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INVESTIGATIONS ON SECONDARY RECOVERY
BY THE
ILLINOIS STATE GEOLOGICAL SURVEY

By Alfred H. Bell

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Introduction

Investigations directly related to the secondary recovery of oil have been carried on by the Illinois State Geological Survey for about sixteen years. They began with (1) studies of the air and gas repressuring operations during the period 1922 to 1931 and (2) studies of natural and accidental water-flooding which seemed to indicate good prospects for oil recovery by intentional water-flooding. Legislation to permit the water-flooding of oil sands was enacted by the State of Illinois in 1933. Several reports on the Survey's investigations, published during the period from 1932 to 1936, called attention to the favorable opportunities for secondary recovery in Illinois, especially by the use of water-flooding.

Illinois Basin Development

In 1937 the first commercial oil was discovered in the central part of the Illinois basin. This brought a great influx of oil operators into the State and a period of intense activity in the development of new fields. The major attention of the industry was naturally directed to these operations, and for several years little attention was given by the industry to secondary recovery. Now, however, ten years after discovery of oil in the basin, activity in the discovery and development of new fields has greatly declined and secondary recovery is again in the center of the

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stage. The old fields, discovered in 1905 and later and located mainly in southeastern Illinois, had a total oil producing area of about 106,000 acres, whereas the new fields, discovered since 1936 and located mainly in the Illinois basin, have a total oil producing area of about 200,000 acres. Thus the area potentially available for secondary recovery operations has been multiplied by three since the development of the basin fields.

Gas Injection

There are several major gas injection operations in Illinois which may or may not be classified as secondary recovery, according to the definition used. These include the operations in the Loudon field in Fayette County, the Salem field in Marion County, and the New Harmony-Griffin field in White County, Illinois, and Gibson County, Indiana. Because these operations were begun relatively early in the productive life of the fields they are generally called pressure-maintenance rather than secondary recovery.

Water-flooding

In recent years water-flooding has been more prominent than air or gas repressuring among secondary recovery operations in Illinois. Water floods were begun in or about 1943 in three widely separated areas, one in the old Siggins pool in Cumberland County and two in the new fields (Patoka and Clay City). They are credited with the recovery of about 6 million barrels of additional oil due to water-flooding, up to the end of 1946, of which it is estimated that about $2\frac{1}{2}$ million barrels were produced during 1946.

Extent of Secondary Recovery

To date the estimated total acreage affected by secondary recovery operations in Illinois amounts to 21,100 acres which is about 7 percent of the total oil producing acreage of some 306,000 acres. This is divided into 7,200 acres affected by intentional water-flooding (confined to the three areas mentioned above) and 13,900 acres affected by air and gas repressuring, mainly in the old Southeastern Illinois field. This does not include areas subject to pressure-maintenance by gas injection which total roughly 17,000 acres or about $5\frac{1}{2}$ percent of the total oil producing area. This makes a total area of about 38,000 acres affected by secondary recovery and pressure-maintenance or $12\frac{1}{2}$ percent of the total oil producing acreage. Although it is not to be expected that all of the remaining $87\frac{1}{2}$ percent or 267,000 acres will yield an economic return

from secondary recovery, opportunities exist for wide extension of these operations, and they will doubtless contribute a substantial addition to Illinois' ultimate oil recovery.

Work of the Survey

At present the Illinois Geological Survey has one petroleum engineer working approximately half time and one geologist working full time on secondary recovery. It is hoped to increase the personnel for these studies within the next year or two. In addition about 10 geologists and assistant geologists are obtaining data and studying the geology of the oil bearing rocks.

The Survey's work on secondary recovery during the past year has consisted chiefly of assembling available data on all the secondary recovery operations now in progress in the State, to be used in a report on Illinois that will be published in the American Petroleum Institute's forthcoming revision of the volume, "Secondary Recovery of Oil in the United States."

The Survey has under way an investigation of the clay minerals in the oil producing sands of Illinois with a view to determining in detail the effect of various clay minerals on the movements of liquids through the sands.

A considerable part of the Survey's work that is not directly on secondary recovery is closely related to it, as follows:

1. Geological studies of the oil bearing rocks and associated strata.
2. Chemical analyses of the reservoir fluids - oils, natural gases, and brines.
3. Physical tests of oil sand cores.
4. Investigations by the Survey's division of groundwater geology and geophysics on water supplies for flooding.

The Survey has issued many reports which include descriptions of the oil bearing rocks, one report on the chemical characteristics of Illinois crude oils and one on the physical tests of oil-sand cores. (See list of publications on secondary recovery, items 14 and 15.)

Future Plans

Plans for the future include preparation of reports evaluating the secondary recovery possibilities of various oil pools and oil producing formations in the State. Such evaluations will be based on available data on the thickness and character of the oil bearing beds and on the production histories for water, oil, and gas. It is anticipated that in some areas available data on the producing formations will have to be supplemented by additional laboratory tests of core samples, and the Survey plans to set up the necessary laboratory facilities.

Publications on Secondary Recovery in Illinois

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2. Alfred H. Bell and Frederick Squires, Preliminary summary of results obtained from a survey of repressuring operations in the Southeastern Illinois oil field: Illinois Geol. Survey Illinois Petroleum 23, 1932.
3. Alfred H. Bell, Further data on natural water-flooding in Illinois oil fields, in "Papers on improved methods of exploring for and recovering petroleum in Illinois," Presented at the Second Annual Petroleum Conference, Friday, June 1, 1934, Robinson, Illinois.
4. W. S. Corwin, Recent results in controlled water-flooding (same as ref. 3).
5. M. H. Flood, Air repressuring in the Colmar Plymouth oil field (same as ref. 3).
6. Frederick Squires, Recent developments in water-flooding in Illinois oil fields: Illinois Geol. Survey Cir. 23 and 23B, 1937.
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9. Frederick Squires, W. H. Voskuil, and A. H. Bell, Secondary recovery can salvage stripper well reserves in Illinois: Oil and Gas Jour., vol. 41, no. 35, January, 1943; Illinois Geol. Survey Cir. 90, 1943.
10. Frederick Squires, Oil field flooding streamlined for war - A suggestion: Oil and Gas Jour., vol. 42, no. 30, December, 1943; Illinois Geol. Survey Cir. 101, 1944.
11. Frederick Squires, Pressure maintenance by conjoint injection of gas and water - A wartime suggestion: Oil and Gas Jour., vol. 42, no. 42, 1944; Illinois Geol. Survey Cir. 103, 1944.
12. Frederick Squires, Resaturate while repressuring: Reprinted from Oil and Gas Jour., vol. 43, no. 44, March, 1945; Illinois Geol. Survey Cir. 118, 1945.
13. Frederick Squires, Flood tide in Illinois: The Producers Monthly, July, 1946; Illinois Geol. Survey Cir. 125, 1946.
14. O. W. Rees, P. W. Henline, and A. H. Bell, Chemical characteristics of Illinois crude oils with discussion of their geologic occurrence: Illinois Geol. Survey Rpt. of Inv. 88, 1943.
15. R. J. Piersol, L. E. Workman, and M. C. Watson, Porosity, total liquid saturation, and permeability of Illinois oil sands: Illinois Geol. Survey Rpt. of Inv. 67, 1940.