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A SUBSURFACE STUDY OF THE PRE-PENNSYLVANIAN ROCKS OF CLEVELAND AND McCLAIN COUNTIES, OKLAHOMA

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A SUBSURFACE STUDY OF THE PRE-PENNSYLVANIAN ROCKS OF CLEVELAND AND McCLAIN COUNTIES, OKLAHOMA

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CHAPTER I

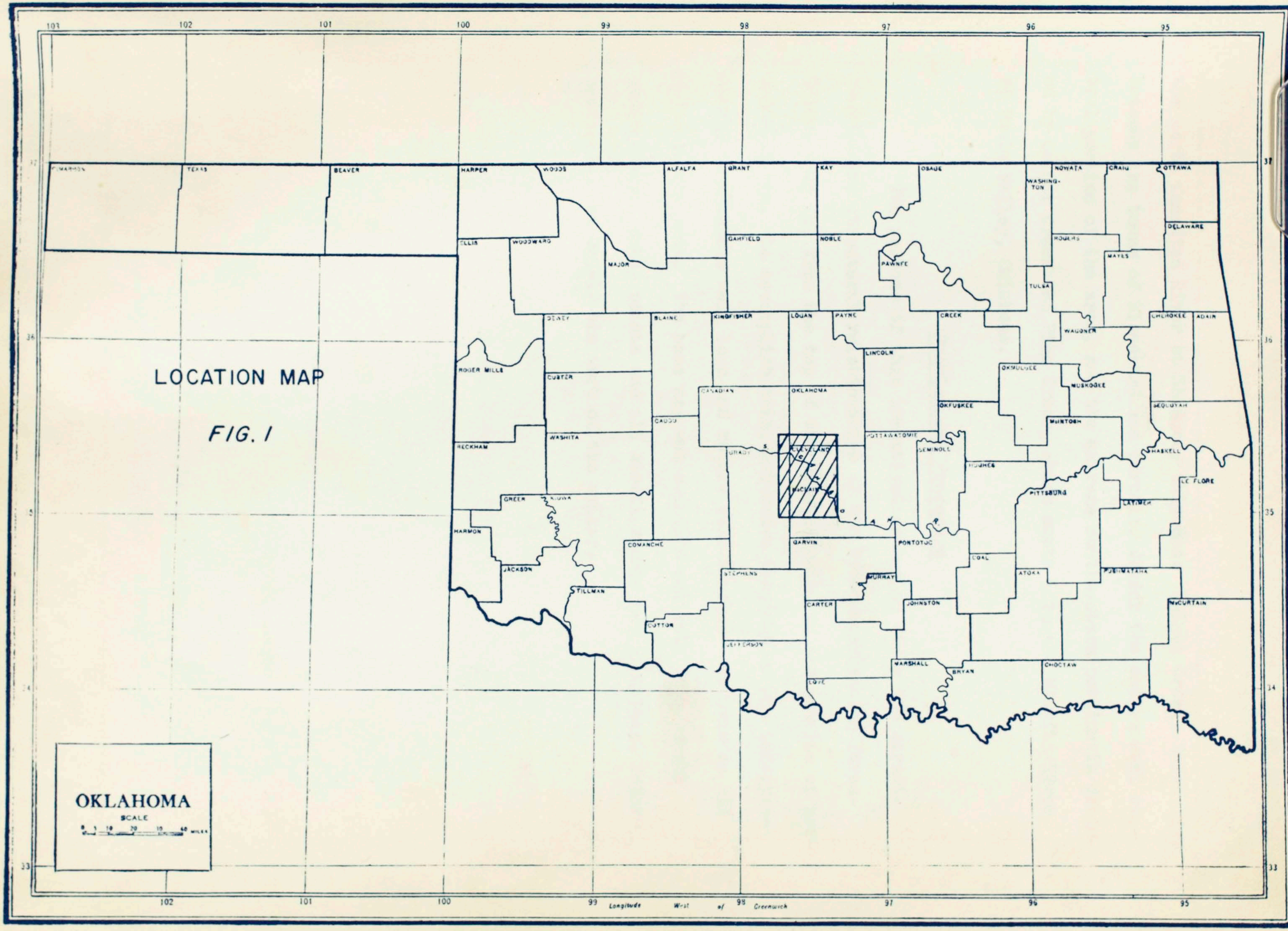
INTRODUCTION

Location

This paper includes an area lying principally in Cleveland and McClain counties with one tier of north-south townships in Grady County and one tier of east-west townships in Oklahoma County. Townships included are from the south line of T. 6 N. to the north line of T. 11 N. and from the east line of R. 2 W. to the west line of R. 5 W. The South Canadian River running from northwest to southeast roughly divides the area in half (Figure 1).

Topography and Drainage

Low rolling plains comprised mostly of shale with a few sandstone escarpments along the border of the South Canadian River flood plain constitute the topography. The flood plain itself consists of alluvium material. The greater portion of the area is drained by the South Canadian River. However, the northeast portion is drained by Little River, which originates not more than $2\frac{1}{2}$ miles east of the South Canadian River, southwest of the town of Moore, and in turn drains into



LOCATION MAP

FIG. I

the North Canadian River at Shawnee, Oklahoma. Walnut Creek, which lies between the towns of Blanchard and Purcell, drains the entire west central portion of the area, and the extreme southwestern portion is drained by Criner Creek and Pine Creek, which empty into the Washita River at Pauls Valley, Oklahoma.

Problem and Procedure

The purpose of this investigation was to study the stratigraphic and structural relationships of the Pre-Pennsylvanian formations, that is, from the top of the Mississippian to the granite of pre-Cambrian age. To accomplish this, extensive examination and interpretation of electric well logs and rotary well samples were made on all wells in the area. The base map was compiled entirely from aerial photographs. Datum points and all stratigraphic and structural interpretations are solely the work of the writer.

CHAPTER II

BASE MAP

The original base map of this area, compiled entirely from aerial photographs, was at the scale of 3 inches to the mile and its dimensions were 9 feet by 6 feet. Since the area was photographed in 1940, the drainage pattern shown on the base map is of that particular date. The county line between Cleveland and McClain counties along the South Canadian River, as it was surveyed in the original survey of 1879, is implied by the dashed line on the surface map (see Plate 1). From this it is evident that the Canadian River has altered its course as much as a mile or more and that land areas formerly on the south side of the river in McClain County are now on the north side, causing small areas of McClain County north of the Canadian River. Conversely, areas in Cleveland County, formerly on the north side, are now on the south side of the river.

All roads, including section line roads, county roads, state highways and Federal highways, are shown on the base map as they existed in 1940. Additions were made where the writer has actually done field work. Section lines without a road are delineated by dashed lines. Railroads in the area were mapped, including the abandoned interurban right-of-way between Oklahoma City and Norman, and the abandoned railroad from Purcell to Chickasha.

The oil wells appearing on the base map in the Oklahoma City field were spotted from aerial photographs. No attempt was made to supplement the wells in this field by additional information. The other wells, both wildcat and field wells, were located from Corporation Commission records and oil company records and are up to date as of September 1, 1949.

Photographs were studied stereoscopically for greater depth perception and magnification. The outcrops shown on the surface map are actual rock ledges or escarpments. No attempt was made to map the surface structure in this area where the attitude and lithology of the beds have long presented a difficult problem to surface geologists. The geology for the surface map (see Map 1) was obtained from G. E. Anderson[1] and A. Travis[2].

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[1]G. E. Anderson, "Cleveland and McClain Counties," Map No. XXI, Okla. Geol. Survey, Bull. 40, 1932.

[2]A. Travis, "Oklahoma County," Map No. XXXVII, Okla. Geol. Survey, Bull. 40, Vol. 2, 1932.

CHAPTER III

STRATIGRAPHY

Surface

Quaternary System

Recent Epoch.--Recent deposits consist of the sands and silts along the entire flood plain of the South Canadian River.

Pleistocene Epoch.--There is abundant Pleistocene material of gravels and coarse sands present in the areas adjacent to the South Canadian River. The hills on which the City of Norman is located are all capped with a gray, argillaceous gumbo-like clay probably of Pleistocene age. In the escarpments along the South Canadian River, Pleistocene gravels and sands identifiable by their yield of bones and teeth of Pleistocene mammals[3] are often found. This material greatly resembles glacial debris which was probably transported from areas farther to the north and northwest and deposited in fairly abundant quantities along the older terraces during Pleistocene time.

Tertiary System

No rocks of the Tertiary are identifiable in this area.

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[3] J. Willis Stovall, oral communication.

Mesozoic Era

No rocks of Mesozoic age are found in this area.

Permian System

<u>General Statement</u>.--The youngest Permian formation, the Duncan sandstone, is found in the western half of T. 10 N., R. 4 W. At the base of the Duncan sandstone are massive bedded red sandstones that form escarpments along the north bank of the south Canadian River in that township. The Chickasha formation, lying above the Duncan, has been questionably mapped in the extreme western portion of the area. This formation is usually termed the Chickasha-Duncan.

Lying immediately below the Duncan sandstone is the Hennessey shale. It is easily recognized as a predominantly barn-red shale with many sandstone stringers at the base. The average thickness is 600 feet. The Garber sandstone lies immediately below the Hennessey. It is a red, massive, cross-bedded sandstone. The Garber sandstone is approximately 400 feet thick.[4] Below the Garber sandstone is the Wellington formation. It is the oldest surface formation and it outcrops in the extreme northeast corner of the area. It is principally a gray shale interbedded with red to fine gray-green sandstones. Facies occur in all the Permian formations.

The outcrops shown on the surface map (Plate 1) are those which could be identified from aerial photographs. It appears from this study that the Permian beds were laid down under swampy deltaic

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[4] Anderson, <u>op. cit.</u>, p. 183.

conditions, and that the sandstone lenses of the lower Hennessey and the sandstone stringers of the Chickasha-Duncan formation are separate thin beds of sandstone, each one in a stratigraphic position different from the next, and that no bed can be followed any great distance without transcending depositional time. If any correlations or any structural studies are to be made, a zone of sandstone stringers would have to be considered as a separate bed and this bed in its entirety would have to be considered a mappable unit.

Subsurface

Pennsylvanian System

Pennsylvanian rocks in this area occur entirely in the subsurface. The top of the Pennsylvanian includes the normal series of rocks found beneath the Permian. In the basal part of the Pennsylvanian are rocks from the Cherokee group to the Springer series. This condition is due in part to onlapping upon the post-Lower Dornick Hills unconformity which truncates all beds between the Springer series and the Arbuckle limestone. The average thickness of the Pennsylvanian rocks in this area is 7,000 feet, and while the lithology is extremely varied, most of the horizon markers can be readily identified. Difficulty arises in correlating the Pennsylvanian rocks in the northern portion of the area with the southern portion due to the differences in the terminology of northern Oklahoma and southern Oklahoma. Herein lies a fascinating problem for future academic study.

Mississippian System

General Statement

Correlation of the Mississippian rocks as accepted in use by the Oil Industry comprise the Caney shale at the top, the Mississippi limestone, also called the Mayes limestone in the southern part of the area, and the Woodford shale at the base. The Misener sand, basal member of the Woodford shale, or an equivalent, is present in several wells.

The Mississippian system is truncated by the major unconformity of post-Lower Dornick Hills--pre-Upper Dornick Hills age. At the base of the Mississippian there is another major unconformity although at less magnitude than the above. Below it lie beds from the Frisco chert of the Hunton formation of upper Devonian age to the Haragan limestone of middle Devonian age. These two major unconformities converge into one at the fringe of the Oklahoma City uplift where all Mississippian beds have been removed. This will be discussed in the following chapter. (See base of the Pennsylvanian aerial geologic map.)

Chesterian-Meramecian Series

Caney Shale.--The Caney shale is brown to black in color and is often bituminous and greasy in appearance. Occasionally the predominant dark color carries a yellowish and reddish hue. Electric well logs indicate that the Caney shale is usually identifiable by a characteristically low self-potential curve and medium high resistivity curve. In thickness the Caney shale varies from 0 to 100 feet. Erratic limy horizons are quite common in this particular section and are sometimes easily confused with a brown shale appearing near the base of the Pennsylvanian.

Osagian Series

<u>Mississippi Limestone and Mayes Limestone</u>.--Using northern Oklahoma terminology, the Mayes limestone is a particular horizon at the base of the Mississippi limestone. However, southern Oklahoma terminology omits the term "Mississippi limestone" and substitutes Mayes for the entire Mississippi-Mayes sequence. In this paper the Mississippi limestone will henceforth be called the Mayes limestone. It is tan to brown, characteristically mottled, finely crystalline to semi-dense and is fossiliferous. The Mayes limestone is not usually well represented in samples. It has an average thickness of 40 feet.

Kinderhookian Series

<u>Woodford Shale</u>.--This is a dark brown to black, bituminous shale commonly carrying thin horizons of pyritic material. The Woodford shale has a characteristically low self-potential curve, usually lower than any other formation in the immediate section and an extremely high resistivity curve on an electric well log. The thickness ranges from 0 to 175 feet. At the base of the Woodford shale in Universal Oil Company's No. 1 Ada Moore, NE NE NE Section 20, T. 7 N., R. 4 W. and Livermore No. 1 Giles NW NW NW Section 35, T. 8 N., R. 5 W., a ten-foot bed of sandstone comparable to the Misener sandstone is present. It is dirty white to dark brown, finely granular, cherty, and extremely

glauconitic.

Siluro-Devonian System

Helderbergian Series

Hunton Group.--This group contains five recognizable units: Frisco chert at the top, Bois d'Arc dolomite and limestone, Haragan limestone, Henryhouse limestone and Chimneyhill limestone and dolomite at the base. The upper three are Devonian in age, while the lower two are Silurian in age. The Hunton group varies in thickness from 0 on the Oklahoma City uplift to a maximum of 640 feet in T. 8 N., R. 5 W., Grady County.

Frisco chert. The Frisco chert is a white creamy, hard, siliceous limestone. It is present in the western part of the area and in the northeastern part of the area adjacent to the Moore pool. In other localities, the Frisco appears to have been removed by post-Devonian erosion.

Bois d'Arc dolomite and limestone. This unit, one of the chief producing horizons of the area is chalky to dirty white, semi-dense to coarsely crystalline, with many calcite rhombohedrons being in evidence. Its thickness ranges from 0 to 100 feet. In general the dolomite content is greater than 50 per cent. Porosity depends almost entirely on dolomitic content. The Bois d'Arc is composed of two distinct sizes of crystals. The coarsely crystalline material is calcitic, with the fine grain material being dolomitic. In thin sections under a petrographic microscope, this fact is apparent. The limestone dolomite ratio varies extremely, both laterally and vertically. No matter how small a specimen was used, no instances were found where the dolomite content was 100 per cent---some calcite is always in evidence.

Dolomitization is the chief factor influencing porosity. Vugs, solution cavities and channels, interstitial pores and primary pores due to organic material, comprise a minority of the different types of porosity. Upon microscopic examination, coralline material is in evidence. This coralline material in all thin sections studied was composed of fine grained dolomite. The coarser calcite crystalline material is made up of crinoid stems. This would indicate that the Bois d'Arc might well contain remains of coral reefs. Study indicates that the porosity, accounting for the accumulation of oil in the Bois d'Arc, is developed in the dolomite.

In detailed study of the wells of the Southeast Newcastle pool, T. 9 N., R. 3 W., it is evident that the unit referred to here as Bois d'Arc was not formed at the time of the original deposition of the formation elsewhere known by that name. The dolomitic zone in the top of the Hunton, called the Bois d'Arc, is said to have been thinned or completely eroded in the Southeast Newcastle area, as indicated by the subsequent erosion of the upthrown sides of faults transversing the pool in an east-west direction. This is not believed to have been the case because if the upper part of the Hunton were faulted up and eroded, then all older beds would have been faulted in the same manner; i.e., the Sylvan shale should reflect these faults, but it does not. Evidently the erosion of the top of the Hunton in this pool was accomplished without the aid of any appreciable faulting. Any area then which is void of the Bois d'Arc member could have been an erosional channel or possibly an area where dolomite simply was not formed. Along this same line of reasoning, the base of the dolomitic zone which is called the Bois d'Arc on the basis of its lithology alone is not parallel to the base of the Hunton, suggesting that this dolomitic zone was formed during or after erosion of the top of the Hunton to a depth depending on the irregularity of the erosional surface.

If this be true, then the Bois d'Arc member in the Southeast Newcastle pool is not a time unit or a depositional unit, but rather its thickness and position in the Hunton group depends on the amount of dolomitization of the upper part of the Hunton, depending in turn on the vertical extent of dolomitization and the irregularity, or the relief, of the erosional surface. In Producers Development No. 1 Harris, C NE SW Section 29, T. 9 N., R. 3 W., the top of the Hunton is below the base of the Bois d'Arc in the Mid-Continent No. 1 Berry Estate, NW SW NW Section 32, T. 9 N., R. 3 W., and yet the Sylvan shale is 81 feet higher in the Harris well than in the Berry well (see cross section No. 1).

This same condition prevails among other wells in the pool where the base of the dolomitic zone in one well is higher than the top of the dolomitic zone in another, and yet the Sylvan shale does not parallel the base of the dolomitic zone as it would if the Bois d'Arc were a depositional unit.

Time of dolomitization of Hunton group. Two factors indicate that the top of the Hunton was dolomitized after its deposition and erosion: the first, based on the data just mentioned, namely, that that surface was eroded prior to dolomitization. The second is a matter of conjecture but, nevertheless, has definite merits.

It is inconceivable that the dolomitization could have taken place after oil had formed or migrated into the Bois d'Arc member. If the oil had formed in place, then the Bois d'Arc could not have become dolomitized, but the Bois d'Arc is dolomitized, indicating that the oil could not have been formed in place. A discussion of this statement follows: In order for magnesium to be precipitated out of solution either as a carbonate or a hydroxide, the alkalinity of the water must increase--the pH value must be at least 9.5. This requires a decrease of CO_2. If anerobic bacteria were reacting on buried organisms, according to the current theories of the origin of oil[5], carbon and oxygen would be freed in large quantities--quantities great enough to produce the carbon necessary to form oil. If, then, oil were formed, the CO_2 content would increase to the point that magnesium could not be precipitated. It follows then that the possibility of the oil being formed in place in the Bois d'Arc is ruled out by this reasoning. By the same reasoning the migration of the oil into the Bois d'Arc could not have preceded the origin of the dolomite. Therefore, the dolomite must have been precipitated as what we recognize to be the Bois d'Arc prior to the migration of the oil into it. And also the oil must not have been formed in place.

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[5]Ben B. Cox, "Transformation of Organic Material into Petroleum Under Geologic Conditions (Geologic Fence)," Amer. Assoc. Pet. Geol., Vol. 30, Bull. 5, May, 1946.

The most plausible source bed for the origin of the oil in the Bois d'Arc member is the Woodford shale. This extremely carbonaceous shale lies unconformably on the Bois d'Arc member. Its resistivity as shown by electric well log is even greater than most oil-bearing limestones. Because of the porous, unconformity zone immediately below the shale, capillarity and surface tension could induce the oil into this porous zone.

Since the dolomite is not primary and the dolomitization would not have been in progress if oil were present, then dolomitization must have taken place after deposition of the Bois d'Arc limestone and before the migration of the oil from the Woodford shale. This could have occurred at the end of the Mississippian or, more probably, some time during the Pennsylvanian. If the source of the oil were not from the Woodford shale, then it was undoubtedly from older shales and/or limestones than the Hunton, and the migration would not have occurred until after the Mississippian was deposited which again allows the same assumptions for the time of migration.

Therefore, in the light of the preceding information, the Bois d'Arc member is believed to have been dolomitized after the erosion of the Hunton group (Pre-Mississippian) and before the migration of the oil into it.

Haragan limestone. The Haragan limestone is white to light gray and buff colored, somewhat chalky, finely crystalline and granular, with some yellow stain. Dolomitic intervals occur indiscriminately throughout. Some brown, dense crystals of limestone are in evidence.

In no wells in the area does the Haragan show porosity or carry an oil stain. The thickness ranges from 0 to 200 feet.

Niagaran Series

Henryhouse Limestone.--This is a white to light gray, finely crystalline limestone. It is difficult to distinguish from the Haragan above and the Chimneyhill below, suggesting the possibility of a depositional transition zone. The thickness ranges from 0 to 130 feet. It is rarely porous and carries no oil stain.

Alexandrian Series

Chimneyhill Limestone.--This member is brown to tan, semi-dense, containing pink crinoidal material, often glauconitic and locally pyritic. It often contains finely granular dolomitic beds that give it some porosity. Often at the very base of the Chimneyhill limestone, there is a cherty zone and an oolitic zone. It shows some porosity and occasionally carries a stain of oil. Production is obtained from the Chimneyhill limestone in the Magnolia No. 1 Ben Arnold, C SW SE Section 13, T. 9 N., R. 4 W.

Ordovician System

Sylvan Shale.--Sylvan shale is commonly green, but occasionally it grades into a dark gray shale. Although it is shaly in appearance, somewhat larger dolomitic crystals appear irregularly throughout. In some wells the Sylvan shale contains conglomeratic limestone nodules with a green shale matrix. The lower part of the Sylvan becomes dark gray to almost black with an olive green hue and has a characteristically high dolomitic content. The Sylvan shale varies from 0 on the Oklahoma City uplift to 140 feet in the southwestern part of the area. However, it maintains an even thickness in a given, local area.

Viola Limestone.[6]--The Viola limestone is composed of two distinct lithological units; namely, Fernvale at the top, and the Trenton beneath.

The Fernvale is clear, white to tan limestone with dark gray to black crystals which give it a mottled and conglomeratic appearance. It is medium to coarsely crystalline with some traces of dolomite. In the lower part of the Fernvale, the limestone occasionally becomes lighter in color, semi-dense in texture and contains irregular cherty and sandy horizons in certain portions of the area. In the Oklahoma City field the Viola has been considered by petroleum geologists as being Fernvale in age[7].

In Livermore No. 1 Giles, C NW NW Section 35, T. 8 N., R. 5 W., the Viola limestone is over 400 feet thick and contains both Fernvale and Trenton members. In Starr Oil Company No. 1 Socher, SW SW NE Section 31, T. 11 N., R. 3 W., the Viola is less than 200 feet thick and contains only the Fernvale member. This onlap relationship can be plainly seen in cross sectional view. (See Cross Section No. 1.)

Simpson Group.--Both northern and southern Oklahoma terms are in current use in the Simpson Group. The following is a simplified

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[6]Sherman Wengard, "Fernvale and Viola Limestones of South Central Oklahoma," Amer. Assoc. Pet. Geol., Vol. 32, 1948, pp. 2183-2253.

[7]A. Travis, op. cit., p. 446.

stratigraphic column:

Northern Oklahoma	Southern Oklahoma
Simpson Group	Simpson Group
Simpson Dense	Bromide Dense
Simpson Dolomite	Bromide Dolomite
First Wilcox sandstone	(Sandy dolomite)
Second Wilcox sandstone	First Bromide sandstone
Tulip Creek formation	Tulip Creek sandstone
McLish formation	Upper McLish sandstone
	Middle McLish sandstone
	Lower McLish sandstone
Oil Creek formation	Oil Creek limestone
	Oil Creek sandstone
Joins formation	Joins limestone
Arbuckle Limestone	Arbuckle Limestone

Simpson "Dense"[8].—This limestone is tan to brown in color and is extremely dense. Calcitic styolites and small calcitic nodules, birdseye-like, are common. Toward the base, the dense commonly gets darker in color with many light colored calcite crystals. Because of its dense nature, it has little or no porosity. The top of the Simpson Dense is almost impossible to pick on an electric well log. It ranges in thickness from 40 to 100 feet.

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[8]The information of the Simpson Group was obtained from the Danciger Oil and Refining Company and has been revised by the author.

Simpson Dolomite. The Simpson Dolomite is a dolomitic limestone at the top and grades into a sandy dolomite at the base. The upper portion is white and chalky with a few well-rounded sand grains, clear in color and coarse grained. The lower portion contains many well-rounded quartz grains ranging from coarse to medium in size and showing considerable frosting. It is usually porous throughout, and in some wells it is heavily stained with oil. At the very base is a thin layer of dolomitic green shale that is typical of the green shales of the Simpson Group. The average thickness is 40 feet.

First Wilcox Sandstone. This is a mottled dolomitic sandstone with dark and light colored calcite crystals. Sand grains are coarse to medium in size and are well-rounded and frosted. The thickness of the First Wilcox sandstone varies from but a few feet to 70 feet. At its base is another green dolomitic shale.

Second Wilcox Sandstone. The Second Wilcox sandstone is white, fine to medium grained, usually exhibiting exceptionally good porosity. Cementing material is generally absent while occasionally it is very dolomitic. Cross bedding has been observed in several cores, and is attributed to current action of water rather than the wind. Sorting is good, but does not show the high degree of sorting produced in eolian sand deposits. The sand grains are generally sub-angular, and do not show the degree of frosting common in the First Wilcox sandstone. The thickness of the Second Wilcox sandstone is 150 feet approximately.

Tulip Creek Sandstone. This is a soft, white, fine-grained sandstone, and is generally dolomitic becoming slightly argillaceous at the base. It appears to be quartzitic, yet shows good porosity. The average thickness of this sandstone is 80 feet.

Upper McLish Sandstone. The McLish sandstone is essentially the same as the Tulip Creek sandstone, except that occasional streaks of green shale are present. The thickness of this sandstone averages about 60 feet.

Middle McLish Sandstone. This is a white, very fine-grained, argillaceous sandstone. It is not as porous as the Tulip Creek sandstone or the McLish sandstone. Dolomite is in evidence throughout the sand. Approximately 35 to 40 feet of dolomite with sandstone and shale streaks separates the McLish sandstone from the Upper Oil Creek sandstone.

Lower McLish Sandstone. This sandstone is white, coarse to medium grained. It is poorly sorted and slightly argillaceous, containing streaks of grey shales. Its thickness is about 30 feet. The Upper Oil Creek sandstone is separated from the Lower Oil Creek sandstone by about 10 to 15 feet of shale.

Oil Creek Limestone. The Oil Creek limestone is actually a shale with many streaks of limestone and dolomite. The limestone streaks are white to grey, finely crystalline, and the dolomite streaks are grey to brown granular appearing dolomite. The thickness of this zone is roughly 90 feet.

Oil Creek Sandstone. The Joins sandstone is white in color, medium fine to fine, with much argillaceous and dolomitic material present showing fair porosity. Its thickness is 80 feet.

Joins Limestone. This is a grey, coarsely crystalline limestone, becoming very dense at the base.

The entire Simpson Group of the Goldsby Field averages 1,200 feet. In Section 24, T. 2 S., R. 1 E., in the Arbuckle Mountains, the Simpson Group is 2,274 feet as measured by C. E. Decker[9].

Arbuckle Limestone. The Arbuckle limestone has been penetrated in but one well in the entire thesis area other than in the Oklahoma City Field. This is in the Danciger Oil and Refining Company No. 1 Vandervoort, NW NE NW, Section 2, T. 7 N., R. 3 W. in the Goldsby Field. The top of the Arbuckle limestone is light grey to tan, finely crystalline to dense. It is very siliceous, showing little porosity. Only the top of the Arbuckle limestone has been penetrated in the area.

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[9] "Field Conference for the Study of the Simpson Formation, Sections 24 and 25, T. 2 S., R. 1 E.," Leader Dr. C. E. Decker. Sponsored by Oklahoma City Geological Society, October 17, 1936.

CHAPTER IV

SUBSURFACE STRUCTURE

Regional

The regional structure of this area involves three major structural features. The first is the southern trace of the Nemaha Ridge which is apparent in the northeastern part of the area beneath the Oklahoma City uplift. The Moore pool on alignment with the Oklahoma City field seems to be the most southern trace of the Nemaha Ridge. South of the East Moore Field the Nemaha Ridge appears to lose its characteristics as a Ridge and plunges rapidly to the south.

A second regional structural feature is the eastern flank of the Anadarko Basin, where it is bounded on the east by the McClain County fault[10].

The third regional structural feature is to the east of this fault. It is a structurally positive area that had remained higher in elevation than the Anadarko Basin throughout pre-Pennsylvanian history. This positive area serves to separate the Anadarko Basin on the west and the McAlester Basin on the east, and can be considered a structural

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[10]Lynn Jacobsen, "Structural Relationships on the East Flank of the Anadarko Basin, Cleveland and McClain Counties, Oklahoma." Amer. Assoc. Pet. Geol., Vol. 33, No. 5, May, 1949, 7 figures, pp. 695-719.

connection between the Nemaha Ridge to the north and the Pauls Valley and Arbuckle Mountain uplifts to the south. The Oklahoma City uplift, culminating prior to Oswego limestone deposition, is the most pronounced structure in the area.

Subsurface Structure of the Oklahoma City Field[11]

The Oklahoma City field has been described in great detail in other publications and the field itself will not be discussed in this paper. However, since it is the area of greatest uplift in central Oklahoma and all of the structural geology is controlled by it, certain observations must be made. None of the wells in the Oklahoma City uplift have been utilized in the preparation of this paper. The wells on the western and southern perimeter of the field have been utilized for control purposes only.

The Arbuckle limestone lies unconformably beneath the Pennsylvanian on the west side of the Oklahoma City fault where the upthrow is greatest. The Simpson group, the Viola limestone, the Sylvan shale and the Hunton group also lie unconformably below the Pennsylvanian in the immediate area, as a direct result of the uplift. On the east side of the Oklahoma City fault, the Mississippi limestone is the oldest formation lying directly beneath the Pennsylvanian, indicating that the uplift to the east was not as severe as the uplift to the west where beds as old as the Arbuckle limestone are in contact with Pennsylvanian

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[11] D. A. McGee and H. D. Jenkins, "West Edmond Oil Field, Oklahoma," Amer. Assoc. Pet. Geol., Vol. 30, No. 11, 1946, pp. 1797-1829.

rocks. The Viola limestone around the perimeter of the Oklahoma City field, where it is in contact with the Pennsylvanian, lies at an average depth of -5220 feet. To the west of the uplift, the Hunton group, where it is in contact with the Pennsylvanian, is -6165 feet in depth, becoming progressively deeper away from the uplift. The unconformity at the base of the Pennsylvanian also dips westward.

Subsurface Structure of the Moore Pool

The Moore Pool is in an alignment to the southeast with the Oklahoma City field. It is faulted on the east side with the west side of the fault being the upthrow side. This fault has a maximum throw on the Viola limestone of 270 feet, while on the base of the Pennsylvanian the throw is only 48 feet. This difference is due to the erosion of the Hunton group as shown by the isopachous map of the Hunton group (see Map No. 4). Less than a half mile west of the fault the maximum thickness of the Hunton group is 30 feet indicating that the fault occurred post-Hunton and pre-Mississippi, and during this hiatus the upthrow side was eroded much more severely than the downthrow side. The Chimneyhill member of the Hunton group underlies the Penneylvanian in the Moore Pool.

Subsurface Structure of the South Moore and West Moore Fields

These two fields have been thoroughly discussed in publications preceding this paper[12]. Both of these fields are an interruption of the southward dip of all the pre-Pennsylvanian beds, the West Moore Field

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[12] Harry G. Hadler, Unpublished Master of Science Thesis, University of Oklahoma, 1947.

having considerably more closure than the South Moore Field (see Map No. 3).

Production in these fields is from two zones in the lower Pennsylvanian, the second Wilcox sandstone, the Simpson dolomite, or the first Wilcox sandstone and the Bois d'Arc member of the Hunton group.

In the South Moore field the Mayes limestone is present at the base of the Pennsylvanian in several wells, while the Woodford shale is present at the base of the Pennsylvanian in the West Moore Field.

Subsurface Structure of the Southeast Newcastle Pool

Using a 100-foot contour interval, the Viola limestone in the Southeast Newcastle pool indicates no more structure than a slight nosing to the south. Contours on the Hunton group, however, show closure at the very center of the field. This closure, however, cannot be attributed to structure as the lower formations show no indication of closure. Deep channeling is in evidence on the eastern flank of the field with the Bois d'Arc portion of the Hunton group persistent. On the northeast edge of the southeast Newcastle Pool there is a broad, flat area where the Bois d'Arc has been removed by erosion. This flattening of dip is indicated in both the Hunton group and the Viola limestone. In the Newcastle pool the Mayes limestone underlies the Pennsylvanian.

Subsurface Structure of the Southwest Goldsby Field

This new field is on a fault block about one and one-half miles wide, located between two north-south fault zones. The fault zone to the east has a maximum throw of approximately 1,000 feet on the Viola limestone, while the fault zone to the west has a maximum throw on the same horizon of approximately 1,200 feet. This places the field on the downthrow side of the east fault zone, and on the upthrow side of the west fault zone. There is about 40 feet closure in this field, and the general attitude of the formations indicates a slight anticlinal structure. An east-west fault in the vicinity of the Mid-Continent No. 1 Boshears, C SE SE, Sec. 24, T. 8 N., R. 3 W. is indicated. Probably this fault is the controlling factor in the trapping of the oil in this field rather than the slight anticlinal structure. The producing horizons are at a depth in excess of 9,300 feet. Four zones in the lower Simpson and one in the upper Simpson were found to be productive.

Subsurface Structure of the Washington Pool

The Washington pool is a small anticline with approximately 58 feet of closure on the Viola limestone. Here the Caney shale lies below the Pennsylvanian. The anticline is bordered to the east by the north-south trending McClain County zone. A probable fault trending east-west may mark the north border. Well spacing for the pool is 160 acres per well, and five producers, entirely owned by the Carter Oil Company, comprise the pool.

To the north of the Washington pool and immediately west of the McClain County fault zone in T. 8 N., R. 3 W., lies a deep synclinal area. Bounding this area to the west is possibly another fault zone of lesser magnitude than the McClain County fault zone. It runs roughly north-south, somewhere either south or east of the Southeast Newcastle pool. If this western fault is present, the deep synclinal structure can be considered a graben. To the south, an east-west fault is likely, separating this graben from the Washington pool.

CHAPTER V

GEOLOGICAL HISTORY

During Middle and Upper Ordovician time, the area was completely covered by the Simpson sea. The Lower Simpson has been penetrated by only a few wells other than in the Oklahoma City Field. These wells have been cored, providing a basis for thorough study of the depositional history of the Simpson formation. Deposition during the Simpson included widespread deposition of limestone with interbedded thick sections of sand. These sandstones are relatively pure and appear to be crossbedded, suggesting the possibility that the sandstones are of eolian origin. However, they are often greenish in appearance and where oil has not accumulated in the sands, they carry connate water.

A possible explanation for crossbedded sands which appear eolian in origin and yet have characteristics of marine deposition is that they were accumulated by the wind and later inundated by the shallow Simpson seas before final consolidation, which apparently had withdrawn during the wind deposition and advanced to completely cover and saturate the sands with saline water. Perhaps the movement of the water was not violent enough, or the nature of the sand was stable enough not to be disturbed by the encroaching sea.

Limestones overlie sandstones and are often interbedded with erratic horizons of green marine shales. Much dolomitic limestone and dolomitic sandstone are in evidence throughout the entire Simpson section. The dolomite present within the sands probably owes its origin to the circulation of highly calcareous magnesium-rich seas that inundated previously existing sands and is due to secondary introduction of these elements into the sand by these seas. The entire Simpson section is suggestive of cyclic sedimentation.

Rocks of Cambro-Ordovician, Silurian and Devonian ages are present throughout the area with the exception of the Oklahoma City uplift, suggesting continual deposition from Arbuckle through Hunton time with the exception of the Viola limestone. In the southern portion of the area, the Viola limestone has a total thickness of at least 400 feet and contains the Fernvale and Trenton members. Northward, the Trenton member is absent due to onlap. This indicates that in post-Simpson time the northern part of the area was positive and was subjected to minor amounts of erosion, followed closely by inundation by the Viola sea from the south. (See Cross Section No. 1) From east to west, the interval between the top of the Viola and the 2nd Wilcox thickens, and from north to south this same condition is also present but it is not as distinct. This south and westerly thickening suggests a basin present to the southwest of this area, which would be the Anadarko basin and would date the basin back into late Simpson time. The eastern flank of the Anadarko basin from Simpson time to the close of Pennsylvanian time, coincides closely with its position at present.

In late Ordovician time, during Sylvan shale deposition, the area appears to have been more or less stable as seen by the uniform thickness of the Sylvan shale over the entire area. Hence, there is no suggestion that the Anadarko basin was subsiding during late Ordovician time.

The Silurian seas completely covered the area and deposited, with uniform thickness, the Henryhouse and Chimneyhill limestones. Lithology of these limestones varies little, suggesting conditions of deposition were essentially uniform.

Deposition evidently proceeded without interruption from Silurian into Devonian time. Depositional conditions appear to be essentially the same since the Haragan limestone deposition continued after the Henryhouse was deposited. The Bois d'Arc immediately overlying the Haragan also probably deposited as a limestone, was altered to dolomite after the retreat of Devonian seas.

The Frisco chert lying at the top of the Devonian was either deposited by the retreating Hunton sea, in which case it would be an offlap deposit or it was eroded throughout most of the area during the post-Devonian, pre-Mississippian hiatus. The post-Devonian erosion cuts deeper in the northern part of the area, suggesting that the Oklahoma City uplift arose for a second time (the first being post-Simpson and pre-Fernvale.) Judging from the erosion in the Hunton beneath Mississippian beds, neither the erosional period nor the uplift to the north were of any appreciable magnitude. The subsidence of the Anadarko basin as evidenced by the thickening of the full Hunton section to the west, seems to be more extreme than was the uplifting to the north during the post-Hunton, pre-Woodford hiatus. At the culmination of this erosional period, the entire area again was lowered to admit the Woodford sea. The Mississippian formations, including the Misener sandstone, which is recognizable in certain areas, the Woodford shale, the Mayes limestone, and the Caney shale, were all deposited by this sea.

Deposition of the Springerian followed the deposition of the Mississippian without apparent interruption.

The unconformity produced by post-Lower Dornick Hills uplift and erosion is greater in magnitude than any others in the area. The duration of this unconformity extends from pre-Upper Dornick Hills deposition in the southern part of the area to the end of the deposition of the Deese of Pennsylvanian time. This unconformity truncates the Caney, the Mayes, Woodford, post-Devonian unconformity, the Frisco, Bois d'Arc, Haragan, Chimneyhouse, Henryhill, Viola, and Simpson and the upper portion of the Arbuckle.

Faulting

General Statement

Faulting along the eastern flank of the Anadarko Basin is extremely complex. The area is completely divided by the north-south trending McClain County fault zone. There are numerous faults paralleling the McClain County fault, such as the fault cutting the Carter No. 1 Fanny Bingham, C SE SW of Section 3, T. 7 N., R. 3 W.; the fault south of the southeast Newcastle Pool; and the fault cut by the Smith No. 1 Morrow unit in C NE NE, Section 18, T. 9 N., R. 2 W. Also many east-west trending faults are thought to exist in the vicinity of the Goldsby area. The time of faulting seems to coincide with the major uplift, that is, the post-Lower Dornick Hills and pre-Upper Dornick Hills uplift. South of the area where a complete section is present, the Springer rests conformably on the Caney. The unconformity that exists at the base of the Pennsylvanian and at the top of the Mississippi in the area of this thesis is actually post-Lower Dornick Hills and pre-Upper Dornick Hills in age. This unconformity represents major tectonic movement in the area at which time the down-warping of the Anadarko Basin was accelerated while the central Oklahoma plateau remained a more or less positive element. The faulting is believed to have occurred during this period of major movement. The Oklahoma City and Moore pool faults are thought to be the same age. The total thickness of the Hunton to the west of the fault on the upthrow side is at a minimum 30 feet. To the east of the fault on the downthrow block, however, the minimum is 231 feet of Hunton. This would suggest the age of the fault to be post-Hunton, but since no Mississippian beds are present over the entire area of the Moore pool, the uplift most probably occurred post-Dornick Hills and all of the Mississippian was removed by erosion together with most of the Hunton on the west side. The base of the Pennsylvanian rests unconformably on a nearly full section of the Hunton on the east side.

CHAPTER VI

FUTURE POSSIBILITIES FOR OIL EXPLORATION

Future possibilities for this area are extremely promising. Structural relationships and a clear concept of the geologic history are of paramount importance in understanding the accumulation of oil. Lying to the west of the area, the Anadarko Basin has long been recognized as an asymmetrical sedimentary basin with tremendously thick and complete sections of marine sedimentary source beds. Undoubtedly the oil, at times of tectonic movement, has migrated from the depths of the basin into the more shallow areas where the oil is retained by either structural or stratigraphic traps. The oil in the West Edmond field may have migrated from the rich source beds of the Anadarko basin along avenues of unconformities and porous zones into lower Pennsylvanian stratigraphic traps and the truncated Hunton limestone.

Likewise, the prolific oil reserves in the Oklahoma City field probably migrated from the Anadarko basin. But not all of this migration was in a direct line from the basin. Eastward, migrating oil was halted by the McClain County fault zone which acted as a barrier for the eastward migration of the oil out of the Anadarko basin. Immediately west of this fault zone the regional dip of the beds is south. Migration would then be diverted from an eastward direction to a northward direction along the west side of the McClain fault. Assuming such migration, any structural or stratigraphic traps along the path of migration should offer rich possibilities for the accumulation of oil reserves.

Oil-bearing formations will range from the upper portion of the Arbuckle limestone to and including Pennsylvanian beds of Cherokee age. Because the McClain County fault was a barrier previous to Lower Dornick Hills time, no appreciable reserve can be expected immediately east of the McClain fault in formations of pre-Pennsylvanian age. This area, however, will probably be productive in sands of Cherokee age in the Pennsylvanian that are pinching out toward the east.

Oil in commercial quantities has been discovered in the Lower Simpson in the area. This means that anywhere structural oil was previously drilled in higher horizons should produce from these lower Simpson zones.

CHAPTER VII

TIME OF ACCUMULATION OF PETROLEUM

Accumulation of oil in the Oklahoma City pool probably began as early as Ordovician time, with the greatest amount of accumulation occurring during the post-Lower Dornick Hills, pre-Upper Dornick Hills movement. Migration probably continued throughout Pennsylvanian or Permian time with the final emplacement of oil occurring at the end of Cretaceous time.

Engineering studies on Oklahoma City field today show some features which are difficult to explain: the gravity movement of oil, and the continuing supply of oil, to mention two. There is a possibility of some continuing migration of oil into the field even to the present time.

Accumulation of oil in the Hunton was not begun until after deposition of the Woodford and was probably not complete until after Lower Dornick Hills time. The oil present in the Wilcox in the South and West Moore fields has undoubtedly come from pre-Silurian source beds, since in the two fields the Wilcox is nowhere in contact with Pennsylvanian beds.

Productive zones have been discovered in the Lower Simpson in the Goldsby area. The Lower Simpson on the downthrow side of the zone is in contact with the Arbuckle limestone on the upthrow side. Time of accumulation could have been any time post-Ordovician and is probably the same as that of the Oklahoma City field.

CHAPTER VIII

CONCLUSIONS

From a study of the subsurface of the pre-Pennsylvanian geology of this area, the following conclusions have been reached:

1) The pre-Pennsylvanian section in the southwestern portion of this area is essentially complete. Post-Lower Dornick Hills uplift and erosion has truncated all older beds, including the Arbuckle limestone at Oklahoma City. In general, east of the McClain County Fault, post-Lower Dornick Hills erosion has cut deeper than on the structurally low west side.

2) The Oklahoma City area was structurally high as early as Ordovician time, as evidenced by the thinning to the north of rocks of Ordovician age.

3) The Anadarko basin was evidently in existence as early as Ordovician time, as evidenced by the thickening of the pre-Mississippian rocks to the west.

4) There is a post-Hunton and pre-Woodford unconformity which bevels the Hunton to the northeast. The thickness of the Hunton is extremely variable, indicating a "Karst topography" surface.

5) The so-called Bois d'Arc member of the Hunton appears to be a zone of dolomitization rather than a depositional horizon. The

Bois d'Arc is found in the southwestern part of the area where the Hunton is 640 feet. In the Southeast Newcastle pool the Bois d'Arc is present where the Hunton is only 248 feet.

6) The unconformity usually designated as post-Mississippian appears to be higher in the Pennsylvanian in the southwestern part of the area. The Springer group and the Caney shale are conformable. This unconformity cuts deep into the pre-Pennsylvanian rocks in the Oklahoma City area. Erosion was deeper along the east side of the McClain County Fault than on the west.

7) All formations of pre-Upper Dornick Hills age are truncated by this unconformity, the highest rate of truncation occurring in the Oklahoma City field. The age of this uplift would be post-Lower Dornick Hills and pre-Upper Dornick Hills.

8) The shoreline of the Pennsylvanian sea migrated northward and eastward as shown by the progressive onlap over the truncated older formations.

9) The area west of the McClain County Fault zone served as an avenue for the migration of oil updip and of the Anadarko basin probably. Rich oil accumulations should be found west of this fault throughout the entire geologic section, but prolific production will probably be confined to horizons of Pennsylvanian age east of it.

10) The Lower Simpson will probably be productive on all anticlinal and domal structures, both discovered and undiscovered.

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