DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

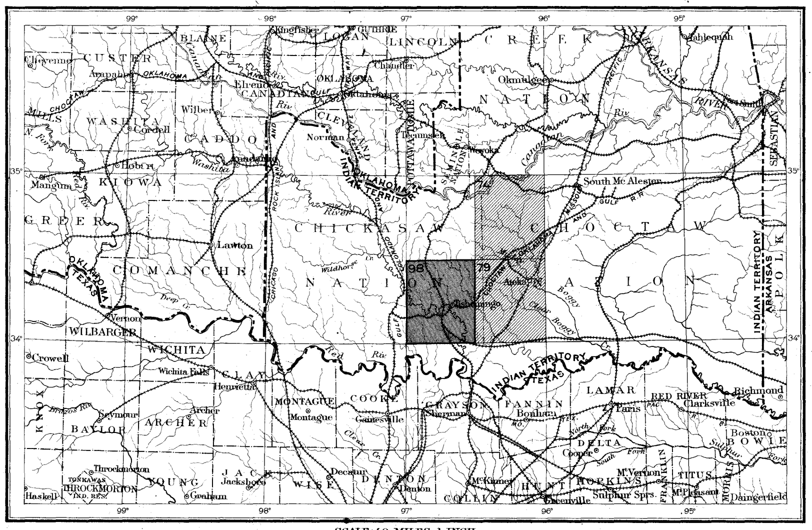
OF THE

UNITED STATES

TISHOMINGO FOLIO

INDIAN TERRITORY

INDEX MAP



SCALE: 40 MILES-1 INCH

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LIBRARY EDITION

TISHOMINGO FOLIO
NO. 98

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

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

1903

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:

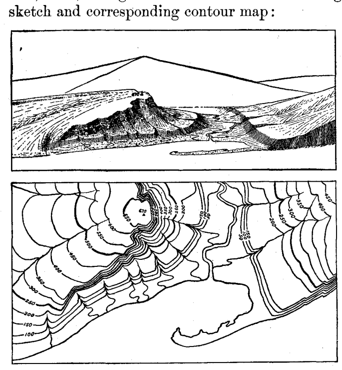


Fig. 1.—Ideal sketch and corresponding contour map.

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 slope at the left. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates 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.—Water courses are indicated by blue lines. If the streams flow 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 of "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 a 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 may consolidate in cracks or fissures crossing the bedding planes, thus forming dikes, or spread out between the strata in large bodies, called sheets or laccoliths, or form large irregular cross-cutting masses, called stocks. Such rocks are called *intrusive*. Within their rock inclosures 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 colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions and groups of the periods, frequently used in geologic writings, are bracketed against the appropriate period names.

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 one at the top of the column (Pleistocene) and the one at the bottom (Archean). The sedimentary 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 is printed evenly over the whole surface representing the period; a dark tint brings out the different patterns representing formations. Each formation is furthermore given

Period.		Symbol.	Color.
Cenozoic	Pleistocene	P	Any colors.
	Neocene {Pliocene, Miocene}	N	Buffs.
	Eocene, including Oligocene	E	Olive-browns.
Mesozoic	Cretaceous	K	Olive-greens.
	Juratrias {Jurassic, Triassic}	J	Blue-greens.
Paleozoic	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.

a letter-symbol composed of the period letter combined with small letters standing for the formation name. 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, chiefly 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 metamorphic rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the 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.

Areal 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:

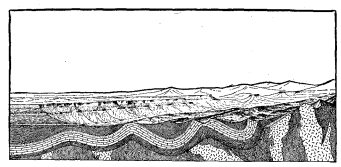


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane, 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:

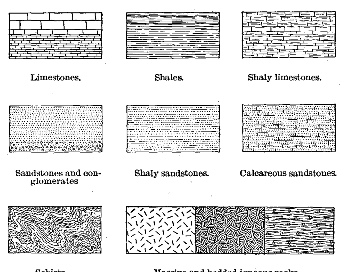


Fig. 3.—Symbols used to represent different kinds of rock.

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. The direction that the intersection of a bed with a horizontal plane will take is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

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. The arches are called *anticlines* and the troughs *synclines*. But the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts slipped past one another. Such breaks are termed *faults*.

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 from the surface of any mineral-producing or water-bearing stratum which appears in the section may be measured by using the scale of the map.

Columnar section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thicknesses of the formations, and 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 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 surficial deposits, 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 are indicated graphically and by the word "unconformity."

CHARLES D. WALCOTT,
Director.

Revised January, 1902.

DESCRIPTION OF THE TISHOMINGO QUADRANGLE.

By Joseph A. Taff.

GEOGRAPHY.

The Tishomingo quadrangle is bounded by meridians 96° 30′ and 97° and parallels 34° and 34° 30′, and occupies one-quarter of a square degree of the earth's surface. It is 34.5 miles long north and south and 28.58 miles wide, and contains about 986 square miles. It lies in the southeastern part of the Chickasaw Nation, Indian Territory, the eastern edge being nearly 3 miles west of the Choctaw–Chickasaw boundary line, and the southern side about 3 miles north of the nearest approach of Red River.

The quadrangle occupies parts of three physiographic regions or provinces which, with three others, constitute the main geographic divisions of Indian Territory. A brief description of these provinces is a necessary introduction to the geography of the quadrangle. Fig. 1 shows the six physiographic provinces in Indian Territory. These are the Ouachita Mountain region, the Arkansas

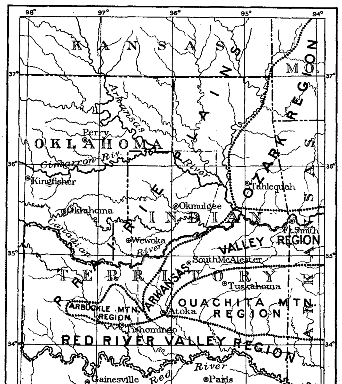


FIG. 1.—Sketch map showing the physiographic provinces of Indian Territory.

Valley region, the Ozark region, the Prairie Plains, the Arbuckle Mountain region, and the Red River Valley region.

The Ouachita Mountain region extends from Atoka, in the Choctaw Nation, to the vicinity of Little Rock, Ark. It is 200 miles long and has an average width of about 50 miles. It is a range of mountains and high ridges bearing generally east and west. These mountains and ridges have horizontal crests, above which no prominent peaks are seen to rise. They are separated usually by wide, flat valleys, some of which are so broad as to partake of the character of plains. These flat valleys are but little above the level of the Arkansas Valley and the Red River Plain, which border the range upon the north and south sides respectively. Near the western end of the range the crests of the ridges are at an elevation of about 1000 feet above the sea and nearly 400 feet above the larger valleys. The ridges rise gradually eastward, and near the Arkansas–Indian Territory line attain elevations of 2900 feet above the sea and nearly 2000 feet above the large valleys. In Arkansas the general elevation of the range decreases until it is only 500 feet above sea at the east end. The highest mountains are in the central part of the range. The gradual rise in elevation of successive ridges from the southside is especially noticeable in Indian Territory. The most prominent mountains of the Ouachita Range in Indian Territory are Jackfork, Windingstair, Buffalo, Rich, Black Fork, and Kiamichi.

The Arkansas Valley region lies between the Ouachita Range on the south and the Ozark Mountains on the north. It is characterized, especially in the western part, by narrow and generally level-crested, low ridges and rolling uplands, which are nearly parallel to those of the range. These ridges rise 100 to 200 feet above the larger valleys and, with the exception of the few isolated mountains which lie in the Arkansas Valley, reach altitudes between 800 and 900 feet above sea. At the confluence of Canadian and Arkansas rivers the Arkansas Valley region contracts, bears southwestward, and joins the Red River Valley region between the Ouachita Mountain and Arbuckle Mountain regions. The Arkansas Valley region, especially in the southern part, resembles very closely the Ouachita Range, but is on a smaller scale.

The Prairie Plains stretch from the Arkansas Valley and Ozark region northwestward and westward across northwestern Indian Territory into Oklahoma and Kansas. They gradually ascend toward the northwest and are characterized in Indian Territory by bench and terrace forms of topography—table-lands and escarpments. The benches or tables are cut into and traversed by valleys, but maintain their generally level form. The escarpments face eastward and southward, opposite to the direction of the dip of the rocks, and have very tortuous courses. The Prairie Plains extend around the Arbuckle Mountain region between it and the Wichita Mountains and bear southward into Texas. The border between the Arkansas Valley region and the Prairie Plains is elevated about 900 feet above sea. From this level the rise is gradual to a general elevation of 1000 feet in northwestern Indian Territory.

The Arbuckle Mountain region extends from the vicinity of Boggy Depot in southwestern Choctaw Nation in a northwesterly direction nearly across the Chickasaw Nation, being about 70 miles long, and having an average width of about 20 miles. The surface rises gradually from 700 feet in the level of the Arkansas Valley Plain at the east end to 1350 feet at the west end. At the east end and southeast side it coalesces with the bordering Red River Plain. In the northern and western parts it rises abruptly 100 to 300 feet above the bordering Prairie Plains. The high land of the Arbuckle Mountain region is a nearly flat plain slightly inclined toward the south. The streams that flow from this high land have cut deep valleys near its borders. Washita River crosses the central part of the region in a deep and narrow gorge cut in the hard rocks of the mountain. Two small districts in the western part of the region, known as the Eastern and Western Wooded Hills, rise slightly above the level of the mountain plain.

The Red River Valley region is a nearly flat plain bordering Red River and extending along the entire south side of Indian Territory. In Indian Territory the plain lies on the north side of the broad valley of Red River and slopes gently southward. In a broad sense the Red River Plain is an extension southward of the Prairie Plains and the Arkansas Valley region, but is separated from them by the Ouachita Mountain and Arbuckle Mountain regions. The Red River Valley region borders the south side of the Ouachita and Arbuckle mountains and touches the Arkansas Valley region and Prairie Plains at the east and west ends, respectively, of the Arbuckle Mountain region. South of the Arbuckle Mountains the northern border of this plain is nearly 1000 feet above sea. Along the south side of the Ouachita Range, in southeastern Indian Territory, it is about 600 feet above sea.

Three main river systems, the Arkansas, the Canadian, and the Red, drain Indian Territory. Arkansas River flows southeastward from the Rocky Mountains across the Great Plains and the Prairie Plains and enters the valley lying between the Ozark and the Ouachita mountains near the eastern border of Indian Territory. Canadian River has its source in New Mexico, flows eastward across the Great Plains and the Prairie Plains, and joins Arkansas River at the border of the Arkansas Valley region. Red River rises in New Mexico, flows eastward through the Great Plains, across the Panhandle of Texas, and thence forms the entire southern boundary of Indian Territory. Its northern tributaries in Indian Territory drain a large part of the area south of Canadian River. One of the larger of these tributaries, the Washita, crosses the Arbuckle Mountains and flows across the central part of the Tishomingo quadrangle. The watershed between the Canadian and the 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 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.

TOPOGRAPHY.

ORIGIN OF THE TOPOGRAPHIC FORMS.

The valleys and hills in this region have been produced by the dissolving, disintegrating action of water and frost and by erosion. The shapes of the valleys and hills and their location depend principally upon the degree of erosion and upon the nature and structure of the rocks. The streams 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. When the streams flow sluggishly and the currents are not able to carry away all of the sediments that are swept from the higher portions of the lands, conditions which occur in the later stages of erosion, the channels tend to become choked and the streams meander from side to side and broaden their valleys. If these conditions continue for a long time the valleys become wide and silted and the hills are gradually reduced nearly to the level of the valleys. If the surface becomes almost flat, though it may be somewhat elevated above the sea, it is said to be a peneplain. Should a part of the land become completely reduced and brought to the level of the sea, such an area would be called a base-level plain.

GENERAL TOPOGRAPHIC FEATURES.

The surface of the north half of the Tishomingo quadrangle is a nearly flat plain which rises very gradually northward and extends beyond the boundary of the quadrangle. This is the plain of the Arbuckle Mountain region. The Trinity sand, which is the lowest Cretaceous formation, outcrops along the south border of this plain. It is the shore deposit of the Cretaceous sea which transgressed northward and westward to an unknown distance beyond the present limit of the Cretaceous rocks and reduced the land to a surface of marine planation. Since the Trinity sand is a soft rock it is being removed so rapidly in comparison with the wear of the hard rocks that considerable areas of the Cretaceous plain are exposed before it is appreciably defaced. The exposed border of this marine plain continues along the outcropping edge of the Cretaceous sediments southward to central Texas, and it extends southeastward beneath the Cretaceous rocks toward the Gulf of Mexico. Northward from this bordering plain the surface of hard rock rises gradually to an elevation of about 1200 feet above sea at the northern edge of the Arbuckle Mountain region, in the adjoining Stonewall quadrangle. In the central part of the Arbuckle Mountain region, including the northern half of the Tishomingo quadrangle and the southern part of the Stonewall quadrangle, the marine Cretaceous plain extends farther north than elsewhere because of the broad expanse of hard rocks composing it.

At the northern and eastern borders of this elevated plain of the Arbuckle Mountain region there is an abrupt descent of 100 to 200 feet to the general level of an undulating plain of later age and broader exposed surface. This plain has been developed generally in softer rocks than occur in the Arbuckle Mountain region, and the agents of erosion which have made it have both uncovered and obliterated much of the marine Cretaceous plain north and east of its present limits above described. Southwestward, toward the Gulf, this plain descends approximately with the grade or fall of the rivers which flow across it. Near the present Cretaceous–Tertiary boundary in northeastern Texas, southeastern Indian Territory, and southwestern Arkansas, it extends beneath widespread deposits of gravel and sand which, in the high lands, rest upon this worn-down surface of early Tertiary, Cretaceous, and Paleozoic rocks. These deposits continue toward the Gulf coast and have been classed with late Tertiary rocks. Though the plain in this region, like its northward extension, has been more or less dissected by recent erosion, yet there are considerable areas near the present Cretaceous–Tertiary boundary where it has been but recently exposed or is still covered by a thin mantle of gravel. This border of the peneplain is analogous to the marine Cretaceous plain described above, in that it descends toward the coast beneath marine sediments. The northern limit of this gravel-covered plain is elevated approximately 600 feet above the sea, and leading from it upward and along the present river valleys there are remnants of flat, meandering channels which are only slightly depressed below the general level of the nearly flat, rolling plain or peneplain, and which contain deposits of gravel and sand. Likewise along and near the Arkansas and Canadian river valleys there are still more extensive but similar ancient wide and flat channels filled with gravel, sand, and silt. This peneplain stretches west and north beyond the Arbuckle Mountain and Ouachita Mountain regions across Indian Territory. It is inclined toward the south at a lower angle than is the Cretaceous base-level and intersects the Cretaceous base-level in the vicinity of the Arbuckle Mountains at elevations between 800 and 900 feet above sea. Toward the north the horizon of the Cretaceous marine plain rises above the land, while this Tertiary peneplain is now preserved in almost innumerable flat-topped ridges and hills in the Arkansas Valley region and in the uplands of the broad valleys of the Ouachita Mountain range. These ridges are composed of beds of hard rock, and their generally level crests rise to an elevation approximating 850 feet. The higher eminences, a few of which rise to 1000 feet above sea, are usually table-like, being protected by flat, hard strata, while in lower eminences the hard ridge-making beds are either steeply upturned or are composed of thin strata. Higher than this peneplain of level-crested ridges and hills in the Arkansas Valley region are limited areas where the broad folds in the strata have favored the preservation of monadnock-like mountains and peaks. The most prominent of these in Indian Territory are the Sansbois, Cavanal, Poteau, and Sugarloaf mountains, which rise to heights of from 1700 to 2500 feet above the level of the sea, approximating the higher levels of the mountains of the Ouachita and Ozark regions. These mountains occupy broad synclines and culminate in narrow crests or peaks and are generally isolated. The broad distribution of surficial deposits in the wide, shallow, elevated river channels, the relation of these deposits to the Tertiary gravels, and the almost universally equal degradation of both hard and soft rocks to the same general level, strongly support the hypothesis that the surface approached near to the level of the sea at the time of its reduction to a peneplain in what has been considered late Tertiary time.

Since Tertiary time the land has been elevated and probably slightly tilted toward the southeast. During and following this elevation, the agents of erosion became more active and removed the softer strata until the wide, flat valleys of the larger streams are now about 200 feet below the Tertiary peneplain. These valleys are so wide and flat and are in so nearly the same level that they may be considered to form rudely a lowest plain, representing the present stage of erosion. Rocks intermediate between the hard sandstones and soft shales and the thinner hard strata steeply tilted, make various levels between the Tertiary and this latest peneplain.

TOPOGRAPHIC TYPES.

Each of the geographic provinces which have been described is characterized by topographic features peculiar to itself. These features are dependent upon the kinds of rocks and their attitudes. It is therefore most convenient to consider separately the more detailed surface configuration of each province in the Tishomingo quadrangle.

Arkansas Valley type.—The rocks of the Arkansas Valley are uniformly varied in character, consisting almost entirely of alternate beds of sandstones and shales. Moreover, the structure is of the same general type throughout the region. It is that of numerous short, lapping or imbricating folds. As already explained, almost the whole region has been worn down to a rolling plain and subsequently the softer strata have been eroded to lower levels in smooth valleys, so that the harder beds now make generally low, level-crested curving ridges or flat-topped hills. The Arkansas Valley region joins the northeast side of the Arbuckle Mountain region and enters the Tishomingo quadrangle in two small areas, one in the extreme northeastern corner of the the quadrangle and the other 4 to 6 miles farther south. These areas represent but a single phase of the Arkansas Valley type of topography—that is, the almost flat, low valleys in the plain developed on the shales which separate the ridges and hills of harder rocks. In this case wide and flat valleys have been cut in the Caney shale, the lowest Carboniferous formation that borders the Arbuckle region. Ridges of hard limestone occur a short distance toward the east, beyond the border of the quadrangle.

Arbuckle Mountain type.—Topographic forms of this class occupy approximately the northern half of the quadrangle. It has been explained that the surface of the hard rocks is an almost flat plain, inclined at a low angle toward the south. This plain was developed early in Cretaceous time, but has been uncovered and modified by recent erosive agents. The Tishomingo granite is uniform in hardness, and the divides between the valleys mark the even surface of the Cretaceous plain. The streams have worn down their beds but slightly below the plain, their valleys forming shallow channels except near the mouths of the creeks which flow into Washita River. Near the river the tributaries flowing in the granite have cut narrow channels 20 to 50 feet in depth. The Arbuckle limestone also is uniformly hard, and being a very thick formation it occurs in large areas. Its structure, however, is variable. In a large part of its area the beds are nearly flat. Near the sides of the folds, however, the strata are generally steeply tilted. Especially is this the condition near the southern border of the region west of the granite, where the rocks are almost upon edge. Whatever the condition of structure, the rocks were reduced to a plain during Cretaceous time and, except near the borders of the areas, where the streams descend to softer rocks at lower elevations, the valleys are shallow and wide. The minor topographic features of the Simpson formation are more varied. This formation is composed of beds differing in hardness, but softer than the adjoining Arbuckle and Viola limestones, and consequently it generally occupies lower elevations. In the northwestern part of the quadrangle the surface of the Simpson formation is nearly flat, being worn down 100 to 200 feet below the general level of the Arbuckle Mountain plain. Near the northeast corner of the quadrangle there is a large area of the Simpson lying nearly horizontal. Here erosion, acting on beds differing in hardness, has produced many flat-topped buttes and terraced hills, the crests of which are almost at the level of the plain about 100 feet above the valleys. The succeeding five formations exposed where the topography is of the Arbuckle Mountain type are much thinner than those below. These are the Viola limestone, Sylvan shale, Hunton limestone, Woodford chert, and Sycamore limestone. These formations are found near the borders of the region and in small areas in the broken synclinal folds in the interior. In almost all instances they are steeply upturned and occur in narrow bands from a few hundred feet to nearly one-quarter of a mile in width. The Viola, Hunton, and Sycamore limestones are hard rocks and make level-topped prairie ridges and hills whose crests are generally in the level of the Arbuckle Mountain plain. The Sylvan shale always makes narrow and smooth wooded valleys between the Viola and Hunton limestone ridges. A part of the Woodford formation is a friable rock and the whole occurs in thin strata and in consequence is rapidly broken to fragments, but on account of its siliceous nature it is not easily dissolved to soil. In those parts of the quadrangle where the succeeding Sycamore limestone is present it is protected on both sides by harder strata and in consequence occurs in elevated saddles between hills and is scored by deep gulches and gullies where the streams are large enough to transport partially disintegrated fragments of chert. In the central and northeastern parts of the Arbuckle Mountain region in this quadrangle the Woodford chert occurs in contact with succeeding Mississippian shales, and makes smooth, rounded hills or slopes bordering hills and ridges of Hunton limestone.

Red River Plain.—The country south of the Arbuckle region in the Tishomingo quadrangle is part of the Red River Plain. It is occupied by Cretaceous rocks and recent river sediments. Each formation is characterized by topographic features which are dependent upon its position, hardness, and structure, and which have been modified or accentuated by Washita River in the places which border its valley. The Trinity sand underlies an area greater than all the succeeding Cretaceous formations in the quadrangle. It is a homogeneous, friable sand with local conglomerate at the base, and where not protected by overlying hard rocks makes a nearly smooth, rolling surface, almost entirely covered by forests. The areas of the Trinity sand east of Tishomingo and in the southwestern part of the quadrangle are of this character. Near Washita River, however, especially on the south side, the minor features of the topography are strikingly different. Near the valley of the river the harder limestone of the succeeding Goodland formation forms elevated terraces and bluffs. Below these terraces and bluffs the streams descend in steep channels, scoring the soft sand and producing rugged gulches and intricate minor badland erosion features. Such features of Trinity topography are very marked also along the border of the river valley north of old Fort Washita.

Remnants of the Trinity conglomerate occur on the high land north of the river in the vicinity of Norton. This conglomerate is composed of hard limestone bowlders cemented by lime, and was deposited upon a plain of soft Carboniferous shales. After wearing through the harder conglomerate the streams cut their channels more rapidly into the soft strata. The shales thus exposed weather rapidly, and each small drainage way cuts by headwater erosion under the conglomerate, producing minor tables and buttes with intricately crenulated borders. The same topographic features occur along the base of the Trinity formation south of the river valley west of Earl.

The Goodland limestone is a thin formation of relatively hard rock and occurs between friable sand below and soft shales above, producing characteristic table and bluff topography. The rapid erosion of the sand from beneath by headwater erosion of minor drainage channels causes the limestone to break from the edge in bowlders and fragments, making constantly receding cliffs. On the watersheds and projecting points of high land between the valleys the succeeding Kiamichi shales have been removed, leaving the Goodland limestone in flat table-lands and buttes, with bluff or cliff faces overlooking the sharply eroded country of Trinity sand. Throughout the exposed occurrence of the Goodland limestone the succeeding soft shales have been eroded from the immediate border, leaving wide flat benches of hard rock. The remnants of the Goodland limestone, locally known as the "Yellow Hill," on the Washita-Red River divide between Durwood and McMillan, are most striking illustrations of the Goodland topography. Not less prominent are the benches and bluffs facing the Washita Valley between Russell and Linn, and between Emet and old Fort Washita.

Except in the gently rolling upland east of Raysville and south of Emet the Kiamichi clay makes smooth, slopes rising from the flat woodland benches to the more elevated topography of the Caddo limestone.

The Caddo limestone is composed of clay marl and limestone interstratified, the latter being the hard rock and occurring most abundantly in the upper part of the formation. These uppermost harder limestone beds make broad, rolling uplands and are bordered by low escarpments and slopes descending over the lower and softer beds.

The succeeding Bokchito formation, like the Caddo, consists of alternating stratified soft clays and sandy and hard siliceous limestone strata. The limestones are thin and occur chiefly in the upper part of the formation. They usually project in ledges or make terraces in the slopes which rise above the country underlain by the Caddo limestone. Where the lower part of the formation is exposed, as it is southwest of Linn, the surface is gently rolling and smooth.

Near the southwest corner of the quandrangle this formation occurs near the river valley and is succeeded by the harder or more resistant beds of the Bennington and Silo formations. As a result it makes rather steep, sharply eroded, and forest-covered slopes.

The Bennington limestone is a thin, hard formation making low bluffs or benches. The succeeding Silo sandstone is composed of soft strata and as it occurs in the highest land in the vicinity it naturally makes undulating and smooth topographic forms.

GEOLOGY.

PRE-CAMBRIAN IGNEOUS ROCKS.

Tishomingo granite.—In the southeastern part of the Arbuckle Mountain uplift there is a large area of granite with a small amount of associated igneous rock. This granite lies entirely within the Tishomingo quadrangle except a portion, about 12 square miles in area, which extends into the western part of the Atoka quadrangle, on the east. It is joined on the north and west by Cambrian and Silurian strata. Cretaceous sandy sediments have been deposited upon it and now occur along most of the southern border. These Cretaceous deposits lie nearly flat, being but slightly inclined toward the south. Near the present contact the sand remains upon the granite as a residual mantle. Except at two localities the granite comes in contact with the stratified rocks throughout its north margin along lines of faulting. It may be observed by reference to the Areal Geology sheet that a long tongue of the Arbuckle limestone has been let down as a faulted block almost separating the granite into two parts. The two places where the strata rest in normal contact on the granite are at the ends of narrow, faulted synclinal blocks, one near Reagan and the other southeast of Belton. A line of faulting borders a part of the southwest side of the granite for a distance of about 3 miles, bringing Ordovician, Upper Silurian, Devonian, and Carboniferous formations successively in contact with the granite. A small area of granite occurs in secs. 22 and 23, T. 2 S., R. 4 E. surrounded by Cambro-Silurian strata. This granite remained as an elevated mass in the sea during the deposition of the rocks that are in contact with it. Elsewhere along the west side the Reagan (Cambrian) sandstone occurs normally as it was deposited upon and against the granite. The granite and its associated or included igneous rocks are older than the earliest Cambrian strata that here rest upon them. There is no means of determining the approximate age of the granite, however, except by its relations to the lowest sediments, which are probably Middle Cambrian.

The granite is named Tishomingo from the capital town of the Chickasaw Nation, which is located upon its border near the center of the quadrangle. This granite is excellently exposed in Pennington, Rock, and Mill Creek valleys near Tishomingo and it has been utilized in the construction of the Chickasaw capitol building.

Quartz-monzonite occurs in intimate relations to the granite and it appears as phases of it. In some instances the monzonite occurs with some definition of boundary. Again it blends with the granite gradually.

The granite has been intruded by numerous dikes of dark-gray to almost black diabase and diorite rock, besides less numerous dikes of pale-pink to white aplite and rarely by dikes of granite-porphyry. These dikes of basic rocks penetrate the granite in many directions, though most of those observed bear in general northwest and southeast. In the eastern part of the granite area relatively few dikes have been found and most of these are small, ranging from a few inches to a few feet in thickness. On going westward, however, they increase in number and in variation in size until near the west border they occur in the granite as a network of sheets ranging from thin stringers to dikes 40 feet thick. Not all of the basic dikes were introduced at the same time. An instance was noted where the finely granular, nearly black variety cut across the more coarsely crystalline and lighter-colored diabase.

The relations of the aplite to the granite could not be determined at a number of places because of the obscure exposures. In a few instances noted the aplite occurs as well-defined thin dikes in the granite. The aplite occurs both in the eastern and western part of the granite mass.

The granite-porphyry was found in but two places, near together, 2½ miles west of Tishomingo. It occurs as distinctly defined bands 20 feet wide in granite, which trend toward each other. It is likely that they are parts of the same dike. A basic dike in one place occurs in contact with and penetrates both granite and granite-porphyry.

Since the surface of the Tishomingo granite is almost flat and is for the most part in the old Cretaceous plain, the rocks are disintegrated and concealed by surficial sand, so that it is not possible to locate or trace even the larger dikes in the granite beyond the channels of the streams where the rocks are usually partially exposed. The following petrographic descriptions are by Mr. Ernest Howe:

The granites are moderately fine grained, with the usual hypidiomorphic granular structure, and are of a pinkish color, becoming dark gray at times, with increase of ferromagnesian constituents. In general they are biotite-granites with small amounts of muscovite almost always present. In one instance, hornblende was found to be extremely prominent. The feldspars are principally orthoclase or microcline with plagioclase (albite and oligoclase) almost always associated with them. Quartz and the accessories are developed in a way common to rocks of this class; titanite is the only remarkable mineral, and occurs in extremely perfect crystals.

Seven specimens of rock from the Tishomingo granite area have been grouped together under the general head of quartz-monzonite, although they show considerable variation in appearance and mineralogical composition. In all a plagioclase-oligoclase, or andesine, is as prominent as orthoclase or microcline, and quartz has nearly the same development as in a granite. With these minerals biotite occurs almost invariably, and in all but two hornblende is abundant. One of these exceptions has diopside as the dark silicate accompanying biotite, and the other is so decomposed that the original mineral, now represented by epidote, can not be determined. One of the rocks has hornblende equal in amount to the plagioclase and alkali feldspar and is remarkable in its very considerable development of quartz. It is a rather unusual medial type between granite and diorite From this intermediate type the tendency in the majority of the rocks of which there are specimens seems to lean toward the side of the granites. There is one exception. This a is very nearly pure diorite, consisting largely of plagioclase feldspar and hornblende, with a little alkali feldspar and quartz. These rocks indicate a very interesting series, worthy of more extended study when more material is available.

Although of considerable variety of texture, the basic dikes represented in this collection are all to be considered as diabases. They vary from very dense, finely porphyritic contact facies to coarse rocks which might almost be considered gabbros. Their composition is very uniform, augite, labradorite, and magnetite being always present, and biotite rarely occurring. In only one was olivine found, or, more correctly, pseudomorphs of serpentine after olivine. Few of the specimens are fresh, and the secondary minerals, chlorite, kaolin, calcite, muscovite, and epidote, are abundant. The structure is ophitic in all but the very coarse rocks. In the dense rocks evidently near the contacts, the groundmass, though very fine-grained, is still distinctly ophitic, delicate skeleton crystals of magnetite adding materially to the felt-like appearance. Phenocrysts are seldom perfect and never large, the plagioclase laths averaging about 1 mm. in length. Augite is always less abundant than plagioclase, and is in rounded grains. The coarser specimens, probably from the central portions of large dikes, show a tendency to assume a granular structure, but this is not complete and, though not marked, their structure would still be described as ophitic.

The aplite examined is pale pink or nearly white in color, containing no ferromagnesian silicates, and is composed almost entirely of feldspars and quartz, with very little magnetite or hematite. The texture of the aplites is even and finely granular. Orthoclase, microcline, and plagioclase are present in all and are slightly greater than quartz in amount.

The granite-porphyries are fine textured and brick red. The phenocrysts are irregular in size and distribution in the dense groundmass, and consist of orthoclase, quartz, and some dark silicate, hornblende, which is now completely altered to chlorite, and the hydrous oxides of iron. The feldspars and what remains of the ferromagnesian silicate are in large imperfect crystals, while the quartz is in very much smaller, rounded, dihexahedral grains. The groundmass is partly a finely granular aggregate of quartz and feldspar, and partly a micropegmatitic intergrowth of these two minerals. Magnetite is abundant and iron stains all the feldspar constituents.

SEDIMENTARY ROCKS.

CAMBRIAN ROCKS.

Rocks of Cambrian age are limited to the Reagan sandstone, at the base of the sedimentary section in Indian Territory, and to the lower part—probably the lower third—of the succeeding Arbuckle limestone, which has a maximum thickness of nearly 5500 feet.

Reagan sandstone.—This sandstone outcrops in three areas in the Tishomingo quadrangle. The largest of these extends along the western edge of the Tishomingo granite, across the axial part of the wide anticlinal fold. The other two are small and occur at the ends of narrow, faulted blocks of the Arbuckle limestone which have been thrown down against the granite in the Buckhorn syncline. One of these is near Reagan and the other south of Belton.

The Reagan sandstone rests upon the Tishomingo granite and associated igneous rocks from which it was in large measure derived and it is succeeded, through gradations of siliceous lime and shaly beds, by the Arbuckle limestone.

The lower part, in contact with the granite, where the formation is thickest, is poorly sorted, coarse, granitic material composed chiefly of grains of quartz with some feldspar. This basal arkose member is variable in occurrence as well as in thickness, and in places is absent altogether, allowing the purer sandstone beds, higher in the section, to rest in contact with the granite. The middle part is composed chiefly of quartz grains, varying in size from that of a pea to fine particles. The upper portion is a calcareous and shaly sandstone, successive beds of which become more limy upward until the purer limestone of the Arbuckle formation is reached. The arkose beds at the base are usually more or less friable at their exposed edges owing to the disintegrating feldspar granules, which are intermingled with the quartz. The succeeding sandstone beds, of purer quartz, are much harder and are usually exposed in rough hills and prominent ledges. Near the top the beds are more calcareous, are commonly stratified with argillaceous layers and even soft shales, and are more easily worn down, occurring usually in depressions poorly exposed. The Reagan sandstone is of variable thickness, due to its having been deposited on the eroded and uneven surface of the granite. Its maximum thickness is estimated at about 500 feet, but in places it is only a few feet thick. The thinning is due to the loss of successive beds from the base upward. In its thinnest part only the uppermost calcareous beds are present. The upper, calcareous portion of the Reagan sandstone contains many fossils of Middle Cambrian age and the following list, comprising the most characteristic ones, is furnished by Mr. Walcott:

Fossils in Reagan sandstone.

Obolus tetonensis ninus Walcott.
Obolus (Lingulella) similis Walcott.
Obolus (Lingulepis) acuminatus Conrad.
Linnarssonella girtyi Walcott.
Acrotreta microscopica Shumard.
Orthis(?) indianola Walcott.
Orthis(?) wichitaensis Walcott.
Orthis(?) remnicha Winchell.
Ptychoparia roemeri Shumard.
Ptychoparia affinis Walcott.
Ptychoparia(?) cf. pernasutus Walcott.
Agraulos convexus Whitfield.
Pterocephalia sancti-sabae Roemer.
Chariocephalus tumifrons Hall and Whitfield.

The Reagan sandstone takes its name from the village which is situated near the small area of the formation in the north side of the granite.

CAMBRO-SILURIAN ROCKS.

Arbuckle limestone.—The Arbuckle limestone occurs in the Tishomingo quadrangle in three large areas in the axial parts of as many broad flat anticlinal folds and in several smaller outcrops in the faulted synclines between these large folds. The only complete section in the quadrangle occurs in the broad, flat arch west of the main granite area. Here the limestone dips regularly about 10° W. for a distance of 6 miles, in which almost every stratum of the formation is exposed. The Arbuckle formation is composed chiefly of hard, bluish-white and cream-colored limestone and dolomite, with a thickness ranging from thin layers of a few inches to beds of 2 to 3 feet, interstratified with slightly argillaceous layers. Occasional siliceous limestone and shale beds were noted. Chert and cherty oolites and limestone breccia are less common and intraformational conglomerate in thin layers occurs rarely at the base.

Beginning at the base there are thin-bedded siliceous limestones 50 feet thick. There is a gradual change upward from these thin beds into the succeeding member, 300 to 400 feet thick, which consists chiefly of heavy-bedded dull-bluish and cream-colored dolomites. Many of these massive beds are indistinctly bedded and weather into very irregular brown and sometimes nearly black bowlders. Others are more crystalline, marble-like and of pinkish or gray colors. Succeeding these come about 250 feet of thin-bedded granular limestone and compact blue limestones which pass gradually into the main body of the formation, consisting of 3500 to 4000 feet of massive, compact magnesian limestone, the lower half of which contains chert in places. These limestones on weathering usually present smooth white surfaces of practically the same color as the fresh rock. As the top of this thick member is approached the limestone beds become less magnesian and thinner and are succeeded by the highest member, which is composed of limestones interstratified with occasional sandy beds and strata of red, yellow, and green clays.

The Cambrian fossils occurring in the lower 700 feet of the Arbuckle limestone consist principally of trilobites with a few brachiopods. Although they do not appear to be specifically identical with described species they are yet all clearly of Upper Cambrian types, as the following brief list by Mr. Walcott will testify:

Fossils in Cambrian portion of Arbuckle limestone.

Dikellocephalus sp. undetermined.
Dikellocephalus(?) cf. angustifrons.
Illænurus cf. eurekensis Walcott.
Illænurus sp. undetermined.
Syntrophia sp. undetermined.

The next fossiliferous horizon occurs approximately 2000 feet above the highest known Upper Cambrian fossils and contains specimens of *Maclurea* and other gasteropods indicating Ordovician age. The lists of fossils and the paleontologic correlations for the Paleozoic rocks above the Cambrian were furnished by Mr. E. O. Ulrich. In the absence of fossils or of any lithologic change in the strata between these two fossiliferous horizons it is not possible to decide where the line between the Cambrian and Ordovician should be drawn. Fossils are relatively most abundant in the highest member of the formation, and this part may always be recognized by *Leperditia*, the coiled shells of *Hormotoma*, and brachiopods of the family Orthidæ, which are restricted to this upper part of the formation and often occur in abundance in single layers. Among the fossils of the Ordovician part of the Arbuckle formation are the following:

Fossils in Ordovician portion of Arbuckle limestone.

Billingsella, 2 species.
Calathium, 2 species.
Maclurea.
Ophileta.
Eccyliopterus.
Euconia (near E. ramsayi Billings).
Hormotoma, 2 species, one very near H. artemesia Billings.
Trochonema.
Orthoceras.
Trochoceras.
Leperditia.
Isochilina.
Primitia.

SILURIAN ROCKS.

ORDOVICIAN.

Simpson formation.—The rocks of the Simpson formation are best exposed in the long belt at the extreme south side of the Arbuckle uplift, where they are steeply tilted toward the southwest, and where many streams are cutting their valleys across them. The same strata, though lying nearly flat, are well exposed also near the northeast corner of the quadrangle in the rough slopes of Little Blue and Delaware creeks. The remaining two large bodies of the Simpson formation in the northwestern part of the quadrangle lie nearly flat and the strata are generally covered by soil.

This formation is composed of sandstones and fossiliferous limestones interbedded with greenish clay shales and marls. There are three sandstone members; one of local occurrence at the base, one near the middle, and another near the top of the formation. Many of the beds occurring in these sandstone members are composed of pure quartz sand. In places such sandstone beds are without distinct bedding and are indurated, while at other localities they are composed of massive, friable sand. Occasionally there are calcareous beds and even limestone layers interbedded with the sandstone. These sandstone members range in thickness from thin strata to beds aggregating 100 feet. This variability in thickness is most pronounced in the basal member, which rests upon the limestone of the Arbuckle formation. In places it is not present, and the limestone of the Simpson formation is in contact with the Arbuckle limestone. Between these sandstone members there are thinner sandstone strata, usually separated by several hundred feet of limestone and shaly strata. The lower and middle sandstone layers are usually thicker than the upper one. The sandstone member near the middle of the formation seems to be the most persistent in character and thickness and beneath it the limestone and shale contain a rather well-defined fauna. When once located it may be easily recognized again and can be used as a reference horizon to separate the formation into two parts.

The middle and upper sandstone members naturally separate the limestone and shaly beds of the formation into three members. The lowest limestone member includes probably a little more than half of the formation and is approximately 1000 feet thick. It consists of granular, semicrystalline limestone in the lower part, which is followed by thin limestone and green shale interstratified. This member contains one and in places two beds of sandstone, usually but a few feet thick. The middle limestone member is approximately 400 feet thick, and consists of interbedded soft shales and limestones. The highest limestone member consists of thin, semicrystalline limestone and shale, similar to much of the deposits lower in the formation.

In this quadrangle and farther west the formation varies in thickness between approximately 1200 and 2000 feet. It appears to be thinnest in the northeastern part of the quadrangle, though the structure there is variable and exposures are so poor that exact measurements could not be made. With the decrease in thickness of the formation, there is a decrease in thickness of limestone and shale and an increase in the relative amount of sandy sediments. From a study of the fossils in connection with the stratigraphy on Falls Creek, in the north side of the Arbuckle Mountains, west of the Tishomingo quadrangle, it appears that approximately 400 feet of rocks are absent from the base of the section, thus indicating a probable unconformity between the Simpson and Arbuckle formations.

The fauna of the lower part of the Simpson formation has decided similarities to that of the Chazy of New York and Canada on the one hand and that of the Pogonip of Nevada on the other. Characteristic fossils from this division of the formation are given in the list below.

Fossils of the lower portion of the Simpson.

Orthis costata.
Orthis (Dalmanella) pogonipensis Walcott
Orthis sp. nov. (near holstoni Safford).
Leperditia sp. near fabulites.
Leperditia bivia White.
Bathyurus sp. undetermined.
Amphion nevadensis(?) Walcott.

Fossils of the upper portion of the Simpson.

[Most of these species are known only in the upper 300 feet of the formation.]

Receptaculites sp. nov.
Platycystites sp. nov.
Amygdalocystites sp. nov.
Stomatopora proutana pertenuis Ulrich.
Phylloporina sublaxa Ulrich.
Rhinidictya nicholsoni Ulrich.
Pholidops trentonensis Hall.
Plectambonites sericea (Stones River variety).
Strophomena filitexta Hall.
Rafinesquina minnesotensis Winchell.
Scenidium anthonense Sardeson.
Orthis tricenaria Conrad.
Dalmanella perveta Conrad.
Hebertella bellarugosa Conrad.
Zygospira (Hallina), sp. nov.
Ampyx sp. undetermined.
Clionychia lamellosa Hall.

As a whole the fauna of the upper division of the Simpson exhibits close relations to that of the upper division of the Stones River group in Tennessee and Kentucky and the equivalent beds in the upper part of the Mississippi Valley. Certain species, however, indicate an age equivalent to that of the Black River fauna in Minnesota, though it may be that these forms appeared earlier in this region.

Viola limestone.—This formation outcrops in but three areas of considerable extent in the quadrangle. One of these is in the south side of the uplift near the Washita River Valley, another lies across the axial part of the broad fold west of the large mass of granite, and the third is found in the northeast corner of the quadrangle. There are no less than 15 other areas of small extent in the faulted synclinal folds in the northern part of the quadrangle, almost all being bounded by faults. The Viola limestone, being harder than the formations with which it comes into contact, is invariably well exposed, occurring in ridges and hills.

This formation is approximately 700 feet thick and represents a continuous but slightly variable deposition of limestone. The upper and lower parts, each approximately one-third of the formation in thickness, are composed of thicker and less evenly stratified beds than is the middle part. In fresh exposures the limestone is massive in appearance. On weathered surfaces the bedding is more pronounced. The layers range in thickness from thin strata to beds rarely more than a foot, and with them are occasional irregular bands and nodular masses of chert. This chert is usually most abundant in the lower and middle parts of the formation. The texture of the middle part of this limestone is generally dense and fine. Some of the beds, especially of the upper part of the formation, are uneven, earthy and coarsely crystalline, while others are composed largely of fossil shell fragments and shells.

There is a gradual transition from a thin-bedded, platy limestone belonging to the Simpson formation upward into the thicker beds of the Viola limestone, while at the top there is an abrupt change from the limestone to the dark-bluish or greenish clay shales of the succeeding Sylvan formation.

A study of both the fossils and rock section in the western part of the Arbuckle Mountains by Mr. E. O. Ulrich shows that there are three faunal divisions, which correspond closely to the three lithologic members. From this study of the fossils it appears that variation in thickness of the basal member is due to the local absence of certain beds. Some characteristic fossils of this member, indicating the latest Black River and earliest Trenton age, are the following:

Fossils of basal member of Viola limestone.

Tetradium columnare Hall.
Phylloporina reticulata Hall.
Rhinidictya mutabilis Ulrich.
Escharopora subrecta Ulrich.
Arthropora bifurcata Ulrich.
Dinorthis pectinella Hall.
Rhynchotrema increbescens Hall.
Vanuxemia gibbosa Ulrich.
Cyrtolites retrorsus Ulrich.
Protowarthia pervoluta U. and S.
Bumastus trentonensis Emmons.

In the middle member of the Viola limestone fossils are not on the whole abundant nor of great variety. At present it appears that the organic remains occur chiefly at three horizons, one near the base, one near the middle, and the third near the top of this member. The first and second of these horizons contain an abundance of graptolites. Next to *Trinucleus* the graptolites are the most characteristic and commonest fossils of this member. Following are some of the characteristic forms from this member, which indicate that the beds were deposited during the latter part of the Trenton epoch:

Fossils of middle member of Viola limestone.

Diplograptus pristis(?) Hall.
Climacograptus typicalis Hall.
Schizotreta minutula W. and S.
Rafinesquina deltoidea Conrad.
Conularia trentonensis Hall.
Trinucleus concentricus Eaton.
Proetus parviusculus var.
Nileus vigilans Meek and Worthen.

The highest member of the Viola is not abundantly fossiliferous except in the uppermost 25 feet. These beds at the top of the Viola limestone have yielded the following forms, which characterize the upper divisions of the Richmond deposits in Minnesota, Wisconsin, Illinois, Indiana, and Ohio.

Fossils of upper member of Viola limestone.

Pachydictya gigantea Ulrich.
Ptilotrypa obliquata Ulrich.
Plectambonites sp. nov. (with denticulate hinge).
Strophomena wisconsinensis Whitfield.
Leptæna unicostata Meek and Worthen.
Orthis kankakensis sweeneyi Winchell.
Dinorthis subquadrata Hall.
Dinorthis proavita W. and S.
Dalmanella macrior Sardeson.
Platystrophia acutilirata Conrad.
Rhynchotrema capax Conrad.
Parastrophia divergens H. and C.

In northern Arkansas the same fauna occurs in the Polk Bayou limestone and in middle Tennessee in the Fernvale formation. This is one of the most widespread fossil horizons, and certainly the easiest to recognize, of the Ordovician rocks.

UPPER SILURIAN.

Sylvan shale.—The Sylvan shale in this region occupies narrow and usually smooth valleys, since the contiguous Viola and Hunton limestones are hard, ridge-making rocks. Throughout almost their entire occurrence in the Tishomingo quadrangle the Sylvan beds are steeply tilted, at angles usually greater than 40°, and since the formation is thin its outcrop is narrow. The largest single area of the shale is on the south side of the broad Tishomingo anticline, at the southern border of the the uplift, from the vicinity of Ravia westward. Numerous small areas occur in the much-faulted minor folds in the large synclinal faulted blocks in the central part of the uplift. These small areas are in the generally flat prairie country, where the formation outcrops in smooth prairie swales between low limestone ridges.

The Sylvan shale, except near the base, consists of greenish, almost structureless clay. When weathered, slight fissility or lamination may be recognized in it. The basal part includes only a few feet and is dark greenish or bluish gray to nearly black. The shale in this basal dark portion is harder than the greenish shale and weathers on fresh exposure to blocks and fissile plates. It contains more lime and carbonaceous matter than the greenish clays.

Along the northeast side of the uplift in the vicinity of Viola and Hunton the formation is estimated not to exceed 60 feet in thickness. At the same localities the overlying Hunton limestone has a thickness of about 160 feet. On the south side of the Arbuckle Mountain uplift in the vicinity of Sylvan the shale is not less than 275 feet in thickness, where the Hunton limestone is absent or is represented by thin strata of siliceous and marly limestone. Farther west, in the Arbuckle Mountains, the increase in thickness continues until the shale is approximately 300 feet thick.

Fossils are rare in the Sylvan shale except in the dark layers near the base, which are in places, especially where they are more calcareous and harder than usual, crowded with graptolites and phosphatic shells. Below is a list of the principal fossils occurring in the dark basal shale:

Fossils in basal shale of Sylvan formation.

Diplograptus sp. undetermined.
Climacograptus sp. near typicalis.
Leptograptus sp. undetermined.
Lingula; short, obtuse form.
Lingulops(?) sp. nov. (flat form obsolete).
Leptobolus sp. near insignis.
Leptobolus(?) sp. nov. (has six strong radiating plications).
Conularia sp. nov., with surface sculpture very similar to that of the Trenton C. papillata Hall.
Conodonts, of forms resembling those referred by Hinde to Prioniodus and Polygnathus.

As may be inferred from the above list the fauna as known is singularly like that of the Utica. Critically compared, however, each species proves to have peculiarities sufficient to distinguish it from its Utica congener. Still the character of the fauna indicates that it is a direct development of the much older fauna of the Utica shale and not of the intervening faunas of the Cincinnati group. Admitting this we must assume that the Utica fauna continued to exist in slightly modifying forms to and after the close of the Ordovician as it is at present understood.

The position in the stratigraphic column to which the Sylvan shale should be assigned may be questioned, but the faunal evidence doubtless is in favor of its Ordovician age. On the other hand, the highest, or youngest, Ordovician known in America is the Richmond group, and the top member of that group underlies the Sylvan shale in the Arbuckle Mountains. Above it are rocks of Clinton age. Elsewhere the Upper Silurian has the Medina sandstone beneath the Clinton, and this sandstone, rightly or wrongly, is universally accepted as younger than the Richmond. According to the present classification, therefore, the line separating Ordovician and Upper Silurian in the Arbuckle Mountains must be drawn between the Viola limestone and the Sylvan shale.

SILURO-DEVONIAN ROCKS.

Hunton limestone.—This formation is composed of thick- and thin-bedded light-blue to cream-colored limestone, shaly limestone, and marl. It is stratigraphically divisible into three fairly well-defined members. These members are distinct as a result of the changes in lithologic characters and of the differences of hardness of beds.

The basal member consists of whitish, massive crystalline limestone which in places includes a bed of oolite at or near the base. A thin-bedded, compact limestone usually may be found at the top. In the Tishomingo quadrangle this member ranges in thickness from thin beds to strata about 25 feet thick.

The middle member is composed of white or cream-colored and occasionally pinkish, rather soft limestone beds interstratified with more friable marly lime and rarely calcareous clay, aggregating an average thickness of about 100 feet. This member, on account of the softness of the beds, usually outcrops in swales or depressions between the harder members on each side. The variability in hardness of different beds, however, causes them to be exposed in miniature terraces and slopes.

The middle member grades upward through a few feet of marly white limestone into the top member, which consists of crystalline and in part cherty bluish to white limestone with occasional thin marly strata. In places this crystalline limestone is overlain by several feet of very cherty limestone. Much of the chert in this limestone is flinty and massive and weathers in angular bowlders after the beds that contained it have decomposed.

The Hunton limestone varies in thickness from 0 to 200 feet; an average is approximately 150 feet. In the vicinity of Sylvan it is absent along the outcrop of contiguous formations for about 10 miles. While certain beds both at the top and bottom of the Hunton limestone seem to be absent in places, the variation in thickness is to be ascribed chiefly to changes in volume of intervening beds.

The change in sedimentation producing lithologic members is also accompanied by a change of fossil contents. The lowest member of the Hunton, exclusive of the few feet of thin beds at the top described above, contains the following fossils:

Fossils in lowest member of Hunton formation.

Favosites favosus Goldfuss.
Rhinopora verrucosa Hall.
Phænopora magna Hall and Whitfield.
Pachydictya bifurcata (Van Cleve) Hall.
Hemitrypa ulrichi Foerste.
Orthis flabellites Hall var.
Triplecia ortoni Meek.
Atrypa marginalis Dalman.

The Bryozoa, together with *Triplecia ortoni*, are so characteristic of the Clinton limestone of Ohio that there can be no reasonable doubt of the equivalence of these two formations. Furthermore the Clinton of that State has precisely the same lithologic character as the Hunton member under consideration. The same horizon is represented in the St. Clair limestone of northern Arkansas.

The following fossils, which indicate Niagara age, occur in the uppermost beds of the lowest member:

Fossils in uppermost beds of lowest member of Hunton formation.

Thecia swinderniana Roemer.
Orthothetes subplanus Hall.
Atrypa reticularis var.
Platyceras niagarense Hall.
Strophostylus cyclostomus(?) Hall.
Orthoceras, sp. undetermined; very slender.
Calymene niagarensis Hall.

The middle member on the whole is very fossiliferous. Among the fossils collected are the following common forms:

Fossils in middle member of Hunton formation.

Favosites conicus Hall.
Camarocrinus saffordi Hall.
Callopora perelegans Hall.
Orthostrophia strophomenoides Hall.
Rhipidomella oblata Hall.
Bilobites varicus Hall.
Delthyris perlamellosus Hall.
Gypidula galeata Dalman.
Dalmanites pleuroptyx Green.
Phacops hudsonicus Hall.

These species show without question the Helderberg age of the middle member of the Hunton limestone. It is to be correlated with the Linden limestone of western Tennessee, and the New Scotland and Coeymans formations of New York and Maryland.

The crystalline limestone of the uppermost member of the formation probably represents the Lower Oriskany of the Appalachian province and the Camden chert of middle Tennessee, as indicated by its fossils, which consist chiefly of gasteropods and large crinoid columns. The local flinty beds at the top are in part fossiliferous. These fossils consist almost wholly of corals, the most conspicuous being a large branching form of *Striatopora*. This flinty horizon may represent the Upper Oriskany or perhaps the Onondaga (Corniferous). In accordance with the classification of the Paleozoic rocks at present in vogue it is called Devonian, but it is so intimately united, both faunally and structurally, with the underlying Helderberg and this with the Niagara and Clinton beneath, that, for this region at least, it does violence to the natural classification of the rocks to divide them. Taking into account both the life history and the stratigraphic succession, the divisional line should be drawn between the flinty beds at the top of the Hunton limestone and the base of the black shale and chert of the overlying Woodford formation.

DEVONO-CARBONIFEROUS ROCKS.

Woodford chert.—It has been explained that the highest member of the Hunton limestone is, in part at least, Devonian in age. Its relations to the limestone members below, however, are such that it can not be separated lithologically. The remaining portion of the Devonian section of this region is limited to a single formation consisting of chert and black shale and known as the Woodford chert. It appears that these chert and shale deposits are, when broadly considered, unconformable with the underlying Hunton formation, as is indicated by the absence of certain flinty limestone beds in places at the top of the latter. These Devonian cherts occur throughout the Arbuckle uplift with little change in thickness or general lithologic character.

Where contact exposures have been seen between the Hunton limestone and Woodford chert the beds of the two formations are parallel. Where the Hunton limestone is absent the Woodford chert rests on the Sylvan shale, but neither here nor elsewhere have there been found very distinct indications of land or shore conditions at the base of the chert.

In places at the base of the Woodford formation certain beds are massive and flinty. At other places a black, fissile, bituminous shale is found near and in rarer instances at the base. As a rule, however, the formation becomes less cherty from the base upward. In the northeastern part of the quadrangle there is a gradation from the cherty shale upward into black, bituminous clay shale which is of Lower Carboniferous age. The chert is even bedded, some of the individual layers being several inches in thickness. Locally such beds make a large part of the formation, occurring either in the lower or middle portions. At other points little else can be found than thin or fissile siliceous black shale. In places also bluish shales have been noted interstratified with black shales and cherts, especially in the upper part of the formation. At various positions in the formation there are small, rounded, marble-like concretions in the more cherty beds. Occasional large nodular segregations also are found embedded in the chert. The Woodford chert is estimated to be about 650 feet thick.

Fossils are very rare in the Woodford chert and the few found are not well preserved. Fragments of fossil wood were noted on the surface, but with

Correlation table of Paleozoic formations below the Carboniferous.

Generalized time scale for central North America.			Formations mapped in the Tishomingo quadrangle.	Formations mapped by G. I. Adams in the Yellville quadrangle, northern Arkansas.
Carboniferous	Mississippian	Kinderhook.		Noel shale.
Devonian		Chemung.	Woodford chert.	Sylamore sandstone.
		Portage.		
		Hamilton.	(Wanting.)	
		Onondaga.		(Wanting.)
		Oriskany.		
Silurian	Upper Silurian	Helderberg.		
		Cayuga.	Hunton formation.	(Wanting.)
		Niagara.		
		Clinton.		St. Clair formation.
		Medina.	Sylvan shale.	(Probably wanting.)
	Ordovician	Richmond.		Polk Bayou limestone.
		Lorraine.		Izard limestone.
		Frankfort.	Viola limestone.	
		Utica.		
		Trenton.		(Wanting.)
		Black River.		
		Upper Stones River.	Simpson formation.	
		Chazy.		Key sandstone (?).
		Beekmantown.	Arbuckle limestone.	Yellville limestone.
Cambrian		Upper Cambrian.		Upper Cambrian.
		Middle Cambrian.	Reagan sandstone.	(Wanting.)

one exception it could not be determined whether they had been derived from the chert or had descended from the Cretaceous sand which once extended over the district. At the south side of sec. 27, T. 3 S., R. 4 E., a fossil tree trunk about 15 inches in diameter was found embedded in the chert parallel with the the strata. In the lower part of the chert a small *Lingula* of the type usually referred to *L. spatulata* Hall, a few conodonts, and the fossil wood which is referred to the genus *Dadoxylon* have been noted. It the shales of the upper part the only recognizable fossils are of two concentrically plicated species of *Productella*, one of which seems referable to *P. concentrica* Hall.

This formation is of the age of the Sylamore of North Arkansas, the Chattanooga formation of Tennessee, the Ohio shale of Ohio, and the Portage and Chemung of New York. At the top it doubtless includes strata corresponding in age with the Noel shale of North Arkansas and the basal shale of the Tullahoma formation in middle Tennessee. The latter are believed to be of Kinderhook age or, according to the present classification, earliest Carboniferous. The exact parting, therefore, between the Devonian and Carboniferous rocks can not be at present certainly defined.

CORRELATION OF EARLY PALEOZOIC FORMATIONS.

The Paleozoic section below the Carboniferous in the Tishomingo quadrangle and elsewhere in the Arbuckle Mountain region is of unusual interest because of the great thickness of limestone and dolomite in practically unbroken sequence. There is a considerable deposit of dolomite in the middle of the Arbuckle formation between the known Cambrian and Ordovician which has not yielded fossils, yet the time scale is represented without a gap from the Middle Cambrian to the Devonian, through a thickness of 8500 feet. This column occurs with identical lithologic character from the base upward through several thousand feet in the Wichita Mountains of southern Oklahoma, and in the northern part of the Llano region in central Texas west and south of the Arbuckle region. In northeastern Indian Territory, northern Arkansas, and southern Missouri are found rocks which partially represent the Arbuckle section, but the thickness is greatly reduced and large gaps occur in the time scale.

While a large part of the abundant faunas of the Arbuckle Mountain section is well known and is common to rocks of the same age occurring in other provinces, there are many new forms to be described in the preparation of a complete report.

The table on page 4 shows the correlation between the formations in the Arbuckle Mountain section mapped in the Tishomingo quadrangle and the Ozark section in the Yellville district of northern Arkansas.

CARBONIFEROUS ROCKS.

MISSISSIPPIAN.

The parting between the Devonian and Carboniferous lies in the shale near the top of the Woodford formation. The Sycamore limestone, which overlies the Woodford, belongs to the Lower Carboniferous, as does also the Caney shale which rests on the Sycamore limestone in part and on the Woodford chert where the limestone is absent.

Sycamore limestone.—This limestone is a lentil or wedge, lying between the Woodford chert below and the Caney shale above. It is spoken of as a wedge, for it increases in thickness westward until it is concealed by late Carboniferous (Permian) deposits at the west end of the Arbuckle Mountains. Along the south side of the Arbuckle region in the Tishomingo quadrangle this limestone is approximately 130 feet thick. It outcrops in the small faulted syncline in secs. 33, 34, and 35, T. 2 S., R. 3 E., in narrow, low ridges and on top of a single knob. Though not far removed from the outcrop in the south side of the uplift, it is here perceptibly thinner. In the north side of the broad fold along the south side of Buckhorn Creek Valley this limestone thins and occurs in a narrow, prominent ridge. At the border of the quadrangle it is about 50 feet thick. At the east end of its outcrop, in the west side of sec. 1, T. 2 S., R. 3 E., the limestone is much thinner, and it is terminated by a fault plane. Farther east in the broken, small folds of the Mill Creek syncline the Sycamore limestone does not occur, though the formations both above and below are present. In the vicinity of Gilsonite, near the northwest corner of the quadrangle a thin, somewhat cherty limestone occurs at the horizon of the Sycamore limestone.

The Sycamore limestone is separated into rather thin beds, a foot, more or less, in thickness. It is a dense, even-textured, bluish limestone which weathers to yellowish hues and is hard and tough. The beds break down usually into small, rudely rhomboidal blocks as a result of jointing running obliquely to the bedding. Wherever present the limestone is always exposed in prominent narrow and generally level-crested ridges. No fossil remains that could be determined have been found in this limestone.

This limestone receives it name from Sycamore Creek, which crosses its outcrop in T. 3 S., R. 4 E.

Caney shale.—Shales of Mississippian age, known as the Caney shale, rest upon the Woodford chert in the northeastern part of the quadrangle and upon the Sycamore limestone in the western part and beyond to the western end of the Arbuckle Mountain region. In the Atoka and Coalgate quadrangles, joining the Tishomingo quadrangle upon the east and northeast respectively, the Caney shale is overlain by a formation of Pennsylvanian age known as the Wapanucka limestone. This limestone is a long lentil extending from near the northeast corner of the Tishomingo quadrangle eastward nearly across the Choctaw Nation. The Wapanucka limestone does not occur in the Tishomingo quadrangle nor west of it in the Arbuckle Mountain region. On the north side of the Arbuckle Mountain uplift, however, the Franks conglomerate overlies the Caney unconformably, and may in part represent the Wapanucka limestone. On the south side of the Arbuckle uplift in the Tishomingo quadrangle and farther west the Caney shale is succeeded by thick deposits of shale and limestone conglomerate of Upper Carboniferous age. Here the line of separation between the Caney and the succeeding rocks can not be drawn with precision on lithologic grounds.

The Caney formation may be separated into two members on account of change of color in the shale and slight lithologic differences. The lower member consists of black, bituminous fissile shale, containing limy spherical segregations and irregular, dense, blue limestone masses. This member is succeeded by blue clay shales which include small ironstone concretions and occasional limy septaria.

The large exposure of this formation in the southern part of the Arbuckle uplift rests directly upon the Sycamore limestone, with beds steeply upturned toward the south. The small elongated area of the Caney shale extending eastward from the border of the quadrangle, in sec. 33, T. 2 S., R. 3 E., occurs as a faulted wedge between older rocks on each side. At the west end of the area the shales with their characteristic limestone concretions occur in contact with the Sycamore limestone. A large, triangular outcrop of the Caney shale in Delaware Creek Valley north of Viola is known locally as Wells Flat. This area extends eastward into the Atoka quadrangle, where the formation is succeeded by the Wapanucka limestone.

Since the Caney shale is everywhere a soft rock it has been worn down to level valleys or gently undulating surfaces. As a consequence good exposures of the fresh rock are of rare occurrence. The surface of Wells Flat near the northeast corner of the quadrangle is nearly level and the rocks are exposed only occasionally in the banks of streams. A small area in the northeast corner of the quadrangle is in flat, wooded land and is a part of a much larger area, which extends into the adjoining Stonewall, Coalgate, and Atoka quadrangles.

On account of the level and poorly exposed surface of the Caney shale the structure can not be made out with sufficient accuracy to determine correctly the thickness of the formation. It is roughly estimated, however, to be 1600 feet thick. In the south side of the Arbuckle Mountains it is probably much thicker. The Caney shale is broken by a great number of faults, shown on the map, and is brought in contact with all the formations below it in this region except the Reagan sandstone. The faults occurring between formations of different kinds can be easily detected. Faults within the shale, however, can not be found, since it contains no distinctive beds by which to locate and estimate displacements.

In Buckhorn Creek Valley, near the northwest corner of the quadrangle, and in the broken, small folds extending southeastward to the vicinity of Reagan, there are several areas where the Caney shale and a part of the succeeding Glenn formation are so folded together that they can not be distinguished. The Caney formation consists almost entirely of shale, and the same is true in a large measure of the succeeding Glenn formation, and since the surface is flat and rock exposures are few, it is necessary to map them together in this area of complicated structure. In Buckhorn Creek Valley, within a mile of the border of the quadrangle, there is a thin lentil or local bed of bluish limestone which contains fossil shells of Upper Carboniferous age. In the eastern part of the same area the lower part of the Caney shale occurs in contact with the Woodford chert, while in the south side of Buckhorn Creek Valley it rests upon the Sycamore limestone.

The black shale in the lower part of the formation contains numerous fossil remains. Fossils collected from the lower part of the Caney shale were studied by Dr. G. H. Girty, who identified the following forms: *Leiorhynchus* sp. resembling *quadricostatum*; small *Posidonomya; Productus hirsutiformis; Seminula* sp.; *Goniatites* related to *G. subcircularis, G. crenistria, G. striatus;* and *Gastrioceras kingi*. This fauna is favorable to correlating it with the upper part of the Mississippian. The blue clay shales higher in the formation have not yielded fossils and the parting between the Lower and Upper Carboniferous can not anywhere be accurately located at the present time.

PENNSYLVANIAN.

Glenn formation.—This formation includes strata of shale and sandstone from the top of the Caney shale upward and may include the highest Carboniferous rocks exposed in the Tishomingo quadrangle. Along the entire south side of the Arbuckle Mountain uplift the upper boundary of the Glenn formation can not be defined. The formation outcrops from the vicinity of Norton westward across the western part of the Tishomingo quadrangle and along the south base of the Arbuckle Mountains nearly across the northern part of the Ardmore quadrangle. The town of Glenn, from which the formation gets its name, is located on the formation in the Ardmore quadrangle. In all places as far as observed north of Washita River the strata dip toward the south, usually at steep angles. South of this area of surficial river deposits the structure is more variable. The sandstone beds, and in one instance a thin limestone conglomerate, are found dipping at steep angles in various directions. Cretaceous sands on one side and the river deposits on the other so obscure these Carboniferous rocks on the south side of Washita River that their position in the section can not be determined. Since they can not be distinguished from the rocks of the Glenn formation occurring on the north side of the river they are necessarily at present included with them in mapping.

The Glenn formation is composed chiefly of friable bluish clay shales and thin beds of brown or drab sandstone. The sandstone beds are usually exposed in the freshly cut stream channels and only occasionally in the uplands. Rarely thin, argillaceous limestone strata are known to occur and at one place a thin limestone conglomerate was found, but these beds are not sufficiently exposed to be traced or accurately mapped. Limestone conglomerate beds interstratified with clays occur in sec. 32, T. 3 S., R. 3 E., just west of the Tishomingo quadrangle, but their relation to the Glenn formation is obscured by the surficial deposits lying immediately east. The beds of the Glenn formation are not sufficiently distinctive or well exposed to give full information concerning their structure, and the thickness of the formation can not therefore at present be determined. Fossils found in the lower beds of the Glenn formation north of Berwyn determine its age as Pennsylvanian.

Franks conglomerate.—In Indian Territory, near the beginning of Upper Carboniferous time, the northwestern part of the Arbuckle Mountain region, which previously had not been disturbed, was uplifted and became high land. During and following this uplift the erosion of streams and of the sea along the coast wore down the rocks to the heart of the uplift, exposing successively all the strata from the Mississippian to the Ordovician and probably to the Cambrian. When the hard limestones of the Silurian were reached in this degradation, thick deposits of conglomerate were formed from them in the bordering Carboniferous sea. The elevated land was reduced finally to low land and submerged before the close of the Carboniferous, and the coarse limestone conglomerate was deposited across the eroded edges of the older Paleozoic strata. A broad belt of this conglomerate extends across the northwestern part of the Arbuckle region from the west end of the Arbuckle Mountains to the vicinity of Franks, in the adjoining Stonewall quadrangle. From the northwest corner of the Tishomingo quadrangle northeastward it crosses the eroded edges of the Ordovician, Upper Silurian, and Devonian formations. From a nearly flat position on the Hunton limestone near Franks it extends southeastward unconformably across the Woodford chert and Caney shale to a position above the latter in the Upper Carboniferous section. Between Franks and the southeast corner of the Stonewall quadrangle the formation changes from a heavy limestone conglomerate, interbedded with sandstone and shale, to a thinner formation of fragmental limestone, shale, and sandstone. At the latter point it is found to occupy a position in the section approximately the same as that of the Wapanucka limestone, at the top of the Caney shale.

The lower part of the Franks conglomerate in the northwest corner of the quadrangle and on Rock Creek in the adjoining Stonewall and Ardmore quadrangles is composed of a heterogeneous mass of limestone bowlders, gravel, and sand. The bowlders and fragments of this conglomerate contain Upper Silurian and Ordovician fossils. In the coarse conglomerate strata the bowlders and pebbles are cemented in moderately hard calcareous sand and grit. Near the surface this matrix has disintegrated, leaving a loose mantle of hard bowlders and gravel. In the southern part of this area southwest of Buckhorn, the formation is composed of limestone and chert conglomerate, sandstone, clay, and limestone interstratified.

The limestone materials in the formation become smaller and less abundant away from their source. Fossiliferous limestones and calcareous sandstones also occur interbedded with shale and conglomerate. The area in the vicinity of Mill Creek is composed chiefly of shale beds with occasional strata of moderately coarse conglomerate and siliceous limestone. Fossils obtained in these limestones are of Upper Carboniferous age. Here, in sec. 7, 8, and 16, T. 2 S., R. 5 E., fossiliferous, thin-bedded limestone occurs, interstratified with the conglomerates and shales. Only part of the Franks conglomerate is exposed in the Tishomingo quadrangle. On account of the irregularity of the deposit the thickness of the formation, even in this quadrangle, can be estimated only approximately. In the northwest corner of the quadrangle it probably does not exceed 200 feet. In the area about Mill Creek post-office it is estimated to be considerably more than 200 feet.

Limestone conglomerates occur above the Glenn formation on the south side of the Arbuckle uplift in the Ardmore quadrangle, interstratified with shales, sandstones, and limestones. Just what part of the conglomerate-bearing beds in the Ardmore region is represented by the Franks conglomerate can not be determined at present.

CRETACEOUS ROCKS.

Cretaceous rocks occupy approximately the southern half of the Tishomingo quadrangle. They are composed of friable sandstone and limestone, marly limestone, marls, clay and sandy shales, and ferruginous sandstones. These formations are conformable and are tilted toward the south at a grade of about 40 feet per mile. They represent the whole of the Lower Cretaceous and the basal formation of the Upper Cretaceous, comprising a thickness of about 1000 feet. This quadrangle lies in an extension of the Cretaceous area of Texas, and the Cretaceous formations here are characterized by the same fossils.

Trinity sand.—The Trinity sand is a beach and near-shore deposit of the Lower Cretaceous sea. This Cretaceous sea transgressed upon the land from the south. Its progress was so slow that all the Paleozoic rocks which are exposed along the north border of the Cretaceous were reduced to a practically smooth plane. Upon this the Trinity sand was laid down in the position in which we now find it.

The Trinity formation is composed of local coarse conglomerate, and fine, compact, incoherent sand, with occasional clay and sandy clay lentils, and aggregates 300 to 400 feet in thickness. The conglomerate occurs invariably at the base and ranges from thin strata to beds more than 50 feet thick. The lower part of the formation from the vicinity of Ravia eastward to the border of the quadrangle, where it rests upon the granite, is composed of sand which has been produced chiefly from the granite. From the vicinity of Ravia westward to the border of the quadrangle, where the lower part approaches the limestone formation of the Arbuckle Mountains, it is composed of a very coarse limestone conglomerate cemented in a matrix of chalky white lime and grit. The materials composing the conglomerate vary from bowlders a foot in diameter to small pebbles, and have originated chiefly from the Cambrian and Ordovician limestones of the Arbuckle Mountain region. This limestone conglomerate grades upward from calcareous sediments into the finer and purer sands of the middle portion of the Trinity formation. No fossils have been found in the Trinity sand except occasional silicified fragments of trees, which were originally driftwood washed from the shores.

In the broader outcrop of the Trinity sand north of Washita River and in the southwest corner of the quadrangle the surface is gently undulating and forest covered. South of the river, where the overlying limestones approach the larger valleys, the friable sand of the Trinity formation outcrops in steep slopes and escarpments and is deeply etched, forming rough lands, which are scantily timbered.

Goodland limestone.—The Goodland limestone is a pure, white, semicrystalline limestone. The beds at its base, in contact with the underlying Trinity sand, are somewhat siliceous and in places are composed to a large extent of oyster and other marine shells. In the middle the limestone is massive. At the top it is thinner bedded and passes by transition into the overlying clay shales. Marine shells are rather abundantly disseminated through the Goodland limestone. The shell substance, however, has been largely removed and in part replaced by crystalline lime. Except at the immediate border of the outcrop of this formation, where it comes in contact with the underlying Trinity sand, it is not covered by timber, and the rocks are usually well exposed. Throughout the occurrence of this limestone it outcrops in terraces, low escarpments, or bluffs projecting above the extremely friable underlying Trinity sand, which is easily eroded.

Like the other Cretaceous formations it dips at a very low angle toward the south. Soft shales follow above, which are easily eroded, leaving rather broad benches or table-lands of the flat Goodland limestone exposed. These features are especially marked in the escarpment south of Washita River west of Linn and on the high divide west of Oakland.

The Goodland limestone is a representative, in part at least, of several formations that occur in the Lower Cretaceous and in central Texas, from which region to Indian Territory it is continuously exposed.

This formation is named from the town of Goodland, in southeastern Choctaw Nation, where it is well exposed and was first studied.

Kiamichi formation.—Upon the Goodland limestone are platy layers of slightly siliceous limestone with thin strata of shaly marls interstratified, which are transition beds between the Goodland limestone and Kiamichi formation. These platy beds are but a few feet in thickness and are not usually well exposed in the flat land immediately above the harder Goodland limestone. Blue clay marl about 30 feet thick succeeds the basal shaly strata. Above are 10 to 20 feet of blue clay marl and oyster-shell beds interstratified. The shell beds occur in strata usually less than a foot in thickness and are composed almost entirely of oyster shells, ranging from small individuals to specimens 3 inches in length, with marly lime cement. These more or less indurated beds, being inclosed in friable marls, are exposed usually as ledges or slabby bowlders making a continuous outcrop near the top of the formation.

The outcrop of this formation occupies usually a narrow and very tortuous strip of land. This is especially noticeable in the region between Oakland and Washita River, where it occupies rather steep slopes above the Goodland limestone escarpment. South and west of Oakland the surface of the country is more generally level and the Kiamichi clays occupy the crests of many low divides. Between Sand and Butcher creeks, east of the river, the Kiamichi clay outcrops in very narrow exposures around the border of the divides, where it is partially concealed by a surficial deposit of gravel and sand. Between Butcher Creek and the eastern border of the quadrangle there is a broad, nearly level upland, that is occupied by the Kiamichi clays. Farther south they outcrop in the rather restricted valley of Rock Creek.

The abundant fossil remains that occur in the shell beds interstratified with the shales are restricted chiefly to a peculiar form of oyster. Occasionally ammonites and other marine shells are also found.

On account of the density of the soil and the semiarid climatic conditions prevailing in this region, it is almost entirely devoid of timber except in the immediate valley of the streams.

The formation receives its name from Kiamichi River, in southeastern Choctaw Nation. In the valley of this river the fossils from the formation were first collected.

Caddo limestone.—This formation is composed of marly white, bluish, and yellowish limestone and shell beds interstratified with lime and clay marls, with a total thickness of about 150 feet. The marly beds are thickest in the lower part, the lower 60 feet being composed chiefly of clay marls, above which there are 20 to 30 feet of lime marl, with strata of chalky white limestone interbedded. In this part of the formation there are some beds of oyster shells similar to but generally larger than those in the top of the Kiamichi formation. Continuing upward the marly beds become thinner while the limestones increase in number and thickness, until near the top the marl occurs in thin irregular partings between limestone beds. Succeeding the thicker limestones and near the top the marly beds become thicker and finally, at the top, is a bed of oyster shells, a variety of the same species as that forming the shell limestone in the lower part of the formation.

The harder limestones at the top of the formation project as ledges and in some instances as bluffs. Many small valleys have their heads in the escarpment made by the hard limestone. The streams cutting across the beds make many fresh exposures. On account of the friable marls above the harder limestone large areas occupied by this formation are smooth and the rocks are not well exposed. A large tract of the formation between Glasses Creek and Washita River forms a gently rolling fertile upland. This character of surface occurs also in the large area south of Glasses Creek. In the eastern part of this area, however, where the larger valley of Glasses Creek approaches it, the land is deeply dissected by small side streams, making rugged surfaces. Here the various hard and soft beds outcrop in benches and terraces in the slopes of the valleys. Northeast of old Fort Washita and near the border of the quadrangle the Caddo limestone appears in gently rolling uplands.

Both the marl and hard limestone beds of this formation contain numbers of marine fossils. As a result of the great abundance of organic remains and the marly sediments the soil of this formation is very fertile, making the most profitable agricultural lands in the region.

Bokchito formation.—This formation is composed chiefly of clay and sandy clay, beds of friable sandstone with ironstone segregations and concretions, and siliceous shell limestone aggregating approximately 140 feet. Ninety feet of the formation from the base upward are sandy clay shale with some ferruginous lime segregations and clay ironstone. Above these sandy clays are, locally, variable calcareous sandstone beds 20 to 30 feet thick. In many places these sandy strata are cross bedded and contain deposits of sandy clays. These locally variable beds are succeeded by bluish shell limestone interstratified with clays. The limestone layers are hard and semicrystalline, and on weathering become yellowish brown or reddish brown. The limestones contain many fossil oyster shells, which are equal in hardness to the limy matrix, so that on weathering they show sections in the surfaces of the rocks. The limestones project in many places, weathering in ledges and bowlders, the intervening shales being rarely exposed. These beds vary in aggregate thickness from approximately 10 to 20 feet. Finally, at the top, there are about 40 feet of sandy and clay shales with locally friable sandstone in the upper part. These sandy beds locally contain indurated ferruginous sandstone segregations and in places siliceous, low-grade iron ores. It has been observed that these sandy beds are occasionally cross stratified and include fragments of soft clay, indicating the presence of variable strong currents of water producing local erosion during sedimentation.

The Bokchito formation occurs in four separated areas in the southeastern part of the quadrangle. Where the upper part of the formation has been removed, leaving the more friable clays, the surface is generally level or rolling. The central area, in the vicinity of Cumberland, is especially of this nature. The area at the southern margin, south of Little Glasses Creek, is deeply eroded by the numerous small streams along the bordering larger valleys. Here the variable hard and soft beds in the upper part of the formation form a succession of terraces and slopes. The irregular and elongated area near the southeast corner of the quadrangle is close to the immediate valley of Washita River, and since the harder beds of the succeeding formations are present here the Bokchito formation forms steep slopes and is sharply cut by rivulets and small streams. It is heavily timbered here. Where the more sandy beds of this formation outcrop they usually support a limited forest. The lower and more argillaceous beds, however, when uncovered are occupied by prairie lands.

This formation has been named Bokchito because of its splendid exposures on Bokchito Creek and in the vicinity of the village of that name.

Bennington limestone.—The Bennington limestone is the uppermost formation of the Lower Cretaceous in this region. The Bennington limestone is generally a massive, dull-blue limestone, and rarely exceeds 10 feet in thickness. It is composed in large part of countless specimens of peculiarly small forms of *Exogyra arietina*. Locally there are thin deposits of marly lime resting on the harder beds of the Bennington, which are believed to be equivalent in age, in part at least, to the Buda (Shoal Creek) limestone, a formation occurring in central Texas.

The Bennington limestone outcrops in a small, narrow, tortuous band in the southeast corner of the quadrangle, where it is overlain by the Silo sandstone. It forms low terraces and bluffs and is rarely found in good exposures on account of the overwash of sand from the soft sandstone lying above it.

In central Texas the representative of the Bennington limestone consists of 80 to 100 feet of calcareous fossiliferous blue clay. This clay formation gradually thins northward, becoming more calcareous until, in the northern part of the State, it changes to limestone with thin clay bands interstratified. Still farther north it becomes hard limestone and occurs as such in southern Indian Territory.

Silo sandstone.—The Silo sandstone is the basal formation of the Upper Cretaceous and, like the Trinity sand, was deposited near the shore of the Cretaceous sea and in part, at least, upon a very slightly eroded surface. In north Texas, about 30 miles south of this quadrangle, the base of the Silo sandstone rests unconformably on eroded surfaces of the Bennington limestone. In this quadrangle, however, its exposures do not satisfactorily determine relations of conformability. The rocks below are classed as Lower Cretaceous, while the Silo and succeeding formations are of Upper Cretaceous age. There is a complete change in fauna from one to the other.

The formation consists of fine, brown sand and sandy clays interstratified. The sandy beds are thickest in the lower and middle part, but clays and sandy clay beds occur in places at the base, resting on the Bennington limestone. Some of the sandstone beds contain segregations of brown siliceous iron ores, which are found as stony fragments on the surface. Toward the upper part of the formation the sands are finer, less abundant, and more generally disseminated with the clays, making deposits of arenaceous clay or argillaceous sand which are not so distinctly stratified as those toward the base.

It is estimated that only the lower 100 feet of the Silo sandstone occur in this quadrangle. The whole formation is believed to be approximately 500 feet thick where it occurs in north Texas, along the south side of Red River Valley. These are the nearest exposures to the Tishomingo quadrangle which show the complete section. The Silo sandstone is a friable deposit, and fresh rock exposures are of rare occurrence except along the channels of streams, where erosion is very rapid. The surface of the land upon the Silo sandstone in the Tishomingo quadrangle is generally smooth, though undulating, and is densely forested.

CORRELATION OF CRETACEOUS FORMATIONS.

The change in the nature of the Cretaceous strata from Indian Territory southward through Texas is such that it is necessary to use different names for the formations deposited during the same geologic time in the two regions. The formations named in this folio or their equivalents have been traced continuously from Indian Territory to the Austin quadrangle in central Texas, and the following table is introduced to show the correlation of strata:

Correlation table of Cretaceous formations.

Names used in this and the Atoka folios.	Names used by Hill and Vaughan in the Austin folio.
Silo sandstone.	Eagle Ford formation.
Bennington limestone.	Buda limestone. Del Rio clay.
Bokchito formation. Caddo limestone. Kiamichi formation.	Georgetown limestone.
Goodland limestone.	Edwards limestone. Comanche Peak limestone. Walnut clay.
Trinity sand.	Glen Rose formation. Travis Peak formation.

PLEISTOCENE DEPOSITS.

Terrace sand and gravel.—Along the valley of Washita River are deposits of gravel and sand resting in nearly horizontal positions at an average elevation of about 100 feet above the river bottom plain. These deposits were found in thinly scattered remnants or mantles of considerable thickness and occur on both sides of the valley. The highest levels reached by these deposits are farthest from the river. In some instances those nearest the river channel were observed to descend almost to the level of the more recent sands and silts of the immediate river valley. The materials of these deposits are quartz, quartzite, jasper, and other hard siliceous gravels, besides sand and silt, and they are found upon the eroded surfaces of both the Paleozoic and Cretaceous rocks. These gravels usually occur at the base of the surficial deposits and are succeeded by sands of finer texture, which are succeeded in turn by fine sands and silts. The coarser gravels are not found at all places at the base of these deposits, however. The finer sediments can not be distinguished from the weathered surface sands of the Trinity formation, both being a fine, yellow quartz sand. Where these surficial deposits come in contact with the Trinity sand it is not possible accurately to draw the dividing line. Abundant gravels occur as a thin mantle spread over the surface in the vicinity of Tishomingo. These gravels are also found upon high land west of Earl and at many other places where the Trinity formation approaches the immediate valley of Washita River. The north and south limits of the areas occurring between Linn and Emet are separated by about 6 miles, the deposits extending gradually downward toward the river valley.

In view of the fact that these deposits occur along the borders of the river valley, and are related in a certain degree to the more recent deposits of the same river, it is considered that they represent deposits of this river when it flowed at elevations of 100 feet and less above its present plain, at some time probably early in the Pleistocene. In the Coalgate quadrangle surficial deposits of practically the same kind occur as remnants in a wide, shallow, and elevated channel contiguous to the valley of Canadian River.

River sand.—Washita River in its course across the Tishomingo quadrangle has a grade approximating 2 feet per mile and at no place observed does it cut bed rock except laterally, where in a few places its meanders approach the outer limit of its sand and silt deposits. In the past its load of sand and silt has been more than it could carry and conditions have not changed materially up to the present time. The excess of sand and silt brought down and deposited along its course has caused the river to meander from side to side until it has built up of these surficial deposits a graded plain in places 4 miles in width. There are some indistinct or limited terraces near the outer border of these deposits, but as a rule the sand plain grades down to the present river flood plain. This flood plain is approximately 20 feet below the general level of the sand plain. In places, however, the sand at the border of the plain reaches 50 feet above the river level.

GEOLOGIC STRUCTURE.

HISTORY OF THE ARBUCKLE MOUNTAIN STRUCTURE.

Near the beginning of Upper Carboniferous time the western part of the Arbuckle Mountain region, including the western part of the Tishomingo quadrangle, was elevated to land and in part to mountainous altitude. The Cambrian, Ordovician, Upper Silurian, Devonian, and Lower Carboniferous rocks, 8000 to 10,000 feet in thickness, were successively exposed by erosion. During this degradation, which occurred in Upper Carboniferous time, extensive limestone conglomerates were deposited with sandy and shaly sediments in the adjoining sea. Before the close of the Carboniferous the Arbuckle uplift, by erosion or subsidence or their combined effects, was submerged, in part at least, and the Upper Carboniferous conglomerates were deposited across it on the eroded edges of older strata. Following the deposition of conglomerates both folding and faulting occurred, since the whole section of the Upper Carboniferous is involved in parts of the uplift both within and upon its borders..

The "Red Beds," here classed as late Carboniferous (Permian), lie nearly flat and lap across the western end of the Arbuckle uplift, resting upon all rocks from Upper Carboniferous to Lower Ordovician. The low westward dip of the "Red Beds" and their extreme unconformity with all the rocks in the Arbuckle uplift indicate that folding had ceased in the western part of the Arbuckle Mountain region at the close of the Carboniferous. The almost universal lack of local coarse material, even at the base of the Trinity sand, which is the beach and near shore deposit, indicates that the land was low and that folding had ceased at the time of the encroachment of the Cretaceous sea.

Following Cretaceous time the whole region was uplifted and slightly tilted southward without folding. This late oscillation of the land and the progress of recent denudation has already been discussed under the heading "Topography."

Folds and faults.—The Arbuckle uplift is composed of a number of folds, which together make a broad arch flexed downward steeply upon the sides. The folds are nearly parallel and bear approximately N. 70° W. The uplift is concealed by the overlap of Upper Carboniferous and Permian strata toward the northwest and by Cretaceous rocks toward the southeast. The axial parts of the anticlines, wherein are exposed a great thickness of massive Cambro-Silurian limestone, are generally broadly flexed; while the younger, softer, and thinner rocks in the intervening synclines are crumpled into many small folds, but in no place are they closely pressed or overturned. These synclines are faulted and displaced to an extraordinary degree. The faults and folds are so related that it is convenient to describe them together.

In the Tishomingo quadrangle and elsewhere in the Arbuckle uplift the main faults are approximately parallel with the folds. The larger synclinal folds are generally faulted on both sides as well as within, and the displacements are downward toward the axis, usually without marked shearing or crushing of the strata near the faults. In some instances the dips in the direction of the movement become greater near the faults. While the faults are generally parallel with the axes of the folds they do not usually follow the strike of the rocks. The discordance in the strike of the rocks and the bearing of the faults is due to the pitch of the axes and to variation in the width of the folds. The strikes of the rocks intersect the faults at all angles.

The general parallelism of the larger folds and faults would suggest that the common cause of their formation was the action of horizontal forces.

Faults of extensive displacements produced by horizontal forces usually develop from folds which are overturned and finally ruptured, the anticlinal portion being thrust over on the synclinal. The plane of such faults would be more or less parallel with the bedding of the overthrust portion. Such conditions do not occur along the faults of this area. The folds are open and never overturned, and the dips of the beds along the faults are usually in the opposite direction from the hade of a theoretical thrust plane.

The general discordance in the strike of the rocks on the opposite sides of the faults, the absence of pronounced shearing or crushing of the strata, even where the displacement is great, the openness of the folding with no indication of overturning or parallelism with thrust movement, and the occurrence of dips in the direction of the downthrow along the faults clearly indicate that the faulting, in most cases at least, is of the normal type or drop faulting.

Hunton anticline.—At the eastern end of the Arbuckle uplift the northernmost fold, called the Hunton anticline, enters the northeast corner of the quadrangle, pitching eastward at an angle of about 10°. It continues eastward about 10 miles into the Atoka quadrangle, where it ends in the side of a broad basin of Coal Measures strata. The axial portion here is flat, while the sides are flexed downward and faulted. The vertical displacement of the faulted strata on each side of the fold is downward several hundred feet. Toward the east these faults die out in the Carboniferous strata. Toward the west the one on the south increases and joins a number of similar faults culminating in a single deep fracture which defines the south side of the fold across the quadrangle.

The fault on the north side decreases and is lost in the axial part of the anticline near Gum Spring. Westward the Hunton anticline becomes broad and flat and ends in the southwestern part of the Stonewall quadrangle, where it is concealed by Coal Measures conglomerate, deposited since the rocks were folded. The rocks on the north limb of this anticline dip steeply toward the northeast, and in the Stonewall quadrangle are broken by faults which strike east and west and displace the strata downward toward the north, as in the northeast corner of the quadrangle.

Wapanucka syncline.—A flat eastward-pitching syncline occurs immediately south of the Hunton anticline. This may be called the Wapanucka syncline because it corresponds to the broad flat valley of Wapanucka Creek. This syncline becomes broader and flatter eastward until it dies out or joins indistinctly the Lehigh basin in the coal field. Westward it contracts by faulting toward the axial part until it practically ceases as a fold 6 miles west of the quadrangle border. Still farther west it occurs in parts along a single fault which extends almost to the northwest corner of the quadrangle. The southern limb of the Wapanucka syncline is very extensively fractured and displaced by a system of faults. Here a number of small faults bearing nearly east-west join a larger one bearing approximately N. 70° W. In each case the displacement is downward, toward the axis of the syncline. Where two or more of these faults, having displacements in the same direction, join, the combined throw is very great. One mile east of the border of the quadrangle Carboniferous shales are brought down into contact with Lower Ordovician limestone in a displacement of probably 4000 feet. Two miles south of Wapanucka and 4 miles east of the Tishomingo quadrangle the vertical throw is even greater. At this place nearly the whole of the Paleozoic section below the Carboniferous, aggregating about 8000 feet, is concealed by cumulative faulting.

Belton anticline.—The granite tongue which extends northwestward in the vicinity of Belton occupies the axial part of an anticlinal fold, the sides of which have been faulted in an extraordinary manner. This fold will be called the Belton anticline, from the town of Belton, which is located upon it 5 miles from the eastern margin of the quadrangle. The anticline bears southeastward nearly to the center of the Atoka quadrangle, where the folded rocks and granite are concealed by the flat-lying Cretaceous strata. The contacts between the Silurian and Cambrian limestones and the granite, except at the extreme southeast end of the granite, are fault contacts. Near the eastern part of the anticline in this and the Atoka quadrangle the massive Cambro-Silurian limestone is steeply tilted and faulted, coming in contact with the granite abruptly and at various angles. Northwest of Belton only the axial part of the anticline is now preserved. The Cambrian and Ordovician rocks are nearly flat except locally along the sides of the uplift, near the lines of faulting. Here the rocks are displaced downward with respect to the older rocks in the axial part of the anticline.

Mill Creek syncline.—The district of the greatest folding and faulting in the Tishomingo quadrangle is found south of the Belton anticline.

It is from one-fourth mile to 2 miles in width, and consists of parts of many small folds faulted together. The relations of these small folds indicate that prior to the faulting they formed crumplings, with a broader syncline which has been depressed and in large part obliterated by greater faults upon each side. This broken fold is known as the Mill Creek syncline. These greater lateral faults have displaced the crumpled and faulted strata of the syncline so that they now occur as a wedge between the older strata. Near the southeast end a long tongue of Cambro-Silurian limestone occurs in the axis of the syncline and is faulted down between the pre-Cambrian granite, almost severing the large granite area into two parts. Here the strata of the Cambro-Silurian limestone, 6000 feet thick, are brought successively against the granite. Farther west the Carboniferous rocks in the broken folds in the syncline are in contact with Ordovician and Upper Silurian strata at a number of places along fault contacts. The structure of the small folds and associated faults within the Mill Creek syncline may be easily read from the map, and it is not considered necessary to explain them in detail. Near the northwest corner of the quadrangle the rocks involved in the Mill Creek syncline are concealed by the overlap of the Franks conglomerate.

Tishomingo anticline.—Lying south of the broken Mill Creek syncline there is a broad westward-pitching anticline called the Tishomingo, in the axial part of which is a large mass of pre-Cambrian granite. This anticline is the southernmost well-defined fold of the Arbuckle uplift in the Tishomingo quadrangle. Faults on both the north and south sides have concealed a large part of the fold by displacement. From the granite westward on the north side especially the limestone strikes abruptly against the fault bordering the Mill Creek syncline. Successively higher rocks are exposed westward upon each side and the anticlinal structure of the fold becomes more pronounced.

A fault extends throughout the south limb of the Tishomingo anticline oblique to the strike of the rocks, so that parts of an adjoining syncline are exposed. Near the border of the quadrangle and north of the fault the north limb and axis of a narrow syncline is shown, where strata from the Ordovician to the Carboniferous are exposed. Near the east end and south of the fault adjoining the granite the south limb of a syncline occurs in the massive Cambro-Silurian limestone. The axes of these parts of folds are nearly parallel and each approaches the fault at a low angle. If they are parts of the same syncline this fact has been entirely concealed by the displacement of the fault through several miles in the central part.

A fault crosses the western border of the quadrangle near the south side of T. 2 S., R. 3 E., bears eastward, and joins the long fault above described. Between these faults a narrow, angular block of soft Lower Carboniferous shale occurs depressed between walls of Ordovician, Upper Silurian, and Devonian rocks. At the west this depressed block is anticlinal in structure and pitches steeply toward the east. At other places farther east the shale is intricately crumpled and sheared.

The southernmost anticlinal fold in the Tishomingo is only partially represented. The fault extending along the south side of the Tishomingo anticline has displaced and concealed the north limb except at the east end in and near the southwest corner of T. 3 S., R. 5 E. The south limb is also cut off by a fault at the western border of the quadrangle. The south limb of this southernmost anticlinal fold dips steeply toward the southwest at angles varying between 40° and 80°.

Red River plain monocline.—The portion of the Red River Plain lying in the Tishomingo quadrangle is confined to the area of Cretaceous rocks. The Cretaceous rocks were deposited after the folding of the older rocks in the northern part of the quadrangle and the sediments were spread across their worn edges, as has been shown in the discussion of the stratigraphy. At the present time these rocks are uniformly and evenly tilted toward the south at the grade of about 40 feet to the mile.

MINERAL RESOURCES.

The mineral resources of this region are asphalt, granite, limestone, and clay. Besides these resources there should be considered also the soils, some of which are very fertile. Asphalt is the only product that has been developed to any considerable extent. Building materials have received less attention, and 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.

ASPHALTIC DEPOSITS.

Asphaltic deposits of economic importance are found in the vicinity of Gilsonite, near the northwest corner of the Tishomingo quadrangle. With the exception of that in the Carboniferous limestone conglomerate near the village of Buckhorn these deposits occur in Ordovician sandstone and limestone in and near the west end of the contorted and faulted anticlinal fold described under the heading "Belton anticline." These bituminous deposits occur chiefly as interstitial impregnations in the sandstone, limestones, conglomerates, and grits of three distinct geologic formations, which will be described in the order of their age, beginning with the oldest. These bitumens when separated from their containing rock, whether it be a friable sandstone or a hard semicrystalline limestone, have practically the same consistency, being semi-liquid or plastic except locally, where the rock has undergone long weathering. In any case the bituminous substance when extracted is classed as mineral tar or maltha, since it is viscous or semifluid in consistency.[1] An asphalt or asphaltite is a solid bitumen and is reduced to a plastic or viscous state by the introduction of other substances or by the application of heat. Where the richer bituminous rocks are exposed to the heat of the sun's rays the tar or maltha will flow from the surface in viscous steams. If the bituminous rock is friable, as is the case with bituminous sandstone, it will become plastic under the stroke of the hammer, is easily pliable in the hands, and the bitumen adheres to the fingers.

Bituminous sandstone.—The bituminous sandstone in the vicinity of Gilsonite occurs in the medial and upper sandstone members of the Simpson formation which is of Ordovician age. These sandstone members, with the exception of local calcareous indurations, are composed of moderately fine even-textured and nearly pure quartz sand. The sand grains are held together by the bitumen which occupies the spaces between them. The bituminous sandstone is not limited by areas or bodies of impervious rock, but is surrounded by porous, compact sand of the same nature as the whole mass before the introduction of the bitumen. The richer bituminous rock contains 7 to 12 per cent of bitumen, and grades outward into the barren sand in

[1] Eldridge, George H., Asphalt and bituminous rock deposits in the United States: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 1, pp. 220-227.

peculiar ways. In some instances the bitumen occurs in layers or streaks parallel with the bedded structure and alternating with the purer and at present porous sand. Mr. Eldridge's investigations showed that, in some instances at least, the pure sand between the bituminous layers contained a considerable percentage of lime, while the bituminous sand contained none. This was interpreted to indicate that these layers originally contained a limy cement which prevented the introduction of the bitumen into them.

There are at least five areas of economically valuable bituminous sandstone in the vicinity of Gilsonite. Four of these are in the Tishomingo quadrangle and the fifth is just beyond the border, on Rock Creek, 2 miles a little north of west from Gilsonite. The places where these bituminous rocks are mined are indicated by mine symbols on the Areal Geology sheet.

The mine at Gilsonite is located in the upper sandstone member of the Simpson formation and the impregnations of bitumen have entered some of the associated siliceous and fossiliferous limestone layers. The bituminous sandstone is closely associated with a fault and occurs in the upthrow side. The bituminous beds are tilted strongly southward by the drag in the downward displacement of the rocks toward the south. The increase in the displacement of faulting eastward conceals the upper sandstone members in the south side of the Belton anticline.

A second area of bituminous sandstone occurs in the upper member of the Simpson formation nearly half a mile west of Gilsonite, also nearly in line with the faults above named, and near a more more extensive cross fault which bears N. 30° W. The downthrow of this latter fault is toward the east and is sufficient to cause a horizontal displacement of the formations of more than a thousand feet. The bituminous sandstone is exposed several hundred feet along the strike in a belt about 50 feet in width. Within this area the rock has been prospected and mined. As at Gilsonite the beds are tilted approximately 25° SE. In the NW. ½ sec. 22, T. 1 S., R. 3 E., in line with the cross faulting above mentioned, there is a third area of bitumen impregnating the middle member of the Simpson formation. This bituminous sandstone occurs in the axial part of the anticlinal fold, where the beds are nearly flat. There are three quarries, known as the Kirby mines, in this area, which is located in the axial trend of the east-west bearing Belton anticline and is about a third of a mile in length. This sandstone is similar to and the impregnations of bitumen are in general respects the same as in the mines upon the upper sandstone member at and west of Gilsonite. The bituminous sandstone in the westernmost of the Kirby mines is overlain unconformably by the Franks conglomerate, which was deposited after the introduction of the bitumen into the sandstone, and is not itself bituminous. Some bowlders and large pebbles of bituminous calcareous sandstone and balls of rolled asphaltum occur in and forming part of the conglomerate, which is made chiefly of rolled Ordovician limestone in a moderately hard gritty matrix. The fourth area of the bituminous sandstone in the quadrangle is in the eastward extension of the same sandstone member as that in which the Kirby mines are located. It is also upon the axial part of the same anticlinal fold, and the beds are practically flat. The two mines located in the bituminous sandstone of this area occur half a mile north of Gilsonite, in the south side and west end of a low ridge capped by a heavy limestone conglomerate, as at the west Kirby mine. This sandstone and the impregnations of bitumen are practically the same as in the other bituminous sandstone, above described.

The fifth and last valuable bituminous sandstone deposit known in this vicinity occurs at the base of the high bluff in Rock Creek, near the southwest corner of sec. 21, T. 1 S., R. 3 E. Only a small area of the highly bituminous sandstone occurs here. The rock has a thickness of about 15 feet as exposed in the mine. The Carboniferous limestone conglomerate makes a cliff 75 to 100 feet high, overlying bituminous sandstone. This conglomerate rests unconformably upon the sandstone and contains but little bituminous material, which appears to be a redeposited bituminous grit with occasional bituminous pebbles and small bowlders such as occur in the conglomerates overlying the sandstone conglomerates in the Kirby mines.

Bituminous limestone.—The bituminous limestones of economic importance in the Tishomingo quadrangle belong to the Viola formation, which is in the upper part of the Ordovician section. The bitumen occurs impregnating massive and hard limestone. A large part of the limestone, especially in the upper half of the formation, is crystalline and is bedded with granular and argillaceous layers. The rock contains cherty segregations and calcite inclusions, the latter being most abundant in the upper part. The bitumen has not entered the calcite bodies except in part and to a very slight degree. Locally the limestone has been crushed and jointed, producing thin fissures into which the bitumen has entered as veinlets. The better grade of bituminous limestone carries 5 to 6 per cent of bitumen. The bituminous limestone occurs in two areas, one at Gilsonite and the other about a mile to the southwest.

Two mines have been located upon the bituminous limestone one mile southwest of Gilsonite. The larger of these is at the extreme west end of the Viola limestone ridge and the other on the crest, about 600 feet farther east. At the largest mine the limestone is abruptly cut off and concealed by heavy deposits of Carboniferous limestone conglomerate. The abrupt ending of the limestone and its non-occurrence farther west suggest strongly the probability of a dip fault and displacement of the limestone similar to that half a mile west of Gilsonite, described above. The bituminous limestones are most advantageously situated for economic mining operations, in a bluff 50 feet high, at the terminus of the ridge where the rocks are steeply tilted southward, exposing more than 300 feet of strata. Of the 340 feet of bituminous limestone at this locality, 128 feet in the lower part contain 5 to 6 per cent of bitumen. The upper 140 feet and a portion at the base of the section are not productive, owing to the quantity of barren rocks associated with the bituminous strata. The mine on the crest of the ridge appears to be in the same body of bituminous limestone, and the same beds have been quarried. The richer bituminous limestones at Gilsonite occur in the Viola limestone ridge on which the post-office is located. The limestone here dips about 30° SE., and the bituminous limestone has been mined by means of slopes. The richer bituminous layers alternate with beds containing little or no bitumen. The better grade of the rock will yield 5 to 6 per cent bitumen.

Bituminous rocks in Carboniferous conglomerate.—Certain beds in the east end of the local flat synclinal fold near the southeast corner of sec. 26, T. 1 S., R. 3 E., about half a mile west of Buckhorn, contain the richest bituminous deposits known to occur in this field. The north limb of the fold near the east end is faulted down toward the south. The bituminous beds in the crest of the hill west of Buckhorn, where a mine has been opened, dip N. 28° W., at an angle of about 30°, and strike against a fault. The bituminous and associated beds consist of conglomerate, grits, shale, and limestone interstratified. The bituminous limestone contains an abundance of shells perfectly preserved and showing the nacreous luster. Some of the calcareous and gritty beds contain many coal fragments having the woody structure preserved. The limy beds are the most bituminous. The richest bed, which is locally conglomeratic at the base and about 10 feet thick, will produce approximately 14 per cent of bitumen.

BUILDING STONES.

Granite.—The Tishomingo granite is exposed in an area of about 100 square miles in the Tishomingo quadrangle. As described under the heading "Geology" the granite is generally of rather coarse texture and of a pinkish or reddish color.

It is variable, however, both in color and texture, ranging from a very coarsely crystalline to a fine-grained rock, and from light pink to almost red. The Tishomingo granite has been intruded by a great number of dikes of diabase, ranging from a fraction of an inch to 40 feet in thickness. The diabase is generally fine grained and varies in color from dark blue to nearly black.

In parts of the area the Tishomingo granite has suffered faulting and jointing to such an extent that it can not be used as a building stone. In such places the rock is intersected in many directions by fractures which cause it to break into small irregular pieces upon being quarried. In a large part of the area, however, it occurs as a massive rock, so that large masses of valuable stone could be quarried.

The granite makes a handsome building stone and will bear a smooth polish in working for ornamental purposes. The basic dark-blue and gray dike rock especially will take the finest polish and will make a handsome building or decorative stone. This rock occurs most abundantly in the western part of the area and is best exposed along Pennington, Rock, and Mill Creek valleys. The granite has been utilized in the construction of the Chickasaw capitol building at Tishomingo. A branch of the St. Louis and San Francisco Railroad has recently been built from northern Indian Territory to Texas across the western part of the granite area and this should induce development of the quarry industry.

Limestone.—A large part of the area lying north and west of the granite in this quadrangle is limestone of the Arbuckle, Simpson, Viola, and Hunton formations. Of these the Hunton and Viola formations contain limestones in large quantity suitable for building stone. In the larger part of these areas the limestones are so steeply tilted that they could not be quarried successfully, even where desirable for building purposes. Certain beds in the upper part of the Arbuckle limestone are hard, white, and evenly bedded. They are found well situated for quarrying across the axial part of the Tishomingo anticline from the vicinity of Wyatt northward, where the rocks dip at low angles toward the west, and across the flat Hunton anticline west of Cartersville, where they are very slightly inclined toward the east. In each case the rocks dip with the grade of the land. The same limestones in the Arbuckle formation are similarly situated in the vicinity of Alhambra and of Vaughn; also north and northeast of Mill Creek, where they dip toward the southwest. Certain beds in the Viola limestone below the center occur in even and moderately thin layers suitable for building stone. This rock is light blue to cream-white and hard, but not exceedingly tough. In the larger areas in the northeast corner and near the western border of the quadrangle west of Nebo these rocks are nearly flat. Elsewhere the formamation has been steeply folded and occurs now with the edges of the beds exposed. Some of the purer limestones in the Simpson formation may be utilized as building stones, but the grade is not equal to that of the Arbuckle and Viola limestones. Certain of these beds outcrop in sec. 11, T. 1 S., R. 3 E., where they have been utilized as building stones in the town of Sulphur, which is situated 1½ miles toward the northwest.

The Goodland limestone is a nearly pure, massive bed of white limestone well situated and structurally disposed for use, but it is generally too soft and weak for a good building stone. It is considered an excellent lime-producing rock and is situated upon the border of the extensive timber belt of the Trinity sands, where fuel for burning lime is abundant.

CLAY.

Clay and shale are the most abundant of the rocks that occur in the Carboniferous formations in this region. These beds vary in quality from very sandy strata to purer argillaceous, finely laminated clays.

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

The Sylvan shale, 100 to 300 feet thick, is composed of fine, friable blue clay. It will require testing to determine whether this clay shale is serviceable for brick making or for other uses.

SOILS.

The soils in the Tishomingo quadrangle are of great variety, ranging from an almost barren stony soil, serviceable only for grazing, to the most fertile river bottom and black marly upland. The soils, excepting those in the stream bottoms, are residual—that is, they are derived directly from the disintegrating rock of the formation lying beneath them. A classification of the soils therefore would correspond practically to the classification of the rock formations.

All the formations that are composed of hard rocks—Arbuckle limestone, Simpson formation, Viola, Hunton, and Sycamore limestones and Woodford chert—especially where steeply upturned, are generally exposed and produce stony or thin soils, and, with the exception of limited areas, are fit only for grazing lands.

The Tishomingo granite lies in a nearly level plain, but for the most part its soils are thin and sandy. In the southern part this soil contains an admixture of loose sand from the Trinity formation, which recently covered it.

The Caney shale is friable and calcareous. It makes flat or gently rolling lands and contains the most fertile soils in the northern part of the quadrangle. The valley of Buckhorn Creek, which is in this shale, is notable for its fertility.

The Glenn formation produces a variety of clay and sandy loamy soils. The relative fertility of these depend in a large measure upon the inclination of the surface. The eastern part of the Glenn formation being somewhat elevated and near the river valley, is sharply cut in small gulches and gullies. Here the soil is thin and suitable only for grazing land.

The Trinity sand produces a loose sandy soil or simply a loose sand without perceptible elements of soil. In places where the country is almost perfectly flat this formation produces a light, loamy soil, moderately fertile, which is best adapted to the production of fruits and vegetables. In the more rolling part and in most of the flat lands the Trinity sand area has still upon it the forest, its best product, which should be carefully preserved.

The Goodland limestone produces a black, calcareous clay soil, but, owing to its outcrop in terrace escarpments and steep slopes, the soil is removed as fast as formed, except in occasional small, flat areas between the valleys. The succeeding Kiamichi, Caddo, and Bennington limestones make black, calcareous clay soils, which are very fertile. These lands are generally smooth, though rolling. The Bokchito formation, being composed of ferruginous sands and clays with occasional limestone layers and forming a more or less hilly or rolling country, produces moderately fertile reddish or brownish loams, which are best adapted to fruit culture. The Silo formation makes a reddish and brown sandy soil resembling that of the Trinity formation. It is more fertile, however, and, besides yielding the usual crop of cotton and grain, it is admirably adapted to the production of peaches and small fruit, especially grapes.

June, 1903.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

TOPOGRAPHY

INDIAN TERRITORY
(CHICKASAW NATION)
TISHOMINGO QUADRANGLE

C.H. Fitch, Topographer in charge.
Van.H. Manning, Topographer Assistant in charge.
Triangulation by C.F. Urquhart.
Topography by R.H. McKee and C.W. Goodlove.
Surveyed in 1897-98.

APPROXIMATE MEAN DECLINATION 1902

Scale $\frac{1}{125000}$

Contour interval 50 feet.

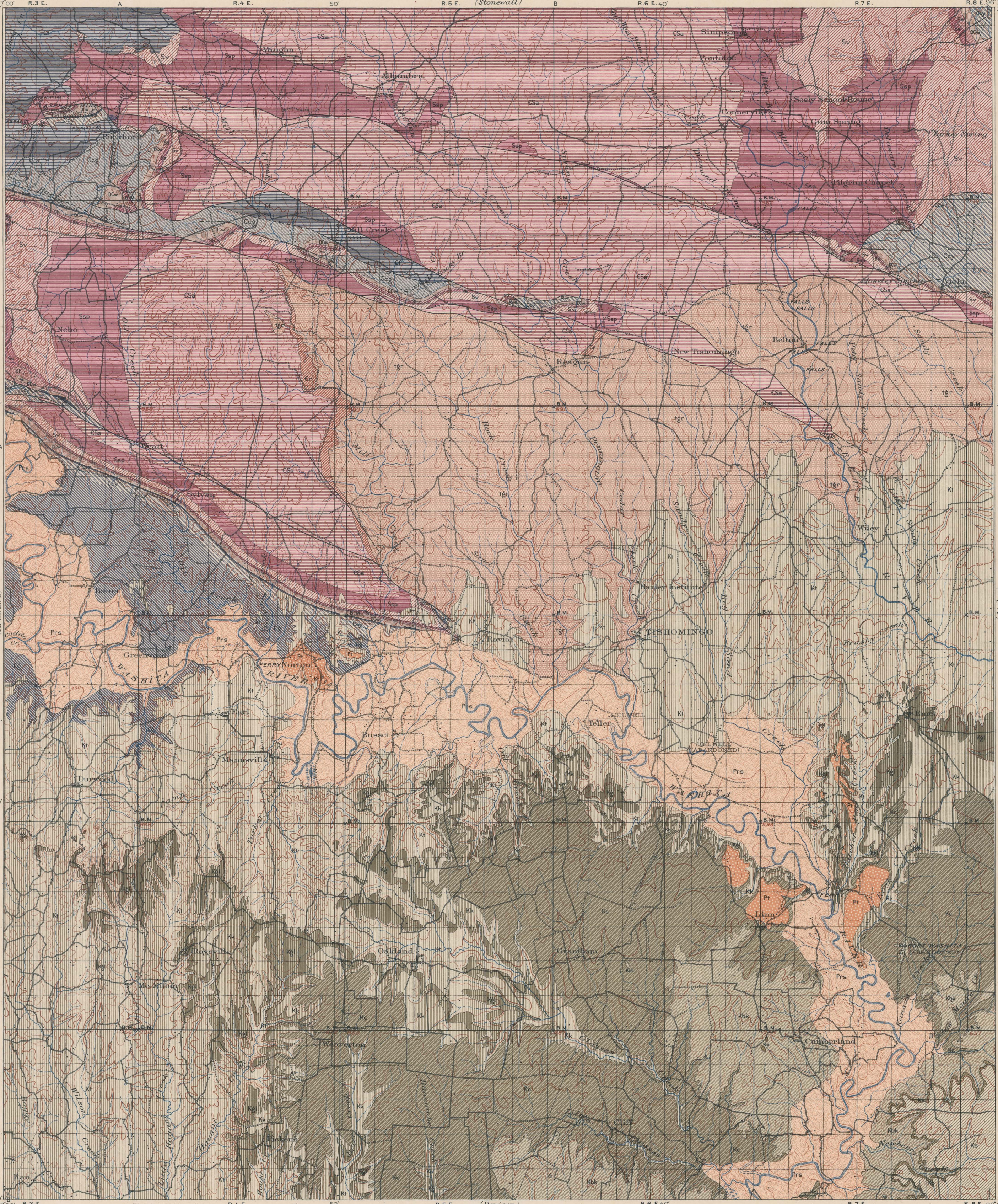
Datum is mean sea level.

Edition of Mar. 1903.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

AREAL GEOLOGY

INDIAN TERRITORY
(CHICKASAW NATION)
TISHOMINGO QUADRANGLE



C. H. Fitch, Topographer in charge.
Van. H. Manning, Topographer Assistant in charge.
Triangulation by C. F. Urquhart.
Topography by R. H. Mc Kee and C. W. Goodlove.
Surveyed in 1897-98.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 50 feet.
Datum is mean sea level.

Edition of June 1903.

DIAGRAM OF TOWNSHIP

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

Geology by Joseph A. Taff.
Assisted by Sidney H. Ball.
Surveyed in 1900.

LEGEND

SURFICIAL ROCKS

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

PLEISTOCENE — *Recent*

- Prs — River sand *(fine yellow sand and alluvium.)*
- Pt — Terrace sand and gravel

SEDIMENTARY ROCKS

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

CRETACEOUS

Gulf series

- Ks — Silo sandstone *(partially consolidated brown sandstone and shale)*

Comanche series

- Kb — Bennington limestone *(blue or yellowish blue compact shell limestone)*
- Kbk — Bokchito formation *(friable shale and sandstone with few beds of limestone)*
- Kc — Caddo limestone *(limestone and marly clay interstratified)*
- Kk — Kiamichi formation *(blue marly clay with shell limestone beds)*
- Kgl — Goodland limestone *(white massive and thin limestone)*
- Kt — Trinity sand *(yellow sand with gravel at the base)*

UNCONFORMITY

CARBONIFEROUS

Pennsylvanian series

- Cf — Franks conglomerate *(coarse limestone conglomerate, shale, and fossiliferous limestone)*

UNCONFORMITY

- Cg — Glenn formation *(shale and thin sandstone)*

Mississippian series

- Ccg — Caney shale and Glenn formation *(undifferentiated in the much disturbed area in the central portion of the Arbuckle uplift)*
- Ccy — Caney shale *(black and blue shale with chert and limestone lentils)*
- Csm — Sycamore limestone *(blue to yellow thin-bedded limestone)*

DEVONIAN

- DCw — Woodford chert *(black flint, chert, and shale)*

SILURIAN

- Sh — Hunton limestone *(white and yellow limestone)*

Ordovician

- Ss — Sylvan shale *(blue friable shale)*
- Sv — Viola limestone *(blue thin-bedded limestone)*
- Ssp — Simpson formation *(thin limestone, shale, and sandstone)*

CAMBRIAN

- €Sa — Arbuckle limestone *(blue thick-bedded limestone)*
- €r — Reagan sandstone *(sandstone and arkose conglomerate)*

Legend is continued on the left margin.

LEGEND
(continued)

IGNEOUS ROCKS

(Areas of Igneous rocks are shown by patterns of triangles and rhombs.)

PRE-CAMBRIAN

- tgr — Tishomingo granite *(pink pegmatitic granite with occasional diabase dikes)*

Faults

Concealed faults *(continuation of known faults beneath later deposits)*

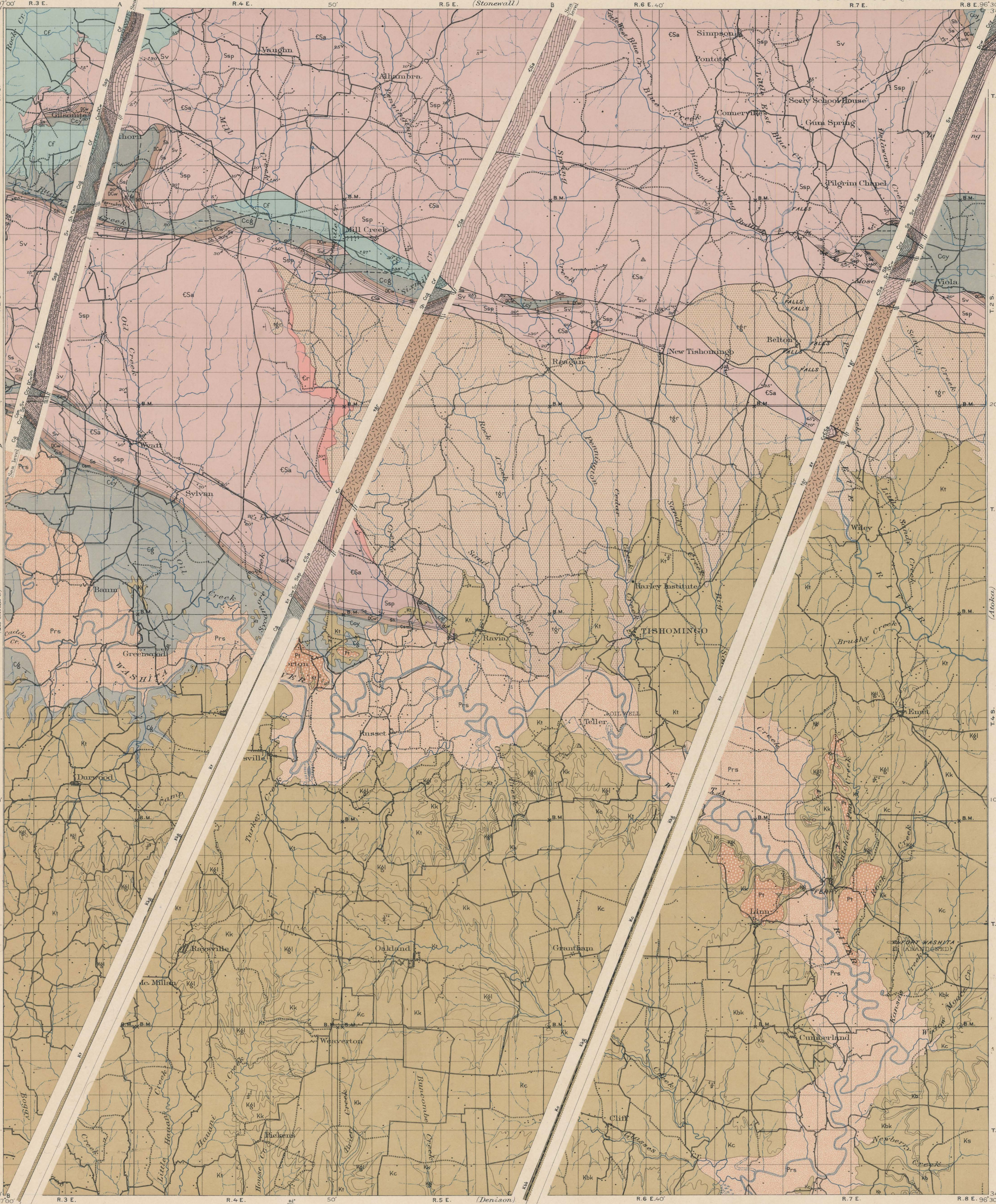
⚒ Asphalt mines

Sections

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

STRUCTURE SECTIONS

INDIAN TERRITORY
(CHICKASAW NATION)
TISHOMINGO QUADRANGLE



LEGEND (continued)

IGNEOUS ROCKS

PRE-CAMBRIAN

SHEET SYMBOL	SECTION SYMBOL	
tgr	tgr	**Tishomingo granite** (pink pegmatitic granite with occasional diabase dikes)

Faults

Concealed faults (continuation of known faults beneath later deposits)

20° Strike and dip of stratified rocks

LEGEND

SURFICIAL ROCKS

PLEISTOCENE — Recent

SHEET SYMBOL	
Prs	**River sand** (fine yellow sand and alluvium)
Pt	**Terrace sand and gravel**

SEDIMENTARY ROCKS

		SHEET SYMBOL	SECTION SYMBOL	
CRETACEOUS	Gulf series	Ks		**Silo sandstone** (partially consolidated brown sandstone and shale)
CRETACEOUS	Comanche series	Kb		**Bennington limestone** (blue or yellowish blue compact shell limestone)
CRETACEOUS	Comanche series	Kbk	Kbk	**Bokchito formation** (friable shale and sandstone with few beds of limestone)
CRETACEOUS	Comanche series	Kc	Kc	**Caddo limestone** (limestone and marly clay interstratified)
CRETACEOUS	Comanche series	Kk	Kkg	**Kiamichi formation** (blue marly clay with shell limestone beds)
CRETACEOUS	Comanche series	Kgl	Combined with Kiamichi formation on sections	**Goodland limestone** (white massive and thin limestone)
CRETACEOUS	Comanche series	Kt	Kt	**Trinity sand** (yellow sand with gravel at the base)
				UNCONFORMITY
CARBONIFEROUS	Pennsylvanian series	Cf	Cf	**Franks conglomerate** (coarse limestone conglomerate, shale, and fossiliferous limestone)
				UNCONFORMITY
CARBONIFEROUS	Pennsylvanian series	Cg	Cg	**Glenn formation** (shale and thin sandstone)
CARBONIFEROUS	Mississippian series	Ccg	Ccg	**Caney shale and Glenn formation** (undifferentiated in the much disturbed area in the central portion of the Arbuckle uplift)
CARBONIFEROUS	Mississippian series	Ccy	Ccy	**Caney shale** (black and blue shale with chert and limestone lentils)
CARBONIFEROUS	Mississippian series	Csm	Csm	**Sycamore limestone** (blue to yellow, thin-bedded limestone)
DEVONIAN		DCw	DCw	**Woodford chert** (black flint, chert, and shale)
SILURIAN		Sh	Sh	**Hunton limestone** (white and yellow limestone)
SILURIAN	Ordovician	Ss	Ss	**Sylvan shale** (blue friable shale)
SILURIAN	Ordovician	Sv	Sv	**Viola limestone** (blue thin-bedded limestone)
SILURIAN	Ordovician	Ssp	Ssp	**Simpson formation** (thin limestone, shale, and sandstone)
CAMBRIAN	Ordovician	€Sa	€Sa	**Arbuckle limestone** (blue thick-bedded limestone)
CAMBRIAN		€r	€r	**Reagan sandstone** (sandstone and arkose conglomerate)

Legend is continued on the left margin.

C.H. Fitch, Topographer in charge.
Van. H. Manning, Topographer Assistant in charge.
Triangulation by C.F. Urquhart.
Topography by R.H. McKee and C.W. Goodlove.
Surveyed in 1897-98.

TRUE NORTH — MAGNETIC NORTH — 8½°
APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Edition of Sept. 1903.

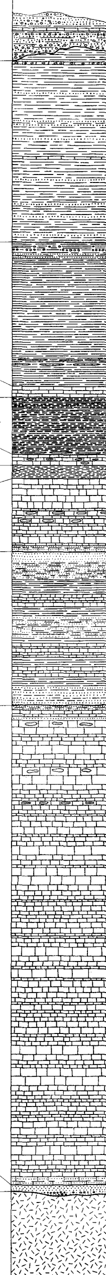
DIAGRAM OF TOWNSHIP

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

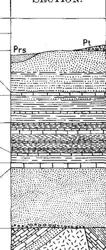
Geology by Joseph A. Taff.
Assisted by Sidney H. Ball.
Surveyed in 1900.

COLUMNAR SECTIONS

GENERALIZED SECTION FOR THE NORTHERN PART OF THE TISHOMINGO QUADRANGLE.
SCALE: 1 INCH = 1000 FEET.

Period.		Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography.
CARBONIFEROUS	PENNSYLVANIAN	Franks conglomerate.	Cf		300–500+	Limestone and chert conglomerates, gritty sandstone, limestone, and shale. Probably represents the upper portion of the Glenn formation and lies unconformably on all the older Paleozoic formations.	Rounded hills and undulating plain.
		UNCONFORMITY.					
		Glenn formation.	Cg		1000–3000	Blue shale with thin brown sandstone and occasional thin limestone.	Rolling plain, locally dissected by deep gullies.
	MISSISSIPPIAN	Caney shale.	Ccy		1500	Blue shale with thin sandy lentils and small ironstone concretions. Black fissile shale with dark-blue fossiliferous limestone concretions.	Level plains and valleys.
		Sycamore limestone.	Csm		0–160	Bluish to yellow limestone.	Narrow, level-topped ridges.
DEV. ?		Woodford chert.	DCw		600	Thin-bedded chert and fissile black shale. Local blue flint lentils at the base.	Low ridges of hilly land.
SILURIAN		Hunton limestone.	Sh		0–200	White and yellowish limestones with flint and chert concretions in upper part.	Sharp, narrow ridges and terraced hills.
		Sylvan shale.	Ss		50–300	Blue clay shale.	Narrow valleys.
	ORDOVICIAN	Viola limestone.	Sv		750	White and bluish limestones with flint concretions in the middle.	Low ridges and hilly land.
		Simpson formation.	Ssp		1600	Bituminous sandstone, calcareous sandstone, and shale. Thin fossiliferous limestone and shale. Bituminous sandstone, calcareous sandstone, and shale. Fossiliferous limestone and shale. Sandstone and shaly beds.	Slopes of shallow valleys.
		SLIGHT UNCONFORMITY.					
? CAMBRIAN		Arbuckle limestone.	€Sa		4000–6000	Massive and thin-bedded white and light-blue limestones with cherty concretions. Dull-blue massive and thin-bedded limestones, sandy at the base.	Slightly dissected rolling plain, recently uncovered from Cretaceous strata.
		Reagan sandstone.	€r		50–150	Coarse dark-brown sandstone at base; calcareous sandstone and shale at top.	
PRE-CAMBRIAN		Tishomingo granite.	tgr			Coarse red granite and monzonite, with diabase, granite-porphyry, and aplite dikes.	

GENERALIZED SECTION FOR THE SOUTHERN PART OF THE TISHOMINGO QUADRANGLE.
SCALE: 1 INCH = 500 FEET.

Period.		Formation Name.	Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.	Character of Topography.
CRETACEOUS		River sand.	Prs			Fine river sand and silt.	River bottom lands.
	GULF	Terrace sand and gravel.	Pt		0–50	Gravel and sand.	Flat benches and low slopes.
		Silo sandstone.	Ks		200+	Brown friable sandstone, locally indurated by ferruginous cement, shale, and shaly sandstone.	Low, round hills and shallow valleys.
		SLIGHT UNCONFORMITY.					
	COMANCHE	Bennington limestone.	Kb		10–15	Blue limestone composed chiefly of shells.	Low escarpments.
		Bokchito formation.	Kbk		140	Red and blue shale with thin ferruginous limestone and lentils of friable sandstone.	Hill slopes and rolling lands.
		Caddo limestone.	Kc		150	Yellow and white limestone and marl.	Low escarpments and rolling land.
		Kiamichi formation.	Kk		50	Blue friable shale; thin limestone composed chiefly of shells in upper portion.	Lower slopes of escarpments and rolling prairie land.
		Goodland limestone.	Kgl		25	Massive white limestone.	Small level benches and bluffs capping escarpments.
		Trinity sand.	Kt		200–400	Fine yellow sand with conglomerate beds locally at the base.	Steep lower slopes of escarpments, rough, hilly land, and low, round hills and wide valleys.
		UNCONFORMITY.					
		Carboniferous, Devonian, Silurian, and Cambrian sediments and pre-Cambrian granite.					

JOSEPH A. TAFF,
Geologist.

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