The Geologic Survey is making a geologic map of the Gulf 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 a geologic map 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 relief, as streams, lakes, and swamps; (2) 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 delimit the horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting parts of the same vertical space between which 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:

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

1. A contour indicates approximately a certain height above sea-level. This is called the contour interval, and the contours are drawn at 50, 100, 150, 200, and 250 feet above sea-level. Along the contour at 250 feet, all points of the surface 250 feet above see-level; 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 200 feet falls feet below the edge of the terrace, while that at 500 feet lies above the terrace; therefore all points on the surface are shown to be more than 100 but less than 200 feet above sea-level. The summit of the higher hill is stated to be 475 feet above sea-level, according to the contour at 250 feet, and 500 feet according to the contour at 200 feet.

In this explanation all the contours are numbered. Where this is not possible, some contours—say every fifth one—are 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 with the surface of the land, it may be said that they are drawn smoothly about smooth surfaces, recede into all extending angles of ridges, and project in passing into all extending angles of valleys. The shape and curvature of the ridges and valleys 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 in an uphill or in a down hill direction; but on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle and close together on steep slopes and mountain sides; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP

The maps representing geologic data show color, geometry, and the distribution of rocks based on the field data, stratigraphic sections, and geologic maps. The map shows the distribution of rock formations on the surface of the earth, and the structure and location map shows their underground relations, as far as known, and in such detail as the scale permits.

LITHOS OF ROCKS

Rocks are of many kinds. The original crust of the earth was probably composed of igneous rocks. These rocks have been derived from them in one way or another. Agents such as temperature, pressure, movement, and chemical action, gradually break up igneous rocks, forming metamorphic, or so-called deposit rocks, of clay, sand, and gravel. Deposits of this class are known as sediments. These are usually hardened into conglomerates, sandstone, shale, and limestone, but they may remain unconsolidated and still be classed as sedimentary rocks.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These beds are shown by the continuous layers in the map. Rocks derived from the sea, or deposited in bodies of water, are called marine deposits. These deposits may be stratified or unstratified. The stratified deposits are called strata, and the unstratified deposits are called breccias.

The geologic history of these rocks is one of deposition, consolidation, and elevation. The processes by which the rocks were formed and consolidated are the same as those by which the original rocks were formed, and the same as those by which the original rocks were formed. The processes by which the rocks were formed and consolidated are the same as those by which the original rocks were formed, and the same as those by which the original rocks were formed.

In this case, the original rocks were formed by the action of the waves of the ocean, which form the sandstone, shale, and limestone. The processes by which the rocks were formed and consolidated are the same as those by which the original rocks were formed, and the same as those by which the original rocks were formed. The processes by which the rocks were formed and consolidated are the same as those by which the original rocks were formed, and the same as those by which the original rocks were formed.

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DESCRIPTION OF THE COLGATE QUADRANGLE.

By Joseph A. Taff.

GEOGRAPHY.

GENERAL RELATIONS.

The Colgate quadrangle is bounded by the meridians 96° and 98° W. and the parallels 34° 30′ and 35° N. They are one quarter of a square degree of the earth’s surface. It is 34 1/4 miles long north and south and 39 5/8 miles wide, and contains nearly 980 square miles. The larger part of the quadrangle lies within the bounds of the Chickasaw Nation. A strip of land 3 miles in width in the western part of the quadrangle south of Canadian River is in the Chickasaw Nation. The area north of the Canadian, except a narrow band one mile in width along the western border, is in the Creek Nation; this narrow band is in the Seminole Nation.

These physiographic regions or provinces are represented in this quadrangle, each of which possesses characteristics which have determined its surface form. These provinces are: the Ouachita Mountain Range, the Arkansas Valley region, and the Prairie Plains. Three other physiographic provinces are to be referred to in the general discussion. These are: the Ozark region, whose western end extends northward into Indian Territory; the Arbuckle Mountain region, which are in the eastern part of the Chickasaw Nation west of the Ouachita Mountains; and the Red River Plain, which includes the eastern portion of the Indian Territory.

The Ouachita Mountain Range, whose ridges cross the northwestern corner of the quadrangle, extends from southeastern Chickasaw Nation near Ada to central Arkansas to the vicinity of Little Rock, and is 220 miles long. It is characterized by numerous ridges and mountains, bearing generally east and west. Near the western end, however, they trend southward and decline rather abruptly to the general level of the Red River Plain. The principal mountains and groups of ridges of the Ouachita Range are separated by relatively wide and flat valleys. These valleys, which are separated by the mountains, descend gradually to the level of Arkansas Valley and the Red River Plain on either side. Near the western end of the range the crests of the ranges are at an elevation of about 1000 feet above sea level and nearly 400 feet above the level of the valley. They gradually descend and near the Arkansas-Indian Territory line attain elevations of about 300 feet above sea, and nearly 1000 feet above the valley of the principal streams. In Arkansas the general elevation of the ridges decreases eastward, until it reaches 500 to 700 feet above sea at the eastern end. Likewise, from the sides toward the center of the range the ridges increase in elevation until they are closed as mountains. Jackfork, Whittingstall, Buffalo, Rich, Blackfork, Kiamichi, and Seven Devils are the more prominent mountains of the Ouachita Range in Indian Territory. The northwestern mountain of the western part of the range, known as Pim Mountain, comes to an end in the south-central part of the Colgate quadrangle.

The Arkansas Valley region lies between the Ouachita Range on the west and the Little Rocky Mountains on the north, and is characterized, especially in the western part, by narrow and generally level valleys, and wide, flat ridges and rolling uplands. At the confluence of the Canadian and Arkansas rivers the Arkansas Valley region contracts, becomes narrower, and joins the Red River Plain opposite the west end of the Ouachita Mountain Range. Its low, level ridges and valleys are much more marked than those of the Colgate quadrangle. The features of the Arkansas Valley region, especially in the southern part, resemble very much reduced forms of the Ouachita Mountain Range. The ridges of the valley region are nearly parallel to the range, but with the exception of the few isolated mountains which lie in Arkansas Valley, they have low slopes. The topographic form is characterized by the relatively long period of time. The larger streams have nearly cut their valleys deeper, and throughout most of their courses are nourishing in the deposits of silt and sand which their currents have deposited in times of flood. The relative permanence of the topographic features in this quadrangle depends upon the thickness and hardness of the sandstone and limestone beds and upon their structure. Hardness enables them to withstand more effectively the beating rain and the eroding streams. When the rocks are tilted at a low angle, the northwestern part of the quadrangle, the sandstone beds when once uncovered resist erosion and protect the surface. The Prairie Plains therefore form distinct gyres, and the walls of the stream valleys falls below the 700-foot level. The valleys are wide and shallow and the streams meander through them. The sandstone and limestone beds on either side of the streamline are unprotected and are rapidly eroded, leaving the sandstone ridges as high and as broad as they were originally.

The Prairie Plains also join the Arbuckle Mountains on the north. In its course through the Prairies, the river descends to the level of the Prairie Plains. In the northern part of the quadrangle, Red River rises in New Mexico, flows eastward through the Great Plains, and enters Arkansas, the Canadian, and the Red—drain the whole area of Indian Territory. Arkansas River rises near the southern boundary of Indian Territory, crosses the Great Plains and the Prairie Plains, and enters the valley between the Arkansas and Red, which forms the northern part of the Colgate quadrangle. Canadian River has its source in New Mexico, flows across the Great Plains and Prairie Plains, and joins Arkansas River at the border of the Arkansas Valley region. In its course through the Prairie Plains it enters the northern part of the quadrangle. Red River rises in New Mexico, flows eastward through the Great Plains, and across the “Panhandle” of Texas, and then forms the eastern southern border of Indian Territory. Its northern tributaries in Indian Territory drain the area at the southern end of the river. The watershed between the Canadian and Red, especially in the Chickasaw Nation, lies within a few miles of the banks of the Canadian. Since Canadian River belongs to the Arkansas River system, the Canadian River watershed is also a part of the divide between the hydrographic basins of Arkansas and Red rivers. It also divides the waters which flow into Mississippi River from those which flow directly into the Gulf of Mexico.

TOPOGRAPHY OF THE QUADRANGLE.

General.

The various forms of the valleys and hills in this region have been produced by the dissolving and disintegrating action of water and frost, and upon the mineral conditions of the rocks. The shapes of the valleys and hills and their location depend principally upon the degree of erosion and upon the character of the rocks. When the land is uplifted and tilted the streams flow more rapidly and cut deep valleys. They erode softer rocks more rapidly than the harder ones, and naturally the softer rocks form valleys and the harder ones, hills, and ridges, and the streams flow through the general surface of the land is nearly level at the beginning of an epoch of erosion, or becomes so by erosion, and joins the Arkansas, Red, and Canadian rivers, which flow through alternate strata. The sandstone beds are usually hard, variable in thickness from thin plates to thick masses, and are separated usually by much thicker beds of shale. These rocks have been crumpled into folds, but, unlike the Ouachita structure, the folds are

that at ordinary conditions the streams meander in rivulets or narrow channels. Indeed, its channels are not at any stage of the river flow on the rock country. During floods, which usually come in the spring and fall, the channels of the river. When quantities of sand are swept down, shifting for- mersheds and channels. Little River, which is tributary to the Canadian, crosses the northwest corner of the quadrangle, forming a relatively wide, gentle valley. It is a short river and its course does not reach the soft deposits of the Plains from which the Canadian receives its supply of sand.

CLASSIFICATION OF THE TOPOGRAPHIC FEATURES.

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

Ouachita Mountain type. The ridges lying east of the Pim River are the northeastern corner of the quadrangle, belong to the foothills of Pine Mountain, which is a member of the Ouachita Mountains. They resemble in form many of the ridges of the Arkansas Valley type, which are adjacent to the west, and their separation from the Arkansas Valley topography would seem arbitrary; but they were determined by different structure and are generally more elevated. They were formed by the gradual erosion of the uplands in the highest ridges of Pine Mountain, the south end of which enters the southeastern corner of the quadrangle.

The ridgeworks are limestone, cherty sandstones, and sandstones, which are separated by thick beds of friable shales. After being crumpled closely in parallel folds the beds have been worn away and their edges exposed. The older beds were eroded more rapidly and formed the ridges, while the latest ones stand out in parallel, nearly perpendicular ridges. Many of the hard beds lying between Limestone Ridge and the southeast corner of the quadrangle have been so broken and crushed by faulting that they have not been able to withstand erosion. They occur in low detached hills and ridges, 50 feet and less in height, and can not easily be recognized in the topography as shown on the map. Limestone Ridge, as well as others south of it, is broken off on the north end by the fault which separates the Ouachita Mountain type of topography and structure from the Arkansas Valley type.

A number of ridges of the same class occur in the McAlaster quadrangle, which adjoins this quadrangle on the east. These ridges are illustrated by the sketch in fig. 9.

Fig. 1.—Profile section of the ridges in the northern foothills of Pine Mountain, from Arkansas River to Pim Mountain. In the Arkansas River valley the channel is cut through the Red River Plain by the Canadian River, which flows through alternate strata. The sandstone beds are usually hard, variable in thickness from thin plates to thick masses, and are separated usually by much thicker beds of shale. These rocks have been crumpled into folds, but, unlike the Ouachita structure, the folds are.
wide and open and no faulting of consequence has occurred. The beds of rock which occur in these folds have been faulted and displaced. The thickness of the beds exposed by this folding aggregates a thickness of nearly 2000 feet, and has been divided into five formations. The area of Caney shale and Watah-muca limestones occurring in this province in the southwestern corner of the quadrangle are too small to be considered. The lowest to be considered, the Atoka formation, is only partially exposed, being concealed in part by the fahs in the southeast and southwest corners of the quadrangle. It is composed chiefly of shale, and, as a result, its surface is generally level. The Hartshorne sandstone, being composed of many thick beds aggregating nearly 200 feet, makes ridges that lie along the northwestern side of North Boggy Valley and the southern side of Clear Boggy Valley, but is worn down to the level of these valleys in many places. The McAlester shale, the next succeeding formation, contains but little sandstone and accordingly it forms shallow, wide, and nearly level valleys and plains. The alternate strata of Clear Boggy Gate-on is upon this shale. Goose and Clear Boggy creeks flow upon it, and it is almost entirely covered by their flood plains. Two other areas occur in this shale northeast of Coalgate. The Savannah sandstone lies next above McAlester shale. This formation is composed of several sandstone beds separated by thick beds of shale, in all 1000 feet thick. These sandstone beds dip at a considerable angle, and as a result form a series of ridges parallel to the axis of the fold with the progress of erosion. Fig. 2 illustrates the form of the ridges in an anticlinal fold at successive stages of erosion. It also illustrates a series of cross sections at intervals along a pitching anticline. The Boggy shale succeeds the Savannah sandstone and occupies a relatively large area. It is composed chiefly of shale and thin beds of sandstone interstratified, and has a thickness of nearly 2000 feet. It is only slightly folded, and dips generally toward the northwest. Because of the soft character of these rocks and their flat structure, the amount of erosion that has occurred is very small. Locally some of the sandstone beds become thicker, and, where they are nearly horizontal, form ridges that are sometimes several miles long. These beds produce very low ridges, or undulations in the plain.

Prairie Plains type—The rocks in the north half of the quadrangle have a thickness of 2000 feet, and are conglomerates, sandstones, and shales. They are first divided into six formations, then into eight formations. These formations are tilted toward the northwest at low angles, the dip ranging from 50 to 100 degrees from the horizontal. With an outcrop in regular order upward from the southeast toward the northwest, and each formation in the same series across the quadrangle produces a feature of the Prairie Plains type of topography. The shale is soft and disintegrates readily into small particles which are easily removed by erosion. Shales are found generally on the top of the tablelands near the next escarpment raise and in the lower slopes of the escarpments below the protecting ledges of harder rocks. The sandstone disintegrates more slowly, breaking into boulders and larger fragments, and thereby resists erosion. They produce the benches, the high tablelands, and the upper slopes and cliffs in escarpments. These bench lands with escarpments are formed by the thick formations of sandstone and shale, and benches with low escarpments by the thinner beds of the same rocks. On going northwest across the country, successive escarpments with nearly equal elevation above the sea will be observed separated by the tilted surfaces of the tablelands and benches.

Sections at intervals across either the anticlinal passing through Coalgate or that passing through Savannah in the McAlester quadrangle will illustrate many stages of the erosion of the Savannah sandstone from the time the highest bed is first exposed until all the sandstones are removed from the axial part of the folds. In cyclical folds the process is the reverse and the ridges produced by the sandstones gradually approach the axis of the fold as erosion advances. In this way successively higher beds of shale or sandstone with the decrease in the size of the anticlines and the thinning out of the material of the core of the anticline, the thickness of the beds exposed by this folding aggregates a thickness of nearly 2000 feet, and has been divided into five formations. The area of Caney shale and Watah-muca limestones occurring in this province in the southwestern corner of the quadrangle are too small to be considered. The lowest to be considered, the Atoka formation, is only partially exposed, being concealed in part by the fahs in the southeast and southwest corners of the quadrangle. It is composed chiefly of shale, and, as a result, its surface is generally level. The Hartshorne sandstone, being composed of many thick beds aggregating nearly 200 feet, makes ridges that lie along the northwestern side of North Boggy Valley and the southern side of Clear Boggy Valley, but is worn down to the level of these valleys in many places. The McAlester shale, the next succeeding formation, contains but little sandstone and accordingly it forms shallow, wide, and nearly level valleys and plains. The alternate strata of Clear Boggy Gate-on is upon this shale. Goose and Clear Boggy creeks flow upon it, and it is almost entirely covered by their flood plains. Two other areas occur in this shale northeast of Coalgate. The Savannah sandstone lies next above McAlester shale. This formation is composed of several sandstone beds separated by thick beds of shale, in all 1000 feet thick. These sandstone beds dip at a considerable angle, and as a result form a series of ridges parallel to the axis of the fold with the progress of erosion. Fig. 2 illustrates the form of the ridges in an anticlinal fold at successive stages of erosion. It also illustrates a series of cross sections at intervals along a pitching anticline. The Boggy shale succeeds the Savannah sandstone and occupies a relatively large area. It is composed chiefly of shale and thin beds of sandstone interstratified, and has a thickness of nearly 2000 feet. It is only slightly folded, and dips generally toward the northwest. Because of the soft character of these rocks and their flat structure, the amount of erosion that has occurred is very small. Locally some of the sandstone beds become thicker, and, where they are nearly horizontal, form ridges that are sometimes several miles long. These beds produce very low ridges, or undulations in the plain.

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Since all these formations dip toward the north- west, their edges are exposed toward the south- east. A great number of small rivulets and streams, with their courses in the valley below, the tableland, are eroded by headwater cutting thereby undermining the sandstones, which fall away in bowlders and larger fragments, and thereby disintegrate into pebbles and sand. In this proc- ess of erosion the escarpments gradually recede northwestward.

Sandstones of the Thurman, Senon, and Calvus formations become thinner and more shaly toward the southeast, and the topographic features pro- duced by them then become smaller in the same direc- tion. The Senon formation, for instance, in the northeastern corner of the quadrangle forms a high plain, with an escarpment 500 feet high facing the east. In the western part of the quad- rangle it is not so well developed as it is in the northeast corner, and its south-facing escarpment does not exceed 100 feet in height. Since this process continues to modify these features of the topography, but it will not obliterate them until the country is brought to base level, where all sandstones are reduced to a plain. Small plains, lies at some remote period of time, yet comparatively recent geologically, a deposit of sand and gravel was formed across the northern part of the Cimarron quadrangle in a general east-west direction. Remains of these uncom- mitted sandstone, in some instances 40 feet thick, 50 feet wide, and several miles long, occur spread across the edges of the Coal Measures rocks, forming low level plains but little higher than the highest land. It extends from the Canadian Val- ley to the eastern side of the quadrangle south- eastward across the watershed and into the hydro- graphic basin of Red River, but near the eastern boundary it merges into a Canadian hydrographic basin, after passing nearly 10 miles south of the present watershed. From the escarpment has been traced thicknesses of strata which extend through the sandstone beds produce very low ridges, or undulations in the plain.
Clayey shale. This formation occurs in two small areas in the Coalgate quadrangle. The one in the southwestern corner includes only the upper beds of a large outcrop of this formation which lies east and north of an extensive body of Shale. This formation is about 300 feet thick.

In Limestone Ridge the thickness is about 150 feet, but it tapers down to 60 feet in the eastern part of the quadrangle. The formation is about 25 feet thick. The lowest part of the formation consists of a sandstone, which is about 15 feet thick and is composed of yellow and red sand. The middle part of the formation consists of a shale, which is about 5 feet thick and is composed of black and green shale. The top part of the formation consists of a sandstone, which is about 10 feet thick and is composed of yellow and white sand.

The Coalgate formation is about 50 feet thick and is composed of a sandstone, which is about 25 feet thick and is composed of yellow and red sand. The middle part of the formation consists of a shale, which is about 20 feet thick and is composed of black and green shale. The top part of the formation consists of a sandstone, which is about 5 feet thick and is composed of yellow and white sand.

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beds. As the sandstone beds become thinner they become more shaly and some of them are calcareous. Many thin fossiliferous limestone beds are to be found in the western part of the quadrangle.

This formation, being high in the series of coal-bearing strata, occurs in the synclinal basins and the region of least disturbance. In the southeastern part of the quadrangle, in the enable passing northeast through Lakach, the beds of the outer portion of the areas of this formation dip at angles from 10° to 35° and the sandstones form low convex ridges. In the larger area, in the central part of the quadrangle, the beds are generally nearly horizontal. By erosion the sand beds are removed, leaving the sandstone capping low flat hills and mesas and low gently-sloping ridges with terraces upon the exposed ledges.

As a result of the broad exposure of sandstones and shales due to the low dip of the rocks, there are produced upon the surface quite extensive stretches of hilly timberland and still broader areas of smooth grassy plains, corresponding respectively to the sandstone and shale areas.

Triassic sandstone—The Thurman sandstone represents the beginning of a marked change in the character of the sediments which were brought into the sea and spread across this region in Carboniferous time. Shales and thin beds of sandstone in the upper part of the Boggy shale are followed by coarse pebbles of white chert mixed with coarse quartz sand forming the lower member of sandstones. This sandstone is cemented by the deposition of this conglomerate, which reached a thickness of about 30 feet in the eastern half of the area and which is most abundant in the Coalguate quadrangle, fine sands were deposited until a maximum depth of more than 200 feet was attained.

In the northeastern corner of the quadrangle the whole formation is about 300 feet thick, while in the western portion it does not exceed 80 feet. This decrease in thickness is gradual and is accompanied by a similar change in the texture of the sandstones. The conglomerate which in places is 50 feet thick at the east is at the west a mere pebble of rock or may be entirely absent. The sandstone beds in the upper part of the formation, while becoming thinner and the texture is texture westward, include beds of shale, and near the border of the quadrangle there are thin beds of impure fossiliferous limestones. The Thurman sandstone dips regularly from 30° to 50° per mile northwestward without its occurrence in this quadrangle.

East of Casey Boggy Creek the Thurman sandstone crops in a very rugged stony highland about 5 miles in width which terminates in the east in precipitous bluffs capped by the sandstone. These bluffs are from 300 to 400 feet high, with a maximum of 570 feet. West of Casey Boggy Creek the width of the surface is from 2 to 3 miles to within a short distance of the Mississippi river where the upper part of the quadrangle where it contacts to an average of less than a mile. The surface, also, grows gradually less rugged toward the west and the southern bluffs and escarpments become lower, and instead of the dense forest of oak and pine upon the formation as in the east there is a diversified prairie and timberland.

Straits—There is a gradual transition upward from the Thurman sandstone through thin beds of shale, sandstone and shale interstratified into the Stuart shale. This formation has a thickness of about 250 feet in the northeastern and central parts of its exposure and about 100 feet in its western part. It is composed of three members, an upper and a lower member of shale interstratified by a very thin sandstone. The upper member of the formation has a nearly constant thickness of about 100 feet from the southern part of the quadrangle to the northwestern part except in rare cases where the shale member becomes more persistent and perfectly preserved fossil shells which it contains. Its full section is at Arlington and Chico, on the Red River, about 10 miles north of the mouth of Little River. Above this, thin shale and sandstone 60 feet thick, 300 feet thick, and sandstone and shales 45 feet thick. This formation is most prominent in the southern part of the quadrangle where it is about 200 feet thick. The upper portion of the formation is about 100 feet thick, while the lower portion is about 50 feet thick. The upper portion of the formation is about 100 feet thick.
10 miles north of the old river channel. These streams have also eroded their valleys nearly 100 feet below the level of the Quaternary sand.

The upper part of the sand is composed of very fine yellow sand or silicious silt, resembling very much the sand now being transported and deposited by the Ogallala river. Near the borders of the old channel, which probably were covered by water only in times of flood, the deposits are usually of fine sand and some gravel in part.

Generally the sand becomes coarsest downstream, ending in gravel at the base. In many places the fine fragments are washed away, leaving beds of coarse gravel and thin mounds of pebbles. In places the deposit is of even thickness, in other places it grades gradually from fine to coarse materials; and in still other places especially noted in wall sections, there are alternate strata of bluish, red, and yellow clay, silt, and sand, usually ending at the base in quicksand or gravel.

The sand is composed of fine white quartz which is usually more or less mixed with yellow silt. The pebbles of the gravel are white and yellow, varying in size and shape, and are generally from 1 to 2 feet in length.

River sand.—All the large creeks and rivers in the Coal Measures or Coalmeasures loam or the plains of Arkansas, Texas and New Mexico, from which it derives large quantities of fine sand. The amount of this sand brought down has been about the same and, as a result, its channel in the region of the Coalmeasures, is choked and filled to a depth of nearly 50 feet, so that at no place does the river touch the country. An estimate of the depth of the sand was obtained for the Limestone Ridge, at Chester, by entering the river and by estimating the volume of sand washed into the river, which gives an estimate of the depth of the sand.

ukings of the surface at the end of the season brings it to the surface to the west. In section B-B the top of the sand is raised 20 feet above the present level of the land in the valley of Coal Creek and probably 6000 feet above the upstream end of the tract. This sand is bluish-gray in color, which strongly tilts the McAlester shale and associated formations. This structure is part of the southern limb of the Carboceous and is a single fold in which the Arbuckle Mountains to the southwest are involved, and is imperfectly represented by the Cretsaceous deposits which are now exposed in the center of the uplift.

The northern limb of one of these anticlines passes across the southeast corner of the quadrangle. The fault which extends along the northern side of this fold is the quadrangle on Cresson Creek is more extensive than the Cretaceous shale. The rocks on the northern side are thrown downward, so that the sandstone and shale beds at the base of the Atoka Formation dip upward on the northern side and against the fault, while the shale beds at the top of the formation dip toward the east. The wavy nature of the Wapanucka limestone in the northwest corner is due to small local, steeply pitching folds or wrinkle in the side of the broader anticline. Another fault of the same nature is the one just described, 8 miles farther south, yet upon the northern limb of the same broad anticline, enters the quadrangle at the southern border, in Cresson Creek valley. This fault, with all other associated faults, has northward dip and is in the quadrangle. It is a direct northwest dipping fault, or as an anticline or syncline, as the case may be to a northwest-dipping monocline. This transition from west to northeast-dipping faults is the southern limb of the Prairie Plains monocline, which continues with gently varying inclination across Oklahoma to Kansas and Kansas to the eastern uplifts of the Rocky Mountains.

The monoclined structure then, in the northern half of the Coalmeasures, is a small part of the southern border of a great province of similar structure. Beginning with the western limb and continuing northeast across the state, the formations show on the map are the exposed edges of these inclined strata.

MINERAL RESOURCES

The mineral resources of this region are coal, limestones, sandstones, and clay. The coal is the only product that has been developed to any considerable extent. The formations of the Quaternary and Cretaceous periods have received less attention, and the clay seams now at all. In a region generally underdeveloped, as this is in the west, civil conditions as have existed in Indian Territory, it is probable that no mineral product would be developed except under favorable external conditions and profit.

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

COAL.

There are two beds of coal of workable thickness both of which are in the McAlester shale. One occurs very near the base and the other about 300 feet below the top of the formation.

The lower bed, which is known locally as the Atoka coal, is about 4 feet thick and has shales in contact both above and below. This coal occupies the same stratigraphic position as the Harrah coal which is worked extensively in the eastern part of the Choctaw Nation. It has been worked in this vicinity at what is known locally as the Hickory Hill mine, which is near the south end of the Lehigh Basin, 3 miles south of Coalgate. The coal at this mine dips to the northeast about 5°. It has been prospected at many places east and west of the mine in the southeastern part of the basin. Coal at this horizon crops on the southern side of Clear Boggy and Goose Creek valleys and has been prospected at Coome and a number of other places. The dip of the coal and associated rocks is about 7° northward. In the southeastern part of the quadrangle the rocks at this coal horizon dip 60° to 80° to the northwest, but the coal is not known to occur here. It should be found, however, it probably could not be successfully or profitably mined on account of the steep dip of the rock and the swampy conditions of the land.

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

The upper coal in the McAlester shale is known locally as the Lehigh coal on account of its most extensive development at the town of Lehigh, 3 miles south of Phillips. This coal runs regularly about 25 feet in thickness and is without shale partings, as far as known. It is not known in the southwestern part of the quadrangle because its crop occurs in the swamps of Clear Boggy and Goose Creek valleys. It crops in Coal Creek, 2 miles west of the border of the quadrangle, but the full thickness of the coal was not exposed.

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

In physical appearance the Lehigh coal is laminated and breaks in mining into gooselined cubic blocks. Thin filaments of iron sulphide and sulphate of lime occur occasionally in the joints of the coal. It is highly bituminous, the percentage of the fuel constituents of the coal being carbon 41.12 and volatile combustible matter 41.61. There is 13.7 per cent of ash 6.5 and per cent of sulphur. These results are from an analysis of the coal taken from shaft No. 5, at Lehigh, about 200 feet beneath the surface.

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

LIMESTONE.

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

SANDSTONE.

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

CLAY.

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

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

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

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

March, 1901.
<table>
<thead>
<tr>
<th>Form</th>
<th>Formation Name</th>
<th>Age</th>
<th>Columnar Section</th>
<th>Acetate in Feet</th>
<th>Character of Rocks</th>
<th>Character of Topography and Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sn3</td>
<td>Rondale conglomerate.</td>
<td>C1</td>
<td>30 30</td>
<td>Gravelly, red</td>
<td>Woody highlands and low escarpments.</td>
<td>Thin, sandy, gravelly soil.</td>
</tr>
<tr>
<td>Sn3</td>
<td>McKeever shale.</td>
<td>C2a</td>
<td>288</td>
<td>Blue and yellow clay shale with thin limestone and sandstone beds.</td>
<td>Stripes of escarpments and level benches.</td>
<td>Fertile soil.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Caloosahatchee sandstone.</td>
<td>Cx</td>
<td>145-180</td>
<td>Thick bedded, hard sandstone, becoming friable, ferruginous, and thin below toward the south.</td>
<td>Nearly level surface.</td>
<td>Sandy soil.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Shasta shale.</td>
<td>Cx</td>
<td>56-300</td>
<td>Blue and black clay shale with sandstone and marl near the base.</td>
<td>Unstable surface with low relief.</td>
<td>Gray, ferruginous soil.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Thurman sandstone.</td>
<td>Cx</td>
<td>56-300</td>
<td>Brown sandstone, shale, and sheet conglomerates near the east; sandy clay in the west.</td>
<td>Rolling highland and escarpments.</td>
<td>Sandy clay with bad and stony.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Bexar shale.</td>
<td>Cx</td>
<td>206-300</td>
<td>Shale, sandy sandstone, and brown sandstone.</td>
<td>Nearly level prairie land interspersed with low, wooded ridges and hills.</td>
<td>Rolling hills and prairie.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Scurumbia sandstone.</td>
<td>Cx</td>
<td>100</td>
<td>Thick bedded sandstone and shale.</td>
<td>Low, pumice, wooded ridges and narrow, gully valleys.</td>
<td>Flat, generally poor soil and rocky.</td>
</tr>
<tr>
<td>Sn3</td>
<td>McKee Formation.</td>
<td>Cx</td>
<td>180-300</td>
<td>Blue and black clay shale and sandstone of variable thickness, with numerous beds of coal, two of which are workable</td>
<td>Rolling and low prairie land.</td>
<td>Rolling and prairie land.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Hartshorne sandstone.</td>
<td>Cx</td>
<td>199</td>
<td>Brown sandstone with sandstone locally interstratified.</td>
<td>Low timbered ridge.</td>
<td>Sandy or gray, sandy soil.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Akoka formation.</td>
<td>Cx</td>
<td>200</td>
<td>Clay shale, sandy shale, and sandstone generally thick bedded and friable in the west; thin in the east.</td>
<td>Local rolling prairie with low, sandy ridges and hills, sandy soil.</td>
<td>Sandy clay and gravel on top, sandy soil on flanks.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Chickasaw chalk limestone</td>
<td>Cx</td>
<td>0-88</td>
<td>White, micaceous, clotted sandstone in the southeast. Position in the section not accurately determined on account of faulting.</td>
<td>Low, sharp, rocky ridge.</td>
<td>Low, sandy, ferruginous soil.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Wapanocca limestone.</td>
<td>Cx</td>
<td>100</td>
<td>White calcite limestone, blue shale, and clastic limestone beds.</td>
<td>Low and nearly level ridge.</td>
<td>Thin, stony, ferruginous soil.</td>
</tr>
<tr>
<td>Sn3</td>
<td>Clayey shale.</td>
<td>Cx</td>
<td>800</td>
<td>Blue and black clay shale with dark-blue limestone segregations.</td>
<td>Nearly level plain.</td>
<td>Fertile, dark clay soil.</td>
</tr>
</tbody>
</table>

JOSEPH A. TAPF.
forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in the valleys of the streams and the resulting aceticritic ridges and mounds of sand and gravel, known as bars, or eskers, and kames. The material deposited by the glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual to class as surficial rocks the sediments of the area 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 formed 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 the earth's surface, is mapped by formations, and the formations are classified into systems. The rocks composing a system are generally of different ages, and the rocks that are given the same name, as, for instance, Cambrian system, Cambrian period.

As sedimentary beds and strata accumulate, the youngest rock on those that are older, and the relative ages of the deposits may be determined by observing their relative positions. This relationship holds except in regions of intense disturbance; sometimes in such regions the disturbance of the beds is such that their position is reversed, and it is often difficult to determine the relative ages of the beds from their positions; then rocks of the same age are referred to as being of the same age, 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, and 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 in the land. Life in the land became more varied. During each period there lived peculiar forms, which did not exist in earlier times and which would not be found again; 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.

To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods differ from the color or symbols assigned to them, given in the table in the next column. The names of certain sub-periods, frequently used in geologic writings, are bracketed against the appropriate period name.

To distinguish the formations of any one period from those of another according to age, the formations of each period are placed in the appropriate periods, which is the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns of geological symbols. The relations of left of the section, the same color-are used; a pale tint (the underprint) is printed over the whole surface 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 geology of the strata of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they passed over 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:

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first set consists of sandstones and shales, which lie in a horizontal position. These sediments are widely distributed, forming a plateau, and their change of elevation shows that a portion of the earth's surface has been uplifted from a lower stage or elevation. The strata of this set are parallel, a relation which is called conformable.

The second set of formations consists of strata which are highly deformed. 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 base 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 bed and the accumulation of the younger. When younger strata 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 crystal line rocks and rocks of unknown origin. At some period in their history the sediments were precipitated by pressure and transformed by erosion of melt rock. These rocks are known as igneous rocks.

The horizontal strata of the plateau are a landscape which is cut off sharply in the foreground by a vertical plane that cuts a section so as to show the underground relations of the rocks. The kinds of rocks 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 common kinds of rock:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sandstone</td>
<td>Lightly stippled, stippled,</td>
</tr>
<tr>
<td></td>
<td>Shale</td>
<td>Fine stippled, finely stippled,</td>
</tr>
<tr>
<td></td>
<td>Limestone</td>
<td>Half stippled, stippled</td>
</tr>
</tbody>
</table>

The plate in fig. 2 presents toward the lower end an escarpment, or front, which is made up of deposits of the strata by the cutting the cliff, or by substituting the slope, 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 contours of limestone and calcareous shales.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred.

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

One of the objects of the section is to show what is called by the name of minerals that are traversed by masses of igneous rock. The strata are much contorted, but the softer rock undercuts the harder rock and cannot be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

CHARLES D. WALCOTT, Director.
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