the upper Carboniferous or Coal Measures. The unconsolidated sands and river deposits are classed as Neocene and Pleistocene.

CARBONIFEROUS.

Caney shale.—This formation occurs in two small areas in the Coalgate quadrangle. The one in the southwestern corner includes only the upper beds of a large outcrop of this formation, which lies east and north of an extensive body of Silurian limestone in the Arbuckle Mountain region. Near the southeastern corner of the quadrangle the Caney shale crops in a narrow strip along the northwest side of Limestone Ridge, and extends northeastward into the McAlester quadrangle. The rocks are faulted along the north side of this area, the beds on the east having been thrust up against younger rocks on the west, thereby cutting out the lower part of the shale. Rocks of the Atoka formation, which belong stratigraphically 1800 feet above the Caney shale, lie in contact with it on the other side of the fault. In each locality of the Caney shale in this quadrangle about 800 feet of rock is exposed, approximately the upper half of the formation. This part of the formation is composed of blue clay shale, with thin beds of clay, ironstone, lenticular concretions, and a few blue limestone septaria. In the lower part of the formation, in the adjoining Atoka quadrangle, the blue shale grades into black, friable, bituminous shale with dark-blue limestone segregations. The Caney shale throughout is laminated, fissile, and friable, and in consequence is rarely exposed. On account of the softness of the rock it is almost universally worn down to level ground or is to be found in the lower slopes of hills which are surmounted by harder rocks of adjacent formations.

Shale the lowest rock exposed.

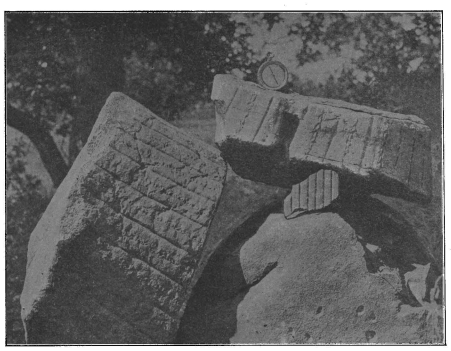


Fig. 5.—Cast of trunk of a coal tree (*Sigillaria*) found in Savanna sandstone 4 miles southwest of Coalgate.

Wapanucka limestone.—The Wapanucka limestone crops as a narrow band along the eastern border of the Caney shale in the southeastern and southwestern corners of the quadrangle. This formation is an extensive but relatively thin lentil, reaching beyond the limits of this quadrangle. It produces ridges, except in those places where the beds have been upturned to a vertical position, thereby permitting the soft shales to be eroded from both sides, leaving the limestone unprotected. The abrupt ending of the formation at the south end of Limestone Ridge is due to its displacement by an extensive fault. Southward the fault follows approximately the strike of the rocks, and the limestone does not come again to the surface in the quadrangle. At Boggy Depot, in the Atoka quadrangle, the Wapanucka limestone emerges from beneath the covering of Cretaceous rocks bearing toward the northwest, and continues in that general direction to the area in the southwest corner of the Coalgate quadrangle.

The beds at the top of this formation are white, massive, and often oölitic. Cherty sandy limestones and shales occur in the central part of the formation. Below these variable beds, a massive white limestone occurs, but it is not constant in thickness and character and in places could not be found. At the base of the formation there are calcareous and cherty sandstones which grade into shales on the one hand and into nearly pure ferruginous sandstones on the other. In Limestone Ridge the lowest strata are thin cherts and flint plates, interbedded with siliceous limestones. In the vicinity of Wapanucka, about 10 miles south of the quadrangle, sandstone beds occur at the base.

Massive limestone beds.

The whole formation grows thinner westward, until but little else than the massive oölitic limestone can be found. In Limestone Ridge the thickness is estimated to be nearly 200 feet. At the western border of the quadrangle it probably does not exceed 30 feet.

Atoka formation.—With the exception of thin lentils of limestone and of calcareous cherty sandstone near the base in the southwestern and southeastern corners of the quadrangle the rocks of the Atoka formation are sandstone and shale. They are estimated to be nearly 3000 feet in thickness, the shale as a whole being very much thicker than the sandstones. The formation is separated by the sandstone strata into divisions varying from thin sheets to beds several hundred feet in thickness.

Beginning of thick deposits of shale and sandstone.

The shales are friable clays and sandy clay shales and they crop in smooth level prairie valleys and in the lower slopes of ridges and hills. Under such conditions fresh exposures of the shales are exceptional and little is known of their original color or physical appearance. When partly weathered, however, they show various shades of yellow and blue. In the Atoka quadrangle just south of the Coalgate quadrangle some fresher exposures in Clear Boggy Creek show dark-blue to black clay shales.

The sandstone beds are many, and vary from thin plates embedded in shale to massive strata several feet in thickness. They are generally extremely variable in thickness and would be classed as lentils. The sandstone strata in the southwestern corner of the quadrangle are in many respects unlike those of the southeastern corner. In the former locality they are softer and more ferruginous. Sandstone beds of considerable thickness occur near the base of the formation in the southwestern corner, and associated with them are local beds of thin impure limestone. In places the sandstone makes prominent ridges and hills, while elsewhere the beds can not be located in the plain. These beds, with higher beds of sandstone and shale, when traced northward apparently come to an end at the south side of Goose Creek Valley near the border of the quadrangle. Their abrupt ending is due to the fault which cuts them off on the north. In the southeastern corner of the quadrangle, beyond the great fault, the lower beds of the Atoka formation have been so folded and faulted that the same beds are repeated many times in long, narrow, parallel belts for a width of nearly a mile. Southeast of this faulted strip the sandstone and shale beds are folded and steeply inclined toward the southeast.

On account of the structure of the rocks east of the great fault, their position in the Atoka formation can not be accurately determined. The narrow belt of shale at the base of the formation and immediately overlying the Wapanucka limestone is an exception, however. The strata exposed between the great fault and the Hartshorne sandstone for nearly one-half mile occur at the top of the Atoka formation. They are concealed here beneath the bottom lands of North Boggy Creek.

Chickachoc chert lentil.—The Chickachoc cherty sandstone is a lentil in the lower part of the Atoka formation and occurs in the faulted strip above referred to. Because of its peculiar and characteristic texture and hardness it has been separated from its associated beds and mapped. It is about 80 feet thick and is composed of stratified, yet massive, calcareous and cherty sandstone. There is but little variation in the character and texture of the rocks in the Chickachoc lentil. Occasionally, however, thin stringers of almost pure flint and siliceous limestones occur in exposures of unweathered rock. When weathered the whole mass becomes nearly white and breaks down into thin, coarse, hackly plates, which feel as if composed of sharp grit. The folding has been so excessive that the beds now rest in almost vertical positions. At their southern ends these chert ridges are abruptly terminated by the great fault which has thrust them against higher beds in the Atoka formation. The chert in some of these ridges near their ends has been thrown into peculiar distorted folds, not to be explained except by the great pressure brought to bear against the ends of the upturned beds.

Hartshorne sandstone.—This sandstone is important chiefly on account of its association with the lowest and most valuable coal bed in the Choctaw coal field. This coal is immediately above the sandstone and is usually separated from it by a thin variable bed of shale. The Hartshorne sandstone is composed of many beds of sandstone, varying from thin plates to massive strata 3 feet in thickness. Thin beds of shale occur in places interstratified with the sandstone but the sandstone beds are so much more conspicuous in outcrop that the shales are rarely seen or their presence detected. The sandstone grades into the shale formations above and below through shaly sandstone beds, and the contact usually must be arbitrarily chosen. The thickness of the formation is estimated to be about 200 feet. In this quadrangle the sandstone is fine grained and usually hard and is brown on weathered surfaces. In the southeastern part of the quadrangle it is steeply upturned, and, except where locally worn down by Boggy Creek, it forms narrow sharp ridges. In the southwestern corner the dips are low and the rocks softer, and the ridges, while wider than in the southeastern part, are lower. The branches of Clear Boggy and Goose creeks cut many gaps in the low ridges, and near the western border of the quadrangle the sandstone is completely concealed in the bottom land.

Horizons of the lowest coal bed of the Choctaw field.

At the center of the southern portion of T. 1 N., R. 9 E., the outcrop of Hartshorne sandstone comes to an end. The rocks are broken by a fault here so that the rocks above the Hartshorne sandstone on the north side are brought in contact with rocks below it upon the south side.

McAlester shale.—Shale, sandstone, and clay comprise this formation, which is estimated to be nearly 2000 feet thick in the eastern part of the quadrangle. The formation becomes thinner westward by a gradual decrease in thickness of both the shale and sandstone beds. Near the western border of the quadrangle the formation does not exceed 1500 feet, and the total thickness of the shales is nearly ten times that of the sandstones. The shales are laminated and are blue and black when freshly exposed. They are chiefly clay shales though sandy shales and shaly sandstones occur interstratified with them. Two local beds of sandstone in the lower half of the formation, separated by nearly 400 feet of shaly strata, outcrop in low ridges near the border of the quadrangle southwest of Coalgate. Two or more thin beds of sandstone occur also in the upper part of the formation, and in places make low hills, but their ledges usually do not outcrop. The sandstone beds are but little exposed in the areas near the southwestern and southeastern corners of the quadrangle because the formation occurs in the nearly level creek valleys. In the area about Coalgate and in the small inlier in the east-central part of the quadrangle only the upper 200 to 500 feet of the formation are exposed.

There are two coal beds in the McAlester shale; one at the base and the other about 200 feet below the top. Both of these beds are of workable thickness and the upper one is extensively mined in the vicinity of Coalgate and at Lehigh, 5 miles south. The coals in this formation will be considered under the heading "Economic geology." An interesting feature, however, of the Lehigh coal, which is the upper bed and the one mined extensively at Lehigh and Coalgate, is the shale bed which forms its roof. This is a black bituminous shale about 18 inches thick which is filled with molluscan shells and the teeth and scales of fish.

Horizon of the Lehigh coal.

The surface of the area occupied by the McAlester shale is a smooth gently undulating prairie land except the two narrow areas in the southeastern and southwestern parts of the quadrangle which lie along the valleys of North and Clear Boggy and Goose creeks. The immediate flood plains of these streams are densely wooded, but the land beyond is prairie with timber interspersed.

Savanna sandstone.—Above the McAlester shale there is a succession of sandstones and shales about 1150 feet thick. The shale beds combined are probably thicker than the sandstones, but the latter are better exposed and their presence is so strongly impressed upon the observer in the prominent ridges which they make that sandstone seems to be a more appropriate term to apply to the formation. There are five, and in some places more, groups of sandstone beds which vary in thickness from about 50 to nearly 200 feet, those at the top and near the base of the formation being generally thicker than the intermediate ones. These beds are so nearly alike in physical appearance that they may be distinguished only by their position in the section, by their thickness, or by the fossil remains which some of them contain. They are generally brown or grayish in weathered exposures and are fine grained and compact, except in very limited localities where they contain an element of chert. In the eastern part of the quadrangle the uppermost sandstone occurs in two members 50 to 100 feet thick separated by a thin variable bed of clay shale and often contains quite massive layers which are in places ripple marked. The formation as a whole becomes thinner from east to west across the quadrangle. The sandstone beds are thicker and generally harder in the more eastern exposures. In the northern part of the Lehigh Basin between Coalgate and North Boggy Creek many of the sandstone beds of the Savanna formation contain considerable quantities of subangular chert pebbles. In places these chert deposits are so abundant as to form beds of conglomerate.

Along the northwestern side of the Coalgate anticline, west of Coalgate, thin siliceous limestones are found associated with the highest sandstone horizon of the Savanna formation. In the local flat syncline which occurs in the southeastern corner of T. 1 N., R. 9 E., these calcareous beds become impure limestones containing abundant fossil remains. These shelly limestones of variable texture are also found at the top of the Savanna sandstone along the north side of Clear Boggy Creek Valley and continue to the western border of the quadrangle.

In the outcrop of the formation in the eastern part of the quadrangle the sandstone beds are most prominent and produce many low parallel ridges which are separated by the smooth and relatively wide shale valleys. The sandstone ridges are generally occupied by strips of forest while the valleys are prairie or glady timber land. In the western part of the quadrangle the sandstone beds generally dip at low angles so that the ridges are less prominent and there is less diversity in the landscape.

No coal of any importance has thus far been located in the Savanna formation. It was reported that coal beds had been found in the vicinity of Nixon and at other localities in the western part of the quadrangle, but their thickness and extent were not determined.

Boggy shale.—Above the Savanna sandstone there is a mass of shales and sandstone interstratified aggregating a thickness of 1200 to 2000 feet. This collection of strata has been named the Boggy shale because of the broad extent of their outcrop in the Boggy Creek valleys. There are probably in the formation not less than 20 sandstone beds, ranging in thickness from thin strata to probably 50 feet and separated by shales which in some places exceed 600 feet.

The sandstones vary but little in physical character, and are generally brownish or gray, and in places rather ferruginous. The shales are exposed only to a very limited extent on account of the generally low relief of the land and the wide, shallow valleys of the streams; but in the few steep slopes and stream cuttings where fresh exposures were observed they consist of laminated, bluish clay shale, containing small ironstone concretions and thin wavy sandstone plates and shaly sandstone beds.

The formation thins from east to west, a result chiefly of the general thinning of the sandstone beds. As the sandstone beds become thinner they become more shaly and some of them more calcareous. Many thin fossiliferous limestone beds are to be found in this formation in the western part of the quadrangle.

This formation, being high in the series of coal-bearing rocks, occurs in the central portions of the synclinal basins and the regions of least disturbance. In the southeastern part of the quadrangle, in the syncline passing northeast through Lehigh, the beds of the outer portion of the areas of this formation dip at angles from 10° to 25° and the sandstones form low concentric ridges. In the larger area, in the central part of the quadrangle, the beds are generally nearly horizontal. By erosion the soft clays and shale beds are removed, leaving the sandstone capping low flat hills and mesas and low gently-sloping ridges with terraces upon the exposed ledges.

As a result of the broad exposures of sandstone and shale due to the low dip of the rocks, there are produced on their surfaces quite extensive stretches of hilly timber land and still broader areas of smooth grassy plains, corresponding respectively to the sandstone and shale areas.

A marked change in the character of the sediments.

Thurman sandstone.—The Thurman sandstone represents the beginning of a marked change in the character of the sediments which were brought into the sea and spread across this region in Carboniferous time. Shales and fine sandy sediments of the Boggy shale are followed by coarse pebbles of white chert mixed with coarse quartz sand forming the Thurman sandstone. After the deposition of this conglomerate, which reached a thickness of about 50 feet in the eastern half of the area now occupied by the Thurman sandstone in the Coalgate quadrangle, finer sands were deposited until a maximum depth of more than 200 feet was attained.

In the northeastern corner of the quadrangle the whole formation is about 250 feet thick, while in the western portion it does not exceed 80 feet. This decrease in thickness is gradual and is accompanied by a similar change in the texture of the sandstone. The conglomerate which in places is 50 feet thick at the east is at the west a mere ledge of pebble rock or may be entirely absent. The sandstone beds in the upper part of the formation, while becoming finer and thinner in texture westward, include beds of shale, and near the border of the quadrangle there are thin beds of impure fossiliferous limestone. The Thurman sandstone dips regularly from 60 to 100 feet per mile northwestward throughout its occurrence in this quadrangle.

East of Caney Boggy Creek the Thurman sandstone crops in a very rugged stony highland about 5 miles in width which terminates on the east in precipitous bluffs capping an escarpment nearly 200 feet in height. West of Caney Boggy Creek the width of the surface is from 2 to 3 miles to within about 6 miles of the western border of the quadrangle where it contracts to an average of less than a mile. The surface, also, grows gradually less rugged toward the west and the south-facing bluffs and escarpments become lower, and instead of the dense forest of oak and pine upon the formation as in the east there is a diversified prairie and timber land.

Stuart shale.—There is a gradual transition upward from the Thurman sandstone through thin beds of shaly sandstone and shale interstratified into the Stuart shale. This formation has a thickness of about 275 feet in the northeastern and central parts of its exposure and about 100 feet in its western part. It is composed of three members, an upper and a lower one of shale separated by a variable sandstone 10 to 50 feet thick. In the central part of the quadrangle a thin sandstone and chert conglomerate lentil occurs in the lower shale member. This lower member of the formation has a nearly constant thickness of about 120 feet from the northeastern corner of the quadrangle southwestward to within 10 miles of the western border where it begins to contract, and at the western border probably does not exceed 50 feet. It is composed chiefly of bluish and black laminated clays. It crops in a level and rolling tract of prairie land which borders the timber belt of the Thurman sandstone on the east. The upper member of this formation is composed of bluish shales and has a thickness of 50 to 120 feet. This shale, unlike the lower member, crops in the steep slopes of the escarpments and hills which are surmounted by the succeeding Senora sandstone, and is, for the most part, wooded and concealed by talus.

The sandstone member of this formation has sufficient thickness to warrant mapping could it be located across the quadrangle. In the eastern half of its outcrop it forms flat-topped ridges and hills with eastward and southward facing bluffs. Westward it gradually changes to thin shaly beds and finally disappears. The whole formation in the western part of the quadrangle is covered for the most part by prairie interspersed with patches of open timber land.

The soils produced from this formation are generally more fertile than those of the shaly strata of the lower formation in the southern part of the quadrangle.

Senora formation.—This formation is composed of interstratified sandstones and shaly beds having a thickness of nearly 500 feet in the northeastern corner of the quadrangle. The thickness of the formation decreases toward the southwest chiefly by the thinning of the sandstone beds until at the western border of the quadrangle it does not exceed 150 feet. The outcrop of the formation in the northern part of the quadrangle averages about 10 miles in width. The lower 320 feet of the formation there is composed almost entirely of sandstone which forms a very rugged and stony highland with sandstone bluffs, in places nearly 100 feet high, along the eastern side. This sandstone grades upward through thin sandy beds into shale strata which are approximately 160 feet in thickness.

Thick sandstones forming a stony highland.

Near the middle of the quadrangle the lower massive sandstone becomes divided and shale beds 20 to 75 feet in thickness appear. With this change in character the surface becomes less rugged and stony. In the western part of the quadrangle the sandstone beds become quite variable in thickness and in their position in the formation. The outcrop of the formation here varies in width from 1 to 4 miles depending chiefly upon the erosion of the streams which cross it. The upper and more shaly member has a variable thickness from 100 to 120 feet in this western part.

In texture the sandstones are generally fine grained and are gray or reddish brown in color. The shales, which occupy the more level land in the western and northern parts of the outcrop, are rarely well exposed and their original physical characteristics were not satisfactorily determined. Bluish clay shales and brownish sandy shales belonging in the upper part of the series, however, are exposed in the deeper cuttings of the streams which flow from the higher land of the succeeding Calvin sandstone.

Calvin sandstone.—Above the Senora formation there is a deposit of massive and thin-bedded sandstone with some shaly beds in the upper part having a thickness of 140 to 240 feet. For nearly 140 feet upward from the base, the rock is a massive but not very hard sandstone. In the northern part of its occurrence this lower and more massive member of the formation crops in the steep hillsides and bluffs overlooking the more level Senora formation toward the east. In the southern part of its outcrop the lower sandy member becomes shaly, and even the massive beds which occur are more friable than the same deposits in the northern part of the quadrangle. Near the middle of this lower sandstone member, west of Sand Creek, there is a shaly and slightly calcareous bed which contains iron in the form of hematite. On account of the bright-red color of the iron upon weathering this bed is a marked feature of the formation.

Bright-red shale colored by iron oxide.

The upper part of the Calvin sandstone is least shaly in the northern part of the area, and many of the beds are hard and weather into slabs and hard plates. The upper 90 to 100 feet of the formation here contains two, and in places more, shaly beds 10 to 20 feet in thickness. The sandstone beds of this upper portion decrease southwestward from 40 feet in thickness to thin layers interstratified with shales.

The land surface of the Calvin sandstone area in the northern part of the quadrangle, especially near the Canadian River, is rugged, being deeply cut by small streams. The soil is thin and poor. Near the western border of the quadrangle, where the rocks are softer and more shaly, the land is gently undulating, and the soil is deeper and more fertile and covered by broken forests.

Wetumka shale.—The shaly beds of the Calvin sandstone grade into the succeeding Wetumka shale, so that the division line between the formations can not be easily determined stratigraphically nor very accurately mapped.

With the exception of thin shaly sandstone layers near the center, the Wetumka shale is composed of friable, laminated clay shales. It is estimated to be about 120 feet thick throughout its occurrence in the Coalgate quadrangle.

From the head of Big Creek to the Canadian River Valley this shale crops in gently rolling prairie land and produces a soil more fertile than is usually found upon other formations in this region. Beds near the top are exposed in many places in the escarpment beneath the sandstone beds of the succeeding Wewoka formation. In the western part of its occurrence the Wetumka shale lies in the nearly level plain of Muddy Boggy Creek Valley.

Wewoka formation.—Above the Wetumka shale there is a succession of massive and, for the most part, friable sandstones and shales, seven in number, in alternate beds 40 to 130 feet thick. These beds together are about 700 feet thick and are named the Wewoka formation, from the town of the same name in the Wewoka quadrangle to the north. The separate massive beds composing the formation are of sufficient thickness to be mapped, but on account of the obscurity of the contact lines, due to the friable nature of the beds, it is not possible to accurately distinguish them.

The lowest of the four sandstone divisions of the Wewoka formation is thinner, though generally harder, than the succeeding ones. At its base there are local indurated beds of sandy chert conglomerate. These conglomerates are most prominent near the western border of the quadrangle where they form bluffs facing Boggy Creek Valley. This group of sandstones and conglomerates becomes thinner eastward and northward, so that its outcrop is hardly perceptible on the border of the Canadian River Valley.

Above this sandstone and conglomerate there is fossiliferous friable blue clay shale for 120 feet, ending locally in thin white fossiliferous limestone. This shale is exposed in many deep gulches bordering the Canadian River on the south, and outcrops in the rolling prairie land between Allen and Leader. Especially good exposures may be seen in the deep ravines in NE. $\frac{1}{4}$ of Sec. 23, T. 5 N., R. 8 E., where abundant fossil shells weather out free and also occur in calcareous clay concretions.

The succeeding sandstone member is about 110 feet thick. It caps the high land near the western border of the quadrangle, south of the Canadian River and forms high bluffs surmounting the escarpments, facing eastward upon the north side of the river. Its beds are massive and friable, breaking down readily into loose sand and weathering into rounded ledges.

Great abundance of well-preserved fossils.

Above this sandstone, and near the middle of the formation, there is a soft fossiliferous blue clay shale nearly 130 feet thick. This shale is remarkable for the abundant and perfectly preserved fossil shells which it contains. Its full section is exposed on the Memphis and Choctaw Railroad, 2 miles north of the mouth of Little River. Above this thick shale there is a sandstone 60 feet thick, which is succeeded by 45 feet of shale. Next above comes the highest sandstone member of the formation, which is estimated to be about 100 feet in thickness. The uppermost beds of this sandstone are shaly and culminate in a shelly sandy limestone. These uppermost strata of the Wewoka formation are concealed for the most part in the valley of Little River, across the northwest corner of the quadrangle.

On account of the friable nature of the sandstone, fine loose sand derived from it is spread over the whole surface of the formation north of the Canadian River, as well as over the western part of its outcrop south of that stream. The soil is a loose sandy loam and the country is covered by heavy forest.

Loose sand derived from the friable sandstone.

Holdenville shale.—This shale, 250 feet in thickness, rests upon the Wewoka formation, and its crop in this quadrangle is limited to a small triangular area in the northwestern corner. The surface of the formation becomes broader northward in the more level country about Holdenville, 3 miles north of the border of the quadrangle.

The formation is composed of friable, blue clay shale, with local thin beds of shelly limestone and shaly calcareous sandstone in the upper part. The sandstone ledges outcrop in terraces around the slopes of the hills bordering the north side of Little River. The thin limestone occurs about 35 feet below the top of the formation, and its outcrop is usually covered by the sandstone and conglomerate débris from the overlying formation. In its usual exposure 1 to 2 feet only of shaly limestone may be seen. At other places a bed of shell breccia loosely cemented is found, representing the thin hard plates of the shelly rock. The shales are rarely exposed. The smooth, grass-covered prairie soil, however, even in the steep slopes, bears evidence of the friable shale beneath.

Chert conglomerate the highest rock exposed.

Seminole conglomerate.—About 50 feet of the lower part of the Seminole conglomerate is exposed in a small area in the northwestern corner of the Coalgate quadrangle. This part of the formation is composed of laminated or stratified subangular chert, with a sprinkling of quartz pebbles from 3 inches in diameter to small grains in a cement of fine brown and usually ferruginous sand. The coarser conglomerate in the beds at the base is loosely cemented and on weathered surfaces it breaks down into rounded bowlders and loose gravel. Forty to 50 feet from the base the conglomerate grades into brown sandstone which continues upward about 100 feet to the top of the formation. The Seminole formation crops in a rugged hilly country northwestward in the Seminole Nation, making rough timbered lands.

NEOCENE.

Scattered deposit of coarse pebbles.

In many places in this region, and at various altitudes from the hilltops down to the present stream valleys, there is a scattered deposit of coarse, hard, well-rounded pebbles, 1 to 4 inches in diameter. They are composed chiefly of quartz and quartzite, and many have become rough or pitted upon the surface and are partly disintegrated through long exposure. These pebbles are found here upon the eroded edges of Carboniferous rocks, and 20 miles south upon Cretaceous rocks. They are too thinly spread over the surface to be mapped, and it is not believed that they now occupy the position of their original deposits, since they occur as abundantly on the low land as on the high. The age of these pebbles is problematical. Some of them at least are of much later age than the Cretaceous, and others are as old or older than the Guertie sand, a well-defined deposit of Neocene or more recent age.

Remnants of elevated sand and gravel deposit.

Guertie sand.—At some remote time, yet of recent geologic age, a river flowed across the Coalgate quadrangle in a southeasterly direction from where Canadian River now enters it at the western side. The river at that time flowed about 100 feet above the present level of Canadian River, and the remnants of the deposit of sand and gravel have an extreme thickness of about 50 feet and a width of nearly 3 miles. The plain of the old river channel has an even grade eastward of about 4 feet per mile. This plain is practically parallel with the present grade of Canadian River. The sand, like that of the present Canadian, is spread evenly over the edges of older rocks, hard and soft alike.

It is evident that Canadian River once occupied this old channel. Since the change to its present course the streams upon the south that flow into Red River have migrated northward, capturing the larger part of the old channel. Caney Boggy, Panther, and Sand creeks may be noted as instances of streams which have migrated northward, the source of Caney Boggy being at present

10 miles north of the old river channel. These streams have also eroded their valleys nearly 100 feet below the level of the Guertie sand.

The upper part of the Guertie sand is composed of very fine yellow sand or siliceous silt, resembling very much the sand now being transported and deposited by Canadian River. Near the borders of the old channel, which probably were covered by water only in times of flood, the deposit is usually thin and is entirely of fine material. Generally the sand becomes coarse downward, ending in gravel at the base. In many places the finer sediments have been washed away, leaving beds of coarse gravel and thin mantles of pebbles. In places the deposit is of even texture; in other places it grades gradually from fine to coarse materials; and in still other places especially noted in well sections, there are alternate strata of bluish, red, and yellow clay, silt, and sand, usually ending at the base in quicksand or gravel.

The sand is composed of fine white quartz which is usually more or less mixed with yellow silt. The pebbles of the gravel are well rounded and smooth, varying in size from that of a hen's egg to a sand grain. They are composed of quartz, quartzite, jasper, and chert, and vary in color from white to yellow, red, and black. Very little material from the country rock, such as limestone, shale, and sandstone, was found mixed with the gravel.

The gravel, where of considerable thickness, and the purer sands are usually covered by forest, and the finer silts and clays by prairie or open forest.

PLEISTOCENE.

River sand.—All the large creeks and rivers in the Coalgate quadrangle deposit sediments in their flat valleys during times of flood. With the exception of Canadian River these streams collect their sediments from the soil of the region, and when laid down it is in the form of fine sand and clay silts. These silts are generally thin and blend with the residual clay soils of the bed rock, and are not of sufficient importance to be mapped.

Toward its source Canadian River flows across late Carboniferous and younger formations in the plains of Oklahoma, north Texas, and New Mexico, from which it derives large quantities of fine sand. The amount of this sand brought down has been more than it could carry, and, as a result, its channel, in the region of the Coalgate quadrangle, is choked and filled to a depth of nearly 40 feet, so that at no place does the river touch the country rock. An estimate of the depth of the sand was obtained from excavations made for bridge piers at Calvin, where the Canadian crosses the Calvin sandstone, its greatest barrier in this region. All of the material at present brought down by the river is composed of fine yellow sand and silt and chocolate-colored clays.

STRUCTURE OF THE ROCKS.

All stratified rocks, especially those of broad extent, were laid down in nearly horizontal positions beneath the water. Their elevation into land and their tilting, folding, and breaking are due to forces of deformation within the earth. Simple tilting of the strata in one direction is termed monoclinal folding; bendings upward into arches and domes and bendings downward into troughs and basins are termed anticlines and synclines, respectively. When the strata are broken and displaced they are said to be faulted. All these kinds of deformation have affected the rocks of the Coalgate quadrangle, and occurred during the Carboniferous period and immediately after.

STRUCTURE SECTIONS.

The folding and faulting which occur in this district are graphically shown on the Structure Section sheet. The sections represent the earth cut vertically along the lines above the sections to a depth of 2500 feet below the level of the sea, the face of the cut being presented to view. By taking the McAlester formation as it is shown in each section, a fair idea of the folding may be obtained, except that in the very greatly folded area in the southeast corner of the quadrangle.

In section A-A the McAlester is not exposed at the surface, but the anticlinal uplift at the southeastern end of the section brings it to the surface to the west. In section B-B the top of the formation, could it be restored, would be 1000 feet above the present level of the land in the valley of Coal Creek and probably 3000 feet above the surface at the great fault near the southeastern end of the section. Southeast of this fault the section shows steeply inclined and faulted strata which occur below the McAlester formation and which have been thrust upward and forward to the northwest. In a similar way the southern end of section C-C shows an uplift which strongly tilts the McAlester shale and associated formations. This structure is part of an uplift of peculiar folding and faulting, in which the Arbuckle Mountains to the southwest are involved, and is but imperfectly represented in this quadrangle.

All the structure sections show the northern two-thirds of the quadrangle with evenly inclined strata dipping at a very low angle toward the northwest.

STRUCTURAL PROVINCES.

The rocks of the Coalgate quadrangle have been affected by forces producing four distinct forms of folded structure occupying separate areas. These areas are but small parts of structural provinces which extend toward the north, east, and west, and which coincide practically with the geographic provinces referred to under the heading "General relations." In this discussion it will be convenient to use the same titles applied there.

OUACHITA UPLIFT.

This uplift is limited on the north by the border of the Ouachita Range, which extends through southwestern Arkansas and southeastern Indian Territory to the vicinity of Atoka. The folds in the central portion of the range, both in Arkansas and in eastern Indian Territory, bear nearly east and west. Near the western end of the uplift the folds, both large and small, curve gradually from east-west to north-south until they are lost beneath a covering of nearly flat Cretaceous sediments. The southern portion of the range is worn down and concealed by these Cretaceous deposits. The northern half of the uplift in Indian Territory contains a great number of overlapping, nearly parallel, narrow folds which have been formed by northward and westward thrusts and in many instances have been overturned and broken.

The northern part of this much folded belt of the Ouachita uplift crosses the southeast corner of the Coalgate quadrangle, and bears southwestward. In Indian Territory this greatly folded belt is limited on the north abruptly and definitely by a very extensive fault. This great displacement, to be referred to as the Choctaw fault, separates the more gently folded northwestward-dipping rocks on the northwestern side from the older, overthrust, southeastward-dipping rocks on the southeastern side.

The Choctaw fault.

The Wapanucka limestone, which crops in Limestone Ridge, is the south limb of an anticlinal fold, of which the north limb is cut off by the fault. The same limestone occurs in the McAlester quadrangle, to the east, in many folds similarly broken by faults. At the southern end of Limestone Ridge the limestone is cut off by an eastward trend of the fault and is not exposed south of this locality.

The Chickachoc chert lentil and associated strata of the Atoka formation southeast of the limestone ridge have been compressed into many narrow, parallel folds, overturned toward the northwest, and overthrust by faulting so that all the rocks dip steeply toward the southeast. These folds are cut off toward the southwest by the Choctaw fault, and the combined forces which operated at the intersection of these structures have crumpled the rocks into many peculiar structural forms.

ARBUCKLE UPLIFT.

The western part of this uplift is coincident with the Arbuckle Mountains. The rocks of the eastern part have been worn down to the Cretaceous base-level, and are in part concealed at the southeastern border by nearly flat Cretaceous deposits.

During early Carboniferous time the region of the Arbuckle Mountains remained at a low level and may have been covered by the sea. At the beginning of the Coal Measures epoch the western part of the district was apparently uplifted into a mountainous country from which the streams, flowing into the sea, brought great quantities of limestone débris, which formed limestone conglomerates along the northern and southern sides of the uplift west of the Coalgate quadrangle.

At this time the Wapanucka limestone and many succeeding beds were formed. A short time after the close of the Carboniferous period the whole Arbuckle region was elevated, and thousands of feet of Carboniferous rock as well as the central mass of older limestone and granite which are now exposed in the center of the uplift were tilted, folded, and faulted.

This uplift is a broad, wrinkled and broken anticline. The strata on both sides, including many formations of Carboniferous and older rocks, dip steeply away. The central part of the uplift is composed of several broad, shallow folds. The anticlines, wherein are exposed a great thickness of massive lower Silurian limestone, are generally unbroken; while the younger, softer, and thinner rocks in the intervening synclines have been crumpled into many small folds. These have been subsequently broken and displaced by tension or normal faults.

Normal drop faulting in the Arbuckle region.

The northern limb of one of these anticlines passes across the southwest corner of the quadrangle. The fault which extends along the northern side of this fold enters the quadrangle in Goose Creek Valley and dies out eastward in the Coal Measures shale. The rocks on the north are thrown downward, so that the sandstone and shale beds at the base of the Atoka formation upon the southern side end against the fault, while the shales near the top of the formation upon the northern side extend parallel with the fault. The wavy outcrop of the Wapanucka limestone in the southwest corner is due to small local, steeply pitching folds or wrinkles in the side of the broader anticline.

Another fault of the same nature as the one just described, 5 miles farther south, yet upon the northern limb of the same broad anticline, enters the quadrangle at the southern border, in Clear Boggy Creek Valley. This fault, with other small associated faults, bears northeastward toward Coalgate and dies out in the strike of the rocks. The northern limb of this anticline, which strikes eastward at the southern border of the quadrangle, coalesces with the northern limb of the Coalgate anticline which bears toward the northeast from this point.

ARKANSAS VALLEY FOLDS.

The structure of the Arkansas Valley region is a direct northward continuation of the Ouachita uplift, but the folds are generally flatter, having received in a less degree the force of deformation. In Arkansas and eastern Indian Territory there is a gradual change northward from the overthrust broken folds into the more symmetrical structures of the Arkansas Valley region. In the western part of the Ouachita uplift, as has been stated and as may be seen in a marked degree in this quadrangle, there is an abrupt change from the narrow, overturned, and broken folds to the wide, flat, and more symmetrical structure.

The folding of the Arkansas Valley region in eastern Indian Territory decreases gradually into the very slightly undulating structure of the immediate valley of the Arkansas River. Thus, beginning at the north, the folds gradually decrease in intensity westward and merge, one after the other, into the monoclinal structure of the Prairie Plains.

The Savanna anticline is one of the last of this series and is the northernmost fold in the quadrangle. It crosses the east central part of the quadrangle and then bears northeastward across the McAlester quadrangle and joins the McAlester anticline in the vicinity of Alderson. In the Coalgate quadrangle it pitches east and west from a dome-like uplift near its western end, and the rocks on the northern side have much steeper dips than on the southern side. This arch flattens out in Caney Boggy Valley and disappears near the middle of the quadrangle in the monoclinal dip to the northwest.

Savanna anticline.

From a wide, indistinct fold at the southern border of the quadrangle the Coalgate anticline contracts and pitches toward Coalgate and then rises beyond in an elongated dome-like arch in Coal Creek Valley. Beyond Coal Creek it pitches rapidly northeastward for 2 miles and then the axial portion becomes nearly level and continues so to near the end of the fold, where it is lost in the south limb of the Kiowa syncline in the McAlester quadrangle. The rocks on the northern side of this arch also have steeper dip than on the southern side. This is especially the case west of Coal Creek.

Coalgate anticline.

The Kiowa syncline, which, within the Coalgate quadrangle, lies between the Savanna and Coalgate anticlines, bears eastward across the McAlester quadrangle for 30 miles. Beyond Kiowa the basin first grows deep and broad and then contracts and becomes flat, ending at the east in the form of a spoon in the Hartshorne basin. At the border of the Coalgate quadrangle the syncline is narrow and shallow. Westward it becomes broader and still shallower until it is lost in the undulating but gently northward-dipping rocks, north of Coalgate.

Kiowa syncline.

The Lehigh basin or syncline lies between the Coalgate anticline and the Choctaw fault. Like the Coalgate fold, its eastern end begins in the southern limb of the Kiowa syncline, a few miles east of the quadrangle. It is unsymmetrical, the rocks on the southeastern side having been steeply upturned by the northwestward thrusts accompanying the adjoining fault. From the northeastern end to a point east of Coalgate it is narrow and shallow. Southward it becomes very much broader, changes its course from southwest to south, and pitches downward, making a deep oval basin which ends in the vicinity of Atoka, 8 miles south of the quadrangle.

Lehigh syncline.

The rocks of the coal-bearing McAlester shale on the eastern side of this basin dip at angles of 50° to 80°, while on the western side the dip does not exceed 5°. The beds at the top of this formation on the western side when followed downward are found to increase in dip to nearly 15° within 2 miles and then gradually to decrease, finally reaching a horizontal position at the center of the basin.

PRAIRIE PLAINS MONOCLINE.

As each successive fold of the Arkansas Valley type comes to an end at the western border of the Arkansas Valley Region, it gradually changes from an anticline or syncline, as the case may be to a northwestward-dipping monocline. This border of transition from folded to northwestward-dipping rocks is the southeastern limit of the Prairie Plains structure, which continues with slightly varying inclination across Oklahoma and Kansas to the eastern uplifts of the Rocky Mountains.

The monoclinal structure then, in the northern half of the Coalgate quadrangle, is a small part of the southern border of a great province of similar structure. Beginning with the Thurman sandstone, the succeeding formations incline toward the northwest at an even dip or grade of nearly 100 feet per mile. The formations shown on the map are the exposed edges of these inclined strata.

MINERAL RESOURCES.

The mineral resources of this region are coal, limestone, sandstone, and clay. The coal is the only product that has been developed to any considerable extent. The limestone and sandstone have received less attention, and the clays none at all. In a region generally undeveloped, as this is, and under such civil conditions as have existed in Indian Territory, it is probable that no mineral product would be developed except under assurances of considerable profit.

All of the deposits of economic value in this region are stratified and may be definitely located in the formations which are outlined on the map. Those formations which contain the most profitable beds of coal, limestone, and sandstone are emphasized on the economic sheet. Nothing very definite is known of the qualities of the clays. Special tests are required to determine whether a clay will produce fire brick, for instance, or may be serviceable in the manufacture of cement, or is suitable for other purposes to which clays are adapted. Clays occur in most of these formations in great quantity, and it is deemed important to point out their occurrence and condition of structure, so that in the future those who wish may investigate them to the best advantage.

COAL.

There are two beds of coal of workable thickness both of which are in the McAlester shale. One occurs very near the base and the other about 250 feet below the top of the formation.

Atoka coal probable equivalent of the Hartshorne bed.

The lower bed, which is known locally as the Atoka coal, is about 4 feet thick and has shale in contact both above and below. This coal occupies the same stratigraphic position as the Hartshorne coal which is worked extensively in the eastern part of the Choctaw Nation. It has been worked in this vicinity at what is known locally as the Hickory Hill mine, which is near the south end of the Lehigh Basin, 9 miles south of Coalgate. The coal at this mine dips to the northeast about 5°. It has been prospected at many places east and west of the mine in the southeastern part of the basin. Coal at this horizon crops on the south side of Clear Boggy and Goose Creek valleys and has been prospected at Oconee and a number of other places. The dip of the coal and associated rocks is about 7° northward. In the southeastern part of the quadrangle the rocks at this coal horizon dip 60° to 80° to the northwest, but the coal is not known to occur here. If it should be found, however, it probably could not be successfully or profitably mined on account of the steep dip of the rock and the swampy condition of the land.

Hickory Hill mine.

The coal as it occurs at the Hickory Hill mine, now being worked by sloping down 600 feet, is laminated and breaks in mining into cuboidal blocks. In the joints of the coal and in places in the laminæ there are thin filaments of iron sulphide, and near the surface there is sulphate of lime. The coal is highly bituminous and is used chiefly for steam purposes.

Lehigh coal bed.

The upper coal in the McAlester shale is known locally as the Lehigh bed on account of its most extensive development at the town of Lehigh, 3 miles south of Phillips. This coal runs regularly about 3½ feet in thickness and is without shale partings, as far as known. It is not known in the southwestern part of the quadrangle because its crop occurs in the swamps of Clear Boggy and Goose Creek valleys. It crops in Coal Creek, 2 miles west of the border of the quadrangle, but the full thickness of the coal was not exposed.

In the southeastern part of the quadrangle rocks at the horizon of the Lehigh coal crop in the hill slopes facing North Boggy Creek and dip to the northwest 15° to 40°. The coal has not been prospected and its condition is not known. The dip increases to 60° at the southern border of the quadrangle, and so continues throughout the eastern side of the Lehigh Basin. On the western side of the basin the coal is well disposed structurally, dipping to the east about 4°. It is actively mined at Lehigh, Phillips, and Coalgate. It pitches eastward beneath the surface in the center of the arch at Coalgate, but rises again in about a mile. From the vicinity of Coalgate eastward the dip of the coal on the southern side of the arch is 10° to 15°, while on the northern side it is much steeper. No mining has been done east of Boggy Creek. From Coalgate southwestward to Clear Boggy Creek the coal dips toward the northwest at about 25°. It is not known whether the coal occurs in the small area of the formation exposed in the dome-like uplift in the east-central part of the quadrangle. It is believed, however, that the coal should crop in the central part of this area.

Character of the Lehigh coal.

In physical appearance the Lehigh coal is laminated and breaks in mining into good-sized cubical blocks. Thin filaments of iron sulphide and sulphate of lime occur occasionally in the joints of the coal. It is highly bituminous, the percentages of the fuel constituents of the coal being carbon 41.12 and volatile combustible matter 41.61. There is 13.7 per cent of ash 4.5 and per cent of sulphur. These results are from an analysis of the coal taken from shaft No. 5, at Lehigh, about 200 feet beneath the surface.

Coal of workable thickness in the Savanna formation is reported in the vicinity of Nixon by prospectors, but it has never been opened, neither has its quality been tested.

LIMESTONE.

The Wapanucka limestone is the only formation in this quadrangle containing lime of any importance. The formation crops in limestone ridges from the southeast corner of the quadrangle northeastward across the McAlester quadrangle and from the southwest corner southeastward nearly to the center of the Atoka quadrangle. It occurs in ample abundance for any purpose to which it may be applied. The beds of purer limestone occur in the upper part of the formation, and these may be utilized in the manufacture of lime. These beds are rather hard, and they may be found in dimensions which render them economically workable for foundations, bridge piers, and for general building purposes. The middle and lower beds contain chert and are interstratified with chert and sandy layers, and they may be used profitably for road material. The Missouri, Kansas and Texas Railroad has established a crushing plant at Chickachoc switch, near the eastern border of the quadrangle, and has utilized the limestone and chert very extensively for its road ballast. The limestone beds which occur locally in the Savanna, Wewoka, and Holdenville formations are too thin to be profitably utilized.

SANDSTONE.

Beds of sandstone occur in the Savanna, Boggy, Thurman, Senora, and Calvin formations which may be serviceable in many ways as building materials. Many of the beds, and especially some of those of the upper part of the Savanna formation, produce excellent building stone. The color of the Savanna stone is yellowish or reddish brown, and the beds are evenly stratified and moderately hard. This stone is quarried successfully in large quantities for dwelling and business houses in South McAlester, in the adjoining quadrangle, where the Missouri, Kansas and Texas Railroad crosses the formation. The thinner and harder beds in this and the Boggy formation will serve as paving materials. The Thurman, Senora, and Calvin formations, especially in their northern parts, contain stone which may be utilized for various building purposes. Certain sandstone strata in the central part of the Stuart formation also may contain beds of workable stone. In the southern and western parts of the outcrop of these formations the sandstones are generally softer, the sand grains which compose them being less strongly cemented together. All of the sandstone beds referred to are fine grained, and yellowish or reddish brown in color. The cementing material which binds the sand is composed either of silica or of silica and oxide of iron together. In the lighter-colored stones the cement is chiefly silica, while in the darker it is in large part an iron oxide. Both are very durable in color as well as strength.

CLAY.

Clay and shale are the most abundant of the three great classes of rocks which occur in this region. They are found in thin strata and of local extent in the Wapanucka limestone, Hartshorne sandstone, Thurman sandstone, Calvin sandstone, and Guertie sand. In all the other formations, except the Seminole conglomerate, beds of clay and clay shale occur in great abundance. These vary in quality from very sandy strata to purer varieties of finely laminated clays.

Associated with coals, usually at their lower contact, are beds of almost structureless blue clay. These beds are not generally thick, but the clay may prove valuable in the manufacture of firebrick. These and other clays associated with the coals may be utilized more economically than others because of their proximity to fuel.

The clay shales vary in hardness usually with the amount of sand and other impurities contained in them. The more impure varieties are almost stony in hardness, while the purer kinds are friable and upon slight weathering are often plastic.

The structure of the formations in which the clays occur has been sufficiently explained, it is believed, to show where they may be profitably exploited.

March, 1901.

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

TOPOGRAPHIC SHEET

INDIAN TERRITORY
COALGATE QUADRANGLE

LEGEND

RELIEF
(printed in brown)

Figures
(showing heights above mean sea level instrumentally determined)

Contours
(showing height above sea, horizontal form, and steepness of slope of the surface)

DRAINAGE
(printed in blue)

Streams

Intermittent streams

Lakes and ponds

Fresh marshes

CULTURE
(printed in black)

Roads and buildings

Railroads

Bridges

Fords

County boundary lines

U.S. township and section lines

Triangulation stations

Bench marks

C.H. Fitch, Topographer in charge.
Van H. Manning, Topgr. Asst. in charge.
Triangulation by C.F. Urquhart.
Topography by C.F. Cook, C.W. Goodlove,
R.A. Farmer, J. Ahern, and D.C. Harrison.
Surveyed in 1895-96.

Scale 1/125000

Contour interval 50 feet.

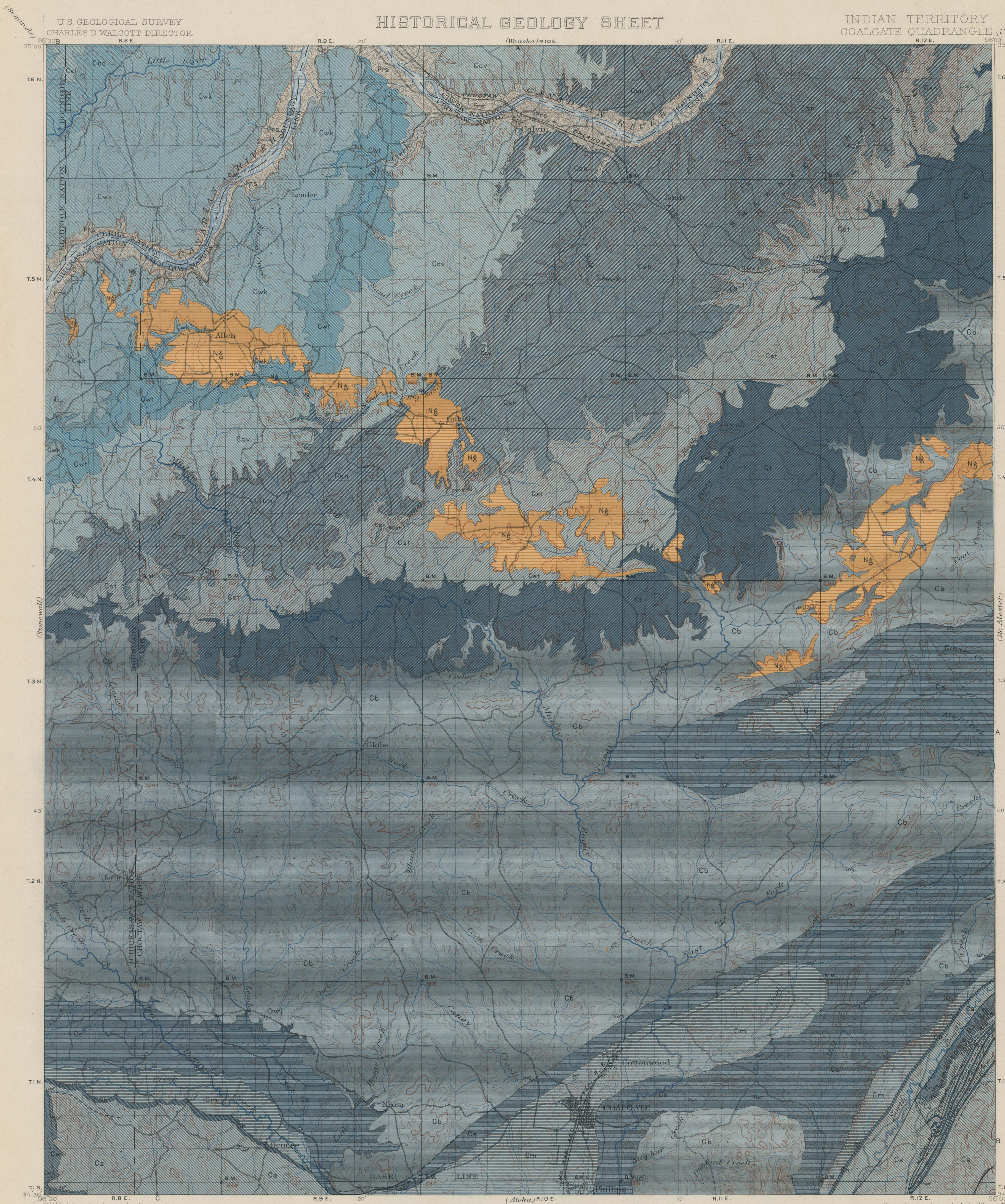
Datum is mean sea level.

Edition of Nov. 1900.

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

HISTORICAL GEOLOGY SHEET

INDIAN TERRITORY
COALGATE QUADRANGLE



LEGEND

SURFICIAL ROCKS

(Areas of Surficial rocks are shown by patterns of dots and circles.)

PLEISTOCENE

Prs — River sand (fine yellow sand and alluvium)

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

NEOCENE ?

Ng — Guertie sand (unconsolidated silt, sand, and gravel on benches above the present drainage)

CARBONIFEROUS

Csl — Seminole conglomerate (sandstone and chert conglomerate)

Chd — Holdenville shale (blue clay shale with thin limestone and sandstone)

Cwk — Wewoka formation (massive soft sandstone and blue clay shale)

Cwt — Wetumka shale (shale and thin sandstone with thin limestone at the top)

Ccv — Calvin sandstone (massive sandstone changing to sandstone and shale toward the west)

Csn — Senora formation (massive sandstone with shale above; becomes shaly toward the west)

Cst — Stuart shale (blue and black clay shale with sandstone near the middle)

Ct — Thurman sandstone (conglomerate, shale, and sandstone changing to shale and thin sandstone in the western portion)

Cb — Boggy shale (shale with many thin sandstone beds and coal in lower part)

Cs — Savanna sandstone (brown sandstone, shaly sandstone, and shale)

Cm — Mc Alester shale (blue and black shale, thin sandstone, and coal)

Ch — Hartshorne sandstone (brown, thick- and thin-bedded sandstones)

Ca — Atoka formation (shales and thin sandstone)

Cc — Chickachoc chert lentil (white calcareous cherty sandstone in the Atoka formation)

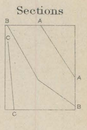
Cw — Wapanucka limestone (massive white limestone, cherty blue limestone, and shale)

Ccy — Caney shale (blue clay shale and fissile black shale with blue limestone segregations)

Observed faults

Probable faults (approximate location)

Sections

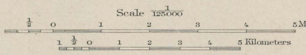


20° Dip and strike of stratified rocks

Vertical dip and strike of stratified rocks

C.H. Fitch, Topographer in charge.
Van H. Manning, Topogr. Asst. in charge.
Triangulation by C.F. Urquhart.
Topography by C.F. Cook, C.W. Goodlove, R.A. Farmer, J. Ahern, and D.C. Harrison.
Surveyed in 1895-96.

Scale $\frac{1}{125000}$



Contour interval 50 feet.
Datum is mean sea level.
Edition of April 1901.

Geology by Joseph A. Taff.
Assisted by George I. Adams.
Surveyed in 1898.

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

ECONOMIC GEOLOGY SHEET

INDIAN TERRITORY
COALGATE QUADRANGLE

LEGEND
(continued)

20° Dip and strike of stratified rocks
Vertical dip and strike of stratified rocks

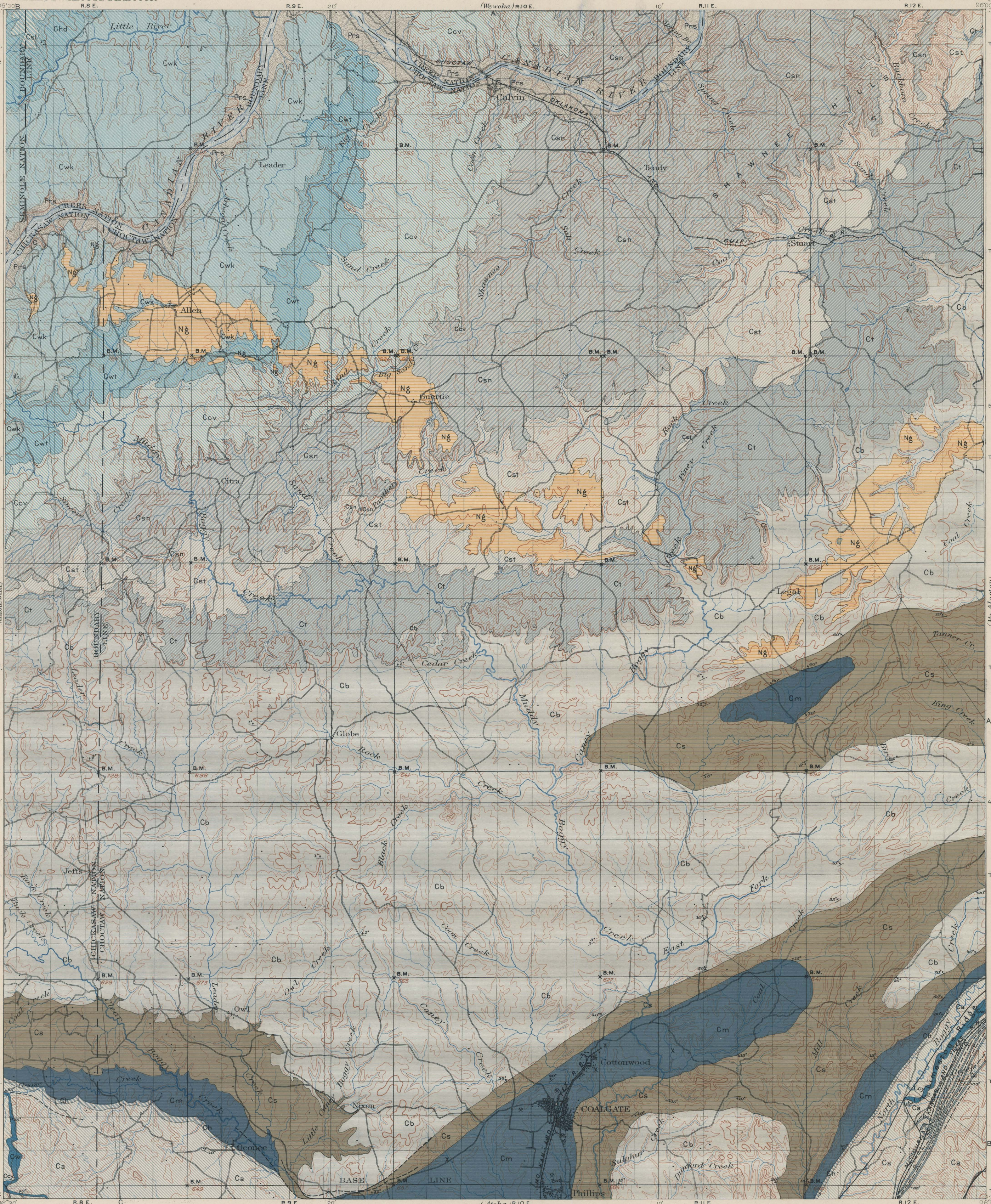
⚒ Coal mines
× Coal prospects

Known productive formations

Cm — **Coal** (Mc Alester shale contains workable coal beds)

Cw — **Limestone** (Wapanucka limestone suitable for lime and building stone)

Cs — **Building stone** (Savanna sandstone suitable for building)



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LEGEND

SURFICIAL ROCKS
(Areas of Surficial rocks are shown by patterns of dots and circles.)

PLEISTOCENE

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SEDIMENTARY ROCKS
(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

NEOCENE ?

Ng — **Guertie sand** (unconsolidated silt, sand, and gravel on benches above the present drainage)

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Cwt — **Wetumka shale** (shale and thin sandstone with thin limestone at the top)

Ccv — **Calvin sandstone** (massive sandstone changing to sandstone and shale toward the west)

Csn — **Senora formation** (massive sandstone with shale above, becomes shaly toward the west)

Cst — **Stuart shale** (blue and black clay shale with sandstone near the middle)

Ct — **Thurman sandstone** (conglomerate, shale, and sandstone changing to shale and thin sandstone in the western portion)

Cb — **Boggy shale** (shale with many thin sandstone beds and coal in lower part)

Cs — **Savanna sandstone** (brown sandstone, shaly sandstone, and shale)

Cm — **Mc Alester shale** (blue and black shale, thin sandstone, and coal)

Ch — **Hartshorne sandstone** (brown, thick- and thin-bedded sandstones)

Ca — **Atoka formation** (shales and thin sandstone)

Cc — **Chickachoc chert lentil** (white calcareous cherty sandstone in the Atoka formation)

Cw — **Wapanucka limestone** (massive white limestone, cherty blue limestone, and shale)

Ccy — **Caney shale** (blue clay shale and fissile black shale with blue limestone segregations)

Observed faults

Probable faults (approximate location)

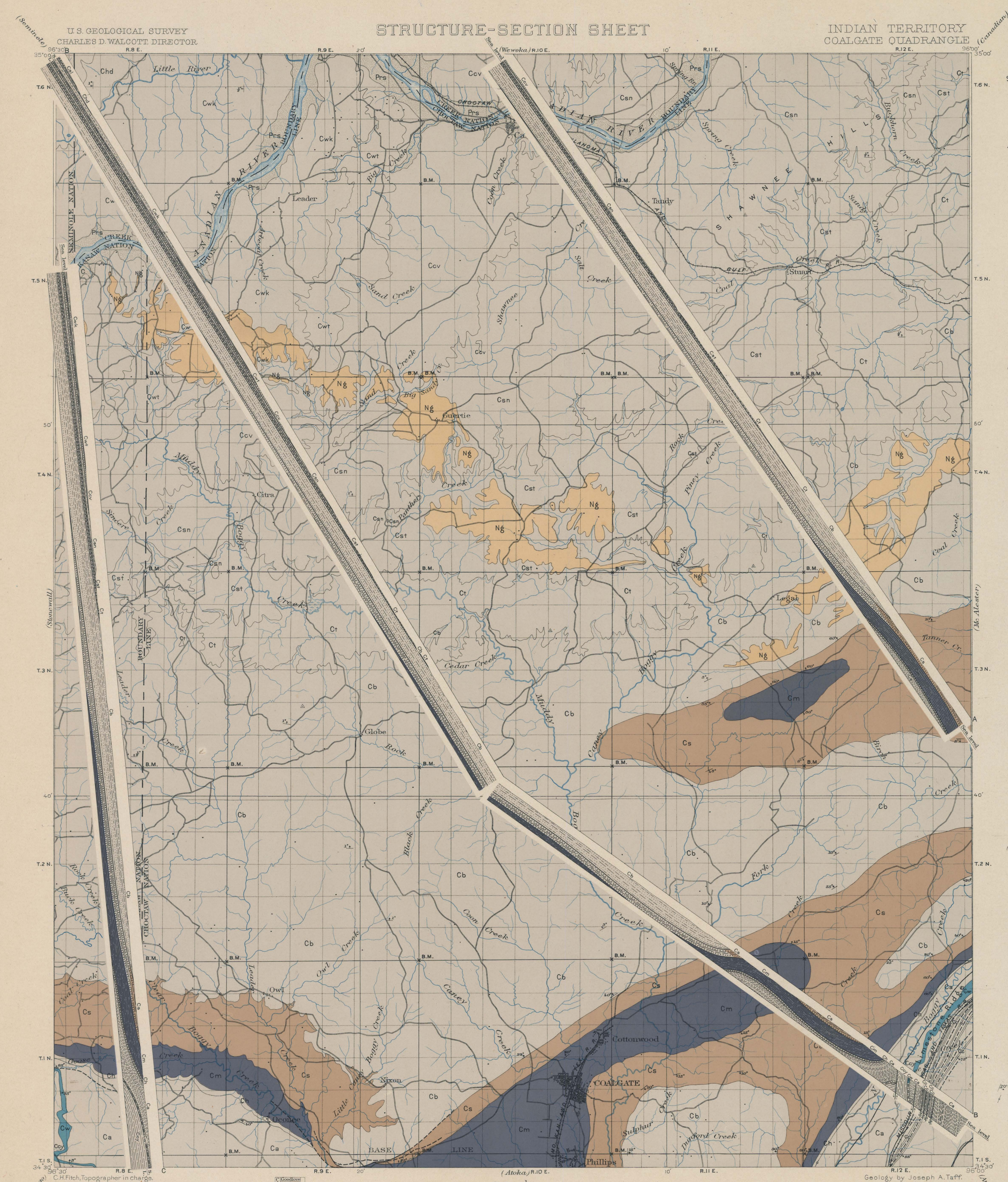
Sections

Legend is continued on the left margin.

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

STRUCTURE-SECTION SHEET

INDIAN TERRITORY
COALGATE QUADRANGLE



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Scale $\frac{1}{125000}$

Edition of May 1901

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LEGEND

SURFICIAL ROCKS

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NEOCENE?

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- Ccy — Caney shale (blue clay shale and fissile black shale with blue limestone segregations)

Observed faults

Probable faults (approximate location)

Dip and strike of stratified rocks

Vertical dip and strike of stratified rocks

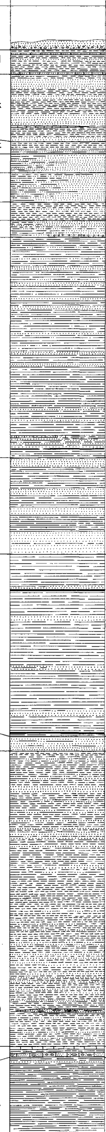
Known productive formations

- Cm — Coal (Mc Alester shale contains workable coal beds)
- Cw — Limestone (Wapanucka limestone suitable for lime and building stone)
- Cs — Building stone (Savanna sandstone suitable for building)

COLUMNAR SECTION SHEET

GENERALIZED SECTION FOR THE COALGATE QUADRANGLE.

SCALE: 1 INCH = 1000 FEET.

Period.	Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography and Soil.
CARBONIFEROUS	Seminole conglomerate.	Csl		50+	Conglomerate of white chert in brown sand matrix succeeded by brown sandstone.	Wooded highlands and low escarpments. Thin, sandy, gravelly soil.
	Holdenville shale.	Chd		260	Blue and yellow clay shale with thin siliceous limestone and sandstone beds.	Slopes of escarpments and level lands. Fertile soil.
	Wewoka formation.	Cwk		700	Massive, brown, friable sandstone, with interstratified soft, blue clay shale and a thin limestone lentil in the lower portion.	Cliffs, escarpments, and undulating uplands. Thin, sandy soil.
	Wetumka shale.	Cwt		120	Clay shale above, sandy shale and thin sandstone below.	Nearly level surface. Moderately fertile soil.
	Calvin sandstone.	Ccv		145–240	Thick-bedded, hard sandstone, becoming friable, ferruginous, and shaly toward the south.	Hilly highland with southeastward-facing escarpments. Thin, stony soil.
	Senora formation.	Csn		140–485	Brown sandstone, generally thick bedded in the northern part, thin and shaly in the southwestern part.	Hilly highland with escarpments, becoming rolling and less hilly to the southwest. Sandy loam soil.
	Stuart shale.	Cst		90–280	Blue and black clay shale with sandstone lentil near the center.	Undulating surface with low south-facing escarpment. Loamy, fertile soil.
	Thurman sandstone.	Ct		80–260	Brown sandstone, shale, and chert conglomerate in the east; shaly in the west.	Rolling highland and escarpments. Soil fertile except where broken and stony.
	Boggy shale.	Cb		2000–2600	Shale, shaly sandstone, and brown sandstone. Local thin siliceous limestone and coal near the base.	Nearly level prairie plain interspersed with low, wooded ridges and hills. Soil thin and often stony, with meadow and pasture lands.
	Savanna sandstone.	Cs		1000	Thick-bedded sandstone and shale.	Low, parallel, wooded ridges and narrow, glady valleys. Soil generally poor and stony.
	McAlester shale.	Cm		1800–2000	Blue and black shale and sandstone of variable thickness, with numerous beds of coal, two of which are workable.	Rolling and level prairie lands with few low parallel ridges. Moderately fertile sandy loam on slopes, sandy clay meadow land in flats, and stony barrens on the crests of ridges.
	Hartshorne sandstone.	Ch		150	Brown sandstone with shale locally interstratified.	Low timbered ridge. Sandy loam or poor, stony soil.
	Atoka formation.	Ca		3100	Clay shale, sandy shale, and sandstone, generally thin bedded and friable in the western part.	Level rolling prairie with few low ridges and hills, usually wooded. Moderately fertile sandy loam and close clay soil; thin and poor on steep slopes and often stony on hilltops.
	(Chickachoc chert lentil.)	(Cc)		(0–80)	White, calcareous, cherty sandstone in the southeast. Position in the section not accurately determined on account of faulting.	Low, sharp, rocky ridges.
	Wapanucka limestone.	Cw		100	White oölitic limestone, blue shale, and cherty calcareous beds.	Low and nearly level ridges. Thin, stony, fertile soil.
CARBONIFEROUS and probably DEVONIAN	Caney shale.	Ccy		800+	Blue and black shale with dark-blue limestone segregations.	Nearly level plain. Fertile dark clay soil.

JOSEPH A. TAFF,
Geologist.

INFORMATION CONCERNING

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