J. Sergeant Price, Esq., Treasurer of the Society, at Cape May, N. J., on August 16, 1897, æt. 66.

A communication for the *Transactions* was presented from Mr. John Van Denburgh, entitled, "Some Experiments with the Saliva of the Gila Monster (*Heloderma suspectum*)."

The following communications were read:

By Dr. N. F. Drake, a paper on "The Geology of the Indian Territory."

Mr. Clarence Alve, "Magnetism in Space."

The Finance Committee presented a report, announcing the death of the Treasurer of the Society, J. Sergeant Price, Esq.

It was ordered "that the Finance Committee be and is hereby authorized to draw upon the funds of this Society for the money necessary to pay the current expenses, and to receive its income during the vacancy in the office of Treasurer of the Society, and the said Committee is authorized to have possession of the financial papers and securities of the Society, until such vacancy shall be filled."

The Society was adjourned by the presiding officer.

A GEOLOGICAL RECONNAISSANCE OF THE COAL FIELDS OF THE INDIAN TERRITORY.[1]

BY NOAH FIELDS DRAKE.

(*Read September 3, 1897.*)

INTRODUCTION.

During the spring, summer and fall of 1896, the writer spent six months making a geological reconnaissance of the larger part of the Coal Measures and adjacent formations of the Indian and Oklahoma Territories. The best maps that could then be had of the region were exceedingly inaccurate. In connection with geologic observations, sketch maps were therefore made of areas that were especially important. Nearly all the area south and east of the Canadian river, shown on the accompanying map, was sketched

[1] A thesis for the degree of Doctor of Philosophy, presented to the Department of Geology of the Leland Stanford, Jr., University, May, 1897.

and studied rather closely, partly because the coal beds of that area are valuable economically, and partly because the folded structure and the resulting topography are of special geologic interest. The bordering areas of the Boone chert and limestones were studied because these beds have a wide distribution, and a knowledge of their relations to overlying beds was essential to an understanding of the structure of the area and of the conditions of deposition.

PART I.

Structural Geology.

Area of the Reconnaissance.—The area over which the reconnaissance was made includes the northern part or nearly half of the Indian Territory, and a little of the adjoining part of Oklahoma. It includes the Cherokee, Creek and Seminole Nations, all the Indian Nations in the northeast corner of the Indian Territory, the northern part or nearly one-third of the Choctaw Nation and a little of Oklahoma adjoining the Creek and Cherokee Nations.

The area is about 165 miles long and about 125 miles wide and covers a little more than 20,000 square miles.

Previous Investigators.—In 1819, Thomas Nuttall[1] made several excursions across this region to study its botany and geology. He passed over the country southwest of Ft. Smith, Ark., between Sugar Loaf and Cavaniol mountains[2] and across Winding Stair mountains; then he went up the Arkansas river to Verdigris river and across the country in a southwesterly direction from Verdigris river. He also went up Grand river to the Salt springs and made short excursions in the vicinity of Salisaw and Lee's creeks. His conclusions regarding this field were: that sandstones, shales and coal-bearing rock extend over most of the area; that limestones and cherts all lie north of the Arkansas river; that the salt-bearing strata of Grand river are different from the salt-bearing red beds in the southwest, and that the mountain chains in central western Arkansas and central Indian Territory have a southwest trend.[3]

[1] *A Journal of Travels into the Arkansa Territory*, by Thomas Nuttall, Philadelphia, 1821, pp. 146–177.

[2] *Cavaniol*, *Caveniol* and *Kavanaugh* are the different ways of spelling the name applied to the mountain lying between the Sugar Loaf and the Sans Bois mountains. *Cavaniol* is the oldest spelling of the name that has been found, and is the one used in this report.

[3] *Jour. Acad. Nat. Sci.*, Vol. ii, p. 49.

In 1822, Edwin James[1] published a geologic section and some explanatory notes of that part of this country lying along the 35th parallel of north latitude. This publication, however, gave very little additional information concerning the geology of this area since it only showed the Ozark mountain strata to be Carboniferous, and the rocks of the Canadian river country to be red beds bearing salt and gypsum.

In 1853, important geologic observations in this country were made by Jules Marcou,[2] geologist to the Pacific Railroad Expedition. His reconnaissance in this field was principally confined to the area lying immediately south of the Arkansas and Canadian rivers. The important additional geologic knowledge he gave of the area was: a better knowledge of the coals, the lithology, and the structure along the line of reconnaissance. He considered the Ozark mountain area an outlying or second fold of the Allegheny mountains.[3]

George G. Shumard made the statement before the St. Louis Academy of Science, in 1857, that he had traced the coal fields from Ft. Smith, Ark., to Ft. Belknap, in Texas.[4] He apparently did not note the break in outcrop of these beds in the southwestern part of the Choctaw Nation, where the Carboniferous is concealed by the overlying Cretaceous.

In 1890, H. M. Chance[5] published "The Geology of the Choctaw Coal Fields," which is the most valuable information yet published on the geology of this area. In this paper he locates the relative stratigraphic position in the Indian Territory of the three productive coal beds, and clearly outlines by description, sections, and maps, most of the Grady and McAlester coal beds along the outcrop from six or seven miles west of McAlester to near the Poteau mountains. He gives a section from the base of the Grady coal bed to the top of Cavaniol mountain, which includes the productive part of the Coal Measures. He also notes the prevailing S. 80° W. axes of folds and the system of southwest folds.

In 1891, R. T. Hill[6] published a paper outlining the Ouachita

[1] *Jour. Acad. Nat. Sci.*, Vol. ii, pp. 326–329.

[2] *Pacific Railroad Reports*, Vol. iii, Part iv. pp. 123–127.

[3] "Esquisse d'une classification des chaines de montagnes d'une partie de l'Amérique du Nord," *Annales des Mines*, 5 me. sér., Tome vii, pp. 339, 340.

[4] *Trans. Acad. Sci.*, St. Louis, Vol. i, p. 93.

[5] *Trans. Amer. Inst. Min. Eng.*, 1890, Vol. xviii, 653–661.

[6] *Amer. Jour. Sci.*, Vol. xlii, August, 1891, pp. 111–121.

Mountain System in the Indian Territory, which further classified the knowledge of this system.

The work of the Arkansas and the Texas geological surveys, the geologic investigations in southeastern Kansas by Prof. Charles S. Prosser, and an unpublished sketch map kindly furnished by Prof. Orestes St. John, showing the general distribution of the geologic formations in the Indian Territory, further assisted in giving an idea of the geology of this area. Taken as a whole, however, the field was comparatively a new one to geologists and it is rather remarkable that it should have so long remained so little known.

Hydrography.—Nearly all of the area under consideration is drained by the Arkansas river and its tributaries. A very little of the southern part, however, is drained by streams tributary to the Red river. The Arkansas river enters the country under discussion a little south of the northwest corner, and runs in a southeasterly direction, thus crossing it diagonally through the central portion. To the north of this river the larger streams, the Illinois, the Grand, the Verdigris, and the Little Verdigris or Caney rivers, flow nearly southward and empty into the Arkansas river. The Illinois river, however, is somewhat deflected to the westward, and the Verdigris and Caney rivers deflected to the eastward. The streams on the north thus have a tendency to flow into the Arkansas river at the same locality.

To the south of the Arkansas river the Cimarron and the Canadian rivers are its largest tributaries. The Cimarron, the most northerly of the two, flows eastward into the Arkansas river, while the Canadian river is slightly deflected to the north in its eastward course, and enters the Arkansas river about twenty miles below the collecting basin of the streams to the north. Between the Cimarron and Canadian rivers, the Deep Fork and North Fork of Canadian rivers, flow almost eastward and unite a short distance above their confluence with the Canadian.

Topography.—There are three general topographic groups in this area. One is the elevated and folded area to the south, which is an extension of the Ouachita mountain system; a second group is the elevated plateau area in the northeast, which widens slightly southward to near the Arkansas and the Grand rivers. This belongs to the Ozark plateau system. The third group is a broad plain-like area that slopes gently eastward in terrace-like escarpments and undulations, and narrows into the low depression between the Ozark

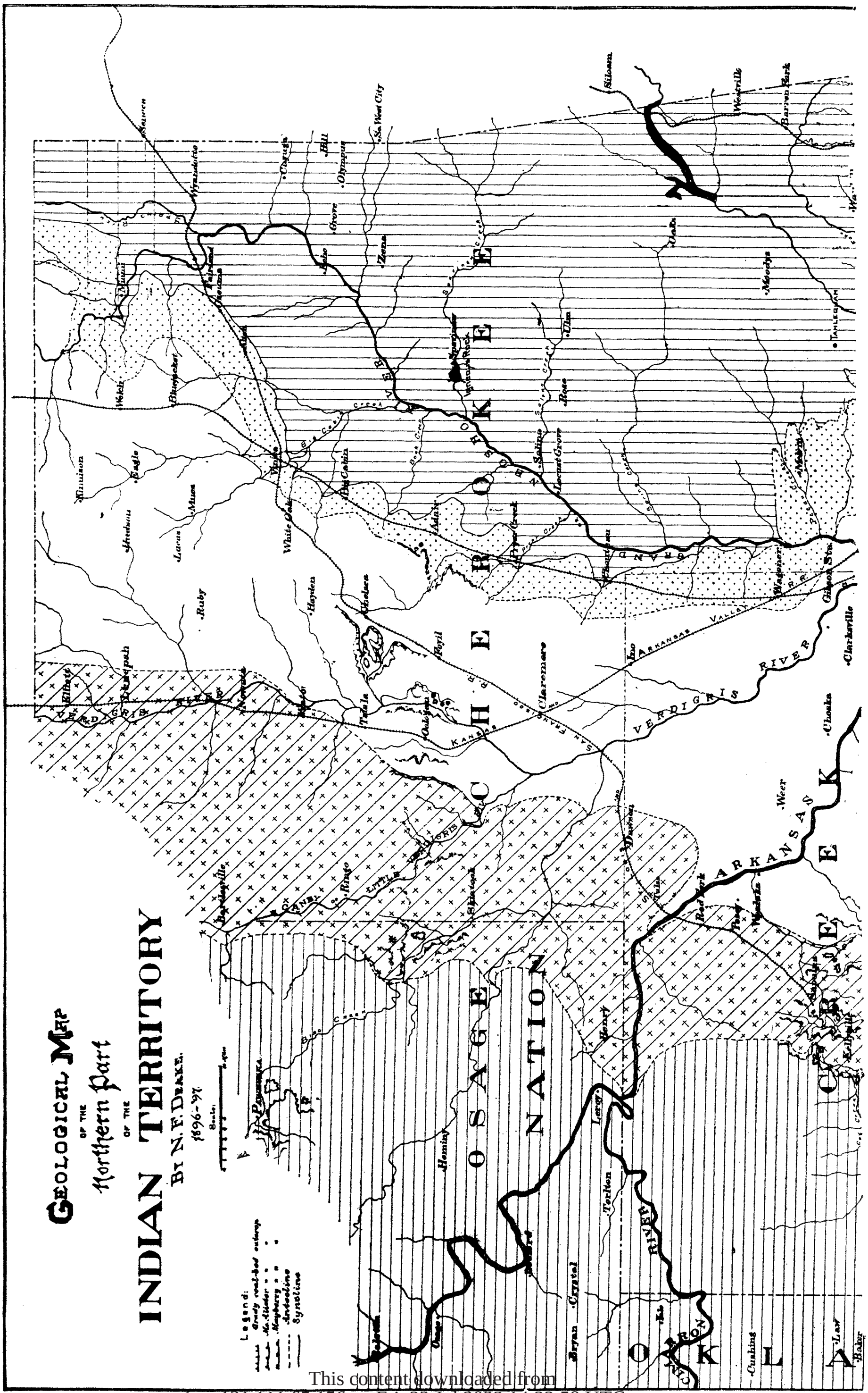
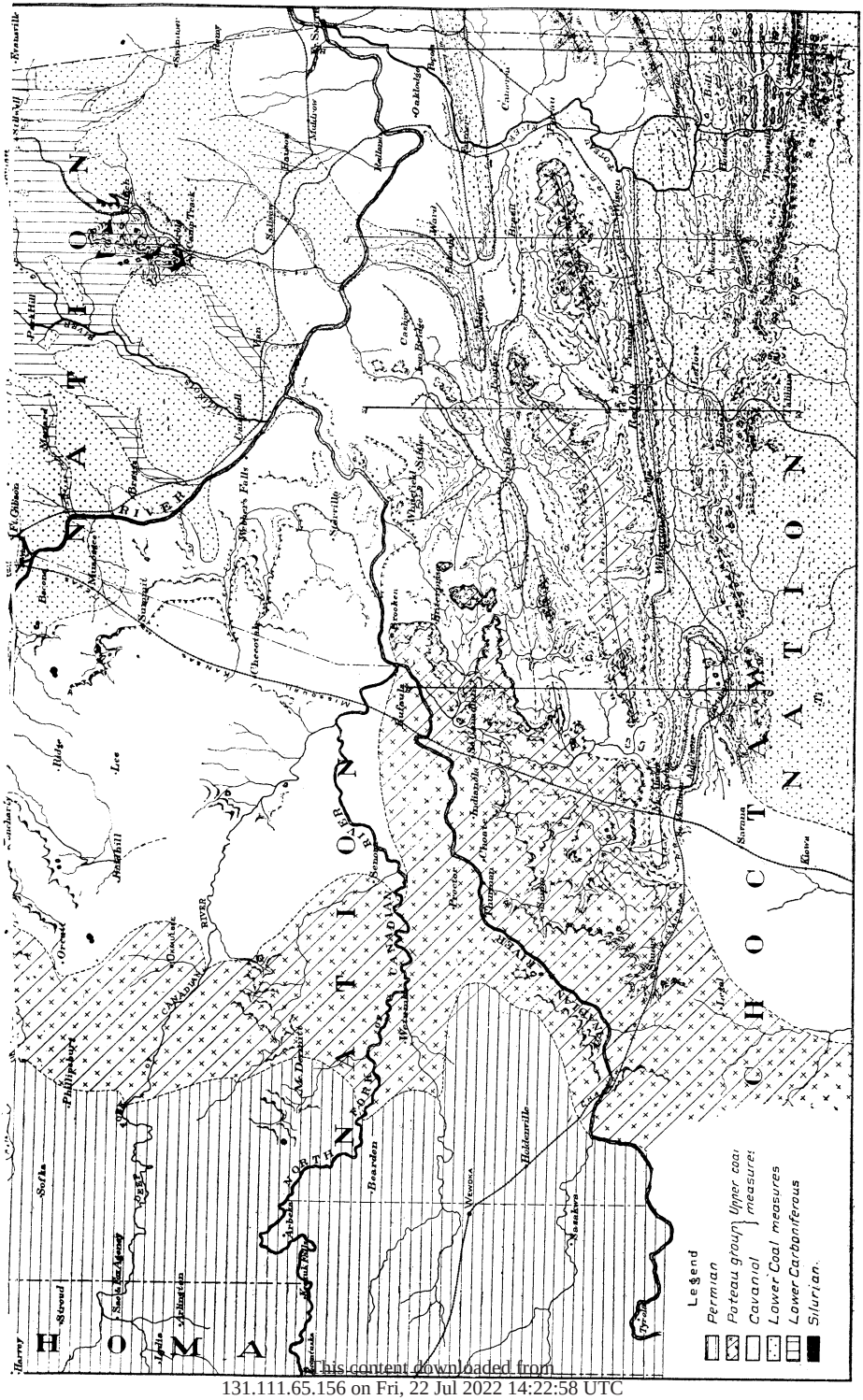


Plate I.



and the Ouachita mountain systems. The westward deflection of the Illinois and Grand rivers is due to the Ozark uplift, while the northern deflection of the Canadian river is caused by the uplifted folds of the Ouachita mountain system. Thus the rivers approach each other on either side of the Arkansas river along the border lines of these topographic groups.

The Ozark Mountain System.—This term was formerly applied to the mountainous area of southern Missouri, northwestern and central western Arkansas and east central Indian Territory. The name is, however, properly restricted to the plateau or northern part of this area, and the name, Ouachita, has been applied to the folded mountains of the southern part of the area.

The Ozark mountains in the Indian Territory are divided into two distinct topographic areas. One lying east of Grand river and north of Tahlequah and Evansville is the lower table-land of the two, and contains flat lands and also areas of sharp narrow ridges and small V-shaped canyons. The other portion of the Ozark system is more elevated and is the western prolongation of the Boston mountains. This area is triangular in shape; the apex of the triangle is about four miles southeast of Fort Gibson, the base lies south of Evansville, and is about fifteen miles across, measured along the Arkansas-Indian Territory line. This table-land is about 1500 feet above tide-level. It is usually bounded by steep escarpments on the north side and by both escarpments and slopes on the south. Several streams have cut through this plateau and at present flow through narrow valleys or canyons. The escarpment on the north side of the Boston mountains has a general east-west direction, but it is a very irregular line with plateau tongues and outliers extending northward along the face of the mountain; these are erosion remnants showing the former extension of the lower carboniferous strata.

The Ouachita Mountain System.—The elevated topographic group in the southern part of the field is an extension of the Ouachita mountain system which forms such a typical area of folded strata and parallel ridges and valleys in western Arkansas. This system was named[1] by Dr. J. C. Branner, who thinks it is an outlier of the Appalachian system and the structural equivalent of the Cincinnati-Nashville anticline. The Appalachian system, he thinks, once extended across the Mississippi Valley south of the Ouachita moun-

[1] *Ann. Rept. Geol. Surv. Ark.*, Vol. ii, 1888, p. 175.

tains, through Mississippi, Louisiana and central Texas.[1] There are two principal types of mountains in the Ouachita system; one of these consists of long ridges, the other is the bench-and-bluff and flat-topped mountain type. The mountains, ridges and valleys of this region trend almost east and west, corresponding to the folds.

The Canadian river and the Arkansas river from the mouth of the Canadian river to Arkansas, practically form the northern boundary of this group. For some fifteen to twenty miles south of these rivers low isolated buttes, table-lands and ridges such as Long mountain, the Seven Devils, McChar mountains and Backbone mountain are the outliers to the typical part of the mountain system. Immediately south of these outliers are the Sugar Loaf, the Cavaniol and the Sans Bois mountains, each rising nearly 3000 feet above tide-level. They all trend about S. 80° W., but are completely separated.

These three mountains, together with the Poteau mountains, and many smaller elevations, are of the bench-and-bluff type. The mountains farther to the south, the Walker, the Blue, the Winding Stair, the Black Fork and the Rich mountains are of the ridge type.

Prairie Plains.[2]—The third topographic division comprises all the country north of the Canadian river and west of Grand river. The predominant topographic feature of this division is a broad southeastward sloping plain, broken by gentle irregular undulations and by long lines of escarpments facing east or east-southeast. Of these features the east-facing escarpments are the most conspicuous. They are usually but fifty to one hundred feet high, although often from ten to fifteen miles long, and even much longer if local breaks are not taken into account. Occasionally gentle westward slopes extend from the top of one escarpment back to the base of the one next west of it, but usually the inclination is not sufficient to bring the base of the western escarpment down to the level of the eastern one.

Structure of the Topographic Groups.—In each of these topographic groups the geologic structure accounts for the topographic forms. The plateau type in the northeast has its strata almost horizontal; the folded type in the southern part of the field has its strata irregularly folded along nearly parallel lines; in the western

[1] *Proc. Bost. Soc. Nat. Hist.*, Vol. xxvi, p. 477; *Am. Jour. Sci.*, November, 1897, pp. 357–371.

[2] J. W. Powell, *National Geogr. Monographs*, Vol. I, No. 3, p. 83.

part of the field the escarpments and undulating topographic features are due to the varying resistant power of gently westward dipping beds.

Ouachita Mountain Structure.—In the central and northern part of the Ouachita area the mountains and mesas are practically all synclinal in structure, and the deeper and broader synclines form the larger mountains, such as Sugar Loaf, Poteau, Cavaniol and San Bois mountains; the mesas, such as the Seven Devils and McChar mountains, occupy the smaller synclinal folds. In the southeastern part of the field all the mountains and ridges are upturned edges of extensive hard rock beds. There is every gradation from the sharp ridge with equal slopes on either side and its steeply dipping strata, to the escarpment or bench topography with its gently dipping beds.

Ouachita Valley Structure.—In the central and northern part of the Ouachita area most of the larger valleys lie along anticlinal axes, while in the southeastern part of the field the valleys are in the softer strata or along faults, and are nearly always parallel to the structural lines.

Folds and Faults.—The folds and faults belong principally to that part of the field included in the Ouachita mountain system. The limits of the folded area are not sharply marked, however, and there are isolated folds and faults through and around the Ozark mountains. There are two distinct systems of folds, a primary system and a secondary one. The axes of the most characteristic or primary system run about S. 80° W. The axes of the secondary system run approximately northeast–southwest, but the different folds of this system vary much in direction on either side of the general direction. It does not appear that these two systems of folds are of different ages, because the topographic features have developed equally along corresponding kinds of folds regardless of the direction of their axes, and also because the two systems are intimately related, as is shown by certain folds lying in both systems. As already stated, the axes of the principal folds run nearly east and west and the folds are quite regular. The distinctness of the secondary folding is shown by the general southwest direction of many axes and by the west-northwest dip of all the rock beds in the central and western part of the whole area of the reconnaissance. These western beds dip nearly northwest in the southern part of the area, to the west-northwest in the central, and to the west in the

northern part of the Indian Territory. Thus the strike swings around so as to become parallel to the western end of the Ozark mountain uplift. This secondary system of folds is more characteristic of the northern part of the region, thus further showing its intimate connection with the Ozark mountains. So it appears that the force that threw the Ouachita mountain system into east and west folds at the same time uplifted the Ozark mountains to the north and started secondary north-south folds.

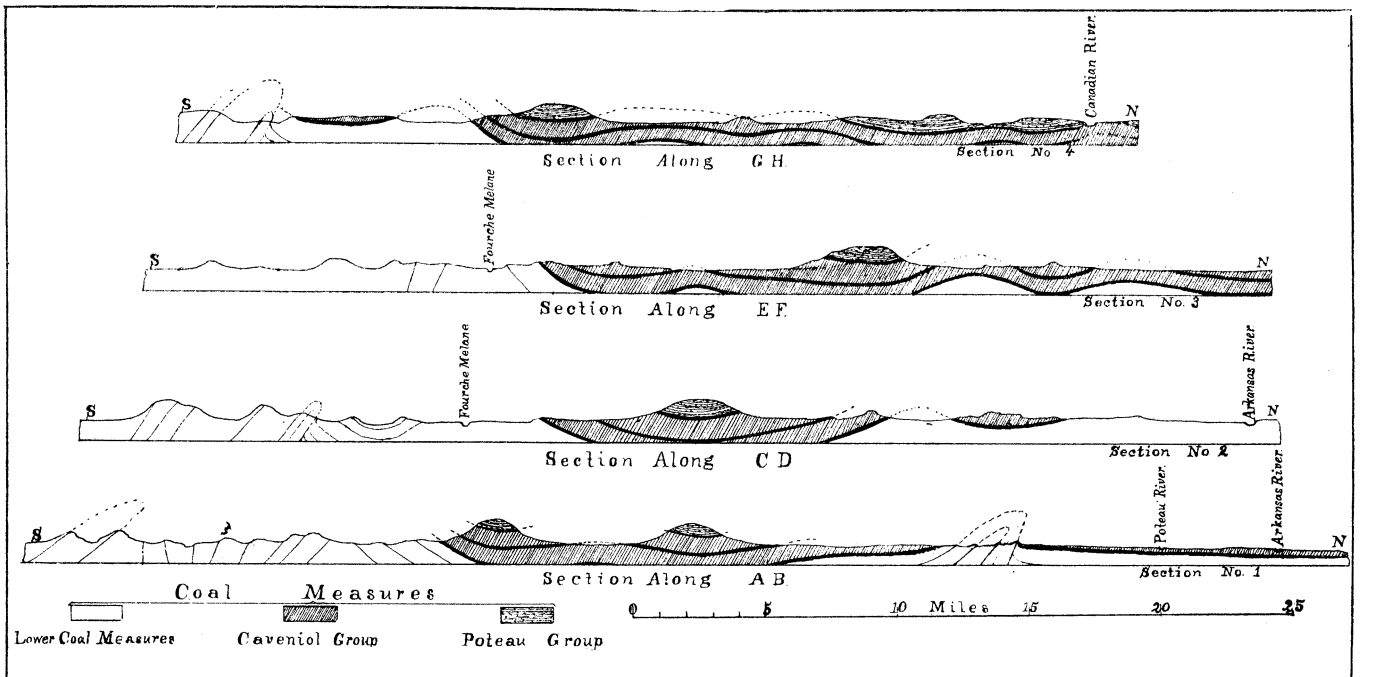
The sketch map of the Choctaw coal field shows that there are three groups of the south 80° west folds that are especially prominent. The group on the north is anticlinal and runs westward from immediately south of Pocola, passing near Farmer and Milton, and running through Sans Bois to the west end of Sans Bois prairie. This group includes three separate anticlinal folds, or the Backbone, the Bokoshe-Milton and the Sans Bois anticlines.

The group lying immediately south of this is composed of three separate synclines, the Sugar Loaf, the Cavaniol and the Sans Bois synclines, giving axial direction to the mountains of those names. The third group, farther to the south, is anticlinal and extends from immediately north of Heavener westward, with some minor deflections, passing near Krebs and through McAlester. This is a continuous anticlinal fold. To the north of these three groups the folds are more gentle and irregular, while to the south of them the folding is also more irregular and decidedly more violent and accompanied by faulting. So in the southern part of the field the structure can only be worked out by detailed study.

Folds of the second system, or those running nearly northeast-southwest, are all gentle and not so extensive. The most prominent folds of this system are those separating the Sugar Loaf, Cavaniol and Sans Bois mountains, and those lying between Ward and Whitefield. Of all these the one separating Cavaniol and Sans Bois mountains is the most prominent, and it is only a gentle roll.

Characteristics and Origin of the Folds and Faults.—The intensity of folding and faulting increases quite regularly southward, as is shown in Secs. 1, 2, 3 and 4, Pl. II, and this intensity of folding extends further westward in the southern part of the area. Along any given east and west line the folding is usually more intense to the east; this, however, is due chiefly to the southward deflection of the west end of the principal folds. As a rule, the strata on the north side of anticlinal folds dip more steeply than on the

Plate II.

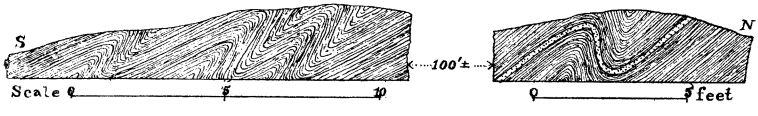


Sections across the Choctaw coal field.

south side of the same folds, as is shown in Secs. 1, 2, 3, 4, 5, 6, 8, and A. This feature is more marked where the folding is intensified. Where the anticlines are very closely pressed, overthrows to the north and often faulting along the north side of the anticlines are the usual consequences; this is shown in Secs. 5, 6 and Pls. II and VII. In the Ozark mountain area the faults are usually normal, while in the Ouachita area the faults are along anticlines.

All mountains of importance in the southern part of the field (Walker, Black Fork, Rich, Blue, Winding Stair, Jack Fork and Kiamichi mountains) have practically all their beds dipping south about 40°. Throughout the area including these mountains, the folds are so closely pressed, overthrown, and faulted that the strata no longer show broad anticlines with low dips.

The elevation of the region, the increased intensity of folding toward the south, and the overthrows toward the north all show an upward and northward movement of the rock beds at the time of folding. In places these movements of the strata have produced wrinkles like that shown in Sec. A.



Sec. A. To illustrate Ouachita folded structure. Sketched from exposures along a railway cut, five miles southeast of Bengal.

This movement has tilted beds 40° to the south, the angle at which they best resisted breaking and crushing. As noted by Marcou,[1] Branner[2] and Griswold[3], these disturbances are probably contemporaneous with the Allegheny mountain uplift, and as noted by Winslow[4] they are probably due to the raising of the isogeotherms in the great thickness of Paleozoic beds.

Lithology of the Area of the Reconnaissance.—This field includes both igneous and clastic rocks. The igneous rocks, however, are confined to one small granitic dike in the Cherokee Nation. Among the clastics, shales, sandstones, limestones and cherts have extensive developments.

[1] *Annales des Mines*, 5me sér., vii, pp. 339, 340.
[2] *Ann. Rep. Geol. Sur. Ark.*, 1890, iii, p. 213.
[3] *Proc. Bost. Soc. Nat. Hist.*, xxvi, pp. 474–479.
[4] *Bull. Geol. Soc. Am.*, 1891, ii, pp 231–234.

Igneous Rocks.

Previous Knowledge of the Igneous Rock.—The existence of igneous rock in the Cherokee Nation has been known for a long time. It was referred to in D. D. Owen's *Second Report of the Geology of Arkansas* as a red granite which occurred at the mouth of Spavinaw creek, some thirty or forty miles west of the Arkansas line. Edward T. Cox failed to find the granite in place, but saw some millstones that were made from it, and obtained specimens which were broken off in fashioning the millstones. He thought this granite underlay the sedimentary rocks of southwestern Missouri and northwestern Arkansas.[2]

The exact locality of this granite outcrop has, however, apparently never been definitely known to any one interested in the geology of the country until 1896, when the writer, after a special search, found the rock in place.

Locality and Mode of Occurrence.—The rock occurs in the Cherokee Nation, on the north side of Spavinaw creek, about six miles from its mouth and three-fourths of a mile west of Spavinaw post-office. It is a dike about twelve hundred feet long by fifty feet wide. The outcrop is not continuously exposed, but the breaks are probably due to a thin covering of detritus from the clastic rock. There are four exposures of the dike rock, which vary in length from about one hundred to two hundred feet, and occur at intervals of about two hundred feet.

This dike runs along the axis of a gentle anticlinal fold which extends about N. 30° E. The dips of the sedimentary beds on either side of the dike are only 5° to 10°, but the fold is broad and affects the rocks for two to three miles to the west and probably as far to the east. Silurian strata which, over the adjoining country, are usually covered by two hundred to five hundred feet of Lower Carboniferous beds, are here exposed to a depth of about two hundred feet and outcrop in the valley, as shown in Pl. III. The Silurian strata along the contact of the dike appear to be free from any special metamorphic action due to the dike rock.

Macroscopic Characters.—The general color of the rock is a light brick red with a mingling of black specks which are slightly grouped and in places so much as to give it a somewhat

[1] *Second Report of a Geological Reconnaissance of the Middle and Southern Counties of Arkansas, 1859 and 1860*, pp. 404, 408.

[2] *Ibid.*, p. 408.

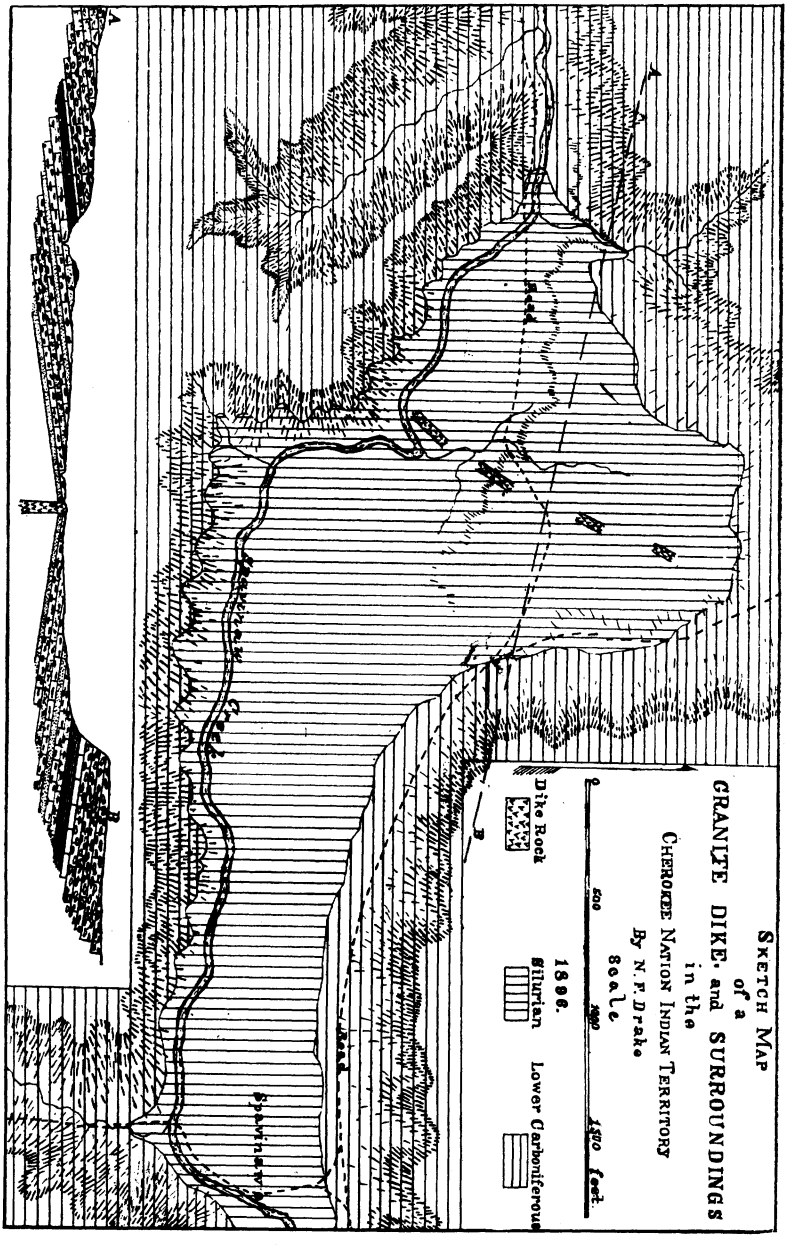


Plate III.

mottled appearance. In the red color are blended a light pink and also deeper red, due to the feldspar crystals, which are red and form by far the larger part of the rock. The black specks are small magnetite crystals. Associated with the black crystals are greenish hornblende and chlorite crystals, which give a greenish tint hardly noticeable on a casual observation. It contains also a few small white quartz crystals. The crystals composing the rock vary in size from those which give a general granular appearance to the ground mass to feldspar crystals that are 1 c. m. or more in length. The freshly broken rock shows a general fine-grained, somewhat shiny and bright appearance with numerous shining crystal faces of the larger feldspars.

Microscopic Examination.—Feldspars, quartz, chlorite and magnetite are the principal minerals of the rock, while hornblende and epidote occur sparingly. A holocrystalline texture is shown throughout the rock. The most striking and general microscopic feature is its granophyric and micropegmatitic texture. Through most of the orthoclase crystals quartz is intergrown in the most intimate manner, so that each feldspar shows radiating or parallel alternating quartz and feldspar in narrow bands, which form fan-shaped or irregular patches. In other cases, the quartz appears in triangular sections along lines through the feldspar crystals, or is micropegmatitic. In any given feldspar crystal, the included quartz plates or prisms show the same orientation. Quartz occurs sparingly isolated in larger crystals, but very rarely shows its outlines. Feldspars are the predominant minerals. They are principally orthoclase, but plagioclase feldspars are of rather common occurrence. The feldspars have a fine granular appearance and a reddish color. Phenocrysts of feldspar are quite common; they, however, generally show irregular outlines instead of crystal faces. Magnetite occurs in small opaque masses, many of which show perfect crystal outlines. They show a slight grouping through the rock and in places give a blended appearance to the crystals.

The hornblende is the greenish variety and of rather uncommon occurrence. The chlorite is common and occurs in greenish bands, spherular aggregates and in minute particles. Epidote is of rather common occurrence.

Chemical Analysis.[1]—	PER CENT.
Loss on Ignition	1.11
Silica (SiO_2)	71.10
Ferric Oxide and Alumina (Fe_2O_3 and Al_2O_3)	20.60
Calcium Oxide (CaO)	2.53
Magnesium Oxide (MgO)	0.99
Potassium and Sodium Oxide (K_2O and Na_2O)	3.76
Total	100.09

Classification of the Rock.—The high percentage of silica, the holocrystalline texture and the general interference of crystallization shown in the irregular crystal outlines at once place the rock in the granitic series. As shown by the feldspars, quartz and magnetite, however, there is a strong tendency to the porphyritic texture: it is, therefore, a porphyritic granite. The minute textures of the feldspars and quartz is designated by the name granophyre.

Age of the Dike.—As noted above, the dike breaks through Silurian strata along the axis of an anticlinal fold. The Lower Carboniferous strata overlying the Silurian are tilted by this fold. The igneous rock was, from this evidence, most likely protruded at the time of the folding. This anticline is one of the outlying folds of that mountain system which is such a marked feature of central western Arkansas and the adjoining part of the Indian Territory. This system of folding is post-Carboniferous, pre-Cretaceous and quite likely pre-Mesozoic, because Upper Coal Measures deposits are folded, Lower Cretaceous deposits lie almost undisturbed upon these folds and no Jurassic or Triassic beds occur over the area.

Relation to the Igneous Rocks of Other Areas.—This dike in the Cherokee Nation is equally distant from three different igneous rock areas, and about two hundred miles from either of them. One lies in southeastern Missouri, one in central Arkansas and the other in the Choctaw and Chickasaw Nations, Indian Territory. The igneous rocks of this latter-named area have not been studied by any one sufficiently to make satisfactory comparisons. The igneous rocks of Arkansas are quite different from the Spavinaw granite. Those of Arkansas "belong to the eleolite syenites and their associated dike rocks;" they are gray or blue in color[2] and are post-Car-

[1] Analysis made by Mr. Chester A. Thomas.

[2] *Ann. Rept. Geol. Surv. Ark.*, 1890, Vol. ii, p. 3.

boniferous in age. In texture, color and mineralogical composition many of the Missouri granites closely resemble those of the Spavinaw area. The resemblance is especially true of the granophyric and micropegmatitic texture. Dr. Haworth says:[1] "The distribution of rocks exhibiting such structure is very wide; there is scarcely a granite in the State in which portions of it are not represented. . . . . The small outlying granitic areas generally have this structure throughout. . . . . This structure is common in the porphyries also."[2]

Iron oxide is a rather common constituent of the Missouri granites, and is especially common in the porphyries.[3] These properties in general are also characteristic of the Spavinaw rock. The age of the Missouri granite, however, is apparently different since it has been referred to the Archean.[4]

Clastic Rocks.

The clastic rocks which cover all this area, except the small dike described, belong to the Silurian, the Lower Carboniferous, the Coal Measures and the Permian.

The Silurian occurs in a few narrow valleys in the northeastern part of the area. The Lower Carboniferous covers about half of the Cherokee Nation, or the northeastern part of the field under discussion. The Coal Measures cover all the rest of the area except a narrow strip along the western edge, which is Permian.

Silurian.

The Silurian areas lie in narrow strips along valleys in the Cherokee Nation, where stream erosion has cut down through the overlying Lower Carboniferous beds. In some places folding has elevated these lower beds so that erosion has more readily exposed them.

Structure.—The Silurian strata lie almost horizontal and closely conform to the inclination of the overlying Lower Carboniferous beds.

Lithology.—The strata are composed of saccharoidal sandstones, marble or highly metamorphosed limestones, chert and dolomitic calcareous sandstones.

[1] *Mo. Geol. Sur.*, Ann. Rept., 1894, Vol. viii, pp. 165-166.
[2] *Ibid.*, p. 193. [3] *Ibid.*, pp. 141, 188. [4] *Ibid.*, pp. 95-96.

Local Development.—The localities where the writer saw and examined Silurian deposits are on Spavinaw creek six to seven miles from its mouth, along the Illinois river southeast of Oaks, along Salisaw creek at and near Marble and on Elk creek west of Bunch.

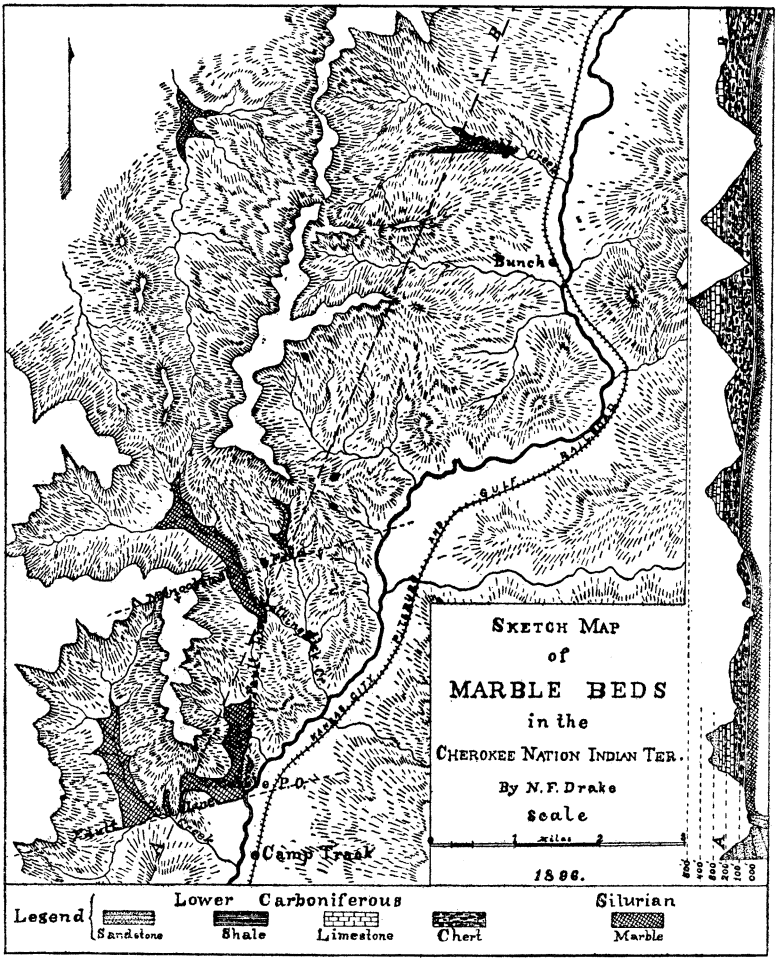
Spavinaw Creek Area.—The area on Spavinaw creek is shown in Pl. III. It is about one mile square, and is exposed mainly on account of an anticlinal fold which elevates the beds so that the erosion of Spavinaw creek has reached and cut into them. About two hundred feet of the strata are exposed. The rocks are mainly cherty limestones, cherty calcareous sandstones and saccharoidal sandstones. The lowest exposed strata lie practically in contact with the igneous dike and are composed of fossiliferous chert. Along the creek at Spavinaw post-office twenty feet or more of the Silurian strata are exposed.

Illinois River Areas.—At the Stewie ford of the Illinois river on the Cincinnati-Oaks road, about seventy-five to one hundred feet of Silurian strata are exposed in the bluffs and the hillsides along the valley. These strata are mainly saccharoidal sandstones, rather thin bedded, but sandy clay shale is quite frequently interstratified with the sandstone. These clays are of a light gray color and in places are slightly blue, and some are yellowish. Silurian strata are exposed on the above-named road also about two miles to the northwest of the ford, at which exposure the beds are saccharoidal sandstones dipping slightly to the southeast. Good exposures of the thin bedded sandstone and shales may be seen at the Stewie schoolhouse about one-half mile northwest of the ford. From the exposures seen along and near the river, it seems likely that the outcrops extend several miles up and down the valley from the ford. Silurian strata are reached by this river erosion along the Arkansas-Indian Territory line, and they are nearly reached in the bed of the river east of Greenleaf courthouse, some twelve to fifteen miles southeast of Tahlequah. So it is probable that exposures may be seen for twenty or thirty miles along the river valley within the Cherokee Nation.

Salisaw Creek Areas.—The exposures of Silurian deposits on Salisaw creek were caused by folding, faulting and erosion. The location and areal outcrop of these beds are shown in Pl. IV. The Silurian strata nowhere rise high upon the hillsides, but are almost entirely confined to the deeper erosion channels of the valleys and cañons. They are exposed, however, only where folding or fault-

ing has brought them to a higher level than they would otherwise have reached. There are in this area two systems of folds and fault lines; one runs about 10° south of west, and the other 10° east

Plate IV.



of north. One of the S. 80° W. fault lines runs from a point about one-half mile southeast of Marble P. O. westward across Dry creek. From the first-named point, a fault line runs N. 10° E. across Walkingstick creek, where it meets a monoclinal fold running

nearly east and west apparently. The uplift of the monoclinal fold being on the north side, outcrops of the Silurian strata extend farther east on that side of the fold. Another east and west anticlinal fold appears to lie about one mile north of Bunch. Silurian rocks are exposed along this uplift one and a half miles northwest of Bunch, and on Elk creek about six miles W. N. W. from Bunch.

Lithology of the Salisaw Creek Area.—Marble and saccharoidal sandstone are practically the only kinds of rocks exposed in these outcrops. There is, however, a bed of chert some twenty-five feet thick one-half mile west of Marble, which is most likely Silurian. This chert consists of angular pieces, from an eighth to a fourth inch in diameter, of pink and also white chert scattered through a ground mass of gray chert. At the base of the chert bed, there is some saccharoidal sandstone containing chert nodules. The saccharoidal sandstone usually lies at the top of the Silurian beds in this area, and is from one inch to twenty-five or thirty feet thick. The grains composing the sandstone vary considerably in size: the largest are about two millimeters in diameter. These sandstones may be seen along Walkingstick creek above the Marble bed, at almost every place where the top of the marble is exposed. They also outcrop one-half mile east of Marble on Salisaw creek, and northwest of Marble along Dry creek. The marbles are generally of a pink color, rather coarsely crystalline, seamed, and lie in massive beds; twenty-five to thirty feet of massive marble is exposed at all the larger Silurian areas marked on Pl. IV, and the base of the marble was not seen at any place. Mr. J. D. Rice, who quarries marble at Marble P. O., gave me the following section from a drill hole on Dry creek, northwest of Marble P. O.

	FEET.
Pink marble	25
Light gray marble	100
Deep pink marble	2½
Dark gray marble	2½
Deep pink marble	5
Dark gray marble	1

Relation to the Silurian of Arkansas.—A section[1] of the Silurian deposits in Arkansas gives something over one hundred and fifty feet of pink, chocolate and gray-colored marbles on top, which beds

[1] *Ann. Rept. Geol. Sur. Ark.*, 1890, Vol. iv, pp. 10, 11, 214.

are called St. Clair marbles. These beds are underlain by blue and gray limestones called the Izard limestone. The Izard limestone is underlain by saccharoidal sandstones, magnesian limestones and cherts.

All the Silurian deposits seen in the Indian Territory, except the Salisaw and Elk creek areas, are composed of saccharoidal sandstones, cherts and calcareous, magnesian sandstones. The Salisaw and Elk creek Silurian rocks, however, are mainly pink and gray marbles, and therefore appear to be the equivalent of the St. Clair marble, while the Illinois river and Spavinaw creek areas belong to the beds below the Izard limestone.

The St. Clair marbles in Arkansas are principally confined to Independence, Izard, Stone and Searcy counties, in the northern part of the State. The Izard limestones have a somewhat wider range,[1] but neither the St. Clair marble nor the Izard limestones are known as far northwest as Benton county, Ark.,[2] or to the west of Benton county, in the Indian Territory. So it appears that these topmost Silurian beds were eroded in the northwest to a greater extent than they were to the south and east, before they were covered by later deposits. Dr. Henry S. Williams,[3] principally from biological investigations, has determined the top of the St. Clair marble to be of Clinton-Niagara age, and the lower part of it to be of Trenton age. From the thickness of the marble beds in the Salisaw creek areas, as shown by drill holes, it is probable that the outcropping part is the equivalent of the Clinton-Niagara part of the St. Clair.

Lower Carboniferous.

Area.—The Lower Carboniferous is confined to the northeast part of the Cherokee Nation and is roughly bounded on the west by the Grand or Neosho river and on the south by the Boston mountains. This area covers about three thousand square miles, approximately one-half of the Cherokee Nation.

Lithology.—The rocks composing the Lower Carboniferous are cherts, limestones, shales and sandstones.

Structure.—The beds as a rule are practically horizontal, especially in the northeastern part of the area. Along the western border of

[1] *Ann. Rept. Geol. Sur. Ark.*, 1890, Vol. iv, p. 112.
[2] *Ann. Rept. Geol. Sur. Ark.*, 1891, Vol. ii, pp. 27–32.
[3] *Am. Jour. Sci.*, 1894, Vol. cxlviii pp. 328, 329.

the area the strata dip slightly to the west, while along the southern border they are somewhat disturbed by gentle folds which usually run a little south of west by north of east; but many run about northeast by southwest. The general result of the disturbance is to make the strata dip with varying steepness to the south.

Eureka Shale.

This shale is black, argillaceous, bituminous and rather friable and varies in thickness from one inch to forty or fifty feet. It immediately overlies the Silurian beds and is apparently unconformable with them since the shale lies on cherts and saccharoidal sandstones along Spavinaw creek and Illinois river, while about twenty-five miles farther south it lies on higher strata composed of one hundred and fifty feet or more of Silurian marble. Similarly, in Arkansas, the shale lies on top of the St. Clair marble and the Izard limestone along the southern border of the Silurian area, while farther to the north it rests on cherts and saccharoidal sandstones which underlie the marbles and limestones.

The shale is apparently conformable with the overlying beds, since the limestone at the base of the Boone chert was found resting on it at every place where it was seen. The shale may be seen at nearly every locality where Silurian beds are exposed, and at a few places where the erosion has not passed through the shale bed. Quite often detritus from overlying rock beds covers and obscures the outcrop of the shale, but by tracing the horizon a short distance it is usually found.

The Eureka shale has a wide distribution outside of the Indian Territory. It is usually found in northwestern Arkansas wherever the base of the Boone limestone is exposed. From its typical development at Eureka springs, Ark., it was named by Dr. J. C. Branner, the Eureka shale.[1]

Dr. Branner says: "The Eureka shale is clearly the equivalent of the Tennessee bed called by Safford the 'Black shale.'"[2] Safford says this shale also occurs in Virginia, Georgia and Alabama.[3]

[1] *Ann. Rept. Geol. Sur. Ark.*, Vol. iv, 1890, p. 345; "Phosphate Deposits of Ark.," *Tran. Am. Inst. Min. Eng.*, 1896, xxxvi, 580–582.

[2] *Ann. Rept. Geol. Sur. Ark.*, Vol. iv, 1888, p. 26; "The Phosphate Deposits of Arkansas," *Trans. Am. Inst. Min. Eng.*, 1896, xxxvi, 582.

[3] *Elementary Geol. of Tenn.*, by James M. Safford and J. B. Killebrew, Nashville, 1885, p. 75.

The "Black shale" of Tennessee was referred to the Devonian[1] by Safford. The Eureka shale of Arkansas was referred doubtfully to the Devonian.[2] Dr. Branner thinks the shale belongs to the Lower Carboniferous,[3] because in places it grades into the overlying Lower Carboniferous limestones, and the few fossils that have been found in the shale belong equally to the Devonian and the Lower Carboniferous. The persistency with which such a thin bed occurs unconformably with the Silurian and conformably with Lower Carboniferous beds in the Territory, as well as in Arkansas, also strengthens the theory that it is Lower Carboniferous.

Spavinaw Creek Area.—Exposures of the shale are common around the border of the Silurian area on Spavinaw creek. One of the best exposures seen there was about one mile west of Spavinaw post-office, on the north side of Spavinaw creek. At that point it is about forty feet thick, and is the usual typical, bituminous, rather friable shale.

Illinois River Areas.—On the north side of the Illinois river, west of the Cincinnati-Siloam Springs road, and near the Arkansas-Indian Territory line, good exposures of the shale may be seen. Near the Stewie ford of the Illinois river, along the Cincinnati-Oaks road, the shale outcrops again. In the limited area examined, no complete section was seen, but it appeared to have its usual thickness and characteristics. West of Bunch, at a point about four miles below the mouth of Elk creek, the Eureka shale outcrops in the bed of the Illinois river.

Salisaw Creek Areas.—About two miles northwest of Bunch, along Marble creek, the valley shows the typical Eureka shale soil, but no good exposures of the shale were seen there. Along Walkingstick creek, however, about three and a half miles north of Marble, good exposures of the shale may be seen. At this locality it is about thirty feet thick and contains some calcareous nodules, otherwise it does not vary from its general characteristics. Along Dry creek, one and a half miles northwest of Marble, good exposures of the shale show it to be about thirty feet thick.

[1] *Elementary Geol. of Tenn.*, by James M. Safford and J. B. Killebrew, Nashville, 1885, pp. 112, 118.

[2] *Ann. Rept. Geol. Sur. Ark.*, 1891, Vol. ii, p. 32.

[3] "Phosphate Deposits of Arkansas," *Trans. Am. Inst. Min. Eng., loc. cit.*

Boone Chert and Limestone.

Stratigraphic Position.—Immediately above the Eureka shale, there is a series of cherts and limestones aggregating from fifty to about five hundred feet in thickness, and averaging about three hundred and fifty feet. It was named the Boone chert by Dr. Branner because of its extensive and typical development in Boone county, Ark.[1] These beds are the probable equivalents of the Burlington-Keokuk divisions of the Lower Carboniferous.

Areal Extent.—The Boone chert and limestones form the principal strata outcropping over several counties in southwest Missouri and northwest Arkansas, and continue into the Territory, where they cover half of the Cherokee Nation—three thousand square miles. They lie in the northeastern and east central part of the Cherokee Nation. Roughly, their western limit is four to five miles west of Grand river and their southern limit some twenty to twenty-five miles north of the Arkansas river. Tracing the boundary more definitely, it enters the Territory south of Baxter Springs, Kans., curves to the southwest, passing through Miami, thence bears southward to near Fairland, whence it extends southwestward to a point on the M. K. & T. Railway, some four or five miles southwest of Vinita. From this point it runs southward in a wavy line between the railway and Grand river to a point about fourteen miles north of Ft. Gibson. From this point it runs eastward in a zigzag way to a point about one and a half miles south of Tahlequah. Then in its eastward course it swings southward, passing a little south of Park Hill, makes deep southward swings on the Illinois river, Salisaw and Lee's creeks, and passes into Arkansas a little north of Evansville. All along this border, and more especially its southern part, there are small isolated areas of higher geologic horizons scattered over the chert area along drainage divides.

Structure.—Over most of this area the beds are practically horizontal, but nearer the borders the strata dip toward and at right angles to the border line. In the northwest part of the area this dip, even along the border line, is barely perceptible, but toward the south the dip increases and also becomes more irregular by the increased folding and some faulting along several axes. These disturbances largely account for the irregular border of the chert area on the southwest and south.

[1] *An. Rep. Geol. Sur. Ark.*, 1890, Vol. i, p. 129.

Stratigraphy.—Most of the formation is chert, and the limestone strata are usually confined to the base and top of it. These two limestone horizons are usually five to twenty feet thick each. The limestone interstratified with the chert is in thin layers, seldom more than two or three feet in thickness, and is of rather rare occurrence.

Characteristics of the Chert.—The chert varies in color from white to gray; light gray or white is the prevailing color, and is especially characteristic of the rock that has been exposed to weathering agencies, or is dry. Weathered pieces, however, are often of a brownish color. The rock is almost a uniform mixture of lime and silica, but the proportion of lime and silica varies somewhat at different horizons or even along the same stratum. In weathering it breaks into rather small sharp angular pieces. The strata are usually thin and present a slight wavy and much fractured appearance. These features are doubtless due to the weathering of rock of an uneven composition. These irregularities and characteristics run through the whole chert bed throughout the entire area.

Limestones.—The limestone at the base of the chert bed corresponds to the St. Joe marble of the Geological Survey of Arkansas;[1] it varies from an inch to about thirty feet in thickness; it is of rather uniform texture, quite crystalline, of a rather dark-gray color, and lies in strata from a few inches to four or five feet in thickness. This bed is rarely missing where the base of the Boone chert was seen. On Spavinaw creek and Illinois river it is from fifteen to twenty feet thick. On Dry creek, one and a half miles northwest of Marble, it is about two feet thick, crystalline, gray in color, and contains greenish specks scattered through it.

The limestone that occurs very sparingly through the chert is rarely more than two or three feet thick. It is usually of uniform texture, tough, and of a gray color.

The limestone at the top of the chert is from fifteen to forty feet in thickness. It is massive, tough, gray and crystalline, but in the northwestern part of the area it is arenaceous and somewhat flaggy. This limestone forms the base of a great many small hills along the border of the chert area. It is often marked by glades due to thin soil. Along the west bank of Spring creek, near the south line

[1] *Ann. Rept. Geol. Surv. Ark.*, 1890, Vol. iv, p. 253.

of the Quapaw Nation, hard gray massive beds of the upper Boone limestone are finely exposed in bluffs and benches known as the Devil's Promenade. Along the east bank of the Neosho river, south and southwest of Miami, the upper Boone limestone forms a long outcrop; the bed is composed of shaly, flaggy and lenticular bedded limestone, some of which near the top and especially along parting planes is decidedly arenaceous. Archimedes are abundant in the upper part of these limestones. Along a little brook, one mile to the west of Big Cabin creek, a full section of the limestone overlying the Boone chert is exposed. The limestone bed is about thirty feet thick and arenaceous throughout, though it varies very much in the proportion of sand and lime in different strata. The beds that are most arenaceous are shaly and lenticular and some contain arenaceous limestone nodules with flinty centres. Archimedes occur in some of these strata. East of Grand river, opposite Chouteau, this bed is arenaceous and flaggy. About seven miles east of Adair the Boone limestone outcrops along streams. The rock is massive, hard, gray, fossiliferous limestone. The outcrops seen northeast of Ft. Gibson, west and southwest of Tahlequah, are practically all gray limestone in rather massive strata. The bed as it occurs along the Illinois river and Greenleaf creek southeast of Greenleaf, is about thirty feet thick, mostly gray and massive limestones. There is at the top of the bed, however, a stratum of bluish limestone which weathers to a whitish color, and the base of the bed is somewhat arenaceous, shaly and wavy.

Along Walkingstick creek, about three miles north of Marble, the stratum is thirty feet thick, and is composed of massive gray limestone. The top of this bed, as seen in the base of a hill one and a half miles south of the Tahlequah-Evansville road and four or five miles east-southeast from Wauhillau, has a little blue limestone that weathers white. Near the base it is decidedly arenaceous and shaly; the rest of the bed, which is the greater part of it, is massive gray limestone as usual. East of Stillwell, south and southwest of Westville, the stratum is from thirty to forty feet thick, and is practically all gray limestone in layers from a few inches to five or six feet in thickness.

Fayetteville Shale.

The Fayetteville shale is probably the stratigraphic equivalent of the Warsaw division, as recognized in Illinois, Iowa, etc.

Secs. a–k, Pl. V, show the variation in thickness and the associated strata of the Fayetteville shale along its line of outcrop through the Indian Territory. These sections were made at the following localities:

Sec. a—About two miles west and southwest of Stillwell.

Sec. b—Four or five miles east-southeast from Wauhillau and one and a half miles south of the Evansville-Tahlequah road.

Sec. c—Compiled from sections made northwest of Marble and southwest of Bunch.

Sec. d—West side of Big Vian creek about one and a half miles northwest of Vian.

Sec. e—Compiled from outcrops along the Illinois river and Greenleaf creek, about five miles east-southeast from Greenleaf.

Sec. f—About one mile north of Fourteen Mile creek and one and a half miles northeast of Grand river.

Sec. g—About two and a half miles south-southwest of Markhain's store or thirteen miles south of Brushtopped mountain.

Sec. h—One and a half miles east of Grand river, opposite Ned Adair's ferry, east of Chouteau.

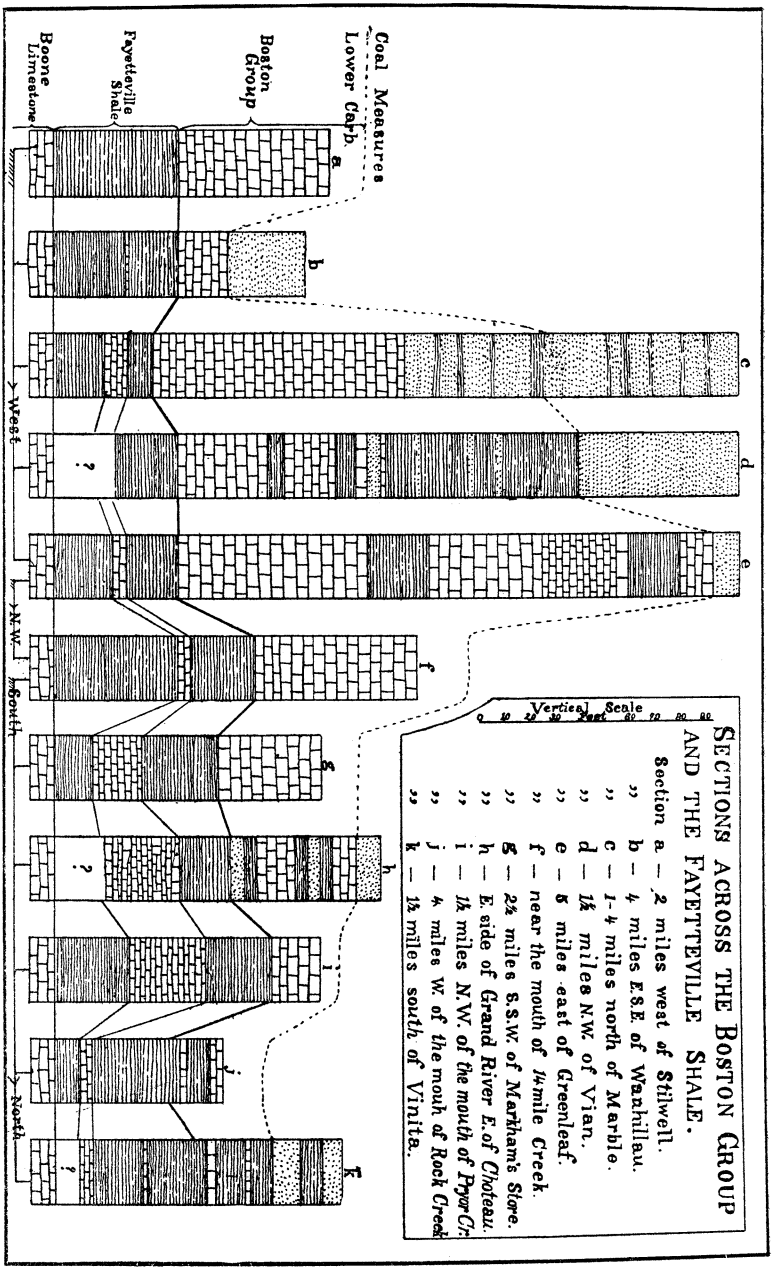
Sec. i—Brushtopped mountain, a small hill one mile north of Pryor creek and one and a half miles west of Grand river.

Sec. j—South side of Rock creek about four miles west of its mouth northeast of Adair.

Sec. k—Along and south of Little Log Cabin creek one and a half miles south of Vinita.

The Fayetteville shale is a black, friable, clay shale, which usually contains clay-ironstone concretions, and has an average thickness of about fifty feet. This shale immediately overlies the upper Boone limestone, and varies but little around the southern and the southwestern border of that limestone, and also along the western border as far north as the Grand river east of Chouteau. Farther to the northward it is more arenaceous and thinner and varies in color from gray to blue and yellowish. It is doubtful whether there are any outcrops as far north as the Indian Territory-Kansas line that may be referred to this shale. The shale is divided throughout by a bed of light blue, friable, fine-grained lime-

Plate V.



stone. The lithologic characteristics of this limestone are quite uniform throughout its extent and are such as to contrast it sharply with the limestones of the associated beds. It varies in thickness from an inch to thirty feet. Along Grand river east of Wagoner, Chouteau and Pryor creek, it is twenty to thirty feet thick; farther northward and southeastward it is usually but five to ten feet thick. This bed is apparently confined to the Indian Territory, since it was not observed north of Vinita and was not noted in Arkansas by the Geological Survey of that State. There is, however, a stratum of limestone about a foot thick in the Fayetteville shale three miles southeast of Westville, which from its position and lithologic characteristics, appears to be this bed.

In the Fayetteville shale exposed around the hillsides southwest of Bunch and along Illinois river east of Greenleaf this limestone occurs almost regularly and is usually five or six feet thick.

Batesville Sandstone.

In the isolated small hills northwest, southeast and south of Westville, sandstone beds twenty feet or more in thickness overlie the Fayetteville shale, and are probably the equivalent of the Batesville sandstone. This sandstone bed is apparently lacking at other places over the field where the Fayetteville shale was seen.[1]

Boston Group.

This group is composed of the uppermost beds of the Lower Carboniferous and corresponds to the St. Louis and Chester horizons of Illinois, etc. The classification of the group into beds as was worked out in Washington county, Ark., by Dr. F. W. Simonds[2] is as follows:

Boston group
- Kessler limestone.
- Coal-bearing shale.
- Pentremital limestone.
- Washington shale and sandstone.
- Archimedes limestone.
- Marshall shale.

These horizons were classified mainly on lithologic characters,

[1] Mr. Stuart Weller has recently shown that the Batesville sandstone is the equivalent of the Aux Vases sandstone of Illinois and Missouri (*Trans. N. Y. Acad. Sci.*, xvi, 251–282).

[2] *Ann. Rept. Geol. Surv., Ark.*, 1888, Vol. iv, p. xiii.

which change rapidly in most of them. These variations are apparently greater in the Indian Territory than they are in Arkansas. In the northern part of the Indian Territory it is doubtful whether the group is represented by any deposits of consequence. It is represented southeast of Vinita by a series of shaly clays and thin beds of impure limestones, aggregating about seventy-five feet in thickness. East of Chouteau, along Grand river, the group is about one hundred feet thick and is rather clearly divided into different beds of limestones and shales. On Salisaw creek and eastward to the Arkansas-Indian Territory line, the group is about one hundred and fifty to two hundred feet thick. The whole group, as outlined in Washington county, Ark., is, however, nowhere in the area studied represented in a characteristic way. The Archimedes and Pentremital limestones are usually together, and it is very doubtful whether the Kessler limestone is at all represented.

This group is usually confined to an escarpment and isolated hills along the western and southern border of the Boone chert and limestone area; at most its outcrop forms a belt only two or three miles wide along the border of the Lower Carboniferous. Secs. a–k, Pl. V, show the development of this group along its line of outcrop from near Stillwell to near Vinita. The hills east, west and south of Stillwell are capped by fifty to seventy-five feet of limestone that belongs to this group. The limestone is usually gray in color, rather massive and in places quite arenaceous. Farther westward, in the isolated hills south of Wauhillau, near the Evansville-Tahlequah road, the limestone and beds of the Boston group are considerably thinner and are overlain by sandstone that is probably Coal Measures. Ten to twenty-five miles south and southwest of Wauhillau, near Bunch, Marble, Vian and along Illinois river east of Greenleaf, the Boston group is one hundred and fifty to two hundred feet thick and probably thicker, since the dividing line that has been used to separate this group from the Coal Measures is largely an arbitrary one and the doubtful beds are mostly classified as Coal Measures. One and a half miles northwest of Marble the lower part of the Boston group beds consists of about one hundred feet of gray limestone slightly interstratified with clay shale and arenaceous shaly limestone. Archimedes occur frequently in the lower part of the limestone bed. Overlying this limestone there is a series of strata aggregating about two hundred feet in thickness, which are composed of sandstones and some interstratified clay shale.

The sandstones vary from massive to flaggy and shaly, and in places near and at the top they grade into a grit. This grit appears to be the equivalent of the so-called Millstone grit of the Geological Survey of Arkansas, since it has the same lithological characteristics and apparently has the same stratigraphic position. It is probable, therefore, that not over one hundred feet of the shales and sandstones overlying the limestones at this place should be referred to the Boston group. The above section (Sec. c, Pl. V), with slight modifications, represents the group as it is shown in outcrops between Bunch and Marble.

The Boston group is well exposed along the west side of Big Vian creek, northwest of Vian, where Sec. d, Pl. V, was made. The section at that place is as follows:

	FEET.
Massive sandstones (Coal Measures ?)	100+
Arenaceous black clay shale	75
Brownish, weathering, hard limestone	½
Shaly sandstone	5
Gray, massive, hard limestone	5
Black clay shale	10
Massive, hard, gray limestone at the base which grades into shaly brownish weathered limestone at the top	15
Clay shale (?)	10
Massive, gray, firm, fossiliferous limestone	35
	135½

The following is a section on the east side of Illinois river, about west-northwest of Marble:

	FEET.
Sandstone and grit (Coal Measures?)	30+
Blue clay shale	5
Uniformly textured, smooth, gray limestone in strata 1 to 2 feet thick	10
Nodular friable limestone in thin, irregular, rough-surfaced strata with clay partings and fillings of lenticular places through the strata	10
Rather uniformly textured, massive, gray, fossiliferous limestone	50
Blue clay shale	20

	FEET.
Hard, gray limestone	2
Sandstone and clay shale	10
Limestone, usually massive, arenaceous, and friable, but it varies to pure, tough limestone of a gray color. Some bluish limestone, which weathers to a white color, occurs near the base of the bed	30
	137

Below this section is about twenty feet of the Fayetteville shale and its included stratum of blue limestone. The limestone at this place is only about two feet thick.

On the west side of Illinois river, about five miles east-southeast from Greenleaf, the following section (Sec. c, Pl. V) may be seen:

	FEET.
Sandstones and grit (Coal Measures?)	at top
Massive, gray, brownish weathering limestone	15
Clay shale	20
Massive gray limestone	4
Blue limestone alternating with a little clay shale. The limestone weathers to a rather smooth but angular wavy surface and a whitish or yellowish color; the weathered cross sections of fossils and wavy branching calcite seams of a darker color than the mass of the rock gives a streaked, wavy and mottled appearance to its surface	30
Rather massive but in part flaggy limestone which in places contains abundant Pentremites	50
Clay shale	25
Gray massive limestone	75
	215

The following section is exposed four miles southeast of Ft. Gibson on the south side of Bayou creek along the Ft. Gibson-Braggs road:

	FEET.
Sandstone (Coal Measures)	at top
Massive gray limestone	10

	FEET.
Argillaceous sandstone, sandstone shale and arenaceous clay shale	20
Limestone: the lower part is brownish weathering and somewhat shaly, the upper part is massive and gray	20
Sandstone	5
Limestone	5
Sandstone	5
Limestone containing Archimedes in the central part of the bed	50
	115
Fayetteville shale and some interstratified blue limestone	at base

West and northwest of Tahlequah, along Pecan creek and Fourteen Mile creek, and along Grand river, east and northeast of Wagoner, the Boston group is usually limited to a fifty to seventy-five foot bed of limestone, which is in places slightly interstratified with clay and contains Archimedes and Pentremites associated throughout almost the entire bed. The Archimedes, however, are more common in the central and lower divisions, while the Pentremites are more common in the central part of the bed. Farther to the north it becomes thinner and more argillaceous until calcareous and arenaceous clays form the principal part of the group as shown in Secs. j and k, Pl. V. East of Pryor creek, Adair, Big Cabin, and south of Vinita, the group is represented by yellowish calcareous clays, friable arenaceous limestones, some hard gray limestone and a little sandstone. The limestone and clays are usually rich in fossils. The following section (Sec. k, Pl. V) will show the general character of the group along its outcrops from the Grand river, east of Chouteau, to within one and a half miles of Vinita.

	FEET.
Brownish weathering massive sandstone (Coal Measures?)	5
Clay shale (Coal Measures?)	10
Sandstone (Coal Measures?)	12
Coal Measures	27

	FEET.
Clay shale which contains some fossiliferous shaly limestone near the base	10
Friable arenaceous fossiliferous limestone	2
Calcareous, fossiliferous, yellowish clays	10
Hard, rough-surfaced, highly fossiliferous limestone	3
Bluish clay shale	25
Limestone	1
	51
Clay shale (Fayetteville shale?)	at base

Fossils of a decided Coal Measures facies were collected from some black clay shale at a place on the M. K. & T. Railway, about four miles north of Vinita. This shale is not more than one hundred and fifty feet above the Boone limestone, so the strata referable to the Boston group, at this place, is probably not more than twenty-five or fifty feet thick.

Between Fairland and Miami the strata that may be referred to this group are gray shales and possibly a little limestone. Northeast of Miami it seems probable that the horizon of the Boston group is overlapped by Coal Measures shales and sandstones, or if this is not the case the group is represented by gray clay shales and some sandstone.

The sections of the Boston group show that it is thicker and apparently has higher beds in the southwestern part of the Lower Carboniferous area where the strata are exposed by being folded or excessively eroded. The same sandstone or grit bed appears to overlie unconformably these different Lower Carboniferous beds at various places. The sandstone beds lying on the Boston group one and a half miles south of Vinita are apparently the same sandstones that rest on the Boone limestone, some six or seven miles southeast of Vinita. Two or three miles southwest from the mouth of Pryor creek a conglomerate sandstone overlies the Boston group to the westward and the Boone limestone to the eastward. The gradual upward change in the Lower Carboniferous deposits from massive and extensive cherts and limestones to shales, arenaceous limestones and sandstones indicate an upward movement of the ocean bottom. This movement may have continued

until the deposited beds were subject to slight erosion before the following subsidence began and the sand and grit deposits laid down over them. The continuity of the fauna and the small amount of overlapping in these deposits could, however, allow only a slight break in deposition.

Coal Measures.

The Coal Measures of the Indian Territory and Oklahoma are a direct continuation of the Kansas, the Arkansas and apparently the Texas Coal Measures. The southward extension of the Coal Measures of Kansas enters the Indian Territory in a belt sixty-five miles wide, which extends from about ten miles west of the northeast corner of the Territory to near the northwest corner. The western limit of this belt through the Territory bears about 10° west of south throughout the area studied. The eastern limit running southward from the Kansas-Indian Territory line extends south 40° W. for a distance of forty miles, then runs nearly south for fifty miles and then with a gentle southward curve and zigzag line extends eastward into Arkansas. The belt through the Territory, therefore, at first contracts from the eastern side for a distance of nearly one hundred miles, then rapidly widens on the eastern side so that the Coal Measures in the territory studied, roughly covers an L-shaped area. The southward continuation of the Coal Measures into Texas is broken in the southern part of the Indian Territory by the overlapping of Cretaceous deposits.

Structure.—The Coal Measures lie in the three structural and topographic groups previously mentioned. The horizontally uplifted plateau, or Ozark type, includes the larger part of the Coal Measures lying between the southern boundary of the Lower Carboniferous area and the northern boundary of the Arkansas river valley. The area of the folded beds, or Ouachita type of structure, lies principally south of the Arkansas river and east of a line connecting the mouth of the Canadian river, Brooken, and a point about seven miles west of McAlester. The remaining and by far greater part of the Coal Measures in the area under discussion belongs to the Prairie Plains region, and consists of gently westward and northwestward dipping strata.

Stratigraphy.—With the possible exception of slight uncomformities produced by overlapping of the basal beds of the Lower Coal Measures, there seems to be no break in the stratigraphy from Lower

Carboniferous into Permian beds. A rough estimate gives a total thickness of 25,000 feet for the Coal Measures deposits. Most of these strata were laid down near shore and are, therefore, subject to the irregularities of near-shore deposits. Arenaceous clay shales, sandstones, limestones, coal, grits and conglomerates occur in relative abundance in the order named. Well-marked beds that may be used for making stratigraphic divisions are for the most part wanting. The limestone beds are mainly confined to the northern part of the field and to the central part of the Upper Coal Measures. The shale and the sandstone beds are so local and repeated in such lithological uniformity that they serve poorly for divisions; fossils, especially in the southern part of the field, are of rare occurrence. The larger coal beds, with some irregularities, extend across the entire field and furnish the best means of grouping the formations. The workable beds of coal are all confined to the lower part of the Upper Coal Measures. The Coal Measures deposits will be considered under the following classification:

Coal Measures.
- Upper Coal Measures.
  - Poteau group.[1]
  - Cavaniol group.[1]
- Lower Coal Measures.

Plates II and VII show the relation of these groups.

The Lower Coal Measures produce no coal; the Cavaniol group contains the workable beds, and the Poteau group contains some thin ones.

Lower Coal Measures.

There are three different areas of the Lower Coal Measures in this field. One lies in the southeastern part of the region, and is bounded on the north by a line running along the southern base of the Poteau mountains and the north side of Fourche Melane valley and Jack Fork mountains; from the latter place the bounding line runs southwesterly and passes out of the field. This area includes the Fourche Melane valley and the upper part of the Kiamichi valley and Walker, Black Fork, Rich, Blue, Windingstair, Jack Fork and Kiamichi mountains and the intervening areas.

[1] These names were taken from the names of mountains in the southeastern part of the field where the beds included in those groups are well represented.

The second area is a strip about four miles wide and twenty-two or twenty-three miles long which extends into the Territory along the Backbone anticline. The third one is an irregular belt bordering the Lower Carboniferous on the south and west. The most of the southern part of this belt lies near and to the north of the Arkansas river, and includes the Boston mountains; the western part of the belt extends along the Missouri, Kansas and Texas railway from Wagoner to Vinita, and from Vinita it runs northeasterly, passing into Kansas at and southwest of Baxter Springs. Along the Arkansas-Indian Territory line this belt is about twenty miles wide, but it gradually narrows to the westward and northwestward until north of Wagoner it is usually but four to five miles wide.

Lithology of the Lower Coal Measures.—Throughout this group there is such a constant repetition of arenaceous gray, clay shales and sandstones of uniform character that the lithology and stratigraphy are exceedingly monotonous.

There is, however, some marked variation introduced by the grits and conglomerates at the base of the group north of the Arkansas river, and by the limestones south of Ponola, Wilburton and Hartshorne. Some minor variations in color and composition also occur in the shales and sandstones. The sandstones are usually massive, but in places they are flaggy or shaly and micaceous, argillaceous, calcareous, ferruginous, or bituminous. A little quartzite occurs in the Windingstair mountains and some conglomerates may be seen in the vicinity of Thomasville.

Thickness of the Lower Coal Measures.—The greatest thickness observed in the Lower Coal Measures was in the southeastern part of the field. In this locality the strata throughout show little variation; extensive faults lie along the north side of Walker, Black Fork, Windingstair and Kiamichi mountains, and smaller faults at other places; and overthrows occur at some places to further complicate the interpretation of the stratigraphy. On account of these difficulties, as well as the limited amount of work the reconnaissance would allow, only rough estimates of the thickness of the exposed beds will be attempted.

The longest continuous section studied in this part of the field was from the base of the Poteau mountains to the south side of Rich mountains. This section extends north and south about three or four miles west of the Arkansas-Indian Territory line. The stratigraphy somewhat generalized along this line is shown in

Sec. 8 (p. 366.) The strata exposed along this section are divided into three divisions by two faulted areas. The division on the north is about seven thousand feet thick, the one next further to the south is about eleven thousand feet thick, but possibly contains as much as six thousand feet of strata that is repeated from the first division, thus leaving only five thousand feet to be added to the seven thousand of the first division, which gives twelve thousand feet. The third and last division is about fifteen thousand feet thick. In this the heavy sandstone beds in the south side of Black Fork and Rich mountains are each about one thousand feet thick, and are so much more massive than any of those exposed to the north, that they are probably lower horizons. There is a strong probability, however, that the strata of Black Fork and Rich mountains are the same, which is the case if the beds are overthrown to the north, as they appear to be. If this is the case, only five thousand feet of the thickness of the strata of the two mountains, should be added to the section already estimated. The remaining five thousand feet of strata to the north of Black Fork mountain is most likely a repetition of the strata exposed and counted farther to the northward. So only five thousand feet more can safely be added to the twelve thousand feet, which gives a total thickness of seventeen thousand feet.

It is possible that this section represents a thickness of as much as twenty-five thousand feet of strata, but under the observed conditions, seventeen thousand feet seems more probable, and even that may be too much. The base of the formation was not seen, but as the thickness exposed is very nearly as much as the estimated thickness of the whole formation in Arkansas,[1] it is probable that almost the total thickness of the beds is exposed in this section. The Lower Coal Measures in Arkansas, however, run a little higher in the section than they do in the Indian Territory, since the Huntington Coal belongs to a higher horizon than the coals farther to the east in Arkansas.[2]

Stratigraphy of the Lower Coal Measures.—The basal beds of the Lower Coal Measures appear to be exposed only in the Cherokee Nation. Overlying the Lower Carboniferous there is a series of sandstones, grits and shales which belong to the basal beds of

[1] Dr. Branner estimates the thickness of these Lower Coal Measures in Arkansas to be 18,480 feet thick (*Amer. Jour. Sci.*, Vol. ii, September, 1896, p. 235)

[2] *Geol. Surv. of Ark.*, Ann. Rep., 1888, Vol. iii.

the Coal Measures. No definite division between the Lower Carboniferous and the Coal Measures could be fixed, but the fossils found in the highest strata, known to belong to the Boston group, are a mingling of species belonging to the highest Lower Carboniferous and the Coal Measures. These sandstones, grits and shales have the same lithological characteristics and stratigraphic position as the so-called Millstone grit of the Geological Survey of Arkansas.[1] There is every gradation from the smooth, fine-grained sandstones to the grits and coarse conglomerates. Good examples of the grit may be seen, north of Camp Track, five miles south of Bunch, in places three to four miles northwest of Vian, and along the east side of Illinois river west-northwest from Marble. This grit is composed of angular grains of quartz, which are usually from one to two millimetres in diameter, but occasionally are from five to six millimetres in diameter. Hematite usually forms the cementing matter for the grit. The basal group of the Lower Coal Measures in the Cherokee Nation is composed mainly of sandstones and grits throughout. No section was made of this group along the Arkansas-Indian Territory line, but it is probably not less than two thousand feet thick. Five to ten miles southeast of Ft. Gibson it is three hundred feet thick; from eight to ten miles northeast of Ft. Gibson it is about two hundred feet thick. From this place further to the north it rapidly thins until from about ten miles north of Wagoner to near Baxter Springs, Kans., it is but five to fifteen or twenty feet thick. In this northern part of the field the grit is usually lacking and the sandstones are very variable. These basal sandstones cap the isolated hills and east-facing escarpments from four to six miles south of Chouteau, one and a half miles south of Vinita, three miles west of Afton, one mile south of Miami, and about two miles south of Baxter Springs, Kans. There is a bed of gray, arenaceous clay shale two hundred and fifty to three hundred feet thick overlying this group of sandstones and grits throughout the Cherokee Nation. This shale is somewhat thicker in the northern part of the field than it is toward the south. It comprises nearly all the Lower Coal Measures strata that lie west of Grand and Spring rivers and throughout that area it is marked by level or gently undulating prairie plains.

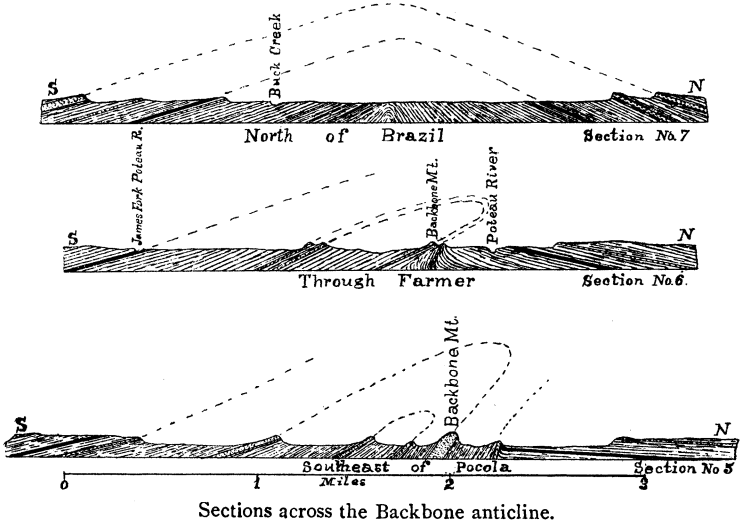
The southern extension of the Lower Coal Measures area of the Cherokee Nation outcrops along the Milton-Bokoshe anticline

[1] *Ibid.*, Vol. iv, p. 106, and 1890, Vol. i, pp. 113–115.

south of the Arkansas river. The rocks exposed along this anticline are mainly sandy clay shales north of Bokoshe, and massive and flaggy sandstones east and west of Milton. The sandstones one mile south of Bokoshe are highly micaceous and often smooth-surfaced flags. About two thousand feet of Lower Coal Measures rocks are exposed on either side of the anticline in this locality.

In the Backbone mountain area of the Lower Coal Measures the beds are massive sandstones and thick gray arenaceous clay shales. The sandstone beds are from about thirty to five hundred feet in thickness and the interbedded shales are from eight hundred to thirteen hundred feet in thickness. The structure of the Backbone ridges that best account for the observed facts is shown in Secs. 5, 6 and 7, Pl. VI and in Pl. I. This overthrown anticline is faulted

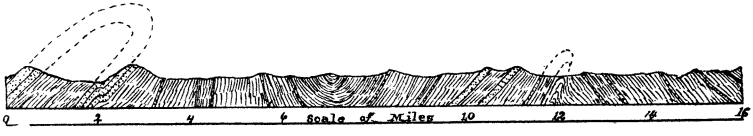
Plate VI.



Sections across the Backbone anticline.

along the north side of the overthrow. The faulting runs westward from Arkansas almost to the western end of the mountains, where it ends rather suddenly. With the gradual lessening of the faulting toward the west the strata on the north side of the fault line increase in dip as they approach the axes of the anticlinal folds. The thickness of strata exposed in this area, on either side of the anticline, is a little over twenty-five hundred feet. The Lower Coal Measures in the southeastern part of the field show very little

variation lithologically from the beds described to the northward; there is, however, a great increase in the thickness of the deposits. The east and west folding in this area has made it possible to get moderately long exposures of the same strata along the axial direc-



Sec. No. 8. Across the Lower Coal Measures, south of Poteau mountain.

tion of the folds. The three groups of strata shown in Sec. 8 are, with modifications, extended to the westward the full length of the area. The faulting along the north side of Walker mountains, along Fourche Melane valley and south of Hartshorne, separates the group on the north from the Central or Walker mountain group. The central and southern groups are in part repetitions of the same strata. The second group comprises the strata of Walker mountains, Blue mountains and nearly all the strata lying between Bengal and Hartshorne. The beds between Hartshorne and Bengal are referred to the second division rather doubtfully, since this necessitates an upthrow of about six thousand feet along the faulted belt south of Hartshorne and along Fourche Melane valley. Such a throw would require the strata in a block about one and three-quarter miles wide to be tilted at an angle of 45° to the south. South of Hartshorne, as shown in Sec. 10, the strata are tilted at angles of 40° to 50° for a distance of about two miles and possibly farther. This tilting is only slightly offset on the north side of the fault line by gentle dips of 4° to 5°. So it seems probable that the throw is as much as six thousand feet at this place. South of Wilburton and southwest of Red Oak the strata on the south side of the Fourche Melane valley do not dip very much more steeply than they do on the north side, and as the dips are in opposite directions the beds appear to be the same. They are, however, not the same, for the coal beds are not repeated on the south side of the valley. Furthermore, the strata are different lithologically, since limestones occur on the south side and may be traced westward to the limestone beds south of Hartshorne, which beds have been shown to probably belong six thousand or seven thousand feet below the

Grady coal bed. The third division comprises the strata of Black Fork, Rich and Windingstair mountains.

The highest bed of the Lower Coal Measures is a sandstone about one hundred and fifty feet thick, although varying in thickness from a few inches to three hundred feet. Mr. H. M. Chance calls it the Tobucksy[1] sandstone. This bed is especially important because it immediately underlies the Grady coal bed and makes a ridge

Sec. No. 9. Across the Winding Stair and the Kiamichi mountains, south of Hanson creek.

of considerable prominence almost all along its line of outcrops, so that the coal may be closely located by tracing the outcrop of this sandstone. It has an unusual persistence for a sandstone, outcropping as it does almost regularly over an area of one thousand square miles, and forming an unbroken ridge excepting at a few places where streams have cut across it, from about three miles northwest of Heavener to Hartshorne. This ridge is a very prominent topographic feature rising usually one hundred to three hundred feet above the surrounding country. South and southwest of Heavener and southwest and west of Milton, this bed is thick and makes ridges from one hundred to three hundred feet high. Where it is thick enough to make a prominent topographic feature it is shown so on the sketch map. The following are approximate sections of the upper part of the Lower Coal Measures as they occur in Secs. 8 and 5; the sections were made south and southeast of Heavener and across the Backbone anticline.

	SEC. 8. FEET.	SEC. 5. FEET.
Sandstone	200	50
Gray arenaceous clay shale	1000	1150
Massive sandstone	50	250
Gray arenaceous clay shale	660	600
Sandstone	30	35
Clay shale	1150	500

[1] *Trans. Am. Inst. Min. Eng.*, Vol. xviii, p. 659.

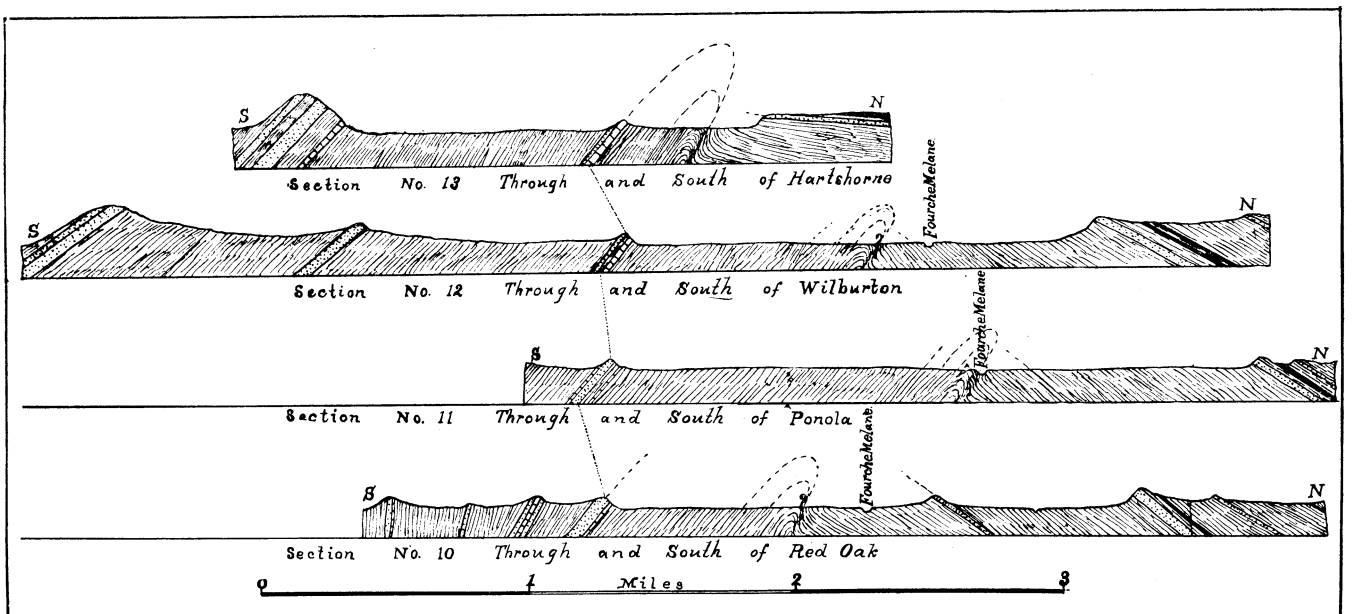
SEC. 8.	FEET.
Sandstone	10
Shale and thin beds of sandstone	800
Sandstone	10
Shale and thin beds of sandstone	800
Sandstone	10
Shale and thin beds of sandstone	2000

The beds that appear to underlie these are those of Walker, Blue and Jack Fork mountains.

They are but little different lithologically from the beds above them, but the shales are of a darker color, and in the western part of the belt there is some limestone to break the usual monotony. The main ridges of Walker, Blue and Jack Fork mountains have sandstones from fifty to one hundred feet or more in thickness in the southern part of the ridges.

Secs. 10, 11, 12 and 13, Pl. VII, show the general character and variation of the rocks on the south side of Fourche Melane valley from a point south of Red Oak to a point south of Hartshorne. Sec. 10 lies south of Red Oak. The limestone, calcareous sandstone and arenaceous limestone shown in this section were seen southwest of Red Oak, but they probably extend farther to the east. In this section the first sandstone bed south of Fourche Melane is about one hundred feet thick, usually massive. Twenty to thirty feet of arenaceous limestone and calcareous sandstone occurs on the north side, or at the base of this sandstone bed. The next ridge to the south is formed by two sandstones each ten to fifty feet thick and separated by about fifty feet of clay shale. This shale southwest of Red Oak is partly replaced by five to ten feet of hard, rather nodular, blue limestone. On the north side of the fourth sandstone—the third prominent ridge south of Fourche Melane—there is more arenaceous limestone and calcareous sandstone. It is only five to ten feet thick at the places where it was seen. Farther west or south of Ponola, Sec. 11 shows the stratigraphy of the first ridge south of Fourche Melane. At this place the strata dip south 50°. There is a hard, blue limestone, fifteen to twenty feet thick, on the south side of the ridge; this limestone is underlain by about one hundred and twenty-five feet of sandstone, of which the upper fifty feet is ferruginous and fossiliferous, and the lower part is hard massive sandstone. This sand-

Plate VII.



Sections across the Fourche Melane valley.

stone is underlain by alternating strata of shaly sandstones and arenaceous clay shale, which in turn is underlain by thirty feet of gray fossiliferous limestone.

Farther west, south of Wilburton, only one limestone bed was seen, but others are probably covered by débris. A somewhat generalized section at this point is shown in Sec. 12. Farther to the west the limestone beds increase rapidly in thickness, until south of Hartshorne the lowest one is about one hundred and fifty feet thick.

Strata of Black Fork, Rich and Windingstair Mountains.—Massive sandstones with regular texture and smooth bedding planes and dark gray clay shales are the prevailing rocks of these mountains. The sandstones in the southern part of Black Fork mountain are about one thousand feet thick, principally massive, and light in color; some flaggy and shaly beds occur near the centre of the section. The sandstones of the south side of Rich mountain appear to be about one thousand feet thick and closely resemble those of Black Fork mountain, but are seemingly somewhat more flaggy and have a little more interbedded clay shale. The strata in the valley between the two mountains and those in the north side of both mountains are principally arenaceous clay shale and thin beds of sandstone. Along Big creek on the north side of Black Fork mountain, the sandstones and shales are distributed in the proportion of about one of sandstone to five of shale. The sandstones are usually from four to eight feet thick and have irregular bedding planes. About one mile east of Page a massive sandstone about fifty feet thick is broken across by a fault and so impregnated with bitumen that the rock has a very black color. There is a small anticline immediately southwest of this point in Big creek.

These irregularities seem to be only local breaks and crumplings on the side of a very large fold. Windingstair mountains appear to be the westward continuation structurally and stratigraphically of Black Fork and Rich mountains. Sec. 9 shows in a general way the stratigraphy of the Windingstair mountains south of Hanson creek. The north side of the mountains at this point is steep and rather free from ridges or cañons running parallel to the range, while the southern slope is broken by a number of ridges running parallel to the main mountain and less elevated toward the south. Deep erosion channels lie between some of these ridges and connect with a cross channel leading into the Kiamichi valley to the south.

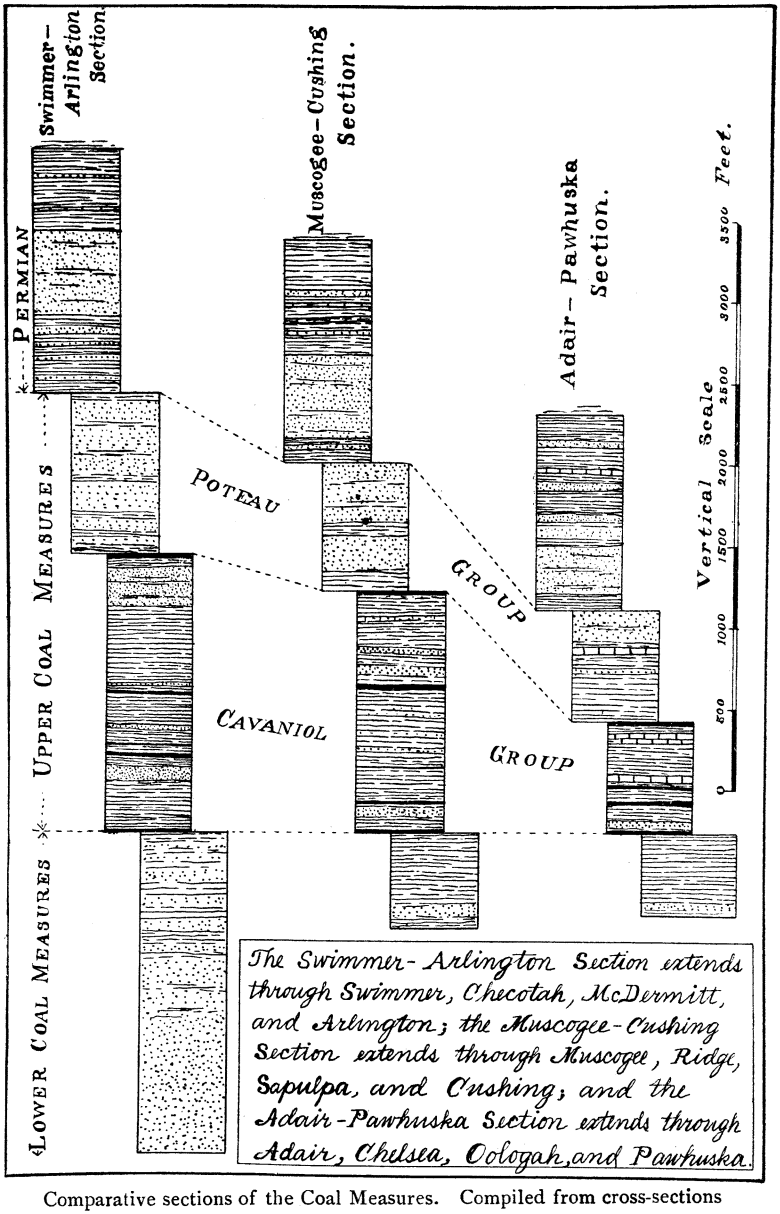
Evidences of faulting and sharp folding may be seen on either side of the mountain along this section, and almost all through the mountain along the St. Louis and San Francisco railway. These orographic movements have metamorphosed the rock locally until the sandstones are quartzites and the shales are hardened. Some limestone concretions and boulders occur in the shales on the north side of the mountain west of the head of Hanson creek and along the railroad four or five miles southeast of Bengal. Occasional chert concretions occur with the limestones. Porous, ferruginous sandstones were found in a number of places on the north face of the mountains and they were usually found to be fossiliferous. The rocks of Kiamichi valley southeast of Talihina appear to be principally dark gray clay shale. Some of this shale that was taken from a well dug at the south side of Windingstair mountain, about ten miles east of Talihina, was almost black and so crushed that every piece showed "slickensides."

The strata of the northern side of Kiamichi mountains bear a close resemblance to and are possibly to be correlated with the massive sandstones of Black Fork mountain, Rich mountain and Windingstair mountain. Sec. 9 shows the structure and approximate stratigraphy of the Kiamichi mountains at the point where they were studied.

Upper Coal Measures.

Cavaniol Group.—This part of the Coal Measures is confined to the area outlined on the map between the outcrops of the lowest and the highest workable coal beds. From Arkansas this coal-bearing belt extends westward into the Territory for a distance of about sixty-five miles and divides into two belts, one of which extends northward and the other southwestward. The belt extending westward from Arkansas lies mainly to the south of Arkansas river and has an average width of about forty miles. The belt extending northward passes through the Creek and Cherokee Nations into Kansas, and has an average width of about twenty-five miles. It lies mainly on the west side of the Missouri, Kansas and Texas railway. The southwest belt extends through the western part of the Choctaw Nation, and has, in the area studied, an average width of about fifteen miles. That part of the Cavaniol group lying to the south and east of Canadian river will be referred

Plate VIII.



Comparative sections of the Coal Measures. Compiled from cross-sections through the Cherokee, Creek and Osage Nations.

to as the Choctaw coal field,[1] since this term has been applied to that area by Dr. H. M. Chance.

Stratigraphy.—The beds of this group consist of shales, sandstones, coals and limestones. The shales comprise the larger part of the strata, but sandstones are very abundant, especially in the southern part of the field, while limestone beds are confined to the northern part. The workable coals are thicker in the southern region, but extend throughout the entire area. The group is thickest in the southeastern part of the field and thinnest in the northern part. The decrease in thickness appears to run regularly to the westward and northward. The most constant and easily recognizable horizons in this division are the coal beds. Three of these are thick enough over most of the field to work. Other thin beds occur locally, and one in particular that lies about one hundred feet above the central coal bed extends almost regularly throughout the field where its horizon occurs. The lowest workable coal varies in thickness from one and a half to six feet; this is the coal that Dr. H. M. Chance named the Grady coal.[2] It proves to be, without any reasonable doubt, the same bed as the one worked at Huntington, Jenny Lind, Hackett and several other places in Arkansas.

The next higher workable coal is the McAlester bed, which varies in thickness from about one and a half to four feet. The highest workable bed is the Mayberry coal, which also varies in thickness from one and a half to four feet. These three coal beds apparently extend throughout the entire area of the Cavaniol group, but north of the Canadian river there are four coal beds that are worked locally. These four beds were not studied in enough detail to correlate them throughout. The outcrops and stratigraphy noted in different sections across the group give some suggestions of correlation, as may be seen in Pls. I and VIII.

The following table shows a rough estimate of the distance between the coal beds at different places in the Choctaw coal field:

[1] *Trans. Am. Inst. Min. Eng.*, Vol. xviii, p. 653.

[2] *Ibid.*, 1890, Vol. xviii, pp. 1, 2.

PROC. AMER. PHILOS. SOC. XXXVI. 156. Z. PRINTED DEC. 21, 1897.

Vertical Distance between the Grady and McAlester Coal Beds.

LOCALITIES.	FEET.
One mile east of Fanshaw	2500
Two miles east of Red Oak	2500
West of Cameron	2000
North of Brazil	2000
South of Milton	2000
North of Wild Horse Prairie	1300
East of Krebs	1000

Vertical Distance between the McAlester and Mayberry Coal Beds.

LOCALITIES.	FEET.
Cavaniol mountains	3000
Northeast end of Sans Bois mountains	2200
West end of Sans Bois prairie	1500

These estimates show a marked tendency throughout the whole division to decrease in thickness towards the west and northwest.

The following sections will show the general stratigraphy of the two lower coal beds and the intervening strata in the Choctaw coal fields:

	One mi. west Fanshaw.	West of Cameron.	South side of Buck Creek Prairie.	North side of Buck Creek Prairie.	Northwest of Wild Horse Prairie.
	FEET.	FEET.	FEET.	FEET.	FEET.
Coal	1½	1½	1½		1½
Shale		1200			
Sandstone		10			
Shale	200	100	200	200	300
Sandstone	25	10	200	25	50
Shale	2000	300	600	900	400
Sandstone	50	25	15	25	100
Shale	300	400	1000	1000	500
Coal	3	3	4	4	3

Two sandstones and three clay shale beds usually form the sequence of strata between the two lower workable coals. This prevailing condition is shown in the above sections. This usual sequence, however, is not constant, for in some places, as northwest of Alderson, only one sandstone intervenes, and in other places, such as west of Cameron, there are three. This table is not intended to show a strict correlation but rather a comparison.

The strata between the McAlester and Mayberry coal beds apparently are more diversified. In the Cavaniol mountains four thick sandstone beds alternating with clay shales intervene between the coals. Northwest of San Bois there are three intervening sandstones, while to the west of Sans Bois two sandstone beds intervene, and east of Brooken only one of prominence lies between the two coal seams. This shows a decrease in the number and thickness of intervening beds to the northwest. The intervening sandstone beds, especially those in Cavaniol and Sans Bois mountains, are usually from fifty to two hundred feet thick and are evenly textured strata that usually have smooth bedding planes, and vary from flaggy to massive sandstone. The first sandstone below the Mayberry coal is especially flaggy and smooth where it was seen on the east end and north side of Cavaniol mountain. The dark gray clay shales interstratified with these sandstones are from two hundred to five hundred feet thick. South of the Arkansas river a coal seam four to eight inches thick occurs almost regularly one hundred feet above the McAlester coal.

A rough estimate of the thickness and stratigraphy of the Cavaniol group north of the Canadian river, along a line running from McDermitt through Checotah and Starvilla to the mouth of the Canadian river, is as follows:

	FEET.	INCHES.
Coal	2	6
Gray, arenaceous clay shale	50	
Friable, shaly and massive sandstone and some clay shale	300	
Gray, arenaceous clay shale	500	
Sandstone	10	
Clay shale	25	
Coal		10
Clay shale	200	
Sandstone	25	
Clay shale	100	
Coal		8
Clay shale	50	
Coal	1	3
Clay shale	50	
Sandstone and some interstratified clay shale	100	
Clay shale	300	
Coal	1	6
Total thickness (approximate)	1700	

A section across the group along a line from Muscogee, through Ridge and Sapulpa to Cushing, is approximately as follows:

	FEET.	INCHES.
1. Coal (Mayberry coal?)	2	
2. Clay shale	100	
3. Sandstone	10	
4. Shale	50	
5. Thin strata of light gray, arenaceous, limestone and calcareous sandstone interstratified with gray calcareous clay shale	25	
6. Gray clay shale	100	
7. Friable, black, carbonaceous, clay shale, which contains near the top some limestone nodules one and a half feet in diameter. These limestone nodules are carbonaceous and black, but weather to a white color and contain numerous calcite seams running through the nodules	50	
8. Sandstone	25	
9. Clay shale	100	
10. Sandstone	50	
11. Clay shale	100	
12. Coal	1	6
13. Gray, arenaceous clay shale containing some thin sandstone strata which are ferruginous in places	500	
14. Coal		4
15. Clay shale	250	
16. Coal	1	
17. Clay shale	100	
18. Sandstone	25	
19. Clay shale	25	
20. Coal (Grady coal?)		8
Total thickness (approximate)	1500	

A section across the group along a line from Adair through Chelsea and Oologah to Pawhuska is as follows:

	FEET.
1. Coal (Maybery coal?)	2
2. Clay shale	100
3. Limestone (Oologah limestone[1])	50
4. Arenaceous clay shale and a little interstratified shaly sandstone	200
5. Gray limestone	15
6. Clay shale	5
7. Coal	1¼
8. Clay shale and sandstone	50
9. Limestone	2
10. Clay shale	50
11. Coal	1½
12. Clay shale and a little sandstone	150
13. Sandstone	25
14. Clay shale	15
15. Coal (Grady coal?)	1½
Total thickness (approximate)	650

These three sections show the Cavaniol group to have the following northward variations: A regular decrease in the thickness of the group and in the relative proportion of sandstones; a gradual increase in the limestones, and a very little variation in the coals. The most marked stratigraphic feature introduced in the northern part of this group is the limestone beds.

Bed 5 of the Muscogee–Cushing section is apparently the Oologah limestone, since it has about the same stratigraphic position and shows the decrease of limestone common to the southward development of the beds. At and in the vicinity of Oologah this limestone is massive, hard, gray, rather unevenly textured, and in places contains gray chert nodules. On weathering, the limestone breaks into irregular-shaped pieces. This bed forms an east-facing escarpment fifty to one hundred feet high along the west side of Verdigris river valley east of Oologah. The limestone bed next in

[1] This bed has been called the Oologah limestone because it is finely exposed in Oologah, along Four Mile creek at the west edge of Oologah, and in an escarpment some three miles to the east of that place.

importance to the Oologah limestone is Bed 5 of the Adair-Pawhuska section. This limestone is beautifully exposed in bluffs along the east bank of Verdigris river, quarter of a mile below the McClellan ford east of Talala. At that place it contains no chert nodules, but in other lithologic characteristics it closely resembles the Oologah limestone.

Poteau Group.—Dr. J. P. Smith was the first to introduce the name Poteau in connection with strata included in this group.[1] It is probable that the Poteau mountain beds do not extend so high as the base of the Permian, but the name "Poteau group" will be applied to the group of beds between the Cavaniol group and the base of the Permian, as outlined in this paper. The dividing line used to separate the Poteau group from the Permian is merely an arbitrary one, and is, in the main, based on the fossils found at different localities. The beds of the Poteau group lie in small isolated areas and in a long belt-like area. The isolated areas are the upper parts of Poteau, Sugar Loaf, Cavaniol, Sans Bois, Tucker Knob and McChar mountains. The long belt-like area lies on the west side of the Cavaniol group throughout the field and has an average width of fifteen to twenty miles. The beds of this area are tilted to the northwest, where they lie against the western limit of the folded region of the Choctaw coal field, but further to the north the beds dip gently to the westward or a little north of westward. Throughout this belt the outcropping hard rock beds form east and southeast facing escarpments.

The Mayberry coal bed was not definitely located in either the Sugar Loaf or the Poteau mountains, but as these mountains do not appear to be situated in quite such deep synclines as the Cavaniol or the Sans Bois mountains the coal must be at a somewhat higher elevation. All four of these mountains are nearly the same in elevation—between twenty-five hundred and three thousand feet. From fifteen hundred to two thousand feet of the upper part of the Cavaniol and Sans Bois mountains belong to the Poteau group and twelve hundred to fifteen hundred feet of the tops of Sugar Loaf and Poteau mountains belong to this group. The group northwest of McAlester is about two thousand feet thick, but probably the top beds represent somewhat higher horizons than the top

[1] *Jour. Geol.*, Vol. ii, pp. 194-196, and *Proc. Amer. Phil. Soc.*, Vol. xxxv, No. 152, p. 17.

beds of the above-named mountains, since the same strata decrease in thickness to the westward and especially to the northward. This group, in the main, consists of arenaceous gray clay shales and massive sandstone beds, but in the northern region limestone beds are included in the group. The sandstone beds of this group are somewhat more massive than they are in the Cavaniol group, as is shown in Plate VIII. In the southeastern region nearly all the sandstones are massive, but southwest of Enterprise they are frequently ripple-marked and thin-bedded. Three miles south of South Canadian, sandstones form a prominent escarpment about one hundred feet high. This sandstone is composed of strata that are usually massive, but sometimes flaggy, so that beautiful smooth flags of varying thickness are common. Five or six miles farther to the west, the dark-gray clay shale overlying this bed contains some black carbonaceous fossiliferous limestone nodules. The shales along Salt creek five miles east of Calvin are light gray, very arenaceous, and carry some thin shaly layers of calcareous sandstone that are quite fossiliferous. The sandstone beds, so prominent a feature of this group in the southeast and southern region, gradually grow less prominent to the northward, but as far north as McDermitt they are the prevailing strata. A section across this group in the vicinity of Sapulpa is as follows:

	FEET.
1. Massive and slightly friable sandstones and a little interbedded clays and shales	400
2. Clay shale	100
3. Massive, rather friable sandstones	200
4. Gray clay shale, calcareous in places, and containing two feet of limestone about one hundred and fifty feet from the base of the bed	100

A section across this group west of Oologah shows the following sequence of strata:

	FEET.
1. Sandstones interbedded throughout with arenaceous clay shale	200
2. Fossiliferous shaly limestone	3
3. Clay shales and shaly sandstone	50
4. Hard, massive, gray limestone	25

	FEET.
5. Clay shale	25
6. Arenaceous limestone	5
7. Sandstone	5
8. Clay shale containing calcareous nodules and some fossils	25
9. Gray clay shale, blackened in places by carbonaceous matter often calcareous and occasionally containing thin shaly sandstone strata	300
Total thickness (approximate)	650

Bed 4 of the above section forms the bed-rock of Bird creek about twelve miles from Skiatook along the Skiatook-Pawhuska road. From that point to the eastward it gradually rises until it forms bluffs on either side of the creek and farther eastward forms an east-facing escarpment.

This escarpment was seen about due west of Oologah and two to three miles west of the Osage-Cherokee Nation boundary line. The limestone bed is very massive, gray in color, unevenly textured, rather highly crystalline and contains little ferruginous masses scattered throughout most of the bed.

Origin of the Sediments of the Coal Measures.—Throughout the Coal Measures the thickness of the sediments gradually decreases northward and westward. The most rapid decrease is toward the north, and the lower beds decrease more rapidly than the higher ones. The Lower Coal Measures decrease from a thickness of about seventeen thousand feet in the southern part of the field to a thickness of five hundred to six hundred feet in the northern part. The Upper Coal Measures across the same field decrease from about seventy-five hundred to twelve hundred feet.

The Permian beds, so far as they were studied, show very little, if any, decrease in thickness toward the north. This continuous northward thinning of the beds in the central and northern part of the field is shown in Pl. VIII. The relative proportion in the amount of shales and limestones to sandstones and conglomerates gradually increases westward and especially northward. Because of these conditions the sediments are considered to have come from a land area lying to the southeast.

PERMIAN.

The Permian area studied lies along the western part of the field and extends into it twenty to forty miles. Only about fifteen hundred feet of Permian sediments are included in the area studied. The base of the Permian deposits, as it is defined in the present paper, begins with the first appearance of Permian species, and not with the disappearance of the Coal Measures fauna, for that usually predominates even to the highest beds studied. The strata of the Permian beds consist of massive sandstones, clay shales, conglomerates and limestones. The clay shales are mostly gray and arenaceous, but toward the top they grade through blue to reddish and red shales and marls. The lower two hundred to one thousand feet is composed of alternating clay shale and sandstone beds in about the proportion of one hundred feet of shale to ten of sandstone. These beds are overlain by two hundred and fifty to five hundred feet of sandstones and conglomerates, and these in turn are overlain by bluish and red clay shales and marls which are interstratified with occasional thin sandstones and limestones. Four generalized sections, at widely separated localities, were made across these Permian beds. The first section extends in a northwest direction from Calvin to a point west of Wewoka near the western boundary line of the Seminole Nation. This section will be referred to as the Calvin-Wewoka section. The other three sections, with their localities, are shown in Pl. VIII.

The following table gives the generalized stratigraphy of these four sections:

		FEET.
Calvin-Wewoka Section.....	Red and blue clay shales and marls interstratified with thin sandstone and very rare limestone beds.....	250+
	Conglomerate and sandstone.....	250
	Gray and blue clay shales interstratified with thin sandstone.....	600
	? Massive yellowish weathering friable sandstone.....	400

Swimmer-Arlington Section.	Red and blue clay shales and marls interstratified with thin sandstone and scarcer limestone beds.....	250+
	Sandstone and conglomerate	500
	Gray arenaceous clay shale beds alternating with sandstone beds in about the proportion of ten of shale to one of sandstone	500
Muscogee-Cushing Section..	Red and blue clay shales and marls interstratified with thin sandstone beds and more rarely thin limestone beds.....	250+
	Alternating blue and gray clay shales and sandstones	200
	Sandstone and a little clay shale.....	500
	Gray clay shales and a few thin sandstone beds.....	100
Adair-Pawhuska Section....	Blue and red clay shales and marls alternating with thin sandstone and a few thin limestone beds.....	500+
	Sandstone and a little clay shale.....	500
	Alternating beds of gray clay shale and thin sandstones.....	200

In general terms, the section farthest to the south, or the Calvin-Wewoka section, shows two thick sandstone groups of beds with an intervening and an overlying clay shale. The other three sections show one principal group of sandstone beds overlain and underlain by clay shales. It may be possible, however, that the lower sandstone group of the Calvin-Wewoka section belongs to the Poteau group, as seems to be the case judging from lithological evidence. If this be true, there are three generalized

groups running through the entire area. The following descriptions of local developments and their general connections will give a better idea of the stratigraphy and lithology.

About five miles northwest of Calvin, along Sandy creek, the strata consist of massive, friable, yellowish sandstones interstratified with gray and yellowish argillaceous compact sand. About a mile farther west, along the Calvin-Wewoka road, there are some sandstone beds exposed which are practically like the above, but are highly fossiliferous and apparently belong either to the Upper Coal Measures, or the Lower Permian. These sandstones are so friable, thick and extensive that the country for fifteen miles or more to the northwest of Calvin is covered by deep loose sand from the disintegration of the rock. Railway cuts three to four miles northwest of Holdenville show the strata at that place to be principally gray arenaceous clays with occasional reddish bands and streaks which carry numerous yellowish, ferruginous, calcareous clay nodules. There is some lenticular interbedded sandstone which is hard and has a clear quartzitic appearance. Similar clay shales and thin interstratified sandstone beds, aggregating a thickness of six hundred feet or more, are the outcropping strata for several miles on either side of Holdenville. It seems probable that this group is the base of the Permian and is the stratigraphic equivalent of about five hundred feet of similar strata outcropping both east and west of McDermitt. Farther to the north it thins quite rapidly or is replaced by sandstone beds until west of Kelleyville and northwest of Skiatook it is but one hundred to two hundred feet thick and contains no red clays. At the top of this group, along the Calvin-Wewoka section, there is a limestone from three to four feet thick. This limestone outcrops about two miles southwest of Wewoka, where it shows a weathered surface of gray and yellowish color, is very friable, and in places is quite arenaceous. About a mile farther west this limestone is overlain by a conglomerate and sandstone bed aggregating two hundred and fifty feet or more in thickness. The larger part of this bed at this locality is conglomerate, composed of rather angular light-colored chert pebbles two to three millimetres in diameter, imbedded in a sand matrix. Occasional well-rounded quartz pebbles, about five millimetres in diameter, also occur in the conglomerate. This conglomerate has the same lithologic characteristics of the conglomerate beds that extend from northern to central Texas through

the Cisco division of the Coal Measures of Texas.[1] The outcrop of this conglomerate and sandstone bed forms a belt ten miles wide that extends nearly north and south through the centre of the Seminole Nation. Farther northward the conglomerate gradually disappears and the beds thicken by addition of other sandstone beds until it is apparently five hundred feet thick and outcrops in a belt about twenty miles wide. This belt lies twelve miles east of Arlington, two miles west of Kelleyville, and about eight or ten miles east of Pawhuska.

The sandstones of this belt are so friable that the country is covered by loose sand derived from the disintegrated rock. About fourteen miles east of Arlington the group contains a bed of light-gray sandy clay shale, seventy-five or one hundred feet thick, which contains some limonite nodules and one thin stratum of rich hematite. There are also two strata of limestone, each one or two feet thick, which occur near the base and top of the shales respectively.

Proceeding upward and westward across this sandstone and conglomerate group of beds from about a mile west of Kelleyville to about eight miles west of that place, the strata are found to be mainly sandstones, which are massive, rather ferruginous, friable and weather into rough irregular shapes. The rapid disintegration of the rock covers the ground with deep loose sand. About nine miles west of Kelleyville the sandstone is slightly shaly in places and some red sandy clays are interstratified with the sandstone beds. The dip of these beds is about fifty feet per mile to the westward, or a little north of westward. The thin interbedded shales and clays and alternating harder sandstone beds allow only very slight escarpments to be formed. On top of these sandstones there is about one hundred feet of gray sandy clay shale and some interstratified shaly sandstone. Over the outcrop of this shale there is not much loose sand and the bed is marked by little prairies. The dip of the strata here is about twenty to twenty-five feet per mile to the westward. Ten to eleven miles west of Kelleyville the rocks are massive cross-bedded sandstones; in these the bedding planes are curved surfaces separating their lenticular and wedge-shaped layers. It is interstratified with a little bluish argillaceous sand, red clays and gray argillaceous sandy shale. For the next five or six miles to the westward the strata lie practically horizontal, then farther west to the top of the sandstone group,

[1] *Geol. Surv. Texas*, Fourth An. Rep., 1892, pp. 372, 445; *Geol. Surv. Texas*, Second An. Rep., 1890, pp. 362, 495, 509, and Pl. xvi.

which is about two miles west of Polecat creek, sixteen miles east of Cushing, the strata apparently dip about twenty-five feet per mile. The top of this group outcrops along the bed of Bird creek, one mile west of Pawhuska. On either side of the creek, beds of gray and bluish clay shales and some thin sandstone beds overlie the main sandstone group, so that it does not form the chief outcrops until a point about ten miles southeast of Pawhuska is reached.

From Pawhuska the rocks of this group outcrop southeastward along the Skiatook-Pawhuska road for about fifteen miles. The principal variation across this Adair-Pawhuska section is a slight increase of argillaceous strata. A three-foot bed of brownish weathering arenaceous limestone occurs about one and a half miles east of the road crossing Birch creek. From Birch creek westward the dip of the strata appears to be twenty-five to thirty feet per mile to the westward, while for five or six miles to the east the strata are almost horizontal.

The next higher group of Permian beds consists of bluish and red clay shales and marls, interstratified at rather wide intervals with thin cross-bedded sandstones and occasional thin limestones. The following local developments will give the usual characteristics. The lower part of this group, as seen eight to nine miles west-southwest from Wewoka, consists of sandy clay shales, bluish and reddish colored, and massive sandstones that have edges and parts of the rock broken into thin shaly wedge-shaped, cross-bedded strata. The sandstone is either light grayish or reddish-colored. The gray sandstone is coarse textured. Farther westward and higher geologically the sandstones decrease in quantity and most of the strata are red clay shales.

Two and a half miles southeast of Econtuska there is a little white, nodular, arenaceous limestone interstratified with yellowish marls. The strata at Bellmont and between that place and Arlington are mainly red arenaceous, calcareous clays interstratified with occasional red sandstones which are usually rather massive, but often broken into shaly and flaggy parts by cross-bedding planes. Some of the sandstone has a light gray-color. There are also rare beds of arenaceous and even quite pure fossiliferous limestone which varies in color from white and gray to red and almost invariably weathers to rough nodular fragments. One of these beds outcrops one mile west of Arlington. Five or six miles east of Arlington there is a one to three-foot bed of hard crystalline red limestone

which is overlain by a thin clay bed, and this in turn by sandstone conglomerate similar to that west of Wewoka.

The limestone that outcrops one mile west of Arlington is probably the same as the one that occurs sixteen miles east of Cushing and two miles west of Pawhuska. Dr. J. P. Smith called the limestone bed that outcrops from two to three miles west of Pawhuska, the Pawhuska limestone.[1]

The limestone bed that outcrops about sixteen miles east of Cushing is from four to six feet thick, gray, bedded in rough, thin layers, and contains *Fusulina* and crinoids. The strata here lie almost horizontal, and the same bed outcrops ten miles east of Cushing along the Kelleyville-Cushing road. About five miles east of Cushing higher beds of massive friable cross-bedded sandstone, red clay, and arenaceous limestone outcrop. Some of the limestone is quite pure, but usually it occurs in nodular form in beds one-half to one foot thick. In the vicinity of Cushing clay shales and marls are the principal strata. Six miles north-northwest from Cushing along the south or east bank of the Cimarron river there is a bluff about fifty feet high showing massive and shaly sandstones of light gray or yellowish and reddish color, sometimes cross-bedded. A little rough concretionary limestone occurs at the top of the bed. The twin peaks from ten to eleven miles north of Cushing are composed of red clays capped by concretionary limestone. Some of the limestone contains chert. The Pawhuska limestone outcrops about twelve miles north of Cushing along branches of Salt creek. The bed at this locality is about five feet thick, gray in color, hard, rough surfaced, unevenly textured and rich in two species of *Fusulina*.

The following section was compiled from outcrops of strata found five to ten miles south of Pawnee.

	FEET.
1. Red clays	at top.
2. Limestone	1½
3. Red, bluish and gray clays	150
4. Limestone (Pawnee limestone)[2]	2
5. Principally gray clay shales	100
6. Pawhuska limestone	5

[1] *Jour. Geol.*, Vol. ii, p. 199.

[2] Stratum 4 appears to be the same as the bed of limestone outcropping on the east side of the courthouse grounds at Pawnee, and for convenience it will be called the Pawnee limestone.

The Pawnee limestone outcrop on the east side of the courthouse grounds at Pawnee consists of three to four feet of hard evenly textured, tough, bluish gray limestone underlain by five to six feet of yellowish blue marls. Both the limestone and marls are rich in fossils. The Pawhuska limestone bed which outcrops in the bed of a creek half a mile northeast of Pawnee at an elevation of about one hundred feet below the Pawnee limestone, is, at this place, about five feet thick; the lower three feet is hard and massive, while the upper part of the bed is friable. *Fusulinæ* are very abundant in this bed.

Four miles south of Ralston in the banks of Coal creek there is a three to five-inch bed of coal which appears to be below the Pawnee limestone. The following section was compiled from exposures of an escarpment facing the Arkansas river valley at a point about two miles southeast of Ralston.

	FEET.
1. Light gray and yellowish weathering sandstone	15
2. Gray clay shale	4
3. Nodular gray limestone (Pawnee limestone?)	3
4. Red clays and light gray shaly sandstones	100
5. Pawhuska (?) limestone	5

The Pawhuska limestone outcrops along the Gray Horse-Pawhuska road at every creek crossing for seven to eight miles from Gray Horse, and also about five miles southwest of Pawhuska. At the latter place it is about ten feet thick, unevenly textured, gray in color, and underlain by yellowish and bluish clays. A section of the strata in the vicinity of Pawhuska is about as follows:

	FEET.
1. Blue and red clays	at top.
2. Pawhuska limestone	10
3. Clay shale	50
4. Sandstone	50
5. Clay shale	150
6. Sandstones	at base.

This limestone outcrop forms a little escarpment facing east and running north about two miles west of Pawhuska, while the first sandstone bed below the limestone cap the buttes and escarpments around the village.

General Classification of Rocks of the Indian Territory.[1]

System.	Series.	Group.	Correlations.	Beds.	Maximum Thickness in Feet.
Carboniferous	Permian.		Albany division, Texas. Neosho and Chase formations, Kansas.	Shales, sandstones, conglomerates and limestones.	1,500
	Coal Measures	Poteau.	Wabaunsee and Cottonwood formations, Kansas. Cisco division, Texas.	Massive and shaly sandstones and shales.	2,000
		Cavaniol.	Missouri formation, Kansas.	Shales, sandstones and coals	5,500
		Lower Coal M.	Strawn, Milsap and Canyon divisions, Texas	Shales, sandstones.	17,000
	Lower Carboniferous.	Boston.	St. Louis.	Limestones, shales and sandstones.	200
		Osage.	Osage.	Batesville sandstone.	25
				Fayetteville shale.	50
				Boone chert and limestone.	500
		Kinderhook.		Eureka shale.	50
				Wanting.	
Devonian.	Devonian.			Wanting.	
Silurian.	Upper Silurian		Niagara, New York. St. Clair Marble, Arkansas.	Marble and saccharoidal sandstone.	75+
	Lower Silurian			Saccharoidal sandstone, chert and dolomitic sandstones and limestones.	200+

[1] Since this paper was put in type Mr. Stuart Weller has definitely correlated the Batesville sandstone of these tables with the Aux Vases sandstone of Illinois. His results show that the hitherto tentative correlations of these Arkansas and Indian Territory rocks require more careful paleontologic study.—*Trans N. Y. Acad. Sci.*, xvi, 251–282.

PART II.

PALEONTOLOGY.

The fossils collected from various localities over the field are listed in locality groups, and arranged in their stratigraphic order. All the species listed here and the originals figured are deposited in the geological museum of Stanford University.

LOWER CARBONIFEROUS.

Upper Boone Limestone (Burlington–Keokuk).—Collections of fossils from the upper Boone limestone were made at three different localities. At the north side of West monntain, three miles southeast of Westville, the following fauna was found :

1. *Productus scabriculus* ? Martin.
2. *Productus cherokeeensis* n. sp. Drake.
3. *Productus* (*Marginifera*) *adairensis* n. sp. Drake.
4. *Productus ovatus* Hall.
5. *Athyris* (*Seminula*) *subquadrata* Hall.
6. *Rhynchonella grosvenori* White.
7. *Spirifer keokuk* Hall.
8. *Eumetria vera* Hall.
9. *Rhynchonella mutata* ? White.
10. *Discina* sp.?
11. *Archimedes* sp.?

Seven miles east of Adair the upper Boone limestone contains the following fauna :

1. *Productus* (*Marginifera*) *adairensis* n. sp. Drake.
2. *Productus ovatus* Hall.
3. *Productus longispinus* ? Sowerby.
4. *Productus* sp.?
5. *Derbya kaskaskiensis* McChesney.
6. *Spirifer keokuk* Hall.
7. *Athyris* (*Seminula*) *subquadrata* Hall.
8. *Orthothetes crenistria* Phillips.
9. *Myalina* sp.?
10. *Archimedes* sp.?

PROC. AMER. PHILOS. SOC. XXXVI. 156. 2A. PRINTED JAN. 18, 1898.

The following fossils were collected from outcrops of the upper Boone limestone found along Ballard's creek one mile west of Echo:

1. *Orthothetes crenistria* Phillips.
2. *Productus cestriensis* Worthen.
3. *Orthis swallovi* Hall.
4. *Eumetria vera* Hall.
5. *Athyris* sp.?
6. *Archimedes* sp.?
7. *Phillipsia* sp.?

Fayetteville Shale (Warsaw).—No fossils were collected from the shale itself, but the limestone bed that occurs near the centre of the shale bed is very fossiliferous in places. One and a half miles south of Vinita *Productus cestriensis* Worthen is a very common fossil in this limestone. East of Chouteau on either side of Grand River valley, opposite Ned Adair's ferry, the following fauna was collected from this limestone:

1. *Productus ovatus* Hall.
2. *Productus cherokeeensis* n. sp. Drake.
3. *Productus alternatus* N. and P.
4. *Productus* sp.?
5. *Productella* sp.?
6. *Athyris* (*Seminula*) *subquadrata* Hall.
7. *Athyris* sp.?
8. *Spirifer keokuk* Hall.
9. *Spirifer trigonalis* Martin.
10. *Rhynchonella* (*Camarophoria*) *cooperensis* Shumard.
11. *Chonetes planumbona* M. and W.
12. *Pentremites godoni* de France.
13. *Pleurotomaria taggerti* Meek.
14. *Pleurotomaria* sp.?
15. *Platyceras* sp.?
16. *Edmondia burlingtonensis* White and Whitfield.
17. *Edmondia ellipsis* White and Whitfield.

Boston Group (St. Louis–Chester).—A very good representative fauna of this group was collected at four different localities. Most of the fossils came from the Archimedes and Pentremital horizons. The following fauna was found in this group east of Grand river,

opposite Wagoner, about one and a half miles northeast of the mouth of Fourteen Mile creek.

1. *Productus ovatus* Hall.
2. *Productus cestriensis* Worthen.
3. *Productella* sp.?
4. *Spirifer* sp.?
5. *Terebratula bovidens* Morton.
6. *Athyris* (*Seminula*) *subquadrata* Hall.
7. *Athyris* sp.?
8. *Camarophoria wortheni* Hall.
9. *Eumetria verneuilana* Hall.
10. *Eumetria vera* Hall.
11. *Aviculopecten simplex* ? Dawson.
12. *Posidonomya fracta*? Meek.
13. *Edmondia* sp.?
14. *Pentremites godoni* de France.
15. *Archimedes communis* Ulrich.
16. *Archimedes swallovana* Hall.
17. *Archimedes terebreformis* Ulrich.
18. *Archimedes* sp.?
19. *Zaphrentis spinulifera* Hall.
20. *Phillipsia* sp.?

The following fauna was collected from this group five miles east of Adair.

1. *Productus* (*Marginifera*) *adairensis* n. sp. Drake.
2. *Productus cherokeeensis* n. sp. Drake.
3. *Productus cestriensis*? Worthen.
4. *Productus pertenuis*? Meek.
5. *Productella* sp.?
6. *Chonetes loganensis*? Hall.
7. *Orthis dubia* Hall.
8. *Orthothetes crenistria* Phillips.
9. *Spiriferina kentuckensis* Shumard.
10. *Rhynchonella grosvenori* White.
11. *Eumetria verneuilana* Hall.
12. *Spirifer keokuk* Hall.
13. *Athyris* (*Seminula*) *subquadrata* Hall.
14. *Phillipsia scitula* M. and W.

Seven or eight miles southeast of Big Cabin the following collection was made:

1. *Productus cherokeeensis* n. sp. Drake.
2. *Productella* sp.?
3. *Athyris* (*Seminula*) *subquadrata* Hall.
4. *Spiriferina kentuckensis* Shumard.
5. *Rhynchonella grosvenori* White.
6. *Eumetria vera* Hall.
7. *Chonetes* sp.?
8. *Archimedes* sp.?
9. *Zaphrentis* sp.

The Boston group contains the following fauna one and a half miles south of Vinita:

1. *Productus cherokeeensis* n. sp. Drake.
2. *Productus cora*? d'Orbigny.
3. *Athyris* (*Seminula*) *subquadrata* Hall.
4. *Chonetes planumbona*? M. and W.
5. *Spiriferina kentuckensis* Shumard.
6. *Spirifer keokuk* Hall.
7. *Straparollus lens*? Hall.
8. *Zaphrentis lanceolata*? Worthen.
9. *Archimedes proutanus* M. and W.
10. *Michelinia eugeneæ* White.
11. *Orthoceras* sp.?
12. *Bellerophon* sp.?
13. *Pleurotomaria* sp.?

Coal Measures.

LOWER COAL MEASURES.

The Lower Coal Measures are very poor in fossils, and collections of any special value were made at only three different localities:

Along the limestone bed and ridge two and a half miles south of Ponola and Wilburton.

1. *Productus longispinus*? Sowerby.
2. *Productus cora*? d'Orbigny.
3. *Derbya crassa*? M. and W.
4. *Rhynchonella illinoisensis* Worthen.

5. *Athyris* sp.?
6. *Spiriferina*? *kentuckensis* Shumard.
7. *Retzia*?
8. *Spirifer* sp.?
9. *Spirifer rockymontanus* Marcou.
10. *Septopora*?
11. *Platyceras* sp.?

One mile south of Muscogee the following fossils were found in shaly and friable limestones and arenaceous clay shales:

1. *Productus pertenuis*? Meek.
2. *Productus splendens* N. and H.
3. *Productus longispinus* Sowerby.
4. *Spirifer lineatus* Martin.
5. *Spirifer rockymontanus* Marcou.
6. *Spirifer* sp.?
7. *Derbya crassa* M. and P.
8. *Discina convexa* Shumard.
9. *Athyris* (*Seminula*) *subtilita* Hall.
10. *Septopora biserialis* Swallow.
11. *Zaphrentis* sp.?

Four miles north of Vinita, where the M. K. & T. railway crosses a brook, the following fauna was collected from some black shale:

1. *Productus pertenuis*? Meek.
2. *Spirifer cameratus* Morton.
3. *Athyris* (*Seminula*) *subtilita* Hall.
4. *Derbya crassa* Meek and Hayden.
5. *Chonetes* sp.?
6. *Bellerophon* sp.?

UPPER COAL MEASURES.

Cavaniol Group.—This group is represented in the collection of fossils from five different localities as follows:

The following fossils were found in a ferruginous sandstone one hundred and fifty feet above the Grady coal and four miles northwest of Hackett, Ark.

1. *Derbya crassa* M. and H.
2. *Nuculana bellistriata* Stevens.
3. *Bellerophon carbonarius* Cox.
4. *Aviculopecten occidentalis* Shumard.

One and a half miles west of Starvilla along a little branch some shaly argillaceous limestone contains great numbers of *Productus pertenuis*? Meek, and *Discina nitida* Phillips occurs rarely. In some ferruginous sandstone, six miles southwest of Salisaw on the east side of Big Salisaw creek, the following fauna was collected:

1. *Productus cora* d'Orbigny.
2. *Terebratula bovidens* Morton.
3. *Athyris* (*Seminula*) *subtilita* Hall.
4. *Spirifer rockymontanus* Marcou.
5. *Retzia* (*Hustedia*) *mormoni* Marcou.
6. *Derbya crassa* M. and H.
7. *Aviculopecten occidentalis* Shumard.

The following fauna was collected from the Oologah limestone in the western part of the town of that name:

1. *Productus semireticulatus* Martin.
2. *Athyris* (*Seminula*) *subtilita* Hall.
3. *Chonetes* sp.?
4. *Syringopora* sp.?

The following fossils were found in the limestone bed that outcrops along Verdigris river a quarter of a mile below the McClellan ford, which is about four miles east of Talala. This limestone belongs about two hundred feet below the Oologah limestone:

1. *Productus punctatus* Martin.
2. *Productus semireticulatus* Martin.
3. *Productus* (*Marginifera*) *splendens* N. and P.
4. *Productus pertenuis*? Meek.
5. *Spirifer cameratus* Morton.
6. *Spirifer lineatus* Martin.
7. *Spiriferina kentuckensis* Shumard.
8. *Athyris* (*Seminula*) *subtilita* Hall.
9. *Chonetes mesoloba* N. and P.
10. *Chonetes* sp.?
11. *Fusulina cylindrica* Fischer.

Poteau Group Fauna.—Collections of fossils were made at four different localities in this group. The shales immediately overlying the Mayberry coal bed at the coal mines, four miles northwest of Poteau, contain the following fauna:

1. *Discina nitida* Phillips.
2. *Aviculopecten rectilaterarius* Cox.
3. *Aviculopecten dubertianus* Dawson.
4. *Nuculana bellistriata* Stevens.
5. *Nucula ventricosa* Hall.
6. *Bellerophon carbonarius* Cox.
7. *Gastrioceras globulosum* ? Meek and Worthen.

Six miles southwest of South Canadian some limestone nodules included in a clay shale bed contain the following fossils:

1. *Nucula ventricosa* Hall.
2. *Pleurotomaria sphærulata* Conrad.
3. *Bellerophon crassus* Meek and Worthen.

Five or six miles northwest of Calvin, the following fauna occurs in friable sandstones:

1. *Productus semireticulatus* Martin.
2. *Productus pertenuis* ? Meek.
3. *Strophalosia* ? *spondyliformis* White and St. John.
4. *Schizodus wheeleri* Swallow.
5. *Nuculana bellistriata* Stevens.
6. *Murchisonia* sp. ?
7. *Pinna peracuta* Shumard.
8. *Aviculopecten catactus* ? Meek.
9. *Gastrioceras globulosum* Meek and Worthen.

Ten miles south of Okmulgee, about one hundred and fifty feet above the base of the Poteau group, the following fossils were found in sandstone:

1. *Aviculopecten occidentalis* Shumard.
2. *Solenopsis solenoides* Geinitz.
3. *Pleurophorus angulatus* Meek and Worthen.

The following fossils were collected west of Oologah, about two miles west of the Cherokee-Osage Nation boundary line:

1. *Productus splendens* N. and P.
2. *Spirifer cameratus* Morton.
3. *Spirifer lineatus* Martin.
4. *Athyris* (*Seminula*) *subtilita* Hall.
5. *Spiriferena kentuckensis* Shumard.

6. *Meekella striatocostata* Cox.
7. *Temnocheilus forbesianus* McChesney.
8. *Chonetes* sp. ?

Near the top of the group, at a place about ten miles northwest of Skiatook, the following fauna was found in sandstone strata:

1. *Chonetes verneuilana* N. and P.
2. *Chonetes laevis* Keyes.
3. *Productus* sp. ?
4. *Sanguinolites* sp. ?

Permian Fauna.

Good collections of fossils were made at three different places from beds that are classed as the lowest Permian. The first two lists given below afford the evidence that has been used to draw the line between the Permian and the Coal Measures. These two collections of fossils come from widely separated localities and apparently from the same stratigraphic position.

Five miles east of McDermitt along the McDermitt-Chelsea road the following fauna was found in beds of sandstone.

1. *Productus semireticulatus* Martin.
2. *Productus nebrascensis* Owen.
3. *Productus auriculatus* Swallow.
4. *Orthis* sp. ?
5. *Derbya crassa* Meek and Hayden.
6. *Nuculana bellistriata* Stevens.
7. *Pinna peracuta* Shumard.
8. *Aviculopecten occidentalis* Shumard.
9. *Aviculopecten* sp. ?
10. *Myalina swallovi* McChesney.
11. *Edmondia aspenwallensis* Meek.
12. *Edmondia reflexa* Meek.
13. *Schizodus wheeleri* Swallow.
14. *Schizodus insignis* nov. sp. Drake.
15. *Macrodon obsoletus* Meek.
16. *Macrodon carbonarius* Cox.
17. *Bakevellia parva* ? M. and H.
18. *Murchisonia marcouiana.*
19. *Gervilia ohioensis* Herrick.

20. *Pleurophorus angulatus* Meek and Worthen.
21. *Pleurophorus* sp.?
22. *Pleurotomaria* sp.?
23. *Pseudomonotis hawni* Meek and Hayden.

Four miles west of Sapulpa and about one-half of a mile north of the Sapulpa-Kelleyville road the following fauna was collected.

1. *Productus cora*? d'Orbigny.
2. *Derbya crassa* Meek and Hayden.
3. *Chonetes verneuilana* Norwood and Pratten.
4. *Chonetes lævis* Keyes.
5. *Myalina swallovi* McChesney.
6. *Nucula bellistriata* Stevens.
7. *Edmondia nebrascensis* Geinitz.
8. *Dentalium meekianum* Geinitz.
9. *Solenopsis solenoides* Geinitz.
10. *Yoldia subscitula* Meek and Hayden.
11. *Schizodus wheeleri* Swallow.
12. *Pseudomonotis hawni*? Meek and Hayden.
13. *Pleurophorus angulatus* Meek and Worthen.
14. *Pleurophorus* sp.?
15. *Pleurophorus* sp.?
16. *Pleurotomaria sphærulata*? Conrad.
17. *Murchisoma* sp.?
18. *Bellerophon carbonarius* Cox.

Three or four miles west of McDermitt, and about one mile west and northwest of the Pigler place, there are some highly fossiliferous sandstones. These beds are three hundred or four hundred feet above the base of the beds containing the fossils of the above two lists. Fossils were collected from two different sandstone beds in these higher horizons four miles west of McDermitt. The lower sandstone bed contains the following fossils:

1. *Productus nebrascensis* Owen.
2. *Productus auriculatus* Swallow.
3. *Pinna peracuta*? Shumard.
4. *Myalina swallovi* McChesney.
5. *Aviculopecten occidentalis* Shumard.
6. *Pleurotomaria* sp.?

The upper fossiliferous sandstone bed lies about fifty to seventy-five feet higher and contains the following fauna:

1. *Productus semireticulatus* Martin.
2. *Productus nebrascensis* Owen.
3. *Productus pertenuis* Meek.
4. *Productus auriculatus* Swallow.
5. *Derbya crassa* Meek and Hayden.
6. *Athyris* sp.?
7. *Orthis resupinoides*? Cox.
8. *Edmondia gibbosa* Swallow.
9. *Pinna peracuta* Shumard.
10. *Myalina swallovi* McChesney.
11. *Myalina recurvirostris*? Meek and Worthen.
12. *Myalina subquadrata* Shumard.
13. *Schizodus wheeleri* Swallow.
14. *Schizodus curtus*? Meek and Worthen.
15. *Bakevellia parva*? Meek and Hayden.
16. *Dentalium meekianum* Geinitz.
17. *Monopteria gibbosa* Meek and Worthen.
18. *Aviculopecten occidentalis* Shumard.
19. *Nucula bellistriata* Stevens.
20. *Pseudomonotis hawni* Meek and Hayden.
21. *Gervillia ohioensis* Herrick.
22. *Loxonema cerithiforme*? Meek and Worthen.
23. *Avicula* sp.?
24. *Avicula* sp.
25. *Pleurophorus* sp.
26. *Sanguinolites*?

The Seminole sandstone and conglomerate beds that run northward through the Territory are, as a rule, barren of fossils, and no collections of importance were made in them.

Pawnee and Pawhuska Beds.—Collections of fossils from these beds were made at ten different localities. These fossils were collected from strata that apparently extend from the base of the Pawhuska limestone to a horizon three hundred or four hundred feet above that limestone. The first five lists of fossils come from strata that appear to belong to the Pawhuska limestone. One to four miles southwest of Arlington the following fossils were found in a limestone bed.

1. *Productus* (*Marginifera*) *splendens* Norwood and Pratten.
2. *Spirifer cameratus* Morton.
3. *Chonetes verneuilana* Norwood and Pratten.
4. *Allorisma subcuneatum* Meek and Hayden.
5. *Pinna peracuta*? Shumard.

The following fauna was found in what appears to be the Pawhuska limestone, along branches of Salt Creek twelve miles north of Cushing.

1. *Spirifer cameratus* Morton.
2. *Spirifer planoconvexus* Shumard.
3. *Athyris* sp.?
4. *Schizodus wheeleri* Swallow.
5. *Zaphrentis* sp.
6. *Fusulina cylindrica* Fischer.
7. *Fusulina gracilis*? Meek.

About ten to fifteen feet above this limestone, at a place eleven miles south of Pawnee, the following fossils were collected:

1. *Productus cora* d'Orbigny.
2. *Chonetes granulifera* Owen.
3. *Spirifer cameratus* Morton.
4. *Athyris sultilita* Hall.
5. *Myalina subquadrata* Shumard.
6. *Bellerophon percarinatus* Conrad.

The following fossils were found in the limestone bed outcropping in the bed of the creek at the road crossing one-half mile northeast of Pawnee courthouse.

1. *Productus* (*Marginifera*) *splendens* Norwood and Pratten.
2. *Chonetes granulifera* Owen.
3. *Chonetes lævis* Keyes.
4. *Rhynchonella* (*Pugnax*) *uta* Marcou.
5. *Spirifer cameratus* Morton.
6. *Athyris* (*Seminula*) *subtilita* Hall.
7. *Fusulina cylindrica* Fischer.

The following fauna was found in the Pawhuska limestone at a place about four and one-half miles southwest of Pawhuska.

1. *Productus semireticulatus* Martin.

2. *Productus cora* d'Orbigny.
3. *Athyris* (*Seminula*) *subtilita* Hall.
4. *Spirifer cameratus* Morton.
5. *Spirifer planoconvexus* Shumard.
6. *Chonetes* sp. ?
7. *Lophophyllum proliferum* Hall.
8. *Pleurotomaria illinoisensis* Worthen.

The following fossils were collected from a friable limestone bed that occurs about one hundred and fifty feet above the Pawhuska limestone, at a place five miles east of Cushing.

1. *Productus pertenuis* Meek.
2. *Derbya crassa* Meek and Hayden.
3. *Chonetes granulifera* Owen.
4. *Spirifer cameratus* Morton.
5. *Aviculopecten occidentalis* Shumard.
6. *Myalina* sp. ?
7. *Rhombopora lepidodendroides* ? Meek.

Ten miles north of Cushing the following fauna was collected from some limestone strata capping Twin hills.

1. *Spirifer cameratus* Morton.
2. *Productus* (*Marginifera*) *splendens* N. and P.
3. *Chonetes granulifera* Owen.
4. *Athyris* (*Seminula*) *subtilita* Hall.
5. *Syntrielasma hemiplicatum* Hall.
6. *Fusulina cylindrica* Fischer.

On the east side of the courthouse grounds at Pawnee there is an outcrop of four feet of limestone, and four feet of fossiliferous calcareous gray clays. Fossils collected from this bed are as follows:

1. *Productus semireticulatus* Martin.
2. *Productus cora* d'Orbigny.
3. *Productus pertenuis* Meek.
4. *Productus nebrascensis* Owen.
5. *Productus* (*Marginifera*) *splendens* N. and P.
6. *Spirifer cameratus* Morton.
7. *Spirifer planoconvexus* Shumard.
8. *Derbya crassa* Meek and Hayden.
9. *Meekella striatocostata* Cox.

10. *Rhynchonella* (*Pugnax*) *uta* Marcou.
11. *Chonetes granulifera* Owen.
12. *Orthis pecosi* Marcou.
13. *Athyris* (*Seminula*) *subtilita* Hall.
14. *Aviculopecten occidentalis* Shumard.
15. *Euomphalus rugosus* Hall.
16. *Fusulina cylindrica* Fischer.
17. *Rhombopora lepidodendroides* Meek.
18. *Zeacrinus* sp.?

The following list of fossils shows the fauna that was found about two miles southeast of Ralston, in a bed of limestone, and marls that appear to be the same as that in Pawnee.

1. *Productus semireticulatus* Martin.
2. *Productus nebrascensis* Owen.
3. *Productus* (*Marginifera*) *splendens*? N. and P.
4. *Rhynchonella* (*Pugnax*) *uta* Marcou.
5. *Derbya crassa* Meek and Hayden.
6. *Spirifer cameratus* Morton.
7. *Spirifer* (*Ambocœlia*) *planoconvexus* Shumard.
8. *Athyris* (*Seminula*) *subtilita* Hall.
9. *Spiriferina kentuckensis* Shumard.
10. *Meekella striatocostata* Cox.
11. *Chonetes granulifera* Owen.
12. *Chonetes lævis* Keyes.
13. *Retzia* (*Hustedia*) *mormoni* Marcou.
14. *Orthis pecosi* Marcou.
15. *Avicuiopecten occidentalis* Shumard.
16. *Aviculopecten* sp.?
17. *Avicula speluncaria* Geinitz (not Schlotheim).
18. *Myalina subquadrata* Shumard.
19. *Myalina perattenuata* Meek and Hayden.
20. *Astarte* sp.?
21. *Bellerophon* sp.?
22. *Lophophylium proliferum* Hall.
23. *Phillipsia scitula*? Meek and Worthen.

The following fauna was collected from sandstone beds that outcrop six to seven miles southwest of Pawhuska along the Paw-

huska-Gray Horse road. These sandstone beds are probably one hundred and fifty feet above the Pawhuska limestone.

1. *Pinna peracuta* Shumard.
2. *Schizodus wheeleri* Swallow.
3. *Schizodus rossicus* Verneuil.
4. *Nucula bellistriata* Stevens.
5. *Aviculopecten* sp. ?
6. *Pleurophorus angulatus* Meek and Worthen.
7. *Pleurophorus* sp. ?
8. *Myalina swallovi* McChesney.
9. *Yoldia subscitula* Meek and Hayden.
10. *Pleurotomaria perhumerosa* Meek.
11. *Bellerophon* sp. ?

Descriptions of Species.

Productus (*Marginifera*) *adairensis* sp. nov. Drake. Pl. IX, Figs. 1–3.

Shell small, the largest specimen found being three-quarters of an inch in height, and seventeen-twentieths of an inch in greatest breadth, at hinge line. Beak highly arched, and projecting one-third of the entire height of the shell above the hinge line. Ears slightly extended. Surface ornamented with very fine ribs, and occasional small spines, and in the region of the beak, with a slight reticulation. The ventral valve has a distinct medial sinus, which begins near the beak. The outside of the shell resembles somewhat *Productus multistriatus* Meek, of the Upper Carboniferous, but has the ribs even finer, and the beak somewhat more slender than that species. The inside of the shell shows the characters

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Plate IX.

PAGE.

Figs. 1, 2 and 3.—*Proauctus adairensis* nov. sp. Drake. Fig. 2, from Boone limestone, seven miles east of Adair. Figs. 1 and 3, from Boston group, five miles southeast of Adair..... 403

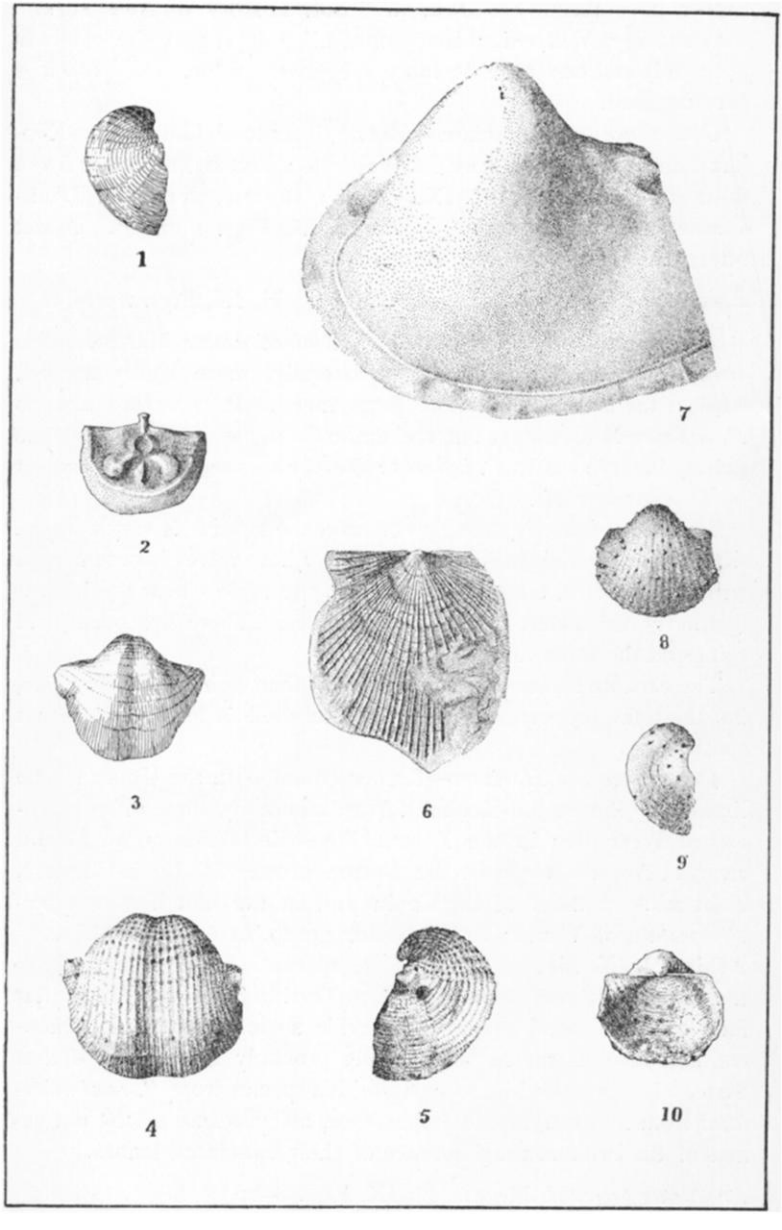
Figs. 4 and 5.—*Productus cherokeeensis* nov. sp. Drake. Boston group, five miles southeast of Adair..... 403

Fig. 6.—*Aviculopecten rectilaterarius* Cox. Upper Coal Measures, Poteau group, four miles northwest of Poteau..... 403

Fig. 7.—*Schizodus insignis* nov. sp. Drake. Permian, five miles east of McDermitt..... 403

Figs. 8, 9 and 10.—*Productus pertenuis* Meek. Lower Carboniferous, St. Louis-Chester, five miles southeast of Adair..... 403

Plate IX.



assigned by Waagen to his genus Marginifera, although Hall and Clarke have recently shown, in "Nat. History of New York," *Palæontology*, Vol. viii, "Brachiopoda," p. 331, that the genus is not valid, and can have at most subgeneric value. As such it is here retained.

Occurrence and Horizon.—Boone limestone (Burlington-Keokuk), three miles southeast of Westville; Boone limestone, seven miles east of Adair, Pl. IX, Fig. 2; Boston group (St. Louis-Chester), five miles east of Adair, Pl. IX, Figs. 1 and 3. About fifteen specimens collected, altogether.

Productus cherokeeensis nov. sp. Drake. Pl. IX, Figs. 4 and 5.

This species resembles closely *P. semireticulatus* Martin, but is always smaller, more compressed laterally, more highly arched, and has the mesial sinus more pronounced. It is nearest akin to *P. inflatus* McChesney, but the umbo is not so prominent, nor so greatly incurved as in *P. inflatus;* also the ribs seem a little coarser on *P. cherokeeensis.*

The dorsal valve is strongly concave, the ventral is very convex, with strong medial sinus. The surface of both valves is ornamented with distinct ribs, often dichotomous; the region near the beak is distinctly reticulated by the growth lines. There are occasional spines on the surface.

The ears are somewhat more extended than on *P. semireticulatus*, but the total proportional width of the shell is less than on that species.

Occurrence and Horizon.—Rather common in the Upper Boone limestone (Burlington-Keokuk), West mountain, three miles southeast of Westville; in the Fayetteville shale (Warsaw), on Grand river, at Adair's ferry; in the Boston group (St. Louis-Chester), eight miles southeast of Big Cabin, and in the same horizon a half miles south of Vinita; in the Boston group, five miles southeast of Adair, Pl. IX, Figs. 4 and 5. The species is confined entirely to the Lower Carboniferous in Indian Territory, and a very similar form has been found in the Fayetteville shale (Warsaw) of Arkansas, and also in the Marshall shale, probably St. Louis, of that State. It is worth while to separate this species from *P. semireticulatus* from its stratigraphic importance, and because of the unlikeness of the two and the difference of their associated faunas.

Productus pertenuis Meek. Pl. IX, Figs. 8–10.

Productus pertenuis Meek. *Final Report U. S. Geol. Survey Nebraska*, p. 164, Pl. I, Fig. 14, Pl. VIII, Fig. 9.

Productus cancrini Geinitz. *Carbon und Dyas in Nebraska*, p. 54, Pl. IV, Fig. 6 (not Murchison, Verneuil and Keyserling).

The specimens referred to *Productus pertenuis* are rather larger than those figured by Meek, and have somewhat stronger radial ribs. But the thinness of the valves, the great convexity of the ventral valve, the lack of a medial sinus, and the disposition of the small spines all agree with the figures and descriptions of Meek's *P. pertenuis*, and the form referred by Geinitz to *P. cancrini* M. V. K.

Adults of the shell average about three-fifths of an inch wide and the same in height; convexity of the valve for a shell of these dimensions is nine-twentieths of an inch. The shell referred by Meek, *Geol. Expl. 40th Parallel*, Vol. iv, p. 78, Pl. VIII, Fig. 4, to *P. longispinus* Sowerby, probably belongs to *P. pertenuis*, for it lacks the medial sinus, and has the other characters of *P. pertenuis*, except that the beak is not quite so slender.

Horizon and Locality.—Lower Coal Measures, four miles north of Vinita; one mile south of Muscogee: Upper Coal Measures, Cavaniol group, McClellan ford on Verdigris river; Poteau group, six miles west of South Canadian; Permian division, upper bed of sandstone four miles west of McDermitt; Pawhuska sandstone, five miles west of Cushing. The same or a nearly related species also occurs in the Lower Carboniferous limestone, Boston group (St. Louis-Chester), five miles southeast of Adair; a specimen from this locality is figured on Pl. XII, Figs. 8, 9 and 10.

Aviculopecten rectilaterarius Cox. Pl. IX, Fig. 6.

Avicula rectalaterarea Cox. *Geol. Survey Kentucky*, Vol. iii, p. 571, Pl. ix, Fig. 2.

The shell is somewhat semicircular in outline, the greatest length being about equal to the greatest width. The hinge line is straight and nearly equal to the greatest width. The beak is small, rounded, does not project above the hinge line. The rounded anterior ear is rather sharply set off from the rest of the shell, and differs slightly from it in having the radial ribs rather coarser and further apart. The left valve has the base of the anterior ear somewhat notched. The posterior ear, which is longer than the anterior, is

not distinctly set off from the rest of the shell, but differs from it in ornamentation, so as to be well marked.

The surface is marked by distinct radial ribs, somewhat narrower than the interspaces. These ribs are often dichotomous, and also increase by intercalation. Near the beak the surface is faintly ornamented with distinct concentric striæ of growth, which grow stronger towards the posterior margin. The ears are ornamented just as the rest of the shell, except that the ribs are somewhat coarser on both anterior and posterior ears.

A. rectilaterarius resembles very closely *A. papyraceus* Sowerby of the European Coal Measures, and indeed a more perfect suite of specimens may show their identity, for many of the species that accompany *A. papyraceus* in Europe have already been found in America.

Horizon and Locality.—Upper Coal Measures, Poteau group, in the shales overlying the Mayberry coal, at the mines four miles northwest of Poteau, Indian Territory.

Schizodus insignis sp. nov. Drake. Pl. IX, Fig. 7.

This species, one of the largest of the genus Schizodus, is represented in the collection only by a cast, so that the generic reference is not beyond doubt. The shell is large, being two and a half inches in length and two inches in height. Convexity of the valve is eleven-twentieths of an inch. The beak is rather high and pointed, rising two-fifths of an inch above the hinge line. The anterior margin is rounded, the posterior is broken off. The anterior and posterior adductor impressions are quite large and distinct. The cast is smooth, so nothing is known of the sculpture of the surface. The only species with which *Schizodus insignis* may be compared is *Schizodus* (*Leptodomus*) *magnus* Worthen, *Geol. Surv. Ill.*, Vol. viii, p. 107, Pl. XVIII, Fig. 2, of the Lower Carboniferous, Chester horizon; but *S. magnus* differs from *S. insignis* in the elongation of the anterior part of the valve, also in the sharp high ridge that runs from behind the beak obliquely to the rear of the shell. Otherwise there is considerable similarity, and the two species may very well belong to the same genus.

Occurrence and Horizon.—In hard sandstone of the Permian horizon, five miles east of McDermitt, Indian Territory; only a single specimen was found.

PART III.

Economic Geology.

The coals of the Indian Territory are at present its most important geologic product. The part of this paper treating of economic geology must therefore be devoted principally to coal.

Coals of the Choctaw Field.

Grady Bed.—The outcrops and workable areas of the Grady coal bed are confined to three continuous narrow belts. One belt encircles the Backbone anticline, one the Bokoshe-Milton anticline, and the other lies at the south bases of the Poteau, Cavaniol and Sans Bois mountains. The bed around the Backbone anticline enters the Indian Territory on the north side of the axis east of Pocola, and runs about S. 80° W. At the Territory line the bed is almost horizontal, or dips slightly to the north, as shown in Section No. 5, which was made across the Backbone anticline southeast of Pocola.

One mile west of Pocola the coal bed dips 15° to 20° to the north; the coal is three feet and seven inches thick, and has one thin parting of shaly coal nineteen inches from the bottom of the bed. Fire clay underlies the coal and arenaceous clay shale overlies it. The increased dip of the coal bed to the west from the Territory line is probably due to the decrease in the throw of the fault along the north side of Backbone mountain, so that the strata enter into the anticlinal fold. It is possible that the Poteau river west and north of Pocola runs along a gentle anticline; if so, the coal bed is deflected down that stream on either side. The dip of the rock west of Pocola, however, does not make this probable. At any rate, a few miles west of Poteau river along the general direction of the coal outcrop, the dip of the rocks shows conclusively that the bed is continued westward from that place. The coal bed has been opened near the Kansas City, Pittsburgh and Gulf Railway at several places on either side of Buck creek prairie and east of Poteau river. This coal is being worked to a very limited extent a half mile east of Poteau river and a half mile south of James fork of Poteau river; the coal at that place is twenty-eight inches thick, dips 10° S. and is overlain and underlain by black clay shale. The bed increases in thickness towards the west, so that a few miles west of Poteau river it is four feet thick. The Bokoshe-Milton anticlinal fold brings this coal bed up so that its outcrop swings

around that anticline. This outcrop has been prospected along most of its length at intervals of one-fourth to one-half mile.

West of Ward the coal is four to five feet thick and dips 25°. Southwest of Ward, at the Coleman place, a well passes through six feet and two inches of coal, including a parting of very shaly coal one and a half inches thick, two feet from the top. One-half mile further south the coal is said to be five and a half feet thick. The dip of the coal bed increases slightly toward the south for a mile or two. South of Bokoshe it is about four feet thick and dips 25°. One and a half miles east of Milton the coal is three feet eight inches thick. A half mile south of Milton, at the Ward Brothers' coal bank, the coal bed is parted by twelve to eighteen inches of shale; the upper stratum of coal is twenty-six inches and the lower forty-four inches thick. Gray clay shale underlies and overlies the coal. A half mile further west the coal bed is parted by five inches of shale, the upper stratum of coal is twenty-two inches thick and the lower four feet two inches thick; the dip is 23°. A half mile still further west the upper stratum of coal is twenty-eight inches thick, the shale parting three inches; only about four feet of the lower stratum of coal was seen, and the bed is a little thicker than that; dip of bed 22° S.

Farther to the west the coal slightly decreases in thickness, while eastward and northward on the north side of the loop it decreases rather rapidly, until it is about eighteen inches thick west of Bokoshe, and about fourteen inches thick northwest of Bokoshe.

This coal bed dips southward under the Sugar Loaf, Poteau, Cavaniol and Sans Bois mountains and comes to the surface again on the south side of those mountains, as shown in Secs. 1, 2, 3 and 4. The coal bed along this south line of outcrops is often split by partings varying in thickness from a few inches to fifty feet, and several thin strata of coal are common near the main bed. The following section, from a railway cut one and a quarter miles south of Heavener, shows the nature of this coal group at that and a number of other places:

	FEET.	INCHES.
Shale	2	
Coal		8
Shale	15	
Shaly coal	1	
Shale and streaks of coal	5	

	FEET.	INCHES.
Coal		6
Carbonaceous shale	1	6
Coal		2
Carbonaceous shale	2	
Coal		4
Carbonaceous shale	1	6
Coal		1½
Carbonaceous shale	1	6
Shale	15	
Sandstone	25	
Shale	12	
Sandstone	5	
Shale	2	
Coal		1
Carbonaceous shale		11
Coal		1½
Carbonaceous shale		6
Coal		2
Shale		3
Coal		1
Shale		2
Coal	1	
Shale	4	
Coal	2	

Three miles east of this section the coal is two feet six inches thick. One and a half miles southwest of Heavener it is twenty-eight inches thick. Three miles northwest of Heavener the coal has been mined considerably and is said to be about four feet thick.

This coal has been mined quite extensively where it is touched and crossed by the St. Louis and San Francisco Railway. At the most easterly point touched by the railway, a place once called Pocohontas, the coal lies in two beds separated by about fifty feet of shale; the upper coal bed is thirty-seven inches thick and the lower one forty-four inches, and the bed dips about 45°.

At Wilburton preparations for extensive coal mining were being made in 1896. The coal occurs in two beds separated by about fifty feet of shale. The upper bed is about four feet thick; the lower one was not accessible in 1896, but the superintendent of the mine

reported it a little over four feet thick. The coal is apparently of uniform good quality. This bed is now being worked extensively at Cherry Vale, about three or four miles northeast of Krebs, where it averages about three feet four inches thick, is uniformly good and dips about 12° N. From this mine the coal outcrop runs but little farther west before it swings to the south and then turns east some twenty miles, when it again swings to the south and back west again, thus forming an S-shaped outcrop at this place. The eastward loop of the S outlines a small synclinal basin called by Dr. H. M. Chance the Grady basin.[1] Coal is extensively mined in this basin at Hartshorne. The coal is composed of one four-foot bed, which is worked, and other higher, thinner beds, not worked. The synclinal fold, forming the basin, is a gentle one so that the dip of the rocks on its sides are only 4° to 5°. Chance[2] says: "The maximum depth of the Grady coal bed in this basin is about 600 feet; but over three fourths of the basin the bed can be reached at depths less than four hundred and fifty feet, and over one-half of the basin the depth will probably not exceed three hundred feet. The basin is about six miles long by three or four wide and contains over 11,000 acres of the Grady bed. Throughout this area the coal is not always of workable thickness; but over a large portion of it the bed will range from three and a half to five feet thick, yielding an average of four feet of clear coal."

This coal outcrop west of Hartshorne is so broken by faults and tilted by very irregular folds that it is not easily located. The three-foot bed of coal that outcrops in Brushy creek, about five miles west of Hartshorne, appears to be the Grady bed. Here it shows a fault of four or five feet and dips to the southwest 5° to 6°. About two miles further west, that is, seven miles west of Hartshorne and one-fourth of a mile northeast of the Brunton place, this coal outcrops again and is three feet eight inches thick, but with two partings of shaly coal in it. One three to four-inch parting is within three inches of the base, and ten inches from the base of the bed there is a shaly parting from one to two inches thick.

McAlester Coal Bed.—The outcrop of the McAlester coal bed is greater than that of the Grady bed, since it does not lie so deep and does not require such excessive foldings to bring it up or such profound erosion to reach it. The outcrop is shown on Pl. I

[1] *Trans. Am. Inst. Min. Eng.*, Vol. xviii, p. 654.

[2] *Ibid.*, p. 659.

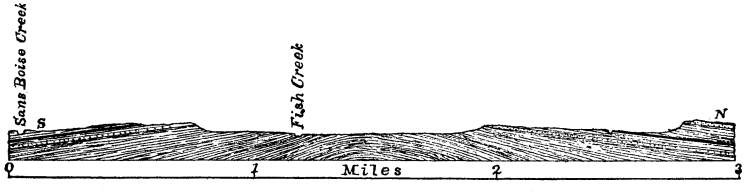
with the exception of areas near the Canadian and Arkansas rivers and around the base of Sugar Loaf and Poteau mountains. These latter places were not sufficiently examined to locate the line of outcrop. This coal bed varies in thickness from about one and a half to about four feet. The thickest part of the bed is in the southwest part of the field or about McAlester, Krebs and Alderson. It appears to thin gradually eastward and northward. In the northern part of the field it is almost regularly eighteen inches thick. This bed is now, and has been for some time, extensively mined at Alderson, Krebs and McAlester. The coal bed at Alderson and Krebs is about three feet six inches thick. One-half mile southwest of McAlester, at D. Edwards & Son's mine, the coal is four feet thick. The dip of the coal bed from Alderson to McAlester varies from about 6° to 25°; the gentler dips are at and near Krebs. The outcrop northwest, north and east of McAlester for some distance lies along a faulted area, so that the coal bed occurs in blocks dipping irregularly and usually at very steep angles. In this faulted area no place has yet been worked extensively and profitably. Farther to the east the coal has not been found sufficiently thick to pay for working. Southeast of Red Oak it is two feet thick and dips 20°. North of Red Oak, in Brazil Creek valley, it is about two feet thick and dips very gently.

At and near Fanshaw the coal is thirty inches thick, dips about 25° and was once considerably but unprofitably mined. About five or six miles east of Fanshaw, in Big Caston creek, the coal is twenty-eight inches thick and dips 35°. The coal once mined at the west edge of Poteau seems to be this bed; it is said to be about two feet thick at that place.

About two and a half miles southwest of Cameron this coal is eighteen inches thick and dips to the southward 2° to 3°. It is occasionally mined to a limited extent by stripping. At this place there is a shale parting in the bed six inches from the base of the coal. In wells on the farm of Mr. Henry Choate, about four to four and a half miles west of Brazil, this coal is reported to be from two to two and a half feet thick. About three miles south of Milton, in Owl creek, near its mouth, this coal bed is eighteen inches thick; some six miles further west in Owl creek, one-fourth mile east of Haney Smith's, the coal is only thirteen inches thick; the dip of the bed about 20°.

Southeast of Sans Bois, along Mountain Fork of Sans Bois creek,

the coal is a little more than a foot thick at the places where it was seen. About three miles west or north of west from Sans Bois, on a branch of Fish creek, in Mr. Scott's pasture, this coal is seventeen inches thick; dips 4° to 5° N. 10° W.



Sec. 14. Across the Sans Bois anticline, four miles west of Sans Bois.

The above cut shows the structure four miles west of Sans Bois. About seven miles west of Sans Bois, in Beaver creek, the coal is fifteen inches thick. About four and a half miles east-northeast from Sans Bois and one-fourth of a mile east of Mr. Ben Noel's place, this coal is eighteen to twenty inches thick; four miles north-northeast of Sans Bois, in the banks of Sans Bois creek, it is eighteen to nineteen inches thick. About three miles north of Sans Bois, along Cedar creek, the coal is eighteen to twenty inches thick, and dips, 5° to 10°. Two miles west of Iron Bridge this coal is twenty-six to twenty-seven inches thick and quite uniform throughout. About four miles west-southwest from Cashier the coal is eighteen inches thick. Two miles west of Stigler, in Cane prairie, the coal is twenty-eight inches thick and of excellent quality. On Rock branch, one mile west of Whitefield, the coal is twenty-seven to twenty-eight inches thick. The Canadian river, north and northeast of Whitefield, appears to run along an anticlinal fold. If this is the case, the east end of the coal outcrop, west of Whitefield, follows down the east side of Canadian river valley and joins the coal outcrop running northward from east of Whitefield; the westward extension of the coal outcrop, west of Whitefield, ascends Canadian river valley probably nearly opposite Brooken before crossing that river and running back east and northeast by Starvilla, as seems to be the case.

Mayberry Coal Bed.—This coal was not located in the Sugar Loaf or Poteau mountains, but it is doubtless represented there. The coal in the east end of San Bois mountains, at some three hun-

dred to four hundred feet above the base of the mountains, and that on the north side of the mountains near the west end, probably belong to this bed. Sans Bois mountains were not studied closely enough to outline the coal outcrop. The final disappearance of the Mayberry bed, under the westward dipping strata, is shown by the coal outcrop located west and southwest of Enterprise. This coal bed is being mined quite extensively in the east end of Cavaniol mountain by the Kavanaugh Coal, Coke and Railway Company. The bed at this place averages about three feet eight inches in thickness and dips slightly to the southwest. On the opposite side of the cañon, from where it is worked and about one hundred and forty feet lower, there is what appears to be another bed of coal. This lower bed contains some shale, as is shown by the following section:

	FEET.	INCHES.
Coal		5
Clay shale		1½
Coal	1	
Shale		9
Coal	2	6

The layers of shale found in this lower bed and its difference in elevation indicate a different horizon from the one that is being worked, but it seems possible, from the cursory examination made, that they may be the same bed. If they are not the same bed, the lower or more shaly bed is probably a local deposit, for but one coal bed of importance was found at other places over the field at the horizon of the Mayberry coal.

On the north side of Cavaniol mountain, at the original place of discovery of the Mayberry coal, the beds show the following sequence:

	FEET.	INCHES.
Coal	1	5
Clay shale		3
Coal		8
Clay shale		3
Coal	1	10

This coal is a short distance above the fourth thick sandstone bed of the Cavaniol mountains.

A coal bed eighteen inches thick outcrops in the northeast end of

Sans Bois mountains one mile south of Henry Blaylock's house and three hundred or four hundred feet up on the mountain side. It is quite uniformly good except one and a half inches of shaly coal three or four inches from the bottom of the stratum. The coal is overlain by sandstone and underlain by clay. This coal was traced one-half mile or more around the hillside and was about the same wherever it was seen. From its position it seems to belong to the Mayberry coal bed. The coal near the head of Ash creek and near the west end of the Sans Bois mountains is said to be about eighteen inches thick. The bed that appears to represent the Mayberry coal, along the western border of the folded area, is from eighteen to twenty-four inches thick and of a good quality. About four miles northeast of Reams, at the west end of Sans Bois prairie, this coal is twenty-four inches thick. The bed is very much fractured at this point, which is on the axis of the Sans Bois anticline. About eight miles south of Enterprise and one and a half miles southwest of Russelville, along the head waters of Old Town creek, the coal is twenty-nine inches thick, including a thin parting of shaly coal eight inches from the base and another seven inches from the top. On the southwest side of McChar mountain, along the head waters of Long Town creek, the coal is nineteen inches thick. One-half mile above the mouth of Old House creek, it is twenty-one inches thick. The coal outcrops on Haytubya creek one-half mile from its mouth and about six miles west-southwest from Enterprise. At this place it is twenty-three inches thick and good throughout, but closely fractured by lines a half to one inch apart; dip of bed 2° to 3°. About four and a half miles west-southwest from Enterprise, the coal has been worked to some extent by stripping. At that place it is twenty-two inches thick and uniform throughout. One and a half miles north of Enterprise, the coal is twenty-six inches thick and is worked for local demands by stripping.

Coals of the Cherokee and Creek Nations.

In those parts of the Indian Territory lying within the Cherokee and Creek Nations the coal beds were not traced in detail, and were seen usually only at widely separated intervals, and cannot therefore be definitely outlined in this discussion. However, the structure of the area is quite regular, so that the general extent and connections of the various coals can be fairly well outlined.

Grady Coal.—The lowest coals found through the Cherokee and Creek Nations will be discussed under this heading, though it is doubtful whether they represent the northern continuation of the Grady bed, or whether they all belong to the same bed. The northern and eastern limit of the Cavaniol group, as outlined on the accompanying map, shows the approximate outcrop of this coal bed. The following local developments were seen: About one mile east of Little Salisaw creek, and one-fourth of a mile south of the Kansas City, Pittsburgh & Gulf Railroad, this bed of coal outcrops and has been worked to some extent by stripping. The coal is said to be one and a half feet thick and of good quality. The strata overlying the bed dip 15° to 20° north-northwest. About three miles southwest of Salisaw Station the same coal outcrops along Coal creek. It is one to one and a half feet thick, and has been mined by stripping. This coal was, in the summer of 1896, being used by blacksmiths in Salisaw, who pronounce it an excellent one for their work. The mines were all filled with water at the time the writer visited the place. Along the south side of Spaniard creek, at the Weber's Falls-Muscogee road crossing, the coal bed is ten to twelve inches thick and is mined for local demands. The bed dips north-northwest about 12°. Going from this point toward Muscogee, the synclinal basin is crossed at right angles and the coal outcrop is again seen about four miles southeast of Muscogee. The eastern end of this synclinal fold lies near Braggs, where the bed has been worked a little. It outcrops along branches about two miles south of Braggs, and is four to six inches thick. It is said to underlie Braggs at an average depth of about thirty feet and is six inches thick. Five miles west of Muscogee and one mile south of the Arkansas river, this coal has been worked a little. At that place the coal is eight to twelve inches thick. It outcrops again four miles north-northwest of Adair, along the side of an east-facing escarpment. Where it was seen (the Ross coal bank), the coal is seventeen inches thick, underlies a gray shale and is apparently rather high in ash and sulphur.

This coal outcrops along Log Cabin creek, about three miles west of Welch, where it is said to be about two feet thick, and is mined for local demands.

McAlester Coal Bed.—This coal outcrop is approximately located on the map from near Starvilla to Dirty or Elk creek, northeast of Checotah. One and a half miles northwest of Starvilla the coal

is about two feet thick. It is mined to some extent along the Thomas fork of Elk creek, at a place about six miles east of Checotah, where it is about fourteen inches thick. Along Elk or Dirty creek, about four miles east of Checotah, the coal is eighteen to twenty-four inches thick. From Starvilla to Elk creek, and doubtless much farther, a five to six-inch seam of coal occurs regularly fifty to seventy-five feet above the McAlester bed. These beds in the Choctaw coal field are separated by about one hundred feet of gray clay shale.

The McAlester coal outcrops six or seven miles southwest of Muscogee, where it is about one foot thick and is worked for local demands.

Another outcrop was seen four or five miles west of Chelsea, where it was worked at several places for local demands. At the Robinson bank it is eighteen inches thick, and of uniform quality throughout. At the McFadden coal bank the same qualities are shown.

About a hundred feet above this bed and four miles farther west, a coal bed fifteen inches thick outcrops. It is also worked somewhat for local use by stripping. This bed is probably not represented south of the Canadian river, but the outcrops along Coal creek, twelve miles east-northeast from Okmulgee, and those five to six miles southwest of Chelsea, are probably the same. On Coal creek the coal is about fifteen inches thick and quite uniformly good. The bed dips 1° to 3°, is overlain by carbonaceous clay shale, and underlain by fire clay. Southwest of Chelsea the coal is about ten inches thick and of very good quality.

Mayberry Coal Bed.—The coals occurring at the top of the Cavaniol group, and that probably represent the northern extension of the Mayberry bed, were seen as follows:

The upper bed outcrops along Coal creek, twelve miles south of Okmulgee, where it is parted by from four to eight inches of shale and shaly coal. The upper stratum of coal is fourteen inches thick and the lower one is from fourteen to sixteen inches thick. Both strata are apparently good, but iron pyrites is rather common in places through the coal. In general appearance this coal is almost identical with that occurring four or five miles west of Chelsea, and the chemical analyses show them to have the same general properties. The next outcrop of this coal bed was seen along Coal creek, about six miles east of Sapulpa. At that place it is from twenty-

two to twenty-four inches thick where it was examined, and has three to four shale partings, which are from a quarter to half an inch thick. Gray clay shale overlies the coal. The Mayberry coal bed was seen next at a place three miles northwest of Oologah, where it is two feet thick and rather uniform throughout. It is mined rather extensively by stripping for shipping to distant markets as well as for local demands. This same bed outcrops along Little Verdigris or Caney river at Mustgroves crossing, where it is about one and a half feet thick, according to report.

These local developments show that the best coals of the Cherokee and Creek Nations are only about two feet thick, but that they extend through the entire length of the Nations.

Coal Analyses.—At each locality where coals were collected for analyses, samples were selected to represent the average coal of that particular place; but as no guide save the appearance of the coal could be used in sampling, the analyses will necessarily not show the quality of the coal as well as may be desired. They will, however, show fairly well the characteristics of the coals and their adaptability to various uses. In the table of coal analyses the coal beds are placed in the same relative position that they occupy in the field, so that the Mayberry coals are first or at the top, the McAlester coals in the centre, and the Grady coals at the bottom. In each group the analyses begin with coals in the west and northwest part of the field and proceed eastward and southeastward. The groups thus proceed from higher to lower coals; the analyses of each group, and the groups also to some extent, run from a region of less to a region of greater folding and crushing. This arrangement clearly shows the decrease in the bituminous nature of the coals toward the region of greater dynamic movements. The coals are practically all bituminous, only that from near the mouth of James fork of Poteau river and that from near Milton being semi-bituminous. All the coals show a probability of coking, and a considerable quantity of slack coal from mines at Alderson and Krebs is now being coked. Most of the coals, however, are too high in sulphur to produce good coke for metallurgical uses. Some of the coals are objectionably high in sulphur, water, or ash, but as a whole they compare favorably with good coals from other fields.

Coal Oil.—During the summer of 1896, several wells were sunk, two hundred to three hundred feet deep, along Spencer creek val-

Coal Analyses by N. F. Drake.

Bed.	Locality.	Thickness of Coal Beds.	Water.	Volatile Hydro-Carbons.	Fixed Carbon.	Ash.	Sulphur.	Fuel Ratio.	Color of Ash.	Coking Tests.	Remarks.
Mayberry Bed.	Three miles northwest of Oologah, Cherokee Nation.	1′ 0″	3.35	34.99	57.88	3.15	1.21	1.65	Light yellow.	Fused and doubled in size.	
	Four miles east-northeast from Reams, Choctaw Nation.	2′ 0″	1.62	32.92	55.79	9.65	. . .	1.69	Lavender.	Fused and increased one and a half times.	Sulphur not determined.
	Twelve miles south of Okmulgee, Creek Nation.	2′ 4″	6.31	30.78	59.92	2.11	0.87	1.94	Light yellow.	Fused and increased in size one and a half times.	
	Six miles west-southwest of Milton, in north end of Sans Bois mountains.	1′ 6″	0.95	31.71	57.75	9.57	. . .	1.82	Brick red.	Fused and increased in size about ten times.	Sulphur not determined.
	Four miles northwest of Poteau, Choctaw Nation.	3′ 8″	1.36	17.23	64.54	12.46	4.40	3.80	Reddish brown.	Fused and increased in size about ten times.	
	Eight miles west of Chelsea, Cherokee Nation.	1′ 3″	2.77	34.61	56.17	6.43	. . .	1.62	Brick red.	Fused and increased in size about five times.	Sulphur not determined.
McAlester Bed.	Four and a half miles west of Chelsea, Cherokee Nation.	1′ 6″	6.26	27.16	64.17	1.84	0.56	2.36	Yellowish white.	Fused and increased in size one and a half times.	
	One-half mile southwest of McAlester.	4′ 0″	3.33	29.75	61.78	4.37	0.75	2.07	Yellowish brown.	Fused and increased one and a quarter times.	
	Alderson, Choctaw Nation.	3′ 4″	2.35	32.42	58.47	4.32	2.42	1.80	Light lavender.	Fused and increased in size one and a half times.	
	Three miles north-northwest of Sans Bois.	1′ 6″	1.60	24.83	68.69	2 95	1.90	2.76	Reddish brown.	Fused and increased in size about ten times.	
	One and a half mile northwest of Starvilla, Cherokee Nation.	2′ 0″	1.25	22.49	62.18	7.88	6.18	2.77	Brick red.		
	Two miles west of Stigler, Choctaw Nation.	2′ 4″	1.66	23.01	72.49	1.92	0.91	3.15	Light yellow.	Fused and increased in size about ten times.	
	Two miles west of Iron Bridge.	2′ 3″	1.21	19.67	73.46	3.40	2.25	3.75	Brick red.	Fused and increased in size about ten times.	
Grady Bed.	Cherry Vale mine, Choctaw Nation.	3′ 4″	2.54	30.90	62.37	3.56	0.60	2.01	Yellowish brown.	Fused and increased in size very little.	
	Hartshorne.	4′ 0″	2.69	35.65	54.91	4.12	2.62	1.54	Reddish brown.	Fused and increased in size one and a half times.	
	Upper stratum of coal bed, one-half mile south of Milton.	2′ 2″	1.12	14.23	77.31	4.04	3.28	5.43	Lavender.	Fused and increased in size about eight times.	
	Lower stratum of coal bed, one-half mile south of Milton.	4′ 2″	0.98	13.60	73.84	7.83	3.72	5.43	Lavender.	Fused and increased in size about eight times.	
	One and a half mile southwest of Heavener.	2′ 4″	3.67	19.46	72.83	3.28	0.74	3.74	Light yellowish brown.	Fused and increased in size but very little.	
	Near the mouth of James fork of Poteau river, Choctaw Nation.	2′ 4″	1.20	13.75	82.95	1.16	0.92	6.03	Yellowish brown or nearly orange.	Fused but increased very little in size.	

ley, four to five miles west of Chelsea. Some of the wells flow, but none of them produce very much oil. The foreman of the works informed me that the greatest flow of any one well was about a barrel per day, and that the oil was struck in a micaceous shaly sandstone. This sandstone is probably the bed that outcrops east of Chelsea, and lies between the two lower coal beds. The rock beds are practically horizontal in the area where the oil wells have been sunk, but the strata passed through, in sinking the wells, come to the surface farther eastward. The oil is probably derived from the Lower Coal Measures shale beds that outcrop along the Missouri, Kansas & Texas Railway, east of Chelsea.

Building and Ornamental Stone.—The sandstones, limestones, marbles and granite that occur in this field are adapted to many uses in construction work. Sandstones are very abundant, except in the Boone chert area, throughout almost the entire field. They are usually evenly textured, massive, tough, and are well adapted for ordinary building purposes. The best limestones for building purposes are confined to the Lower Carboniferous and especially to the upper Boone limestone horizon. Massive beds of tough gray evenly-textured limestone are common in the Boone limestones. The Boston group also contains some good building limestones and occasional thin beds of limestone were seen in the Permian area that are fairly good for building purposes. The outcrops of the marble beds are shown in Pl. IV. Massive beds of marble, twenty-five to thirty feet thick, outcrop at nearly every marble area shown in that plate. The thickness of the marble beds has not yet been determined, but from drill borings it appears to be one hundred and fifty feet or more. The marble is usually pink colored, but some of it is gray and a little is practically white. So far, the marble that has been quarried contains a great many fractures and rather abundant small cavities, partly or entirely filled with large calcite crystals. Further investigation may result in finding better marbles than the surface outcroppings. Some of the bed that is at present being quarried can be advantageously used for building and ornamental uses.

The granite found on Spavinaw creek is an excellent stone for building and ornamental purposes, but it is at present too far from any railway to be profitably quarried for marketing. For a more extended discussion of the various kinds of rock previous pages may be consulted.