Current Oil Exploration in Oklahoma

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Oklahoma has been an important oil-producing state for more than a half a century. Since the first recorded production in 1891, 6½ billion barrels of oil have been recovered from beneath the surface. The peak production was reached in 1927 when 277,775,000 barrels of oil were recovered.

Today, twenty-five years after the peak production year, oil remains Oklahoma's most important economic resource. Ninety per cent of the total value of all minerals in Oklahoma is assigned to petroleum. In production the state ranks fourth in the nation, in spite of fifty years of exploitation of this valuable underground product.

The total footage penetrated by drill bits in search of oil in Oklahoma last year exceeded twenty million feet. Reduced to miles, this amounts to 3900 miles of hole. To the inquisitive mind the questions arise: "Why is there so much drilling in the state now, after fifty years of production? How long can the oil industry afford to continue to increase yearly the total footage drilled in Oklahoma as they have the past few years? And finally, what is the future of Oklahoma with regard to oil production?"

When I selected the answering of these questions as the basis for my talk to you today, I was of the opinion that the answers would center about the results of scientific research in methods of exploration and exploitation. I thought the subject was pertinent and of both academic and practical interest. As the subject began to develop, however, I found myself emmeshed in legal and economic aspects of the oil industry which rapidly overshadowed the importance of improvements due to scientific research. The information (I think of it more as a revelation) that I am going to give you is therefore largely a summary of the results of many hours of conferences with lawyers, accountants, engineers and geologists associated with the oil industry.

The reasons 3900 miles of hole were drilled in Oklahoma may be classified into four categories: (1) price of oil, (2) the tax situation, (3) improvement of methods and techniques, and (4) new oil discoveries.

The price of crude oil today is $2.63 per barrel. This is not an all-time high; in 1920 the price was $3.50. On the other hand, it is far from the low of 1933 (May) when oil was twenty-five cents per barrel. It is customary these days to compare prices with those in 1939. Crude oil in 1939 averaged $1.05 per barrel. It is obvious that oil today, even in terms of the inflated dollar, is worth considerably more than it has been during the last twenty years. Naturally, this has encouraged drilling operations.

The present tax situation is probably the most important single reason for the extensive drilling campaign being carried on today. A number of citizens and corporations have found themselves in the 80 per cent bracket. The government takes 80 cents out of every dollar they earn. The oil business offers investors the opportunity to "write off" a number of items as current tax deductions. In other industries similar items would be pro-rated over a number of years.

When an individual or company invests a considerable sum in the purchase and development of an oil lease, all of these expenses can be deducted if a dry hole results. If they find oil, they can still deduct the drilling costs, and in addition, they are assured that 27½ per cent of their income from the well is tax-free. Such an arrangement brings about an unusual situation. A well can be drilled which costs $80,000. Let's assume that this well will produce $60,000 worth of oil during its lifetime. The apparent loss is $20,000. However, if this well were financed with capital subject to 80 per

cent tax, it actually cost the investors $16,000. In other words, it was drilled with "twenty-cent dollars." Had the investors not spent the $80,000 on the well, taxes would have taken 80% of the sum and left them only $16,000. Of the $60,000 returns from the well, 27½ per cent is tax-free—roughly $15,000. The investor will pay 80 per cent tax on the remaining $45,000, leaving him $13,000. He therefore invested $16,000 and his returns are 15,000 tax-free dollars plus the $13,000. He has netted $12,000 on the project. If the well had been a dry hole, he could sell the equipment and deduct the remaining as capital loss. It is easy to understand why oil investors range from high-salaried movie actors to large corporations, in no way connected with the oil industry.

The third reason to account for the drilling of 5,626 wells in Oklahoma last year is the improvement of drilling and production techniques. As these two subjects are so inclusive, it is necessary to separate them for discussion, and even then I shall mention only a few of the important advances. Considering improvements in producing techniques first, we are immediately in a complex and highly technical field. I will speak of these improvements in general terms, not because I am doubtful if my audience would understand the detailed explanation, but because I am not well-acquainted with the details myself.

The degree of permeability in a reservoir bed often determines the success or failure of an oil well. For at least 20 years attempts have been made to increase the permeability of an oil zone by acidizing it or by exploding nitroglycerin against the face of the zone in the well. A considerable degree of success has been attained by these methods. Within the last four years an entirely new technique for increasing the permeability has been introduced in Oklahoma. Fluid pressure is applied to the potential producing formation down in the well with such intensity that the formation is literally split apart with many small fractures. Sand grains are often introduced into the formation which serve to hold the fractured surfaces apart. The resulted increased permeability created by this method has apparently made producers out of many wells which otherwise would have been abandoned as dry holes or non-commercial wells.

Improved methods of recovery are constantly being studied in both the field and laboratory. It is estimated that in a body of oil-saturated rock the usual recovery is only fifty per cent of the total oil. By carefully studying the reservoir conditions, that is pressure, the oil, gas and water ratio, and the permeability, a greater recovery is possible now than was obtained twenty years ago. Many of the oil pools in Oklahoma are of the desirable type suited for secondary recovery by "water flooding." Basically, the process consists of forcing water into some wells and letting the water flush the oil out of the containing sand through other wells. Water flooding projects were in operation in 64 separate pools last year. The most extensive of these projects is the North Burbank project in Osage County. It is expected to raise field production from 4,500 to 20,000 barrels of oil per day. Another method of secondary recovery is the restoration of pressure by the injection of gas in old fields.

Improvements in drilling techniques have been numerous. To mention only a few: The widespread use of the portable and semi-portable drilling rigs has been an important factor in reducing the cost of drilling, thus encouraging more drilling. Improvements in well-testing apparatus have undoubtedly resulted in the completion of wells which would have been abandoned in the thirties. Most important is a better understanding of the electric log, a method whereby the electrical properties of the formation are measured. The results are then interpreted in terms of type of rock and type and amount of fluid contained in the rock.

The mechanics of actually testing a possible oil-bearing formation without the expense of cementing thousands of feet of pipe in the hole have

been considerably improved. The improved method of testing, combined with the information obtained from the electric log, assures the investors that most possible producing zones are now examined, thus decreasing the possibility of abandoning a potential producer.

A large industry has developed whose sole product is the mud which comprises the drilling fluid so necessary with the rotary rig. The weight, viscosity, and gel properties of a mud are tailor-made for each drill hole today. The importance of the selection of the correct type of drilling mud is exemplified in the Golden Trend area west of Pauls Valley. The producing sandstone of Pennsylvanian age contains clay material. It was discovered that the water used in the drilling mud was being absorbed by the clay, thus causing the clay to expand. The expansion was sufficient to block the permeability of the sandstone and prevent the flow of oil into the drill hole. An oil base mud was substituted. The oil did not affect the clay and flowing wells were developed.

The final major factor contributing to the present extensive drilling campaign in Oklahoma is the continual discovery of new production. Deeper production is being found in oil fields; shallower production is being found in old deep fields; known fields are being extended in one or more directions; and finally, oil is being found away from present producing areas.

Approximately 900 wells were drilled last year which can be classed as "exploratory" wells. An exploratory or "wildcat" well is one drilled to an untested reservoir bed or one drilled on an unexplored trap. Of the 900 exploratory wells, 20 per cent were successful. The percentage is high. Only about 10 per cent located oil at some distance away from older producing areas. This figure is close to the national average of successful "wildcats;" that is, only one out of every ten produces oil in commercial quantities.

The last subject of my talk is the investigation of the nature of these new discoveries in Oklahoma. Since no really new oil zones have been found in our state for a number of years, some explanation of the new oil fields is in order.

New fields in the western half of the state are of most interest because this large area is comparatively untested. Most of western Oklahoma is underlain by a broad downwarp of the rocks known as the Anadarko Basin. The axis of the basin trends in a northwesterly direction between the Arbuckle-Wichita Mountain trend on the south and a rather indefinite northern margin extending into Kansas. The region is considered to be one of the most favorable in the United States for future oil development. Unproved land is being leased today at prices ranging from one to twenty-five dollars an acre, depending upon the nearness of known occurrences of oil.

The development of the area is slow because exploration is very expensive. Single test wells frequently cost from $200,000 to $700,000. Drilling locations are usually determined by seismograph surveys and regional subsurface geologic studies. The basic measurement obtained by a seismograph is the determination of the depth of a "key bed." This is ascertained by measuring the time it takes for a shock wave to travel down to this key bed and return to the recording instruments at the surface. Underground structures favorable for the accumulation of oil may be discovered by determining the position of a key bed over a selected area. There have been a number of improvements in mapping by seismic methods in recent years. The main reason all possible structures are not checked by seismograph before drilling is economics. It costs about $600 a day to keep a seismograph crew in the field. Many of the independent operators would rather invest their money in a test hole than to obtain further information regarding subsurface conditions.

The regional geologic work entails the determination of possible reservoir rocks, their location, mapping possible producing structures with information obtained from previous test holes, and general guesswork from any information that is available.

The test wells now being drilled in western Oklahoma are usually located on some type of arching in the rocks as determined by seismograph in areas where subsurface geologic studies indicate favorable reservoir beds. For example, an exploratory test in Ellis County was drilled about 21 miles west of Woodward last summer (Sec. 22-T.23N.-R.24W.). The company financing the well bought acreage in this general area because their subsurface studies indicated that conditions here were favorable for the stratigraphic accumulation of oil. Then sent a seismograph crew into the area hoping that they would discover a structural "nose." The results were even better than they anticipated—the existence of an anticline was determined. The well was drilled on the anticline and production was obtained from a sandstone of Pennsylvanian age at a depth of 8,455 feet, thus opening a new field.

A similar discovery was made by another company about eighteen miles to the northwest in Harper County (Sec.4-T.25N.-R.25W). Production comes from the same general zone. The well was located by the same type of information.

The history is the same for most of the other recent discoveries in western Oklahoma. In the absence of surface geologic information and of sufficient subsurface knowledge, exploration is slowly progressing by seismograph and regional studies. Single well locations are made with a certain amount of pessimism, but each hole adds necessary knowledge which makes the next location appear a little more encouraging. An interesting example is a well completed last September sixteen miles northeast of Enid (Sec. 20-T.24N.-R.4W). Seismograph exploration accomplished fifteen years ago indicated an anticline. As there were no nearby wells giving information on subsurface conditions, the prospect was shelved. In 1949, the Rich Valley discovery was made about ten miles to the north (Sec.36-T.26N-R.5W.) In 1951, the Southeast Rich Valley field was discovered. The company decided that the anticline they found fifteen years ago was along the trend, so they drilled it, "Stratofraced" the pay zones, and obtained a 368 barrel a day discovery well from a basal Mississippian sandstone and an Ordovician sandstone.

There seems to be little question regarding the presence of numerous stratigraphic traps existing in the western half of the state. The problem is to locate the traps. There is no instrument or divining rod which will indicate their location. The typical stratigraphic trap in the region consists of sandstone bodies which disappear updip. The oil migrates through the porous sandstone and accumulates in the area where the sandstone disappears. Just last month one of the major companies completed a 566 barrel well in a Pennsylvanian sandstone of this nature (Sec. 1-T.3N-R.4W) about twenty miles west of Pauls Valley in Garvin County. Again the well was located on a seismograph "high" in an area of suspected stratigraphic traps.

Occasionally, a producing well is completed in an area of numerous dry holes. One such producer will revive interest over a number of townships. Such a well was brought in two months ago near El Reno (Sec. 14-T.12N-R.7W.) The well was located on seismograph information and found Ordovician sand production at a depth of 10,318 feet. The well produced fifty barrels of oil and 12 million cubic feet of gas in twenty-four hours. As a result, Canadian County will be the site of much more activity in the coming months.

There is no assurance that additional drilling around a new discovery will always be profitable. The West Noble Pool, about seven miles southwest of Norman (Sec.30-8N-2W) is a one-well pool in which no oil

has been found except at the original discovery site. The sixth dry hole within a half-mile of the discovery test was abandoned last week. In this pool the total footage penetrated by seven wells is 61,500, as the pay zone is more than 8000 feet below the surface.

Eastern Oklahoma, the location of most of the older oil fields of the state, is still a very active area today. Generally, wells in this part of the state are not such rank "wildcats" as those in the other half of Oklahoma. In much of the area it is difficult to find a drilling location which is not within two miles of an earlier test. The distribution and stratigraphic position of the reservoir beds is well-defined compared to western Oklahoma. Exploration is largely a matter of detailed subsurface geologic work in areas which have previously been hastily examined and, in many cases, hurriedly drilled.

New production in eastern Oklahoma is found under several conditions. Additional drilling in older producing fields is common. In some cases, new production is obtained from reservoir beds lying several hundred feet above the current producing zone. For example, the West Norfolk Pool just north of the town of Cushing produced oil for years from an Ordovician sandstone at an average depth of 3900 feet. At the present time, appreciable production is obtained from a Pennsylvanian sandstone occurring about 1000 feet closer to the surface. The shallower production was discovered by re-examining the records of the old wells. Indications of gas at shallower depths were noted in some of the logs. A small enterprising company decided to test the sand, and the new production was obtained.

Most of the older oil pools in Oklahoma were drilled with one particular oil zone as the objective. Little attention was given to other possible producing zones. Many of the discoveries in northeastern Oklahoma of the past few years have capitalized on this error in earlier drillings. Of course, the discovery of a new oil zone in an old field stimulates activity in all nearby fields.

Many of the oil pools drilled from 1912 to 1930 in northeastern Oklahoma produced from the prolific Pennsylvanian sandstones, such as the Bartlesville, at relatively shallow depths. Considerable drilling in later years has been directed toward deeper oil zones in these fields. Although not many pools remain which have not been tested for deeper production, additional reserves are found every year in reservoir beds below the chief producing zone in old fields. Just two weeks ago, a well was drilled in an old Bartlesville sandstone field in southern Tulsa County (Sec.36-T.17N-R.13E.) The well was completed as a thousand barrel a day well from the Arbuckle limestone, the oldest producing formation in Oklahoma. The well was drilled on the structurally highest part of the old Bartlesville field.

New production in eastern Oklahoma is not limited to the discovery of new "pay zones" in old fields. New areas of production are found yearly. Oil accumulates under so many varying conditions in this part of the state that it is impossible to discuss the details of the individual discoveries. Stratigraphic traps similar to those in western Oklahoma have been recognized for years. They usually consist of masses of sandstone which disappear laterally for various reasons. As in western Oklahoma, these types of oil traps are difficult to locate and therefore have not all been found and tested. Every year a few more are found in areas where they were not suspected in previous years. They are located by careful subsurface geologic work. An excellent example is presented in a pool nine miles west of Oilton in Payne County. An anticlinal pool producing oil from an Ordovician sandstone was established. It was noted that a very thin sandstone several hundred feet above the pay zone was encountered in a few of the wells on the west side of the pool. A light oil stain in this sandstone was recorded in the record of one of the wells. Recognizing that the sandstone might be better developed westward, a geologist persuaded

his company to drill west of the old field to examine this Pennsylvanian sandstone. The well opened an entirely new pool.

Nearly all of the easily-found structures in which oil accumulates have been tested in eastern Oklahoma. Exploration for new oil areas is conducted largely by regional mapping using information obtained from the thousands of drill holes to determine the attitude of the underground rocks. The map work will often reveal anomalies in the position of the strata. If the structural anomaly is of the type favorable to oil accumulation, a test well may be drilled. Sometimes the structure revealed by regional mapping may be checked by seismic methods before the test well is drilled.

Another important reason to account for the extensive drilling in eastern Oklahoma is the finding of oil accumulations in areas previously tested. Wells making more than 200 barrels per day have been completed within 300 feet of test wells which were abandoned as dry holes.

In 1943 one of the major oil companies drilled to the Ordovician sandstone about three miles southwest of Stillwater (Sec.31-T.19N.-R.2E.) The test was abandoned as a dry hole in November of that year. Five years later a second test was made of the same structure with identical results. Both holes were drilled to the Ordovician sandstones which produce in so many fields in Oklahoma. Normally, two tests on a single structure are sufficient to discourage further interest in the area. In this case, however, a company not involved in the first two wells decided that the holes drilled did not adequately test all possible producing zones. They drilled a third well 300 feet away from the first dry hole and obtained a 60 barrel well from a basal Mississippian sandstone occurring about 200 feet above the Ordovician reservoir beds. In July of this year the second dry hole that was drilled earlier was reworked and converted into a producer. The limits of the new field are not yet defined.

An example of actually converting a dry hole into an oil well is found three miles west of Langston (Sec.16-T.17N-R.1E), northeast of Guthrie. A small independent company financed a test hole down to the Ordovician sandstone in 1945. After samples were examined and an electric log was made of the hole, the project was abandoned as a dry hole. Six years later another small company re-evaluated the electric log and samples. They were convinced that the Ordovician sandstone which was penetrated in the well should have produced. The lease was obtained and the old hole was reconditioned. The entire hole was cased with iron pipe and then the casing was perforated opposite the top part of the sandstone. The test was completed as a 225 barrel well. Success such as this will cause all companies to re-examine the records of dry holes in the area.

I have in no way presented a complete picture of recent petroleum discoveries in eastern or western Oklahoma. I have attempted, with the aid of examples, to discuss the more obvious reasons why there have been so many wells drilled in Oklahoma the past few years. New discoveries have been emphasized because the future of Oklahoma's oil industry is determined largely by the remaining undiscovered reserves. The 58,320 oil and gas wells in the state last year produced crude oil, natural gasoline and natural gas having a total value of nearly 550 million dollars. I hope that by discussing the reasons for the drilling of 3,900 miles of hole, I have shown you that the great oil industry of Oklahoma will continue to prosper for many years. For a concluding paragraph, a statement prepared in 1951 by the United States Geological Survey for the Senate Committee on Interior and Insular Affairs is adequate:

"If the future can be judged by the past, oil and gas will be found in sufficient quantities for many years to come. In the U.S. adequate production has been a direct function of economic incentive. Until the unpredictable date at which that incentive fails to provide the needed supplies, there will be no convincing evidence that we have reached the limits of our ability to expand the potential ultimately recoverable reserves of petroleum."