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Chas. N. Gould, Director

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# OIL AND GAS IN OKLAHOMA

## GEOLOGY OF SEMINOLE COUNTY

By

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## FOREWORD

In 1917 the Oklahoma Geological Survey issued Bulletin 19 part 2 entitled, "Petroleum and Natural Gas in Oklahoma." This volume was so popular that the supply was soon exhausted, and for several years copies have not been obtainable.

The present director has seen the need of a revision of this bulletin. On account of lack of appropriations he has not been able to employ sufficient help to compile the data, and has called on some twenty representative geologists throughout the state to aid in the preparation of reports on separate counties. These gentlemen, all busy men, have contributed freely of their time and information in the preparation of these reports.

It will be understood that the facts as set forth in the various reports represent the observation and opinion of the different men. The Oklahoma Geological Survey has every confidence in judgment of the various authors, but at the same time the Survey does not stand sponsor for all statements made or for all conclusions drawn. Reports of this kind are, at best, progress reports, representing the best information obtainable as of the date issued and doubtless new data will cause many changes in our present ideas.

With the permission of the Independent Oil and Gas Company

During the year 1927, Seminole County produced more petroleum than any other county in Oklahoma. The production has been practically altogether from the "Wilcox" sand, a sand lying at a horizon which a few years ago, was believed to be below the greatest depth at which petroleum could be produced in this State. Mr. A. I. Levorsen, who has prepared this chapter, has been in very close touch with conditions in Seminole County from the time of the first production in the Seminole field; and is in many ways better fitted than any other man in the State to write the chapter on this most important oil-producing county in Oklahoma.

CHAS. N. GOULD
Director

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# GEOLOGY OF SEMINOLE COUNTY

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## INTRODUCTION

During recent years Seminole County has attracted a great deal of attention as an oil-producing region and at present it is one of the leading producing areas of the United States. The oil production during the last week in July, 1927, reached 562,000 barrels per day, of which 527,400 barrels were produced from 637 wells situated in the west half of the county. This would have been greater but for cooperative measures which restricted it to a maximum of 450,000 barrels per day in this area. This amount was sufficient, especially owing to its high gravity, to be an important factor in influencing the oil market of the country. There are at present eleven producing areas within the county, of which seven may be classed as major fields. In addition, six wildcat wells have been drilled, in each of which oil has been discovered. The production in these varies from 50 to 150 barrels per hour, but they are now shut in waiting for more favorable market conditions. Several of these wells will probably open up fields of major importance in the future, so that the story of the oil industry in Seminole County is by no means complete at this time.

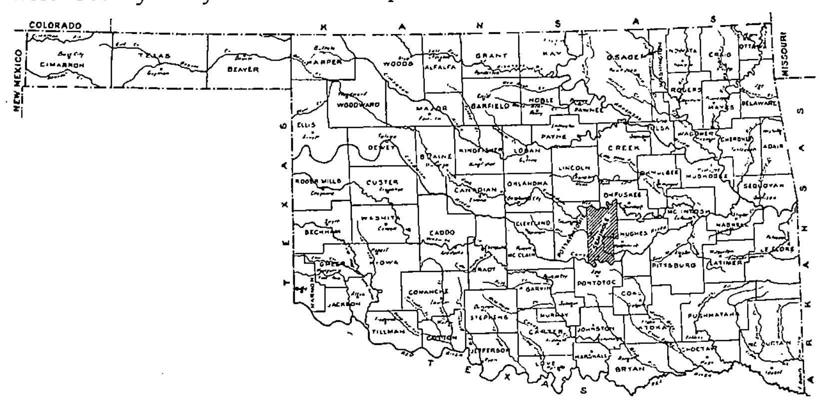



Figure 1. Map showing location of Seminole County.

This paper is not a complete report but merely summarizes the information that has been gained in the exploration of the present producing areas. In the development of the geology of Seminole County, the most advanced methods and technique in sampling, micropaleontology, microlithology, geophysical exploration, water analysis, surface structural detail, and subsurface mapping have been employed. The major companies have established geological departments consisting of specialists in each of the different branches and are having more scientific work done than ever before in the history of oil geology in Oklahoma.

In the preparation of this report it has been the writer's intention to gather together as many facts as possible in the alloted time and to leave to some future writer much of the theory and the discussion of the purely geological problems. Fully 90 per cent of the material presented in this report has been obtained from other geologists, but the writer assumes the responsibility for the statements made herein. It has been his privilege to merely sift the different ideas and material and to attempt to put them in usable form. The exception to this is the discussion of the structural history and origin of folding which is the writer's interpretation of the information available at this time.

The geologic literature which applies to Seminole County is not extensive but the papers that have been published are very excellent. In the order of their publication, they are:

Geology of the Stonewall Quadrangle, Oklahoma, by Geo. D. Morgan, Bureau of Geology, Bulletin No. 2, 1924. This is the standard reference for all geologists working Seminole County. Since the Stonewall quadrangle extends into southern Seminole County, it has been particularly valuable in both surface and subsurface work. It contains a detailed description of all of the formations found in Seminole County and the geologic history, folding, and faulting of the northern part of the Arbuckle Mountains.

Petroleum Engineering in the Cromwell Oil Field, by C. O. Rison and John R. Bunn, United States Bureau of Mines, 1924. This report was prepared during the later part of the development of the Cromwell field and discusses the history, stratigraphy, subsurface structure, and production and operating methods of that field.

The Seminole Uplift, Oklahoma, by Sidney Powers, Bulletin of the American Association of Petroleum Geologists, Vol. 11, pp. 1097-1108, 1927. The geology, structure of the rocks, the origin of the folds, the accumulation of the oil and the history and statistics of the fields of the Greater Seminole area are described one year after its discovery. A great deal of information is contained in this paper, including two maps of the structural conditions of the Seminole City field.

The writer has drawn freely from the literature mentioned, and has embodied in this report many of the statements and ideas of the several authors. He gratefully acknowledges the assistance of many geologists and others working out the problems of Seminole County and is indebted to Geo. S. Buchanan, C. W. Byron, L. C. Case, Ira H. Cram, Robert H. Dott, Oscar Hatcher, J. H. Nelimark, O. E. Nordman, J. T. Richards, Charles Ryniker, Edward F. Shea, Jess Vernon, and Luther White, for valuable suggestions, information and criticism; to the Gypsy Oil Company for statistical data, and to The Independent Oil and Gas Company for permission to publish this report.



## GENERAL FEATURES

Seminole County covers an area of about 630 square miles and is located a short distance southeast of the geographical center of the state.

Most of Seminole County covers what was formerly the land of the Seminole Nation, an Indian Tribe, from which the county also derives its name. Wewoka, the county seat, was the capital of the Seminole Nation. These Indians, an offshoot of the Creek tribe, were originally from Florida. By 1842, and after considerable fighting and a number of treaties with the Government, they were transferred to Oklahoma and became one of the Five Civilized Tribes. In March, 1906, their tribal government ceased and by reason of Acts of Congress passed in 1904, 1906 and 1908 their lands, which had previously been alloted in severalty, were in part open to purchase and settlement. The alloted lands which remained restricted, together with the lands later purchased or acquired by Seminole Indians, at present do not constitute over a fifth of the land of Seminole County.

Seminole County is bounded and drained on the north by the North Fork of Canadian River and on the south by the Canadian River. Wewoka Creek, Little River, and Salt Creek, all flowing in a southeasterly direction, drain the central part of the county. The surface elevation ranges between 800 and 1,050 feet above sea level. The topography, which represents a mature stage of erosion, consists of low rounded hills, low east-facing escarpments, gentle west slopes and alluvial bottom land along the streams.

The soil is sandy, owing to the large number of sandstone layers in the bed rock, and much of it is unfit for cultivation. The principal crops are cotton and corn, generally grown in the small valleys and along the flood plains of the streams. Black jack, postoak, and some hickory cover the more sandy and higher areas and wild pecan, sycamore, elm, and cottonwoods grow along the streams and valleys.

The south half of the county is served by three railroads, the M. K. & T., the Rock Island, and the Frisco, all of which are branch lines. The active oil development has brought a great deal of new wealth into the county and has probably doubled its population. Numerous new boom towns have sprung up in the oil fields and the original towns of Wewoka and Seminole have had a large increase in population and business activity.

## GENERAL GEOLOGY

### Surface Formations

Shale, sandstone, conglomerate and limestone of upper Pennsylvanian age compose the rocks outcropping through most of Seminole County. The exceptions are the belts of river sand and alluvium along the larger drainage channels and the areas of Guertie sand found in the south side of the county, both of Quaternary age. Shales constitute 76 per cent, sandstone and conglomerate 23 per cent and limestone one per cent of the outcropping rocks. However, owing to the more resistant qualities of the sandstones, conglomerates and limestone, the shales cover a lesser area than their thickness would indicate.

The source of the sediments comprising the rocks found at the surface is not yet known. The conglomeratic material was derived from the Arbuckle Mountains to the south which were rising and undergoing rapid erosion at this time. During Vanoss time the pre-Cambrian granites of the Arbuckle Mountains were probably exposed to erosion as evidenced by the arkosic material characteristic of the Vanoss formation. The Arbuckle Mountains did not supply the material for all of the sediments, however, since the conglomerates grade laterally into rocks of an entirely different character in other parts of the Mid-Continent region. The writer's idea is that the erosion of the Arbuckle Mountains to the south merely contaminated a sea already having a more or less stable source of sediments and well established over the Mid-Continent region.

In Figure 2 is shown the character of the outcropping formations, as described by Morgan[1] along the south side of the county and the character of the same formations as found by O. E. Nordman[2] in a section across the county through T. 9 N., 20 miles north of Morgan's section.

The reader is referred to the "Geologic Map of Oklahoma"[3] published by the United States Geological Survey in cooperation with the Oklahoma State Geological Survey for the location of the formation boundaries, areas covered by the different outcropping formations, and for the location of the surface faults.

A detailed description of the outcropping formations follows:

### VANOSS FORMATION

The Vanoss formation occupies an area covering approximately the west half of Seminole County. It ranges in thickness from 250 to 520 feet and consists of shales, arkosic sands, conglomerates, and a few thin limestones. Of the limestones, the Pawhuska (?) limestone at the base of the formation is of most importance. It is a thin, gray, fossiliferous limestone of variable thickness outcropping in the Seminole City, Bowlegs, and Little River fields. In these fields it is used as the datum to which the surface structure is referred. The following description of the Vanoss formation as given by Morgan in his description of it in the Stonewall quadrangle applies equally well to Seminole County[4]:

1. Morgan, Geo. D., The Geology of the Stonewall Quadrangle, Oklahoma: Bureau of Geology, Bull. 2. 1924.
2. Nordman, O. E., Gypsy Oil Company, Personal communication.
3. Miser, H. D., Geologic Map of Oklahoma: U. S. Geol. Survey, Washington, D. C., 1926.
4. Morgan, Geo. D., Op. cit., pp. 133-137.

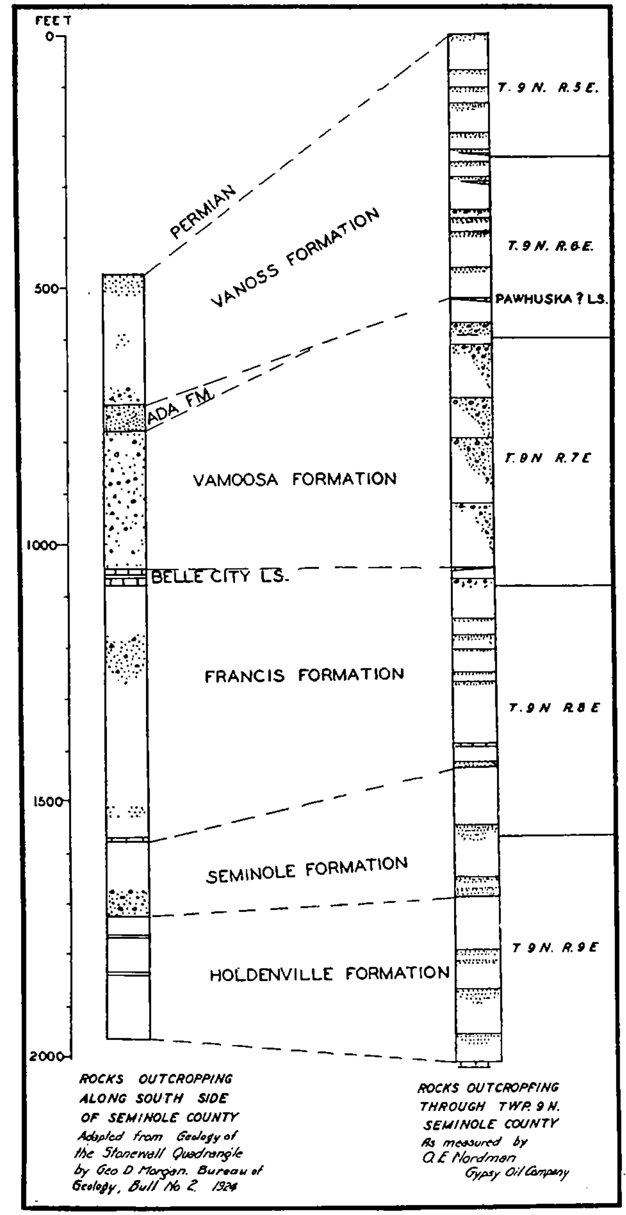



Figure 2. Geologic section showing the nature of formations outcropping in southern and central Seminole County.

##### Name

The name of this formation is after the town of Vanoss which is situated on the outcrop in the north central part of T. 3 N., R. 4 E.

##### Thickness and Character

The Vanoss formation consists of alternating sandstones, conglomerates, shales and a few thin limestones. All the strata are arkosic, some of the sandstones so much so that at first glance a few of them might be mistaken for true granites.

The base of the Vanoss rests on the Ada formation, the contact between the two being the plane dividing the arkosic and non-arkosic materials. Due to the lenticular nature of strata along the contact and to the fact that the Vanoss is progressively overlapping southward no one stratum can be selected to mark the adjacent limits of the formation. The base of the arkosic zone, however, is relatively contemporaneous * * * *

##### Age and Correlation

* * * * The Vanoss formation is probably equivalent to the upper Putnam of Texas, and to the late Wabaunsee of Kansas and Missouri.

#### ADA FORMATION

The Ada formation occupies an area up to 2 miles in width in R. 6 E., in the southern part of the county. It becomes thinner and is either absent or cannot be differentiated north of T. 7 N. It consists of sand and shale and reaches a maximum thickness of 60 feet. The following description of it in the Stonewall quadrangle as given by Morgan[5] applies equally well to the remainder of Seminole County:

##### Name

The formation is here named after the town of Ada within and to the west of which lies the type area.

##### Thickness and Character

The average thickness of the Ada formation is about 100 feet. Limestone conglomerates and coarse sandstones are very prominent along the greater portion of the outcrop. Clastic material becomes less toward the north, however, and in the vicinity of Vamoosa is very scarce. With the decrease in the amount of clastic material northward the formation becomes thinner and at the northern edge of the sheet has a total thickness of only 60 feet.

Although fossils are very scarce in the Ada formation a few species were found which indicate that the sediments are of marine origin.

#### VAMOOSA FORMATION

The Vamoosa formation occupies a belt two to eight miles wide through Rs. 6 and 7 E. It consists mainly of conglomerates, sandstones, and variable amounts of shale and furnishes the most pronounced topographic expression of any of the formations. The conglomerates consist of rounded to sub-angular quartz pebbles, weathered chert pebbles, and sand grains, cemented by siliceous material. The size of the pebbles is generally less than one inch in diameter but locally pebbles up to six inches in diameter occur. Cross-bedding, lensing, and rapid lateral variations are common throughout the formation. It thins toward the south from 525 feet in T. 9 N., to 325 feet in the south part of T. 6 N. An interesting fact is the occurrence of the largest boulders in the conglomerate in T. 9 N., R. 7 E., where the formation is thickest.

5. Morgan, Geo. D., Idem., pp. 128-132.



Morgan[6] originally describes it in the southern part of the county, the following extracts being from his report:

##### Name

A suitable geographic name was not available for this formation. The term finally selected is after the village of Vamoosa which is located in the northern part of the Stonewall quadrangle, about one-half mile west of the outcrop. The formation is typically developed on the main road between Sasakwa and Konawa.

##### Thickness and Character

Where all of the formation is exposed the entire section has an average thickness of 260 feet. At the base is about 30 feet of dark shale that might easily be mapped as a sparate formation. No collections were made from this member, but it is very probably fossiliferous. The main mass of the formation is above this shale and has a maximum thickness of about 230 feet. It consists in large part of the chert conglomerates, of massive, coarse, red and brown sandstones, and red shales. The clastic material is finer near the top and the red coloration is there also less pronounced.

The chert conglomerates of the Vamoosa formation closely resemble those of the Wewoka, Holdenville, Seminole, and Francis formations, but may be distinguished from somewhat similar beds in the Pontotoc terrane because of arkosic material contained in the latter. The Vamoosa formation contains a greater thickness of chert conglomerates than does any other formation of the area.

Overlap of the Vamoosa formation, by the succeeding Ada formation, is progressive southward. For this reason only the lower shale and about 30 feet of the clastic portion of the formation are exposed near Byng.

No fossils were found nor is it highly probable that any are present in the clastic beds of the Vamoosa.

##### Age and Correlation

Because of the absence of collections from the Vamoosa formation and the paucity of fossils in the succeeding Ada formation and the still higher Pontotoc terrane, the problem of

6. Morgan, Geo. D., Idem., pp. 125-128.

correlating the Vamoosa and later strata is very difficult. As stated elsewhere, the method used in determining the correlations here suggested are largely based on the percentage and average range of common speies.

The evidence derived from a strict application of this method to the Vamoosa and Ada formations, as well as to the strata of the Pontotoc terrane, is conflicting and contradictory. The general weight of evidence, however, seems to favor a correlation of the Vamoosa with the lower Putnam of Texas, and with a portion of the Wabaunsee of Kansas and Missouri. Evidence supporting this correlation is contributed by two collections of plant fossils from the Pontotoc terrane. The plants indicate that the Pennsylvanian-Permian contact lies near the top of the Vanoss formation of the Pontotoc terrane.

## BELLE CITY LIMESTONE

Morgan[7] describes the Belle City limestone as follows:

### Name

Belle City limestone is the manuscript name given by Boone Jones to a formation that is well developed in the Stonewall quadrangle. The name is after Belle City, a village in Seminole County.

### Thickness and Character

The formation has an average thickness of 30 feet. It is composed of two limestones of varying thickness with an intervening shale. The upper lime is generally thicker and much more massive than the lower. Its range in thickness is from one foot, as just south of Byng, to as much as 15 feet near Canadian River. The bed is white or light gray in color and is often characterized by well developed styliolites. Pronounced weathering along joint cracks is common and in the eastern part of sec. 24, T. 6 N., R. 6 E., results in the formation of small sink-holes at the intersection of a few of the prominent joints.

The lower limestone bed is buff colored. Its range in thickness is from one foot, as in the vincinity of Byng, to as much as five feet near Canadian River and northward. At variance with the massive character of the upper member of the formation the bedding of this stratum is relatively thin.

The interval between the upper and lower limestones is composed of shale that ranges in color through shades of green, blue, and black. Its average thickness is 12 feet.

### Fossils

All three members of the formation are fossiliferous, but the largest fauna is from the massive limestone at the top.

### Age and Correlation

The Belle City limestone is to be correlated with at least a part of the Moran of Texas, and is equivalent to a part of the Wabaunsee of Kansas and Missouri.

7. Morgan, Geo. D., Idem., pp. 123-125.



## FRANCIS FORMATION

The following extracts from Morgan's[8] report on the Stonewall quadrangle show its characteristics and apply equally well to the formations found farther north in Seminole County:

### Thickness and Character

In the type area and northward the Francis formation has a thickness of 500 feet. In the vicinity of Ada and southward only the lower part of the formation is exposed, the upper part being overlapped by the Ada formation.

At the base, but within the Francis formation, is the DeNay limestone member, the lower part of which marks the top of the Seminole formation. Above this limestone is an interval of about 30 feet that is represented by dark blue and black shales. These grade upward into sandstones which on the creek bluff northwest of Sasakwa have a thickness of nearly 20 feet. This is the sandstone that outcrops in the railroad cut below the viaduct in the northeastern part of Francis and is also correlated with the sandstone ledge in the road cut just north of the brick plant and railroad crossing near the southeast corner of Ada. Above the sandstone member is a series of thick, dark and sometimes calcareous shales The average thickness of this part of the formation is 250 feet. In the northern part of the type area it is slightly more than this, but in the southern part it seems to be slightly less. West of Sasakwa the surface of this deposit extends to beyond the residence of the former Governor Brown of the Seminole Nation. Most of the town of Francis is located on these shales and they are typically developed around the water tower there. Shales of this member are utilized by the brick plant at Ada. As is clearly shown in the pit at the latter place, the lower part of the shale is much darker and is more calcareous than the upper part. One of the most characteristic features of the shale series is the abundant limestone concretions which it contains. These vary in size from less than an inch in diameter up to as much as a foot. When freshly broken the central mass consists of a dense, dark blue limestone, on weathering, however, the color becomes yellow or yellowish brown. The concretions are often very fossiliferous. Other concretions collected from the shales were of the cone-in-cone type.

Above the shale series is a thickness of almost 100 feet within which coarse brown sandstones and chert conglomerates predominate. Only occasional fossils were found within this member. Although much higher in the geologic column some of these conglomerates greatly resemble the conglomerates at the base of the Seminole in the type area of that formation. For that matter, however, they also closely resemble the conglomerates of the Wewoka, Holdenville, and Vamoosa formations, and were it not for the presence of arkose in the Pontotoc strata, hand specimens of Francis conglomerate could probably not be distinguished from similar specimens of the chert conglomerates in that terrane. All the very similar chert conglomerates in the Pennsylvanian section must have had a similar source. The writer is in agreement with Taff's suggestion that this source was the Ouachita area.

8. Morgan, Geo. D., Idem., pp. 114-115.

The upper part of the Francis formation is a shale that is about 100 feet thick. This part carries a few thin sandstones and one rather persistent conglomeratic limestone. The limestone is often very fossiliferous and is typically exposed in the road about 100 yards west of the school house in the southeast corner of sec. 19, T. 6 N., R. 7 E. In the vicinity of Ada this shale and a part of the underlying sandstone member is overlapped by the Ada formation. Southwest of Ada successively lower beds are overlapped until in the vicinity of Fitzhugh the entire formation is concealed by the Ada formation.

#### Fossils

The Francis formation carries its most prolific fauna in the thick shale series which is quarried at the Ada brick plant. At the latter point 50 well preserved species were collected.

#### Age and Correlation

The Francis formation is thought to be equivalent to the Pueblo and lower Moran of Texas, and to the Shawnee and lower Wabaunsee of Kansas and Missouri.

### SEMINOLE FORMATION

The Seminole formation outcrops in a narrow belt in the southeastern part of the county. It consists of 150-250 feet of shale with prominent sandstone layers at the top, middle, and base of the formation. It is correlated by Morgan[9] with the Harpersville and Thrifty formations of Texas and with most of the Douglas of Kansas and Missouri.

## Subsurface Formations

### PENNSYLVANIAN ROCKS

Rocks of Pennsylvanian age extend below the surface to depths varying from 3,400 to 4,000 feet and consist of alternating shales, sands, conglomerates, and thin limestones. The following tables shows the amounts of each encountered in wells of three areas within the county:

*Character of Pennsylvanian Sediments*

| AREA | SHALE | | SAND | | LIMESTONE | | Total Feet |
|---|---|---|---|---|---|---|---|
| | Feet | Per cent | Feet | Per cent | Feet | Per cent | |
| Cromwell field | 2825 | 82 | 470 | 13 | 155 | 4 | 3450 |
| Wewoka field | 2905 | 87 | 380 | 11 | 40 | 1 | 3325 |
| Earlsboro field | 2950 | 77 | 750 | 19 | 140 | 3 | 3840 |

In the eastern part of the county, where a number of wells were drilled by the cable tool method, the different formations can be traced

9. Morgan, Geo. D., Idem., p. 112.



from well to well and finally to the outcrop at the surface, but in the western half of the county, where rotary drilling prevailed, the individual beds can be followed in well logs with difficulty if at all. Of these, the Calvin series, which includes beds up to the basal sand of the Wewoka formation, is the most important structurally. It forms a persistent series of sands interstratified with shales 200-250 feet thick and is used as a datum in mapping the subsurface Pennsylvanian structure. The basal sand of this series quite often contains gas and oil and occasionally in commercial quantities. The Calvin series is correlated with the Oswego lime horizon of northern Oklahoma. The Calvin sands are progressively deeper from east to west and conform with the regional dip of the surface rocks. Thus in the Cromwell field they are found at 1,400-1,900 feet, in the Seminole field at 2,300-2,500 feet, and in the Earlsboro field at 2,900-3,200 feet below the surface.

In the eastern part of the county the lower part of the Pennsylvanian (the Pottsville) is of commercial importance and consists of the following subdivisions:

*Lower Pennsylvanian sands in eastern Seminole County*

| Sand | Thickness | Description |
|---|---|---|
| Booch sand | 0-60 | Sand |
| Gilcrease horizon | 0-300 | Sand, shale, and limestone |
| Cromwell sand | 0-100 | Sand |

Oil is produced from the Booch sand in the Bethel field and minor quantities have been produced from it in other areas, but it is in general water bearing. It is correlated with the productive Booch or Taneha sand of the Okmulgee District and with the Hartshorne sandstone which outcrops in eastern Oklahoma.

The Gilcrease horizon is a variable series of sand, sandy limestone, and limestone separated from both the Booch sand above and the Cromwell sand below by a shale interval. It is productive locally, the accumulation being related more to its porosity than to folding. In this respect it is similar to the Dutcher series farther northeast with which it is correlated. The writer believes it can be correlated with the Atoka formation which outcrops in the Atoka region and is therefore of Pottsville age. It thins to the west by progressive overlap, the higher members extending farthest west.

The Cromwell sand is productive in the Cromwell field, and in the Wewoka field where it is known as the Smith and Sykes sands. It is the basal sand of the Pennsylvanian, varies from 0 to 100 feet in thickness, and extends as far west as the east side of R. 6 E. A thin limestone, which thickens to 125 feet farther east, there known as the Lyons limestone, is found capping it in several places. The Lyons limestone is correlated with the Morrow and Wapanucka limestones of the outcrop, which in turn are correlated by Plummer and Moore[10] with the Marble Falls limestone of north-central Texas. Thus the Cromwell sand of Seminole County is approximately of the same age as the Bend producing horizon of Texas.

The structure of the upper part of the Pennsylvanian rocks is the same as that of the surface beds. The westward regional dip varies from 50 to 90 feet per mile and would normally carry the basal part of the Pennsylvanian to a depth of 4,700 feet on the west side of the county. However, the lower formations of the Pennsylvanian are progressively cut out by overlap at nearly the same rate as the surfece regional dip carries them downward, the result being that the base of the Pennsylvanian is much nearer the same level in all parts of the county than would be expected. The basal Pennsylvanian formation, however, is not the same throughout the county. Thus on the east side it is the Cromwell sand, farther west the Booch sand, and on the west side of the county either the McAlester shale or the Boggy formation, the intervening 1,000 or 1,200 feet being progressively cut out toward the west through non-deposition. This westward thinning and other details of Pennsylvanian stratigraphy are shown in the cross-sections of Fig. 6. The convergence is the cause of the westward shifting and the apparent sharpening of the structures on depth.

In the western part of the county, particularly in the Earlsboro area, the base of the Pennsylvanian is commonly identified by a sandy shale zone up to 40 feet thick, containing subangular to rounded sand grains, weathered chert, traces of glauconite, lignite fragments, and other conglomeratic material. A number of round, frosted sand grains resembling those of the Simpson sandstones are found. In this part of the county progressively younger beds of the Pennsylvanian system rest on the upper or shale member of the Caney formation with structural and erosional unconformity. Where the lower part of the Pennsylvanian is mostly shale and rests on the Caney shale member of the Mississippian, samples of the cuttings offer the only evidence of the contact. In places very little contact material is found in the samples and the general lithologic change between the Pennsylvanian and Mississippian is used to approximately define the contact. The Pennsylvanian shales are variegated, granular, "greasy", fossiliferous, non-calcareous, and slightly sandy in contrast to the underlying, uniform, fine grained, dull, non-fossiliferous, slightly calcareous Caney shales containing disseminated pyrite in the upper part and mica in the lower part, and no sand.

## MISSISSIPPIAN ROCKS

### CANEY FORMATION

In Seminole County the Caney formation includes the beds lying between the base of the Pennsylvanian and the top of the Chattanooga shale. The lower 90 to 110 feet is locally termed the "Mayes" limestone and the shales above it are called the Caney shale.

10. Plummer, Frederick B., and Moore, Raymond C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. of Texas, Bull. 2132, pp. 53-54, 1921.



*Caney Shale Member.* As observed in well cuttings the upper shale member is a bluish-gray, uniformly fine grained, fissile shale. It drills easily but caves badly. It is slightly calcareous and contains small amounts of finely disseminated pyrite. Toward the base it becomes more granular in texture and apparently grades into the lower calcareous member, locally known as the "Mayes" limestone.

*"Mayes" Limestone Member.* The "Mayes" limestone is a black to brown, finely crystalline, highly calcareous shale or argillaceous limestone. It does not cave and drills easily. At the base occurs a variable, thin, gray limestone bed, and this is underlain by a very persistent layer containing considerable glauconite and some sand grains.

A few microfossils are found in the Caney formation. The following fossils have been observed:

**Hindeodella sp.**
**Caneyella wapanuckensis**
**Orthoceras sp.**
**Kirkbya sp.**

The thickness of the Caney formation varies from 120 to 700 feet depending on the depth of the post-Mississippian erosion. Of this thickness, the lower or "Mayes" limestone member is uniformly 90 to 110 feet thick. The upper shales vary from 20 to 600 feet in thickness, the thin areas being high structurally whereas the thick areas are low structurally.

The Caney formation is overlain unconformably by rocks of Pennsylvanian age. This unconformity is both structural and erosional, the erosion in places having removed up to 600 feet of Caney shale prior to the deposition of the Pennsylvanian sediments. The Pennsylvanian formations which overlie the Caney formation range in age from the Cromwell sand up to the McAlester or Boggy formations. Apparently faulting and folding occurred during post-Mississippian or early Pennsylvanian time, followed by base-leveling and the progressive westward overlap of the Pennsylvanian formations. Thus the structurally higher parts of the Mississippian were eroded to a greater depth than those areas which were structurally low and protected. The presence of the persistent glauconite layer and the local sandy phases at the base of the "Mayes" limestone member, would indicate that a stratigraphic break separates it from the underlying Chattanooga shale. Otherwise the basal contact appears to be conformable.

The Caney formation of Seminole County is correlated with the lower or Mississippian Caney shale of the Arbuckle Mountain region to the south, which in turn has been correlated by Girty[11] as being litho-

11. Girty, Geo. H., The fauna of the Moorefield shale of Arkansas: U. S. Geol. Survey, Bull. 439, 1911.

logically and faunally similar to the Moorefield shale of northern Arkansas. For this reason it would be of pre-Chester age. The "Mayes" limestone member of the Caney formation can be traced northward in well cuttings and correlated with the black Mississippi limestone of the Ponca City district. The variable white limestone layer occurring at the base of the "Mayes" limestone member is undoubtedly represented in the Arbuckle Mountain section by the Sycamore limestone.

### CHATTANOOGA SHALE

The Chattanooga shale as observed in well cuttings is a black noncalcareous, uniformly fine grained shale. It contains an abundance of coarsely crystalline pyrite in irregular nodules. Local occurrences of black chert have been noted. It drills like the overlying "Mayes" limestone member of the Caney formation and is not as a rule distinguished from it by the drillers in the field.

The following microfossils are known to occur in the formation:

Mississippian Conodonts
Large numbers of **Sporangites huronense**

The thickness of the formation ranges from 30 to 40 feet in the north part of the county to 100 feet at Earlsboro, 165 feet in the Little River field, and over 200 feet at the south side of the county. The Chattanooga shale is overlain by the "Mayes" limestone member of the Caney formation which contains glauconite and locally sandy layers at its base which would indicate a stratigraphic break. The base of the Chattanooga shale rests with erosional and angular unconformity upon beds ranging in age from middle Sylvan to upper Hunton.

The Chattanooga shale is equivalent to the Chattanooga shale of northern and eastern Oklahoma, and also to the Woodford chert of the Arbuckle Mountain region to the south.

In the field, the names Chattanooga shale and Woodford shale are both used. The term Chattanooga shale is preferable since as a subsurface formation it is better established in Oklahoma and is so well known and wide-spread in east-central United States. The age of the Chattanooga shale was originally determined as upper Devonian and is still considered as such by the United States Geological Survey. An increasing number of geologists, however, believe that from both paleontological evidence and stratigraphic relations it bears a closer relation to the Mississippian and should be considered as the basal member of that system. The major unconformity at its base and the Mississippian fossils found in the formation in Seminole County are the basis for placing it in the Mississippian system in this report.

A few feet of sand resembling the Simpson sand is found locally at the base of the Chattanooga shale. This sand farther north in Oklahoma is called the Misener sand. In some areas, particularly in the



Bowlegs and Little River fields, it contains a considerable amount of limestone conglomerate and this has been mistaken for the Hunton limestone. The Misener sand has produced some oil in Seminole County. White's[12] description of it in northern Oklahoma applies to the few occurrences in Seminole County. He states:

> A surprisingly small amount of erosion debris was left upon this old eroded surface. However, there were a few sand dunes composed of sand derived from the Simpson formation. In addition to a few well developed dunes a thin veil of wind-blown sand was scattered over broad areas. This sand was preserved by the deposition of the Chattanooga shale above it. Where it is exposed in eastern Oklahoma and Arkansas it is known as the Sylamore sandstone. By the drillers in the oil country, it is called the "Misener" sand. Because of its source of origin, therefore, samples of it from wells resemble samples from the "Wilcox" or "Burgen". It is extremely lenticular in extent. Wells drilled to this sand are often dry, even though higher structurally than offset wells producing from it, because of its absence. Where the "Misener" is sufficiently wide-spread for structure to affect the accumulation of oil, it produces on domes or anticlines. In most cases, however, it produces as a true lense without reference to structure.

## DEVONIAN-SILURIAN ROCKS

### HUNTON FORMATION

The Hunton formation, or Hunton limestone as it is commonly called, where a full section is developed in Seminole County ranges from a light gray to white, fine-grained, cherty limestone at the top (the Bois d'Arc member) to a darker gray, crystalline limestone at the base (the Chimneyhill member). Locally each of the three members into which the Chimneyhill or lower Hunton is divided, the pink crinoidal member, the glauconitic member, and the oolitic member, have been identified in well cuttings. The average Hunton limestone is difficult to distinguish from the Viola limestone by its physical appearance in well samples. Its position in the geologic section below the black Chattanooga shale and above the green to gray Sylvan shale and its abundance of microfossils, in general, offer the best evidence for its identification.

It contains a wide variety of microfossils, particularly ostracods and crinoids of which but few are as yet known to be diagnostic of individual beds. It is of interest to note that the systemic boundary between the Silurian and Devonian occurs within the Hunton limestone.

Depending on the post-Hunton erosion and the extent of the unconformities within the Hunton formation, the thickness varies from 0 to 195 feet. Where the Hunton is thin the lower or Chimneyhill member is the division encountered and this indicates that the princi-

12. White, Luther H., Subsurface distribution and correlatiton of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey, Bull. 40, p. 22, 1926.

pal reason for the change in thickness is the erosion of the upper members. Throughout a large, irregular area across central Seminole County the Hunton is entirely absent or very thin as shown in Fig. 3. Apparently a broad, irregular arch extending through this area existed at the end of Hunton time, the crest having been eroded during the peneplanation which preceded the deposition of the Chattanooga shale.

The upper contact of the Hunton formation is an erosional and gently angular type of unconformity, the Chattanooga shale resting on the different members of the Hunton formation or upon the underlying Sylvan shale, depending on the depth of the erosion. The Hunton limestone rests conformably on the Sylvan shale.

The Hunton formation outcrops on the north side of the Arbuckle Mountains 20 miles south of Seminole County. Reeds[13] has subdivided it into four separate formations as shown in the generalized geologic section of Seminole County. He places the upper two formations (Bois d'Arc limestone and Haragan shale) in the Devonian and the lower two formations (Henryhouse shale and Chimneyhill limestone) in the Silurian system. The unconformities within the Hunton formation as described by Reeds have not been observed in the samples from the Hunton limestone in Seminole County.

Oil in commercial quantities has been found in the Hunton limestone of Seminole County in the Wewoka, Searight, Seminole, and Bowlegs fields. The oil occurs in solution cavities, small vugs, fissures, and other secondary features in the limestone. It is generally found near the top, indicating that the porosity is an effect of the pre-Chattanooga weathering and erosion.

## ORDOVICIAN ROCKS

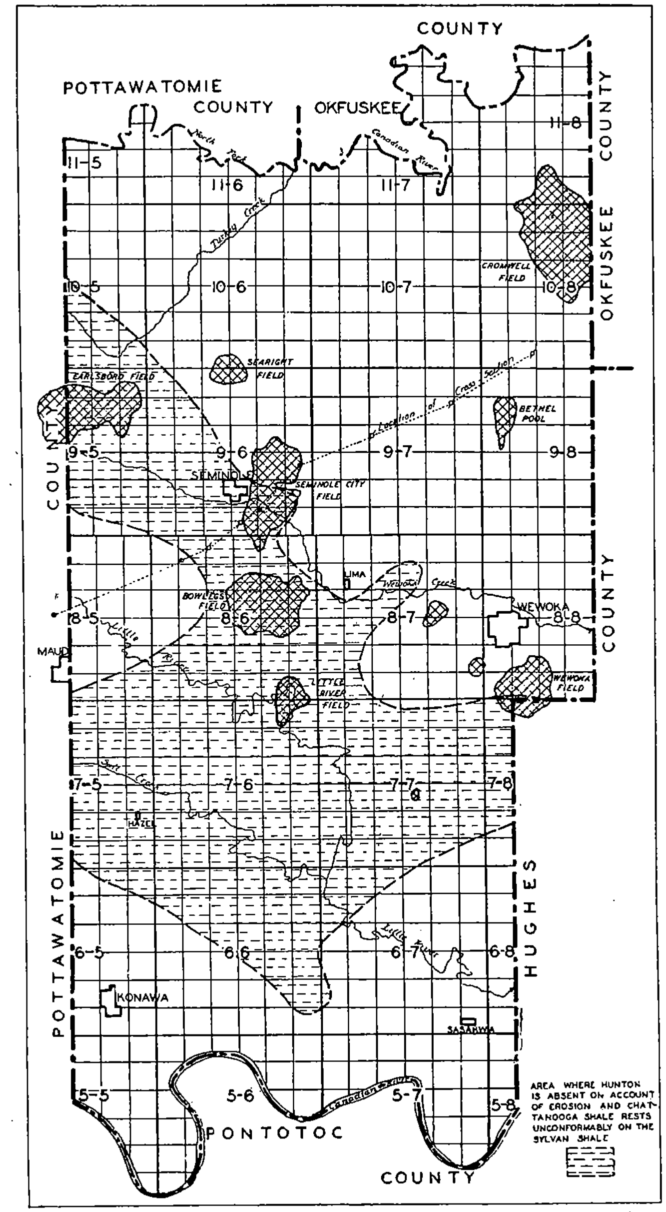
### SYLVAN SHALE

The Sylvan shale as observed in well cuttings is a gray to light gray uniformly fine textured shale. The upper five or ten feet is characteristically light green in color but due to pre-Chattanooga erosion is missing in many areas. The Sylvan shale drills easily and fast but caves badly when wet. It is slightly effervescent in dilute hydrochloric acid. It contains finely disseminated pyrite. The basal 5 to 10 feet is darker, more calcareous, locally sandy, and in one well[14] was found to contain considerable arkosic material. The Sylvan shale has a "soapy" or "slippery" feel when wet.

In the basal five or ten feet are found some graptolites of Medina[15] age; otherwise the Sylvan shale is unfossiliferous.

The thickness of the Sylvan shale ranges from 30 to 100 feet. The Sylvan is in general thickest where overlain by the Hunton limestone

13. Reeds, Chester A., The Hunton formation of Oklahoma: Amer. Jour. Sci., vol. XXXII, October, 1911.
14. Cram, Ira, personal communication.
15. Buchanan, Geo. S., personal communication.




ƒure 3. Seminole County, showing the position of the oil fields, the location of the cross section shown in Figure 6 and the area where the Hunton lime has been removed and the Chattanooga shale rests uncomformably on the Sylvan shale.

and thin where pre-Chattanooga erosion has removed the Hunton limestone and the upper part of the Sylvan shale. Since nearly all of the wells are remeasured at the base of the Sylvan shale or the top of the Viola limestone, the variable thickness reported in some cases is not real but is due to the correction of the drilling measurement.

The Sylvan shale is normally overlain conformably by the Hunton formation but throughout the central part of the county where pre-Chattanooga erosion has removed the Hunton limestone, the Chattanooga shale rests with erosional and slightly angular unconformity on different horizons of the Sylvan shale depending on the depth of erosion (See figure 3). The Sylvan shale rests conformably on the Viola limestone unless the lithologic change at the base of the Sylvan shale and at the top of the Viola limestone can be construed as indicating a break in sedimentation.

The Sylvan shale has been considered to be upper Ordovician in age and is still so considered by the United States Geological Survey.[16] Ulrich[17] believes it to be of Silurian age and his most recent paper[18] on the problem presents a very convincing argument in favor of such a change. It is placed in the Ordovician in this report only because the writer has no information of his own to offer on the subject and this is the generally accepted correlation. Eventually the Sylvan shale and the underlying upper Viola limestone will undoubtedly be generally regarded as Silurian in age.

#### VIOLA LIMESTONE

The Viola limestone is generally used as the datum for Ordovician structure. It is a light gray to gray, coarsely crystalline limestone 30 to 40 feet thick. The upper five to ten feet is milky white, flaky and soft. The remainder of the formation is denser, drills hard, and furnishes an excellent casing seat. The Viola limestone contains no dolomite and effervesces strongly in dilute hydrochloric acid.

The Viola limestone contains very few microfossils in contrast to the highly fossiliferous Hunton limestone. Some crinoid stems and some simple ostracods have been found in it.

The Sylvan shale rests conformably on the Viola limestone unless the lithologic change at the base of the Sylvan and the white, flaky upper part of the Viola limestone can be taken to indicate a stratigraphic break. Locally the Viola limestone is apparently conformable on the underlying Simpson formation but over broad areas it overlaps the entire middle and lower Viola and the upper Simpson section.

16. Geologic Map of Oklahoma: United States Geol. Survey, 1926. Compiled by Hugh D. Miser.
17. Ulrich, E. O., Revision of the Paleozoic systems: Bull. Geol. Soc. of America, vol. 22, 1911.
18. Ulrich, E. O. Relative values of criteria used in drawing the Ordovician-Silurian boundary: Bull. Geol. Soc. of America, vol. 37, no. 2, June, 1926.



Fannie C. Edson[19] states that the Viola limestone of the Mid-Continent "consists of two members, an upper, coarsely crystalline, Richmond bed, and a lower dense, buff, 'lithographic' bed, probably upper Black River in age." This dense lithographic limestone underlies the Viola limestone in Seminole County and is here considered as the upper member of the Simpson formation. The exact stratigraphic position of this limestone has not been worked out and either interpretation may be correct. In Seminole County the dense limestone member seems to be more closely associated with the Simpson formation than with the Viola limestone and the "top of the Simpson" as commonly reported in the field is the top of the dense brown limestone.

The Viola limestone is considered to be of Ordovician age by the United States Geological Survey.

White[20] states that the Viola limestone observed throughout east-central Oklahoma is the Richmond phase of the Viola limestone of the Arbuckle Mountains and correlates with the Fernvale limestone of Arkansas. Ulrich[21] places the Richmond and consequently this upper phase of the Viola limestone in the Silurian system. It is assigned to the Ordovician system in this report since the writer has no special knowledge on the problem and as it is the commonly accepted correlation. Like the Sylvan shale, the upper or Richmond phase of the Viola limestone eventually will probably be assigned to the Silurian as suggested by Ulrich.

#### SIMPSON FORMATION

In Seminole County the Simpson formation consists of several members in descending order as follows:

Simpson formation:

| | |
|---|---|
| Dense limestone member | "Simpson" formation of the oil fields |
| First dolomite member | |
| Seminole sand member | "Wilcox" or "First Wilcox" sand of oil fields |
| Second dolomite member | |
| Wilcox sand member | "Second Wilcox" sand of oil fields |

*Dense Limestone Member*. This is a dense, brown to gray, lithographic limestone, locally containing thin dolomitic layers. Microfossils are abundant, particularly ostracods, but very few of them have been described. It underlies the white to gray, coarsely crystalline Viola limestone and is readily distinguished from it by the drillers. It is reported in the well logs as the "top of the Simpson." It varies in thickness from 5 to 50 feet, the average thickness being about 15 feet.

*First Dolomite Member*. This is a gray to brownish-gray, coarsely crystalline dolomite. It is of lighter color and coarser texture than

19. Edson, Fannie Carter, Ordovician correlations in Oklahoma: Bull. Am. Assoc. Pet. Geol. vol. 11, pp. 968-970. 1927.
20. White, Luther H., op. cit. p. 18.
21. Ulrich, E. O., op. cit., p. 339.

the dense limestone member which together with its greater magnesian content offers a means of distinguishing it. The lower 5 to 10 feet in the producing fields is more coarsely crystalline, very hard, and contains increasing amounts of Simpson sand grains with depth. It varies in thickness from 15 to 50 feet, the average thickness being 25 feet.

*Seminole Sand Member*. This is the most important producing horizon of Seminole County. It consists of a bed of uniformly fine grained, slightly dolomitic sandstone up to 80 feet thick. The sand grains are subangular to rounded, many of the round grains being larger and frosted or etched. The Seminole sand drills alternately hard and soft, the greater production generally coming from the softer horizons. The hard layers are probably due to local cementation or dolomitization and the softer parts are less consolidated.

The Seminole sand member is commonly known in the Seminole County fields as the "Wilcox" or "First Wilcox" sand. It has been recognized, however, by nearly all of the geologists working in the field as a younger and different sand than the true or original Wilcox sand of Oklahoma. The writer is indebted to Luther White[22] for his suggestion of the need of a separate name for this sand, and for the name Seminole sand member. The Seminole sand member is a definite stratigraphic unit in the upper part of the Simpson formation; it has been definitely recognized as a distinct horizon throughout most of Seminole County and in the surrounding counties, particularly those to the north and northeast of Seminole County; it is uniformly bounded above and below by dolomite layers; lithologically it differs from the original or true Wilcox sand by containing considerable amounts of dolomite; and stratigraphically it is younger than the original Wilcox sand and separated from it by a layer of dolomite or sandy dolomite. Since it has reached its maximum geological and commercial development in Seminole County, the name Seminole sand member is introduced as an appropriate name for this sand.

The Wilcox sand was discovered and originally developed for oil in the Okmulgee district of Oklahoma, where it was found underlying the Viola limestone. Later developments showed that in a number of areas it was separated from the overlying Viola limestone by a variable series of dolomites, dolomitic limestones, interbedded green shale and dolomite, and standstone. This series has been termed the "post-Wilcox" Simpson by Luther H. White.[23]

He states:

> The group of rocks referred to as the post-''Wilcox'' Simpson is a series of brown or gray sandy dolomitic limestones interstratified with some green shale and thin sandstone members. Wells in the vicinity of Holdenville, Okemah, Stroud, and Cushing and all intervening territory encounter a series of this character having a minimum thickness near Stroud of 140 feet. At the latter point it is composed almost entirely of light brown dolomite with about 5 feet of sand at its upper contact. This group occurs between the Viola limestone above and the ''Wilcox'' sand below. It is referred to as the Simpson because the sand grains are rounded and etched, the shales present are green and the dolomite is more characteristic of the Simpson than the Viola limestone. It is desirable to differentiate it from the ''Wilcox'' sand, since it produces oil and gas in small quantities, the oil generally being much lower in gravity than that found in the ''Wilcox'' sand. It is also possible that water may be encountered in this horizon before reaching the ''Wilcox'' sand * * * * *
>
> From a study of the well records in the vicinity of Ada and northward it appears that the rocks referred to here as post-''Wilcox'' belong to the upper Simpson and would comprise all the beds from the top of the Simpson formation down to the top of the bed of glass sand at Roff * * * * The term post-''Wilcox'' is not used as a name but merely a descriptive term to indicate a certain portion of the Simpson formation, namely that part above the ''Wilcox'' sand.

22. White, Luther H., personal communication.
23. White, Luther H., Subsurface distribution and correlation of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey, Bull. 40, p. 16, 1926.



The first four members of the Simpson formation, of which the Seminole sand is one, therefore comprise the post-"Wilcox" Simpson of Luther White in Seminole County.

The Seminole sand member is probably a lense, grading into dolomite toward the southern part of Seminole County and thinning out toward the north and northeast parts of the State either by erosion and overlap of the overlying Viola limestone, non-deposition, or gradation into dolomite. It is distinguished in well cuttings from the Wilcox sand by its dolomite content and the uniformity and slightly smaller size of its sand grains. The Wilcox sand contains a few feet of characteristically coarse sand grains at the top and is interstratified with thin layers of green shale rather than dolomite.

*Second Dolomite Member*. Below the Seminole sand member is found a dolomite, sandy dolomite, or interstratified shale and dolomite from 10 to 100 feet in thickness. It is persistent throughout Seminole County, the thicker beds being found where the Seminole sand is thin or absent as in the southern part of the county. There it is not distinguished from the first dolomite member.

*Wilcox Sand Member*. The main sand body of the upper Simpson formation is found below the second dolomite member or from 150 to 200 feet below the top of the Viola limestone. Wells in the Seminole and Wewoka fields have penetrated it a depth of 217 and 675 feet respectively and have not encountered the base. In both fields it was found to be interstratified with thin layers of green shale. The upper few feet in all wells which are known to have reached it characteristically consist of coarse grained sand. Dolomitic layers have been found but they are not common as in the Seminole sand member and in general the quartz is clearer in the Wilcox sand grains than in those of the Seminole sand. The Wilcox sand member ("Second Wilcox" of the oil fields) produces some oil in the Seminole County fields at locations structurally high. Most of the wells, however, which have been drilled into it have found only water.

The above divisions of the Simpson formation are in general true for the producing fields of the county. Toward the southern part of the county, however, particularly through Tps. 5, 6, and 7 N., the interval between the base of the Viola limestone and the top of the first saturated sand increases to 200 feet or more. The reason for this increase is not known. A possibility is that the Seminole sand member ("First Wilcox") plays out toward the south by grading into dolomite. A sandy lime, one or two feet thick carrying water or small amounts of oil quite often occurs 100 to 150 feet below the Viola limestone and 50 to 100 feet above the top of the saturated sand in the southern parts of the county. This may mark the southern edge of the prolific producing Seminole sand member of the oil fields farther north. The first and second dolomite members would in this case occupy the position of the Seminole sand member and the saturated sand occurring 200 feet below the Viola would correlate with the Wilcox ("Second Wilcox") sand member of the oil fields. The water of this lower or true Wilcox sand becomes dilute and contains increasing amounts of hydrogen sulphide gas as the Arbuckle Mountains are approached, indicating a connection with the outcropping sands of the Simpson in that area.

Farther south in the Arbuckle Mountains, the upper or Richmond phase of the Viola limestone is separated from the Simpson formation by 500 to 600 feet of middle Viola limestone. This middle Viola limestone is not present in Seminole County, probably due to erosion and overlap by the succeeding Richmond member. This unconformity is evidence by local sandy lenses between the Viola limestone and the dense member of the Simpson formation which contain small amounts of oil.

Figure 4 ideally indicates the relations of the various members of the Simpson formation as found in Seminole County, and the nomenclature herein proposed. The right side of the diagram represents the conditions as found in the northern part of the county and in the producing fields and the left side the relations of the southern half of the county.

## STRUCTURAL GEOLOGY

### Surface Structure

The structure or attitude of the Pennsylvanian rocks exposed at the surface is one of a gentle west-dipping monocline, progressively younger and higher beds occupying the surface from east to west. This monocline is a part of a similar but larger structural feature covering,



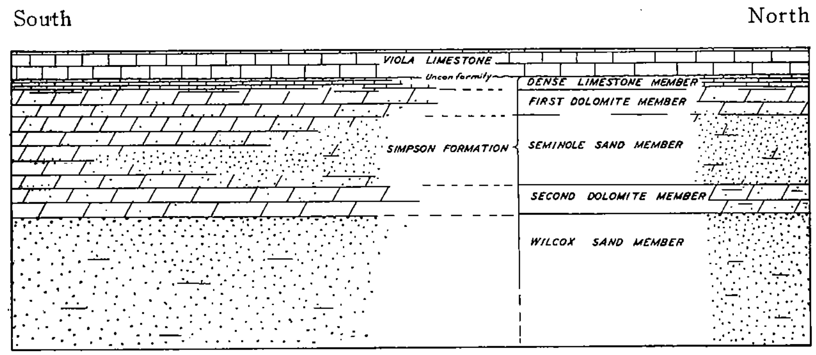



Figure 4. Ideal diagram of relations of various members of Simpson formation as found in Seminole County.

with but few interruptions, the area from Texas to Iowa and generally known as the Plains Monocline. The west dip varies from 50 to 90 feet per mile, a fair average being 70 feet per mile. Thus a formation which outcrops in the Cromwell field is found at a depth of 1,400 feet in the Earlsboro field 20 miles further west.

This west-dipping monocline is uniform only when viewed as a whole for on close examination it is found to contain numerous irregularities covering areas ranging from several square miles to a few acres. These irregularities consist of flattening of the normal dip or terraces; folds where the strata instead of dipping to the west, dip to the north or northwest and to the southwest along a common axis, thus arching the intervening area; and in places where the breaking strength of the rocks was exceeded, they were broken and faulted. These minor irregularities on the surface are found by means of close observation and accurate detailed methods of surveying and have been mapped throughout the county by most of the major companies. Each of the oil fields found thus far have been located under or adjacent to one or more of these irregularities and while all of them do not produce, yet the only indication at the surface of buried folds is to be found in these areas of abnormal structure. Their location, character, and relations are therefore of direct commercial importance. The surface structure of the Seminole City field is shown in Fig. 7.

The writer knows of no folds in the county which, when referred to sea-level datum, can be classed as domes or closed folds. When referred to the average west dip or natural datum, these terraces and folds become closed folds or true domes.

The faults in Seminole County are of the normal or gravity type. They strike N. 35°-40° W. and have vertical displacements up to 140 feet, but most of them range between 20 and 50 feet and generally are not over 2½ miles in length. They probably do not extend to great

*Generalized Geologic Section, Seminole County, Oklahoma.*

Note: The formations below the Francis formation known only from well logs.

| SYSTEM | | FORMATION | THICKNESS | CHARACTER OF SEDIMENTS |
|---|---|---|---|---|
| QUATERNARY | | Recent | 0-40 | Alluvium, sand, clay and conglomerate *Unconformity* |
| | | Pleistocene | 0-50 | Guertie sand and gravel *Unconformity* |
| PENNSYLVANIAN | | Vanoss formation | 250-500 | Shale, arkosic sand, and conglomerate |
| | | Ada formation | 0-50 | Sand and shale. Thins out northward |
| | | Vamoosa formation | 270-525 | Conglomerates, sands, shale. Thins southward |
| | | Belle City limestone | 0-30 | Gray, fossiliferous limestone. Thins northward |
| | | Francis formation | 370-500 | Shale with interbedded sandstone layers |
| | | Seminole formation<br>Holdenville shale | 800–1000 | Shale with interbedded sandstone layers |
| | | Wewoka formation<br>Wetumka shale<br>Calvin sandstone | 250-300 | "Calvin sand series" of well logs. A persistent series of sands extending from the base of the Calvin sandstone to the top of the basal sand of the Wewoka formation. |
| | | Senora formation (?)<br>Stuart shale (?)<br>Thurman sandstone (?)<br>Boggy formation<br>Savanna sandstone (?)<br>McAlester shale | 600–1400 | Shale with several variable sandstones including the Earlsboro sand. The Senora, Stuart, Thurman, and Savanna formations probably represented only in southeastern part of county if at all. |
| | Pottsville | Hartshorne sandstone | 0-60 | Booch sand of oil fields *Unconformity, structural and erosional* |
| | Pottsville | (?) Atoka formation | 0-300 | Gilcrease horizon of oil fields. Shale, limestone and sandstone. Thins westward. *Unconformity. Atoka overlaps Wapanucka* |
| | Pottsville — Wapanucka | Wapanucka limestone member | 0-10 | "Cap rock" of Cromwell field. Thickens eastward |
| | Pottsville — Wapanucka | Cromwell sand member | 0-100 | Produces oil in Cromwell and Wewoka oil fields *Unconformity (?)* |
| MISSISSIPPIAN | Caney Formation | Caney shale member | 20-600 | Bluish gray, fine grained shale overlain unconformably by formations up to Boggy shale |
| | Caney Formation | "Mayes" limestone member | 90-110 | Argillaceous, black to brown limestone Sycamore limestone at base. *Unconformity (?)* |
| | | Chattanooga shale<br>Misener sand at base | 20-220 | Uniform, black shale, thickens southward. Woodford chert of Arbuckle Mtn. section *Unconformity, structural and erosional* |
| DEVONIAN | | Bois d'Arc limestone<br>Haragan shale | 0-195 | Hunton limestone of oil fields. Locally produces oil in weathered zone near top or porous horizons within the formation. Generally not differentiated in wells. Faunal hiatus separates each member below Haragan shale. |
| SILURIAN | | Henryhouse shale<br>Chimneyhill limestone:<br>Pink crinoidal member<br>Glauconitic member<br>Oolitic member | | |
| ORDOVICIAN | | Sylvan shale | 35-100 | Gray-green shale |
| | | Viola limestone (Fernvale) | 20-40 | White to gray limestone *Unconformity* |
| | Simpson Formation | Dense lime member | 5-50 | |
| | Simpson Formation | First dolomite member | 30-125 | |
| | Simpson Formation | Seminole sand member | 0-80 | Main producing horizon. "First Wilcox" |
| | Simpson Formation | Second dolomite member | 15-100 | |
| | Simpson Formation | Wilcox sand member | 500 ± | Locally productive. "Second Wilcox" |



depths, certainly not below the base of the Pennsylvanian. The individual faults are *en echelon* in trends or belts striking N. 5° E., extending beyond the limits of the county. Two such *en echelon* fault trends are known in Seminole County, one on the east side of R. 6 E., the other on the west side of R. 8 E. Five of the major oil fields of Seminole County lie along these two fault trends and surface faulting is known to occur in two other fields. These *en echelon* fault trends are similar to those found farther north in Creek, Osage, and other counties of northern Oklahoma.

Foley[24] has described the mechanics by which the individual faults were formed and Fath[25] has postulated an origin of the *en echelon* belts in the transmission of horizontal forces through the massive basement rocks which are reflected in the shallow and incompetent Pennsylvanian formations as tears. Vertical readjustment followed, resulting in the present systems of *en echelon* faulting.

The writer would add his belief that the original deformation occurred after the end of the Mississippian period, probably during Pottsville time; was fundamentally a gravity fault deformation with associated folding; and that the surface fault belts as now observed were formed when the westward tilting occurred which developed the present Plains Monocline of the Mid-Continent region. This tilting would cause horizontal differential movement along the buried fault trends which would fracture the surface beds as shown by Fath and Foley.

### Subsurface Structure

The discussion of the structure of Seminole County may be conveniently divided into two parts according to age, as that of the Pennsylvanian and that of the pre-Pennsylvanian formations.

#### PENNSYLVANIAN STRUCTURE

Since most of the wells are drilled through the Pennsylvanian formations by the rotary method, but little definite evidence as to the structural details of the upper part of the geologic section can be obtained. Such information as we now have checks with that found in adjoining counties where more is known of the upper Pennsylvanian structure. The structure of the upper 2,000 feet or more of the Pennsylvanian section is similar to that of the surface, consisting of terraces and noses. Thus the Calvin sand structure, as far as can be determined, shows little if any closure over the producing folds. The lower part of the Pennsylvanian, owing to its decreasing thickness toward the west or convergence of the strata in this direction, will contour as dome folds. This is true of the Cromwell sand of the eastern part of the county and of the basal Pennsylvanian zone of unconformity of the western part.

24. Foley, L. L., The origin of the faults in Creek and Osage counties, Oklahoma: Bull. Amer. Assoc. Pet. Geol. vol. 10, pp. 293-300, 1926.
25. Fath, A. E., The origin of the faults, anticlines, and buried granite ridge of the northern part of the Mid-Continent oil and gas field: U. S. Geol. Survey, Prof. Paper 128-C, 1920.

### PRE-PENNSYLVANIAN STRUCTURE

In general the individual members of the pre-Pennsylvanian formations are nearly parallel and the structure of the upper part of the Mississippian is the same as that of the Simpson sandstones. The thickening of the Chattanooga shale toward the south and southwest

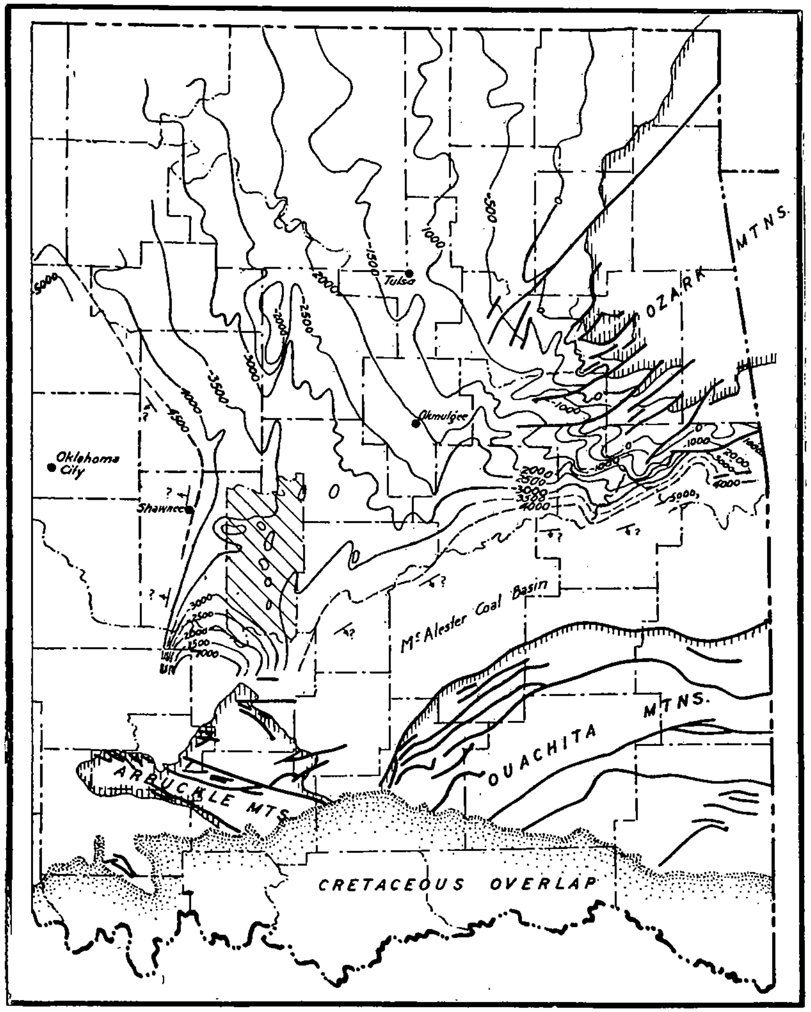



Figure 5. Showing position of Seminole County (cross-hatched) on the regional structure of eastern Oklahoma. Contours on Ordovician and in part adapted from map published by W. T. Thom, Jr., Oklahoma Geological Survey and U. S. Geological Survey.



and the variable thickness of the Hunton lime gives slight structural divergence over wide areas. However, a discussion of the structure of the Viola limestone will essentially cover the structure of all the overlying rocks up to the top of the Mississippian.

Regionally, Seminole County is located on the saddle between the Arbuckle uplift to the south and the Ozark uplift to the northeast. This can be seen in Figure 5, which shows the generalized structure of the Viola limestone and Simpson formation in eastern Oklahoma. The writer's opinon is that the Arbuckle folding and faulting, a later movement than the Ozark uplift, does not have as great an influence on the Seminole region as the Bend Arch of Texas which can be directly correlated with the Ozark Arch of northeastern Oklahoma. In other words Seminole County is fundamentally on the saddle between the Bend Arch of Texas and the Ozark Arch of Oklahoma and Missouri.

The west side of this saddle is indicated by a relatively steep west dip. This is possibly a post-Mississippian fault similar to those described in the section on structural history.

Seminole County has a total structural relief of 2,035 feet, the lowest point on the Viola being 3,750 feet below sea level and the highest point 1,715 feet below sea level. The highest structure is in the south side of the county where the Viola and Simpson formations are rising and continue to rise until they outcrop 15 miles south of the county line in Pontotoc County. In the oil fields the Viola lime of the highest wells is 2,950 feet below sea level, and it is of interest to note that structurally one of the lowest known points in the county is in the heart of the Bowlegs field.

The true details of the Viola structure are difficult to map. The nature of some of these problems is brought out more fully in later paragraphs. In general it may be said that the principal difficulties are: whether to contour the area as smooth dip or whether the evidence warrants faulting as a contributing factor to the irregularities. The writer believes that early Pennsylvanian and post-Mississippian faulting is one of the major structural factors throughout the county and that until we obtain a better idea as to the direction of these faults it is impractical to publish a contour map of the Viola lime which one might hope would even in a small measure prove of permanent value.

With the present control, then, all of the present oil fields and two of the wildcat wells, (Gypsy in sec. 5, T. 8 N., R. 6 E., and Barnsdall in sec. 23, T. 7 N., R. 6 E.) are structurally high and with the exception of the south side, which is rising regionally to the south, the remainder of the county is relatively low.

In Figure 6 is shown cross-sections through the central part of the county from southwest to northeast. The same logs are used in both sections. In the section to the left the logs are arranged using sea level datum to show the present structure and in the other the logs are referred to the top of the Calvin series as a datum and show the structure of the older rocks during Calvin time.

A statement of interest to geologists working in the Seminole County region was made by Barton in discussing the geophysical methods now in use in the United States. He states:[26]

> The torsion balance is being tried out extensively in the Mid-Continent and West Texas areas, but as yet little drilling has been done on structures discovered by it. In the Seminole district the Bowlegs oil field was predicted in advance from torsion balance work and the eastward and north-westward extension of Earlsboro.

### Structural History and Origin of Folds

The rocks of Seminole County so far as known are all of sedimentary origin and, with the exception of weathered horizons, fault planes and associated zones, are unaltered. It is therefore inferred that neither igneous nor volcanic activity has occurred nor has folding and deformation been sufficient to metamorphose or change the character of the sediments since their consolidation. We do find, however, that their original attitude has been changed and through the inferences drawn from the surface and subsurface records of Seminole County, together with those of the surrounding structural province of which Seminole County is a part, at least some idea is gained as to the succession of events during geologic history which left the rocks in their present structural position.

A correct interpretation of the structural history of a region is of commercial importance to the geologist in that, if rightly understood in one locality, it often furnishes a key as to what may be expected in another area where development is beginning. On account of the economic importance of the oil fields of Seminole County and because of the many new and different erratic structural conditions found in them, the origin of the producing structures has been given a great deal of thought by a large number of geologists. Opinion regarding the origin of these structures varies from settling over buried hills to settling over buried sink holes and from pure folding to pure faulting. The writer is of the opinion that the present structure of the producing fields can best be explained by a combination of both faulting and folding.

The following are some of the essential facts which must be considered in any theory of the origin and history of the folds of Seminole County: (1) As a background there are a number of fields in Oklahoma which have a similar and very definite geologic history. The Thomas[27] and Tonkawa[28] fields have been described. The Blackwell,

26. Barton, Donald C., Applied geophysical methods in America: Econ. Geol. vol. 22, p. 661, Nov. 1927.
27. Clark, Stuart K., Thomas oil field, Kay County, Oklahoma: Bull. Amer. Assoc. Pet. Geol., vol. 10, p. 650, 1926.
28. Clark, Glenn C., Wilcox sand production, Tonkawa field, Oklahoma: Bull. Amer. Assoc. Pet. Geol. vol. 10, pp. 889-90, 1926.



Cushing, Braman, and other fields in Oklahoma together with the granite region of Kansas undoubtedly have a like structural history. This history consists essentially of pre-Chattanooga arching and erosion, early Pennsylvanian or post-Mississippian faulting and associated folding followed by erosion, and post-Permian folding.

(2) Structural erratics are common in the Searight, Seminole, Bowlegs, and Little River fields and occur in the Earlsboro field. They are here defined as small areas consisting of a few acres in which the producing horizons vary as much as 600 feet structurally in adjacent wells. The average difference in structural elevation in the erratic areas ranges between 100 and 300 feet. These structural erratics are the reason for the wide difference of opinion among geologists regarding the origin of the Seminole County structures and are a new phase of Oklahoma structural geology.

(3) As far as the writer knows these erratic areas are in almost every case downward relative to the average surrounding wells as a study of the profiles of the Seminole and Bowlegs fields, Figures 9 and 13, discloses.

(4) The elimination of these low, erratic datums in any given field leaves a structure consisting of one or more relatively simple dome folds.

(5) The several members of the pre-Pennsylvanian section, as shown by the thousands of samples that have been collected from them, are remarkably uniform in thickness within the different fields. The tendency is for a decrease in thickness which suggests faulting, rather than an increase in thickness suggestive of steeply dipping beds. This uniform thickness is constant within and without the erratic areas and erratic wells are discovered as soon as the first identifiable upper Mississippian beds are reached.

(6) Faults, as an explanation of these erratics, are difficult to map because of the small areas affected. To postulate faulting as being the cause of the erratics, one must in many cases assume three faults which completely surround an area, enclosing one or two wells as a triangular downthrown block. At the present time there are but very few areas in which the erratics can be lined up to conform to any regular system. One such alignment is possible through section 14 of the Bowlegs field where several erratic wells, all dry holes, line up in a direction slightly east of north. In this area there is direct evidence of faulting in two of the wells. The structure map of the Seminole field, Figure 8, suggests alignments of erratics but in each case other alignments are possible, which may be as correct as those shown. This structure map is shown merely to indicate a possible method of associating erratics in the different parts of the field.

(7) Of all the wells drilled in the Greater Seminole area only 10 or 15 can be definitely said to have crossed faults. This is remarkable

since such a large number of faults are required to account for the erratics. Faults have been crossed, however, and in those areas the resultant structure is identical with that of the erratic areas where no direct evidence of faulting has been found. The evidence in the wells which show faulting is the shortening of the section within the Mississippian equal in amount to the difference in structural elevation. (See Little River field, page 60).

(8) In the areas of regular dip the water level of any field is relatively uniform. It usually occurs 3,300 feet below sea level in the Seminole sand member. Within and adjacent to the erratic areas, however, this water-oil level is also erratic and commercial wells producing oil with no water have been found as much as 300 feet below the average water level of the field.

(9) The geologic section involved in the erratic areas varies from 700 to 900 feet in thickness. To postulate the origin of the erratics by folding would require the parallel downward folding of this entire section a vertical distance of 600 feet and up again, in a horizontal distance of 1,320 feet, an improbable condition.

(10) The writer knows of no geologic literature which describes closed synclines or basins similar to those required to account for the erratics found in Seminole County. If close folding were the cause of the erratics, the folds would elevate the strata relative to the surrounding area rather than depress them. There are, however, a number of descriptions of block faulting in the literature which would appear to satisfy the conditions found in the erratic areas of Seminole County. A few of these areas are the Cave-in-Rock Quadrangle in western Kentucky,[29] the Silver City district of New Mexico,[30] and some of the Rocky Mountain structures.[31]

(11) Contractors and drillers in the fields report numerous "crooked holes." Some of these are so crooked that a new hole has to be drilled, while others merely make drilling more difficult. It is certain, however, that many of the holes are not straight and the general opinion is that the path of the crooked hole is that of a long spiral. A survey of a drill hole has been made in California[32] and the results show that the errors in both horizontal and vertical measurement may be considerable. Errors due to deflected holes are undoubtedly present in the oil fields of western Seminole County, and are a factor that may, after more information is available, be of considerable importance, particularly in structural differences up to 100 feet.

The writer believes that the present structure of Seminole County was developed in the following manner:

29. Weller, Stuart, Geology of the Cave-in-Rock Quadrangle: Kentucky Geol. Survey, Series VI., vol. 26, p. 104. 1927.
30. Paige, Sidney, Geology of the Silver City Quadrangle, New Mexico: U. S. Geol. Survey, Geol. Atlas, Silver City folio (No. 199), 1916.
31. Irvin, J. S., Faulting in the Rocky Mountain Region: Bull. Amer. Assoc. Pet. Geol., vol. 10, Figures 4, 5, and 6, 1926.
32. Hudson F. S., and Taliaferro, N. L., An interesting example of a survey of a deep bore hole: Bull. Amer. Assoc. Pet. Geol., vol. 10, pp. 775-785 1926.



At the close of Devonian time several low broad arches were formed in the eastern half of what is now the United States. One of these is the renewal of the folding of the Ozark region of Missouri and northeastern Oklahoma; and another but smaller arch through central Seminole and adjacent parts of Pottawatomie and Hughes counties, Oklahoma. In Seminole County this arch had a structural relief of at least 195 feet or equal to the thickest section of Hunton lime that has been found. (See Fig. 3, page 23).

During or immediately following this uplift, base leveling occurred and the formations were eroded from structurally high areas and were left in full thickness in areas of low structure. Thus in Figure 3 the area in which the Hunton is gone and the Mississippian rests directly on Sylvan shale, in general, outlines the crest of the arch. During this same period of erosion the Arbuckle limestone was exposed in the Ozark arch as shown by Luther White.[33]

If any oil were present in the Simpson formation sands at that time there would have been a tendency for it to migrate into this area of higher structure.

Following this peneplanation, the Chattanooga shale was laid down over the flat surface throughout Seminole County as well as a large part of the eastern United States. The deposition of rocks of Mississippian age followed in regular succession culminating in the beds of upper Mississippian age. Gentle downwarp of southeastern Oklahoma and relative upwarp of the remainder of the State at the end of the Chester time exposed all but the southeast quarter of the State to erosion. This warping or tilting was at first very gentle allowing the deposition of the Morrow-Wapanucka limestone (lower Pottsville age) in the southeastern part of the State, the western limits of which were probably in Seminole County.

The arching increased following the deposition of the Morrow-Wapanucka limestone and exposed a greater Mississippian section to erosion in central and western Oklahoma and allowed the deposition of great quantities of shale, limestone, and sand (Atoka formation) in the southeastern part of the State. The deposits of Pottsville or Atoka age progressively overlapped one another toward the west from the bottom to the top of the formation. In other words, in proceeding from east to west, progressively younger Pottsville (Gilcrease formation of the oil fields) beds are in contact with the underlying Morrow-Wapanucka limestone and the older Mississippian formations. Thus in the southeast part of the State the oldest Pottsville rests on the youngest Mississippian, in the Seminole fields the upper Pottsville rests on pre-Chester Mississippian, while farther northwest in Kansas erosion had removed the entire Mississippian section and post-Pottsville Pennsylvanian formations rest unconformably on beds of Ordovician age. This

33. White, Luther, Idem., pp. 21-22.

unconformity is probably represented in the Earlsboro field by the "unconformity zone" at the base of the Pennsylvanian, in this case either McAlester or Boggy formation. This subsidence and deposition of the thick Pottsville toward the southeast and erosion of the older formations toward the northwest can be traced with but little variation from Texas to Pennsylvania. Thus, up to this time the structural and geologic history of Seminole County is but a part of a system of much wider extent.

During Pottsville time the downwarp toward the southeast had developed a structural relief in eastern Oklahoma of over 10,000 feet. Probably as a readjustment of this tilting, the rocks were faulted in a great many places. Nearly all of these faults were of the normal or gravity type and in general they were in trends N. 5°-25° E. Associated with these faults were cross faults, in general parallel to the present fault pattern of the Arbuckle Mountains, and in Seminole County a large number of fault blocks probably varying from 10 acres up to a township or larger in size, were dropped down. Arching and some steep dips were associated with the faulting, but these are of lesser importance structurally.

Following this period of faulting and associated folding, erosion continued, leaving the younger formations which were protected, in the down blocks. In Seminole County the thickest section of Caney shale member which has been found is 600 feet. In the areas of folding and faulting it is reduced by erosion to a thickness as low as 20 feet. Thus several hundred feet of material was removed before the Pennsylvanian sea covered the western part of the county, and this eroded material was undoubtedly carried southeastward into the seas of late Pottsville and early Allegheny time.

This period of faulting and associated folding is well known in the Tonkawa[34] and Thomas[35] fields of northern Oklahoma, and is probably one of the controlling factors in the Cushing, Blackwell, Wewoka and some other fields of Oklahoma, and of the granite ridge of Kansas. The faulting in the western Seminole County fields differs from the faulting in the other fields mentioned only in the limited size of many of the areas affected. In discussing the Seminole City field, K. C. Heald[36] best expressed the situation by calling it a "fault mosaic."

Any oil in the Simpson formation which had been localized within the pre-Chattanooga arch would have been further localized at this time along and around the areas which were faulted and deformed. The fact that oil is found in the erratic areas at very irregular depths, would indicate that there had been a considerable accumulation of oil in the Wilcox sand up to that time and that it was faulted down and sealed by the fault planes and by the associated steep dips.

34. Clark, Glenn C., op. cit., pp. 888-889.
35. Clark, Stuart K., op. cit., pp. 650-651.
36. Heald, K. C., March, 1927 meeting of Amer. Assoc. Pet. Geol., Tulsa, Okla., Discussion of Seminole Field.



The Pennsylvanian seas continued to advance over the area and over 3,800 feet of sands, shales, and limestones were deposited. Deposition of the Permian shales, sands, and red beds continued without break after which the entire Mid-Continent region was gently folded into west to northwest striking anticlines and synclines, most of which were relatively small. The surface folds of Seminole County were probably formed at this time. Later or possibly as a related movement the entire Mid-Continent region was tilted up toward the east and southeast resulting in the present Plains Monocline or regional west to northwest dip. This tilting caused horizontal differential movement along the underlying Mississippian fault zones and is expressed in the surface formations as the present belts of *en echelon* faulting.

Fully 75 per cent of the folding of Seminole County, both surface and subsurface, occurred during this post-Permian deformation. The subsurface reflection of it is found in the relatively regular dome folds which result if the structural erratics in the oil fields are disregarded, as previously described. The closure on depth is a function of the convergence of the Pennsylvanian formations.[37]

A further and probably major localization of the oil occurred, the oil migrating into these post-Permian folds. It is probable that there was also some shifting of the earlier localization along the faulted area due to the differential movements recurring at this time and to the deflection of the migrating oil by the fault zones.

## OIL DEVELOPMENT

Development of the oil fields of Seminole County began with the discovery of the Wewoka field by R. H. Smith in the spring of 1923. Gas had previously been found in the Cromwell structure but the active development of that field did not start until after oil was discovered in the fall of 1923. During the drilling of the Cromwell sand in these two fields, the wildcatters were busy but had rather disappointing results. Several small areas of production from lower Pennsylvanian sands were discovered but none of these were of commercial importance. The Simpson formation had been found to be non-productive beneath the top of the Cromwell structure as well as in several large structures east of the county and not much hope was expressed for its commercial possibilities. This continued until late in the fall of 1925 when the Magnolia Oil Company completed a 4,000 barrel well in the Seminole sand member of the Simpson formation in what was then believed to be the south flank of the Wewoka structure. This was followed in rapid succession by the discovery of oil in the Seminole sand member in the Seminole City, Searight, Earlsboro, Bowlegs, and Little River fields during 1926 and 1927. These are all in the west half of the county and comprise what is known as the Greater Seminole area.

37. Levorsen, A. I., Convergence studies in the Mid-Continent region: Bull. Amer. Assoc. Pet. Geol., vol. 11, pp. 657-682, Fig. 7, 1927.

Along with the development of the fields, much lease and royalty buying and trading was going on, royalty selling for as high as $11,000.00 per acre and leases as high as $16,000.00 per acre in areas that were believed to be proven. Most of the producing leases are owned by the major oil companies of Oklahoma and nearly every company is interested, thus insuring as orderly development as is possible. The market price of the Wilcox sand oil was $2.63 per barrel during the summer of 1926, but through several cuts was reduced to $1.34 per barrel by the early spring of 1927. Most of the oil was produced when selling at the lower price.

A more detailed description of the history, production, surface and subsurface geology of the major producing fields follows.

### Wewoka Field

The first commercial oil production of Seminole County was in the Wewoka field located two miles southeast of the town of Wewoka. On March 17, 1923, R. H. Smith and others found a sand at a depth of 3,150 to 3,157 feet in their No. 1 Betsy Foster located in the NW.¼ SW.¼ NW.¼ sec. 33, T. 8 N., R. 8 E., which produced at the rate of 3,500 barrels per day. This sand, named the Smith sand, occurs in the upper part of the Cromwell horizon. The development of this sand continued until sections 32 and 33 were completely tested. A lower sand in this horizon, found in Magnolia's No. 1 Jones in the NE.¼ SE.¼ NW.¼ sec. 32, produced at the rate of 290 barrels per day, and was completed October 20, 1923. It was later learned that this represented a separate and important producing horizon when Louis Sykes completed his No. 1 Boggs in the NE.¼ SE.¼ NE.¼ sec. 31 on June 26, 1924, for 1,100 barrels at a depth of 3,160 to 3,183 feet. This lower sand, called the Sykes sand, is separated from the Smith sand by 50 feet or less of shale and is productive in secs. 31 and 32, T. 8 N., R. 8 E., and in the northern part of sec. 6, T. 7 N., R. 8 E. The Dixie Oil Company's No. 5-A John Long in the NW.¼ SW.¼ SE.¼ NE.¼ sec. 32, T. 8 N., R. 8 E., first found the Hunton limestone and was completed as a 50 barrel well from a sandy phase of the limestone at a depth of 3,873 to 3,891 feet. After the development of the Smith and Sykes sands when the structure appeared to be closed in all directions and the limits of the field defined, the Magnolia Petroleum Corporation drilled its No. 1 Skinner in the NW. cor. sec. 5, T. 7 N., R. 8 E., on the south flank of what was then the Smith sand structure. In this well the Seminole sand was found at a depth of 4,074 to 4,091 feet and it was completed December 18, 1925, as a 4,000 barrel well. At that time it was far in advance of Wilcox sand production in Oklahoma.

Production from the Hunton limestone was obtained in secs. 31 and 32, T. 8 N., R. 8 E., and Seminole sand ("Wilcox") production found in these two sections and in secs. 5 and 6, T. 7 N., R. 8 E., where the top of the Simpson structure is located. The peak of the Smith and Sykes sand production was reached during the week ending June 12, 1925, when 134 wells averaged 19,860 barrels per day. The peak production from the Seminole sand was 29,023 barrels per day during the week ending August 20, 1926. During the week ending November 22, 1927, the entire field averaged 10,326 barrels per day from 215 wells. The limits of the field are completely defined and it covers an area of 1,700 acres. In the spring of 1927, Shea and Mossberg[38] estimated the recovery up to that time to be as follows:



| | |
|---|---|
| Smith sand | 3,500,000 barrels |
| Sykes sand | 4,500,000 barrels |
| Seminole sand and Hunton limestone | 7,000,000 barrels |

The surface formations of the Wewoka field consist of the shales and sandstones of the Francis and Seminole formations. The surface structure of the Smith sand area in secs. 32 and 33, T. 8 N., R. 8 E., is a normal west dipping regional monocline and shows no irregularity. In sec. 31, T. 8 N., R. 8 E., and in secs. 5 and 6, T. 7 N., R. 8 E., the regular dip is broken by several surface faults which probably belong to the same *en echelon* belt which passes through the Cromwell field farther north. Associated with these faults are some abnormal dips.

The Pennsylvanian rocks extend below the surface to a depth of 3,200 to 3,300 feet and contain the highly productive Smith and Sykes sands at the base. The top of the Calvin series is found at a depth of 1,000 to 1,100 feet. Locally, production has been obtained from the Booch sand and Gilcrease sands but this has not been of much importance. The structure of the Smith sand is an irregular dome roughly outlined by the present limits of production, on which are superimposed a number of minor domes covering 40 to 80 acres. This fold is cut off on the west by a gravity fault downthrown approximately 300 feet on the west and striking roughly north and south. As near as can be determined from the rotary logs, this fault ends in or near the top of the Gilcrease horizon, which would place its age as upper Pottsville.

Below the Pennsylvanian the following formations are found:

*Pre-Pennsylvanian formations.*

| | Feet |
|---|---|
| Mississippian: | |
| Caney formation: | |
| Caney shale member / "Mayes" limestone member | 740 |
| Chattanooga shale | 40-110 |
| Devonian-Silurian: | |
| Hunton limestone | 0-195 |
| Ordovician: | |
| Viola limestone | 30- 40 |
| Simpson formation: | |
| Dense limestone member | 15- 30 |
| First dolomite member | 15- 35 |
| Seminole sand member | 50- 70 |
| Second dolomite member | 20+ |
| Wilcox sand member | 675+ |

38. Shea, Edward F., and Mossberg, L. G., The Wewoka oil field, Oklahoma: Paper read before Tulsa meeting of Amer. Assoc. Pet. Geol., March, 1927.

The structure of the Ordovician rocks as described by Shea and Mossberg[39] is a dome of 200 feet closure, the highest part of which is in secs. 5 and 6, T. 7 N., R. 8 E. This fold is cut off on the west side by the same fault which cuts off the Smith sand structure as described above. Over the highest parts of the Ordovician structure the Hunton limestone is thin or missing. It thickens rapidly, however, toward the north and in secs. 31 and 32, T. 8 N., R. 8 E., reached a thickness of 165 feet. This is the top of the Hunton high, the southward shifting of the Wilcox structure being in part caused by the southward thinning of the Hunton limestone.

The following is an average of the logs of the Wewoka field with correlations by the writer:

*Average section Wewoka field, sec. 5, T. 7 N., R. 8 E.*

Average Elevation: 875′ Above Sea Level

| Top | Bottom | Formation |
|---|---|---|
| 0 | 160 | Shale |
| 160 | 170 | Sand |
| 170 | 300 | Shale |
| 300 | 315 | Sand |
| 315 | 390 | Shale |
| 390 | 400 | Sandy lime |
| 400 | 510 | Shale |
| 510 | 530 | Sand—water |
| 530 | 700 | Shale |
| 700 | 730 | Sand—water |
| 730 | 840 | Shale |
| 840 | 850 | Lime |
| 850 | 875 | Sand—water |
| 875 | 1085 | Shale |
| 1085 | 1095 | Sand—water (Top Calvin Series) |
| 1095 | 1305 | Shale |
| 1305 | 1315 | Sand |
| 1315 | 1340 | Shale |
| 1340 | 1370 | Sand—water |
| 1370 | 1810 | Shale |
| 1810 | 1830 | Sand—water |
| 1830 | 2070 | Shale |
| 2070 | 2090 | Lime shells |
| 2090 | 2290 | Shale |
| 2290 | 2300 | Lime shells |
| 2300 | 2450 | Shale |
| 2450 | 2455 | Sand—water |
| 2455 | 2835 | Shale |
| 2835 | 2850 | Sand—oil (Booch sand) |
| 2850 | 2970 | Shale |
| 2970 | 3005 | Sandy lime shells (Gilcrease) |
| 3005 | 3140 | Shale |
| 3140 | 3160 | Sand—oil (Smith sand) |
| 3160 | 3190 | Shale |
| 3190 | 3325 | Sand—gas oil & wtr. (Sykes sand) |
| 3325 | 3790 | Lime shells |
| 3790 | 3940 | Shale |
| 3940 | 4025 | Sandy lime—oil (Hunton 0-165′ thick) |
| 4025 | 4087 | Shale (Sylvan) |
| 4087 | 4122 | Lime, (Viola) white |
| 4122 | 4165 | Lime, brown |
| 4165 | 4190 | Sand [Seminole ("Wilcox")] |

**Cromwell Field**

Gas was first found in the Cromwell field in the Cosden Oil & Gas Company's No. 1 Jim Wallace located in the SE.¼ SE.¼ NW.¼ sec. 15, T. 10 N., R. 8 E., which was completed November 11, 1922, as a 30,000,000 cubic foot gas well in the Cromwell sand found at 3,456 to 3,466 feet. The field was named after the Cromwell Oil & Gas Company, which on October 2, 1923, completed the first oil well in the field.

39. Shea, Edward F., and Mossberg, L. G., op. cit.



This was their No. 1 Bruner located in the NW.¼ NE.¼ SW.¼, sec. 15, in which the Cromwell sand was found at a depth of 3,467 to 3,475 feet and had an initial production of 312 barrels per day. The active development of the field followed the completion of this well and the peak production was reached during the week ending August 20, 1924, when 75 wells averaged 62,391 barrels per day. During the week ending November 22, 1927, the production was 10,823 barrels per day from 393 wells. The initial production of most of the wells ranges between 500 and 2,500 barrels per day although wells with a production as high as 5,600 barrels per day were reported.

The field covers an area of 4,700 acres, of which 140 acres are in Okfuskee County, and its limits are fully defined. The gravity of the oil varies between 38.0 and 40.0 degrees Baume. The elevation of the surface is between 850 and 1,000 feet above sea level and the average depth to the Cromwell sand between 3,300 and 3,400 feet.

The rocks that outcrop in this area are the shales, sands and, conglomerates of the Vamoosa and Francis formations. The Belle City limestone practically plays out, only a few scattered remnants being found. The surface structure consists of several smaller folds on a large northwest pitching terrace which is bounded on the east by a belt of *en echelon* faulting.

The Pennsylvanian rocks extend to the base of the Cromwell sand or to a depth of 3,400 to 3,500 feet. Locally the Calvin sand series, the top of which occurs at a depth of 1,400 to 1,600 feet, the Booch sand and the Gilcrease sand of Pennsylvanian age produce relatively small amounts of oil. The Cromwell sand which covers a large area in this part of Oklahoma is believed to be the basal sand of the Pottsville series. It is overlain by the Lyons limestone which is merely a thin cap rock in the Cromwell field but farther east increases in thickness to 125 feet.

The structure of the Cromwell sand consists of three west to southwest pitching folds, the largest of which runs through the center of sections 9 and 10. The east side is cut off by an abrupt dip or fault. It is probably due to early Pennsylvanian deformation underlying the belt of surface *en echelon* faults. The structure has a relief of over 200 feet, of which the highest parts have produced only gas. The largest oil production was found in the local saddles and along the flanks of the local highs.

The Seminole sand member has been found at several places in the field but has only been found to be productive in sec. 33, T. 11 N., R. 8 E., where wells averaging 200 to 400 barrels have been completed. It occurs at 4,100 to 4,200 feet below the surface or 650 to 750 feet below the base of the Cromwell sand and the details of its structure are yet unknown. The structure of the Ordovician will probably parallel that of the Cromwell sand in a general way. The following pre-Pennsylvanian formations are found in the deep holes within the field:

*Pre-Pennsylvanian formations.*

| | Feet |
|---|---|
| **Mississippian:** | |
| Caney formation | 400-450 |
| Chattanooga shale | 30- 40 |
| **Devonian-Silurian:** | |
| Hunton lime | 75-145 |
| **Ordovician:** | |
| Sylvan shale | 75- 90 |
| Viola limestone | 30- 40 |
| Simpson formation: | |
| Dense limestone member | 5- 15 |
| First Dolomite member | 15- 35 |
| Seminole sand (oil bearing) | |

An average log of the Cromwell sand wells drilled in the southern part of the field with correlations by the writer follows:

*Cromwell, Oklahoma, field, sections 21 and 22, T. 10 N., R. 8 E.*

Average Elevation: 900 Feet Above Sea Level

| Top | Bottom | Formation | Top | Bottom | Formation |
|---|---|---|---|---|---|
| 0 | 40 | Shale | 1540 | 1575 | Sand—water |
| 40 | 60 | Sand—water | 1575 | 1605 | Shale |
| 60 | 240 | Shale | 1605 | 1650 | Sand—water |
| 240 | 300 | Sand—water | 1650 | 1750 | Shale |
| 300 | 595 | Shale | 1750 | 1780 | Sandy lime —water |
| 595 | 605 | Lime | 1780 | 1950 | Shale |
| 605 | 685 | Shale | 1950 | 1960 | Lime |
| 685 | 695 | Lime | 1960 | 2035 | Shale |
| 695 | 855 | Shale | 2035 | 2045 | Sandy lime |
| 855 | 865 | Lime | 2045 | 2785 | Shale |
| 865 | 925 | Shale | 2785 | 2800 | Sandy shale |
| 925 | 955 | Sandy lime —water | 2800 | 3050 | Shale |
| 955 | 1075 | Shale | 3050 | 3075 | Sand, gas, oil —water (Booch) |
| 1075 | 1130 | Sand—water | 3075 | 3200 | Shale |
| 1130 | 1280 | Shale | 3200 | 3290 | Lime shells (Gilcrease) |
| 1280 | 1290 | Sandy lime —water | 3290 | 3430 | Shale |
| 1290 | 1470 | Shale | 3430 | 3475 | Sand—oil (Cromwell) |
| 1470 | 1505 | Sand—water (Top Calvin Series) | | | |
| 1505 | 1540 | Shale | | | |

Note: The interval between the top of the Booch sand and the top of the Cromwell sand decreases toward the north and is 200-250′ at the north end of the field.

### Bethel Field

The Bethel pool in the northwest part of T. 9 N., R. 8 E., is a small but interesting field. The discovery well was the Independent Oil & Gas Company's No. 1 Cobb and Hill located in the NE.¼ SE.¼ NE.¼ sec. 7, which was completed for 200 barrels per day in the Booch sand found at a depth of 3,275 to 3,302 feet, on December 9, 1924. The Cromwell sand found at a depth of 3,600 to 3,700 feet and the



Simpson formation at a depth of 4,350 to 4,550 feet, have both proven unproductive in this area. The field is of interest because of the production being confined to the Booch sand, which is in general water-bearing; also to the slow decline of the wells. The highest production of the field was reached during the week ending April 12, 1927, when it averaged 2,786 barrels per day. During the week ending November 22, 1927, the field had declined to 1,065 barrels per day from 50 wells. The initial production of most of the wells ranges between 20 and 100 barrels per day although wells with a production as high as 200 barrels have been reported. The gravity of the oil varies between 38° and 40° Baume.

The field covers an area of 500 acres but its limits are not fully defined. The elevation of the surface varies from 950 to 1,000 feet above sea level and the average depth to the Booch sand is between 3,200 and 3,300 feet. The Booch sand is between 25 and 50 feet thick and most of the wells drill through it and into the underlying shale.

The surface formations consist of the shales, sands, and conglomerates above and below the Belle City limestone. The outcrops of the Belle City limestone are poor in this area, consisting of small patches of impure, fossiliferous limestone. The surface structure consists of minor folding and faulting which is difficult to determine accurately on account of the soft, friable nature of the outcropping sandstones.

The top of the Calvin sand series occurs at a depth of 1,600 to 1,650 feet. The Booch sand, which is the producing horizon of this field, is believed to be the equivalent of the Hartshorne sandstone (top of the Pottsville) of the eastern part of the State. It certainly can be correlated with the highly productive Booch or Taneha sand of the Okmulgee district farther northeast.

The subsurface structure of the Booch sand is a north-south closed fold producing through a structural range of 40 feet.

The following is an average of the logs of the Bethel field with correlations by the writer. Most of these wells were drilled by the cable tool method so that more of the details of the Pennsylvanian stratigraphy are known here than farther west in the area where wells were drilled with rotary tools:

*Average section Bethel pool, sec. 7, T. 9 N., R. 8 E.*

Average Elevation: 960 Feet Above Sea Level

| Top | Bottom | Formation | Top | Bottom | Formation |
|---|---|---|---|---|---|
| 0 | 55 | Sand—water | 425 | 435 | Shale |
| 55 | 95 | Shale | 435 | 450 | Sand—water |
| 95 | 150 | Sand—water | 450 | 460 | Sand & shale |
| 150 | 305 | Shale | 460 | 480 | Sand—water |
| 305 | 315 | Lime | 480 | 568 | Shale |
| 315 | 420 | Shale | 568 | 595 | Sand—water |
| 420 | 425 | Lime | 595 | 795 | Shale |

(Continued on page 46)

| Top | Bottom | Formation |
|---|---|---|
| 795 | 800 | Lime |
| 800 | 865 | Shale |
| 865 | 885 | Sand—water |
| 885 | 1080 | Shale |
| 1080 | 1085 | Lime shells |
| 1085 | 1100 | Sand—water |
| 1100 | 1110 | Shale |
| 1110 | 1120 | Sand |
| 1120 | 1215 | Shale |
| 1215 | 1225 | Lime shells |
| 1225 | 1240 | Sand & shale |
| 1240 | 1245 | Sand—water |
| 1245 | 1255 | Sand & shale |
| 1255 | 1268 | Sand |
| 1268 | 1390 | Shale |
| 1390 | 1400 | Sand—water |
| 1400 | 1505 | Shale |
| 1505 | 1540 | Sand—water |
| 1540 | 1605 | Shale |
| 1605 | 1615 | Lime (Top Calvin Series) |
| 1615 | 1620 | Sand—gas |
| 1620 | 1660 | Sand & shale —water |
| 1660 | 1690 | Sand—water |
| 1690 | 1875 | Shale |
| 1875 | 1900 | Sand—gas |
| 1900 | 1920 | Sand & shale |
| 1920 | 1945 | Sand—water |
| 1945 | 1960 | Sand & shale |
| 1960 | 1980 | Sand |
| 1980 | 2275 | Shale |
| 2275 | 2280 | Sandy lime —gas |
| 2280 | 2350 | Shale |
| 2350 | 2360 | Sand & shale |
| 2360 | 2365 | Sand—gas |
| 2365 | 2370 | Sand & shale |
| 2370 | 2372 | lime shells |
| 2372 | 2595 | Shale |
| 2595 | 2600 | Sand |
| 2600 | 2700 | Shale |
| 2700 | 2720 | Sand—show of oil |
| 2720 | 3220 | Shale |
| 3220 | 3250 | Sand—oil (Booch) |
| 3250 | 3342 | Shale |
| 3342 | 3357 | Lime shells (Gilcrease) |
| 3357 | 3490 | Shale |
| 3490 | 3500 | Sandy lime |
| 3500 | 3560 | Sand —HFW (Cromwell) |
| 3560 | 4120 | Shale (Caney and Chattanooga) |
| 4120 | 4215 | Lime—HFW (Hunton) |
| 4215 | 4265 | Shale (Sylvan) |
| 4265 | 4300 | Lime (Viola) |
| 4300 | 4340 | Sandy lime (Upper part of Simpson) |
| 4340 | 4390 | Sand HFW (Seminole) |

### Seminole City Field

The discovery well of the Seminole City field was the Indian Territory Illuminating Oil Company's No. 1 Jones located in the NW.¼ NW.¼ SE.¼ sec. 24, T. 9 N., R. 6 E. This well was completed on March 7, 1926, as an 1,100 barrel well in the Hunton limestone found at a depth of 3,975 to 4,012 feet. It was later deepened to the Wilcox sand where water was encountered. A quarter of a mile east of this well on July 6, 1926, the Amerada Petroleum Corporation drilled in a 60 barrel well in the Seminole sand found at a depth of 4,258 to 4,277 feet. The well which started the active drilling of western Seminole County, however, was the Independent-Garland's No. 1 Fixico located in the NW.¼ NW.¼ SE.¼ sec. 26. In this well only 4 feet of Hunton lime was found and, after deepening to the Seminole sand (First "Wilcox") found at a depth of 4,065 to 4.073 feet, was completed on July 16, 1926 as a 6,120 barrel well. The field then developed rapidly, reaching its peak during the week ending February 28, 1927, when 211 wells averaged 253,192 barrels of oil per day. On November 1, 1927, its production had declined to 64,351 barrels of oil per day from 326 wells and up to this date it had produced a total of 51,250,633



barrels of oil. One-third of the wells are showing water. In Figure 7 are shown the production curves of the Seminole City field.

The initial production of most of the wells ranged between 1,000 and 3,500 barrels per day, although wells as high as 9,000 barrels per day were reported. The high production generally followed shooting

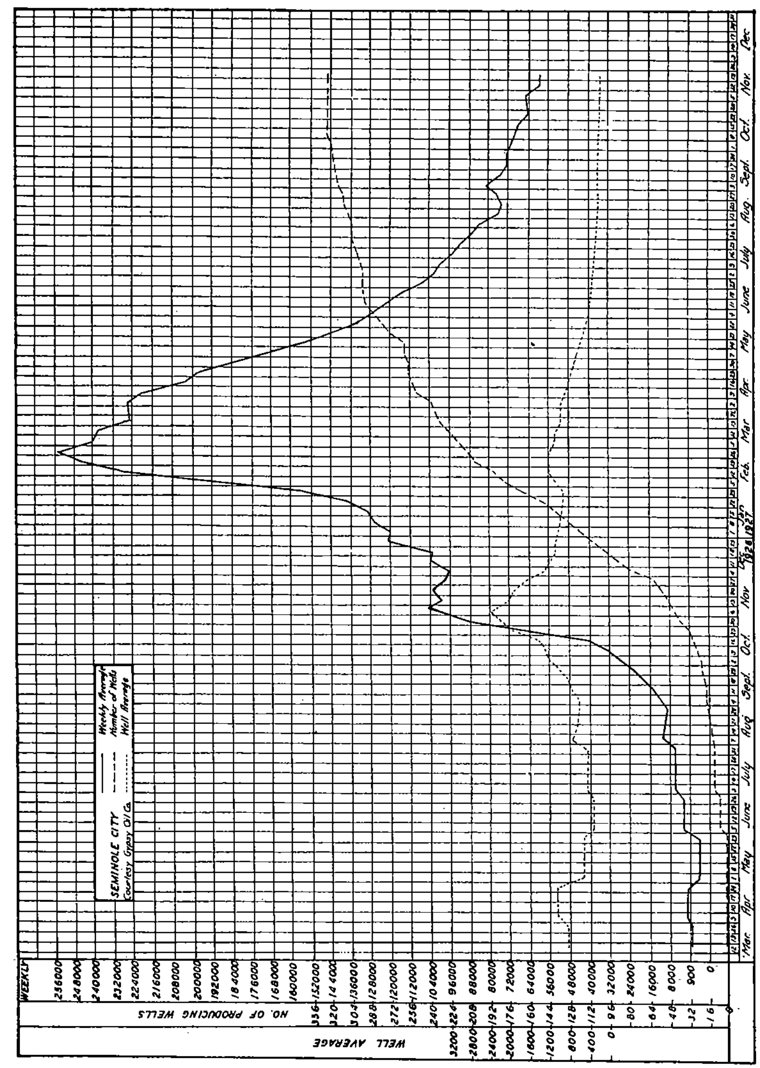



Figure 7. Curves showing the average daily production, number of producing wells, and the average production per well of the Seminole City field.

or the application of air lift. The gravity of the oil varies between 40° and 42° Baume.

The limits of the field are now fairly well defined and it covers an area of 3,600 acres. The elevation of the surface varies from 840 feet to 940 feet above sea level and the average depth to the Seminole sand from 4,000 to 4,300 feet.

The surface formations of the Seminole City field include the shales, sands, and conglomerates of the Vanoss and Vamoosa formations. The Pawhuska limestone, occurring at the base of the Vanoss formation, is well developed in the field and is the datum to which the surface structure is referred. Figure 8 is a map showing the surface structure of the Seminole City field.

Rocks of Pennsylvanian age extend to a depth of 3,400 to 3,600 feet and consist of alternating shale and sand layers. The top of the Calvin sand series occurs at a depth of 2,100 to 2,300 feet. The details of the Pennsylvanian stratigraphy are not definitely known due to the rotary method of drilling to depths below the base of the Pennsylvanian formations. The Seminole City area probably marks the western limits of the Cromwell sand due to erosion and overlap by younger formations. No commercial production has been obtained from the Pennsylvanian sands.

Below the Pennsylvanian rocks and separated from them by an erosional and structural unconformity, the following geologic section is encountered:

*Pre-Pennsylvanian formations.*

| | Feet |
|---|---|
| Mississippian: | |
| Caney formation: | |
| Caney shale member (Av. 275 ft.) | 150-400 (?) |
| "Mayes" limestone member | 90-110 |
| Chattanooga shale | 90-110 |
| Devonian-Silurian: | |
| Hunton limestone, Oil bearing | 0- 75 |
| Ordovician: | |
| Sylvan shale | 80-100 |
| Viola limestone | 30- 40 |
| Simpson formation: | |
| Dense limestone member | 10- 20 |
| First Dolomite member | 30- 50 |
| Seminole "Wilcox" sand member, Oil bearing | 40- 80 |
| Second Dolomite member | 15- 30 |
| "Wilcox" sand, some oil | 30 (?) |

The structure of the Ordovician rocks in general consists of three domes, located in sections 23 and 24: 34, 35; and 36, and a smaller dome in section 25. Each of these underlie surface folds. These Ordovician folds are broken by a number of erratics where offset wells show a structural difference in elevation up to 500 feet. The structural relief of the

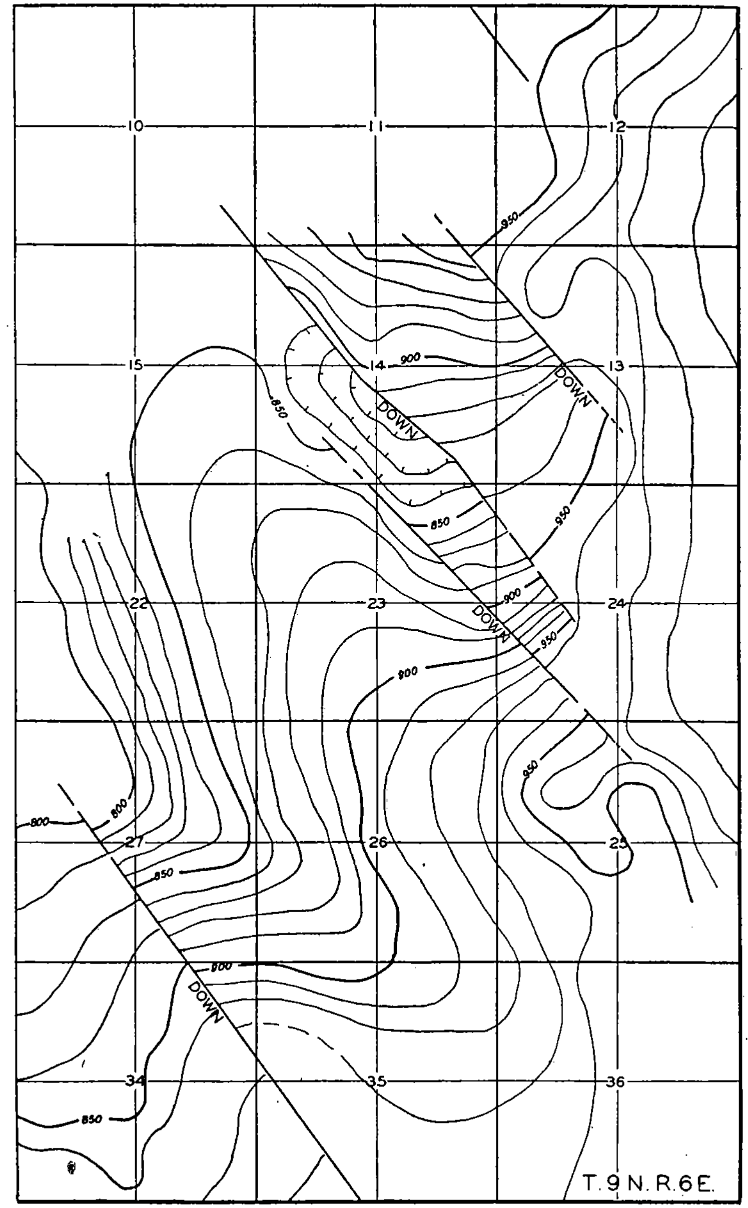



Figure 8. Map showing the surface structure of the Seminole City field. Contours referred to Pawhuska (?) limestone and contour interval is 10 feet. Compiled from various sources including map by Indian Territory Illuminating Oil Company published by The Oil and Gas Journal, April 8, 1927.

folds is roughly 250 feet but the erratics bring the total relief of the field up to 600 feet or more.

In Figure 9 are shown the structure and a series of profiles of the top of the Viola limestone. The contour interval is 100 feet and the heavy — 3,200-foot contour line roughly outlines the general structure and marks the normal position of the oil-water contact in the field. An examination of the structure and profiles shows that the primary structure consists of regular dome folds and that the erratics are minor features superimposed upon them.

The following is the log of the discovery well of the Seminole field with correlations by the writer. It is the only complete cable tool test drilled in the field:

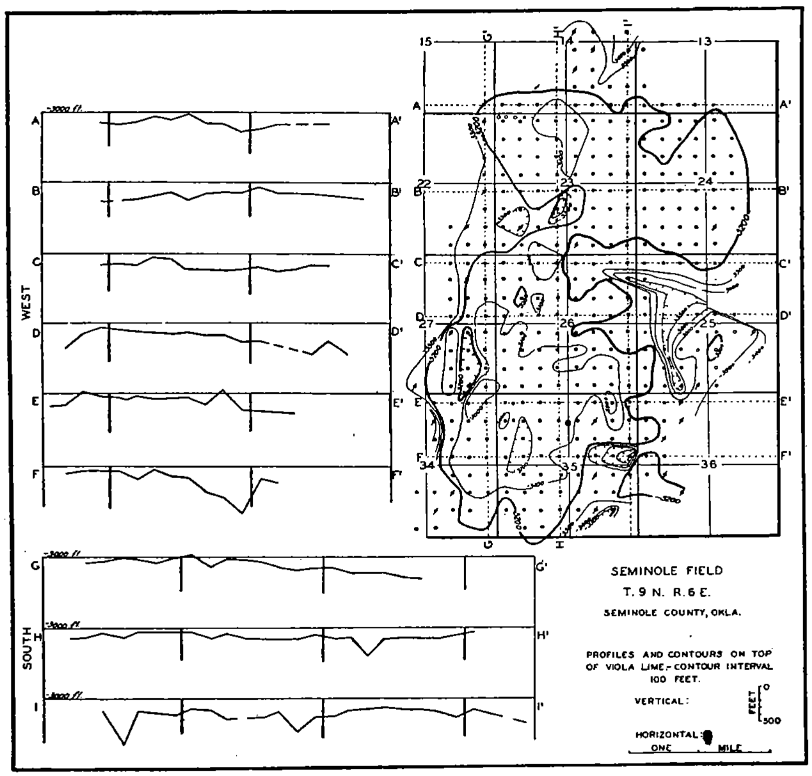



Figure 9. Structure and profiles on the Viola limestone in the Seminole City field. Contour interval is 100 feet. The heavy 3200-foot contour roughly outlines the structure and marks the normal position of the water-oil contact.



*I. T. I. O. Well No. 1 James, NW. cor SE.¼, section 24, T. 9 N., R. 6 E., Seminole County, Oklahoma.*

Elevation: 938 Feet Above Sea Level

| Top | Bottom | Formation |
|---|---|---|
| 0 | 15 | Sand |
| 15 | 20 | Lime |
| 20 | 55 | Sand & red rock |
| 55 | 125 | Red rock |
| 125 | 135 | Shale |
| 135 | 155 | Sand—water |
| 155 | 170 | Shale |
| 170 | 215 | Sand |
| 215 | 230 | Shale |
| 230 | 270 | Sand—water |
| 270 | 280 | Shale |
| 280 | 295 | Sand—water |
| 295 | 305 | Red rock |
| 305 | 320 | Sand |
| 320 | 328 | Red rock |
| 328 | 370 | Shale |
| 370 | 440 | Sand—water |
| 440 | 450 | Shale |
| 450 | 465 | Sand |
| 465 | 475 | Shale |
| 475 | 490 | Sandy shale |
| 490 | 575 | Shale |
| 575 | 585 | Sandy lime |
| 585 | 595 | Shale |
| 595 | 620 | Sand |
| 620 | 625 | Shale |
| 625 | 630 | Sand |
| 630 | 690 | Shale |
| 690 | 715 | Sand |
| 715 | 730 | Sandy shale |
| 730 | 740 | Sand |
| 740 | 755 | Shale |
| 755 | 762 | Sand |
| 762 | 772 | Red rock |
| 772 | 782 | Shale |
| 782 | 792 | Sandy lime |
| 792 | 820 | Shale |
| 820 | 827 | Lime |
| 827 | 880 | Sand—water |
| 880 | 925 | Shale |
| 925 | 1095 | Shale |
| 1095 | 1105 | Lime |
| 1105 | 1155 | Shale |
| 1155 | 1180 | Sand—water |
| 1180 | 1190 | Lime |
| 1190 | 1265 | Shale |
| 1265 | 1285 | Sand—water |
| 1285 | 1300 | Shale |
| 1300 | 1325 | Sand—water |
| 1325 | 1330 | Shale |
| 1330 | 1350 | Sand—water |
| 1350 | 1700 | Shale |
| 1700 | 1755 | Sand—water |
| 1755 | 1860 | Shale |

| Top | Bottom | Formation |
|---|---|---|
| 1860 | 1880 | Sand—water |
| 1880 | 1885 | Shale |
| 1885 | 1895 | Sand |
| 1895 | 2015 | Shale |
| 2015 | 2025 | Sand—water |
| 2025 | 2050 | Sandy shale |
| 2050 | 2060 | Shale |
| 2060 | 2065 | Lime |
| 2065 | 2080 | Shale |
| 2080 | 2085 | Lime |
| 2085 | 2115 | Sand—water |
| 2115 | 2205 | Shale |
| 2205 | 2215 | Sand (Top Calvin Series) |
| 2215 | 2225 | Shale |
| 2225 | 2260 | Sand—water |
| 2260 | 2265 | Lime |
| 2265 | 2275 | Shale |
| 2275 | 2280 | Lime |
| 2280 | 2290 | Shale |
| 2290 | 2305 | Sand |
| 2305 | 2320 | Shale |
| 2320 | 2327 | Lime |
| 2327 | 2340 | Shale |
| 2340 | 2342 | Lime |
| 2342 | 2450 | Shale |
| 2450 | 2475 | Sand—show of oil |
| 2475 | 2482 | Shale |
| 2482 | 2555 | Sand |
| 2555 | 2772 | Shale |
| 2772 | 2785 | Lime |
| 2785 | 2820 | Shale |
| 2820 | 2825 | Lime |
| 2825 | 2910 | Shale |
| 2910 | 2915 | Lime |
| 2915 | 2935 | Shale |
| 2935 | 2950 | Sand |
| 2950 | 2995 | Shale |
| 2995 | 3005 | Lime |
| 3005 | 3020 | Shale |
| 3020 | 3040 | Sand |
| 3040 | 3125 | Shale |
| 3125 | 3135 | Sand |
| 3135 | 3170 | Shale |
| 3170 | 3190 | Sandy shale |
| 3190 | 3445 | Shale |
| 3445 | 3460 | Sand (Cromwell) |
| 3460 | 3650 | Shale |
| 3650 | 3655 | Lime |
| 3655 | 3710 | Sandy shale—show oil |
| 3710 | 3830 | Shale |

(Continued on page 52)

| Top | Bottom | Formation | Top | Bottom | Formation |
|---|---|---|---|---|---|
| 3830 | 3835 | Lime | 4125 | 4165 | Lime (Viola) |
| 3835 | 3860 | Lime shells | 4165 | 4175 | Sand |
| 3860 | 3885 | Shale | 4175 | 4176 | Lime |
| 3885 | 3930 | Lime shells | 4176 | 4185 | Sand |
| 3930 | 3975 | Shale | 4185 | 4215 | Lime |
| 3975 | 3977 | Lime | 4215 | 4263 | Sand } Simpson |
| 3977 | 4012 | Sandy lime | 4263 | 4266 | Shale |
| | Hunton | 0-75′ | 4266 | 4270 | Sand |
| 4012 | 4048 | I ime | 4270 | 4277 | Shale |
| 4048 | 4125 | Blue shale (Sylvan) | 4277 | 4289 | Lime |

### Searight Field

The Searight field is named after F. J. Searight who drilled the discovery well. This well, No. 1 Youngblood, located in the SE.¼ NE.¼ SE.¼, sec. 33, T. 10 N., R. 6 E., after drilling for nearly two years, was completed on April 21, 1926, for 312 barrels in the Hunton limestone found at a depth of 4,090 to 4,157 feet. On October 11, 1926, the Searight Oil Company's No. 3 Youngblood, located in the NW.¼ NE.¼ SE.¼, sec. 33, found the Seminole sand at a depth of 4,315 to 4,317 feet and started flowing 4,572 barrels of oil per day. The field was developed in both the Hunton limestone and the Seminole sand (First "Wilcox"), reaching its maximum daily production during the week ending June 21, 1927, when 42 wells averaged 39,857 barrels of oil per day. The field, whose limits are defined except on the west, covers an area of 700 acres and on November 1, 1927, it had produced a total of 11,282,174 barrels of oil. On this date its production was 25,663 barrels from 62 wells, with 20 to 25 per cent of the wells showing water. In Figure 10 are shown the production curves of the Searight field. This field differs from the other fields in the western half of the county in the slower decline of its production.

The initial production of most of the wells ranges between 500 and 2,000 barrels per day although several wells as high as 4,500 to 5,000 barrels per day were reported. The gravity of the oil varies between 39° and 42° Baume.

The elevation of the surface varies between 960 and 1,065 feet above sea level and the average depth to the Seminole sand member from 4,300 to 4,400 feet.

The surface rocks of the Searight field consist of the shales and sands of the Vanoss formation of upper Pennsylvanian age. The surface structure is a west pitching "nose" type of fold with short *en echelon* faults cutting it off on the east side.

The Pennsylvanian rocks extend to a depth of 3,700 to 3,850 feet and consist of alternating shales and sands. The top of the Calvin sand series occurs at a depth of 2,500 to 2,600 feet. The details of the stratigraphy are unknown as all the drilling except the discovery well was by the rotary method. Below the rocks of Pennsylvanian age and sep-

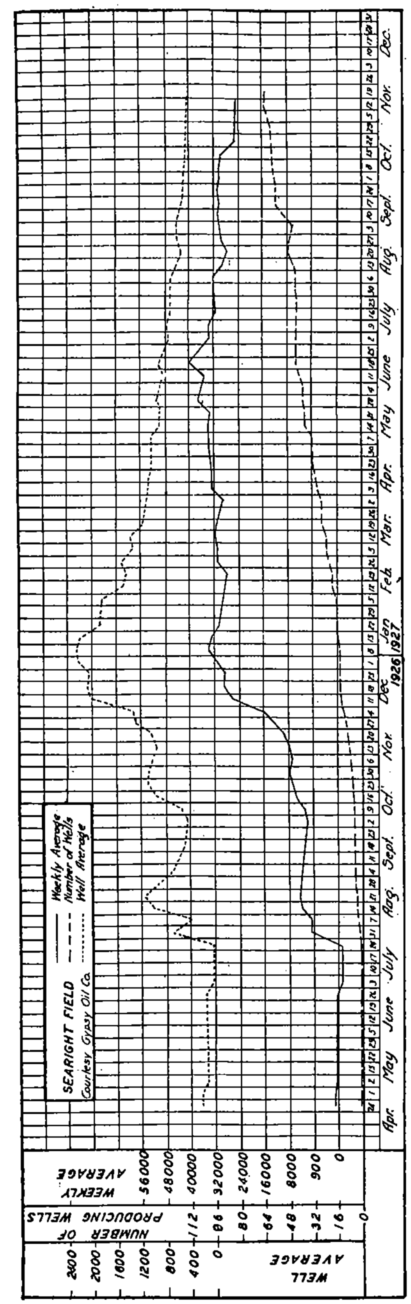



Figure 10. Curves showing the average daily production, number of wells drilled, and the average production per well of the Searight field.

arated from them by an erosional and structural unconformity, the following geologic section is encountered:

*Pre-Pennsylvanian formations.*

| Formation | Feet |
|---|---|
| Mississippian: | |
| Caney formation: | |
| Caney shale member | 200-300 (?) |
| "Mayes" limestone member | 90-100 |
| Chattanooga shale | 40- 60 |
| Devonian-Silurian | |
| Hunton Lime, oil bearing | 85-160 |
| Ordovician | |
| Sylvan shale | 70-100 |
| Viola limestone | 34- 40 |
| Simpson formation: | |
| Dense limestone member | 5- 15 |
| First Dolomite member | 30- 50 |
| Seminole sand member, Oil bearing | |

The structure of the Ordovician rocks is an irregular dome with 80 to 100 feet of closure which is broken by several structural erratics giving it a total structural relief of 385 feet.

### Earlsboro Field

The first oil production in the Earlsboro field was found in Morgan & Flynn's No. 1 Ingram located in the NW.¼ NW.¼ SE.¼ sec. 10, T. 9 N., R. 5 E., which on March 1, 1926, was completed as a 200 barrel well from what is now called the Earlsboro sand found at a depth of 3,560 to 3,580 feet. On December 3, 1926, the Gypsy Oil Company et al completed their No. 1 State located in the NE. cor. sec. 16 as an 8,050 barrel well in the Seminole sand found at a depth of 4,275 to 4,291 feet. This started the active development of the field which reached a maximum average daily production of 205,286 barrels from 135 wells during the week ending August 9. 1927. On November 1, 1927, the field had declined to 148,361 barrels per day from 248 wells and up to this date it had produced a total of 28,230,350 barrels of oil. About one-fifth of the wells are showing water. The curves showing the average daily production, number of wells drilled, and average production per well are shown in Figure 11.

The initial production of most of the wells ranged between 1,000 and 4,000 barrels per day although wells as high as 14,000 barrels per day were reported. The high production was generally the result of shooting and the application of air lift. The gravity of the oil varies between 40° and 42° Baume.

The major part of the field, which covers an area of 2,830 acres, is in Seminole County although the town of Earlsboro from which it derives its name and the Seminole sand discovery well of the Gypsy Oil Company are both located in Pottawatomie County. The elevation of

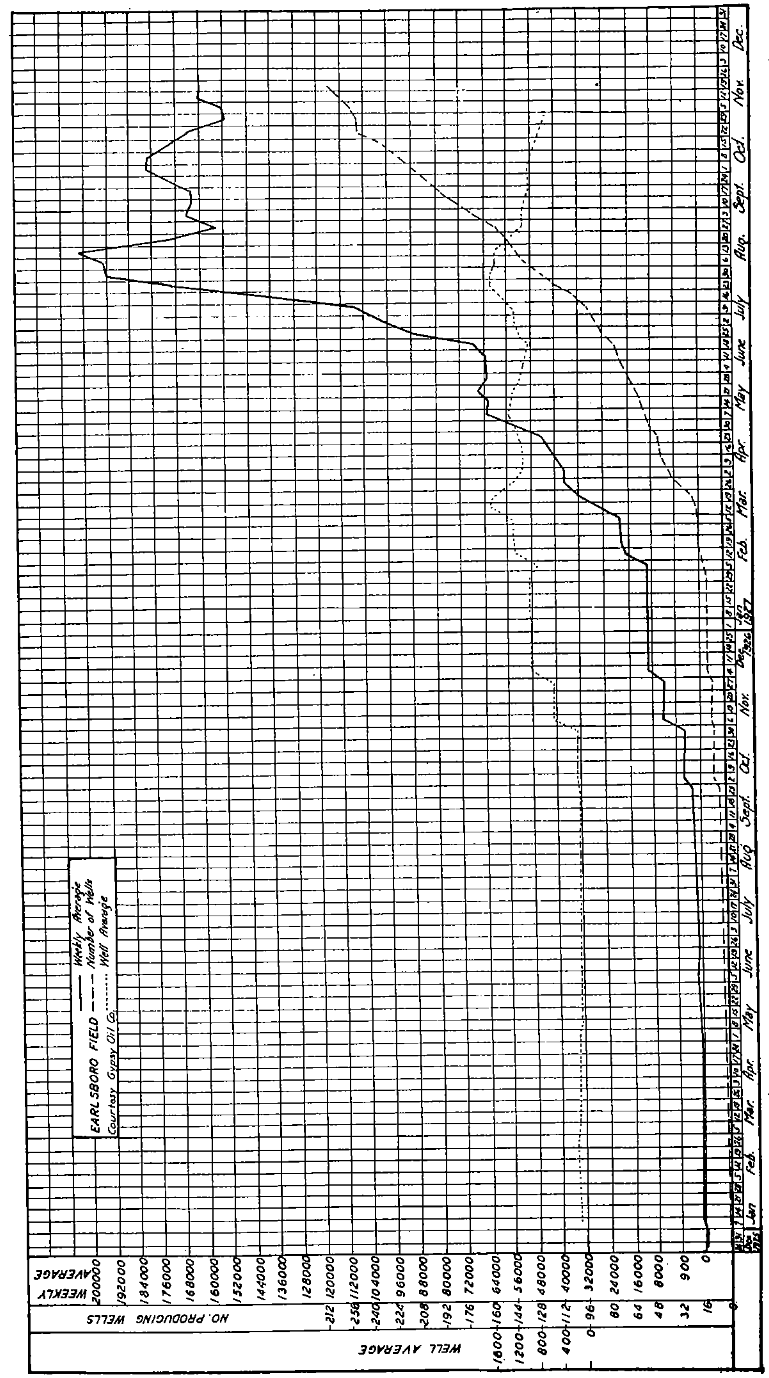



Figure 11. Curves showing the average daily production, the number of wells drilled and the average production per well of the Earlsboro field.

the surface varies from 935 to 1,050 feet above sea level and the average depth to the Seminole sand member between 4,200 and 4,300 feet.

The rocks outcropping in the Earlsboro field are the shales and sands of the Vanoss formation of upper Pennsylvanian age. The Permian-Pennsylvanian contact is believed to be in the low hills a mile west of the town of Earlsboro. The surface structure differs from that of the other fields of Seminole County by the absence of surface faults, or if present, they are of minor importance. The surface structure consists of several terraces and minor flattenings passing into a broad arch on the west end of the field. From east to west there is a total reduction of 90 to 100 feet in the normal west dip.

The Pennsylvanian formations extend to a depth of 3,800 to 3,900 feet and contain the Earlsboro sand about 250 feet above the base. Several wells have been drilled in the Earlsboro sand with production up to 700 barrels per day of 38 gravity oil but the average initial production is between 100 and 300 barrels per day. The sand is a lense-shaped body and production from it is erratic. The top of the Calvin series occurs at 2,850 to 3,000 feet.

Below the Pennsylvanian and separated from it by a structural and erosional unconformity is the following geologic section:

*Pre-Pennsylvanian formations.*

| | Feet |
|---|---|
| Mississippian: | |
| Caney formation: | |
| Caney shale member | 20-200 |
| "Mayes" limestone member | 90-100 |
| Chattanooga shale | 100-125 |
| Devonian-Silurian: | |
| Hunton lime | 0- 30 |
| Ordovician: | |
| Sylvan shale | 90-110 |
| Viola limestone | 30- 40 |
| Simpson formation | |
| Dense limestone member | 10- 20 |
| First dolomite member | 40- 50 |
| Seminole sand member, oil bearing | 50-100 |
| Second dolomite member | 5- 30 |
| Wilcox sand, some production | |

The structure of the Ordovician rocks is a dome fold extending east and west through sections 9, 10, 11 and into 12, and having a closure of about 150 feet. This fold is broken by several structural erratics which bring the total structural relief of the field up to 360 feet. It is the most regular of any of the large producing folds of the western part of the county. Wells several miles north and south of the field find the Simpson formation 700-1,000 feet lower than those situated on the top of the Earlsboro fold.

The following is the log of the Wilcox sand discovery well, drilled with cable tools:



*Gypsy No. 1 State, NE. cor. section 16, T. 9 N., R. 5 E., Seminole County, Oklahoma*

Elevation: 986 Feet Above Sea Level

| Top | Bottom | Formation | Top | Bottom | Formation |
|---|---|---|---|---|---|
| 0 | 90 | Red shale | 1600 | 1670 | Sandy lime |
| 90 | 118 | Sand—water | 1670 | 1700 | Shale |
| 118 | 120 | Red rock | 1700 | 1780 | Red rock |
| 120 | 140 | Sandy lime | 1780 | 1830 | Sand |
| 140 | 175 | Red rock | 1830 | 1860 | Shale |
| 175 | 180 | Sandy lime | 1860 | 1960 | Shale |
| 180 | 270 | Red rock | 1960 | 1980 | Sandy lime |
| 270 | 280 | Sand | 1980 | 1990 | Lime |
| 280 | 305 | Red rock | 1990 | 2015 | Sandy lime |
| 305 | 315 | Sandy lime | 2015 | 2035 | Lime shells |
| 315 | 330 | Red rock | 2035 | 2040 | Sandy lime |
| 330 | 340 | Sandy lime | 2040 | 2055 | Sand—water |
| 340 | 390 | Shale | 2055 | 2060 | Shale |
| 390 | 425 | Sandy lime | 2060 | 2080 | Sand |
| 425 | 485 | Lime shells | 2080 | 2150 | Shale |
| 485 | 520 | Sand & shale | 2150 | 2175 | Sand |
| 520 | 550 | Shale | 2175 | 2340 | Shale |
| 550 | 570 | Sand | 2340 | 2350 | Sandy lime |
| 570 | 590 | Shale | 2350 | 2470 | Shale |
| 590 | 615 | Sand—water | 2470 | 2475 | Lime |
| 615 | 625 | Shale | 2475 | 2555 | Shale |
| 625 | 630 | Red rock | 2555 | 2560 | Sandy lime |
| 630 | 640 | Shale | 2560 | 2570 | Sand |
| 640 | 660 | Sandy lime | 2570 | 2595 | Sandy lime |
| 660 | 690 | Shale | 2595 | 2600 | Shale |
| 690 | 710 | Sand—water | 2600 | 2610 | Sandy lime |
| 710 | 720 | Shale | 2610 | 2700 | Shale |
| 720 | 730 | Red rock | 2700 | 2705 | Sand & shale |
| 730 | 750 | Sand | 2705 | 2715 | Shale |
| 750 | 755 | Lime | 2715 | 2730 | Sand—water |
| 755 | 810 | Shale | 2730 | 2735 | Sandy lime |
| 810 | 815 | Sand—water | 2735 | 2740 | Lime |
| 815 | 825 | Red rock | 2740 | 2790 | Shale |
| 825 | 885 | Shale | 2790 | 2800 | Sand |
| 885 | 910 | Sand | 2800 | 2938 | Shale |
| 910 | 940 | Shale | 2938 | 2970 | Sand—water |
| 940 | 1045 | Sand—water | 2970 | 2985 | Shale |
| 1045 | 1060 | Shale | 2985 | 2995 | Sand |
| 1060 | 1070 | Sandy lime | 2995 | 3015 | Sandy lime |
| 1070 | 1090 | Red rock | 3015 | 3035 | Shale |
| 1090 | 1110 | Sand—water | 3035 | 3055 | Sandy lime |
| 1110 | 1120 | Shale | 3055 | 3060 | Shale |
| 1120 | 1140 | Sand—water | 3060 | 3075 | Sandy lime |
| 1140 | 1175 | Red rock | 3075 | 3115 | Shale |
| 1175 | 1178 | Sand | 3115 | 3130 | Lime shells |
| 1178 | 1182 | Red Rock | 3130 | 3135 | Shale |
| 1182 | 1215 | Sand | 3135 | 3140 | Lime |
| 1215 | 1250 | Red rock | 3140 | 3150 | Shale |
| 1250 | 1260 | Sand—water | 3150 | 3160 | Sand—show of oil |
| 1260 | 1340 | Sandy lime | | | |
| 1340 | 1455 | Shale | 3160 | 3162 | Shale |
| 1455 | 1465 | Lime | 3162 | 3260 | Sand—water |
| 1465 | 1505 | Shale | 3260 | 3265 | Lime |
| 1505 | 1540 | Sand—water | 3265 | 3305 | Sandy lime |
| 1540 | 1600 | Sand | 3305 | 3400 | Shale |

(Continued on page 58)

| Top | Bottom | Formation |
|---|---|---|
| 3400 | 3485 | Lime shells |
| 3485 | 3490 | Shale |
| 3490 | 3495 | Lime |
| 3495 | 3520 | Sand & shale |
| 3520 | 3605 | Shale |
| 3605 | 3645 | Sand & shale (Earlsboro sand) |
| 3645 | 3840 | Shale |
| 3840 | 3860 | Sandy shale (Base Pennsylvanian) |
| 3860 | 3880 | Shale (Caney) |
| 3880 | 3980 | Lime, soft (Mayes) |
| 3980 | 4090 | Shale, Black (Woodford) |
| 4090 | 4180 | Shale, green (Sylvan) |
| 4180 | 4260 | Lime & sandy lime (Viola and Simpson) |
| 4260 | 4290 | Sand—oil (Seminole) |

**Bowlegs Field**

The discovery wells in the Bowlegs field were drilled by the Indian Territory Illuminating Oil Company. On June 18, 1926, its No. 1 Goforth, located in the SW.¼ SW.¼ NE.¼ sec. 15, T. 8 N., R. 6 E., was completed as a million cubic foot gas well in the basal sand of the Calvin series found at a depth of 2,426 to 2,443 feet. The active development of the field was started by the same company's No. 1 Davis, located in the SW. cor. sec. 13, in which on January 4, 1927, the Seminole sand was found at a depth of 4,194 to 4,200 feet and completed as a 5,500 barrel well. The peak production was reached during the week ending August 2, 1927, when 173 wells averaged 190,408 barrels per day. On November 1, 1927, the production had declined to 115,513 barrels per day from 265 wells and up to this date the field had produced a total of 30,230,067 barrels of oil. About one-fifth of the wells are showing water. In Figure 12 are shown the production curves of the Bowlegs field. (Page 59).

The initial production of most of the wells ranges between 1,000 and 4,000 barrels per day. The gravity of the oil varies between 40° and 42° Baume. The limits of the field have been nearly defined and it covers an area of 2,800 acres. The elevation of the surface varies between 870 and 950 feet above sea level and the average depth to the Seminole sand betwen 4,000 and 4,300 feet.

The surface rocks exposed in the field consist of conglomerates, sands, and shales of the upper part of the Vamoosa conglomerate and the lower portion of the Vanoss formation, both of upper Pennsylvanian age. A thin, variable, fossiliferous sandy limestone, the Pawhuska (?) limestone outcrops in the field and is the datum to which the surface structure is referred. The surface structure is similar to that of the Seminole City field to the north in that it consists of several small terraces and folds complicated by the same belt of *en echelon* faults.

In the Bowlegs field the sands and shales of Pennsylvanian age extend to a depth of 3,300 to 3,500 feet. The top of the Calvin sand series is found at a depth of 2,050 to 2,200 feet. As the Pennsylvanian and upper part of the Mississippian are drilled by the rotary method, the base of the Pennsylvanian and the details of the Pennsylvanian



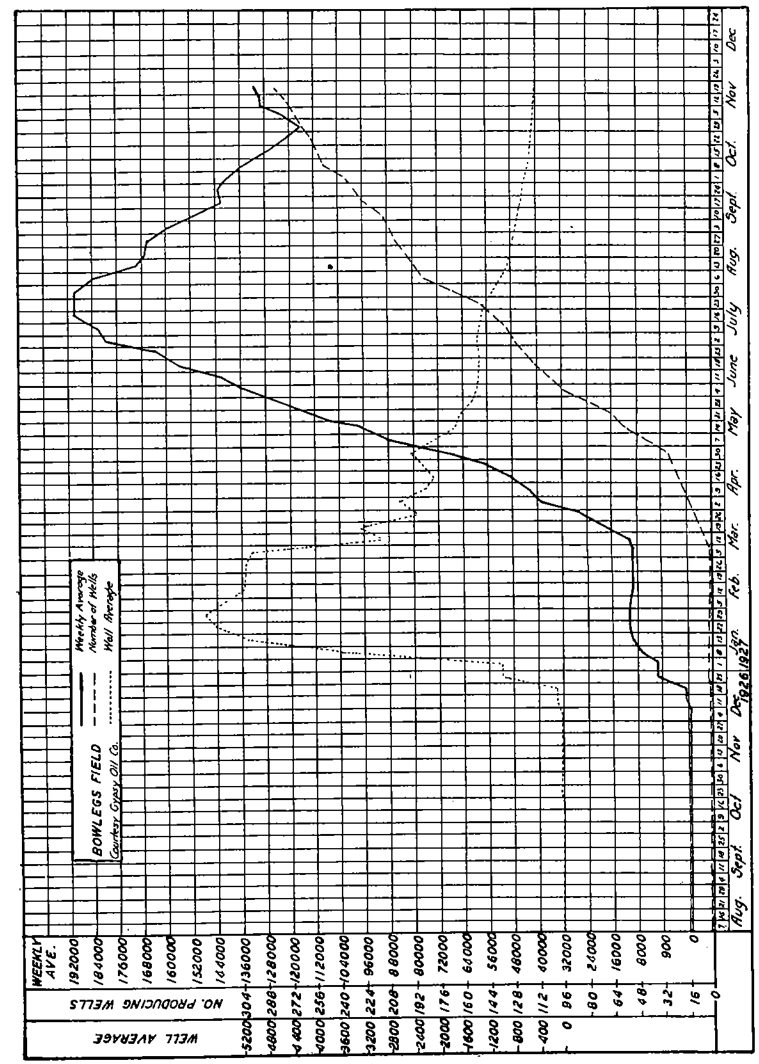



Figure 12. Curves showing the average daily production, number of wells drilled and the average production per well of the Bowlegs field.

stratigraphy are difficult to determine. Below the Pennsylvanian series and separated from them by an erosional and structural unconformity, are the following formations:

*Pre-Pennsylvanian formations.*

| | Feet |
|---|---|
| Mississippian: | |
| Caney formation | |
| Caney shale member | 150-450 (?) |
| "Mayes" limestone member | 90-100 |
| Chattanooga shale (Av. 125 ft.) | 120-150 |
| With Misener sand at base | 0- 15 |
| Devonian-Silurian: | |
| Hunton limestone, oil bearing | 0- 5 |
| Ordovician: | |
| Sylvan shale | 60- 90 |
| Viola limestone | 30- 35 |
| Simpson formation: | |
| Dense limestone member | 10- 50 |
| First dolomite member | 30- 50 |
| Seminole sand member (oil bearing) | 40-100 |
| Second dolomite member | 10- 40 |
| Wilcox sand, locally productive | |

The subsurface structure is in general that of a broad dome roughly outlined by the present limits of production and has a closure of 300 feet. As in the Seminole field it is broken by a number of structural erratics in which offset wells show a structural difference in elevation of 100 to 300 feet, the maximum difference being 600 feet. The largest of these erratics is found in sections 11 and 14 where a number of dry holes have been found abnormally low. Two of these show definite evidence of faulting. These erratics increase the total structural relief of the field to over 800 feet, the lowest structure being within the producing area of the field.

In Figure 13 are shown profiles of the top of the Viola limestone in the Bowlegs field. They show that the erratics are in every case downward relative to the average surrounding structure and, if the erratics are disregarded, the resultant structure is a relatively uniform dome fold.

### Little River Field

The discovery well of the Little River field was drilled by the Indian Territory Illuminating Oil Company. The company's No. 1 House located in the NW. cor. sec. 1, T. 7 N., R. 6 E., was completed for 13,541 barrels per day on July 1, 1927, in the Seminole sand found at a depth of 4,017 to 4,028 feet. The field is still in the process of active development and its limits are not defined. On November 1, 1927, its production was 45,361 barrels from 59 wells and up to this date the field had produced a total of 2.644,830 barrels of oil. One-eighth of the wells were showing water. The curves showing the production of the field, the number of wells drilled and the average daily production per



well are found in Figure 14. The initial production of the wells ranges between 200 and 2,000 barrels per day, although the discovery well produced over 13,000 barrels per day. Due to the co-operative agreement and the erratic structure, the field has not developed as rapidly or over as great an area as was originally anticipated.

The elevation of the surface varies between 820 and 940 feet above sea level and the average depth to the Seminole sand is between 4,150 and 4,500 feet. Little River flows through the field and the bottom lands along it have been flooded a number of times since the field was discovered, thereby making operations more difficult.

The surface formations consist of the shales, sands, conglomerates and limestones of the lower Vanoss and upper Vamoosa formations. The Pawhuska (?) limestone outcrops in the field and is the datum to which the surface structure is referred. The surface structure consists

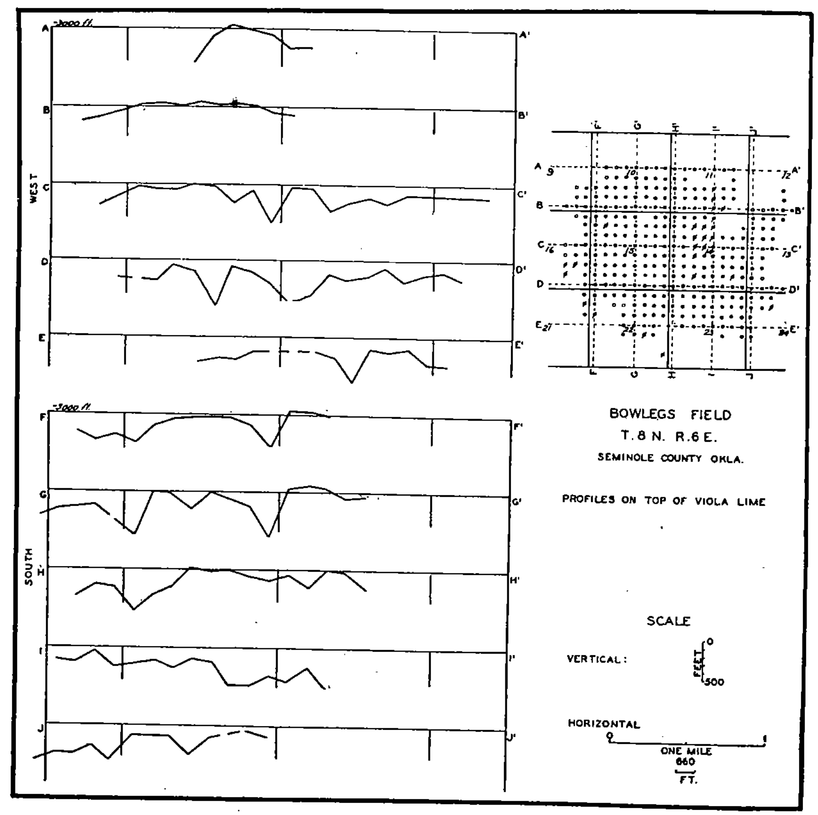



Figure 13. Profiles on the top of the Viola limestone in the Bowlegs field.

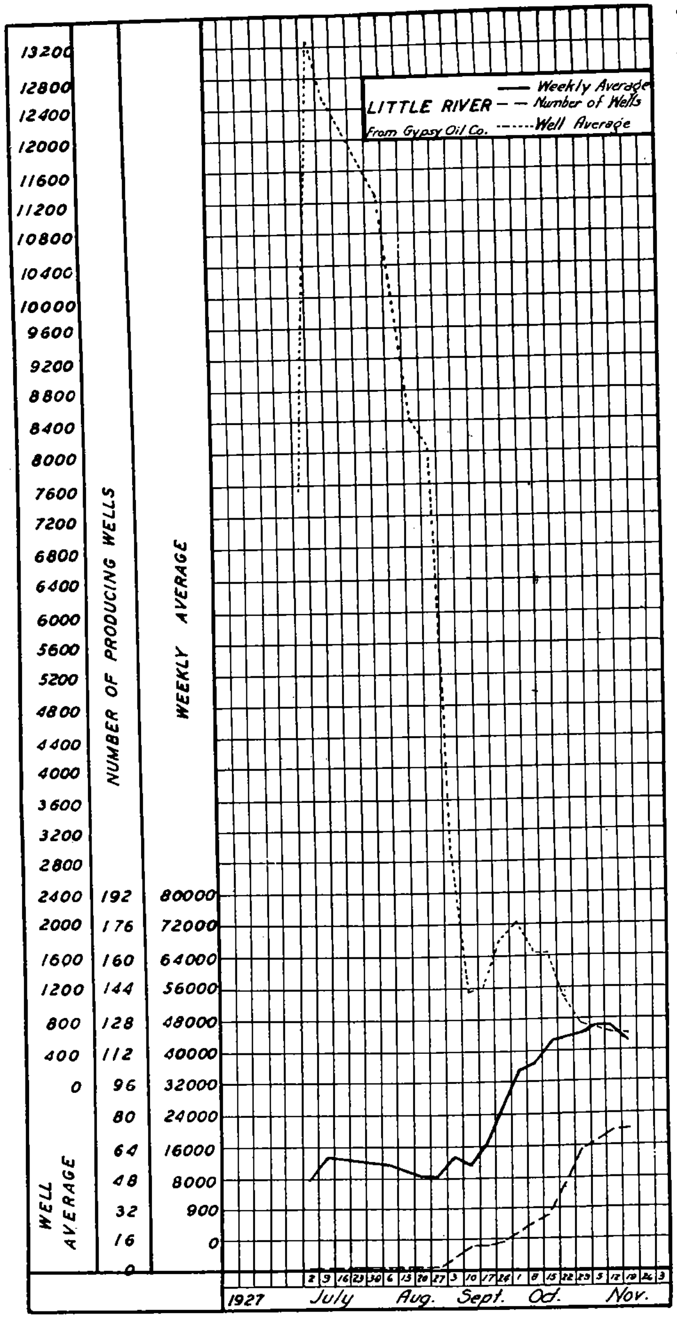



Figure 14. Curves showing the average daily production, number of wells drilled and the average production per well of the Little River field.



of a broad northwest pitching fold broken by a belt of *en echelon* faulting on the west side as in the Seminole City and Bowlegs fields. The surface faults are all of the normal or gravity type with the downthrow side toward the southwest.

The Pennsylvanian rocks extend to a depth of 3,200 to 3,300 feet below the surface. The top of the Calvin series occurs at a depth of 1,900 to 2,000 feet. A well in the SE. cor. sec. 4, west of the field, is producing a small amount of oil from a sand in the lower part of the Pennsylvanian, possibly the equivalent of the Earlsboro sand. Below the Pennsylvanian and separated from it by an erosional and structural unconformity, the following formations are encountered:

*Pre-Pennsylvanian formations.*

| | Feet |
|---|---|
| Mississippian: | |
| Caney formation: | |
| Caney shale member | |
| "Mayes" limestone member | 90-100 |
| Chattanooga shale | 165-175 |
| With Misener sand at base | 0- 15 |
| Devonian-Silurian: | |
| Hunton lime | 0 |
| Ordovician: | |
| Sylvan shale | 40- 60 |
| Viola limestone | 30- 40 |
| Simpson formation: | |
| Dense limestone member | 10- 20 |
| First dolomite member | 10- 50 |
| Seminole sand member (Oil producing) | |

The subsurface structure of the Ordovician rocks is not yet defined. Present indications are that in this field occur more erratics than in any other field of Seminole County. The known structural relief is 400 feet with the lowest well within the producing area. The best evidence of pre-Pennsylvanian faulting as the cause of the structural erratics exists in the Little River field. In several wells the formations are found to be abnormally thin and these are offset by wells showing normal thicknesses. If this shortening of section occurred at the base of the Chattanooga shale it might be interpreted as folding and erosion below the basal Mississippian unconformity. Thus far, however, it has been found to occur within the Chattanooga shale and is interpreted by the writer as being due to post-Mississippian or early Pennsylvanian faulting, the missing beds being cut out by the faults. A good example of this is found in the Prairie Oil & Gas Company's No. 2 House located in the SW.¼ NW.¼ SE.¼ sec. 2. In this well the top of the Chattanooga shale was found at 4,015 feet below the surface or structurally low: the Sylvan shale was encountered at 4,030 feet and the top of the Viola limestone 4,050 feet, or structurally the second highest well in the field. Since only 15 feet of Chattanooga shale and 20 feet of Sylvan shale were found as compared to a normal thickness of 165 feet of Chattanooga shale and 50 feet of Sylvan shale, the total shortening is 180 feet, or the amount of abnormal structural difference between it and the offset wells.

## ANALYSIS OF CRUDE OIL

A. J. Kraemer[40] of the Bureau of Mines summarizes the results of a number of analyses of Seminole crude oils as follows:

### Discussion of Results

Although there are a number of producing sands in the Seminole District, it does not seem possible to ascribe definite and distinctive characteristics to the production from any of the sands. The Wilcox is the most productive sand in all of the pools in the district. On the basis of the samples that the Bureau of Mines has analyzed, (not all of which are included in the report) the gravity of crude oil from the Wilcox sand in this district ranges from 37.6° to 43.2° A. P. I., with the average about 40° A. P. I. The sulphur content ranges from 0.25% to 0.43%, with the average about 0.33%. The "gasoline and naptha" content ranges from 34.1% to 41.3%, with the average about 38.4%. The production from the Hunton lime ranges in gravity between 37.8° and 40.4° A. P. I. with the average about 38.8° A. P I. The sulphur content ranges from 0.22% to 0.30%, with the average about 0.26%. The "gasoline and naptha" content of the crude from the Hunton lime ranges from 34.7% to 37.3%, with the average about 36.0%.

## OIL FIELD WATERS

The writer is indebted to L. C. Case of the Gypsy Oil Company for the following data concerning the chemical nature of the waters found in the Hunton lime and the Simpson formation sands of the oil fields.

The Hunton lime and Seminole sand waters in the western part of the county are quite similar, the chief difference being in the sulphate content which is generally higher in the Hunton lime water. The Earlsboro field, in which the Hunton is generally missing, shows the most characteristic and uniform water analyses of any of the fields. Any one of the seven analyses averaged under *C* is very nearly the mean. The Hunton water of the Searight field, averaged under *B*, carries a characteristic high sulphate content but is otherwise very similar to the Seminole sand water. In the Seminole City, Bowlegs, and Little River fields the Seminole sand water shows as great differences as those found between the Hunton Lime and Seminole sand waters.

No difference has been found in the waters of the Seminole sand and Wilcox sand members which have been analyzed from several wells, in each case the water from the Seminole sand being cased off before drilling into the Wilcox sand.

40. Kraemer, A. J., Analyses of crude oils from the Seminole District, Oklahoma: U. S. Bureau of Mines, Department of Commerce, Repts. of Investigation, Serial No. 2824, pp. 2-3, August, 1927.



Throughout the north half of the county, the water is a typical oil field brine having a concentration of 150,000 to 170,000 parts per million. A decided dilution of the Simpson formation water occurs south of T. 7 N. This is in the area where wells are commonly reported to be flowing "sulphur water" but the analyses show none or only a trace of sulphate. The odor is due to hydrogen sulphide gas.

The average of the Cromwell sand water analyses shown under *A* indicates it to be similar to the Seminole sand water of the Earlsboro field. Pennsylvanian waters higher in the geologic section toward the surface show a progressive decrease in the amounts of sodium, calcium, magnesium, and chloride and an increase in the amount of sulphate. The total concentration also decreases in the shallower sands.

*Table Showing Averages of Analyses of Waters from Producing Horizons of Seminole County.*

PARTS PER MILLION

| | A | B | C | D |
|---|---|---|---|---|
| Silica, $SiO_2$ | 154 | | | |
| Iron, $Fe_2O_3$ & $Al_2O_3$ | 2568 | | | |
| Sodium, Na | 58002 | 49939 | 52097 | 47844 |
| Calcium, Ca | 9836 | 7341 | 8460 | 7834 |
| Magnesium, Mg | 1605 | 1540 | 1793 | 1553 |
| Sulphate, $SO_4$ | 248 | 1022 | 163 | 499 |
| Chloride, Cl | 98841 | 93706 | 99379 | 91537 |
| Bicarbonate, $HCO_3$ | 0 | 48 | 54 | 52 |
| TOTAL | 171254 | 153596 | 161946 | 149319 |

PERCENTAGE VALUE (Palmer)

| | A | B | C | D |
|---|---|---|---|---|
| Silica, $SiO_2$ | | | | |
| Iron, $Fe_2O_3$ & $Al_2O_3$ | 1.60 | | | |
| Sodium, Na | 37.31 | 40.75 | 39.85 | 40.24 |
| Calcium, Ca | 8.74 | 6.86 | 7.53 | 7.39 |
| Magnesium, Mg | 2.35 | 2.34 | 2.62 | 2.40 |
| Sulphate, $SO_4$ | .09 | .40 | .06 | .16 |
| Chloride, Cl | 49.89 | 49.61 | 49.93 | 49.80 |
| Bicarbonate, $HCO_3$ | .00 | .02 | .01 | .01 |
| TOTAL | 99.98 | 99.98 | 100.00 | 100.00 |

**A.** Cromwell Field, Cromwell sand water. Average of 5 analyses from south half of field. Analyses by Bartlesville Station, U. S. Bureau of Mines. "Petroleum Engineering in the Cromwell Field" by C. O. Rison and John R. Bunn, U. S. Bur. of Mines publication, pp. 34-35.

**B.** Searight Field, Hunton lime water. Average of 2 analyses. Analyses by L. C. Case, Gypsy Oil Company.

**C.** Earlsboro Field, Seminole sand water. Average of 7 analyses. Analyses by L. C. Case, Gypsy Oil Company.

**C.** Seminole City Field, Seminole sand water. Average of 3 analyses. Analyses by L. C. Case, Gypsy Oil Company.

## DRILLING AND PRODUCTION METHODS

The early drilling of the Cromwell sand in the Wewoka and Cromwell fields was done with standard or cable tools. Later the rotary tool method was introduced and now is in general use throughout the county. The general practice is to drill the deep wells with rotary tools to a depth of 3,500 to 3,900 feet, cement the 8¼″ pipe, and complete the drilling with cable tools. A string of 6⅝″ pipe is also used, which is set in the Viola limestone about 10 to 25 feet below the top.

In wells where the Hunton limestone is encountered, if it carries oil or water, the 6⅝″ casing is used to shut off the Hunton limestone as the underlying Sylvan shale caves badly while drilling when wet. In this case a string of 5³⁄₁₆″ casing or a liner is set in the Viola limestone.

After the Seminole sand has been reached and it shows indications of being a producing well, an oil and gas separator, flow lines, and flow tanks are installed and a control head set, and the well is drilled into the sand, usually a foot or two at a time. The production of each good well is increased with each foot of deeper drilling. Some wells start flowing immediately while others, possibly on account of tight sand, or low gas pressure, require swabbing or a light 10 to 20 quart shot before they will flow.

The common practice is to install the air plant as soon as possible, and those wells which do not flow naturally quite often will flow with the aid of air or gas. A number of wells from which a maximum of 500 or 1,000 barrels of oil per day could be swabbed, are increased to 4,000 or 5,000 barrel wells with the application of air lift. Air is injected near the base of the oil column, the exact point generally being determined by experiment at different depths, under a starting pressure, where the well is not flowing, of 350 to 800 pounds per square inch. After the well starts flowing the pressure is reduced to 200 to 325 pounds, which is normally the working pressure. Each well is an individual problem and although the practice varies in detail, the general conditions are similar.

With but few exceptions the wells are drilled one well to 10 acres, with a spacing of 660 feet or 330 feet from the property lines. Twin wells are drilled in where both the Earlsboro and Seminole sands are producing, as in the Earlsboro field; in those areas where both the Hunton limestone and Seminole sand are producing, as in the northeastern part of the Seminole City field; and where the Cromwell, Hunton, and Seminole sands are producing as in a part of the Wewoka field.

The average drilling time ranges from 45 to 75 days, for a 4,200 foot well. Crooked holes, collapsed pipe, caving formations, lost tools, and twisted-off drill pipe are some of the common mishaps encountered in all of the deep drilling and serve to increase the time and expense of drilling.



The daily production figures of the fields in the Greater Seminole area are assembled and shown by curves in Figure 14.

The cost of drilling the deep holes of the western part of the county averages from $55,000.00 to $70,000.00, if a producer, and from $45,-

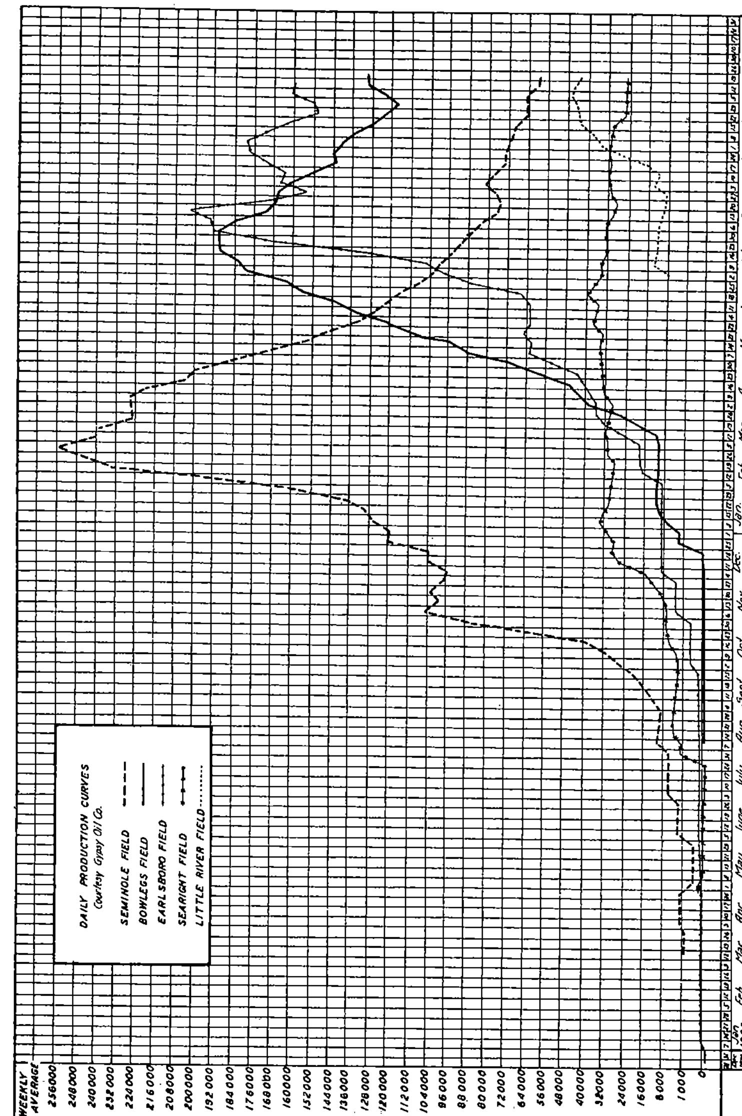



Figure 15. Assembly of daily production curves of f ields in Greater Seminole District.

000.00 to $50,000.00 if a dry hole. For a producing well an additional expense of $18,000.00 to $25,000.00 is necessary to equip it with an oil and gas separator, flow lines, flow tanks, an air plant, and other equipment.

The following figures show the average cost of five wells in different parts of the area, together with the average cost of a dry well and the average cost of a producing well. They represent a fair lower average, but a larger expense is the rule due to the many fishing jobs, collapsed pipe, lost hole, and other difficulties encountered in all the fields.

*Average Cost of Five Deep Wells in Seminole District—1927*

| | | | | |
|---|---|---|---|---|
| Rig—122 foot Turnbuckle type | | $ 6,500.00 | | |
| Slush pit | | 350.00 | | |
| Teaming | | 1,000.00 | | |
| Drilling contract, 4200 ft. @ $7.50 per ft. | | 31,500.00 | | |
| Fuel, Oil, Water | | 3,500.00 | | |
| Tank—250 bbl. wood | | 235.00 | | |
| Cement and cementing | | 825.00 | | |
| Pipe | | | | |
| 50- 100′ 15½″ 70 lbs. | 420.00 | | | |
| 3900′ 8¼″ 32 lbs. | 8035.00 | | | |
| 4200′ 6⅝″ 24 lbs. | 6230.00 | 14,685.00 | | |
| Miscellaneous expense, small pipe, fittings, etc. | | 1,750.00 | | |
| Total cost of well to top of Wilcox sand | | | $60,345.00 | |

The average recoverable material of a dry well would be:

| | | |
|---|---|---|
| 8¼″ casing | 3500.00 | |
| 6⅝″ | 5000.00 | |
| Rig | 6000.00 | |
| Tank | 200.00 | |
| Miscellaneous pipe, fittings, etc. | 750.00 | |
| Recoverable material | | 15,450.00 |
| Average cost of dry hole | | $44,895.00 |

The following additional expense would ordinarily be incurred with a producing well:

| | | |
|---|---|---|
| Separator | $1165.00 | |
| Flow line, control head, connections, labor, teaming | 500.00 | |
| 6-500 bbl. steel vapor pressure tanks | 6000.00 | |
| Air plant complete per well | 15000.00 | |
| Additional material | | 22,665.00 |
| Average total cost completed well | | $83,010.00 |



The following miscellaneous information is of interest in showing the extent of some of the operations connected with the development of the fields of the western half of the county:

*Steel Storage, Greater Seminole District; November 1, 1927.*

| | |
|---|---|
| Capacity | 21,894,000 barrels |
| Oil in storage | 16,705,600 barrels |
| Storage building | 4,505,500 barrels |

Steel tankage divided as follows:

| Present Capacity | Number | Building |
|---|---|---|
| 10,000 bbl. tanks | 4 | 0 |
| 55,000 bbl. tanks | 207 | 13 |
| 80,000 bbl. tanks | 136 | 51 |

*Status of Wells, Greater Seminole District; October 31, 1927.*

| FIELD | On Air or Gas Lift | Flowing | Swabbing | Pumping | Off Production | Showing Water |
|---|---|---|---|---|---|---|
| Seminole | 127 | 8 | 28 | 131 | 31 | 105 |
| Bowlegs | 192 | 4 | 21 | 13 | 24 | 48 |
| Earlsboro | 86 | 53 | 29 | 28 | 24 | 46 |
| Searight | 22 | 22 | 1 | 12 | 2 | 14 |
| Little River | 13 | 7 | 9 | -- | 5 | 8 |

*Summary of the Gasoline Plant Operations of the Greater Seminole District; November 22, 1927.*

| Company | Operating No. of Plants | Present Output Gals. Per Day |
|---|---|---|
| Amerada Petroleum Corporation | 3 | 32,200 |
| Barnsdall Oil Company | 1 | 27,000 |
| Carter Oil Company | 3 | 149,000 |
| Crosbie Oil Company | 1 | 10,000 |
| Empire Gas & Fuel Company | 5 | 49,000 |
| Gypsy Oil Company | 1 | 6,000 |
| Independent Oil and Gas Company | 1 | 12,000 |
| Magnolia Petroleum Corporation | 1 | 10,000 |
| Pure Oil Company | 2 | 44,000 |
| Roxana Petroleum Corporation | 1 | 10,000 |
| Sinclair Oil & Gas Company | 5 | 280,000 |
| Victor Gasoline Company | 4 | 34,000 |
| TOTALS | 27 | 663,200 |

(The gas from the oil wells is recycled and returned to flow the wells and the gasoline recovered.)

*Summary of the Compression Plants Operating in this Area.*

| Company | No. of Plants Operating | Present Output Gals. Per Day |
|---|---|---|
| Carter Oil Company | 4 | 35,000 |
| Forrest E. Gilmore | 3 | 21,000 |
| Indian Territory Illuminating Oil Company | 10 | 103,000 |
| TOTALS | 17 | 156,000 |

This is a total of 819,200 gallons of gasoline per day from 44 plants located in the western half of the county.

*Production Statistics, Greater Seminole District as of January 1st, 192*

| Field | No. Wells Producing | No. Acres Producing | Total Production up to Jan. 1st, 1928—Bbls. | Yield Per Producing Acre up to Jan. 1st, 1928 Bbls. | Yield Per Producing Well up to Jan. 1, 1928 | Ag Mon |
|---|---|---|---|---|---|---|
| Seminole | 319 | 3600 | 54,795,543 | 15,221 | 171,459 | 17 |
| Searight | 68 | 700 | 12,754,929 | 18,221 | 187,572 | 14 |
| Earlsboro | 286 | 2830 | 37,775,722 | 13,348 | 132,083 | 13 |
| Bowlegs | 292 | 2980 | 37,617,193 | 12,623 | 128,825 | 12 |
| Little River | 93 | 940 | 5,188,523 | 5,519 | 55,791 | 6 |
| TOTALS | 1,060 | 11,050 | 148,137,080 | 13,406 | 139,741 | |