GEOLOGIC FACTORS INFLUENCING OIL PRODUCTION IN WABAUNSEE COUNTY

by

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B. S., Kansas State College
of Agriculture and Applied Science, 1954

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1956

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INTRODUCTION

It was necessary to study the geology, the erosional history, and the structural features prevailing in Wabaunsee county in order to evaluate the geologic factors influencing oil accumulation and production. The purpose of the investigation was to review and describe the available information regarding oil pool structures, and the origin of the major structural features in the county; to offer a reasonable explanation for the association of the pools with local structural features, and to show how the area is related to the Mid-Continent. It was not the purpose of this thesis to indicate the possible future areas for exploration. However, an analysis of the structural data may have some economic significance in exploration works.

A knowledge of the geologic history of the region is of fundamental importance. It concerns two major structural features, (1) the Nemaha uplift which extends into Nebraska to the north and into Oklahoma to the south, and (2) the Forest City basin, which covers most of northeastern Kansas, and parts of Missouri, Nebraska, and Iowa.

The Forest City basin, since the discovery of the Davis Ranch pool in April, 1949 by Carter Oil Company, received widespread attention and now has 750,000 acres under lease.

Geographically, all Kansas oil fields are in the Mid-Continent province; geologically, they lie within the Western Interior coal basin. This coal basin is bounded on the north by the Wisconsin shield, on the east by the Ozark uplift, and on the south by the Ouachita and Arbuckle-Amarillo uplifts. Most of Wabaunsee county lies in that portion known as the Forest City basin. The positive areas surrounding this basin are the Nemaha ridge on the west, the Ozark uplift on the east and southeast, and the Bourbon Arch on the south. The tectonic setting is reflected in the surface and subsurface structures of the rocks, and has influenced the accumulation and migration of the oil.

There has been much speculation regarding the Nemaha anticline. It has been established that differential vertical uplift in the basement rocks, and horizontal compression have operated in the area to produce the uplift. How much of this energy has been expended in faulting is not known.

Geologists believe that all local structures are produced by one or more of the following processes: (1) vertical uplift, (2) intrusions of magmas or of rock salt, (3) differential compaction of sediments, (4) original sedimentation, (5) horizontal compression, (6) rotational warping stress. Therefore, the local structures in Wabaunsee county must fit one or more of these categories.

The erosional history indicated that the county, as well as the state of Kansas has suffered post-Ordovician, pre-Mississippian, and post-Mississippian erosion. The major unconformities occur at the end of Arbuckle and Mississippian times. The maximum thickness of sedimentary rocks in the county is 4,000 feet.

The basement complex stands at an average elevation of approximately 3,000 feet below sea level. In places on the Nemaha uplift the basement rocks are within 500 feet of the surface or approximately more than 600 feet above sea level. The absence of certain sediments over the uplift is believed to be the result of erosion rather than non-deposition. The area has been subjected to several periods of structural folding, erosion, and tilting before it reached its present position.

There are six oil pools in Wabaunsee county: (1) the Davis Ranch pool, (2) the Davis Ranch East pool, (3) the Woodbury pool, (4) the Mill Creek pool, (5) the Newbury pool, and (6) the Wheat pool. The principal producing zone is the Viola. The structural traps are faulted, and non-faulted anticlines.

EARLIER PUBLICATIONS

There have been few publications concerning the structural features in Wabaunsee county. Most are concerned with the Nemaha uplift, and the Forest City basin.

In 1949, Smith and Anders published a report reviewing the drilling activity, the present interpretation of the subsurface relationships, and the engineering aspects, and also the general description of the structure and the stratigraphy.

In 1943, Wallace Lee published a paper on the Forest City basin. It gives detailed descriptions of the stratigraphy, and an attempt to analyze the different major structural movements and their relationships to the occurrence of oil and gas in all of northeastern Kansas.

In 1920-1922, 1920, 1922, and 1917, Moore, Fath, Powers, and Taylor respectively, published a few papers concerning the origin of oil and its relationship to centers of accumulation.

Rieb, 1954, and Koons, 1956, have unpublished Masters' theses pertaining to the area.

HISTORY OF DRILLING

Very few wells had been drilled in Wabaunsee county prior to 1949. The county is in the southwestern portion of the Forest City basin, and since the basin is a structural syncline, it was not actively explored until recently.

The Davis Ranch pool--Sec. 33, T. 13 S., R. 10 E.--was discovered in April, 1949, by the Carter Oil Company. Early in its life, the pool was producing from eight wells; two were dry holes. Well No. 55 (Fig. 6 and Table 1, Appendix) was the discovery well. The production is from the Viola limestone. The discovery of the pool attracted many oil companies and exploration using surface maps, core drilling, and seismic methods were employed.

Four other pools were discovered in Wabaunsee county, but with lesser production than the Davis Ranch pool. In 1950, the Davis Ranch East--Sec. 34, T. 13 S., R. 10 E.--was discovered, and later abandoned because of lack of sufficient production.

Approximately six miles north of the Davis Ranch pool, the Mill Creek pool--Sec. 2, T. 13 S., R. 10 E.--was opened in 1950.

The production is from the Viola which lies between 2,923 to 2,927 feet. The pool consists of six oil wells, four are producing and two are dry holes. Well No. 39 was drilled in 1951 and was producing from the upper zone of the Viola at a depth of 2,917 feet.

The Newbury pool--Sec. 11, T. 11 S., R. 11 E.--is approximately 12 miles north and east of the Mill Creek pool. It was opened in 1950. The pool consists of nine wells, of which six are producing. The production is from the Viola at a depth of 2,901 feet.

In 1951 two additional pools were completed. (1) The Woodbury pool located in Sec. 11, T. 15 S., R. 10 E. had two wells drilled in 1954 which gives the pool a total of four wells. Well No. 103 produces from the Viola at a depth of 3,214 feet and well No. 96 from the St. Peter sandstone at a depth of 3,335 feet. (2) The Wheat pool which is located five miles east of the Woodbury pool in Sec. 10, T. 15 S., R. 11 E., well No. 125 (Fig. 6 and Table 1, Appendix) produces from the Simpson group at a depth of 3,230 feet. In Wabaunsee county, at the present, there are 127 wells drilled, 31 wells are producing, one is a gas well, and one is abandoned. There are 96 dry holes.

MAPPING PROCEDURE

Units Mapped

The Viola of Middle Ordovician age was mapped because it is the main producing zone in Wabaunsee county. It was also necessary to map four other formations of the overlying rocks to show the extent of the subsurface structures, and how they are related to the oil pools. The Hunton, Mississippian, Kinderhookian, and Lansing groups were chosen for this purpose. Most of these units cover the entire county with the exception of the Mississippian and Kinderhookian rocks which are eroded or are absent over the Nemaha uplift.

Since the Davis Ranch pool is the biggest producing pool in the county, its surface structure was mapped using the base of the Florence limestone in order to correlate it with the subsurface maps. (Table 2, Appendix.) A plane table and alidade was used to construct the surface map. Additional surface data was obtained from State Highway maps. All rock shots were corrected to the base of Florence limestone.

Source of Data

The data obtained for the 127 wells drilled in the county up to 1954 has been taken from the following sources: (1) Driller's logs from the library of the State Geologic Survey of Kansas in Lawrence, and from the files at Kansas State College Geology Department, Manhattan, Kansas; (2) the Geology of the

Davis Ranch Oil Pool, Wabaunsee, Kansas, State Geologic Survey, Bulletin 90, Part 2, Lawrence, Kansas, 1951; (3) Master's thesis, K. S. C., Nelson, 1952; S. Rieb, 1954; and D. Koons, 1956; (4) State Highway Commission of Kansas, Topeka, Kansas.

Map Data

The original scale used for the construction of the subsurface structural maps was one inch to a mile but the maps which are enclosed in the thesis have been reduced to half an inch to the mile. A contour interval of 20 feet was chosen for the purpose of illustrating the regional, as well as the local structures to the best advantage.

The scale used for the surface structural map was five inches to a mile and a contour interval of five feet was used. The final map was reduced to half scale.

For the cross sections, the horizontal scale was one inch to a mile, and the vertical scale one inch to 200 feet. The cross sections in the thesis were reduced to a quarter of the original size.

All well locations were plotted on the basis of quarter, quarter, quarter sections; the elevations of key-bed datums were obtained by subtracting the top hole elevation of each well from the depth penetrated to the top of each key formation.

TECTONICS

General Statement

In order to arrive at a clear understanding of the tectonics involved in producing the structures that exist in Wabaunsee county, a review of the folding, faulting, and the erosional history which has a direct or indirect relationship to the area--Wabaunsee county--was made. And, since some confusion regarding the origin of many structures in the Mid-Continent region exists, it was thought proper to review some of the general tectonic concepts.

Origin of Folds and Faults

The most widespread of the early ideas concerning the origin of the structural features of the Mid-Continent region attributed the deformation to horizontal compression and some differential compaction to produce practically all of the folding. But, Clark (1932) and Powers (1922) disapproved of this possibility. It is obvious that shearing failures resulting from horizontal compression of strata will produce thrust faults. The normal faulting associated with the folds is interpreted as a failure due to diagonal shearing stresses, induced by vertical compression, which becomes effective when the opposing stresses are relieved in the unsupported limb of the fold. Therefore, the author believes that the thrust faulting is associated with horizontal compression, and normal faulting is associated with vertical forces.

Fath (1920) suggested the following ideas about the folding and faulting:

> It is a commonly recognized fact that faulting resolves itself in distance into folding. It is possible that where these displacements die out rapidly in both directions, the resultant fold in the overlying sediments will not be elongated into an anticline but will assume the more local form of a dome. The displacement of the faults observed at the surface increases with increasing depth until they reach the competent rocks in which the controlling forces operate.
>
> The origin of anticlinal folds--they are generally regarded as due to the buckling of strata accompanying compression at right angles to the axes of the folds. In assuming that those belts of folding are due to vertical displacement along master faults or shear zones in the basement complex, it must not be concluded that the displacement along any such fault would be of equal magnitude throughout, or in other words, that the result of such displacement is a single continuous and uniform anticline in the surface rock. A 100 foot displacement at any one place might disappear within a short distance, and the resulting anticline in the overlying beds would have definite termini. A combined horizontal and vertical displacement may produce both faulting and folding.
>
> The increasing amount of folding with increasing depth and the consequent possibility that well developed folds exist in oil bearing sands without any corresponding flexures in the surface rocks are of great economic significance. Oil and gas may accumulate in such places where there is little or no folding in the surface rocks and where the conditions cannot be determined by structural geologic investigation in advance of prospecting. The absence of anticlinal folding in the surface rocks, therefore, does not absolutely condemn any locality for its oil and gas prospects.

Fath also published the hypothesis of R. H. Wood which is concerned with torsional faulting along lines of weakness.

Fath believes that zone of weaknesses existed in the basement terrane in pre-Cambrian time and that later displacement and readjustments deformed and fractured the overlying sediments along the weak zone, although many of the fractures did not reach the surface. To supplement his hypothesis, he pointed out the asymmetrical form of many anticlines, and also the increase of folding with depth. Fath also mentioned the origin of structures due to rotational stresses originating in the competent crystalline rocks, and transmitted into overlying sediments producing faults and anticlines.

Uplift and Downwarping

The vertical uplifts and buried hills played a big part in the Mid-Continent region, and especially in the accumulation of oil and gas. Such structural movements made possible the erosion of anticlinal areas without producing erosional topography elsewhere. The deposition occurred in the areas adjacent to the uplifts.

Downwarping is probably the main factor in creating regional dip. A great synclinal trough is developed where downwarping continues for a long time. Finally, broad, regional uplift terminates the subsidence.

STRATIGRAPHY

Pre-Cambrian

Maps made by Rieb (1954), Nelson (1952), and Koons (1956) show the surface of the pre-Cambrian in great detail. They all show that the east flank of the Nemaha uplift in Wabaunsee county has been faulted more than 1,000 feet. Maps made in this investigation reflect the faulting in the basement complex as shown by five of the structural maps, Figs. 1, 2, 3, 4, and 5, Appendix.

The east side of the Nemaha ridge drops off very rapidly, for example, well NE¼ Sec. 15, T. 13 S., R. 12 E., was drilled to a depth of 3,652 feet to granite. The granite in the Root well (Root near Bardwell well No. 2, Zeandale) is approximately 55 feet below sea level, while the granite in the Henderson well (well No. 69, Table 1, Appendix), 21 miles southeast of the Root well, is 2,455 feet below sea level, a difference of 2,400 feet.

The pre-Cambrian rocks consist of granite, gneiss, schist, quartzite, and other igneous and metamorphic rocks. The pre-Cambrian surface was subjected to erosion for a long time before the deposition of the Lamotte sandstone. Rieb's (1954) structural map shows that the Nemaha ridge is asymmetrical with the steeper side on the east flank. It also shows normal faulting on the east flank of Nemaha, with the east side the downthrow block. The east side of Zeandale dome is also faulted.

There have been three periods of erosion of the pre-Cambrian rocks. (1) The area was eroded before the deposition of the first Cambrian sediments, Lamotte sandstone of Upper Cambrian age. (2) Twice later were portions of the area in the north uplifted and eroded, eventually stripping and eroding the pre-Cambrian rocks. (3) The third period was a result of the major uplift that closed the Mississippi Period, and brought into existence the Nemaha Ridge. The first period of erosion resulted in the peneplanation of the pre-Cambrian rocks, and the last two periods did not meterially alter the peneplane.

Paleozoic Era

Cambrian Rocks. Most of the Cambrian rocks have been removed prior to the deposition of the Lamotte sandstone. There is a great unconformity separating the Lamotte sandstone from the underlying pre-Cambrian rocks. The Lamotte grades upward into the overlying Bonneterre.

Ordovician Rocks. The Ordovician rocks are very important in this investigation, because the Viola limestone (Fig. 5, Appendix) of Middle Ordovician age was used as the principal mapping unit. It is the main oil producing zone in the county. The other rocks that are encountered are the Lower Ordovician--Arbuckle group (Fig. 5, Rieb). The Arbuckle dolomite has been eroded away over the Nemaha Granite ridge, and the Chautauqua arch where it is overlain by successively younger beds to the kinderhook. The Middle Ordovician, represented by the St. Peter sandstone of the Simpson group, is the producing horizon in the Woodbury pool. The Sylvan (Maquoketa) shale is also encountered in the Upper Ordovician system.

The St. Peter sandstone rests unconformably on the Arbuckle dolomite, and underlies the Viola limestone. Few wells in Wabaunsee county show Decorah shale which separates the St. Peter sandstone from the Viola limestone. The base of the St. Peter sandstone gradually thins from SE to NW. The northwest portion of the county shows an absence of St. Peter sandstone which was removed by post-Mississippian erosion.

The Viola (Kimmswick) limestone is approximately 107 feet thick in the central part of the county. It is found conformably below the Sylvan shale. Variations in thickness is due to peneplanation. Part of the Viola limestone was removed by post-Mississippian erosion in the northwest portion of the NE-SW trending Nemaha uplift.

The Sylvan shale is very constant in thickness, which suggests that it was deposited on a flat or peneplained surface of Viola limestone. The approximate thickness in Wabaunsee county is 75 feet, but there is an exception in well No. 53 which shows a thickness of 150 feet. This increase in thickness is probably due to a reverse fault.

There are many unconformities of Ordovician age. The most important is the one at the base of the St. Peter sandstone which rests on the Arbuckle. Continued subsidence or downfaulting along the east flank of the Nemaha ridge generally protected the formations from post-Arbuckle to Permian from extensive erosion. The intermittent periods of folding and erosion increased the complexity of the structure on the deeper beds.

Silurian Rocks. The Hunton limestone is one of the mapped units (Fig. 4, and Table 1, Appendix). It is an undifferentiated dolomite of Siluro-Devonian age. It is quite variable in thickness and in characteristics with unconformities both above and below. Well No. 66 (Table 1, Appendix) produces from the Hunton dolomite.

Devonian Rocks. The Devonian rocks are separated from those below and above by angular unconformities. The Chattanooga shale is not differentiated, but it is designated as Devonian or Mississippian. Smith and Anders (1951) mentioned in their report on the Davis Ranch pool that the average thickness of the Chattanooga shale is 180-185 feet. They note an abnormal thickness in well No. 81 (Table 1, Appendix) 260 feet. They believe the thickening is due to reverse faulting.

In the county, the Devonian is thickest in the north and progressively thins toward the southeast. This indicates that there was a great subsidence to the northwest and elevation toward the Ozark area. The greatest thickness of the Hunton was in the center of the Forest City basin, indicating that probably the basin was sinking faster than the margin. In the northwest portion of the county, the Devonian rocks are removed by post-Mississippian erosion (Fig. 4, Appendix).

Mississippian Rocks. The Mississippian rocks are present in all parts of the county except over the Nemaha uplift, where they have been completely removed by post-Mississippian erosion (Fig. 2, Appendix).

The post-Mississippian interval is very important in Kansas because during that time widespread regional deformation and deep erosion of high areas occurred. All the Mississippian and older rocks on the crest of Nemaha ridge were removed. The truncated surface was overlapped by Pennsylvanian sediments. The Nemaha Ridge is a very prominent structural feature of late Mississippian time, as are the folds along the eastern flank of the Nemaha in Wabaunsee county.

Mc Clellan (1930) summarizes the pre-Mississippian rocks:

> The pre-Mississippian rocks in Kansas are a result of long history, which included three periods of major crustal warping, and one period of sharper folding and faulting, with consequent erosion following each period. Some of the broader arches began their history during the pre-Cambrian, and were repeatedly uplifted by later movements, while the smaller anticlines and faulted structures are early Pennsylvanian in age and have since been affected only by Pennsylvanian and Permian folding.
>
> Three structural depressions occur between the elevated structures, namely, the Forest City basin in the northeast, the Salina Basin in the north-central, and a basin in the southwestern part of Kansas for which the name Dodge City Basin is proposed. As pointed out by Fath, as the sedimentary series is obviously unable to transmit horizontal stresses so far from centers of orogeny, the structural lines must indicate lines of faulting or folding in the basement rocks.

Pennsylvanian Rocks. The Lansing group of the Missourian Series was the only one of the Pennsylvanian System mapped in this investigation (Fig. 1 and Table 1, Appendix). The basal member of the Pennsylvanian is the Cherokee shale of the Desmoinesian Series. It was unconformably deposited on the depressed erosional surface of the Mississippian rocks.

The re-elevation of the Nemaha anticline at the time of the formation of the Forest City basin produced an eastward-facing escarpment bounding the basin on the west. North of Geary county, the crest of this escarpment consists mainly of pre-Cambrian granite. To the north, the crest of the escarpment is underlain mainly by rocks of Arbuckle age (Lee, 1943).

The average thickness of the Cherokee around the Davis Ranch pool is 375 feet. In well No. 50 (Table 1, Appendix), it was 420 feet thick, presumably because it filled a sink in the top of the Mississippian beds (Smith and Anders, 1951).

The Pennsylvanian rocks underlie the entire county, and outcrop in the eastern part as a thin belt trending north to south. Pennsylvanian rocks rest directly on pre-Cambrian rocks (Fig. 1, Appendix). Different members alternate with coal beds in a scheme of cyclic sedimentation indicating shallow, fluctuating seas. The pre- Pennsylvanian deposition is largely marine limestone, dolomite and chert, with sand in the Simpson (Decorah). The Pennsylvanian and Permian rocks consist principally of interbedded marine shales, limestones, and sandstones.

Permian Rocks. The Permian rocks outcrop across the entire county, except the eastern margin where the Pennsylvanian rocks outcrop. In the county, the Admire, Council Grove, and Chase groups of Wolfcampian Series outcrop. The Wolfcamp is the only series represented in the county. Rocks younger than the Doyle shale formation of the Chase group do not outcrop in Wabaunsee county. The surface rocks show many flexures on the east flank of the Nemaha uplift that possess relatively steep dips.

STRUCTURAL GEOLOGY REVIEW

In reviewing the major and minor structural features in Wabaunsee county, emphasis is directed toward the regional geologic structures, as well as the local ones in order to portray and interpret the structural picture that will properly reveal the part played by these features in the accumulation and migration of oil and gas in Wabaunsee county.

Pre-Mississippian Structures

The major pre-Mississippian structural provinces are: (1) the North Kansas basin to the north, (2) the Ozark monocline to the east and trending northeast to the southwest, (3) the Chautauqua arch to the south (Jewett, 1951).

Post-Mississippian Structures

The major post-Mississippian structural provinces are: (1) the Nemaha anticline--it is believed by many geologists that it is faulted in many areas on the steeper east flank. Today, it is the most striking tectonic feature in Kansas, and it crosses the state from north to south, plunging to the south. The uplift is reflected in the overlying sediments as an anticlinal structure dotted with domes. The Nemaha uplift has divided the North Kansas basin into the Salina Basin on the west, and the Forest City Basin on the east. (2) The Forest City Basin--it is the structural and deposition basin between the Ozark uplift on the east, and the Nemaha uplift on the west. The Bourbon arch lies to the south. Jewett (1951) defined the basin

> .....as a structural negative segment of the pre-Mississippian rocks formed at different times by the uplifting of the Chautauqua arch (ancestral Ozark uplift), the Nemaha anticline, and other segments and by down warping within the basin itself.

It is a topographic basin resulting from the Nemaha uplift and the down warping of the peneplaned Mississippian surface. (3) Bourbon arch--it separates the Forest City basin to the north from the Cherokee basin on the south. The Mississippian rocks increase in thickness northward and southward from this arch. This would indicate erosion of the arch before the deposition of the Pennsylvanian beds (Jewett, 1951). The Bourbon arch is low and broad consisting of Mississippian rocks and overlain by Cherokee shale. It is similar to an arch in northeastern Missouri, the Northeastern Missouri arch, separating the Forest City basin from the Illinois basin. (4) The Alma anticline--the axis of this anticline parallels the Nemaha anticline, and extends the entire length of the county. Most of the oil pools are located on it.

Ozark Dome

The Ozark uplift is structurally, as well as topographically, a broad, low dome of elliptical outline, and was formed in Mid-Ordovician time. Erosion has removed practically all the Paleozoic sediments, laying bare rocks of pre-Cambrian age.

The dome lies between the Arkansas basin on the south, in the foreland of Ouachita system, and the interior Illinois and Forest City basins on the northeast and northwest, respectively. Most of the structural relief is caused by the initial dip existing on the basement rocks (King, 1951). The surface Pennsylvanian and Permian rocks dip west from the dome into Kansas forming the Prairie Plains homocline. All the Paleozoic strata have a gentle westward dip from the Ozark uplift into a subsurface synclinorium beneath the Great Plains.

EVALUATION AND INTERPRETATION OF THE INVESTIGATION

General Statement

In the evaluation and interpretation of the data in this investigation, it was necessary to point out (1) the possible relationships of the structural traps in the Mid-Continent region to the local structural traps in Wabaunsee county, (2) the influence of the regional structural features in limiting oil accumulation and migration to the area of investigation, (3) the relationship of the oil reservoirs in Wabaunsee county to those of the adjacent areas.

In general, the flexures in the Mid-Continent region consist of faulted and non-faulted anticlines, domes, homoclines, monoclines, terraces, and noses. Many surface folds have closures that do not exceed 20 feet. But, in the subsurface the closures sometime exceed 100 feet.

Nemaha Uplift

The Nemaha was raised in the late Mississippian or early Pennsylvanian, tilted westward, and faulted on the east side. All the maps, and the cross sections I, II, and III show that the Nemaha is faulted. The east, steep flank, is the down thrown side, and the west flank is the up thrown side.

In Wabaunsee county, the Nemaha uplift is plunging to the south. In post- Mississippian time the rocks of Kinderhookian and Mississippian age are completely eroded over the Nemaha ridge. The uplift continued during the Pennsylvanian and Permian periods, but was not as extensive as that of the Mississippian. The Pennsylvanian and Permian rocks overlie the uplift. (Figs. 2, 3, Appendix, and Plate II.)

The most extensive faulting and erosion occurred in the northwestern part of the county. It is clear from Figs. 4 and 5 that in the southwestern part of the county the Viola and the Hunton were not eroded away, whereas in the northwest they have been removed by post-Mississippian erosion.

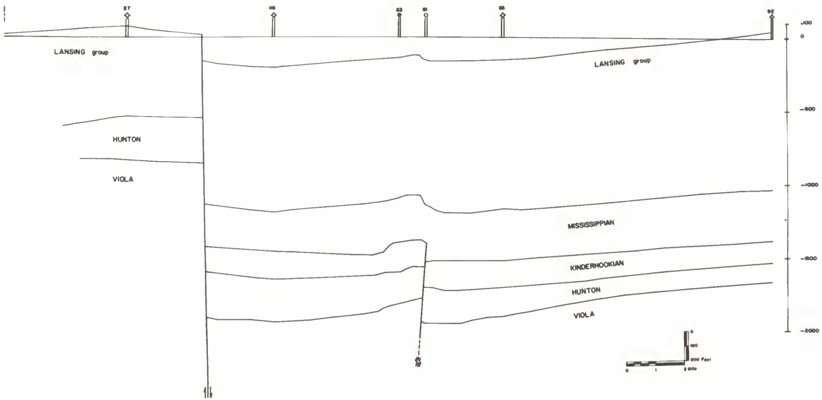
The maximum displacement of the pre-Cambrian rocks along the east flank of the Nemaha in the northern portion is

EXPLANATION OF PLATE I

The cross section AA' shows the structural relationship between the Davis Ranch pool and the Nemaha uplift.

PLATE I

CROSS SECTION- AA'

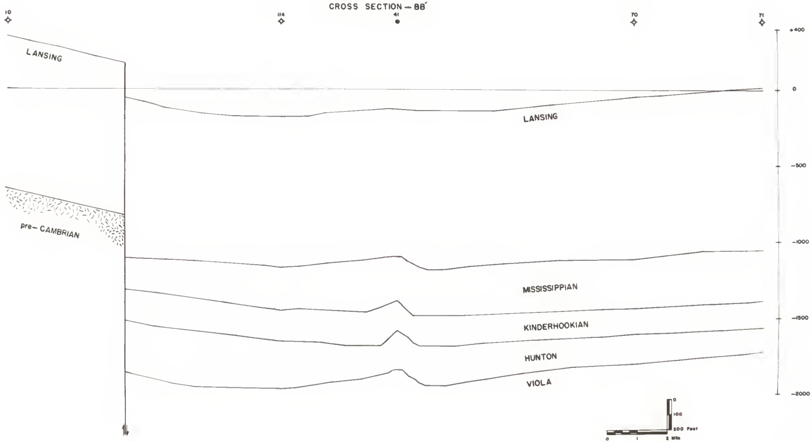


EXPLANATION OF PLATE II

The cross section BB' shows the structural relationship between the Mill Creek pool and the Nemaha uplift.

PLATE II

CROSS SECTION — BB′



approximately 1,400 feet (Plate II), whereas the maximum displacement as measured on the Viola in the southern portion is approximately 1,100 feet (Plate II).

Practically all the subsurface structural maps show a structural depression or syncline (Figs. 2 and 3, Appendix) in the east-central area of the Nemaha uplift.

The displacement, therefore, is not a simple fracture, but is a major zone of shearing between the positive Nemaha element on the west, and the negative Forest City basin on the east. In Wabaunsee county, oil is not found over the top of the Nemaha anticline.

In the northwest corner of the county, the Zeandale dome is faulted on the east side (Fig. 1, Appendix, and Plate III). The maximum displacement as measured on the Lansing group is approximately 250 feet. The displacement increases with depth. Since the oil-bearing horizons are absent on the Zeandale dome, the local folds are not productive.

Surface Structural Map

The surface structural map shows only the structure of the Davis Ranch pool. Its datum is the base of the Florence limestone, which outcrops on the west side of the pool.

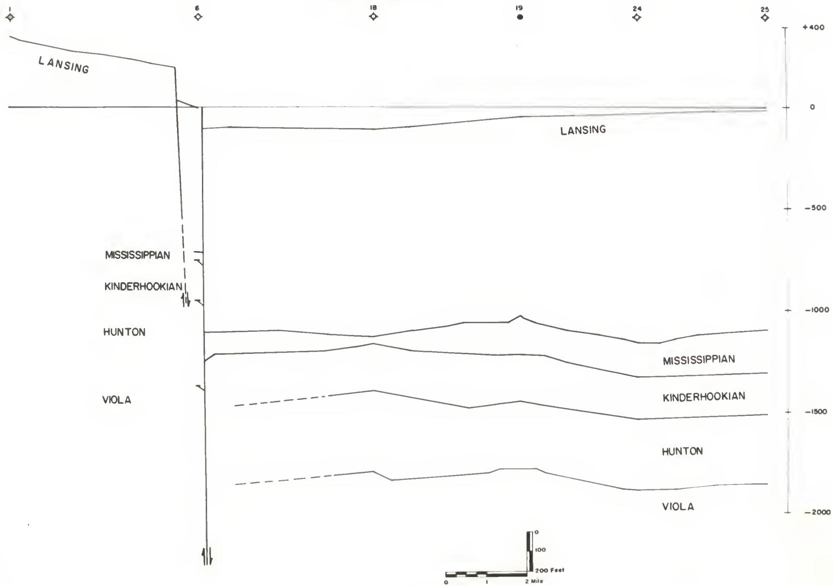
The surface map shows an anticline with a closure of 10 to 15 feet (Plate V). It is one mile long, and half a mile wide. The axis trends northeast to southwest, and favors the east flank, which is steeper than the gentle west slope. It parallels the

EXPLANATION OF PLATE III

The cross section CC' shows the structural relationship between the Newbury pool and the Nemaha uplift.

PLATE III

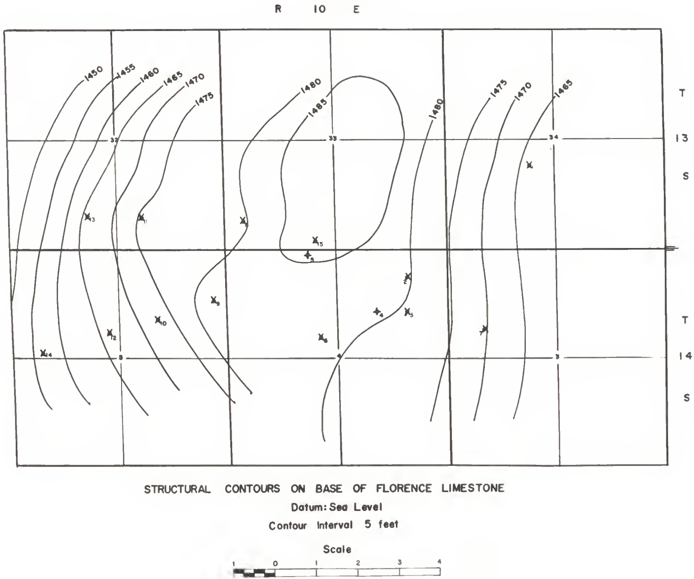
CROSS SECTION – CC′



EXPLANATION OF PLATE V

Shows the surface structural map of the Davis Ranch pool on the base of the Florence limestone. The X mark with the numbers indicates the outcrop shots, and the numbers correspond to the numbers in Table 2.

PLATE V



STRUCTURAL CONTOURS ON BASE OF FLORENCE LIMESTONE

Datum: Sea Level

Contour Interval 5 feet

Scale

Alex A. Kotoyantz

Nemaha anticlines on the west.

The correlation of the surface and subsurface structural maps (Figs. 1, 2, 3, 4, and 5, Appendix, and Plate V) reveals that there is a close relationship in production between the subsurface and surface structure. In the subsurface, the steep side of the Davis Ranch Pool is on the east side of the anticline, and the gentle dip is on the west flank. The subsurface shows a parallelism with the Nemaha uplift on the west. The subsurface reveals a syncline on the east side of the Davis Ranch anticline, and there is a correlation with the surface map. But, there is no faulting evidence on the surface structural map.

Oil Pools in Wabaunsee County

Davis Ranch Pool. The production of the Davis Ranch Pool is from the Viola limestone, except well No. 66 (Table 1, Appendix) which is producing from the Hunton.

The structural map (Fig. 5, Appendix) on top of Viola shows a faulted asymmetrical anticline, with a closure of 100 feet. It is approximately four miles long and two miles wide. The strike of the axis of the anticline is approximately northeast to southwest. This parallels the Nemaha anticline. The maximum displacement of the Viola is 150 feet (Plate I). The beds on the west side are dipping gently to the west. The east flank is steeply dipping into the structural depression or syncline to the east.

The author has examined all available electric logs, and has studied the information obtained from the well samples and the electric logs that were examined by Smith and Anders (1951). The electric logs show that a fault plane exists in well Nos. 53, 61, 81 (Fig. 6, Appendix, and Table 1). These wells show an abnormal thickening of almost twice the normal thicknesses. For example, in well No. 53 (Fig. 6, Appendix), the normal thickness of Sylvan shale is 75 feet, but in the faulted well 150 feet of Sylvan exist. Therefore, 70 feet of Sylvan shale is repeated.

The structural maps show that the faulting in the Davis Ranch pool decreases upward from the Lower Mississippian to the Kinderhook, and might extend into the Osagian Series, and the Warsaw limestone of the Meramecian Series (Figs. 3 and 4, Appendix).

As the fault in the Davis Ranch pool dies out upward, it resolves itself into an anticline fold. This is a typical structural relationship in the Mid-Continent region. The anticlines in the Mississippian rocks show 60 feet of closure, and 40 feet closure in the Lansing group (Figs. 1, 2, Appendix, and Plate I). There is little available data of the downward extension of the fault below the Viola, since most of the wells in the Davis Ranch pool do not penetrate any deeper. The production is on the up-thrown limb.

There is a parallel and similarity of structural movement between the Davis Ranch pool and the Nemaha uplift. The structural maps (Figs. 2, 3, 4 and 5, Appendix) show constant closure of the folds, with little variation, between the top of the Viola and the Mississippian. This indicates that they were formed by one movement, probably at the end of post-Mississippian or pre-Pennsylvanian times. The close relationship of folding and faulting suggests that the present structures followed old lines of faulting in the basement rocks.

Mill Creek Pool. This pool follows the structural trend of the Davis Ranch pool, with a synclinal saddle between it and the Davis Ranch anticline. The steep flank is on the east side of the fold, and trends northwest to southeast. But, there is no indication of faulting, and the west flank dips gently into the syncline on the west. The axis of the Mill Creek anticline favors the steeper east flank, and the production is on the west side of the axis.

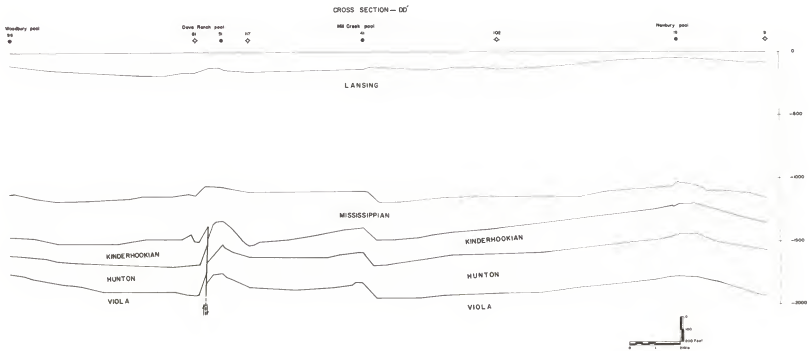
The closure on the Viola limestone is 60 feet. The amount of closures on the formations between the Viola and the Mississippian are fairly constant. The movement, as in the other instances, also occurred before the close of Mississippian, and pre-Pennsylvanian time (Figs. 2, 3, 4, 5, Appendix, and Plate IV). The closure on top of the Mississippian and on the Lansing group is about 20 feet. The magnitude of the fold decreases upward.

Newbury Pool. The Davis Ranch pool, the Mill Creek pool, and the Newbury pool follow the same structural trend known as the Alma anticline. These pools are separated by synclinal

EXPLANATION OF PLATE IV

The cross section DD' shows the structural relationship between the Davis Ranch pool, the Mill Creek pool, and the Newbury pool.

PLATE IV


CROSS SECTION — DD'
Woodbury pool
Davis Ranch pool
117
Mill Creek pool
41
102
Newbury pool
9
LANSING
MISSISSIPPIAN
KINDERHOOKIAN
HUNTON
VIOLA
KINDERHOOKIAN
HUNTON
VIOLA
0
-500
-1000
-1500
-2000

saddles. The production is from the Viola limestone. The Newbury pool is the same type of structural trap as the others, except that the steepening is not so pronounced, and occurs on the northeastern side. The closure is not so pronounced and is about 60 feet. The closures on top of the formations between the Viola and the Mississippian is fairly constant. Therefore, the movement must have taken place between post-Mississippian and pre-Pennsylvanian.

The northeast to southwest trending Alma anticline rises progressively from the Davis Ranch pool to the Newbury pool and plunges to the southwest (Figs. 2, 3, 4, 5, Appendix, and Plates III and IV).

The closure on top of the Mississippian rocks is 40 feet and the fold develops into a gentle homocline on the Lansing (Fig. 1, Appendix, and Plates III and IV).

Woodbury and Wheat Pools. There is a lack of geologic evidence regarding these pools. Consequently, no Simpson group structural map to define the exact configuration of the pools could be constructed. However, the structures of both pools appear to be a gentle and gradual dip to the northwest. Both pools plunge northwest and are flanked by the Nemaha uplift. Such flanking structures are common in the Mid-Continent region. A break in the eastward and south-eastward dip will accumulate oil, (Fig. 6, Appendix, and Plate IV), localize it near the center of the uplift.

Relation of Oil Accumulation and Distribution to the Structures

In areas of gentle dip or homoclinal structures, and gentle folding, the folds near the center of the major uplift, show steeper dips than those farther away. The greatest accumulation of oil is in the minor folds rather than in the major ones. The accumulation is on the gentle dips of the fold rather than on the summit or in the steep flanks. It is observed that the crest axes of the folds favor the gentle side, and progressively move toward the gentle slope with depth.

The configuration of the basement complex, and the granite uplifts controls most of the structural features in Kansas, and has a direct relationship to oil accumulation. It is a known fact that vertical forces are very important, especially in the Mid-Continent region. The Nemaha uplift and the Bourbon arch have acted as barriers for oil migration and have played an important role in restricting the oil accumulation to the eastern flank of the Nemaha and north of the Bourbon arch. The carrier beds were eroded over the Nemaha uplift in Wabaunsee county. Whereas southward, where the Nemaha uplift plunges to the southwest, the source beds and the reservoir rocks have not been eroded. For example, in the El Dorado field in Butler county, production is on the Nemaha uplift.

It is typical to find in the Mid-Continent region, especially in Wabaunsee county, homoclinal, synclinal, anticlinal, and faulted anticlinal structures. Igneous or metamorphic rocks are found on the up-thrown side of the faulted areas. The structural highs which favor the accumulation of oil, occur almost entirely in the major basins. In general, the normal faults occur in synclines or basins, and the reverse faults occur on anticlines.

CONCLUSIONS

The granite Nemaha uplift, and the basement rocks that underlie the entire state of Kansas, had an important and direct influence on the development of the structural features in Kansas, and in the area that has been investigated in this thesis. The major diastrophic movements occurred in post-Mississippian, and early Pennsylvanian times.

The Nemaha uplift was produced by faulting on its east flank as a result of vertical and horizontal tension forces. These forces operated along a line of weakness in post-Mississippian or pre-Pennsylvanian times. The displacement was sufficient to raise the Nemaha anticline, and to cause the erosion of the oil bearing beds across the uplift. On the eroded crest, the Pennsylvanian rocks lie directly on the pre-Cambrian surface. Farther south, the uplift, and the erosion were not extensive enough to remove the Viola and Hunton of Ordovician and Silurian age, respectively. Here the Viola and Hunton lie directly on the pre-Cambrian surface.

In the area investigated, the commercially producible oil accumulated in closed anticlines, and faulted anticlines. The main producing zone is the Viola limestone.

The fault in the Davis Ranch pool appears to extend from the Viola to Kinderhookian rocks. There is no direct evidence how far the fault extends downward or upward. The only fault manifestation in the upper beds is a steepening of dips. This is exhibited in the Mississippian and the Lansing. The fault on the east side of the Davis Ranch pool might trend towards the Mill Creek, and the Newbury pools.

It is hoped that this study will aid in the further exploration and development of the area, and will help to determine the influencing factors of the accumulation of oil.

ACKNOWLEDGMENTS

The writer wishes to extend his appreciation and grateful acknowledgment to Dr. J. R. Chelikowsky for his assistance, and advice, in preparation of this thesis.

The writer also extends special thanks to Mr. J. D. Mc Neal, Chief Geologist of the Kansas State Highway Commission for making State Highway surface data available.

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APPENDIX

Table 1. Data on wells drilled in Waubaunsee county, Kansas.

(*All elevations are below sea level unless otherwise indicated.)

No. on Index Map	Location	Datum elevations of Formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
1	SW NE 28-10-9E	+354					1093	Dry
2	NW SE NE 12-10-10E						2015	D & A
3	NE NE NE 13-10-10E	74	1069	1273	1479	1901	3206	D & A
4	SW SW NW 28-10-10E	+159		346	533		1918	D & A
5	SW SW SE 32-10-10E	+239			224	389	1720	D & A
6	SW SW SE 33-10-10E	7	717	755	956	1374	2705	D & A
7	SE SW NW 34-10-10E	115	1111				2371	Dry
8	SE SE SE 26-10-11E	59	1072	1263	1486	1853	3243	D & A
9	SW SW NE 30-10-12E	88	1158	1351	1570	1931	3200	D & A
10	cNW SW 1-11-9E	+347					2000	Dry

Table 1. (Cont.)

No. on Index Map	Location	Datum elevations of formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
11	NEc SW 24-11-9E						2350	Dry
12	SE SE SE 4-11-10E	118	1123	1278			2575	D & A
13	SE SE SE 5-11-10E	+98		466	673	1101	2489	D & A
14	NW NW SW 5-11-10E	+287					1523	D & A
15	SW SW NE 6-11-10E	+310					1234	D & A
16	SW SW SE 27-11-10E	128	1139	1351	1558	1927	3365	D & A
17	SE NE NE 2-11-11E	70	1110		1472		2835	Dry
18	SW NW NW 5-11-11E	111	1131	1162(?)			2700	Dry
19	NW SW NE 11-11-11E	48	1028	1215	1447	1773	2904	254 BOPD 10W
20	NE SE NW 11-11-11E	44	1074	1208	1453	1777	3130	SWDW

Table 1. (Cont.)

No. on Index Map	Location	Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
		Datum elevations of formations*						
21	SE NW NE 11-11-11E	48	1048	1198	1438	1767	2885	380 BOPD & water
22	cNW NE 22-11-11E						500	D & A
23	SWc 31-11-11E						2006	D & A
24	SE SE SW 8-11-12E	35	1160	1326	1535	1887	3227	D & A
25	cN½ SW NE 14-11-12E	14	1096	1307	1512	1854	3094	D & A
26	SW SW NE 26-12-9E	167	1126	1380	1572	1927	3135	D & A
27	SE SE NE 29-12-9E	+77			533	821	2421	D & A
28	NW SE SE 9-12-10E						276	44,000 cu.ft. Gas
29	cNW SE SE 9-12-10E	181	1141				2339	Dry
30	NE SW SW 36-12-10E	150	1183	1494	1695	1952	3063	D & A

Table 1. (Cont.)

No. on Index Map	Location	Datum elevations of formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
31	SE SW SW 3-12-11E	103	1193	1413	1619	1903	3383	D & A
32	NW NW NE 5-12-11E	128	1143	1348	1581	1905	3184	D & A
33	SW SE 17-12-11E						1880	D & A
34	SE NE SW 18-12-11E	115	1128	1414	1587	1912	3168	D & A
35	SEc 19-12-11E	144	1130	1445	1635	1930	3431	Dry
36	NW SE SE 2-13-8E						2385	Dry
37	SE NW SE 2-13-10E	123	1080	1397	1596	1840	3307	D & A
38	SW SE NE 2-13-10E	127	1089	1371	1573	1818	2932	3000 BOPD
39	NW NE SE 2-13-10E	121	1105	1371	1573	1818	2921	121 BOPD
40	SW NE SE 2-13-10E	121	1096	1386	1582	1828	2934	1156 BOPH 24/hrs.

Table 1. (Cont.)

No. on Index Map	Location	Datum elevations of formations*: Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
41	NW SE NE 2-13-10E	131	1096	1384	1583	1836	2941	33.35 BO & 2% H_2O
42	SE SW SW 4-13-10E	195	1216	1483	1665	1952	3430	D & A
43	SE SW NW 6-13-10E	219	1194		1624	1948	3307	D & A
44	NEc W½ SW¼ 11-13-10E	131	1106				2405	D & A
45	NW NW SW 11-13-10E	129	1093	1434	1622	1878	3320	D & A
46	SE SE SW 13-13-10E	181	1219	1512	1705	1931	3405	D & A
47	NE NW NE 22-13-10E	149	1123	1435	1611	1860	3360	D & A
48	cNE SW 25-13-10E	153	1203	1511	1701	1912	3518	D & A
49	SW SW SE 27-13-10E	167	1209	1554	1670	1926	3290	D & A
50	SW SE SW 28-13-10E	144	1148	1363	1550	1782	3192	2911 BOPD

Table 1. (Con .)

No. on Index Map	Location	Datum elevations of formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
51	SW SW SE 28-13-10E	132	1065	1337	1524	1749	3181	2735 BOPD & 60% H_2O
52	SW NW SE 28-13-10E	142	1082	1375	1561	1789	3139	83 BOPD
53	SW SE SE 28-13-10E	142	1083	1389	1602	1941	3308	D & A
54	NE NE SW 32-13-10E	140	1101	1433	1595	1827	3381	D & A
55	SW SE SW 33-13-10E	127	1064	1383	1563	1789	3206	2580 BOPD
56	SW NE SW 33-13-10E	122	1059	1374	1552	1780	3425	2936 BOPD
57	SW SW SE 33-13-10E	113	1059	1353	1535	1759	3190	3000 BOPD
58	SW SE NW 33-13-10E	136	1065	1362	1546	1764	3186	3000 BOPD
59	SW NE NW 33-13-10E	122	1068	1348	1541	1752	3203	3000 BOPD
60	SW NW SE 33-13-10E	111	1050	1352	1534	1753	3192	2990 BOPD

Table 1. (Cont.)

No. on Index Map	Location	Datum elevations of formation*: Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
61	SW SE SE 33-13-10E	159	1132	1501	1685	1929	3341	D & A
62	SW NW NW 33-13-10E	146	1086	1369	1565	1785	3221	3000 BOPD
63	SW SW NW 33-13-10E	139	1075	1375	1577	1797	3255	1574 BOPD & 30% H_2O
64	SW SW NE 33-13-10E	123	1049	1346	1522	1750	3162	3000 BOPD
65	SW NW NE 33-13-10E	114	1059	1326	1508	1737	3182	3000 BOPD
66	SW NW NE 33-13-10E	110	1057		1505		2938	44 BO & 176 Bw
67	SW SW SW 34-13-10E	167	1172	1508	1676	1907	3314	25 BOPD & 91% H_2O
68	SW SW NW 11-13-12E	+26	1049	1384	1556	1745	3142	D & A
69	NE SW NE 15-13-12E		988				3652	Dry
70	SW SW NW 19-13-12E	48	1112	1435	1607	1800	3410	D & A

Table 1. (Cont.)

No. on Index Map	Location	Datum elevations of formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
71	SE SE NE 34-13-12E	+10	1057	1388	1566	1725	3270	D & A
72	CSL SE NW 35-13-12E	+24	1061				3640	Dry
73	NE SW SE 1-14-8E						625	D & A
74	c NE ¼ 2-14-8E						618	D & A
75	SWc SW 2-14-8E						520	D & A
76	cSW NW 11-14-8E						604	D & A
77	SW NE NW 4-14-10E	109	1046	1378	1560	1773	3220	3000 BOPD
78	SW SE NW 4-14-10E	130	1058	1396	1569	1790	3205	3000 BOPD
79	SW NW NE 4-14-10E	126	1051	1377	1559	1767	3183	3000 BOPD
80	SW SW NE 4-14-10E	131	1099	1389	1575	1777	3191	3000 BOPD

Table 1. (Cont.)

No. on Index Map	Location	Datum elevations of formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
81	SW NE NE 4-14-10E	154	1115	1432	1692	1928	3306	D & A
82	SE SW NW 3-14-10E	172	1176	1516	1701	1921	3250	D & A
83	NW SW NW 12-14-10E	151	1164	1500	1680	1876	3515	D & A
84	SE SE SE 17-14-10E	157	1130	1446	1610	1867	3398	D & A
85	NW NW SE 19-14-10E	168	1137	1460	1637	1840	3522	D & A
86	SW NW SE 20-14-10E	139	1091	1414	1567	1781	3490	D & A
87	SW SW SW 21-14-10E	142	1109	1421	1572	1778	3472	D & A
88	SE SE NW 22-14-10E	170	1177	1532	1697	1902	3614	D & A
89	SW SW NE 23-14-10E	143	1166	1494	1682	1866	3409	D & A
90	NW NW NW 35-14-10E	152	1192	1526	1674	1856	3401	D & A

Table 1. (Cont.)

No. on Index Map	Location	Datum elevations of formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
91	SWc SW 17-14-11E						2665	D & A
92	NE NE SW 16-14-12E	+40	1037	1384	1533	1664	3223	D & A
93	SWc NE 29-14-12E	+29	1031				2510	D & A
94	SW SW NE 6-15-10E	188	1141	1465(?)	1625	1829	3446	D & A
95	SE SW NE 11-15-10E	95	1114	1465	1613	1769	3294	D & A
96	SE NW NE 11-15-10E	105	1130	1469	1616	1766	3335	108 BOPD & 11 BW
97	NE SW NE 5-15-11E						1052	D & A
98	SE NE SE 29-14-10E	155	1150		1696	1896	3492	D & A
99	NE NE NE 13-13-10E	156	1188	1499	1688	1921	3336	D & A
100	SE SW SE 20-12-10E	191	1150	1449(?)	1646	1965	3280	D & A

Table 1. (Cont.)

No. on Index Map	Location	Datum Elevations of Formations* Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
101	NE NW SE 23-12-10E	146	1172	1459	1654	1949	3330	D & A
102	SW SW NW 8-12-11E	134	1134	1390	1593	1907	3130	D & A
103	SE SW SE 2-15-10E	114	1120	1477	1634	1778	3218	135 BOPD & 40% H_2O
104	NE SE SE 2-11-11E	45	1042	1200	1426	1772	2889	Pumped 25.74 bbls oil w/sli.trace H_2O in 8 hrs.
105	SW SE SE 2-11-11E	42	1052	1184	1433	1762	2865	324 BOPD & H_2O
106	cNW NW NE 11-11-11E	47	1036	1205	1449	1770	2910	360 BOPD & 80% H_2O
107	NW NE NE 11-11-11E	40	1037	1185	1420	1767	2877	667 BOPD & 2% H_2O
108	NW SE NE 11-11-11E	51	1047	1210	1445	1771	2885	125 BOPD & 50% H_2O
109	SE NE NE 11-11-11E	74	1062	1206	1448	1777	2880	D & A
110	SE SE SW 24-11-11E	32	1063	1226	1467	1765	2977	D & A

Table 1. (Cont.)

No. on Index Map	Location	Datum Elevations of Formations*: Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
111	NW SE NE 12-11-12E						1910	Plugged
112	SE NW SE 7-12-10E	173	1149	1376	1613	1986	3551	D & A
113	NW SE NE 12-12-10E	80					2215	D & A
114	NE SW SW 15-12-10E	184	1167	1451	1655	1969	3051	D & A
115	SW SW NW 23-13-8E	+63			451	673	2401	D & A
116	NW SW NW 13-13-9E	204	1174	1439	1629	1918	3436	D & A
117	SW SE SW 21-13-10E	156	1105	1530	1620	1860	3370	D & A
118	NEc SW 32-13-12E							D & A
119	SW NW SE 8-14-10E	158	1118	1442	1627	1842	3394	D & A
120	SW NW NE 17-14-10E							D & A

Table 1. (Concl.)

No. on Index Map	Location	Datum Elevations of Formations*: Lansing	Mississippian	Kinderhookian	Hunton	Viola	Total Depth (Feet)	Initial Production
121	SE SE NW 32-14-10E	143	1093	1423	1578	1774	3396	D & A
122	SE SE SW 36-14-10E	102(?)	1150(?)	1503	1668	1824	3395	D & A
123	SE SE NE 15-14-11E	51	1091	1421	1581	1734	3404	D & A
124	SE SE SE 2-15-10E	120	1139	1499	1645	1803	3190	D & A
125	cNW SE NE 10-15-11E	26	1028	1423	1563	1696	3234	40 BOPD & 12 BW
126	NW NW NW 11-15-11E	64	1038	1420	1571	1712	3265	D & A
127	½ Mi.So.Zeandale NWc NW 28-10-9E						1080	D & A

Table 2. Surface data.

Station	Elevation	Formation	Datum Base of Florence Ls.
X_1	1321.75	Base of Funston limestone	1463.5
X_2	1374.54	Base of Threemile limestone	1480.8
X_3	1373.54	Base of Threemile limestone	1479.8
⌖$_4$	1322.24	Base of Middle ledge Crouse limestone	1478.9
⌖$_5$	1390.6	Base of non-cherty zone in Threemile (11.5 feet above base)	1484.3
X_6	1375.95	Base of Threemile	1481.3
X_7	1307.94	Base of Crouse limestone	1470.8
X_8	1401.1	Base of Schroyer limestone	1479.8
X_9	1409.4	Top of Schroyer limestone	1482.0
X_{10}	1471.94	Base of Florence limestone	1471.9
X_{11}	1430.34	Top of Kinney limestone	1475.4
X_{12}	1465.69	Base of Florence limestone	1465.7
X_{13}	1393.39	Top of Schroyer limestone	1466.0
X_{14}	1458.07	Base of Florence limestone	1458.1
X_{15}	1380.8	Top of cherty zone in Threemile limestone (8 feet above base)	1487.1

FIGURES 1 TO 6 INCLUSIVE

(in accompanying plate box)

GEOLOGIC FACTORS INFLUENCING OIL PRODUCTION
IN WABAUNSEE COUNTY

by

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of Agriculture and Applied Science, 1954

AN ABSTRACT OF THE THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1956

The area of investigation is Wabaunsee county, Kansas. It lies in the southwestern part of the Forest City basin, which is located in the Mid-Continent region.

The study covers the geologic factors, and structural features inducing the accumulation of oil in Wabaunsee county. The investigation was concerned with the mapping of key horizons of production; also, four subsurface, non-producing, stratigraphic zones, and one surface horizon, the base of the Florence limestone were mapped. Correlation of the surface, and subsurface structural maps, showed how the surface map of the Davis Ranch pool correlated with the subsurface maps.

The discovery of the Davis Ranch pool was in April, 1949. After its discovery, exploration activity by many oil companies was increased and resulted in the leasing of 750,000 acres. Surface mapping, core drilling, and seismic methods were employed. At the present, there are 127 wells drilled in Wabaunsee county, 31 wells are producing, one is a gas well, one is abandoned, and there are 96 dry holes. The main production is from the Viola limestone.

The structural traps in Wabaunsee county are associated with (1) folded anticlines, (2) faulted anticlines, and (3) gently dipping noses.

The major structural features, namely, the Nemaha uplift, the Forest City basin, and the Bourbon arch have been the principal factors in the accumulation of the oil. But, the single, most fundamental control lies in the configuration of the pre-Cambrian basement rocks.