OKLAHOMA GEOLOGICAL SURVEY

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GEOLOGY OF THE REDBEDS OF OKLAHOMA.

A DISCUSSION OF THE SURFACE GEOLOGY AND SUBSURFACE GEOLOGY AS REVEALED BY WELL LOG DATA.

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INTRODUCTION.

The purpose of this report on the Redbeds is not primarily to discuss the many questions which arise as to the origin, age, distribution, and character of the so-called "Redbeds" formations, but the assembling of data which would be of importance from a commercial, as well as a scientific standpoint. For many years the Redbeds of Oklahoma were regarded as very improbable territory for the discovery of oil and gas pools. Many people who have visited the famous Cushing oil field and noticed outcrops of red clay in some places in the vicinity of the field called the material "Redbeds," and on noticing a formation of similar color in the typical Permian Redbeds area, thought the latter place had just as good prospects for finding oil or gas as the Cushing field. Such conditions the geologists have tried to explain as being entirely different. The explanation is that surface rocks of red Pennsylvanian age occur in parts of the Cushing field and below these the productive horizons occur in the non-red Pennsylvanian; but in the Permian Redbeds area, these so-called red sediments are thicker and in some places the depth to the base of them is so great that it is impracticable to explore for oil and gas at the present time.

The Redbeds, with the exception of the Healdton, Gotebo, Wheeler, Loco, and several other fields in southern Oklahoma, are non-productive of oil and gas. These beds do not contain sufficient organic matter to form these products. However, this does not preclude the possibility of finding oil or gas in the Redbeds; as in the Healdton field and some other pools, there is evidence that the oil has migrated into the Redbeds from older formations.

The general direction of the movement of development in the oil fields of this State has been from the eastern and northeastern part of the State to the west and southwest. The westernmost fields of the northern half of the State are Ingalls, Blackwell, Billings, and Garber. The first two of these fields are near the contact of the Redbeds with the non-red Permian or Pennsylvanian. The discovery of new fields in the areas above named and other places, supplemented by encouraging showings, together with the demand and high price of petroleum, has tended to stimulate a greater drilling campaign in the Redbeds region than ever before.

Since the general characteristics, depth of the Redbeds, occurrence and prospects for oil and gas in the formations in the Redbeds area are items of considerable importance for prospecting, the main purpose of this report is to give such information, briefly, in so far as the best available data can be interpreted.

In the preparation of this report, considerable use was made of the material already published concerning the Redbeds of Oklahoma. Among the publications containing such data are those by Gould*, Snider**, and Beede.***

DEFINITION OF REDBEDS.

The Redbeds, as defined and treated in this report, is the term applied to the red formations of both Permian and Pennsylvanian age, which are predominantly red in color. The term, as ordinarily used, does not include the non-red Permian, red Pennsylvanian, and non-red Pennsylvanian, but in this report the red Pennsylvanian is included.

DISTRIBUTION.

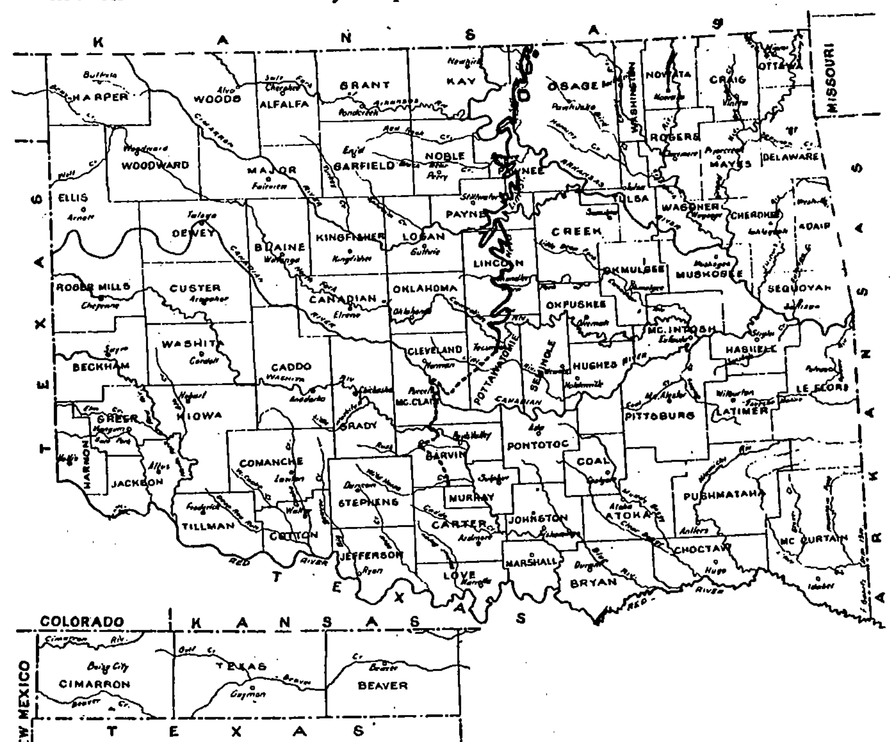
The Redbeds area of Oklahoma forms a part of the larger area which extends from southwestern Kansas almost to the Pecos River in southwest Texas. The outcrop at the north end is narrow, but widens rapidly to the south and includes most of the western half of Oklahoma. From Red River south the belt narrows until on Colorado River it is about one-half as wide as it is in Oklahoma. The narrowing of the outcrops in both directions from Oklahoma is accounted for in a large measure by the covering of the Redbeds by younger formations, and in part by the thinning of the beds. To the west, south, and north the beds disappear under younger formations—Lower or Upper Cretaceous or Tertiary. They are continuous beneath these younger formations to the west and reappear in a belt along the base of the Rocky Mountains in New Mexico. A narrow strip along Canadian River connects the New Mexico and Oklahoma areas across the Panhandle of Texas. Areas of red rocks in the eastern part of Colorado and Wyoming probably belong to the same great body of Redbeds.

In Oklahoma the Redbeds region embraces at least one-half of the State, including all or a part of the following counties: Alfalfa, Beaver, Beckham, Blaine, Caddo, Canadian, Cimarron, Cleveland, Comanche, Carter, Cotton, Custer, Dewey, Ellis, Garfield, Garvin, Grady, Grant, Greer, Harmon, Harper, Jackson, Jefferson, Kay, Kingfisher, Kiowa, Lincoln, Logan, Major, McClain, Murray, Payne, Pontotoc, Pottawatomie, Roger Mills, Seminole, Stephens, Texas, Tillman, Washita, Woods, and Woodward.

*Gould, C. N., Water Supply Paper, U. S. Geol. Survey, No. 148, 1906.
**Snider, L. C., Bull. Okla. Geol. Survey, No. 11, 1913.
***Beede, J. W., Bull. Okla. Geol. Survey, No. 21, 1914.

CHARACTER OF THE ROCKS.

In general, the Redbeds consist entirely of red shales and sandstones. The red color varies greatly in shade in different horizons and from place to place in the same horizon. All gradations from vermillion to maroon or very deep red brown can be observed in short distances where good exposures are common. In general, however, the vermillion and brick reds seem to be more common in the lower Permian formations in which shales predominate, and the deeper reds in the upper formations in which sandstones are more abundant. The sandstones are usually composed of very fine, rounded grains, and are cross-bedded and lenticular to a pronounced degree. The sandstones often grade into shales in a very short distance, but probably more



MAP SHOWING APPROXIMATE EASTERN LIMIT OF PERMIAN ROCKS.

Figure 1.

often they pinch out very quickly and are replaced abruptly by shales which contain very little sand. Locally the sandstones are quite coarse and in a few instances are conglomeratic.

The shales are usually very fine-grained, slightly consolidated, and very plastic, with high shrinkage in drying. They usually contain considerable quantities of soluble salts. The color of the clay shales is usually a brighter brick red or vermillion than that of the sandy shales or the sandstones. In the red Pennsylvanian a few blue shales occur, but are of minor importance.

The gypsums, although they occur in ledges of 60 feet or more in thickness and cover considerable areas, are relatively unimportant when considered as a part of the Redbeds as a whole. Closely associated with the gypsums are white to greenish sandstones and shales, which, on account of their color, often have a very striking appearance in fresh exposures. The stratification of these whitish or greenish rocks is very irregular. A greenish band may appear, thicken to 5 or 6 feet, and pinch out in a few rods. The stratification of these light-colored bands is probably no more irregular than that of the minor variations in the red rocks, but is much more noticeable on account of the contrast in colors. Two or three ledges of dolomite, usually less than 5 feet in thickness, are the only carbonate rocks found in the gypsum bearing series.

In the Kay County area several beds of limestone occur in the Permian. These are discussed in another part of this report.

In the red Pennsylvanian several red to gray limestones occur. However, they are thin and usually sandy. From Pawnee County southward the limestones become thinner, contain more sand, and change in color to red. Some of the sandy limestones extend as far south as Chandler, but to the southward they grade into sandstone or shale.

AGE AND RELATIONS OF THE REDBEDS.*

GENERAL STATEMENT.

"The Redbeds of the area under discussion were studied in Kansas and Texas several years before they were in what is now Oklahoma. Before 1893 the Kansas beds had been usually referred to the Jura-Trias, or definitely to the Triassic,** although some of the earliest observers had ascribed them to the Upper Carboniferous and some to

*Snider, L. C., Op. Cit., pp. 107, 112-114.

**Hay, Robert, The Triassic rock of Kansas: Trans. Kans. Acad. Sci., vol. 6, 1889, p. 36; and Cragin, F. W., Geological notes on the region south of the great bend of the Arkansas: Bull. Washburn Col. Lab. of Nat. Hist., vol. 2, 1889; and A Geological Reconnaissance in Southwestern Kansas: U. S. Geol. Survey, No. 57, 1890, pp. 20-21; Williston, S. W., Geol. Map of Kansas, 1892.

the Lower Cretaceous. All these correlations were made on lithologic or stratigraphic grounds.

"As has been shown in the preceding paragraphs, the greater part of the Redbeds is generally regarded as of Permian age. In Kansas, only the upper portion of the Permian rocks is red, but near the Kansas-Oklahoma line the limestones and non-red shales of the lower part of the system grade southward into red shales and sandstones so that the line between the red and non-red rocks descends lower in the system and the line between the outcrops swings to the southeast. As a result there is only a small area of non-red Permian rocks in Oklahoma, most of Kay County, and portions of Osage, Noble, and Pawnee counties. The same change takes place in the rocks in the upper part of the Pennsylvanian system, i. e., the limestones in Kansas give way to shales and sandstones in Oklahoma, with most of the sandstones dying out before they reach Arkansas River. To the south of the Arkansas the shales, and farther south the sandstones, take on the red color and become part of the Redbeds. The line betweem the red and non-red beds passes about midway between Pawnee and Stillwater and southeastward to Stroud, where it swings to the west of south and passes around the west end of the Arbuckle Mountains. The line between the Pennsylvanian and Permian enters the State a few miles east of the northeast corner of Osage County and bears a little to the west of south to the west side of the Arbuckle Mountains. The Pennsylvanian and Permian rocks, then, occur in the following areas: (1) A large area of red Permian rocks in the central and western part of the State, (2) a small triangular area of non-red Permian rocks in Kay County and adjoining parts of Osage, Noble, and Pawnee counties, (3) a small area of red Pennsylvanian rocks between the two lines mentioned above, and (4) the non-red Pennsylvanian rocks covering most of the eastern half of the State.

"The relations of the red and non-red rocks in Texas and in Kansas have been shown* to be similar. The Permian in central Texas (Albany) is white, but becomes red to the north (Wichita), and limestones give way to sandstones and shales from south to north in the same way that the limestones of Kansas do from north to south.

"The upper limit of the Redbeds in Oklahoma is irregular and is always one of unconformity. Limestones of Lower Cretaceous (Comanchean) age occur in small areas in Woods, Woodward, Dewey, Custer, and Washita counties. The patches seldom exceed a few acres in extent and are on top of the hills or broad divides between the streams. The limestone is seldom over 3 or 4 feet thick, and usually seems to have been let down from above as the shales and soft sandstones worked out from beneath it. In the rest of the area in

*Cummins, W. F., The Texas Permian: Tex. Acad. Sci., vol. 2, 1897, pp. 93-98; Adams, George I., Stratigraphic relations of the Redbeds to Carboniferous and Permian in Northern Texas: Bull. Geol. Soc. America, vol. 14, 1903, pp. 191-200; Gordon, C. H., Jour. Geol., vol. 19, 1911, pp. 110-125.

Oklahoma the Redbeds pass under the Tertiary or Quaternary sands. In Texas the Dockum beds, Redbeds of Triassic age, occur unconformably above the Permian Redbeds, but this formation is not present in Oklahoma."

PENNSYLVANIAN-PERMIAN CONTACT.

GENERAL STATEMENT.

The latest work on the contact between the Pennsylvanian and Permian was done by J. W. Beede*, who places this line at the base of the Elmdale formation of Kansas, and who traced the Neva limestone, which is the first stratigraphic unit above the Elmdale and a persistent horizon marker, into Oklahoma and mapped the outcrop of this horizon as far south as Shawnee, Pottawatomie County. The Neva limestone, although not the exact contact line, may be considered approximately so for practical purposes.

Plate II shows the generalized outcrop of the Neva limestone from the State line south to several miles beyond Pawnee. Figure 1 shows the approximate line of contact between the Pennsylvanian and Permian rocks.

NATURE OF LITHOLOGIC AND COLOR CHANGES IN THE PENNSYLVANIAN AND PERMIAN.**

"One of the most interesting features of this whole region is the nature of the changes from the light-colored limestones and shales to the dark red sandstones and peculiar shales of the Redbeds.

"The shales are red much farther north, as a rule, than are the limestones and sandstones. The change in color is frequently accompanied by some change in the character of the shale. The red shales are usually much less compact and durable and in the immediate region covered by this report seem to become more or less charged with very fine sand. On account of the fact that the shales are usually hidden from view, the nature of the transition has not been observed so carefully as has the transition from limestone to sandstone.

"In the case of some of the higher limestones, Wreford, Fort Riley, etc., sand appears in the limestones which have usually thinned appreciably. The sand may gradually increase for considerable distances, say from a few rods to a few miles, and become first a very sandy limestone, then a calcareous sandstone. Followed still farther, the traces of calcium carbonate disappear, sometimes to reappear as limestone in some areas. Again, as is shown along the Shawnee branch of the Santa Fe railroad from Kaw City to Skedee, or the upper

*Beede, J. W., The Neva limestone in northern Oklahoma, with remarks upon the correlation of the vertebrate fossil beds of the State: Bull. Okla. Geol. Survey, No. 21, 1914.

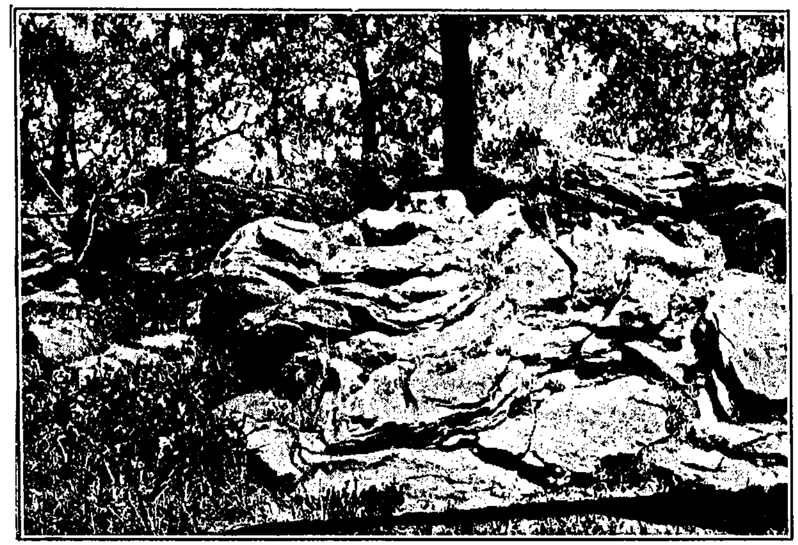
NOTE:—Dr. J. W. Beede is in charge of a party doing further detailed work on the stratigraphy in the immediate vicinity of the Pennsylvanian-Permian contact during the present field season (1917).

**Op. Cit., pp. 24-32.

Wreford limestone at Hardy, the first traces of the transition are seen in purple blotches scattered through the stone. These may enlarge and increase in number until the whole stratum is practically a purple or red limestone. In other regions the limestone may turn almost scarlet in a rod or two, as is the case with a limestone in the escarpment south of Cushing. The red limestones of the latter class usually dissipate quickly into sandstones. They are usually fossiliferous.

"Sometimes a limestone layer will grade into a sandstone layer and then change back again into limestone in a few rods. Indeed, this is not infrequent in the region between Kaw City and Pawnee, and west and northwest of Pawnee. An instance of this as it occurs in the

PLATE III.



CROSS-BEDDING IN WHITE SANDSTONE OF FORT RILEY HORIZON, 1½ MILES SOUTHWEST OF DEAL RANCH HOUSE, OSAGE COUNTY.

section north of Pawnee is shown in the accompanying photographs. Sometimes these sandstone replacements may not be more than 3 or 4 rods across. Several were seen in which, at a moderate distance, the whole transition from limestone into sandstone and back into limestone could be taken on an ordinary kodak negative. The sandstone in such cases is usually calcareous, but in some instances it is not.

"At one point a ledge was made up of sandstone and limestone in indiscriminate masses, which were very irregular in form. The masses were all rather small, hardly ever over 2 feet in diameter and ranging from that to mere pockets. Sometimes there were pockets of sandstone in the limestone and sometimes pockets of limestone in the sandstone. That is, sometimes one or the other forms the predominating rock. On the whole the exposure was largely limestone. In most all cases the transition from the light-colored sandstone to red sandstone takes place before going a great distance. The accompanying photographs illustrate the conditions. Opportunity to work out the history and significance of all these changes has not yet presented itself.

"After passing some distance south or southwest of the region of transition just described, in which the sandstones maintain their usual thickness and relative positions, we pass into another zone where they thicken and thin, pinch out, end, and even cut out intervening beds of shale and limestone. An instance of the latter is shown in the accompanying diagram. In this region stratigraphic work becomes more uncertain, the fossils are wanting, and there seems to be no character of the rocks to tie to. At the bridge at Ripley is a sandstone about 40 feet in thickness which elsewhere is usually about 4 or 5 feet. All the sandstones of the section at Vinco are thicker than the average but appear to pinch out on the south side of the river between Vinco and Goodnight, so far as it is possible to determine by surface exposures. At Goodnight they have more than normal thickness. These belts of thickened sandstones extend nearly north and south, with the region of very thin sandstones, or mere traces of white sand and iron concretions marking their horizons, between them.

"These long stretches of sandstone extend from just west of Pawnee, nearly straight south to the vicinity of Shawnee, a distance of 60 miles on an air line. Wherever the region of shales west of this belt was crossed, as near Lela, west of Stillwater, Goodnight, etc., another belt of thickened sandstones was found. Another feature of this region that must not be lost sight of is the fact that the lower horizons traced eastward grade out into normal light-colored beds of marine origin, at least nearly as far south as Shawnee. Whether these great masses of sand were thrown up as barriers along the southern tongue of the sea to the north and northeast, or whether they represent river debouchures from the mountains to the southward has not yet been determined. For a number of reasons, some of which will follow, the writer is at present inclined to the opinion that they are connected with rivers. With further work it appears now that the question can be settled quite definitely and the origin of the sediments determined. If they were barriers, it would seem peculiar that the different layers should thicken and thin so nearly simultaneously, while this is what would be expected if the sand were brought down to mouths of rivers whose channels at times extended well out across low fans, coastal plains, and shallow waters.

"In some places the deposition of sandstone is very irregular. Over some areas a sandstone may be wanting and its place apparently filled with soft shales that weather and slump very rapidly, forming great amphitheaters. In some instances, the sandstones occupy beds

cut in the soft shales by current of some kind. Thus, at a place 5 miles southwest of Glencoe, a cut in the railroad reveals such a case, which is shown in the series of photographs here reproduced. In the ditch where the wagon road crosses the railroad is a conglomerate bed over which are conglomeratic sandstones cross-bedded in three direc-

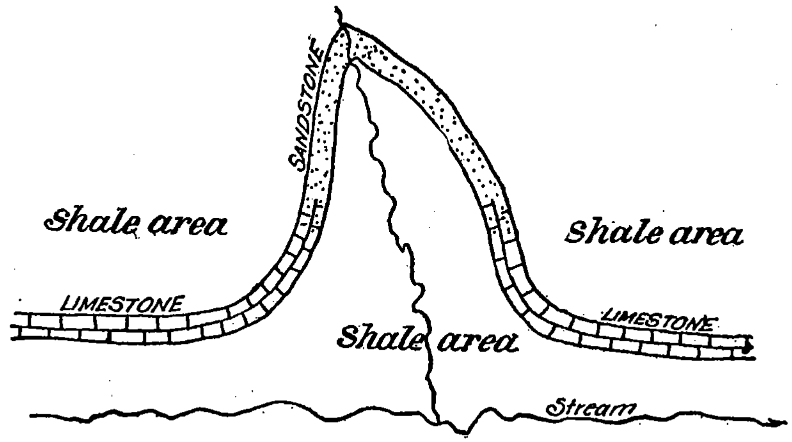


FIGURE 2. SHOWING A LITTLE RAVINE CUTTING THROUGH LEDGE OF LIMESTONE WHICH IS LOCALLY CHANGED TO SANDSTONE. THE SANDSTONE OUTCROP IS ABOUT 450 FEET IN LENGTH. THE SANDSTONE IS LESS RESISTANT THAN THE LIMESTONE. LOCATION NORTH OF PAWNEE AND WEST OF RALSTON.

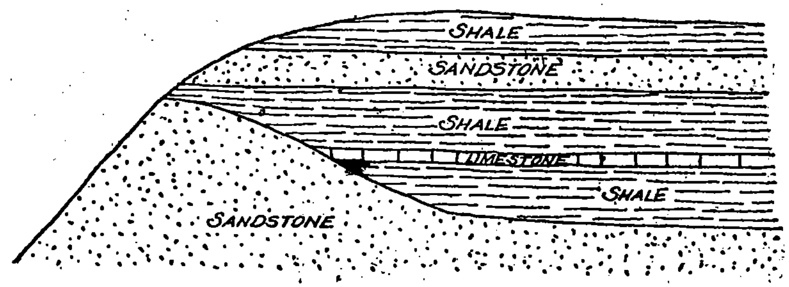


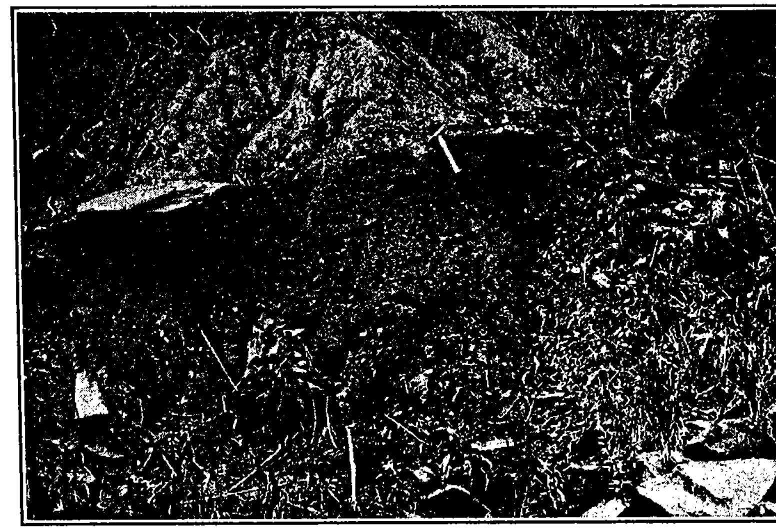
FIGURE 3. SHOWING A BED OF SANDSTONE THICKENING AND NEARLY UNITING WITH THE LAYER ABOVE. THE LIMESTONE WAS DEPOSITED UP TO THE SANDSTONE ELEVATION. LOCATION WEST OF PAWNEE.

tions, in a cross-section of about 15 square feet. On top of this, and appearing in the west end of the cut, is a coarse sandstone. A little higher and farther east the sandstone is fine-grained and abuts a nearly vertical bank of soft shale. On the south side of the cut the appearance is that of a fault, though there are no indications of it in the contact, and on the opposite side of the cut the top layer of sandstone extends far over the shale bed which would be impossible were it a fault. A sandstone appears in the cut a few rods farther east, which may or may not represent the same sandstone. It is fairly thick at the west end of the cut, and coarse in the lower part, but thins to a few inches in the central part, and again thickens and then disappears near the east end. Where the sandstone in the first cut came against the shale there was pronounced fan-shaped cross-bedding radiating from the shale. From the assortment of materials it looks as though this were a stream deposit.

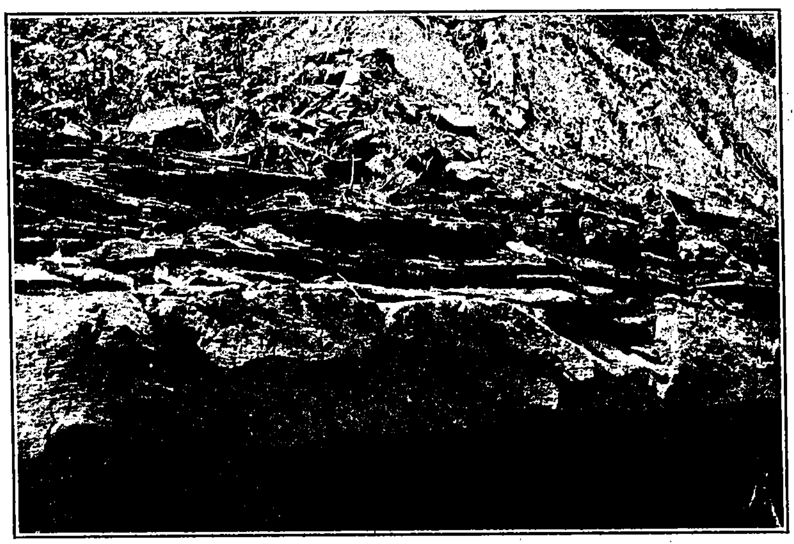
"At another place two sandstones occurred about 30 feet apart with a thin limestone near the top of the intervening shales. Following the outcrop of this limestone south on the east side of the hill for less than a quarter of a mile the lower sandstone was found to thicken and approach the limestone, appearing to cut it off, and nearly joined the sandstone above. A half mile farther west the entire section presented its normal thickness with all the strata in place as usual.

"Many of the peculiarities which have been described occur in the northern part of the state. Farther south and especially farther west they appear to be more complicated. Another feature that was noted was that some of the beds became quite coarse by the time the latitude of Shawnee was reached. Our studies did not extend south of Shawnee.

"The fact that the stratigraphy is more regular in the same horizons in the eastern part of the region studied than in their western extensions, as well as the fact that the same formations contained limestones with marine fossils at their eastern outcrop for some distance south of Pawnee, would seem to indicate that an arm of the sea at Neva time extended south from the great northern area as far as Cimarron River, or a little beyond, but that its waters were extremely shallow, if present, on the flats west of the 96° 45′ meridian. The disappearance of the fossils, and the irregular and interrupted character of the stratification seems to indicate the passing from marine conditions on the northeast to shallow water or even subaerial conditions to the south and west. This would appear to be the direct result of the influence of the Arbuckle Mountain region upon the sedimentation of the time. Subaerial conditions continued near the mountains and marine conditions beyond the influence of its fans."



A. SHOWING SANDSTONE LEDGE PINCHING OUT, IN RAILROAD CUT, S. W. COR. SEC. 16, T. 20 N., R. 3 E., 5 MILES SOUTHWEST OF GLENCOE, PAYNE COUNTY.

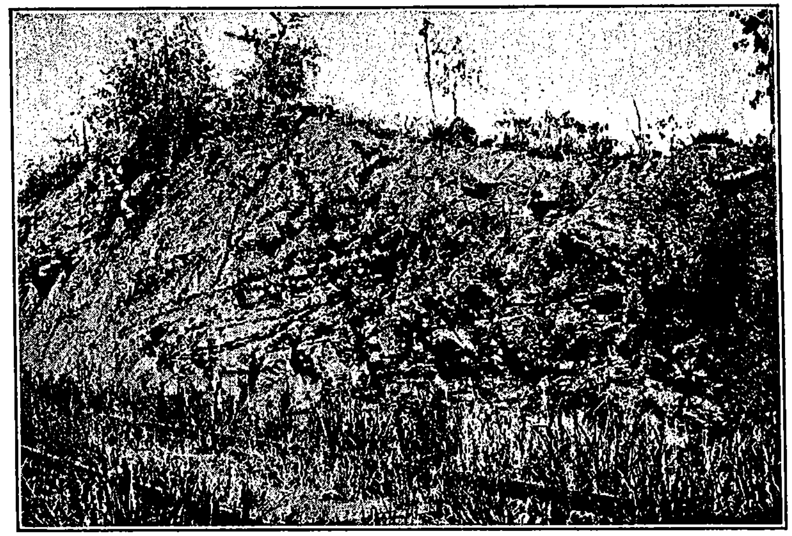


B. SHOWING CHARACTER OF SANDSTONE LEDGE AS EXPOSED NEAR MIDDLE OF RAILROAD CUT, 5 MILES SOUTHWEST OF GLENCOE, PAYNE COUNTY.

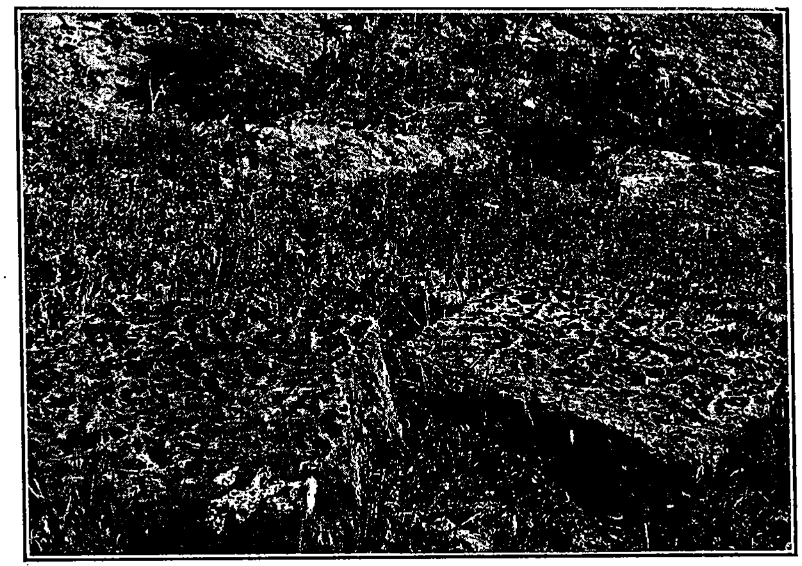
The following table shows the Pennsylvanian and Permian section of Kansas:

	Series	Stage	
PERMIAN	V	Well.	Wellington shales
PERMIAN	V	Marion	Abilene conglomerate Pearl shales Herington limestone Enterprise shales Luta limestone
PERMIAN	IV	Chase	Winfield limestone Doyle shales Fort Riley limestone Florence flint Matfield shales Wreford limestone
PERMIAN	IV	J	Florena shales Neosho member } Garrison formation Cottonwood limestone
PERMIAN	IV	I	Eskridge shales Neva limestone Elmdale formation
PENNSYLVANIAN	III	H	Americus limestone Admire shales Emporia limestone Willard shales Burlingame limestone Scranton shales
PENNSYLVANIAN	III	G	Howard limestone Severy shales Topeka limestone Calhoun shales Deer Creek limestone Tecumseh shales Lecompton limestone Kanwaka shales
PENNSYLVANIAN	III	F	Oread limestone Lawrence shales Kickapoo limestone Leroy shales Stanton limestone Vilas shales Allen limestone Lane shales
PENNSYLVANIAN	II	E	Iola limestone Chanute shales Drum limestone Cherryvale shales
PENNSYLVANIAN	II	D	Dennis limestone
PENNSYLVANIAN	II	C	Galesburg shales Mound Valley limestone Ladore shales Bethany Falls limestone
PENNSYLVANIAN	I	B	Pleasanton shales Coffeyville limestone Walnut shales Altamount limestone Bandera shales Pawnee limestone Labette shales Fort Scott limestone
PENNSYLVANIAN	I	A	Cherokee shales

Table from Journal of Geology.—Beede.



A. SANDSTONE EXPOSURE IN RAILROAD CUT SOUTH OF TRYON, LINCOLN COUNTY.



B. SHOWING CHARACTER OF LOWER LIMESTONE LAYER, EAST OF CHANDLER, LINCOLN COUNTY.

FORMATIONS BELOW THE REDBEDS.

GENERAL STATEMENT.

The formations below the Redbeds range in age from pre-Cambrian to the non-red Pennsylvanian. In the Arbuckle and Wichita mountains there were no great changes or breaks in the deposition of the sediments laid down in the sea or ocean which covered that section of Oklahoma until the Pennsylvanian period. During this time interval between the Cambrian and Pennsylvanian a thickness of about 10,000 feet of sediments was deposited.

In early Pennsylvanian times there was a great uplift in this region. The rocks were folded and faulted and elevated into land. A period of erosion followed which exposed the rock section down to the Cambrian in some places. Either by erosion or submergence, or perhaps both, the Franks conglomerate and Glenn formation of Pennsylvanian age were deposited. Near the close of the Pennsylvanian the region was uplifted and eroded again. In the next submergence the Pennsylvanian and Permian Redbeds were deposited. After the deposition of the Redbeds the region was elevated into land and remained so until Cretaceous times. The next period of elevation followed the Cretaceous.

In the western part of the Arbuckle Mountain region the Redbeds rest unconformably upon all formations from the Arbuckle limestone to the Glenn formation. In the Wichita Mountain region the Permian Redbeds rest in the same manner upon formations from the pre-Cambrian granites to the Viola limestone. They are undoubtedly unconformable on higher formations above the Viola not exposed in this region.

The conditions in the Ozark Mountains and the region affected by the uplift are somewhat different from those of the Arbuckle region. Most of the folding and faulting occurred in late Pennsylvanian times, but the intensity of the uplift was minor in comparison with that of the Arbuckle Mountains. The Pennsylvanian is unconformable upon the Mississippian, but the Permian is conformable upon the former.

The Ouachita Mountain uplift is probably equal in intensity to the Arbuckle and Wichita mountain uplifts, and also occurred in Pennsylvanian times. It is not known whether this uplift combined with the Arbuckle uplift had any effect on the elevation of the land to the north and northwest in Seminole and Pottawatomie counties previous to the deposition of the red Pennsylvanian. However, the Seminole conglomerate is suggestive of an unconformity.

GEOLOGIC SECTIONS.

The following sections of Pennsylvanian and Permian rocks in northeastern Oklahoma, Pennsylvanian rocks in the east-central part of the State, and Paleozoic rocks in the Arbuckle and Wichita mountains, will give a general idea of the formations lying below the Redbeds.

Section of Pennsylvanian and Permian rocks in northeastern Oklahoma, the contact between the two lying at the base of the Elmdale formation.

		Feet
25.	Unclassified shales, with thin limestone and sandstone members	
24.	Herington limestone	18-20
23.	Uncas shale	50
22.	Winfield Limestone	10-15
21.	Doyle shale	22-35
20.	Fort Riley limestone	40
19.	Matfield shale	70
18.	Wreford limestone	40
17.	Undescribed series in Osage Nation	700
16.	Elgin sandstone	50-140
15.	Oread limestone	0-17
14.	Buxton formation	450-600
13.	Wilson formation (Avant limestone)	280-400
12.	Dewey limestone	23
11.	Unclassified shales and sandstones	75
10.	Hogshooter limestone	10
9.	Coffeyville formation	370
8.	Lenapah limestone	20
7.	Nowata shale	100
6.	Altamont limestone	35
5.	Bandera shales	0-120
4.	Pawnee limestone	43
3.	Labette shale	120
2.	Ft. Scott formation	38-65
1.	Cherokee formation	450-500

Section of the Pennsylvanian south of Arkansas River.

		Feet
14.	Seminole conglomerate	50
13.	Holdenville shale	260
12.	Wewoka formation	700
11.	Wetumka shale	120
10.	Calvin sandstone	200
9.	Senora formation	500
8.	Stuart shale	90-280
7.	Thurman sandstone	80-250
6.	Boggy shale	2,000-3,000
5.	Savanna sandstone	1,200-1,500
4.	McAlester shale	2,000-2,500
3.	Hartshorne sandstone	100-200
2.	Atoka formation	2,000-7,000
1.	Wapanucka limestone	100

Arbuckle Mountain section from pre-Cambrian to Pennsylvanian.

		Feet
12.	Franks conglomerate	
11.	Glenn formation	3,000
10.	Caney shale	1,600
9.	Sycamore limestone	200
8.	Woodford chert	550
7.	Hunton formation	
	Bois d'Arc limestone	0-90
	Haragan shale	0-166
	Henryhouse shale	0-223
	Chimneyhill limestone	0-53

6. Sylvan shale		60-300
5. Viola limestone		
	Upper, Middle, Lower	500-700
4. Simpson formation		1,300-2,000
3. Arbuckle limestone		4,000-6,000
2. Reagan sandstone		500
1. Granite		

Wichita Mountain section below Redbeds.

	Feet
Viola limestone	
Simpson formation	
Arbuckle limestone	
Reagan sandstone	
Pre-Camrian granites	

ORIGIN OF THE REDBEDS.

The origin and source of the sediments comprising the Redbeds is a question which has not been satisfactorily answered up to the present time. The non-red Permian deposits in northern Oklahoma and north-central Texas were laid down in an ocean, as the limestones of this series contain marine fossils; but some of the Permian Redbeds, on the other hand, appear to have been fluviatile or estuarive sediments deposited during a semi-arid climate. The gypsum deposits in the Redbeds suggest that they were formed by evaporation of water in relatively shallow basins, which, at least temporarily, had more or less connection with the sea. The source of the material has not been determined.

CLASSIFICATION OF THE REDBEDS.

GENERAL STATEMENT.

The classifications of the Permian Redbeds of Kansas and Oklahoma have been discussed at some length by Cragin*, Gould**, and Snider***, and the red Pennsylvanian by Beede****. The changes which have been made in the divisions and terms used give the general classification as follows:

*Cragin, F. W., The Permian system in Kansas: Colorado Col. Studies, vol. 6, 1896, p. 3.
**Gould, C. N., Water Supply Paper, U. S. Geol. Survey, No. 154, 1906, pp. 23-24.
***Snider, L. C., The gypsum and salt of Oklahoma: Bull. Okla. Geol. Survey No. 11, 1913, pp. 114-115.
****Beede, J. W., Bull. Okla. Geol. Survey No. 21, 1914.

Permian:

Quartermaster formation.		
Greer formation		Mangum dolomite member. Collingsworth gypsum member. Cedartop gypsum member. Haystack gypsum member. Kiser gypsum member. Chaney gypsum member.
Woodward formation		Day Creek dolomite member. Whitehorse sandstone member. Dog Creek shales member.
Blaine formation		Shimer gypsum member. Medicine Lodge gypsum member. Ferguson gypsum member.
Enid formation.		

Red Pennsylvanian.

RED PENNSYLVANIAN.

The red Pennsylvanian is a term applied to an undifferentiated series of sandstones and shales, predominately red in color and very similar to the Permian Redbeds, occupying an interval between the non-red Pennsylvanian and the Neva limestone or equivalent horizon. This interval is not constant. The red Pennsylvanian is first recognized near Pawnee in following the Pennsylvanian-Permian contact line southward. It becomes more prominent and attains its maximum thickness in Lincoln, Pottawatomie, Cleveland, and McClain counties as far as known from outcrops.

The red Pennsylvanian and Seminole conglomerate in a section across the northern part of Pottawatomie and Seminole counties is the approximate equivalent of the following-named formations of the Kansas Pennsylvanian section: Bethany Falls limestone, Ludora shales, Mound Valley limestone, Galesburg shale, Dennis limestone, Cherryvale shales, Drum limestone, Chanute shales, Iola limestone, Lane shales, Allen limestone, Villas shales, Stanton limestone, LeRoy shales, Kickapoo limestone, Lawrence shales, Oread limestone, Kanwaka shales, LeCompton limestone, Tecumseh shales, Deer Creek limestone, Calhoun shales, Topeka limestone, Severy shales, Howard limestone, Scranton shales, Burlingame limestone, Willard shales, Emporia limestone, Admira shales, Americus limestone, and Elmdale formation. The thickness of the red Pennsylvanian and Seminole section is approximately 800 feet, while that of the equivalent Kansas section is about 1,800 feet.

PERMIAN REDBEDS.

ENID FORMATION.

The Enid formation includes the rocks from the base of the Permian Redbeds to the lowest heavy gypsum ledge. The Pennsylvanian-Permian contact has been taken as a line crossing the Oklahoma-Kansas state line north of Pawnee, and extending south to that town, then west of south to Purcell, and south to the west end of the

Arbuckles. The most recent work* has shown that the line should be drawn more nearly south from Pawnee. However, this line is not the lower limit of the Enid formation throughout its course. From Pawnee south the Enid is equivalent to the following section near the Kansas line:

	Feet
Enid formation	1,000*
Unnamed limestone and shales	
Herington limestone	17
Uncas shale	54
Winfield limestone	15
Doyle shale	35
Fort Riley limestone	52
Matfield shale	70
Wreford limestone	12
Garrison formation	140
Cottonwood limestone	6
Eskridge shale	40
Neva limestone	10
Elmdale formation	130

As mapped by Gould* the Chandler formation lies below the Enid formation in the central part of the State. The former is limited above by the Payne sandstone, which is thought to be equivalent to the Wreford limestone. It can be readily seen that the Enid formation is not a constant stratigraphic unit, including in some places more than in others, and is therefore a term applied to a part of the lower Permian Redbeds, and does not include the non-red Permian even though it is of the same age as the lower part of the Enid.

The upper limit of the formation is the base of the lowest gypsum of the Blaine formation. Owing to the lenticular nature of the gypsum this is not an exact limit, but is still a well-defined horizon.

The line between the Enid and Woodward to the south or southeast of El Reno is very indefinite. The Enid formation occupies all or part of the following counties: Grant, Alfalfa, Woods, Major, Garfield, Noble, Payne, Lincoln, Logan, Kingfisher, Blaine, Canadian, Oklahoma, Cleveland, and McClain. The Redbeds in western Garvin and Carter counties may belong to part of this formation.

The Enid consists almost entirely of red shales with soft, lenticular, red sandstones. The lower portion contains relatively more sandstone than the upper, but the shales predominate throughout and comprise practically all of the upper part. Throughout the Enid there are veins of white sandy material. These sometimes occur as lenses having considerable thickness at the center but pinching out rapidly. Lentils as much as 3 feet thick in the center have been observed to pinch out in a very few (10 or 12) rods. Some of the beds of white

NOTE:—The descriptions of the Enid, Blaine, Woodward, and Greer formations is in part summarized from the discussions of the subjects by L. C. Snider, in Bulletin No. 11, Oklahoma Geological Survey, and in part his report is printed in full.

*Gould, C. N., Water-Supply Paper, U. S. Geol. Survey No. 148, 1905.

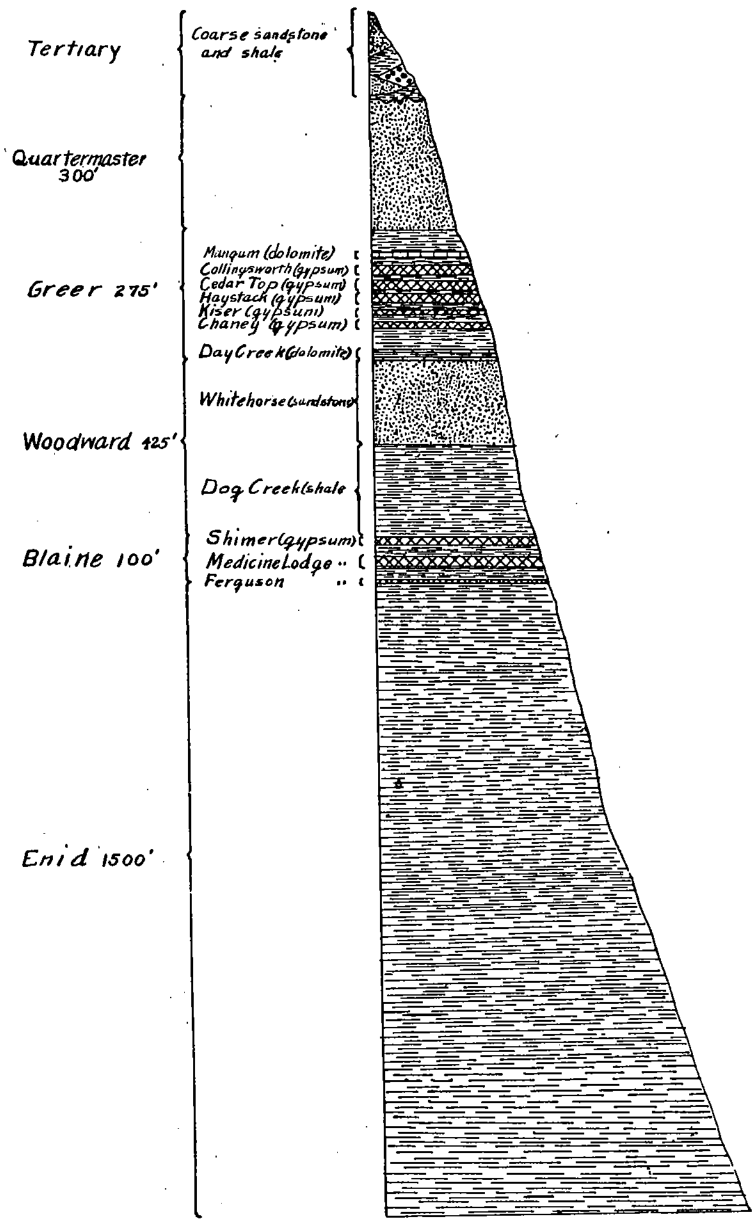


FIGURE 4. GENERALIZED SECTION OF PERMIAN REDBEDS IN OKLAHOMA.

sand are 4 feet, or even more, thick and cover areas of several acres. In a few cases of exceptionally good exposures, layers of this white sand less than an inch thick can be traced for about one-fourth mile. The grains of the ordinary red sandstones, as well as those of the white layers, are very fine—a large percentage passing a 200-mesh sieve. The shales grade from very sandy to clay shales. The latter are very fine-grained, very plastic when wet, and have great drying shrinkage.

The red color of both the sandstone and the shales is due to iron (ferric) oxide, which forms a thin coating over the grains of sand in the sandstones and presumably over the clay particles in the shales. In the uppermost 100 feet some of the shales have a green color. This color is probably due to some form of iron, but since these green shales are largely gypsiferous the color may be due to a compound of iron and calcium. The green color is often mistaken for copper stain.

At about 100 feet below the top of the formation the shales locally are very salty and give rise to salt springs at Ferguson in Blaine County, at the Big and Little Salt Plains on the Cimarron near the Kansas-Oklahoma state line, and at the Salt Plain near Cherokee. It is not to be understood that the salt occurs in these different localities at exactly the same horizon. The water carrying the salt at Cherokee is probably from a horizon considerably lower than that from which the salt water of the springs at Ferguson comes, while the salt horizon at the Salt Plains on the Cimarron is probably somewhat higher.

The shales for 25 or 30 feet below the gypsum ledge are very gypsiferous and the exposures show many veins of satinspar and selenite. This vein material has almost certainly been derived from the solution of gypsum by water passing through the ledges above and has been deposited near the surface of the exposure by the evaporation of the water. Near the bottom of the strongly gypsiferous layer is a persistent layer 1 to 2 feet thick of greenish selenite, the crystals of which are usually about an inch long, and a single layer of concretions of pure white, fine-grained gypsum. The concretions are in the shape of flattened ellipsoids and all lie with the long axis horizontal. The short or vertical diameter is usually about 2 inches and the long diameter 3 to 6 inches. These concretions lie almost or quite touching each other, forming a layer in the shale. On account of the persistence and uniformity of this double layer it is believed that it is the result of original deposition.

The surface of the territory underlaid by the Enid is in general a plain into which the streams have cut shallow valleys. The eastern portion of the outcrop is somewhat hilly on account of the sandstones in the lower part of the formation. This portion is covered by oak trees, but the greater part of the area is prairie and only a few cottonwoods and elms occur along the streams. The thickness of the Enid was estimated by Gould at 1,200 to 1,500 feet.

BLAINE FORMATION.

The Blaine is the great gypsum-bearing formation of the northwestern part of the State. In this connection only a brief notice will be given to the character of the formation and its relations.

The Blaine formation consists typically of three gypsum members separated by shales. The formation always forms a pronounced escarpment, as the soft, easily eroded shales of the Enid are eroded much more rapidly than the gypsums. This escarpment and the outliers have been known since early times as the "Gyp Hills." The hills enter the State from Kansas on the south side of the Salt Fork of Arkansas River, follow down that stream a few miles, swing back northwest up the Cimarron, cross the Cimarron just north of the Kansas-Oklahoma state line, and follow down the south bank of that river gradually getting farther from it. The formation is well developed as far southeast as Watonga, but from that point on the gypsums become lenticular and the formation plays out about 5 miles north of El Reno. The formation ranges from 75 to 100 feet thick.

WOODWARD FORMATION.

This formation is well described by Gould* and his description is given in its entirety.

Dog Creek shales member.—The Dog Creek member is composed mainly of clays, containing occasional thin ledges of magnesian limestone, which in places grade into a fair quality of dolomite.

The ledges, however, are usually thin and rarely sufficiently conspicuous to be worthy of more than passing notice. Professor Cragin's original description of this member is as follows:**

'The Dog Creek * * * consists of some 30 feet, or locally of a less or greater thickness, of dull-red argillaceous shales, with laminae in the basal part and one or two ledges of unevenly lithified dolomite in the upper. The color of these shales resembles that which prevails in most of the divisions below rather than of the terraces above the Dog Creek.'

In his second paper he modifies his description in this way:

'In central Oklahoma it is a great dolomite formation, laminated dolomite occupying a considerable part of the thickness.' ***

In his second paper he suggests that the name Dog Creek be changed to Stony Hills. The writer agrees that the name Dog Creek is, perhaps, not the best that could be used, but in view of the fact that the dolomites which make up the Stone Hills in eastern Blaine County belong to the Blaine formation and do not belong to the Dog Creek, there seems to be no good reason for using the name Stony Hills to designate this member.

"Studies made during the last three years have demonstrated that in many parts of Oklahoma the thickness of the Dog Creek is much greater than that given by Professor Cragin. Near Quinlan, in eastern Woodward County, the aneroid readings indicate 225 feet as the thickness of these beds, measured from the top of the underlying gypsums of the Blaine formation to

*Gould, C. N., Water-Supply Paper, U. S. Geol. Survey No. 148, 1904, pp. 15-59.

**Cragin, F. W., The Permian system in Kansas: Colorado Col. Studies, vol. 6, 1896, p. 32.

***Cragin, F. W., Observations on the Cimarron series: Am. Geologist, vol. 19, 1897, p. 358.

the standstones of the next higher formation of this member, the Whitehorse, and in a number of localities 150 and 175 feet were recorded. Exposures are common along the top of the Gypsum Hills from Canadian County to the Kansas line and beyond.

Whitehorse sandstone member.—The Whitehorse sandstone was also described (under the name Red Bluff sandstone) by Professor Cragin in his first paper, as follows; *

'This formation consists of some 175 or 200 feet of light-red sandstones and shales. * * * Viewed as a whole it is very irregularly stratified, being in some cases considerably inclined, in others curved, and this oblique and irregular bedding, being on a much larger scale than that of the ordinary cross-bedding, at first glance gives the impression of dips, anticlines, synclines, etc., that have been produced by lateral pressure, the dips, however, being in various directions. * * * The Red Bluff beds exhibit the most intense coloration of any of the rocks of the series. When the outcrops are wet with recent rains their vividness of color is still greater, and the contrast of their almost vermillion redness with colors of the landscape is most striking. Spots and streaks of bluish or greenish gray sometimes occur in these rocks, but not to nearly so great an extent as in the lower beds. The sandstones of the Red Bluffs are generally too friable for building stone, but in some instances selected portions have proved hard enough for such use and are fairly durable.'

In Oklahoma the Whitehorse member often weathers into conspicuous buttes and mesas. For instance, in eastern woodward and western Woods counties a row of these buttes, which rise 100 to 200 feet above the surrounding country, extends from the vicinity of Whitehorse Springs, whence the name, southwest across the Cimarron, to the high divides beyond. To some of these buttes characteristic names have been given, as Lone Butte, Potato Hill, Watersign Hill, Wild Cat Butte, and the like. The noted Red Hill between Watonga and Geary in southern Blaine County, is composed chiefly of the Whitehorse formation. South of Canadian River this sandstone thickens and on weathering often forms conspicuous bluffs, such as the famous Caddo County Buttes, southwest of Bridgeport. The Whitehorse sandstone is exposed along the Washita near Chickasha, continuing westward, where in the vicinity of Anadarko it forms bold bluffs both north and south of the river, and extends as far west as Mountain View. Ledges which probably belong to the same general horizon outcrop north of the Wichita Mountains in the vicinity of Hobart and Harrison, and it is not impossible that further studies may demonstrate that the same beds extend under the upper gypsums, across Greer County.

Day Creek dolomite.—Resting upon the upper part of the Whitehorse sandstone in Kansas and Oklahoma is a conspicuous ledge of hard, white dolomite, first described by Professor Cragin from exposures in southern Kansas, as follows:

"Upon the latest of the Red Bluff rests a persistent stratum of dolomite varying in thickness from less than a foot to 5 feet or more. * * * It is true dolomite, containing with the carbonate of lime an equal or even

*Cragin, F. W., The Permian System in Kansas: Colorado Col. Studies, vol. 6, 1896, p. 40.

PLATE VI.

A. JOINT BLOCKS ON SANDSTONE RIDGE, AT TONY HOLLOW, SOUTHWEST OF CHICKASHA, GRADY COUNTY.

B. MASSIVE SANDSTONE IN SANDSTONE RIDGE, AT TONY HOLLOW, SOUTHWEST OF CHICKASHA, GRADY COUNTY.

greater percentage of carbonate of magnesia. Though not of great thickness, it is an important member of the upper Permian of southern Kansas and northern Oklahoma, owing to its persistence, which makes it a convenient horizon of reference. * * * The stone is nearly white in fresh fracture, weathering gray, and often has a streaked and gnarly grain resembling that of fossil wood. * * * Its cherty hardness and fracture are not due to the presence of silica, as one is tempted to infer, but are characters belonging to it as a dolomite. It is a durable building stone."

In his second paper on the Permian rocks, in describing a typical Oklahoma locality, Professor Cragin says:

"The brow of the Red Hills near Watonga, Okla., is capped with the Day Creek dolomite, which here presents itself as a compact stratum of gray, somewhat pinkish or reddish tinged cherty-hard rock, little different from the typical ledge that skirts the flanks of Mount Lookout in Clark county, Kansas. The stratum here has a thickness of 3 feet."

The line of outcrop of the Day Creek in Oklahoma is not continuous; nevertheless, it is found in numerous localities, and on account of its distinctive lithological appearance it is always easily recognized. It is displayed on many of the hills of Woodward county, not only north of the Cimarron, but also between the Cimarron and the North Canadian and south of the latter stream. In Blaine county it forms the caps of a number of the prominent hills, notably the Red Hills between Geary and Watonga. South of Canadian River in Caddo County the dolomite covers the Whitehouse buttes southwest of Bridgeport and outcrops southwestward as far as the headwaters of Cobb Creek and on the west side of that creek past Colony. In the vicinity of Mountain View, in the valley of Washita River, a ledge of dolomite appears at the same general level as that occupied by Day Creek, and another dolomite ledge in the hills north of Harrison may provisionly be referred to this horizon."

GREER FORMATION.

The Greer formation outcrops in two areas. The eastern one begins in the southeast corner of Woodward County and extends east of south in a widening belt through the central part of Dewey and Custer counties and eastern Washita County. In the southeastern part of Washita the belt divides, one branch swinging more to the east through the southwestern parts of Caddo and Grady counties into northwestern Stephens County. The other swings west along the south line of Washita County and is thought to connect with the western area in Beckham and Greer counties, although the connection cannot be made out on account of the covering of alluvium and sand in the valley of North Fork of Red River. The western area of the Greer occupies all of Harmon, southern Beckham, western Greer, and western Jackson counties.

The Greer formation is made up of sandstones, shales, and gypsums, with a ledge of dolomite, having a total thickness of about 150 to 300 feet. The stratification in the eastern area is extremely erratic and no horizon can be traced sufficiently far to be used as a basis for separating the formation into members. The gypsums are lenticular and in the northern part of the area are few in number and not very thick; to the south the gypsum lentils become more numerous and thicker, reaching their maximum in eastern Washita County. Farther southeast the ledges thin out.

In the western area the stratification is more regular and five distinct beds of gypsum and one of dolomite can be traced for considerable distances and are classed as members of the formation.

QUARTERMASTER FORMATION.

The Quartermaster in Oklahoma has been described by Gould* as follows: Consequently his description is given in full.

"Above the Greer are 300 feet or more of soft, red sandstones, and arenaceous clays and shales to which the name Quartermaster has been applied. So far as known this is the highest formation of the Redbeds in Oklahoma.

"In the lower part of the formation the rocks are chiefly shales, typically red, but sometimes containing greenish bands and layers. The shales become more arenaceous above, and in places form a strong, consolidated sandstone,

PLATE VII.

GYPSUM BLUFF ALONG NORTH FORK OF RED RIVER, NEAR CARTER, BECKHAM COUNTY.

which is rather thin-bedded and prone to break into small rectangular blocks, and weather queerly into long and narrow buttresses or rounded, conical, or nipple-shaped mounds from 10 to 50 feet or more high. These mounds may be solitary, but in some areas hundreds of them occur in a single quarter-section. The sandstone is further characterized by the marked and very peculiar dip of the rocks in certain directions. The strata often dip at angles

*Gould, C. N., Op. cit., pp. 72-73.

of from 20 to 40 degrees to all points of the compass, even in a small area. These dips often produce escarpments that have the appearance of those formed by regularly bedded dipping strata. The most plausible explanation of this phenomenon is that the erratic dipping is caused by the undermining of deep-seated rocks, probably some of the various gypsum members of the Greer.

"In this sandstone, particularly in its upper part, there are many springs of soft water, which usually issue as seeps at the head of deep canyons or beneath bluffs of red sandstone. While few of them have large flows, many are large enough to supply farmhouses, or, in some cases, to furnish stock water for ranches. Wells in these sandstones frequently yield good water at moderate depths. In fact, with the exception of the eastern area of the Enid, the Quartermaster is the only Redbeds formation in which any large amount of good water is found.

"Except where covered by younger rocks, the Quartermaster outcrops over practically all of Day and Roger Mills counties (Ellis and Roger Mills), and is also extensively developed in the western part of Dewey, Custer, and Washita counties. To the south and east it is underlaid by the Greer, while to the west and north it disappears beneath the sands of the Tertiary. Streams tributary to the South Canadian, Washita, and the North Fork of Red River in the region form canyons in this rock and are fed by springs issuing from it. The name is from Quartermaster Creek, which flows from Day county through the exteme northwestern corner of Roger Mills county and empties into Washita River in Washita County. Along this creek both the lower shales and the sandstones higher up in the formation are well exposed. The peculiarities of structure and weathering are also well exemplified along this stream. In the present state of our knowledge it is not deemed advisable to attempt to subdivide the Quartermaster formation."

GENERAL CHARACTERISTICS OF THE REDBEDS AREA FROM A STUDY OF WELL LOGS.

GENERAL STATEMENT.

The well record, or log, as it is commonly called, is a record or list of the formations encountered in drilling from the surface downward into the earth. The ordinary log records the nature, characteristics, and thickness of the formations. In some logs a record is kept of the sands only.

VALUE OF WELL LOGS.

A log of a well is of great value in many ways. In "wildcat" territory, a second well in the vicinity can be drilled much more rapidly and with less expense, on account of the knowledge of the formations which will be encountered and their nature, whether cavey or capable of standing up without casing; and also as to the information concerning the depth, thickness, and oil, gas, or water conditions in the various sands. Such advance information is always of value to the driller. The information secured from the logs is of special importance to the geologist in studying the subsurface geology and determining the underground structure.

INACCURACY OF WELL LOGS.

To be used to advantage from the practical standpoint of drilling,

not even taking into account the scientific value, it is evident that the accuracy of the log is very important and essential. If a man is traveling through a strange country and is using a map which serves to guide him by streams and other features, he may get lost or lose considerable time in finding his way if the map is wrong. This example is applicable to the accuracy of the log. An inaccurate log is of no value and may cause much confusion if any attempt is made at interpretation.

It is not to be understood that all well logs are inaccurate. Many logs are very accurate and detailed. Some of the large companies are beginning to realize the importance of the well log, especially in an undeveloped territory. They are now placing more faith in the work which can be done from a study of accurate logs. In some places, where the surface outcrops are insufficient to determine the underground structure, the logs of wells which have been drilled in this area are the only means of working out the structure. Certain horizons can be correlated in the different wells, and knowing the altitudes at the surface, the structure in many cases can be determined.

It is a known fact that many drillers do not pay very much attention to the logs. For example, in off-set wells drilled by different parties a comparison of the logs will show that the horizons will vary in every manner, or may be present in one and missing in another. In one well a dry sand of perhaps 15 feet in thickness may be recorded and in the adjoining well the driller may record no sand at all.

Many drillers will be confused as to the lithologic character of a formation. For instance, they may call a sandy shale a sand, shale, red rock, or almost anything. One of the most vague terms used by drillers is red rock. It never means the same thing to all drillers. If it did, it would have a value, but as it is it means any kind of a formation that may have a red color. It may mean a red shale, which it very often does, but on the other hand it may mean a red limestone or sandstone. After a drill has passed through red shale, it may go through limestone, and if the sediments of the red shale have a chance to become mixed with the white limestone sediments, the red color will predominate. Under such circumstanes a careless driller will take it for granted he is still drilling in red rock.

Especially are the above facts brought to our attention when trying to study, or determine correlations in logs of wells drilled in the Redbeds area. As stated above, the term red rock has no definite meaning and should be eliminated on that account, and more definite terms used.

THICKNESS OF THE REDBEDS AS DETERMINED FROM WELL LOGS.

GENERAL STATEMENT.

In the first part of this report the surface formations of the Redbeds were described in detail. Their thickness, character, etc., were given, in so far as they could be determined, from the surface. This information, however, is not complete, because there is no positive way of knowing the conditions of a formation which is overlaid by considerable sediments and is far removed from its outcrop, except as revealed by the drill. Some formations vary to quite an extent in several hundred miles, especially in thickness and character. The Redbeds, which are supposed to have an average maximum thickness of 2,500 feet, vary in thickness even when wells are started on the same surface horizon and no appreciable difference is apparent from the surface.

Outside of the Healdton and other proved oil and gas fields more than 200 wells have been drilled in the Redbeds area. Some of these wells were abandoned at shallow depths and were not drilled through the Redbeds. For use in this report the logs of such wells are of no special value.

What has been said concerning the inaccuracy of logs is especially applicable to those of this area. In some logs it is almost impossible to estimate the contact of the Redbeds with the non-red formations below.

Over 200 logs have been examined with the primary purpose of estimating the thickness of the Redbeds in various localities. Some of these wells are widely scattered, and it is necessary to use surface information between such places, and also to take into consideration the general trend of conditions in areas not far distant where conditions have been worked out from logs. Some of the logs were incomplete and poor, while others seem to be very accurate.

The following tables (Plate VIII) show the name of the nearest town, location of each well, the surface horizon, depth to base of Redbeds, formations below the Redbeds, total depth of the well, and remarks concerning it. In these tables the term "depth to base of the Redbeds" is in almost all cases equivalent to the thickness of the Redbeds because most of the wells considered start on the Redbeds. Several wells begin above the Redbeds, but these horizons are usually shallow and the Redbeds are encountered within a few hundred feet.

Plate I shows the depth of the base of the Redbeds, plotted on a geologic map of the State. Lines are drawn through points of equal depth. It is necessary to explain that these lines shown do not represent structural conditions in all instances. This feature will be taken up in another part of this report.

SPECIAL AREAS.

GENERAL STATEMENT.

The data for Plate I are based on a study of logs of wells drilled in the Redbeds area. No doubt some of the logs were inaccurate and the depth to the base of the Redbeds may be in doubt. The results, however, are in general only approximate, and the lithobathyc lines give only an idea of the depth to the base of the Redbeds.

As shown by the map there are several features of prominence; namely, the influence of the Arbuckle and Wichita mountains on the depth of the base of the Redbeds; the deep area of Redbeds in the central part of the Redbeds area; the changing in character of the red sediments to non-red sediments in the northern part, and a possible slight southeast dip in the surface formations causing the lithobathyc lines to run in a northwest direction; the north and south areas in proximity to the contact line of the Permian and Pennsylvanian; and the Red River region including the deep basin of Redbeds in Cotton and Jefferson counties south of the Wichita Mountains. Each of these respective areas will be considered.

ARBUCKLE MOUNTAIN REGION.

LOCATION.

The Arbuckle Mountain area embraces all of Garvin County with the exception of the southeastern corner, the southeastern corner of Stephens County, the northeastern corner of Jefferson County, and that part of Carter County lying west and southwest of the western end of the Arbuckle Mountains.

GENERAL FEATURES.

The Redbeds are unconformable upon all formations involved in the Arbuckle Mountain uplift, as explained before under the heading "Formations below the Redbeds." After the first great uplift of this region in early Pennsylvanian times, it was followed by a second uplift after the deposition of the Franks conglomerate, also of early Pennsylvanian age. The western part of the uplift was submerged in late Pennsylvanian times and the Permian sea encroached upon this area from the west. After the Redbeds were deposited the region was elevated into land.

From surface exposures it is known that the deposits near the mountains are of a different character from those farther removed. Near the mountains the sediments are composed principally of limestone, conglomerate, and shale, but may vary according to the formation from which deposits were derived. Farther away they change to argillaceous limestones, sand, sandstone, and bluish and red clays. Still farther removed they consist almost entirely of red clays and sandstones.

Logs of the Healdton, Wheeler, and Loco fields and the Fox district have been examined and further remarks are given in the following paragraphs.

HEALDTON FIELD.

The Healdton Field, now having the largest production of oil of any field in the State, is located principally in T. 4 S., R. 3 W., Carter County. The surface over almost all of the area is Permian Redbeds. The depth to the base of the red sediments varies somewhat in different parts of the field. Comparison of logs will show that the formations in one part of the field may be red and in another blue. Generally the red sediments continue to a depth of 300 to 400 feet, and are followed by blue clays. It is not known definitely to what depth the Permian persists. It is thought that most of the production is encountered in the Permian, but has migrated to this horizon from older formations, possibly the Simpson formation, of Ordovician age, or Pennsylvanian deposits. Recently, some fossils of Simpson age were found in drill cuttings from a formation below the Permian and a paper on this subject has been given by Sidney Powers of the Producers Oil Company before the last meeting of the Geological Society of America.

There is no doubt that there is an unconformity between the Permian and older formations. The Permian Redbeds are variable, but on the average are from 300 to 400 feet in thickness; below this lies the non-red Permian.

WHEELER FIELD.

The Wheeler field is located in T. 3 S., R. 2 W., northeast of the Healdton field. The surface outcrops are Permian Redbeds. The average depth to the base of the Redbeds appears to be about 900 feet. Below that depth there are usually 50 feet or more of non-red Permian. The Pennsylvanian lies unconformably below the Permian. The oil production comes from the Permian. It is thought that the Permian, as a whole, is not as thick as in the Healdton field, but that some of the sediments of an equivalent horizon in the latter field are not red. The reason for this difference in character of the sediments is not clear, but it is thought that the formations from the non-red Permian in the Healdton field were deposited near and derived, at least in part, from a formation composed principally of limestones. While the Redbeds of the Wheeler field were probably derived from formations consisting principally of sandstones and shales deposited under normal conditions.

LOCO GAS FIELD.

The Loco Gas field is located in T. 3 S., R. 5 W., Stephens County. The surface formations are unclassified Permian Redbeds. The red sediments extend to a depth of 500-700 feet, and the non-red Permian continues to an average depth of 850 feet. The principal oil and gas sands occur in the Permian, but have migrated into it from older formations, possibly of Pennsylvanian age. The Pennsylvanian underlies the Permian and is unconformable with it.

FOX DISTRICT.

The Fox district, as commonly called, is located in T. 2 S., Rs. 2 and 3 W. The surface formations are unclassified Permian Redbeds. The subsurface Redbeds are similar to those in the Healdton field. The formations which are red in one well may be of a different nature and color in other wells. The red color is prominent in most wells to

depths ranging from 500 to 1,000 feet. It is not known to what depth the Permian extends. From the character of the deposits below 1,000 feet in T. 2 S., R. 3 W., it is possible that they are Pennsylvanian, which, if true, is the horizon of the oil and gas of this field. However, this point has not been investigated thoroughly enough to say that such is the case. In sec. 18, T. 2 S., R. 2 W., the log of a well drilled by the Louisiana-Oklahoma Oil Company shows red formations to extend to a depth of 1,590 feet.

MISCELLANEOUS WELLS.

The log of a well drilled near Brock in sec. 24, T. 5 S., R. 1 W., shows the depth to the base of the Redbeds to be 210 feet. The surface formation is Trinity sand, which at this place is about 20 feet thick. The highly tilted formations of the Pennsylvanian outcrop only a short distance to the east of this location and lie unconformably below the Redbeds.

Near Pauls Valley the log of the well drilled in sec. 33, T. 3 N., R. 1 E., is not very good, so that it is difficult to determine the depth of the base of the Redbeds. Below a depth of 634 feet limestones, and at various depths down to 1,214 feet, red shales are encountered. This series may be red-Pennsylvanian. The base of the Redbeds may be at 634 feet or 1,214 feet.

A well drilled near Oswalt in sec. 12, T. 6 S., R. 2 W., penetrated the Redbeds at about 847 feet. The surface horizon is a covering of Trinity sand of Cretaceous age. The Pennsylvanian probably underlies the Redbeds unconformably.

In the well drilled near Rubottom, Love County, the Redbeds appear to have a thickness of 1,010 feet. The log shows several horizons of "red rock" below this depth, which may be red Pennsylvanian. The surface horizon is the Trinity sand of Cretaceous age, but is only a shallow covering above the Redbeds. The Redbeds probably overlie the Pennsylvanian, but the contact may be unconformable.

WICHITA MOUNTAIN REGION.

LOCATION.

The Wichita Mountain region is located in the southwestern part of the State in the vicinity of the Wichita Mountains, and embraces a part or all of the following counties: Kiowa, Comanche, Caddo, Greer, Jackson, and Washita.

GENERAL FEATURES.

As previously stated, the Redbeds in this region are unconformable upon all the formations of the Wichita Mountain region from the pre-Cambrian granites to the Viola limestone at least, and probably upon higher formations in the section not exposed in this region, but present in the Arbuckle Mountain region. The geological history of the region is similar to that of the Arbuckle Mountain region.

Near the mountains the sediments are composed principally of conglomerates. Near the contact with the old igneous rocks the conglomerates contain considerable angular breccia, but farther away from the mountains they are made up of smaller angular pebbles. Still farther removed the deposits are composed of fine conglomerates, grits, red and green shales, and argillaceous limestones and sandstones. Logs of wells in the vicinity of Lawton, Granite, Gotebo, Alden, and Cement have been examined.

The Redbeds were probably penetrated in the above mentioned wells at the following depths: 500, 915, 550, 500, and 465 feet respectively. In the wells at Gotebo, Lawton, and Granite, the thicknesses as given probably represent the whole of the Permian, but at Cement it is possible that some of the formations below the 465-foot depth are non-red Permian. In the well northeast of Granite the Simpson formation probably underlies the Redbeds, while at Gotebo it is probably the Viola limestone, and at Lawton the Arbuckle limestone.

These wells show that the thickness of the Redbeds increases rapidly in all directions away from the mountains. From Gotebo they increase from a thickness of 550 feet to over 2,500 feet at Clinton. This great increase is not necessarily due to structure. There are probably two factors responsible: (1) the dip of the Redbeds, as measured at the surface, away from the mountains is very slight, being almost flat. The relation of the Redbeds to the mountains is that of an overlap, and the basal part near the mountains is younger than the basal part farther away; and (2), in the well at Clinton the 2,500 feet of Redbeds also may include some of the red Pennsylvanian. Where the Permian Redbeds and Pennsylvanian are in contact the former is probably unconformable upon the latter throughout this area.

STEPHENS COUNTY REGION.

LOCATION.

The Stephens County region lies between the Arbuckle and Wichita mountains and includes a part or all of the following counties: Stephens, Garvin, and Grady.

GENERAL FEATURES.

The surface formations are an unclassified series of Redbeds composed of sandstones and red, green, and blue shales. To the east and west near the Arbuckle and Wichita mountains the sediments become coarser, while in this area they are fine. The surface structure is that of a monocline dipping at a low angle to the west.

The Duncan or Cruce gas field lies in this area. It is located in T. 1 N., R. 6 W. The Redbeds have an average thickness of about 1,000 feet. This is not the depth to which the red sediments are limited, but they are predominate down to this depth. Below 1,000 feet several limestones, white, brown, blue, and red shales, and sandstones

are encountered. The last mentioned series may be of Pennsylvanian age. The main production of oil and gas comes from the Redbeds, but these materials have migrated into that horizon from other sources.

On Plate I the lines show a large trough between the Arbuckle and Wichita mountains. This, however, is probably not due to structure, but represents in a general way the old surface conditions before the deposition of the Redbeds. The lines also show that the Redbeds become deeper both to the north and south of this area, showing that even though it is a low depression between the two uplifts there is the remnant of a ridge connecting them.

RED RIVER REGION.

LOCATION

The Red River region is located between the Arbuckle and Wichita mountains and Stephens County areas on the north and Red River on the south, and includes all or a part of the following counties: Tillman, Cotton, Jefferson, and Love.

GENERAL FEATURES.

The surface formations over practically all of this region are the unclassified series of the Permian Redbeds. In Love County and the southeastern part of Jefferson County the Trinity sand of Cretaceous age covers the Redbeds. The surface rocks, with the exception of the Cretaceous, which dips to the southeast at a low angle, in general dip to the southwest at a low angle.

In the Grandfield district the logs of wells drilled in that area differ so much that the base of the Redbeds cannot be determined with certainty. The depth to the base of the Redbeds varies from about 1,000 to 1,500 feet. The lower part of this may be red Pennsylvanian. General information concerning these wells is given on Pl. ———.

The Pennsylvanian probably underlies the Permian throughout this region, but there is some question as to whether or not the latter is unconformable upon the former. If the logs of the different wells can be relied upon the lines on Plate I show a long basin of Redbeds deposits, which extends from the western part of Cotton County eastward paralleling the Arbuckle-Wichita mountains ridge, to the northeastern part of Love County. The deepest part of this basin is just northeast of Grandfield.

CENTRAL REGION.

LOCATION.

The Central region is located in the central part of the Redbeds area and includes a part or all of the following counties: Roger Mills, Ellis, Dewey, Custer, Washita, Caddo, Blaine, Canadian, Kingfisher, Logan, Oklahoma, Cleveland, and McClain.

GENERAL FEATURES.

The surface formations consist almost entirely of the Permian Redbeds. The subdivisions exposed, from oldest to youngest, are Enid, Blaine, Woodward, Greer, and Quartermaster formations. The characteristics and distribution have already been described under "Classification of the Redbeds." The Permian Redbeds probably lie conformably upon the red Pennsylvanian, which in turn lies in the same manner upon the non-red Pennsylvanian. A few remnants of Cretaceous deposits in Custer and Dewey counties lie unconformably upon the Redbeds. Tertiary deposits in Roger Mills and Ellis counties also lie unconformably upon the Redbeds.

The surface rocks in the eastern part of the area dip at a low angle to the west, while those near the central and western parts of the area are almost flat with possibly a slight southeast or east dip in the western part.

The total thickness of the Redbeds, according to the average estimate made by Gould* is 2,500 feet. Well logs show the thickness to be even greater in Custer County. The minimum thickness of the Redbeds in this region is about 1,200 feet, which is near the eastern edge of Oklahoma County and central parts of Logan, Cleveland, Grady, Caddo, and Washita counties.

Wells as located on Plate I, near Meridian, Spencer, Oklahoma City, El Reno, Hydro, and Clinton show the following thickness of the Redbeds: 1,180, 1,400, 1,400, 1,800, 2,490, 2,507 feet, respectively. Plate I shows a deep basin of Redbeds sedimentation extending from Roger Mills County eastward to Oklahoma County. The various thickiesses as given above include both Permian and Pennsylvanian Redbeds.

NORTHERN REGION.

LOCATION.

The Northern region lies in the northern part of the Redbeds area of this State and north of the Central region. It includes all or a part of the following counties: Ellis, Woodward, Beaver, Harper, Woods, Major, Alfalfa, Garfield, Grant, and Noble.

GENERAL FEATURES.

The surface deposits of the Redbeds range from the Enid formation to the Redbeds of uncertain relationship in Harper and Beaver counties. The Pennsylvanian probably underlies the Permian and the contact is conformable. All of the Pennsylvanian formations and the basal part of the Permian are non-red. From north to south the Permian changes from non-red to red, as explained previously in another part of this report.

The surface rocks in the eastern part of the region dip to the

*Gould, C. N., Water-Supply Paper, U. S. Geol. Survey, No. 148, 1905.

west at a low angle, and near the central and western parts to the southeast and perhaps east.

The maximum thickness of the Redbeds does not exceed 2,500 feet, but the depth to the base of the Redbeds in the extreme northwestern part of the region probably does. Logs of wells from near the towns of Enid, Alva, and Gate have been examined, and the following thicknesses found: 1,000, 1,100, and 1,725 feet, respectively. In all of these wells the base of the Redbeds is not the base of the Permian. In the well at Gate the Pennsylvanian was probably encountered at a depth of 2,400 feet.

Plate I shows the lithobathyc lines swinging to the northwest from the Central region. One of the principal factors causing this is that some of the Permian and Pennsylvanian red sediments in the Central region have changed to non-red sediments in the Northern region.

PENNSYLVANIAN-PERMIAN CONTACT REGION.

GENERAL STATEMENT.

This region is located near the eastern edge of the Redbeds area. For the convenience of discussion it is divided into a northern and southern area.

NORTHERN AREA.

LOCATION.

The northern area includes a part or all of the following counties: Grant, Kay, Noble, and Pawnee. It is in the vicinity of and closely follows the change of color line as shown on Plate I from the Kansas line southeastward to the southern boundary of Pawnee County.

GENERAL FEATURES.

The surface formations are Pennsylvanian and Permian in age. Near Pawnee the Redbeds include the Permian formations only, but farther north some of the Permian Redbeds change to non-red Permian. The Enid formation, lower Permian, does not include as much in the northern part of the area as in the southern part for the above reason. The Permian is conformable upon the Pennsylvanian. The surface rocks dip at a low angle to the west.

The thickness of the Redbeds ranges from 0 to about 700 or 800 feet. Logs of wells located near Morrison, east of Billings, south of Billings, and west of Blackwell show the following thicknesses of the Redbeds: 295, 200, 625, and 200 feet, respectively. In all of these wells the non-red Permian lies below the Redbeds.

As shown on Plate I, the lines swing to the northwest on account of the changing in character and color of the sediments, which is revealed both from the surface and well logs.

SOUTHERN AREA.

LOCATION.

The southern area extends from Pawnee County southward to Garvin County. It is limited on the west by the Central region and on the east by the non-red Pennsylvanian. It includes a part or all of the following counties: Payne, Lincoln, Creek, Okfuskee, Seminole, Pottawatomie, McClain, Pontotoc, and Cleveland.

GENERAL FEATURES.

The surface formations consist almost entirely of the red Pennsylvanian and the Enid formations of the Permian Redbeds. From north to south the red sediments gradually extend farther down into the Pennsylvanian, and reach the lowest point (stratigraphically) in the Pennsylvanian in the eastern part of Garvin and northwestern part of Murray counties. The surface rocks dip at a low angle to the west.

The thickness of the Redbeds varies from 0 to about 700 feet in this area. At Stillwater the Redbeds have a thickness of about 500 feet, and at Perkins, Lincoln County, they are about 50 feet thicker. Southeastward from these places the Redbeds are thicker, and the red color extends down to considerable depths. In the Cushing field the red color is prominent to a depth of about 1,000 feet and southward there is a tendency of the shales to become red in color. At Avery, Paden, and Stroud, logs of wells show the red color prominent to a depth of over 800 feet.

Plate I shows the lithobathyc lines swinging to the south and southwest from the east central part of Lincoln County. This feature is not due to the same cause as in the northern area, where the lines swing to the northwest on account of the change from red to non-red sediments to the north, but is principally due to a conforming to the general strike of the formations.

DEVELOPMENT IN THE REDBEDS AREA.

EARLY DEVELOPMENT.

It is not known when the first well was drilled in the Redbeds area. Some of the early discovered fields are Granite, Wheeler, Lawton, Gotebo, Loco, and Cruce in the Arbuckle and Wichita regions. The Wheeler field was discovered in 1904 by the Santa Fe Railroad Company. In all of the above fields, the production was very small, and found near the base of the Redbeds. In this early stage, the production so far found was little, which, together with the low price of oil and the success in the northeastern fields, tended to retard development.

DISCOVERY OF THE HEALDTON FIELD.

In 1913, the Healdton oil field was discovered. The first wells were small producers, but later large wells were completed and considerable development followed. At the present time this field is producing more oil than any other field in the Mid-Continent area. The Ripley field, near the eastern edge of the Redbeds, was also discovered during this period.

RECENT DEVELOPMENT.

Many of the northeastern fields are exhausted. This, together with the high price of oil, has tended to stimulate development in all parts of the State, but more especially in the Redbeds area. In the search for oil, the operators began migrating to the west, and new fields were discovered.

The most important fields recently discovered (1915) are Billings and Garber. The shallow production and high grade oil in the Garber field, and the completion of several good producers in the Billings field, have stimulated considerable development in the vicinity of these fields.

The discovery of oil and gas in the Fox district, north of the Healdton field, is very important, and development is increasing in that area. Other places, where there are a few good oil and gas wells, and good showings of oil and gas, are in the vicinity of Wynnewood, Kilgore, Cement, Walters, Morrison, Ingalls, and Maud. The last three mentioned are located near the eastern edge of the Redbeds.

FUTURE DEVELOPMENT.

At the present time, there are over 200 drilling wells, outside of the Healdton, Fox, Loco, Garber, and Billings fields, in the Redbeds area. The production of oil in Oklahoma is gradually decreasing because of the exhaustion of the older prolific fields. The price of oil is not decreasing. The tendency to seek new fields is very strong. Hence, many of the operators will be drawn to the Redbeds area, where a large amount of acreage may be obtained for drilling a well.

In the eastern part of the Redbeds area, there is some chance for success in bringing in new fields. Here, the Redbeds are relatively thin and can be easily penetrated. Any locality in this part of the Redbeds area having proper structure is fully worthy of a deep test under present conditions. All or part of the following counties in the Redbeds area may be classed under probable territory: Woods, Alfalfa, Grant, Kay, Noble, Garfield, Payne, Logan, Kingfisher, Major, Oklahoma, Lincoln, Cleveland, McClain, Garvin, Carter, Stephens, Grady, southern parts of Caddo and Washita, southeastern part of Beckham, eastern parts of Greer and Jackson, Tillman, Carter, Jefferson, and that part of Comanche, Kiowa, Caddo, and Greer counties outside of the Paleozoic rocks area in the Wichita Mountains. The depth to the base of the Redbeds in the above mentioned area ranges from 200 to about 1,500 feet.

Improbable territory in the Redbeds area lies in the western part of the central region and may be said to include all or a part of the following counties: Roger Mills, Custer, Dewey, northern parts of Caddo, Washita, and Beckham, Woodward, Ellis, Harper, Beaver, Texas, and Cimarron counties. In this region, the depth to the base of the Redbeds ranges from 1,500 to over 2,500 feet. The deepest part of the Redbeds is in Custer, Roger Mills, Ellis, Beaver, Texas, and Cimarron counties, and it is thought that, even with good structure, this area is not worthy of exploration under the present conditions.

WELL LOGS IN THE REDBEDS REGION.

The following well logs are given to show the character and thickness of the formations in the Redbeds region:

Log of Emily Kunsemuller Well No. 1, sec. 32, T. 6 N., R. 9 W., near Cement.

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Soil	5	5	Oil sand	30	700
Quicksand	85	90	Water sand	37	737
Red rock	5	95	White flake	3	740
White sandy shale	8	103	Gas sand	5	745
Red rock	27	130	Showing of oil	15	760
Gray sand-shale	3	133	Sandy blue shale	65	825
Red rock	17	150	Light brown shale	85	910
Dark blue mud	5	155	Blue shale	10	920
White sand-shale (g.)	50	205	Light brown shale	30	950
Red rock	65	270	Brown shale	135	1,085
White sand-shale	5	275	White sandy shale	15	1,100
Red rock	100	375	Blue sandy shale	45	1,145
White sand-shale (g.)	5	380	Blue sand	10	1,155
Red rock	15	395	Blue shale	25	1,180
Blue sand-shale (w.)	10	405	Brown blue mud	15	1,195
Red rock	25	430	Blue shale	20	1,215
Blue sandy shale	15	445	Brown sand	20	1,235
Red mud	15	460	White slate	10	1,245
Sand (water)	5	465	Hard brown shale	50	1,295
White flake	5	470	Hard shell	5	1,300
Sand	25	495	Brown sand (little oil)	5	1,305
Blue mud	15	510	Blue shale	10	1,315
Sand	15	525	Brown shale—caving	65	1,380
Hard sandy shale	10	535	Hard shell	5	1,385
Blue mud	3	538	Blue shale	26	1,412
Water sand	22	560	Gas sand, little gas	3	1,415
Blue shale	25	585	Gas sand, big gas	25	1,440
White sand	5	590	Brown sand	25	1,465
Blue shale	10	600	White slate	5	1,470
Brown sand	15	615	Oil sand, little oil	25	1,495
White slate	20	635	Oil sand, showing more oil	15	1,510
Brown sand	35	660			
Blue slate	10	670	Total depth		1,520

Log of well being drilled by J. L. Nations, sec. 22, T. 7 N., R. 16 W., Near Gotebo.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Red and blue shale	500	500	Lime	10	1,715
Lime, shale, and			Black shale	75	1,790
granite boulders	150	650	Lime, broken form	275	2,065
Blue limestone	80	730	Blue shale formation	20	2,085
Sandy blue shale,			Lime	30	2,115
show oil and gas	20	750	Blue shale	30	2,145
Hard blue limestone	85	835	Sand, show oil and gas	40	2,185
Red shale, cavy	15	850	Lime	50	2,235
Hard limestone	270	1,120	Sand, with more gas	25	2,260
Brown slaty limestone	60	1,180	Lime	15	2,275
Hard flinty limestone	245	1,425	Hard sandstone	60	2,335
Blue and black shale	200	1,625	Lime	95	2,430
Gray limestone	65	1,690	Blue shale, at	35	2,465
Brown sandy formation	15	1,705	Still drilling.		

Log of Langley Well No. 5, located in the SE. ¼ sec. 13, T. 7 S., R. 3 W.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Red clay	18	18	Blue marl	31	595
Water sand	8	26	Sand	25	620
Gravel	14	40	Blue marl	42	662
Water sand	15	55	Sand	18	680
Red bed	38	93	Redbeds	18	698
Water sand	22	115	Redbeds	60	759
Redbeds	59	174	Hard shell	6	764
Sandy red rock	41	215	Redbeds	71	835
Salt water sand	25	240	Water sand	17	852
Red beds	40	280	Blue marl	16	868
Sand	10	290	Red rock	142	1,010
Blue marl	20	310	Blue marl	5	1,015
Sand	12	322	Red rock	8	1,023
Blue marl	26	348	Blue marl	22	1,045
Hard shell	4	352	Water sand	45	1,090
Redbeds	65	417	Blue marl	20	1,110
Water sand	28	445	Blue shale	62	1,172
Redbeds	65	510	Blue shale	38	1,210
Sand	7	517	Sand—salt water	40	1,250
Redbeds	43	560	Blue shale	15	1,265
Hard shell	4	564	Sand	20	1,285

Log of Langley Well No. 5, located in the SE. ¼ sec. 13, T. 7 S., R. 3 W.—(Continued).

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Red rock	100	1,385	Water sand	17	1,742
Sand	12	1,397	Blue shale	8	1,750
Blue shale	86	1,483	Red rock	20	1,770
Red rock	37	1,520	Blue shale	17	1,787
Salt water sand	58	1,578	Water sand	25	1,812
Blue shale	47	1,625	Blue shale	14	1,826
Red rock	20	1,645	Sand	84	1,910
Blue shale	10	1,655	Slate	8	1,918
Sand	45	1,700	Lime—very hard	10	1,928
Blue shale	25	1,725	Sand and lime shells	81	2,009

W. C. Broyles Well No. 1, SE. ¼ sec. 23, T. 18 N., R. 4 E., Payne County.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Soil and sand	60	60	Sand	10	1,535
Water sand	18	78	Blue slate	20	1,555
Hard lime	4	82	Hard lime shell	5	1,560
Gumbo	18	100	Slate	10	1,570
Red clay or mud	401	501	Lime shell	3	1,573
Blue clay or mud	170	671	Sand	12	1,585
Sandy slate	39	710	Slate	125	1,710
Hard lime	4	714	Sand	25	1,735
Blue mud	46	760	Slate and shells	115	1,850
Hard lime	10	770	Shell	6	1,856
Blue mud	30	800	Oil sand	4	1,860
Red rock	20	820	Hard sand	4	1,864
Blue mud	50	870	Slate	13	1,877
Hard lime shell	1	871	Sand	30	1,907
Blue mud	84	955	Sand	43	1,950
Hard lime	8	963	Shell	10	1,960
Blue mud	117	1,080	Sand	130	2,090
Hard lime	10	1,090	Shale	23	2,113
Gumbo	23	1,113	Sand	17	2,130
Water sand	57	1,170	Shale	8	2,138
Gumbo	30	1,200	Sand	12	2,150
Red mud	30	1,230	Lime (hard)	3	2,153
Shale	10	1,240	Black slate	127	2,280
Gumbo	40	1,280	Gas sand	20	2,300
Red bed	5	1,285	Shale and slate	500	2,800
Gumbo and blue slate	240	1,525	Sand	40	2,840

W. C. Broyles Well No. 1, SE. ¼ sec. 23, T. 18 N., R. 4 E., Payne County.—Continued.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Sandy shale	100	2,940	Sand	23	3,153
Lime	36	2,975	Slate	104	3,257
Slate	5	2,980	Sand	17	3,274
Lime	30	3,010	Sandy shale	181	3,455
Slate	20	3,030	Sand	10	3,465
Shale	100	3,130	Slate	96	3,561

Mollie Ingram, Well No. 1, sec. 17, T. 4 S., R. 3 W.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Soil	5	5	Blue shale	5	870
Red mud	65	70	Sand and salt water	25	895
Blue mud	20	90	Brown shale	105	1,000
Red mud	55	145	Sand and salt water	30	1,030
Sand and water (s. w.)	15	160	Blue slate	20	1,050
Red shale	10	170	Brown shale	50	1,100
Blue shale	20	190	Blue shale	35	1,135
Red shale	35	225	Sand and salt water	20	1,155
Sand and water (s. w.)	25	250	Blue shale	5	1,160
Red shale	24	274	Red shale	20	1,180
Sand and water (s. w.)	26	300	Sand and salt water	25	1,205
Red shale	15	315	Pink shale	35	1,240
Sand and salt water	45	360	Brown shale	20	1,260
Red shale	70	430	Sand and salt water	12	1,272
Sand and salt water	45	360	Pink shale	8	1,280
Red shale	70	430	Blue shale	10	1,290
Sand and water (s. w.)	45	475	Sand and salt water	10	1,300
Red shale	81	556	Blue shale	22	1,322
Sand and salt water	21	577	Sand and salt water	11	1,333
Red shale	68	645	Sandy lime	8	1,341
Sand and salt water	30	675	Dark blue shale	12	1,353
Blue shale	20	695	White shale	12	1,353
Red shale	65	760	Brown shale	15	1,380
White shale	15	775	Sand and salt water	20	1,400
Lime shell	5	780	Blue shale	105	1,505
Sand and salt water	65	845	Sand and salt water	18	1,523
Blue shale	10	855	Blue shale	42	1,665
Sand and salt water	10	865	Sand and salt water	35	1,600

R. V. Newton, Well No. 1, sec. 29, T. 4 S., R. 3 W.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Red clay	30	30	Red rock	22	710
Water sand	5	35	Water sand	20	730
Red rock	95	130	Red rock	70	800
Water sand	5	155	White shale	20	820
Red rock	235	370	Red rock	60	880
Gray slate	90	460	Brown shale	10	890
Water sand	5	465	Red rock	40	930
Red rock	45	510	White shale	20	950
Blue shale	120	630	Red rock	25	975
Water sand	5	635	Water sand	15	990
Blue sand-shale	45	680	Gray slate	13	1,003
Water sand	8	688			

Log of El Reno Well, in sec. 3, T. 12 N., R. 7 W.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Black gumbo soil	3	3	Fine red sand	15	1,600
Coarse gray sand	50	53	Red shale	60	1,660
Red shale	1,042	1,095	Fine brown sand	12	1,672
Coarse red shale	127	1,222	Red shale	8	1,680
Fine red sand	6	1,228	Fine red to white sand	3	1,683
Red shale	17	1,245	Red shale	62	1,745
Fine red sand	5	1,250	Brown sand	5	1,750
Red shale	25	1,275	Red shale with nodules	20	1,770
Coarse red sand with clay nodules	7	1,282	Coarse brown shale	50	1,820
			Blue shale	10	1,830
Red shale	60	1,342	Brown shale	20	1,850
Red sand	6	1,348	Blue shale	15	1,865
Shale	7	1,355	Brown shale	5	1,870
Fine red sand	47	1,402	Brown shale	15	1,885
Red shale	10	1,412	Brown sand	5	1,890
Red sand	15	1,427	Brown sand	15	1,905
Red shale	8	1,435	Brown shale	25	1,930
Red sand	40	1,475	Blue shale	10	1,940
Red shale (with nodular grains)	20	1,495	Brown shale	10	1,950
			Blue shale	10	1,960
Fine red sand	49	1,544	Brown shale	40	2,000
Coarse red shale	8	1,552	Blue to brown shale	10	2,010
Fine red sand	8	1,560	Brown to blue shale	20	2,030
Red shale	8	1,568	Blue shale	10	2,040
Fine red sand	11	1,579	Brown shale	10	2,050
Red shale	6	1,585	Blue slate	265	2,315

Log of El Reno Well, in sec. 3, T. 12 N., R. 7 W.—(Continued).

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Coarse brown shale	5	2,320	Blue shale	17	3,002
Blue shale	50	2,370	Blue shale	46	3,048
Brown shale	100	2,470	Sand and lime conglomerate	30	3,078
Blue nodular shale	145	2,615	Coarse brownish shale	107	3,185
Blue shale	218	2,845	Brown sand	5	3,190
Brown shale	35	2,880	Coarse brownish shale	30	3,220
Blue shale	20	2,900	Brown shale	95	3,315
Limestone	2	2,902			
Brown shale	83	2,985			

Log of Well near Tecumseh, on Spencer farm, T. 9 N., R. 3 E.

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Soil	1	1	Sand rock	7	597
Sand	8	9	Red clay shale	17	614
Red clay shale	20	29	Sand rock	8	622
Gravel (with fine water)	4	33	Red clay shale	8	630
Red clay shale	117	150	Sand rock	16	646
Sand rock	6	156	Limestone	24	670
Red clay shale	119	275	Blue sky shale	9	679
Red sand shale	8	283	Limestone	8	687
Sand shale	29	312	Red and blue shale	37	724
Sand (with water)	5	317	Blue clay shale	7	731
Red clay shale	5	322	Red clay shale	6	737
Sand	5	327	Blue clay shale	25	762
Sand rock (water)	15	342	Red clay shale	17	779
Red clay shale	23	365	Hard pan	5	784
Sandy shale	9	374	Red clay shale	8	792
Gray clay shale	82	456	Hard pan	16	808
Sandy shale	5	461	Red clay shale	2	810
Sand rock (hard)	2	463	Hard pan	17	827
Red clay shale	24	487	Blue clay shale	6	833
Sand rock	4	491	Red clay shale	34	867
Red clay shale	5	496	Gray clay shale	27	894
Sand rock (water)	10	506	Red and green clay shale	15	909
Sandy shale	40	546	Red clay shale	3	912
Red clay shale	14	560	Sand	7	919
Sand rock (red cast)	18	578	Red clay shale	5	924
Red clay shale	12	590	Gray sand	3	927

Log of Well near Tecumseh, on Spencer farm, T. 9 N., R. 3 E. (Continued).

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Red clay shale	4	931	Gray sand	10	1,504
Limestone (mixed with sand)	7	938	Sandy shale	10	1,514
Sand rock (gray)	3	941	Red clay shale	30	1,544
Red clay shale	24	965	Gray clay shale	9	1,553
Gray clay shale (also shell)	6	971	Gray lime	2	1,555
Red and gray clay shale	30	1,001	Red clay shale (with lime shale)	5	1,560
Red clay shale	19	1,020	Sand rock	15	1,575
Red and gray clay shale	15	1,035	Gray clay shale	6	1,581
Limestone	11	1,046	Red clay shale	2	1,583
Sand rock (salt water)	24	1,070	Gray sand rock	15	1,598
Red clay shale	9	1,079	Red clay shale	7	1,605
Red clay shale	20	1,099	Red clay shale	4	1,609
Gray clay shale	21	1,120	Limestone	20	1,629
Blue clay shale	3	1,123	Blue clay shale	6	1,635
Limestone	3	1,126	Gray clay shale	10	1,645
Red clay shale	3	1,129	Red clay shale	10	1,655
Gray clay shale (lime)	3	1,132	Sand rock	44	1,699
Red clay shale	28	1,160	Gray clay shale	2	1,701
Sand rock (salt water)	16	1,176	Limestone	12	1,713
Red clay shale (shells)	15	1,191	Gray clay shale	10	1,723
Red clay shale	13	1,204	Red clay shale	5	1,728
Gray clay shale	5	1,209	Sandy shale	8	1,736
Red clay shale	21	1,230	Red clay shale	7	1,743
Sand rock (salt water)	16	1,246	Gray clay shale	20	1,763
Gray clay shale	24	1,270	Limestone (hard)	9	1,772
Red clay shale	8	1,278	Impure limestone (sandy)	9	1,781
Gray clay shale	24	1,302	Limestone	17	1,798
Red clay shale	2	1,304	Blue clay shale	6	1,804
Sand shale (little water)	8	1,312	Red clay shale	7	1,811
Red clay shale	22	1,334	Blue clay shale	8	1,819
Gray clay shale	26	1,360	Gray sand	6	1,825
Red clay shale	90	1,450	Red clay shale	8	1,833
Gray sand	11	1,461	Gray clay shale	2	1,835
Gray clay shale	2	1,463	Gray sandy shale	10	1,845
Red clay shale	19	1,482	Gray sand (with salt water)	17	1,862
Red clay shale with limestone	4	1,486	Sandy rock	14	1,876
Red clay shale	8	1,494	Gray shale	5	1,881
			Red clay shale	8	1,889
			Red shale	5	1,894
			Sandy shale	12	1,906

Log of Well near Tecumseh, on Spencer farm, T. 9 N., R. 3 E. (*Continued*).

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Sand rock	15	1,921	Sand rock	7	1,954
Gray shale (shells of ss.)	26	1,947	Red clay shale	2	1,956

Thompson Well No. 1, NE. cor. S. ½ SE. ¼ sec. 23, T. 18 N., R. 5 E.,

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Soil	15	15	Sand	25	1,125
Sand	10	25	Red rock	10	1,135
Red rock	45	70	Slate	55	1,190
Slate	5	75	Sand	20	1,210
Red rock	35	110	Slate	5	1,215
Sand	40	150	Sand	10	1,225
Slate	10	160	Slate	20	1,245
Red rock	50	210	Lime	10	1,255
Slate	20	230	Sand	30	1,285
Red rock	50	280	Slate	135	1,420
Lime	7	287	Sand	10	1,430
Red rock	58	345	Lime	11	1,441
Sand	111	456	Sand	19	1,460
Slate	34	490	Slate	67	1,527
Lime	15	505	Lime	3	1,530
Slate	30	535	Sand	25	1,555
Sand	10	545	Slate	65	1,620
Slate	15	560	Lime	6	1,626
Sand	25	585	Slate	59	1,685
Slate	17	602	Sand	75	1,760
Sand	15	617	Lime	20	1,780
Slate	63	680	Slate	70	1,850
Sand	35	715	Lime	15	1,865
Slate	23	738	Slate	65	1,930
Sand	10	748	Lime	10	1,940
Slate	52	800	Slate	40	1,980
Sand	40	840	Lime	5	1,985
Slate	50	890	Slate	85	2,070
Red rock	105	995	Lime	10	2,080
Sand	45	1,040	Slate	62	2,142
Red rock	20	1,060	Sand (1 M. gas)	36	2,178
Sand	10	1,070	Slate	23	2,201
Red rock	30	1,100	Lime	5	2,206

Thompson Well No. 1, NE. cor. S. ½ SE. ¼ sec. 23, T. 18 N., R. 5 E., (*Continued*)

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Slate	25	2,231	Slate	90	2,730
Lime	4	2,235	Sandy shale	105	2,835
Slate	3	2,238	Lime	30	2,865
Sand (¼ M. gas)	5	2,343	Slate	20	2,885
Slate	102	2,445	Lime	37	2,922
Lime	10	2,455	Slate	7	2,929
Slate	70	2,525	Lime	3	2,932
Lime	15	2,540	Slate	12	2,944
Slate	55	2,595	Lime (1 M. gas)	3	2,947
Lime	45	2,640	Sand (17 M. gas)	9	2,956

Log of Howe Well No. 1, located on the NE. ¼, sec. 11, T. 19 N., R. 1 W., Payne County, Oklahoma, known as the Von Tacky well.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Conductor	36	36	Red rock	10	860
Surface clay	24	60	Water sand	40	900
Quicksand	20	80	Blue slate	10	910
Red rock	20	100	Red rock	40	950
Shally formation	35	135	Water sand	10	960
Red rock	65	200	Brown shale	30	990
Sandy formation	10	210	Red rock	25	1,015
Brown shale	80	290	Water sand	5	1,020
Red rock	70	360	Lime	5	1,025
Lime shell	5	365	Blue shale	25	1,050
Blue slate	35	400	Lime shell	5	1,055
Red rock	50	450	Brown shale	5	1,060
Sandy formation	10	460	Water sand	5	1,065
Brown shale	40	500	Blue slate	30	1,095
Red rock formation	100	600	Red rock	30	1,125
Lime shell	10	610	Lime	10	1,135
Red rock	55	665	Blue slate	35	1,170
Water sand	10	675	Red rock	30	1,200
Lime	5	680	Lime	15	1,215
Red rock	20	700	Red rock	35	1,250
Blue mud	45	745	Lime	10	1,260
Water sand	5	750	Blue slate	10	1,270
Blue slate	30	780	Lime	10	1,280
Water sand	20	800	Blue slate	20	1,300
Red rock	8	808	Lime	15	1,315
Water sand	32	840	Blue slate	15	1,330
Blue slate	10	850	Lime	15	1,345

Log of Howe Well No. 1, located on the NE. ¼, sec. 11, T. 19 N., R. 1 W., Payne County, Oklahoma, known as the Von Tacky well.
—Continued.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Red rock	30	1,375	Lime	5	1,805
Lime	5	1,380	Blue slate	5	1,810
Blue slate	40	1,420	Black slate	5	1,815
Red rock	10	1,430	Lime	5	1,820
Lime	5	1,435	Blue slate	5	1,825
Red rock	10	1,445	Lime	3	1,828
Lime	5	1,450	Blue slate	12	1,840
Sand	5	1,455	Red rock	5	1,845
Red rock	3	1,458	Sand	10	1,855
Sand	2	1,460	Lime (gas)	5	1,860
Lime	5	1,465	Blue slate	40	1,900
Blue slate	55	1,520	Red rock	5	1,905
Lime	10	1,530	Blue slate	5	1,910
Blue slate	35	1,565	Red rock	5	1,915
Red rock	5	1,570	Blue slate	5	1,920
Blue slate	10	1,580	Lime	5	1,925
Sandy formation	10	1,590	Blue slate	5	1,930
Lime	10	1,600	Red lime	2	1,932
Red rock	5	1,605	Blue slate	3	1,935
Lime	15	1,620	Lime	11	1,946
Black slate formation	15	1,635	Black slate	4	1,950
Lime	5	1,640	Lime	30	1,980
Black slate	10	1,650	Blue slate	5	1,985
Lime	2	1,652	Red rock	20	2,005
Black slate.	6	1,658	Lime	10	2,015
Lime	2	1,660	Red rock	5	2,020
Black slate	15	1,675	Blue slate	17	2,037
Red rock	5	1,680	Sand and water (gas)	18	2,055
Black slate	10	1,690	Lime	5	2,060
Lime	5	1,695	Slate	60	2,120
Black shale	15	1,710	Lime	10	2,130
Lime	5	1,715	Slate	5	2,135
Blue slate	10	1,725	Sand	13	2,148
Red rock	35	1,760	Sandy slate	27	2,175
Blue slate	15	1,775	Lime	25	2,200
Lime	5	1,780	Slate	20	2,220
Sand	10	1,790	Sand	20	2,240
Lime	5	1,795	Slate	20	2,260
Blue shale	5	1,800	Lime		

Log of well, John Barnes No. 1, NE. ¼, SE. ¼ sec. 23, T. 19 N., R. 2 E., SE. part of city.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Surface clay	28	28	Sandstone	15	555
Quicksand	10	38	Clay	20	575
Red clay	25	63	Sandstone	10	585
Sandstone	25	88	Black shale	60	645
Red clay	20	108	Limestone	5	650
Sandstone	10	118	Black shale and slate	24	674
Red clay	12	130	Sandstone	10	684
Sandstone	10	140	Black shale and slate	30	715
Gray slate and lime	15	155	Sandstone	8	723
Clay	10	165	Shale and slate (caving)	90	813
Sandstone	15	180	Sandstone	5	818
Clay	25	205	Black slate	13	831
Sandstone	15	220	Limestone	8	839
Clay	25	245	Slate	10	849
Sandstone	17	262	Sandstone	5	854
Clay	26	288	Black slate	25	879
Sandstone	5	293	White sand (heavy water)	40	917
Clay	22	315	Gray shale	40	959
Sandstone	25	340	Sandstone (heavy water)	20	979
Clay	40	380	Oil sand at		970
Gray slate	10	390	Shale	10	989
Clay	32	422	Dry sand, trace of oil	171	1,200
Sandstone	10	432	Shale	171	1,200
Clay	28	460			
Sandstone	15	475			
Blue slate	35	510			
Clay, chocolate	30	540			

Log of Reform School Well. NW. ¼ sec. 33, T. 3 N., R. 1 E.

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Surface clay	10	10	Red gumbo	6	724
Soft sand rock	15	25	Shale	40	764
Hard sand rock	45	70	Shale	36	800
Salt water sand	10	80	Blue lime	4	804
Soft dry sand	22	102	Red shale	60	864
Pack sand, dry	44	146	Blue lime	12	876
Hard gumbo	12	158	Red shale	15	891
Pack sand, dry	26	184	Gypsum	57	948
Pack sand, dry	12	196	Shale	37	985
Shale	17	213	Rock	17	1,002
Hard gumbo	10	223	Lime rock	23	1,025
Hard sand rock	11	234	Red shale	20	1,045
Gumbo	8	242	Flint rock	15	1,060
Pack sand	16	258	Red shale	10	1,070
Hard shale	19	277	Lime rock	12	1,082
Rock	3	280	Red shale	18	1,100
Hard shale	100	380	Lime rock	24	1,124
Soft shale	143	423	Blue sand	11	1,135
Shale gumbo	18	441	Flint rock	3	1,138
Gumbo	7	448	Red shale	76	1,214
Sand rock	18	466	Flint rock	2	1,216
Shaly gumbo	20	486	Shale	11	1,227
Shale	63	549	Soft sand rock	15	1,242
Red gumbo	12	561	Blue gumbo	14	1,256
Shale	35	596	Hard flint rock	3	1,259
Shale	34	630	Sand rock	42	*1,301
Sand	4	634	Sand and salt water	16	1,317
Lime rock	6	640			
Shale	74	714			
Rock	4	718	*Show of oil and gas.		

Apple & Franklin, Well No. 1, sec. 8, T. 4 S., R. 3 W.

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Red rock	120	120	Sand	20	380
Water sand	30	150	Blue shale	246	626
Red rock	70	220	Gas sand (no gas)	8	634
Water sand	25	245	Blue shale	210	844
Red rock	35	280	Oil sand (2 bbl. well at 844)	41	885
Sand	25	305	Blue shale	46	931
Red rock	25	330	Oil sand (oil and gas at 933)	16	947
Water sand	10	340			
Blue shale	20	360			

Log of Deep Well Drilled at Clinton, Custer County, Oklahoma.

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Soil	5	5	Blue clay	45	945
Clay	10	15	Red rock	455	1,400
White sand	20	35	Sand, dry	12	1,412
Quicksand and water	67	102	Red rock	98	1,510
Gyp rock	12	114	Blue clay	90	1,600
Sand	151	265	Red rock	190	1,790
Quick sand	137	402	Blue clay	10	1,800
Gyp rock	10	412	Red rock	200	2,000
Sand and water	38	450	White sand, dry	15	2,015
Red clay	30	480	Red rock	25	2,040
Quick sand	17	49[illegible]	Blue clay	40	2,080
Red clay	53	550	Red rock	60	2,140
Blue clay	50	600	Blue shale	10	2,150
Red clay	100	700	Red rock	82	2,233
Blue clay	15	715	Shell	5	2,238
Red clay	30	745	Sand, dry	12	2,250
Blue clay	100	845	Red rock and thin shell	257	2,507
Gyp rock	20	865	White sand, dry	15	2,522
Red rock	35	900			

Enid Well, NW. cor. sec. 30, T. 23 N., R. 6 W.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Surface	48	48	Red rock	10	2,615
Red sand and shale	782	830	Lime	25	2,640
Lime shell	2	832	Red rock	20	2,660
Red and sandy shale	168	1,000	Slate (white)	20	2,680
Shale	430	1,430	Lime	5	2,685
Lime	10	1,440	Slate (white)	5	2,690
Shale	160	1,600	Lime	60	2,750
Lime shell	5	1,605	Slate (white)	20	2,770
Slate and rotten shale	195	1,800	Slate cave (bk.)	15	2,785
Lime	20	1,820	Slate (white)	15	2,800
Slate	70	1,890	Lime	5	2,805
Lime	40	1,930	Slate (white)	45	2,850
Slate	70	2,000	Lime	10	2,860
Lime shell	10	2,010	Slate (white)	40	2,900
Slate	105	2,115	Lime	10	2,910
Sand	50	2,165	Slate (white)	35	2,945
Red rock	55	2,220	Lime	5	2,950
White slate	40	2,260	Slate (white)	50	3,000
Lime stone	8	2,268	Lime shells	10	3,010
Red rock	72	2,340	Slate	20	3,030
Slate (white)	30	2,370	Lime shells	30	3,060
Red rock	40	2,410	Slate	55	3,115
White slate	20	2,430	Lime shells	1	3,116
Red rock	55	2,485	Slate	11	3,127
Slate (white)	35	2,520	Lime	15	3,142
Red rock	30	2,550	Slate	23	3,165
Lime	10	2,560	Lime	10	3,175
Lime (bk.)	20	2,580	Sand	7	3,182
Slate (white)	10	2,590	Slate	28	3,210
Lime	5	2,595	Lime and slate	155	3,365
Slate (bk.)	10	2,605	Water at		3,365

Green River Oil and Gas Company's Well No. 1, NE. ¼ sec. 25, T. 4 S., R. 13 W.

Character of rock.	Thickness Feet.	Depth Feet.	Character of rock.	Thickness Feet.	Depth Feet.
Mud, variegated, red, brown, light colors	600	600	on top	50	1,622
Brown sand with water	8	608	Shale, white, bad caye	108	1,730
Mud of many colors	117	725	Shale, black	15	1,745
Sand, dry	7	732	Slate, blue	25	1,770
Mud	60	792	Red bed	31	1,801
Dry sand	8	800	Shell, hard	5	1,806
Mud	258	1,058	Slate, red, caving a little	5	1,811
Water sand	30	1,088	Sand, shell and hard boulder cave	20	1,831
Slate, brown	32	1,120	Brown mud	9	1,840
Dry sand	10	1,130	Blue clay	44	1,884
Slate, red, bad cave	30	1,160	Water sand	24	1,910
Slate, blue. (Water shut off at 1,168 fet.)	20	1,180	Red clay	15	1,925
Dry sand	5	1,185	Blue shale and thin shell	57	1,982
Slate, blue	22	1,207	Lime	20	2,002
Water sand	58	1,265	Blue shale	5	2,007
Red	5	1,270	Brown shale, thin shells	18	2,025
Slate, blue (water shut off 1,275 feet)	68	1,338	Hard shell	2	2,027
Water sand	17	1,355	Red cave	3	2,030
Slate, blue	10	1,365	Slate and shells	12	2,042
Red cave	5	1,370	Water sand	15	2,057
Slate, light color (bad cave)	78	1,448	Shale and sand shells	243	2,300
Red mud	11	1,459	Sand, white, full of water	18	2,318
Slate, blue	11	1,470	Sand, dark	5	2,323
Sand and water	23	1,493	Shale, blue	37	2,360
Slate, light color	22	1,515	Sandy shale, shell	165	2,525
Red mud	35	1,550	White slate	47	2,572
Slate, blue	15	1,565	Brown shale cave	15	2,587
Brown mud	7	1,572	Water sand (hole filed up)	8	2,595
Slate, blue, thin shell					

Log of well in NE. corner of SE. ¼ sec. 33, T. 5. N., R. 28 E., near Gate, Beaver County.

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Soil	5	5	Lime	10	1,015
Sandy clay	20	25	Red rock	30	1,045
Red rock	15	40	Salt	3	1,048
Water sand	8	48	Sandy lime	17	1,065
Red rock	35	83	Red rock	2	1,067
Water, sand	7	90	Sandy lime	13	1,080
Red rock	80	170	Red rock	5	1,085
Water, sand	8	178	Sandy lime	15	1,100
Red rock	87	265	Red rock	23	1,123
Sandy lime	3	268	Red lime	7	1,130
Red rock	7	275	Red rock	10	1,140
Sand	25	300	Sandy lime	15	1,155
Red rock	50	350	Red rock	5	1,160
Sandy lime	3	353	Salt	6	1,166
Red rock	9	362	Lime, gray	11	1,177
Lime and gypsum	33	395	Red rock	11	1,188
Lime, white	17	412	Red rock	12	1,200
Blue shale	8	420	Blue lime	13	1,213
Brown shale	30	450	Lime	20	1,235
Sandy lime	17	467	Red rock	15	1,250
Salt	100	567	Salt	38	1,288
Red rock	5	572	Red rock	2	1,290
Salt	13	585	Salt	105	1,395
Red rock	35	620	Blue slate	10	1,405
Salt	10	630	Salt	25	1,430
Red rock	40	670	Red rock	80	1,510
Salt	50	720	Blue slate	18	1,528
Red rock	20	740	Red rock	20	1,548
Sand	3	743	Blue slate	15	1,563
Red rock	97	840	Red rock	12	1,575
Sand	2	842	Brown slate	25	1,600
Red rock	18	860	Red rock	25	1,625
Sandy lime	5	865	Brown slate	25	1,650
Red rock	25	890	Red rock	75	1,725
Sand	2	892	Blue slate	40	1,765
Red rock	13	905	Lime	5	1,770
Blue slate	5	910	Blue slate	5	1,775
Red rock	60	970	Lime	5	1,780
Lime	8	978	Blue shale	15	1,895
Red rock	7	985	Lime	25	1,820
Sandy lime	15	1,000	Blue shale	3	1,823
Red rock	5	1,005	Lime	17	1,840

Log of well in NE. corner of SE. ¼ sec. 33, T. 5 N., R. 28 E., near Gate, Beaver County.—(Continued).

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Blue slate	15	1,855	Lime	5	2,107
Lime	40	1,895	Salt	58	2,165
Slate	5	1,900	Lime	5	2,170
Lime	5	1,905	Salt	20	2,190
Slate	10	1,915	Slate	15	2,205
Lime	3	1,918	Lime	40	2,245
Slate	25	1,943	Slate	3	2,248
Lime	15	1,958	Lime	117	2,365
Salt	17	1,975	Sand—lime	5	2,370
Lime	15	1,990	Salt	25	2,395
Salt	7	1,997	Lime	109	2,504
Shale	18	2,015	Lime	161	2,665
Salt	5	2,020	Gray slate	2	2,667
Lime	15	2,035	Sandy lime	83	2,750
Salt	5	2,040	Water sand	15	2,765
Sand lime	10	2,050	Slate	5	2,770
Salt	13	2,063	Water sand	5	2,775
Lime shale	24	2,087	Red slate	5	2,780
Lime	5	2,092	Sandy lime, water	52	2,832
Lime and slate	10	2,102	Slate	5	2,837

Log of Merchants Oil & Gas Company well No. 1, in the NE. cor. SW. ¼ sec. 5, T. 11 N., R. 2 W.

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Surface soil, sandy loam	23	23	Red clay and shale	45	650
Sand, fresh water	4	27	Red clay, shale, boulders	45	695
Red shale and soft red sand rock	12	39	Sand rock	4	699
Dark hard gumbo	2	41	Red clay and shale	10	709
Soft red sand rock	219	260	White sand, rock, trace gas	11	720
Red clay and gumbo	70	430	Blue shale	2	722
Soft sand shell	2	432	Red clay, shale, gypsum	78	800
Red beds, kaolin and chalk	76	508	Red beds—clay, shale, gypsum, boulders	68	868
Gypsum	4	512	Hard white rock	11	879
Red shale and clay streaked with gypsum	68	580	Red shale, clay, and boulders	46	925
Gypsum	5	585	White sand rock	5	930
Red shale with gypsum	20	605			

Log of Merchants Oil & Gas Company well No. 1, in the NE. cor. SW. ¼ sec. 5, T. 11 N., R. 2 W.—Continued.

Character of rock.	Thickness *Feet.*	Depth *Feet.*
Soft red clay	20	950
White sand rock	10	960
Red shale, broken rock	40	1,000
Red shale, clay and gypsum streaks	50	1,050
White sand rock	5	1,055
Red soft clay	15	1,070
Red shale, broken rock	19	1,089
Red gumbo	21	1,110
Hard sand rock	2	1,112
Red shale, clay, gypsum, boulders	38	1,150
White sand rock	10	1,160
Red shale	40	1,200
Red gumbo	18	1,218
Hard white sand rock	11	1,229
Red shale and broken rock	19	1,248
Red clay	5	1,253
White sand rock	3	1,256
Red clay, gypsum streaks	4	1,260
White sand rock	3	1,263
Red clay, gypsum streaks	20	1,283
Red shale, boulders	7	1,290
Red gumbo	21	1,311
Crystal gypsum	2	1,313
Red clay	7	1,320
White sand rock	3	1,323
Red shale, boulders	5	1,328
White sand rock	14	1,342
Red clay and blue gypsum	8	1,350
Red shale and gypsum	40	1,390
Hard sandy rock	10	1,400
Brown and blue shale	72	1,472
Brown shale	26	1,498
Sandy shale	2	1,500
Brown and blue shale	100	1,600
Soft sand rock	2	1,602
Brown shale	38	1,640
Brown clay and shale	60	1,700
Brown and blue shale	65	1,765
Brown gumbo	32	1,797
Shell rock	1	1,798
Dark gray shale	77	1,875
Hard white lime rock	7	1,882
Sandy shale, boulders	18	1,900
Lime rock	1	1,901
Brown and gray shale	47	1,948
Brown gumbo	24	1,972
Brown and gray shale boulders and gumbo	90	2,062
Brown and gray shale	30	2,092
White lime sandy rock pyrites in bottom	65	2,157
Brown gumbo	4	2,161
Brown shale, trace oil	17	2,178
Brown gumbo	8	2,186
Shell rock	1	2,187
Yellow and brown clay mixed with lime	8	2,195
Lime rock	9	2,204
Brown clay, boulders	7	2,211
Blue shale, boulders	70	2,281
Blue lime rock	7	2,288
Blue shale, boulders	9	2,297
Hard blue lime rock, sandy	7	2,304
Blue shale	8	2,312
Blue lime rock	2	2,314
Blue shale	10	2,324
Lime rock, blue and sandy	12	2,336
Blue mixed shale	46	2,382
White and red mixed sand rock	4	2,386
Blue and brown shale	31	2,417
Sandy lime rock	8	2,425
Blue, brown and yellow shale, lime and sand streaks	75	2,500

Log of Merchants Oil & Gas Company well No. 1, in the NE. cor. SW. ½ sec. 5 T. 11 N., R. 2 W.—(Continued).

Character of rock.	Thickness *Feet.*	Depth *Feet.*
Blue shale, muddy, with traces of lime	85	2,585
Sandy lime rock	5	2,590
Mixed shale, lime	20	2,615
Hard sandy lime	5	2,615
Mixed shale, lime	20	2,635
Soft blue shale	45	2,680
Lime rock	28	2,708
Tough blue shale or gumbo	6	2,714
Hard lime rock	4	2,718
Mixed shale	6	2,724
Lime rock	6	2,730
Mixed shale, lime streaks	45	2,775
Hard mixed shale	49	2,824
Hard gray rock, sandy	6	2,830
Mixed shale	16	2,846
Hard gray rock	4	2,850
Mixed shale	32	2,882
Gray sandy rock	4	2,886
Blue shale	49	2,935
Gray sandy rock	25	2,960
Blue shale	20	2,980
Gray sandy rock	5	2,985
Blue shale	10	2,995
Sandy lime rock	6	3,001

Chandler deep well, in sec. 4, T. 14 N., R. 4 E.

Character of rock.	Thickness *Feet.*	Depth *Feet.*
Red clay	30	30
Red sand	30	60
Water, sand	5	65
Water, sand	70	135
Red shale	30	165
White shale	70	235
Red shale	10	245
White shale	15	260
Red shale	30	290
White shale	30	320
Blue shale	30	350
Red shale	200	550
Water, sand	10	560
Blue shale	40	600
Red shale	40	640
Lime	5	645
Blue shale	10	655
Water, sand	15	670
Blue shale	20	690
Lime	6	696
Blue shale	10	706
Water, sand	40	746
Blue shale	50	796
Red shale	30	826
Yellow clay	15	841
Blue shale	20	861
Red shale	4	865
Sand	8	873
Blue shale	6	879
Water, sand	30	909
Blue shale	50	959
Red shale	31	990
Lime	8	998
Yellow clay	20	1,018
Red shale	182	1,200
Water, sand	80	1,280
Blue shale	20	1,300
Lime	20	1,320
Blue mud	70	1,390
Lime	4	1,394
Blue mud	10	1,404
Lime	2	1,406
Red mud	20	1,426
Red shale	50	1,476

Chandler deep well, in sec. 4, T. 14 N., R. 4 E.—(Continued).

Character of rock.	Thick-ness Feet.	Depth Feet.	Character of rock.	Thick-ness Feet.	Depth Feet.
Sand	24	1,500	Blue mud	10	2,090
Blue mud	50	1,550	Sand	50	2,140
Red mud	40	1,590	Blue mud	10	2,150
Sand	30	1,620	Water, sand	50	2,200
Blue mud	30	1,650	Blue mud	20	2,220
Red rock	40	1,690	Sand	20	2,240
Sand	30	1,720	Blue shale	60	2,300
Red mud	40	1,760	Sand shale	4	2,304
Blue mud	20	1,780	Blue shale	76	2,380
Water, sand	20	1,800	Water, sand	10	2,390
Lime	10	1,810	White slate	5	2,395
Blue mud	40	1,850	Brown slate	13	2,408
Water, sand	50	1,900	Lime and sand	20	2,428
Blue mud	75	1,975	Blue shale	7	2,435
Water, sand	25	2,000	Sand and lime	40	2,475
Blue mud	20	2,020	Blue shale	5	2,480
Sand	60	2,080	Sand	45	2,525

Log of Well in W. ½ sec. 24, T. 7 N., R. 21 W.

Character of rock.	Thick-ness Feet.	Depth Feet.	Character of rock.	Thick-ness Feet.	Depth Feet.
Red clay	8	8	Red and soft green, and red shale	50	850
Quicksand	10	18	Conglomerate, salt water	65	915
Green shale	92	110	Mixed sand and shale	5	920
Brown shale	4	114	Green shale	8	928
Green shale	20	134	Mixed green and light shale	10	938
Red shale	46	180	Green shale	77	1,015
Light gray sand rock	5	185	Sand rock, oil show	44	1,059
Shale	135	320	Sand rock, oil showing prominently	12	1,071
Gyp rock	3	323	Sand rock, soft	6	1,077
Green shale	5	328	Mixed sand, green and red shale	73	1,150
Red shale	28	366	Mixed hard and soft sand rock	30	1,180
Green shale, some gas	15	371	Coarse sand rock	35	1,215
Red shale	307	678	Mixed sand	25	1,240
Green shale	3	681	Sand rock	176	1,416
Red and green shale	19	700			
Hard and soft strata, showing of oil and gas at 750 feet, red and green shale, hard shells	100	800			

Log of Well in W. ½ sec. 24, T. 7 N., R. 21 W.—(Continued).

Character of rock.	Thick-ness Feet.	Depth Feet.	Character of rock.	Thick-ness Feet.	Depth Feet.
Quartz	100	1,516	Gray sand rock	241	1,865
Sandstone	59	1,575	Shale	5	1,870
Mixed green and red shale	15	1,590	Sandy shale	90	1,960
Gray sand rock, some oil and gas	34	1,624	Sandy shale	25	1,985
			Bituminous sand rock	150	2,135

Baker, No. 1, sec. 19, T. 6 N., R. 4 W., near Grady.

Character of rock.	Thick-ness. Feet	Depth. Feet	Character of rock.	Thick-ness. Feet.	Depth. Feet.
Surface soil	5	5	Sand (salt water)	30	630
Red clay	45	50	Sandy blue shale	230	860
Blue shale	50	100	Sand (salt water)	28	888
Red rock (cover)	200	300	Blue shale	72	960
Blue shale	20	320	Dry sand	7	967
Water sand (fresh)	30	350	Blue shale	263	1,230
Blue shale	150	500	Sand (salt water)	15	1,245
Red rock	50	550	Blue shale (bad cave)	175	1,420
Blue shale	50	600	Sand (salt water)	15	1,435

Well at Mulhall in NE. ¼ sec. 4, T. 18 N., R. 2 W.

Character of rock.	Thick-ness. Feet	Depth. Feet	Character of rock.	Thick-ness. Feet.	Depth. Feet.
Surface soil	47	47	Gray shale	128	908
Red shale	225	272	Lime	9	917
Lime	3	275	Gray shale	8	925
Red shale	21	296	Lime	3	928
Sand	6	302	Gray shale	12	940
Gray shale	5	307	Sand	18	958
Lime	28	335	Gray shale	57	1,015
Red shale	103	438	Red shale	30	1,045
Lime	12	450	Brown shale	25	1,070
Red shale	135	585	[illegible]	[illegible]	1,074
[illegible]	17	602	Blue shale	41	1,115
Gray shale	13	615	Lime	22	1,137
Lime	28	643	Sandy shale	28	1,165
Gray shale	32	675	Sand	30	1,195
Red shale	5	680	Blue shale	17	1,212
Lime	55	735	Lime	19	1,231
Gray shale	45	780	Gray shale	29	1,260

Well at Mulhall in NE. ¼ sec. 4, T. 18 N., R. 2 W.—(Continued).

Character of rock.	Thickness *Feet.*	Depth *Feet.*	Character of rock.	Thickness *Feet.*	Depth *Feet.*
Lime	6	1,266	Red shale	5	1,615
Red rock	5	1,271	Salt water sand	20	1,635
Blue shale	43	1,314	Red shale	5	1,640
Lime and shale	6	1,320	Blue shale	15	1,655
Sand and water	12	1,332	Lime	5	1,660
Red rock	2	1,334	Red shale	15	1,675
Sand	21	1,355	Sand and water	15	1,690
Shale	14	1,369	Blue shale	10	1,700
Lime	8	1,377	Sand	5	1,705
Brown shale	23	1,400	Blue shale	35	1,740
Sand shale	13	1,413	Shale and lime	10	1,750
Brown shale	17	1,430	Brown sand	10	1,760
Blue shale	7	1,437	Blue shale	10	1,770
Lime	8	1,445	Brown shale	5	1,775
Blue shale	38	1,483	Blue shale	15	1,790
Lime	20	1,503	Sand shale	5	1,795
Blue shale	17	1,520	Blue shale	10	1,805
Brown shale	5	1,525	Red shale	20	1,825
Sand (showing)	15	1,540	Lime and sand	5	1,830
Sand and shale	10	1,550	Blue shale	10	1,840
Blue shale	10	1,560	Blue sandy shale	10	1,850
Loose sand	10	1,572	Blue shale	10	1,860
Fine sand	4	1,576	Brown shale	10	1,870
Red shale	4	1,580	Red shale	10	1,880
Salt water sand	30	1,610	Abandoned in lime formation.		

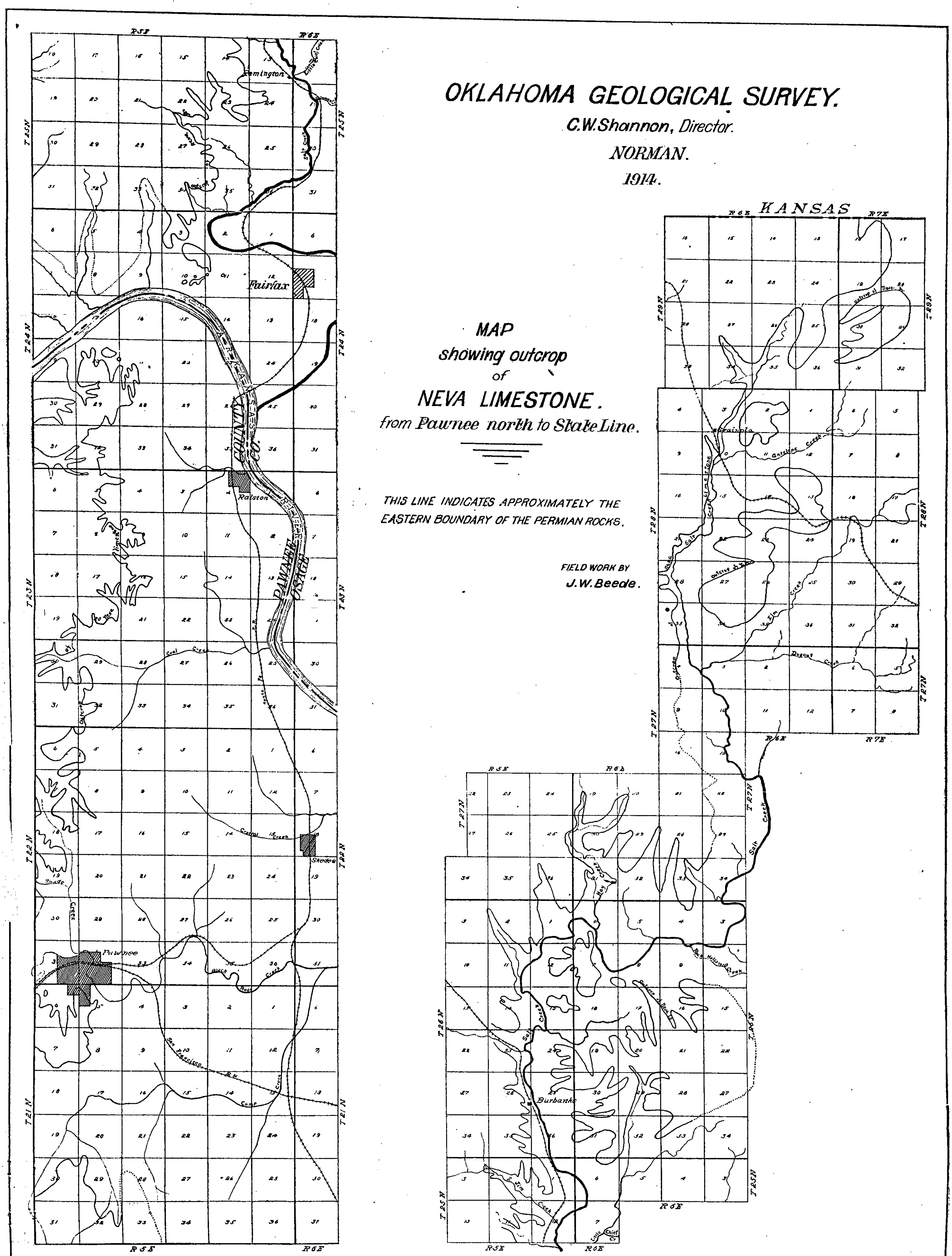
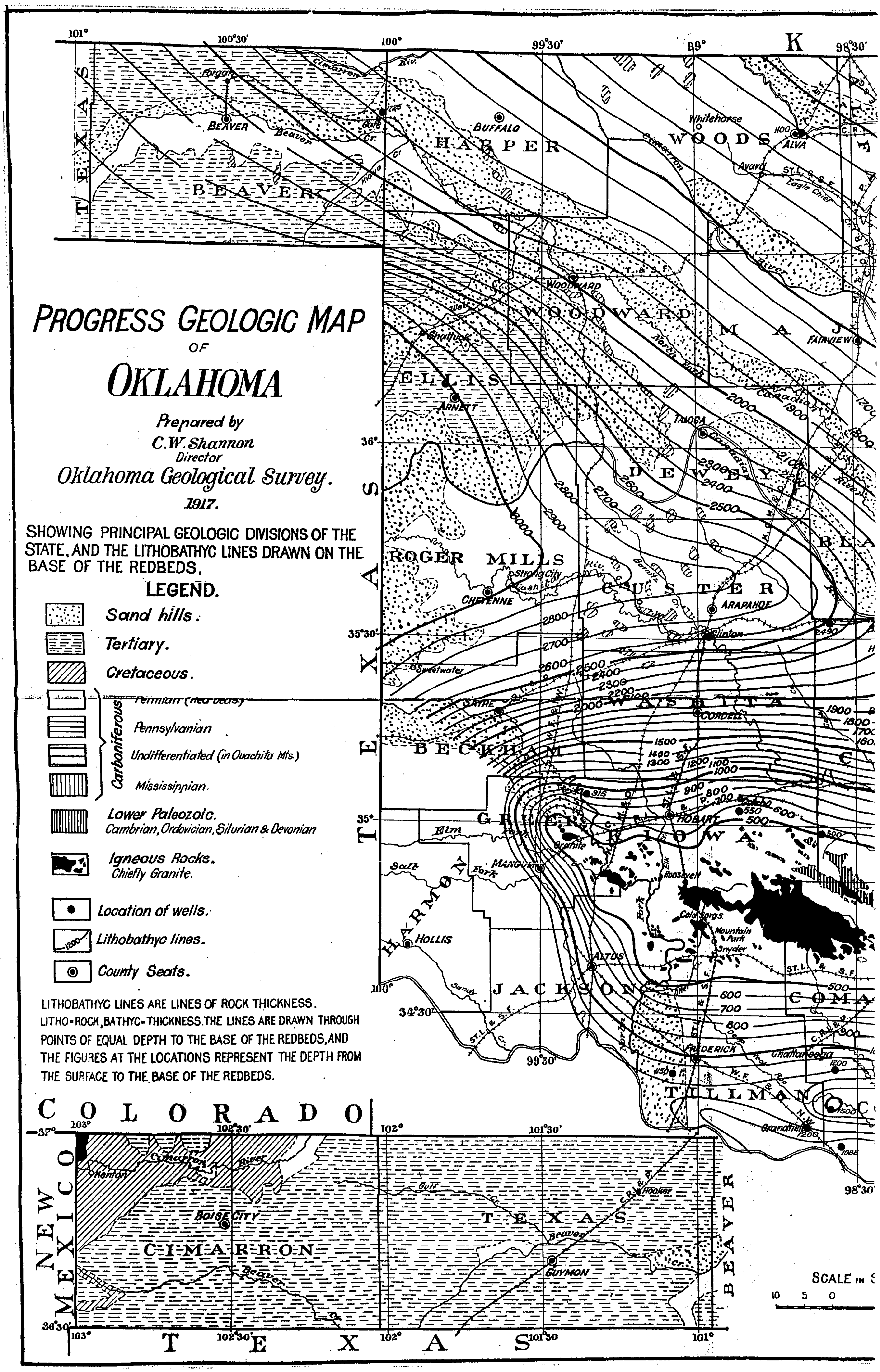
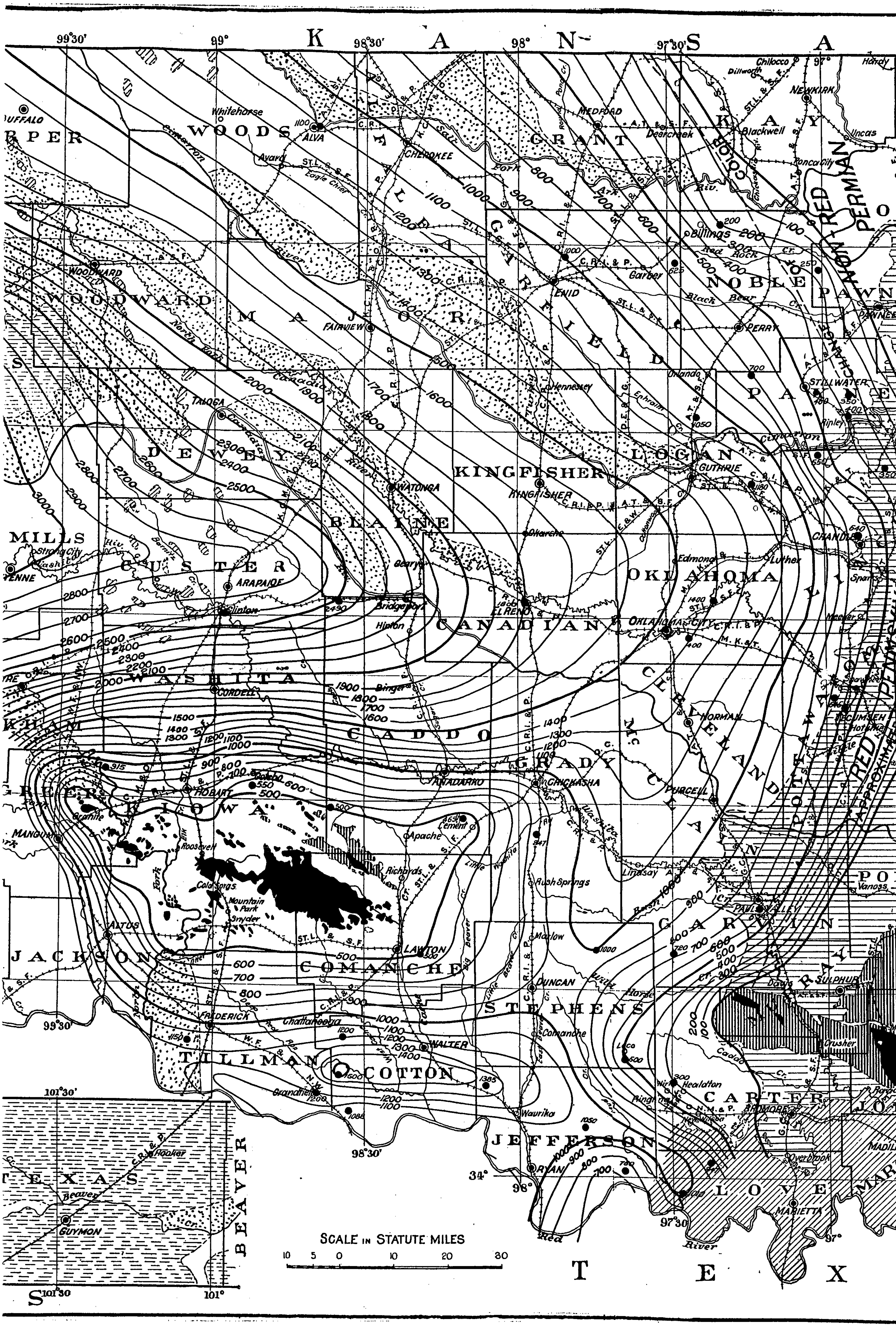

OKLAHOMA GEOLOGICAL SURVEY.
C.W.Shannon, Director.
NORMAN.
1914.
MAP
showing outcrop
of
NEVA LIMESTONE.
from Pawnee north to State Line.
THIS LINE INDICATES APPROXIMATELY THE
EASTERN BOUNDARY OF THE PERMIAN ROCKS.
FIELD WORK BY
J.W. Beede.
KANSAS
Fairfax
Ralston
Pawnee
Burbank
PAWNEE
OSAGE
COUNTY

PLATE II.

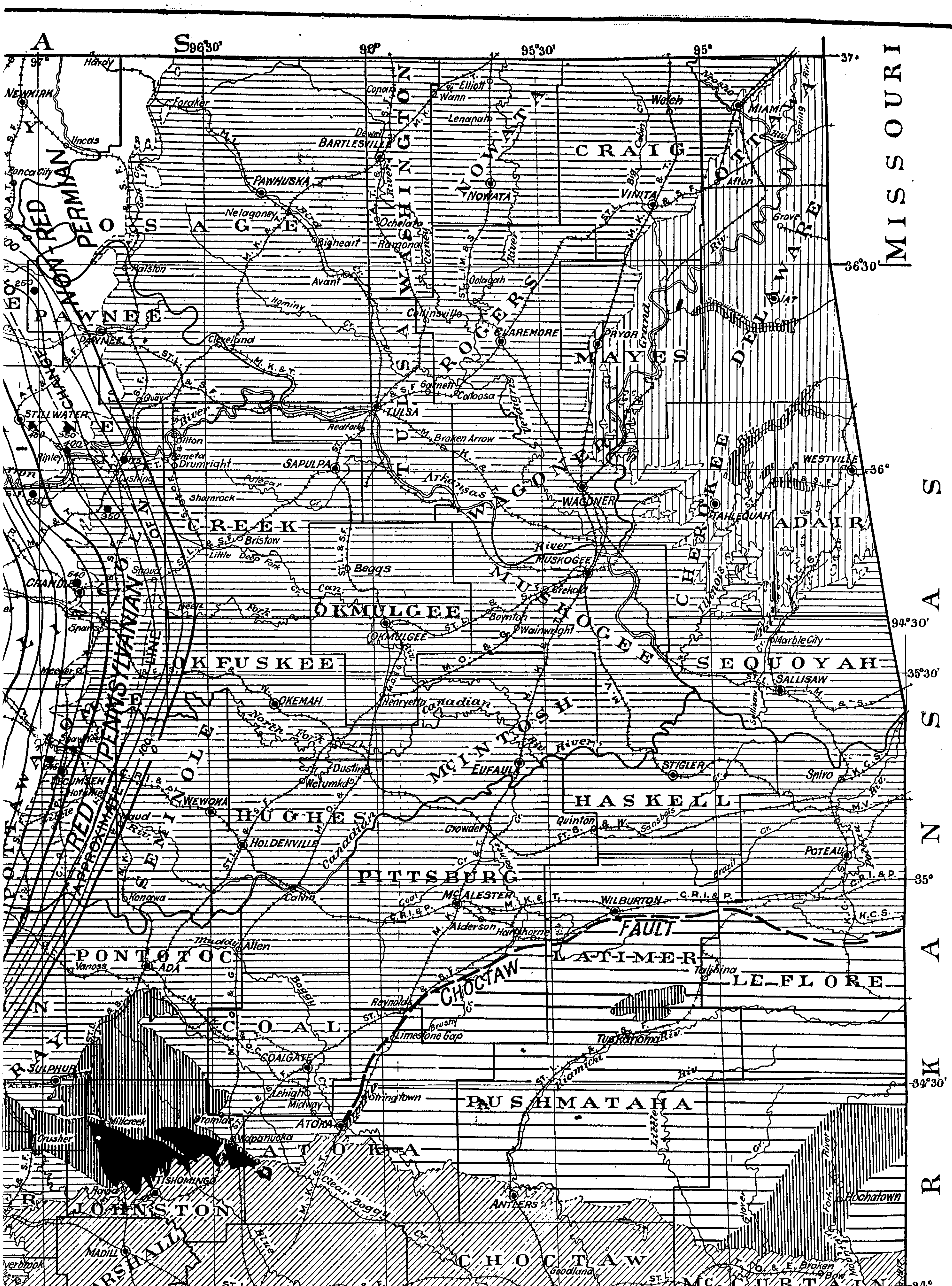


PROGRESS GEOLOGIC MAP
OF
OKLAHOMA
Prepared by
C.W. Shannon
Director
Oklahoma Geological Survey.
1917.
SHOWING PRINCIPAL GEOLOGIC DIVISIONS OF THE STATE, AND THE LITHOBATHYC LINES DRAWN ON THE BASE OF THE REDBEDS.
LEGEND.
Sand hills.
Tertiary.
Cretaceous.
Permian (Red beds)
Pennsylvanian
Undifferentiated (in Ouachita Mts.)
Mississippian.
Carboniferous
Lower Paleozoic.
Cambrian, Ordovician, Silurian & Devonian
Igneous Rocks.
Chiefly Granite.
Location of wells.
Lithobathyc lines.
County Seats.
LITHOBATHYC LINES ARE LINES OF ROCK THICKNESS. LITHO=ROCK, BATHYC=THICKNESS. THE LINES ARE DRAWN THROUGH POINTS OF EQUAL DEPTH TO THE BASE OF THE REDBEDS, AND THE FIGURES AT THE LOCATIONS REPRESENT THE DEPTH FROM THE SURFACE TO THE BASE OF THE REDBEDS.
TEXAS
BEAVER
HARPER
WOODS
WOODWARD
ELLIS
DEWEY
ROGER MILLS
CUSTER
WASHITA
BECKHAM
GREER
KIOWA
HARMON
JACKSON
TILLMAN
COLORADO
NEW MEXICO
CIMARRON
TEXAS
BEAVER
TEXAS
Forgan
Beaver
Buffalo
Whitehorse
Alva
Avard
Woodward
Shattuck
Arnett
Fairview
Taloga
Strong City
Cheyenne
Arapahoe
Clinton
Sweetwater
Sayre
Cordell
Hobart
Granite
Mangum
Roosevelt
Cold Sprgs.
Mountain Park
Snyder
Hollis
Altus
Frederick
Chattanooga
Grandfield
Kenton
Boise City
Hooker
Guymon
SCALE IN



K A N S A S
99°30'
99°
98°30'
98°
97°30'
97°
WOODS
Whitehorse
ALVA
CHEROKEE
Avard
ALFALFA
GRANT
MEDFORD
Deercreek
KAY
Blackwell
NEWKIRK
Chilocco
Ponca City
GARFIELD
ENID
Garber
Billings
NOBLE
PERRY
PAWNEE
RED
NON-RED
PERMIAN
APPROXIMATE CHANGE
WOODWARD
MAJOR
FAIRVIEW
TALOGA
DEWEY
KINGFISHER
Hennessey
LOGAN
GUTHRIE
PAYNE
STILLWATER
Ripley
BLAINE
WATONGA
Okarche
Edmond
Luther
CHANDLER
MILLS
Strong City
CUSTER
ARAPAHOE
Clinton
Geary
Bridgeport
Hinton
CANADIAN
EL RENO
OKLAHOMA
OKLAHOMA CITY
WASHITA
CORDELL
Bridger
CADDO
CLEVELAND
NORMAN
TECUMSEH
POTTAWATOMIE
GRADY
ANADARKO
CHICKASHA
McCLAIN
PURCELL
GREER
Granite
MANGUM
KIOWA
HOBART
Roosevelt
Cold Springs
Mountain Park
Snyder
Apache
Cement
Richards
Rush Springs
Lindsay
PAULS VALLEY
GARVIN
PONTOTOC
Vanoss
JACKSON
ALTUS
COMANCHE
LAWTON
Marlow
DUNCAN
STEPHENS
Comanche
MURRAY
Davis
SULPHUR
Crusher
FREDERICK
Chattanooga
WALTER
TILLMAN
COTTON
Grandfield
Waurika
Loco
Healdton
Ringling
CARTER
ARDMORE
Overbrook
JEFFERSON
RYAN
LOVE
MARIETTA
Red River
34°
TEXAS
Hooker
Beaver
GUYMON
BEAVER
101°30'
101°
T E X
SCALE IN STATUTE MILES
10 5 0 10 20 30

PLATE I.



MISSOURI
ARKANSAS
TEXAS
OSAGE
WASHINGTON
NOWATA
CRAIG
OTTAWA
DELAWARE
ROGERS
MAYES
PAWNEE
TULSA
WAGONER
CHEROKEE
ADAIR
CREEK
OKMULGEE
MUSKOGEE
SEQUOYAH
OKFUSKEE
SEMINOLE
McINTOSH
HASKELL
HUGHES
PITTSBURG
LATIMER
LE FLORE
PONTOTOC
COAL
PUSHMATAHA
ATOKA
JOHNSTON
CHOCTAW
McCURTAIN
MARSHALL
BRYAN
RED PERMIAN
PENNSYLVANIAN
APPROXIMATE LINE
CHOCTAW FAULT
NEWKIRK
PAWHUSKA
BARTLESVILLE
NOWATA
VINITA
MIAMI
PAWNEE
STILLWATER
CLAREMORE
PRYOR
TULSA
SAPULPA
WAGONER
TAHLEQUAH
WESTVILLE
MUSKOGEE
CHANDLER
OKMULGEE
OKEMAH
SALLISAW
EUFAULA
STIGLER
WEWOKA
HOLDENVILLE
POTEAU
McALESTER
WILBURTON
ADA
COALGATE
SULPHUR
ATOKA
TISHOMINGO
ANTLERS
MADILL
DURANT
HUGO
DABEL
97°
96°30'
96°
95°30'
95°
94°30'
37°
36°30'
36°
35°30'
35°
34°30'
34°

TABLE SHOWING GENERAL FEATURES OF SOME OF THE WELLS DRILLED IN THE REDBEDS AREA.

Name.	Location of Well.	Surface horizon.	Depth to base of Redbeds.	Formation below Redbeds.	Total Depth.	Remarks.
			Feet.		*Feet.*	
Healdton.	T. 4 S., R. 3 W.	Unclassified Permian.	200-400.	Non-red Permian.	800-1,500.	Oil at various horizons in Permian. Permian unconformable on older formations.
Wheeler.	T. 3 S., R. 2 W.	Unclassified Permian.	400+ Penn. at 985 ?	Non-red Permian.	600-3,612.	Oil at various horizons in Permian. Permian and Penn. unconformable.
Loco.	T. 3 S., R. 5 W.	Unclassified Permian.	500-700 Penn. at 850+.	Non-red Permian.	550-1,400.	Oil and Gas at various horizons in Pemian. Permian and Penn. unconformable.
Brock.	Sec. 24, T. 5 S., R. 1 W.	Trinity sand on surface.	210.	Pennsylvanian.	1,601.	Dry. Unconformity between Permian and Pennsylvanian.
Pauls Valley.	Sec. 33, T. 3 N., R. 1 E.	Permian.	634.	Pennsylvanian.	1,435.	Dry.
Ostwalt.	Mann & Burford well, Sec. 12, T. 6 S., R. 2 W.	Covering of Cretaceous. Redbeds below.	847.	Pennsylvanian.	2,002.	Dry.
Apache.	Sec. 1, T. 4 N., R. 12 W.	Base of unclassified Permian.	405.	Arbuckle limestone or Simpson formation.	1,838.	Slight showing.
Cement.	Sec. 32, T. 6 N., R. 9 W.	Woodward.	465?	Non-red Permian?	1,520.	Oil well.
Lawton.	Ts. 1 & 2 N., Rs. 10 & 11 W.	Unclassified Permian.	400-900.	Usually Arbuckle limestone.	800-2,348.	Oil sand about 800'.
Cruce.	T. 1 N., R. 6 W.	Unclassified Permian.	1,000+.	Non-red Permian.	850-2,000.	Oil and gas sands at various horizons in the Redbeds. Permian and Pennsylvanian unconformable.
Ninnekah.	T. 5 S., R. 7 W.	Top of Woodward.	847.	Pennsylvanian or Permian.	1,500.	Dry.
Grady.	Sec. 19, T. 6 S., R. 4 W.	Permian.	750.	Pennsylvanian.	1,435.	Dry.
Oscar.	Sec. 28, T. 6 S., R. 5 W.	Permian.	680.	Pennsylvanian?	2,091.	Dry.
Colony.	Sec. 5, T. 10 N., R. 13 W.	Permian Redbeds.	----------	------------------------	1,003.	Dry. Not through Redbeds.
Alden.	Sec. 6, T. 5 N., R. 13 W.	Base of unclassified Redbeds.	498.	Arbuckle limestone.	648.	Dry.
Granite.	Sec. 24, T. 7 N., R. 21 W.	Unclassified Permian and dune sand.	915.	Simpson formation?	2,135.	Several showings of oil. Redbeds appear to be thicker than expected.
Gotebo.	South of Gotebo.	Unclassified Permian.	550.	Viola limestone.	1,680.	Show of gas.
Pluver.	Sec. 23, T. 5 S., R. 6 W.	Unclassified Permian.	1,050+.	Pennsylvanian.	2,114.	Dry. Formations are red Pennsylvanian immediately below Permian.
Randlett.	Sec. 25, T. 4 S., R. 13 W.	Wichita formation.	1,088.	Pennsylvanian.	2,592.	
Hastings.	Sec. 1, T. 4 S., R. 9 W.	Wichita formation.	1,385.	Pensylvanian. Some red Penn.	2,185.	Dry.
Grandfield.	Sec. 9, T. 4 S., R. 14 W.	Wichita formation.	1200.	Pennsylvanian or Permian.	1,705.	Several showings. In wells in vicinity. Redbeds appear to be about 1,000-1,400'.
Loveland.	Sec. 9, T. 3 S., R. 15 W.	Wichita formation.	1,025.?	Pennsylvanian.	-----------	Dry. Red clay and blue shale mixed. Line of separation between Permian and Penn. not distinct.
Apheatone.	T. 2 S., R. 13 W.	Wichita formation.	1,200+.	------------------------	1,200.	All Redbeds. Show of oil at about 1,075.
Devol.	Sec. 28, T. 3 S., R. 13 W.	Wichita formation.	1,500.	Pennsylvanian.	1,520.	Dry.
Burt Switch. Northwest of Frederick.	Sec. 28, T. 2 S., R. 18 W.	Recent dune sand covering Redbeds.	1,150.	Pennsylvanian?	1,900.	Dry.
Clinton.	Near Clinton.	Upper Greer formation.	2,507+.	------------------------	2,507.	Dry. All Redbeds.
El Reno.	Near El Reno.	Upper Enid formation.	1,800.	Pennsylvanian.	3,200.	Dry.
Meridian.	Sec. 30, T. 16 N., R. 1 E.	Middle Enid formation.	1,180.	Pennsylvanian.	2,727.	Dry.
Watonga.	Sec. 10, T. 16 N., R. 11 W.	Lower Woodward formation.	-------------	------------------------	1,024.	Dry. Not through Redbeds.
Orlando.	Sec. 11, T. 19 N., R. 1 W.	Lower Enid formation.	700.	Pennsylvanian.	2,260.	Dry.
Oklahoma City.	Sec. 5, T. 11 N., R. 2 W.	Enid formation.	1,400.	Pennsylvanian.	3,001.	Dry. Several showings of oil reported.
Spencer.	--------------------	Enid formation.	1,400.	Pennsylvanian.	2,002.	Dry. Several showings reported.
Mulhall.	--------------------	Middle Enid formation.	1,050.	Pennsylvanian.	1,755.	Dry. Lower part of Redbeds is red Pennsylvanian.
Alva.	½ mile east of Alva.	Upper Enid formation.	1,100.	Non-red Permian.	3,500.	Gas showing at 3,300'.
Enid.	Sec. 30, T. 23 N., R. 6 W.	Upper Enid formation.	1,000.	Non-red Permian.	3,365.	Dry.
Hooker. (Texas County.)	Sec. 24, T. 3 N., R. 17 E.	Tertiary.	-------------	------------------------	1,053.	Dry. Not through Redbeds.
Gate. (Beaver County.)	Sec. 33, T. 5 N., R. 28 E.	Tertiary or Recent dune sand.	1, 725.	Non-red Permian.	2,837.	Dry. Penn. strata probably penetrated at 2,400 feet.
Morrison.	Sec. 33, T. 23 N., R. 3 E.	Permian Redbeds.	250.	Pennsylvanian or non-red Permian.	2,040.	Gas well, 35 M. at 2,020 feet.
Stillwater.	Sec. 23, T. 19 N., R. 2 E.	Base of Enid formation.	460.	Pennsylvanian.	1,200.	Dry. Showing of oil at 970 feet.
Tecumseh.	Spencer farm, T. 9 N., R. 3 E.	Near Permian-Pennsylvanian contact.	646.	Pennsylvanian.	1,956.	Dry. Redbeds mostly red Pennsylvanian.
Chandler.	Sec. 4, T. 14 N., R. 4 E.	Near Neva sandstone horizon.	640.	Pennsylvanian.	2,525.	Dry. Redbeds are red Pennsylvanian.
Avery.	Sec. 16, T. 16 N., R. 5 E.	Near Neva sandstone horizon.	350.	Pennsylvanian.	3,915.	Dry. Several showings of oil.
Ripley.	Sec. 23, T. 18 N., R. 4 E.	Near Neva sandstone horizon.	400.	Pennsylvanian.	3,561.	Oil well. Redbeds are red Pennsylvanian.