GEOLOGY OF WENGER-UNGER POOLS AREA
MARION COUNTY, KANSAS

by

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CONTENTS

INTRODUCTION

The Wenger-Unger pools area covered in this report consists of two pools, the Wenger pool and the Unger pool.

The Wenger pool (Fig. 1) located 5 miles west of the normal trend of producing pools in southern Marion County, was discovered by Goering and Branine and designated as the No. 1 Wenger situated NW$\frac{1}{4}$ NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 11, T. 21 S., R. 3 E. in December 1947. Petroleum was found in the "Hunton" limestone of Silurian and Devonian age at 2,771 feet. Initial production was 50 barrels per day. The peak in production was reached in 1949 with 28 wells producing from an area of approximately 2$\frac{1}{2}$ square miles. The pool has steadily declined since that year and as of December 1958, 13 wells had been abandoned and the remaining 15 produce a total of 62 barrels per day. The cumulative production to the end of 1957 was 921,428 barrels.

The Unger pool (Fig. 1) is located in southwest Marion County approximately 3 miles west of the Wenger pool. The Unger, also producing from the "Hunton" limestone, was discovered in June 1955 by the Charles Carlock No. 2 Unger well in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 8, T. 21 S., R. 3 E. Initial daily production was 122 barrels of oil per day from a depth of 2809 feet.

In January 1956, the Unger Southwest field was discovered by E. K. Carey Drilling Co., Inc. in the drilling of No. 1 Warkentin in the SW$\frac{1}{4}$ SW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 7, T. 21 S., R. 3 E. which had an initial daily production of 4,257 barrels at 2,812 feet depth. The greatest amount of drilling in Marion County in 1956 was

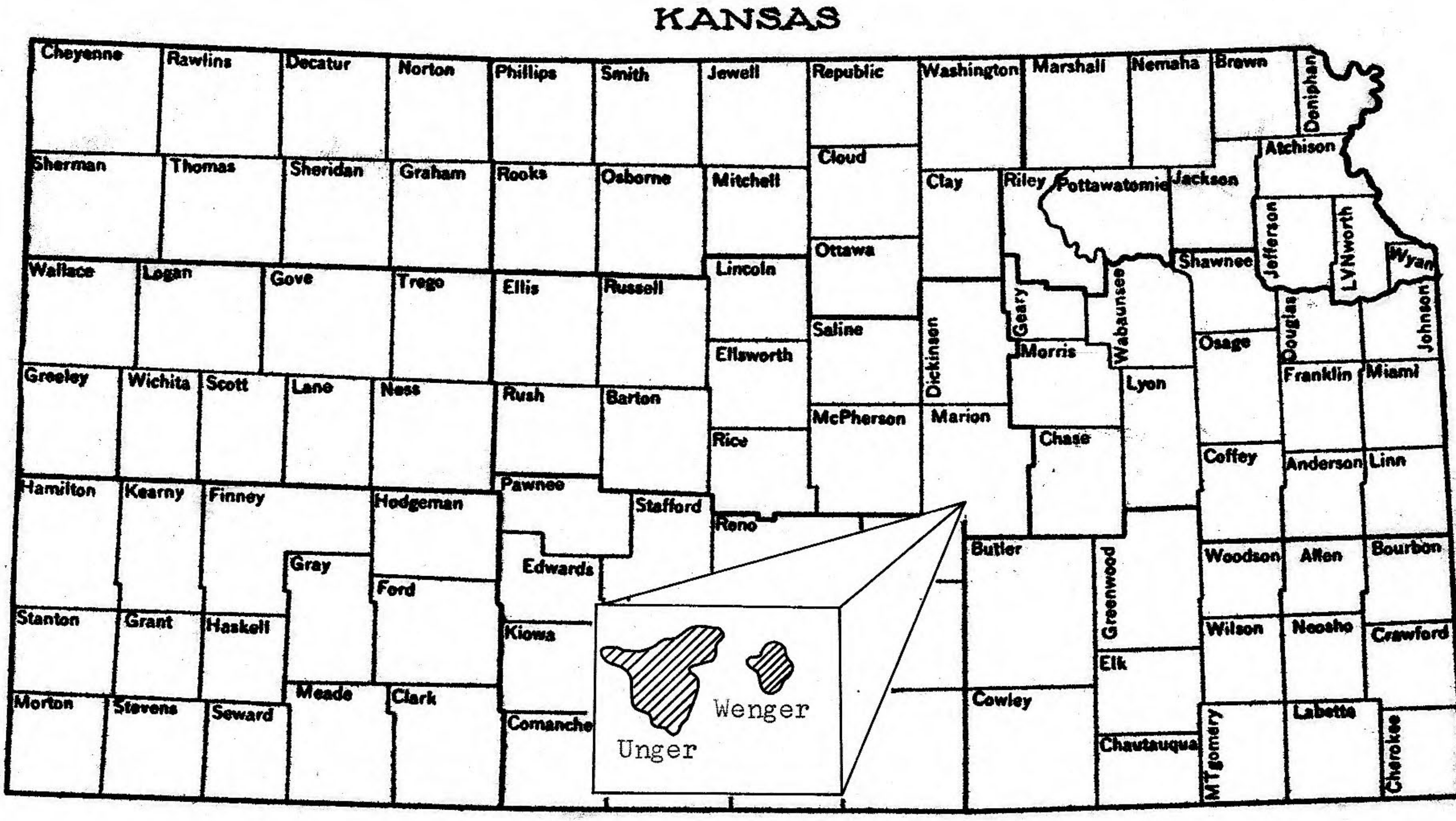


Fig. Index map of Kansas showing Wenger and Unger pools T. 21 S., R. 2 E. and R. 3 E. in Marion County in the Unger Southwest pool where 67 oil wells and 17 dry holes were completed.

The Unger and the Unger Southwest pools were combined in 1957 to the Unger pool composing an area of approximately 5 square miles. The cumulative production to the end of 1957 was 1,565,721 barrels.

The Wenger and Unger pools, situated 3 miles apart, both produce from the "wedge-edge" of the "Hunton" limestone. As a result of geologic similarity and the close geographic positions, these pools were studied as a unit.

The study of the Wenger and Unger pools was undertaken to determine the relationship of petroleum accumulation to stratigraphy, structure and type of trap for oil and gas.

Location

The Wenger pool, an area of petroleum accumulation of approximately 2½ square miles, lies entirely within T. 21 S., R. 3 E. of Marion County, Kansas.

The Unger pool, an area of petroleum accumulation of approximately 5 square miles, lies within the W½ T. 21 S., R. 3 E. and E 1/3 T. 21 S., R. 2 E. of Marion County, Kansas.

The Wenger-Unger pools area discussed in this report covers a 46 square mile area. The study was extended to areas surrounding the pools to define any structural anomalies that may affect petroleum accumulation.

The pools are approximately 13 miles west of Florence and

6 miles northwest of Peabody. The area lies within the Flint Hills Upland physiographic province. (Frye and Swineford, 1949)

Previous Investigations

Previous investigations in the Wenger-Unger pools area consist of unpublished individual studies of the pools and studies of the area included with regional investigations.

Jewett (1949, pl. 4) constructed a diagrammatic geologic cross-section between Ranges 2 E. and 3 E. in Kansas extending from T. 1 S. to T. 35 S. The line of this cross-section passes directly through the Wenger-Unger pools area. Lee, Leatherrock and Botinelly (1948) and Lee (1956) discussed the stratigraphy and structural development of the Salina basin. Taylor (1946) described the stratigraphy and structure of the "Hunton" limestone, the Maquoketa shale (Taylor, 1947a) and the Viola limestone (Taylor, 1947b). Upper Cambrian and Lower Ordovician rocks were described by Keroher and Kirby. (Keroher and Kirby, 1948) Lee in 1940 described the Mississippian rocks. (Lee, 1940)

Kornfield (1941, 1941a) mapped the Kinderhook-Misener thickness, the Mississippian limestone thickness and the Simpson formation thickness. Lee (1939) constructed a stratigraphic cross-section from McPherson County to Bourbon County. The line of this cross-section passes through the Wenger-Unger pools area. Keroher and Kirby (1948) also constructed a cross-section from Logan County to Crawford County. The line of this cross-section passes approximately 7 miles south of the Wenger-Unger pools area.

Purpose of Investigation

The purpose of this report is to investigate the relationship of petroleum accumulation to the stratigraphy and structural attitude of the "Hunton" limestone.

Proximity of the eroded boundary of the "Hunton" limestone suggests a stratigraphic trap. An investigation into the stratigraphy and structural features of the pools should determine whether petroleum accumulation is in a purely stratigraphic, a purely structural or a combination structure-stratigraphic type trap.

STRATIGRAPHY

Sedimentary rocks in the Wenger-Unger pools area range in age from Lower Ordovician to the Wellington shale in the Permian system. (Fig. 2)

Stratigraphic information below the Silurian and Devonian systems is incomplete. Few wells have been drilled through the Maquoketa shale of Ordovician age and no wells have reached Cambro-Ordovician rocks within the producing pools. A few have been drilled to the Arbuckle group around the margins of the pools.

Pre-Cambrian Rocks

The pre-Cambrian rocks in the Wenger-Unger pools area probably consist of igneous and metamorphic rocks. Rocks of pre-Cambrian age have not been penetrated by any well in the

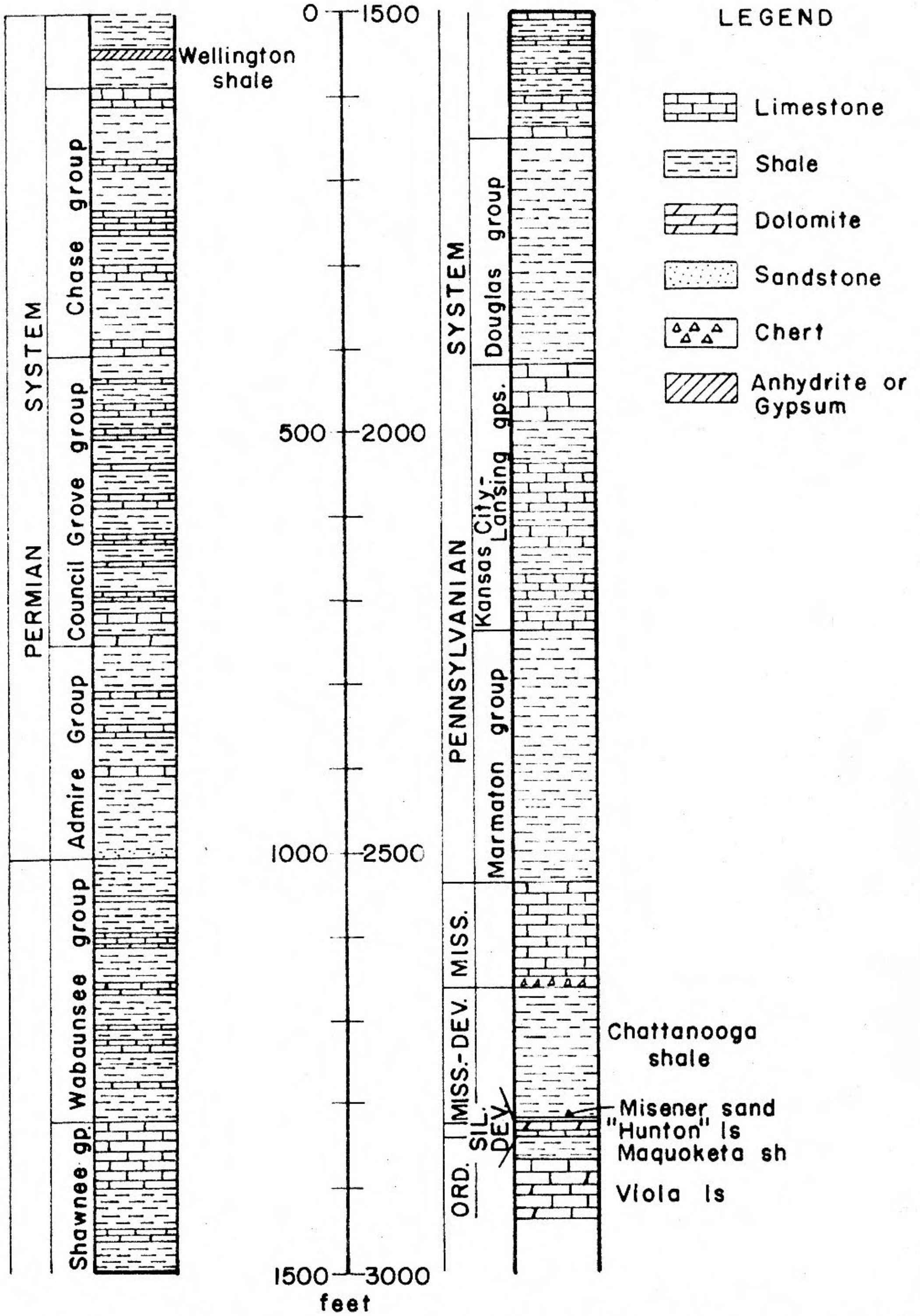


Fig. 2 Generalized stratigraphic sequence in Wenger-Unger Pools Area

area. Deep wells in adjacent areas have encountered igneous and metamorphic rocks below the Cambrian.

Upper Cambrian - Lower Ordovician

Arbuckle Group. The Arbuckle group (dolomite) is the term applied to the formations between the top of the Cambrian Bonneterre dolomite and the bottom of the Simpson Group of Ordovician age. The Arbuckle group includes the following formations, in ascending order: the Eminence dolomite of Late Cambrian age, the Gasconade dolomite, the Roubidoux formation and the Cotter and Jefferson City dolomites, undivided, of Early Ordovician age.

In the Wenger-Unger pools area only two formations of the Arbuckle group are present, the Roubidoux dolomite and the Cotter and Jefferson City dolomites.

The Roubidoux dolomite consists of sandy dolomite and fine angular sand, with cherty dolomites near the middle of the formation in some areas. The line which separates the Roubidoux dolomite on pre-Cambrian and Bonneterre dolomite crosses east to west across the center of Marion County. (Keroher and Kirby, 1948) The Roubidoux rests unconformably upon pre-Cambrian granite. The Roubidoux is approximately 200 feet thick in the Wenger-Unger pools area.

The Jefferson City-Cotter sequence overlies the Roubidoux dolomite. The dolomites of the Jefferson City-Cotter sequence are variable in character and may differ from those above and below in color and texture. The most common type is a white to gray coarsely granular chert bearing dolomite. The great variety of the cherts and dolomites offers considerable contrast to the white coarsely crystalline, sandy dolomite of the Roubidoux. So few wells in the area of this report have penetrated the Arbuckle group, that recognition of the different formations is difficult.

Ordovician Rocks

Simpson group. Lying unconformably on the Arbuckle group is the Simpson group which includes the St. Peter sandstone and the Platteville formation of Middle Ordovician age. So few wells in the area are drilled to the Simpson that separation of the St. Peter sandstone from the Platteville shale was not feasible. The St. Peter in adjoining areas consists of rounded, frosted quartz grains with varying amounts of green shale.

The Platteville consists of sandy dolomite and green dolomitic sandy shales.

Viola limestone. The Viola limestone of Middle Ordovician age overlies the Simpson group and ranges from an average thickness of 40 feet on the southwestern part of the area to 100 feet on the northeastern part of the area. A clear structural and stratigraphic analysis of the Viola limestone cannot be made from the few wells penetrating this rock unit.

The Viola consists of gray to tan crystalline limestone and dolomitic limestones.

The Viola does not contain a producing zone in the Wenger-Unger pools.

<u>Maquoketa shale</u>. The Maquoketa shale of Upper Ordovician age overlies the Viola limestone and varies from a soft gray shale near its base to a green to dark gray, siliceous, dolomitic shale at the top. The Maquoketa shale averages about 37 feet in thickness.

Figure 3 is a structure contour map depicting the structural attitude of the Maquoketa shale. The Maquoketa structure contour map was constructed in an attempt to resolve the erratic distribution of the "Hunton" limestone.

The Maquoketa is considered by Taylor (1947b) and Lee (1956) to be absent in the pre-Chattanooga Valley, termed the McPherson Valley, (Appendix, Fig. 1) in the center of Marion County just north of the Wenger-Unger pools. In sections 6 and 7, T. 22 S., R. 3 E. and sections 1 and 2 T. 22 S., R. 2 E., the Maquoketa is missing and the "Hunton" limestone lies unconformably on the Viola limestone. Where the "Hunton" is missing the Chattanooga shale lies unconformable upon the Maquoketa shale.

Silurian - Devonian Rocks

<u>"Hunton" limestone</u>. The limestones and dolomites lying between the top of the Maquoketa shale and the Chattanooga shale are referred to as the "Hunton" formation or group by drillers and geologists. The "Hunton" contains rocks of Silurian and Devonian age. The separation of Silurian rocks from Devonian rocks is difficult and is not attempted in this report. The thickness of the "Hunton" limestone varies in the area of the report from 0 to 57 feet.

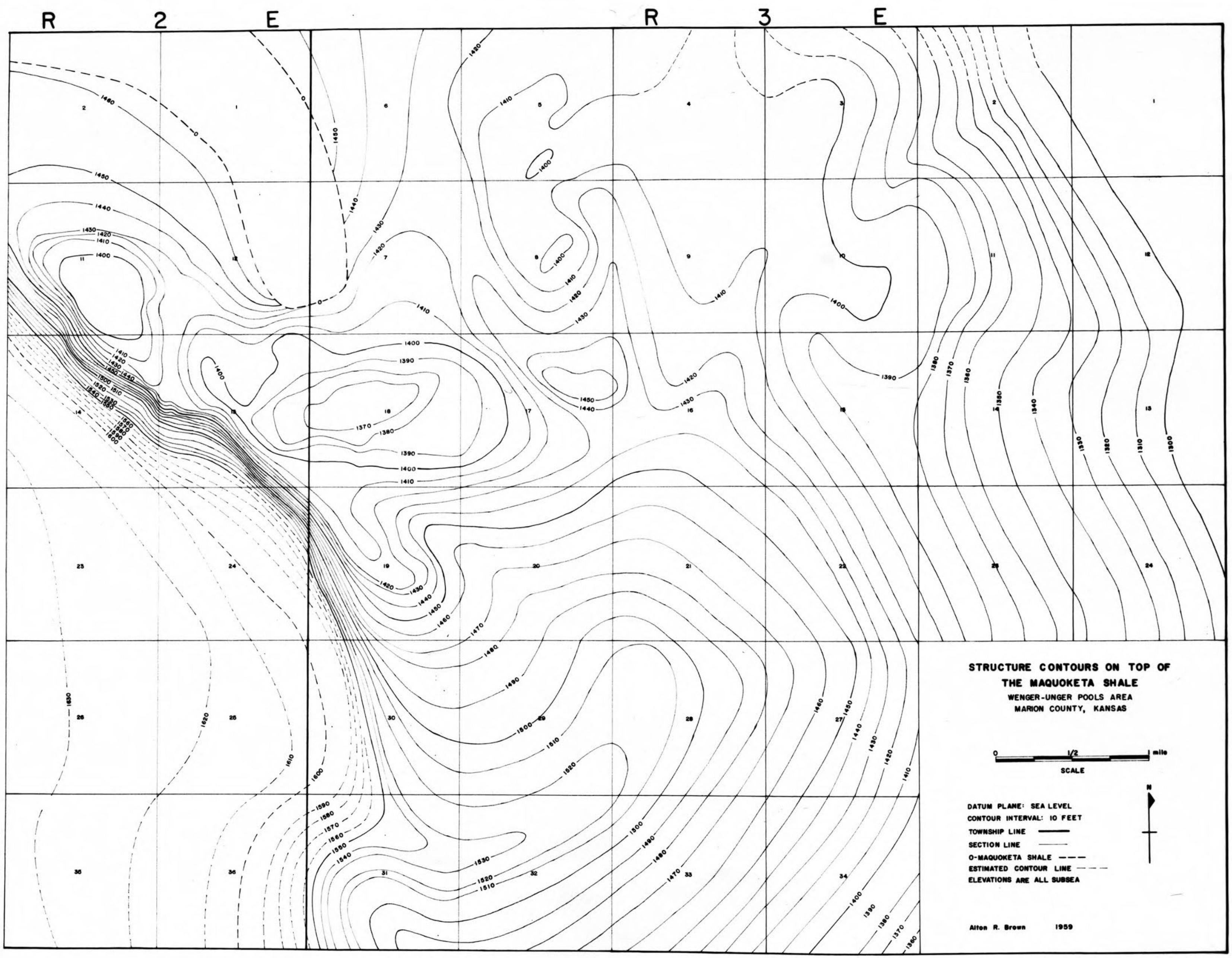
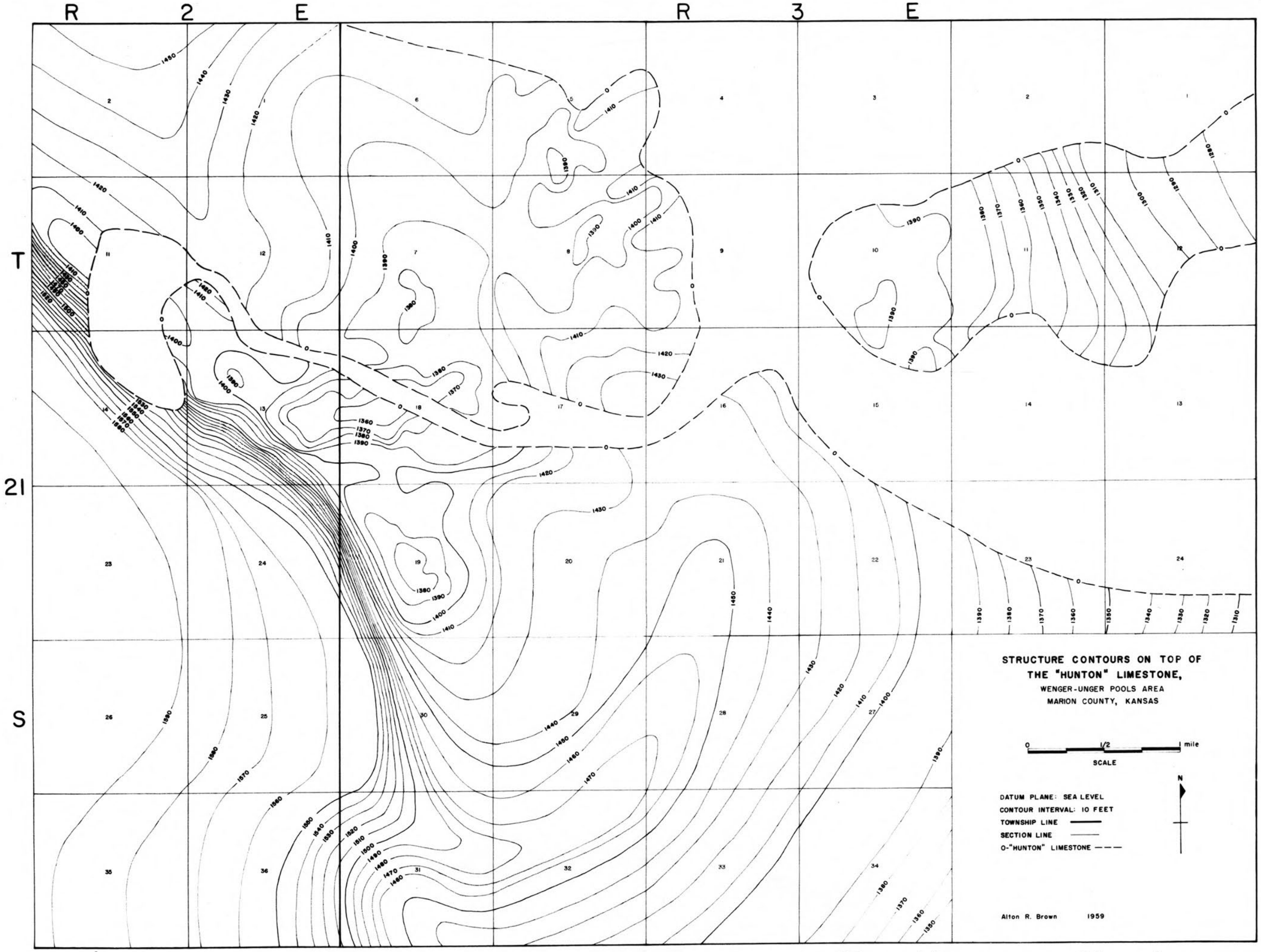


Fig. 3 Structure Contour Map of the Maquoketa Shale

Figure 4 is a structure map contoured on top of the "Hunton" limestone employing ten foot intervals. The map shows the areas in which the "Hunton" is absent and the location of the "Hunton" highs with respect to the zero edge. The "Hunton" limestone is absent north of the Wenger-Unger pools, between the Wenger pool and Unger pool, south of the Wenger pool and in a narrow band cutting across the Unger pool.

The "Hunton" within the pool areas shows considerable variation in lithology. In Sec. 11, T. 21 S., R. 2 E., the "Hunton" is a tan, fine crystalline, slightly sandy dolomite with good vuggy, and fossil cast, porosity. Reef-like porosity is probably indicated by the presence of many brachiopods, bryozoan, crinoid casts, and considerable coral growth. (Fig. 5) The "Hunton" in sec. 19, T. 21 S., R. 3 E. is a tan to gray, finely crystalline to dense dolomite. (Fig. 6) In the Unger pool the "Hunton" in sec. 7, T. 21 S., R. 3 E. is a grainy, finely crystalline sucrosic dolomite containing scattered stringers of limestone. The "Hunton" near the northern zero edge is a dolomitic limestone that contains some gray and tan chert which is splotched with darker gray and black areas, that resembles a chert found in other areas where the "Hunton" disappears. Figure 7 is an isopachous map of the "Hunton" limestone also using ten foot contour intervals. The "Hunton" production is restricted to the 5 to 40 foot thickness zone. It is probable that the thicker "Hunton" sections are partly erosional debris accumulations due to reworked "Hunton" from nearby high areas.



Elevations are all subsea

Fig. 4 Structure Contour Map of the "Hunton" Limestone

EXPLANATION OF FIGURE 5

Actual size core sample of "Hunton" dolomite 2869-70, from APCO#1 H. Manneman, NE¼ SE¼ SE¼ sec. 11, T. 21 S., R. 2 E., Marion County, Kansas. The section is tan, fine crystalline, slightly sandy dolomite with good vuggy and fossil cast porosity. Reef accumulation is indicated by the presence of many Brachiopod, Bryozoan and Crinoid casts and considerable coral growth.

Fig. 5 Photograph of core from Wenger-Unger pools area

EXPLANATION OF FIGURE 6

Actual size core sample of "Hunton" dolomite 2844-2845, from APCO#3, L. D. Slocombe, NW¼ SW¼ SE¼ sec. 19, T. 21 S., R. 3 E., Marion County, Kansas The Section is tan to gray, fine crystalline to dense with minute to large fractures. Several angles of fracturing are present with the vertical ones most prominent. The recrystallized material in the solution enlarged fractures is where the best oil saturation occurs.

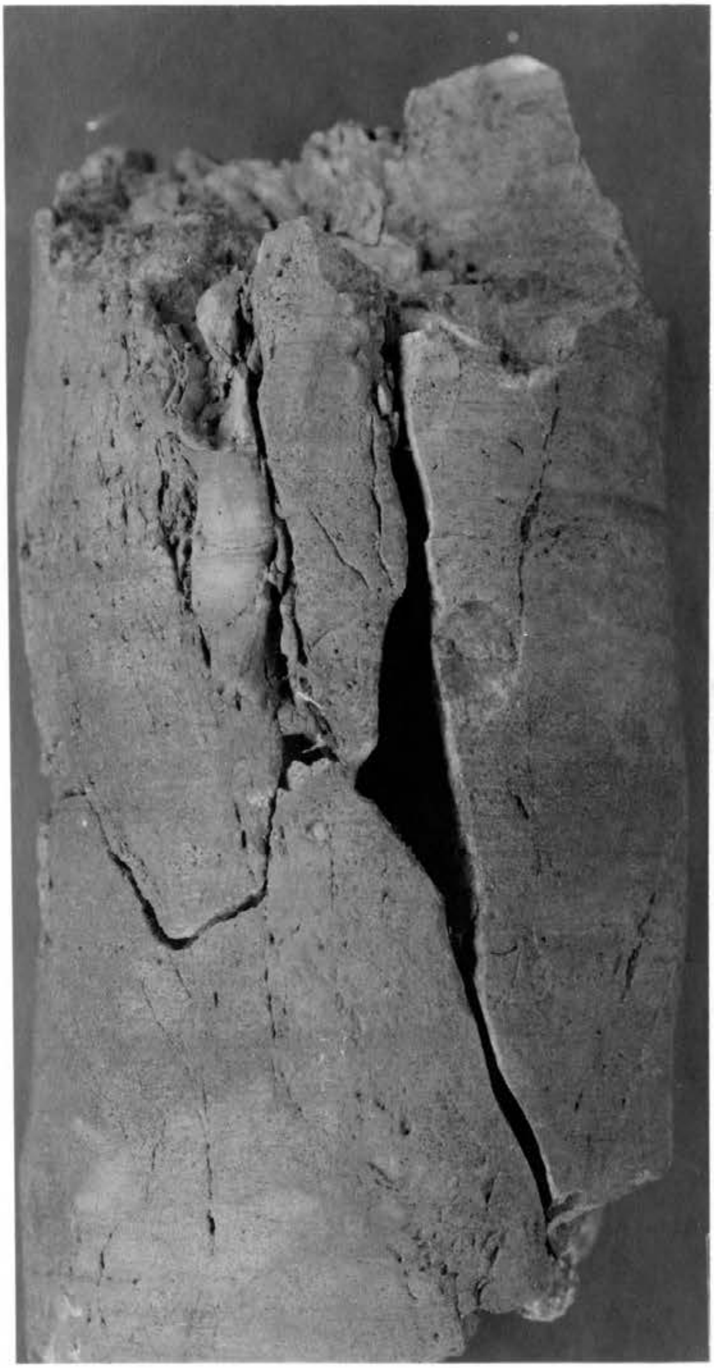


Fig. 6 Photograph of core from Wenger-Unger pools area

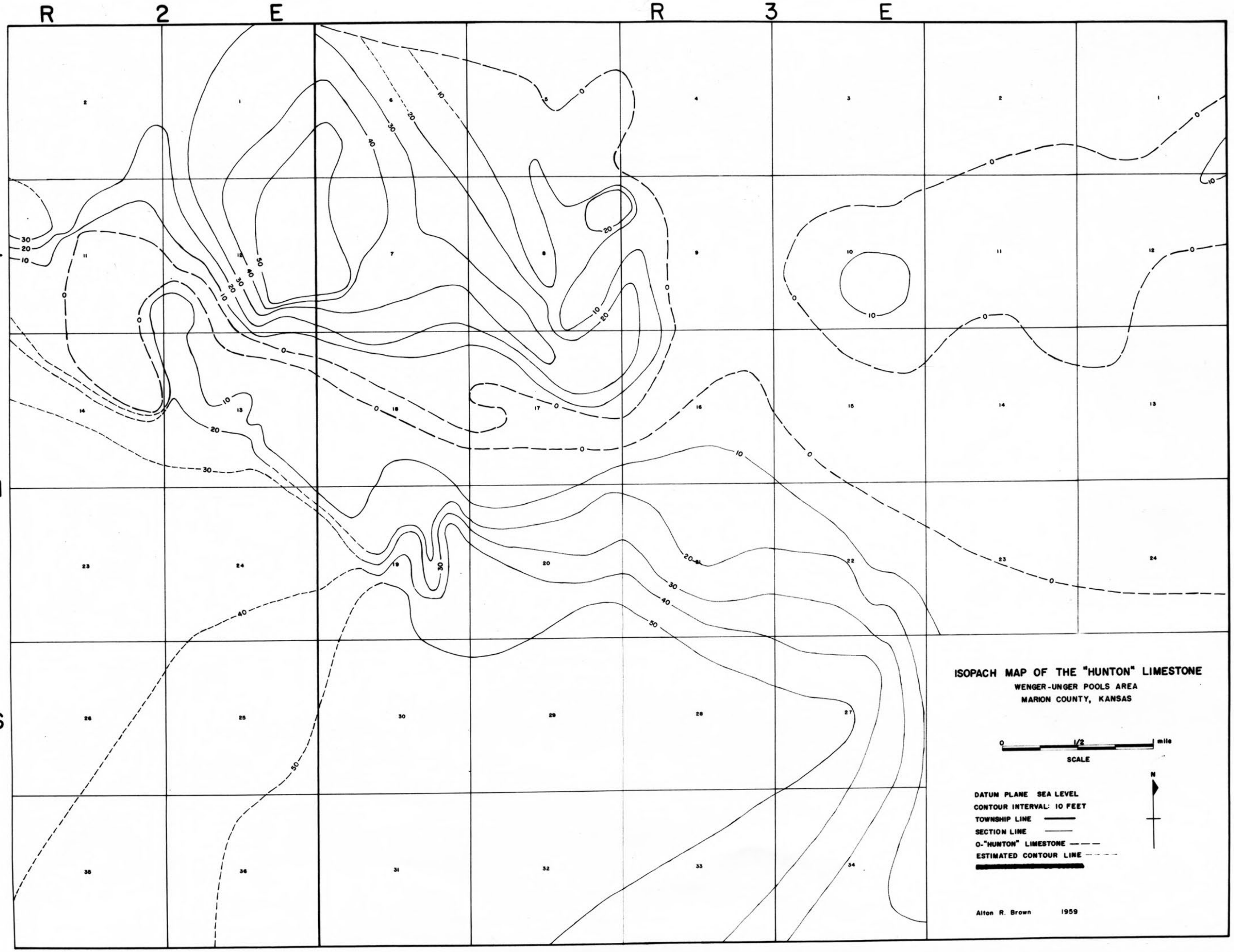


Fig. 7 Isopach Map of the "Hunton" Limestone

Lee and others (1948) and Lee (1956) separated the Silurian and Devonian rocks of the "Hunton" on the basis of a widespread disconformity. Lee (1956) puts the conjectural margin of Silurian rocks on a pre-Devonian surface east-west across central Marion County. Lee (1956) separates the Silurian into five zones and the Devonian into two zones within the Salina basin.

The first, or oolitic zone of Silurian age, overlies the Maquoketa and is composed of sucrosic or fine grained dolomite characterized by dolomitized oolites. The oolites are variable but the sucrosic texture is typical of this zone.

The second, or white chert zone, normally overlies the oolitic zone, but is missing in some areas. The zone consists mainly of medium to coarse crystalline dolomite with only minor amounts of white opaque or white tripolitic chert.

The third zone includes foraminifera and overlies the white chert zone. The lower part of the zone is a fine textured, dense to sucrosic dolomite but the upper part of the zone is coarsly crystalline and coarsly vuggy with many voids resulting from the solution of fossil fragments.

The fourth zone is composed mainly of siliceous dolomite with minor amounts of interbedded limestones.

The fifth zone is composed of interbedded limestones and dolomites.

The lower zone of the Devonian contains a lower sandy bed and an upper cherty bed. The sandy bed at the bottom is usually dolomitic, but may locally be a limestone. The cherty dolomite at the top is identified by the fact that part of the chert is gray and opaque and contained a massive to grainy spicular texture.

The upper zone above the white chert is extremely variable. The zone varies from a dolomite to interbedded limestone and dolomite to a red, brown and gray limestone.

Post-"Hunton" erosion removed much of the "Hunton" over an irregular surface and produced considerable topographic relief in Marion County. Topographic relief governed the thickness of the "Hunton" so the thickness is very irregular. The "Hunton" is absent across an area at least 12 miles wide crossing central Marion County. The area in which the "Hunton" is absent separates the Salina basin "Hunton", of northern Marion County, from the Wenger-Unger pools "Hunton" of southern Marion County.

Devonian - Mississippian Rocks

Chattanooga shale. The shale sequence that lies between the Mississippian and Siluro-Devonian limestones is the Chattanooga shale. It is often called the "Kinderhook shale" and is either Devonian or Mississippian in age. The Chattanooga lies unconformably above the "Hunton" limestone and the Maquoketa shale in the Wenger-Unger pools area.

The Chattanooga has an average thickness of 155 feet and consists of gray or black to green fine micaceous shales. The Chattanooga thickens toward the McPherson Valley to the north of the Wenger-Unger pools area.

The Boice shale may overlay the Chattanooga shale in the area of this report, no attempt was made to separate the two. Lee (1956) believes redeposited material from weathering and erosion of the Chattanooga shale constitutes the Boice shale.

The Misener sand at the base of the Chattanooga shale covers the Wenger-Unger pools area with a blanket of sand about one foot thick. A few wells in the areas where "Hunton" is missing show more than one foot of sand. In the NW¼ SE¼ SE¼ of sec. 18, T. 21 S., R. 3 W. the Misener is four feet thick.

Mississippian Rocks

Mississippian rocks vary in thickness as a result of the erosion during and after Mississippian time. Mississippian and Pennsylvanian rocks are separated by a mojor erosional unconformity.

Rocks of Mississippian age are primarily chert-bearing limestones and dolomitic limestones. During the post-Mississippian erosional period the less resistant limestone was removed from the chert which produced an erosional surface with a thick mantle of resistant chert. The weathered and eroded chert is usually imbedded in red and vari-colored clay and shale or, where the clay and shale is missing, is cemented by quartz or chalcedony. The "chat" may also be found in an unconsolidated state. The weathered zone is often called the Mississippian "chat". This "chat" zone is considered by many authors to be the basal Pennsylvanian conglomerate and was first described as such by Moore (1926). However in this report the "chat" section had been included with the Mississippian rocks. Maps of the Mississippian rocks were not prepared for this report. A preliminary investigation indicated that the structure of the Mississippian rocks does not reflect the structure of the underlying "Hunton" limestone in the Wenger-Unger pools area. The Mississippian "chat" is only included with Mississippian rocks on the cross-sections through the pools (Plate 1). Producing zones are not found in the Mississippian formations in the Wenger or Unger pools.

The Mississippian section has been divided into three series in the area of this report by Lee (1940, 1948, 1956). These are, in ascending order, the Kinderhookian, the Osagian and the Meramecian.

The Mississippian formations are the Sedalia dolomite and Gilmore City limestone of Kinderhookian series. The St. Joe limestone, the Reeds Springs limestone, Burlington and Keokuck limestones of the Osagian series and the "Warsaw" and Spergen limestones of the Meramecian series.

Pennsylvanian Rocks

Pennsylvanian rocks average 1625 feet in thickness in the Wenger-Unger pools area. Rocks of Pennsylvanian age contain no petroleum in the Wenger or Unger pools.

The Pennsylvanian system may be divided into six units; in ascending order, the Pennsylvanian basal conglomerate, the Marmaton Group, the Lansing-Kansas City Groups, the Douglas Group, the Shawnee Group and the Wabaunsee Group.

The Lansing-Kansas City is usually the first formation top recorded by geologists in the Wenger-Unger pool. The tops of these groups are found between 1960 and 2060 feet of depth in the pools. The interval from the Lansing-Kansas groups to the Mississippian average 560 feet. The various red, purple and green shales and prominent limestones provide good marker beds in the Pennsylvanian subsurface. A generalized stratigraphic column of the Pennsylvanian rocks is shown on figure 2.

Permian Rocks

The lower part of the Wellington shale of the Leonardian Series of Permian age is exposed at the surface on the Wenger-Unger pools area (Swineford, 1955). The thickness of the Permian rocks in the area of this report average 900 feet. (Jewett, 1949)

STRUCTURE

Regional Structures

The Wenger-Unger pools area is located on the east flank of the Nemaha anticline, south of the Salina basin, south of the McPherson Valley, to the north of the Sedgwick basin and to the west of small structures such as the Voshell anticline and the Halstead-Graber anticline. (Appendix, Fig. 1)

Salina Basin. The Salina basin occupies an area in north-central Kansas between the Central Kansas uplift and the northern end of the Nemaha anticline. Mississippian and older rocks are depressed between the two high areas and are bounded on the south by an unnamed arch-like structure that separates the Salina and

Sedgwick basins.

Lee (1956) distinguished five periods of folding in the Salina basin. (1) Upper Cambrian and Lower Ordovician dolomites of the Arbuckle group were uplifted and then eroded before deposition of the St. Peter sandstone on the eroded surface. (2) The second period of folding extended from St. Peter time to the beginning of deposition of the Mississippian limestone. After deposition of the "Hunton" widespread erosion followed and in places the "Hunton" was deeply eroded or completely removed. Pre-Chattanooga Valleys carved into the "Hunton" were then filled with Chattanooga shale. (3) A third period of uplift followed deposition of the Mississippian rocks. The principal structural feature produced was the Nemaha Anticline which divided the North Kansas basin into the Forest City Basin on the east and the Salina basin on the west. (Appendix, Fig. 1). Small local folds paralleling the Nemaha are considered to have formed during this period of folding. (4) A fourth period of deformation of post-Permian to pre-Cretaceous time developed a broad synclinal basin in southeastern Kansas which gave the Permian and Pennsylvanian rocks in eastern Kansas a south-westward dip. (5) A fifth period of post-Cretaceous deformation tilted the rocks in western Kansas to the northeast and the rocks of central Kansas to the north and northwest.

<u>Nemaha Anticline</u>. The Nemaha anticline or uplift is a major post-Mississippian element that plunges to the southwest just east of the Wenger-Unger pools area (Appendix, Fig. 1).

The Nemaha is an asymmetrical anticline that dips more steeply on the east. Its structural configuration resembles a normal fault scarp and the eastern flank is believed to be faulted in several places.

The northeast-southwest trending anticline is located approximately 15 miles to the east of the Wenger-Unger pools. Lower Paleozoic rocks have a regional dip toward the west and increase in dip toward the anticline. (Plate 1)

Sedgwick Basin. The Sedgwick basin, regarded as one of the major post-Mississippian structural provinces in Kansas, occupies an area southward from McPherson and Marion Counties (Appendix, Fig. 1). The basin is west of the Nemaha anticline and south of a low arch-like, unnamed, structure that separates the Sedgwick from the Salina basin. The Wenger-Unger pools are located on the extreme northern flank of the Sedgwick basin.

Central Kansas Uplift. The Central Kansas uplift occupies an area in central Kansas. The north-westward trending structure has been developed by several periods of uplift and erosion with subsequent truncation of sedimentary rocks, the earliest of which began in pre-Cambrian time. Uplift and warping has occured chiefly in post-Proterozoic, post-Canadian, post-"Hunton", early Pennsylvanian, post-Missouri and post-Cretaceous time. Cambro-Ordovician and Pennsylvanian strata were the most affected by thinning toward the north and west. (Koester, 1935) Appendix, Fig. 1)

McPherson Valley. In McPherson and Marion counties, the pre-Chattanooga surface was dissected by a broad valley having a topographic relief of more than 200 feet. (Appendix, Fig. 1) In Harvey County on a pre-Chattanooga hill the Chattanooga shale is 5 feet thick and in Marion County, a distance less than 25 miles, thickens to more than 200 feet. The pre-Chattanooga exposure of Silurian rocks in Lyon County suggests that the west-trending McPherson Valley headed in that county. A tributary entered the main Valley in western McPherson County from the south (Lee, 1940, Pl. 4) and on Figure 3 the Maquoketa shale is missing in an area that is also a possible tributary to the McPherson Valley. The Wenger-Unger pools are located approximately 5 miles south of the southern edge of the pre-Chattanooga valley.

Voshell Anticline. The Voshell anticline (Appendix, Fig. 1) approximately parallels the Nemaha anticline and lies in Saline, McPherson, Harvey and Reno counties. The Voshell is an anticlinal fold extending in a northeastward direction and bounded on the west by a reverse fault with a throw of about 400 feet.

The major structural uplift is considered to have taken place in post-Mississippian time with minor movements in late or post-Permian time. The Voshell anticline, in all probability, was formed at the same time as the Nemaha anticline. (Jewett, 1951)

Halstead-Graber Structural Trend. The Halstead-Graber trend is an anticline in McPherson and Harvey counties approximately parallel to and ten miles to the east of the Voshell anticline. (Appendix, Fig. 1)

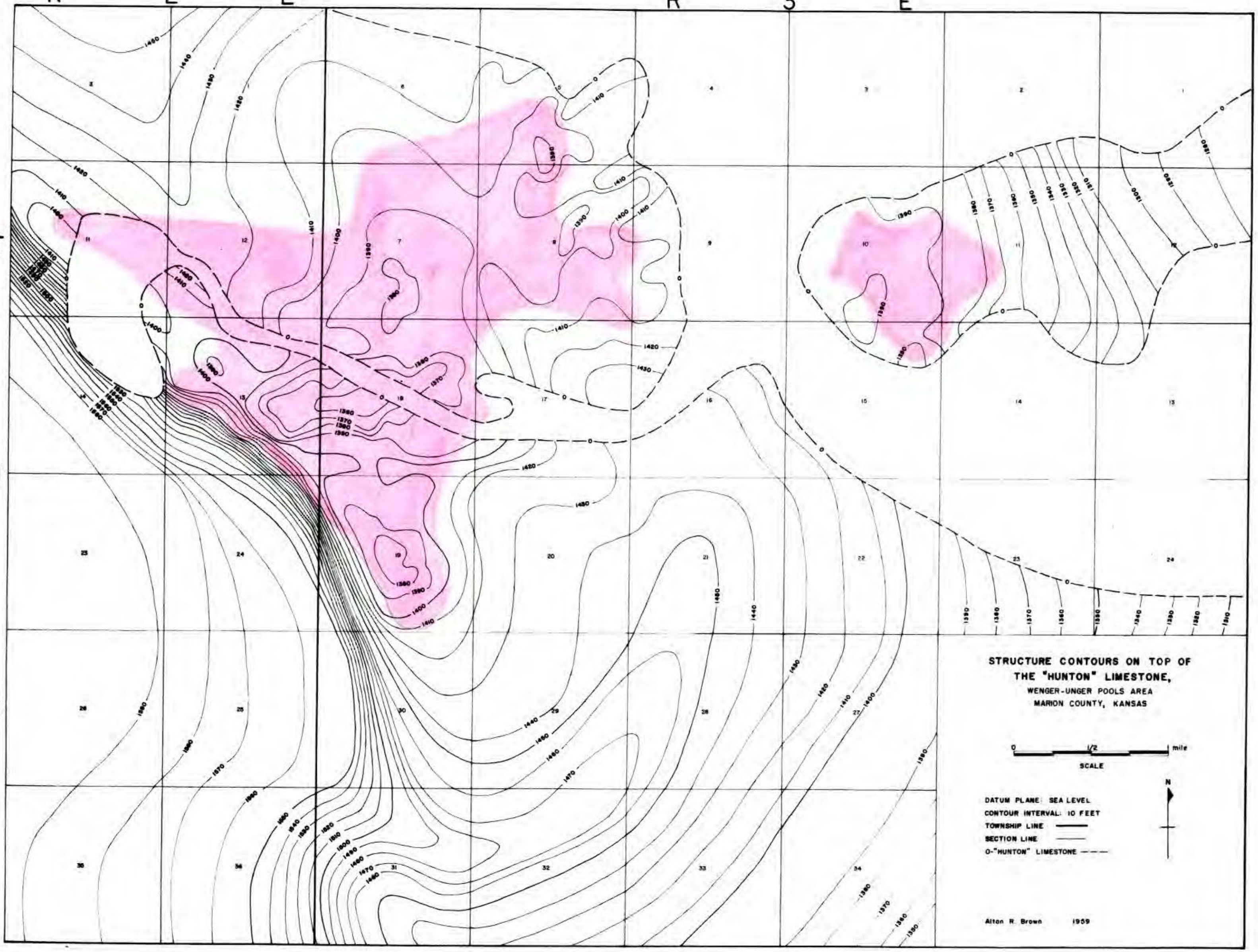
In all probability the folding of the Halstead-Graber structural trend was contemperaneous with the forming of the Voshell and Nemaha anticlines. (Jewett, 1951)

Structure within Wenger-Unger Pools Area

The structure map of the "Hunton" limestone, (Fig. 4) although contoured on the surface of this irregular erosional surface, shows west regional dip. Some topographic relief reverses the regional dip locally and it is in these areas that petroleum is found. Figure 3 contoured on top of the Maquoketa shale, exhibits a structure closely resembling the structure of the "Hunton" limestone.

In the Wenger pool two minor anticlinal "closures" are delineated. (Fig. 8) In the S½ of sec. 10, T. 21 S., R. 3 E. and the N½ N½ sec. 15, T. 21 S., R. 3 E. closure exists within the "Hunton". In the NE¼ sec. 15, T. 21 S., R. 3 E. a small high "closes" against the zero edge of the "Hunton". The "Hunton" in the Wenger pool shows a uniform dip westward to sec. 10 T. 21 S., R. 3 E. where it "flattens" out as a broad terrace. It is within this "flattened" area of the "Hunton" where petroleum has accumulated.

The Unger pool is found almost entirely within areas lying structurally above the 1400 foot contour line. (Fig. 8) A small narrow strip of missing "Hunton" cuts southeast to northwest across the center of the pool. The Maquoketa shale, in the areas where the "Hunton" is absent, has the same structural elevation as the truncated "Hunton".



Areas of petroleum accumulation

Fig. 8 Areal extent of Wenger and Unger pools

The "Hunton" is missing in the Unger pool across the NE¼ sec. 13, T. 21 S., R. 2 E. and east to west across the center of sections 17 and 18, T. 21 S., R. 3 E. The "Hunton" is also absent north, northeast and east of the pool.

Several local "closures" occur within the pool, the largest and containing the most prolific producing wells is in E½ sec. 13, T. 21 S., R. 2 E., SW¼ and NE¼ sec. 18, T. 21 S., R. 3 E. Other local "closures" are delineated in sec. 19, in S½ sec. 7, in S½ S½ sec. 5 and in W½ E½ sec. 8 all in T. 21 S., R. 3 E. each closing against the zero edge of the "Hunton".

To the southwest of the Unger pool the "Hunton" dips steeply to the southwest and flattens out onto a broad gently dipping surface.

Figure 7 is an isopach map of the "Hunton" limestone contoured on 10 foot intervals which shows the "Hunton" thinning over the structural "highs" and thickening on the flanks to the south and to the northwest.

A preliminary study of the structure of the Chattanooga shale and the Mississippian rocks revealed a southwest regional dip and showed little or no relation to the "Hunton" structure below. (Plate 1)

GEOLOGIC HISTORY

The first evidence of an unconformity appears at the base of the Arbuckle group. Uplift followed by erosion has beveled pre-Cambrian rocks and removed the lower formations of the Arbuckle group, if the formations were deposited.

The next major unconformity occurs at the base of the St. Peter. The Arbuckle group and older rocks were uplifted and eroded, creating an erosional topography for deposition of the St. Peter. The depositional environment following the Arbuckle erosional period was a shallow transgressing sea in which the St. Peter sandstone, a basal formation of the Simpson group, was deposited. The St. Peter is separated from the Platteville shale, the upper Simpson formation, by a minor unconformity. The fact that the St. Peter was deposited on an erosional surface and is overlain unconformably by the Platteville and is everywhere present over a wide area indicates only minor topographic relief on the Arbuckle surface and the Platteville surface.

Viola limestone deposition followed Simpson time and although a hiatus exists between the Simpson and the Viola a basal non-cherty zone of the Viola indicates the surface of the St. Peter was one of very low relief. The Viola was then uplifted and broadly dissected by pre-Maquoketa erosion. The Maquoketa was then deposited over the dissected Viola filling in the eroded areas to present an almost level surface for Silurian deposition.

The Silurian is essentially conformable upon the Maquoketa. Lee (1956, Pl. 2) places the conjectural zero isopach across the center of McPherson and Marion counties. The marginal line lies approximately 12 miles to the north of the Wenger-Unger pools area. The Silurian rocks were originally deposited through the area, but repeated uplifts and erosion has removed the Silurian from many areas. The unconformity above the Silurian has beveled older rocks as far down as the Arbuckle group.

Deposition of the Devonian on the local eroded hills of the Silurian surface produced extremes of thickness of the Devonian rocks. The Devonian rocks originally overlapped from the Silurian onto the Maquoketa but much was later removed by pre-Chattanooga erosion. After Devonian deposition the area was again subjected to uplift and erosion. Unconformities at the top and bottom of the Devonian and the Silurian has so restricted and complicated the distribution of the separate rocks that the term "Hunton" is used to include all the carbonate rocks between the Maquoketa and Chattanooga shales.

Pre-Chattanooga erosion incised deeply into the "Hunton" and removed it completely in some areas. This period of uplift and erosion is probably responsible for the missing "Hunton" in the Wenger-Unger pools area. The McPherson Valley was deeply eroded at this time prior to deposition of the Chattanooga shale.

The Chattanooga shale of Devonian or Mississippian age was deposited over a broad area with thicknesses of over 250 feet in the McPherson Valley. After deposition of the Chattanooga, the area was uplifted and probably subjected to minor warping.

At the end of Mississippian time the area was uplifted and the Mississippian limestones and dolomitic limestones were eroded to produce a major unconformity. The Nemaha anticline was formed and continued uplift followed by increased erosion caused the beveling of Mississippian rocks and exposed Arbuckle rocks to the northeast and the Chattanooga shale to the east of the area of this report. (Lee, 1956, Pl. 6) Erosion of the

Mississippian cherty limestone produced the basal Pennsylvanian sediments.

Continued marine sedimentation through Pennsylvanian and Permian time was interrupted by minor unconformities which indicates diminished structural movement. Interbedded limestones and shales were deposited into Permian time.

Following Permian time the area has been subjected to repeated periods of deposition and erosion. Permian formations younger than the Wellington shale and all rocks of Triassic, Jurassic, Cretaceous, Tertiary and Quaternary rocks are absent in the area. The younger Permian rocks must have spread over the area but were later eroded.

Triassic and Jurassic rocks are absent in the area. Erosion has removed rocks of these ages if they were deposited.

Rocks of Cretaceous age were probably deposited but were also subjected to later erosion and removed. Cretaceous rocks out crop approximately 16 miles northwest of the area.

Tertiary and Quaternary rocks are also absent in the Wenger and Unger pools but are found outcropping approximately 8 miles west of the area.

PRODUCTION OF PETROLEUM

The Wenger pool, discovered in 1947, produced a maximum of 184,766 barrels of oil in 1949 and has steadily declined since that time. At the peak in production in 1949 the Wenger pool had 28 wells producing. In December 1958 the pool had only 15 wells producing a total of 62 barrels per day. Figure 9 summarizes the yearly production of the Wenger pool. The estimated cumulative production to the end of 1957 totals 921,428 barrels as recorded in the files of the Kansas Geological Survey. (Table 1

The Wenger is a water-drive pool and little or no gas is produced. Rotary tools are used in the field to drill to the top of the "Hunton", where pipe is set, then cable tools are used to drill a few feet into the production zone. Most of the producing wells were drilled between 4 and 6 feet into the "Hunton".

The Wenger pool covers a very restricted area being bounded on three sides by the "Hunton" zero-edge and to the east by a thinning of the reservoir rock to less than 5 feet. The field seems to be a purely stratigraphic trap having little structural deformation within the pool.

The Unger pool, discovered in 1955 and combined with the Unger southwest pool in 1956, is a prolific producer with exceptional production for shallow wells. The estimated cumulative production to the end of 1957 totals 1,565,721 barrels as recorded in the files of the Kansas Geological Survey. (Table 1) Figure 10 summarizes the yearly production of the Unger pool. The rapid increase in 1956 was due to the combining of the two pools.

The discovery well of the Unger southwest pool had a daily initial production of 4,257 barrels per day, other wells in sec. 18, T. 21 S., R. 3 E. when brought in would have produced as high as 6,000 barrels per day. In December 1958 the Unger pool had 147 wells producing 3,259 barrels per day.

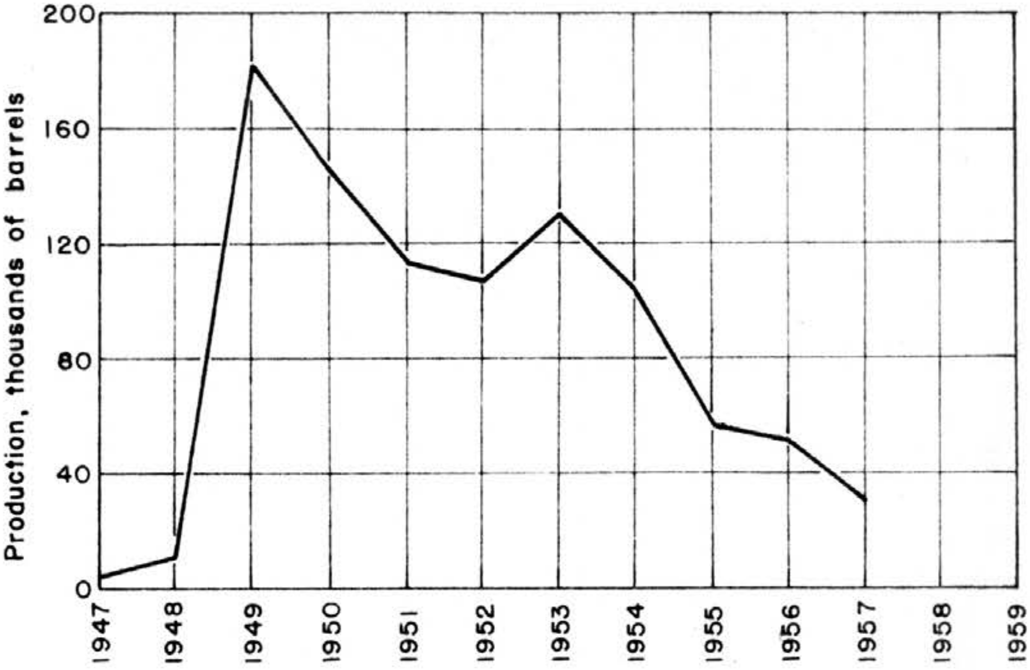


Fig. 9 Production Chart for Wenger Pool

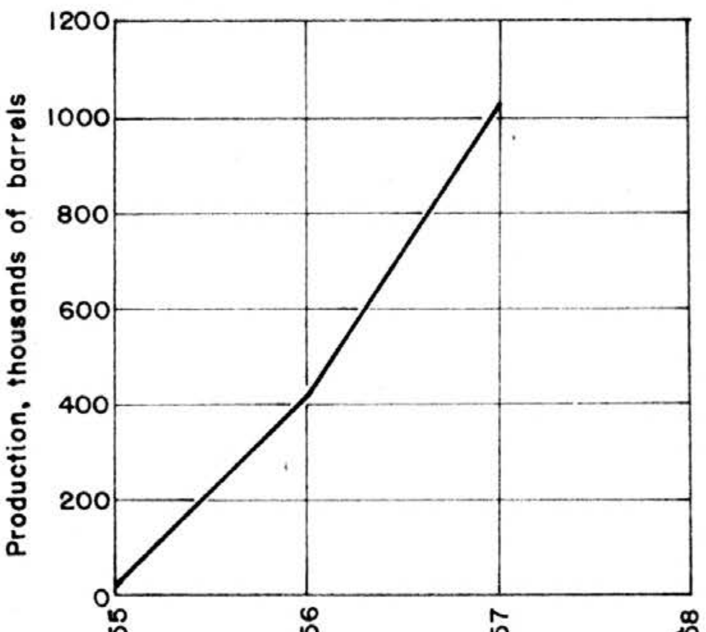


Fig. 10 Production Chart for Unger Pool

Table 1. Yearly production for Wenger and Unger Pools.

Year	Area Acres	Barrels per year	Cumulative Production	Producing wells
Wenger Pool				
1947		2,760		
1948		11,074	13,834	1
1949	500	184,766	188,573	1
1950	500	141,112	329,686	15
1951	500	112,499	442,185	15
1952	800	106,979	549,164	15
1953	1000	129,636	678,800	23
1954	640	103,520	782,320	28
1955	480	56,696	839,016	26
1956	480	51,177	890,193	24
1957	480	31,235	921,428	18
1958 (June)			1,040,692	16
Unger Pool				
1955	480	20,114	20,114	4
1956	480	146,825	166,939	20
Unger Southwest Pool				
1956	1100	273,518	273,518	67
Combined Unger and Unger Southwest Pools				
1957	2500	1,125,264	1,565,721	91
1958 (June)			2,135,089	

The Unger pool is a high pressure water drive pool with little gas. The water in the field has encroached only slightly into the producing wells. After 3 years of production the Unger pool had the following oil-water relationship:

Location	Section	Percent oil	Percent water
T. 21 S., R. 3 E.	S½ 7	25	75
	18	75	25
	N½ 19	75	25
	S½ 19	50	50
T. 21 S., R. 2 E.	13	25	75

The estimated total reserves in sec. 18, T. 21 S., R. 3 E. is 75,000 barrels per well on 10 acre spacing and in sec. 7 T. 21 S., R. 3 E. 50,000 barrels per well on 10 acre spacing.*

The range in lithology in the reservoir rock has caused different well completion methods. It has been the practice in the dense fractured "Hunton" dolomite to set casing through the producing formation and perforate into the "pay zone". It is believed that this type completion will better control the water encroachment. In the sucrosic and calcareous "Hunton" casing is set into the top of the producing formation and "drilled in" with cable tools, then acidized. Both type completion practices have been used, perforation and "drilling in", and it has been found that the "drilled in" type completion produces the most oil.

Well completions are determined by the individuals drilling the well and each may have a preference for a certain type well completion, but in general the methods as stated are the completion practices used in the pools.

* Don Hollar, personal communication, 1959

RELATIONSHIP BETWEEN PETROLEUM ACCUMULATION AND GEOLOGIC FACTORS

Figure 4 shows the relationship between the petroleum reservoir rock, the "Hunton" limestone, and the structure. Figure 3 contoured on top of the Maquoketa shale, shows the Unger pool lying on a Maquoketa "high" and the Wenger pool lying on a local flattening in the regional dip of the Maquoketa. There are two possible explanations of the Maquoketa "high". Lee and others (1954) showed small folding of the Viola and older rocks through the area, the Maquoketa then may represent a small anticline or pre-"Hunton" erosion may have produced a topographic Maquoketa "high".

The production zone of the "Hunton" in the Wenger pool is in the 5 to 10 foot thickness. The pool is almost purely stratigraphic with very little structure and produces along the wedge-edge of the "Hunton".

The production zone of the "Hunton" in the Unger pool seems to be in the 5 to 40 foot thickness, with most of the petroleum concentrated in the 10 to 20 foot zone. The pool produces on a wedge-out edge of the "Hunton" in a stratigraphic type pool with structure as a secondary factor.

Plate 1 shows stratigraphic cross-sections both north to south and east to west across the Wenger and Unger pools. (Appendix, Table 2) Cross section A-A' and B-B' (Plate 1) shows the "Hunton" thickening in the areas of the Unger pool and the wedge-out on the Maquoketa "high" in NW¼ SE¼ SE¼ sec. 18, T. 21 S., R. 3 E. The Wenger pool, cross-section A-A' and C-C' show the "Hunton" lying on a flattened Maquoketa surface.

The "Hunton" in the small area of the Wenger-Unger pools displays a profound and varied facies change. In sec. 11, T. 21 S., R. 2 E. the "Hunton" is a highly fossiliferous rock with a vuggy type porosity and in S½ sec. 19, T. 21 S., R. 3 E., it is a dense dolomite with porosity created by fractures. In the N½ sec. 18 and sec. 8, T. 21 S., R. 3 E. the "Hunton" is a fine sucrosic, grainy, dolomite and changes northward into a limestone

The "Hunton" undoubtedly existed in parts of the area as a reef type structure. Recrystallization of the reef debris associated with a later diastrophism may have produced the fractured dolomite. Reworking and recrystallization of the "Hunton" north of the Maquoketa "high" may have caused deposition of the sucrosic dolomite and the limestone was deposited from normal marine waters. The sucrosic dolomite and the limestone may be of younger age than the dense dolomite.

The strip of missing "Hunton" through the area is difficult to explain. Two explanations seem equally possible.

The "Hunton" when deposited over the area would be thinner over the Maquoketa "high". When subjected to erosion the thinner area of "Hunton" would be removed first, and underlying shale would be easily cut into to provide channeling toward the pre-Chattanooga valley to the north. The areas of missing "Hunton" seem to occupy a stream channel pattern (Fig. 4), but deposition of river debris does not occur in the areas of missing "Hunton". The Misener thickens slightly from a blanket of one foot over the entire area to 4 feet in the strip of missing

"Hunton" across the Unger pool suggesting a possible channel in that area.

The other possibility is the "Hunton" existed as a reef. Some cores taken from the area prove definite reef possibilities. The erosion would be due to wave action and the areas of missing "Hunton" could be explained as scour channels or inter-reef channeling erosion. The wave action would keep the channel swept clean and no debris would be deposited. The growing reef and the wave action may also explain why the areas of missing "Hunton" are not incised deeper into the underlying shale. Maps of recent reefs show the same general configuration as the present "Hunton" structure (Link, 1950), with channels and bays on one side and dipping steeply on the other.

The thickness of the overlying Chattanooga shale shows no marked increase in the areas of missing "Hunton".

In summary, accumulation of petroleum in the Wenger-Unger pools is associated with the following features: (1) the westward dipping flank of the Nemaha anticline, (2) truncated edges of the "Hunton", (3) local closed "highs" in the Unger pool, (4) gentle structural terraces in the Wenger pool, and (5) prolific production from the 10 to 20 feet "Hunton" thickness.

OIL RESERVOIR CHARACTERISTICS

Oil in the Wenger and Unger pools is produced from only one formation, the "Hunton" limestone.

The "Hunton" "pinches out" on the extremes of the Wenger pool, hence a trap for oil accumulation is formed by the thinning and wedging-out of the reservoir rock. The Unger, also on the truncated edge of the "Hunton" has local "closed highs" in the pool and thus produces from a combination structure-stratigraphic trap. In both pools the overlying Chattanooga shale and the underlying Maquoketa shale come into juxtaposition to seal the porous "Hunton" limestone.

The distribution of the producing zone is very irregular. A 10-acre offset from a producing well may miss the "Hunton" completely. The thickness distribution is equally erratic varying from less than one foot to 57 feet thick in the area.

The porosity of the reservoir rocks varies from a high vuggy porosity in a fossiliferous rock, to a fracture-type porosity in a dense dolomite, to void spaces between grains in a sucrosic dolomite.

The migration of oil into the trap necessarily occured after development of reservoir porosity, the majority of which probably formed during the long periods of erosion. The Maquoketa shale and the Chattanooga shale are two possible sources for the petroleum accumulated in the pools. It is probable that oil migrated from the underlying or overlying shales or if no migration occurred, the petroleum may have formed in place. Oil migration up dip from the Viola does not seem probable, although the "Hunton" in the vicinity of the Wenger and Unger pools overlies the Viola in small restricted areas. Oil migration into the Wenger pool from the Viola would have had to occur prior to the Nemaha structural movement because at present the Wenger producing "Hunton" is downdip from the "Hunton" where it rests unconformably on the Viola east of the pool.

FUTURE EXPLORATION

Future possibilities for discovery of petroleum reserves in the area covered by this report are very small. The Wenger pool is completely encircled with "dry holes" and the producing formation is absent on three sides of the pool. The Unger pool, also encircled by "dry holes", may have few possibilities of extensions around the edge of the pool. Detailed mapping in sec. 11 and sec. 12, T. 21 S., R. 2 E. may reveal local highs for future drilling. Another possibility would be a small "Hunton" outlier within the areas of missing "Hunton" which have not been discovered.

Production in older formations is also possible. Exploration of the Viola and Arbuckle in the pools have been almost negligible. In Marion county, T. 21 and 22, R. 4 E., production has been found in several Viola limestone anticlines. (Thomas, 1927).

In younger formations a slight show of oil was found in the Mississippian in one well in NW¼ SE¼ NW¼ sec. 11, T. 21 S., R. 2 E. The younger formations were all "drilled through" to reach the "Hunton" and none contained commercial quantities of oil.

The type traps found in the Wenger and Unger pools area are the type traps which generally are not reflected by overlying formations. Discovery of pools of this type must depend on accurate structural and stratigraphic analysis after an initial drilling program has begun.

SUMMARY

The Wenger and Unger pools are primarily stratigraphic type traps with structure as a secondary factor. The truncated edge of the "Hunton" presented a difficult geological interpretation problem due to its irregular distribution and the facies change within the reservoir rock has caused different completion methods to be employed.

The limited extent of the Wenger pool restricts the petroleum reservoir and depletion may occur in a relatively few years. The pool in less than 12 years, averages only 4.1 barrels per well per day. The Unger pool, also a small pool, with limited areal extent has an estimated reserve as high as 7,500 barrels per acre in parts of the pool.

The oil accumulation in the Wenger pool is probably due, primarily, to causes other than structure. The flattened gentle terrace surrounded by the truncated edge of the "Hunton" provides an almost purely stratigraphic trap. The closure in the Unger pool is probably both topographic and structural relief. Structure contours drawn on the overlying formations reflect none of the structures of the beds lying below the unconformity.

The principle factors that would account for oil accumulation in the Wenger and Unger pools are:

1. Limited distribution of the "Hunton" limestone.
2. Truncation of the "Hunton" around the edges of the pools.
3. An impermeable seal above the producing formation.
4. Localized structural "highs".
5. The localized high effective porosity and permeability.

The porosity of the field has been developed through dissolved fossil parts in a reef-like accumulation, fracturing of dense dolomite and probably dolomitization.

The type trap represented by the Wenger and Unger pools is difficult to discover. Surface and subsurface mapping does not reveal favorable petroleum accumulation areas. Kornfield (1941) suggested 5 methods employed in the modern search for stratigraphic traps as follows:

1. "Search for geologic wedges through studies of past work along the strike.
2. Search for off shore bars through the use of isopach and maps.
3. Search for terraces flanking uplifts, through regional structural studies.
4. Search for flank, truncated zones, which are beveled from crest.
5. Search for porosity changes, through checking samples, principally on terraces."

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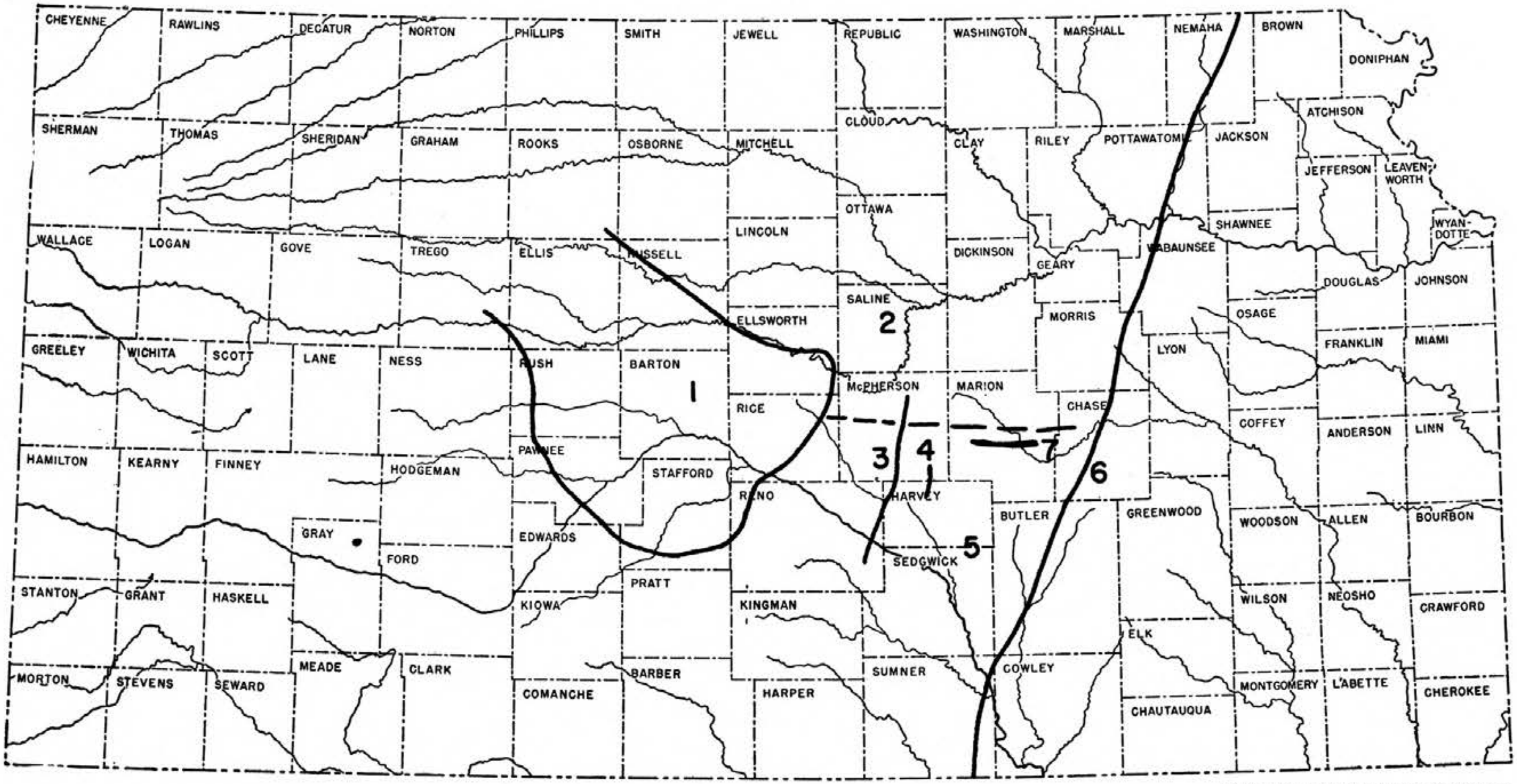
APPENDIX



State Geological Survey of Kansas

1. Central Kansas Uplift
2. Salina Basin
3. Voshell Anticline
4. Halstead-Graber Trend
5. Sedgwick Basin
6. Nemaha Anticline
7. McPherson Valley

Fig. 1 Structural features in Kansas

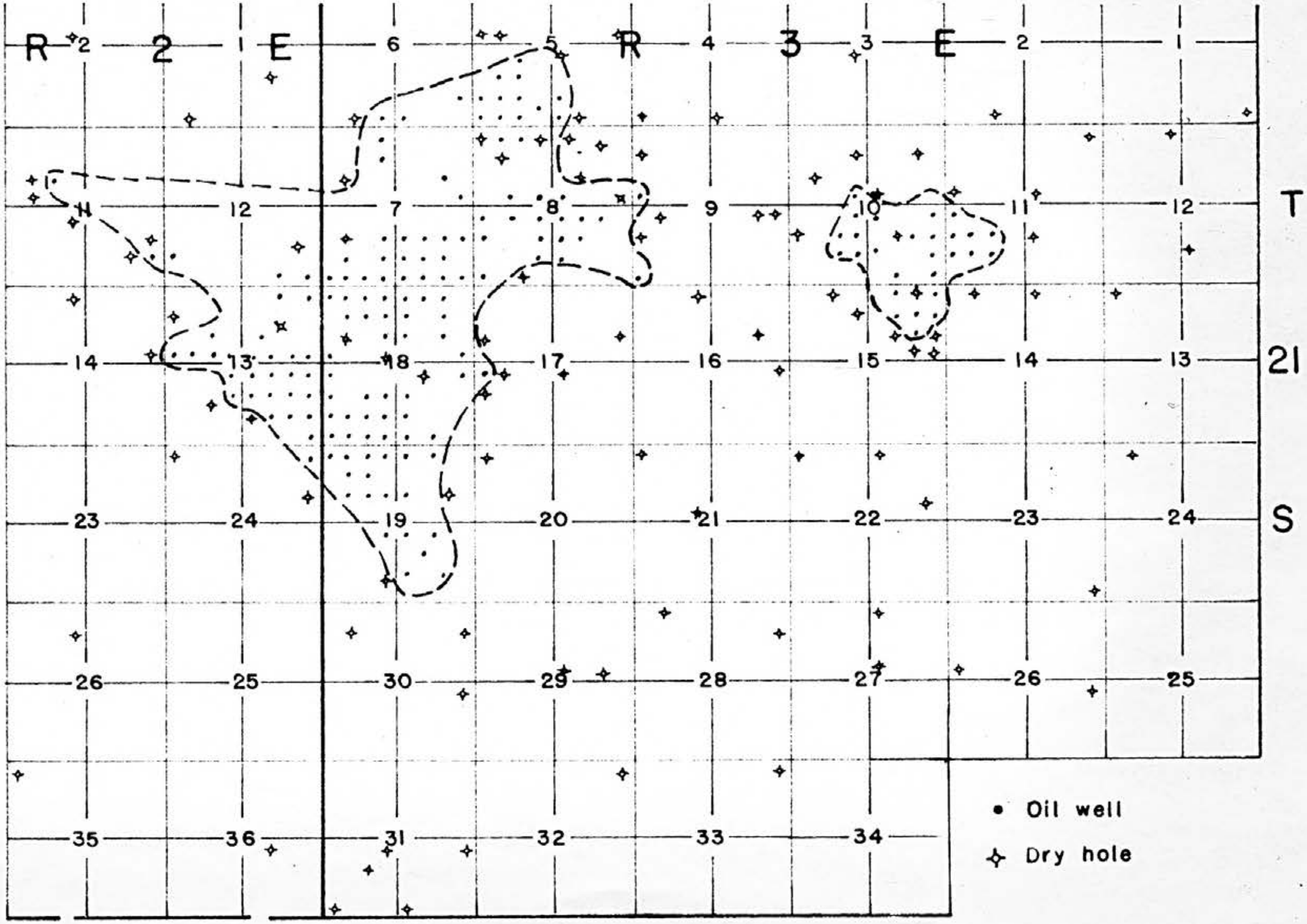


FIG. 2 Subsurface control points on the "Hunton" limestone

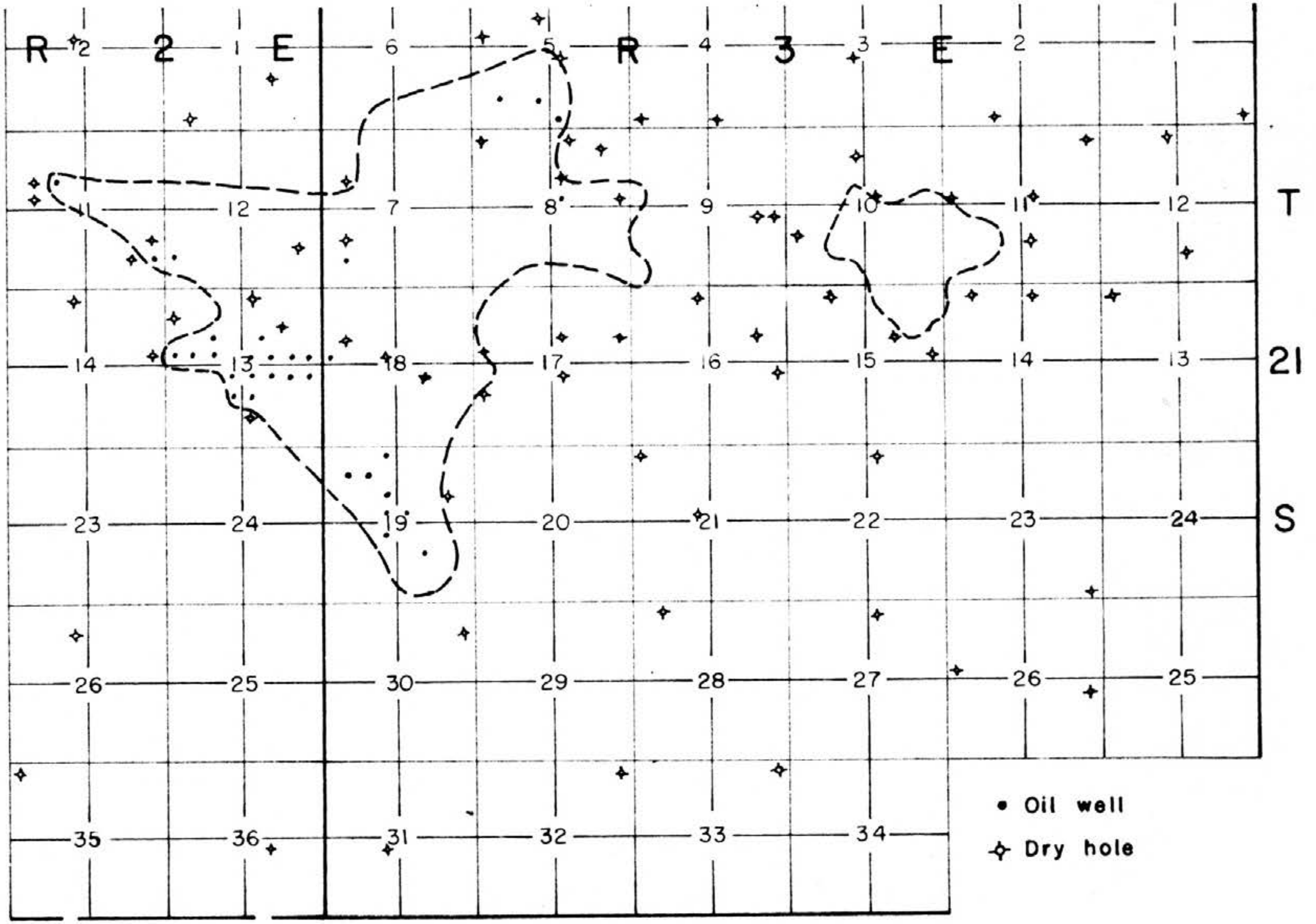


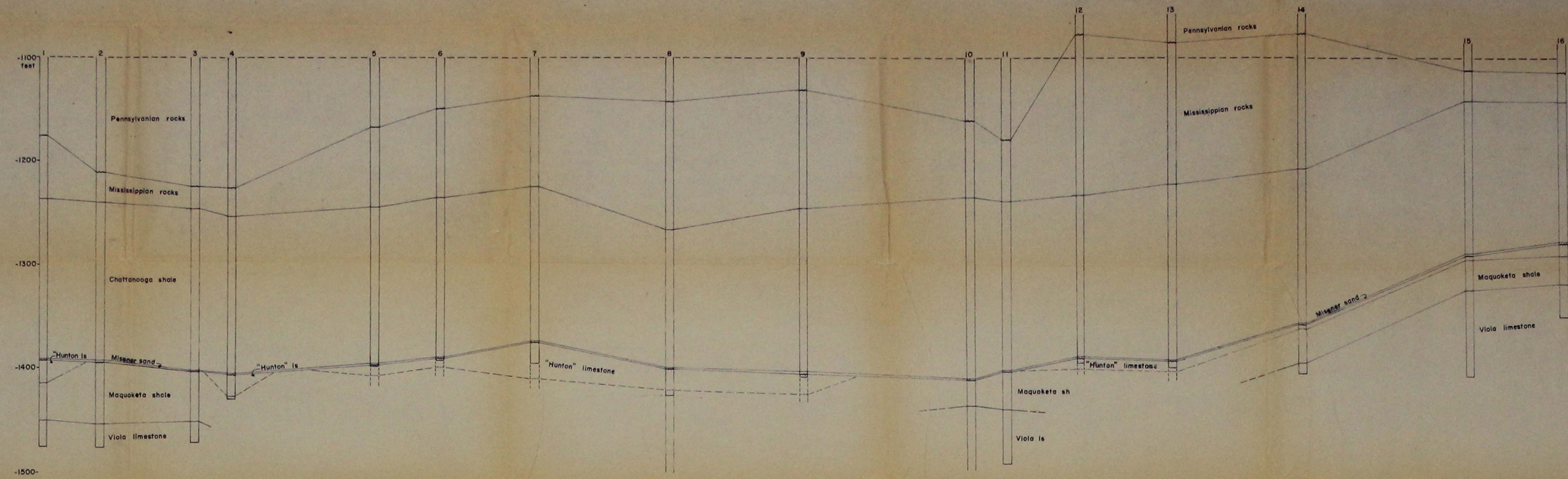
FIG. 3 Subsurface control points on the Maquoketa shale

Table 2. Location of wells for stratigraphic cross-sections in Township 21 South, Wenger-Unger pools area, Marion County, Kansas

Well nos.	Section	Location	Range	Total depth below sealevel
		A -- A'		
1.	11	SE SW NW	R. 2 E.	1470
2.	11	NE NE SW	2	1476
3.	11	SE NE SE	2	1472
4.	12	NE SW SW	2	1426
5.	13	CN_2 N_2 NE	2	1400
6.	7	SW SW SW	3	1393
7.	7	NW SW SE	3	1397
8.	8	SW SE SW	3	2072
9.	9	SW SW SW	3	1409
10.	9	NE NE SE	3	1624
11.	10	SW NW SW	3	1492
12.	10	NE SE SW	3	1394
13.	10	NE SE SE	3	1401
14.	11	SW SW NE	3	1419
15.	12	NE NE NW	3	1407
16.	1	SE SE SE	3	1350
		B -- B'		
17.	5	NE SE NW	3	1466
18.	5	CE_2 SE SW	3	1393
19.	8	NW NW NW	3	1433
20.	7	NW SE NE	3	1400
21.	18	NE NE NW	3	1387
22.	18	NE SE NW	3	1376
23.	18	SE SE NW	3	1492
24.	18	NW NW SW	3	1438
25.	18	NW NE SW	3	1379
26.	19	SE SE NW	3	1430
27.	19	NE NE SW	3	1416
28.	30	SE NE NE	3	1784
		C -- C'		
29.	10	SE NE NW	3	1420
30.	10	SE SE NW	3	1402
31.	14	NE NE NW	3	1471

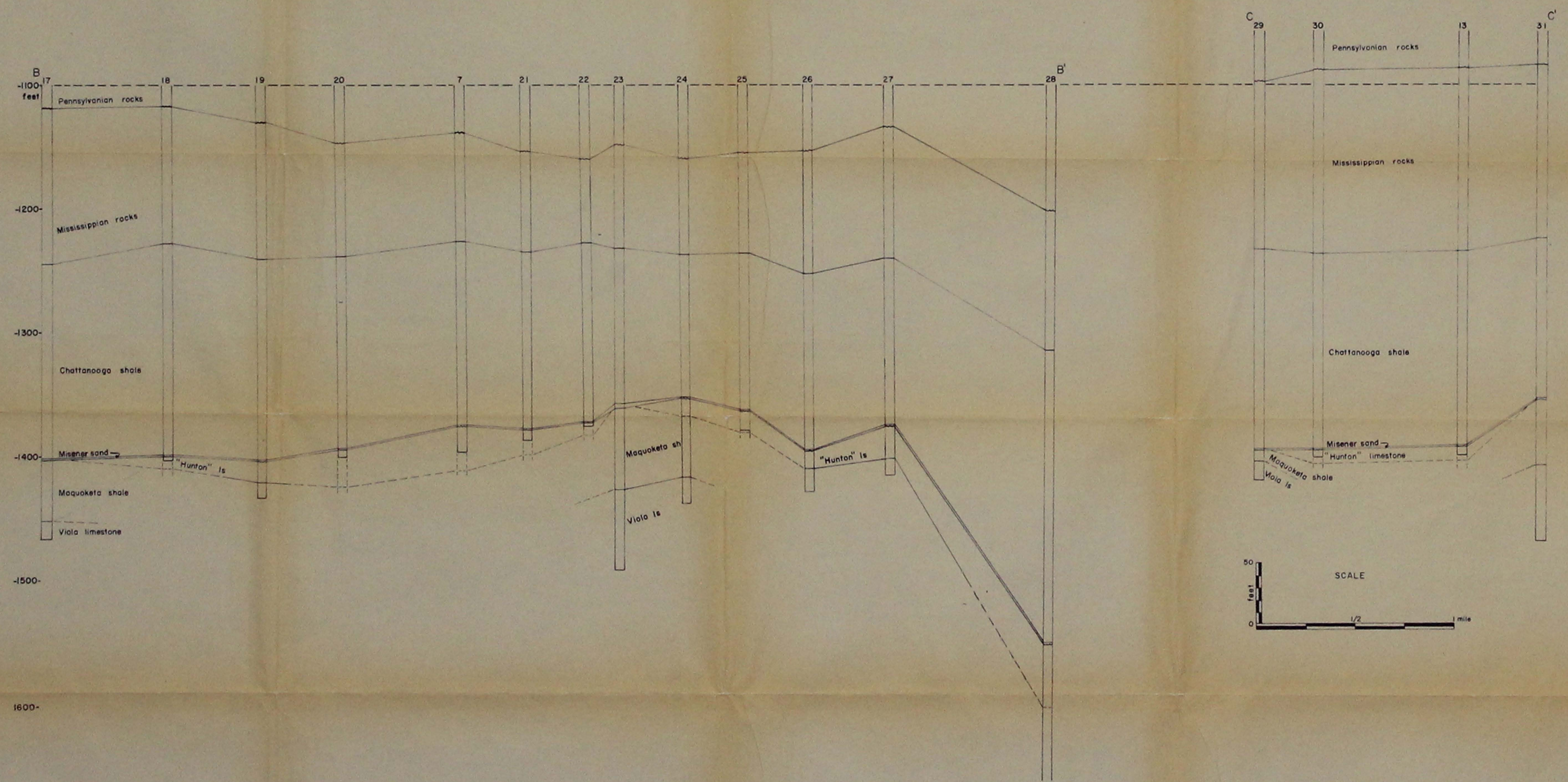
PLATE 1. Stratigraphic Cross-sections, Wenger-Unger Pools Area, Marion County, Kansas

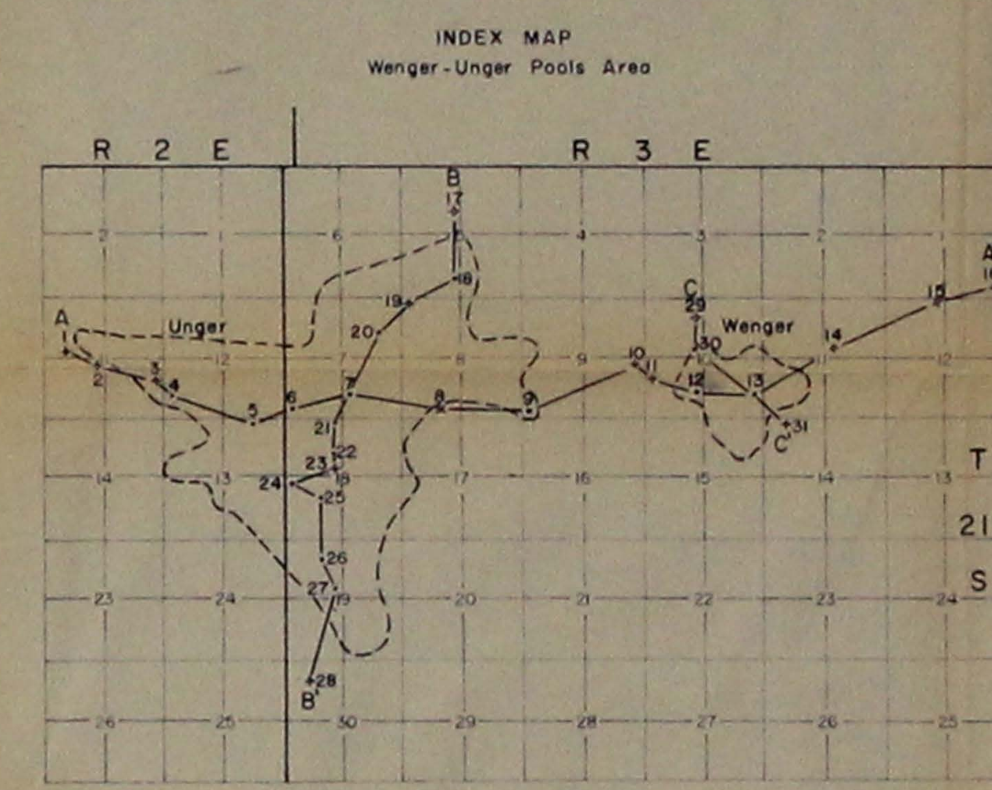
CHAMPION CLASP NO. 63 $6\frac{1}{2} \times 9\frac{1}{2}$



STRATIGRAPHIC CROSS SECTIONS

PLATE I





DATUM PLANE: SEA LEVEL

Approximate correlation

Unconformity

GEOLOGY OF WENGER-UNGER POOLS AREA
MARION COUNTY, KANSAS

by

ALTON ROE BROWN

B. S. University of Illinois, 1958

AN ABSTRACT OF A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1959

The Wenger-Unger pools area analyzed in this report consists of two pools, the Wenger pool and the Unger pool. The purpose of this investigation was to determine the relationship of petroleum accumulation to stratigraphy, structure and type of trap for oil and gas.

The Wenger pool located 5 miles west of the normal trend of producing pools in southern Marion County was discovered by Goering and Branine in December 1947. Petroleum was found in the "Hunton" limestone of Silurian and Devonian age at 2,771 feet. The peak in production was reached in 1949 with 28 producing wells and has steadily declined since that year. The cumulative production to the end of 1957 was 921,428 barrels.

The Unger pool, discovered in June 1955 by Charles Carlock, is located in southwest Marion County approximately 3 miles west of the Wenger pool. Initial daily production from the "Hunton" limestone was 122 barrels of oil per day from a depth of 2809 feet.

In January 1956, the Unger Southwest field was discovered by E. K. Carey Drilling Co., Inc. Initial daily production from the "Hunton" limestone was 4,257 barrels at 2,812 feet depth. The Unger and the Unger Southwest pools were combined in 1957 to the Unger pool composing an area of approximately 5 square miles. The cumulative production to the end of 1957 was 1,565,721 barrels.

A structure map of the "Hunton" and a map depicting the thickness of the "Hunton" were constructed to define the areal extent and thickness of the producing zone. A structure contour map of the underlying Maquoketa shale was constructed to aid in resolving the erratic distribution of the "Hunton". Stratigraphic cross-sections were employed to show the relationship of the "Hunton" to underlying and overlying sediments.

The structure in the Wenger-Unger pools area has been developed by several periods of uplift and erosion with subsequent truncation of sediments. The stratigraphic sequence of marine sediments encountered range from Ordovician to Permian rocks.

The "Hunton" limestone within the pools exhibits a varied facies change. The "Hunton" varies from a fossiliferous limestone with vuggy porosity, to a dense dolomite with porosity due to fractures, to sucrosic dolomite with porosity due to void space between grains.

The Wenger and Unger pools although both producing from the "Hunton" exhibit slightly different type traps. The Wenger pool produces from a gentle terrace with almost no structural relief and is classified as a stratigraphic trap. The Unger pool, although primarily a stratigraphic trap, exhibits sufficient structural relief, as a secondary factor, to be classified as a combination structure-stratigraphic type trap.

Future possibilities for the discovery of petroleum reserves in the area of these pools are slight. The Wenger and Unger pools are both outlined by "dry holes". Other possibilities are production from older formations or the discovery of an isolated "Hunton" outlier.