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THE SHULER FIELD, ARKANSAS
An Historical Summary of Fifty Years of Oil Production 1937 - 1987

by
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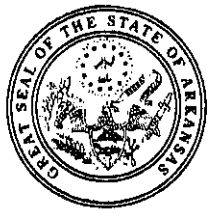

Little Rock, Arkansas
1987

STATE OF ARKANSAS
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The Shuler field, Arkansas: An historical summary of fifty years of oil production, 1937-1987

John G. Ragsdale

QUEST BEFORE THE FIELD

After the initial oil discovery in Union County, Arkansas (Fig. 1) in 1921, there followed development in the El Dorado South, El Dorado East, Smackover, Lisbon, Urbana and Champagnolle fields (Weeks, 1939). The producing zones, such as the Nacatoch, Tokio, and Travis Peak, were principally in the Gulfian and Comanchean Series (Fig.2). Most of the wells drilled before 1935 were drilled to depths of less than 4,000 feet.

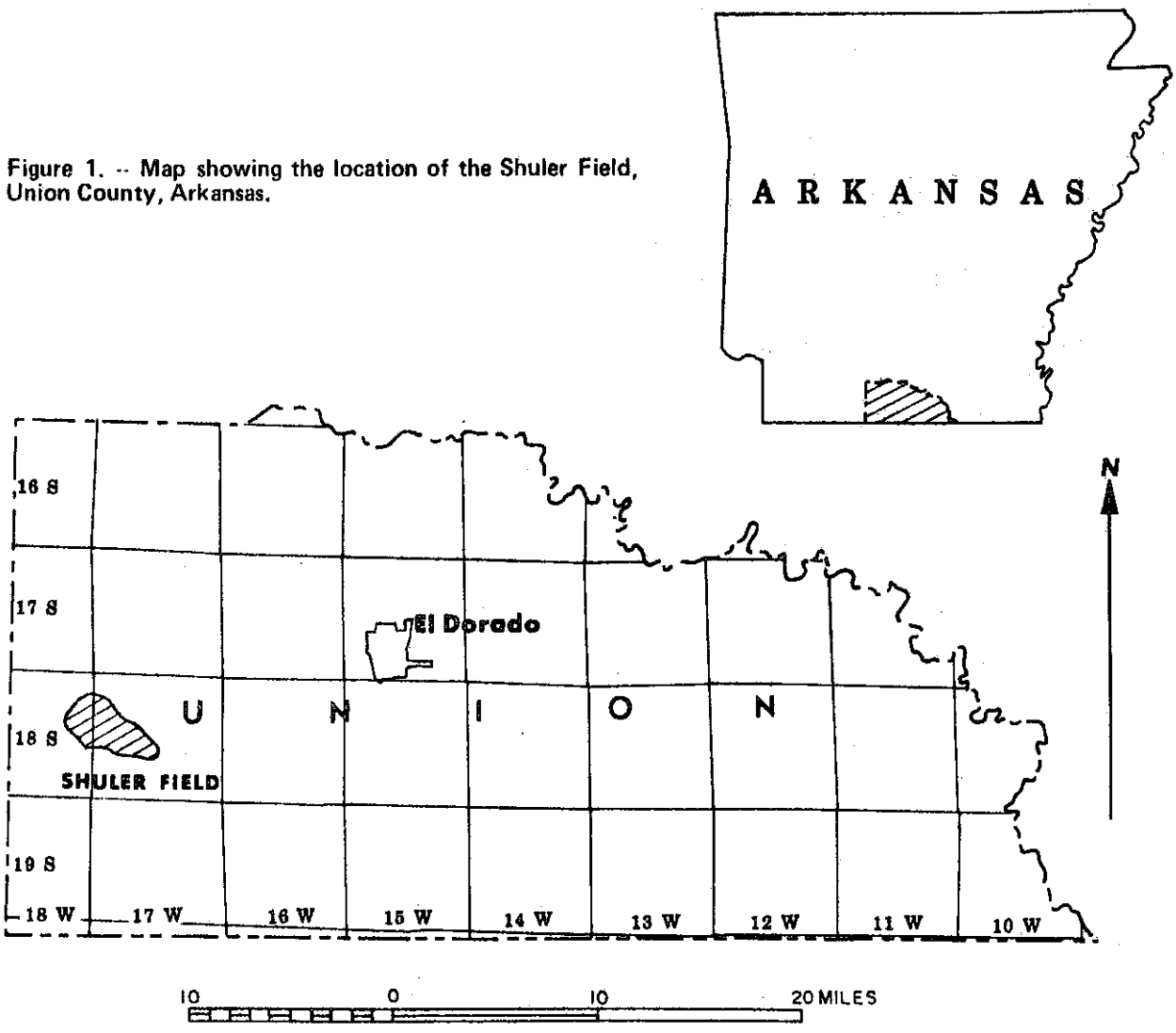


Figure 1. -- Map showing the location of the Shuler Field, Union County, Arkansas.

A few wells had penetrated the Comanchean and older units but were described only by drillers' logs which were often not reliable in identifying formations and depths. Many logs reported shale or gumbo or boulders for primary description. Information was available for many of the upper formations but few cores or cuttings were available for study of the deeper formations.

By 1935 several deeper tests were planned to be drilled below the red beds of the Comanchean to an underlying limestone. One of these wells was the H. L. Hunt's Gregory No. 15 well in the Rainbow area of the Champagnolle field (Weeks, 1938). Warren B. Weeks, a geologist with Phillips Petroleum Company, arranged to construct a sample box in the mud ditch and catch samples as drilling progressed. This well was in sec. 10, T.17S., R.14W., and it was in this well that the oolitic Smackover Limestone with visible porosity was first observed in cuttings by Weeks. The well did not produce, but before it was plugged, a seismic velocity survey was run, allowing correlation with some previously determined zones in wells to the north.

ERA	SYSTEM	SERIES		GROUP	FORMATION	PRODUCING ZONE
CENOZOIC	Quaternary	Holocene				
	Tertiary	Eocene		Claiborne Wilcox		
		Paleocene		Midway		
MESOZOIC	Cretaceous	Upper Cretaceous	Gulfian	Navarro	Arkadelphia Nacatoch	
				Taylor	Saratoga Marlbrook Annona Ozan	
				Austin	Brownstown Tokio	
				Woodbine	Eagle Ford Tuscaloosa	Tuscaloosa
		Lower Cretaceous	Comanchean	Trinity	Rodessa James Pine Island	Hill Pettet
			Coahuilan	Nuevo Leon	Sligo Pettet Hosston (Travis Peak)	
	Jurassic	Upper Jurassic		Cotton Valley	Schuler	Morgan Mayfield Lagrone Leona Jones
					Smackover	Reynolds Oolite

Figure 2. Classification of rocks encountered in the Shuler field.

Subsequently, Phillips Petroleum Company drilled the Reynolds No. 1 well (sec. 27, T.15S., R.15W.) On May 8, 1936, at a depth of about 4800 feet, the first production was obtained from the Smackover Limestone. This development in the eastern area of the Smackover field was named the Snow Hill field and the formation was referred to as the Reynolds Oolite, actually the Smackover Limestone (Weeks, 1938).

The Snow Hill field covered only a few hundred acres (Fancher and McKay 1946) and about ten wells produced about 904,000 barrels of oil up through 1984 from the Reynolds Limestome or Oolite. Although the Snow Hill field was a limited discovery, it was the impetus for extensive exploration and development in South Arkansas. After Phillips Petroleum Company drilled several other prospective areas south and east of the Snow Hill discovery without encountering productive zones, further drilling for the Reynolds Limestone slowed.

During 1935, Phillips Petroleum Company arranged with the C. H. Murphy interests to secure a block of thousands of acres in the southern and western portions of Union County for a 4800-foot deep test. Phillips then drilled the Edna Morgan #1 well (sec. 18, T.18S., R.17W.) to a depth of 4270 feet, but, having encountered no productive zones, plugged the well on September 3, 1936.

Subsequently, the Lion Oil Refining Company requested a farm-out of certain acreage in the Snow Hill field from Phillips Petroleum Company. Phillips agreed to the farm-out with a Smackover drilling obligation to Lion, but also stipulated that Lion would drill a well to the Reynolds Limestone, or to a producing zone at a shallower depth, in the area of the previous Edna Morgan #1 well.

DISCOVERY

Consequently, the Lion Oil Refining Company deepened the Edna Morgan No. A-1 well (Figs. 3 and 4), (center of lot 1, SW 1/4, sec. 18, T.18S., R.17W.) and completed the well in a sandstone at 5560 feet, 140 feet below the top of the Cotton Valley Formation. This well, in the Morgan Sand, was completed April 5, 1937, in the interval 5556-5559 feet.

Then Edwin M. Jones and others, including the C. H. Murphy interests, drilled the Marine Fee No. 1 well about two miles east of the Edna Morgan No. A-1 well. It was located in the NW 1/4, SW 1/4, SE 1/4 sec. 17, T.18S., R.17W., and was completed on September 17, 1937 at 7454-7571 feet, flowing 1500 barrels of oil per day and was the discovery well of the Jones Sand.

By this time, the Lion Oil Refining's Morgan No. A-1 in the Morgan Sand had declined greatly and the well was re-entered. It was deepened to 7683 feet, encountering the Jones Sand from 7500 to 7575 feet and the Reynolds Limestone at 7603 feet. The Morgan No. A-1 was completed on October 21, 1937, producing 14,000 MCF gas and 720 barrels of oil per day in the Reynolds Limestone between 7608 to 7635 feet. The well was subsequently recompleted in the Reynolds Lime from 7623 to 7627 feet. This recompletion was tested at 760:1 gas-oil ratio and 264 barrels of oil per day.

From this point on the Shuler field boom was on! By the end of 1939, 140 wells had been

Figure 3. Spectators at the site of the Edna Morgan A-1 well--the discovery well of the Shuler field. Photo courtesy of Lion Oil Company, El Dorado, AR.

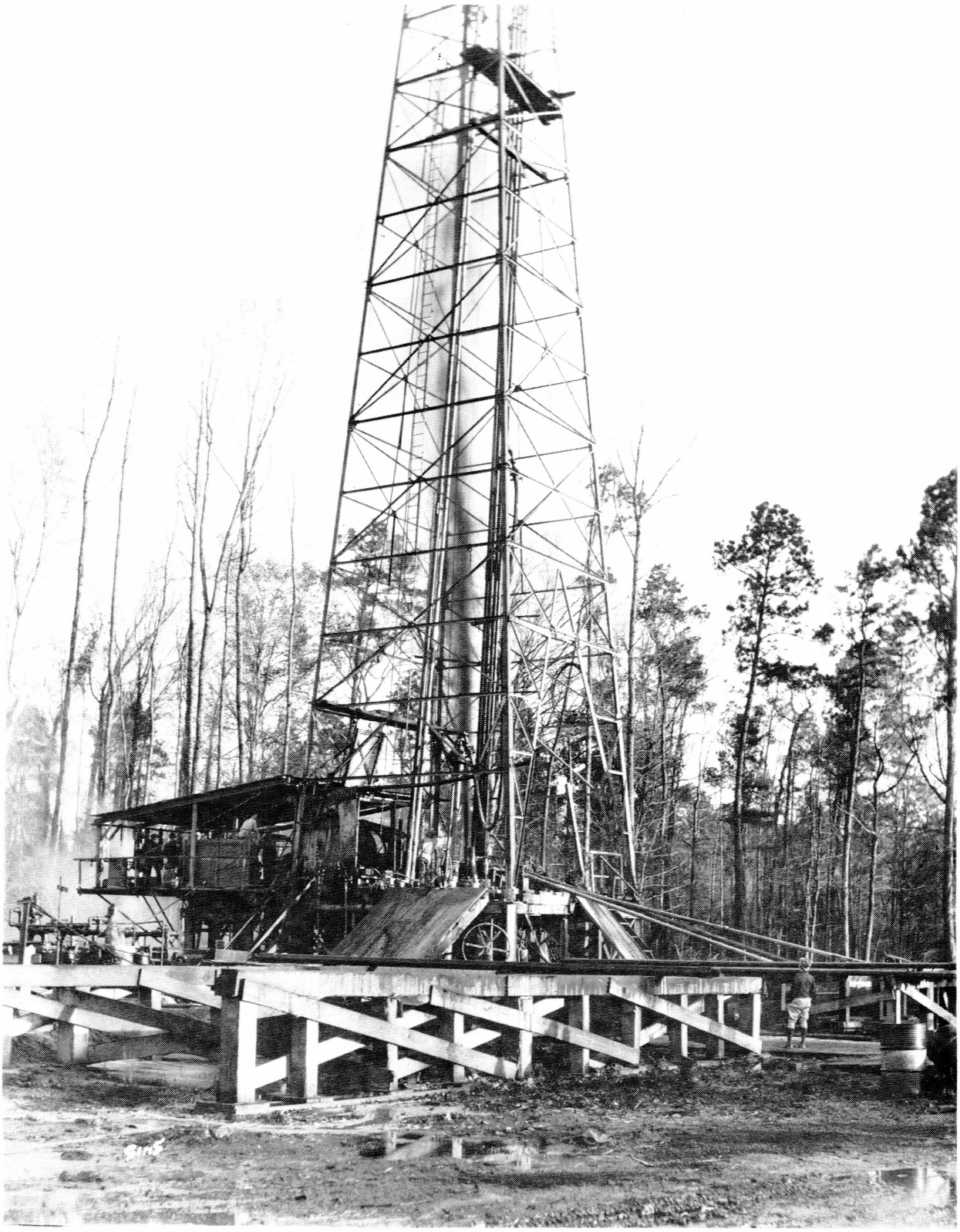


Figure 4. A closer view of the Edna Morgan A-1 well during a drill-stem test. Photo courtesy of Lion Oil Company.

completed in the Jones Sand and 16 wells in the Reynolds Limestone. The Jones Sand was developed on a 20-acre spacing and the Reynolds Limestone on 40-acre spacing.

FURTHER DEVELOPMENT

In February 1941, the Shuler Unit was made effective for all depths through the Jones Sand, providing for pressure maintenance of the Jones Sand. During primary production from the Jones Sand and the Reynolds Lime, other wells were completed in some of the many lenticular stringers in the Cotton Valley. With the history of unknown predictability for the Cotton Valley completions and the available cased holes that previously had been drilled to the deeper Jones Sand and Reynolds Limestone, the Shuler Unit operator made a review of the zones above the Jones Sand in 1951. This study resulted in a plan to drill a test well through all shallower zones to allow coring, logging, or testing to provide an evaluation of future testing throughout the Shuler Unit. This well, Shuler Unit No. 144, was drilled in March 1951 and provided valuable information for a thorough geological study of the immediate area of the Shuler field.

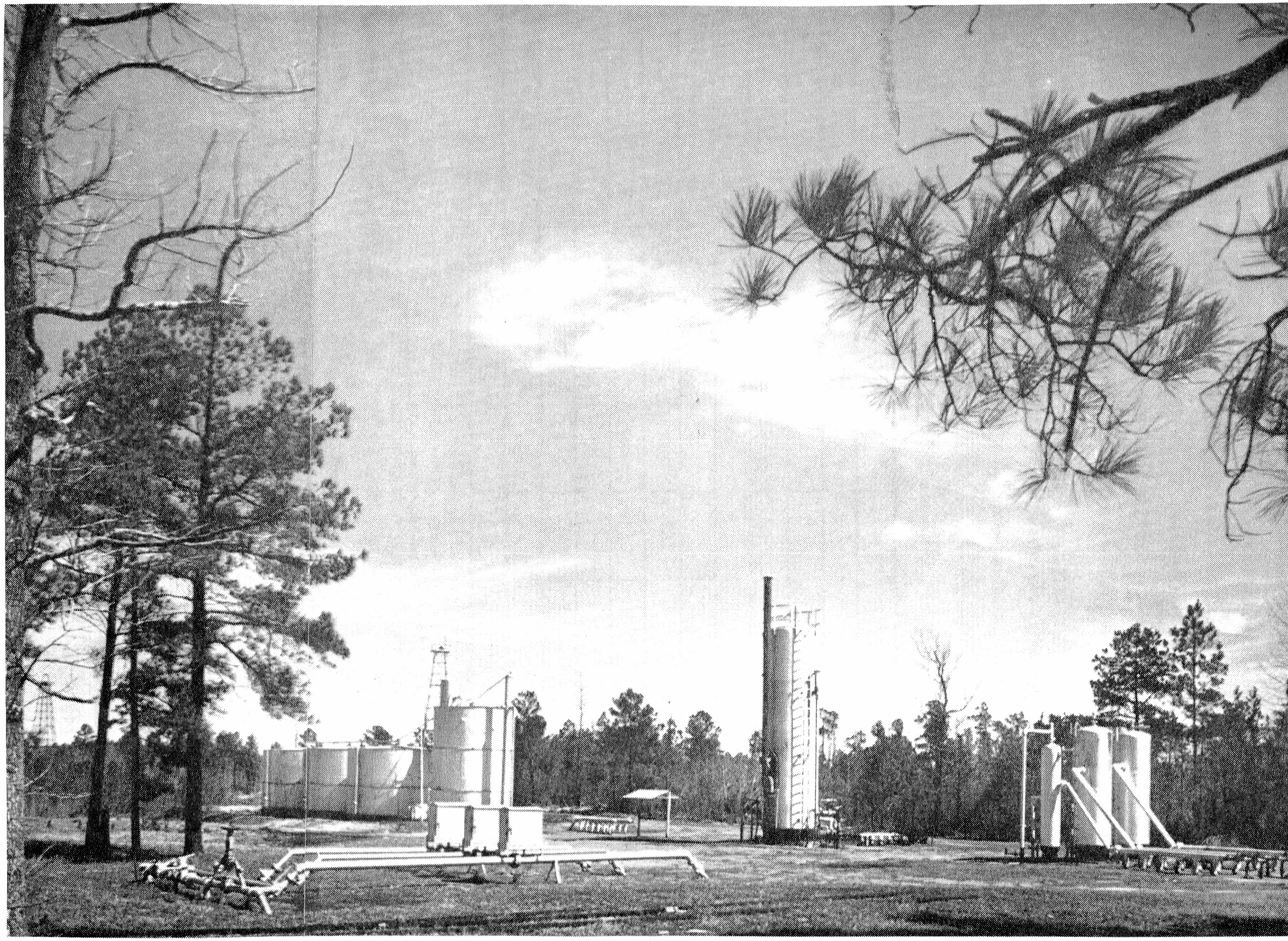
Subsequent testing and recompletion of wells in the Shuler Unit provided a substantial increase in oil production from the Cotton Valley for several years after 1953. These additional recompletions resulted in increased interest and in development of the area immediately east of the Unit. Many producing wells were completed in the mid-1950's in the area to the east, which was called the Shuler Extension by some. Ultimately it was included in the Arkansas Oil and Gas Commission's definition of the Shuler field (Fig. 5). Additional development also resulted in many completions in the Tuscaloosa, Hill, Pettet, Mayfield and LaGrone Sands.

The field name has changed during the time of production. In the early years of development and production, the name of a local family, Schuler, was used. Because a post office of Shuler was located in the northern portion of the field, the name "Shuler" was more commonly used and became the more widely accepted name. Records in the Oil and Gas Commission in 1969 also describe the name modification from Schuler to Shuler.

MORGAN SAND

The Morgan Sand was the initial discovery zone of the Shuler Field, first producing from a depth of 5556-5559 feet in the Lion Oil Refining Company's Edna Morgan A-1 well on April 5, 1937. The Morgan Sand is a series of lenticular sandstones in the upper part of the Cotton Valley formation, usually at a depth of about 5500 to 6000. About fourteen wells were drilled within a year and an area of about 500 acres was developed. The gas was depleted rapidly, and by mid 1938 all the producing wells were on artificial lift (Weeks 1939). Records of gas production and reservoir pressure are limited, but with the

Figure 5. A typical tank battery in the Shuler field. Photo courtesy of Lion Oil Company.



early depletion of gas volumes and rapid pressure decline, the wells were produced by beam pumping units. Many of the wells produced water soon after completion and continue to produce some water, but there is little evidence of an active water drive. In 1986, the water produced from this zone is in the range of 90%.

Thirteen wells were effectively produced from this zone and are located in the central area of the structural high in the field. When the Unit agreement for the Cotton Valley and Jones Sands was prepared, these specific wells were excluded from Unit ownership and continued to be produced by lease operators. Two of these wells were producing in 1986. Oil production to the end of December 1986 was 4,440,000 barrels and the current producing rate is twenty barrels of oil per day. The production history is provided on Figure 6.

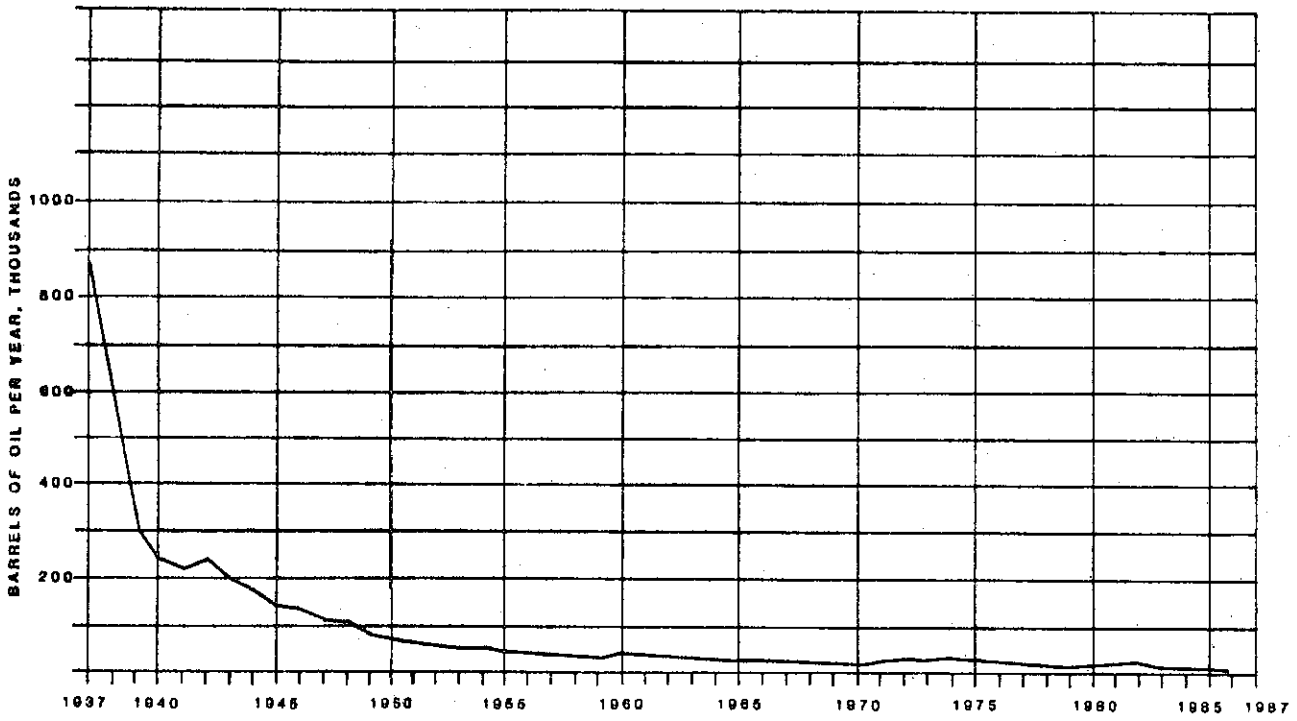


Figure 6. Oil production from the Morgan Sand.

REYNOLDS LIMESTONE

Initially, the Lion Oil Refining's Morgan No. A-1 well was completed in the Reynolds Limestone, producing oil with a high gas-oil ratio. Later, the original producing interval was squeezed and the well recompleted at a lower interval, producing oil at a rate of 264 barrels per day with a gas-oil ratio of 760:1. Subsequently offset wells were drilled and sixteen wells had been completed in the Reynolds Limestone by the end of 1939.

The well-defined anticlinal structure enabled oil to be trapped in the well-developed oolitic section of the limestone (Weeks and Alexander, 1942). A gas cap was present above the oil-saturated

productive zone. Most of the wells were cored and logged, providing good initial reservoir information. Reservoir pressures, gas, and other fluid production records were also gathered by the operators and the Oil and Gas Commission. Basic information on the reservoir is:

Well spacing	40 acres
Gas-oil contact	7394' subsea
Oil-water contact	7420' subsea
Effective section	20'
Porosity, average	20%
Permeability, average	1500 millidarcys
Connate water	20%
Formation volume factor	1.59
Oil gravity	38^{o} A.P.I.
Reservoir pressure, original	3550 psig

With good reservoir characteristics, a gas cap, and strong water drive, the reservoir was an excellent producing zone. During nineteen years of production, from 1937 to 1955, 7,729,000 barrels of oil were produced. See Figures 7 and 8.

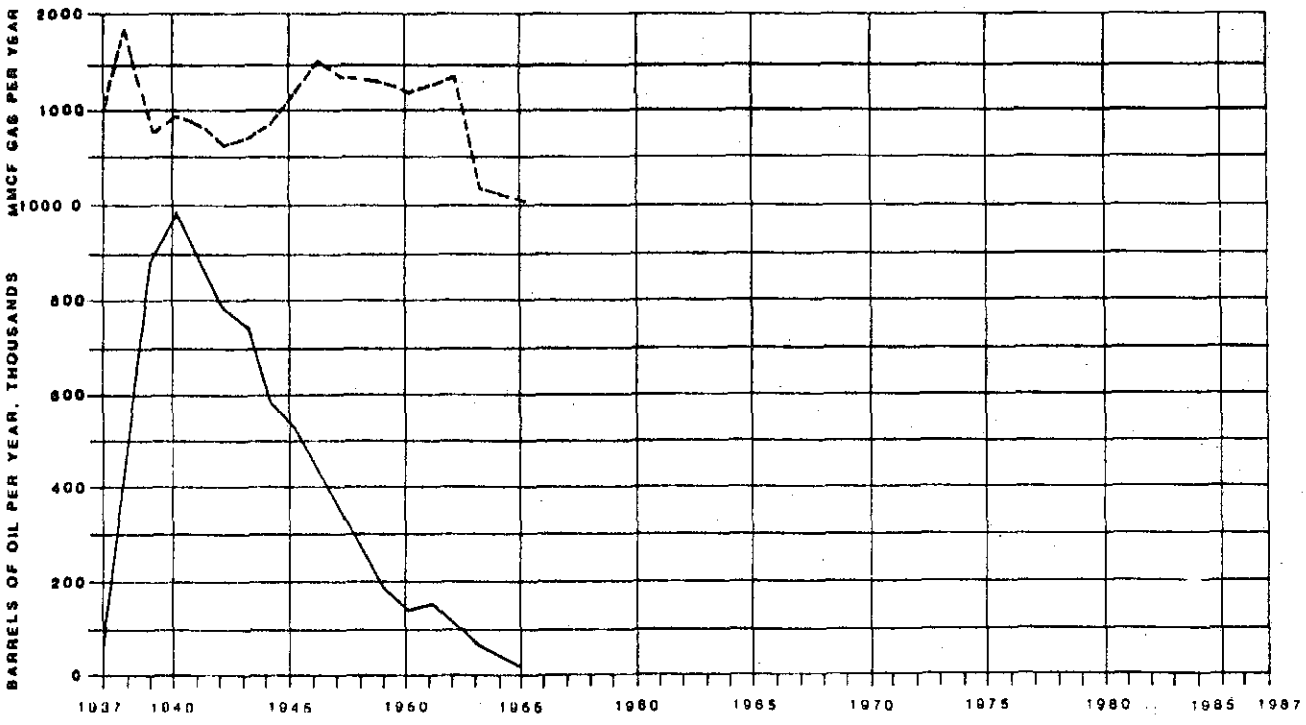


Figure 7. Oil and gas production from the Reynolds Limestone.

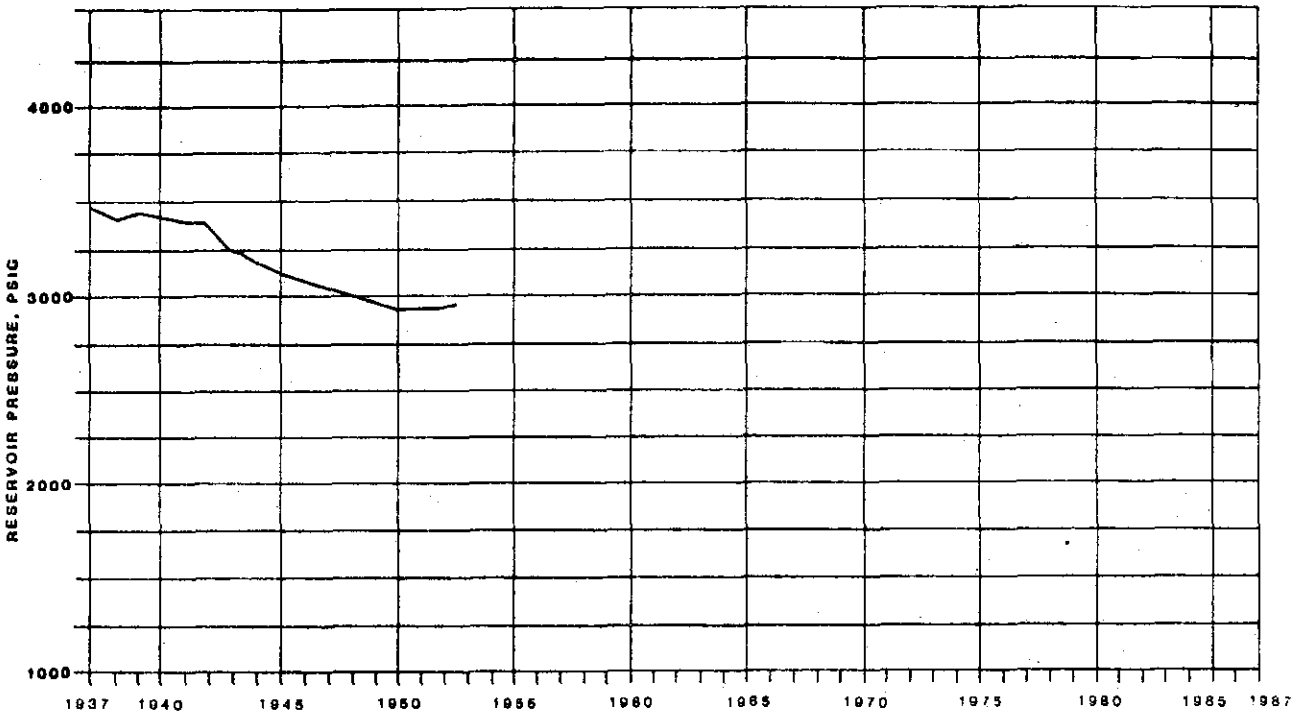


Figure 8. History of reservoir pressure of the Reynolds Limestone.

JONES SAND

The Jones Sand is the principal reservoir in the field, having the most well completions, largest area, and greatest oil production. The reservoir also provided a major lesson in securing reservoir information, an example of industry advancement and use of technical development.

Most of the wells drilled to the Jones Sand were cored, core analyses performed, and electric logs run on all wells -- a great advancement in 1937 to 1939. Many drilling-time logs and sample logs were prepared during drilling, bottom- hole pressures were measured, and records of oil, gas, and water volumes provided an abundance of information during development of the field and during the years of production.

The Jones Sand reservoir is an anticlinal trap with a small gas cap and a gas pressure depletion type performance. The permeable section of the sand thins to the east and around the flank of the structure. This condition provided isolation of the reservoir from the water-bearing sandstone. (Weeks and Alexander 1942). Basic information on the reservoir is:

Well spacing	20 acres
Gas-oil contact	7280' subsea
Oil-water contact	7380' subsea
Effective section	87.5'
Porosity, average	20.2%
Permeability, average	355 millidarcys
Connate water	30.2%
Formation volume factor	1.52
Oil gravity	34° A.P.I.
Reservoir pressure, original	3520 psig

The pressure history of the Jones Sand is a very interesting facet in the reservoir performance. Fortunately, technical leaders provided for regular and multiple bottom-hole pressure measurements. As noted on the reservoir pressure records (Fig. 9), the original pressure in September 1937 declined by about 50 percent by the end of 1940. This caused some wells to cease flowing and to be placed on artificial lift equipment. Because of the reduced oil flow and the cost of the installation of larger mechanical equipment, some wells were quickly approaching the limit of economic feasibility.

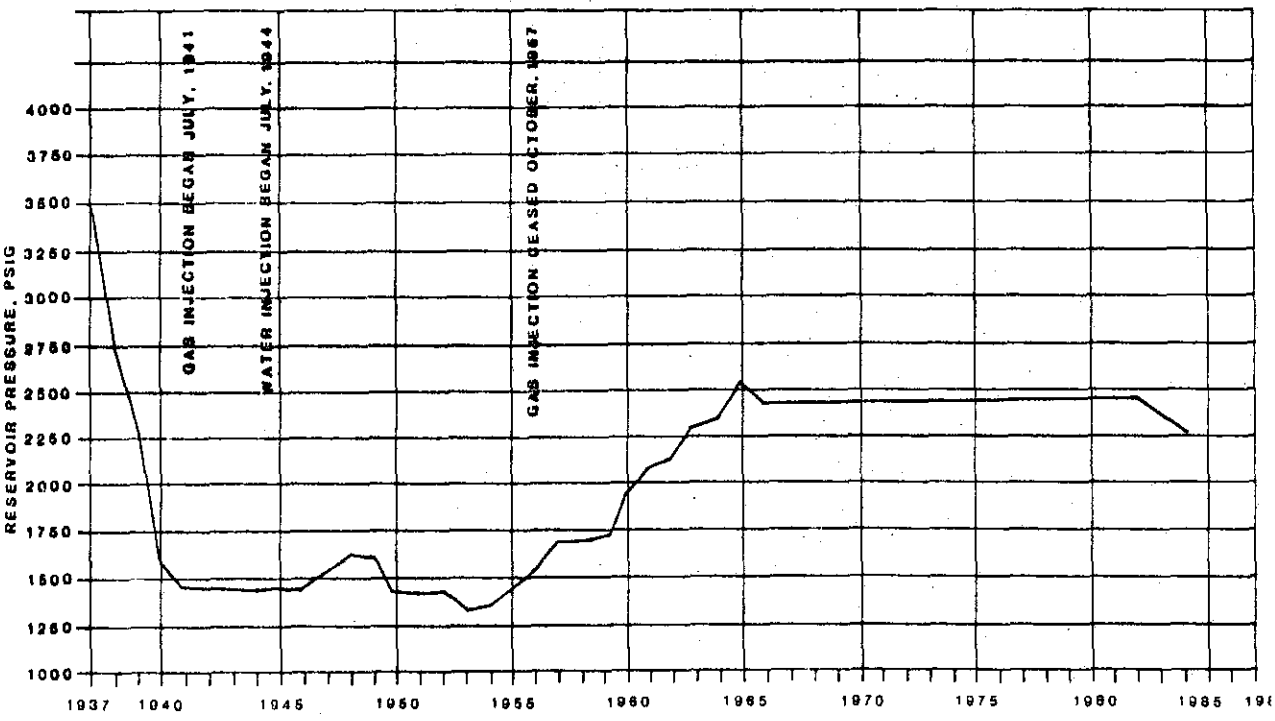


Figure 9. History of reservoir pressure of the Jones Sand.

Impending conditions dictated that action was needed. Representatives of the several operators were aware that all operators were in the same position. Some of those persons were Col. T. H. Barton, T. M. Martin, and J. E. Howell with Lion Oil Refining Company, C. P. Dimit with Phillips Petroleum Company, O. G. Murphy, C. D. Lange, and E. Boyd Alderson with Marine Oil Company, C. H. Murphy, Sr., E. M. Jones, and Joe B. Hurley. Aware of the results of no regulatory control in the preceeding years when large shallower fields were developed, the potential of technical support in this field, and the willingness of operators to support it, voluntary oil allocation was begun January, 1938, and following its predecessors, the Arkansas Oil and Gas Commission was formed on January 1, 1939. This agency was the vehicle to allocate production quotas and maintain well and field records.

To reduce the decline in reservoir pressure and conserve energy, allowed oil-producing rates were lowered and a maximum permissible gas-oil ratio of 2500 cubic feet per barrel was provided. (Kaveler 1943) This was ordered by the Oil and Gas Commission on April 1, 1939, and resulted in a beginning of conservation of the reservoir pressure.

Further, by Act No. 105 of the 1939 Arkansas Legislature, provisions were made for the field-wide unitization of reservoirs. Unitization could be ordered by the Oil and Gas Commission if at least 75 percent of the working interests and 75 percent of the royalty interests approved the formation of a field-wide unit. The operators were still faced with declining pressures in the reservoir and could foresee the problems if some stern measures were not adopted. Consequently, the lease operators sought and received approval of 100 percent of the working interest owners and over 84 percent of the royalty interest owners to form a field-wide unit effective February 15, 1941. This utilization of the Jones Sand reservoir included all leases except two and included 140 of the 146 Jones Sand wells in the reservoir area.

The unitization agreement also provided that all zones from the surface down through the Jones Sand be included in the unit. This left the 15 Reynolds Limestone wells continuing to be operated by the existing owners. In 1957, after the Reynolds Lime reservoir had ceased to be produced, some of these cased holes were sold at a nominal salvage value to the Shuler Unit. Also excluded from the Shuler Unit were the thirteen Morgan Sand wells. These earlier wells continued to be produced as separate lease wells.

Participation in the Shuler Unit was based on oil production allowed to each operator in the August 1, 1940 Arkansas Oil and Gas Commission allowable schedule. This seems relatively simple compared to some complicated and sophisticated arrangements in later units. However, this was a rather unique effort for these working interest and royalty owners to adapt in order to combat a substantial depletion in reservoir pressure. This was the first unitization in Arkansas and it certainly presented dramatic use of technical operation. It was also the first operation in the State to use gas-injection and water-injection pressure maintenance programs.

After the Shuler Unit was formed on February 15, 1941, the gas-cap injection commenced July 1, 1941. Plans were to re-inject most of the gas gathered from field separation facilities. The unit

owners were able to secure one allowable for the combined leases in the Unit and then shut in the wells producing the higher gas-oil ratios. Gas produced from the Cotton Valley wells in the Unit area was also injected into the Jones Sand reservoir. Gas gathering and injection continued until October 1957, when gas volumes were insufficient to provide for the compression and injection operations.

Water injection into the Jones Sand reservoir began on July 1, 1944 and has continued to date. Initially, salt water was used, and in May 1945 fresh water from the Sparta Sand was also used to increase the volume of water injected. Injection of fresh water ceased on March 1, 1966 and since that time only salt water has been used.

Water produced from all zones throughout the Shuler Unit area has been gathered by a cooperative group of operators, known as the Shuler Salt Water Disposal Association. Expenses for gathering the water have generally been prorated to the producers in proportion to volumes of water produced. The gathered water is then transferred to the Shuler Unit for injection. This group effort has most economically solved the gathering and disposal/injection needs of all operators. The volumes of water produced and injected are shown in Figure 10.

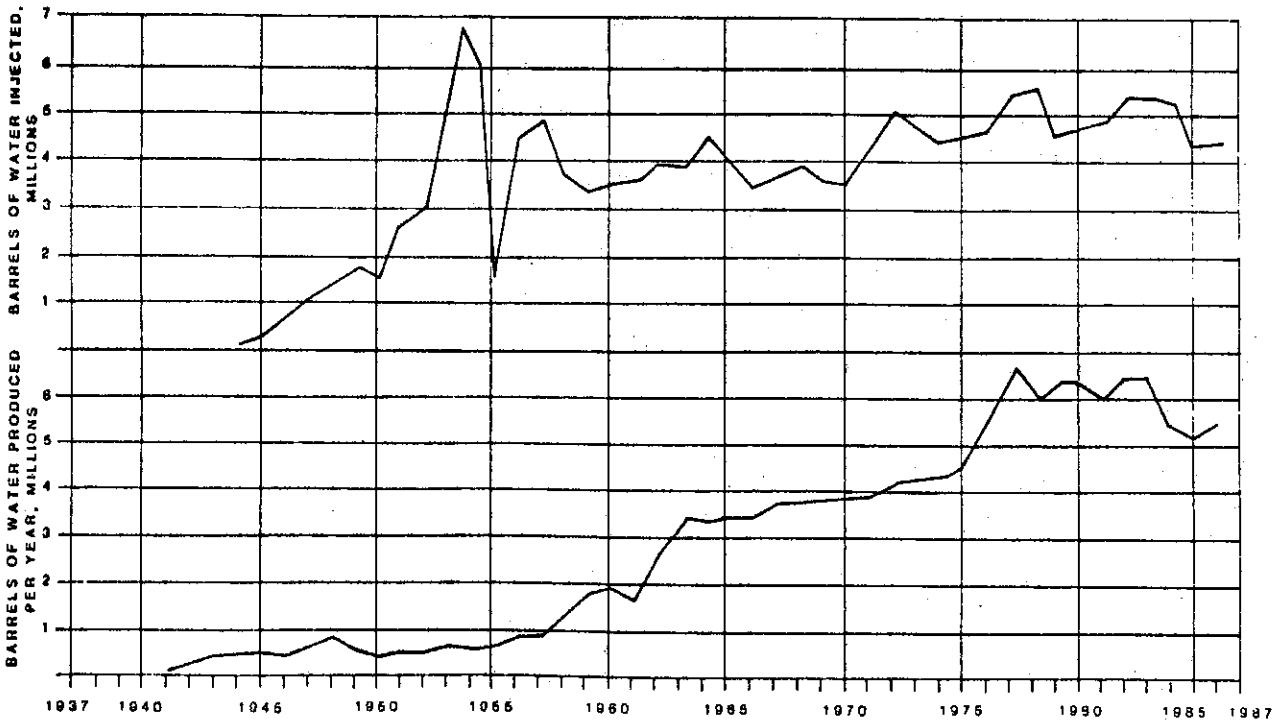


Figure 10. Water-production and water-injection histories of the Jones Sand.

Reserve estimates for original oil in place have ranged from 110 (Tarner, Evans and Kaveler 1951) to 120 million barrels of stock tank oil. Recovery to date has been almost 80 million barrels of oil, a recovery of about 70%. Early estimates indicated that 34 million barrels of oil would have been

produced under primary recovery without unitized operations (Kaveler 1943). Efficient reservoir unitization and the use of gas cap gas injection and water injection for pressure maintenance have been of monumental assistance in secondary recovery of oil from the reservoir.

Presently there are 26 wells producing from the Jones Sand, with a daily combined rate of 600 barrels of oil. Production rates are indicated on Figure 11.

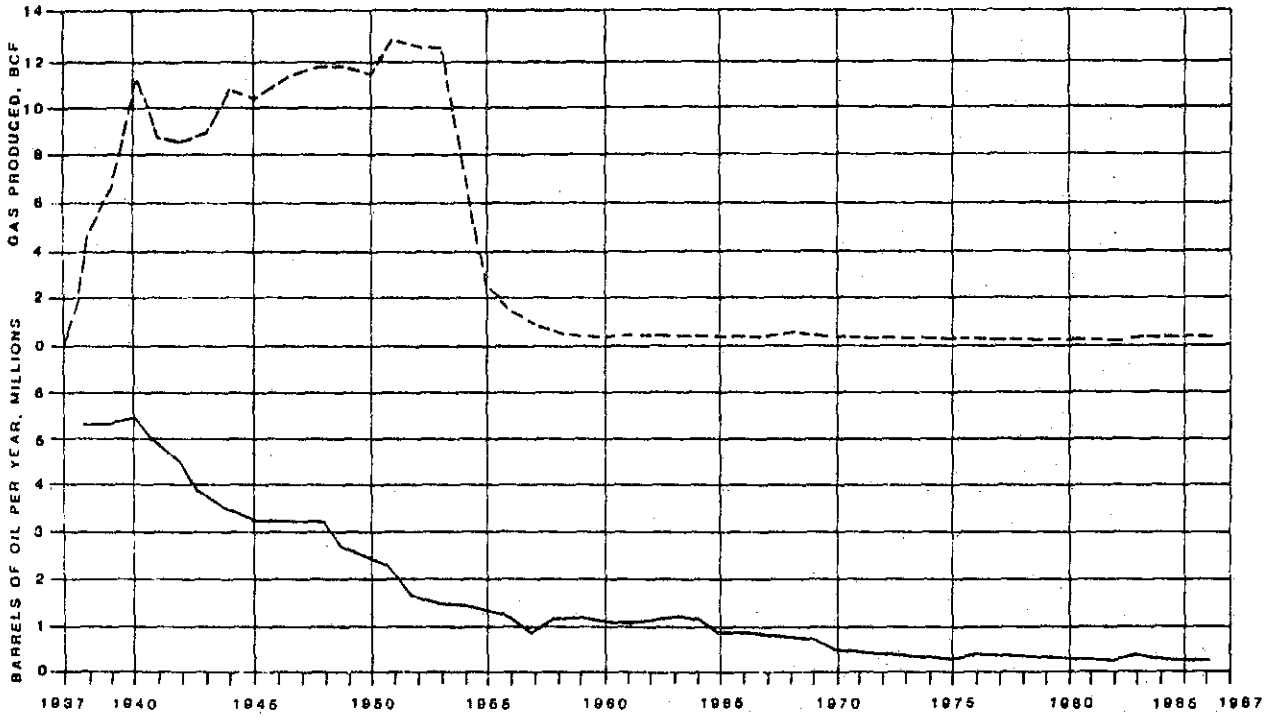


Figure 11. Oil and gas production from the Jones Sand.

COTTON VALLEY

The Cotton Valley zone is that interval from about 6000 feet to the top of the Jones Sand at about 7500 feet. This interval contains many lenticular sand reservoirs imbedded in shale.

The initial completion was in the Phillips Petroleum Company Leona #1 well in 1942. It was completed in a well-developed lens named the Leona Sand, 6922 to 6928 feet, pumping 80 barrels of oil per day (Weeks and Alexander 1942).

A systematic testing and completion effort was made after the geological study which followed drilling and testing of Shuler Unit well #144 in 1951. Many wells have produced from the Cotton Valley sand lenses, both in the Shuler Unit and in the eastern area of the field. To date the zone has produced over 8,000,000 barrels of oil, and about 20 wells were still producing in 1986. Production is shown on Figure 12.

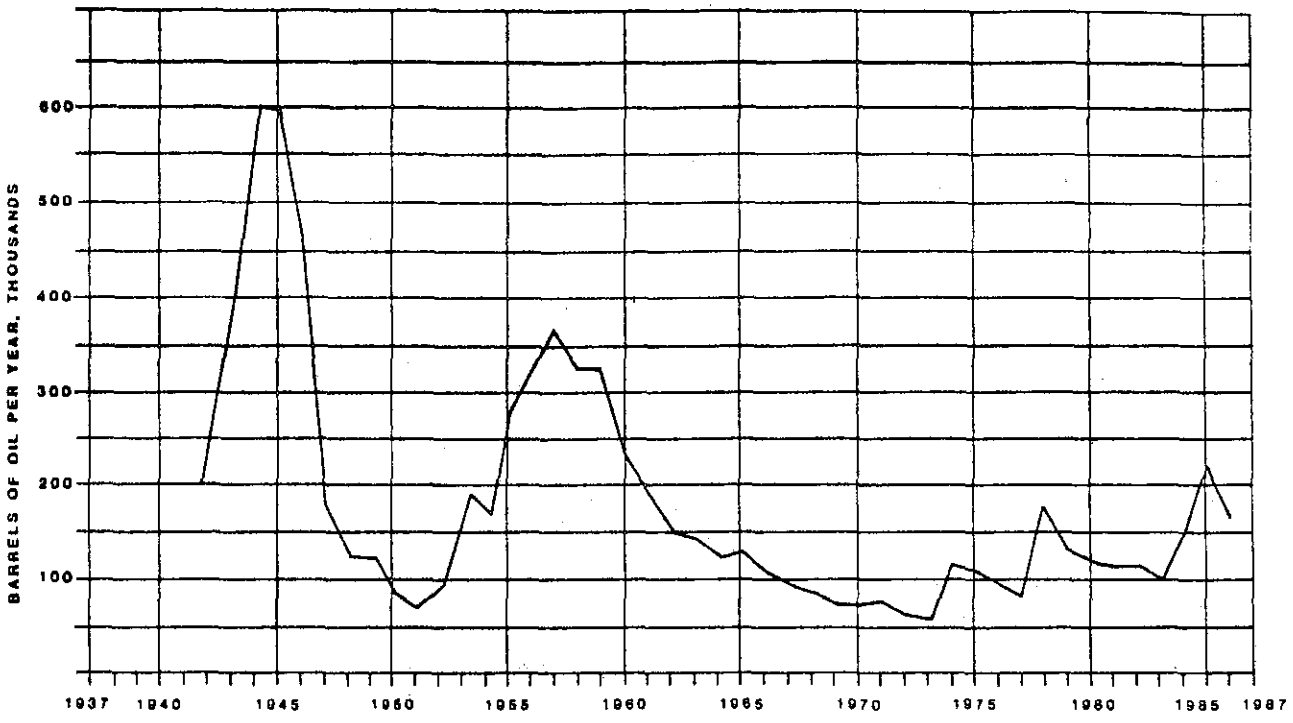


Figure 12. Oil production from the Cotton Valley.

PETTET

In 1951 the initial completion was made in the Pettet zone. The Pettet has produced 2.6 million barrels of oil to December 31, 1986, and 13 wells were still producing. The production history is shown in Figure 13.

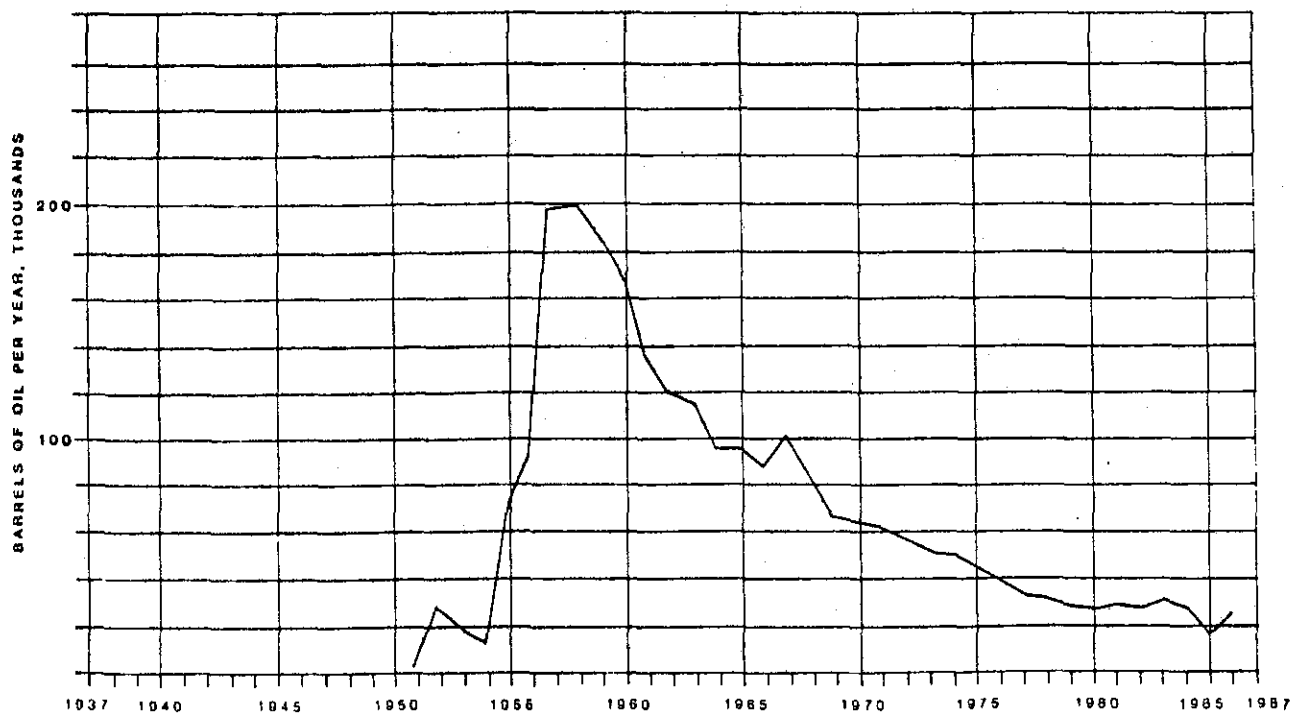


Figure 13. Oil production from the Pettet Lime.

TUSCALOOSA

The Tuscaloosa Sand was first discovered in the Carter Oil Company E. M. Woolsey #1 (NE 1/4,NE 1/4, sec.28,T.18S., R.17W.) in October 1952. The well initially produced 47 barrels of oil per day with 30% water, from the interval 3104-3118 feet. Over 500,000 barrels of oil have been produced through December 1986, at which time one well was still producing. Production information is shown on Figure 14.

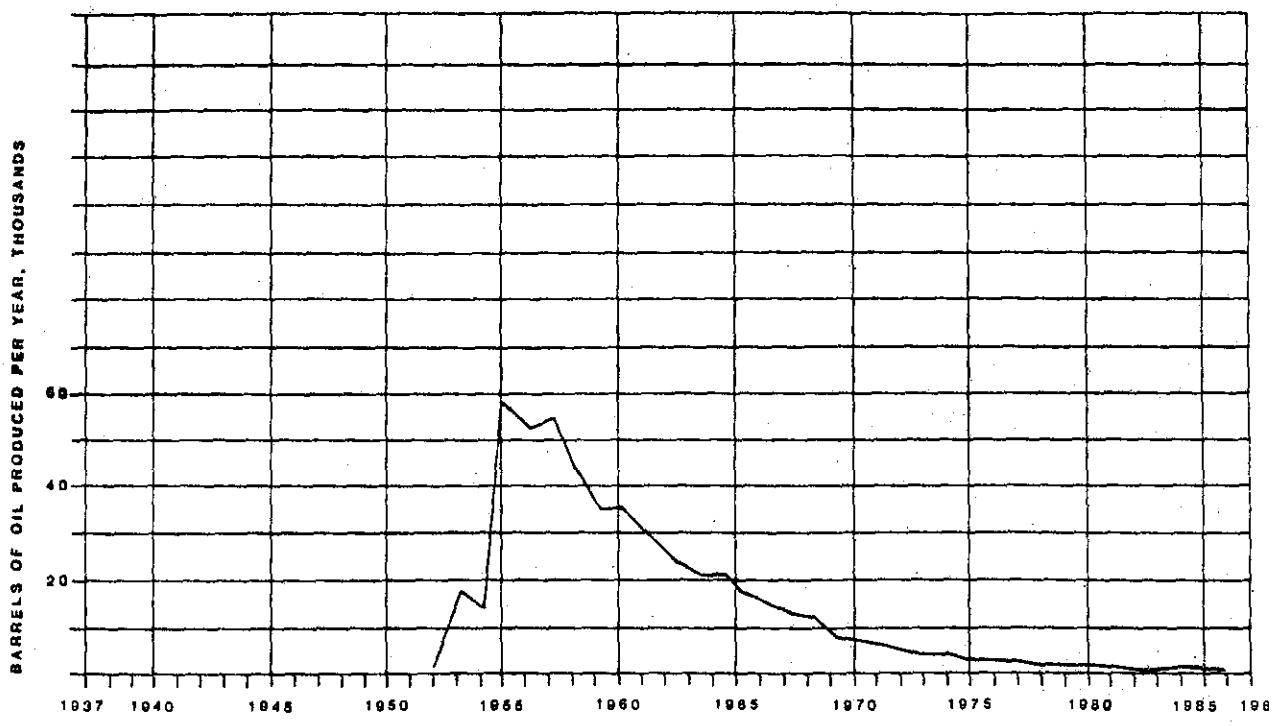


Figure 14. Oil production from the Tuscaloosa Sand.

MAYFIELD SAND

The Mayfield zone was first produced in the Lawton Oil Company Mayfield #A-1 well (SW 1/4, NW 1/4, NE 1/4, sec. 21, T.18S., R.17W.) in September 1952. Production was from the interval 5672-5678 feet at the rate of 135 barrels of oil per day on October 6, 1952. The interval is one of the lenticular Cotton Valley series of sands.

Later completions were from another Cotton Valley interval, usually designated as the Mayfield B zone. Oil from the Mayfield was first produced from the Lawton Oil Company Mayfield No. B-1 well (NE 1/4, SW 1/4, NE 1/4, Sec. 21, T.18S., R.17W.) on November 1, 1952. Production was from the interval 5586-96 feet, initially at the rate of 192 barrels of oil per day. A group of the wells completed in this interval in Section 22 and the southern one-quarter of Sec. 15, T.18S., R.17W. were included in the B-Sand Unit. The wells in this immediate area appeared to be a continuous development of the sand, and the B-Sand Unit was formed to water flood the zone. The unit operated from 1955 through

1964 and produced over 400,000 barrels of oil. After operation of the B-Sand Unit, the wells were returned to the previous operators for normal lease operation. Six of the wells produced in 1986, with a water cut of about 70%. Production rates are shown on Figure 15.

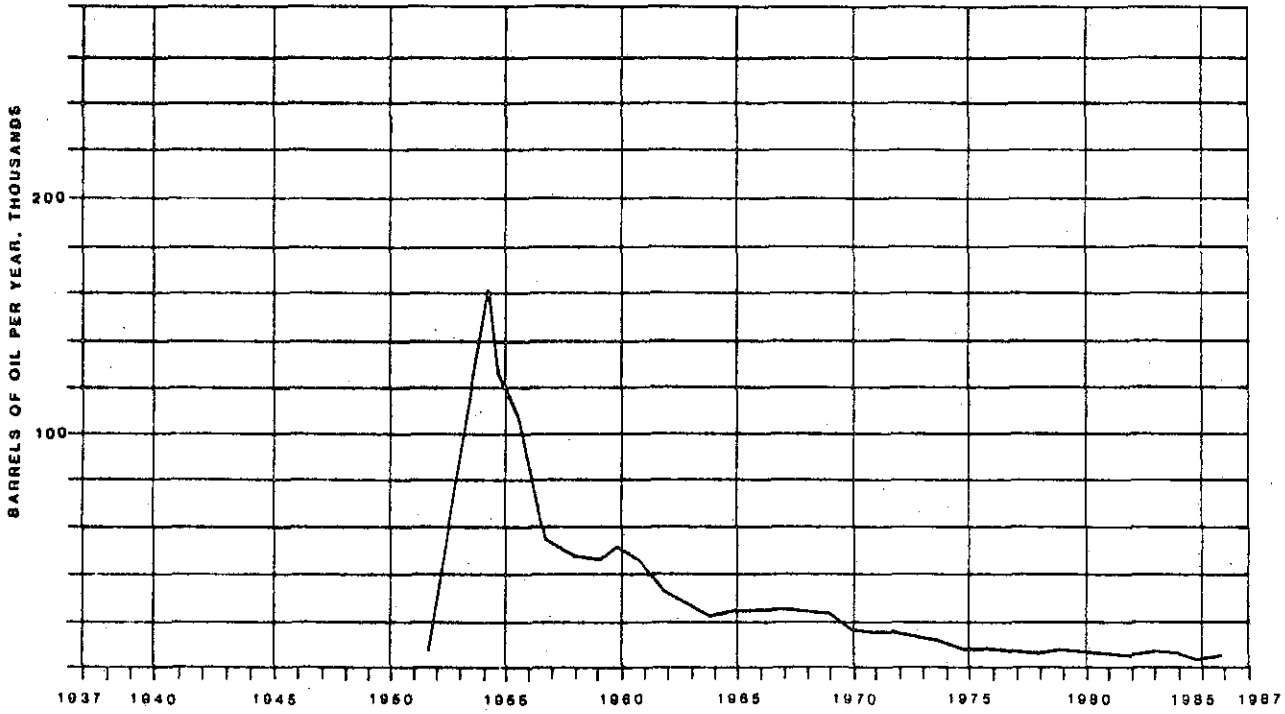


Figure 15. Oil production from the Mayfield Sand.

LAGRONE SAND

The LaGrone Sand was another Cotton Valley sand which was well developed in Sec. 22,T.18S., R.17W. This sand was about a hundred feet below the B sand and was first produced in the Crow Drilling Company and L. J. Peters' W. L. LaGrone No. 1 well. Initial production, August 2, 1953, was 302 barrels of oil per day from the interval 5709-5711 feet. The LaGrone Sand unit was formed simultaneously with the B-Sand unit and most of the interests were in common ownership. The LaGrone Sand was water flooded from 1955 through 1964 and the zone produced over 1,800,000 barrels of oil.

With cessation of unit operations, the wells were returned to the previous owners for lease operations. In 1986, five wells continued to produce from this zone with about an 80% water cut. The oil production history of the zone is on Figure 16.

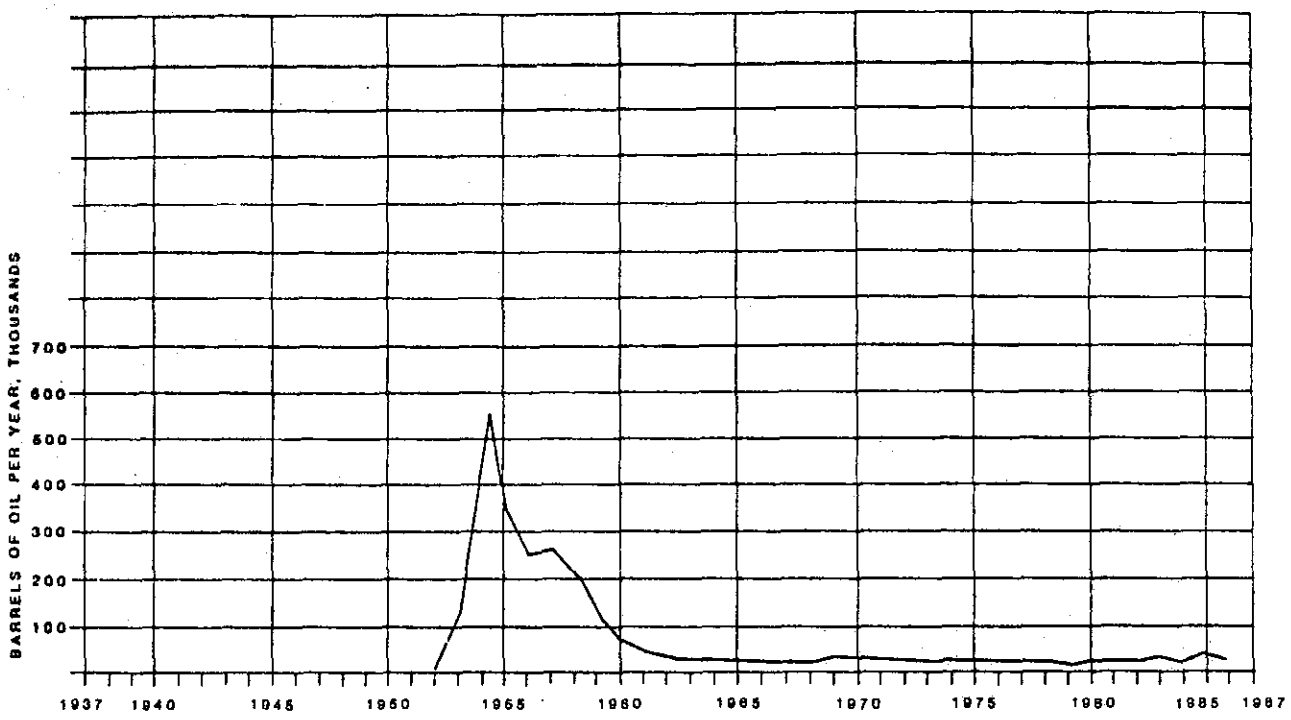


Figure 16. Oil production from the Lagrone Sand.

HILL SAND

Exploration Drilling Company Wooley No. 1 well (NW 1/4, NE 1/4, sec. 28, T.18S., R.17W.) was the initial well in the Hill Sand. This well was completed in the interval 3162-3169 feet on December 18, 1954 and produced at the rate of 70 barrels of oil per day.

Production through 1986, shown on Figure 17, has been about 1,180,000 barrels of oil. Four wells produced from this zone in 1986.

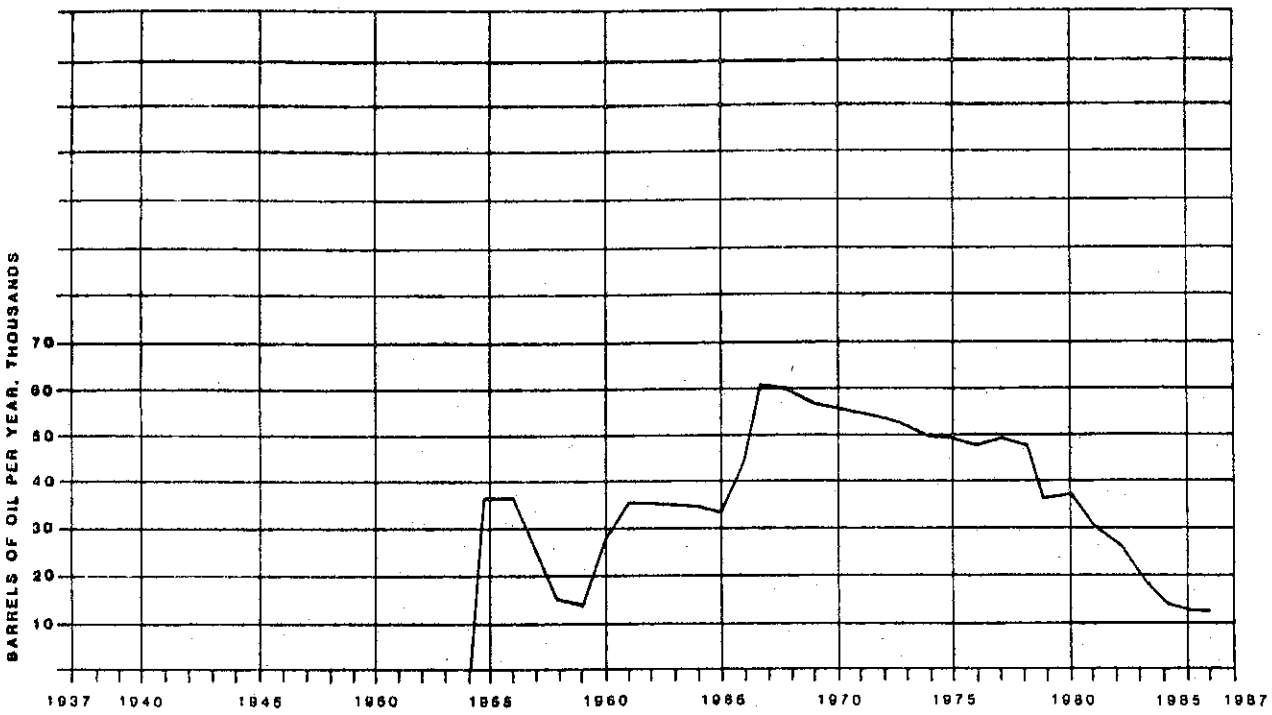


Figure 17. Oil production from the Hill Sand.

SUMMARY

The Shuler Field has been a prime example of the value of reservoir data, the use of technical skills, and of systematic field operation. In Arkansas this field was the first reservoir to be unitized, the first to use gas injection to maintain reservoir pressure, and the first to use water injection for pressure maintenance.

Oil production from the field was developed from two major reservoirs, the Jones Sand and the Reynolds Lime. In addition, substantial production has obtained from the Morgan, Cotton Valley, Pettet, Tuscaloosa, Hill, Mayfield, and LaGrone intervals. Total production during fifty years of operations through December 31, 1986 has been over 107 million barrels of oil.

ACKNOWLEDGEMENTS

I would like to acknowledge the information and assistance provided to me by the following:

Mr. E. Boyd Alderson, Independent Oil Operator, Chairman of the Arkansas Oil and Gas Commission, formerly Production Manager of the Marine Oil Company, and subsequently with Murphy Oil Corporation.

Mr. A. R. Atkinson, Production Manager with BHP Petroleum (Americas) Inc., and current Shuler Unit operator.

Mr. John H. Gray, Consulting Geologist.

Mr. Charles J. Hoke, Geologist, formerly with Phillips Petroleum Company and Murphy Oil Corporation.

Mr. Charles H. Murphy, Jr., Chairman of the Board, Murphy Oil Corporation.

Mr. Wilson H. Sewell, President, Shuler Drilling Company.

Mr. Joe L. Stires, Petroleum Engineer with BHP Petroleum (Americas) Inc.

Mr. Warren B. Weeks, Geologist, formerly with Phillips Petroleum Company.

Arkansas Oil and Gas Commission for well records and reservoir production records.

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