University of Kentucky
College of Arts and Sciences

KENTUCKY GEOLOGICAL SURVEY

ARTHUR C. McFARLAN, Director
DANIEL J. JONES, State Geologist

SERIES IX

BULLETIN — NO. 14

Geology of the Morganfield South Oil Pool, Union County, Kentucky

By
E. Boyne Wood

Printed by the Authority of the State of Kentucky

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LETTER OF TRANSMITTAL

Dean M. M. White
College of Arts and Sciences
University of Kentucky

Dear Dean White:

The Kentucky Geological Survey is publishing Bulletin No. 14, *Geology of the Mogranfield South Oil Pool, Union County, Kentucky,* by E. Boyne Wood, a former member of the Survey staff. It is one of a series planned to cover the oil and gas pools of the Western Coal Field in an attempt to determine the controlling geology of each pool. This then becomes a basis for more efficient prospecting and a contribution to the better understanding of oil field geology.

Sincerely yours,

ARTHUR C. MCFARLAN, *Director*
Kentucky Geological Survey

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INTRODUCTION

The Morganfield South Pool is located in western Kentucky, in central Union County, south and west of the town of Morganfield. The pool extends approximately 3½ miles in an east-west direction and is slightly less than 1 mile wide. It lies within the southern portions of Carter coordinates 0-19 and 0-20 and in the northern portions of N-19 and N-20. With one exception, it is the southernmost pool in the county, and is bounded on the south by the Shawneetown-Rough Creek fault system. The location of this and other Union County oil pools can be seen in figures 1 and 2.

Lithologic descriptions of both Pennsylvanian and Mississippian formations were made from cuttings of several wells located in various parts of the pool. More emphasis was placed on the Mississippian strata, because they include the more important oil producing formations. Excellent electric log coverage greatly facilitated stratigraphic and structural interpretations. All subsurface elevations are based on sea level and the rotary drive bushing elevations of the wells.

The writer is greatly indebted to Edward J. Combs, Donald G. Sutton, and Avery E. Smith of the Sun Oil Company and to Earl C. Cockrum of the Carter Oil Company who made certain electric logs and well cuttings available for study. Appreciation for the well location map furnished by the Sun Oil Company is hereby expressed. For helpful criticisms, the writer wishes to thank Arthur C. McFarlan and Vincent E. Nelson, Department of Geology, University of Kentucky, and Daniel J. Jones, State Geologist of Kentucky.

HISTORY OF DEVELOPMENT

The Morganfield South Pool produces oil commercially from at least 7 different formations. Oil production in the Pennsylvanian system comes from 2 or more sandstone beds and in the Mississippian from 4 Chester sandstones and from 1 of the McClosky zones of the Ste. Genevieve limestone. All wells in this pool are produced by pumping.

The pool discovery well was the Sun Oil Company No. 1 Lillie Binford located in SW NE SE 23-0-19 and completed March 31, 1948. Initial production on pump was 14 barrels of oil and no water. The producing formation is a Caseyville sandstone of Pennsylvanian age, located near the base of the section at a depth of 1,406 feet. The thickness of the formation is 14 feet and the gravity of the oil is 32.2 degrees.

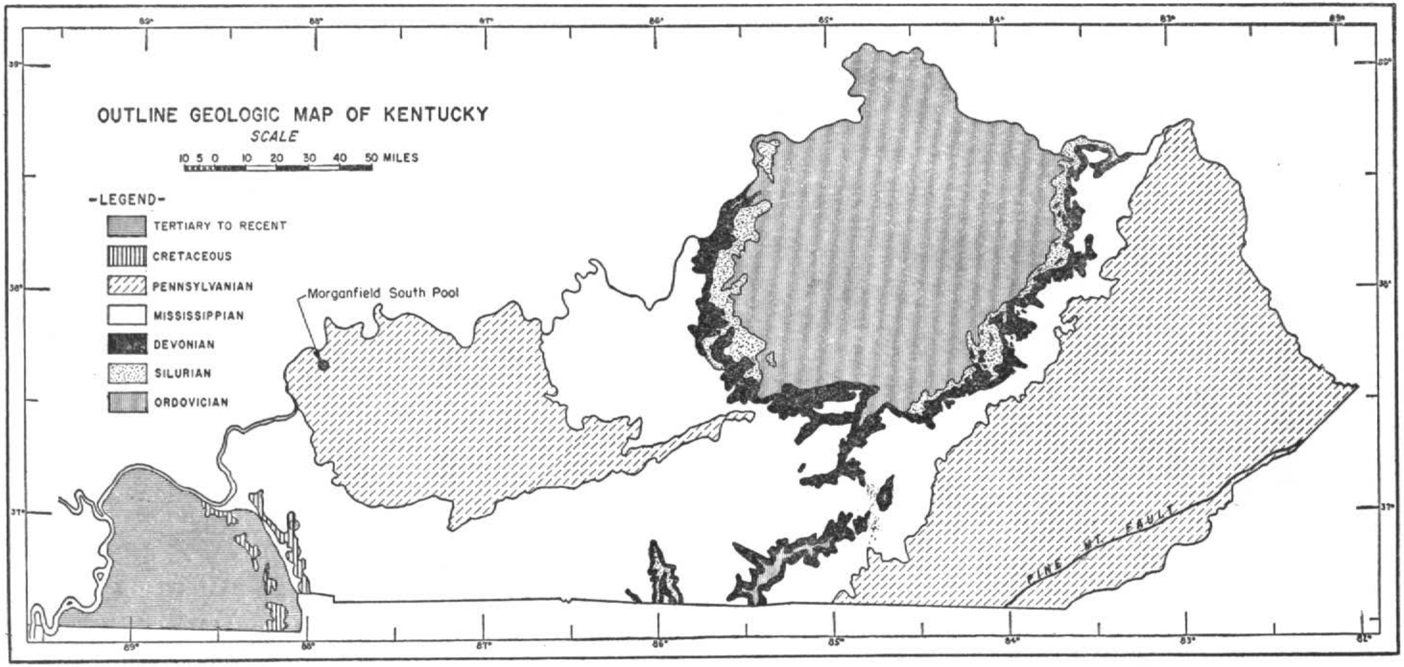

Fig. 1. Outline geologic map of Kentucky showing location of Morganfield South Pool.

Production from other Pennsylvanian sandstones in the central and eastern parts of the pool followed. The next oil bearing formation to be discovered was the Waltersburg sandstone, which is productive from a depth of 1,793 to 1,807 feet in the Sun Oil Company No. 2 Lillie Binford. This well was completed in May 1948 and had an initial production of 175 barrels of oil and no water. In June, the Sun Oil Company No. 1 W. A. and N. Anderson, 23-0-19, was completed in the McClosky zone. The pay is from 2,531-36 feet, and the well had an initial production of 40 barrels of oil and no water. The Hardinsburg sandstone was first productive in the Texas Company No. 1 W. C. Offutt, located in 23-0-19, which was completed in July 1948. Initial production was 17 barrels of oil and 33 barrels of water from 2,066-75 feet. Cypress production was first discovered in the Sun Oil Company No. 1-B Reyburn, 22-0-19, and completed July 14, 1949. This well produced initially on pump 123 barrels of 38.5-gravity oil from 2,267-86 feet. Tar Springs production was first obtained from the Sun Oil Company No. 6 S. S. McBride, which was completed at a depth of 1,942 feet.

The multiple producing horizons create something of a production problem, which is handled in various ways. In some cases, where more than one producing horizon is encountered, twin or triplet wells are drilled within a few feet of one another, each producing from a different reservoir. This well arrangement can easily be recognized on the accompanying maps. Other wells are completed as dual producers, with oil being produced from more than one reservoir in the same well.

As of May 1, 1952, there were 133 producing wells in the pool, and the cumulative oil production totaled 2,900,652 barrels. The Morganfield South Pool was classified as the best Kentucky discovery in 1948 by the Western Kentucky Oil Scouts Association (1949, pp. 256-70).

Plate 1 shows the leases, location of the cross sections, and the areal extent of the various producing horizons.

GEOLOGIC SETTING

The Morganfield South Pool is located in the northwestern part of the Western Kentucky Coal Basin, which is a southern extension of the Illinois Basin. It is a structural as well as a topographic basin, in which Recent, Pleistocene, Pennsylvanian, and Mississippian formations outcrop. Generally, it is characterized by a plateau of low relief with alluvial-filled valleys and abruptly rising hills and ridges. Prominent ridges occur along the Shawneetown-Rough Creek fault system, as well as around the rim on the south end of the basin. This fault

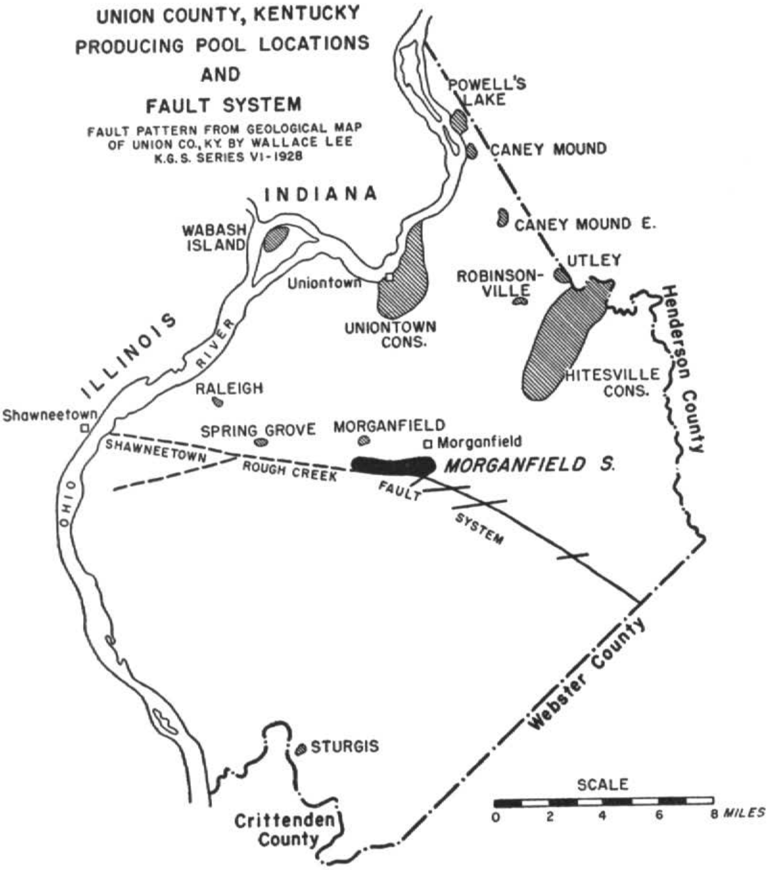

Fig. 2. Outline map of Union County, Kentucky, showing locations of producing pools and fault systems.

system crosses the basin in an east-west direction, with faulted anticlines on the north side of the fault and steeply dipping strata on the south side (Russell, 1932, p. 232). Some of these major faults are essentially vertical (Clark and Royds, 1948, p. 1741).

From the Ohio River to the southern limits of the pool, relief does not exceed 100 feet, and the topography consists of the broad flood plain, the alluvial-filled tributaries of the Ohio River, and rolling hills. However, just south of the pool an abruptly rising escarpment known as Chalybeate Ridge is present, which is 300 feet above river level. This ridge has an east-west trend and is due to resistant Pennsylvanian sandstones being faulted to the surface.

SURFACE STRATIGRAPHY

Outcropping strata in Union County include Recent and Pleistocene alluvial deposits of sand, clay, and gravel, which are found mainly along the Ohio River Valley and in the valleys of its tributaries. Pennsylvanian sediments cover most of the area in and around the pool, with some Mississippian sediments being present over limited areas. Within Union County, L. C. Glenn (1928) has mapped Conemaugh, Allegheny, and Pottsville formations of Pennsylvanian age, and in one area south of the town of Morganfield, near the pool, he recognized faulted upper Mississippian shales, cherts, and limestones, which he classified as Leitchfield. These Mississippian sediments are exposed on the upthrown side of the Shawneetown-Rough Creek fault which cuts across the south end of the pool, as shown in figure 2.

SUBSURFACE STRATIGRAPHY

A subsurface study was made of a 2,600-foot section of Pennsylvanian and Mississippian sediments from the microscopic examination of well cuttings and from electric logs. A great variety of sediments are present, including various types of sandstones, shales, siltstones, limestones, dolomites, and coal.

Pennsylvanian

The maximum thickness of Pennsylvanian formations is 1,800 feet and includes the Conemaugh, Allegheny, and Pottsville. In general, the uppermost recognizable Pennsylvanian unit is the Providence limestone. The Conemaugh is represented in only a few places by the thin section of sediments above the No. 12 coal. The Allegheny is 600 feet thick, the base being marked by the Curlew sandstone just above the No. 4 coal. It includes the No. 9 coal, the Sebree sandstone, and the No. 6 or Davis coal. The Pottsville contains the No. 4 coal, the Finnie and Grindstaff sandstones, the No. 1A coal, and the basal Pennsylvanian sandstones and shales.

These same Pennsylvanian sediments may also be divided into the Carbondale, Tradewater, and Caseyville, as shown in plate 2.

Carbondale formation.—The Carbondale in the Morganfield South Pool consists of some 500 feet of section, including the Providence limestone, the No. 9 coal, and the Sebree sandstone which marks its base. The Providence limestone, where present, is gray and finely crystalline and sometimes consists of two layers. Other similar thin limestones, some of which are fossiliferous, are present, one rather consistently below the No. 9 coal. The shales of this section are mostly micaceous, gray to dark-gray with some brownish and greenish color. They are sometimes very silty and occasionally calcareous. Pyrite is also present in places throughout the section. The sandstones of the Carbondale, including the Sebree, are composed largely of subangular to angular, medium to coarse quartz grains, which may or may not be well cemented together. They may contain pyrite, reddish-brown siderite, and mica. Thin coals are sometimes interbedded with the sandstones. The No. 9 is the most prominent and easily recognized coal in the Carbondale, and it occurs 100 to 200 feet above the Sebree sandstone but is not present over the entire area. It has an average thickness of 5 feet. Other less conspicuous coals are the Nos. 8 and 8B.

Tradewater formation.—The Tradewater is marked near its uppermost limit by the No. 6 coal (sometimes called the Davis coal), which has a thin sandstone present directly below. This gives a rather characteristic double "kick," which is easily recognized, on the No. 2 or short normal curve of the electric log. Inasmuch as the No. 6 coal is present throughout the area, it makes a good Pennsylvanian structural datum. The Tradewater extends downward for a thickness of some 700 feet to and including the No. 1A coal. The shales are similar to those above, and such prominent sandstones as the Curlew, Finnie, and Grindstaff are present. These sandstones consist of angular to subangular quartz grains ranging in size from fine to coarse and being well sorted in some places. In general, these sandstones resemble those of the Carbondale. Of the limestones present, the most conspicuous is the Curlew, which is about midway in the section and from 50 to 75 feet below the Curlew sandstone. It is a tan to cream limestone with some gray color in it. Coals present include the Nos. 6, 5, 4, 2, and 1A. A sandstone which may be the Finnie produces oil in the eastern part of the pool.

Caseyville formation.—The Caseyville sediments are similar to those above, with the exception of the basal sandstones. These are composed of different types of sand, ranging from small angular to large rounded and frosted grains, with some granules. They represent the basal conglomerate marking the unconformable Pennsylvanian-Mississippian contact. Occasionally, some limonite, pyrite, and hard brown limonitic sandstone were noted in this lower Caseyville section. Oil production in the western part of the pool comes from one of these Caseyville sandstones.

All of the Pennsylvanian sandstones vary considerably in thickness and sometimes change to shales within a very short lateral distance. Likewise, the coals are quite erratic in thickness and extent. This makes interpretation of possible faulting within the Pennsylvanian system difficult.

Mississippian

The Mississippian formations herein described include some 800 to 900 feet of Chester sandstones, shales, and limestones of various types and 300 feet of Meramec limestones and shales. The youngest Chester formation consistently present throughout the pool is the Menard limestone, but in some areas the Kinkaid and intervening formations are present. This is due to the unconformable contact between the Mississippian and Pennsylvanian systems. One well in the pool penetrated the entire Ste. Genevieve and St. Louis sections and bottomed in the Salem limestone, but since no cuttings from this well were available, no lithologic description of this part of the section was made.

Chester

Post-Menard formations.—The post-Menard section, where present, consists of shales, sandstones, and limestones, and the total thickness varies considerably due to the above-mentioned unconformity. The maximum thickness noted was 100 feet, and the uppermost formation is the Kinkaid limestone.

Menard formation.—The Menard is 80 feet thick and can be divided into three units. The Upper consists of 20 to 30 feet of gray, white to tan limestone, finely crystalline and fossiliferous. The Middle or Massive Menard is 40 feet of limestone with some thin shales. The Little Menard has an average thickness of 7 feet, ranging from 4 to 10 feet. This lowermost unit is a white to buff to tan, finely crystalline limestone with fossil fragments. In some wells it is dolomitic. The Little Menard is persistent throughout the pool and overlies the Waltersburg formation.

Waltersburg formation.—The Waltersburg consists of 55 to 80 feet of shale and sandstone. The sandstone member is the more widespread and the most important oil producing reservoir in the pool. It is lenticular in nature and ranges from 0 to 64 feet thick. Where present, it is usually one continuous bed consisting of fine to medium, angular quartz grains either poorly or well cemented. On the south edge of the pool, along the fault plane, there are two sand bodies present. The shale member is usually gray and in some places is rather silty. An isopach map on the sandstone member is shown in plate 5.

Vienna limestone.—The Vienna limestone lies about 75 feet below the Little Menard, except in one area of poor Waltersburg development where the interval is only 55 feet. This thin section, which is shown in the cross section in plate 3, is due to the greater compaction of the shales where the sand is missing. The Vienna is a tan to brown with cream and gray, fine- to coarse-crystalline limestone with fossil fragments. It is about 8 feet thick, ranging from 4 to 12 feet, and is usually well developed and easily recognized on the electric log by its thin, highly resistive character and low spontaneous potential. In the above-mentioned area of poor Waltersburg sandstone development, the Vienna has a peculiar appearance on the electric log, as seen in plate 3. It has a greater spontaneous potential and two highly resistive curves. The lower resistivity kick in the #3 McBride well is caused by an oil and gas bearing sandstone. No cuttings from any wells in this area were available for study, and therefore no lithologic description was possible.

Tar Springs formation.—The Tar Springs formation is represented by those shales and sandstones between the Vienna and Glen Dean limestones. This interval ranges in thickness from 74 to 131 feet, because of what is interpreted as an erosional unconformity at the top of the Glen Dean. In most wells no distinct sand bed was noted, but some wells show as many as three thin sandy zones, any one of which rarely exceeds 10 feet in thickness. In areas where an appreciable thickness of sand is present, such as in the northern part of 1-N-19, some oil production has been obtained.

Glen Dean limestone.—This limestone ranges in thickness from 17 to 60 feet, because of the absence in some places of the upper portion. In all wells examined the Lower Glen Dean is present and with little variation averages 17 feet. It is easily recognized in examining well cuttings by the predominance of white to buff, fine to coarsely crystalline limestone with many fossil fragments. A structure map on the base of this limestone is shown in plate 6.

Hardinsburg formation.—This series of shales and sandstones occupies about 100 feet between the Glen Dean and the Golconda limestone. In some wells the presence of much red and green shale is striking, and the sandstone body ranges from 5 to as much as 48 feet thick. The shales are usually dark-green, with dense siderite sometimes present. The sand may occur as a single bed or as several thin beds. When well developed, the sandstone is made up of fine grains either well or poorly cemented.

Golconda formation.—The Golconda consists of about 50 feet of white and gray with some buff to tan, fine- to coarse-crystalline limestone with numerous thin shale partings.

Big Clifty formation.—Underlying the Golconda is a 50- to 60-foot section with some gray, red, and green shales, and sandstones varying from a few thin scattered beds to massive beds as much as 20 feet thick. When a massive sandstone is encountered, it is referred to by drillers as Jackson.

Barlow.—Beneath the Jackson and overlying the Cypress is the thin Barlow limestone, which is characteristically dark-gray to brown mottled, fine- to coarse-crystalline, and fossiliferous. About 20 to 40 feet higher in the section another similar limestone bed is sometimes present, but the lower one is considered the Barlow in this area. A structure map on the base of the Barlow is shown in plate 7.

Cypress formation.—This formation averages 75 to 100 feet in thickness and is composed of fine to coarse angular quartz grains and some red and green shales. It may be separated into two or more sand beds by thin shales, but it usually consists of one well developed sandstone body.

Paint Creek formation.—The Paint Creek consists of white to tan, fine- to medium-crystalline limestone with some clastic limestone composed of fossil fragments. It is about 80 feet thick and is separated into two limestone members by 40 feet of shales and sandstones. The upper limestone is 6 to 8 feet thick and lies directly under the Cypress. The lower bed is some 25 feet thick, and in some wells it has a pinkish color and contains clay pellets.

Bethel formation.—The Bethel is represented by approximately 30 feet of gray and dark-gray, red and green shales and some thin sandstones. It is not productive.

Renault formation.—The Renault consists of two or more limestones separated by shales and has a total thickness of 80 feet. Most of the limestone is white to tan, finely crystalline to almost lithographic and fossiliferous, with dark-gray fossil fragments and clay pellets. In some places the limestone is pink in color. Oolites occur varying in color from white to tan and in some cases a bright purple-red.

Aux Vases formation.—This formation is represented by 15 to 20 feet of shales and fine-grained sandstones with a calcareous cement. It marks the base of the Chester.

Meramec

Ste. Genevieve formation.—The Ste. Genevieve consists of massive limestone, white to tan in color, some beds of which are very fine to medium-crystalline. Other zones are composed of oolites which may be either well cemented or very loosely cemented. In these loosely cemented oolitic zones porosity is usually well developed. It is in these zones of porosity which are commonly referred to as McClosky, and in some highly fractured zones that the Ste. Genevieve limestone produces oil and gas in the Morganfield South Pool and in other pools in the Illinois Basin.

Well cuttings from Mississippian formations below the Ste. Genevieve were not available for study.

STRUCTURE

The general structural features present in that part of the Eastern Interior Basin known as the Western Kentucky Coal Basin have been well outlined in papers by Russell (1932, pp. 232-33) and by Clark and Royds (1948, pp. 1748-49). Structural relationships in specific areas have been described by Jacobsen (1950), Bruce (1949), Bowen (1952), Bybee (1948), and Wesley (1936), to name a few.

The Morganfield South Pool is an east-west trending anticlinal fold, the south limb of which is faulted by a high-angle reverse fault. The fold has a gentle north dip on the north side, toward the center of the basin, while the south limb is sharply folded into the fault. The structure map on the base of the Little Menard (pl. 4) shows that the lowest structural point of the Little Menard in the extreme west end of the pool on the south limb is in the No. 6 Waller well. Here the Little Menard has an elevation of –1,489 feet, while in the No. 13 W. A. Anderson well to the northeast it is –1,354 feet. This is a difference of 135 feet and represents the difference in elevation of the fold between these two wells. On the base of the Lower Glen Dean, as shown in plate 6, the difference is only 51 feet. This decrease in amount of structural relief with depth is contrary to the results of simple folding alone, in which case the older, deeper beds, having been subjected to more folding for a longer period of time, should have more structural relief than the younger, shallower beds. This shows that much of the structure in the Morganfield South Pool is actually due to the repeated deposition of sand bodies one on another along the crest of the gentle anticlinal fold and to the effect of differential compaction of the sediments. In this way the younger beds show more structural relief than the older. The coincidence of the maximum thickness of Waltersburg sandstone with the structural high can be seen by comparing plates 4 and 5.

The sharp folding along the fault plane is not shown on the structure map because of lack of control and for the sake of clarity, as it would necessitate crowding of contours into the narrow space between the two lines representing the throw of the fault. Actually, the structural contours should extend to the lower or southernmost line, which represents the downthrown side of the fault. Since only the No. 1 Wathen well cut the fault, it is the only source of control for mapping structure along the fault plane. Elevations of the Little Menard and Lower Glen Dean on both the upthrown and downthrown sides of the fault are shown, on the map, adjacent to the Wathen well. Since there was no Barlow on the upthrown side, only the elevation on the downthrown side appears on the Barlow structure map in plate 7.

The aforementioned folding must have commenced at least by middle Mississippian time prior to Chester time, in order to provide loci of deposition for the Chester sands. The actual folding was very gentle, and its effect on the anticline as now mapped was not so pronounced as the subsequent sand deposition and differential compaction. The cross section in plate 3 shows the effect of differential compaction on structure by showing a low on the Little Menard where the more easily compacted Waltersburg shales are present in place of the sandstone. On the Barlow, which is just above the massive Cypress sandstone in this same area, such a structural low does not exist, because compaction of the massive sandstones was relatively little.

As mentioned before, the only well in the pool which actually cuts the high-angle reverse fault on the south side of the pool is the Sun Oil Company No. 1 Wathen, located NE SW NE 2-N-19. The diagram in figure 3 and the cross section in plate 8 show the fault to have a vertical displacement of about 775 feet. In the Wathen well, the Vienna limestone was encountered on the upthrown side at an elevation of −735 feet below sea level and again on the downthrown side at −1,507 feet. This is a difference of 772 feet and represents the vertical displacement at the Vienna level. This is in accordance with observations on other Chester beds.

The Wathen well cuts the fault at 1,430 feet or −979 feet below sea level. At this point the well leaves the Upper Chester beds on the upthrown side and goes into Pennsylvanian sediments on the downthrown side, penetrating the downthrown Menard limestone again at a depth of 1,860 feet, and thence through a fairly normal Chester sequence to the Cypress, in which the well is completed. In the lower-level Chester sequence the Waltersburg sandstone is either poorly developed or has been faulted out. Examination of the well cuttings reveals a very thin sandstone layer present at 1,950 feet, just below the Menard limestone, in the Waltersburg position, but it does not show up on the electric log.

In order to construct the attitude of the fault plane, the relation of the fault to the Wathen well and to the Sun Oil Company No. 5 McLeod Unit well was considered. The latter is the nearest well to the fault on the north or downthrown side and is about 450 feet from the Wathen well. In the writer's opinion, there is no faulting of the same magnitude in the No. 5 McLeod Unit well as occurs in the Wathen well. However, some faulting which may be the result of the bifurcating of larger, deeper faults may occur in the Pennsylvanian section of the McLeod Unit well above the depth of 600 feet. Inasmuch as no major faulting occurs below 600 feet, the minimum possible dip of the fault plane would be 75 degrees. Any less dip would cause the major fault to cut the McLeod Unit well below the depth of 600 feet.

In order to show the true dip of the fault plane, it is necessary to construct a cross section through a line perpendicular to the direction of the strike of the fault. Considering that the fault has an approximate east-west strike, a north-south cross section B-B′ was made from the Wathen well to the Sun Oil Company No. 18 McBride, with a plotted intermediate point X. This cross section appears in figure 3 and shows the minimum possible dip of 75 degrees. It also shows the structural relationship of the Chester formations on the downthrown side of the fault. From the No. 18 McBride, the formations dip rather steeply southward toward the Wathen well. It is interesting to note the change in rate of dip within each older formation between the two wells. For example, the elevation of the Little Menard is 100 feet lower in the Wathen well than in the McBride, while the difference in elevation on the deeper Barlow horizon between the same two wells is only 10 feet. This shows that in the Wathen well the Menard is closer to the fault plane and to the sharp folding which parallels it. At the Barlow level the southward dipping fault plane is farther away, and the sharp dip into the fault plane has not taken place. Along this same line of reasoning, the fault plane would be even farther to the south at the McClosky and lower levels and could allow for accumulation on the south flank of the anticlinal fold in these lower beds.

The 80 feet of limestone that is shown in plate 8 just under the Lower Glen Dean, on the upthrown side, at a depth of 1,304 feet in the Wathen well is not normal in this stratigraphic sequence. The simplest explanation for the presence of this unusually great thickness of limestone where the Hardinsburg would normally be, is that a minor sliver fault is present which caused a tilting of the Golconda, thus increasing its apparent thickness and completely displacing the Hardinsburg. This interpretation is shown in the diagram in figure 3. The dip of the sliver fault is exaggerated in the diagram for the sake of clarity.

The pool structure can best be seen in the various structure maps (pls. 4, 6, and 7) and in the cross section B-C (pl. 8). The direction of this cross section is not perpendicular to the strike of the fault plane, and therefore the angle of dip of the fault plane appears to be considerably less than the true dip of 75 degrees.

In the west end of the pool there are two intersecting cross faults forming a triangular horst with the main reverse fault. Based on the four-well control within this fault block, the dip is to the north, where-

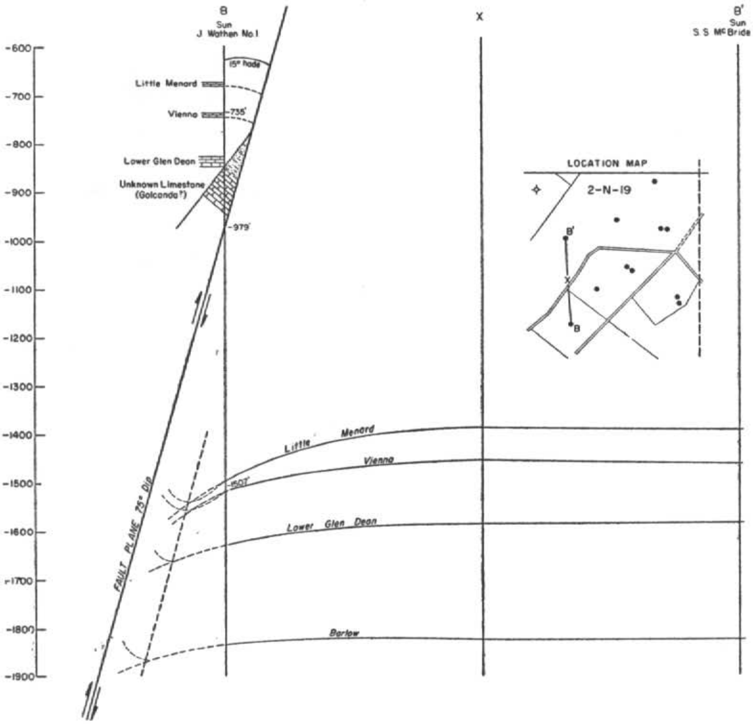

Fig. 3. Cross section B-B' showing stratigraphic relations adjacent to fault.

as it is to the south outside of the horst. These cross faults were so mapped as the simplest and most likely structural interpretation based on the available data. Since no wells actually cut these faults, they would of necessity be very high angle. Such high-angle cross faults have been observed elsewhere in the basin (Clark and Royds, 1948, p. 1748).

OIL AND GAS

The main Pennsylvanian reservoir is a Caseyville lenticular sandstone body which averages 12 feet in thickness. It produces in the western part of the pool at a depth of 1,400 feet. The oil-water contact in this sand occurs at an elevation of –1,034 feet. Production from shallow Pennsylvanian sandstones in the central and eastern parts of the pool is found in four wells along the boundary line between sections 21-0-19 and 1-N-19 on the W. H. Hagan and R. R. Taylor tracts and in the No. 2 J. Offutt and No. 6 A. C. Hancock in 22-0-19. No water contact is known in these wells.

The youngest Mississippian formation to produce oil is the Waltersburg sandstone. It is best developed in the east lens but also is of appreciable thickness in the center and west lenses and is productive over a larger area than any other formation. The lenticular nature of the Waltersburg sandstone is indicated in plates 3 and 5. The isopach map of this sand (pl. 5) shows that it averages at least 23 feet in thickness. Operators have placed the oil-water contact at –1,424 feet, with an average of 16 feet of net effective sand. In the center lens the maximum thickness is 43 feet in the No. 1A Addie Lillie. The east lens, which is the largest, has a maximum sandstone thickness of 46 feet in the No. 3 Hagan well. Along the southern edge of this lens and on the south flank of the anticline, the sand divides into two bodies. The upper ranges in thickness from 6 to 20 feet and the lower from 2 to 16 feet.

Other Mississippian sandstones such as the Tar Springs, Hardinsburg, and Cypress also act as reservoirs. They are similar in nature to the Waltersburg and are thickest along the crest of the anticlinal fold in the same relative position as the Waltersburg. There is no known water level in the Tar Springs, but operators have determined the water contact to be at –1,687 feet in the Hardinsburg and –1,868 feet in the Cypress. The latter is next in importance to the Waltersburg as an oil producer.

Production from the McClosky zones is limited to five wells along the west end of the pool. These wells are just north of the main reverse fault and are near the intensely faulted triangular horst. The producing horizon occurs at a depth of 2,560 feet in the No. 3A Risinger and at 2,588 feet in the No. 2A Risinger.

The lenticular nature of the reservoir rocks makes the migration of oil and gas over great distances seem quite improbable. The Pennsylvanian and Mississippian shales associated with the reservoir rocks could well be the source beds from which oil and gas moved into the adjacent porous strata. Movement to the highest stratigraphic or structural trap within each reservoir then took place, and since the thickest sand development is on the crest of the anticlinal fold, it is along this structural high that production occurs.

This accumulation and migration of oil must have been concurrent with the folding from the time of deposition of the Chester series. The fault which cuts the south limb of the fold is dated as post-Pennsylvanian and pre-Tertiary by the fact that it displaces Pennsylvanian but not Tertiary sediments. This fault is parallel to the fold and may be due to the same forces which caused the folding or to tensional forces set up by subsidence of the basin. In any case, the faulting occurred after the oil was in place. That no oil has been found on the upthrown side of the fault indicates that those formations were below the water level prior to the time of faulting and that no vertical migration took place along the fault plane. The same Chester and Pennsylvanian shales which served as local source beds for oil could easily have sealed off the fault plane and prevented any upward migration.

A local source for oil in the Meramec limestone is difficult to visualize, inasmuch as the relatively small thickness of shales in this part of the section could hardly be considered as adequate source beds. However, the great thickness of competent, brittle Meramec limestones would be highly fractured and shattered by faulting. With no appreciable shales to seal off the fault, oil could easily have migrated upward from deeper source beds and spread laterally into porous oolitic beds and into fractured zones.

FUTURE POSSIBILITIES

The productive limits of the Pennsylvanian, Waltersburg, Hardinsburg, and Cypress have been outlined by water encroachment and "shale cuts" of these sandstone reservoirs. No known water level exists in the Tar Springs at this time. In lenticular reservoirs where the productive limits are dependent on irregularly developed sandstone bodies, and especially where no known water level exists, extension of the field is particularly erratic. For possible extension of the productive limits of the reservoir, a careful study should be made to determine the possibilities of good sandstone development out from the edge of the main lenticular sandstone body.

The McClosky and other limestone reservoirs, being dependent on the vertical migration of oil along fault planes and through fractures from deeper source beds, may be present near faulted areas, especially where there is intense faulting and fracturing. Porosity in such reservoirs may be due to loosely cemented oolites, intercrystalline void spaces, and fractures. Inasmuch as these conditions of porosity are unpredictable, exploration and development of such reservoirs must be guided by the proximity of faulting. Thus, future production from Meramec and older limestones is more likely to be found along fault planes where fracturing and shattering have occurred.

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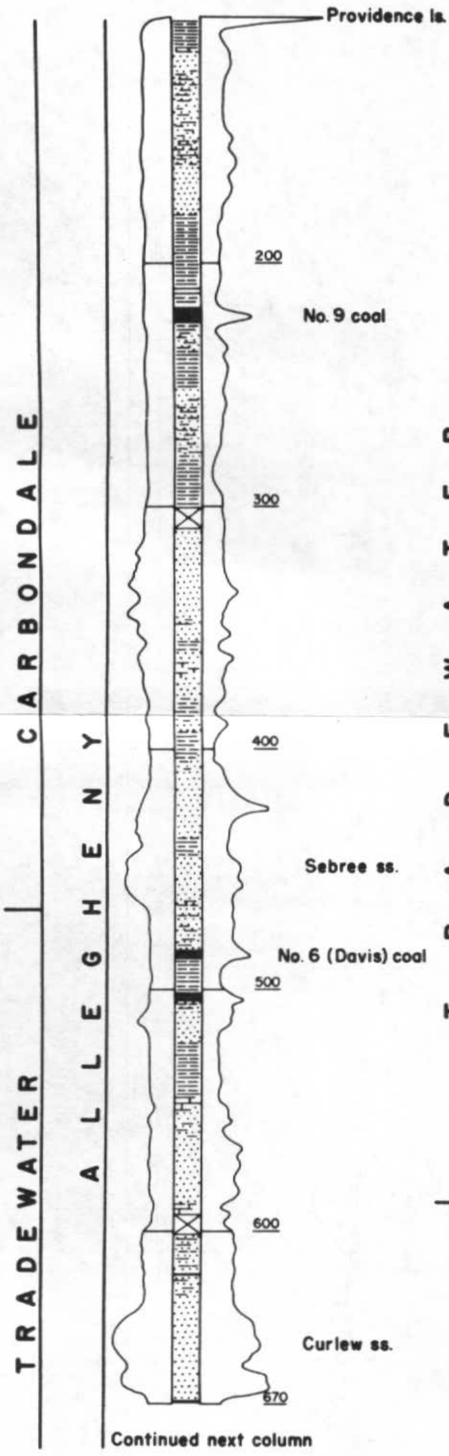
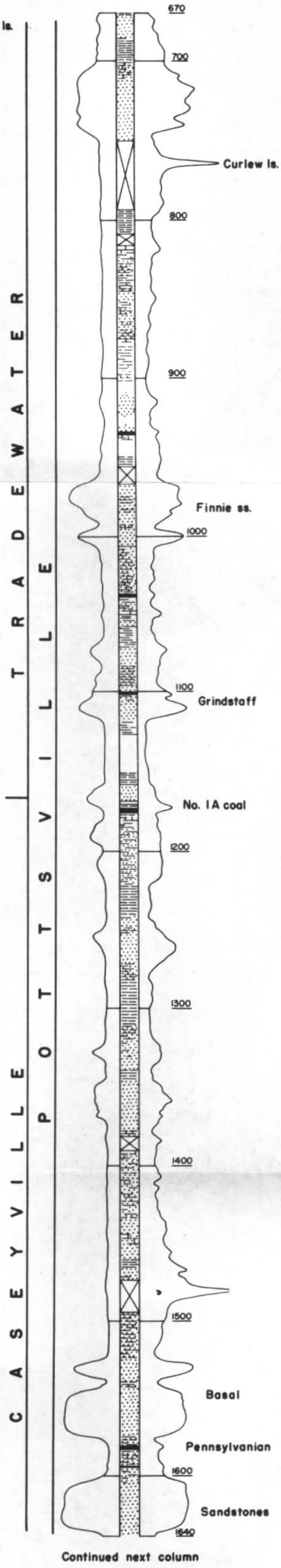
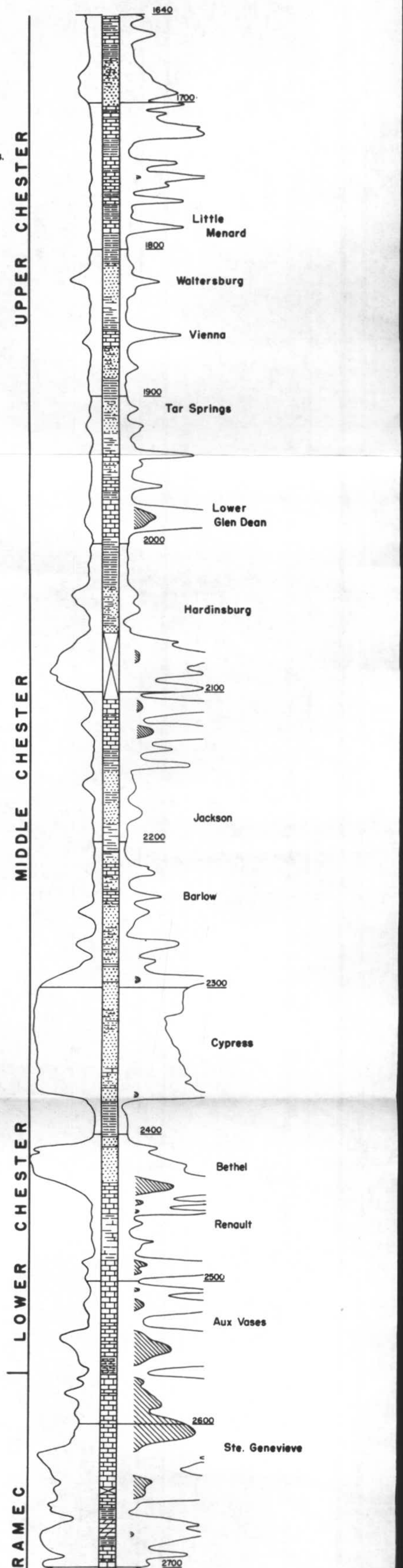
WELL LOCATION MAP OF MORGANFIELD SOUTH POOL SHOWING DISTRIBUTION OF PRODUCING HORIZONS AND POSITION OF CROSS SECTIONS



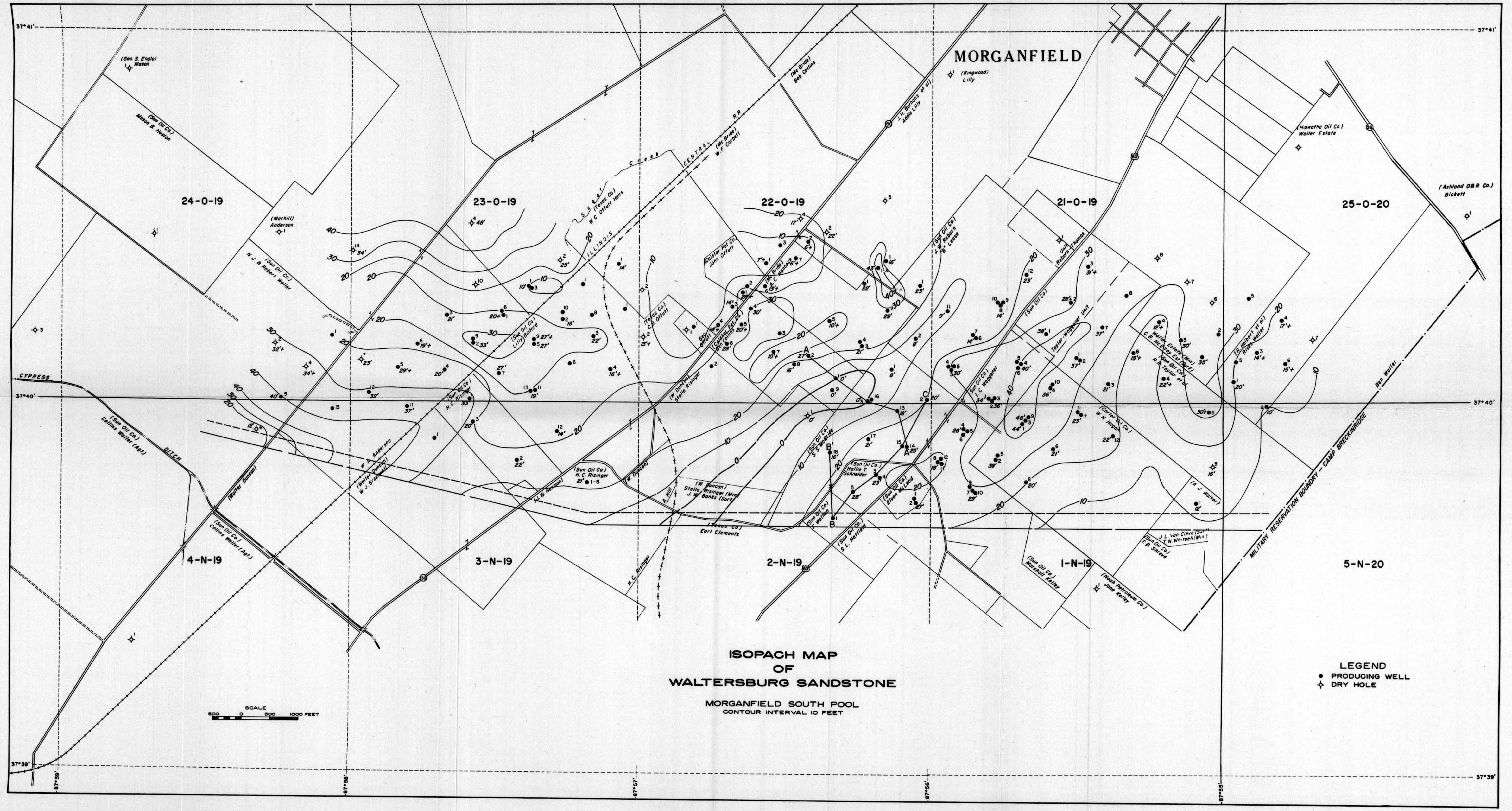




GENERALIZED STRATIGRAPHIC SECTION

PENNSYLVANIAN	Conemaugh	0-100'
	Allegheny	Carbondale 500'
		Tradewater 700'
	Pottsville	Caseyville 500'
MISSISSIPPIAN	Chester	Post Menard 0-100'
		Menard 80'
		Waltersburg 55'
		Vienna 4-12'
		Tar Springs 74-131'
		Glen Dean 17-60' ?
		Hardinsburg 100'±
		Golconda 100' ±
		Cypress 75-100'
		Paint Creek 80' ±
		Bethel 30'
		Renault 80'
		Aux Vases 15'
	Meramec	Ste. Genevieve

ELECTRIC AND LITHOLOGIC LOG
(THE TEXAS CO., NO. 1 W. C. OFFUTT)



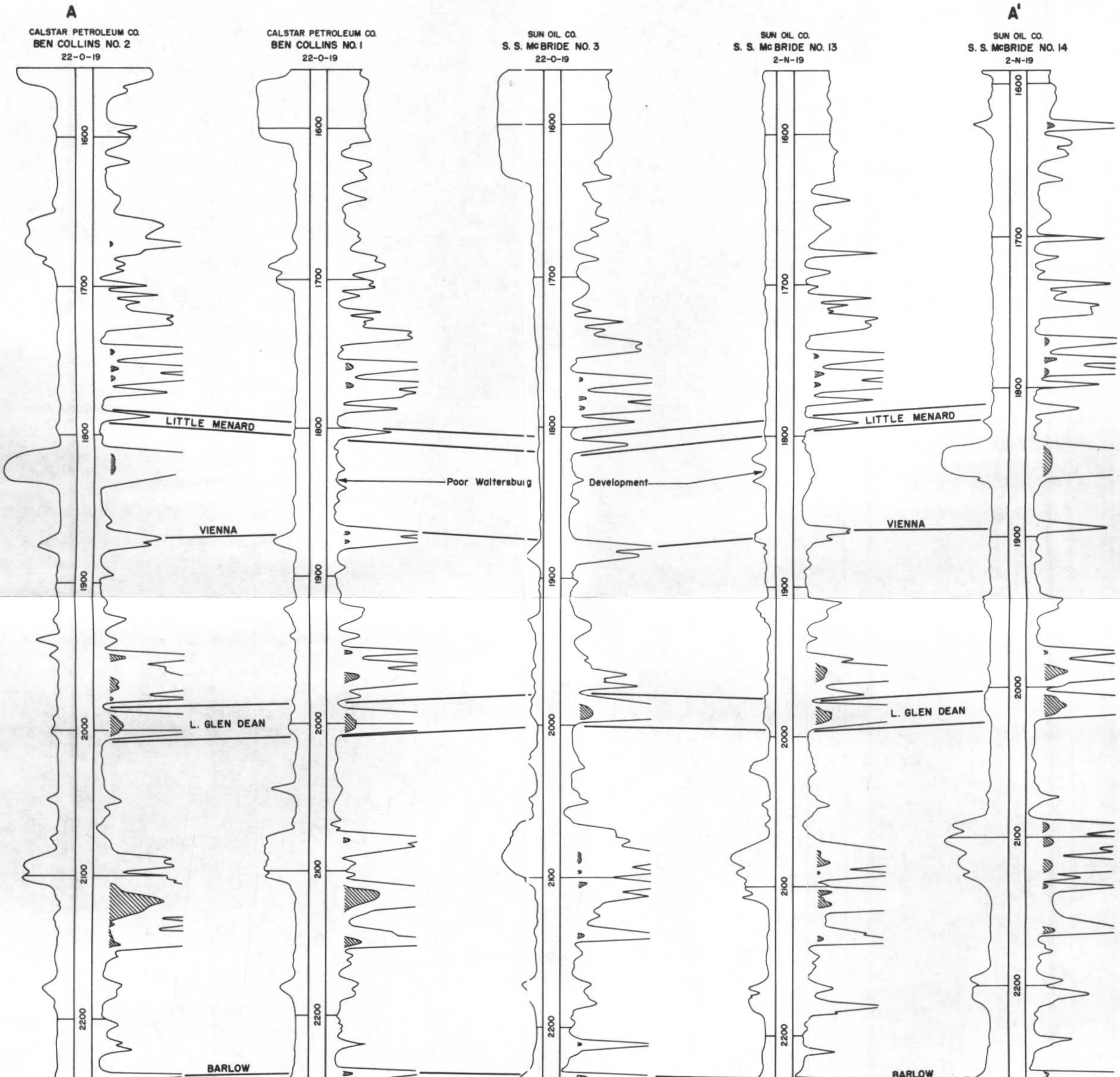
ISOPACH MAP OF WALTERSBURG SANDSTONE

MORGANFIELD SOUTH POOL

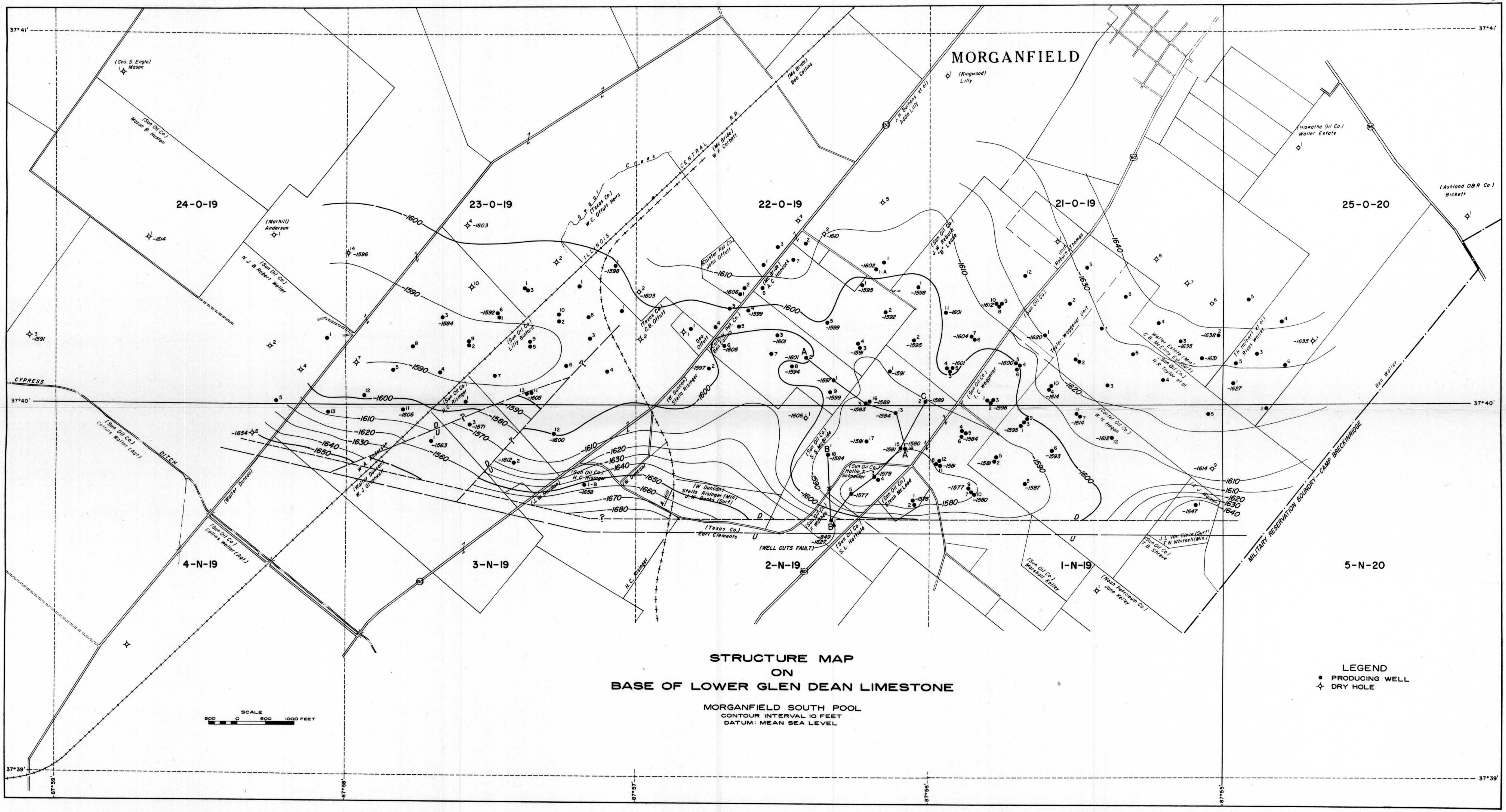
CONTOUR INTERVAL 10 FEET

LEGEND

- ● PRODUCING WELL
- ✧ DRY HOLE

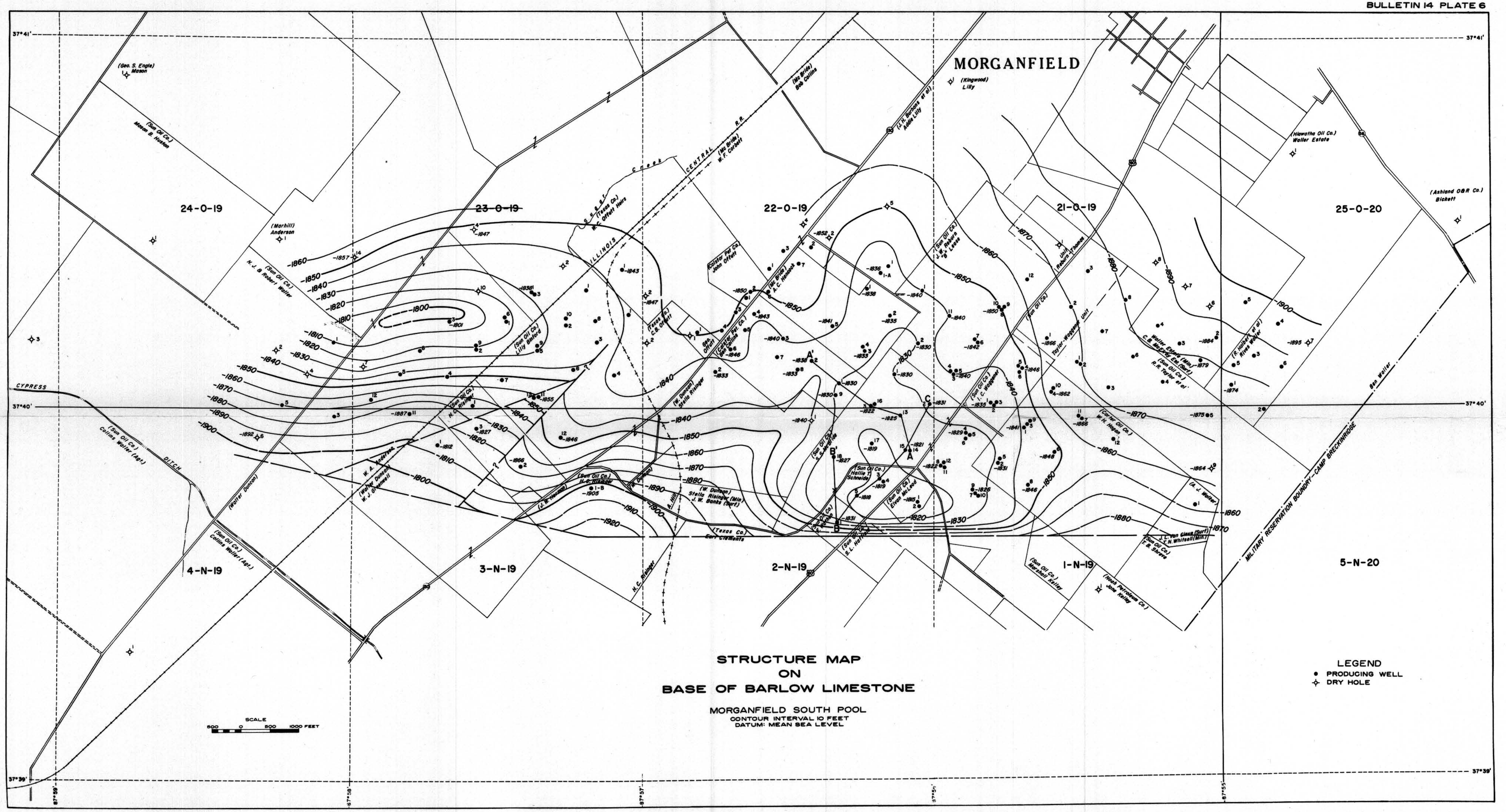


CROSS SECTION A–A'
SHOWING LENTICULAR CHARACTER
OF WALTERSBURG SANDSTONE



STRUCTURE MAP
ON
BASE OF LOWER GLEN DEAN LIMESTONE

MORGANFIELD SOUTH POOL
CONTOUR INTERVAL 10 FEET
DATUM: MEAN SEA LEVEL

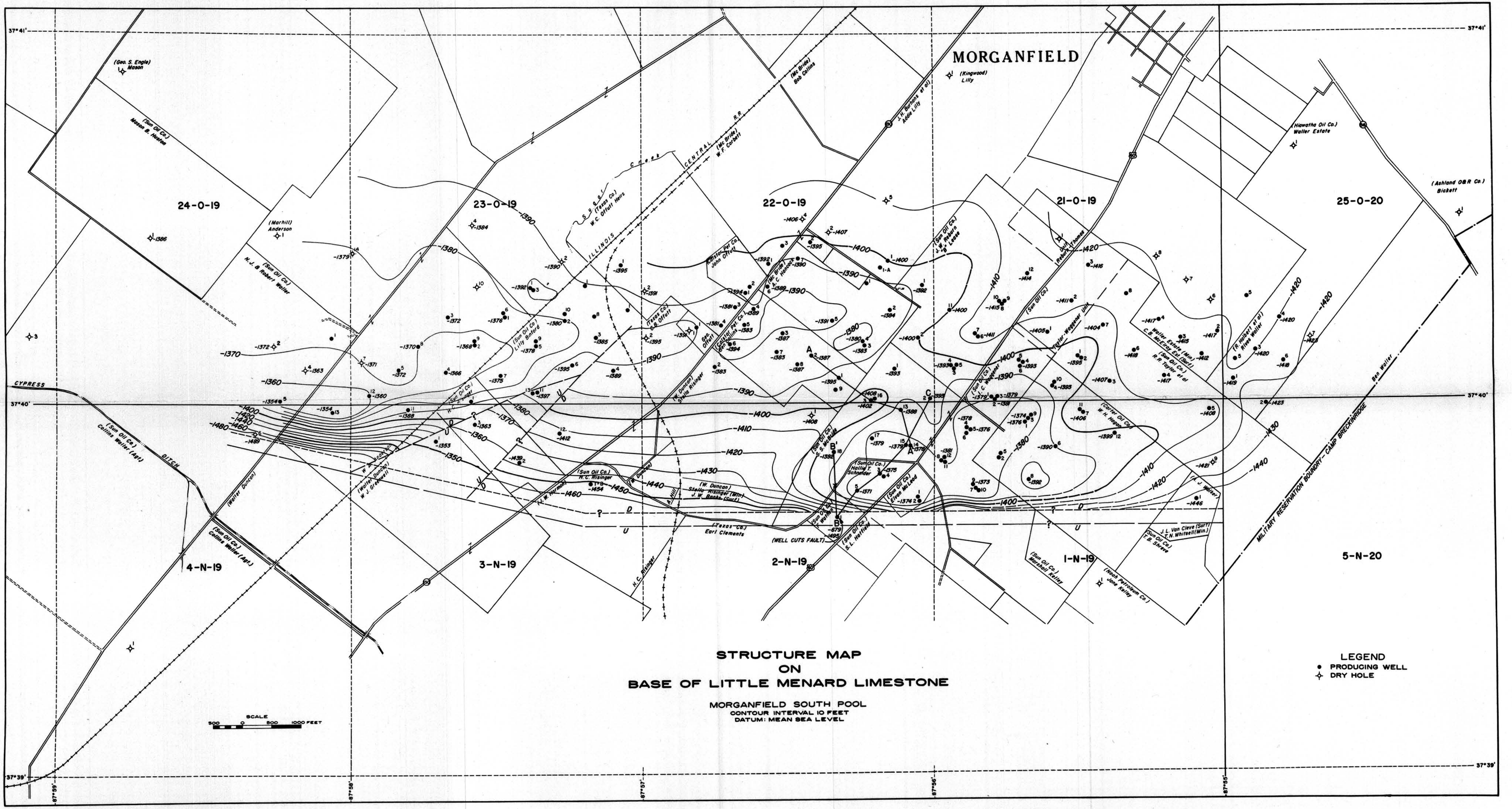


STRUCTURE MAP ON BASE OF BARLOW LIMESTONE

MORGANFIELD SOUTH POOL

CONTOUR INTERVAL 10 FEET

DATUM: MEAN SEA LEVEL



STRUCTURE MAP
ON
BASE OF LITTLE MENARD LIMESTONE

MORGANFIELD SOUTH POOL
CONTOUR INTERVAL 10 FEET
DATUM: MEAN SEA LEVEL

CROSS SECTION B-C SHOWING STRUCTURAL AND STRATIGRAPHIC RELATIONSHIPS