

PETROLEUM IN SOUTHEASTERN OHIO

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Next to Pennsylvania, Southeastern Ohio is the oldest oil producing region in the United States. However, at no time in its history has it been a large producer, and for the past forty years production has been gradually declining. This paper considers only those areas which produce Pennsylvania grade oil. All oil produced from Washington, Carroll, Columbiana, Harrison, Jefferson, Belmont, Meigs, Monroe, Hocking, Perry, Noble, and Tuscarawas counties is Pennsylvania grade, except the oil from the Corning pool in Perry county. This grade of oil is also produced in parts of Athens, Fairfield, Vinton, and Muskingum counties. Washington and Monroe have been by far the largest producers.

The pools, while numerous, are mostly small and not more than two or three include ten square miles. From the beginning of exploration in 1860 to the present time between 65,000 and 70,000 wells have been drilled, giving a developed area of more than 300,000 acres. Condit (1916) estimates the wells drilled in the Woodsfield quadrangle alone number about 2,000. There are now approximately 12,800 producing wells averaging about one-fourth barrel per day. The wells vary in depth from twelve to 3,300 feet. A number of the shallow wells, especially those in the Cow Run sand, are long lived. Wells in southeastern Ohio have nearly all been small, and the records rarely show one having an initial production as high as 500 barrels per day, though as high as 2,400 barrels has been known (Bownocker, 1921). The Pennsylvania grade oil varies from 28 to 50 degrees Baume in density. The most common color of the oil is dark green, but in places it is a bright red and elsewhere black.

GEOLOGY

The Appalachian geosyncline is the major tectonic element which accounts for the presence of oil in southeastern Ohio. The western flank of the syncline underlies this portion of Ohio. The regional dip is, therefore, to the southeast at the rate of about 35 feet to the mile (Verwiebe, 1930). At least three prominent structural features modify this large basin. Most prominent of these is the Cambridge Arch, known as the Burning Springs-Volcano anticline in West Virginia, which crosses the Ohio River into southern Washington county and can be traced into central Noble, western Guernsey, and eastern Coshocton county where it dies out. Paralleling the Cambridge Arch on the west is the deep Parkersburg-Lorain syncline. It begins in southern Washington county, trends northwest through western Morgan, western Muskingum, central Coshocton, and on into central Holmes county. Minor structural elements such as domes, noses, ravines and terraces are present in considerable abundance.

Producing Horizons.—The number of producing horizons in southeastern Ohio suffers by comparison with the large number found in Pennsylvania. Nevertheless, 24 different sands have produced either oil or gas, and of these twelve are of importance. In making correlations in eastern Ohio the principal reference bench is the Pittsburgh or No. 8 coal which lies at the base of the Monongahela formation of the Pennsylvania system. It is the most prominent coal bed of the state, and is sufficiently near the surface to act as a guide of reference to the Penn-

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sylvanian and Mississippian oil horizons. In descending order the major productive sands are: (Lockett, 1942)

Sand	Depth in Feet Below Pittsburgh	Sand	Depth in Feet Below Pittsburgh
First Cow Run.....	300	Maxton.....	950
Buell Run.....	350	Big Lime.....	975
Peeker or Second Cow Run.....	525	Keener.....	1,060
Macksburg.....	650	Big Injun.....	1,100
Salt Sand Group.....	750	Berea.....	1,600

The First Cow Run sand is the principal producer in the Cow Run, Newell's Run, and Moore's Junction pools. About one-third of the wells are dry holes, because of the erratic thickness and distribution of the sand (O'Rourke, 1942). The Macksburg sand is most important as a producer in the vicinity of Macksburg, but has produced some oil and gas in Noble, Athens, Meigs, Morgan and Monroe counties. It is patchy, rather coarse, and varies from 10 to 50 feet in thickness. The Second Cow Run sand has produced only in the area where it was first named in Washington county. The Salt sand was named because of the large amount of salt water commonly found in it. Scattered gas and oil wells produce from Meigs to Columbiana county. The Maxton sand is of somewhat greater importance, but because of its position at the base of the Pottsville is extremely erratic in its distribution.

The Big Lime of southeastern Ohio has produced considerable oil and gas in Belmont, Monroe, Athens, and Washington counties. The oil lies in thin layers of quartz sand which are interbedded with shaly limestone. The Keener sand lies below this limestone. It is an important producer of gas and oil in Monroe, Washington, Morgan, Athens, Noble, Guernsey, and Belmont counties. It is formed of alternating beds of fine and coarse grained sandstones, and in many places carries considerable brine. The average thickness is from 25 to 35 feet. This sand has been most important in the Graysville, Jackson Ridge, and Moose Ridge fields. The Big Injun sand is usually separated from the Keener by a few feet of shale. Sometimes they merge, and the entire sand is called the Big Injun. Only commercial production of oil and gas has been found in Washington and Monroe counties, and has been most important in the Sistersville field. The sand is coarse textured and contains some beds of conglomeratic nature. The thickness varies from 70 to 260 feet. It contains a great deal of brine, and many good Keener wells have been ruined by drilling into Injun water.

The most important horizon for oil and gas is the Berea, an exceptionally persistent sandstone which produces in every county in southeastern Ohio. Its thickness varies from 200 feet in the northern part of the area to as little as five feet, or even disappears in the southernmost sections. As a rule it is fine grained and light colored, but contains erratic lenses of coarser sand in which the oil and gas are found. In places it is interbedded with shales, and it may be represented only by sandy shales. Because of its widespread occurrence it has become the key horizon for sub surface mapping.

Relation of Production to Structure.—In southeastern Ohio, Cottingham (1927) states, three factors appear to govern the accumulation of oil: local structure, water content and energy of movement in the sand, and the porosity of the sand. The majority of the producing fields display some relationship to structure, although the relationship is rarely ideal. It has been estimated that 65 per cent of the shallow oil sand production, including the Berea, has some structural basis (Cottingham, 1927). Most of the crests of the anticlines or domes are devoid of oil. On the whole more oil has been found in the Berea on low noses, low on flanks of folds, or in shallow synclines, than on the crestal areas. Many of the Berea pools are at the upper end of structural embayments (Condit, 1912). Porosity alone can hardly account for this situation because it occurs too frequently with the

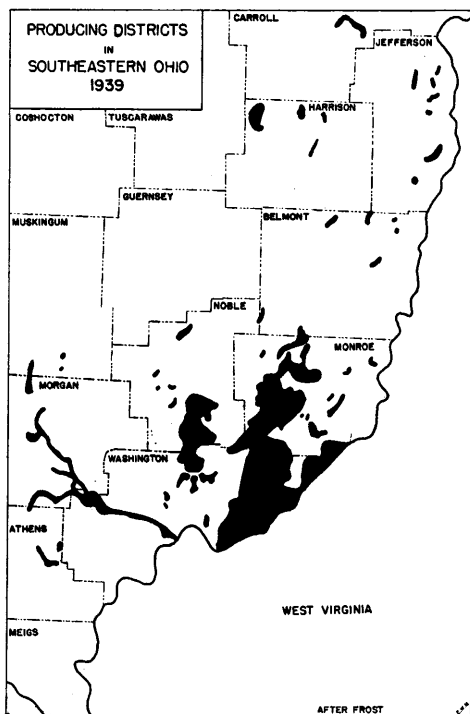
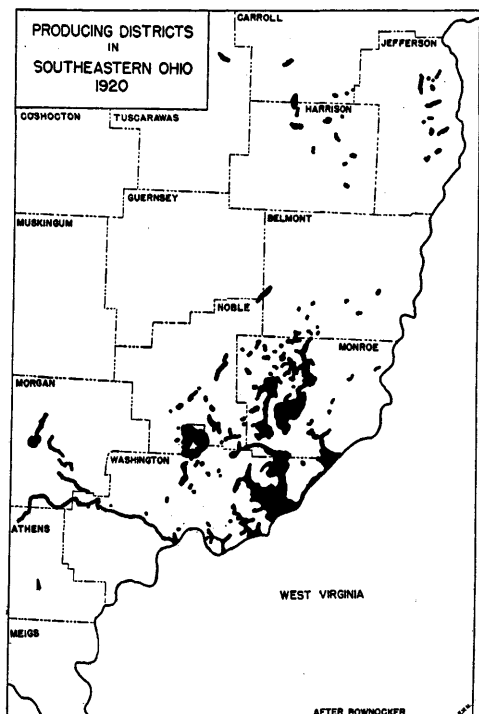
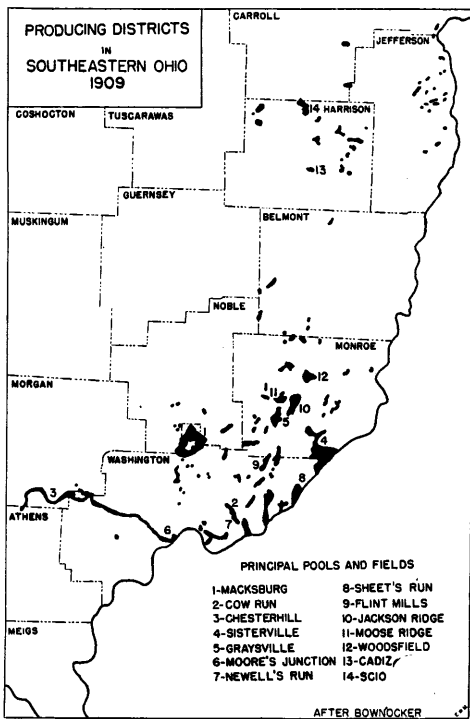
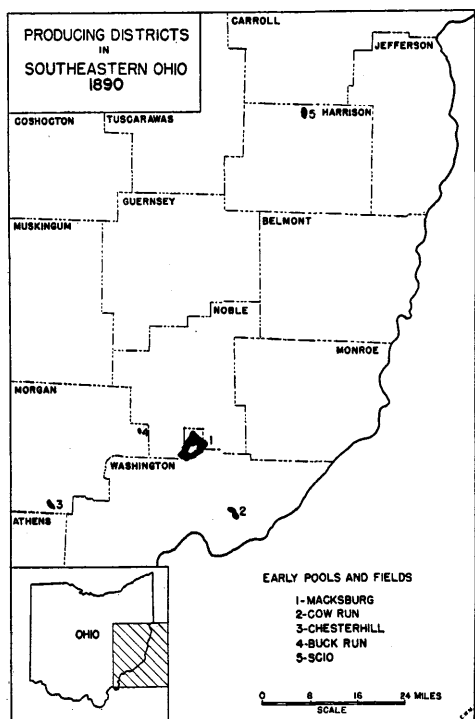


FIG. 1. The development of the Oil Region of Southeastern Ohio by periods.

same type of structure. Artesian conditions apparently prevail in the shallow sands, with the water movement being away from the hydraulic head along the Appalachian Plateau. Since the hydraulic gradient is low, and many sands are fine grained, the water movement is slow. It is possible that the disseminated oil was carried to the structural embayments and deposited because the velocity of the water movement is greatly reduced in these features (Rich, 1921). However, since so many pools are found where there are structural irregularities, it is safe to say that structure is the principal factor for the oil accumulations.

EARLY DEVELOPMENTS, 1814-1870

Oil from southeastern Ohio was known as early as 1814 when this substance was obtained as an impurity in the salt wells of Noble county. Occasionally, gas also escaped from such borings, and was looked upon with disfavor, because it was inflammable, and therefore dangerous. The first shipment of oil from this region occurred in 1843 when five barrels of "Seneca Oil" were shipped from Marietta to New York, by way of New Orleans. The oil was sold on arrival in New York to a drug house at 90 cents per gallon (Minshall, 1888). The principal use of petroleum at that time was medicinal, and from time to time small quantities were sold to drug companies. In 1852 a Pomeroy merchant made one of the largest shipments. One hundred barrels of oil were sent to St. Louis, and sold under the trade name of "Nerve and Bone" liniment (Bownocker, 1903). The first kerosene produced commercially in Ohio was distilled from Ohio shale near Buena Vista and from cannel coal from Flint Ridge, Warsaw and Canfield, about 1856-57. Twenty-five stills were in operation by 1860 and the business on a stable basis (Stout).

The finding of petroleum through drilling in Pennsylvania in 1859 prompted men in southeastern Ohio to investigate those areas where oil seeped from the earth, or gas issued from rock crevices. The first well was drilled in 1860 near a seepage on Duck Creek in Washington county. At a depth of 59 feet oil began to flow. Martin (1904) in his history of Ohio states, "In a few weeks the territory was full of prospectors and one could see derricks in every direction." Most of these shallow wells were producers, but excessive flows of water caused much trouble. In 1861 oil was discovered at Cow Run, and for a brief period this new area attracted the drillers. However, oil had been steadily declining in price, and since the only way to get it to market was to haul it by wagons over primitive roads to the Muskingum River, the profit of the individual producer was greatly reduced (Howe, 1891). Most of the shallow wells were short lived, and with the outbreak of the Civil War all efforts to develop the pools were abandoned.

The speculative flurry which swept the country at the close of the Civil War again directed attention to the oil possibilities of southeastern Ohio. Speculators from New England, New York, and Pennsylvania invaded the region for the purpose of leasing the land. Soon incorporated companies were formed with capital stock ranging from \$100,000 to \$1,000,000. Marietta alone had fourteen companies with a total capital stock of \$8,300,000 (*Marietta Register*, March 4, 1897). At this time the greatest development occurred south of Macksburg when a 50-barrel well was drilled at a depth of only 500 feet. Drilling progressed rapidly for several weeks, but the production did not meet with expectations, and transportation was inadequate. With the passing of the period of inflation the price of oil soon dropped, and as a result of economic conditions most of the principal producers withdrew from the field. Thus, the speculative period passed with no real discovery of oil.

While these developments were going on at Macksburg, drilling was almost at a standstill at Cow Run. In the spring of 1866 a well was drilled which had an initial flow of 100 barrels per day. Here again was the great expectation, and

the usual excitement. Territory that was regarded as productive sold at exorbitant rates. Chamberlin (*Oil News*, July 29, 1899) has described the development: "Excitement ran high. At one time there was a community of thousands at the Run and the hungry prospector had a hard time to find rations. I doubt if we shall ever see in this county (Washington) again such a jam of human beings and capital on so small a space of territory. . . . The derricks were so close together that it was difficult to drive a wagon through the valley." According to Minshall (1888) the production of the field from January, 1867, to August, 1868, was about 150,000 barrels. At first the oil was hauled to Marietta by wagons, but in 1868 the first pipe line in Ohio was laid from the field to Parkersburg, West Virginia, five and one-half miles away. Most of the wells drilled were small producers and short lived so that the production in 1869 had decreased to 89,000 barrels.

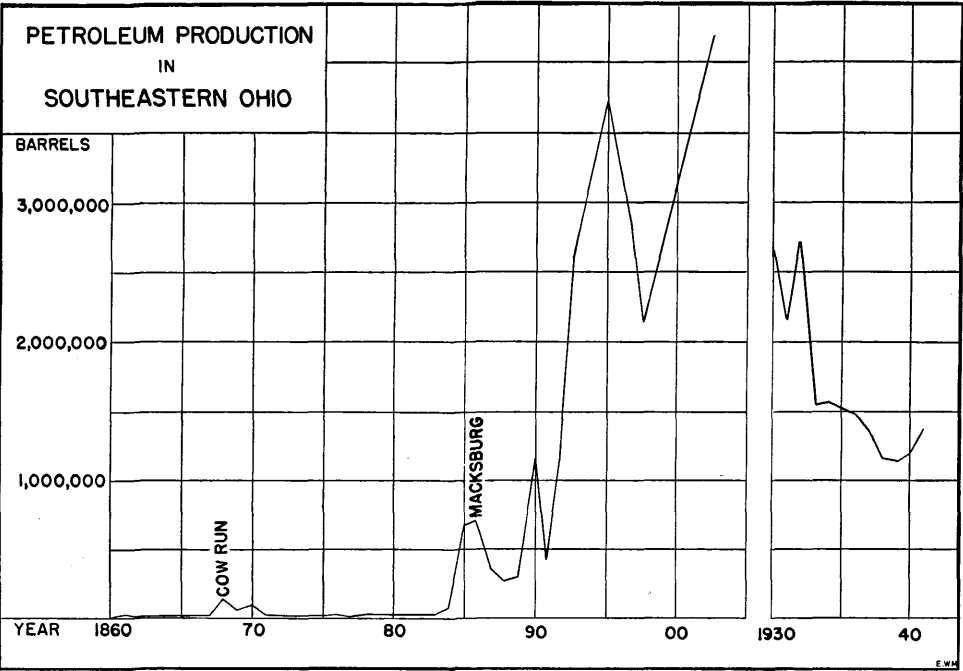


FIG. 2. Trend of petroleum production in Southeastern Ohio.

Little activity occurred until 1872 when a private producer started to survey the area around Macksburg. Minshall (1888) states, "The object of the survey seemed to be to start at Burning Springs and run a line through the producing districts of West Virginia and Ohio, taking the courses and distances of the producing wells, making a single map of the whole." During the survey a well was found that had been drilled in 1865 which was still pumping five barrels a day. After the well was cleaned out and torpedoed, production increased to 50 barrels per day. In the meantime the Cleveland and Marietta Railroad had been completed through Duck Creek Valley, making Macksburg a more desirable location for operations than it had been earlier. In 1874 one well yielded 150 barrels a day at a depth of only 150 feet. By 1877 thirty wells had been drilled in this vicinity (Lewis, 1928).

Most of the wells were either small or failures, and none went deeper than the Macksburg 500 foot sand. In 1877 a group of producers started to drill in search of the Berea sand, which was yielding oil in the White Oil district of West Virginia at a depth of about 1,400 feet. This first well in search of a deeper producing horizon reached the Berea at 1,427 feet, but it produced only brine and gas. This failure delayed the drilling of the second well until 1879, which flowed 15 barrels of oil per day, besides sufficient gas to pump the shallow wells. It was now proved that the Berea was productive in the area, but the production was too small to attract immediate attention.

MACKSBURG FIELD, 1879-1889

The development of the Macksburg field was retarded in the early 1880's by the country's financial depression which resulted in lowered oil prices, (*Marietta Times*, February 19, 1885), and by the unfavorable drilling conditions. The large body of salt water, between 900 and 1,100 feet, called for the latter amount of casing if the well was to be drilled to the Berea dry. So long as the production remained small, this added cost of casing acted as a prohibitive factor to any large scale development.

In 1883 a well was drilled on the upland which started at 100 barrels. This was the first of the large Berea producers, and at once led to extensive operations. The demonstration that oil existed beneath the hills, as well as in the valleys, greatly extended the possibilities of the field. In 1884 wells were drilled in rapid succession so that by January, 1885, more than 5,000 acres had been proved as productive territory. At that time there were 70 producing wells with a daily average of 700 barrels (*Marietta Times*, February 19, 1885). Drilling for the Berea also led to the development of the Macksburg 500 foot sand, and the Macksburg 140 foot sand. The production of the field increased rapidly as well after well was drilled. In August, 1884, it was 4,600 barrels; in December, 1884, 10,000 barrels; in March, 1885, 21,600 barrels; and in July, 1885, 79,700 barrels. From that time production decreased, the output having been 66,175 barrels in December, 1885, and 57,700 barrels in February, 1886 (Bownocker, 1903). For a yearly total the largest production occurred in 1886 when 703,945 barrels were produced.

There are no records as to the actual number of wells drilled, but the *Marietta Times* on February 5, 1885, reported, "About 100 new rigs are up in the Macksburg District for the purpose of putting down new wells," indicates that the number drilled must have been in the hundreds. The two largest wells drilled in 1885-86 are reported to have each started at 400 barrels, but the great body of Berea wells produced initially from 15 to 60 barrels per day. All contained sufficient gas to flow the oil, thus the operating costs were small.

One of the first problems with which the Macksburg producer had to contend was getting the oil to the market. The completion of a pipe line to the Cleveland and Marietta Railroad in the fall of 1883 gave temporary relief. A year later a pipe line was laid to the Muskingum River near Lowell, and the oil loaded on boats. Early in 1885 owing to cold weather the pipe lines were unable to carry the oil from the wells so that many tanks ran over, but it was considered a small loss because of the low price of oil (*Marietta Times*, February 5, 1885). In the summer of 1885 the National Transit, a subsidiary of the Standard Oil Company, laid a three-inch pipe line to Parkersburg, West Virginia. Shortly afterwards the National Transit bought the local pipe lines, and the transportation of the oil was from that time a comparatively easy problem.

As production increased at Macksburg, it became the Mecca of the oil fraternity. Hundreds of people poured into the area, largely from the Pennsylvania fields. The small country village of Macksburg grew into a city almost overnight. Hotels, saloons, drinking and gambling dens, brothels and boarding

houses were built by the score. With the population increasing so rapidly a food scarcity soon faced the inhabitants. Prices increased at tremendous rates. Many of the natives of Macksburg resented the influx of oil men with the resulting disorder. A number of ministers attempted to control the lawlessness, but before much could be accomplished production decreased, and the oil men began to direct their attention on new areas. By 1900 Macksburg was once again a small country community.

GREATEST REGIONAL DEVELOPMENT, 1890-1903

With the rapid decline of production in the Macksburg field, the drillers began to explore the adjoining regions. In 1890 a wild-cat well was drilled near Sistersville in Monroe county at a locality known as Pole-Cat. A vast reservoir of brine was found in the Big Injun sand, and the well considered worthless, and left standing for 18 months. In 1891 another well was drilled nearby and started to produce from 10 to 15 barrels daily. This was the first producer of the Sistersville field, and opened one of the largest oil districts in southeastern Ohio. As other wells followed, oil was secured in all, but with a flood of brine. In 1892 it was decided to pump the Pole-Cat well with the hope of reducing the salt water and thus securing oil. About 3,500 barrels of brine per day were pumped for weeks. Finally, it began showing oil and gas; this steadily increased until 500 to 600 barrels of oil per day were produced. Attention was now focused on the Sistersville field. Drilling progressed rapidly, and some of the wells made as much as 1,200 to 1,500 barrels daily (Bownocker, 1903).

By 1892 oil in southeastern Ohio had been found in a sufficient number of places to bring the entire region under consideration. In the next ten years thousands of exploratory wells were drilled. Every township had at least one wild-cat well. Since most of the drilling was carried out on unproven territory the percentages of failures were high. From 1891 to 1899, 2,450 recorded wells were drilled; of this number 860 were dry holes, or 34 per cent of the total. The greatest amount of drilling was centered in Washington and Monroe counties, but there was also considerable drilling in Harrison, Jefferson, Belmont, and Noble counties.

During this period 37 major pools were discovered. Production continued to rise from 1890 until 1903 when the peak was reached. In that year approximately 4,200,000 barrels of Pennsylvania grade oil were produced (Fig. 2).

Along with the drilling in new areas, the Macksburg field and a number of the older pools again attracted attention. Most of the wells drilled in the 1880's into the Berea were drilled wet. The object of the casing, which usually extended 65 feet below the Macksburg 140 foot sand, was merely to prevent caving, and not to exclude water. The salt water was kept from the oil horizon by placing a packer around the tubing a few feet above the sand. This could not be removed, since the salt water above would at once enter the sand and cause a deposit of paraffin around the hole. Thus, when sand obstructed the hole in the bottom of the tubing, or the pores of the rock became closed the production of the well ceased though the oil was not exhausted. Redrilling began about 1895. The new wells were drilled dry, and by 1903 most of the older productive territory had been reworked. The majority of the wells started from 4 to 50 barrels, while formerly their initial production ranged from 10 to 400 barrels (Bownocker, 1903).

While many pools caused local boom conditions during the 1890's, none attracted more attention than Scio in Harrison county. The search for oil in this area began in the early seventies, but drilling at that time was too shallow to reach the pay horizons. The discovery of oil near Jewett in 1895 appears to have encouraged a renewed interest in the vicinity of Scio. Progress was slow, but by 1898 the Scio Oil and Gas Company was organized with a capital stock of \$10,000. However, the people had little faith in the company and the stock did not sell rapidly. Even after the first producer little attention was paid to the oil industry.

The first well drilled to the Berea began to produce June 7, 1898, at 18 barrels per day. The second well was also a small producer, and on its completion was not pumped for several days, at the end of which time it began to flow. As a result, the gas caught fire from the boiler and burned the derrick. This accident was widely publicized, and as usual the production exaggerated. This attracted the attention of the oil men, and started a boom which in a short time revolutionized the village.

At the time of the discovery of oil, Scio had a population of about 900, composed largely of farmers and merchants. It had long been the favored spot of Methodist ministers who had gone there because of the advantage the Scio College offered their children. Only once in 18 years had there been a saloon in the town

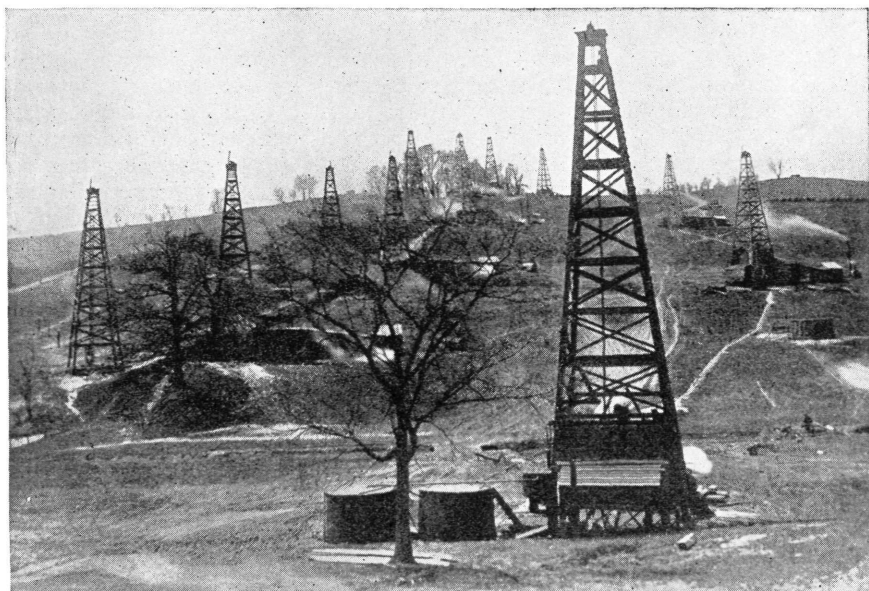


FIG. 3. Scio Oil Field during the Boom. (Courtesy of Ohio State Museum.)

and it was driven out by the angry citizens. The discovery of oil made a complete change in the appearance of the town. The population by January, 1899, was over 12,000.

"The village was unable to care properly for one-tenth of the people who had so suddenly gathered there. They lived in tents, shanties, reconstructed stables, boiler houses, or wherever they could find shelter. Many slept in chairs. Hundreds unable to find lodgings left on evening trains for nearby towns, returning the following morning" (Bownocker, 1903). There were eleven saloons in the town and an unknown number of "speakeasies." The barrooms and inns were a wild mass of teamsters, producers, workmen, speculators, mechanics, fakirs, gamblers, prostitutes, and hotel keepers all carrying on business and carousing. These features so horrified the staid citizens that many sold or rented their property and moved away.

Teamsters were in so great demand that frequently \$40.00 a day was paid for their services. One operator reported having paid twenty dollars to have an ordinary boiler dragged sixty feet. The macadamized streets of the village were

soon cut through and converted into mere mud channels. As the town grew, the fire hazard became greater so that insurance rates for choice locations were frequently as high as \$100 per month. With the coming of oil the college almost disappeared. In eight weeks' time the attendance dropped from 300 to about 25, and all departments of the school except two were moved to New Philadelphia.

The time of greatest excitement occurred in the early months of 1899, when there were 75 strings of tools at work. After that a rapid decline set in, so that by 1900 the population had dwindled to about 1,200. Nevertheless, the village did not recede to its former condition, for an enormous amount of money was left in the community.



FIG. 4. Bishop Oil Field, Woodsfield, Monroe County, 1900.
(Courtesy of Ohio State Museum.)

The total number of wells drilled was about 1,000. Of these perhaps 220 were within the corporation limits of Scio. Bownocker (1903) states that from a financial viewpoint the village wells were failures because of their close spacing. At the height of the boom about 5,000 barrels of oil were produced per day, but by 1901 this had decreased to 300 barrels. Today the field is still producing in very small quantities.

PERIOD OF DECLINE, 1903-1942

Since 1903 there have been no important discoveries of oil in southeastern Ohio. The drilling policy has been to extend the limits of the fields and to maintain as stabilized production as possible. Drilling, as previously, has been most active in Washington and Monroe counties. The possibility of securing a gas well along with a small amount of oil has been the principal incentive for drilling during the past two decades. Production has declined uniformly at the rate of two to four per cent each year; so that the 1941 production was 1,176,000 barrels.

Southeastern Ohio was the scene of one of the first attempts of producers to increase the rate of production by secondary recovery methods. In 1903 a pioneer producer in the Macksburg field began to repressure using gas. After applying pressure for ten days, it was released and the well produced at a great rate. This procedure became known as the Smith-Dunn process.

In 1911 repressuring was again tried near Chesterhill in Morgan county. About 150,000 cubic feet of air per day was forced into one well at a pressure of 40 pounds, and within a week the production of the surrounding wells had increased (Schaefer, 1941). After the initial success at Chesterhill, the process soon spread to other areas. Lewis in 1917 stated that about 4,000 wells were affected by repressuring on more than 90 leases. It is estimated that approximately 80 per cent of the early projects were successful, and records from 32 properties show an average increase of three and one-half times the production from time repressuring began (Schaefer, 1941). Gas was used when available, but more than 90 per cent of the repressuring units used air.

At the present time the largest repressuring project in Ohio is located in the Sistersville field. The productive area is now approximately 10,590 acres. The wells very early in the life of the field were placed on vacuum pump, and as larger and more pumps were installed the vacuum was increased in 1910 and 1916. Just prior to the introduction of pressure in 1933 the vacuum over the entire pool was 25 inches (Schaefer, 1941). Approximately 1,500 wells were completed in the pool since 1892. There was originally one well to 6.84 producing acres, but because of many abandonments there is now one well to 17.7 acres. To the time of repressuring the average production per well was 13,450 barrels and a recovery of 1,965 barrels of oil per acre. There are now 374 producing wells in the field. Five operators control the production, and all have agreed to repressure as a unit operation. Gas is injected in fourteen old wells and five new ones. Each well has its own pressure plant. Injection pressures vary from eight to ten inches vacuum in the center of the pool to 100 pounds pressure on the northwestern edge (Schaefer, 1941). The average daily intake volume is from 100,000 to 150,000 cubic feet. In the beginning about ten million cubic feet of outside gas was used to establish the cycle. At present about three million cubic feet of gas is pumped daily, of which 1,600,000 cubic feet is returned to the sand. At the start of the gas injection in June, 1933, the average daily production of the pool was 124 barrels per day. This slowly increased and reached a peak of 337 barrels per day in March, 1939, a gain of about 172 per cent. Since that time a slow decline has set in.

At present there are eight repressuring projects in Washington, Morgan, and Monroe counties. The shallowness of the producing sands, the close spacing of the wells, and the low injection pressure required are the chief factors that favor repressuring. The greatest disadvantages are the lack of preliminary work done to determine the exact nature of the horizontal and vertical changes in porosity and permeability of the sand reservoir. There is also some difficulty in the by-passing of gas from the injection wells to the producing wells so that in certain cases the gas does not move through those areas that are still saturated with oil.

The possibility of water flooding as a means of secondary recovery has been considered in southeastern Ohio. The Berea formation has been successfully flooded in northeastern Ohio in Medina county. The Big Injun and Cow Run formations have high permeability and could be flooded. The greatest disadvantage to water flooding is that the average recovery per acre of petroleum in southeastern Ohio has been low. Therefore, water flooding recovery methods using new drilling would not be economically applicable in many places (O'Rourke, 1940). Financial success of flooding will depend largely on acquiring leases at a reasonable price that have had a satisfactory natural production. It has been

estimated that with a spacing of one well to four acres, which will permit five rows of five inputs and four rows of four producers in each quarter-section, the cost of flooding will be (O'Rourke, 1940):

Depth	Cost per Acre
450 feet.....	\$ 650.00
700 feet.....	1,100.00
1,200 feet.....	1,600.00
1,500 feet.....	2,000.00

One of the first horizontal wells in the world was drilled in southeastern Ohio. The process of horizontal drilling requires the sinking of a shaft to the oil sand and then drilling horizontally into the sand. Ranney (1941), the inventor of the process of horizontal drilling, states, "In the Ohio experiment six wells were drilled horizontally from a shaft in the First Cow Run sandstone. These three-inch wells were drilled in opposite pairs, half of them to property lines. While a 50-foot core was being pulled from one well, the drill rods (and duplicate tools) were being run into the opposite well. This was accomplished by a new machine, known as a 'rod puller,' which moves the rods at the rate of 100 feet per minute. The drill rods, in ten-foot lengths, were not disconnected until both wells were completed. In deep holes this cuts drilling time at least 75 per cent."

Horizontal drilling has a number of advantages over the usual method. It conserves steel, for horizontal wells require neither derricks, casing, nor tubing. The drilling of this type of well requires less than one-tenth of the power for the same length of sand exposed by vertical operations, and each shaft operating upwards of 400 acres exposes some 50,000 feet of producing oil sand. The greatest disadvantage to the extensive use of this method in Ohio is the initial cost. The total cost of shaft, equipment and two wells is about \$75,000. At the present time the production from the Ohio horizontal well is about 2,000 barrels per year.

PRESENT CONDITIONS

The oil industry of southeastern Ohio has been suffering from depressed conditions for more than two decades. In 1939 the *Oil Weekly* reported that Ohio had the least return per dollar spent of all petroleum producing states. If both oil and gas were included for that year, there would have been a 75-cent return for each dollar spent. It is difficult to present actual costs of producing a barrel of oil in this section because of a lack of records for most leases, and in many instances producers' records are not kept under the desired classifications. The most recent attempt to consider production costs was made in 1941 when the Pennsylvania Grade Crude Oil Association prepared a brief for the Office of Price Administration. In order to obtain costs for the district, the most accurate method seemed to be to obtain from the producer the total "out-of-pocket" expense paid in connection with the given production. From the producer's total expense any amount paid for new drilling, new equipment of a capital nature, and interest on borrowed money were eliminated. A reasonable amount to represent compensation for personal services was included. To this was added the cost of depletion, depreciation, amortization, gas sales, and interest on investments as given for the past eight years by the Petroleum Administrative Board and the United States Tariff Commission. The total was then considered to be the total of the producer's operating and general overhead expense.

The data gathered covered eleven properties on which are located 1,630 wells. The total production of the wells was 147,534 barrels, which was thirteen per cent of the total for southeastern Ohio. It was found that it cost \$2.70 for each barrel of oil produced in 1940. The costs were divided in the following manner: depletion, 14 cents; depreciation, 35 cents; amortization of intangible development costs, 27 cents; general expenditures, \$1.83; interest, 30 cents; less 19 cents for

the sale of gas. In 1940 the average price paid for the Pennsylvania grade crude of Ohio was \$1.87. This crude was sold at a loss because it had to compete with areas of lower cost production.

Table I is a summary of production costs which shows the percentage of Pennsylvania grade oil that can be produced at or below 1940 costs in each of the producing states, i.e., Pennsylvania, New York, West Virginia, and Ohio. A special study was also completed by the Pennsylvania Grade Crude Oil Association

TABLE I
PERCENTAGE OF PENNSYLVANIA GRADE OIL PRODUCED BY STATES, AT OR BELOW
COST SPECIFIED FOR THE YEAR 1940

	Penn- sylvania	New York	West Virginia	South- eastern Ohio
Less than .40 per barrel.....				
Less than .80 per barrel.....				
Less than 1.20 per barrel.....				
Less than 1.60 per barrel.....	9.87			
Less than 2.00 per barrel.....	43.04		3.88	
Less than 2.40 per barrel.....	53.69	38.00	8.12	49.10
Less than 2.80 per barrel.....	64.90	46.00	10.92	51.62
Less than 3.00 per barrel.....	79.77	59.00	58.30	55.16
Less than 3.20 per barrel.....	90.87	86.50	64.22	100.00
Less than 3.40 per barrel.....	94.31	92.30	97.37	
Less than 3.60 per barrel.....	97.86	94.70	98.23	
Less than 3.80 per barrel.....	98.41	96.00	98.63	
Less than 4.00 per barrel.....	99.00	96.70	98.95	
Less than 4.20 per barrel.....	99.06	97.00	98.95	
Less than 4.40 per barrel.....	99.42	97.30	100.00	
\$4.40 and over per barrel.....	.58	2.70		

TABLE II

	Crude Market 1941	Production Barrels per Year—1940	Per Cent and Barrels Which Can be Produced Without Loss Under Present Crude Market	
			Per Cent	Barrels
New York (Allegheny).....	\$2.75	3,462,120	45	1,557,954
Bradford.....	2.75	14,285,000	76	10,856,600
Kane to Butler.....	2.68	3,713,000	15	690,717
Pennsylvania (Comp.).....	2.73*		63	
West Virginia.....	2.34	3,400,000	4	137,760
Southeastern Ohio.....	2.30	1,176,000	24	282,240
		26,036,120	52	13,525,271

*Weighted price.

to determine the percentage of crude that could be produced profitably from each of the districts at the market price of August 23, 1941. This was done by direct calculation of the costs for producing a barrel of crude oil. These percentages together with the market price of crude, the yearly production for each district for 1940, and the barrels of crude that can be produced without loss under the stated market price are shown in Table II. Multiplying the production of each

district by the percentage which can be produced at a profit gives the number of barrels that can be produced without loss. This shows that of the 1,176,000 barrels produced in southeastern Ohio in 1940 only 283,240 barrels, or 24 per cent, were marketed profitably.

However, it can be expected that this region will continue to produce at a gradually decreasing rate for many years. In 1941 the American Petroleum Institute estimated the Pennsylvania grade oil reserve of Ohio at 595,000,000 barrels. Of this amount 30,284,000 barrels are recoverable under present methods. Little or no allowance was made for secondary recovery methods; so it can be reasonably assumed that the actual recoverable reserve is twice the above figure, or 60,000,000 barrels. At the present rate of production this is approximately a 50-year reserve.

In spite of the fairly large recoverable reserve, the low price of oil has resulted in many abandonments, as illustrated by the following chart:

Year	Production	New Wells	Abandonments	Average Crude Prices
1938	1,161,000	72	1,105	\$1.40
1939	1,160,000	70	823	1.60
1940	1,176,000	112	739	1.87
9 months 1941		121		

At the present time the junk value of wells is \$800 to \$1,000 and the need for steel will doubtless stimulate this trade unless a higher price for oil is obtained. Many producers find it preferable to salvage material and obtain cash rather than to continue production.

The increased demand, created by the present war needs, has stimulated new developments slightly. Production in 1941 increased approximately 500 barrels a day over that of 1940, and could be further increased. There was considerable development in older areas and wild-cattling for new pools resulted in the discovery of the Clayton Perry Pool in Clayton township, Perry county. Its area is about 2,000 acres and is now producing at the rate of 1,400 barrels per day with an estimated total recovery of 3,000,000 barrels. Its area has not been completely defined, nor, due to the 3,200 foot depth and corresponding drilling costs, will there be substantial further development under conditions as they exist today. There are a number of areas which will be prospected for new pools with a rise in the market price, some cleaning out of old wells will be done, some new secondary recovery projects will help maintain or increase production, but for the immediate future the main increase in production will come from new areas and further development of the Clayton Perry Pool.

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