75

STATE OF ILLINOIS
DWIGHT H. GREEN, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK G. THOMPSON, *Director*

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

CIRCULAR NO. 75

ROLE OF FUNDAMENTAL GEOLOGIC PRINCIPLES IN THE OPENING OF THE ILLINOIS BASIN

BY

ALFRED H. BELL

REPRINTED FROM ECONOMIC GEOLOGY,
VOL. 36, NO. 8, PP. 774–785, DECEMBER, 1941

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS
1941

Reprinted from ECONOMIC GEOLOGY, Vol. XXXVI, No. 8, December, 1941
Printed in U. S. A.

ROLE OF FUNDAMENTAL GEOLOGIC PRINCIPLES IN THE OPENING OF THE ILLINOIS BASIN.[1]

ALFRED H. BELL.

ABSTRACT.

The opening of the Illinois basin to oil production in 1937 was the beginning of a large-scale development that restored Illinois to the position of a major oil producing state after the lapse of a quarter-century. The delay in the opening of the Illinois basin was the result of several factors, the most important of which was perhaps the theory that oil had migrated outward from the central parts of large structural basins and that consequently the central parts were barren of oil and not worthy of prospecting.

This paper discusses first the sequence of events leading up to the discovery of oil in the Illinois basin, with special emphasis on the influence of geologic theory, second the application in the area of the new techniques of exploration and development including geophysical methods, rotary drilling, and electric logging. The use of the reflection seismograph method proved highly successful.

INTRODUCTION.

THE discovery of oil in the Illinois basin in 1937 was the beginning of a rapidly expanding new development of oil production which now, nearly five years later, is still in progress. It restored Illinois to the position of a major oil-producing state after a lapse of a quarter-century. The purpose of this paper is to discuss the circumstances which led to the development of the Illinois basin oil fields with special regard to the influence of geological theory. In view of the magnitude of these oil deposits, their proximity to old producing fields, and their relatively shallow depth as compared with many of the new fields in other states, it is natural to inquire why they remained so long undeveloped.

[1] Read at the Fiftieth Anniversary Celebration of the University of Chicago, September, 1941.

Published with the permission of the Chief, Illinois State Geol. Survey, Urbana

ILLINOIS BASIN.

The term, Illinois basin,[2] is applied in this paper to the central deepest portion of the Eastern Interior basin (Fig. 1). It includes approximately 8000 square miles between the Centralia-

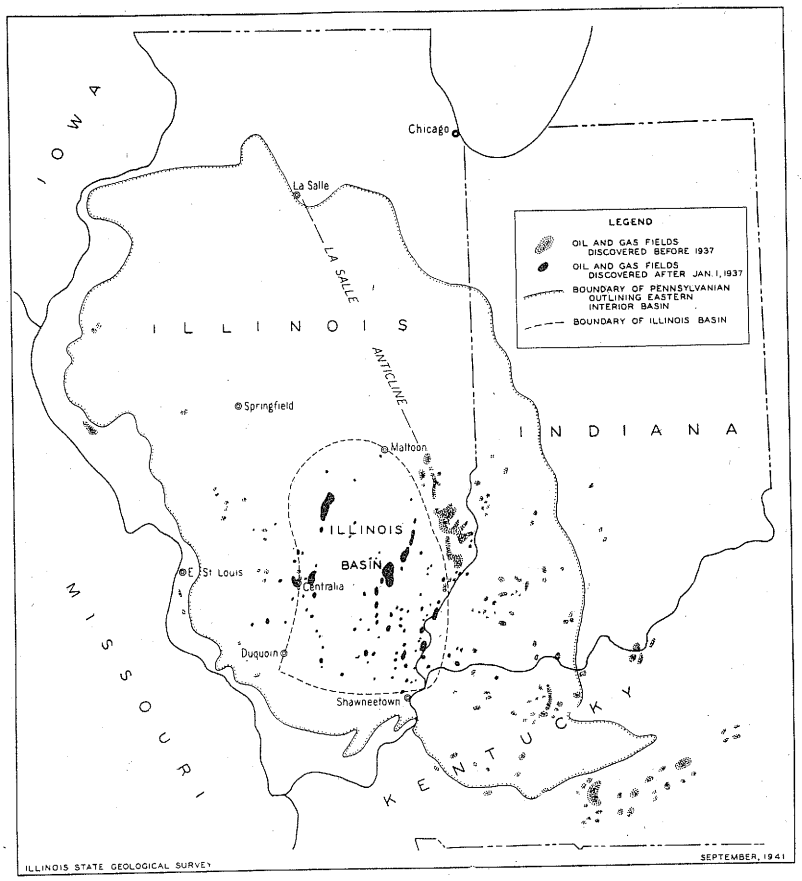

FIG. 1. Map of Eastern Interior basin and Illinois basin showing oil and gas fields.

[2] The term "Illinois basin" has sometimes been used as an alternative for Eastern Interior basin. However, several earlier writers, including R. S. Blatchley (I. G. S. Bull. 16, 1909, pp. 63, 97, 110, 129) and L. A. Mylius (I. G. S. Bull. 54, p. 28, Pl. I) confined the term "Illinois basin" to an area west of the LaSalle anticline and therefore did not use it as a synonym for "Eastern Interior basin."

DuQuoin monocline on the west and the LaSalle anticline on the east (70 miles) and approximately from the latitude of Mattoon on the north to that of Shawneetown on the south (125 miles).

HISTORICAL BACKGROUND.

Oil production of minor importance was obtained in western Illinois near Litchfield about 1886, and production in this field continued until 1903. In 1904 a gas well was drilled in what is now the Westfield pool in Clark County. This was followed by an oil well nearby in 1905 opening the Southeastern Illinois oil field, one of the nation's major fields. In 36 years this field has produced 430 million barrels of oil or 61 per cent of the State's total production to date. Prior to the opening of the Illinois basin in 1937, however, the Southeastern Illinois field had yielded 98 per cent of the State's total. Therefore, up to 1937, the oil history of Illinois is largely the history of one major field. The peak of production for that period came in 1908 when Illinois produced 33.7 million barrels and ranked third in the nation. From 1910 to 1936 the State's production declined rather steadily to a level of less than 4½ million barrels annually.

Beginning about 1910 some important oil discoveries were made in Oklahoma, and these proved to be sufficiently attractive to draw away from Illinois in the next few years many of the oil men most active in "wildcatting." Some good but small oil fields had been discovered in western Illinois—for example, Sandoval in 1908 and Carlyle in 1911—but nothing to compare with the Southeastern Illinois field. One thing that encouraged prospecting in this marginal area to the west of the Illinois basin was the large amount of information on subsurface structure provided by coal data in mines and test borings. However, in the Illinois basin itself, few data on bedrock structure were available because there was very little coal mining or prospecting, and because the bedrock is hidden by glacial drift or alluvium throughout large areas.

Because structural data on the Illinois basin were meager, there was a tendency for geologists to assume that it was a simple flat-bottomed geosyncline, uninterrupted by folds or other structures

that might serve as oil traps. Furthermore, test wells drilled west of the west edge of the Southeastern Illinois oil field found the oil sands structurally lower and saturated by salt water. Hence, by extrapolation, the conclusion was reached that the sands contained nothing but salt water across the basin.

Another consideration that pointed to the same conclusion was the theory of hydraulic accumulation and long-distance migration of oil. According to this theory, water and oil migrate outward from the central parts of large basins, and the oil accumulates in underground traps in the marginal areas, leaving the central parts barren of oil.

Strangely enough there was already a perfectly good demonstration of the occurrence of commercial deposits of oil and gas in the central parts of geosynclines in the fields of western Pennsylvania, West Virginia, eastern Ohio and Kentucky, all within the Appalachian geosyncline. The failure to apply this lesson earlier in the Michigan and Illinois basins may have been due to the idea that the Appalachian geosyncline is a different type of structure, being long and narrow and situated adjacent to the belt of intense folding of the Appalachian Mountains. Another difference appeared in the fact that some of the Appalachian basin fields, for example the Copley and Cabin Creek fields in West Virginia, have no water in the oil sands. The Pure Oil Company, however, entered upon a program of extensive pioneer exploration work in the Michigan basin, and it took the jolt of that company's discovery of oil at Mt. Pleasant in the center of the Michigan basin in 1928 to cause geologists elsewhere to consider seriously the oil possibilities of the Illinois basin.

Recognition by geologists of favorable prospects for oil production in the Illinois basin was only the first step toward actual development. It was then necessary to formulate plans for exploring this extensive territory. Recommendations for such planning are contained in a paper presented by the writer [3] before the Illinois Academy of Science in May 1930.

[3] Bell, A. H.: The relation of geology to the development of the petroleum industry of Illinois. Illinois Acad. Sci. Trans. 23, No. 3: 367–370, 1931.

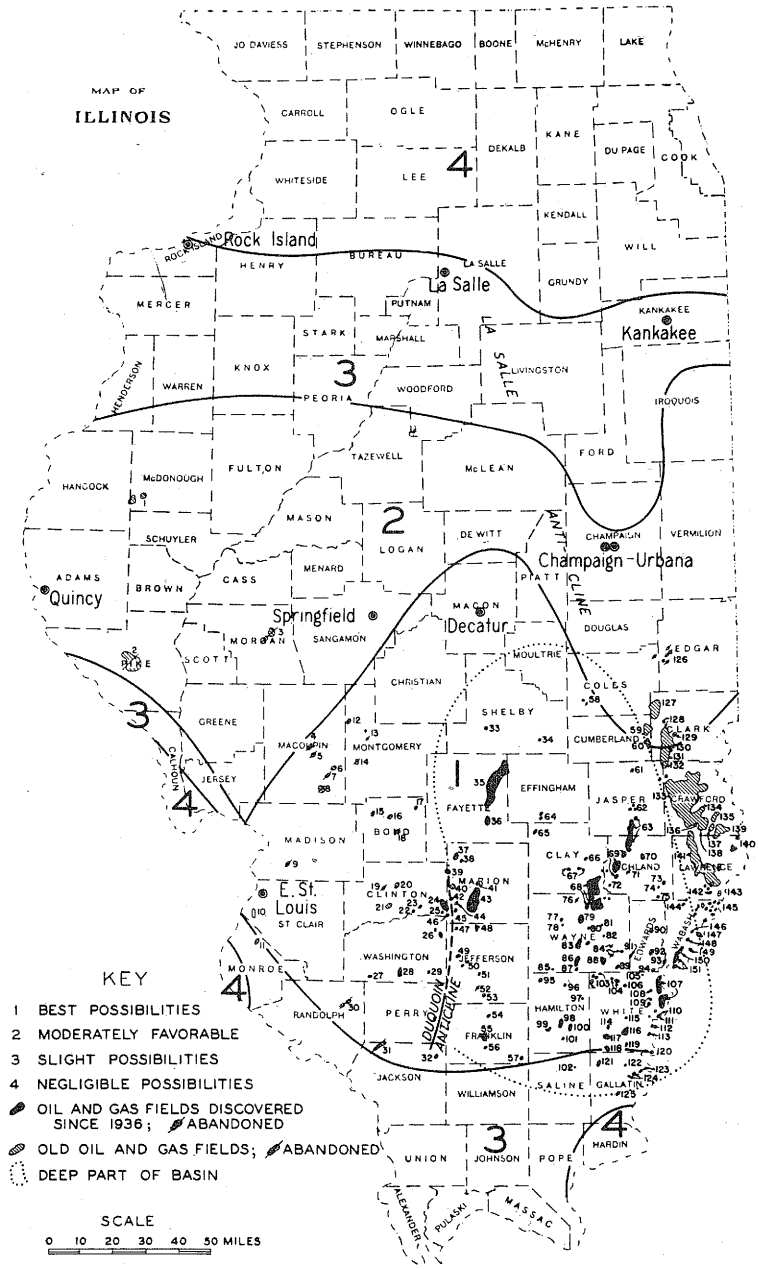

FIG. 2. Map classifying oil and gas possibilities in Illinois prepared in 1930, showing location of oil and gas fields as of September 1941.

INDEX TO POOL NUMBERS.

Name of Pool—County

1 Colmar-Plymouth—McDonough, Hancock
2 Pittsfield (gas, abd. 1930)—Pike
3 Jacksonville (gas, abd. 1937)—Morgan
4 Carlinville (abd. 1925)—Macoupin
5 Spanish Needle Creek (gas, abd. 1931)—Macoupin
6 Gillespie-Wyen—Macoupin
7 Gillespie-Benld (gas, abd. 1935)—Macoupin
8 Staunton (gas, abd. 1919)—Macoupin
9 Collinsville (abd. 1921)—Madison
10 Dupo—St. Clair
11 Waterloo—Monroe
12 Waggoner—Montgomery
13 Raymond—Montgomery
14 Litchfield (abd. 1904)—Montgomery
15 Sorento—Bond
16 Ayers (gas)—Bond
17 Woburn—Bond
18 Greenville (gas, abd. 1923)—Bond
19 Frogtown (abd. 1933)—Clinton
20 Carlyle—Clinton
21 Bartelso—Clinton
22 Posey—Clinton
23 Hoffman—Clinton
24 Centralia—Clinton, Marion
25 West Centralia—Clinton
26 Irvington—Washington
27 McKinley—Washington
28 Cordes—Washington
29 Dubois—Washington
30 Sparta (gas, abd. 1900)—Randolph
31 Ava-Campbell Hill (gas, abd. 1934)—Jackson
32 Elkville—Jackson
33 Lakewood—Shelby
34 Stewardson—Shelby
35 Louden—Fayette, Effingham
36 St. James—Fayette, Effingham
37 Patoka—Marion
38 Patoka (East)—Marion
39 Fairman—Marion, Clinton
40 Sandoval—Marion
41 Tonti—Marion
42 Junction City—Marion
43 Salem—Marion
44 Langewisch-Kuester—Marion
45 Brown—Marion
46 Wamac—Marion, Clinton, Washington
47 Cravat—Jefferson
48 Dix—Jefferson
49 Roaches—Jefferson
50 Woodlawn—Jefferson
51 Marcoe—Jefferson
52 Elk Prairie (abd. 1940)—Jefferson
53 Ina—Jefferson
54 Whittington—Franklin
55 Benton—Franklin
56 West Frankfort—Franklin
57 Thompsonville—Franklin
58 Mattoon—Coles
59 Siggins—Cumberland, Clark
60 York—Cumberland
61 Hidalgo—Jasper
62 North Boos—Jasper
63 Dundas Consolidated—Jasper, Richland
64 Mason—Effingham
65 Iola—Clay
66 Sailor Springs—Clay
67 Flora—Clay
68 Clay City Consolidated—Clay, Wayne
69 Noble—Richland
70 Olney—Richland
71 South Olney (abd. 1941)—Richland
72 Schnell—Richland
73 Bonpas—Richland
74 Bonpas (West)—Richland
75 Parkersburg—Richland
76 Rinard (abd. 1939)—Wayne

Name of Pool—County

77 Johnsonville—Wayne
78 Roundprairie—Wayne
79 Cisne—Wayne
80 Jeff—Wayne
81 Mt. Erie—Wayne
82 S. Mt. Erie—Wayne
83 Boyleston—Wayne
84 Goldengate—Wayne
85 Mayberry—Wayne
86 North Aden—Wayne
87 Aden—Wayne, Hamilton
88 Barnhill—Wayne
89 Leech Twp.—Wayne
90 Bone Gap—Edwards
91 Ellery—Edwards, Wayne
92 Albion—Edwards
93 Cowling—Edwards
94 Grayville—Edwards, White
95 Dahlgren—Hamilton
96 Belle Prairie—Hamilton
97 Bungay—Hamilton
98 Hoodville—Hamilton
99 Rural Hill—Hamilton
100 Dale—Hamilton
101 Walpole—Hamilton
102 Eldorado—Saline
103 Mill Shoals—White, Hamilton
104 Burnt Prairie—White
105 Grayville West—White
106 Centerville—White
107 New Harmony Consolidated—White
108 Calvin—White
109 Phillipstown—White
110 New Harmony South—White
111 Maunie North—White
112 Maunie—White
113 Maunie South—White
114 Stokes—White
115 Carmi—White
116 Storms—White
117 Iron—White
118 Roland—White
119 Herald—White
120 New Haven—White
121 Omaha—Gallatin
122 Inman North—Gallatin
123 Inman East—Gallatin
124 Inman—Gallatin
125 Junction—Gallatin
126 Warrenton-Borton—Edgar
127 Westfield—Clark, Coles
128 Casey—Clark
129 Martinsville—Clark
130 North Johnson—Clark
131 South Johnson—Clark
132 Bellair—Crawford, Jasper
133 Main—Crawford
134 New Hebron—Crawford
135 Flat Rock—Crawford
136 Chapman—Crawford
137 Allison-Weger—Crawford
138 Parker—Crawford
139 Birds—Crawford, Lawrence
140 Russellville—Lawrence
141 Lawrence—Lawrence, Crawford
142 South Lawrence—Lawrence
143 St. Francisville—Lawrence
144 Lancaster—Wabash, Lawrence
145 Allendale—Wabash
146 West Mt. Carmel—Wabash
147 Mt. Carmel—Wabash
148 Maud—Wabash
149 East Keensburg—Wabash
150 Keensburg—Wabash
151 Griffin—Wabash

CLASSIFICATION MAP.

In September 1930, at the invitation of the Western Society of Engineers, Chicago, the Illinois State Geological Survey prepared an exhibit of the scientific data which it had accumulated during its previous 25 years of activity, on the mineral wealth of Illinois, and the geological-engineering conditions within the State. As a part of this exhibit a map was prepared classifying the State into areas according to the relative probability of finding new oil fields. In this map the Illinois basin and part of the marginal area to the west were given the highest rating. The classification was based mainly on two factors: (1) the presence or absence of strata known to be oil producing, and (2) the varying character of the structural deformations in various regions. Fig. 2 shows the original classification and the location of oil pools as of September 1941.

Among those who attended the conferences and exhibit of the Western Society of Engineers and State Geological Survey in Chicago in September 1930 were representatives of the Pure Oil Company. Having for some time considered the possibilities of the Illinois basin as a productive province, and encouraged by development in Michigan resulting from their early work there, the Pure Oil Company, shortly following this meeting, undertook additional subsurface geological studies of the Illinois basin and then a torsion balance survey across the basin. According to Wasson, "This work, which started at the Indiana line and crossed a portion of the old fields, indicated a gravitational disturbance similar to that found on the south end of the old fields."

Economic conditions necessitated the abandonment of further geophysical investigations for the next few years.

REFLECTION SEISMOGRAPH.

The key that unlocked the door to hidden oil structures in the Illinois basin proved to be the reflection seismograph method. Encouraged by the success of this method in Oklahoma and Texas, the Pure Oil Company introduced it into Illinois in the

fall of 1935. Following a reconnaissance seismograph survey of a large area in the fall and winter of 1935–1936, the Pure Oil Company acquired a block of leases in April 1936, covering about 250,000 acres in Wayne, Richland, and Jasper counties, and extending approximately from Fairfield on the south to Hunt City on the north. Up to date some 25,000 acres are producing oil in the area of this block. These new fields extend with minor breaks for nearly 35 miles in a northeast-southwest direction.

STUDIES OF PENNSYLVANIAN STRATIGRAPHY.

The seismograph method, however, was not the only guide to exploration in the Illinois basin. Beginning in 1926, the Illinois Geological Survey began a far-reaching investigation of Pennsylvanian stratigraphy under the direction of J. M. Weller.

Reconnaissance studies by Weller resulted in the formulation of a theory of Pennsylvanian cyclical sedimentation that was tested by H. R. Wanless in the detailed mapping of two western Illinois quadrangles. Later reconnaissance studies by Wanless demonstrated that Pennsylvanian cyclothems, about 50 of which are now recognized in Illinois, can be traced and correlated for long distances. This new approach to the complex problems of Pennsylvanian stratigraphly has made possible the correlation of Pennsylvanian beds and the mapping of small subdivisions of the Pennsylvanian system in great detail. These studies were continued as rapidly as possible by Weller, Wanless, and assistants until all of the Pennsylvanian area in Illinois (about ¾ of the State) had been covered in reconnaissance. Evidence of structures favorable to the occurrence of oil in the basin was uncovered and the results for one of the most promising areas were published by the Survey early in 1936.[4] The report contains a structure contour map on the Omega limestone, which crops out in the area described.

[4] Weller, J. M., and Bell, A. H.: Geology and oil and gas possibilities of parts of Marion and Clay Counties, with discussion of the central portion of the Illinois Basin. Illinois Geol. Surv. Rept. Inv. No. 40, 1936.

Mr. M. W. Fuller, at that time a graduate student in the University of Illinois assisted in field studies of the Pennsylvanian in western and extreme southern Illinois as an employee of the Survey. Following his resignation from the Survey staff in the spring of 1934, Mr. Fuller was employed by the Carter Oil Company and later that year was assigned to studies of the stratigraphy and structure of outcropping beds in the Illinois basin and surrounding areas under the direction of Mr. E. V. Whitwell. Messrs. Fuller and Whitwell independently discovered and mapped the structures described in the Survey report mentioned above. Beginning in the fall of 1935 leases were taken in these and other areas on the basis of geologic studies of outcropping beds.

The pioneering efforts of the Pure Oil Company and the Carter Oil Company in exploring the Illinois basin and in leasing large blocks of acreage were followed by investigations and leasing by numerous other oil companies, both major and independent. Among the companies that undertook geological studies in the area in the fall of 1935 were the Shell Oil Company and the Texas Company. The publication of Report of Investigations 40, by the Illinois Geological Survey March 1, 1936, greatly stimulated interest in the territory. The first deep test wells in the Illinois basin were begun by the Pure Oil Company in the late fall of 1936 and were drilled with cable tools. In the meantime the first well drilled with rotary tools in Illinois was begun by the Adams Louisiana Oil Company, now Adams Oil and Gas Company, near Patoka in late December 1936. This well was located on a coal structure,[5] which was also mapped by seismograph. It came in for a 52 barrel producer from the Benoist sand, depth 1391–1418 feet, January 27, 1937, and was the discovery well of the Patoka pool. The Patoka pool is located on the west margin of the basin about 10 miles north of the old Sandoval pool, and accordingly was not as noteworthy a discovery as the first two wells in the central part of the basin. These were the Pure Oil Company's Weiler No. 1, completed February 26, 1937, as a 40-barrel producer in the

[5] Blatchley, R. S.: Illinois oil resources. Ill. Geol. Surv. Bull. 16, 1910, Pl. 14, opposite p. 142.

Cypress sandstone from 2608 to 2613 feet, the discovery well of the Clay City pool, Clay County, and the same company's Bradley No. 1, completed March 4, 1937, estimated initial production 100 barrels in the Aux Vases (basal Chester) sandstone, discovery well of the Cisne pool, Wayne County.

The first big producer in the Illinois basin was the Pure Oil Company-B. Travis No. 1, the discovery well of McClosky production in the Clay City pool, completed May 15, 1937, for an initial production of 2642 barrels.

Once large scale competitive leasing got under way in the Illinois basin there was little opportunity to use detailed surface geology as a guide to leasing because by the time detailed work could be completed in one area, the land would be leased by competitors. Some companies leased large areas, in some cases almost entire counties, and then began their detailed structural or seismograph investigations, or both. Numerous fields were discovered by a combination of geological and geophysical methods in which the seismograph work was located in an area where surface or coal data suggested the presence of favorable structure. The Louden and Patoka fields are examples of this.

NEW TECHNIQUES.

New techniques introduced into Illinois in connection with the development in the Illinois basin include rotary drilling, electric logging, and drilling-time logging. Coring and the testing of cores for porosity, permeability and saturation, acidizing limestone pays, cementing casing in wells, the shooting with nitroglycerin of sandstone pays, are among those techniques previously in use in the state but which were greatly expanded during the development of the new fields. Electric logs have proved a great boon both to production men and geologists. Where many wells are being completed in a short time the electric logs provide a ready means of obtaining stratigraphic and structural data important in planning further development. If it were necessary to depend for this upon sample study logs the time necessary to

obtain these data that are needed immediately would be greatly increased.

As has been pointed out by Levorsen in a recent paper,[6] the use of rotary drilling "gave a final and lasting boost to geology." In the old days of cable-tool drilling, logs were made by the driller, but owing to the nature of rotary drilling it is difficult or impossible for the driller to make a good log. Because the services of a geologist are needed to make an adequate log of a rotary well, in the words of Levorsen, "a much closer relationship developed between the geologist and the oil industry with the change of drilling."

In 1926 when the writer joined the staff of the Illinois Geological Survey he knew of only one oil company geologist resident in the State who was actively concerned with Illinois oil geology. Beginning about 1937 there was a rapid increase in the number of oil geologists employed in the State and at present the number is something like 200.

FUTURE TRENDS IN GEOLOGIC STUDIES.

Having considered the part played by geological theory in beginning the new development in the Illinois basin, let us consider briefly how the new data resulting from this development may influence geological theory and geological studies in the future.

The drilling of more than 13,000 wells for oil and gas in southern Illinois in the past 5 years has provided a wealth of new information on the subsurface geology of the State. The interpretation of these data in terms of geologic history is a formidable task. It is going forward in the offices of many oil companies and in the State Geological Survey. A forum for the discussion of common problems is provided in the monthly meetings of the Illinois Geological Society which is affiliated with the American Association of Petroleum Geologists.

[6] Levorsen, A. I.: Geology and oil discovery. Presented before the Illinois-Indiana Pet. Assoc. at Robinson, Illinois, June 7, 1941.

The fundamental problems of petroleum geology—the origin of oils, their mode of occurrence, migration, and accumulation, the nature and origin of the reservoirs and the reservoir rocks and their contained fluids, etc., will continue to engage the attention and thought of geologists in Illinois as elsewhere. Because a great majority of the oil pools of Illinois are found to be on or near anticlinal structures, efforts have been devoted largely, perhaps too much so, to the search for anticlinal structures. The importance of lenticular sands has been recognized in some areas, for example the old fields of Crawford County, and similar conditions are being revealed in some of the new fields in the Wabash River area. With increased knowledge of subsurface stratigraphy it is to be expected that more effort will be devoted to the search for stratigraphic traps. Although we may not have an East Texas it is quite possible that important oil occurrences under similar geological conditions may yet be revealed.

In conclusion, I should like to quote from a recent paper [7] by Levorsen.

> Thus we see how, as our theories and ideas change, our concept of the undiscovered reserve changes and that it has increased exactly in proportion as our limiting view points were destroyed. And so it goes, with the result that today our mental limitations on what constitutes favorable oil territory are at the lowest in our history and the favorable areas for future possible discoveries the highest.

The Illinois basin is an example of a prolific oil-bearing area where mental limitations in the past prevented exploration. Once these mental limitations were removed its opening could not long be delayed.

ILLINOIS GEOLOGICAL SURVEY,
URBANA, ILL.,
Nov. 4, 1941.

[7] Op. cit.