Letter of Transmittal

STATE OF OKLAHOMA

OKLAHOMA GEOLOGICAL SURVEY

NORMAN, OKLAHOMA

July 25, 1958

To the Honorable Board of Regents, and
to President George L. Cross.

Gentlemen:

At the close of the fiftieth year of work of the Oklahoma Geological Survey I submit to you for transmission to the Governor of the State the report of the Director.

The report includes the record of the biennium 1956-1958 in a general summary of the activities of the Survey in its first fifty years. Publication of this report was authorized by the Board of Regents of the University of Oklahoma at its meeting in September, 1956.

Respectfully submitted,

Carl C. Branson, Director

Letter of Transmittal

THE UNIVERSITY OF OKLAHOMA

NORMAN, OKLAHOMA

To the Honorable Raymond Gary
Governor of the State of Oklahoma, and
Members of the Twenty-sixth Legislature

Gentlemen:

It is my pleasure to submit to you the Semi-centennial Report of the work of the Oklahoma Geological Survey, which operates under the supervision of the Regents of the University of Oklahoma, with funds allocated directly by the Oklahoma State Regents for Higher Education.

For fifty years the Oklahoma Geological Survey has been producing reports of research that has been of fundamental importance to the economy and industry of the state. Basic to the development of Oklahoma is scientific and technical information about our mineral deposits and our ground water. This information is the responsibility of the Oklahoma Geological Survey to develop, clarify, and make available to the people of the state.

The funds that are devoted to this kind of research constitute a sound investment in the welfare of all the people. The University of Oklahoma is proud of its affiliation with this important agency, and we are gratified by the record that it has accumulated during the first fifty years of its work.

Respectfully submitted,

G. L. Cross, President

Norman, Oklahoma

June 10, 1958

PREFACE

The establishment of a geological survey was directed in the State Constitution. Article V, section 38 reads, "The legislature shall provide for the establishment of a State Geological and Economic Survey."

The first State legislature did provide for the establishment. The pertinent laws now governing the Survey are:

Title 74, section 231. There is hereby created a bureau to be known as the "Oklahoma Geological Survey". (Laws 1907-08, p. 431)

section 232. The Geological Survey of the State of Oklahoma located at Norman, Oklahoma, is hereby placed under the direction and supervision of the Board of Regents of the University of Oklahoma. (Laws 1923-24, ch. 46, p. 49, section 1).

section 234. The said bureau shall have for its object and duties the following:

First. A study of the geological formations of the State with special reference to its mineral deposits, including coal, oil, gas, asphalt, gypsum, salt, cement, stone, clay, lead, zinc, iron, sand, road building material, water resources and all other mineral resources.

Second. The preparation and publication of bulletins and reports, accompanied with necessary illustrations and maps, including both general and detailed descriptions of the geological structure and mineral resources of the State.

Title 70, section 1981 classifies the Oklahoma Geological Survey as an institution of higher learning and as such it receives its allotment of funds from the appropriation for such institutions, the amount determined by the Oklahoma State Regents for Higher Education.

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Foreword

Oklahoma celebrated her fiftieth year of statehood in 1957. The Oklahoma Geological Survey was established in the State Constitution and is thus as old as the State. The Survey was activated on July 25, 1908. It seems appropriate on this anniversary to summarize the record of the half century.

The Nineteenth Century

The area which is now the State of Oklahoma was the most neglected such area in the United States in geologic work. For the first ninety years of the nineteenth century, the total of published work on geology of the area is not only minute, but was almost without value. Thomas Nuttall visited extreme southeastern Oklahoma in 1819 and published a few observations. The Long expedition of 1819 and 1820 returned from the Rocky Mountains down the Canadian River. The geologist and botanist of the expedition, Edwin James, published a report, but little of that report is on Oklahoma and nothing in his work is important. The most elaborate expedition was that led by Captain Randolph B. Marcy up the Red River in 1852. Marcy reported that members of the expedition had panned gold in the Wichita Mountain area. A totally unsuccessful gold rush, which did not entirely die out within the century, resulted from the report, indeed the greatest excitement was in 1901 after the area was opened to settlement. Dr. George G. Shumard was surgeon and collected specimens of fossils, rocks, and minerals. President Hitchcock of Amherst examined the rocks and minerals, B. F. Shumard the fossils. Coal was noted near present Coalgate. On page 159 Hitchcock made a shrewd observation to Marcy "But though your discovery of gold will probably exite more attention, I feel that the great gypsum deposit of the West, which you have brought to light, will be of far more consequence to the country". The geologic map was the first of consequence of any part of Oklahoma.

Jules Marcou accompanied the expedition of 1853-1854 to determine a railroad route to the Pacific. His report and a map by W. P. Blake were published in 1856. The map is of historical interest and it is noteworthy that it was printed by A. Hoen & Company of Baltimore, the company which printed the Survey's maps of Hughes, Okfuskee, and Seminole Counties in 1955 and 1956.

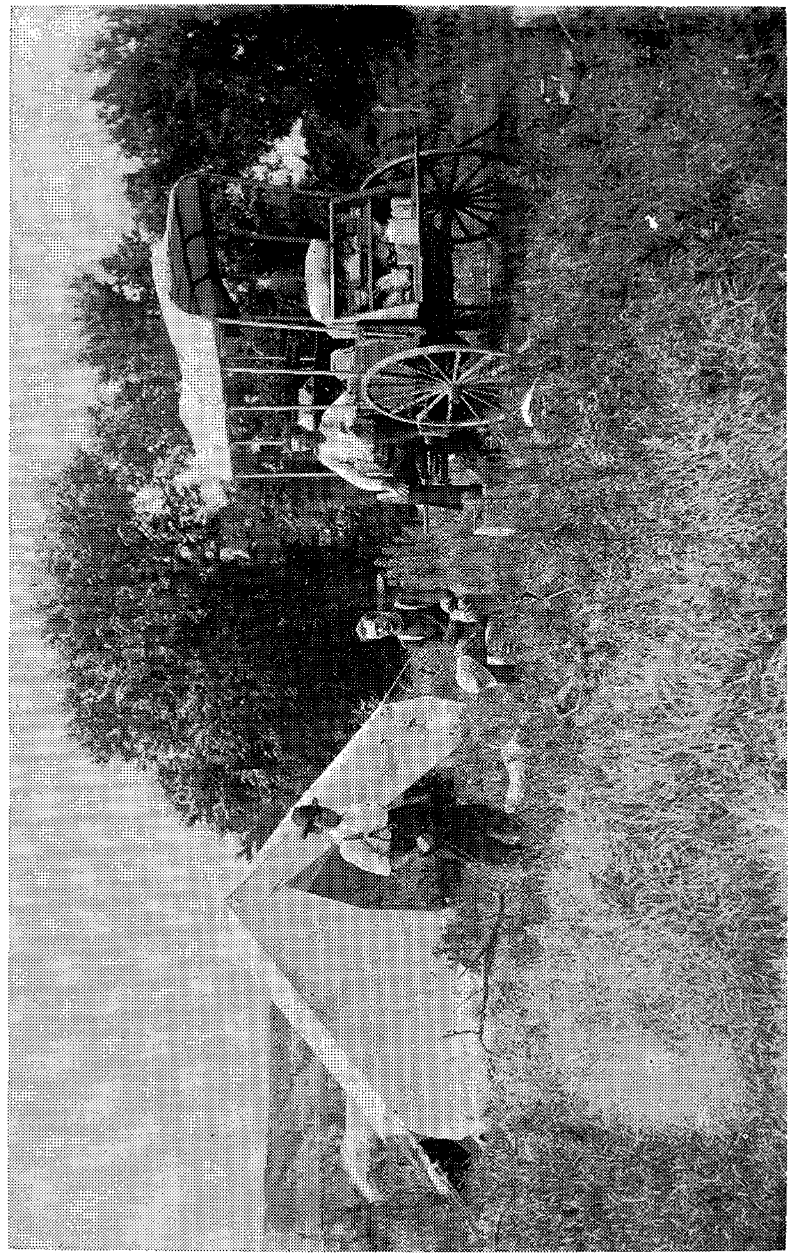
The first detailed geologic report on part of Indian Territory is that of H. M. Chance in 1890. His maps are remarkably accurate and his descriptions are recognizable in present-day terms.

Parties from the United States Geological Survey began work in the State in 1890, especially in connection with coal on the lands of the Choctaw Nation. Joseph A. Taff was the principal worker in the area, and his labors resulted in the publication of a report on the McAlester-Lehigh coal field in 1899.

J. P. Smith had been working in Arkansas for that state survey and one of his assistants (Herbert C. Hoover) in 1892 noted the limestone west of Pawhuska. Smith published the name Pawhuska limestone and credited it to Hoover. The name is still as current as is the name of the author. Another of Smith's students at Stanford University was N. F. Drake, who for his doctoral dissertation mapped and reported upon the geology of the entire northeastern quarter of Oklahoma. He found the granite at Spavinaw and the limestone at Marble City, named the Oologah limestone, and mapped the Mississippian-Pennsylvanian contact. The report was a remarkable contribution for the time.

Territorial Survey

The Oklahoma Territory Department of Geology and Natural History Survey was authorized in 1898 and activated in 1900. Dr. A. H. Van Vleet was director and C. N. Gould was geologist. Available funds were $200 per year in 1899 and in 1900, $300 per year in each of the succeeding 7 years. Gould used the meager funds for field assistants and was able to publish two slender volumes on geology with accompanying botanical and zoological articles. The manuscript of what would have been the first biennial report of the Territorial Survey was burned in the fire which destroyed the university's only building. Gould also worked with the U. S. Geological Survey in those years and the results of his work are published in the important pioneer paper "Geology and water resources of Oklahoma", 1905. Gould is truly the



First field trip of Territorial Survey. Camp in Blaine County in 1900. C. N. Gould by wagon, helpers are White (sitting) and Haddell.

"Father of Oklahoma Geology" as attested by his 19 papers on Oklahoma geology from 1900 to 1907, as well as by his equally important later work in the State.

Federal geologists, and Joseph Taff in particular, were doing excellent work in the territory. Taff published his maps and reports on the Coalgate quadrangle, the Atoka quadrangle, the Tishomingo quadrangle, the Tahlequah quadrangle and the Muskogee quadrangle, as well as 8 reports on coal fields.

The training of geologists at the University of Oklahoma began in this eight-year period under the tutelage of Gould and E. G. Woodruff. Eight students had received degrees by June of 1908.

Oklahoma Geological Survey, 1908-1923

In 1907 the State Constitution was written and Oklahoma was granted Statehood on November 16. Article V, Section 38 of the State Constitution reads "The Legislature shall provide for the establishment of a State Geological and Economic Survey." The enabling act was passed by the First Legislature and signed by the Governor on May 29, and the Oklahoma Geological Survey came into being on July 25, 1908. The enabling act, Senate Bill No. 75, reads in part:

There is hereby created a bureau, to be known as the "Oklahoma Geological Survey . . . .

The said bureau shall have for its object and duties the following:

First: A study of the geological formations of the State with special reference to its mineral resources . . . .

Second: The preparation of and publication of bulletins and reports accompanied with the necessary illustrations and maps, including both general and detailed descriptions of the geological structure and mineral resources of the State.

Third: The consideration of such other scientific and economic questions as shall be deemed of value to the people.

Charles N. Gould was elected Director of the Survey and rooms were rented in private residences. The survey staff consisted of L. L. Hutchison and assistants Ben C. Belt, Artie C. Reeds, W. J. Cross, and T. R. Corr; H. A. Everest and assistants E. Z. Carpenter, H. G. Powell, E. L. DeGolyer, and John Bennett; Chester A. Reeds; Pierce Larkin; Dr. J. W. Beede; Frank A. Herald and Chester

Chester A. Reeds, Geologist. 1905 to 1910. Arbuckle Mountains geology.

C. Clark; G. W. Kneisly; Gaylord Nelson; Key Wolf. This list emphasizes the importance of survey work in training geologists. These men became prominent in geology and in other fields. Hutchison, DeGolyer, Belt, Larkin, Herald, Everest, Carpenter, and Nelson became successful oil geologists. Reeds was a geologist and is a building contractor, Cross is with the University Athletic Association. The majority of the hundreds of staff members and assistants of the Survey have been unusually successful in their careers.

In 1909, the Survey moved into a wooden building just vacated by the Department of Engineering upon the completion of their new building. Dr. D. W. Ohern joined the Survey in that year and Chester A. Reeds resumed his work in Oklahoma under Survey auspices. Since the work of the State Survey has been the most significant influence on Oklahoma mineral industry and geologic investigation since 1908, an examination of the titles of the 78 bulletins, 45 circulars, 35 mineral reports, and approximately 50 other publications is the best means of ascertaining the types of investigation carried out (see p. 105). In addition, Survey geologists have published, with the authorization of the Director, more than 200 geologic articles in scientific journals.

Daniel Webster Ohern, Director, 1911 to 1914. Dr. Ohern helped to form Fortuna Oil Company in 1914, a highly successful firm.

The history of the Survey is bound up with that of the economic progress of the state. Gould resigned on October 7, 1911, to enter the oil business. He was succeeded by Ohern, who in January, 1914, also resigned to enter the oil business. C. W. Shannon became Director, and among the 16 bulletins issued by

him was the influential bulletin on oil and gas in Oklahoma (1915-1917). Federal geologists prepared the excellent report on Osage County, issued 1918-1922. The American Association of Petroleum Geologists grew from a meeting in Norman in 1916 and a first meeting in Tulsa as the Southwestern Association of Petroleum Geologists. The organization, with headquarters in Tulsa, now has more than 13,000 members and is the largest organization of geologists in the world.

After three wooden buildings had burned, with attendant destruction of notes and equipment, the Survey moved into the basement of the old library in 1913. An appropriation of $100,000 for a building for the Survey and for the Department of Geology was made in 1917, and this building was occupied from 1919 to 1952.

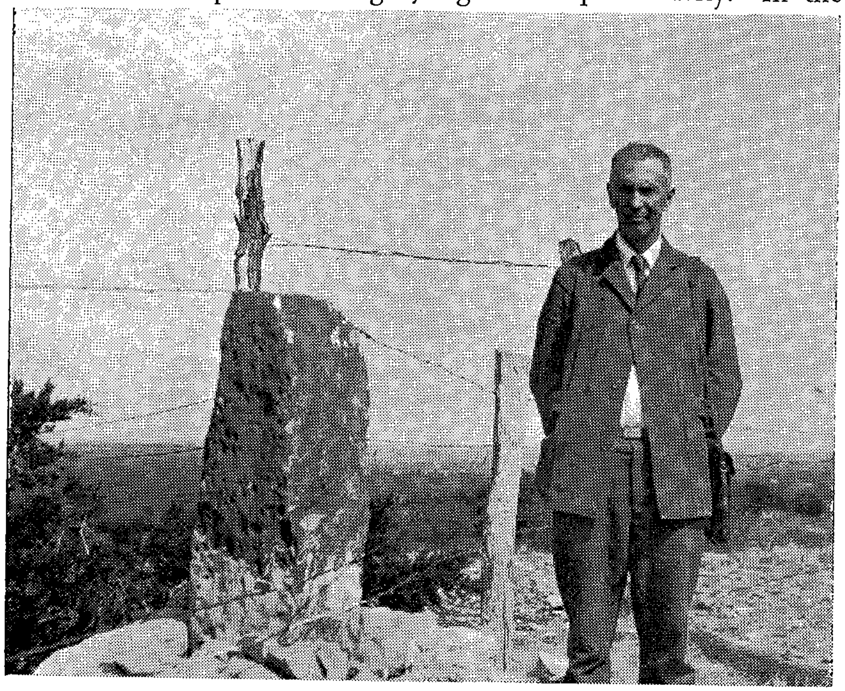
C. W. Shannon, Director, 1914 to 1923

The work of the Survey was abruptly terminated in 1923 when the then governor, Jack Walton, vetoed the appropriation. Shannon attempted to keep the work going on a self-supporting basis as the Bureau of Geology. An important bulletin on the Stonewall quadrangle was published and two short Circulars were issued. The Bureau failed financially even though it offered to give an authorative report on any township for $25. Dr. H. D. Miser began his preparation of a state geologic map and C. W. Honess' significant report on the Ouachita Mountains was issued with funds raised by geologists of the State and with $2,500 secured from Walton by Sidney Powers. The geologic map had to be financed by private subscription of 260 geologists who contributed $3,396.25, and preliminary black and white copies were issued to the subscribers. The map appeared in color in 1926; the first geologic map of the State of reasonable scale and accuracy.

Dr. Charles E. Decker served as custodian of Survey inventory from July 1, 1923 to June 30, 1924, when the Survey was reactivated after the impeachment and conviction of Walton. The legislature in special session in 1924 placed the Survey under the control of the Board of Regents of the University of Oklahoma.

Gould as State Geologist

C. N. Gould assumed the directorship of the Survey in 1924 and initiated a period of highly significant productivity. In the



C. N. Gould, State Geologist, taken at initial point of land survey, Murray County, about 1927.

succeeding 10 years he published 27 bulletins and 9 circulars. Among these was Bulletin 40, a three-volume work on oil and gas in Oklahoma by 46 authors, a monumental accomplishment.

Dr. Gould organized and participated in 21 field conferences from 1925 to 1930. These led to the program of field conferences by geological societies, now widely attended and appreciated.

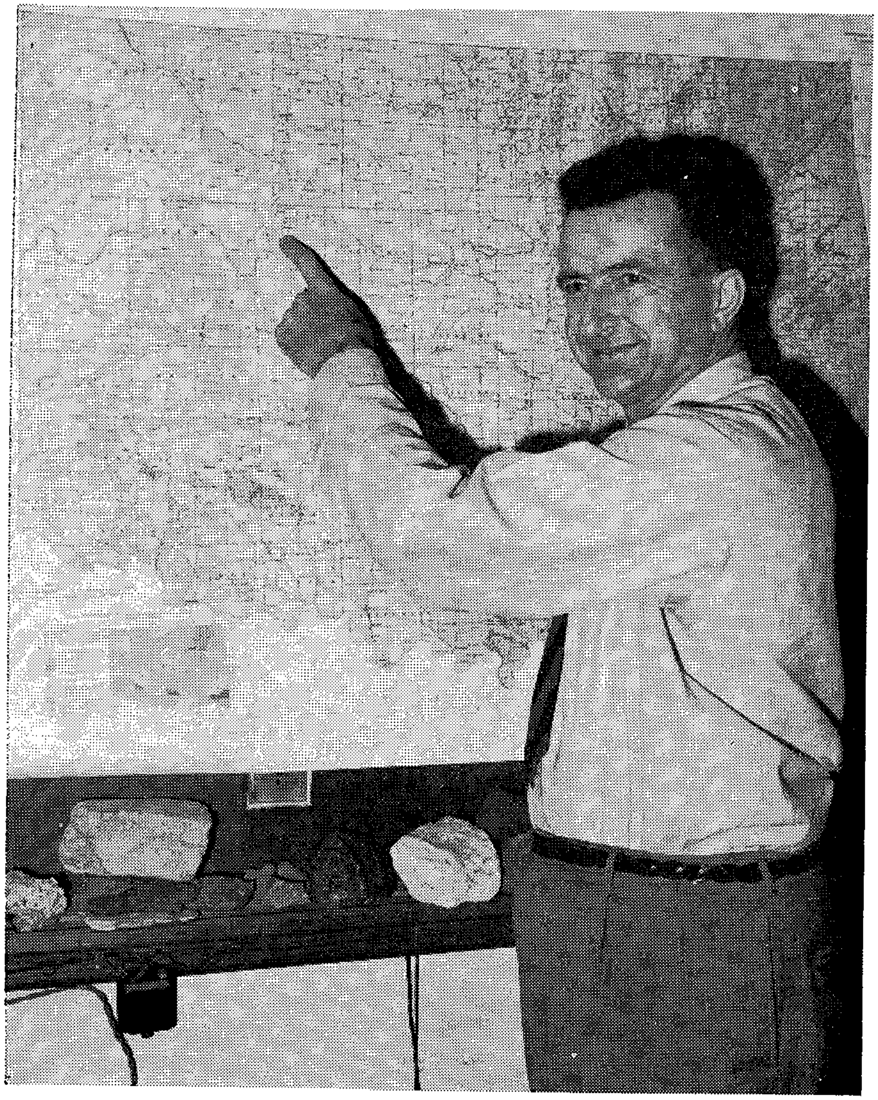
In 1931 the Survey was one of the victims of the political maneuvers of "Alfalfa Bill" Murray. The inventory was again placed under the care of Custodian C. E. Decker; this time for four years. The important manuscript by Weidman on the zinc-lead district was published by the University of Oklahoma Press.

Robert H. Dott, State Geclogist

In 1935 the Survey was reactivated and Robert H. Dott was selected Director. His efforts were at first largely occupied in supervising a State Mineral Survey on funds of Works Progress Administration. Hundreds of field workers visited all parts of the State and recorded construction materials, economic minerals, and ground water supplies. The accumulated information is an important file which is drawn upon for all related survey work.

Dott emphasized the mineral raw materials of the State and their value as the basis of new industry. The reports on rock wool, on glass sand, on barite, on coal, on expanded volcanic ash, on high purity limestone, on ilmenite, and short reports on phosphate, copper, maganese, and ground water aided greatly in industrial expansion. The Survey initiated a series of Mineral and Industrial tours, showed an exhibit of minerals and mineral products in cities of the State, and under editorship of J. O. Beach issued The Hopper, a mimeographed periodical on useful geology for industrialists and geologists.

Dr. Miser was assigned in 1947 by the Federal survey to work with the State survey on a new State geologic map. A great deal of the effort of the Survey was directed toward that necessary project. G. G. Huffman and 26 students under his direction mapped the difficult Ozark area. M. C. Oakes, already the author of bulletins on Washington County and Haskell County, as well as many other reports, mapped by reconnaissance a large area, supervised the field work in a further large area, and published a closed in the Spring of 1952 and Dr. Miser took the manuscript bulletin on Tulsa County. The Norman part of the work was maps to Washington to see the final map to press.



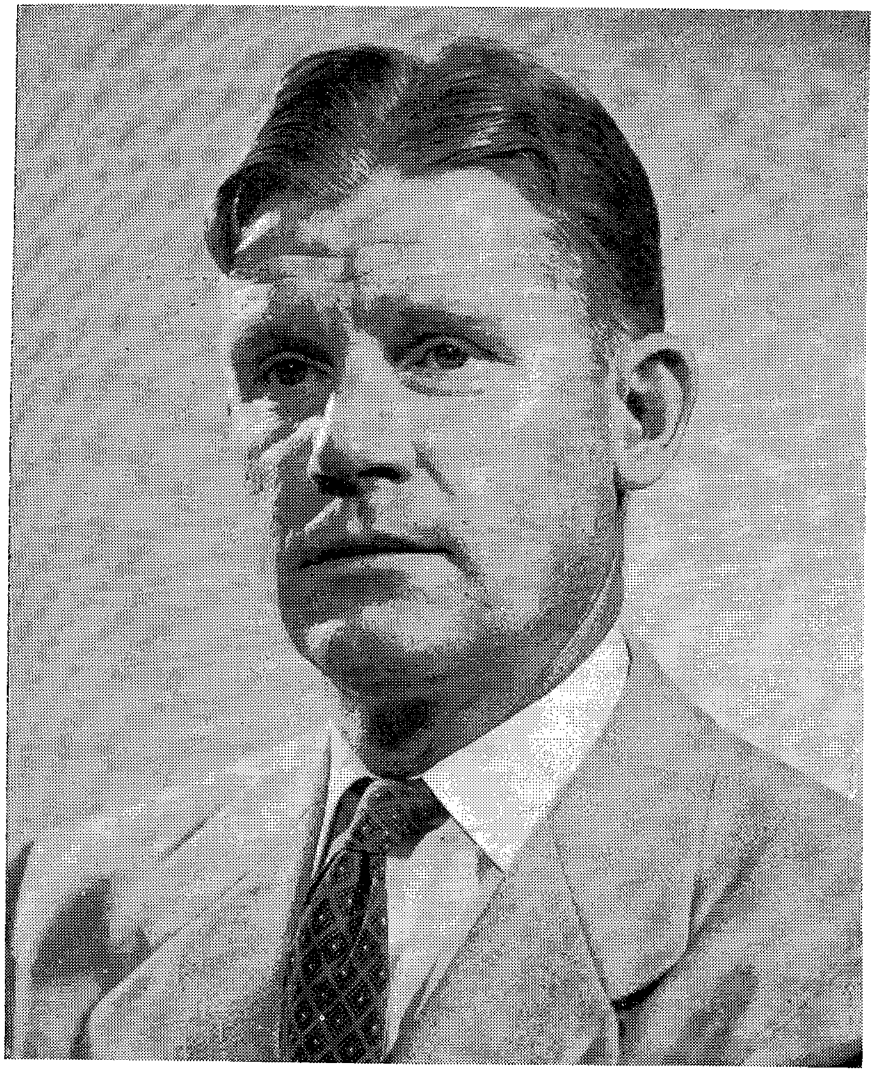
R. H. Dott, Director, 1935 to 1952. Mr. Dott is now Executive Director of the American Association of Petroleum Geologists.

Recent Years

After 17 fruitful years, R. H. Dott resigned his directorship of the Survey on June 30, 1952, in order to accept the position of Executive Director of the American Association of Petroleum Geologists. Dr. W. E. Ham acted as Director for nearly two years, during which time several major projects moved forward, including his own mapping of the Arbuckle Mountains. The south wing of the new geology building, Gould Hall, was constructed for the use of the Survey, and was occupied in August 1952. The wing contains 14 offices, the laboratory, the stock rooms, and file rooms.

The present Director took office in February of 1954 and has continued the wise policies of his predecessors. Mineral investigations, especially upon resources for future State industry, have first priority. Several reports on gypsum resources have been issued and three more are in press or are being prepared for the press. An extensive investigation of coal resources is more than 75 percent complete. W. E. Ham's report on asphaltite has been published. A. L. Burwell has issued his report on marlstone and Wayland and Ham a report on high-purity limestone. Three reports on uranium have been printed and a major study is in preparation. The limestone resources of northeastern Oklahoma are being investigated.

Basic geologic work, upon which all special investigations depend, has not suffered. The new geologic map of Oklahoma was released on December 31, 1954. It is perhaps the best geologic map of a state ever printed. G. G. Huffman's report on the Ozark area has been published. Bulletins on Hughes, Okfuskee, Grady, Ottawa, and Seminole Counties have been published. County reports on Wagoner, Rogers, Craig, Nowata, Okmulgee, McIntosh, Creek, Lincoln, Payne, Pawnee, Osage, Kay, Noble, Blaine, and Harper Counties are complete or nearly so. These, added to the previous county reports printed since 1937, will make available to the people useful and authoritative geologic reports on 29 of the 77 counties. Investigations of all or part of nearly all of the other counties are currently under way.



William E. Ham, Geologist since 1941, Acting Director 1952 to 1954.

The Survey Staff

The present staff of the survey is an experienced, well-trained, and dedicated group. M. C. Oakes is the senior in service with 20 years of continuous work as geologist. He is preparing a report on Creek County and has supervised the completed mapping of Okmulgee and McIntosh Counties. Dr. W. E. Ham has been with the Survey since 1941. His work on Arbuckle Mountain

geology and on industrial minerals has been and is outstanding. He is author or co-author of seven major reports. Albert L. Burwell has ably filled the position of Industrial Chemist since 1941 and is author of numerous Survey reports. In 1955 Mr. Burwell attained the age of 70 and has been active part-time for the past three years. Dr. Louise Jordan joined the Survey in 1955 to engage in subsurface oil and gas investigations. Her report on subsurface units is published and her section on subsurface geology of Creek County will appear with Oakes' surface geology report.

Dr. Thomas W. Amsden in his two years with the Survey has been studying the Hunton group of rocks. Three of his reports have been published and another is in press. Neville M. Curtis has been engaged in educational work of the Survey and is studying rocks of Bryan County. John A. Schleicher is Geochemist with the Survey. His specialty is spectrometry and a spectrometer will be provided for his work when funds permit. He is assisted by Ralph Slate and John Bland.

The drafting department is under Roy D. Davis with Marion Clark assisting. Fred Englund ably cares for the stock room and for shipping and mailing. Mrs. M. E. Reeds, administrative secretary, handles the office excellently and is assisted by Zoleta Rogers.

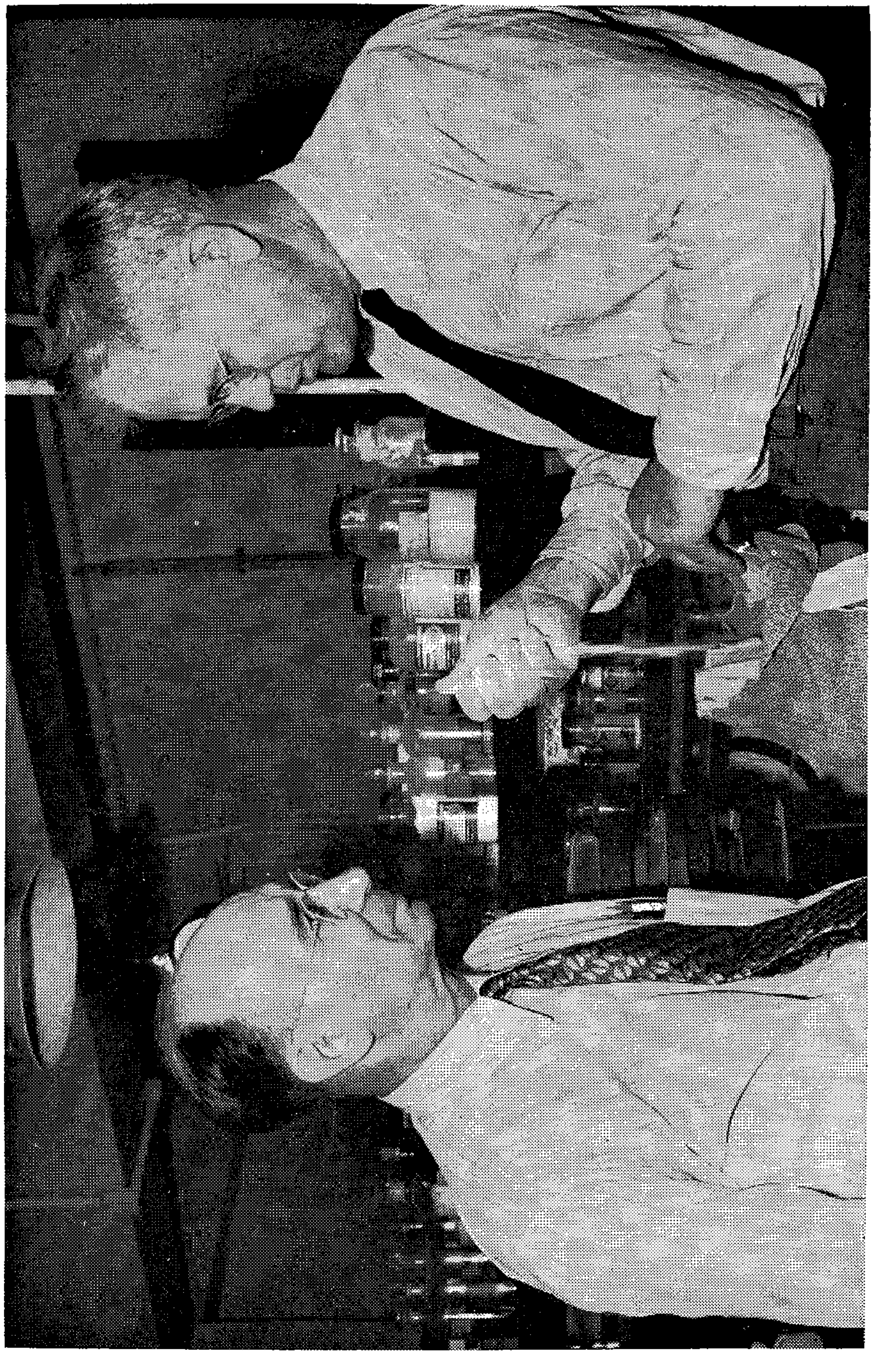
The Survey divides the time of three geologists with the School of Geology. Teaching half-time and engaged in Survey work half-time are:

Dr. L. R. Wilson, micropaleontologist
Robert O. Fay, working on a report on Blaine County
Edward A. Stoever, Jr., economic geology

The Survey is fortunate that it has been able to interest members of the teaching staff of the School of Geology in working on Survey projects during the summers. During the past two summers the following have been so engaged:

Dr. C. A. Merritt, Lake Altus area
Dr. G. G. Huffman, Ozark area
Dr. R. W. Harris, Simpson group
Dr. W. D. Pitt, stratigraphy
Dr. D. B. Kitts, Roger Mills County

Graduate students who have worked on Survey projects dur-



M. C. Oakes, Geologist, and A. L. Burwell, Industrial Chemist.

ing the past two years are too numerous to list, but approximately 35 have done field work.

The services of the Survey to the State and its people in other ways are great. Sets of 100 rocks, fossils, and minerals accompanied by a 90-page book are given to high-schools of the State. The Survey staff answered 2,674 inquiries by letter, held 968 consultations with visitors, and examined and reported upon 683 submitted specimens. The staff prepared or helped to prepare reports on industrial possibilities for eleven communities of the State. Dr. Ham supervised core-drilling for the Chambers of Commerce of Clinton and Weatherford and provided them with a report on gypsum reserves and a map of occurrences. This was a happy collaboration and of a type to be desired. Staff members spoke before civic and professional groups upon some 50 occasions. They serve on numerous university, State, and national committees.

Cooperative Activities

The Oklahoma Geological Survey carried on research on ground water by means of a match-funds cooperation with the Ground-water Branch, U. S. Geological Survey. Just completed are studies on ground water of southern McCurtain County, of Canadian County, and of the Garber sandstone reservoir in Cleveland and Oklahoma Counties. A study of the ground-water characteristics of the Rush Springs sandstone in western Oklahoma is in its third year.

Statistics on production of mineral resources are gathered in cooperation with the U. S. Bureau of Mines, and the Survey publishes these data annually in a mineral report. State production of minerals in 1956 amounted to $754,100,000, a new record.

Publications

The Survey publishes a semi-popular pamphlet on economic and geologic progress in the State under the title "Oklahoma Geology Notes." There are ten issues a year, continuing "The Hopper", sent to a mailing list of 1,400. The publication is in its eighteenth volume. During the triennium July 1, 1955, to June 30, 1958, the Survey published six bulletins, 14 circulars, 8 mineral reports, 4 guide books, and 30 numbers of Oklahoma Geology Notes. The total number of pages printed was 3,023, and three important maps were issued separately.

Program for Biennium 1958-1960

The Survey has been and is the agency which determines the presence of useful mineral raw materials, assesses their reserves, and finds uses for them. A report on the gypsum reserves of the Carter area has been printed and one on gypsum in the Clinton-Weatherford area will be ready this year. Further investigations of gypsum reserves are scheduled. Mr. Burwell has assigned his patents on uses of gypsum to the Research Foundation, and they are a potential basis of new industries.

Ceramic industries have declined from their peak, but special varieties are always of commercial value. A source of buff-burning clay has been found. The Survey in cooperation with the Bureau of Mines demonstrated the feasibility of coking blended coal, a process now in wide use. A lengthy report on Oklahoma coals is being prepared.

Limestones are valuable as rock aggregate, as dimension stone, and as chemical grade limestone. The limestones of northeastern Oklahoma have been mapped and are now being tested, and estimates of reserves are being prepared.

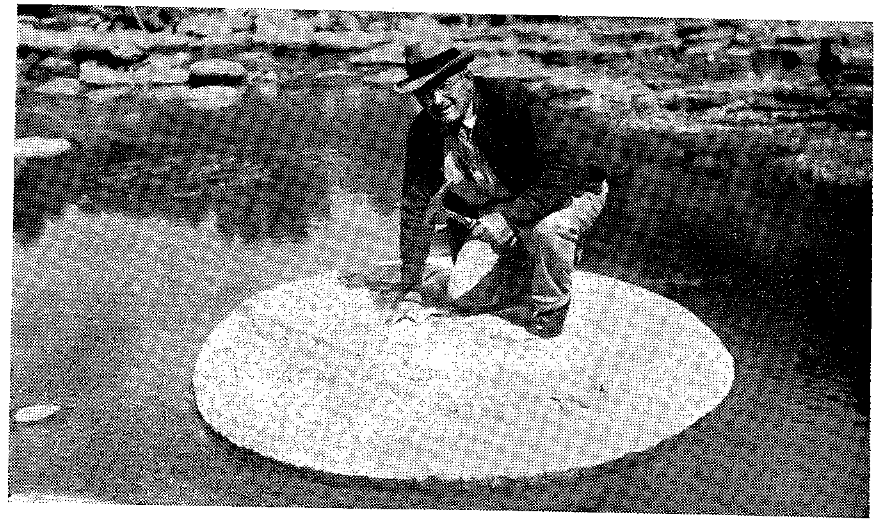
Subsurface geologic information is greatly needed. A program of preparation of subsurface maps is well along and it is hoped that many can be published during the next biennium.

The general geologic background of the State is fundamental to all studies. Geologic maps of all parts should be available on a scale of one inch to a mile or greater. Such maps of more than half of the State are now in Survey files, those of 14 counties already printed, of 3 counties in press. Several more counties will be mapped during the next biennium.

Requirements for Future Work of Survey

When the Naval Air Training Station was reactivated the Survey industrial laboratory, which was housed there, had to be closed. A portion of the planned Survey wing of the new geology building was not built because of inflationary cost increases. This portion should be built, amounting to space on the third floor of 37 feet by 40 feet. Part of this space is needed for a spectrometry laboratory, and a spectrometer is urgently needed for mineral investigations.

The Survey is handicapped in its work in many regions of deep soil by lack of information. A truck-mounted core drill capable of reaching a depth of 300 feet is relatively inexpensive and would make it possible to determine reserves of industrial minerals, would aid in mapping investigations, and would augment work on coal reserves.



Hugh D. Miser, author of both the 1926 and 1954 editions of the Geologic Map of Oklahoma. Dr. Miser is on a Caney concretion in Jackfork Creek.

Completed maps and reports in the files are necessary and desirable, but they are in effect accessible only to Survey staff. Such reports must be published in order to be available to the people. A colored geologic map of a county costs more than $2,000 to print. Manuscript maps and accompanying reports of 19 counties are at present on hand and only about six can be printed with funds of this biennium (1957-1959).

Educational work is highly desirable to provide readable geologic information to teachers and students. Five educational maps have been printed and are available, a booklet on Oklahoma geology is being prepared, and reports on Robbers Cave State Park and on Roman Nose State Park are in preparation. Programmed are reports on Beaver's Bend State Park and on Alabaster Caverns State Park. A guide book on Turner Turnpike, with chapters on botany and history, was issued in 1955. More of this type of public service is desirable and a staff member who can devote full time to the work is needed.

Summary

The Oklahoma Geological Survey has played a major part in industrialization of the State. It's work has been in large measure responsible for the glass industry, for production of coking-coal, for production of high-purity limestone and of lime flux, and for production of light-weight aggregate. The value of its services to the oil and natural gas industry can not be accurately evaluated, but is certainly great. Completed and future work on ceramics, titanium, uranium, ground water, asphaltite, and gypsum are certain to add to the industrial development of the State.

In our State, which produces three-quarters of a billion dollars worth of mineral raw materials a year, a strong and energetic geological survey is vital. The Survey has been and is an important factor in the growth of industry. With its excellent staff and its dedication to the welfare of the people of the State, it will continue to render valuable service.

ANNUAL APPROPRIATED FUNDS OF THE SURVEY COMPARED TO STATE MINERAL PRODUCTION

Territory of Oklahoma

Department of Geology and Natural History

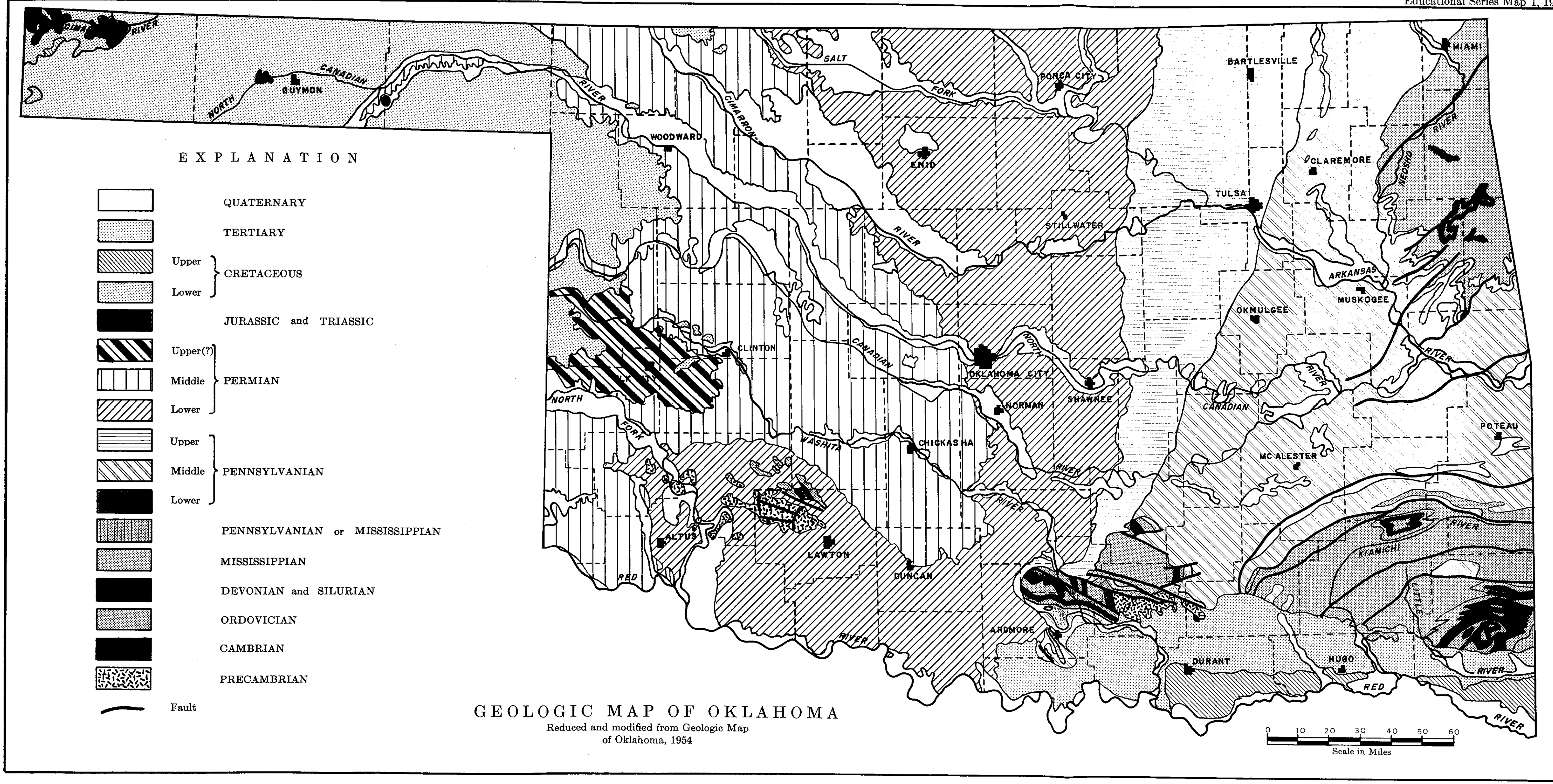
1898	$ 200.00	$ 2,053,168	
1899	200.00	2,570,527	
1900	300.00	3,271,987	
1901	300.00	4,553,005	
1902	300.00	5,110.784	
1903	300.00	7,626,465	
1904	300.00	8,082,093	
1905	300.00	10,682,679	
1906	300.00	15,458,488	
1907	300.00	26,908,968	
1908	7,500.00	26,908,968	(1907)
1909	7,500.00	26,586,751	(1908)
1910	17,245.00	29,008,138	(1909)
1911	17,245.00	32,988,865	(1910)
1911-12	18,800.00	42,678,446	(1911)
1912-13	18,800.00	53,614,130	

1913-14	24,480.00	80,168,820
1914-15	24,480.00	78,744,447
1915-16	24,500.00	81,311,962
1916-17	24,500.00	169,556,331
1917-18	24,580.00	259,134,377
1918-19	24,680.00	336,857,921
1919-20	44,095.00	291,078,174
1920-21	44,095.00	493,320,359
1921-22	45,000.00	269,882,786
1922-23	45,000.00	369,069,612
1923-24	0	398,810,630
1924-25	15,789.35	393,030,665
1925-26	25,000.00	501,767,118
1926-27	25,000.00	569,518,693
1927-28	45,000.00	524,594,732
1928-29	45,000.00	486,634,347
1929-30	51,000.00	516,685,232
1930-31	51,000.00	390,170,991
1931-32	0	181,904,857
1932-33	0	185,120,909
1933-34	0	172,560,924
1934-35	0	237,208,583
1935-36	22,500.00	251,700,898
1936-37	22,500.00	305,191,649
1937-38	33,000.00	367,444,222
1938-39	33,000.00	272,860,078
1939-40	19,914.00	236,194,064
1940-41	19,914.00	235,535,062
1941-42	39,522.55	263,763,923
1942-43	38,443.93	271,298,469
1943-44	37,200.00	254,642,000
1944-45	34,800.00	260,832,000
1945-46	57,489.90	296,564,000
1946-47	50,175.04	326,148,000
1947-48	60,381.00	355,750,000
1948-49	60,381.00	506,846,000
1949-50	98,102.00	483,696,000
1950-51	92,024.00	527,095,000

1951-52	98,940.00	607,486,000
1952-53	93,462.00	621,351,000
1953-54	123,200.00	678,577,000
1954-55	123,200.00	650,205,000
1955-56	125,912.00	708,592,035
1956-57	129,270.00	754,122,600
1957-58	151,849.00	817,100,000

APPROPRIATIONS OF STATE SURVEYS OF ADJACENT STATES
(1957-1958, last year for which figures are available)

Kansas	$347,822
Missouri	300,000
Arkansas	155,000
Texas	154,950
New Mexico	244,091
Oklahoma	151,849



GEOLOGIC MAP OF OKLAHOMA

Reduced and modified from Geologic Map of Oklahoma, 1954

PETROLEUM AND NATURAL GAS

Louise Jordan

Introduction

In the year of the fiftieth anniversary of the founding of the Oklahoma Geological Survey, the State of Oklahoma ranks as the fourth largest producer of crude petroleum in the nation, a position which it has held for twelve consecutive years. It is the second largest producer of liquefied petroleum gases (butane, propane and other materials for fuels and chemical raw material), fourth largest producer of natural gas, and of natural gasoline and cycle products. The $772,300,000 value of these products in 1957 amounted to 94.5 percent of the total value of mineral production in Oklahoma.

Oklahoma's first year of production in 1891 was 30 barrels. Through 1957, it has now produced nearly 7.7 billion barrels of oil and 500 million barrels of natural gasoline and related products, and more than 14.3 trillion cubic feet of gas. Total value of these commodities is 15.2 billion, as shown in Table 1 which gives production and value beginning with the first year of production.

The industry employs approximately 60,000 persons in occupations directly related to the production phase of the business. Additional employment to many thousands is given by industry-affiliated manufacturers and distributors of oil field supplies, drilling contractors, and other technical and scientific organizations. Total wages of about $200,000,000 annually are paid to oil people, which is an exceptionally important factor in the economic life of Oklahoma. In addition to royalties from producing land, estimated to be about 1,500,000 acres, land owners of Oklahoma benefit materially from leasing of land for oil and gas. At the beginning of 1956, the area under lease was estimated to be in the neighborhood of 18,360,000 acres. Approximately 45 percent of the total land area of the State is either productive or is leased for oil exploration. A study of western Oklahoma reveals that this income alone in many instances is more than 25 percent of the total income received from the land. In addition, the value of mineral rights, due to exploration, has generally increased the average value of land investment more than 30 percent.

MARKETED PRODUCTION AND VALUE OF PETROLEUM, NATURAL GAS, NATURAL GASOLINE, AND LIQUEFIED PETROLEUM GAS IN OKLAHOMA, 1891-1957[1]

CRUDE PETROLEUM				NATURAL GAS			NATURAL GASOLNE[4]			LIQUEFIED PETROLEUM GAS		
Year	1,000 bbls. (42 gals.)	Value $1,000	Average $ value per bbl.	Year	1 million cu. ft.	Value $1,000	Year	1,000 gals.	Value $1,000	Year	1,000 gals.	Value $1,000
1891-1900	11		0.71									
1901	10	7	0.70									
1902	37	33	0.89									
1903	139	142	1.03									
1904	1,367	1,326	0.97									
1905	8,264	4,296	0.55	1902-05		171						
1906	18,091	8,247	0.44	1906	3,520	260						
1907	43,524	17,514	0.40	1907	4,867	417						
1908	45,799	17,695	0.39	1908	11,925	860						
1909	47,859	17,429	0.36	1909	28,037	1,806						
1910	52,029	19,923	0.38	1910	50,430	3,491						
1911	56,070	26,452	0.47	1911	67,276	6,732	1911	388	21			
1912	51,427	34,673	0.67	1912	73,799	7,407	1912	1,576	100			
1913	63,579	59,582	0.94	1913	75,018	7,436	1913	6,463	578			
1914	73,632	57,253	0.78	1914	78,167	8,050	1914	17,278	1,113			
1915	97,915	56,706	0.58	1915	87,517	9,196	1915	31,666	2,361			
1916	107,072	128,464	1.20	1916	123,517	11,984	1916	48,460	5,865			
1917	107,507	181,647	1.69	1917	137,617	13,985	1917	115,123	21,542			
1918	103,347	231,136	2.24	1918	124,317	15,805	1918	163,701	28,389			
1919	86,911	184,100	2.12	1919	163,649	23,650	1919	189,995	32,565			
1920	106,206	356,440	3.36	1920	154,467	25,805	1920	178,857	31,334			
1921	114,634	183,185	1.60	1921	124,058	23,429	1921	185,341	22,066			
1922	149,571	258,160	1.73	1922	140,631	33,476	1922	189,404	24,914			
1923	160,929	279,700	1.74	1923	203,082	31,214	1923	270,249	23,012			
1924	173,538	272,450	1.57	1924	214,452	31,046	1924	301,062	23,338			
1925	176,768	348,230	1.97	1925	249,285	36,121	1925	390,861	40,973			
1926	179,195	413,900	2.31	1926	286,421	42,140	1926	475,716	41,433			
1927	277,775	397,200	1.43	1927	326,864	41,391	1927	548,109	29,114			
1928	249,857	347,600	1.39	1928	320,861	47,476	1928	619,691	40,959			
1929	255,004	364,650	1.43	1929	357,893	53,528	1929	676,030	42,766			
1930	216,486	279,250	1.29	1930	348,116	47,632	1930	591,194	29,148			

TABLE 1 (Continued)

1931	180,574	119,200	0.66	1931	263,685	32,593	1931	454,886	12,619			
1932	153,244	137,920	0.90	1932	255,487	28,108	1932	378,584	8,083			
1933	182,251	120,800	0.66	1933	245,759	23,760	1933	360,488	12,177			
1934	180,107	183,700	1.02	1934	254,457	23,744	1934	355,438	10,728			
1935	185,288	189,000	1.02	1935	274,313	26,541	1935	379,913	14,593			
1936	206,555	232,100	1.12	1936	280,481	28,847	1936	418,591	17,516			
1937	228,839	283,500	1.24	1937	296,260	32,039	1937	492,290	20,272			
1938	174,994	209,500	1.20	1938	263,164	27,391	1938	468,499	14,373			
1939	159,913	166,300	1.04	1939	250,875	28,103	1939	436,123	15,502			
1940	156,164	162,500	1.04	1940	257,626	31,603	1940	399,369	8,926			
1941	154,702	174,800	1.14	1941	234,054	29,821	1941	362,247	16,084	1941	91,136	2,076
1942	140,690	168,000	1.19	1942	269,704	38,270	1942	336,707	12,655	1942	108,408	2,853
1943	123,152	146,550	1.19	1943	285,045	42,503	1943	309,942	15,663	1943	112,371	2,858
1944	124,616	153,290	1.23	1944	310,888	46,346	1944	301,246	16,200	1944	120,522	3,400
1945	139,299	177,050	1.27	1945	357,530	66,014	1945	284,334	15,223	1945	131,850	3,276
1946	134,794	194,100	1.44	1946	380,938	76,000	1946	283,915	12,907	1946	131,076	2,955
1947	141,019	270,760	1.92	1947	419,010	16,509[3]	1947	280,891	18,690	1947	165,602	5,700
1948	154,455	398,490	2.58	1948	480,573	23,356	1948	272,897	26,143	1948	196,581	10,963
1949	151,660	388,250	2.56	1949	435,262	20,327	1949	287,910	20,360	1949	236,472	8,408
1950	164,599	423,020	2.57	1950	482,360	23,636	1950	335,160	21,579	1950	283,626	8,393
1951	186,869	480,250	2.56	1951	538,756	28,554	1951	397,236	27,498	1951	339,528	12,436
1952	190,435	487,510	2.70	1952	554,033	29,918	1952	405,720	29,459	1952	376,026	14,090
1953	202,570	546,940	2.70	1953	599,955	41,397	1953	433,650	28,066	1953	414,036	14,886
1954	185,851	518,520	2.79	1954	616,355	43,145	1954	478,590	24,332	1954	453,810	13,506
1955	202,817	565,280	2.79	1955	614,976	45,508	1955	504,692	28,770	1955	512,320	14,297
1956[2]	215,640	601,647	2.79	1956	662,000	48,988	1956	526,768	28,530	1956	621,520	20,989
1957[2]	213,800	665,000		1957	681,000	57,300	1957	490,000	26,500	1957	580,000	23,500
Total	7,659,450	$12,663,367			14,321,232	$1,484,829		15,437,250	$945,759		4,874,884	$164,586

TOTAL VALUE: $15,258,541,000

[1] Figures from Okla. Geological Survey, Circ. No. 29, compiled from various federal government publications; *Minerals Yearbook*, U. S. Bureau of Mines; and mineral reports prepared cooperatively by the U. S. Bureau of Mines and the Oklahoma Geological Survey.

[2] Preliminary figures.

[3] 1947-56 values estimated at wells; value for previous years is at point of consumption.

[4] Natural gasoline includes natural and finished gasoline, naptha and other products, and liquefied petroleum gas (LP-gases) through 1940; LP-gases volume and value listed separately beginning in 1941.

Oil or gas has been discovered and produced in seventy of the seventy-seven counties of the State, and it seems probable that future exploration in geologically favorable areas will ultimately develop production from as many as 74 of these counties. In Figure 1 is shown the date of discovery or of production of either oil or gas in each county.

Those counties that are outstanding for large production of petroleum and natural gas are Carter, Creek, Garvin, Oklahoma, Osage, Pontotoc, Seminole, Stephens, and Texas; and at least 50 other counties have yielded substantial production. Although the seventy counties from which oil or gas has been produced are widely scattered throughout Oklahoma, through strange geologic coincidences the seven unproductive counties are at or near the borders of the State. Harmon and Roger Mills in the west are now unproductive, but they overlie sedimentary basins that probably contain oil, and Choctaw and Pushmataha Counties in the southeast have been partly drilled, with some encouraging shows. Only in Adair, Cherokee, and Delaware Counties, in the Ozark region of northeastern Oklahoma, are the geologic relations unfavorable; and perhaps this northeast area is the only part of the State that will not produce mineral fuels.

Every county in which substantial quantities of oil and gas have been discovered has benefited with better schools, more improved roads, and greatly increased business and industrial activity. Community prosperity has always gone along with oil field operations, as most pools produce many years after flush production has settled into stripper operations.

Major oil fields, that is, those in which the estimated ultimate production of oil will be 100 million barrels or more, account for more than fifty percent of the world's total production. In the United States, there are 204 such major or "giant" fields, of which 20 are located in Oklahoma (*Oil and Gas Journal,* 1958, vol. 50, No. 4, p. 162). It is predicted that 53.0 percent of Oklahoma's crude oil and natural gas liquids discovered up to this time will ultimately come from these fields. In 1957 they yielded 42.4 percent of the annual production and contained 48.1 percent of the remaining estimated proved reserves. The search for fields of this magnitude is a continuing project in the petroleum industry.

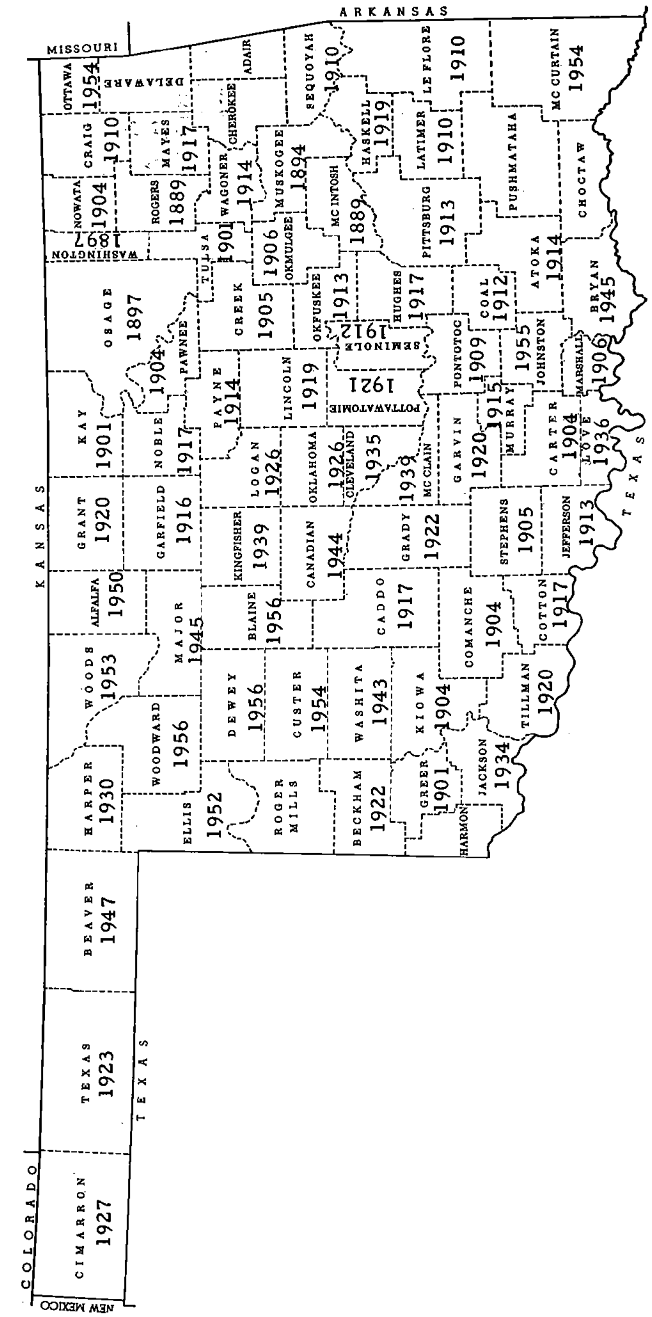


Figure 1. Date of discovery or of production of oil or gas in counties of Oklahoma

TABLE 2

OIL WELLS, GAS WELLS, CONDENSATE WELLS, AND DRY HOLES DRILLED AS EXPLORATORY TESTS IN OKLAHOMA, 1937-1957

	OIL PRODUCERS		GAS PRODUCERS		CONDENSATE PRODUCERS		TOTAL PRODUCERS		DRY HOLES		GRAND TOTALS		Average Depth of Hole in feet
	No. Holes	Footage	No. Holes	Footage	No. Holes	Footage	No. Holes	Footage	No. Holes	Footage	No. Holes	Footage	
1937	21	83,752	7	18,837	*		28	102,589	146	596,257	174	698,846	4,016
1938	27	125,891	5	12,328	*		32	138,219	92	372,123	124	510,342	4,116
1939	17	64,386	4	17,886	*		21	82,272	91	388,470	112	470,742	4,203
1940	35	133,291	6	14,744	*		41	148,035	144	534,822	185	682,857	3,702
1941	54	209,671	12	43,521	*		66	253,192	180	657,777	246	910,969	3,703
1942	32	137,542	3	6,782	*		35	144,324	219	884,543	254	1,028,867	4,051
1943	48	211,169	15	53,604	*		63	264,773	293	1,168,207	356	1,423,980	4,025
1944	71	278,712	16	51,866	*		87	330,578	297	1,252,837	384	1,583,415	4,123
1945	78	385,824	16	54,067	*		94	439,891	343	1,489,721	437	1,929,612	4,416
1946	91	395,791	25	91,502	*		116	487,293	474	1,685,488	590	2,172,781	3,683
1947	129	573,344	35	112,590	3	28,980	167	714,914	724	2,475,578	891	3,190,492	3,581
1948	117	555,643	29	147,988	1	9,708	147	713,339	646	2,620,291	793	3,333,630	4,204
1949	143	558,469	24	74,604	2	10,922	169	643,995	656	2,328,918	825	2,972,913	3,604
1950	169	657,258	17	59,003	6	42,912	192	759,173	858	2,998,774	1,050	3,757,947	3,579
1951	169	655,571	18	80,907	2	25,994	189	762,472	712	2,850,558	901	3,613,030	4,010
1952	126	576,685	23	99,805	8	68,228	157	744,718	735	3,311,043	892	4,055,761	4,547
1953	177	811,183	44	202,068	7	36,742	228	1,049,993	736	3,045,422	964	4,095,415	4,248
1954	152	670,726	28	122,057	10	69,869	190	862,652	754	3,121,701	944	3,984,353	4,[illegible]21
1955	144	707,513	47	217,457	14	96,844	205	1,021,814	718	2,912,546	923	3,934,360	4,263
1956	185	839,494	64	326,679	17	120,123	266	1,286,296	863	3,541,653	1,129	4,827,949	4,276
1957	145	649,372	43	220,412	12	93,650	200	963,434	823	3,342,246	1,023	4,305,680	4,209

* Condensate producers included with gas wells.

Figures compiled from annual June issue of American Association of Petroleum Geologists Bulletin.

In 1956, 470 wells were drilled as new-field or "rank" wildcats resulting in the discovery of 74 fields (*Amer. Assoc. Petrol. Geologists,* vol. 41, p. 993). However, these wells were only part of the exploratory efforts of the industry, which drilled an additional 659 tests searching for long extensions to partly developed fields or for new reservoirs in areas already productive. Of these, 192 were successfully completed as producers. Table 2, which is a compilation of data on exploratory drilling in Oklahoma from 1937 through 1957, shows that 1956 was an exceptional year in the history of petroleum exploration for the State. In that year 266 producers of either oil or gas were discovered by drilling 1,129 exploratory holes, giving an abnormally high 23.56 percent of successful ventures compared with the national average of 19.79 percent. Wells drilled in already producing areas and not considered exploratory numbered 6,493 of which 4,880 or approximately 70% were successfully completed as oil or gas wells. As a result of exploratory and development drilling, proved reserves of the State were estimated at the beginning of 1957 as 2,139 million barrels of crude oil, 13,775 billion cubic feet of gas, and 356 million barrels of natural gas liquids. By the end of 1957, the estimated reserves of these products had increased oil by 2 million barrels, natural gas liquids by 31 million barrels and natural gas by 725 billion cubic feet.

The importance of exploration in relation to reserves is shown rather aptly in Table 3 which compares the estimated proved reserves of liquid and gas hydrocarbons as of January 1, 1950, with the actual production for the eight-year period to January 1, 1958. The amount of crude petroleum produced was actually 233 million barrels greater than the reserves in sight at the end of 1949, and an additional 2,141 million barrels of reserves had been discovered. The question, do we have any oil left in Oklahoma, is obviously and fully answered, for as a result of vigorous exploration our proved reserves *continue to increase* despite heavy withdrawals to meet steadily rising markets.

In Table 3, the statistics for estimated proved reserves at the beginning of 1950 are from the U. S. Bureau of Mines *Yearbook,* whereas those at the beginning of 1958 are from the *Oil and Gas Journal.*

TABLE 3

	Proved Reserves 1-1-1950	Production 1950 thru 1957	Proved Reserves 1-1-58
Crude petroleum (million bbls.)	1,330	1,563	2,141
Natural-Gas liquids (million bbls.)	234	170	387
Gas (billion cubic feet)	11,626	4,749	14,500

At least 237,600 holes have been drilled in Oklahoma since 1903 (see Table 4). Of this total number, 156,354 were oil wells, 16,827 were gas wells, and 64,086 were dry holes. In 1956, a total of 8,056 tests were drilled in Oklahoma, not as many as in the two previous years, but a greater number than in any year since 1920. The number of tests decreased 1,821 in 1957. An estimated 4,400 were producing gas and 77,610 were producing oil at the end of the year. About 75,600 of the oil wells are producing by artificial lift and the remainder are flowing. Approximately 58,000 of these wells are of the stripper type, that is, they produce an average of less than four barrels of oil per day. In 1956, 82,169,000 barrels or nearly 39% of the state's total production of crude oil came from wells having an average daily production of 3,87 barrels. These wells have produced several billion barrels of oil and it is estimated that with the use of secondary recovery methods at least 1.1 billion barrels of additional oil will be recovered from them. (Petroleum Week, vol. 6, no. 11, p. 15.) Secondary recovery in old fields, and pressure-maintenance projects using water, gas, or liquefied petroleum gas in newly developed fields, increase the reserves of recoverable oil in the State. At the present time the tempo of research in the laboratory and in the field is increasing, with the hope that methods will be developed which will lead to 100 percent recovery of oil from known reservoirs. Recovery of 50 percent of the oil in place in a reservoir is now considered exceptional. Table 5 gives the available statistics on recovery of oil from water-flood and gas-injection projects in Oklahoma from 1920 to 1956.

To help increase reserves, and in line with the national trend, Oklahoma geologists and geophysicists are concentrating more of their efforts toward finding oil-bearing stratigraphic traps. They are also carefully scrutinizing producing structures in which oil might be found by drilling deeper.

TABLE 4

ANNUAL DRILLING STATISTICS FOR OKLAHOMA, 1903-1957

Year	Number of Wells Drilled: Oil	Gas	Dry	Total	Footage drilled in thousands of feet [1]	Average footage of all wells drilled [1]	Gas wells producing as of Dec. 31st	Oil wells producing as of Dec. 31st	Average production per well per day
1903-26[2]	90,626[2]	9,416[2]	25,366[2]	125,408[2]				[6]	
1927	2,562	508	1,443	4,513				61,750	12.3
1928	1,961	491	1,227	3,679				62,900	11.0
1929	1,999	369	1,245	3,613			3,060	61,180	11.3
1930	2,061	403	1,002	3,466			3,217	63,600	9.5
1931	498	186	374	1,058			3,091	56,720	8.2
1932	643	106	381	1,130			2,803	57,100	7.4
1933	668	72	353	1,093			2,770	56,850	8.3
1934	1,161	91	465	1,717	5,181	2,961	2,710	56,650	8.7
1935	1,321	110	579	2,010	6,682	2,017	2,640	54,600	9.1
1936	1,790	126	649	2,565	8,969	3,139	2,610	54,800	10.3
1937	1,852	123	697	2,672	8,731	2,984	2,630	55,900	11.3
1938	986	160	545	1,691	6,180	2,961	2,480	54,400	8.7
1939	1,045	151	603	1,799	5,941	2,855	2,420	54,500	8.0
1940	1,011	176	657	1,844	4,904	2,674	2,430	53,400	7.9
1941	1,099	140	582	1,821	5,530	2,621	2,400	54,200	7.9
1942	524	86	549	1,159	3,934	3,394	2,250	53,000	7.2
1943	543	92	549	1,184	3,945	3,332	2,330	53,100	6.4
1944	1,031	212	647	1,890	7,172	3,794	2,450	51,900	6.5
1945	1,426	250	833	2,509	10,048	3,986	2,680	52,000	7.3
1946	1,654	341	1,001	2,996	9,771	3,204	3,000	52,170	7.1
1947	1,989	302	1,532	3,823	12,151	3,590	3,250	52,200	7.4
1948	2,417	258	1,588	4,263	15,515	3,614	3,400	53,000	8.0
1949	2,483	213	1,612	4,308	15,339	3,525	3,500	54,400	7.7
1950	3,304	249	1,812	5,365	19,865	3,639	3,600	56,800	8.1
1951	3,109	265	2,075	5,449	20,542	3,651	3,600	57,600	9.0
1952	3,086	295	2,247	5,628	21,621	3,740	3,700	60,320	8.8
1953	4,596	339	2,525	7,460	26,122	3,440	3,900	63,400	9.0
1954[3]	5,417	383	2,986	8,786	29,463	3,553	4,100[5]	67,580	7.6
1955[3]	5,131	359	2,921	8,411	27,532	3,273	4,300[5]	74,700	7.4
1956[3]	4,825	321	2,476	8,056[4]	27,821	3,453	4,400[5]	75,750	7.7
1957[3]	3,536	234	2,148	6,235[4]	21,595	3,463	4,407[5]	77,610	7.5
Total	156,354	16,827	64,086	237,601					

Data from U. S. Bureau of Mines except [1] *World Oil* from 1934-1939, *Oil and Gas Journal* from 1940-1956. (Footage drilled divided by total number of wells drilled will not necessarily give average footage drilled since total number of wells is not always the same as that of U. S. Bureau of Mines). [2] Annual data for years 1903-1926 available in Oklahoma Geological Survey Bull. 40, vol. 1, p. 87. [3] Annual data from *Oil and Gas Journal*. [4] Includes service wells. [5] *World Oil*. [6] Annual data for years 1903-1926 available in "Oil and Gas in Oklahoma" published by Mid-Continent Oil and Gas Association, 1942.

TABLE 5

SECONDARY RECOVERY OF PETROLEUM IN OKLAHOMA, 1920-1956[1]
(thousand barrels)

	Gas Injection[2]	Water-Flood[3]	Annual Total	Cumulative Total
1920	350		350	
1921	600		600	950
1922	900		900	1,850
1923	1,200		1,200	3,050
1924	1,500		1,500	4,550
1925	1,800		1,800	6,350
1926	8,000		8,000	14,350
1927	15,000		15,000	29,350
1928	23,725		23,725	53,075
1929	24,000		24,000	77,075
1930	23,775		23,775	100,850
1931	24,000		24,000	124,850
1932	25,000		25,000	149,850
1933	26,000		26,000	175,850
1934	27,000		27,000	202,850
1935	28,470	50	28,520	231,370
1936	24,000	800	24,800	256,170
1937	20,000	1,200	21,200	277,370
1938	19,500	2,400	21,900	299,270
1939	19,000	3,680	22,680	321,950
1940	18,425	2,800	21,225	343,175
1941	17,000	2,900	19,900	363,075
1942	16,000	2,900	18,900	381,975
1943	15,000	1,900	16,900	398,875
1944	14,000	1,600	15,600	414,475
1945	13,075	1,400	14,475	428,950
1946	11,375	1,500	12,875	441,825
1947	9,000	1.500	10,500	452,325
1948	8,000	2,500	10,500	462,825
1949	7,000	3,500	10,500	473,325
1950	6,000	4,000	10,000	483,325
1951	8,000	5,000	13,000	496,325
1952	10,000	12,000	22,000	518,325
1953	10,500	18,975	29,475	547,800
1954	10,385	23,465	33,850	581,650
1955	9,060	27,850	36,910	618,560
1956	[4]15,000	[5]37,000	[4]52,000	670,560

1 Data from Secondary Recovery Committee, Interstate Oil Compact Commission.
2 Total production from gas-injection projects does not necessarily reflect entirely secondary recovery since the figures include pressure-maintenance projects.
3 Estimated production from water-flood projects.
4 Preliminary figure.
5 Preliminary figure which may include pressure-maintenance projects employing water-injection not thought to be included in production figures for previous years.

The powerful impact of the discovery and production of liquid fuels on the growth and development of Oklahoma is summarized chronologically in the following pages, and Figure 2 shows graphically the production and value of petroleum, the most important commodity, for the period 1904-1957.

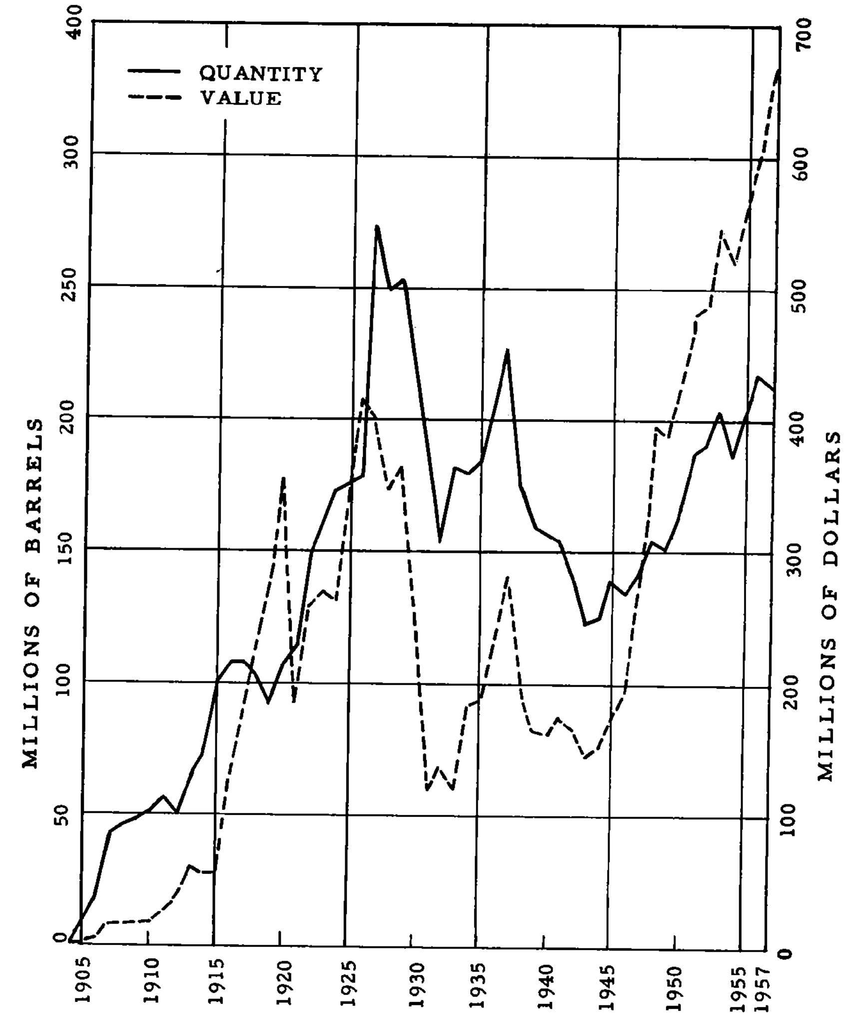


Figure 2. Production and value of crude petroleum in Oklahoma, 1904-1957.

1901-1906

The petroleum industry commenced active development in Indian Territory with the discovery of a producing oil well in the Red Fork-Tulsa district 56 years ago, in 1901. Previous to this time, in 1894, oil had been discovered by drilling in the city of Muskogee. In 1889, three wells were drilled near Chelsea, and in 1900 other wells were developed and oil was piped to Chelsea. Five wells drilled prior to 1901 in the Osage reservation just west of Bartlesville produced 10,000 barrels of oil that year. By the end of 1906, oil development was active in the vicinity of Alluwe, Bartlesville, Bird Creek, Boston, Broken Arrow, Claremore, Cleveland, Depew, Dewey, Lenapah, Madill, Morris, Muskogee, and Wheeler. Considerable gas had been discovered in the Hogshooter field in northern Oklahoma, and also in the vicinity of the Graham and North Cruce fields in southern Oklahoma. In addition to the active development in some of these areas, the Avant discovery in 1904 and the Glenn discovery in November, 1905, located two major fields from which more than 350,000,000 barrels have already been recovered. At the end of 1906, Oklahoma was the leading crude producer in the Southwest,—a supremacy maintained until 1928 when Texas attained the lead. It had already produced 27,500,000 barrels of oil valued at approximately $14,000,000.

1907

At the close of 1907, the new state ranked first in the production of petroleum in the nation, overtaking California and producing 43,500,000 barrels of oil valued at $17,500,000. Twenty million barrels, nearly half the total, was attributed to the Glenn field, which attained a rate of production as high as 120,000 barrels daily. More than 9,500 wells, of which 8,490 produced oil or gas, were drilled in the four years from the beginning of 1904 to the end of 1907. It is estimated that 7,850 wells were producing oil at the end of 1907, and it is recorded that 344 gas wells supplied 11,038 domestic users and 277 industrial users. During this year, additional oil discoveries were made at Bald Hill, Canary, Copan, Coalton, Cruce, Wann, and Schulter-Henryetta.

1908

About 1,100 fewer wells were drilled in 1908 than in 1907, but production increased 2,200,000 barrels owing to the discovery of deeper sands in producing fields and to higher production of individual wells. Glenn, Bartlesville, Cleveland, and Muskogee fields were the centers of greatest activity. The price of oil remained at the stationary price of 41 cents per barrel. At the end of the year there was no market for one-fourth of the total production. Delaware-Childers, Nowata-Claggett, Tiger Flats, and Gotebo fields were discovered. A map of the developed oil fields published by the Oklahoma Geological Survey in November of 1908 shows three fields in southwest Oklahoma (Wheeler, Gotebo, Lawton), two fields in south Oklahoma (Cruce, Madill), two fields in Kay County (Blackwell and Ponca City townsites, both producing gas), and 32 fields in the area along the 96th meridian from the state line to Okmulgee and Muskogee Counties, including gas at Bristow in Creek County and light oil at Wewoka in Seminole County.

1909

Operators, through the Producer's Association, made strenuous efforts to suspend drilling operations and thus check production. Extreme drouth prevailed in the fall and somewhat hindered drilling, but still production increased 2,000,000 barrels over the previous year. Several new fields were discovered: Ada, Duncan, Caney, Hamilton Switch, Preston, Haskell, and Ralston. The natural gas industry started a phenomenal rise in 1909. The value of gas produced and consumed and the number of domestic users doubled while number of industrial users jumped fivefold from 356 in 1908 to 1,527 in 1909.

1910

Prices were advanced from 28 cents for heavy crude to about 42 cents for all grades, and production increased some 4,000,000 barrels. Gas was discovered at Poteau, and oil at Henryetta, Vian, Wainwright, Red Oak, Ochelata, and Kiefer.

1911-1912

Oklahoma petroleum stocks were reduced in 1911 and the price advanced to 50 cents, then to 83 cents in 1912. During these two years, developments were steadily increasing the size of the fields and new oil discoveries were made at Adair, Glenoak, French, and Wewoka. Gas was found in Coal County, and also near Duncan in Stephens County. The most striking feature of new development was the discovery of the Cushing field in Creek County in March of 1912. By the end of the year over 70 producing oil wells and 10 gas wells had been completed with a total production of 800,000 barrels. This field has produced more than 405,000,000 barrels, and in 1957, 45 years after discovery, it produced over 2,600,000 barrels.

1913

DeGolyer mentioned this year as the date of actual acceptance of geology as a guide to prospecting by the oil industry. The Federal and State Surveys had employed geologists and published their reports, which had direct bearing on the discovery of new fields. There had been some geologists in the state who had examined oil and gas seeps, mapped geologic structures, and aided in the discovery of new fields, but many operators had a hostile attitude toward the science of geology. Now geological departments were introduced into organizations which were searching for oil. Surface geologists were employed to map surface rocks and to find closed structures as possible drill sites for wildcat exploration. Geologists encouraged the drillers to make more complete records of the rocks being drilled so that they could extend their knowledge below the surface. Thus the field known as subsurface geology was born. However, samples of the rocks being drilled were not taken, preserved, and studied until about 1923. History also records 1913 as the year in which an intensive scientific search for oil began in southern Oklahoma. The discovery of Healdton field in August, 1913 stimulated exploration and development in this region. Healdton was the third major field discovered in the State and has produced over 229,000,000 barrels. The Allen field of Pontotoc County was also discovered during the latter part of the year, and, though not considered of great importance at the time, it has developed into another major field of the 100 million-barrel classification. Other fields discovered that year include Loco in Stephens County, Catoosa and Inola in Rogers, Owasso in Tulsa, Weleetka in Okfuskee, and the Mervine field in Kay County.

Over 75,000,000 cubic feet of natural gas was produced from 1,052 wells and there were an estimated 20,620 producing oil wells. One might say that the state of the industry was one of feverish activity, as records show that 9,131 wells were drilled, of which 7,225 were oil wells and 589 were gas wells. This is the highest number of wells drilled and oil wells completed in one year in the history of the petroleum industry in the State of Oklahoma. However, the average depth of these wells was probably less than half the present-day figure of 3,450 feet.

1914-1915

Oil operations in the area east of the Rockies was dominated by production from the Cushing field in 1914 and 1915. The discovery of Bartlesville sand production caused increased operations and production above the market demand. After a drop in the price of crude in the early part of 1914, the Corporation Commission attempted to regulate drilling and transportation of oil without great success. However, the enactment of two statutes in 1915 one for oil and one for gas, for the first time introduced the theory that production of oil or gas in excess of market demand constituted waste. In June of 1915, the Corporation Commission commenced regulating oil production in the Healdton field.

Numerous extensions to old fields were made, and some small fields were discovered such as Boynton, Blackwell, Bixby, Coweta, Spiro, Stidham, Wagoner, Wimer, Wildcat Jim, and Yale. In southern Oklahoma, geologists had mapped the Fox anticline and a large gas well was completed. In December, 1915, the Oklahoma Geological Survey again issued a map showing the location and names of oil and gas fields. Now 110 areas were listed as compared to the 39 in 1908. The productive area of northeastern Oklahoma had been extended from Kay and Craig Counties in the north, to Pontotoc, Coal, Pittsburg, Latimer, and LeFlore Counties in the south. In southern Oklahoma, 12 fields had been discovered.

1916-1919

Our participation in World War I brought about a more intensive search for oil. Among the fields discovered in southern Oklahoma were Milroy, Kilgore, Walters, Graham, Enos, Cement, Velma, Comanche, Hewitt, and West Duncan. Of these, Velma, Cement and Hewitt have developed into major fields. Cement and Hewitt have produced respectively 88,571,000 and 151,903,000 barrels of oil by the end of 1957. Velma had produced 108,231,000 barrels before it was combined with Sholom Alechem and Tatums into Sho-Vel-Tum in 1955. Some of the other fields discovered in northern Oklahoma were Red Bank, Garber, Yahola, Fields, Wilcox, Yeager, Slick, Youngstown, Bristow, Iron Post, Continental, and Jennings. After 10 years of statehood, it is estimated that there were 41,700 producing oil wells, nearly 34,000 more than in 1907.

Until this time, all the oil produced in Oklahoma was thought to have come from Pennsylvanian rocks, but in 1916, oil was discovered in Permian rocks in the Garber field, and Ordovician microfossils were recognized for the first time in a well at Healdton. Oil in Permian rocks changed the idea that prevailed among geologists that no oil would be found west of a north-south line through Blackwell. Ordovician oil had been produced, but not recognized as such, in Glenn, Flat Rock, Cushing, Bixby, and Blackwell fields. Now drilling to this horizon was stimulated in areas where most of the wildcats had stopped in the top of the "Mississippi lime" and not reached the "second break". Tulsa County drillers had called this pay, Sapulpa or Mounds, as early as 1908, and it was called "Wilcox" after 1914.

An important milestone in the development of petroleum geology occurred during this period. Some fifty geologists gathered in Norman in January of 1916 to hear papers dealing with the many phases of geology of the southwest. A decision was reached that annual meetings, where papers dealing with geology related to oil finding could be presented and discussed, would be of great value to geologists in the petroleum industry. This gathering is considered to be the first annual meeting of the organization now known as the American Association of Petroleum Geologists. The membership list dated May 19, 1917 includes ninety-four names. Today, forty-one years later the association has over 14,000 members who are located all over the world.

1920-1929

The 1920's were important years for petroleum exploration and exploitation in Oklahoma and the southwest. Many new methods of exploration were introduced or used more extensively. Core drilling and photogeology were employed to supplement

surface mapping. Although core drilling had been introduced into Oklahoma by the Federal government in 1919, it was not until 1922, following the discovery of the Tonkawa field, that it played a major role in mapping structures. With the use of photogeologic methods, it followed that extensive aerial photographic surveys of the country would be made. It was also during this time that methods of seismic exploration were being developed and had their first successes. The first successful seismic reflections were made in 1921 in the Arbuckle Mountains. In 1927, the Maud pool in T. 8 N., R. 5 E. in Seminole County was mapped by the refraction method. The discovery of the South Earlsboro (Edwards prospect) field in 1930 is credited to mapping by reflection seismograph technique which was started in the area in 1926.

With the discovery that microfossils could help solve problems of correlation, an intensive campaign to save rock samples from wells was initiated by geologists in 1923. Previously the industry had accepted the unscientific descriptions made by drillers. Rotary method of drilling was introduced into Oklahoma in 1924. Coring of wells became widespread and core analysis was used to determine the oil content of reservoirs. In 1929, electric logs were run in Oklahoma wells in one of the first applications of this technique, but it was not until after 1940 that this geologic tool was in general use in the industry.

Interest in gas injection and its application spread into Oklahoma from the Eastern states, and the first secondary recovery project of this type was started in the Alluwe district of Nowata County in 1920. By the end of 1925, it was estimated that approximately 3,000 acres with more than 1,000 producing wells and 65 injection wells were being repressured or plants were under construction to place them under repressuring. In many of these early projects, increases of 50 to 500 percent in the rate of production were common. The number of projects applying gas-injection to increase recovery of oil grew rapidly from 1925 to 1940, at which time discontinued projects were converted to water floods.

It was during the twenties that ten fields which were areas of major oil accumulation were discovered. Development of the Osage Nation lands reached its height with the discovery of the prolific Burbank field in 1920. This field has produced approximately 334,000,000 barrels, primarily from the Burbank sand. The Tonkawa field, discovered in 1921, had wells with initial production of 3,000 barrels per day in the Tonkawa sand, and 10,000 barrels in the Ordovician "Wilcox" sand. It has now produced over 126,500,000 barrels.

In southern Oklahoma, Sholom Alechem was discovered in 1923 and Tatums-Tussy in 1927, both of which were destined to be major fields. The potential of these fields was not recognized until oil was found in Springer sandstones on the northeast flank of the Velma structure in 1944, and in the Sholom Alechem field in 1946. By the end of 1954, these two fields had produced over 190,000,000 barrels from some 26,000 acres. In 1955, the Sho-Vel-Tum district was formed to include these along with Fox-Graham, Velma, and adjacent small fields. The area of this district is approximately 69,000 acres and it has 6,931 wells which produced about 29,000,000 barrels of oil in 1957. Its accumulative production was 473,000,000 barrels and estimated reserves were 327,000,000 barrels at the end of 1957.

The area now known as "Greater Seminole" was an important factor in southwest crude production during this decade. Development, centering in Seminole County, was initiated in 1923 by the discovery of 2,800-barrel producer in the Wewoka field, followed by discovery of the Earlsboro, Seminole City, and Searight fields in 1926, and Little River and Bowlegs in 1927. The price of oil was $2.50 a barrel when the Seminole City field came in. With rapid development of the area quickened by widespread use of rotary drilling equipment and early application of air-gas lift to wells even before natural flow ceased, peak production was reached in July 1927 with a daily yield of 527,000 barrels. Attempts to limit the drilling of new wells and to limit flow of oil by voluntary means were not particularly successful. Even the drop of the market value of crude to thirty-nine cents for 40 degree gravity oil was of minor importance in regulating the field's development. In 1928, development of the St. Louis field commenced with the discovery of oil in the Ordovician "Wilcox". (One of the first wells to find oil in the Hunton limestone of Silurian-Devonian age was drilled in this area, sec. 18, T. 7 N., R. 5 E., in 1921). Up to January 1, 1929, total production was more than 275,000,000

barrels of oil from 1,700 wells on 17,700 acres. St. Louis, Earlsboro, Seminole, Little River, and Bowlegs are major fields having produced over 750,000,000 barrels of oil and having estimated reserves of another 50,000,000 barrels at the end of 1957.

In June of 1928, the Oklahoma Geological Survey again published a map showing oil and gas producing areas of the State. The named fields now numbered 324, with oil and gas in 39 counties and gas only in 8 counties. Except for 3 small gas areas in the Panhandle, no production is shown north of Township 9 North and west of Range 4 West. It is rather interesting to note that a small dot just north of Oklahoma City limits must have been placed there due to the showings of oil and gas found by Cromwell Oil and Gas Company in 1926. Except for this dot, no production is shown in Central Oklahoma in the area from Township 1 North to 18 North, and Ranges 4 East to 5 West.

Conditions of the crude petroleum market were not improved by the completion on December 4, 1928 of a 5,000-barrel well in the Lower Ordovician Arbuckle, a well which opened the Oklahoma City field. The discovery of oil in the Arbuckle at this depth revised the accepted geological ideas regarding central Oklahoma, an area in which there had been little hope of finding oil. This one well produced 712,000 barrels of oil before the second well was completed in June of the following year. In August, 1929 more than 1,000,000 barrels were produced from 13 wells. Operators had rejected any voluntary well-spacing proration agreements. Overproduction grew weekly and in September the Corporation Commission issued its first state-wide order for a thirty-day shut-down of producing wells. This order was not particularly effective in reducing the flow of oil as new wells were constantly being brought in. In December, 59 wells produced 2,312,000 barrels and production in the 13-month period totaled 8,300,00 barrels. This was just the beginning of the development of a field which, because of its prolific production and location within the limits of a city, the capitol of Oklahoma, attracted international attention. It also attained the distinction of being the first major field in which wells were over a mile deep, the major pays being between 6,100 to 6,500 feet. Its peak of production occurred in August of 1933, when 828 wells produced 8,289,000 barrels. During that year over 63,500,000 barrels of oil poured into a market already flooded with oil from Greater Seminole and the East Texas field. Oklahoma City field has now produced over 707,000,000 barrels of oil, it has reserves of another 63,000,000, and it covers 14,300 acres.

A historical study of the development of this field shows that the conflicting interests of operators, many of whom had utter disregard for orders of the Corporation Commission in regard to conservation measures, production, or spacing regulations, necessitated and caused enactment of a more comprehensive conservation law in 1933 implementing the statutes of 1915, which left no doubt that the state regulatory body had full power to prescribe rules and to issue orders for prevention of waste. An article written in 1931 states that the Oklahoma City field was under a stringent proration program almost from its discovery. Yet production statistics show that in July 1930, the average monthly production per well was 9,266 barrels; in July 1931, 9,021 barrels; and in August 1933, 10,011 barrels. This was a real restriction compared to the year 1929 when the monthly production per well for the year averaged 49,465 barrels, but certainly not stringent compared to the present daily basic allowable of approximately 66 barrels for wells in this depth classification.

Although the prolific production of the Greater Seminole area and Oklahoma City field dominated the industry during the twenties and part of the thirties, development in other areas was also important to the future of Oklahoma. In southern Oklahoma, besides the discoveries of Sholom Alechem and Tatums fields; gas was found at Sayre and Chickasha in 1922; oil at Empire, Robberson, Red River, and North Duncan in 1920; Bayou and Woolsey in 1921; Brock and Doyle in 1922; Knox in 1923; and at Oscar and Seay in 1924. In the Panhandle a showing of oil was found about 10 miles north of Boise City in Cimarron County; gas was discovered at Texhoma in 1923 and near Zea in 1926 in Texas County. Bristow, Chandler, Cromwell, Papoose, Sasakwa, Mission, Brannon, Davenport, Sac and Fox, Lovell, Deer Creek, Konawa, Maud, Lyons-Quinn, Deaner, Naval Reserve, and Stroud were among the fields discovered in central and northern Oklahoma.

Oklahoma was not only one of the major-producing crude petroleum states in the 1920's, but it ranked very high in regard to natural gas and natural gasoline. In 1925, Oklahoma produced more natural gas than any other state—21 percent of the total for the nation, and made more gasoline than any other—36 percent of the total. Oklahoma Geological Survey Bulletin 40, published in July, 1928, listed 310 refineries and natural gasoline plants in the State.

1930

Production from Oklahoma City and Greater Seminole fields dominated the market during the early thirties. Generally exploration extended former producing areas and discovered oil in lower stratigraphic horizons. In 1930 the number of dry holes reached the lowest level in 15 years, indicating that the low price of crude, lack of support by major operators and proration had effectively curtailed prospecting. Prospecting was most active in the western part of the state. An interesting well drilled by Sinclair Oil and Gas Co. (Howell No. 1, sec. 14, T. 26 N., R. 24 W.), in Harper County to a depth of 8,589 feet, the deepest hole of the State, discovered gas and distillate and revealed an unusual thickness of late Mississippian formations heretofore unsuspected in western Oklahoma. This test was the actual discovery of a new reserve of petroleum and natural gas for the State in which development did not commence until 1952. Other fields located include Wanette, Edmond, Brown, and South Earlsboro whose discovery was credited to reflection seismograph. Production was found for the first time in sandstones of Pennsylvanian age in Cement field. There were 6 producing gas wells in Texas County with an open-flow of about 31 million cubic feet and it was predicted by geologists that some 190,000 acres in Texas and Beaver Counties should produce gas, but development in this area did not commence until after 1940.

1931

No new discoveries were made and the price of oil went from $0.65-1.07 to a low of $0.10-0.20. Oklahoma City and Seminole Counties produced 96,000,000 barrels of crude, all others 79,000,000. This was the first year of production from the East Texas field, which flowed 109,500,000 barrels. The use of the seismograph largely replaced all other geophysical methods of exploration. The first organized water-flood project was started in the Chelsea field on a lease in sec. 22, T. 24 N., R. 16 E. in Rogers County, However, it was not until 1935 that this method of oil production attracted the attention of Oklahoma producers. Oklahoma had the deepest well (Mid-Kansas-Ramsey No. 6 Preston Culp, sec. 6, T. 5 N., R. 9 W.) in the United States, second in the world, drilled to a total depth of 10,079 feet in Pennsylvanian rocks in the Cement field. In this well, the longest string of 6⅝ inch casing ever run in the world was set at 9,777 feet. In 1956, a string of 7 inch casing was set nearly 10,000 feet deeper at 19,752 feet in Louisiana.

1932

Middle Ordovician "Wilcox" oil was found at Lucien, and a few small fields, such as West Holdenville and Lincreek, were opened. The use of acid to increase production, which was to be important in the development of Fitts, Britton, and Edmond fields, was introduced into the southwest. At the end of 1932, it was observed that 65 percent of the total production of Oklahoma had come from rocks of Pennsylvanian age, 35 percent from those older than Pennsylvania.

1933

Discovery of the Fitts field in Pontotoc County opened up an area on the northeast side of the Arbuckle Mountains which at that time was considered unfavorable for oil production. There was a general uptrend in activities in the last quarter of the year. Crescent, Saskawa Townsite, Keokuk Falls, Olive, and West Chandler fields were discovered. Oklahoma, Seminole, Creek, Pottawatomie and Carter Counties, listed in order of rank, were the leading producers in the state, the first two accounting for 52 percent of the total crude.

1934

It was recognized that the Fitts field was a major discovery, the nineteenth for the State, when oil was found by deepening to the "Wilcox". This field has produced over 114,000,000 barrels of its estimated 125,000,000-barrel reserve. Other fields located that year were Altus, the first production on the southwest flank of the Wichita Mountains, South Burbank, Polo, Dill, Wilzetta, Olympic, and Erick. Development in the northeast part of the

State in shallow producing areas became more active, particularly in Osage County, which again ranked third in amount of production among the counties. Operators were again interested in repressuring of fields and in the study of possible favorable locations for water-flood prospects, since considerable success had been attained in the water-flood undertaken in Rogers County in 1931. In southern Oklahoma an interesting wildcat (Denver Producing and Refining Co., No. 1 Noe, sec. 34, T. 10 N., R. 10 W.) found oil just above 10,000 feet, but production tests were disappointing and drilling continued to 11,230 feet, still in Pennsylvanian rocks.

1935

Forty-four of the 77 counties were producing oil or gas in commercial quantities. The most important development was the discovery of large production in a deeper horizon, Simpson, in the old Fox field. This test (Carter Oil Co. No. 1 Williams, sec. 27, T. 2 S., R. 3 W.) began flowing oil at the rate of 10,000 barrels daily from a depth of 8,088 feet, and opened the entire southern Oklahoma area to a deep exploration campaign for Simpson and also deeper Pennsylvanian production on the south flank of the Arbuckle Mountains. The Fitts field enjoyed the distinction of holding first place in development and another new producing horizon, McLish, was found. A two and one-half mile extension of "Wilcox" production in the "Mansion area" at Oklahoma City was another outstanding feature of the year. New fields discovered include Jesse, Hoyt, Grayson, South Keokuk, Wofford, Britton, and Moore. A number of water-flood projects were under way in Nowata, Rogers, and Washington Counties; gas-repressuring operations were undertaken in the Cromwell field and in several fields in Osage County. Unitization of a 2,400-acre block in the South Burbank field was accomplished, and repressuring of the Burbank sand with more than one million cubic feet daily was commenced.

Several other happenings during 1935 are of interest. The State Legislature passed House Bill 187 permitting the Corporation Commission to establish well-spacing units in new pools. Under the law, 10-acre spacing was established in Edmond, Jesse, and Fitts-Upper Simpson fields. At the end of the year, Oklahoma Oil Scouts organized a local chapter of the National Oil Scouts Association which had been founded in Texas in 1924.

Starting with Year Book 1936 of the Association, in which pertinent data concerning the older fields was segregated, the Oklahoma chapter has contributed yearly to one of the most valuable sources of statistical information concerning the oil industry. "Oil and Gas Field Developments in the United States" is published annually by the National Oil Scouts and Landmen's Association, as it is now known.

It was also during this year that the Interstate Oil Compact Commission, which now serves 30 member states, was formed with headquarters in Oklahoma City. This interstate compact was approved by the legislatures of California, Illinois, Kansas, New Mexico, and Oklahoma, and by the federal government, and was formed primarily to prevent federal control of the oil industry. The commission serves the public and industry by promoting and encouraging the conservation of oil and gas through established state agencies. It has standing committees on education, engineering, law, public lands, regulatory practices, research, and secondary recovery and pressure maintenance, which compile and publish information in their respective fields.

In January of 1935, the Oklahoma Nomenclature Committee of the Mid-Continent Oil and Gas Association completed the herculean task of selecting and bestowing a proper name upon each of the oil fields of Oklahoma. Oil men, scouts, writers, geologists, engineers, and attorneys formed the committee. It found many duplications, and in quite a number of instances companies reporting on an area submitted duplicate reports because their departments used varying names. On January 20th, the Tulsa Daily World published a list of 408 officially approved pool names. Since that time, this committee has met several times a year to name new fields, define their limits, and, if necessary, abandon names where drilling had joined two or more named producing areas.

1936

Production of 206,500,000 barrels of petroleum was the largest annual total reached in Oklahoma since 1930. There were 8,150,000 acres under lease, of which approximately 650,000 acres were productive. Most production of the State was coming from Middle Ordovician Simpson rocks. The largest increase in any field was

at Fitts, which yielded about 20,000,000 barrels as compared to 7,000,000 in 1935, raising Pontotoc to the position of third producing county. Other notable gains in output were recorded in South Burbank, Keokuk Falls, Olympic, and Edmond. Most of the discoveries were extensions or deeper zones in old fields. New fields included Dora, N. Bethel, Frederick, and North Earlsboro. The first commercial production was recorded for Love County with the discovery of the Stockton field.

1937

Exploration activity in Oklahoma made 1937 one of the best years since 1926. According to National Oil Scouts Association 1938 Yearbook, 313 exploratory tests representing a total footage of 905,682 were drilled at an estimated cost of $317,000,000. Of these, 37 or 11.5 percent were completed as oil producers and 13 or 4.01 percent resulted in gas producers. Twenty-six new oil areas were found including South Cromwell, Langston, Sporn, N. Wellston, and West Frederick. Interest was evident in secondary recovery, as 427 water-intake and 132 gas-intake wells were drilled and 26 projects were being operated in Nowata, Osage, Rogers, Tulsa, and Washington Counties.

Interest in the tremendous problem of surface water pollution by oil field brines and other wastes resulted in the creation of the Division of Water Resources of the Oklahoma Planning and Resources Board. Several major disposal systems and a number of smaller units had been constructed or were in the process of construction at Edmond, Fitts, Lucien, Crescent, Billings, Tipton, and Oklahoma City, representing an expenditure of $850,000.

1938

Records show that nearly 1,000 fewer wells were drilled in Oklahoma in 1938 than in the previous year, and that geophysical activity showed a 25 percent decrease. This was attributed to the interest of oil operators in developments in the Illinois basin. The discovery of the Ramsey field in Payne County was considered an outstanding feature of the year. Six wildcats were completed as gas wells in Texas County, proving the extension of the Hugoton gas field of southeast Kansas into Oklahoma. Seismic exploration was credited with 15 oil discoveries and 21 dry holes. New fields included Hillsdale, Waukomis, Southeast Braman, Coyle, Noble, Meridian, Southeast Britton, Avoca, Hazel, Grayson, and Swan.

1939

During the late thirties, there had been considerable leasing in northwestern and western Oklahoma. In 1939, wildcats were drilled in Alfalfa, Canadian, Dewey, Ellis, Harper, Kingfisher, Kiowa, and Washita Counties. Explorations by seismograph was under way in Major and Woods Counties. Of chief import was the number of deep dry tests drilled in western Oklahoma. One such test (Continental No. 1 Proctor, sec. 28, T. 10 N., R. 20 W.), drilled to 14,582 feet in Pennsylvanian rocks, the deepest test ever drilled east of California at the time. It is interesting because it missed by less than a half mile the discovery of the great Elk City field. In Kingfisher County, gas found in sec. 15, T. 18 N., R. 9 W., was the first evidence of the petroleum possibilities of that county. Oil found in the Viola at Northeast Byars (sec. 16, T. 5 N., R. 3 E.) was also the first production for McClain County. Discovery of Viola production at 1,050 feet at Hobart (sec. 20, T. 7 N., R. 17 W.) was considered a geologically interesting find. Of importance to the industry in southern Oklahoma was the plugging back of depleted Ordovician producers to the Hunton pay in the old Milroy and Fox fields.

1940

Development and production activity in Oklahoma were of a routine nature. Oklahoma City was far ahead as the leading field, accounting for 24 percent of the total crude production for the state. Oklahoma, Seminole, and Pontotoc were still the leading producing counties. By this time electric logging of wells had become a standard procedure, and it is recorded that the first commercial gamma-ray well-logging service was performed on a well in the Polo field during 1940. Because of lack of success of wildcats drilled in northern and northwestern Oklahoma, many leases were being dropped. This was not true in Texas County or in Cimarron County, where 719,400 acres and 152,125 acres, respectively, were under lease. The principal fields discovered as the result of exploratory drilling were Cumberland in Marshall County, East Cromwell in Okfuskee, and Prague in Lincoln County. Air-repressuring of a 160-acre tract (SW¼ sec. 17, T. 17 N., R. 12 E.)

in the Glenn field attracted attention in that it had already produced in excess of 3,500,000 barrels in the previous 32 years.

1941

In 1941, the search for new oil resulted in the discovery of 41 new pools out of 81 successful exploration operations. Forty-two of the 77 counties were now producing oil or gas. Five counties—Oklahoma, Seminole, Pottawatomie, Osage, and Carter—accounted for 58.9 percent of the state's production. Apache in Caddo County was the most important new field from the standpoint of potential production and of the new territory opened on the northeast flank of the Wichita Mountains. Other new fields included Guthrie, Navia, East Tecumseh, and West Hotulke. Simpson production was discovered in the old Velma field. Most gas wells being drilled were in old eastern areas led by Muskogee, Okmulgee, Creek, Wagoner, Okfuskee, and Latimer counties. Only one well was drilled in Texas Co., but its completion increased the already vast area proven for gas production. The main product from the treatment of natural gas up to this time had been natural gasoline. During the late thirties, the market for liquefied petroleum gases had such phenomenal growth that annual sales in 1941 had quadrupled as compared with 1936. Production of liquefied petroleum gas has increased from 91,000,000 in 1941 to 622,000,000 gallons valued at approximately $21,000,000 in 1956. In 1957 the production of this liquid fuel decreased about 40,000,000 gallons, but the marketed value increased $2,500,000.

1942

Drilling operations declined 45 percent below the previous year as a result of application of the 40-acre spacing rule, which affected field development. There were 75 successful exploratory operations, of which the discovery of Pauls Valley field climaxed a 25-year search by operators in this area. Three structures, known since the days of earliest geological work in Oklahoma, were successfully tested by discovery of the Aylesworth field on the Madill anticline, Caddo field on the Caddo anticline and Ardmore field on the Overbrook anticline. This latter field opened the first commercial production sandstones of the Springer formation south of the Arbuckle Mountains. Among the important dry holes listed were one each in Cimarron, Kingfisher, Atoka, and Harmon

Counties, two in Jackson County, and four in Caddo County.

The State had approximately 775 oil fields with 53,000 producing wells located in 42 counties. However, production had dropped 14,000,000 barrels below the 1941 total, and Oklahoma, though ranking as third-producing state in the nation, produced less oil than it had for 20 years. Activity in the Hugoton gas field was stopped during the year by order of the Petroleum Administration for War. This tremendous reservoir of gas was still virtually untouched in Oklahoma.

1943

Oklahoma's crude oil production reached a final low, decreasing 11.8 percent below the previous year. Louisiana took its place as the third ranking state. Most of the new discoveries were small, but it was a banner year in that the twentieth major reserve for the state was discovered at the West Edmond field in Oklahoma County with oil from the Hunton limestone. This was the first important production on the west flank of the Nemaha ridge in central Oklahoma. By the end of 1957, this field had been extended into parts of four counties, it had produced 107,000,000 barrels, and it had estimated reserves of another 23,000,000 barrels. Following this discovery, the first high potential production in Simpson sandstones west of the ridge was found at West Moore (sec. 29, T. 10 N., R. 3 W.). West Sentinel opened the first production in Washita County and gas was discovered in a basal Pennsylvanian sandstone at Keyes in Cimarron County. The Oklahoma Panhandle, from which one-third of the gas of the state is now produced, was in 1943 just started to be developed. There was no production in Beaver County and except for the new discovery at Keyes, none in Cimarron County. At the end of the year, there were 87 producing gas wells in the Oklahoma portion of the Hugoton field, 26 of which had been drilled that year. Of the 4,407 gas wells now producing in the state, 1,611 or 27 percent are located in the Panhandle, 1,374 in the Guymon-Hugoton field.

1944

Both reserves and production of crude petroleum increased for the first time in several years. The number of wells drilled was 59 percent higher and the rate of discovery of new oil was maintained with 36 new oil fields, 8 gas fields, 30 extensions to old fields, and 27 new producing formations. At the end of the year there were 325 producers in West Edmond field as compared to 15, twelve months previous. Production extended into Canadian County, increasing the number of counties producing oil. Trade journals stated that the field contained the greatest concentration of drilling equipment in the United States with 117 rigs running at the end of the year.

Prolific oil production found in Springer sandstones in the old Velma field started a search for oil in this geologic horizon, which greatly increased the production and reserves of southern Oklahoma. Other fields discovered that year included Southwest Lone Grove, South Moore, East Pauls Valley, Northwest Hoover (sec. 14, T. 1 N., R. 1 W.), and West Marlow. West Noble and Washington fields were rather discouraging results of search for oil west of the Nemaha ridge. The Oklahoma Geological Survey again published a map of the minerals of the state. Except for the Hugoton gas field in the eastern half of Texas County, there was no production shown north of Township 9 North, nor west or Range 7 West, nor any in Bryan, Choctaw, Pushmataha, McCurtain, Johnston, Harmon, Cherokee, Adair, and Delaware Counties.

1945

Oklahoma, Seminole, Osage, Creek, Carter, and Caddo Counties led, in the order given, producing 60.6 percent of the total crude oil in the State. More new oil and gas fields were discovered during the year than in any previous year for several years. With a 21.1 percent increase in the number of exploratory tests (418), the number of new fields increased from 44 to 73, or 41.6 percent. Most of the new discoveries were considered of little importance from the standpoint of reserves. However, Simpson production was found at North Lindsay (C SW¼ NW¼ sec. 22, T. 5 N., R. 4 W.) and East Antioch (SE¼ SW¼ SE¼ sec. 13, T. 3 N., R. 2 W.), both now included in the Golden Trend field. Oil production was discovered for the first time in Major County at Ringwood, in Kingfisher County at Northwest Cashion, in Bryan County at Southeast Aylesworth, and in Cimarron County at Keyes. Chitwood, Camp, South Marlow, and West Velma fields were new finds in southern Oklahoma. Two of the dry tests listed as important geologically were Superior's well (sec. 17, T. 19 N., R. 10 W.) in Blaine County which was abandoned at 11,008 feet in Arbuckle, and California's deep test (sec. 1, T. 8 N., R. 17 W.) in Washita County, on the south flank of the Anadarko basin 12 miles from an Arbuckle outcrop, which was still in Pennsylvanian at total depth of 11,130 feet.

1946

The most promising discovery, but not classed as important from the standpoint of reserves at the time, was the Southwest Antioch field, located by Globe-Vickers No. 1 Gibson (sec. 30, T. 3 N., R. 2 W.). This well is considered the discovery of the Golden Trend field, officially named in 1954 to include some 22 named fields which were found during rapid development of the area in the following two years. This twenty-first major field discovery for Oklahoma now covers 73,280 acres, has produced 153,000,000 barrels of crude, and ranks second to Sho-Vel-Tum with estimated reserves of 147,000,000. Other discoveries that year included Cache Creek, Essaquanahdale, and Soldier Creek in Cotton County, Holdenville in Hughes County, Coon Creek in Logan County, Fourdee in Noble County, and North Alma in Stephens County. Of the many important dry exploratory tests, the most interesting was that drilled in Dewey County (sec. 6, T. 17 N., R. 14 W.) to 12,610 feet into Simpson sandstones. Testing of a Pennsylvanian sand at 9,420 feet yielded a showing of oil and gas. A well (sec. 17, T. 20 N., R. 2 W.) to test the Reagan sandstone was drilled to 7,088 feet in the Lucien field, Noble County, and penetrated 39 feet of granite.

1947

This was a year of high-level exploration, exploitation, and production which in many respects exceeded all previous records. Oklahoma ranked second to Texas in number of holes drilled and in proved reserves (297,000,000 barrels) of crude oil, and maintained its position of fourth-ranking state in production of petroleum and natural gas. Stimulated partly by increases in the price of crude oil, areas were being carefully checked for additional producing zones and earlier-drilled prospects that had appeared marginal were being reexamined. The most active exploratory

effort was in the Golden Trend area, which resulted in discovery of seventeen new fields (now all included in Golden Trend field), with important reserves in Deese sandstones. Exploration was focused in southern Oklahoma on the search for new Springer accumulations within and adjacent to older fields, with the result that production was found in this formation in the old Sholom Alechem field. Elk City, the twenty-second major field for Oklahoma, was found in Beckham County. This discovery stimulated intensive exploration in the entire southwest Anadarko basin region. By the end of 1957, more than 47,000,000 barrels of oil have been produced from an estimated 120,000,000-barrel reserve in the Elk City field. Beaver was added to the list of producing counties with the discovery of oil and gas in Mississippian limestone in the Light field (sec. 9, T. 6 N., R. 21 ECM.).

A new depth record was established in the United States by a well (sec. 11, T. 8 N., R. 12 W.) drilled to 17,823 feet in Caddo County. Of unusual geologic interest was a Reagan sandstone test (SW¼ NE¼ NW¼ sec. 19, T. 11 N., R. 2 W.) located in the Oklahoma City field, which encountered Arbuckle at 6,055 feet, granite at 8,265 feet, and drilled to a total depth of 8,344 feet.

1948

A large number of successful drilling ventures resulted in the addition of important new reserves and in the realization that the reserves in Elk City, Velma, Sholom Alechem, and Golden Trend fields were of great magnitude. For the first time a field in southern Oklahoma, Velma, produced more oil during the year than any other single field in the State. A second oil well on the Elk City structure, two miles southeast of the discovery, gave impetus to the largest leasing and exploration activity in the State. Considered the most important development in the southeastern embayment of the Anadarko basin was the drilling of Gulf Oil Company's No. 1 Mainka (sec. 12, T, 5 N., R. 5 W.) which discovered the deepest production in Oklahoma and one of the deepest in the world at that time. It was completed in Bromide (Simpson) sandstone from 13,137 to 13,250 feet. In January of 1949 it was deepened and completed to produce from Bromide and Tulip Creek sandstones from 12,855 to 13,611 feet with an initial potential of 1,068 barrels. An important extension 20 miles west of the nearest production was the discovery of S. W. Dover field in Kingfisher County. Other fields discovered that year included Short Junction (now West Moore), North Ringling, Southwest Goldsby, North Hoover, North Cement, North Foster, East Evansville, North Garden Grove, East Castle, and North Webb. Six tests, considered regionally important, were drilled on the northern flank of the Anadarko basin without success.

1949

Both exploration and exploitation within the State increased in 1949 although total production declined owing to state-wide reduced allowables. Oklahoma ranked second only to Texas in exploration, development, and total wells drilled. It ranked fourth among the states in reserves and production of crude oil, natural gas, and natural gas liquids. Further increases in price of crude continued to act as a stimulus to drilling of hundreds of wells in older producing areas that in former years would have been uneconomic. Wildcat wells, numbeirng 825, resulted in 169 new discoveries, with a discovery ratio of 20.48 percent, which was one of the highest in the State's history. Reserves were added as the result of extensions to existing producing field areas rather than from new field discoveries. There were new fields and extensions in 12 areas along the Golden Trend producing from both structural and stratigraphic traps. Development of Springeran sandstone production continued at Velma and Sholom Alechem. The areas of Bayou, North Alma, Southwest Lone Grove, West Brock, Palacine, and West Sholom Alechem fields expanded greatly, producing from multiple pays in Pennsylvanian sandstones. Elk City was now more than seven miles in length and Ringwood field in Major County had forty-four wells producing from the Mississippian "Manning zone." Happy Valley in Lincoln County and Northwest Mount Hope in Payne County were considered the best discoveries of the year in the older areas of the State. The northeastern part of the State was undergoing a rapidly expanding water-flood program where oil was being flushed from numerous shallow Pennsylvanian sands.

1950-1957

Exploration activities of the petroleum industry in Oklahoma during this period will be noted for successes in the northwest counties of the State where commercial production was found for the first time in Alfalfa County in 1950, Ellis County in 1952, Woods County in 1953, and in Blaine, Dewey, and Woodward Counties in 1956. Rapid development started in southwestern Harper County, which had been quiescent since gas and condensate were discovered in 1930. Increased activities in the Panhandle counties resulted in finding more reserves of gas and locating new oil fields with high gravity oil. Discovery of Simpson production at 15,310 feet in the old Knox field in 1956 stimulated a new search for oil in this geologic horizon in producing structures not previously tested.

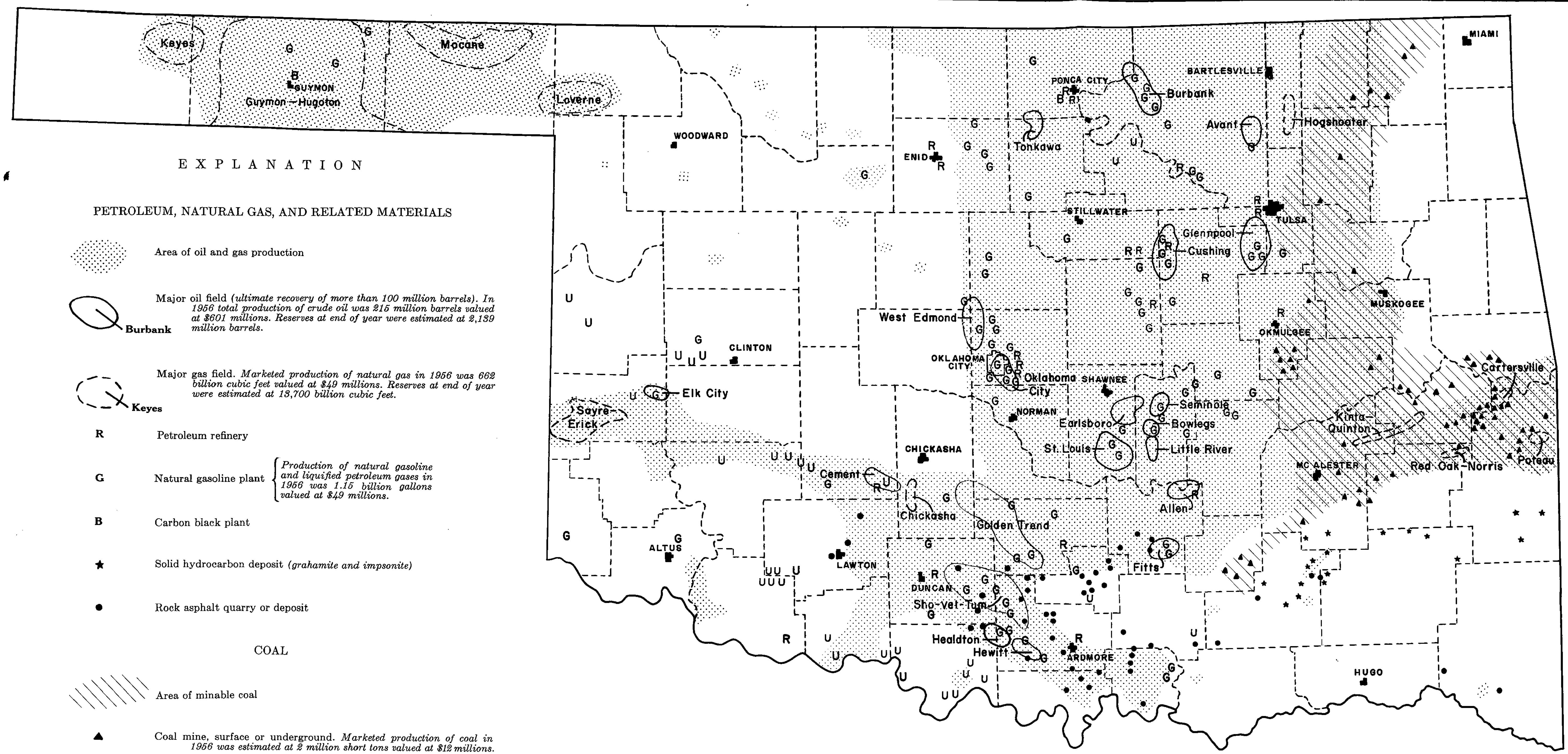
At the end of 1957, there were 1,840 named producing areas in Oklahoma ranging in size from a 40-acre tract to a field of over 73,000 proved acres. Small amounts of oil were found for the first time in McCurtain and Ottawa Counties in 1954, and in Johnston County in 1955.

From 1931 to the end of 1949, secondary recovery projects had produced approximately 33,000,000 barrels of oil. After this long prelude of study and preparation, secondary recovery from water-flood and gas-injection and from pressure maintenance programs has become a reality on a major scale in Oklahoma. More than 200,000 acres are now being flooded with almost unbelievable results. From 1950 to the end of 1956, an estimated 207,235,000 barrels have been produced. In early 1957, *Research Oil Reports,* "Analysis of Available Data on Secondary Recovery in Oklahoma" listed 462 water-flood projects in operation, 25 new projects approved. It was stated that approximately 3,600,000 barrels of oil per month were being produced from this source. Nearly 2,500,000 barrels or about 70% were produced monthly from projects in 18 fields. The percentage of the State's annual total of crude oil produced by these means has rapidly increased: 6 percent in 1950 and 1951, 12 percent in 1952, 17 percent in 1953, 20 percent in 1954 and 1955, and 24 percent in 1956.

Two outstanding water-flood projects are North Burbank Unit, which recovered 8,500,000 barrels in the six year period, 1951-1956; and Olympic in which 14,700,000 barrels, some 1,000,000 more than had been recovered by primary means, were produced in the same length of time. Other important floods include those in Little Chief, Sholom Alechem, Delaware, Childers, Yale-Quay and Davenport fields, all of which produce more than 100,000 barrels of oil per month. Among the reservoirs to which water stimulus is being applied are Allen, Bartlesville, Booch, Burbank, Cromwell, Hoxbar, Muncrief, Red Fork, Skinner, Thurman, Wayside, Wilcox, Hunton, Viola, and Mississippi "Chat".

Commending in 1949, successful hydraulic fracturing of tight reservoirs has stimulated exploration in the northeast part of the State and had increased recoverable reserves. In 1954, 70 percent of the new discoveries were treated in some form of artificial stimulation prior to completion; 60 percent were fractured and 10 percent were acidized. In 1956, 25 dry holes, some of which were as old as ten years, were successfully reworked and completed as 12 new fields and 15 new pools. These results can be attributed in part to hydraulic fracturing but also to re-interpretation of graphs of electrical and radioactive logging devices. Tremendous strides in development of these instruments have led to many new types of logs, such as dipmeter, induction and micrologs, which assist geologists in interpreting the subsurface geology of an area and in determining fluid content and reservoir possibilities of individual rock units.

Improvements in drilling equipment too numerous to mention have accelerated the search for new oil at depths below 15,000 feet at a phenomenal rate in the 1950's. The first well drilled in the United States below 15,000 feet was completed in 1938. (The Petroleum Engineer, vol. 29, no. 3, p. B-22.) In this depth classification, 32 holes of which 28 were wildcats were drilled up to 1950. At the end of 1956 208 wildcats and 169 development wells had been completed. Of these 377 wells, 150 were drilled in 1956. At the end of 1956, ten such tests, of which four resulted in producers, have been drilled in Oklahoma at an average cost of $790,000 per well. Three of these tests were drilled in 1956. During 1956, one test (Frankfort No. 1 Pruit, sec. 16, T. 4 N., R. 8 W., West Chickasha field, Grady Co.), the deepest in Oklahoma at the time, found non-commercial oil at 17,300 to 17, 382 feet and was abandoned



FUELS MAP OF OKLAHOMA

0 10 20 30 40 50 60
Scale in Miles

EXPLANATION

PETROLEUM, NATURAL GAS, AND RELATED MATERIALS

Area of oil and gas production

Major oil field *(ultimate recovery of more than 100 million barrels). In 1956 total production of crude oil was 215 million barrels valued at $601 millions. Reserves at end of year were estimated at 2,139 million barrels.*

Burbank

Major gas field. *Marketed production of natural gas in 1956 was 662 billion cubic feet valued at $49 millions. Reserves at end of year were estimated at 13,700 billion cubic feet.*

Keyes

R Petroleum refinery

G Natural gasoline plant *Production of natural gasoline and liquified petroleum gases in 1956 was 1.15 billion gallons valued at $49 millions.*

B Carbon black plant

★ Solid hydrocarbon deposit *(grahamite and impsonite)*

● Rock asphalt quarry or deposit

COAL

Area of minable coal

▲ Coal mine, surface or underground. *Marketed production of coal in 1956 was estimated at 2 million short tons valued at $12 millions.*

URANIUM

U Uranium occurrence

at 18,158 feet. Another (British-American No. 2 Harrison, sec. 29, T. 3 N., R. 6 W.) resulted in the deepest producing well in Oklahoma, the third deepest in the United States and discovered gas-condensate in the Bromide formation (Simpson group, Ordovician) in the old Knox field of Grady Co.

Both of these records for Oklahoma deep tests were broken in 1957. A gas well (British-American No. 1 Krieger, sec. 3, T. 2 N., R. 5 W. on the Stephens County side of the Knox field) was first completed in Oil Creek sandstone at 16,490 to 16,612 feet with an initial potential of 23.6 million cubic feet of gas and 8 barrels of condensate per million. Due to spacing regulations, it was plugged back to the Second and Third Bromide sandstone which are the regular deep pays of the Knox field. Production is now obtained from perforations in the Second Bromide at 14,805 to 14,882 feet and in the Third Bromide at 15,034-15,208 feet. When producing from the Oil Creek formation, it was the third deepest producing well in the United States being surpassed in production depth by two wells in Louisiana (Richard and Bass et al's well in Plaquemines Parish and Hunt Oil's well, offshore in the Coon Point field, Ship Shoal area). In the Cement field of Caddo County, a geological wildcat (Magnolia No. 1 Sterba, sec. 35, T. 6 N., R. 10 W.) reached the top of Mississippian Sycamore limestone at 19,970 feet penetrating it to a total depth of 20,426 feet. A test, contracted to a depth of 24,000 feet, is now under way on the Fort Cobb anticline (sec. 4, T. 9 N., R. 12 W.) that may even break the world's record in the next two years.

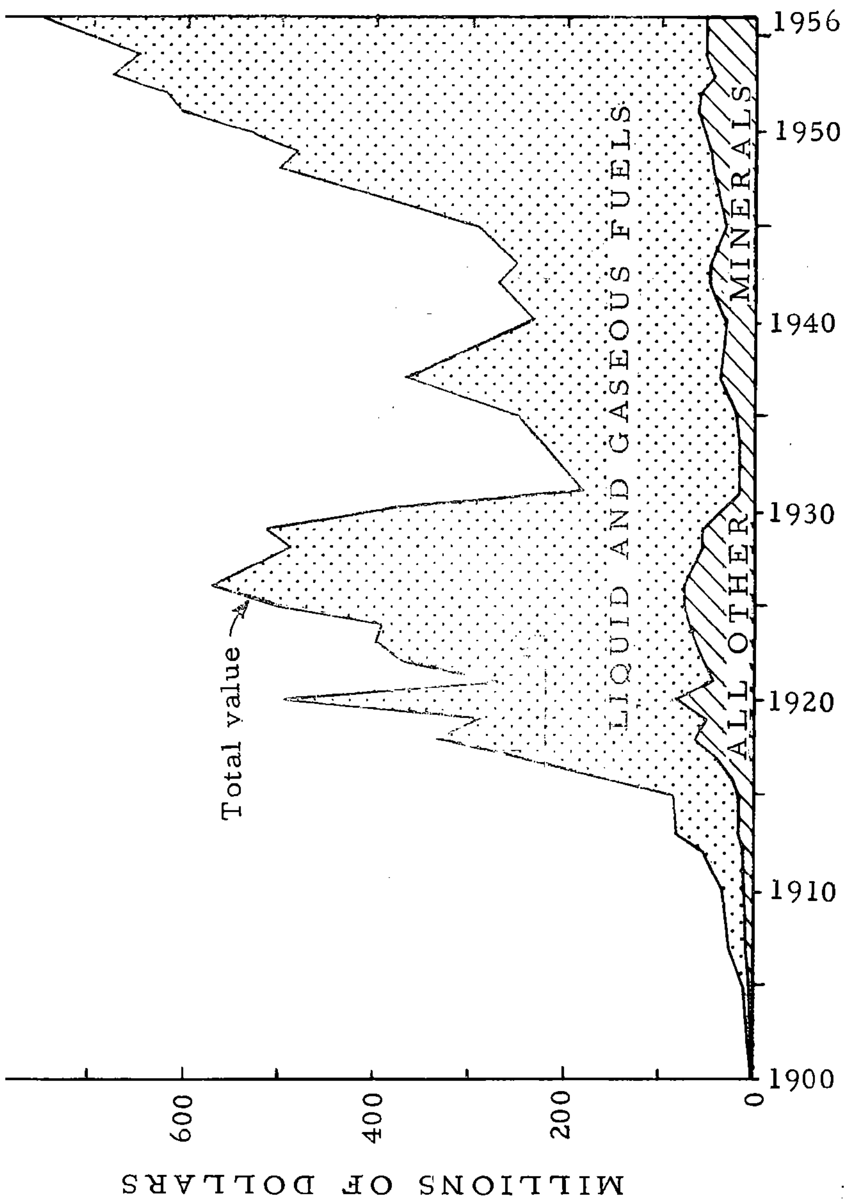


Figure 3. Value of mineral production in Oklahoma, 1900-1956, comparing liquid and gaseous fuels with all other minerals.

COAL, METALS, AND NONMETALS IN OKLAHOMA

By William E. Ham

Introduction

So far as records are available we must assume that active exploration for useful minerals and rocks in Oklahoma began in the middle part of the 19th century, and that the first materials to be extensively used were salt, coal, and lime made from limestone. These were found exposed at the surface and could be had for the taking. Indians before this time doubtless used flint for arrow points and scrapers, and some probably used clay which they molded and hardened by fire to make useful pottery.

Lime mortar, made by burning limestone and then slaking the resulting quicklime, was used in masonary construction at Fort Towson, Choctaw County, when that fort was established in 1824. Mortar also was made from local limestones for building five other forts through 1869. Salt was being worked in the Cherokee Nation as early as 1850, and in 1859 a well drilled for salt brine at Salina is reported to have been a flowing oil well. Presumably oil, obtained principally from oil springs and seeps, was used at this early date for medicinal purposes. But economic interest in the use of salt, oil, and lime was greatly overshadowed by the discovery of coal in eastern Oklahoma.

Coal mining was started on a substantial scale in 1872, and by 1880 annual coal production had already reached 120,000 tons. Coal and the coke made from it were the only minerals produced in quantity through 1890. At this time the cumulative production of coal and coke was 5,200,000 tons and their annual value was $1,600,000. Thus the first giant of Oklahoma mineral resources was coal, while oil, later a contender and finally the overpowering master, was lying dormant in underground reservoirs.

The beginning of diversification came in 1891. Oil, lead, asphalt rock, and manganese were produced for the first time. Zinc and tripoli were added in 1893, gypsum in 1894, clay and clay products in 1896, limestone and grahamite in 1898, salt and granite in 1900, lime, natural gas and sandstone in 1902, sand and gravel in 1905, and portland cement in 1906.

Now standing at the threshold of Statehood, Oklahoma already had in production the primary mineral fuels, ores, and non-metallic resources on which she was to build in later years.

The population of Oklahoma increased from 800,000 in 1900 to 1,400,000 in the statehood year of 1907, and mineral production increased to meet the demands of this new and rapidly growing State. In 1900 the total value of mineral production was $3,270,000 whereas in 1907 it was $27,000,000, an eight-fold increase in dollar value. Through successive years the value of mineral production increased to the first maximum of $570,000,000 in 1926, decreased to a temporary low of $173,000,000 in 1933, then rose to the present record of $817,000,000 in 1957.

TABLE 6

PRINCIPAL MINERALS PRODUCED IN OKLAHOMA, WITH DATE OF FIRST PRODUCTION

Minerals being produced at Statehood (1907)	New minerals produced, 1907-1932	New minerals produced, 1932-1957
Fuels		
Asphaltite (grahamite) 1892	Natural gasoline..1911	Liquefied petroleum gases ca. 1935
Coal and coke........ca. 1870	Carbon black 1919	Uranium 1956
Natural gas 1902		
Petroleum 1891		
Metals		
Lead 1891		
Zinc 1893		
Nonmetals		
Asphaltic rock 1891	Glass sand............1913	Pottery clays 1933
Building stone: Limestone..ca. 1898	Volcanic ash..ca. 1925	Fullers earth ca. 1935
Building stone: Marble 1896		Dolomite 1948
Building stone: Sandstone..ca. 1895		Sulfur 1953
Clay and clay products 1896		Expanded aggregates 1953
Crushed stone..........ca. 1895		
Granite 1900		
Gypsum 1894		
Lime 1902		
Portland cement............1906		
Salt 1900		
Sand and gravel....ca. 1895		
Tripoli 1893		

Miscellaneous minerals and metals produced intermittently, as by-products, or in small volume: Cadmium, copper, carbon dioxide, gallium, germanium, indium, iron ores, manganese, mineral waters, pyrite, silver, and vanadium.

Since Statehood, many new minerals have been added to the production list, and many new deposits of earlier-listed minerals have been opened. Natural gasoline was first produced in quantity in 1911. Production of high-purity glass sand began in 1913, carbon black in 1919, volcanic ash in 1925, fullers earth and liquefied petroleum gases in 1935, high-purity dolomite in 1948, sulfur from natural gas in 1953, and uranium in 1956. The list of minerals produced in Oklahoma, together with the date of their first production, is given in Table 6.

Oklahoma has celebrated her semicentennial anniversary. With 70,000 square miles Oklahoma is the 17th state in area, and with 2.4 million inhabitants it has 1.4 percent of the total United States population, yet in 1957 it produced more than three-quarters of a billion dollars in mineral wealth to contribute nearly 5 percent of the United States total. From the time that records were first kept, Oklahoma has produced minerals having a total value of $17.3 billions, and instead of declining, mineral production continues to soar upward. The rate and character of this increase are shown graphically in Figure 3.

COAL

Pre-Statehood

The first record of coal occurrence in what is now eastern Oklahoma was made by French explorers in 1719. At this time there were few inhabitants and virtually no use was made of the coal, but by the middle part of the 19th century it was used locally by the Indians. It was mined by hand and was sold by the bushel.

Commercial development could not be started, however, until a cheap method of transporting this bulky fuel was available, and hence the early history of coal production in Oklahoma was closely linked with the construction of railroads. The period of most active railroad building was from 1872 to 1900.

The Missouri, Kansas, and Texas Railroad was the first to be built. Begun in southeastern Kansas, it was constructed southward across Indian Territory into Texas and was completed in 1872. It passed through "The Crossroads", an important trading post later known as McAlester, thus opening for commercial development the immense reserves of bituminous coal in the southern part of the Oklahoma coal field. From the beginning of mining

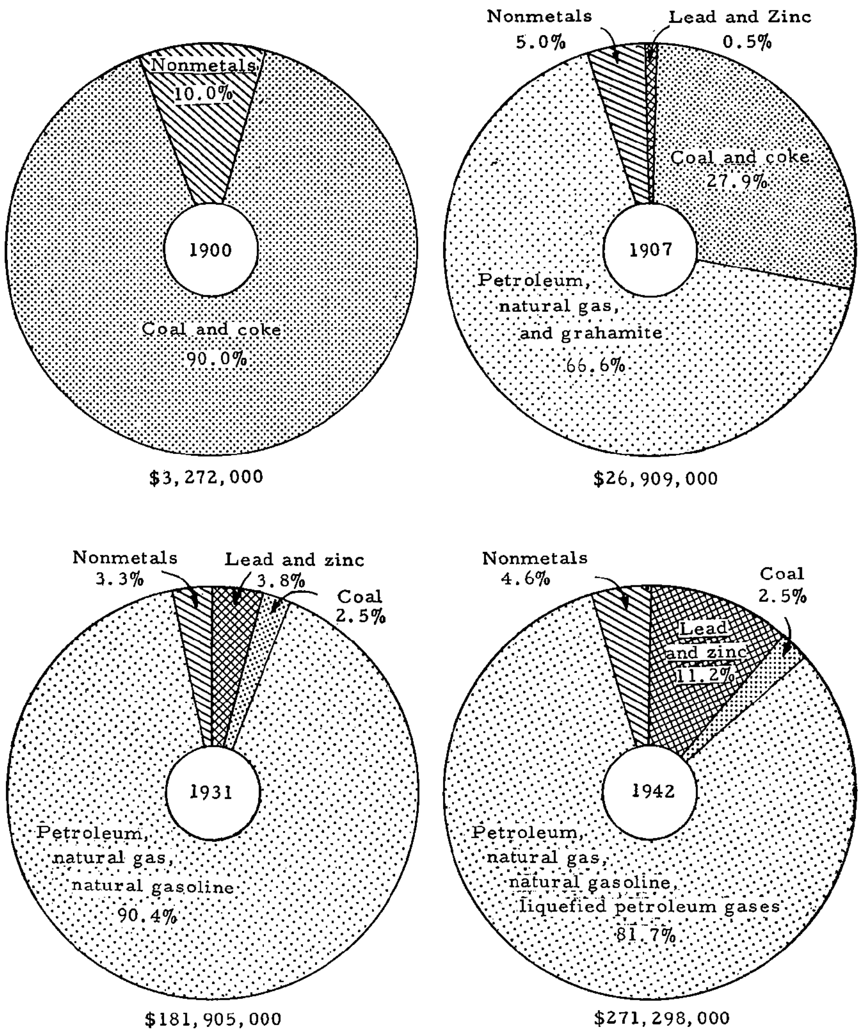


Figure 4. Diagrams showing mineral production, by groups, in Oklahoma for selected years, 1900-1956.

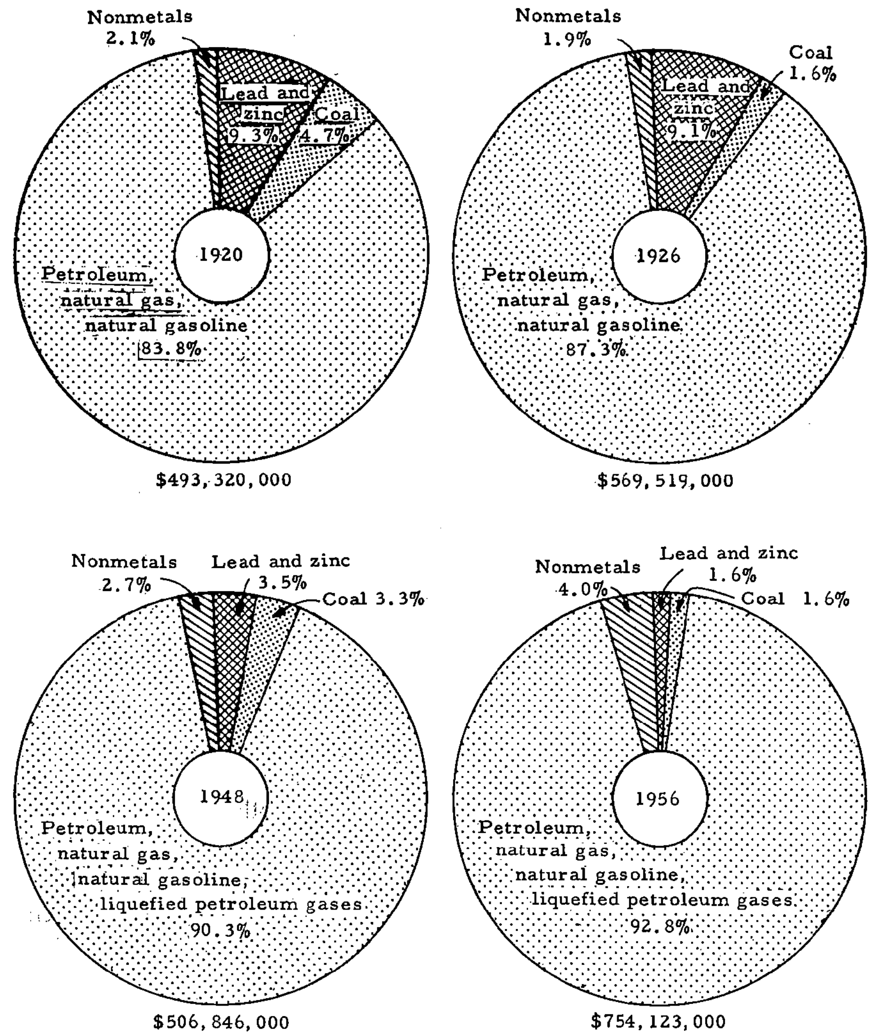


Figure 4. Diagrams showing mineral production, by groups, in Oklahoma for selected years, 1900-1956.

in 1872 through 1880, half a million tons of coal was produced, all mined from the McAlester district.

The building of other railroads through the central part of Indian Territory was doubtless influenced strongly by the knowledge that coal could be mined in a large area. A branch of the MKT railroad was extended to the coal seams at Savanna and Lehigh in 1881; coal beds at Poteau, Cameron, and Wister were opened by construction of the St. Louis-San Francisco Railway in 1887; and in 1889, with construction of the Choctaw, Oklahoma, and Gulf Railroad (later Rock Island), extensive and rich coal deposits were opened in a 70-mile belt that extended from McAlester eastward through Hartshorne, Wilburton, Red Oak, and Wister. Coal was so important to the Choctaw, Oklahoma, and Gulf railroad that its first train to Oklahoma City, carried over a line completed in 1895, was loaded only with coal.

The last railroads to be constructed within the southern part of the coal field were the Kansas City Southern in 1897, which served Panama, Poteau, and Heavener, and the Midland Valley Railroad, which was built through Stigler in 1900.

In 1880 total production of coal was 120,947 tons. But with the opening of additional mines as the new railroads were completed, production increased to 869,000 tons in 1890 and to 1,922,000 tons in 1900. In 1900 all the operating mines were in the southern part of the Oklahoma coal field, in the area from Coalgate through McAlester to Poteau and Heavener, with the exception of a small tonnage being produced by strip mines near Collinsville and Dawson, in Tulsa County.

Production of coal continued to increase through 1907, when 3,643,000 tons was produced; and to the end of 1907 there had been a total cumulative coal production of 37,327,000 tons. All this coal had been produced from Indian Territory and had been obtained principally from lands in the Choctaw Nation. Only a small percentage came from the Cherokee and Creek Nations, where the coals in most places are thinner and were worked almost exclusively by stripping methods. The Henryetta district in the Creek Nation, however, was destined to become an important producer in later years, and so also were the shallow coals in the Cherokee Nation destined to yield major contributions.

As railroads had already been built through much of the coal-bearing area, and as coal mining had been firmly established, Oklahoma entered Statehood with strong expectations of a long and successful period of coal production. Oil and gas had been discovered before 1907, but there were no large markets or distributing facilities for these liquid and gaseous fuels, and furthermore, at this time, coal was the leading fuel of the world.

Coke also was being made from coal in Indian Territory. Fine-grained coal, called slack, is invariably produced in mining and processing, and this slack was converted in beehive ovens to coke that was widely sold for foundry use in Mexico. In 1906, 490 coke ovens were in operation by five companies at Alderson, Howe, Krebs, Buck, and McCurtain, producing 49,782 tons of coke valued at $204,205.

Presaging the later trend in coal, coke production dropped to only 19,089 tons in 1907 and to 2,944 tons in 1908, and since 1908 little or no coke has been produced in Oklahoma. Total production of coke through 1908 was 545,000 tons valued at $2,049,000. One of the principal reasons for the failure of coke manufacturing in Oklahoma was the increasing demand for slack coal for use by railroad locomotives, but a contributing reason was that natural gas production in Oklahoma increased from 4.9 billion cubic feet in 1907 to 11.9 billion cubic feet in 1908. Distributing facilities for natural gas were increasing each year, and in 1909 twenty-eight billion cubic feet was marketed from Oklahoma wells.

Coal production, however, continued to increase unsteadily. Despite competition from natural gas and loss of production from prolonged strikes in 1910 and 1919, there was an increase of coal tonnage from 2,948,000 tons in 1908 to the peak year of 1920, when 4,849,000 tons valued at $23,294,000 was produced. This record has not been closely approximated either in tonnage or value in subsequent years through 1957.

1908-1931

In the first twenty-four years of Statehood, Oklahoma produced 81 million tons of coal valued at $241 millions. Average annual production over this period was 3.38 million tons, the largest sustained volume in the history of the State. Truly this was the golden age of coal in Oklahoma.

Coal was produced in 14 counties—Atoka, Coal, Craig, Haskell, Latimer, LeFlore, Mayes, Muskogee, Okmulgee, Pittsburg, Rogers, Sequoyah, Tulsa, and Wagoner. With McAlester as its center, Pittsburg led all counties throughout the entire period with the exception of 1920 and 1924. In those years Okmulgee County, generally in second place, took the first position. Other leading counties were Latimer, Coal, and LeFlore, each of which temporarily was in second or third place, although Tulsa was ranked third in 1922.

Until about 1913 at least 90 percent of all coal produced in Oklahoma was mined underground from the Hartshorne and McAlester seams of middle Pennsylvanian age. Each of these beds is 3 to 5 feet thick and is medium-volatile to low-volatile bituminous coal. Mines were worked in slopes generally ranging between 5° and 30°, and nearly all the coal was obtained in the southern part of the Oklahoma field, in Coal, Pittsburg, Latimer, Haskell, and LeFlore Counties.

By 1914 the Henryetta coal in Okmulgee County, also middle Pennsylvanian in age but younger than the seams in the southern counties, was being worked in increasing tonnage. This seam is generally 3 feet thick, it is good quality bituminous coal, and it has the advantage of lying in a nearly horizontal seam which is easier to work than the steeply dipping seams of the southern coal-field counties. Although coal mining had begun near Henryetta when the St. Louis-San Francisco Railway was constructed in 1903, production in 1908 was only 173,000 tons. The mining advantages were quickly realized and Okmulgee County became the fastest growing coal-producing county in the State. Production doubled by 1911, quadrupled by 1913, and for the first time attained a million-ton volume in 1917. Through this great increase the county rank jumped from fourth in 1908-1912 to third in 1913 and second in 1914-1919. The year of greatest coal production in Oklahoma was 1920, when 4,849,228 tons valued at $23,294,000 was produced. In that year Okmulgee was the leading county with 1,477,677 tons or 30 percent of the entire state production. Okmulgee County was displaced from the first position by Pittsburg County in 1921-23, but it emerged first again in 1925. The zenith had now been reached. From 1926 through 1930 Okmulgee

County maintained second place, and with the effects of the depression being strongly felt, dropped to third in 1931.

1932-1938

The depression caused many marginal mines to close, and producers began to seek more economical properties in order to gain a competitive advantage for the diminishing market. A new era in Oklahoma coal mining began to emerge. Prior to 1932 approximately 85 percent of all coal produced in the State was taken from underground mines. The remaining 15 percent was mined by stripping, a method whereby coal near the surface is uncovered by removing the overlying soil and rock overburden, the coal then being worked in open pits. Small quantities of coal had been stripped from flat-lying seams in Rogers, Tulsa, and Wagoner Counties from the times of earliest mining in Oklahoma, but no substantial volume had ever been obtained through this means because these coal beds are relatively thin, and power equipment for stripping had not yet come into general use.

By about 1932, earth-moving power shovels and draglines had been so perfected that coal could be mined, under favorable conditions, more cheaply by stripping than by underground methods. As a result the percentage of coal stripped in Oklahoma increased from a 1928-1931 average of 14.4 percent to 27.6 percent in 1932 and to 36.0 percent in 1938.

The leading counties in this period still produced coal underground. LeFlore County was the leader most of the time, its first appearance in the leading rank. It was followed in second place by Okmulgee County, but Pittsburg County, the previous leader, was now in third or fourth place. In these underground mines only 2.5 to 4.0 tons of coal was produced per man per day, whereas 11 tons was produced per man-day in the strip pits. In consequence, coal produced by stripping in Rogers and Wagoner Counties more than doubled, increasing from about 200,000 tons in 1935 to 437,000 tons in 1937. Strip mining was now beginning to offer a strong challenge for supremacy as the leading mining method in Oklahoma.

Total tonnage of coal mined during the 1932-1938 depression years was small. Production averaged only 1.77 million tons per year, hardly half the annual average of 3.38 million tons for

1908-1931. Such a decrease had no bearing on general trends in the use of coal itself, however, for the same fate was shared by petroleum, natural gas, and all other mineral commodities in Oklahoma and in the Nation.

1939-1943

This period is characterized by two distinguishing elements—(a) partial market recovery from effects of the depression, aided by the entry of the United States into World War II, and (b) the continued rise and ultimate dominance of strip mining over underground mining methods. Average production of coal steadily increased to 2.84 million tons in 1943, and the average annual production for the five-year period was 1.97 million tons. Tonnage produced during 1943, in fact, had so increased that it exceeded slightly the production for 1930.

The major areas from which coal was obtained, and the mining methods used, were drastically changed. The trend toward strip mining that began abruptly in 1932 was further accelerated. Strip mining yielded 42.1 percent of all coal mined in 1939 and 51.1 percent in 1943. In 1943, for the first time, coal produced in Oklahoma by stripping exceeded that from underground mining, and since then the percentage has increased even more.

The strip pits of Wagoner, Rogers, McIntosh, Muskogee, and Craig Counties were put into large-scale production. The greatest tonnages were taken from the Broken Arrow (Croweburg) seam in Wagoner and Rogers Counties and from the Secor seam in McIntosh County. Strip coal mined in these three counties was 1.2 million tons in 1943, 84.1 percent of the coal mined by stripping and 42.5 percent of all coal mined in the State.

Other leading counties were mining coal underground. Okmulgee and LeFlore Counties showed a considerable rise in production and were temporarily second, third, or fourth in rank. Okmulgee County tonnage gained consistently, increasing from 232,000 tons in 1939 to 640,000 tons in 1943. The operations of all the companies mining coal underground were becoming increasingly mechanized, in order to cut costs. In 1943, 90.2 percent of all coal mined underground in Oklahoma was cut by machines, in comparison with 83.3 percent in 1939 and only 63.4 percent in 1928.

1944-1956

During World War II a new market was found for Oklahoma coal which in subsequent years has played such a vital role that, without it, production doubtless would have fallen below the annual average for the depression years of the middle 1930's.

That Oklahoma coal would make coke was well known from pre-Statehood years, when a total volume of 540,000 tons of coke had been produced from beehive ovens in the southern part of the Oklahoma coal field. After 1908 coke was not produced within the state, nor was Oklahoma coal used for making coke elsewhere.

With the greater demand for steel in the war effort, iron ore deposits in east Texas were investigated and, although low in grade, they were pronounced suitable for making pig iron and steel. Metallurgical coke was needed. While the steel mills at Daingerfield and Houston were being planned, coal from Oklahoma was carefully reexamined and tested for coking properties. The U. S. Bureau of Mines and the Oklahoma Geological Survey cooperatively reported in 1941 and 1942 that metallurgical coke could be made from Henryetta coal and from McAlester coal, particularly when blended with low-volatile coal from eastern Oklahoma or western Arkansas. The two steel plants in Texas were completed in 1944 and Oklahoma coal was used as a source of coke for smelting. Although average production of coal for coke-making was only 214,000 tons per year in the period 1944-1947, it increased to well over a million tons per year for the period 1950-1953. Texas furnaces were the prime market, but shipments also were made to California, Utah, Colorado, Alabama, Missouri, and Illinois. Statistics showing the growth and the relative importance of the coke market are shown in Table 7.

In spite of rising demand for coking coal, total production from Oklahoma mines is slowly diminishing. From a post-war peak of 3.46 million tons in 1948, coal tonnage reached a temporary low of 1.9 million tons in 1954 and then increased slightly to 2.16 and 2.0 million tons, respectively, in 1955 and 1956. Less than a million tons per year is now being sold to markets other than for coking coal.

TABLE 7

OKLAHOMA COAL PURCHASED FOR COKE-MAKING, 1944-1953

Year	Purchased for coke-making, tons	Percent of total Okla. production	Total Okla. production, tons
1944	278,953	8.7	3,208,534
1945	191,569	6.5	2,908,976
1946	32,437	1.2	2,647,380
1947	363,306	10.6	3,420,563
1948	836,585	24.2	3,462,184
1949	841,956	27.9	3,021,859
1950	1,021,540	37.8	2,678,581
1951	1,119,582	50.5	2,223,229
1952	987,739	45.1	2,193,409
1953	1,315,594	60.7	2,167,594

One great market now almost completely lost to Oklahoma coal producers is the railroads, which formerly burned coal in locomotives, but which now have converted to diesel engines burning a petroleum fuel. Even in the strip pits themselves coal is no longer used as fuel. In 1949, 51 power shovels and dragline excavators were in use in Oklahoma, but only ten used coal—28 were powered by diesel engines, 10 were electric, and 3 were powered by gasoline!

Coal mining in Oklahoma since 1943 has undergone profound additional changes. Okmulgee County recaptured first rank in 1944 and retained it through 1952, reaching an annual volume slightly greater than 1.1 million tons in 1947-1948. Half this production was obtained by stripping, rather than wholly obtained by underground mining as in earlier years. Rogers County maintained a strong position in second or third place, based entirely on strip coal. LeFlore County has been mostly in third place among the counties but has fluctuated from second through fourth. Since 1953 the new leader is Haskell County, where the Stigler or McAlester seam is extensively worked, two-thirds of it being mined by stripping.

For 85 years coal has been mined in Oklahoma, always in a parade through changing scenes. At one time or another Pittsburg, Okmulgee, LeFlore, Wagoner, and Haskell Counties have held first rank; and Coal, Latimer, and Rogers Counties, though never first, have made major contributions. Probably at least 90 percent of all coal produced in the State has been mined in these eight counties. With the changing scene, old leaders drop out to make room for new ones. Wagoner, Coal, Tulsa, and Muskogee

Counties have been prominent in the past, each having had annual production of one-quarter million tons or more, but now they have a combined production of less than 20,000 tons per year.

And yet much coal lies in reserve. New and more accurate mapping of coal seams has consistently led to new production. The resurgence in recent years of Haskell County to take first place, based on new stripping operations near Stigler, followed detailed geologic mapping by modern methods in which extensive use was made of aerial photographs. Oklahoma Geological Survey Bulletin 67, *Geology and Mineral Resources of Haskell County,* published in 1948, has been widely consulted by coal producers and has doubtless been of great benefit in the opening of new pits.

To the end of 1956, total coal produced in Oklahoma was 174 million tons having a cumulative value of $533 millions. In Oklahoma coal is a ranking mineral commodity, it has the longest record of production, and it is known to be present in a region covering nearly 20,000 square miles in the eastern half of the State.

LEAD AND ZINC

One of the most easily recognized of all minerals is galena, a dark gray sulfide of lead characterized by bright metallic luster, perfect cubic cleavage, and leaden color. Containing nearly 87 percent lead, the mineral is truly almost "as heavy as lead", and accordingly its specific gravity of 7.5 is the highest of all common minerals. As it also is metallurgically easy to smelt, being reduced to metallic lead just by heating with charcoal as in an ordinary campfire, there is little doubt that Indians and early settlers found and used the lead from small outcropping patches of galena that occur in Ottawa, Delaware, Cherokee, and Adair Counties in northeastern Oklahoma, and in the Ouachita, Arbuckle, and Wichita Mountains of southern Oklahoma.

The modern field geologist working in these areas commonly is conducted by local residents to localities that are proudly said to be sites at which a father or grandfather obtained lead for his bullets, having learned of the deposit through friendly Indians. A small amount of galena can be found in bedrock at some of these localities, giving credence to these stories and supporting the belief that lead actually was used in the early settlement of Oklahoma.

Occurring with galena in many deposits is the mineral sphalerite. Composed of zinc and sulfur, it contains 67 percent metallic zinc yet it has a resinous rather than metallic luster, and when smelted in the ordinary manner it yields no metal. The name sphalerite itself came from a Greek word meaning treacherous, alluding to this property. When properly smelted through distillation, however, sphalerite does yield zinc metal, and it is the most important source of zinc in the world.

For Oklahoma, sphalerite has been its greatest metallic mineral resource, having yielded concentrates which through 1956 were valued at $766 million, or approximately three-fourths of all metals mined in the State. Oklahoma's production of zinc in the past has been so great that for many years it was the leading producer of zinc in the United States.

Strangely, the value of sphalerite and other zinc minerals was not recognized when lead was first discovered near Joplin, Missouri, in 1848. Although lead mining began in 1850 and continued through the Civil War, at different times supplying lead to both sides in the conflict, zinc minerals were not shipped for smelting until 1872. Gradually zinc surpassed lead in value, and by 1910, with many new discoveries, the Tri-State district of southwestern Missouri, southeastern Kansas, and northeastern Oklahoma became known as one of the major zinc deposits of the world.

Before Statehood in 1907, most of the production was from Missouri and Kansas, together with a small amount from Quapaw and Commerce in Oklahoma. Then, in 1914, the main ore bodies were discovered in the Picher field and almost overnight Oklahoma became a major zinc-producing state. Production in Oklahoma jumped from 14,000 tons of zinc in 1914 to 29,000 tons in 1916, 86,000 tons in 1917, and 161,000 tons in 1918. Unranked in 1914, Oklahoma was third in the nation in 1917 and first in 1918. From 1918 onward through the 1920's, Oklahoma was the leading zinc producer in the United States, yielding one-third to one-half the annual national total. Peak production of 283,000 tons was reached in 1925, and Oklahoma was the greatest zinc producer in the world.

Zinc and lead minerals occur together in brecciated chert, jasper, limestone, and dolomite of the Boone limestone, middle

Mississippian in age. The lower three formations of the Boone—Warsaw, Keokuk, and Reeds Spring—have yielded virtually the entire metal production of the Tri-State district. In Oklahoma the ore-bearing parts of the Boone are covered at most places by 100 to 400 feet of Chester limestone (upper Mississippian) and McAlester shale (Pennsylvanian). The ores occur within box-work structures formed by faults and flexures that trend both northeast and northwest. The Picher field itself—the richest in the district—is developed at the junction of the northeast-trending Miami trough with the Bendelari trough. Ores occur both in "sheet ground", or tabular deposits generally paralleling stratigraphic beds, and in "runs", which are vertically inclined bodies believed to be related to shear zones.

Zinc and lead mining in Oklahoma has been declining since 1925, and the future of Ottawa County is clouded by uncertainties resulting from the low grade of the remaining ore, unstable prices, and competition with imported ores. The following statement by J. B. Elizondo[1] of the Eagle-Picher Company is significant, for this company has been the leading producer of zinc and lead in Oklahoma since its discovery of the Picher field in August, 1914.

"The (Picher) field developed rapidly and within a few years became the greatest zinc producer in the world. It reached its peak in 1925 and 1926, yielding in those two years over 28 million tons of mined rock which produced nearly 1½ million tons of zinc (concentrates) and one-quarter million tons of lead (concentrates). By this time more than 250 individual mills and a vastly greater number of mines were in operation.

"Small lease units were common in the older fields of the Tri-state where much of the mining was done by individual operators on leases as small as town lots. It was therefore only natural that the later fields should follow suit. During the early phases of development the Picher field was divided into scores of 20-acre and 40-acre tracts, each of which according to lease requirements supported a separate mill . . . .

"This hodgepodge of leases resulted in hundreds of individual mining concerns that dotted the 25-square mile area that com-

[1] Elizondo, J. B., 1957. Development and Mining Trends in the Tri-State District, Univ. Missouri School of Mines and Metallurgy, Bull., Technical Ser., no. 94, p. 1-15.

prises the Picher field. The ore bodies were literally "gutted" in the short space of ten years. The operations for the most part were very inefficient with no concern for the future. The end result was a multitude of marginal mines that have for the past 30 years been a challenge to mining ingenuity.

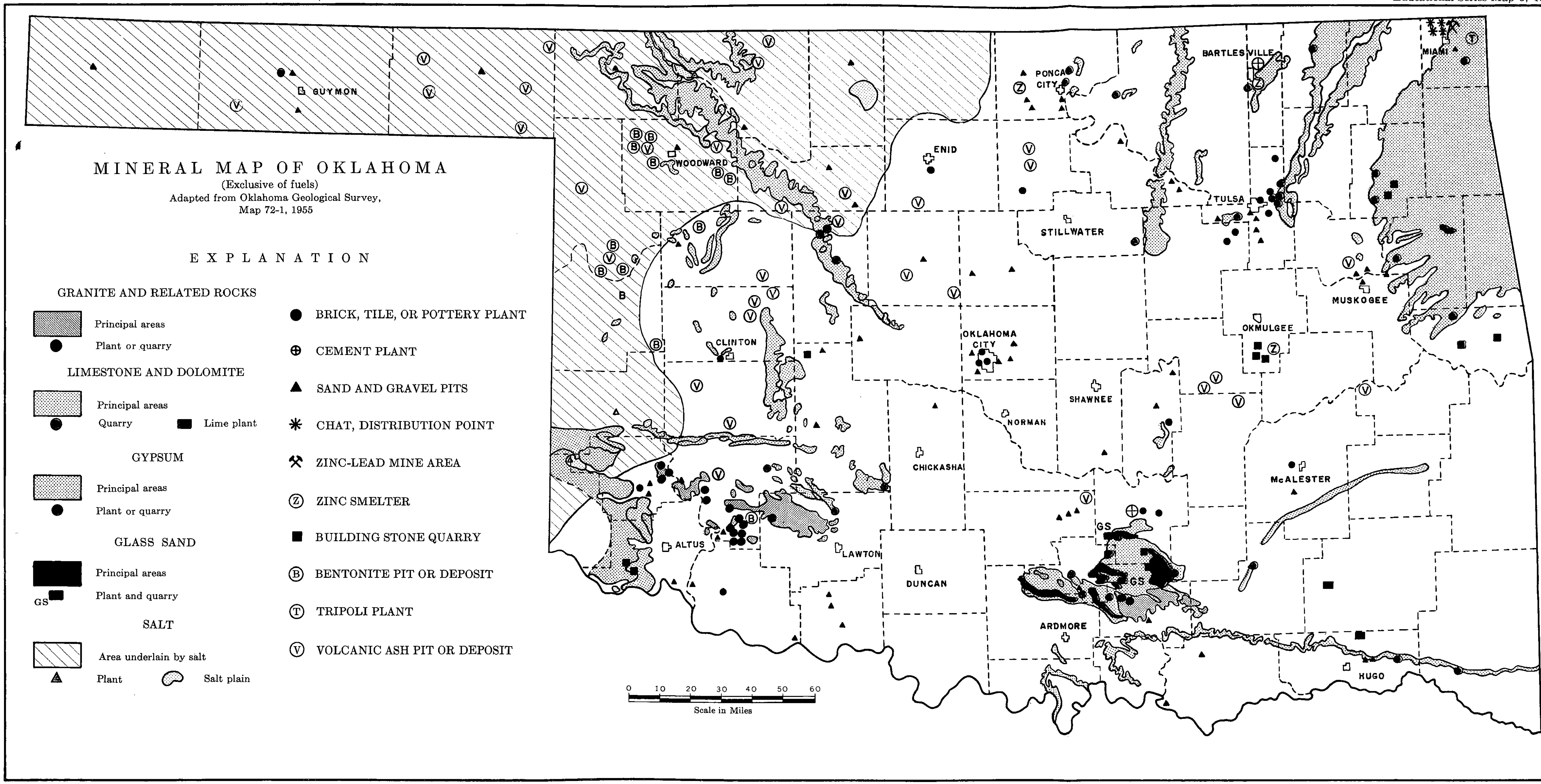
"Since 1926 the Picher field, as well as the district as a whole, has been fading. Impetuses such as centralized milling, mine mechanization, comingling of ores from different allotments, and the application of geological controls have aided considerably in prolonging the life span.

"The Tri-State, unlike most large operating mining districts, contains virtually no proven ore reserves. Indicated or possible reserves, yes; but blocked proven reserves, no. The validity of calculating ore reserves connected with the run-type deposit is one of our most controversial subjects. Owing to the erratic nature of such occurrences, it is extremely difficult to outline, with any degree of accuracy, potential grades or tonnages, except on a very limited scale. Added to this dilemma is the fact that within the boundaries of most of the known camps of the district the plausibility of virgin ore runs is practically nonexistent.

"Owing to the haste and inefficiency in which much of the early mining was done, considerable ore, especially the low-grade variety, was bypassed. Such ore is represented by edge mineralization bordering previously mined runs—locally termed "skinning". These thin zones, as well as runs that tended to obscure themselves behind geological camouflage, have for many years been the reserves that have kept the mines alive. Rehabilitation of old mined-out areas and making them accessible to our present workings for the purpose of checking for overlooked ore possibilities and final cleanup is our present trend of development."

NONMETALS

The numerous nonmetallic minerals produced in Oklahoma are to a large extent processed and manufactured within the State. This is possible because fuels which are required in most manufacturing processes are readily and inexpensively available from large reserves of petroleum, natural gas, natural gasoline, liquefied petroleum gases, and coal. The advantages of having high-purity mineral raw materials close to fuel resources has resulted in the


MINERAL MAP OF OKLAHOMA
(Exclusive of fuels)
Adapted from Oklahoma Geological Survey, Map 72-1, 1955
EXPLANATION
GRANITE AND RELATED ROCKS
Principal areas
Plant or quarry
LIMESTONE AND DOLOMITE
Principal areas
Quarry
Lime plant
GYPSUM
Principal areas
Plant or quarry
GLASS SAND
Principal areas
GS
Plant and quarry
SALT
Area underlain by salt
Plant
Salt plain
BRICK, TILE, OR POTTERY PLANT
CEMENT PLANT
SAND AND GRAVEL PITS
CHAT, DISTRIBUTION POINT
ZINC-LEAD MINE AREA
ZINC SMELTER
BUILDING STONE QUARRY
BENTONITE PIT OR DEPOSIT
TRIPOLI PLANT
VOLCANIC ASH PIT OR DEPOSIT
GUYMON
WOODWARD
ENID
PONCA CITY
BARTLESVILLE
MIAMI
TULSA
STILLWATER
MUSKOGEE
OKMULGEE
CLINTON
OKLAHOMA CITY
SHAWNEE
NORMAN
CHICKASHA
McALESTER
ALTUS
LAWTON
DUNCAN
ARDMORE
HUGO
0 10 20 30 40 50 60
Scale in Miles

establishment in Oklahoma of many manufacturing plants, and from these plants a substantial part of the production is exported to neighboring states.

The principal nonmetallic minerals of Oklahoma are limestone, dolomite, granite, gypsum, shale, sand and gravel, salt, and silica sand, all present in virtually inexhaustible deposits. Also produced in lesser volume are tripoli, volcanic ash, fullers earth, and sulfur.

From these mineral resources several hundred useful products are made. Some of the more important are plate and window glass, pyrex glass, and flint glass for containers, tableware, and art objects. Twelve glass plants in Oklahoma utilize the natural combination of silica sand, limestone, dolomite, and natural gas for making these diverse kinds of glass.

More than 125 gypsum products are made from thick beds of gypsum in western Oklahoma, where four quarries are active. Portland and masonry cement are made in two large plants, using limestone, shale, and natural gas. Lime is produced from deposits of nearly pure limestone in eastern Oklahoma. In addition to the use of lime for water treatment, building mortar, and metallurgy, it is the raw material used for the manufacture of calcium carbide in a plant near Pryor. Pottery, brick, tile, and expanded construction aggregates are made in 16 major plants widely distributed over the State.

Salt for stock use and for recharging water softeners is produced at three plants in western Oklahoma. Pink, gray, and black granite for monumental and decorative use is worked at six quarries in southwestern and southern Oklahoma. Building sandstone and limestone, mostly for home and office construction, are worked from ten quarries. Fullers earth, a special type of clay found in western Oklahoma, is extensively used as an absorbent. Tripoli and volcanic ash, entirely different in origin but similar in physical properties, are produced from large deposits in northwestern and northeastern Oklahoma. And, finally, the important materials of construction—crushed stone, sand, and gravel—are produced from a hundred quarries and pits throughout the State for concrete roads, streets, bridges, home foundations, and general construction use.

A second major category of nonmetallic products is derived from the mineral fuels of Oklahoma. Both petroleum and natural gas, in addition to being the source of essential gasoline and motor oils, are widely used as raw materials for the manufacture of numerous other valuable products. Some of the more important are asphalt for highway construction, special paints, and floor tile; carbon black for making rubber, paints, and ink; waxes for waterproofing disposable cartons; solvents for cleaning and industrial use; and sulfur, extracted from natural gas in southern Oklahoma, used for making sulfuric acid. Even deposits of naturally occurring asphaltic sand and limestone are quarried from the Arbuckle Mountains and used for the building of roads.

The value of all these nonmetallic minerals and products can be estimated only in general terms. The raw materials as they are produced at the quarries have an annual value of approximately $35 millions, but the products made from them are valued at several hundred million dollars per year. Nearly all this value is "made in Oklahoma", and it all contributes to a well-balanced mineral economy.

History of Non-metallic Mineral Production

With the great abundance of mineral resources in most parts of Oklahoma, it is easily understandable that the early settlers would find and use the deposits which were exposed at the surface and which were accessible to the principal markets. Coal, long the standard fuel of the early days, was found and mined in eastern Oklahoma as early as 1870; and, although no records of production are available, it is certain that Indians and transient white men had used salt from western Oklahoma springs and salt plains more than 150 years ago.

With the exception of coal, it is doubtful that any mineral was produced from Oklahoma deposits for commercial trade before 1890. Part of Oklahoma Territory was opened by the Run of April 22, 1889, making land available for permanent settlement and bringing in the first flood of land-hungry pioneers. This was the time when a concentrated production of mineral resources would begin, and by the year of Statehood, eleven nonmetallic commodities had been discovered and produced commercially.

Natural Asphaltic Rocks

Asphaltic sandstone and limestone were found shortly after the Run, in the Buckhorn area of the Arbuckle Mountain region, near Sulphur, and these deposits were immediately opened as surface quarries. A rare commodity, produced at only a few localities in the world, this black and gummy rock found a ready market as street-paving material. From the time of first production in 1891 the Buckhorn deposits and others in southern Oklahoma have yielded approximately 3 million tons of natural asphaltic rock. The deposits near Sulphur and Dougherty are still being worked, despite competition with asphalt from oil refineries, and the area is famous throughout the world for its asphalt-rich rocks. These strata expose at the surface the roots of oil pools from which the lighter gasoline and kerosene have been volatilized, leaving the heavy asphalt to impregnate the porous rocks of the ancient reservoir.

Tripoli

A peculiar lightweight form of silica rock, known from its first discovery in 1868 as tripoli, probably was the second nonmetallic mineral to be produced in Oklahoma. First worked in 1871 from deposits at Seneca, Missouri, the material was found in 1893 near Peoria, in the northeast corner of Oklahoma. The best deposits proved to be in Oklahoma, and for many years they have been the principal source of a highly specialized product. The high-silica tripoli rock occurs in the Boone formation of Mississippian age. Being porous, mildly abrasive, and chemically inert, it was used first as an abrasive and, later, to manufacture filter stones for domestic water treatment. The filter stones were turned to precise size and shape on a lathe and were widely sold both in this country and abroad. With the advent of greatly improved municipal water systems, usage of filter stones gradually declined until, in 1924, manufacture of the stones was discontinued. The main use since 1885 has been in pulverized form, as a fine abrasive in scouring and polishing compounds. At the present time it is widely used in the best grades of automobile polishes. Other important uses are as facings or partings in foundrys and as an admixture in concrete. The tripoli from Ottawa County, Oklahoma, produced by the American Tripoli Division of The Carborundum Company, for many years has furnished a world-famous abrasive material.

Gypsum

The date of first recorded production of gypsum in Oklahoma is 1894, and accordingly this vastly important mineral commodity, of which Oklahoma has one of the major reserves in the nation, came to be the third nonmetallic mineral of commerce. Gould, the first director of the Oklahoma Geological Survey, estimated in 1907 that Oklahoma had reserves of gypsum exceeding 125 billion tons. The estimates were made from reconnaissance mapping which indicated that gypsum occurs to a depth of at least 100 feet in 12 counties of western Oklahoma.

More recent investigations, still in progress by the Geological Survey, have confirmed the order of magnitude of Gould's estimates. A program of drilling in southeastern Custer County alone has revealed 1.3 billion tons of gypsum in a bed covering 24 square miles and having an average workable thickness of 36 feet. At the current rate of gypsum production in the United States, this one deposit would be sufficient for the Nation's needs for 100 years. And yet this deposit has not been worked, for others are more conveniently located with respect to transportation and markets.

In the geologic investigations of western Oklahoma, it has been found that gypsum occurs as two principal sequences—the Blaine formation and the Cloud Chief formation, both of Middle Permian age and both consisting of evaporation products of ancient seas desiccated under desert or semi-desert climates. The Cloud Chief is the younger, and it consists of one main bed as much as 100 feet thick, distributed over parts of Custer, Washita, and Caddo Counties. In all this area only one small deposit near Cement, Caddo County, has been mined.

The older sequence of gypsum beds, in the Blaine formation, is much more widely distributed. It crops out over enormous tracts of land in Jackson, Harmon, Greer, and Beckham Counties, in southwestern Oklahoma; and it extends as a wide belt through Blaine, Major, Woodward, Harper, and Woods Counties in northwestern Oklahoma. In all these counties the Blaine formation contains at least three gypsum beds having a combined thickness

of 40 feet or more, and in the southwestern counties there is an additional gypsum bed at the top which locally is 85 feet thick. Near Erick, in the southwestern part of Beckham County, the Blaine gypsums attain their maximum thickness of 160 feet—a truly enormous thickness of high-purity gypsum. Paradoxically, the rock gypsum of the Blaine has never been mined from these very thick deposits in the southwestern counties of Oklahoma.

From the earliest days the center of the gypsum industry has been in Blaine County, from which the Blaine gypsums take their name. The towns of Bickford, Ferguson, Southard, Homestead, Okeene, and Watonga became prominently known for gypsum mining and the manufacture of gypsum plaster. Seven gypsum mills operated within the county in the first 20-year flush of production. During the same period mills sprang up at Okarche, Alva, Rush Springs, Eldorado, and McAlester, but not all of them were well planned or well located, and some did not survive. With the closing of gypsum mills, a few towns, such as Bickford and Ferguson, became ghosts and disappeared.

There were 10 gypsum mills in the State in 1907 and 12 in 1913. Five of the plants used rock gypsum exclusively; two of them used only gypsite, an earthy and somewhat impure form of gypsum; and all others used both rock gypsum and gypsite. Gypsite was favored at first by most operators because it was easy to mine and did not have to be crushed. The deposits themselves were not consistently pure, however, and all the plants using gypsite were gradually forced out of business by competition from the much purer rock gypsum. The last gypsite deposit to be worked was that at Eldorado, in southern Jackson County near Red River.

Although the number of plants decreased, production and value of gypsum steadily increased. Through 1900 the average annual production was 12,100 tons valued at $37,000. In 1921 the comparative figures were 209,000 tons valued at $1.29 million, and the 1923-1929 average was 327,000 tons with an annual value of $2.3 millions. During the depression of the 1930's, production sank to less than 150,000 tons per year, and all the plaster-making mills except the one at Southard were closed.

New production records were established after World War II.

The old record of 397,000 tons in 1928 was first surpassed in 1951 when 414,000 tons was produced. A new record of 445,000 tons was made in 1955, and in 1956 the all-time record of 468,000 tons was established.

During 1956 four quarries were being operated, one each near Southard, Okeene, and Watonga in Blaine County, and one near Cement in Caddo County. Three of these supplied gypsum for use as retarder in the manufacture of portland cement and as soil conditioner. The largest quarries and the only mill in Oklahoma are at Southard. There the United States Gypsum Company operates the same deposits it acquired in 1912, making more than a hundred kinds of plasters, cements, wall board, fillers, and specialty products. Natural gas is utilized to process the gypsum.

Resurveying the history of gypsum in Oklahoma, we see that 11 million tons has been mined in the first 63 years of production, and that the total value of this gypsum and the products made from it exceed $50 millions. The main sources have not yet been touched, and new reserves of natural gas are being found each year both in the southwestern and northwestern counties where the gypsum deposits are exceptionally large. In terms of modern use, the gypsum deposits of western Oklahoma are inexhaustible, and they are one of our great natural resources.

Asphaltite

Solidified pure asphalt or asphaltite, known as grahamite and impsonite, were discovered in the Ouachita Mountains as early as 1890, when that region was part of the Choctaw Nation in Indian Territory. At first believed to be coal, because it had a black color, conchoidal to hackly fracture, and would burn with a hot flame, the material was later shown by geologic investigations to be related to asphalt and thus to have been derived from petroleum.

The deposit in Impson Valley, near the town of Jumbo in northwestern Pushmataha County, was opened in 1892, and by 1901 it was being worked in two levels, 20 and 35 feet beneath the surface, that extended as much as 120 feet along the vein.

In the early 1900's there was considerable demand for waterproofing compounds, which at that time were derived mostly from asphaltites and native asphalt rather than from petroleum refining. Encouraged by the discovery of the apparently large deposit in

Impson Valley, search went forward vigorously for new deposits. This search was successful, resulting in the discovery early in 1906 of an even larger deposit in Jackfork Valley, near the present town of Sardis. This proved to be the largest known grahamite vein in the world.

Some of the chief uses of grahamite were in the manufacture of roofing compounds, paints, varnishes, electric wire insulation, and the lining of chemical tanks. In the first quarter of the twentieth century, practically the entire production of grahamite in the United States came from Oklahoma deposits. Ninety thousand tons was produced between 1903 and 1925. In 1925 the mines were closed owing to competition with refined petroleum asphalts, and they have not been reopened.

Superfically related to grahamite is impsonite, a material first worked in 1900 from a deposit near Page, LeFlore County. It is infusible, insoluble, and is characterized by fixed carbon content normally ranging between 75 and 80 percent. Because of its insolubility, impsonite could not be used successfully in waterproofing compounds. It was soon discovered, however, that vanadium was contained in the Page impsonite. During World War I this valuable steel-alloying element was recovered by burning the impsonite to ash, which contained approximately 20 percent vanadium oxide. After one shipment was made the deposit was closed. During World War II no attempt was made to use impsonite for its vanadium content, as richer supplies were available from uranium-vanadium ores of Colorado, Utah, and Arizona, and from ores mined in Peru.

At the time of their discovery, the grahamite deposits of the Ouachita Mountains were widely hailed as an important source of a valuable waterproofing material. Through the growth of the petroleum industry, better material for the same uses could be obtained from refineries at much less cost, and accordingly grahamite came to be a mineral of the past.

Salt

The earliest production of salt in Oklahoma has never been recorded, but from the knowledge that salt is essential to human life, and knowing that great quantities of it are spread on glistening white plains in seven major localities of western Oklahoma, free for the taking, we can be sure that this salt was used by the first men coming into the region. Salt springs also are numerous in both western and northwestern Oklahoma. It is known that such springs were used at Salina in the Cherokee Nation as early as 1850, when the Cherokees even drilled shallow wells to increase the flow of salt-laden brines.

Recorded production began in 1900, when 6,861 barrels of salt was sold for $6,136. This doubtless was commercial production, that is, it was produced by an organization for sale on the open market to anyone wishing to buy it. A barrel of salt weighs 280 pounds, so that production for the first year of the century was 1,921,080 pounds or 960 short tons.

Obviously such production was not built up in one year, but rather it was the result of growth from earlier beginnings. Gould stated in 1907 that salt from the Kiser and Chaney salt plains, on Elm Fork of Red River in northern Harmon County, had been used for twenty years, i.e., since about 1885. In some years, he stated, as much as 600,000 pounds of salt was made from the springs on each plain. This salt was produced by solar evaporation.

Salt was being produced also from springs on the salt plains near Carter, Beckham County; on Salt Creek in northern Blaine County; and from the two salt plains on Cimarron River. From these springs salt was made by filling kettles or pans and evaporating the liquid either by fire or by the sun's heat. One of the most extensively worked areas in pre-Statehood days was the Salt Creek plain, where shallow wells were dug and the brines pumped by hand into vats for evaporation by boiling. Cedar and oak obtained from nearby canyons were the chief fuels. Three buckets of brine yielded one bucket of salt.

Salt has now been produced in Oklahoma for more than a hundred years, but at no time has a great industry been established on the basis of this commodity. At the present time three plants are in operation, supplying salt for stock use and for recharging water softening systems. The largest plant is at Sayre, where fresh water is pumped into an underground salt bed and recovered as a saturated brine. This brine is evaporated in tanks, using natural gas as fuel. A second plant produces salt by solar evaporation of the salt springs in northern Harmon County, and a third producer harvests salt encrustations on the Big Salt Plain of the Cimarron River near Edith.

Current annual tonnage is more than 10 times the production in 1900, but it still is far short of the known potential. Thick salt beds of Permian age, formed by evaporation of inland seas in much the same manner as the gypsum beds, underlie 12 counties in western Oklahoma, making up a reserve so vast that it has not been calculated. The great value of salt lies in its utilization by chemical industries, as in Michigan, New York, West Virginia, Texas, and Louisiana, and a similar promise of industrialization based on salt and natural gas is in store for Oklahoma.

Materials of Construction

Nonmetallic minerals and rocks useful in general construction were in great demand during the early growth of Oklahoma. At the time of the Run of 1889, the inhabitants probably numbered a few tens of thousands, mostly engaged in the farming of isolated tracts or clustered around small settlements. But the population increased to 800,000 in 1900 and to 1,400,000 in 1907. All the major towns and communities had been established by 1907, and the need for stone, cement, lime, sand and gravel, and clay products was at first greater than could be furnished by local sources of supply.

In the eastern half of Oklahoma building stone was quarried from beds of sandstone, limestone, and marble; quarries were opened in the high hills of varicolored granites in the Wichita Mountain region of southwestern Oklahoma. Stone for concrete was crushed from enormous deposits of limestone in the Arbuckle Mountains, from the Limestone Hills north of Lawton, from flat-lying strata near Tulsa, and from widely scattered deposits within the Ozark dome area of northeastern Oklahoma and the Osage Plains in northern Oklahoma.

Clay derived from thick beds of shale in every segment of the State was mined for making bricks and vitreous tile for homes, offices, streets, and the few highways that were being constructed. Natural gas for burning the clay already in 1907 was available from numerous fields in eastern Oklahoma. At this time Oklahoma City was being supplied with gas, and pipe lines were being extended to Chickasha, Lawton, El Reno, Kingfisher, Enid, Perry, Stillwater, Guthrie, and intermediate points. Manufacture of portland cement and lime was begun by 1907, utilizing as fuel either natural gas or coal, depending on availability. Sand and gravel for concrete aggregate was produced from deposits around the metropolitan centers.

Arriving at Statehood in 1907, Oklahoma had proved through actual production that large deposits of essential raw materials were abundantly present.

Stone

Stone is a building material which, like water and air, is taken for granted. As long as supplies are available, materials of this class seem to have little or no value. But many parts of the earth contain only unconsolidated sediments, too soft for building use of any kind, and accordingly the necessary building materials must be imported.

Most of the rocks cropping out in Oklahoma are old, even in terms of the geologic time scale. Over at least 75 percent of the State, rocks ranging in age from 200 million years to 1,380 million years are exposed at the surface. Being of this ancient vintage, the rocks are mostly well consolidated, and many of them are well suited for construction. It was therefore with little difficulty that early builders found granite, dimensional sandstone, dimensional limestone, marble, and stone for crushing as building aggregate.

Granite was one of the first stones used. Both pink granite and black granite (gabbro) crop out in many bold hills of the Wichita Mountain region, and quarries were opened at the towns of Granite and Cold Springs. Small knolls of pink coarse-grained granite crop out over an extensive granite plain in the southern part of the Arbuckle Mountains, where the stone was worked in quarries at Tishomingo and Troy. The State Capitol building in Oklahoma City, as well as post office buildings in Ardmore, Oklahoma City, and Guthrie, and the government building of the Chickasaw Nation in Tishomingo, were constructed in part from Arbuckle Mountain granite.

Statistics of production of granite in Oklahoma were first recorded in 1900. Through 1956 the cumulative total was 1.2 million tons valued at $12.2 millions. Nearly all this stone was produced in the Wichita Mountain region, now for more than fifty years the center of the granite industry in the State, and one of the famous granite-producing districts of the world. The stone is produced chiefly for monuments and for exterior trim of buildings.

At the present time five companies produce granite from six principal quarries in the Wichita Mountains and from one quarry in the Arbuckle Mountains. Four large finishing plants in the Wichita Mountains, three of them near Snyder and one at Granite, saw the rough-quarried blocks into slabs which are cut and polished to a magnificent and extremely durable finish for shipment to all parts of the United States.

Crushed granite likewise is produced intermittently for building aggregate, yielding a superior building material.

Building sandstone, building limestone, and marble had been used in hundreds of cities and towns in Oklahoma at Statehood. Sandstone was by far the most common, as deposits are plentiful in the eastern half of the State and are locally distributed elsewhere. Building sandstone valued at $43,403 was produced in 1907, increasing to $90,971 in 1911. No deposit was extensively worked, however, and as the building boom subsided and local demands were filled, most of the quarries were abandoned. Following World War II, a new period of building activity resulted in the reopening of old quarries and the establishment of new ones, prominent of which are those at Locust Grove, Henryetta, Muldrow, and Moyers. Well-bedded strata of Pennsylvanian age are produced for dimension and veneer stone. The greatest production, in 1954, was 6,000 tons valued at $89,000.

Although no deposits of true marble are known in Oklahoma, a search by the earliest inhabitants revealed in Sequoyah County a deposit so closely resembling marble that the stone was quarried and, for a short time, widely used. A quarry was in operation in 1896, and a small town named Marble City was established when the Kansas City Southern Railway was built through this area in 1897. Production was valued at $16,805 in 1907, and throughout the course of its brief productive history this quarry yielded cut stone that was used in the Pioneer Telephone building in Oklahoma City and for buildings at Rice Institute in Houston, Texas. This stone, the St. Clair limestone of Silurian age, occurs in both pink and white even-grained varieties of pleasing color and excellent durability, but lack of a firm market forced the quarry to close in 1914. Although the deposit has not been reopened for dimension marble, it has been used since 1937 as a source of high-purity lime.

Building limestone likewise has had a colorful history. In the Choctaw Nation of southeastern Oklahoma the Goodland limestone of Cretaceous age was cut and used for buildings long before Statehood. Before 1900 the Mangum dolomite of Permian age and the Arbuckle limestone of Cambrian and Ordovician age were extensively used in southwestern Oklahoma; and by 1907 quarries had been opened in limestones of Pennsylvanian and Lower Permian age at Newkirk, Pawnee, Ponca City, Pawhuska, Bartlesville, Claremore, Nowata, Tulsa, Skiatook, Jennings, and many other places.

Heralded as a great event was the discovery and beginning of quarrying of the thick oolitic limestone in the Wapanucka formation near Bromide, Johnston County. Closely resembling the famous building stones of Bedford, Indiana, and Bath, England, and being fully equal to these stones in appearance, purity, and durability, the Wapanucka oolite was cut with wire saws from a massive homogeneous face and sold widely for building construction. The quarry was worked from 1911 through 1914 and then, owing largely to lack of market as in the case with marble, it was abandoned.

Production of dimensional limestone through the following decades has been of small tonnage and mostly for local consumption. In 1956 four quarries were in operation, two producing the pale green McLish limestone (Ordovician) from the Arbuckle Mountains, one producing a white oolitic stone from the Mangum dolomite (Permian) near Eldorado, Jackson County, and one producing laminated pink and gray stone from the Weatherford dolomite (Permian) near Hydro, Caddo County.

Crushed stone. Compact and durable rock aggregates are essential for concrete construction and for all types of road building. Gravel or crushed stone is generally used, depending on local supply of suitable material. Gravel deposits are widely distributed along major streams in Oklahoma and have been extensively used from the earliest times, particularly in the western part of the State, but the main source of building aggregates are limestones that are available from six major regions in the southern half and northeastern quarter of Oklahoma.

Hills of Arbuckle limestone more than 200 feet high were

first quarried in 1906 at Crusher in the Arbuckle Mountains and at Richards Spur, at the east end of the Wichita Mountain region. These quarries at present are the largest in the State and have been in continuous production, yielding a large percentage of the total tonnage of crushed stone in Oklahoma. Also before Statehood, quarries had been established for crushed stone in Pennsylvanian and Permian limestones at Lost City (near Tulsa); Avant, Osage County; Uncas, Kay County; Lenapah, Nowata County; and Limestone Gap, Atoka County. The quarries at Lost City, Uncas, and Lenapah are still in production, the stone being used for railroad ballast, concrete aggregate, and agricultural limestone.

Probably no less than 200 quarries in 30 Oklahoma counties have been opened for crushed limestone since 1907, demonstrating the widespread occurrence of this commodity. Many of these quarries were opened by contractors for a particular segment of road construction. Portable crushing equipment is used to obtain the nearest material of suitable quality, and on completion of the highway the quarry is abandoned and the equipment moved to another site.

In 1957 there were 25 permanent quarries and 10 temporary quarries from which crushed limestone was produced in Oklahoma, distributed in Atoka, Coal, Comanche, Craig, Delaware, Garvin, Johnston, Kay, Kiowa, Love, Mayes, Marshall, Murray, Nowata, Osage, Pittsburg, Pontotoc, Rogers, Sequoyah, Tulsa, and Washington Counties. Total production in 1956 was 8.6 million tons valued at $10.6 million.

Another source of crushed stone in Oklahoma is chat, a by-product waste material from the milling of zinc-lead ores in Ottawa County. Composed mostly of chert, limestone, and dolomite, it is used extensively for railroad ballast and for highway construction. Since the great Picher field was discovered in 1914, as much as 4 million tons of chat per year has been used, and enormous piles remain for use in the future.

Clays and shales

Building bricks, made from shales or from weathered clay, were in strong demand for construction of homes, offices, sidewalks, streets, and even highways at the time of Oklahoma's rapid growth just before Statehood. With deposits of clays in virtually every county in the State, brick plants had been established in 25 cities by 1907. The red shales of western Oklahoma were made into bricks at Oklahoma City, Chandler, Guthrie, Purcell, Chickasha, El Reno, Kingfisher, Enid, Alva, Geary, Mangum, Gotebo, and Hobart. Brick and tile likewise were made from local shales at Bartlesville, Ramona, Ochelata, Tulsa, Red Fork, Sapulpa, Cleveland, Okmulgee, Vinita, Claremore, Muskogee, and McAlester. Despite this large number of plants, the demand was so great that bricks were being imported from Kansas and other states.

The plants in eastern Oklahoma had a competitive advantage in the availability of either coal or natural gas for fuel, whereas the brick plants in western Oklahoma, like the gypsum plants in this region, had no coal and only small supplies of natural gas. More than half the plants were forced to close as competition grew keener and the building boom began to fade. The surviving plants were well located with respect to markets, transportation, fuel, and raw clay of high quality, with the result that clay products valued at approximately $2,000,000 per year were manufactured in Oklahoma in the years between 1917 and 1929.

A significant trend in the manufacture of clay products was the displacement of coal by natural gas as the preferred fuel. Pipelines were bringing natural gas to every large city and most of the smaller towns, so that fuel was made available to every deposit for which there was a market.

In 1957 brick and tile were manufactured from shale, entirely of Pennsylvanian and Permian age, in 14 plants at Ada, Clinton, Collinsville, Enid, Mangum, McAlester, Oklahoma City, Sapulpa, Stroud, Tulsa, and Wewoka. Common brick, face brick, and hollow tile are the chief products made.

Other uses have been found for Oklahoma shales. In 1906, when portland cement plants were established at Dewey and Ada, shale was quarried and ground with limestone for making the cement clinker, a process still being used today in these plants. Pottery clays valuable for making art objects, dinnerware, and flower pots are used in 5 plants at Sapulpa, Tulsa, Oklahoma City, Perry, and Frederick. Beginning in 1933 Oklahoma shale has been used for the main part of the ceramic body of dinnerware and

flower pots, but imported white clays are used for the manufacture of art objects in some plants.

A special kind of absorbent clay called fullers earth, associated with volcanic ash deposits in Dewey and Woodward Counties, has been produced intermittently since 1935 for use in special packing compounds that absorb water for the protection of valuable equipment. The most recent new use for clay is for the manufacture of expanded light-weight aggregates used in concrete building blocks for home and office construction. Expanded aggregates made from Oklahoma clay, begun in 1953, are now manufactured in two plants, one at Tulsa and one at Choctaw, near Oklahoma City.

Sand and Gravel

Sand and gravel deposits for building use are widely distributed throughout Oklahoma, supplying a critical need for aggregates, mortar sand, concrete sand, and well-packing gravel. In 1956 sand and/or gravel were produced in 57 counties from 109 pits, of which 55 were operated as permanent plants and 54 as temporary plants using portable equipment for contract jobs on highway construction. These pits yielded 6 million tons of sand and gravel valued at $5 millions.

First commercial production was reported in 1904, and to the end of 1957 the cumulative production was 91 million tons with a total value of $57.5 million. Rate of production has increased greatly, especially in recent years. Production in 1904 was less than 1,500 tons, but this figure was increased rapidly to 108,000 tons in 1907; 682,000 tons in 1909; and 1.5 million tons in 1914. The 1914-1951 production fluctuated between 0.4 and 3.1 million tons, and averaged 1.37 million tons.

The greatest expansion in the production of sand and gravel in the history of Oklahoma took place in the six-year period 1952-1957, when the average annual production was 5.4 million tons. Total production during this period was 32.4 million tons, more than a third of the cumulative production yielded by all the pits since 1904. An ambitious program of highway and general building construction accounted for this great increase.

Supplies of sand and gravel in Oklahoma are related primarily to the geologic history of the central part of the United States beginning during the Pleistocene epoch—the time of widespread continental and alpine glaciation in the northern hemisphere of the world. At that time all the major east-flowing streams of Oklahoma were larger and were carrying a greatly increased load of gravel and coarse sand derived from the Rocky Mountain region to the west. The Arkansas River still obtains sediment from this Rocky Mountain source and accordingly its sands, being coarse-grained, are extensively used from Kaw City to Muskogee. Seventeen permanent plants, nearly one-third of all such plants in the State, are producing Arkansas River sand along this course of the river.

The majority of all other permanent and temporary sand and gravel plants are producing from deposits along Pleistocene courses of our present-day streams. These former channels now occur mostly as terrace benches 50 to 200 feet above the present streams. Deposits of this type are worked at Waynoka, Orienta, Dover, Crescent, and Guthrie along the Cimarron River; at Woodward, Watonga, Hydro, Geary, Tuttle, and Oklahoma City along the North Canadian and Canadian Rivers; at Butler, Clinton, Pauls Valley, and Wynnewood along the Washita River; at Erick, Mangum, and Frederick along North Fork and Salt Fork; and at Grandfield and near Durant along Red River.

Two other major sources of sand and gravel are available. The largest supplies are from coarse sediments in stream channels within hilly regions underlain by compact limestones, sandstones, and chert, such as in the Ozark region of northeastern Oklahoma, Ouachita Mountains of southeastern Oklahoma, and the Arbuckle and Wichita Mountains in south-central and southwestern Oklahoma. The other source, worked least of all because most deposits are small and unsuitable, are conglomerate beds of Paleozoic age that occur locally in the Arbuckle and Wichita Mountains, and in Permian and Pennsylvanian strata in central Oklahoma. Both sources are worked to supply local demand, and some of the largest deposits along railroads are worked continuously by permanent plants.

Portland Cement

In Oklahoma portland cement is the giant of all nonmetallic commodities. This vastly important material of construction

yields in normal years approximately one-third of the total nonmetal value produced within the State. The advantages of having abundant fuel supplies in the midst of inexhaustible cement raw materials were quickly realized even before Statehood, and in 1906 two plants were established, one at Ada in Pontotoc County and one at Dewey in Washington County. Both have maintained continuous operation to the present time, increasing their combined annual capacity from approximately 2 million barrels in 1906 to more than 6 million barrels in 1957.

Availability of cheap fuel encouraged the beginning of portland cement manufacture. In 1907 natural gas could be obtained for industrial use at 2 cents per thousand cubic feet; yet at this price more gas was available locally than could be sold, and wells with a potential flow of 10 million cubic feet per day were shut in for lack of market. The first gas used for manufacturing in Oklahoma was by a brick plant at Red Fork in 1904. In 1906 the Dewey cement plant also used natural gas as fuel, and in the following year a zinc smelter at Bartlesville began using gas. The Ada portland cement plant at first used coal obtained from the mines near Coalgate, but later changed to natural gas following discoveries in Pontotoc County. Although the average price of natural gas produced in Oklahoma increased irregularly to 10 cents per thousand cubic feet in 1912, it has since undergone a net decrease to 8 cents in 1956. Coal has competed successfully with natural gas, and at times the plant at Dewey used powdered coal for burning the cement materials to clinker.

For making cement at Ada, the Fernvale limestone and Sylvan shale of Ordovician age are used, and at Dewey the interbedded limestones and shales of the Dewey formation, Middle Pennsylvanian in age, are used. Other cement-making materials occur in abundance in many parts of Oklahoma, especially in the Limestone Hills of the Wichita Mountain region, the Arbuckle Mountain region, along the belt of outcrop of the Goodland limestone (Cretaceous) in southeastern Oklahoma, and in wide areas of limestone and shale outcrop in northeastern Oklahoma.

In 1910 construction was begun on the plant of the Choctaw Portland Cement Company near Hartshorne, in Pittsburg County, with plans of using the Wapanucka limestone and underlying shale together with powdered coal from nearby mines. This plant was constructed but never put into successful operation, and in later years it was dismantled. In 1956 construction was started on the plant of the Ozark Portland Cement Company near Locust Grove, Mayes County, the plant having a planned capacity of 1,500 barrels per day. Production had not started by the end of 1957.

A potential source of raw material for portland cement manufacture is in the enormous gypsum and anhydrite deposits of western Oklahoma. In Europe anhydrite is burned for recovery of sulfur dioxide to make sulfuric acid, and the by-product residue of calcium oxide is then used for making portland cement. So long as sulfur is available more cheaply in the United States from salt domes of the Gulf Coast, it will not be economical to use Oklahoma gypsum or anhydrite in the European process, although in future years these reserves may form the basis for a valuable cement and sulfuric acid industry.

Lime

The use of lime in Oklahoma dates back at least 125 years, when it was used for mortar in masonry construction. Between 1824 and 1869, lime was made from Oklahoma deposits for building six forts and at least one Indian Academy. As these were widely distributed in eastern and southern Oklahoma, it was clear at this early date that limestone of high purity, suitable for burning to lime for use as mortar, was available at many localities in rocks of widely ranging age. The following list shows the early buildings constructed and the probable stone used for the lime.

1. Fort Towson, Choctaw County, established 1824, used Goodland limestone (Cretaceous).
2. Fort Smith, Arkansas, established 1838, probably used Pitkin limestone (Mississippian) obtained by barge on the Arkansas River from near Muskogee.
3. Fort Washita, 18 miles south of Tishomingo, built in 1852, used either Goodland or Duck Creek limestone (Cretaceous).
4. Fort Gibson, Muskogee County, rebuilt of masonry in 1848, used St. Joe limestone (Mississippian).
5. Choctaw Indian Academy, near Bromide in eastern Johnston County, built 1850, used Wapanucka limestone (Pennsylvanian).

6. Fort Arbuckle, southern Garvin County, near Davis, built 1852, probably used Kindblade limestone of Arbuckle group (Ordovician).
7. Fort Sill, near Lawton, established 1869, used Arbuckle limestone, probably lower or Cambrian part.

Beginning in 1902 and extending through 1916, lime was produced at various times in 17 counties, including Adair, Atoka, Carter, Cherokee, Coal, Comanche, Craig, Delaware, Dewey, Johnston, Marshall, Mayes, Murray, Nowata, Pawnee, Pontotoc, and Sequoyah. Most of these kilns were worked for a year or two and then closed down, so that not more than four were active in any given year. The outstanding plants were those of the Grove White Lime Company at Grove, the Viola White Lime Company at Bromide, both established in 1908, and the Fort Towson White Lime Company, established in 1914, at Fort Towson. The stones used by these plants were, respectively, St. Joe limestone (Mississippian), Viola limestone (Ordovician), and the Goodland limestone (Cretaceous). Their capacities ranged from 125 to 200 barrels (11 to 18 tons) per day, and the average annual production for the State was about 2,200 tons valued at $17,200.

None of these plants is now in operation, although the deposits at Fort Towson and at Bromide were worked for lime as late as the 1940's. At Fort Towson lime was made by the Dunlap Company until 1937, when a new quarry was opened by the company at Marble City, Sequoyah County, in large deposits of the St. Clair limestone of Silurian age. The Dunlap Company at first operated a kiln at Oklahoma City, using stone produced at Marble City. In 1939 the company reorganized as the St. Clair Lime Company and established a modern shaft kiln plant at Sallisaw, 12 miles south of Marble City. Natural gas was used as fuel. This plant in the only lime producer in Oklahoma, it is the first truly modern plant in the State, and it has established a fine reputation for the production of high-purity lime for water treatment, building mortar, fluxing stone for manufacture of aluminum metal and steel, and as raw material for the manufacture of calcium carbide. The limestone itself, unburned, is extensively used in the manufacture of flint and container glass at plants in Oklahoma, Arkansas, and Texas.

At first working the stone in open-face quarries 100 feet high, the company in 1954 began to mine the stone underground by the room and pillar method, whereby the high quality of the limestone could be better maintained. Daily lime capacity has increased from 100 tons in 1939 to 300 tons in 1957. Average value of lime produced in 1952-1956 was $9.87 per ton, and the total value of lime produced in 1957 alone was such an enormous increase over the early years that it was more than 5 times greater than all lime produced in the State from 1902 through 1916.

Glass sand

The history of glass manufacturing in Oklahoma is closely linked with the comparative availability of raw materials, not only in Oklahoma but in Indiana and Kansas as well. For years the center of glass making was in the northeastern states, but early in the twentieth century supplies of natural gas began to fail, particularly in Indiana, and many glass plants were moved to the newly discovered gas fields of southeastern Kansas. During the period 1902-1905, twenty plants were established in Kansas and one at Bartlesville across the line in Indian Territory. These plants were supplied with glass sand from the St. Peter sandstone in eastern Missouri (Pacific-Crystal City district), the freight charges bringing the total cost of the sand to about four times its price at the quarry. Besides the high cost of sand, the glass plants were at times unable to obtain shipments and accordingly they were forced into costly shutdowns. This condition of unfavorable supply eventually led to the decline of glass manufacturing in Kansas. Whereas there were 20 plants in 1905, there were only 5 plants in 1919, 2 in 1927, and 1 in 1929.

A similar fate might have befallen the glass industry in Oklahoma had it not been for the high purity glass sand deposits in this State. After the discovery of natural gas in northeastern Oklahoma beginning about 1904, there was some migration of the Kansas plants into Oklahoma. The change probably was caused in part by a desire to escape keen competition in Kansas, and at the same time a new market was being created by the demands of a greatly increased population in Oklahoma. By 1913 there were 6 plants in Oklahoma, two each at Tulsa and Okmulgee and one each at Bartlesville and Avant, and all of them were obtaining glass sand

from eastern Missouri. In that year production of glass sand was started in the Arbuckle Mountain region of south-central Oklahoma, the first car being shipped from Roff in August, 1913, by the Mid-Continent Glass Sand Company. After 25 years of continuous production, this plant is still in operation.

When the sand at Roff proved to be satisfactory for making glass containers, windows, and polished plate, the future of glass in Oklahoma was assured and the industry gradually expanded. In 1919 there were in Oklahoma 16 establishments employing 1,692 wage earners and making glass products valued at $4,750,844. Afterward there was a decline in the number of establishments to 10 in 1929, 9 in 1937, and 10 in 1945, although the value of the products increased to $6,200,000 in 1937. By 1947 the industry employed 2,650 wage earners making products valued at $13,000,000; and in 1954, 4,200 employees were paid $15,000,000 to produce glass products valued at more than $25,000,000. This five-fold increase since 1919 is owed to the supplies of Oklahoma glass sand, natural gas, and limestone, all of which are available in ample volume at reasonable cost. With the exception of California, more glass is produced in Oklahoma than in any other state west of the Mississippi River.

Production of sand in the Arbuckle Mountain region has expanded to meet the rising markets, or rather, expansion of the glass industry has been possible because glass sand could be obtained. About 1918 two additional pits were opened, one near Hickory and another at Mill Creek. A fourth plant, that of the Sulphur Silica Company, was built in Sulphur in 1944, producing washed and dried sand from a deposit 3.5 miles south of town. Natural gas was used for drying. The plant had a capacity of 200 tons of dry sand per day, and most sales were to glass plants in Oklahoma and Texas, although at times sand was shipped as far away as Illinois. After four years of discontinuous production, the plant closed late in 1947.

The deposit at Hickory was operated intermittently until the middle 1920's, and was reopened by a modern plant of the Oklahoma Silica-Sand Company in October, 1945. This plant was destroyed by fire in 1947, rebuilt in 1953, and operated until

April, 1955. On being closed, the plant was partly dismantled and the deposit was idle through 1957.

At Mill Creek, Johnston County, is the largest glass sand plant and quarry in Oklahoma. Operated by the Mill Creek Sand Company as a captive plant supplying sand to the two Oklahoma glass plants of the Hazel-Atlas Company, the property was sold in 1947 to the Pennsylvania Glass Sand Corporation, the largest producer of glass sand in the United States. Through succeeding years the plant was completely modernized, its capacity was greatly enlarged, and grinding mills were added for the production of ground silica. Sand of the highest quality, containing 99.85 percent silica and less than 0.02 percent iron oxide, is widely sold in Oklahoma, Texas, Louisiana, and Mexico for the manufacture of container, plate, and window glass, for the manufacture of sodium silicate, and as foundry sand. Ground silica is shipped to many states for use in abrasive detergents, pottery, and as fillers. The sands are worked from the sandstone member of the Oil Creek formation in the Simpson group, Middle Ordovician in age. From the open pits, as much as 85 feet deep, sand is hydraulicked to a sump and pumped to the plant for washing and drying. The deposits at Sulphur and Hickory also are in the Oil Creek formation, whereas at Roff the sandstone of the McLish formation in the middle part of the Simpson group is worked.

In 1957, twelve glass manufacturing plants operated in Oklahoma, producing more than 50 types of glass containers, windows, figured sheet glass, pyrex ware, and art objects. The period of greatest growth since the early years took place after 1945, when plants of Corning Glass Works, Brockway Glass Company, and American Window Glass Company, all nationally recognized firms, were established.

Volcanic Ash

The unconsolidated volcanic ash of Oklahoma occurs in surficial deposits of late Tertiary and Pleistocene age, associated with other unconsolidated sediments such as sand and clay. The known outcrops occur widely scattered in 25 counties, chiefly in western, central, and east-central Oklahoma. Individual deposits are small and lenticular, and many are associated with terrace deposits of major streams.

The maximum observed thickness in Oklahoma volcanic ash deposits is 70 feet, but ranges downward to only a few feet, and most deposits are less than 20 feet thick. So far as known, all deposits are less than 1 square mile in areal extent, and the greatest estimated volume at a single locality is 10 million cubic yards. Some deposits are nearly pure unaltered volcanic ash; some are interbedded with sand and clay; and in other deposits the glass shards themselves are altered to montmorillonite so that the ash beds grade into bentonitic clays. A few volcanic ash deposits are cemented by calcium carbonate or contain concretions of it. A fresh-water snail fauna is found in some deposits, and all have yielded the opal tests of aquatic diatoms.

From the purely volcanic character of the glass shards, which predominate in all the ash deposits of the State, it is clear that the materials were derived chiefly from a volcanic source. The glass shards together with other volcanic materials such as orthoclase and biotite were explosively ejected from a volcano or group of volcanoes and carried by wind to or near the sites of the present deposits. The nearest volcanoes that were active during Pleistocene and Pliocene time, and which are likely to have been the source, are those near Santa Fe, New Mexico.

Volcanic ash deposits are plentiful in Texas, Oklahoma, Kansas, and Nebraska, and many deposits in this region have been worked intermittently as a source of abrasive powders, particularly cleansing compounds, and for an admixture in pozzolan cement. At least a dozen such deposits in Oklahoma have been worked since about 1925, including those near Custer City, Custer County; at Dustin, Hughes County; at Tullahassee, Wagoner County; and near Stigler, Haskell County.

Some of these deposits were opened to supply volcanic ash for pozzolan cement, which, compared with portland cement, has superior strength at a late age and is resistant to saline and acidic solutions. Most of them, however, were produced for use in abrasive powders. The deposit at Gate is the largest known in the State and has been worked more or less continuously for the past ten years. It was actively worked in 1957 by the Salyers Refining Company of Oklahoma City.

Potential new uses as an insulating compound have been described in reports by the Oklahoma Geological Survey, and it is entirely possible that production of volcanic ash in Oklahoma will increase substantially.

Dolomite

Deposits of dolomite, a magnesian variety of limestone, have been known from large areas in the Arbuckle Mountains, and from smaller deposits elsewhere in Oklahoma, since the earliest investigations by geologists in Indian Territory. No dolomite was produced specifically for its magnesium content untl 1948, when the Rock Products Manufacturing Corporation opened a large deposit of high-purity dolomite in the Royer formation, of Cambrian age, near Troy in Johnston County. Previous mapping and evaluation by the Oklahoma Geological Survey made possible the opening of this deposit.

Construction of the crushing mill and 3-mile narrow-gauge rail line began in 1946. The project was completed, the quarry opened, and shipments of stone were first made in June, 1948. The principal use at first was for flux in iron ore smelting. About 300 to 500 tons of 1- to 6-inch stone was shipped per day for this use, all shipments being made to the Lone Star Steel Company at Daingerfield, Texas, where East Texas brown iron ore is smelted to pig iron.

At a later date the company ceased production of fluxing stone and specialized in making minus-ten mesh dolomite for glass manufacture, chiefly window glass for which dolomite is preferred over limestone because the glass melt has greater fluidity while being drawn as sheets through extruding machines. Other products include finely ground dolomite for use in prepared fertilizers and feeds, and for application as soil conditioner.

Enormous tonnages of dolomite are available in the Mill Creek-Ravia area. The Royer dolomite is 550 feet thick, and at least 150 million tons are readily accessible for working as open-face hillside quarries. The stone is uniformly of high purity, containing approximately 99 percent theoretical calcium-magnesium carbonate and thus comparing favorably with the best grades sold from deposits in other parts of the United States. The manufacture of refractories, basic magnesium carbonate, and magnesium metal are other possible uses for Oklahoma dolomite, and this commodity will doubtess continue to be produced in increasing volume.

Sulfur

Sulfur in the native state is not known in Oklahoma, but the element does occur abundantly in sulfide ores, in sulfate rocks such as gypsum and anhydrite, and as the ill-smelling hydrogen sulfide in what is known as sour natural gas. The smelter of the National Zinc Company at Bartlesville produces zinc by roasting and reducing sulfide ores; and in the smelting process sulfur dioxide gas is given off as a by-product. For many years this gas has been converted into sulfuric acid, for which native sulfur is most commonly used, and so in fact Oklahoma has been a sulfur producer without having made sulphur itself.

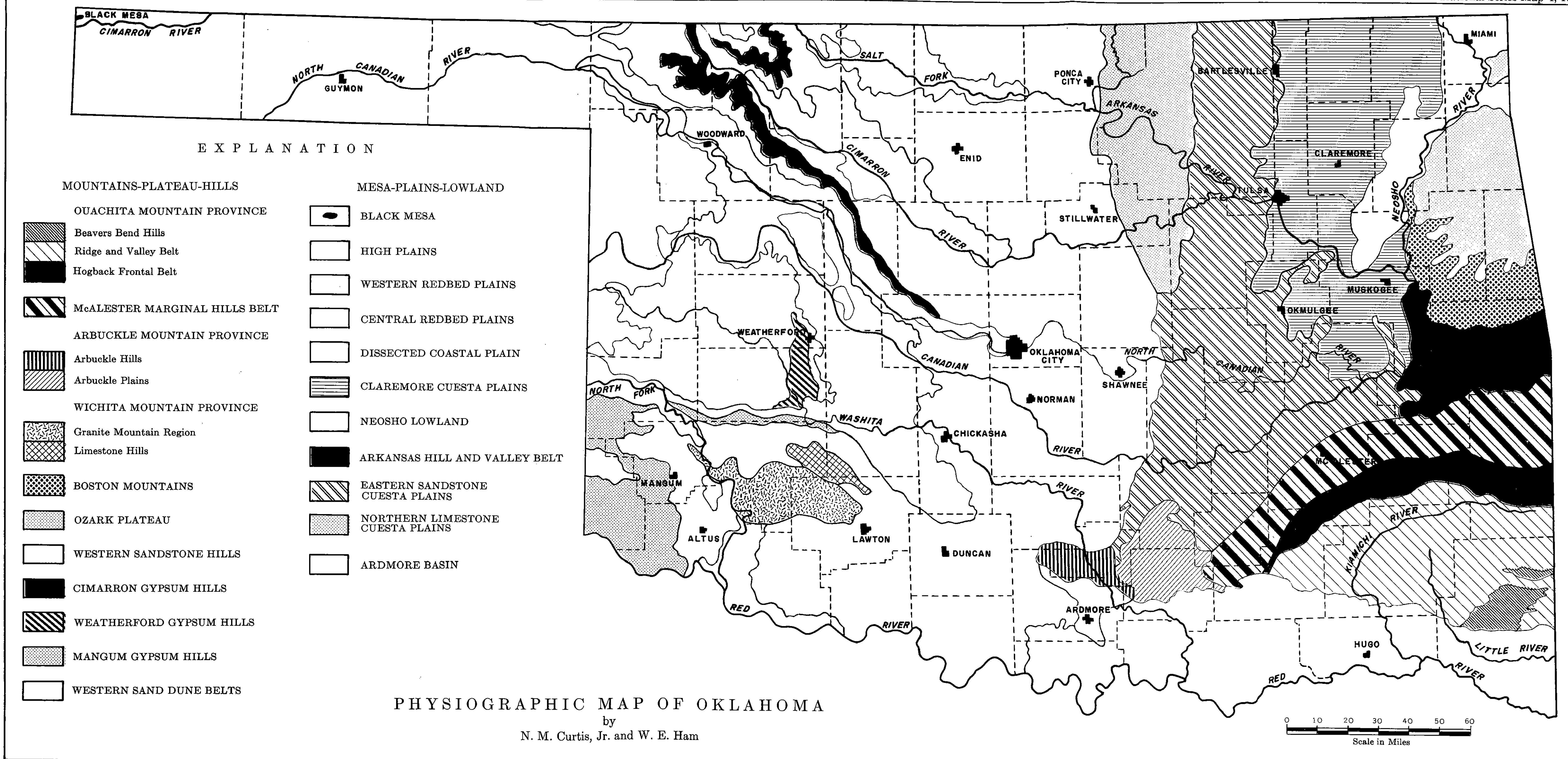
The first elemental sulfur plant in Oklahoma was erected by Joe L. Parker in 1952, just east of Madill in Marshall County, recovering sulfur by a modified Claus process from waste natural gases furnished by the Warren Petroleum Company gasoline plant. All sulfur produced at this plant is trucked in liquid form to Tulsa, where it is used in manufacturing sulfuric acid. The plant continues to operate in 1958 as the Central Chemical Company.

Although not yet worked for sulfur, the gypsum and anhydrite deposits in western Oklahoma constitute a large potential reserve for production when market conditions are favorable.

Miscellaneous Nonmetals and Ores

Many minerals, such as oolitic hematite, limonite, pyrite, manganese, silver, copper, and vanadium, have been produced from deposits too small to support sustained production. Others are or have been made by by-products, chief of which are cadmium, gallium, germanium, and indium obtained from smelting zinc ores; carbon dioxide for making dry ice, obtained from flue gases of the Ideal Portland Cement plant at Ada; and sulfur dioxide obtained from the zinc smelter at Bartlesville.

A third category includes materials which as yet have not been produced in quantity but do offer future promise. Outstanding among these materials are uranium, ilmenite, and anorthosite. Approximately 50 tons of uranium ore was sold in 1956 to the Atomic Energy Commission buying station at Grants, New Mexico, from deposits at Cement, Caddo County, and near Cheyenne, Roger Mills County. No large deposits have been found to date, but the Cement deposit was exceptionally rich, thus giving hope that similar discoveries will be made. In the alluvial sands in and around the Wichita Mountains the mineral ilmenite, valuable as a source of titanium for making white pigments, occurs as sporadic deposits. Anorthosite, a rock composed almost exclusively of plagioclase feldspar, makes up an entire chain of hills in the central part of the Wichita Mountains. This rare type of rock is rich in alumina, which can be extracted for refractories and as a source of aluminum metal. In present day metallurgy, bauxite is the primary source of alumina, but when bauxite deposits are exhausted the hills of Wichita Mountain anorthosite may well become a prime ore.



PHYSIOGRAPHIC MAP OF OKLAHOMA

by

N. M. Curtis, Jr. and W. E. Ham

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*Circular 4. The trees and shrubs of Oklahoma, by C. W. Shannon. 41 pages.			1913

*Circular 5. Rock asphalts of Oklahoma and their use in paving, by L. C. Snider. 22 pages, 7 figures.		1913
Circular 6. Animal and plant life in Oklahoma. 66 pages, 1 plate.	0.10	1917
*Circular 7. Correlation of the oil sands of Oklahoma, by Fritz Aurin. 16 pages, 1 plate.		1917
*Circular 8. Methods of exploring for oil and gas, by George E. Burton. 20 pages, 2 plates, 2 figures.		1917
Circular 9. The Sycamore limestone, by C. L. Cooper. 27 pages, 5 plates, 4 figures.	0.30	1926
Circular 10. A Siluro-Devonian oil horizon in southern Oklahoma, by Geo. D. Morgan. 13 pages.	0.30	1922
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Circular 12. Stratigraphic position of the Franks and Seminole formations of Oklahoma, by Geo. D. Morgan. 17 pages, 1 plate.	0.30	1923
*Circular 13. The Permian of western Oklahoma and the Panhandle of Texas, by Chas. N. Gould and Frank E. Lewis. 29 pages, 2 plates.		1926
Circular 14. The Arbuckle Mountains, Oklahoma, by Chester A. Reeds. 15 pages, 11 figures.	0.15	1927
Circular 15. Physical characteristics of the Arbuckle limestone, by Charles E. Decker and Clifford A. Merritt. 56 pages, 5 plates, 2 figures.	0.30	1928
*Circular 16. Oklahoma, the geologists' laboratory, by Chas. N. Gould. 16 pages, 7 plates.		1927

Circular 17. Road materials of western Oklahoma, by O. F. Evans. 19 pages, 1 plate, 1 figure.	0.30	1928
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Circular 21. Foraminifera from the Atoka formation of Oklahoma, by J. J. Galloway and Charles Ryniker. 37 pages, 5 plates.	0.30	1930
*Circular 22. Progress report on the classification of the Timbered Hills and Arbuckle groups of rocks, Arbuckle and Wichita Mountains, Oklahoma, by Charles E. Decker. 62 pages, 5 plates, 1 figure.		1939
Circular 23. Barite in Oklahoma, by William E. Ham and C. A. Merritt. 42 pages, 4 plates, 2 figures.	0.30	1944
Circular 24. Broken Arrow coal and associated strata, by Malcolm C. Oakes. 40 pages, 2 plates.	0.30	1944
Circular 25. Fluoride removal from drinking water, by A. L. Burwell, L. C. Case, and C. H. Goodnight. 41 pages, 1 plate, 4 figures.	0.05	1945
Circular 26. Geology and dolomite resources, Mill Creek-Ravia area, Johnston County, Oklahoma, by William E. Ham. 104 pages, 12 plates, 5 figures, map.	0.85	1949

Circular 27. Cellular products from Oklahoma volcanic ash, by A. L. Burwell, with a section on geology and petrology, by William E. Ham. 89 pages, 10 plates, 7 figures.		0.85	1949
Circular 28. Ground water resources of the Arkansas River flood plain near Fort Gibson, Muskogee County, Oklahoma, by Stuart L. Schoff and Edwin W. Reed. 55 pages, 12 plates, 1 figure.		0.60	1951
Circular 29. Mineral production of Oklahoma 1885-1949, by Phyllis Dale and J. O. Beach. 38 pages, 4 figures.		0.30	1951
Circular 30. Ilmenite in alluvial sands of the Wichita Mountain System, Oklahoma, by G. W. Chase. 44 pages, 10 figures, 2 plates. Report on drill samples, revealing a supply of titanium ore.		0.60	1952
Circular 31. Desmoinesian fusulinids of northeastern Oklahoma, by R. D. Alexander. 58 pages, 4 collotype plates. Description of 20 species, 7 of them new. Fourteen fusulinid faunules identified and fixed stratigraphically.	1.60	1.25	9-1954
Circular 32. Microfossils of the Croweburg coal in Oklahoma, by L. R. Wilson and W. S. Hoffmeister. 57 pages, 5 collotype plates.	1.75	1.25	4-13-1956
Circular 33. Geology and economic possibilities of the Baum limestone, by John Rex Wayland and W. E. Ham. 44 pages, 9 plates. Colored geologic map; scale 2 inches equal 1 mile. Detailed study of a limestone of high-calcium content. Discussion of reserves and possible commercial usages.	2.25	1.75	7- -1955
Circular 34. Geology of the core of the Ouachita Mountains of Oklahoma, by			

William D. Pitt. 34 pages, 15 figures. Colored geologic map; scale 1.5 inches equal 1 mile. Detailed study of stratigraphy and structure of pre-Bigfork formations. Evidence for domal structure rather than fenster.	2.00	1.50	6-21-1955
Circular 35. Post-Boone outliers of northeastern Oklahoma, by R. C. Slocum. 44 pages, 8 colored maps.	2.00	1.50	11-10-1955
Circular 36. Spores of the McAlester-Stigler coal of Oklahoma, by J. L. Morgan. 54 pages, 3 plates, 3 figures.	2.00	1.50	11-23-1955
Circular 37. A new Pleistocene fauna from Harper County, Oklahoma, by Dwight W. Taylor and Claude W. Hibbard. 23 pages, text figure.	1.00	0.50	9- 5-1955
Circular 38. Catalog of fossils from the Hunton group, Oklahoma, by Thomas W. Amsden. 63 pages.	1.25	0.75	6-23-1956
Circular 39. Chester Foraminifera and Ostracoda from the Ringwood pool of Oklahoma, by R. W. Harris. 41 pages, 4 plates.	1.50	1.00	6-23-1956
Circular 40. Geology of northeastern Osage County, Oklahoma, by W. F. Tanner. 76 pages, 17 figures, colored geologic map; scale 1 inch equals 1 mile.	2.25	1.50	10-31-1956
Circular 41. Two measured sections of Jackfork Group in southeastern Oklahoma, by L. M. Cline and Frank Moretti. 20 pages.		0.35	10- 1-1956
Circular 42. Geology and gypsum resources of the Carter area, Oklahoma, by George L. Scott, Jr., and William E. Ham. 64 pages, 8 plates, 5 figures. Colored map, scale 2 inches equal 1 mile.	2.75	2.25	9-20-1957
Circular 43. Catalog of Middle and Upper Ordovician fossils, by Thomas W. Amsden. 41 pages.	1.25	0.75	3- 1-1957

Circular 44. Introduction to stratigraphy of the Hunton group, by Thomas W. Amsden. 57 pages, 4 figures.	1.50	1.00	6-28-1957
Circular 45. A Pliocene vertebrate fauna from Ellis County, Oklahoma, by David B. Kitts. 27 pages, 1 plate.	1.00	0.50	8- 2-1957

Mineral Reports

	Price Paper	Date
*Mineral Report 1. Volcanic ash and tripoli, compiled by J. O. Beach. 27 pages, 1 plate.		1938
*Mineral Report 2. Phosphate, compiled by M. C. Oakes. 24 pages, 1 plate, 1 figure.		1938
*Mineral Report 3. Glass sands, compiled by Charles N. Gould and J. O. Beach. 21 pages, 1 figure.		1939
*Mineral Report 4. Iron ores, by C. A. Merritt. 38 pages, 1 figure.		1940
*Mineral Report 5. Limestone analyses, by S. G. English, Robert H. Dott, and J. O. Beach. 28 pages, 1 plate.		1940
*Mineral Report 6. Dolomite and magnesium limestone, by J. O. Beach and S. G. English. 20 pages.		1940
Mineral Report 7. A selected bibliography on the theories of the origin of oil, by Alan G. Skelton and Martha B. Skelton. 14 pages.	0.05	1940
*Mineral Report 8. Copper in the 'Red Beds' of Oklahoma, by C. A. Merritt. 20 pages.		1940
Mineral Report 9. Raw materials used in glass making, by Jay Randolph. 21 pages.	0.05	1941
Mineral Report 10. Manganese deposits of Oklahoma, by C. A. Merritt. 36 pages, 3 figures.	0.05	1941
*Mineral Report 11. Geology of Oklahoma ground water supplies, by Robert H. Dott. 30 pages, 6 plates.		1942
*Mineral Report 12. Carbonizing properties of Henryetta bed coal from Atlas No. 2 Mine,		

Henryetta, Okmulgee County, Oklahoma (preliminary report), by Joseph D. Davis and D. A. Reynolds. 8 pages, 7 tables.		1941
*Mineral Report 13. Mineral production of Oklahoma 1885-1940, compiled by J. O. Beach. 38 pages, 9 figures.		1942
*Mineral Report 14. The possibility of magnesia from Oklahoma oil field brines, by A. L. Burwell. 26 pages, 1 plate.		1943
*Mineral Report 15. Carbonizing properties of McAlester bed coal (preliminary report), by Joseph D. Davis and D. A. Reynolds. 10 pages, 1 figure, 7 tables.		1943
Mineral Report 16. Geology and chemical composition of the St. Clair limestone near Marble City, Oklahoma, by W. E. Ham, R. H. Dott, A. L. Burwell, and M. C. Oakes. 24 pages, 2 plates.	0.05	1943
Mineral Report 17. Bibliography of oil pool names in Oklahoma for 1942, by Alan G. Skelton. 48 pages.	0.05	1944
Mineral Report 18. Ground-water irrigation in the Duke area, Jackson and Greer Counties, Oklahoma, by Stuart L. Schoff. 10 pages, 1 plate.	0.05	1948
Mineral Report 19. Ground water in Kingfisher County, Oklahoma, by Stuart L. Schoff. 23 pages, 1 plate.	0.05	1949
Mineral Report 20. Ground water supplies in the Oklahoma City area, Oklahoma, by C. L. Jacobsen and E. W. Reed. 21 pages, 2 plates.	0.05	1949
Mineral Report 21. Ground water in the Cherokee area, Alfalfa County, Oklahoma, by Stuart L. Schoff. 17 pages, 1 plate.	0.05	1950
Mineral Report 22. Ground water in the Pond Creek basin, Caddo County, Oklahoma, by Leon V. Davis. 23 pages, 1 plate, 5 figures.	0.05	1950

Mineral Report 23. Oil possibilities near Idabel, McCurtain County, by L. V. Davis. 26 pages, map.	0.15	1953
Mineral Report 24. Lightweight aggregates from certain Pennsylvanian shales, by A. L. Burwell. 20 pages, 1 plate. Offset. Data on expansion of shales.	0.35	9-24-1954
Mineral Report 25. Mineral industry of Oklahoma in 1952, by F. F. Netzband, W. E. Ham, and J. H. Warren. 26 pages with 7 tables, offset. Final production figures and outline of mineral industries in each county.	0.25	11-17-1954
*Mineral Report 26. Occurrence of radioactive material in sandstone lenses of southwestern Oklahoma, by Gerald W. Chase, 7 pages, map.		11- -1954
Mineral Report 27. Uranium in Oklahoma, 1955, by Carl C. Branson, A. L. Burwell, and G. W. Chase. 22 pages, 2 maps. Supersedes Mineral Report 26. Advice to uranium seekers, discussion of known radioactive occurrences.	0.50	9- 2-1955
Mineral Report 28. The Henryhouse marlstone in the Lawrence uplift, Pontotoc County, Oklahoma, and its commercial possibilities, by Albert L. Burwell. Offset. Description and analyses of a source of hydraulic lime.	0.25	11-17-1955
Mineral Report 29. An investigation of industrial possibilities of Oklahoma gypsum and anhydrite, by Albert L. Burwell. Offset. 21 pages. Occurrences and uses of gypsum and anhydrite.	0.25	11-17-1955
Mineral Report 30. Asphaltite in the Ouachita Mountains of southeastern Oklahoma, by William E. Ham. 12 pages, map. Information on occurrence and uses of mineral hydrocarbons.	0.25	2- 7-1956
Mineral Report 31. The mineral industries of Oklahoma in 1954 and 1955, by P. E. Tribble, E. F. Netzeband, and W. E. Ham. 13 pages.		

Final advance summary of mineral industry operations in 1954; preliminary annual summary for 1955.	0.25	3- 8-1956
Mineral Report 32. The mineral industries of Oklahoma in 1955 and 1956, by Peter Grandone and William E. Ham. 13 pages. Final advance summary for 1955, preliminary annual summary for 1956.	0.25	5- 6-1957
Mineral Report 33. Uranium-bearing carbonaceous nodules in Oklahoma, by James W. Hill. 8 pages, map, plate.	0.30	9- -1957
Mineral Report 34. The mineral industries of Oklahoma in 1956 and 1957, by Peter Grandone and William E. Ham. 24 pages.	0.25	5-22-1958
Mineral Report 35. Gypsum resources of the Clinton-Weatherford area, by William E. Ham and Neville M. Curtis. 32 pages, map.	0.75	6-10-1958

Control Survey Circulars

*Control Survey Circular 1. Traverse and leveling in central Oklahoma. 111 pages, 1 plate, 5 figures.		1940
*Control Survey Circular 2. Traverse and leveling in south-central Oklahoma. 167 pages, 1 plate, 6 figures.		1941
*Control Survey Circular 3. Traverse and leveling in north-central Oklahoma. 99 pages, 1 plate, 5 figures.		1941

Director's Biennial Reports

Director's Biennial Report for 1935-1936, by Robert H. Dott. 63 pages.	0.05	1936
Director's Biennial Report for 1937-38. The Oklahoma Geological Survey, what it is-what it does, by Robert H. Dott. 34 pages.	0.05	1938
Director's Biennial Report for 1939-40. The Oklahoma Geological Survey and industrial development, by Robert H. Dott. 32 pages.	0.05	1940

Director's Biennial Report for 1941-1942, Mineral resources and mineral industries, an outline for future development in Oklahoma, by Robert H. Dott. 48 pages.	0.05	1942
Director's Biennial Report for 1943-1944, Research and industrial development, by Robert H. Dott. 24 pages.	0.05	1944
Director's Biennial Report for 1945-1946, Oklahoma needs more manufacturing, by Robert H. Dott. 32 pages.	0.05	1947
Director's Biennial Report for 1947-1948, Minerals of Oklahoma, by Robert H. Dott. 32 pages.	0.05	1949
(No biennial report issued for 1949-50, 1951-52.)		
Director's Biennial Report for 1953-1955. 18 pages. Free of charge. Postage and handling $0.10.	0.10	1955
Semi-centennial Report of the Director. In press.		1958

Guide Books

Guide Book I—Pre-Atoka rocks of northeastern Oklahoma, by G. G. Huffman. 41 pages. Veritype. Road log and description of outcropping rocks in the area of Ft. Gibson, Tenkiller Dam, Pryor, and Pensacola Dam.	1.10	4-24-1953
Guide Book II—Desmoinesian rocks of northeastern Oklahoma, by Carl C. Branson. 41 pages. Veritype. Road log and description of outcropping rocks from Miami to Lenapah, Claremore, Pryor, Wagoner, Porter, Concharty Mt.	1.10	5-14-1954
Guide Book III—Part 1—Geology of the Arbuckle and Timbered Hills groups in the Arbuckle Mountains; Part 2—Regional stratigraphy and structure of the Arbuckle Mountains, by W. E. Ham. 61 pages, 21 figures. Colored geologic map of Arbuckle Mountains, same as Map A-2.	4.00	4-22-1955
Guide Book IV—Geology along the Turner Turnpike. Prepared by Oklahoma Geological		

Survey, Oklahoma City Geological Society, Tulsa Geological Society, University of Oklahoma. Road log and strip map 3 inches to one mile, Tulsa to Oklahoma City; topographic and geologic profile, historical sites, botany, subsurface geology, oil and gas fields.	2.00	4-13-1956
Guide Book V—Field conference on the geology of the Wichita Mountain region, by William E. Ham, Clifford A. Merritt, and E. A. Frederickson. 58 pages, 1 table, 1 map. 14 figures.	3.00	5- 2-1957
Guide Book VI—Subsurface stratigraphic names of Oklahoma, by Louise Jordan. 200 pages.	3.00	12-31-1957
Highway Geology of Oklahoma. 172 pages. Published by Oklahoma City Geological Society. Available at Oklahoma Geological Survey for over-the-counter sale. By mail $3.25.	3.00	1955

Geologic Maps and Charts

*Geologic Map of Oklahoma, by H. D. Miser.		1926
Geologic Map of Oklahoma. by H. D. Miser. New colored map, entirely revised. Scale 1/500,000.	2.50	12-31-1954
*Oil and gas maps, by Bess M. Bullard.		1926
*Oil and gas fields of Oklahoma.		6- -1928
*Oil and gas map of Oklahoma.		1- -1931
*Mineral map of Oklahoma.		1940
*Minerals of Oklahoma.		1944
Map 72-1. Mineral Map of Oklahoma, by John H. Warren. Scale 1 to 750,000, in 3 colors.	0.75	9- -1955
Map 72-2. Map of ground-water reservoirs of Oklahoma, by S. L. Schoff. Scale 1 to 750,000, in 2 colors. Accompanied by text describing ground-water conditions.	0.50	11- -1955
Map GM-3. Tectonic Map of Oklahoma, by J. Kaspar Arbenz. In 4 colors; scale 1 to 750,000. folded 0.50	rolled 0.65	11-19-1956

Map GM-4. Geologic Map of the Criner Hills area, by E. A. Frederickson. Colored. Scale 3 inches equal 1 mile.	0.75	9- 1-1957
Map A-1. Geologic map of basic igneous rocks in the Raggedy Mountains, Wichita Mountain System, Oklahoma, by G. W. Chase. Scale 2 inches equal 1 mile.	0.60	1950
Map A-2. Geologic map and sections of Arbuckle Mountains, by W. E. Ham and M. E. McKinley. Colored. Scale 0.88 inch equals 1 mile.	2.00	1955
Map A-3. Geologic map of northeastern Osage County, by W. F. Tanner. Colored. Scale 1 inch equals 1 mile. Plate I of Circular 40.	0.60	1956
Map A-4. Geologic map of the Carter area, by George Scott, Jr. Scale 2 inches equal 1 mile. Colored. Plate I of Circular 42.	1.25	1957
Map A-5. Geologic map of the Lake Altus area, by C. A. Merritt. Colored. Scale 2 inches equal 1 mile. Plate I of Bulletin 76.	1.00	1957
*Map C-1. Geologic Map of Washington County; same as that accompanying Bulletin 62. Scale 1 inch equals 1 mile.		1940
Map C-2. Geologic Map of Hughes County: same as that accompanying Bulletin 70. Colored. Scale 1 inch equals 1 mile.	1.25	1954
Map C-3. Geologic Map of Okfuskee County: same as that accompanying Bulletin 71. Colored. Scale 1 inch equals 1 mile.	1.25	1954
Map C-4. Geologic map of Seminole County: same as that accompanying Bulletin 74. Colored. Scale 1 inch equals 1 mile.	2.00	1956
Map of Cimarron County, showing geology and depths of water in wells. Scale 1/425,000. Same as Plate I in Bulletin 64.	0.25	1943
Geologic map of northwestern Cimarron County, by J. W. Stovall. Scale 1/62,500. Same as Plate II, Bulletin 64.	0.25	1943

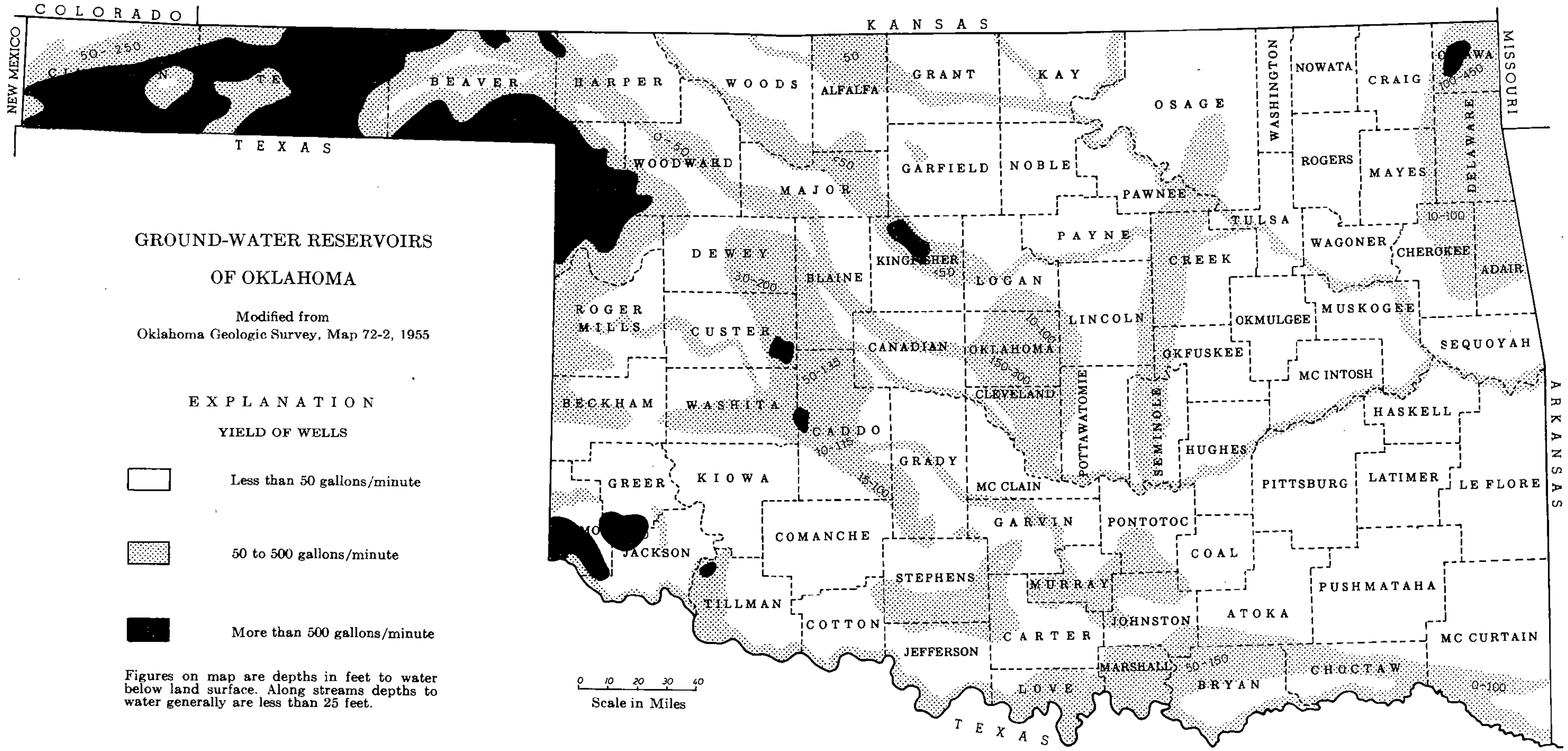
Geologic map of Haskell County, by M. C. Oakes and M. M. Knechtel. Scale 1 inch equals 1 mile. Plate I of Bulletin 67.	0.50	1948
Structure map of Haskell County. Plate II of Bulletin 67.	0.50	1948
Geologic map of Tulsa County, by M. C. Oakes. Plate I of Bulletin 69. Colored. Scale 1 inch equals 1 mile.	1.00	1952
Geologic map of the Muskogee-Porum district, by C. W. Wilson. Scale 1 inch equals 1 mile. Plate I of Bulletin 57.	0.75	1937
Geologic map of northern LeFlore County, by M. M. Knechtel. Scale 1 inch equals 1 mile. Plate I, Bulletin 68.	0.50	1949
Map of Texas County, showing geology and depths to water in wells. by S. L. Schoff.	0.50	1939
Geologic map of Pawnee County, by P. Greig. Scale 1 inch equals 1 mile.		1958
Chart: General geologic section of Oklahoma oil producing areas, by Robert H. Dott. Reprinted from National Oil Scouts and Landmen's Association Yearbook.	0.05	1944
Chart: General geologic section of Oklahoma oil-producing areas, by Carl C. Branson. Reprinted from National Oil Scouts and Landmen's Association Yearbook.	0.10	1956

PUBLICATIONS OF BUREAU OF GEOLOGY AVAILABLE AT OKLAHOMA GEOLOGICAL SURVEY

Bulletin 2. Geology of the Stonewall Quadrangle, by Geo. D. Morgan, published by the Bureau of Geology. 248 pages, 53 plates, 2 figures.	1.10	1924
Circular 2. Boggy unconformity and overlap in southern Oklahoma, by Geo. D. Morgan. Published by the Bureau of Geology. 8 pages, 2 plates.	0.10	1924

OKLAHOMA GEOLOGICAL SURVEY Carl C. Branson, Director

Educational Series Map 5, 1957



GROUND-WATER RESERVOIRS OF OKLAHOMA

Modified from
Oklahoma Geologic Survey, Map 72-2, 1955

EXPLANATION

YIELD OF WELLS

- Less than 50 gallons/minute
- 50 to 500 gallons/minute
- More than 500 gallons/minute

Figures on map are depths in feet to water below land surface. Along streams depths to water generally are less than 25 feet.

Circular 3. Geology of southern LeFlore and northwestern McCurtain Counties, Oklahoma, by C. W. Honess. Published by the Bureau of Geology, 23 pages, 5 plates, 2 figures.	0.10	1924
*Bureau Monthly, Vol. 1, No. 1, 28 pages.		4- -1925

CO-OPERATIVE REPORTS PUBLISHED BY OTHER AGENCIES

(Available only at agency listed)

Stabilization of the petroleum industry, by Leonard Logan (Bulletin 54 of Oklahoma Geological Survey but sale copies do not contain bulletin number), University of Oklahoma Press, 248 pages. Available only at University Press, Norman, Oklahoma.	2.50	1930
The chemical analyses of the waters of Oklahoma, including notes on geological occurrence. Prepared through co-operation of Department of Chemistry, Oklahoma A. and M. College; Oklahoma Health Department; and Oklahoma Geological Survey. xxii, 474 pages, 15 plates, 21 figures. Available at Engineering Experiment Station, Oklahoma State University, Stillwater.		10- -1942
*The clays and shales of Oklahoma, by Leonard Francis Sheerar, with samples and field data supplied by John S. Redfield. Prepared jointly by the Oklahoma Geological Survey and Engineering Experiment Station, Oklahoma A. and M. College, Division of Engineering Publ., vol. 3, no. 5; Engineering Experiment Station, Publ. No. 17, 251 pages, map.		9- -1932

Territorial Survey (1900-1908)

Department of Geology and Natural History, Territory of Oklahoma.

*First Biennial Report, Advance Bulletin. Invertebrate paleontology of the Red Beds, by J. W. Beede, 11 pages, 1 plate.		1902

*Second Biennial Report, 1901-02
  General Geology of Oklahoma, by C. N. Gould, pages 17-61, 69-74.
  On some vertebrate fossils from the Permian beds of Oklahoma, by E. C. Case, pages 62-68.
  Oklahoma gypsum, by C. N. Gould, pages 75-137.
  Plants of Oklahoma, by A. H. Van Vleet, pages 138-160.
  Birds of Oklahoma, by A. H. Van Vleet, pages 161-166.
  Snakes of Oklahoma, by A. H. Van Vleet, pages 167-173.

*Third Biennial Report, 1903-1904 — 1904
  A preliminary report on the contact of the Permian and the Pennsylvanian in Oklahoma, by Charles Townsend Kirk, pages 5-14.
  Geology of the Wichita Mountains of Oklahoma, by C. N. Gould, pages 15-22.
  Present status of the mining industry in the Wichita Mountains of Oklahoma, by E. G. Woodruff, pages 23-34.

Industrial Field Trip Guides

Mineral Resources Field Trip, Ada District, by W. E. Ham. 17 mimeographed pages.	11-30-1945
Mineral Resources Field Trip, Wichita Mountain District, by William E. Ham. 14 mimeographed pages.	5-21-1946
Mineral Resources Field Trip, Ada District, by W. E. Ham. 19 mimeographed pages.	11-8 and 9-1946
Industrial Tour. Manufacturing Districts of Tulsa and Sand Springs, by Malcolm C. Oakes. 10 mimeographed pages.	11-18-1947
Field trip in the Arbuckle Mountains for Industrial Minerals Division, AIME, by William E. Ham. 30 mimeographed pages.	10-19 and 20-1950

Topographic Maps

Topographic maps of lead and zinc area: Four topographic maps of part of northern Ottawa County. Scale 4 inches to 1 mile. Contour interval: 10 feet. Set of four maps. — 0.10

The Oklahoma Geological Survey keeps a stock of U. S. Geological Survey topographic maps of Oklahoma quadrangles. Quadrangle maps are priced at $0.30 post paid.

34 quadrangles available at scale of 1 to 125,000.

44 quadrangles available at scale of 1 to 62,500.

50 quadrangles available at scale of 1 to 24,000.

3 sheets along North Canadian River.

The new series at 1 to 250,000 is priced at $0.50 per sheet. Available sheets are Tulsa, Ft. Smith, McAlester, Ardmore, Oklahoma City, Texarkana, Clinton, Lawton, Woodward, Perryton, Dalhart.

Approximately half of the State has not been mapped topographically. The existing topographic maps of about a quarter of the State are inadequate.

Index to topographic mapping in Oklahoma. Free 12- -1957

Progress of Topographic Mapping

The best type of maps for geologists as for highway builders, irrigation engineers, drainage planning, and for many other uses is the topographic map. Modern maps are one inch to the mile or larger. Fifty-five quadrangles at the 1-62,500 scale are in print and thirty-eight others are being prepared. Forty-eight quadrangles at the 1-24,000 scale are in print and fifty-eight others are in preparation. When the quadrangles now in preparation are issued, 37 percent of the state will be covered by modern topographic mapping.

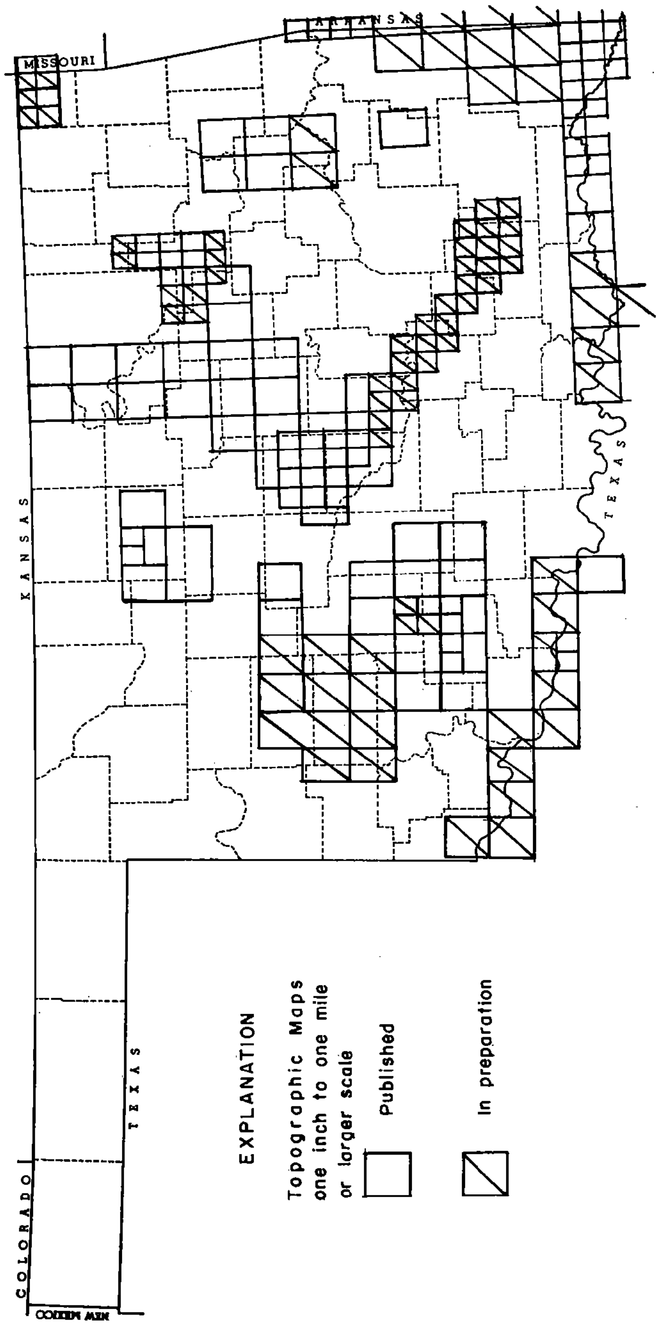


Figure 5. Map showing progress of topographic mapping.

Publications not in Series

*Descriptive catalogue of the geological and mineralogical collection presented to colleges, normal schools and high schools of Oklahoma, by Fred Bullard. 12 mimeographed pages.	11- -1921
*Catalog of one hundred rocks, minerals, and fossils from Oklahoma, by W. M. Plaster.	1- -1928
*Second Edition, by W. M. Plaster. 39 pages.	8- -1936
*New edition, by W. E. Ham, with a glossary by Eloise Tittle. 90 pages, 39 figures.	1942
*Oklahoma glass sands, by C. N. Gould and J. O. Beach. 12 pages.	1- -1930
*Summer birds of Oklahoma, by L. B. Nice and M. Nice. 7 mimeographed pages.	9- -1930
*Robberson oil and gas field, Garvin County, Oklahoma, by Leon E. English and L. T. Burlingame. Map with text on reverse. Press Bulletin 10.	3- 3-1922

Oklahoma Geology Notes

Printed in 12 numbers as 10 issues annually. Continues The Hopper. Now in the eighteenth volume. Contains mineral statistics, bibliographic data, original articles. Subscription $2.00 per year, single numbers $0.25.

Available Maps from Out-of-print Publications

Progress geologic map of Oklahoma. Bull. 19, pt. 2, Pl. 1	0.10	1916
Geologic map of Eastern Oklahoma. Idem, Plate 2	0.10	1916
Geologic map of western Oklahoma. Idem, Pl. 3	0.10	1916
Geologic map of Atoka Co. Idem, Pl. 5	0.10	1916
Geologic map of Carter Co. Idem, Pl. 7	0.10	1916
Table of general features of wells drilled in Red Beds area. Pl. 8	0.10	1916
Production map of Healdton Field. Idem, Pl. 9	0.10	1916
Structure Map of Healdton Field. Idem, Pl. 10	0.10	1916

Geologic map of Coal Co. Idem, Pl. 11	0.10	1916
Geologic map of Caddo, Comanche, Greer, Jackson and Kiowa Cos. Idem, Pl. 12	0.10	1916
Structure map of Cushing field. Idem, Pl. 14	0.10	1916
Structure map of Glen Pool. Idem, Pl. 17	0.10	1916
Geologic map of Garber anticline. Idem, Pl. 18	0.10	1916
Principal folds and axes of East Central Oklahoma. Pl. 20	0.10	1916
Production map of Muskogee field. Pl. 27	0.10	1916
Production map of Nowata district. Pl. 29	0.10	1916
Production map of Okmulgee-Morris district. Pl. 31	0.10	1916
Production map of Dewey-Bartlesville fields. Pl. 40.	0.10	1916

PAMPHLETS

*Resources of Oklahoma in a pocket-book, by C. W. Shannon. 64 pages.	9- -1912
*Handbook on the Natural Resources of Oklahoma. 98 pages.	9- -1916
*Facts about Oklahoma, by Fred M. Bullard. 12 pages.	9- -1920
*Facts about Oklahoma, by Fred M. Bullard. 12 pages.	9- -1921
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Geologic Mapping

The basic data of all geologic investigations are those on a geologic map. Mineral investigations are greatly facilitated by the existence of an adequate map of the sort. Geologic maps of modern accuracy and adequate scale have now been printed by the Survey for complete counties (Murray, Haskell, Washington, Tulsa, Seminole, Hughes, Okfuskee, Grady, Ottawa, Cimarron, and Texas). Maps of large parts of LeFlore, McCurtain, Osage, Johnston, Mayes, Cherokee and Adair Counties have been printed. The Federal Survey has printed adequate maps of Pittsburg County and of parts of Coal, Latimer, LeFlore, Cotton, and Tillman Counties. The Oklahoma Geological Survey has completed mapping of Harper County (in press), Creek County (in press), Pawnee, Osage, Okmulgee, McIntosh, Noble, Nowata, Craig, Blaine, and Mayes Counties, and has maps of large parts of several other counties completed. About half the State has been mapped or is currently being mapped. Figure 6 shows the larger areas of completed geologic work done by the Survey.

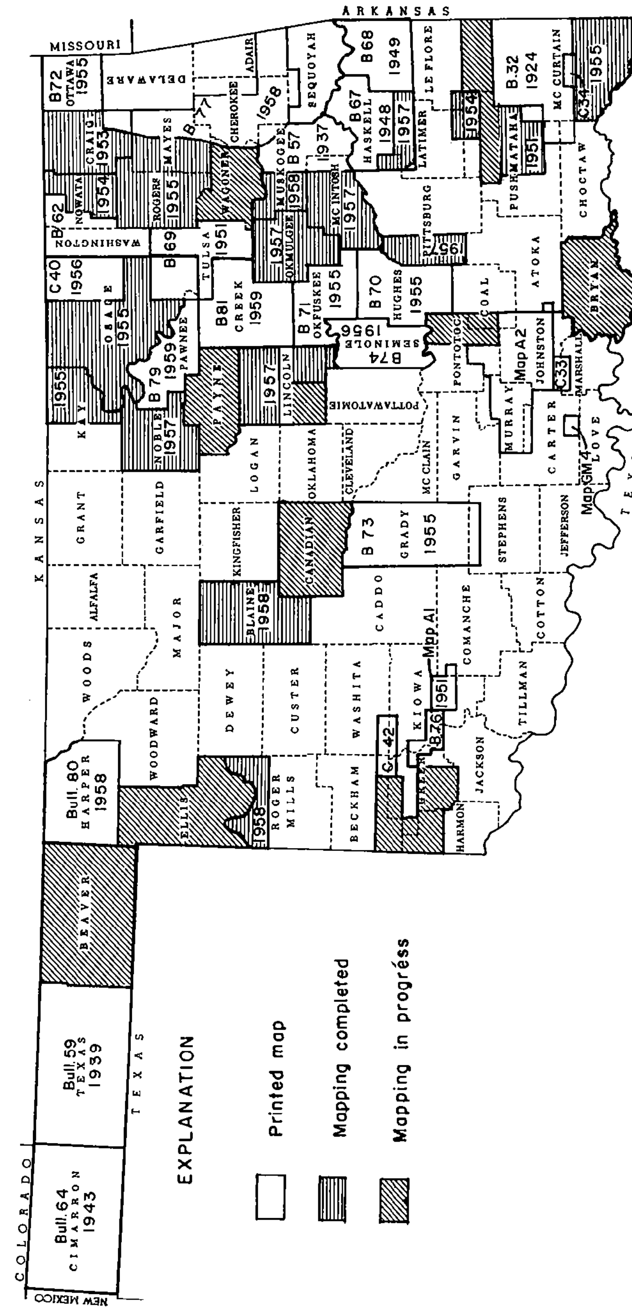

Figure 6. Map showing progress of geologic mapping.