REPORT OF INVESTIGATIONS—NO. 16

THE OIL AND GAS RESOURCES OF THE AVA-CAMPBELL HILL AREA

BY

TOWNER B. ROOT

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

1928
STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
A. M. SHELTON, Director

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, Chief

Committee of the Board of Natural Resources and Conservation

A. M. SHELTON, Chairman
Director of Registration and Education

CHARLES M. THOMPSON
Representing the President of the University of Illinois

EDSON S. BASTIN
Geologist

JEFFERSON PRINTING & STATIONERY CO.
SPRINGFIELD, ILLINOIS
1928
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>5</td>
</tr>
<tr>
<td>Previous work and acknowledgments</td>
<td>5</td>
</tr>
<tr>
<td>Location and general description</td>
<td>6</td>
</tr>
<tr>
<td>General structural relations</td>
<td>7</td>
</tr>
<tr>
<td>Geology</td>
<td>7</td>
</tr>
<tr>
<td>Stratigraphy</td>
<td>7</td>
</tr>
<tr>
<td>Chester beds</td>
<td>7</td>
</tr>
<tr>
<td>Pottsville beds</td>
<td>9</td>
</tr>
<tr>
<td>Higher Pennsylvanian beds</td>
<td>10</td>
</tr>
<tr>
<td>Structural geology</td>
<td>10</td>
</tr>
<tr>
<td>Sources of information</td>
<td>10</td>
</tr>
<tr>
<td>Structure</td>
<td>11</td>
</tr>
<tr>
<td>Faults</td>
<td>12</td>
</tr>
<tr>
<td>Oil and gas</td>
<td>13</td>
</tr>
<tr>
<td>Producing areas</td>
<td>13</td>
</tr>
<tr>
<td>Lange pool</td>
<td>13</td>
</tr>
<tr>
<td>Rickenburg pool</td>
<td>16</td>
</tr>
<tr>
<td>Combs-Carter pool</td>
<td>16</td>
</tr>
<tr>
<td>Carter pool</td>
<td>17</td>
</tr>
<tr>
<td>Combs pool</td>
<td>17</td>
</tr>
<tr>
<td>Ditch pool</td>
<td>18</td>
</tr>
<tr>
<td>Downen pool</td>
<td>19</td>
</tr>
<tr>
<td>Geberding pool</td>
<td>20</td>
</tr>
<tr>
<td>Morris pool</td>
<td>21</td>
</tr>
<tr>
<td>Smaller producing areas</td>
<td>22</td>
</tr>
<tr>
<td>Exploration outside the producing area</td>
<td>22</td>
</tr>
<tr>
<td>Gas and oil showings</td>
<td>22</td>
</tr>
<tr>
<td>Dry holes</td>
<td>23</td>
</tr>
<tr>
<td>Untested strata in the main Campbell Hill Anticline</td>
<td>24</td>
</tr>
<tr>
<td>Shallow testing of other structures</td>
<td>25</td>
</tr>
<tr>
<td>Levan anticline</td>
<td>25</td>
</tr>
<tr>
<td>Minor structures</td>
<td>26</td>
</tr>
</tbody>
</table>
ILLUSTRATIONS

**Figure**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Index map showing the area of this report.</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Cross-section along the axis of the Campbell Hill anticline (Pl. III line A-B)</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Cross-section through Geberding-Lange pools (Pl. III line E-F)</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Cross-section through Modglin-Ditch and Carter pools (Pl. III line C-D)</td>
<td>20</td>
</tr>
</tbody>
</table>

**Plate**

<table>
<thead>
<tr>
<th>Pocket</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
</tr>
<tr>
<td>II</td>
</tr>
<tr>
<td>III</td>
</tr>
</tbody>
</table>
OIL AND GAS RESOURCES OF THE
AVA-CAMPBELL HILL AREA
By Towner B. Root

INTRODUCTION

The Ava-Campbell Hill district of southwestern Illinois has been producing natural gas for more than ten years. Drilling during and before 1916 had shown the presence of both oil and gas, and the gas from one well on the Froemling property was piped for use in the house of the land owner. Nevertheless, systematic and extensive development was not begun until the Mid Egypt Oil and Gas Company started operations in the region in February, 1918. Gas was first marketed in October, 1921, and since then has been produced at a rate of about 450,000 to 500,000 cubic feet per day. The oil production has been less important; the estimate of total production up to midsummer, 1925, was from 20,000 to 25,000 barrels. The production of both gas and oil has declined recently, and drilling in the last few years has developed progressively smaller wells.

PREVIOUS WORK AND ACKNOWLEDGMENTS

In 1912 Mr. E. W. Shaw and Dr. T. E. Savage reported on the Murphysboro quadrangle in folio No. 185 of the United States Geological Survey. In 1914 Mr. H. A. Wheeler published a map of Illinois, showing an area of gas production in the Ava region, in Volume 48 of the Transactions of the American Institute of Mining Engineers. In 1917 Mr. Stuart St. Clair published a short report on the "Oil possibilities of the Ava area" in Bulletin 35 of the Illinois State Geological Survey. In 1919 Dr. J. Marvin Weller mapped the geology of the Campbell Hill quadrangle for this Survey, but this has not been published. Grateful acknowledgment is given for the material obtained from these sources.

The cooperation of the Mid Egypt Oil and Gas Company and of the Willis Coal and Mining Company in making available important data is gratefully acknowledged. Thanks are especially due to Dr. U. S. Grant of Northwestern University, geologist for the Mid Egypt Oil and Gas Company, and to Mr. A. L. Pratt, head driller, and Mr. Fred A. Krewer, engineer of the Willis Coal and Mining Company.
The field work was done during the summers of 1924 and 1925, and the writer was assisted by Mr. William E. Powers, Mr. John T. McCormack, and Mr. Joseph H. Markley, Jr.

LOCATION AND GENERAL DESCRIPTION

The Ava-Campbell Hill district is located in southwestern Illinois and includes the northwest corner of Jackson County, the southwest corner of Perry County, and an adjacent strip of Randolph County (fig. 1). All but one of the producing wells of the district are located in Bradley Township, (T. 7 S., R. 4 W.) in the northwest corner of Jackson County.

The district is naturally divided into two contrasting physiographic units: (1) a more or less rough and broken highland to the south and west; (2) relatively level lowlands to the north and east. The boundary between the two is indefinite except at the northeastern edge of the Campbell Hill anticline where it is marked by an abrupt change in topography. The highland is underlain by the older rocks of early Pennsylvanian (Pottsville) and late Mississippian (Chester) age, principally
sandstones in this area, which resist erosion and produce the rough topogra­phy. The lowlands are underlain by the softer beds of later Pennsyl­vanian age (Carbondale and McLeansboro), which consist largely of shale with some sandstone, limestone, and coal beds.

GENERAL STRUCTURAL RELATIONS

The principal structural feature of the region is the Campbell Hill anticline, an asymmetrical fold dipping more steeply to the north, which is elongated in a general southwest direction. The highland of the area is directly due to the physiographic effect of the Campbell Hill anticline. The areas northwest and southeast of the anticlinal ridge show somewhat less markedly the physiographic effect of the underlying structural basins and small subsidiary anticlines locally show up as ridges, as for example at Wine Hill, and in secs. 10 and 16, T. 8 S., R. 3 W., (Levan Township) Jackson County.

GEOLOGY

STRATIGRAPHY

The columnar section (Pl. 1) shows the character of the rock forma­tions which occur in the Campbell Hill area as determined from examina­tions of well records and outcrops. The best known of these beds are as follows: (1) The Chester series of formations of the upper Mississippian, (2) the Pottsville series of the lower Pennsylvanian, and (3) the Car­bondale and McLeansboro coal-bearing beds of upper Pennsylvanian. Data on the beds underlying the Chester were obtained from one well only, for no others in the area have penetrated these lower strata. Below the Chester the rocks are predominately limestone. (See the columnar section and the table of data for a general description of these beds.)

CHESTER BEDS

The Chester beds, from which the gas and oil of the region are de­rived, consist of sandstones, shales, and limestones, and show this se­quence of beds repeated several times. The sandstones are typically the lowest beds in each group and commonly lie on an eroded limestone surface.

As shown in the columnar section, the Chester series in this region consists of 16 formations. All of these may be recognized more or less clearly in those well logs of the area which are detailed and accurate. Production is limited to two of these formations: (a) the Cypress sand­stone, fifth from the base, the more important producer; and (b) the Tar Springs sandstone, ninth from the base, which is productive only locally.
Formations below the Chester series as known from record of deep well, Lange No. 4, sec. 15, T. 7 S., R. 4 W.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Character</th>
<th>Thickness</th>
<th>Well From</th>
<th>Depths To</th>
<th>Water condition</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ste. Genevieve</td>
<td>Oolitic limestone</td>
<td>135</td>
<td>1235</td>
<td>1370</td>
<td></td>
<td></td>
</tr>
<tr>
<td>St. Louis</td>
<td>Hard, fine-grained limestone</td>
<td>220</td>
<td>1370</td>
<td>1590</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spergen</td>
<td>Oolitic limestone</td>
<td>190</td>
<td>1590</td>
<td>1780</td>
<td>Salt water</td>
<td>1612-1667</td>
</tr>
<tr>
<td>Warsaw-Keokuk</td>
<td>Fine-grained limestone</td>
<td>80</td>
<td>1780</td>
<td>1860</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burlington</td>
<td>Light buff and white coarse limestone</td>
<td>160</td>
<td>1860</td>
<td>2020</td>
<td>Salt water</td>
<td>1964-1992</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2009-2019</td>
</tr>
<tr>
<td>Kinderhook-Chattanooga</td>
<td>Dark siliceous shale; limestone beds in upper part</td>
<td>390</td>
<td>2020</td>
<td>2410</td>
<td></td>
<td>1955-1995</td>
</tr>
<tr>
<td>Devonian (Kimmswick?)</td>
<td>Very cherty limestone</td>
<td>120</td>
<td>2410</td>
<td>2530</td>
<td>Very light showing of oil 2423-2503</td>
<td>Drill cuttings to 2520 only</td>
</tr>
</tbody>
</table>

AVA-CAMPBELL HILL AREA
Because of the erosional unconformity at the base of the Pennsylvanian series, one or more of the upper formations of the Chester series is usually missing. The three upper formations, the Clore, Degonia, and Kinkaid, outcrop in the valleys along the southern and western edges of the area described.

The total thickness of the Chester series is more than 1000 feet. At Sugar Hill, in secs. 4, 8, and 9, T. 7 S., R. 3 W. (Ora Township), it is 1,268 feet thick.

POTTsville beds

The Pottsville beds outcrop over a larger part of the area than do the Chester formations, and consist largely of massive sandstone beds alternating with shales, shaly sandstones, and local beds of coal. The beds are not uniform in character, but range from cross-bedded and ripple marked sandstones to shales which vary widely in both composition and thickness. In places the shaly layers thin out and disappear so that locally two or three of the sandstones may form an apparent stratigraphic unit, as for example, at Sugar Hill. The sandstones are more abundant toward the south and east, thinning out among the increasingly shaly beds towards the north and west. None of the Pottsville beds is productive of oil or gas in this region.

A shale bed which is fairly persistent and extensive occurs in the upper part of the Pottsville and for the sake of convenience is called the Ava Shale. It can be identified in many outcrops and well records. Throughout the greater part of the area the Ava shale has been used as the key horizon for the contour map which shows the structure of the Pennsylvanian beds (Pl. II). Although the Ava shale is irregular in thickness and locally is missing in both outcrops and well logs, it was found to be the best horizon to use over so large an area.

The maximum thickness of the Pottsville is difficult to measure because the top of the Pottsville is arbitrarily taken as the base of the Murphysboro (No. 2) coal, and the coal has been removed by erosion in most of the places where wells have been drilled through to the Chester. Also the unconformity immediately above the Chester brings the basal Pottsville sandstone in many places in contact with very similar upper Chester sandstones, so that from a well log it is difficult to locate the contact. In certain wells in the eastern part of the area the Pottsville is not less than 400 feet thick but it is thinner in most other sections, particularly at the western edge of the area where at Wine Hill its thickness is estimated at 175 feet.
The higher Pennsylvanian beds, of the age usually described as Carbondale and McLeansboro, are more uniform in character than the Pottsville. Shale is the dominant rock. There are some irregular sandstone beds, notably one slightly above the basal coal that has been named the Vergennes sandstone, and another immediately below the Herrin (No. 6) coal at the top of the Carbondale. In addition to the shales and sandstones there are several important coal seams with associated thin limestone layers. None of these upper Pennsylvanian beds is productive of oil or gas in this area.

The Carbondale immediately overlies the Pottsville and includes the group of beds which occurs between the base of the Murphysboro (No. 2) coal and the top of the Herrin (No. 6) coal. A third important coal, the Harrisburg (No. 5), occurs a short distance below the top of the Carbondale group.

The thickness of the Carbondale is about 275 feet in the Gallagher well, sec. 17, T. 6 S., R. 4 W., Perry County, just north of the area, where the best data on the thickness were available.

The Herrin (No. 6) coal at the top of the Carbondale is about the highest recognizable bed which is persistent in the structurally low portions of the area. Therefore, it has been used as a key horizon for structure contours in the north parts of the area where data on the Ava shale are lacking. Intervals between the two Pennsylvanian key horizons were determined as follows: SW. corner sec. 4, T. 7 S., R. 4 W. (Bradley Township) 314 feet; NW. ¼ sec. 31, T. 6 S., R. 2 W. (Duquoin Township) 335 feet; NE. ¼ sec. 32, T. 6 S., R. 4 W. (Southwestern Township), 393 feet. Although the variation in this interval is considerable over distances of a few miles, the local variation appears to be generally slight, so that the structure of the Herrin (No. 6) coal may be given the same consideration as that of the Ava shale.

The greatest measured thickness of McLeansboro strata, or the Pennsylvanian strata above the Herrin (No. 6) coal, in this area, is 97½ feet, recorded in the log of a well two miles north of Willisville.

**Structural Geology**

**Sources of information**

Outcrops in the northeastern plains part of the area are rare because of a covering of glacial and alluvial debris. In the highland area to the south and west outcrops are more abundant, although locally there is

---

much unconsolidated surficial material. Levels were run with a planetable and a telescopic alidade to outcrops which could be used for determining structural conditions, and to wells, mines, and borings for which data are available. The structural data obtained from a study of outcrops have been supplemented wherever possible by data from well logs and mines.

As shown on the structure map, data on the Ava shale were available for the greater part of the area. In the low area to the north, test borings for coal provided useful data for determining the structure. Oil and gas tests are numerous along the crest of the anticline and provide data both on the shallow Pennsylvanian beds and on the deeper Chester beds.

**STRUCTURE**

The principal structural feature of the Ava-Campbell Hill district is an elongate, irregular, asymmetrical anticline. The location, extent, and character of the folds are shown on Plate II by structure contours on Pennsylvanian beds.

From the southwest portion of the area mapped to the east line of Bradley Township the axis of the Campbell Hill anticline trends about N. 55° E.; there the trend changes to nearly due east. The highest part of the anticline is located along the axis in secs. 12, 13, and 14, Bradley Township. The crest of the fold slopes gently from this high area to the southwest, and near the edge of the area mapped it rises again almost to the altitude of the highest part of the anticline, as the general structure map (Pl. II) shows. The plunge of the fold to the east is more marked, particularly eastward from the vicinity of sec. 4, Ora Township. The north and west slopes of the arch are notably steeper than the south slopes. The local dips on the northwest flank are commonly 5° to 8°; but the maximum sustained dip is less than 3 1/2°. On the southeast flank local dips are usually less than 5° and the steepest sustained dip is slightly over 1°. On both flanks, however, irregularities and reversals of dips occur and locally higher angles of dip are found.

On the north and northwest of the Campbell Hill anticline gentle dips in a northerly direction are prevalent. Eastward dipping strata on the west side of the area form a basin.

West of this basin there is a local uplift of some prominence known as the Wine Hill dome. Only one structure contour completely encloses this dome on the map, but the dips on three sides are fairly pronounced. A fault, trending nearly parallel to the strike of the beds, probably lies a short distance southwest of the highest part of this uplift.

South of the Campbell Hill anticline the dips are rather irregular and generally are low.
The Levan anticline is located in the southeast part of the area mapped, in Levan Township. This structure is elongated in a north-south direction and is situated just west of a zone of pronounced eastward dip which occurs along most of the east side of the area. The Levan anticline dips more steeply to the east, instead of to the northwest as does the Campbell Hill anticline. The territory between the Levan anticline and the larger Campbell Hill anticline to the north is structurally higher than that either east or west of it, thus forming a saddle.

Other less important structural features, several of which are described below, as well as the details of their character and location, are shown on the structural geology map (Pl. II).

**FAULTS**

A southeast-northwest fault probably crosses the Wine Hill dome as mentioned above. The fault is nowhere visible, but it is strongly suggested by local changes in key-bed elevations and by abrupt changes in stratigraphy.

A zone of faulting is clearly seen in outcrops north of the east end of the main arch, especially in sec. 4, Bradley Township. One fault in secs. 2 and 11, Bradley Township, which can be seen in two places, has a vertical displacement of about 10 feet and two smaller faults, one on either side of the large fault at the northwestern exposure, have smaller displacements. The faults are roughly parallel and trend N. 40° W., with the downthrow sides to the northeast. One of the faults of this zone probably extends northwest, for it is indicated by abrupt changes in key-bed elevations in the area southwest of the one-contour elevation in secs. 32 and 33, Southwestern Township. The extension of the fault was not seen in the field but its supposed course is shown on the map by broken red line (Plate II). Where visible, the downthrow side of this fault is to the southwest. Its trend is parallel to the structure contours in the south central part of sec. 32.

Faults have been observed in other parts of the area. In general the trend of the faults is northwest to west-northwest, nearly at right angles to the axis of the arch. The known faults are closely related to the topography and correspond in position to certain indentations of the topographic contour lines. Similar indentations of the topographic contour lines, where faults could not be directly observed, may likewise be related to faults or they may represent the dying-out of faults in cross folds. It seems possible that most or all of these offsets in the regularity of the topographic outline of the arch along the north flank in the northwest part of Ora Township may have been caused by undetected fault-
ing. It is probable that in the area as a whole faulting has taken place to a far greater extent than can be observed from present outcrops. None of the known faults has a great displacement, in so far as determinable. The only one of considerable displacement is just east of the center of sec. 4, Bradley Township, where the northeast side rises about 60 feet.

**OIL AND GAS**

Although oil and gas both are produced in the area, the gas production has been of greater commercial importance thus far, and as yet there is no expectation that oil production will increase in importance to any marked degree. None of the wells obtained large production, probably because of the irregularity and thinness of most of the Chester sands. The discovery of larger production appears to depend on the possible presence of deeper and more favorable productive sands. This is discussed on a later page.

The producing areas as shown in Plate II are on the high part of the main Campbell Hill anticline. The relation of the producing areas to the structure of the Menard limestone of the Chester series, as well as of the oil to gas producing areas, is shown on Plate III.

Marketable oil and gas have come from only two of the Chester formations in the Campbell Hill area; the Tar Springs and the Cypress sandstones. The larger part of the gas production, and the oil production in two of the three oil pools, is from the Cypress sandstone.

As the map shows (Pl. III), the productive areas are small in extent and are not all located on the highest points of the local domes along the Campbell Hill anticline. The relations between the geologic conditions and the accumulation of oil and gas in this area are further shown by the several detailed cross-sections.

**Producing Areas**

**LANGE POOL**

The Lange pool, as is shown on Plate III, has the largest producing area, and extends over the highest portion of the Chester structure shown on the map. Eight of the twenty-seven producing wells in the area are located in this pool.

The gas production is obtained from the lower sandstone member of the Cypress, here 33 feet thick and 900 feet below the surface at the crest of the structure. This bed is usually permeable and porous; therefore accumulation of gas on the highest part of the structure, as found here, is to be expected. This relation is shown by the cross-sections
Fig. 2. Cross-section along axis of Campbell Hill anticlinal to oil and gas accumulation.
III) showing the structure and sand conditions and their re-
The producing area of the Lange pool is outlined by wells which found water in the lower Cypress sand. A test on this part of the structure has been drilled through the Thebes sandstone to a total depth of 2530 feet and found nothing below the Chester except a show of oil in the top of the Thebes sand.

The Rickenburg pool, which is second in size, is mostly in the NE. ¼ sec. 11, Bradley Township. As the structure contours show (see Pl. III) the Menard limestone here reaches an altitude of about 230 feet, second only to the height attained in the Lange pool. Production occurs over the higher part of this local dome. The limit of the producing area, it should be noted, does not conform closely to the structure contours, but extends somewhat farther down the west slope of the dome than on the other sides.

Gas occurs in the Tar Springs sand in the highest part of the Rickenburg pool. Production to the east is apparently limited by a change in character of the sand, which probably becomes nonpermeable and therefore nonproductive. Wells drilled to the west, down dip from the highest part of the structure, found oil in the Tar Springs sand below the gas, and water in the lower part.

In the producing wells the sand is commonly reported to have a thickness of from 13 to 37 feet and is thickest in the northern and eastern part of the pool. It is found at a depth of about 560 feet in the higher part of the structure. Tests on this part of the structure have been drilled into the Aux Vases or basal sandstone of the Chester series, at a total depth of 1165 feet, and were dry below the Cypress formation.

A small gas pool in the Cypress formation underlies the southeast part of the area of Tar Springs production in the Rickenburg pool. The gas is in the lower thick Cypress sand, which is encountered at a depth of 840 to 890 feet. The sand is some 40 feet thick here and thins to the northward. The pool extends from the top of the Rickenburg closure down its southern slope and produces from five wells. A well at the northern end of the closure and another down its northeastern slope encounter only salt water in the sand. This peculiar location of the gas on the southern slope of the structure is probably to be explained by a change to finer texture of the sand to the northward.

The Combs-Carter pool is composed of a pool in the lower thick Cypress sandstone, principally underlying the Combs farm, and of a pool
in the Tar Springs sand, principally underlying the Carter farm. These pools partially overlap as shown on Plate III but for convenience they are described separately, the former as the Combs pool and the latter as the Carter pool. The relations of sand conditions and structure to production are shown in figure 2 and particularly well in figure 4.

CARTER POOL

The Carter pool, narrow and elongate in form, lies mostly in the north central part of sec. 12, Bradley Township. The structure contours on Plates II and III show that the pool lies along the southeast flank of the arch rather than at the crest. The bed which produces the gas is the thick lower sandstone of the Cypress formation.

The location of the gas pool on the flank instead of along the crest of the arch is apparently due to a lack of permeability of the Cypress sand near the crest. Samples from a well near the center of the NW. 3/4 sec. 12, on the crest of the structure, show the Cypress to be mostly shale, containing sandstone fragments, and it may be that this is also the condition along the crest immediately above the pool. This seems a reasonable explanation for the trapping of the gas in the open-textured part of the bed on the flank of the structure. The producing area is outlined to the east and south by wells that show water in the Cypress sand (fig. 4).

Four wells produce gas from this pool. The sand has a maximum thickness of about 30 feet but in this vicinity shows great variability in both character and thickness. It is reached at depths of 820 to 900 feet and no wells have been drilled through it in this pool.

COMBS POOL

Along the northern edge of sec. 12, Bradley Township, to the northwest of and partly overlapping the Carter pool, lies the smaller Combs pool, which produces gas from three wells in the Tar Springs sand. Plate III shows that the area of production extends from the top of a small one-contour closure dome down its southeastern slope. The Tar Springs sand is 30 feet thick here, but in the dry hole just southwest of the pool it is recorded as only 7 feet thick and shaly in character. Just south of the pool it thins to 5 feet or less. Accordingly, thinning of the formation and decreased porosity in this direction are believed to account for the location of the pool on the eastern slope of the dome. The sand also thins to the northeast, but thickens towards the southeast and west. It is reached at a depth of 515 feet. Wells have been drilled only as deep as the Cypress sand which produces gas in the eastern bor-
der of the Carter pool. However, the lower sands have been tested in the dry hole, in the northwest corner of sec. 12, Bradley Township (Pl. III), which went through the Yankeetown and Aux Vases sandstones of the lower Chester, with no show of oil or gas in either.

Fig. 3. Cross-section through the Lange-Geberding pools along line E-F (Pl. III) showing the relation of structure and sand conditions to oil and gas accumulation.

DITCH POOL

The Ditch pool, which produces oil only, lies in the north central part of sec. 12, Bradley Township, south and southeast of the Carter and Combs pools. It is more compact in form, and on both Plates II and III is shown to lie in a rather ill-defined minor structural trough which heads
at the side of the closure occupied by the Combs pool and descends and broadens out towards the southeast.

Eight wells have produced oil from this pool. The oil comes from a thin lenticular upper sandstone layer of the Cypress formation, which here as in many other parts of the area is separated from the main sandstone bed below by a zone of shale and limestone layers about 25 feet thick. The upper sand in the Ditch pool varies from 6 to 11 feet in thickness. The lower sandstone was nonproductive where tested in this pool.

The peculiar location of the pool in the structural trough on the flank of the main structure is explained by the fact that in the unproductive wells, shown on Plate III, between the pool and the crest of the arch, and in the wells in the Carter pool and along the crest of the arch, the upper Cypress sand thins from 5 feet to 2 feet and finally lenses out. This relation is plainly seen in the cross-section (fig. 4). It is absent also in the wells in the Morris pool to the east and is thin or absent to the southeast and south. It seems that the upper Cypress bears oil in this vicinity only where it is fairly thick, as in the Ditch pool, and therefore the location of the pool is primarily a matter of the development of the sand rather than of structure.

The producing sand is reached at a depth of 750 to 830 feet. Wells in the pool have not been drilled below the producing sand, but wells nearby have been drilled through the Yankeetown to the Aux Vases sand. Results were negative with two exceptions; one test a quarter of a mile northeast of the pool found showings of oil in the lower Cypress and the Yankeetown sands; another test an eighth of a mile southeast had a showing of gas in the main lower Cypress sand.

DOWNEN POOL

The Downen pool is located in the west central part of sec. 15, Bradley Township. It is elongate in form and lies along the crest of the arch at the southwestern tip of its productive portion. (See Pls. II and III). Four wells produce gas from the Tar Springs sand in this pool. Plate III shows a slight rise of the arch at the southwestern end of the pool, which seems to be the factor causing local gas accumulation. The Tar Springs sand is from 19 to 46 feet thick in the producing area and is encountered at a depth of about 590 feet. Within the limits of the pool the deepest drilling has gone only as far as the lower Cypress sand, which gave a flow of gas in the two eastern wells, described as the southwestern end of the Lange pool. Southwest of the pool two holes drilled through to the Yankeetown sand were dry; and southeast of it two dry holes
gave showings of oil in the Yankeetown sand, which was as far as they were drilled.

**GEBERDING POOL**

The Geberding pool is small and is long and narrow in form, extending in a north-south direction a little north of the center of sec. 14,

Bradley Township. The three wells in it have produced oil from the thin upper Cypress sand, which is 6 to 7 feet thick and is encountered at
a depth of about 845 feet. None of these wells reached the thick lower Cypress sand, but holes nearby were drilled through the Cypress and the Yankeetown sands, both of which showed water, and also through the Aux Vases sandstone, but found no showings of oil or gas in any of these lower sands. One well drilled to the northwest of the pool, between the Geberding and the Lange pools found a showing of gas, with water below, in the thick lower Cypress sand.

Structurally the Geberding pool is located on the southeast flank of the main anticline, and there is little in the structure shown on Plate III to account for the localization of the oil other than a slight flattening of the dip. However, the lack of water in the sand, its irregular, lenticular nature, and the peculiar disconnected occurrence of the gas pools found in it at the crest of the fold indicate that the accumulation of commercial amounts of oil and gas in this sand is as dependent on local variations in the texture and nature of the sand as on the structural features resulting from folding. The cross-section (fig. 4) shows changes of this type between Geberding No. 5 and adjacent wells.

Drilling around the Geberding pool has been unsuccessful in developing commercial production. The testing, moreover, has been thorough enough so that the absence of any important producing area in the Chester series has been demonstrated. Five wells drilled close to the pool found shows of oil in the thin upper Cypress sand. Farther from the producing wells the sand does not give even a show of oil, and in only one hole, at the southeast edge of the pool, is a flow of water recorded. Two isolated wells about three-fourths of a mile apart found flows of gas in the upper Cypress sand. These wells are indicated by shading on Plate III, one in the center of the Lange pool at the highest point on the dome; the other to the northwest between the Lange and Rickenburg pools.

**MORRIS POOL**

The Morris pool, also small in size and elongate in form, is located in the northeastern part of sec. 12, Bradley Township. Two gas wells producing from the thick lower sand of the Cypress formation comprise this pool. Neither well was drilled through the producing sand, but the logs of wells drilled nearby give its thickness as from 22 to 42 feet. The sand is encountered at a depth of about 810 feet. Plate III shows that the pool is located on a small anticlinal nose extending southward from the main anticline, and nearly closed off from it. A dry hole just north of the pool penetrates the Yankeetown sand, in which there was a show of oil with sulfurous salt water below; it also was drilled through the
Aux Vases sandstone but found no show of oil or gas in that formation. Two wells located on the top of the main anticline between the Morris and Carter pools tested the main Cypress sand. The Cypress was present in both wells, and in one was found carrying water and a small showing of oil.

**SMALLER PRODUCING AREAS**

Two smaller producing areas lie near the Morris pool; one is half a mile east of it along the northern edge of sec. 7, Ora Township; the other is in the NE. ¾ SE. ¾ sec. 12, Bradley Township. Each of these pools is limited to one producing gas well. Both pools get gas production from the thick lower Cypress sand. The logs of wells drilled nearby show that the sand is about 23 feet thick.

The eastern one of the two pools lies along the crest of the main anticline at a point where the eastward pitch of the anticlinal axis increases a little. The local gas accumulation is probably related to the steepening of the dip. The producing sand in this pool was found at a depth of 850 feet.

The relation of the location of the other pool to structural conditions is less apparent. It lies along the southern slope of the anticline, at the lower edge of a terrace-like flattening, which apparently served as a trap for gas migrating through the sand at that point. There the depth to the gas sand is 780 feet.

In the vicinity of each of these pools deeper holes found only water in testing all the sands including the Yankeetown.

**EXPLORATION OUTSIDE THE PRODUCING AREA**

Outside of the immediate area which has been proved productive there has been extensive testing of the Chester sands, particularly on the more favorable structures. Showings of oil and gas in the Tar Springs and Cypress sands have been found near the producing areas and these have been to some extent described in connection with these pools. Other noteworthy showings of oil and gas are described below.

**GAS AND OIL SHOWINGS**

In the NW. ¼ sec. 22, Bradley Township, on the south flank of the anticline, three holes encountered shows of oil in a thin upper sand of the Yankeetown formation, and found salt water below it in the thick main sand. A showing of oil was also found in this thin upper Yankeetown sand in a well in the center of NW. ¼ sec. 8, Ora Township. This well had a small show of gas in the thick lower Cypress sand. In another
well to the east in the SW. corner SE. ¾ SW. ¾ sec. 4, Ora Township, (see Pl. II) a light show of oil was found in the thick lower sand of the Yankeetown. Both of these last wells are located on the top of the anticline east of the producing area. The second well and a dry hole in the NE. corner sec. 8, Ora Township, tested the small one-contour closure shown on Plate II in the southwest part of sec. 4 and the northwest part of sec. 8.

In a well along the SE. ¾ SW. ¾ sec. 1, Bradley Township, (see Pl. III) a show of gas appeared in the upper part of the Glen Dean limestone, which lies below the Tar Springs sandstone, and another in the upper part of the Golconda limestone, which overlies the Cypress sandstone. A show of oil was reported from the lower part of the Glen Dean limestone in a well near the center of sec. 11, Bradley Township. Another well, in the southeastern part of sec. 6, Ora Township, showed gas in the lower part of the Golconda.

Dry Holes

Dry holes have been drilled to the Chester sands at various points outside the producing area, as shown on Plates II and III. They have tapped the sands at the more favorable points along the crest of the anticline to the east of the producing area, in the southern part of secs. 4 and 6, the northwestern part of sec. 7, the northern part of sec. 8 and the SW. ¾ NW. ¾ sec. 9, Ora Township. To the east of them, in the NW. corner sec. 8, Vergennes Township, (see Pl. II) another dry hole was drilled into the base of the Chester, probably well into the Aux Vases sandstone. It is located on what is apparently the eastward continuation of the main Campbell Hill anticline, here reduced to a low arch of little or no surface expression.

To the southwest of the producing area, holes have been drilled along the more favorable parts of the anticline in the SE. ¾ sec. 16 (see Pl. III), the NW. ¾ SW. ¾ sec. 15, and NW. corner SE. ¾, SW. corner NE. ¾, and SW. corner SE. ¾ SE. ¾ sec. 20 of Bradley Township. Several of these penetrate the Yankeetown sand, and the one at the crest of the arch in NW. corner SE. ¾ sec. 20 goes into Aux Vases sand. All of them are dry, and they serve to delimit the Chester production towards the southwest, for the arch flattens out in that direction beyond them.

Within this area only two wells have been drilled into the productive sand horizons south of the main anticline and both of these are dry holes. One of them tested the highest part of the Levan anticline in NE. ¾ SW. ¾ sec. 10, Levan Township (see Pl. II). The other is located in the SW. corner NW. ¾ NW. ¾ sec. 24, Bradley Township, at the
southeastern border of the Campbell Hill anticline, where the structural slope flattens out into the saddle mentioned on page 12. Both holes were drilled through the base of the Chester beds and into the Ste. Genevieve limestone below.

North of the Campbell Hill anticline two wells have been drilled into the Cypress formation and both were dry holes. One of these lies in the NE. ¼ NE. ¼ sec. 32, Southwestern Township, on the lower north flank of the anticline. The other is nearly three miles to the north, in sec. 17 of Southwestern Township, and is in an area which is structurally nearly flat.

Other dry holes are shown on Plates II and III, but most of them test only the Pennsylvanian or upper Chester rocks and have not penetrated the oil- and gas-bearing beds of the lower Chester.

UNTESTED STRATA IN THE MAIN CAMPBELL HILL ANTICLINE

Recent development in the more favorable local domes along the highest part of the Campbell Hill anticline has resulted in thorough testing of the more shallow zones. Each of the suitable localities has been tested to the Yankeetown sand, and a well was drilled to test lower formations in the Lange pool in the NW. ¼ SE. ¼ NE. ¼ sec. 15, Bradley Township, which reached a total depth of 2530 feet, the greatest depth attained by any well in the area or nearby.

This deep well passed through the recognized Chester and Lower Mississippian series and entered a thick shale sequence at 2020 feet, the correlation of which is uncertain. This shale occupies the normal place in the stratigraphic section of the Kinderhook-Chattanooga formations, but it more closely resembles the Maquoketa shale in lithology. If this is the Maquoketa shale, the Silurian and Devonian formations have been removed by pre-Mississippian erosion in this area, as they were in Monroe County on the Waterloo and Valmeyer anticlines. Immediately beneath the shale, at a depth of 2410 feet, the drill entered a very cherty limestone, in which the well ended at a depth of 2530 feet. The very cherty character of this limestone is typical of the Devonian limestone underlying the Chattanooga shale, whereas the Kimmswick limestone beneath the Maquoketa formation has very little chert. It seems likely, therefore, that the normal stratigraphic sequence prevails here.

2 The study of the Lange well was made by other members of the Survey staff who also collaborated in preparing the statement regarding the testing of deeper strata in the main Campbell Hill anticline. The author of this report did not have opportunity to study the well cutting samples from the well or to compile the generalized columnar section below the Chester series shown on Plate I.—Editor's note.
Assuming this to be true, the possibilities of the Kimmswick-Plattin ("Trenton") limestone have not been determined. The top of the Kimmswick probably lies about 1000 feet beneath the base of the Kinderhook-Chattanooga shale.

If this shale is the Maquoketa, the St. Peter sandstone would be reached at a depth of some 600 feet beneath this shale. The St. Peter sandstone is of interest to oil men at the present time for it is similar in character to and is the approximate stratigraphic equivalent of the Wilcox sand of Oklahoma. Further, the generally open texture of this sandstone gives promise of good possibility of the proper conditions of permeability for satisfactory oil or gas production. The overlying limestone may be assumed to have contained abundant source material for forming petroleum and gas. In view of the above considerations it is believed that drilling to test the St. Peter sandstone is desirable.

If the structure is to be tested thoroughly, two deep wells will be necessary. One of these should be located in the NW. ¼ NW. ¼ sec. 14, Bradley Township, near or within the highest structure contour as shown on Plate III, and the other either in the structurally high area of the Rickenburg pool in the NE. ¼ sec. 11 (see Pl. III) or in the structurally high area in the NE. ¼ NW. ¼ sec. 12, Bradley Township. Because of the faulting to the west of this second location, which should serve to interrupt the circulation of fluids through any porous rock bed, it seems possible that the latter location is to be preferred to the one in sec. 11.

SHALLOW TESTING OF OTHER STRUCTURES

LEVAN ANTICLINE

The Levan anticline is the most pronounced structure outside of the strongly folded Campbell Hill anticline. As Plate II shows, the highest point of this structure is located in sec. 10, Levan Township, and is marked by a two-contour closure. This structure has been tested through the Chester by only one well which found no showings of oil or gas. According to the best available information this well does not condemn the Levan anticline any more than one of the dry holes drilled on the Campbell Hill anticline condemns that structure, for the presence of properly permeable sand bodies, as well as favorable structural features, is necessary for oil and gas production. The records available do not show whether this well on the top of the Levan anticline found any water in either the Tar Springs or Cypress sands, although it is known that in a well drilled in sec. 16 in which the Tar Springs sand was only 10 feet lower structurally, salt water was found. The Cypress sand, however, was not reported to have contained water in this latter well.
In case the dry hole in sec. 10 failed to find water in either the Tar Springs or Cypress sands, then only the location and not the structure is condemned.

**Minor Structures**

Other structures possibly favorable for oil and gas accumulation which might be worth testing through the Chester will be described, in so far as possible in their order of merit, although there is little choice between them. None of them is strongly folded, and in even the most favorable the uncertainty of getting production is high because of the very irregular and unpredictable occurrence of the oil and gas in the Chester beds. Consequently a structure should not be condemned on the basis of only one dry hole.

On the eastern extension of the main anticline there is a spot in the NW. ¼ sec. 11, Ora Township, where a test might be made. The anticline is narrow here, and the topography indicates a local bulge on it which the structural data were not complete enough to show. The nearest oil tests are two wells a mile and a half to the west-northwest along the southern boundary of sec. 4. Both of these go through the base of the Chester; one found only a small show of oil in the lower Yankeetown, the other was dry. A dry hole is also located about three miles to the east in the northwest corner of sec. 8, Vergennes Township, referred to before as having gone into the Aux Vases sandstone with negative results. A single additional hole should suffice to test the possibilities of the structure, and it should be located on the crest of the ridge at or near its highest point, in the NE. ¼ NW. ¼ sec. 11. The Tar Springs sand should be encountered at a depth of from 700 to 750 feet; the Cypress at from 880 to 930 feet; and the Yankeetown at from 1140 to 1190 feet.

The area which appears to have the next best possibilities for testing is the Wine Hill dome in sec. 5 of Wine Hill Township. This structure was described on page 11 as a one-contour dome, and reference was made to the fault along its southwest flank. The possibility of a detrimental effect on possible oil and gas accumulation as a result of this faulting seems negligible, for in the Rickenburg, Combs, and Carter pools nearby, faulting apparently has had little effect either in the accumulation or dispersion of the oil and gas. No deep wells are known near the Wine Hill structure except one about four miles northwest, in sec. 23 of Bremen Township, in which some gas was encountered but was drowned out by salt water. The horizon which showed the gas has not been determined but it is known that it is in the Chester series. A single test well on the Wine Hill dome might be enough to test it and should be located on the highest part of the hill, either in the area shown on the topographic map as inclosed by the 620-foot contour or slightly
north of it. The Tar Springs sand should be encountered at a depth of about 400 feet; the Cypress sand at about 650 feet; and the Yankeetown sand at about 750 feet.

Another place for a test is shown on Plate III as a broad one-contour closure in the E. ½ sec. 32 and the W. ½ sec. 33, Southwestern Township. The data are not full enough to recommend an exact location for drilling but a hole about in the middle of the eastern boundary of sec. 32 would test the structure. There are no deep drill-holes nearer than those along the Campbell Hill anticline three miles southeast. The Tar Springs sand should be entered at a depth of about 575 feet; the Cypress at about 850 feet; and the Yankeetown at about 975 feet.

Near the SW. corner sec. 34, Bradley Township, there is another location which might repay a test. It is a two-contour closure of small area, flanked on the west by a rather steep syncline. No holes which encounter the productive sands are nearer than those along the main anticline to the north, in secs. 20 and 22, Bradley Township. The structure could be tested by a single well located about 700 feet east and 200 feet north of the SW. corner sec. 34. The Tar Springs sand should be encountered at a depth of about 450 feet; the Cypress at about 750 feet; and the Yankeetown at about 875 feet.

In secs. 33 and 34 of Ora Township the flattened northern end of the Levan anticline offers another site for testing the Chester sands. This is the least favorable of all the locations shown on Plate II, for there is no closure, and the crest of the anticline is broad and ill-defined. The test hole should be located near the line between secs. 33 and 34, about three-eighths of a mile north of their southern boundary. The nearest well which penetrates the Chester sands is the one in sec. 10 which was referred to before as a dry hole. The Tar Springs sand should be entered at a depth of about 700 feet; the Cypress at about 1025 feet; and the Yankeetown at about 1175 feet.
Generalized columnar section for the Ava-Campbell Hill area
General map of the Ava-Campbell Hill area with structure contours showing the elevation of the Ava shale in black and the Herrin (No. 6) coal in red. The producing areas, areas recommended for prospecting, and all other drilled outside the producing areas are shown by appropriate symbols.