OKLAHOMA GEOLOGICAL SURVEY.
Governor Robert L. Williams, State Superintendent R. H. Wilson,
President Stratton D. Brooks, Commission.
C. W. Shannon, Director.

BULLETIN NO. 22.

PART I.

DIRECTOR'S BIENNIAL REPORT. TO THE GOVERNOR OF OKLAHOMA, 1914.

PART II.

MINERAL RESOURCES OF OKLAHOMA AND STATISTICS OF PRODUCTION FROM 1901 TO 1914.

BY
C. W. SHANNON.

NORMAN
December, 1914.

SCIENTIFIC STAFF

C. W. Shannon.....Director
L. C. Snider.....Assistant Director
L. E. Trout.....Field Geologist
Fritz Aurin .....Chemist

LETTER OF TRANSMITTAL.

To His Excellency, Governor Robert L. Williams.
Sir:

In compliance with section four of the law establishing the Oklahoma Geological Survey, I present herewith the third biennial report of the Director of the Survey covering the calendar years 1913 and 1914.

This report includes also, as Part II, a brief discussion of the mineral resources of the State, and statistics of production from 1901 to 1914.

Respectfully submitted,

C. W. SHANNON, Director.

Norman, Oklahoma, December 31, 1914.

PART I.
DIRECTOR'S BIENNIAL REPORT

CONTENTS

DIRECTOR'S BIENNIAL REPORT

PURPOSE OF REPORT.

The purpose of the biennial report is chiefly administrative and sets forth very briefly the results of the scientific and field work of the State Geological Survey.

Part I deals with the historical facts, the financial statements, amount of appropriations, the character of field investigation, the needs of the Geological survey, and recommendation for legislative action.

Part II included in the report gives a brief discussion of the occurrence of the mineral resources of the State, their development, and statistics of production from 1901 to 1914.

CONSTITUTIONAL PROVISION.

The Constitution of Oklahoma provides for the establishment of the Survey. Section 37 of Article 5 reads:

The legislature shall provide for the establishment of a State Geological and Economic Survey.

ESTABLISHMENT OF SURVEY.

In accordance with the constitutional provision, the first Legislature of Oklahoma established the Survey by the following bill:

Senate Bill Number 75.

An Act

To authorize a Geological Survey of the State, provide for a Geological Commission, and define the powers and duties of the same. Be it Enacted by the People of the State of Oklahoma.

Section 1. There is hereby created a bureau, to be known as the "Oklahoma Geological Survey," which shall be under the direction of a commission, to be known as the State Geological Commission, composed of the Governor, the President of the State University, and the State Superintendent of Public Instruction.

Section 2. The said Commission shall serve without compensation, but shall be reimbursed for actual and necessary expenses incurred in the performance of their official duties, said Commission shall have general charge of the bureau, and shall appoint as director of the survey, a geologist of established reputation, who may, with the approval of the Commission, appoint such assistants and employees as may be necessary to carry out the provisions of this Act. The director, assistants and employees shall receive such salaries, or compensations as may be determined by this Commission.

Section 3. 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 oil, coal, gas, asphalt, gypsum, salt, cement, stone, clay, lead, iron, sand, road building material, water resources, and all other mineral resources.

Second: The preparation 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, in the judgment of the Commission, shall be deemed of value to the people.

Section 4. The director shall present to the Governor a biennial report, ready for printing, showing the progress and conditions of said bureau, together with such other information as the Commission may deem necessary: Provided, that the Commission shall have authority to print and to distribute said report.

Section 5. All materials collected, having served the purpose of the bureau shall be deposited in the State Museum: Provided, that duplicates may be distributed to the various educational institutions of the State under such regulations as the Commission shall formulate.

Section 6. In order to carry out the provisions of this Act, it shall be lawful for all persons employed by the bureau to enter and cross all lands within the State: Provided, that in so doing, no damage is done to private property.

Section 7. Until suitable laboratories, libraries and testing apparatus are provided by the State for prosecuting the work of the survey, said survey shall be located at the State University. The Commission shall enter into arrangements with the Board of Regents of the State University for the use, by members of the staff of the survey, of such rooms, laboratories, libraries and apparatus as may be necessary for the carrying on of such work.

Section 8. The sum of fifteen thousand dollars ($15,000), or as much thereof as may be necessary, is hereby appropriated out of the funds in the State Treasury, not otherwise appropriated, to provide for the payment of actual expenses of the Commission, and for other expenses authorized by them, and for the salaries or other compensation of the director, assistants or other employees.

Section 9. For the preservation of the public peace, health, and safety, an emergency is hereby declared to exist by reason

whereof this Act shall take effect and be in force from and after its passage and approval.

GEORGE W. BELLAMY, President of the Senate.
WM. H. MURRAY, Speaker of the House of Representatives.

Approved May 29, 1908.

C. N. HASKELL, Governor of the State of Oklahoma.

ORGANIZATION.

This bill was approved by the Governor, May 29th, 1908. The Commission met at the call of the Governor July 25, 1908, and the organization of the Survey was accomplished.

The Governor, C. N. Haskell, the State Superintendent of Public Instruction, E. D. Cameron, and the President of the State University, A. Grant Evans, met in the Governor's office.

Upon motion of E. D. Cameron, seconded by A. Grant Evans, Governor C. N. Haskell was elected President of the State Geological Commission.

The State Superintendent, E. D. Cameron, was elected Secretary of the Commission, and the President of the State University, A. Grant Evans, was elected Executive Officer. Upon motion, the Secretary was directed to purchase a substantial record book and to make a record of all actions of the Commission therein.

On motion, Chas. N. Gould, a geologist of established reputation, and now acting as Professor of Geology at the State University, was elected Director of the Geological Survey.

The following resolutions were adopted:

That the Executive Officer be empowered to certify to the State Auditor, the amount of money required to pay the salaries of the Director and other expenses as may be authorized by the Commission.

That the Executive Officer be empowered to arrange with the Board of Regents of the State University for such rooms, laboratories, libraries, and testing apparatus as may be necessary for the work of the Survey, as provided in Section 7 of the Act establishing the Survey.

That the President of the Commission make known to the Director of the United States Geological Survey, in Washington, and to heads of the Geological Surveys in the neighboring states the organization of the Oklahoma Geological Survey, and to ask their official aid and cooperation.

That the Director of the Survey be authorized in the name of the Commission, to solicit the friendly aid and cooperation of all

the citizens of Oklahoma, and particularly all teachers, and other professional men of the State.

That in conformity with Section 3 of Article 3 of the Act establishing the Commission, the Executive Officer is authorized on the advice of the Director to appropriate such funds of the Survey as he thinks wise to the investigation of zoological and botanical problems of the State.

That the Executive Officer is authorized to apportion the funds of the Survey, to approve the appointment of assistants and other employees and to see that the instructions of the Commission are faithfully carried out.

At the same meeting of the Commission the following general instructions were given to the Director of the Survey:

To proceed to ascertain the relations existing between the different rock formations at or near the surface of the earth in Oklahoma and to prepare reports properly illustrated, setting forth these facts.

To answer all reasonable inquiries relative to the mineral resources of the State and prepare reports outlining their distribution.

To collect, name, and arrange a collection of specimens illustrating the geology and mineral resources of the State.

To assist the colleges and high schools in making collections of geological and mineralogical specimens.

To disseminate, as widely as possible, particularly by correspondence and public addresses, correct ideas as to the occurrence, origin, and relation of rocks, minerals and ores.

To answer all reasonable inquiries relative to the mineral resources of the State.

To examine, upon petition of fifty freeholders, properly certified by the county clerk, lands upon which valuable mineral resources may be thought to exist.

To analyze free of cost, such specimens as in the opinion of the Director, may be thought to contain valuable minerals or which would further the work of the Survey.

To prepare a schedule of prices to be charged by the chemist of the Survey for analysis made of such material, as is not analyzed on the authority of the Director.

To cooperate with the United States Geological Survey, other bureaus of the United States Government, and other State Surveys, whenever benefit will accrue to the State.

The Director was also given special instructions as follows:

Begin immediately to investigate the location and accessibility of various building stones of the State, including limestone, marble, sandstone, granite, gabbro, gypsum, and porphyry, with pressure tests to determine the availability of all this stone for the construction of public buildings.

Begin immediately to investigate the location and availability of all stone, clay and other minerals of the State, suitable for the construction of roads, with ample tests to determine the relative value of the different materials in the construction of roads.

Begin immediately to investigate as fully as possible the oil and gas fields of Oklahoma. Also to prepare and present to the Commission, reports fully illustrated setting forth the facts relating to these subjects.

APPROPRIATIONS

FOR 1908 AND 1909.

The first Legislature provided for the Geological Survey in Section 8, Senate Bill No. 75, as follows:

"Section 8. The sum of fifteen thousand ($15,000) dollars or so much thereof as may be necessary, is hereby appropriated out of the funds in the State Treasury, not otherwise appropriated, to provide for the payment of actual expenses of the Commission, and for other epenses authorized by them, and for the salaries or other compensation of the director, assistants or other employees."

FOR 1910 AND 1911.

The second Legislature, which met in 1909, passed the following bill providing funds for the maintenance of the Survey until June 30th, 1911:

Senate Bill No. 318.

An Act

Making an appropriation to pay the expenses of the Oklahoma Geological Survey, for the fiscal years ending June 30th, 1910, and June 30th, 1911, Be it enacted by the people of the State of Oklahoma:

Section 1. That there is hereby appropriated out of any money in the State treasury, not otherwise appropriated, the sum of thirty-four thousand six hundred fifty dollars ($34,650.00), or so much thereof as may be necessary to pay the expenses of the Oklahoma Geological Survey for the fiscal years ending June 30, 1910. and June 30, 1911, and the State Auditor shall issue warrants upon the State Treasurer for such portion thereof as may be found to be due upon the auditing of the respective claims in favor of the persons to whom such claims are allowed. Provided, that all claims and accounts against the State shall be itemized and sworn to as

true and correct, and shall bear the approval of the Director of the Oklahoma Geological Survey, before being audited.

Section 2. The appropriation for the Oklahoma Geological Survey shall be apportioned as follows:

Salaries	For the fiscal June 30, 1910;	year ending June 30, 1911.
Director	$2,500.00	$2,500.00
Assistant director	1,500.00	1,500.00
Chemist	1,200.00	1,200.00
Draftsman	900.00	900.00
Two stenographers	1,200.00	1,200.00
Laborer	480.00	480.00
	$7,780.00	$7,780.00
Office and incidental expenses		
Commission expense	$ 100.00	$ 100.00
Stationery, blanks and note books	225.00	225.00
Filing cases	125.00	125.00
Postage	300.00	300.00
Express	75.00	75.00
Freight	200.00	200.00
Chemicals and reagents	300.00	400.00
Testing road material	225.00	250.00
Photography	250.00	200.00
Lithographic work	350.00	300.00
Scientific apparatus	350.00	450.00
Typewriter	90.00	
Travelling expenses for director and assistant	800.00	800.00
Total	$3,390.00	$3,425.00

Special investigations for gold, silver, copper, lead, zinc, and other metals, $4,000.00 per annum.

Printing reports	For the fiscal June 30, 1910;	year ending June 30, 1911.
Bulletin No. 5, mineral resources of the Arbuckle Mountains	$ 450.00	
Bulletin No. 6, preliminary report on coal	600.00	
Bulletin No. 7, preliminary report on asphalt	525.00	
Bulletin No. 8, preliminary report on Portland cement rock	500.00	
Bulletin No. 9, report on lead and zinc		$ 450.00
Bulletin No. 10, report on clay and shale		650.00
Bulletin No. 11, report on gypsum		425.00
Bulletin No. 12, report on salt		375.00
Director's biennial report		300.00
	$2,075.00	$2,200.00
	$17,245.00	$17,405.00
Grand total		$34,650.00

Approved except as to "Special investigations gold and etc., $4,000 per annum," which $8,000 is disapproved.

C. N. HASKELL, Governor.

FOR 1912 AND 1913.

Provision for maintenance of the Survey for 1912 and 1913 was made in the General Appropriation Bill.

Senate Bill No. 517.

An Act

Making general appropriations for the expenses of the Executive, Legislative and Judicial Departments of the State, and for the interest on the public debt, for the fiscal years ending June 30th, 1912, and June 30th, 1913.

Geological Survey

	For the fiscal June 30, 1912.	year ending June 30, 1913.
Office and incidental expenses	$ 3,000.00	$ 3,000.00
Printing	2,400.00	2,400.00
Field work	3,000.00	3,000.00
Cooperative work with U. S. Geological Survey and other Federal bureaus	3,000.00	3,000.00
Salary of director	2,500.00	2,500.00
Salary of assistant director	1,500.00	1,500.00
Salary of chemist	1,200.00	1,200.00
Salary of clerk	480.00	480.00
Salary of two stenographers	1,200.00	1,200.00
Salary of laborer	600.00	600.00
Total	$18,800.00	$18,800.00

Approved March 25, 1911.

LEE CRUCE, Governor of the State of Oklahoma.

FOR 1914 AND 1915.

Provision for maintenance of the Survey for 1914 and 1915 was made in the General Appropriation Bill.

House Bill No. 117

An Act

Making general appropriations for the expenses of the Executive, Legislative and Judicial Departments of the State, and for the

interest on the public debt, for the fiscal years ending June 30th, 1914, and June 30th, 1915.

Geological Survey.

	For the fiscal year ending June 30, 1914.	June 30, 1915.
Office and incidental expenses	$ 2,000.00	$ 2,000.00
Printing	2,000.00	2,000.00
Field work	3,000.00	3,000.00
Salary of clerk and stenographer	1,680.00	1,680.00
Cooperative work	3,000.00	3,000.00
Salary of director	2,500.00	2,500.00
Salary of assistant director	1,500.00	1,500.00
Salary of chemist	1,200.00	1,200.00
Field geologist	1,800.00	1,800.00
Salary of laborer	600.00	600.00
Salary of draftsman	1,200.00	1,200.00
Educational work	1,000.00	1,000.00
Contingent expenses, postage, telephone and telegraph, freight, and express	3,000.00	3,000.00
Total	$24,480.00	$24,480.00

Approved July 3rd, 1913.

LEE CRUCE, Governor of the State of Oklahoma.

EXPENDITURES.

The people of the State maintain the work of the Survey and should, therefore, know what disposition is made of the funds appropriated to carry on this work. In this report it will be impossible to give an itemized statement of disbursements. The total amount of money appropriated for the work of the Survey and the general allotment of such appropriation is given in the preceding pages of this report. The general discussion concerning the field work and publications of the Survey will give a fair idea concerning the expenditures. In previous years it has been the custom to file with each member of the Commission an itemized account of the expenditures, but this year, in order to comply with the requirements of a bill passed by the last Legislature, a special, carefully itemized report, voluminous in size, was prepared and a copy filed with the President of the University, another with the Superintendent of Public Instruction, and three copies with the Governor of the State. The three copies filed with the Governor are required in order that he may have a copy for his own use and a copy for the use of each House of the Legislature when it convenes in January. The bill requiring reports to be filed in this manner is found in Senate Bill No. 301, Section 1, Chapter 119, Session Laws of 1913. The section is as follows:

Section 1. The head of each department of the State or of any public institution thereof, shall make a report to the Governor, at the close of each fiscal year, giving a detailed statement of the manner in which all contingent or special funds of his department, or public institution, has been expended, giving the names of every person to whom any portion thereof has been paid; and, if for anything furnished, the quantity and price; and, if for any service rendered, the nature of such service and the time employed, and the particular occasion or cause, in brief, that rendered such necessary, and the amount of all former appropriations in each case on hand or in the Treasury; and he shall be required to return a precise and analytical statement and receipts, or copies thereof, for all moneys which have been expended by him or under his direction.

The preparation of these reports to meet the requirements of the above law cost the Geological Survey about $250.00.

PERSONNEL OF STAFF.

The personnel of the staff of the Survey from the time of its organization to the present is as follows:

Director, Chas. N. Gould, July 25, 1908, to October 7, 1911; D. W. Ohern, October 7, 1911, to January 1, 1914; C. W. Shannon, January 1, 1914, to the present.

Assistant Director, L. L. Hutchison, September 1, 1908, to November 11, 1910; L. C. Snider, November 11, 1910, to the present.

Field Geologist, C. W. Shannon, September 6, 1911, to January 1, 1914; L. E. Trout, January 1, 1914, to the present.

Chemist, L. C. Snider, July 1, 1909, to November 11, 1910; Frank Buttram, November 11, 1911, to December 1, 1913; W. A. Buttram, December 1, 1913, to September 1, 1914; Fritz Aurin, September 1, 1914, to the present.

Draftsmen, Frank Gahrtz, Leo Gorton, and Leon Asbury have served intermittently since the organization of the Survey, and Frank Gahrtz continuously since July 1, 1913.

Assistant Geologists, D. W. Ohern, Chas. H. Taylor, Chester A. Reeds, J. W. Beede, and B. F. Wallis have served as heads of State parties doing geological work.

Chief Clerk, Miss Louise S. Taylor, August 1, 1911, to February 1, 1913; M. A. Cox, February 1, 1913, to August 1, 1913; Miss Charlie Nickle, August 1, 1913, to the present.

Field Assistants: 1908 to 1912, Pierce Larkin, Frank A. Herald, C. C. Clark, H. A. Everest, Key Wolf, John Bennett, W. J. Cross, E. L. DeGolyer, T. R. Corr, Ben C. Belt, E. Z. Carpenter, H. G. Powell, W. J. Hazeltine, J. C. Thompson, T. F. Eyerly, C. W. Hamilton, Lloyd Maxwell, A. C. Reeds, Robt. H. Wood, John Herald, J. B. Newby, Fred Capshaw, John A. Newby, Glenn C.

Clark, Robt. E. Garrett, M. L. McCance, B. H. West, Harve Loomis, Geo. H. Myers, L. E. Trout, Irving Perrine, and Burr McWhirt have done service in the field.

During 1913 the following men were employed as field assistants on the Survey: Chas. H. Taylor, Frank Buttram, J. B. Newby, J. W. Beede. Robt. E. Garrett, Geo. H. Burress, Wm. A. Buttram, Glenn C. Clark, Sam Hodgson, George Morgan, and Harve Loomis.

G. W. Stevens, of Alva, Oklahoma, assisted by D. C. Brooks and R. W. Chestnut carried on field work concerning the flowering plants of the State. Leo Gorton and Leon Asbury served as assistant draftsmen and office helpers.

In the cooperative work field investigations were carried on by C. H. Wegemann, M. J. Munn, R. W. Howell, A. E. Fath, and Robt. H. Wood, of the United States Geological Survey, and Charles C. Turnbull and E. C. Parker as State assistants.

During the field season of 1914 the following men were employed: C. A. Reeds, B. F. Wallis, W. A. Buttram, Geo. D. Morgan, C. Z. Logan, C. E. Hyde, Carl Clarke, Don Walker, L. B. Snider, E. V. Woolsey, C. R. Thomas, Dean Stacy, L. G. Hurst, J. D. Watson, Robert Goodrich, Geo. H. Myers, Harve Loomis, and Burr McWhirt.

Rayburn Foster and Sam Hodgson were employed as stenographers and office helpers.

Ed Crabb has been employed as ornithologist from October 1, 1913, to the present.

The cooperative work in the State has been in charge of C. H. Wegemann, A. E. Fath, R. W. Howell, Robt H. Wood, and W. B. Emery. Dr. Stuart Weller, of Chicago University, was employed for a few days to give expert service in regard to certain problems concerning the Mississippian area in northeastern Oklahoma.

OFFICES.

The Law creating the Survey provides that:

Until suitable laboratories, libraries and testing apparatus are provided by the State for prosecuting the work of the Survey, said Survey shall be located at the State University. The Commission shall enter into arrangements with the Board of Regents of the State University, for the use, by members of the staff of the Survey, of such rooms, laboratories, libraries, and apparatus as may be necessary for the carrying on of such work.

At present the Survey has quarters in the basement of the Carnegie Library building at the University. The space occupied consists of the Director's office, general office and library, drafting room, and three small offices for the other members of the staff. The chemical laboratory is crowded into two small rooms in one of the

temporary frame buildings on the campus. The office and workshop of the ornithologist are in these same rooms. Some of the supplies and field outfits are stored partly in another frame building, others under the bleachers on the athletic field, and still others at various places about Norman. The museum is in the basement of Monnet Hall, and is in combination with the Historical Society exhibit.

The work of the Survey is seriously handicapped by lack of adequate facilities, especially laboratories and storage rooms. This inadequacy causes much loss of time and detriment to property. The University cannot spare more room for the work of the Survey. A new and separate building is needed on the campus of the University for the work of the Oklahoma Geological Survey. Offices, laboratories, storage rooms, and museum should be included in the one building.

WORK OF THE SURVEY.

FIELD WORK.

Since the establishment of the Survey in 1908, field investigations have been carried on practically without interruption. The work of the Survey from 1908 to 1912 has been included in the biennial reports for 1908, 1910, and 1912.

WORK OF 1913.

A large amount of field work was carried on during 1913, although the work for the first part of the year was much handicapped because the Legislature did not pass the appropriation bill until late in June, and the amount of funds which would be available after July 1st. was not known, hence no definite plans for work could be undertaken until after this date.

Early in the year, C. W. Shannon, then Field Geologist, continued his investigations in the coal fields of the State. This work was begun in 1911. The report dealing with the results of this field work is discussed in the following pages under the heading of "Coal."

During the latter half of the year the Field Geologist gave his attention to a study of the geology and structure of southwestern Oklahoma, especially in the region about the Wheeler and Healdton oil fields and south to Red River. The Director of the Survey did a little reconnaissance work in this region early in the summer. Late in August the first well in the Healdton field was brought in, and much interest centered about that locality. Field work was begun in this part of the State in order to assist in the determination of geologic structure, and the finding of new localities which might prove good territory from an oil and gas standpoint. After some preliminary investigations in the area, it was found that there were many perplexing problems concerning the geology of the region.

which would require much time to work out. But because of the important bearing of these geological problems it was decided best to continue the field work from that point of view. Consequently the work was continued until about the first of the year. Conditions were found which have prevented the completion and publication of the results of these investigations. However, much of the data secured have been used in the working out of preliminary reports and the correlation of geologic information. It is planned to do additional field work in this region again during the present winter. Several geologists, including three or four from the United States Geological Survey, have done work in this area since the beginning of the work, and the data collected by all will be available for the State's use. The principal trend of the work is toward the differentiation of the geological formations of different ages, as they occur in this part of the State.

L. C. Snider, Assistant Director, was in charge of a party of four doing field work in east central Oklahoma. The work had to do principally with the geology of that part of the State, but was done with special reference to the occurrence of oil and gas. The work consisted almost entirely of the determining of the structure, special attention being paid to the location of anticlines. The results of this investigation were published in Bulletin No. 17.

Frank Buttram, assisted by Frank Gahrtz and George Burress, did detailed work in the Cushing oil field and adjacent territory. The work concerned the geology, structure, development, and production. Four months were spent in the field by the party, and since that time one or two men have spent much time in the field and a very large amount of office work has been done in compiling maps and preparing manuscript for publication. The publication is just now completed and is known as Bulletin No. 18.

Cooperative work was carried on in the vicinity of Waurika and Loco. The work was in charge of Carrol H. Wegemann and Ralph W. Howell. This work was general reconnaisance work, and a brief bulletin prepared by the United States Geological Survey will soon be available upon the work done by this party.

Robt. H. Wood completed the field work for folio publication of the Hominy quadrangle. The folio is now being prepared at Washington and will be available within the near future.

Topographic work was done in the Foraker quadrangle in northeastern Oklahoma. The field work for the primary control was completed early in 1914.

WORK FOR 1914.

In 1914 several parties were in the field during the regular field season. The Director having oversight of all parties in the field,

and a large amount of office work in connection with the preparation of various publications, did not pursue independently any particular phase of geological work.

L. C. Snider with George Morgan and Thomas Jackson as assistants, continued field work in northern Oklahoma in the Mississippian area. The work was begun in 1910 and has been pursued at irregular intervals each year since. The field work was completed in September, 1914, and work is now being done on the preparation of the manuscript. The report will deal with the general geology, paleontology, and economic value of the Mississippian rocks.

B. F. Wallis, a graduate student of Johns Hopkins, was placed in charge of a party of four to make a detailed study of the Wapanucka limestone and associated formations. The Wapanucka includes our most valuable building limestone, known as the Bromide oolitic limestone, and other parts offer excellent material for the burning of lime and the manufacture of Portland cement. The work was begun in the vicinity of Wapanucka and carried along the outcrop of this formation running in a curved line to the north and east about parallel with the Choctaw fault to the Arkansas line. This piece of work produced some very gratifying results. The published report will deal with the general geology, paleontology, and economic values.

L. E. Trout, Field Geologist, with Harve Loomis and Robert Goodrich as assistants, has been carrying on detailed geologic and structural work in the vicinity of Blackwell. Some field work is yet necessary in order to determine the exact structural conditions existing there. Considerable gas and some oil have been found in the region, and it is hoped that the results of the investigation will lead to much further discovery of these minerals in paying quantities. The surface conditions in this area are such that very careful detailed work is necessary in order to work out any structure which may be present. Alidade levels are being made on all outcrops of the rock formations taken as key rocks and the structure will be mapped from the data thus secured.

E. V. Woolsey and L. G. Hurst made a preliminary survey of the Canadian River from the Norman bridge to the Texas line. This work consisted in making special investigations concerning flood conditions, damages by floods, changes in stream, character of surface and underground water, depth to water table, and general conditions concerning the use of the water in the region for irrigation and domestic purposes. This piece of work proved very satisfactory and arrangements are being made to continue the work next season, thus covering as many of the drainage lines of the State as possible before the printed report is prepared.

W. A. Buttram and Dean M. Stacy made special investigations in the oil fields of the State. The work consisted in gathering statistical data, the initial production and character of wells, thickness and character of oil sands, correlation of sands, waste of oil and gas, refineries and pipe lines, and much other general information which will be of the highest value in the preparation of reports. Much of the statistical data included in this publication concerning oil and gas was compiled by Stacy from the material which was collected while the men were in the field.

In addition to the valuable help in the preparation of bulletins on oil and gas, the data will be most valuable in answering the numerous inquiries which are made concerning various phases of oil and gas industry of the State.

The American Museum of Natural History of New York City and the Geological Survey did cooperative work in the Arbuckle Mountains. A party of 4 was in charge of C. A. Reeds, Assistant Curator of the Museum. A special study was made of the Hunton, one of the principal formations in the Arbuckle Mountains. The work consisted in mapping the formation and making a detailed study of the paleontology and economic geology. The Survey paid the salaries of the assistants and the expenses of the entire party. Reeds' salary and expenses outside the State were paid by the Museum. The total cost to the State was about $600. The report will be prepared and printed in New York. This work will cost about $2,500. The State may secure as many copies of the report as needed for its use for the actual cost of printing. In addition to the publications, the Museum will furnish a carefully labeled duplicate set of all fossil forms and rock samples from the collection made and several hundred species of fossils from other localities. A number of valuable scientific books will also be given to the Survey to aid in building up its library, the only charges being for transportation.

EDUCATIONAL WORK.

Various phases of educational work come within the scope of the work of the Geological Survey of the State. The Survey originated as a Geological and Biological Survey of Oklahoma Territory. In the regular duties the members of the Survey secure a large amount of material and information concerning the natural resources of the State. This information is given to the citizens of the State through articles in the newspapers and by the publication of circulars and bulletins.

A study of the trees and shrubs of Oklahoma was begun in 1912, and has been continued to the present. A preliminary circular was issued giving the names of trees and shrubs found in the State, and the localities where they were known to occur. A large amount of data has been secured and it is planned to publish a complete

report with photographs and detailed descriptions of all species found. Specimens of all the plants listed are secured for a herbarium, which will be used as a checking list in the preparation of a report. In the preliminary circular issued there are probably a number of errors, and any additions, corrections, or suggestions which will be of value for the final report will be gladly received. It is of special importance that a careful study be made of our native trees, both from a scientific and economic point. The information so far collected has been secured while carrying on the regular field duties, and without additional cost to the State.

A bulletin is being prepared on the flowering plants of the State. Field work has been in progress for more than two years and most of the State has been covered in collecting material for this report.

Another line of work is the study of the birds of the State. Special investigating and collecting have been carried on in practically every county in the State, and the report is now being prepared for publication. The bulletin will be of much value in showing the economic value of bird life. It will be especially adapted for the general public and for use in the schools of the State.

Other Special bulletins will include reports on Oklahoma minerals, Oklahoma physiography, and related subjects. A new sectionized State map 27 by 50½ inches has been published and other maps of special educational value have been printed.

HIGH SCHOOL COLLECTIONS.

The Survey prepares sets of Oklahoma minerals which are representative of the mineral resources of the State. These collections contain about 60 different specimens properly labeled and are furnished to high schools, private schools, normals, and colleges which request such for use in connection with geography and physical geography work. The only cost to the school is the transportation charges. The weight of the shipment is usually less than 100 pounds. Complete sets of all bulletins and maps published by the Survey are included, as well as other publications and helps which the Survey is able to secure which may prove valuable as helps to teachers in their science work. These sets of minerals and publications have been furnished to a large number of schools. Numerous requests are being received this year and special attention is given to the preparation of the sets to make them of the highest value possible.

PUBLIC LECTURES.

The members of the Survey staff have given lectures before commercial clubs, public schools, normal schools, and other institutions of the State, and before popular audiences. This work is re-

garded as educational. The people of the State are very desirous of knowing of the mineral resources and the lectures have been well received. Commercial clubs and other business and industrial organizations are anxious to know where they can obtain printed information about the resources of the State, and where attempts are being made to bring about development, talks before such clubs give an idea of the value of the resources considered.

It is hoped that in the future more attention can be given to this plan of disseminating knowledge over the State concerning the mineral resources. Every effort will be made to assist organizations in securing information concerning the State, which will be of value in the securing of industrial enterprises to bring about development of the natural materials.

PUBLIC ROADS.

The Survey is devoting special attention to the study of road materials of the State. Very little road improvement has been done, but the time is not far distant when there will be an enormous demand for good road material that is easily accessible in the various parts of the State. A report has been issued on "Road Materials," but this deals only in a preliminary way with the subject, and special investigations are being continued.

Realizing that the advancement of our State depends in a large measure on the building of good roads, the Survey desires to assist in every way possible in finding of suitable material. The direction of the building of good roads does not belong to the Geological Survey. Considerable agitation has been made toward the passing of road laws and the establishing of a public road commission. The aim has been to include this work either directly or indirectly under the Geological Survey. This phase of the work belongs to a separate department and should not be connected with the Survey, which has for its prime purpose the investigation and development of the natural resources. The Survey, however, is willing to serve as a cooperative organization in every way possible in the work of road improvement.

STATE FAIR EXHIBIT.

The Geological Survey has charge each year of a special exhibit of the mineral resources of the State at the State Fair at Oklahoma City. A building 50x100 feet is devoted exclusively to this exhibit. In 1908 and 1909 the mineral display occupied a small corner in the second story of the main exposition hall. In 1910 it was given half the space of the present building, and since 1911 the entire building has been filled to capacity.

It is the purpose of this exhibit to bring before the people of the State a creditable display of all the mineral resources. Few people realize the value of our minerals and mineral products. The

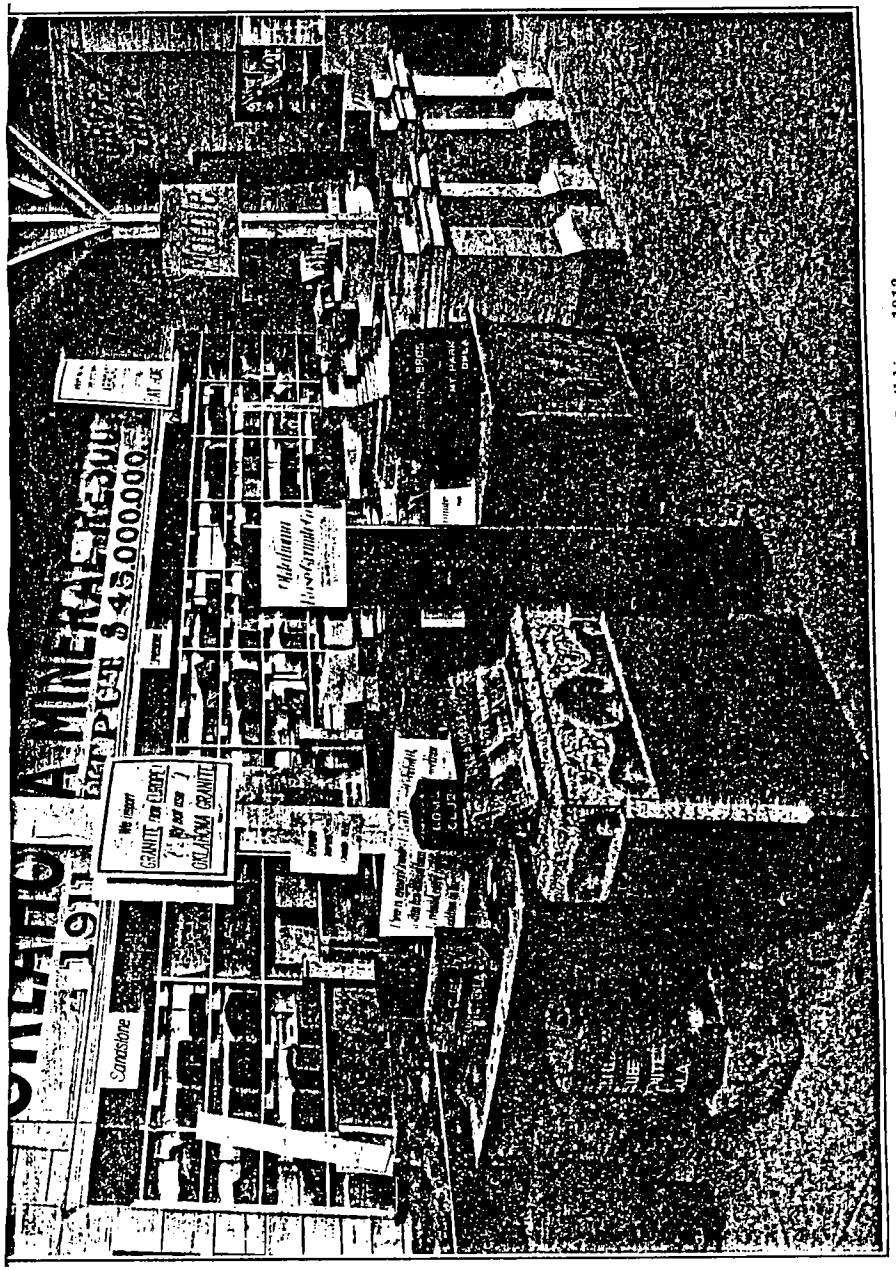
View in miscellaneous exhibit in Mineral Building, 1913.

State has no general museum which can be visited by the people of the State, and the exhibits in the Mineral Building are therefore of special interest. From 2,000 to 20,000 people visit the building each day of the Fair, and hundreds spend much time in the examination and study of the minerals displayed.

Each year one of the regular members of the Survey staff is in direct charge of the exhibit. He is assisted by other members in part, but largely by the field assistants and advanced students from the department of Geology in the State University. These men are in the building to answer the questions of interested persons and to give to visitors from outside the State, and to our own citizens as much information as possible.

The mineral exhibit has for its primary motive the display of samples of each and every kind of Oklahoma minerals. In many cases the display is carried one step further. That is, some of the manufactured products are exhibited along with the raw material. In each case labels and printed descriptions give some idea as to locality, amount, and possibilities for future development. The State Geological Survey has for its object the exploration, exploitation, and development of our mineral resources. This can best be accomplished where the people have been educated to an understanding of the value and extent of the minerals of our State. In a new state like Oklahoma we must generally look elsewhere for funds for development. Each year hundreds and thousands of men from the east come to the western states in search for an opening. It is a natural thing for them to visit the place where most can be seen in the shortest time, so they go to the State Fairs. This is really more true in Oklahoma than elsewhere, as Oklahoma has made a very enviable record since statehood. Many interested persons who visit the mineral exhibit express surprise at the display made, become interested, and are ready to assist in building up new industries, or adding more capital to those which already exist.

Although the idea of bringing outside capital into the State is worthy within itself, it is doubtful if this is the greatest advantage to be derived from such exhibit at the State Fair. Within our State are 800,000 to 1,000,000 school children. Thousands of these children visit the State Fair. Out of curiosity and interest the children are attracted by the various materials which are on display. In arranging the exhibit, those in charge try to have something there from every locality. People are eager to see something from their own community, and such displays stir up great interest and numerous inquiries from both children and grown-ups. High school pupils, especially those who are studying physical geography or physiography, may derive much good from their visits to this building. Teachers make use of the opportunity, to have pupils make special examinations and study of the mineral exhibit, and



View in building stone section of exhibit in Mineral Building, 1913.

the material gathered is of use in the future school room work. Thus the children are educated to a better understanding of our State and its possibilities. A special exhibit known as the model high school collection is prepared by the Survey, and those schools requesting such for their use and insuring proper care of such collection may obtain these without cost, except transportation charges. From these collections and exhibits may be gained a knowledge of the name, occurrence, and character of our common rock, minerals, fossils, and a few of our manufactured products.

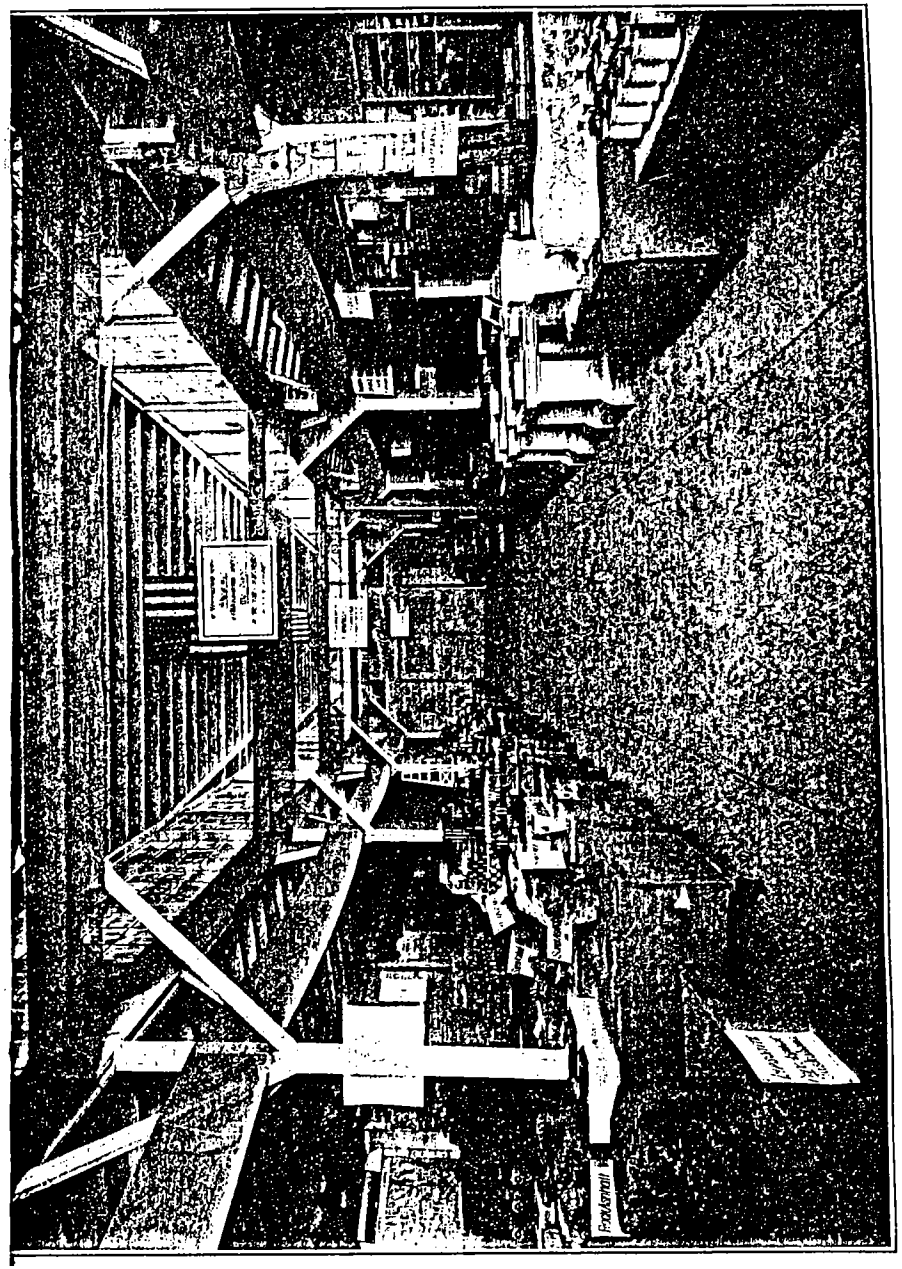
The State Geological Survey is continually making investigation of new deposits of minerals, and several bulletins, circulars, and maps are issued each year covering the results of the field investigation. Hundreds of people know nothing of the Geological Survey and the printed material which may be secured, until they visit the State Fair mineral exhibit. As an educational and commercial means of reaching thousands of people within and without the State the Survey exhibit stands on its own merits.

COOPERATIVE WORK.

The Geological Commission instructed the Survey to cooperate with the United States Geological Survey, other bureaus of the United States Government, and State Surveys wherever benefits will accrue to the State.

Cooperative work was begun between the United States Geological Survey and the Oklahoma Geological Survey in 1909. The first cooperation was in the mapping of the geology in the Pawhuska quadrangle. This work was in charge of Carl D. Smith of the Federal Survey, assisted by the field men of the State Survey. During the field season of 1909-10 D. W. Ohern and party made a geologic map of the Nowata quadrangle. In 1910, $1,500 was allotted to this work. The Federal Department assisted in the matter of testing road materials to approximately $500, and in the testing of Oklahoma clays under the direction of L. C. Snider at the Pittsburg plant. It was estimated that the amount of cooperation furnished by the Government Survey amounted to $1,500.

Since 1911, $3,000 of the geological appropriation has been available each year for cooperative work with the United States Geological Survey. This work is discussed somewhat in detail since so few of our citizens understand the exact nature of cooperative work. In this work the State Survey and Federal Survey share equally in the expenses for work to be done. That is, if $3,000 be allotted to cooperative work in the State the Federal Survey will give an equal amount to carry on the particular piece of work for which the allotment was made. In addition to this, the Federal Survey engraves and publishes the maps and prints the report without additional charge to the State. In many cases the Federal Survey has contributed much more than the sum allotted by the State.



General view of exhibit in Mineral Building 1914.

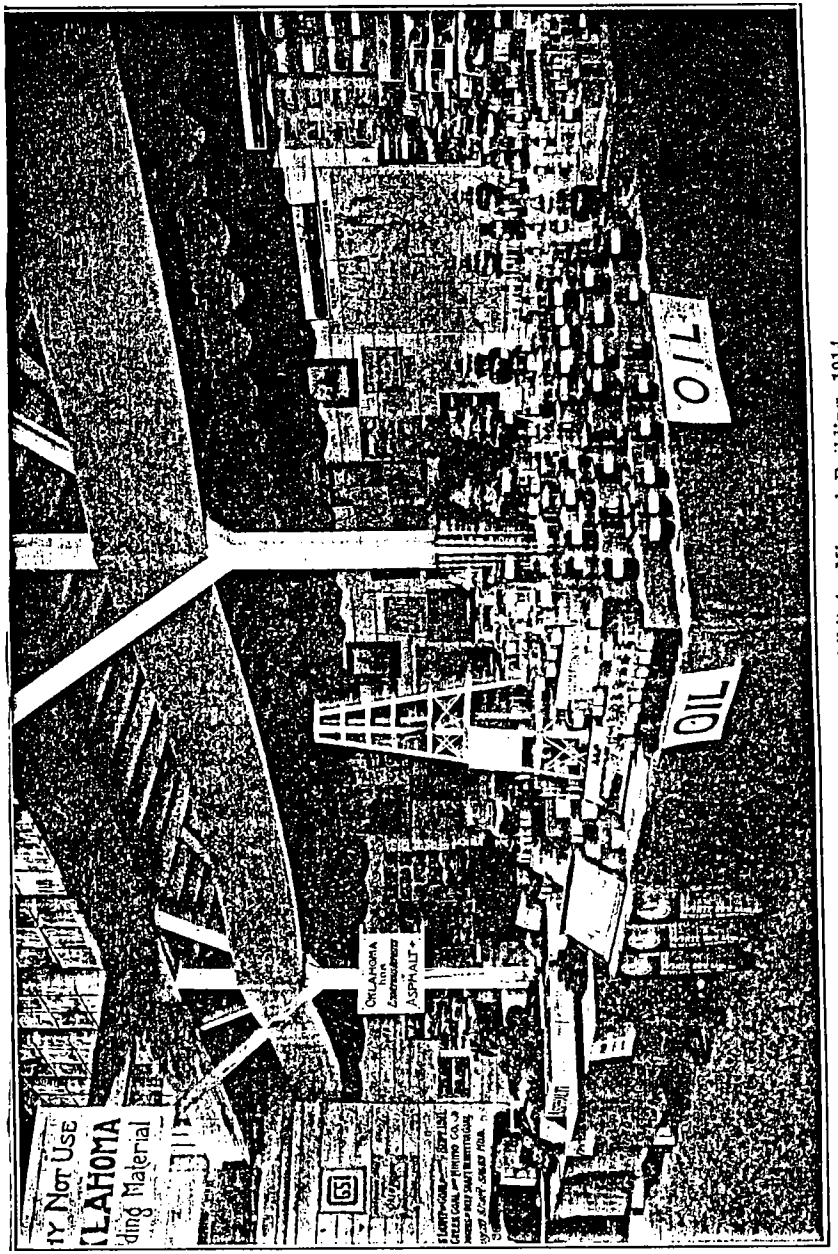
In addition to the cooperative work the United States Geological Survey has done a vast amount of independent work in the State. Several years ago a geologic survey was made of a considerable area of the coal region in the eastern part of the State. The publication of the reports on this work have been unavoidably delayed. These reports are now being pushed to completion and will be issued at an early date.

Under cooperative agreement topographic sheets have been made of the Nowata, Vinita, Claremore, and Hominy quadrangles. The field work on topographic survey has been completed for Foraker quadrangle. In the first four named general areal and structural work has been done and the manuscript and maps have been prepared for publication. Preliminary bulletins dealing with the geology and economic phases will be published on each area in advance of the complete geologic folio, which will be published, including the topographic and geologic maps. Topographic sheets of the first three named are now available, and that of the Hominy quadrangle will be available soon, the advance sheets having been issued. These quadrangles lie in the oil region of the State. Accurate topographic maps are essential for working out the geological and structural features of oil and gas fields.

In 1911, $1,000, one-third of the cooperative fund was allotted to topographic work. By agreement the Federal Survey was to give a like amount, but in this particular case contributed three or four times as much as the original allotment. The remaining $2,000 was allotted for geologic work. Five hundred dollars was given to the work of C. H. Taylor on the granites of the State. Some small additional allotments have since been made to this work. The report has been prepared and will be published in the near future. As in other cases of cooperative work this bulletin would be published at Washington, but since it is of special economic importance to the State it is possible that arrangements will be made whereby the Geological Survey will publish the report as one of its regular series. Seven hundred and fifty dollars was allotted to D. W. Ohern, then field assistant of the Survey, for work in Vinita quadrangle, and the same amount to Carl D. Smith for work in the Claremore quadrangle.

During 1912, $1,500 of the cooperative fund was allotted to Robt. H. Wood for geologic investigation in the Hominy quadrangle, which is in the vicinity of Cleveland and Tulsa. Five hundred dollars was allotted to cooperative work in Tillman and Cotton counties, under the direction of M. J. Munn of the United States Geological Survey. The remaining $1,000 was used in completing the work of the topographic survey of the Hominy quadrangle.

The field investigations of Munn's party have been published as Bulletin 547, Reconnaissance of Grandfield district. The area



View in fuel section of exhibit in Mineral Building, 1914.

surveyed covers a part of Cotton and Tillman counties, as indicated It deals with the general geological and structural features of the area with special reference to the probable occurrence of oil and gas. Two lithographic maps are included in the report. This is a valuable phase of the Federal Survey work which cannot be accomplished by the State Department on account of insufficient printing funds. The State can print maps only in black and white from ordinary zinc etchings.

In 1913 an additional allotment was made to complete the geological work in the Hominy quadrangle. The work has been completed and the maps and reports are being prepared for publication. The report is to be published as a geologic folio.

Carrol H. Wegemann of the United States Geological Survey was placed in charge of a party to make a reconnaissance survey of the region east of the Grandfield district. This work extends as far east as Waurika and north as far as the northern boundary of the Grandfield area. Additional work was done in the vicinity of Loco and the immediate Healdton field. An allotment of $1,500 was made for this work. The bulletin has been prepared for publication on the first area, and a preliminary report will soon be available concerning the Loco and Healdton areas. Topographic work was begun in the Foraker quadrangle, $1,000 being allotted for this purpose

The cooperative work of 1914 was equally divided between three localities, $1,000 being given to each division. The topographic field work in the Foraker quadrangle was completed and the survey of the Nuyaka quadrangle taken up. The work in central and southwestern Oklahoma was continued under the direction of Wegemann. The area covered extends north from the Grandfield district and that area surveyed by the Wegemann party in 1913, as far north as Lawton and east to include the region about Duncan. Some additional work was done in the vicinity of Loco in order to find if there were structural relationships between the Healdton-Loco-Duncan areas. The results of the investigation will be covered briefly in a press bulletin to be issued in advance of the regular publication.

A. E. Fath and W. B. Emery did reconnaissance work in the Okmulgee and Nuyaka region. Little attention was given to stratigraphy, the principal object being the location and mapping of structure, with special reference to the occurrence of oil and gas. The field work was completed December 15, 1914, and a preliminary report will also be issued on this area in advance of a more complete publication.

In addition to the cooperative work during 1914, the United States Geological Survey made special investigations in the Healdton region during the latter part of the year, and some other preliminary investigations were made in different parts of the State.

The United States Bureau of Mines has been carrying on extensive investigation in the coal and oil fields of the State. This work has resulted in much good to the State. Perhaps the greatest benefit has been in the conservation of the gas supply by the successful capping of strong gas wells, and by the use of a mudding up process in oil wells to prevent the waste of gas while the wells were being completed. Other special investigations are being made. While no definite plan of cooperation has been undertaken by the Bureau of Mines and the State Survey, much of the work has assumed a cooperative character and the exchange of data has materially aided each department. It is hoped that in the future cooperative work may be carried on between these departments, especially in the matter of the conservation of our mineral resources.

Since 1912 the Bureau of Mineral Statistics and the State Survey have cooperated in the gathering of mineral statistics of the State. Much valuable information was derived early in the year by this plan. However, the cooperation has been abandoned for the present for the reason that the Survey did not have sufficient money which it could use for this line of work.

PUBLICATIONS.

The work of the Geological Survey is made known to the public chiefly through the publication and distribution of its printed reports and maps. Only a limited number of the various reports can be published, the number ranging from 1,000 to 3,500 copies. The manner of distribution of such publications cannot be readily solved. The United States Geological Survey distributes most of its publications free to citizens of the United States. Others of its publications are sold at a low cost which covers the expense of printing. There are no transportation charges, Government franks being used. Some of the State Geological Surveys furnish all publications absolutely free to the public, not even requiring postage. Others require postage, and still others find it necessary to sell the publications at a moderate price in order that the work of the Survey may be maintained. The policy of the Oklahoma Geological Survey has been to send publications free to the public and especially to citizens of the State. When a publication is issued, press notices are mailed out to individuals and to all the leading newspapers of the State. In this way a large number of the people of the State learn of the publication, and those interested have an opportunity to secure such reports as long as available. In the notices sent out the amount of postage necessary for the mailing of the report is requested but is not insisted upon.

When any charge is placed upon a publication there are many who will not secure the information. The people of the State pay for this work and should have the benefit of the investigations with-

out further cost. However, on the other hand the amount of postage required for any one publication is so insignificant that the person requesting same does not feel any hesitancy in forwarding mailing charges, and in this manner the funds of the Survey for other purposes are materially increased. Thousands of requests come from people outside the State, and it is largely from such sources that many of our great industrial enterprises and mineral developments have arisen. January 1st, 1914, the mailing list of the Survey was revised and cut to about 800, but at the present time it is about 2,500, and many additional requests for information on the resources of the State are coming in daily.

In addition to the regular form of the printed report press bulletins are issued, newspaper articles are furnished by the different members of the staff concerning the resources of the State, and occasionally articles are sent to mining and mineral journals and magazines.

In the list of publications concerning Oklahoma, given below, are included those published by the Oklahoma Geological Survey, the State University research bulletins, and the theses written by advanced students in the Department of Geology, two copies of each thesis being placed in the University Library, and those of the United States Geological Survey.

A bibliography of all publications concerning Oklahoma is being prepared and will be published in the near future.

PUBLICATIONS OF THE OKLAHOMA GEOLOGICAL SURVEY.

BULLETINS.

Preliminary report on the mineral resources of Oklahoma, by Chas. N. Gould, L. L. Hutchison, and Gaylord Nelson: Bull. Okla. Geol. Survey No. 1, 1908, 80 pp., (Edition Exhausted.)

Preliminary report on the rock asphalt, asphaltite, petroleum, and natural gas in Oklahoma, by L. L. Hutchison: Bull. Okla. Geol. Survey No. 2, 1911, 256 pp., 13 pls. (Edition exhausted.)

A report on the geological and mineral resources of the Arbuckle Mountains, Oklahoma, by Chester A. Reeds: Bull. Okla. Geol. Survey No. 3, 1910, 69 pp., 24 pls. (Edition exhausted.)

Coal of Oklahoma: Bull. No. 4, replaced by Bull. Okla. Geol. Survey No. —, now in press. Postage 25 cents.

Preliminary report on the structural materials of Oklahoma, by Chas. N. Gould: Bull. Okla. Geol. Survey No. 5, 1911, 182 pp. Postage 6 cents.

Director's biennial report to the Governor of Oklahoma, 1910, with brief chapters on Oklahoma's mineral resources, by Chas. N. Gould: Bull. Okla. Geol. Survey No. 6, 1910, pts. I and II, 96 pp. Postage 3 cents.

Preliminary report on the clays and clay industries of Oklahoma, by L. C. Snider: Bull. Okla. Geol. Survey No. 7, 1911, 270 pp., 11 pls. Postage 10 cents.

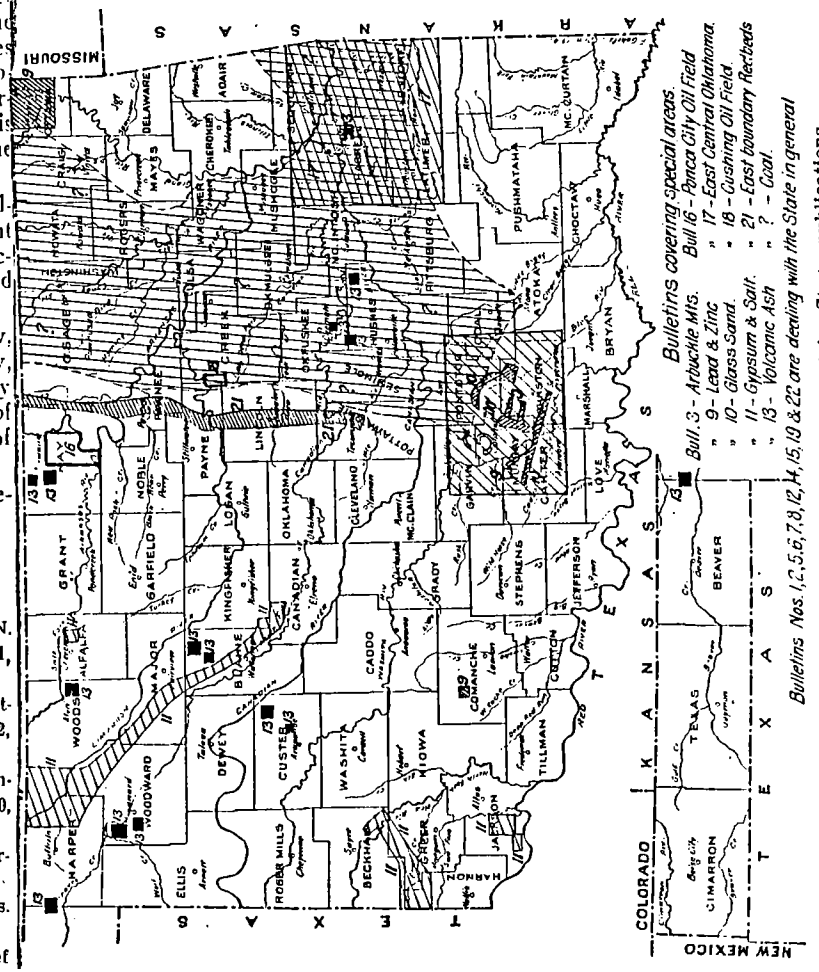


Figure 1. Map of Oklahoma showing area covered by State publications.

Preliminary report on the road materials and road conditions of Oklahoma, by L. C. Snider: Bull. Okla. Geol. Survey No. 8, 1911, 190 pp., 3 p. Postage 7 cents.

Preliminary report on the lead and zinc of Oklahoma, by L. C. Snider: Bull. Okla. Geol. Survey No. 9, 1912, 97 pp. Postage 4 cents.

The glass sands of Oklahoma, by Frank Buttram: Bull. Okla. Geol. Survey No. 10, 1913, 91 pp., 8 pls. Postage 4 cents.

The gypsum and salt of Oklahoma, by L. C. Snider: Bull. Okla. Geol. Survey No. 11, 1913, 214 pp. Postage 9 cents.

Mineral waters in Oklahoma, by C. W. Shannon: Bull. Okla. Geol. Survey No. 12 (In preparation). Postage 6 cents.

Volcanic ash in Oklahoma, by Frank Buttram: Bull. Okla. Geol. Survey No. 13, 1914. Postage 6 cents.

Asphalt in Oklahoma, by C. W. Shannon: Bull. Okla. Geol. Survey No. 14, (In preparation). Postage 7 cents.

Director's biennial report to the Governor of Oklahoma, 1912, with mineral production of Oklahoma from 1901 to 1911, as pt. II, by D. W. Ohern: Bull. Okla. Geol. Survey No. 15, 1912, 47 pp. Postage 3 cents.

The Ponca City oil and gas field, by D. W. Ohern and Robt. E. Garrett: Bull. Okla. Geol. Survey No. 16, 1912, 30 pp. Postage 2 cents.

Geology of east central Oklahoma, by L. C. Snider: Bull. Okla. Geol. Survey No. 17, 1914, 25 pp., 2 pls. Postage 3 cents.

Report on Cushing oil field, by Frank Buttram: Bull. Okla. Geol. Survey No. 18, 1924, 110 pp., 1 fig., 12 pls. Postage 10 cents.

Petroleum and natural gas in Oklahoma, by C. W. Shannon and L. F. Trout: Bull. Okla. Geol. Survey No. 19, 1914. Postage 10 cents.

The Neva limestone in northern Oklahoma with remarks upon the correlation of the vertebrate fossil beds of the State, by J. W. Beede: Bull. Okla. Geol. Survey No. 21, 1914, 37 pp., 8 pls., 3 figs. This bulletin also contains a discussion of the eastern outcrop of the Permian Redbeds in Oklahoma, and of the color and color changes. Postage 5 cents.

Director's biennial report for 1913-1914, by C. W. Shannon: Bull. Okla. Geol. Survey No. 22, 1915. Postage 5 cents.

Coal and coal mining in Oklahoma, by C. W. Shannon: Bull. Okla. Geol. Survey No. —, 1915 (In press.) Postage 25 cents.

CIRCULARS.

Origin, scope, and purpose of the Oklahoma Geological Survey, by Chas. N. Gould: Cir. Okla. Geol. Survey No. 1. (Edition exhausted.)

Brief statement of the geological history of Oklahoma, by Chas. N. Gould: Cir. Okla. Geol. Survey No. 2, 1911. Postage 1 cent.

Oklahoma among the southern states, by Chas. N. Gould: Cir. Okla. Geol. Survey No. 3, 1911. Postage 1 cent.

The trees and shrubs of Oklahoma, by C. W. Shannon: Cir. Okla. Geol. Survey No. 4, 1913. Postage 2 cents.

Rock asphalts of Oklahoma and their use in paving, by L. C. Snider: Cir. Okla. Geol. Survey No. 5, 1913. Postage 2 cents.

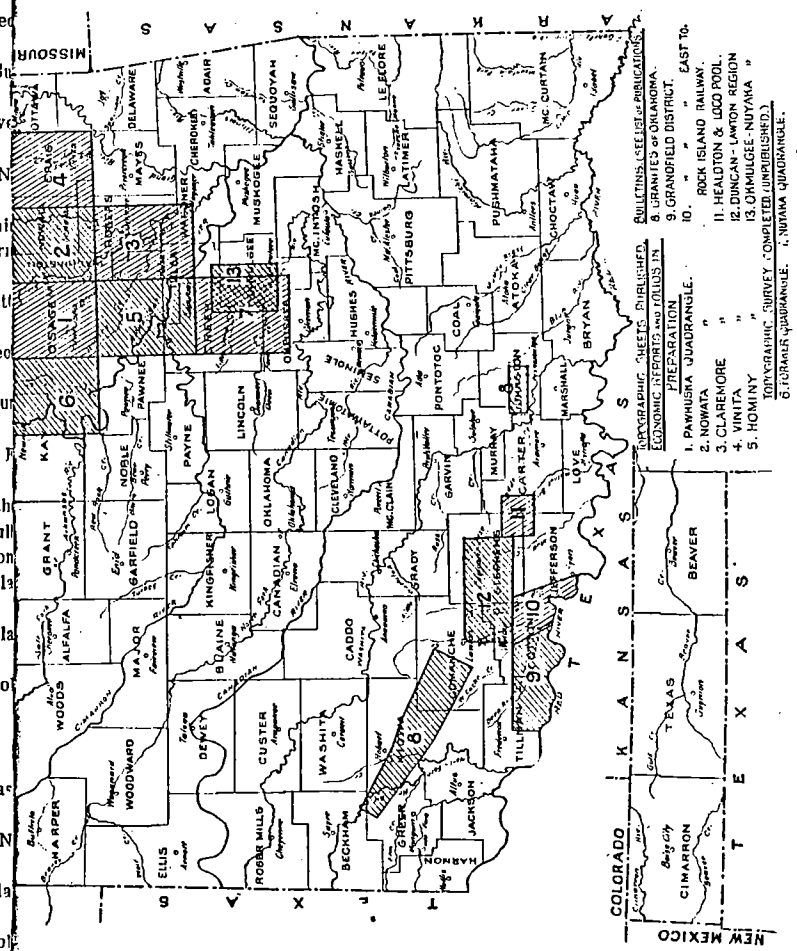


Figure 2. Map of Oklahoma showing area covered by cooperative work.

BOOKLET.

Resources of Oklahoma in a pocketbook, by C. W. Shannon: Booklet 1912. Postage 2 cents.

MAPS.

Distribution of Oklahoma minerals. Postage 2 cents.

Physiographic map of Oklahoma. Postage 2 cents.

Progressive geologic map of Oklahoma. Postage 2 cents.

Structural map of the Cushing oil field. Postage 2 cents.

Map of the State of Oklahoma. Postage (folded) 3 cents; (in tube 10 cents.

RESEARCH BULLETINS.

Proposed group of Pennsylvanian rocks of eastern Oklahoma, by Cha N. Gould, D. W. Ohern, and L. L. Hutchison: Research Bull. Okla. Univ. N 3, 1910, 15 pp., 1 map.

Stratigraphy of the older Pennsylvanian rocks of northeastern Okl homa, by D. W. Ohern: Research Bull. Okla. Univ. No. 4, 1910, 40 pp., 1 ma

GEOLOGICAL THESES.

A preliminary study of the Canadian river, by Charles Townsend Kir B. A., 1904.

A preliminary list of the fossils of Oklahoma and Indian Territory, b Chester Albert Reeds, B. S., 1905.

The geology of Oklahoma City and environs, by William Hancock Lo B. A., 1906.

Anticlinal structure of the rocks of the oil and gas regions of Okl homa, by Robert Richard Severin, B. A., 1907.

The stratigraphy of Oklahoma north of the parallel of thirty-five de grees and thirty minutes, by Lon Lewis Hutchison, B. A., 1907.

Portland cement resources of Oklahoma, by Gaylord Nelson, B. A., 190

Lead and zinc ores of northeastern Oklahoma, by William Japhet Cross, B. A., 1909.

A preliminary report of the Cretaceous of Oklahoma, by Pierce Larki B. A., 1909.

The physiography of the Washita Valley region in the Arbuckle mou tains, by Charles Raymond Eckes, B. A., 1910.

The gypsum of Oklahoma, by Chester Charles Clark, B. A., 1910.

The geology of asphalt deposits of the vicinity of Ardmore, Oklahom by Benjamin Carlton Belt, B. A,. 1910.

"The Oologah formation," by Artie Carl Reeds, B. A., 1910.

The geology of the southwestern quarter of the Nowata quadrangle, b Robert Harrison Wood B. A., 1911.

The Cherokee formation, by Robert Ernest Garrett, B. A., 1912.

Glass sands of Oklahoma, by George Franklin Butrtam, M. A., 1912.

The geology and paleontology of the Simpson formation, by Laurenc Emory Trout, M. A., 1913.

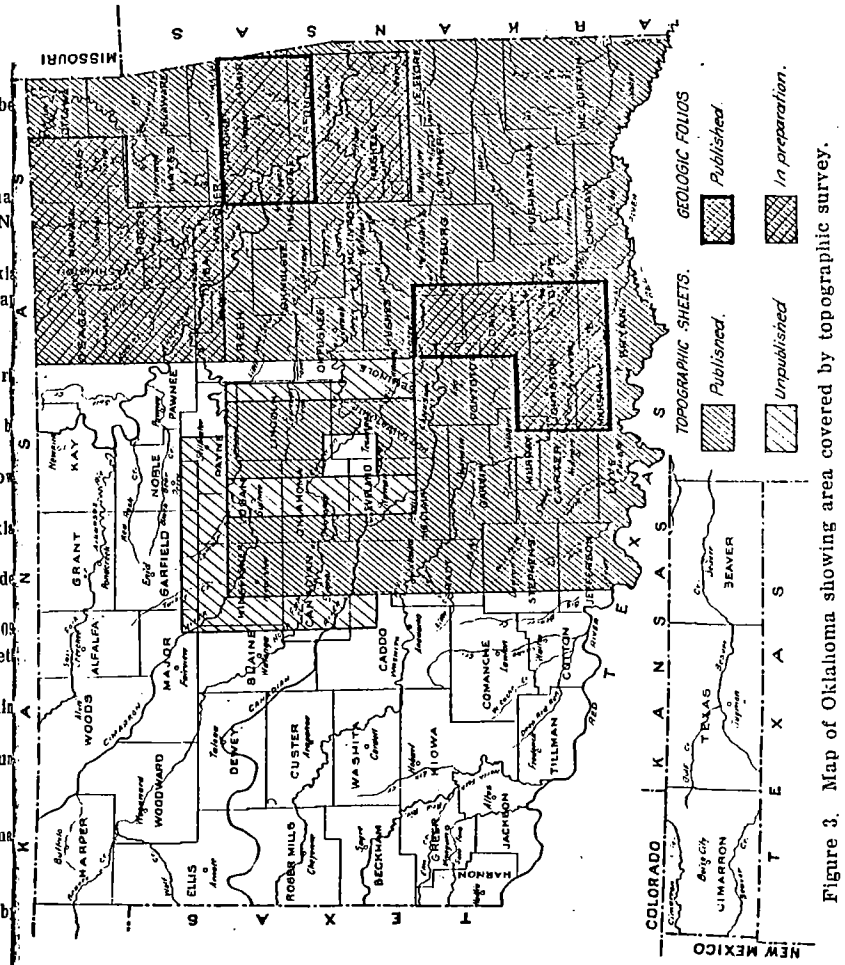


Figure 3. Map of Oklahoma showing area covered by topographic survey.

UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS ON OKLAHOMA.

ANNUAL REPORTS.

Geology of the McAlester-Lehigh coal field, by J. A. Taff: Nineteenth Ann. Rept. of the U. S. Geol. Survey, pt. III, 1899, pp. 429-457.

Report on the fossil plants from the McAlester coal fields, by David White: Nineteenth Ann. Rept. of the U. S. Geol. Survey, pt. III, 1899, pp. 457-539.

Report on the Paleozoic invertebrate fossils from the McAlester coal fields, by G. H. Girty: Nineteenth Ann. Rept. of the U. S. Geol. Survey, pt. III, 1899, pp. 539-602.

Geology of the eastern Choctaw coal field, by J. A. Taff and G. I. Adams: Twenty-first Ann. Rept. of the U. S. Geol. Survey, pt. II, 1901, p. 257.

Woodland of Indian Territory, by C. H. Fitch: Twenty-first Ann. Rept. of the U. S. Geol. Survey, pt. V., 1900, p. 603.

Asphalt and bituminous rock deposits of Indian Territory, by G. H. Eldridge: Twenty-second Ann. Rept. of the U. S. Geol. Survey, pt. I, 1901, pp. 263-319.

The southwestern interior coal field, by J. A. Taff: Twenty-second Ann. Rept. of the U. S. Geol. Survey, pt. III, 1902, pp. 367-415.

PROFESSIONAL PAPERS.

Preliminary report on the geology of the Arbuckle and Wichita mountains, by J. A. Taff: Prof. Paper U. S. Geol. Survey No. 31, 1904, pp. 11-82.

Appendix on reported ore deposits of the Wichita mountains, by H. F. Bain: Prof. Paper U. S. Geol. Survey No. 31, 1904, pp. 82-94.

BULLETINS.

Triangulation and spirit leveling in Indian Territory, by C. H. Fitch: Bull. U. S. Geol. Survey No. 175, 1900, 141 pp., 1 map.

Oil and gas fields of the western interior and northern Texas coal measures, by G. I. Adams: Bull. U. S. Geol. Survey No. 184, 1901, pp. 11-29.

Gypsum deposits in Oklahoma, by C. N. Gould: Bull. U. S. Geol. Survey No. 223, 1904, pp. 60-68.

Reported gold deposits of the Wichita mountains, Okla., by H. F. Bain: Bull. U. S. Geol. Survey No. 225, 1904, pp. 120-123.

Portland cement resources of Oklahoma, by E. C. Eckel: Bull. U. S. Geol. Survey No. 243, 1905, pp. 275-277.

A gazetteer of Indian Territory, by Henry Gannett: Bull. U. S. Geol. Survey No. 248, 1905, 70 pp.

Progress of coal work in Indian Territory, by J. A. Taff: Bull. U. S. Geol. Survey No. 260, 1905, pp. 382-402.

Notes on the geology of the Muskogee oil field, Indian Territory, by J. A. Taff and M. K. Shaler: Bull. U. S. Geol. Survey No. 260, 1905, pp. 441-446.

Mineral resources of northeastern Oklahoma, by C. E. Siebenthal: Bull. U. S. Geol. Survey No. 340, pt. I, 1907, pp. 187-229.

Grahamite deposits of southeastern Oklahoma, by J. A. Taff: Bull. U. S. Geol. Survey No. 380, pt. I., 1908, pp. 286-299.

Analyses of crude petroleum from Oklahoma and Kansas, by D. T. Day: Bull. U. S. Geol. Survey No. 381, pt. II, 1910, pp. 494-504.

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Portland-cement resources of Oklahoma, by E. C. Eckel: Bull. U. S. Geol. Survey No. 522, 1913, pp. 304-307.

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Structure of the Fort Smith-Poteau gas field, Arkansas-Oklahoma, by C. D. Smith: Bull. U. S. Geol. Survey No. 541-B, 1912, pp. 3-14.

The Glenn oil and gas pool and vicinity, Oklahoma, by C. D. Smith: Bull. U. S. Geol. Survey No. 541-B, 1912, pp. 14-28.

WATER-SUPPLY PAPERS.

Stream measurements, Platte, Kansas, Meramec, Arkansas, and Red River drainages, by M. C. Hinderlider and J. C. Hoyt: Water-Supply Paper U. S. Geol. Survey No. 131, pt. VIII, 1905, 203 pp., 2 pls.

Geology and water resources of Oklahoma, by C. N. Gould: Water-Supply Paper U. S. Geol. Survey No. 148, 1905, 178 pp., 22 pls.

Stream measurements, Meramec, Arkansas, Red and lower western Mississippi River drainages, by M. C. Hinderlider, J. M. Giles, and J. C. Hoyt: Water-Supply Paper U. S. Geol. Survey No. 173, pt. IX, 1906, 105 pp., 1 pl.

Surface water supply of the lower western Mississippi River drainage, by R. I. Meeker and J. M. Giles: Water-Supply Paper U. S. Geol. Survey No. 209, 1907, 79 pp., 2 pls.

Surface water supply of the lower Mississippi basin, by W. B. Freeman, W. A. Lamb, and R. H. Bolster: Water-Supply Paper U. S. Geol. Survey No. 247, 1910, 124 pp., 2 pls.

Surface water supply of the lower Mississippi River basin, by Robert Follansbee: Water-Supply Paper U. S. Geol. Survey No. 327, 1914, 84 pp., 2 pls.

Ground water for irrigation in the vicinity of Enid, Okla., by A. T. Schwennesen: Water-Supply Paper U. S. Geol. Survey No. 345, 1914, 13 pp., 1 pl.

Ground water for irrigation in the valley of North Fork of Canadian River near Oklahoma City, Okla., by A. T. Schwennesen: Water-Supply Paper U. S. Geol. Survey No. 345, 1914, 11 pp., 1 pl.

MINERAL RESOURCES.

Mineral Resources of the U. S. Geol. Survey from 1901 to 1914.

SENATE DOCUMENTS.

Coal land in Oklahoma: Senate document 390. A message from the President of the United States concerning investigations to determine ex-

tent and value of coal deposits under the segregated coal lands of the Choctaw and Chickasaw nations—Oklahoma. The report includes reports and maps issued as Circular Nos. 1, 2, 3, 4, 5 covering the segregated coal lands in the following areas:

Cir. No. 1. The McAlester district.
Cir. No. 2. The Wilburton-Stigler district.
Cir. No. 3. The Howe-Poteau district.
Cir. No. 4. The McCurtain-Massey district.
Cir. No. 5. The Lehigh-Ardmore district.

GEOLOGIC FOLIOS.

Published.	In preparation.	
Coalgate	Sanbois	Hominy
Atoka	Sallisaw	Wyandotte
Tishomingo	Vinita	Claremore
Tahlequah	Nowata	McAlester
Muskogee	Pawhuska	

TOPOGRAPHIC SHEETS.

Addington	Darlington*	McComb	Sac & Fox*
Agra	Denison	Montague	Sallisaw
Alikchi	Edmond*	Moore*	Sanabois
Antlers	Euchee Creek*	Mulhall*	Seminole*
Ardmore	(Mallon)	Muskogee	Shawnee
Asher*	Foraker**	Norman*	Sheridan*
Atoka	Ft. Smith	Nowata	Siloam Springs
Bonham and	Gainesville	Nuyaka**	Stillwater
Paris*	Guthrie*	Omega*	Stonewall
Boggy Creek*	Hennessey*	Okmulgee	Tahlequah
Canadian	Hominy	Pauls Valley	Tishomingo
Chandler	Kingfisher	Pawhuska	Tuskahoma
Chickasha	Lacey*	Perkins	Vinita
Claremore	Lukfata	Poteau	Wewoka
Clarksville and	Luther	Prague*	Winding Stairs
Shawneetown*	Maud	[illegible]or Creek	Winslow
Coalgate	McAlester	Rush Springs	Wyandotte

*Advance sheets have been issued.

**Preliminary field work completed.

Note:—The field work for the Claremore, Hominy, Vinita, and Nowata folios was done under cooperative agreement. Geologic folios may be obtained from the U. S. Geol. Survey, Washington, D. C., for 25 cents each. Topographic sheets are 10 cents each.

BULLETINS PUBLISHED BY THE U. S. GEOLOGICAL SURVEY, FIELD WORK BEING DONE UNDER COOPERATIVE AGREEMENT BETWEEN THE U. S. GEOL. SURVEY AND OKLA. GEOL. SURVEY.

The economic geology of the Vinita and Nowata quadrangles, by D. W. Ohern. (Ready for press.)

A preliminary report describing the structure of the area between the Grandfield district and the Rock Island railway, by C. H. Wegemann and A. E. Fath. (Ready for press.)

A preliminary roport on the structure of the Healdton and Loco pools, by C. H. Wegemann. (Ready for press.)

The granites of Oklahoma, by Chas. H. Taylor. (Ready for press.)

A preliminary report on the Duncan-Lawton region, by C. H. Wegemann and R. W. Howell. Field work completed, Oct., 1914.

A preliminary report on the Okmulgee-Nuyaka region, by A. E. Fath and W. B. Emery. Field work completed, Dec., 1914.

Reconnaissance of the Grandfield district, Oklahoma, by M. J. Munn: Bull. U. S. Geol. Survey No. 547, 1914, 85 pp., 5 pls.

STATE MAP.

A new State map of Oklahoma has been prepared. The first edition of the map was published about October 1st, 1914. This first lot was exhausted a few days after becoming available, and a second order for 2,500 has been filled. Existing State maps have been found to be lacking, especially in the proper location of railroads and the smaller towns. The prime purposes in the publication of this map are: (1) To have a sectionized base map of the State upon which results of geological investigations of a general nature may be imposed accurately in regard to proper location of towns, railroads, and streams. (2) To supply State, county, and business offices, school rooms and other public buildings with accurate State maps. The maps are also furnished to individuals.

In the construction of the new map the base was made on a scale of approximately one-fourth inch to the mile, giving a base 54 inches by 101 inches as the full size of the original map. The published map is one-half this size, being 27 inches by 50½ inches.

On the original map was imposed the area covered by the United States Geological Survey topographic sheets. These sheets which are named from some important place within the quadrangle cover areas of 30′ latitude and longitude with a few 15′ sheets. The boundaries, section line offsets, streams, and other data were transferred from these sheets to the original base by pantograph reduction. All the part of the State east of longitude 96°30′ west of Greenwich and that part which lies south of 36°30′ latitude has been covered by topographic surveys. (See fig. 3, showing area of State covered by topographic survey). The balance of the State was mapped according to the United States Post Route Maps of

1914, thus eliminating all those little places which occur on former maps as villages with perhaps a store and a couple of houses, and formerly having a postoffice, but now abandoned. New towns were added. All the place names on the new map are either railroad stations or post offices.

By courtesy of the different railroad companies it was possible to give actual locations of their lines. Many of the county surveyors of the State responded to requests for informations, thus giving much valuable assistance. Since publication a few minor errors have been found on the map. Any person detecting errors will confer a favor by reporting same so that such may be checked and corrected for future maps published. All available data have been consulted, but at the present age of our State it would be impossible to produce a map absolutely correct.

Printing funds were not sufficient to enable the Survey to print the map in colors. Arrangements have been made whereby a limited number of the maps can be furnished, with the country boundaries in colors, for a cost of 50 cents each in addition to the postage charges. The map when folded requires 3 cents postage, when mailed in tube, 10 cents.

RELATION OF THE SURVEY TO THE PUBLIC.

The chief purpose of the Survey is to investigate the mineral resources of the State. Field work is carried on by members of the staff and field assistants, and upon the completion of a particular piece of field work, a bulletin or circular is prepared setting forth the results of the investigation. In its proper scope the work of the Survey includes certain features which may be classed as educational. The several parties of the Survey in pursuit of geological investigations readily obtain a vast amount of other valuable information which no one else in the State is in a position to secure. This information belongs to the State. The field man who is interested in geological studies usually is interested in other nature studies. Therefore, in connection with his regular duties he is able to collect much valuable information along other lines. This interest may be along the line of special research in geology, or in the study of the flora or fauna in the region where he works. In fact the relation of nature or wild-life to surface geology is a very important one.

These data collected may be given out to the public through lectures, brief papers published, special reports on the birds, insects, trees and shrubs, flowering plants, and many other special subjects. When it is found that a large amount of such information can be secured on a subject someone is appointed to make special investigation along that line. At the present time there is scarcely

no available source of information on the mineral resources and natural history of the State, except such as can be furnished by the Survey.

In the field work the Survey endeavors to locate the various deposits of valuable minerals, determine their value and accessability. After the work has been completed the publication makes known the facts to the public.

The development of our resources requires money and every effort must be made to bring our great natural wealth to the notice of interested capital. The publications of the Survey go into every state and into many foreign countries. Each day brings many inquiries from outside the State to the office of the Survey for information concerning the minerals of the State. Numerous instances might be given of industries established in the State through the information disseminated by the Geological Survey.

The Survey has not only been the means by which capital has been properly invested within the State, but it has attempted to prevent the useless expenditure of money in regions where geologic conditions preclude the possibility of the occurrence of minerals sought. Much useless prospecting has been done in the State. Large sums of money have been expended in drilling for oil and gas in western Oklahoma, where conditions were most unfavorable. More than 25 wells have been put down, costing from $10,000 to $35,000. Such work was done without geological advice. While it is impossible for any person to tell absolutely where oil and gas will occur, many areas can be indicated where such will not be found.

The Survey is willing to assist in making examinations which will aid in determining whether areas are within probable territory. The plan used at present is that such examinations will be made upon request of 50 freeholders of a community signing a petition for a geologist to make such investigations. The expenses are paid by the petitioners and a typewritten report, whether favorable or unfavorable, will be given to them. A copy of all such reports is kept in the office of the Survey. It is observed from an examination of these reports that more areas have been condemned than recommended for the particular mineral desired and from this plan alone thousands of dollars are saved to the people of the State each year. In some cases petitions cannot be answered for the reason that the region has previously been investigated or such investigation would prove absolutely worthless. Under existing conditions the only course to pursue is to let the merits of each case determine what action shall be taken. Experience has shown conclusively that the entire time of the staff and field men would be consumed and the regular work of the Survey neglected if every petition requested were granted, and every individual service performd.

The policy of the Survey is not to give out information in advance of the completion of the field work, or the publication of the report or press notice as regards the regular line of field investigations. This is governed by several conditions. For example, when the data affect only a small part of the State or a group of citizens, the information may be given out in advance. Members of the Survey are willing to be interviewed at any time and to give such assistance and advice as can consistently be rendered without interrupting the regular work of the Survey.

In some cases promoters have used reports from the Survey as a means of advertising their own wares. To this there is no objection when properly quoted, but in a number of instances reports were only partly given, and the statements were misleading. In other cases individuals have represented themselves as being connected with the Geological Survey, or at some time or other have been officially connected and thereby hope to obtain certain privileges for themselves. Each representative of the Survey carries an identification card, giving his name and title, and signed by the director of the Survey and the President of the State University as chairman of the Geological Commission.

PROGRESS OF SPECIAL INVESTIGATIONS.

TOPOGRAPHIC SURVEY.

The United States Geological Survey is preparing a topographic map of the United States. The work has been in progress for about 25 years. This map is issued in sheets of convenient size, each representing a rectangular area called a quadrangle. The areas already mapped are widely scattered, nearly every state being represented. The sheets published number about 1800.

In making these maps three scales are used, the largest scale being 1:62,500, or very nearly 1 mile to 1 inch; that is, 1 linear mile on the ground is represented by 1 linear inch on the map. This scale is used for maps of those parts of the country that are thickly settled or industrially important. For maps of the greater part of the country a scale of 1:125,000, or about 2 miles to 1 inch, is employed. A third and still smaller scale, 1:250,000, or about 4 miles to 1 inch has been used in maps of the desert regions of the Far West. The sheets on the largest of the three scales defined above cover 15 minutes of latitude by 15 minutes of longitude, those on the ittermediate scale 30 minutes of latitude by 30 minutes of longitude, and those on the smallest scale 1 degree of latitude by 1 degree of longitude. A few special maps of small areas in mining districts are made on larger scales.

The topographic maps are of great value as the base upon which the geology and mineral resources may be represented. They

are also of the highest value in working out the structural features of oil fields and of value in the location of roads, railroads, and other features dependent upon the surface conditions.

The features shown on topographic maps are classed in three groups: (1) Water, shown by blue lines; (2) relief, including mountains, hills, valleys, cliffs, etc., shown by brown lines; and (3) culture, the works of man, such as towns, cities, roads, railroads, and boundaries, by black lines.

The sketch map shows the area which has been covered in Oklahoma by topographic survey. Much of this work was done in the Indian Territory part of the State prior to statehood. To the present time 67 quadrangles have been surveyed and the sheets published on all except 18. Sixteen of these have the advance sheets issued and in 2, the Foraker and Nuyaka, the preliminary field work is completed. The State Survey has been cooperating with the Federal Survey for several years in doing topographic work, but the amount of money which could be used for this purpose was only $1,000 a year, and hence great returns could not be expected. Considerable independent work has been carried on by the United States Geological Survey.

A number of the first sheets issued were found to be considerably in error and the United States Geological Survey is having these sheets revised at its own expense. A large number of permanent bench marks are established over the fields, and these are of great value for future use in running levels and survey lines.

The State should have an increase in funds for carrying on the topographic cooperative work. It is a line of work which is of the highest value in the State, but which could not be carried on by the means at the disposal of the State alone, hence must be done under cooperative agreement.

PETROLEUM AND NATURAL GAS.

During the past two years several new oil and gas fields have been discovered and extensions to old pools developed. The Newkirk, Cushing, and Healdton fields are those of most importance brought in since the beginning of 1912. Oklahoma stands second among the oil states in production, and first in the value of production for the past two years. In 1912 the production amounted to 51,427,071 barrels, valued at $34,672,604; in 1913, 63,579,384 barrels, valued at $59,581,948.

The big decline in the price of oil came early in the year, when the State was showing a daily production of more than 250,000 barrels. This first decline in price, further added to by the war conditions, has brought about a curtailment of development and production has been reduced to the lowest figure possible. Just at the present date the outlook is a little brighter and no doubt in a few

months conditions will be so adjusted that development will aga
reach an active stage, although it is not likely that the price w
immediately reach the figure attained prior to the decline.

The following publications have been issued by the Geologic
Survey since the last biennial report was published:

Bulletin No. 16, The Ponca City Oil and Gas Field; Bulle
No. 17, Geology of East Central Oklahoma; Bulletin No. 18, T
Cushing Oil Field; and Bulletin No. 19, Petroleum and Natural G
in Oklahoma. The first was issued in December, 1912. The fi
work was done by D. W. Ohern, then director of the Survey, a
Robt. E. Garrett, field assistant. The field investigations were beg
in the vicinity of the Ponca City oil wells. The structure was work
out by alidade elevations, and an anticline was found to extend
the northeast for a distance of 12 miles to the Arkansas River. T
highest part of the structure is to the north, and shortly after t
publication of the report drilling began in the locality east of Ne
kirk and several producing wells have been brought in. Betwe
this area and the Ponca City area, where the anticline is not so w
developed, some drilling has been done, but no good production
oil has been found. Some gas has been encountered. The produ
tion in this new field has been good and there would have beg
much further development if pipe line facilities had been secure

Bulletin No. 17, while dealing principally with the geology
east central Oklahoma was written with special reference to th
occurrence of petroleum and natural gas in that part of the Stat
The field work was done during the field season of 1913. L. C. Sn
der, Assistant Director of the Survey, was in charge of a party
four, who carried on field work for the report. The work consiste
almost entirely in the determination of the structure, special atte
tion being paid to the location of the anticlines. In the greater pa
of the area the folds are sharp and the dips sufficiently steep to b
read with an ordinary clinometer. In the northwestern part of th
area, it was necessary to do some areal mapping, and to take som
aneroid readings to determine the structure. All of the structura
lines mapped were of sufficient prominence that no alidade work wa
carried on. In general, the outcrops are sufficiently numerous to pe
mit the axis of the fold to be located with a considerable degree
accuracy, but in some cases the distance between observed outcrop
of different dips was found to be considerable and the location
axes could only be approximated. Little attention was given t
stratigraphy, except in the vicinity where the dips were too sma
to make clinometer reading sufficiently accurate to determine th
dip and structure. A large part of the geology had been previousl
worked out in considerable detail in this region, both by the Unite
States Geological Survey and the Oklahoma Geological Survey.

Bulletin No. 18 deals with the geology, structure, developme
and production in the immediate Cushing field and adjacent terri

tory. The field work for the report was done during the summer of 1913. Frank Buttram, field assistant of the Survey, was in charge of a party of three to work out in detail the entire region embodied in this report. In beginning the field work it was found that there was no base map of the area available, except the ordinary county map. It was necessary to use this for the plotting of all data obtained. All the information gained concerning the surface geology and structure was placed on this map. In order to determine the structure a line of levels was run to the field with a spirit level from the government bench mark located at the southwest corner of sec. 3, T. 17 N., R. 6 E. This primary level line was carried to different parts of the field and temporary bench marks were established. From these established bench marks secondary spirit level lines were run to all the wells in the field, which at that time approximated 700. The elevation and location of each well was determined and plotted. Later the log of each well was obtained. These logs usually gave the depths of the producing sands, the amount of initial production, the lease name, number, the owner of the well, and some other special information. The principal geological formations were placed upon the map and the elevation of a large number of points on the several outcrops determined. As the Pawhuska limestone is easily recognized, and outcrops appear over a large part of the field, it was selected as the key rock. The elevations determined were calculated in terms of this limestone, and the structural contours drawn upon it. After the field work had been completed a map was prepared for publication showing the contour lines as obtained from the upper Pawhuska limestone. The principal axes of the anticlines and synclines, and the location of wells were also shown upon the map. This map was published several months in advance of the complete bulletin. A few weeks after the map appeared, and it was found necessary to still further delay the printing of the full report, a lengthy press notice was published in the leading papers of the State and several thousand copies printed for special use of the Geological Survey. This press bulletin stated the nature of the work which had been done, and gave the location and extent of the structural features which had been worked out by the men in the field. Through the distribution of this map and press notice much interest was taken in certain extensions and drillings to deeper sands as indicated, and it is readily shown that the advance publications have given considerable influence to the activity in the Cushing field. The complete report has just come from the press and is now being distributed over the State.

Bulletin No. 19 on petroleum and natural gas in Oklahoma has just been prepared by C. W. Shannon and L. E. Trout in order to give to the public as much general information as possible concerning the oil and gas industry in Oklahoma, pending the publication of a more complete report along this line. All publications of simi-

lar nature prepared by the Oklahoma Geological Survey have bee completely exhausted. The demand for oil and gas publications great. At present about 2500 names are on file awaiting the mai ing out of such information as can be offered concerning these fu materials. The history of development, production, and data co cerning refineries, pipe lines, and other general phases of the oil an gas industry are briefly discussed in this report, which has ju come from the press.

Work has been in progress for more than a year toward th preparation of a rather complete publication on petroleum and na ural gas in Oklahoma. This bulletin when ready for the press wi total approximately 500 pages of printed matter, etchings, and ha tones. It is the plan to give consideration to the oil industry fro the beginning of work in the Mid-Continent field down to the pre ent time. Old fields are being studied and a discussion of eac will be given, including past and present development and possi bilities of future extensions. New areas are being studied in deta and encouraging discoveries are being made. This new work i being done in some parts of the State by the independent work o the State Survey, and in other parts by cooperation between th United States Geological Survey and the State Survey. Arrange ments have been made in regard to the cooperative work, whereb the State may secure in time for this publication such informatio as is available from this source in advance of the complet publication which will be published by the Federal Survey. Othe independent work of the United States Geological Survey will als be available so that results may be published by the State. A larg amount of most valuable information reaches the offices of the Sur vey through the oil companies and their geologists. In some area there are geologic conditions which cause considerable difference of opinion, and these varied opinions which may be offered are th best means of checking the facts of doubtful conditions. Logs o several thousand wells are on file and much tabulated material con cerning initial production, rate of decline, and life of fields ha been collected.

COAL AND COAL MINING.

The State Geological Survey has been carrying on work in th coal fields of the State for three years. A full report, entitled Coal and Coal Mining in Oklahoma, has been prepared, including the results of the field work, the investigations conducted in th laboratory of the Survey, and the data previously obtained by th United States Geological Survey and Oklahoma Geological Survey.

Many subjects of general interest in regard to coal and coal mining are included in the report. The coal area is situated in th eastern part of the State. The greater number of the people of the State, and especially those in the central and western parts being

so far removed from the coal area, know little or nothing, about the coal of the State, or the mining conditions in the field.

While it is plain that mining rates are higher in Oklahoma than in other states, it is readily shown that the miners are not in any better circumstances because of the fewer number of days worked. It is also evident that the operators have not realized proper returns from their investment in the field. Both wholesale and retail prices of coal increased and the production decreased from 1907 to 1912, at which time there was considerable increase in production and a slight reduction in the cost of mining the coal. The price of coal to the people of the State still remains high. The production of 1913 still shows an increase over that of the previous year.

Our coal is suited for a great many purposes. The chief uses are for steam coal and for domestic fuel. It is a matter of great concern to the people of the State to know at least something of our coal supply, the demand, and the conditions under which our fuel is secured. The question of getting the best results from the coal burned is also of very great importance. That there is a great difference in the quality of fuel used, and that some fuels are better adapted to certain purposes, is beginning to be extensively realized. It is the purpose of this report which has been prepared for publication, to set forth those things which will be of general interest and value to the people of the State concerning our fuel resources.

Maps of the coal fields are included in the report. One, a general map of the field showing the geological formations and their contained coal beds, is given on a small scale, the original being four miles to the inch and reduced for publication to a scale of six miles to the inch. Six maps of the various divisions of the coal field were drawn on a scale of two inches to the mile and reduced to one inch scale. These maps show the outcrops, dip and thickness of the various beds of coal. The location, name, and number of mines, both the working and the abandoned, are given so far as it is possible to ascertain the latter. The transportation facilities are shown and all shipping points are indicated. The geology is given in a general way, and prominent structural features, such as faults, anticlines, and synclines, are pointed out. The topography of the country is shown by the drawing in of the 750-foot and 1,000-foot contours, and striking topographic features are shown by special markings. The bench mark elevations of the township corners and other permanent elevation marks are indicated.

Several cross sections are given representing lines several miles in length; also about 50 logs of wells as determined by core drilling. A number of pages of sections of coal beds are included, and many sketches, diagrams, and sections showing special structural features, conditions in mines, and method of working, are embraced

in the description. About 100 half tones are used showing mine buildings, special machinery, mine equipment, methods of prospecting and mining, as well as a number of general views showing conditions throughout the field.

Much of the geology of the coal fields has been worked out in considerable detail in former years, both by the United States Geological Survey and the State Survey. Supplemental structural and areal work was done by the writer during 1912-14, while working on this report. However, since so much has been done and results published, less attention was paid to geological features and most of the time was given to the distribution, character, quantity, and availability of the coals, transportation facilities, and general mining conditions.

Special attention has been given to the uses which may be made of Oklahoma coals. A large number of samples for chemical analysis and heat tests were collected from the mines, cars, and bins. These samples were taken according to standard specifications adopted by the United States Geological Survey and the United States Bureau of Mines. The result of the analyses and tests are given in full in the report. Following the description of each mine will be found the analyses and tests of samples taken from the mine, and in addition to this will be found tables in which analyses are collected for comparison. The heat units were chiefly determined by Parr's Standard Calorimeter under carefully standardized conditions. Several determinations and a large number of checking tests were made by the use of other calorimeters. The make of apparatus used is stated in the tests given. The heat value is of very great importance in comparing different kinds of steam coal since the generation of heat is the primary object.

In addition to the large number of new analyses the results of 100 former analyses have been compiled for use in the report. These analyses are in large part from tests made by the United States Geological Survey and the United States Bureau of Mines, with others furnished by the various coal companies of the State.

As a result of using every effort to make this report of value to the general public, parts of it may seem elementary to coal mining men and to others, who are familiar with coal mining operations. The purpose has been to give persons not acquainted with coal mining an idea of the occurrence of coal and the manner in which it is obtained from the ground.

The active interest in the conservation of our natural resources is of special importance to coal mining. While it is true that even under the best mining conditions which can be secured there is a considerable waste of coal, it is also true that most areas of coal mining show that a large percentage of the coal is being needlessly wasted. In the utilization of our coal there is excessive waste,

and only a small percentage of the efficiency of the coal is derived from it. On the average from 40 per cent to 60 per cent of our coal is being wasted before it reaches the consumer. This is a matter of great importance to the State, and is a question which should receive serious consideration and legislation.

In the course of the investigations in the field, and in the preparation of the report, extensive use was made of all published information concerning the Oklahoma coal fields. Various reports on the coals of areas adjoining the Oklahoma fields were of value in the correlation and general information concerning the geological formations and horizons. In addition to the published reports some material was on file in the offices of the Geological Survey. This consisted chiefly of sections, sketch maps, and field notes gathered in connection with other work.

The writer is indebted to the various coal companies and many individuals for the liberal assistance in securing fullest information. The superintendents and other officials of the companies operating in the field, with few exceptions, gladly granted access to mine maps, records, statistics; gave all assistance possible for the examination of the mines, and answered the many inquiries directed to them in detail. In going over the field and through the mines much valuable information was freely given by mine foremen, engineers, and miners. Much of the statistical data were secured in the first place from persons interviewed, and from records in the offices. These were supplemented and checked by comparison with figures contained in various reports of the Chief Mine Inspector of the State, and from the signed production cards of the operators which are on file in the offices of the Geological Survey. Many tables and compilations were taken from coal statistics published by the United States Geological Survey. It may be stated that such information as published during the past three years by the Federal Survey, concerning Oklahoma, has been largely gathered through cooperative work with the State Geological Survey.

Much of the historical matter was secured from persons who had been in the Oklahoma fields many years, and from the reports of the United States Mine Inspector for Indian Territory prior to the year 1907.

The printed report will make a publication of approximately 500 pages, including half-tones and one-page etchings. Several of the etchings are larger than one page and must be tipped in the publication. All zinc etchings and half-tones have been prepared and the manuscript is ready for publication, except for a final proof reading and correction. During the latter part of June of the present year, specifications were prepared for the publication of the report, and bids received from several printing companies over the State, but the lowest bid received was so high that there were not

in the description. About 100 half tones are used showing mine buildings, special machinery, mine equipment, methods of prospecting and mining, as well as a number of general views showing conditions throughout the field.

Much of the geology of the coal fields has been worked out in considerable detail in former years, both by the United States Geological Survey and the State Survey. Supplemental structural and areal work was done by the writer during 1912-14, while working on this report. However, since so much has been done and results published, less attention was paid to geological features and most of the time was given to the distribution, character, quantity, and availability of the coals, transportation facilities, and general mining conditions.

Special attention has been given to the uses which may be made of Oklahoma coals. A large number of samples for chemical analysis and heat tests were collected from the mines, cars, and bins. These samples were taken according to standard specifications adopted by the United States Geological Survey and the United States Bureau of Mines. The result of the analyses and tests are given in full in the report. Following the description of each mine will be found the analyses and tests of samples taken from the mine, and in addition to this will be found tables in which analyses are collected for comparison. The heat units were chiefly determined by Parr's Standard Calorimeter under carefully standardized conditions. Several determinations and a large number of checking tests were made by the use of other calorimeters. The make of apparatus used is stated in the tests given. The heat value is of very great importance in comparing different kinds of steam coal since the generation of heat is the primary object.

In addition to the large number of new analyses the results of 100 former analyses have been compiled for use in the report. These analyses are in large part from tests made by the United States Geological Survey and the United States Bureau of Mines, with others furnished by the various coal companies of the State.

As a result of using every effort to make this report of value to the general public, parts of it may seem elementary to coal mining men and to others, who are familiar with coal mining operations. The purpose has been to give persons not acquainted with coal mining an idea of the occurrence of coal and the manner in which it is obtained from the ground.

The active interest in the conservation of our natural resources is of special importance to coal mining. While it is true that even under the best mining conditions which can be secured there is a considerable waste of coal, it is also true that most areas of coal mining show that a large percentage of the coal is being needlessly wasted. In the utilization of our coal there is excessive waste,

and only a small percentage of the efficiency of the coal is derived from it. On the average from 40 per cent to 60 per cent of our coal is being wasted before it reaches the consumer. This is a matter of great importance to the State, and is a question which should receive serious consideration and legislation.

In the course of the investigations in the field, and in the preparation of the report, extensive use was made of all published information concerning the Oklahoma coal fields. Various reports on the coals of areas adjoining the Oklahoma fields were of value in the correlation and general information concerning the geological formations and horizons. In addition to the published reports some material was on file in the offices of the Geological Survey. This consisted chiefly of sections, sketch maps, and field notes gathered in connection with other work.

The writer is indebted to the various coal companies and many individuals for the liberal assistance in securing fullest information. The superintendents and other officials of the companies operating in the field, with few exceptions, gladly granted access to mine maps, records, statistics; gave all assistance possible for the examination of the mines, and answered the many inquiries directed to them in detail. In going over the field and through the mines much valuable information was freely given by mine foremen, engineers, and miners. Much of the statistical data were secured in the first place from persons interviewed, and from records in the offices. These were supplemented and checked by comparison with figures contained in various reports of the Chief Mine Inspector of the State, and from the signed production cards of the operators which are on file in the offices of the Geological Survey. Many tables and compilations were taken from coal statistics published by the United States Geological Survey. It may be stated that such information as published during the past three years by the Federal Survey, concerning Oklahoma, has been largely gathered through cooperative work with the State Geological Survey.

Much of the historical matter was secured from persons who had been in the Oklahoma fields many years, and from the reports of the United States Mine Inspector for Indian Territory prior to the year 1907.

The printed report will make a publication of approximately 500 pages, including half-tones and one-page etchings. Several of the etchings are larger than one page and must be tipped in the publication. All zinc etchings and half-tones have been prepared and the manuscript is ready for publication, except for a final proof reading and correction. During the latter part of June of the present year, specifications were prepared for the publication of the report, and bids received from several printing companies over the State, but the lowest bid received was so high that there were not

sufficient funds available to print the bulletin. The report now lies in the vault in the Administration Hall of the University and will be resurrected the first of the year and an appropriation of funds asked for its publication.

Hundreds of requests are now on file for the coal bulletin. Many of these are from citizens of the State who wish to know something of our coal resources. Many others are from persons outside the State who contemplate investments in the State and desire to know something of the coal for ordinary fuel purposes, or as fuel for various industrial enterprises.

RECOMMENDATIONS.

INVESTIGATION OF WATER RESOURCES.

Hundreds of requests come to the Geological Survey for information on water supply for irrigation and domestic purposes. No systematic work concerning water resources has been undertaken by the State. The United States Geological Survey and the Reclamation Service have made preliminary investigation in certain parts of the State, but there is now available very little information that is definite and specific, and in such form that it can be readily used by the average citizen. The work that has been done is included chiefly in Water Supply Paper No. 148, by C. N. Gould, which covers all of "old Oklahoma;" and No. 345, by A. T. Schwennesen, which deals with water for irrigation in the vicinity of Enid, and in the valley of North Fork of Canadian River near Oklahoma City. Several other papers give some information in connection with discussion of neighboring states.

The work of the State Survey has consisted in the investigation of a number of reservoir sites, principally for the storage of water for irrigation, and city water supplies. Examination has been made of water from wells, springs, and surface streams and ponds to determine whether suited for special purposes. Extensive use is now being made of surface water for stock, by ponding in ravines.

During the past season a party of two made a preliminary survey along the Canadian River, from the Norman bridge to the Texas line. This work consisted in making special investigation concerning flood conditions, damages by floods, changes in streams, character of surface and underground water, depth to water table, and general conditions concerning the use of the water in this region for irrigation and domestic purposes. This piece of work proved very satisfactory and arrangements are being made to continue the work next season, thus covering as many of the drainage lines of the State as possible before a printed report is prepared.

In the western part of the State the mineral resources are very limited and the rainfall is scarcely sufficient to supply the demand for water through the entire year, since a considerable part of the

rainfall occurs during the time of year when not needed for growing crops. In order that crops may be properly grown and the amount of moisture necessary retained in the soils, irrigation is necessary. An extensive investigation of a supply of water for irrigation is one of the most important lines of work that can be undertaken by the State. In pursuing such work, plans should be carefully outlined as it would be an extremely easy matter to expend hundreds of thousands of dollars on the investigation of water resources and the preliminary work of irrigation projects without results. The soils throughout a greater part of the semi-arid region of the State are very productive and if arrangements can be made whereby water for irrigation can be furnished, this region will become one of the most productive parts of the State. Several irrigation projects on a small scale have been undertaken by individuals, and the degree of success obtained is such as to insure good results in a proper system of irrigation. Much of the surface water is unfit for growing crops and the supply must be obtained from wells which must be put down to levels where suitable water can be obtained.

In addition to the lack of water suitable for irrigation there is also need for good boiler water. Railroads, manufacturing concerns, and others write to the Survey asking assistance in finding water which can be used for manufacturing purposes. Such industries should be aided in every way possible, and the State, through its department of natural resources, should be able to supply much accurate information.

Whether investigations regarding water resources be carried on by the Geological Survey or by some other Department of State, is a matter of little importance. The point is that some State Department should be enabled to undertake the work at the very earliest date possible.

MINERAL EXHIBIT AT THE PANAMA EXPOSITION.

The mineral exhibit at the State Fair and the value derived from such exhibits have been discussed in another part of this report. The time for the opening of the Panama Exposition at San Francisco is drawing near. Oklahoma's mineral resources should be displayed. The State's mineral wealth was admirably represented at the St. Louis Exposition in 1904, and no doubt the interest aroused by the display caused much capital to come into the State, which has led to the wonderful growth and development of the resources during the past few years.

Funds are not available for the purpose of making an exhibit of the State's resources at the Exposition. The regular funds appropriated for the Survey work can not justly be used for such work, although this means would give better returns for the money invested than any other line of work which might be pursued. A

special appropriation of a few hundred dollars would enable the Survey to provide a very creditable exhibit of all the State's mineral resources. An Oklahoma building is being constructed from funds which many of the progressive citizens have contributed through various clubs and organizations. Space for a geological exhibit has been assured in this building, provided funds can be secured for such purpose.

Material for a mineral exhibit is partly assembled. The work of collecting was begun in the summer of 1912, and has been continued through the field seasons since, in connection with the regular field work of the Survey. This work, while done in anticipation of proper arrangements has been accomplished with little additional expense to the State, and many valuable exhibits are in such position that they can be readily prepared for shipment. The Survey is in touch with all of the mineral producers of the State, and many of them have been solicited and have shown a keen interest in the exhibit, and the Survey feels confident of assistance and cooperation from every mineral producer in the State. There is no reason why the State, with a reasonable expenditure of funds should not have an excellent mineral and mineral products exhibit which would aid materially in the future development of our resources.

CONSERVATION.

The need of conservation is apparent to members of the Survey. In their investigations it is found that great waste is going on in connection with the development of our natural resources. There is scarcely a line of work where the waste is not evident.

In the mining of our coal 40 to 60 per cent. is wasted before the product reaches the consumer. Mining methods produce 25 to 50 per cent. slack and fine coal, much of which finds its way to the dump. A large percentage of the coal bed is left in the mine, as supports for the roof. The results are that much of our coal is being wasted for all time, and at present our citizens are paying eorbitant prices for coal suitable for domestic purposes.

Over-production and inadequate facilities for handling oil have caused enormous waste. However, the greatest losses of oil have been by unavoidable conditions. Lightning frequently strikes storage tanks and causes disastrous fires. Earthen tanks give way in time of heavy rains and much oil escapes down the streams. Various methods are being used to prevent this waste. The companies which have sustained such losses are the leaders in these plans for protection. In the Cushing and Healdton fields alone during the past year hundreds of thousands of barrels of oil were lost. Large amounts of oil are wasted from the "gushers" when first brought in.

The waste of our natural gas in the past has been unequalled anywhere. People do not realize the value of our gas supply. The consumer who knows little of gas except what he sees of its consumption thinks the supply inexhaustible. It is difficult to convince him that when this fuel is gone it is gone forever, whether it be properly utilized or recklessly wasted. Methods of field operations allow great waste. These wastes are discussed more fully under the heads "Natural Gas Exhaustion," and "Natural Gas Gasoline."

To say the least, Oklahoma, even with the best enforcement of existing laws and methods of gas conservation, is losing thousands of dollars every day.

Extensive waste and destruction might be shown for practically all the mineral resources, and especially might such be shown in regard to our soils, which in so many instances are being depleted of all plant food or badly eroded by careless cultivation. Wanton destruction of our forest and our wild animal life, especially the birds, is going on at a rate never before equalled. It is essential that the spirit of conservation and practical application be given serious consideration for all of our resources.

PERMANENT QUARTERS FOR GEOLOGICAL SURVEY.

The present quarters of the State Geological Survey are discussed briefly under "Offices." This discussion, with additional suggestions, is given here in order that the reader may realize the inadequacy of the space occupied.

The Survey offices have been located in the basement of the Carnegie Library Building since July, 1913. Prior to that time the headquarters were in one of the temporary frame buildings on the campus. This building being only one story and covered with metal was so hot that work could not be carried on during summer months and so cold in winter that the staff could not work in comfort. The present location is a great improvement over the former. The space occupied consists of the director's office, general office and library, drafting room, and three small offices for other members of the staff. The Geological laboratory is crowded into two small rooms in a one-story frame building. The office and workshop of the ornithologist are in these same rooms, and for several months the campus gardner has occupied the same office. These rooms are not even suited for any one of the uses now made of them. Some of the supplies and field outfits are stored partly in another frame building, others under the bleachers of the athletic field, and still others at various places about Norman. The museum is in the basement of Monnet Hall, in connection with the Historical exhibit. There is no chance for growth, and besides, the entire room is needed by the University for the Historical display.

The nature of the Survey work is not known to many people of the State, nor is it known that the Survey works under a distinct

appropriation and is not connected with the other departments. This misunderstanding of the purpose and the needs no doubt has prevented the department from being properly provided for by the State.

The work of the Survey is seriously handicapped by lack of adequate facilities, especially laboratories and store rooms. This inadequacy causes much loss of time and detriment to property.

The University cannot spare more room for the work of the Survey. A new and separate building is needed on the campus of the University for the work. Offices, laboratories, store rooms, and museum should be included in one building. At least seven offices are needed, adapted to the use of the various divisions of the work. A separate room is needed for the library, and a properly lighted one for drafting. Special laboratories are of highest importance. The examination of the ordinary mineral samples is essential and in the future detailed analyses and tests must be made of our fuel resources, coal, oil, and gas. Hence, a fuel laboratory is urgent.

Much valuable material and supplies are in great danger of loss by fire. A vault is needed for the storing of reserve publications, manuscript, records, and general office supplies. Sufficient material is in possession of the Survey to arrange a geological museum exhibit, which will be of much value to the State from an educational and scientific standpoint.

The State's mineral production for 1913 was more than $80,000,000.00, an increase from $4,500,000.00 in 1901. The thousands of inquiries and the eagerness with which the Survey publications are received give evidence of the value of the Survey in assisting in the development of mineral resources. The expenditure of a few thousand dollars would provide a building for the Survey that would enable it to do much more efficient work and better meet the inquiries of the citizens of the State.

PART II.

MINERAL RESOURCES OF OKLAHOMA AND STATISTICS OF PRODUCTION FROM 1901 TO 1914.

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CONTENTS

ILLUSTRATIONS.

MINERAL RESOURCES OF OKLAHOMA AND STATISTICS OF PRODUCTION FROM 1901 TO 1914.

INTRODUCTION.

Oklahoma is larger than any state east of the Mississippi River, the area being 70,470 square miles. The mineral resources of the State are abundant. There are enormous supplies of coal, oil, gas, asphalt, gypsum, lead, zinc, shale, clay, glass sand, building sand, gravel, sandstone, granite, gabbro, limestone, marble, Portland cement rock, and salt, besides smaller deposits of iron, tripoli, novaculite, volcanic ash, and a little gold and silver.

In its natural resources Oklahoma stands among the first in the states of the Union. While not containing an abudance of the precious metals, its resources are varied in character and are very valuable, and the State is rapidly growing as a mineral producing and manufacturing center. While there has been such a wonderful growth in the development of natural resources, there has been so little done that no one can estimate either the amount or the value of these resources. The discovery and development of these materials in the State have added to the building up of great enterprises which have brought millions of dollars into the State to be invested in economic interests which are paying handsome dividends on the money invested.

Few states can show a more marked advance in the amount and value of mineral products during the past 10 or 12 years than Oklahoma. In 1901, with an output valued at $4,552,555 the advance has been steady, yet so rapid as to be little short of phenomenal. The total value in 1911 was $42,678,347, an increase of 839 per cent over 1901, an average yearly gain of about 83 per cent. In 1912 the output amounted to $53,958,695, and in 1913 to $80,031,630.

Oklahoma's greatest need today is more factories and mills. With unlimited natural resources, both agricultural and mineral, with a great supply of fuel and excellent waterpower Oklahoma is at present manufacturing only a small percentage of the materials used in the State. The people of the State are paying market price, plus the freight, for imported products. The valuable resources of the State must be exploited and attention called to the need for their development. This is the work that the State Geological Survey is trying to accomplish. It endeavors in every way possible to bring these materials to the notice of investors and to interest capital in their development. To this end the Survey most heartily invites the cooperation of the people of the State that the welfare of the State may be advanced.

Another thing which the Survey endeavors to do is to discourage useless prospecting for minerals in regions where geological conditions are such that no minerals need be expected. For instance, during the past few years thousands of dollars have been

spent prospecting for oil where the conditions are such that there is little or no chance of finding anything of value.

The precious metals are not always most valuable. There is a desire on the part of prospectors to always be searching for gold or silver while in the same region may be deposits of clay, shale, or other common mineral substances which are much more valuable than the quantity present of those which they seek. The search for precious and useful minerals has been diligently prosecuted since the days of earliest civilization, and the legends and literature are full of the stories of hidden treasures and fields of valuable minerals which were known to a certain person or tribe. In many instances these materials have been the object of search for centuries, but just as much in vain as the child's search for the pot of gold at the end of the rainbow. Gold, silver, and diamonds have been the principal source of attraction, and minerals of great abundance and value have been passed by in the desire to reach the precious metals.

Among the most valuable of natural resources of Oklahoma are the fertile soils. All the great business enterprises are dependent to a large extent on the productiveness of the soil.

The minerals which are always of very great importance to the upbuilding of any region are the fuels, coal, oil, and gas. In many parts of the country the fuel must either be hauled long distances to the raw material, or the raw material hauled to the fuel. Oklahoma's fuel supply is enormous. Coal, oil, and gas are all present in large amounts. This means that not only will the raw material in the State be manufactured at home, but mineral production from other states will be shipped here to be manufactured.

The numerous requests which are received at the office of the Geological Survey for information concerning the mineral resources and mineral products of the State can not be met by the special publications on the various resources, or by individual correspondence in all cases. It is the purpose of this report to give some general information concerning each of the minerals and the statistics of production.

The statistical data for the years 1901 to 1910 inclusive, are taken largely from the various publications of the United States Geological Survey. Those for 1911 to 1914, inclusive, are from records in the office of the Survey and were collected in cooperation with the United States Geological Survey. In most cases where estimates are given it will be found that data are for two or more products or the production for two or more states are combined by the Federal Survey. This is done when not more than three producers report from the State, in order to conceal figures of the individual producers.

In the preparation of this bulletin the various members of the Staff contributed much to the work. While the report is based

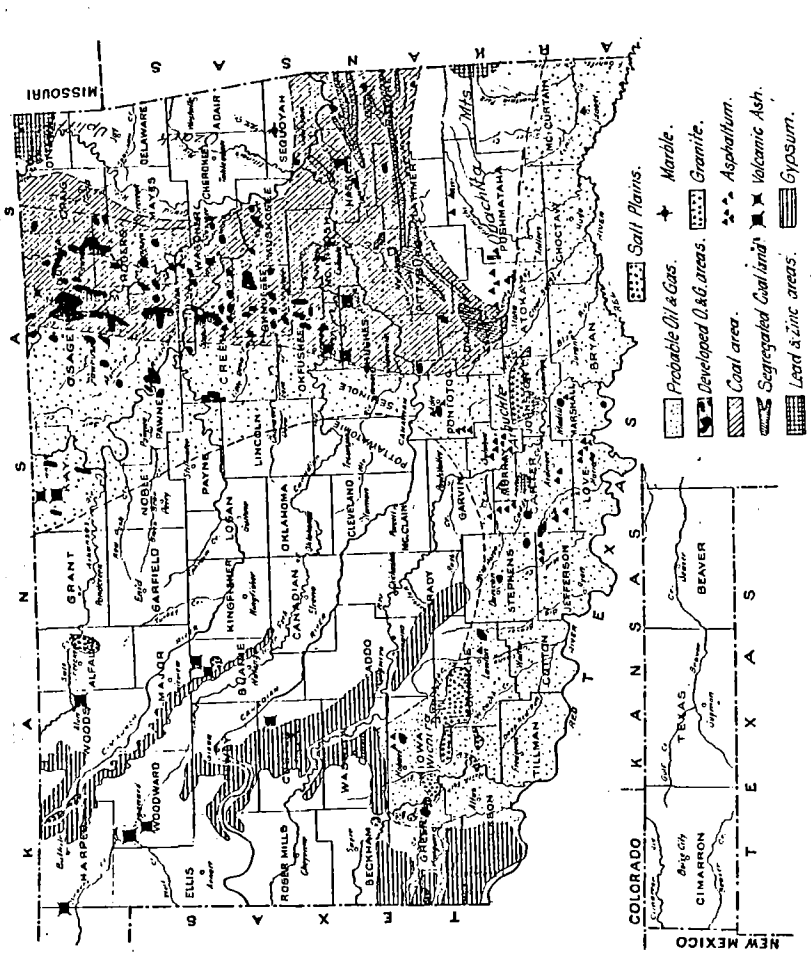


Fig. 1. Map of Oklahoma showing distribution of mineral resources.

together, being separated by only a few inches of clay shale. The coal has practically the same aspect and quality as the lower bed. West of McAlester it is 5 feet in thickness and in the Wilburton district it is 4 feet 6 inches thick. In the extreme eastern part of the field it thins out locally to 2 feet or less. The variation in thickness seems to occur without material change in quality, except in a few places where clay or shale partings occur within the bed.

In various parts of the areas covered by these coal beds, drilling, prospecting, and the sinking of shafts have revealed the presence of other thin beds of coal above the two principal beds. The roof above both Hartshorne coals is good. The material is usually a hard slate shale locally replaced by sandstone. The immediate floor of the lower bed varies from clay shale to slaty sandstone, while that of the upper is a compact fire clay usually containing a large percentage of carbonaceous matter.

In the south end of the field the Hartshorne coal is known as Atoka coal. It has not been extensively prospected, and but few places have been developed. It appears that two or three small operations are being carried on. The thickness is approximately 4 feet, and it is usually clear of impurities and of fair quality. The table of analyses following shows the character of these coals in the various parts of the field. The analyses are arranged in order from the west end to the east. Going eastward the volatile matter decreases and fixed carbon increases, and the percentage of ash also decreases. In the extreme eastern part of the field the coal is classed as semi-anthracite.

McALESTER COALS.

The McAlester coal occurs in the McAlester shale, 1200 to 1500 feet above the Hartshorne coals, or about 700 feet below the top of the formation. The bed has an outcrop length of 70 miles in the southern part of the district. The coal varies in thickness from 4 feet 6 inches in the west end of the district to about 3 feet in the east. In the south end of the field it has a thickness of 3 feet 6 inches to 5 feet. This coal contains no shale partings. It is of high quality, mines well, and is a good shipping coal.

Several thin beds of coal occur in the upper part of the McAlester shale, but none of workable thickness, except locally. Four or five thin beds are also found below the main McAlester bed in the same formation. Some beds of varying thickness and quality are found in the Boggy shale. Several years ago one of these beds was mined southwest of McAlester, and at a few localities there are a few small operations on these thin beds.

Stigler coal.—In the area lying directly south of the junction of Canadian and Arkansas rivers is a considerable area of coal known as the Stigler coal. It occupies approximately the same position geologically as the McAlester coal, but it has not been determined definitely whether it is the exact equivalent. In this region there is but one bed of any considerable value and the chief bed is thinner than the McAlester coal in the vicinity of McAlester, the thickness being less than 2 feet 6 inches. The coal lies in a basin, the axial part of which extends in a northeast-southwest direction. The coal is inclined toward the center at angles from 2° to 10° at the outcrop. Several small mining operations have been carried on in this vicinity, but at the present only a very limited amount of work is being done for local use. The coal is well suited for shallow mining. The quality is good and the impurities and ash content are low.

Lehigh coal.—In the south end of the coal field in Atoka and Coal counties the McAlester coal is known as the Lehigh bed. Several of the most important mines of the State operate on this bed in this section. The coal is of good quality and maintains a fairly uniform thickness over this area. The ash content is a little higher and the heat value a little less than is shown by the coal from the same bed in the immediate McAlester field.

CAVANAL COAL.

The Cavanal coal is found in the eastern part of the field chiefly in the northern part of Leflore County. The coal was named for Cavanal station on the St. Louis & San Francisco Railroad. The coal outcrops at the foot and almost entirely around Cavanal Mountain, and the dip is from 6° to 10° toward the center of the mountain. It is the best workable thickness on the east and south sides. The bed varies in thickness from 2 feet to 3 feet 6 inches.

At several other localities a coal bed in the same stratigraphic position as the Cavanal occurs.

The quality of the coal is fair to good. Some thin bands of shale and bony with sulphur concretions occur near the top of the bed. The roof is of hard, slaty shale and the floor is compact clay. This coal is a good fuel for steam and domestic purposes.

WITTEVILLE COALS.

The Witteville coal beds receive their name from the village of Witteville located at the east end of Cavanal Mountain. There are 2 beds separated by about 200 feet of shale and sandstone. These coals are the highest, geologically, of any found in the area of segregated coal lands, or to the south of Canadian River. Both beds have been prospected and mined, but the upper bed is not extensively developed. One of the beds is mined at Sutter. The coal occurring in the mountainous region north of McAlester, in the vicinity of Featherston and Quinton, occupies the same stratigraphic position and is probably upper Witteville. In this region and to the westward about Blocker, this coal is called the Jones Creek coal.

In the vicinity of Witteville the upper bed is 3 feet 10 inches thick, being separated into 2 almost equal benches by a shale parting. The lower bed is 4 feet 8 inches and is separated into 3 benches. The lower bed occurs at the top of the Savanna formation, while the upper bed is in the Boggy shale, 800 to 1000 feet above the Cavanal coal.

HENRYETTA COAL.

The Henryetta coal is the principal bed in the coal area north of Canadian River. The mining of this coal is carried on in the vicinity of Schulter, Henryetta, Dewar, and Coalton, in Okmulgee County.

The coal bed is from 2 feet 10 inches to 3 feet in thickness. The coal is fairly free from impurities. In part of the field the coal constitutes a solid bed, while in some of the mines the bed is separated by a thin bony and shale parting. In general the roof is a good quality of shale, and the immediate floor consists of 3 to 6 inches of soft clay, below which is a harder rock. The dip of the bed is southwest about 20 feet to the mile.

Under the method of shooting from the solid this coal produces a large amount of slack and fine coal. As a result of this, most of the mines are installing machines. Some of the operations are slope mines, others are shafts, the deepest of which are a little more than 300 feet. The coal when properly mined and shipped gives good results as a domestic fuel. All grades, including mine run, and crushed grades of fine coal are sold for industrial purposes.

SEGREGATED COAL LANDS.

A few years ago about 500,000 acres of coal lands in Indian Territory (Oklahoma) were segregated or set apart for the benefit of certain Indian nations. The segregation was done before the Choctaw and Chickasaw Indians took their allotment as a result of a treaty between these nations and the Government. The work of segregation was done by the United States Geological Survey and five years were spent in investigating the field and mapping the outcrops of the coal deposits and estimating the amount of available coal. The area was divided into tracts of 960 acres each and offered for sale at two different times, all bids being rejected in each instance. Much of the segregated land has been leased to individuals and companies which are operating mines. A royalty of 8 cents per ton is paid the Government for the benefit of the Indians. The value of the royalty is from $250,000 to $300,000 yearly. By a recent provision of Congress the surface of segregated lands has been appraised and the lands are being sold during November and December, 1914. Only the surface is sold, the mineral rights being held for the Indians.

All the coal lands of the State are not included in the segregation. Lying chiefly to the north of the segregated area and extending to the Kansas line much good coal is found. After the segregation of the coal lands considerable controversy arose as to the actual value and amount of coal available in the districts. A careful examination of the coal lands followed. Arrangements were made whereby a considerable amount of diamond core drilling and other prospecting was done to determine the extent of dip and character of coal at various distances from the outcrop, and in localities where mining operations had not been carried on from which the data could be secured.

HEATING VALUE.

The chief uses of coal are for steam purposes and for domestic fuel. The question of obtaining the best results from coal burned is of very great importance. The primary object in the burning of coal is the generation of heat. It is readily observed that there is a great difference in the quality of different fuels and in the burning of fuels it is found that some are better adapted for special purposes. The most valuable coal is that which gives up the most heat for a given weight when burned.

During the past few years much coal has been bought and sold on the basis of the heat value. The value is indicated by the number of heat units which the coal contains. This heating value is usually expressed in terms of British thermal unit (B. t. u.) per pound of coal, and the determination is made by means of a special apparatus called a calorimeter. That those persons not familiar with the method of determining the heating value of coal may properly interpret the tables, the following explanation is given. A British thermal unit is the amount of heat required to raise the temperature of one pound of water through 1° F. That is, a pound of coal containing 14,000 B. t. u. would increase the temperature of 14,000 pounds of water through 1° F., if all the heat could be utilized, or would convert 14.5 pounds of water at 212° F. into steam if no heat were lost in the process. In actual use a part of the heat from burning the coal is necessarily lost in the escape of gases, in the radiation from the boiler and furnace, so that only 60 to 75 per cent is actually used in generating steam. In purchasing coal for any purpose the aim should be to obtain such fuel as will produce the greatest amount of heat for the least cost.

A large number of calorific determinations have been made of Oklahoma coals and it has been found that an average value is obtained of 200 B. t. u. for each per cent of volatile matter, and 120 B. t. u. for each per cent of fixed carbon. The heat value may then be roughly estimated as equal to 200 times this percentage of volatile matter plus 120 times the percentage of fixed carbon. It will be observed that when the ash content is high and the fixed carbon

is an average or below, the B. t. u. determination from the analyses will be considerably higher than that given by a calorimeter, and in those samples where the volatile matter is low, the carbon content high, and generally high ash, the B. t. u. is lower than the calorimeter determination. The heat units of Oklahoma coals as tested range from about 9,000 to 14,000 B. t. u.

PRICES OF COAL.

The price of coal in Oklahoma to the consumer is high. This is due to several causes. Mining conditions in the State cause the coal to cost more in mining than in most other states. Freight rates are higher than in other coal states, and the middleman's profit is large. Consequently, practically all grades of lump coal cost the people of the State, who are any distance removed from the coal field, from $7 to $8 per ton, while the nut, chestnut, and mine run coals cost from $6 to $7 per ton. Competing coals from other states sell at about the same price and being brought to us in a better shipping condition are gaining a strong foothold in the market for Oklahoma coal.

MINING COAL BY STRIP PITS.

In Oklahoma at the present time there are about 125 mines, including shaft, slope, and strip-pits. In northeastern Oklahoma and southeastern Kansas there are several thin beds of coal covering large areas. Until very recently these coals had not received very favorable notice. These deposits consist of almost continuous beds and are from 1 foot 6 inches to 2 feet in thickness. The coal is of extra good quality for shallow coal. These beds are covered with an overburden of shale and clay from less than 10 to 30 feet in thickness. Some of these deposits, as well as narrower strips along the outcrop of the principal beds in the main part of the field, have been worked in the past by stripping with horses and scrapers, but this method was not found practicable where the covering is more than 10 feet. During the past few years steam shovel operations have begun in these areas and a marked development has taken place. On the Kansas side at least 20 shovels are at work in the vicinity of Pittsburg, and 2 shovels of the largest type are operating in the Oklahoma field. The steam shovel seems to have fully solved the problem of mining these coals in an economic

STATISTICAL INFORMATION.

HISTORY OF DEVELOPMENT AND PRODUCTION.

The following paragraphs and tables, give statistical information from the earliest development of Oklahoma coals to the present time:

1872 First date on which coal was mined on commercial scale in Indian Territory. (Oklahoma Almanac 1909.)

1880 The tenth United States census contains the first published record of coal production in Oklahoma (Indian Territory), although since a small quantity of coal was mined in Arkansas as early as 1840, it is probable that some was produced in the Territory earlier than 1880. In this year 120,947 tons were produced.

1884 Term "windy shot" originated. Miners in Indian Territory fired their own shots until 1885. Miners working in slopes and entries fired their own shots until 1892. Since that time no one but shot firers have been allowed to fire shots in Oklahoma mines that were considered dangerous.

1890 Oklahoma produced 869,230 short tons.

1897 United States Geological Survey began the survey of the Choctaw coal field, starting at the west end, where the work had been in progress and continued to the east end of the McAlester district. A report on the economic features of the coal was published in Part III of the Nineteenth Annual Report in 1899. After nearly the whole of the Choctaw coal field had been surveyed, a summary of the knowledge of the coal in Indian Territory, Arkansas, and Texas, entitled "The Southwestern Coal Field," was published in Part III of the Twenty-second Annual Report of the Survey, in 1900-1901.

1900 Oklahoma produced 1,922,300 short tons.

1907 This was a boom year in coal production in Oklahoma, there being a maximum production of 3,642,658 short tons.

1908 Oklahoma produced 2,948,116 tons of coal.

1909 Oklahoma produced 3,119,377 tons of coal.

1910 Total production of coal in the United States was 501,596,378 short tons, spot value $629,557,021. The first time that the United States attained the half-billion mark in short tons.

1910 The great output was obtained in spite of the fact that most of the mines of Illinois, Missouri, Kansas, Arkansas, and Oklahoma were closed down for nearly six months by one of the most bitterly contested strikes in the history of the industry.

1910 Oklahoma produced 2,646,226 tons of coal. Oklahoma was one of the states most seriously affected by the prolonged strike.

1911 During this year the coal production in Oklahoma amounted to 3,074,242 tons, an increase of 428,016 tons over 1910. However, with this increased output the tonnage for 1911 was less than the average for the preceding eight years by more than 10,000 tons. The price per ton at the mine declined from $2.22 in 1910 to $2.05 in 1911.

1912 Oklahoma's coal production was 3,675,418 tons, exceeding by nearly 33,000 tons the record production of 1907. The average price advanced from $2.05 to $2.14. The increase was due chiefly to the decrease in the use of natural gas and oil for fuel purposes.

1912 On March 23, a gas explosion occurred in the San Bois mine No. 2 at McCurtain, resulting in the loss of 73 lives. A total of 99 fatal accidents were reported for the year, all underground.

1912 The number of men employed in the mines of the State for the year was 8,785. In 1911 there were 8,790. The average number of days worked was 174 as against 156 in 1911. The average production per man was 2.4 tons, as compared with 2.24 tons in 1911.

1913 The production for this year exceeded the output of 1912 by 490,352 short tons with an increase in value of $675,417. The average time made by the 9,044 men employed was 197 days, as compared with 8,785 men for 174 days in 1912. The average total production per man was 461 tons, against 418 tons in 1912, but the average daily production by each employee fell off slightly, from 2.4 to 2.34 tons.

1914 The average conditions over the field were not as good as in the previous year. Statistics are not available for the entire year, but the indications are for a marked decline in production. Returns for 7 months of the year show 2 months with an increase of 57,533 tons over the same months in 1913, while the total decrease for 5 months was 143,996 tons, a decrease for the 7 months of 86,463 tons. Several of the principal mines were either closed the entire year or operated only a part of the time.

Quantity and value of coal produced in Oklahoma, 1880-1913.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1880	120,947	$.....	1897	1,336,380	$1,797,358
1881	150,000	.....	1898	1,381,466	1,827,638
1882	200,000	.....	1899	1,537,427	2,199,785
1883	350,000	.....	1900	1,922,298	2,788,124
1884	425,000	.....	1901	2,421,781	3,915,268
1885	500,000	.....	1902	2,820,666	4,265,106
1886	534,580	.....	1903	3,517,388	6,386,463
1887	685,911	.....	1904	3,046,539	5,532,066
1888	761,986	.....	1905	2,924,427	5,145,358
1889	752,832	.....	1906	2,860,200	5,482,366
1890	869,229	.....	1907	3,642,658	6,253,367
1891	1,091,032	1,897,037	1908	2,948,116	5,976,504
1892	1,192,721	2,043,479	1909	3,119,377	6,253,367
1893	1,252,110	2,235,209	1910	2,646,226	5,867,947
1894	969,606	1,541,293	1911	3,074,242	6,291,494
1895	1,211,185	1,737,254	1912	3,675,418	7,867,331
1896	1,366,646	1,918,115	1913	4,165,770	8,542,748

Coal production in Oklahoma in 1908, 1909, 1910, 1911, 1912 and 1913, by counties, in short tons.

County.	1908	1909	1910	1911	1912	1913
Coal	576,746	658,159	498,658	778,546	816,155	889,299
Haskell and Latimer .	674,636	739,806	675,953	701,374	766,798	738,679
LeFlore' ...	187,624	128,376	87,628	122,468	150,511	201,853
Okmulgee .	172,934	262,310	227,107	408,202	629,989	820,659
Pittsburgh	1,294,936	1,271,109	1,083,343	1,018,742	1,234,334	1,429,350
Rogers and Wagoner	.....	14,556	27,618	18,784	30,756	31,067
Tulsa	39,848	39,834	40,007	21,422	39,964	52,300
Small mines	1,392	6,227	6,012	4,704	6,911	2,563
Total ...	2,947,116	3,119,377	2,646,226	3,074,242	3,675,418	4,165,770
Total value	$5,976,405	$6,253,367	$5,876,947	$6,291,494	$7,867,331	$8,542,748

Average prices for coal at the mines in Oklahoma and neighboring regions, 1900-1906.

State.	1900	1901	1902	1903	1904	1905	1906
Alabama	$1.17	$1.10	$1.20	$1.22	$1.20	$1.21	$1.34
Arkansas	1.14	1.14	1.31	1.51	1.54	1.49	1.61
Colorado	1.12	1.13	1.13	1.23	1.31	1.22	1.26
Illinois	1.04	1.03	1.03	1.17	1.10	1.06	1.08
Indiana	1.03	1.01	1.10	1.23	1.11	1.05	1.08
Iowa	1.38	1.39	1.47	1.65	1.61	1.56	1.60
Kansas	1.22	1.22	1.30	1.52	1.52	1.46	1.49
Kentucky	.92	.95	.99	1.06	1.04	.99	1.02
Missouri	1.21	1.24	1.38	1.61	1.63	1.58	1.63
New Mexico	1.37	1.42	1.43	1.37	1.31	1.33	1.34
Oklahoma	1.45	1.62	1.51	1.82	1.82	1.76	1.92
Texas	1.63	1.72	1.64	1.62	1.66	1.64	1.66

1907-1913.

State	1907	1908	1909	1910	1911	1912	1913
Alabama	$1.29	$1.26	$1.19	$1.26	$1.27	$1.29	$1.31
Arkansas	1.68	1.68	1.48	1.56	1.61	1.71	1.76
Colorado	1.40	1.41	1.33	1.42	1.45	1.49	1.52
Illinois	1.04	1.05	1.05	1.14	1.11	1.17	1.14
Indiana	1.09	1.06	1.02	1.13	1.08	1.14	1.11
Iowa	1.60	1.63	1.65	1.75	1.73	1.80	1.79
Kansas	1.52	1.49	1.44	1.61	1.53	1.62	1.67
Kentucky	1.06	1.01	.94	.99	.99	1.02	1.05
Missouri	1.63	1.64	1.65	1.79	1.72	1.76	1.73
New Mexico.....	1.46	1.37	1.29	1.39	1.44	1.42	1.46
Oklahoma	2.04	2.03	2.00	2.22	2.05	2.14	1.05
Texas	1.69	1.80	1.72	1.67	1.66	1.67	1.77

ANALYSES.

In the preparation of the report on Coal and Coal Mining in Oklahoma a large number of Coal samples were analyzed, and many others compiled from various sources. Several of these analyses are given in the following tables.

Analyses of Oklahoma Coals.

Coal Bed and Location.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus.	B. t. u.	Kind of sample.
Lower Hartshorne Halleyville No. 1..	2.60	37.36	52.86	6.46	.70	...	13,707	Mine sample
Lower Hartshorne Halleyville No. 2..	3.21	40.28	50.87	4.41	1.23	...	14,000	
Lower Hartshorne Hartshorne No. 3..	4.32	38.57	48.42	7.30	1.39	...	13,900	
Lehigh								nut & slack
Lower Hartshorne Hartshorne No. 7..	3.10	37.91	50.79	6.56	1.64	...	13,640	Mine sample
Lower Hartshorne Gowen No. 40.....	3.00	39.34	50.86	5.66	1.14	...	13,701	Mine sample
Lower Hartshorne Panama	1.49	37.83	53 06	7.02	1.01	.023	.....	
Lower Hartshorne Red Oak	1.52	32.76	59.90	4.52	1.30	...	14,500	
Lower Hartshorne Southwest of Howe	.45	20.89	68.86	9.80	.69	.063	.....	
Lower Hartshorne Hughes	2.92	32.45	60.26	3.47	.90	...	14,500	
Lower Hartshorne Panama No. 2.....	.94	15.88	72.47	9.25	1.46	...	13,875	Mine run
Upper Hartshorne Wilburton	1.43	38.15	50.76	9.66	.038	.052	.....	
Upper Hartshorne Howe	.41	18.23	76.53	3.77	1.06	...	.....	
Upper Hartshorne Panama	.17	16.53	78.27	5.02	.88	.033	13,698	Stand. samp.
Lower Panama Adamson Nos. 3 & 4	1.82	37.95	54.07	5.46	.70	...	14,070	Car lump
Lower Panama Adamson No. 4....	1.95	34.99	55 95	5.65	1.46	...	13,769	Mine sample
Lower Hartshorne Pocahontas No. 2..	2.45	37.92	52.82	5.91	.90	...	13,932	Mine sample
Lower Hartshorne Pocahontas No. 2..	2.25	38.01	47.39	10.08	2.27	...	13,200	Lump
Lower Panama E. of Bokoshe No. 3	1.85	15.86	63.11	17.86	1.32	...	11,337	Nut & slack
Lower Panama W. of Bokoshe No. 7	1.18	16.32	69.53	10.51	2.46	...	12,678	Mine run

Analyses of Oklahoma Coals.

Coal Bed and Location	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus.	B. t. u.	Kind of sample.
Lower Panama West of McCurtain	2.11	22.66	66.83	7.24	1.16	...	13,289	Mine sample
Lehigh Lehigh No. 5.....	3.75	38.15	45.77	12.33	3.83	...	13,122	Mine sample No. 1.
Lehigh Lehigh No. 5.....	4.69	39.76	46.06	9.49	3.74	...	12,775	Mine sample No. 2.
Lehigh Lehigh No. 5.....	3.56	41.61	41.12	13.71	4.56	.024	13,256	Car load Commercial
Lehigh Lehigh No. 5.....	6.24	35.44	45.33	12.99	3.86	...	11,998	Car load
Lehigh Lehigh No. 8.....	5.54	38.12	40.42	11.16	4.76	...	12,100	Mine run
Lehigh Coalgate No. 5.....	5.96	36.03	44.44	10.48	3.09	...	12,194	Mine sample
Lehigh Coalgate No. 10....	5.42	36.47	49.18	6.98	1.95	...	12,877	Mine sample
McAlester Pittsburg No. 1....	4.79	37.30	47.58	10.33	3.93	...	13,088	Car load
McAlester Pittsburg No. 1....	4.80	33.91	57.47	2.42	1.40	...	13,124	Dom. lump
McAlester Pittsburg No. 1...	4.79	37.30	47.58	10.38	3.93	...	13,088	Car load nut & slack
McAlester Craig No. 4.....	2.44	37.73	50.91	7.91	.38	...	13,592	Car load nut
McAlester S. W. Hailleyville 6	3.55	35.85	56.43	3.07	1.10	...	13,865	Car lump
McAlester Dow Nos. 2 & 5....	2.99	35.72	56.12	3.80	1.37	...	13,897	Car lump Mine No. 2
McAlester Dow No. 9.....	2.64	36.02	54.72	5.42	1.20	...	13,789	Mine sample
McAlester Alderson No. 5.	2.17	37.95	54.88	3.98	1.02	...	14,434	Mine sample
McAlester S. of Krebs No. 8..	2.50	35.82	53.50	6.79	1.39	...	13,686	Mine sample
McAlester Busby No. 5.....	2.83	34.14	55.40	6.93	.70	...	13,673	Mine sample
McAlester Baker No. 9.....	3.56	36.22	51.44	6.81	1.97	...	13,235	Mine sample
McAlester Buck No. 6.....	1.04	37.96	55.84	5.16	2.00	0.12	14,293	

Coal Bed and Location.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Phosphorus.	B. t. u.	Kind of sample.
Henryetta Creek No. 1.....	6.59	33.17	51.99	7.24	1.01	...	12,873	Mine sample
Henryetta Victoria No. 1.....	5.50	35.61	49.84	7.34	1.71	...	13,009	Mine run
Dawson Broken Arrow strip pit	.05	20.07	78.63	1.25	...	...	13,449	
Dawson Collinsville	.05	20.05	78.60	1.30	...	...	13,442	

COKE.

The State has manufactured no coke since 1908. In 1905 the coking industry was thriving, but from that time until 1908 there was a steady decline in the output.

At one time there were 5 coke plants in the State, one located at each of the following places: Howe, Alderson, Henryetta, Krebs, and McCurtain. These 5 plants had a total of 536 ovens, 50 of which were constructed as late as 1908. All are now idle and several have been allowed to go to ruin. This discontinuance of coke manufacture is due to several causes: (1) Much of the coal failed to produce satisfactory coke. (2) Gas as a cheap and convenient fuel was available for factories and smelters. (3) The ovens were built to use slack coal and the present demand for slack coal increased the price so that it was no longer profitable to manufacture coke.

A briquetting plant was built at Hartshorne for the briquetting of slack coal, but this plant has not been operated since the demand increased for this grade of coal.

The following table shows the amount and value of the coke production from 1901 to 1908:

Quantity and value of coke produced in Oklahoma, 1901-1908.

Year	Quant'y sh. t'ns.	Value	Year	Quant'y sh. t'ns.	Value
1901	37,374	$154,834	1905	54,781	$199,424
1902	49,441	202,921	1906	49,782	204,205
1903	49,818	227,542	1907	19,089	82,447
1904	44,808	209,165	1908	2,994	(e) 13,473

PETROLEUM AND NATURAL GAS.

HISTORY OF DEVELOPMENT.

GENERAL.

The Mid-Continent field.—The Mid-Continent oil and gas field is composed of the petroleum producing regions of Kansas, Oklahoma and northern Texas.

Prospecting for oil and gas began near Panola, Kans., as early as 1860, and by 1873 considerable gas had been found near Iola, and Panola was heated and lighted by natural gas in 1882. Real development began in 1890 and production has gradually increased until the Mid-Continent field ranks first among the producing regions of the United States, the total amounting to practically one-fourth of the total production of the country. In 1912 the production of the field amounted to 65,400,000 barrels, in 1913 to over 66,500,000 barrels, and the first half of 1914 showed a further increase but the condition of the oil business the latter half of the year will cause a big decline in the total production for the year.

Petroleum was first discovered in Texas about 1860, near Nacogdoches at a depth of 100 feet. The Sour Lake find was in 1893. Many of the first wells had a depth of about 280 feet. The Corsicana field was developed in 1894 and 546,000 barrels of oil were produced in 1898, but the real importance of Texas in oil production did not begin until 1901, with the bringing in of the Lucas well at Beaumont (Spindletop). The production placed Texas second in rank in 1905, but decline soon followed, until the opening of the Electa, Petrolia (Henrietta), and Burkburnett fields. Other small fields recently opened are those of Iowa Park, Powell, and the fields of Marion County. The Electra field was opened in 1899, when showings of oil were found at depths of 200 and 500 feet. Six years later a well drilled 1850 feet gave only showings of

oil. In the spring of 1910 the Producers Oil Company drilled six other wells within a radius of one-half mile of the initial well and little is known of these undertakings except that enough oil was found to pay for pumping. By September, 1911, there were 18 producing wells. Drilling was begun on the well in the Burkburnett region about the first of 1912, and completed the first of July, which gave an estimated production of 100 to 200 barrels. The wells were owned by the Corsicana Petroleum Company, and the leases on the land ranged from $5 to $50 per acre, with some valuations as high as $10,000 for 80 acres. The Iowa Park field was opened in 1913. The first well came in as a producer of about 30 barrels at a depth of 475 feet. In a short time the production was down to 5 barrels and the well was drilled deeper.

The Saratoga pool was opened in 1901 with small production, but in 1903 produced 150,000 barrels. The Matagorda field has been principally developed since 1903. The Batson Prairie pool was opened in 1904, and in one year produced 10,000,000 barrels. The fields of Humble and Dayton and some other small fields were opened between the years 1903 and 1905.

The Texas areas, the production of which is included in the Mid-Continent field, comprise those in northern Texas, Corsicaa, Henrietta, Powell, Electra, South Bosque, those in Marion County, and a few minor pools. The present production of the states in the Mid-Continent field shows for northern Texas 5,275,524 barrels in 1912, the total for the State being 11,735,057 barrels. The first reported production from the field was 1400 barrels in 1896. Kansas produced 500 barrels in 1889, and reached its maximum in 1905-06, when over 6,000,000 barrels were produced. Oklahoma is credited with 30 barrels of oil in 1891 and did not reach the 1000 barrel mark until about 1900, but in 1904 the production passed the million barrel mark, that for 1912 being 51,427,071 barrels, and in 1913, 55,018,541 barrels. These high productions placed Oklahoma in second rank in production and first in value of oil.

OKLAHOMA.

The discovery of oil in Kansas created excitement on the Indian Territory side and in 1884 the Choctaw Oil and Refining Company was formed. One well was begun about 20 miles north of Tahlequah and another on Clear Boggy Creek, about 14 miles west of Atoka. Neither produced more than showings of either oil or gas. There was no further activity until 1894, when the Cudahy Oil Company drilled two wells at Muskogee, each of which showed good prospects, but no active development took place in this field until 1904, when it became possible to secure proper titles to land and to have allottees' leases approved by the Department of the Interior.

The Red Fork-Tulsa district was opened by the drilling of a producing well in 1901. Practically all the activity in the early part of 1904 was confined to the Osage Nation. The Cleveland field was opened in September, 1904, and some development occurred in the vicinity of Muskogee, Chelsea, Red Fork, Bartlesville, Alluwe, Lenapah, and Dewey. In the same year there was considerable active development and extension of known fields.

The Wheeler field, northwest of Ardmore, was discovered in 1905. In 1906, in addition to active development, the famous Glenn Pool was opened. This pool reached its maximum production in March, 1911, when 2,584,464 barrels were produced. The field about Dewey was opened in 1906, as was also the Morris pool. By the close of the year the production for the State was about 7,000,000 barrels. In 1908 a new pool of excellent high-grade oil was found at Muskogee. The principal features of this year were high production wells and the finding of deeper sands in the producing fields.

The production and activity of 1910 considerably surpassed that of 1909. The chief centers of new activity were Henryetta and Osage. Gas was discovered at Poteau. In 1911 further development was shown in the fields and a special increase in the Hogshooter region.

Early in 1912 the price of oil advanced from 50 cents to 83 cents per barrel. Drilling was greatly stimulated, and as a result old fields were extended and much "wildcatting" was done which proved successful. The principal feature of the new developments was the discovery of the Cushing field. Other important developments were—the discovery of deeper sands in the Cleveland field; the eastward extension of the Glenn Pool district; the opening of the Adair pool, west of Nowata; renewed activities in the Ponca City field; and in Okmulgee County. A good gas well was brought in near Duncan, and some development was made at Loco.

In 1913 the price of oil advanced to $1.05 per barrel, with a premium of 20 to 50 cents per barrel additional for certain light grade oils. During this year the principal new development was the opening of the Healdton field. The first well was drilled in August, and by the close of the first year more than 300 wells had been drilled, with 270 of these as producers. Several shallow wells were drilled in the vicinity of Lawton and numerous "wildcatting" adventures were made throughout central and southwestern Oklahoma. Activity was renewed in the Madill region. Several new fields were added to the list early in the year by the bringing in of good producers in localities outside the proven fields. The conditions of the oil market have prevented further drilling in these localities. During 1913 and the early part of 1914 drilling operations reached the highest point of activity. When the drop in the price

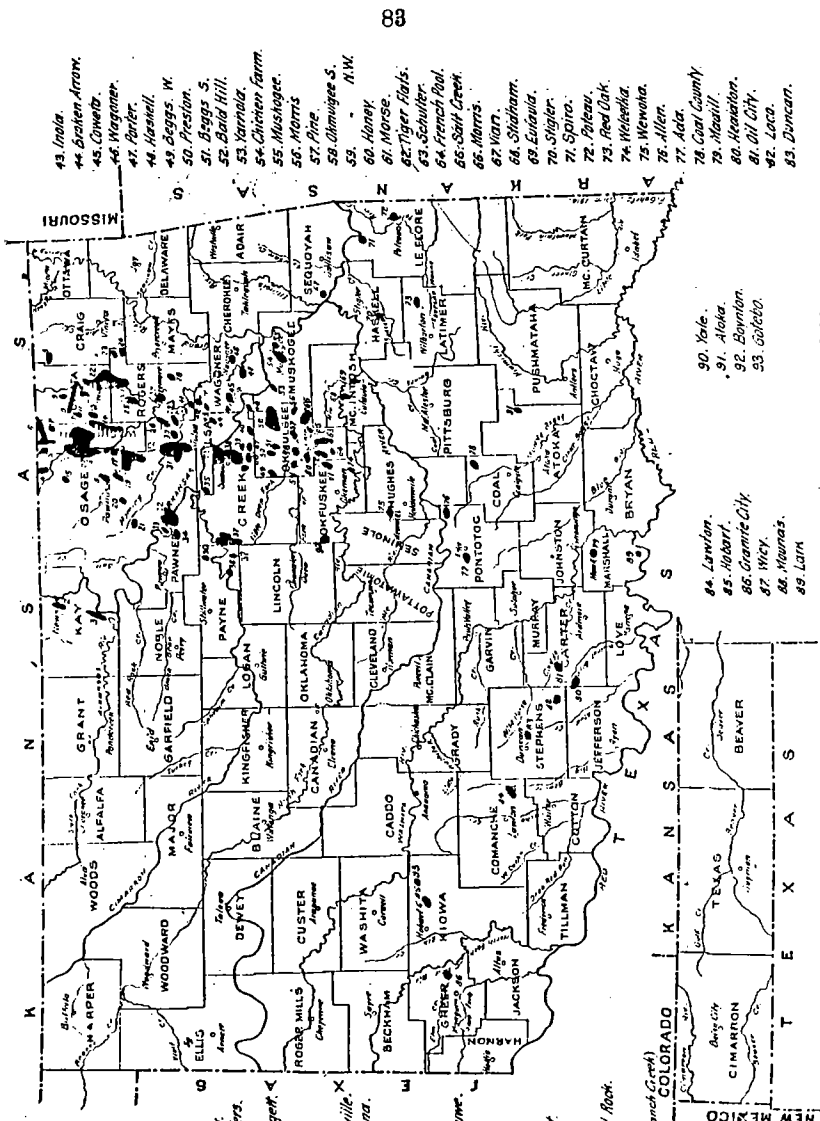


Fig. 2. Map of Oklahoma showing location and names of oil and gas fields

came in the early part of 1914 the State was producing over 250,000 barrels of oil daily. The first half of the year showed a total production of 45,600,650 barrels. In the latter half of the year development was as much curtailed as possible.

Production, value, and average price of oil, 1901-1913.

Year.	Barrels.	Total value.	per bbl. Av. price
1901 ...	10,000	$ 7,125	$0.712
1902 ...	37,100	32,940	.888
1903 ...	138,911	142,404	1.025
1904 ...	1,366,748	1,325,745	.97 (e)
1905 ...	6,466,200	3,524,122	.545(e)
1906 ...	18,030,600(e)	8,000,000	.443(e)
1907 ...	43,524,128	17,213,524	.402
1908 ...	45,598,765	17,694,843	.386
1909 ...	47,859,218	17,428,990	.364
1910 ...	52,028,718	19,922,660	.383
1911 ...	56,069,637	26,451,767	.470
1912 ...	51,427,071	34,672,604	.674
1913 ...	58,203,740	55,018,541	.937

(e) Estimated.

LIST OF OIL AND GAS FIELDS IN OKLAHOMA.

Ada	Coal County	Hominy	Pine
Adair	Coody's Bluff-	Hominy	Ponca City
Allen	Alluwe	Inola	Porter
Anabel	Copan	Jenks	Poteau
Atoka	Collinsville	Kiefer	Preston
Avant	Coweta	Lark	Ramona
Back Creek	Cruce	Lauderdale	Ranch Creek
Bald Hill	Cushing	Lawton	Red Fork
Bartlesville	Delaware-Childers	Leonard	Red Oak
Bartlett	Delaware-Ext.	Lightning Creek	Salt Creek
Beggs South	Dewey	Loco	Schulter-Henryetta
Beggs West	Duncan	Lost City	Spiro
Bigheart	Eufaula	Madill	Stidham
Big Creek	Eram	Mannsville	Stigler
Bird Creek	Flat Rock	Morris	Tanecha
Bixby	French Pool	Mounds	Tiger Flats
Blackwell	Granite City	Morse	Turley
Boston	Glenoak	Muskogee	Vian

Boynton	Glenn Pool	Nelagony	Wagoner
Broken Arrow	Gotebo	Neodesha	Wainwright
California Creek	Hamilton Switch	Newkirk	Wann
Canary	Harry	Nowata	Weimer
Caney	Haskell	Ochelata	Weleetka
Catoosa	Healdton	Oil City	Wewoka
Chelsea	Hichita	(Wheeler)	Wicey
Chicken Farm	Hickory Creek	Okmulgee S.	Woodville
Claggett	Hobart	Okmulgee NW.	Wynona
Claremore	Hoffman	Oolagah	Yale
Cleveland	Hogshooter	Owasso	Yarhola

REFINERIES.

GENERAL.

Any information which may be prepared for publication concerning oil refineries is soon out of date, for the reason that new refineries are constantly being constructed and old plants rebuilt or enlarged. The fact that 8 modern refineries were built in Oklahoma in 1913, and enough improvements made in the old plants to make the total daily capacity of all plants in the State 20,000 barrels greater than that of the previous year would serve as a proof of this. Large amounts of Oklahoma crude are carried to refineries in Kansas, Indiana, and other states by the pipe lines of the Prairie Oil and Gas Company, and to the refineries in Texas and Louisiana by the Texas Company, Gulf Pipe Line Company, and Oklahoma Pipe Line Company. The refineries of the Cudahy and National companies are also large users of crude from Oklahoma. About 30 per cent of the State's production is refined in the State. In discussing the refining of Oklahoma oils it is necessary to give the development of that industry in Oklahoma, Kansas, Illinois, Missouri, Indiana, north Texas, and Louisiana, because of the fact that most of the refineries in these states have been using Oklahoma crude almost since production began and many of the refineries outside the State have been built exclusively for the use of Oklahoma crude.

Prior to 1905 there were only 2 refineries in the Mid-Continent field—the Standard Oil Company's plant at Neodesha, Kans., constructed in 1897 with only 2 stills, and the plant of the Webster Refining Company at Humboldt, Kans., with a capacity of 350 barrels. At the begining of 1907 there were 13 refineries in operation and 5 under process of construction, the total capacity being about 16,700 barrels. In July, 1913, there were 40 plants in the field with a daily capacity of 150,000 barrels. In addition to these the Prairie Oil and Gas Company was sending 60,000 barrels daily to eastern refineries, the chief one being the Standard, near the coast of Staten Island, New Jersey. The total capacity of the refineries using Oklahoma crude will exceed 200,000 barrels daily. April 1, 1914, the daily production of the Mid-Continent field reached 300,000 barrels.

LOCATION OF REFINERIES.

The location of refineries is determined, by facilities for securing the crude product from the field, either by pipe lines or railroad transportation, by conditions suitable for distribution of refined products, and a suitable water supply. If the transportation facilities be favorable a plant may be located some distance from the field. Many of the plants outside of Oklahoma were originally built to use crude in the immediate vicinity but the decline in production led to the use of Oklahoma oil.

PROFITS IN REFINING.

The price paid for crude oil and the price secured for refined products allows a handsome dividend to be paid on money invested in the refining industry. The highest price paid for Oklahoma oil has been $1.05 with 20 to 50 cents additional premium for certain light oils. By present refining processes about 240 products are manufactured from crude oil. These include benzine, gasoline, naptha, kerosene, fuel oils, lubricating oils, illuminating oils, and paraffine which is used for many purposes, including the manufacture of chewing gum, asphalt products, axle grease, coal tar, and washing, scouring, and shaving soaps.

From a barrel of crude oil about 6 gallons of gasoline, 11 gallons of kerosene, and many of the other by-products can be manufactured. The usual sale price of gasoline and kerosene is from 8 to 10 cents per gallon, thus giving a value of $1.35 to $1.70 for these two products derived from a barrel of oil, in addition to the value of the other products.

With oil selling at $1.00 to $1.30 per barrel the profit is large, but at the present selling price of 50 cents per barrel the profits are larger. The refining of oil is the most profitable phase of the oil business. One refinery is said to have paid 2 to 3 per cent actual profit a month during 1913, while another cleared $100,000 on the investment for the year. One of the new refineries in the State paid 70 per cent dividend for the first 6 months of 1913.

The building of refineries immediately follows the development of new fields. The Cushing field opened about 2 years ago and now has 5 refineries of good capacity. The cost of the refineries in the State ranges from $25,000 to $2,000,000. Refineries operating in the State up to November 1, 1914, are given in the following table:

REFINERIES USING OKLAHOMA CRUDE.

Refineries in Oklahoma.

Name.	Location.	Cap. Bbls.
American Refining Company	Okmulgee	3,000
Ardmore Refining Company	Ardmore	1,500
Bartlesville Refining Company	Bartlesville	1,000
Brown's Refining Company	Cushing	500
Cosden and Company Refinery	Sand Springs	4,000
Chelsea Refining Company	Chelsea	1,500
Cleveland Refining Company	Cleveland	3,000
Constantine Refining Company	Tulsa	1,000
Consumers Refining Company	Cushing	3,000
Colonial Refining Company	Cushing	800
Cushing Refining Company	Cushing	1,500
Indiahoma Refining Company	Okmulgee	1,000
Merchants Oil Company Refinery (Leased by Cudahy Refining Co.)	Muskogee	500
Milliken Refining Company	Vinita	1,000
Midland Refining Company	Coalton	3,000
Muskogee Refining Company	Muskogee	1,000
Nassar Refining Company	Dewey	...
New State Refining Company	Cushing	1,000
Oklahoma City Refining Company	Oklahoma City	600
Pierce Oil Refining Company	Sand Springs	4,000
Phoenix Refining Company	Sand Springs	3,000
Ponca City Refinery	Ponca City	800
Sapulpa Refining Company	Sapulpa	3,000
Southwestern Refining Company	Bigheart	850
Texas Oil Company Refinery	Tulsa	5,000
Uncle Sam Refining Company	Tulsa	1,000

Independent refineries outside of Oklahoma using Oklahoma crude.

Name.	Location.	Cap. Bbls.
Alluwe Refining Company	Coffeyville, Kans.	1,250
Cudahy Refining Company	Coffeyville, Kans.	3,000
Eastern Kansas Refining Company	Moran, Kans.	500
Great Western Refining Company	Era, Kans.	2,000
Kanotex Refining Company	Caney, Kans.	1,200
Kansas City Refining Company	Kansas City, Kans.	1,400
Kansas Co-operative Refinery Company.	Chanute, Kans.	1,000
Kansas Oil Refining Company	Coffeyville, Kans.	2,000
Miller Refining Company	Humboldt, Kans.	700
National Refining Company	Coffeyville, Kans.	6,500
Niotaze Refining Company	Niotaze, Kans.	1,200
Paoli Refinery	Paoli, Kans.	150
Uncle Sam Refinery	Cherryvale, Kans.	200
Webster Refining Company	Humboldt, Kans.	350
Wilhait Refining Company	Joplin, Mo.	...

Note: Other refineries at Roland, Langston, and Bronson, Kans. have daily capacities of 150, 100, and 75 barrels, respctively.

Non-independent Refineries.

Name.	Location.	Cap. Bbls.
Gulf Refining Company	Fort Worth, Texas.	...
Gulf Refining Company	Port Arthur, Texas.	...
Magnolia Pipe Line Plant	Corsicana, Texas.	...
Magnolia Pipe Line Plant	Beaumont, Texas.	...
Magnolia Pipe Line Plant	Fort Worth, Texas.	...
Petroleum Products Company	Independence, Kans.	...
Standard Oil Refinery	Neodesha, Kans.	8,000
Standard Oil Company of Indiana	Alton, Ill.	65,000
Standard Oil Company of Indiana	Whiting, Ind.	
Standard Oil Company of Indiana	Sugar Creek, Mo.	
Standard Oil Refinery	Baton Rogue, La.	...
Standard Oil Refinery	Staten Island, N. J.	...
Texas Oil Company	Fort Worth, Texas.	...
Texas Oil Company	Port Arthur, Texas.	...
Texas Oil Company	Dallas, Texas.	...

PIPE LINES.

In this publication it is impossible to give much detailed information concerning the transportation of petroleum through the pipe lines of the State. Besides the four or five big pipe line systems there are about 35 local companies operating lines in the State. Some of these small lines are owned and operated by refineries, some are operated by producers, and others by individual industries or corporations.

Pipe lines, like refineries, are continually increasing their capacity to keep up with the increase in production. Consequently no report on either capacity or extent of lines can be considered accurate for any length of time.

The first pipe lines constructed in Oklahoma were built by the Prairie Oil & Gas Company as extensions of their lines in Kansas. In 1893 and 1894, with a little line from wells at Thayer, Kans. to a small refinery at Neodesha, Kans., the company's system has gradually broadened until it is now the largest organization of its kind in the Mid-Continent field, and one of the largest in the world. All the crude transported through the pipe lines of this company is used by the Standard exsubsidiaries, especially the Standard plants at Whiting, Ind.; Wood River, Ill.; Sugar Creek, Mo.; and Neodesha, Kansas. In December, 1913, the total runs amounted to about 60,000 barrels daily to the Atlantic Coast by way of Whiting, Indiana.

When this company began the extension of its lines from Thayer, extensions were made to Peru, Sedan, Coffeyville, and other places in Kansas, and then into the Osage Nation in the Indian Territory. When production became too large for local Mid-Continent refineries the line was built, in 1907, from southern Kansas to Whiting, Ind., a distance of 600 miles, to which place the Prairie Oil & Gas Company has 4 main lines. Also in 1907, 240 miles of 8-inch pipe line were laid between Humboldt, Kans., and Griffith, Indiana. As production increased and it became necessary to put thousands of barrels a day in storage, a line was built to Carlton, Ill., and about 20,000 barrels a day were sent to the plant in that place. This line was built in the summer and autumn of 1913. This company now has lines to all the principal fields in northern Oklahoma. In the year 1907 these lines handled about 30,000,000 barrels of crude oil, or about 75 per cent of the total Mid-Continent production. In 1913 the total runs amounted to 38,720,262 barrels, an average of 106,082 barrels a day.

Until 1907 the Prairie Oil & Gas Company was the only large organization of its kind in the Mid-Continent field. In that year the Gulf and Texas companies built lines into Oklahoma for the purpose of securing crude for the refineries in Texas. The Gulf Pipe Line Company, the producing end of which is the Gypsy

Oil Company, came to Oklahoma in 1907, after the decline in the Texas production, and the advance in the Oklahoma output. In the same year an 8-inch pipe line was built from Glenn Pool to Sour Lake, Texas. Last year this line was extended by a loop from Oklahoma to Port Arthur, Texas, which, together with the increased efficiency of the Fort Worth, Texas, and Shreveport, La., branches enables the company to run approximately 30,000 barrels daily. In 1913 a 6-inch line was laid from Perryman, Texas, to the Cushing and Cleveland fields. In addition to the pipe line facilities this company has steel storage capacity for about 6,000,000 barrels of oil in Oklahoma. It transfers its crude to the plants of the Gulf Refining Company at Fort Worth and Port Arthur.

The Texas Pipe Line Company (Producers' Oil Company) was organized in 1902. An 8-inch pipe line was built from Glenn Pool to Dallas, Texas, and later to Corsicana and Humble, Texas. Pumping stations to Dallas are located at the following places in Oklahoma: Keifer, Henryetta, Stuart, Coalgate, and Armstrong. The crude is transferred to the refineries of the Texas Company at Dallas, Port Arthur, and Port Neches, Texas.

The Magnolia Pipe Line Company is the last large pipe line company to enter the State. In the early part of 1914 an 8-inch line from Alvord, Texas, was built to the Healdton field, and it has been stated that the intention of the company was to build the line through to the Cushing field with branches to the Glenn Pool and Okmulgee region. The Magnolia Refining Company of Texas, with which the Magnolia Pipe Line Company is associated, has a line from Electra to Beaumont, Texas. The Oklahoma crude handled by this pipe line company is transported to the Refining Company's plants at Corsicana and Beaumont, Texas.

The Oklahoma Pipe Line Company has an 8-inch pipe line from Jenks, Okla., to Baton Rouge, Louisiana. This line was laid in 1910. The line has a daily capacity of 17,500 barrels.

Several of the new and smaller fields over the State which have been developing during the past years have been seriously handicappd by the lack of pipe line facilities. Prior to January 20, 1914, there were no pipe line connections with the Newkirk, Inola, or Healdton fields. Two small companies were formed to lay lines into the Inola field and a little later the Magnolia Company built its line into the Healdton fields. One of the companies in the Inola field is known asthe Inola Pipe Line Company and a 4-inch line has been laid from the field to the Missouri Pacific Railroad, a distance of 8 miles. The company has one pumping station and a 12-car loading rack. The other line is known as the Protection Line, and is a combination 3 and 4-inch line from the field to West Tulsa, a distance of 23 miles. It has one pumping station.

Several other companies have contemplated building lines into the Oklahoma field, but the present decline in the oil business has stopped such projects, for the present at least. Independent producers have under consideration various schemes for the building of pipe lines and the installation of refining plants to take care of their production. The Atchison, Topeka & Santa Fe Railway, which owns the greater part of the production in the Wheeler oil field, has a pipe line from that field to Ardmore to the main line railroad. A small line from the wells in the region of Madill extends to the St. Louis & San Francisco Railroad east of Madill where a small loading station has been constructed.

NATURAL GAS IN OKLAHOMA.

The natural gas industry showed much improvement during the year 1913 and the first half of 1914. The output has been gradually increasing and new fields of importance have been developed. Cushing is the largest and most important of the new gas fields. Many gas wells are reported here with large volumes and high rock pressures. The chief gas sands are the Layton, Jones, Wheeler, and Bartlesville, with some 6 other sands reported as containing gas in commercial quantities.

During 1913 about the only demand put on this vast amount of gas was the field operations, the refineries, two casing-head gasoline plants, and the towns of Cushing, Drumright, and Dropright. But during the year 1914, the Creek County Gas Company, besides supplying Cushing, Sapulpa, and Okmulgee was also selling considerable gas to the Wichita and Quapaw companies which furnish Wichita, Kans., and Joplin, Missouri. The Oklahoma Natural Gas Company had also completed a line to Cushing and was supplying Oklahoma City with gas from this field.

Even with these demands there is much gas either closed in, or being wasted. Gas men say that our present methods of drilling alone wastes 10 times as much gas as is ever usefully consumed. During 1913 the government sent two experts from the Bureau of Mines to Oklahoma to show the drillers how to prevent a large part of this waste. They started their experiments in the Cushing field and in most cases received the hearty cooperation of the drillers in making their tests. Their first attempts were remarkably successful, as they succeeded in drilling two wells through the gas stratum with practically no loss of gas, which would have had a combined waste of more than 20,000,000 cubic feet daily under the old method of drilling. They also directed the drilling of other wells through the gas horizon without waste of gas. Briefly, the system consists in pumping a mud-laden fluid into the porous space, thus sealing up the stratum so that the gas can not penetrate the well. It is not denied that this system will prevent the waste of gas, but it is claimed by some that it is too expensive. Actual tests,

however, go to prove that this is not the case and some of the prominent oil companies have witnessed to this fact. The system has other merits besides the preservation of the natural gas. It furnishes a method whereby a gas stratum with an enormous rock pressure can be penetrated without loss of time. Under the old method of drilling, such a well would either be allowed to exhaust itself or never be drilled deeper. Also it is claimed that in some cases under the new method water is prevented from coming in and drowning out the oil sand.

Another field that has produced a large amount of natural gas, only a small amount of which has been utilized, is Healdton. Some one has estimated that enough gas has been wasted in this field to supply Oklahoma with heat for two years. In Muskogee, Wagoner, and McIntosh counties much gas has been discovered over wide territory; for instance, in McIntosh County some 240 square miles of territory has been tested and found to have some gas scattered all through it. Several big gas wells have been closed in this district awaiting better market conditions.

The older gas fields such as Glenn Pool and Hogshooter have practically been exhausted as far as piping the gas out in concerned, but the casing-head gas gasoline industry has been established profitably here and in other older oil fields. At one time the great Hogshooter field was actually piping out 200,000,000 cubic feet per day, while in the fall of 1914 it was piping out practically nothing.

In Tulsa and Osage counties much new gas has been discovered, especially in the Bird Creek area. A new gas field was opened up in Osage County, 5 or 6 miles west of Hominy, in the latter part of 1913. This has been piped to Hominy for city use.

Gas from Kay County wells was piped to Ponca City, Tonkawa, Newkirk, Uncas, Blackwell, Braman, and Kildare. In Okfuskee County a small quantity of gas was furnished to Okemah. In Stephens County a new gas field was discovered and some 10 wells with 250 to 280 pounds pressure were piped to Duncan, Marlow and Lawton. These wells ranged from 702 to 907 feet in depth and showed no evidence of being exhausted at the close of 1913. Comanche County produced some gas most of which was piped to Lawton and consumed there.

The number of productive gas wells at the close of 1913 was 1,052, as compared with 936 at the close of 1912. During the year 721 wells were drilled for gas, 423 of which were productive, and 289 dry. In all, there were 307 wells abandoned during the year of 1913.

In comparing the production of natural gas by states, Oklahoma ranks third, being surpassed by Pennsylvania and West Virginia. However, in ranking the states according to the value received from

the natural gas, Oklahoma ranks fourth being excelled by Pennsylvania, West Virginia, and Ohio.

Estimates of the quantity of natural gas that will be consumed daily in the larger cities and manufacturing centers in Oklahoma for the winter of 1914-1915 are as follows: Oklahoma City 20,000,000 cubic feet; Tulsa 12,000,000 cubic feet; Muskogee 12,000,000 cubic feet; Shawnee 8,000,000 cubic feet; Guthrie 8,000,000; Ardmore 5,000,000 cubic feet; Bartlesville with the zinc smelter 18,000,000 cubic feet; the two zinc smelters at Collinsville 11,000,000 cubic feet; Okmulgee with the glass factories and refineries 18,000,000; Cushing with the refineries, and Sapulpa with a glass factory and refinery 20,000,000.

There is something like 100 other smaller towns using gas for domestic and industrial purposes the aggregate amount of which will be large. Also it is estimated that something like a total of 100,000,000 cubic feet will be piped daily to Wichita, Kans., and Kansas City, St. Joseph, and Joplin, Missouri. Added to this is the amount that will be used in field operation, and also the amount used for the casing-head gas gasoline plants. From these figurs it is evident that the outlook for the natural gas industry is better for Oklahoma than in any year previous.

PRICES OF NATURAL GAS.

On the whole, the year of 1913 was a prosperous year for the natural gas industry in Oklahoma. The total production was 75,017,668,000 cubic feet, valued at $7,436,319, or 9.91 cents per 1000 cubic feet, as compared with 73,799,319,000 cubic feet, valued at $7,406,528, or 10.04 cents per 1000 cubic feet in 1912. It will be noted that there was a decrease in the average price of natural gas per 1000 cubic feet from 10.04 cents in 1912 to 9.91 cents in 1913. This was probably due to the fact that there was a large increase in the amount of natural gas used for manufacturing and industrial purposes within the State. In 1913, the amount of natural gas consumed for industrial purposes in Oklahoma was 44,210,098,000 cubic feet, valued at $2,484,163, as compared with 35,049,341,000 cubic feet, valued at $1,860,482 in 1912. The various industries that consumed large quantities of natural gas in this State were zinc smelters, cement plants, glass factories, brick plants, a carbon-black plant, gas engines, and steam engines operating in oil fields and elsewhere.

Another interesting phase of the development of the Oklahoma natural gas industry in 1913 which has a bearing on the price also, was the fact that more natural gas was consumed in Oklahoma and less was piped out of the State as compared with 1912. In 1913, 48,553,886,000 cubic feet of natural gas were consumed within the State, while in 1912 only 41,549,403,000 cubic feet were used. The amount of natural gas produced within the State and consumed out-

side in 1913 was 27,463,782,000 cubic feet, as compared with 32,249,916,000 cubic feet in 1912. The consumption of natural gas for domestic purposes showed an increase in amount and a slight decrease in price. In 1913, the amount used for domestic purposes was 7,039,196,000 cubic feet, valued at $1,256,818, as compared with 6,500,062,000 cubic feet, valued at $1,288,894 in 1912.

In comparing the actual fuel value of the amount of heat-energy produced by natural gas with coal, one can easily see the advantage that gas has over coal. In the first place, natural gas is more convenient in handling. In the second place with the present rate of natural gas in Oklahoma, it furnishes more heat-energy for the same cost. Few actual analyses and heat value tests of Oklahoma natural gas have been made. The University Geological Survey of Kansas has made some such tests of the gas from fields in southeastern Kansas and their figures show that the amount of heat was about 930 B. t. u., per 1000 cubic feet. Assuming this to be about the average efficiency of Oklahoma natural gas and figuring the fuel value of Oklahoma coal at 12,000 B. t. u. per pound and also taking into consideration the fact that in using coal there is always more or less waste due to incomplete combustion, it is calculated that about 20,000 cubic feet of natural gas equals one ton of coal in fuel value. From this it is evident that when gas can be bought for 9.91 cents per 1000 cubic feet it can compete with coal at $2.00 per ton. Many factories and plants are taking advantage of this cheap, efficient fuel that is offered in natural gas in Oklahoma. The supply is good for many years yet and it is hoped that various other industries will come into the State because of this cheap fuel-energy. The list of cities and towns furnished with gas, which is given in another part of this report, have in most cases a good supply of gas and can furnish it for manufacturing purposes at reasonable rates.

Value of gas in Oklahoma, 1902-1913.

Year.	Value.	Year.	Value.
1902	$ 360	1908	$ 860,159
1903	1,000	1909	1,806,193
1904	49,665	1910	3,490,704
1905	130,137	1911	6,731,770
1906	259,862	1912	7,406,528
1907	417,221	1913	7,436,389

LIST OF CITIES AND TOWNS SUPPLIED WITH NATURAL GAS IN OKLAHOMA.

Ada	Cross	Lawton	Ramona
Afton	Cushing	Lefeber	Red Fork
Alluwe	Davenport	Lenapah	Ringling
Arcadia	Dawson	Luther	Ripley
Ardmore	Delaware	Madill	Sand Springs
Atoka	Depew	Marlow	Sapulpa
Avant	Dewar	Meeker	Schulter
Barnesdale	Dewey	Miami	Shawnee
Bartlesville	Dropright	Midlothian	Skiatook
Beggs	Drumright	Mohawk	Sperry
Bigheart	Duncan	Morris	South Coffeyville
Bixby	Dustin	Mounds	Stone Bluff
Blackwell	Edmond	Muskogee	Stroud
Bluejacket	Eram	Natura	Tahlequah
Bowden	Eufaula	Nelagony	Terlton
Boynton	Ft. Gibson	Newkirk	Tonkawa
Braman	Glenpool	Neodesha	Tulsa
Bristow	Gotebo	Nowata	Turley
Broken Arrow	Guthrie	Ochelata	Vera
Cameron	Hallett	Oglesby	Vian
Catale	Haskell	Okemah	Vinita
Catoosa	Hattonville	Oklahoma	Wagoner
Chandler	Healdton	Okmulgee	Wainwright
Chelsea	Henryetta	Oologah	Wann
Childers	Heyburn	Osage	Welch
Choteau	Hominy	Owasso	Wellston
Claremore	Hoffman	Pawhuska	Wheeler
Cleveland	Inola	Ponca	White City
Coalton	Jenks	Porter	(Ragtown)
Collinsville	Jennings	Poteau	Wilson
Copan	Kiefer	Preston	Yale
Kelleyville	Kildare	Prue	
Coweta	Crekola	Pryor Creek	

NATURAL GAS GASOLINE.

Throughout the oil and gas fields of the State there has been a tremendous waste of the gas. Various plans have been adopted to preserve this gas, but even with the most satisfactory arrangements the waste is great. Wells having a capacity of from 2,000,000 to 50,000,000 cubic feet per day have been allowed to run unchecked for days, weeks, and even months. Gas torches needlessly burn the entire 24 hours. Stoves burn full blast because gas is cheap or free. In some fields there is no available market or the wells decline so rapidly that the transportation of gas through pipe lines

is not profitable. The best efforts at proper conservation have not been entirely successful.

During the past few years a process for the separation of the more volatile grades of gasoline from natural gas issuing from the wells has become a profitable industry of importance.

Natural gas may be divided into two classes, (1) a so-called "dry gas" known and used as a natural gas of commerce, and (2) a gas containing easily liquefiable vapors, known as "wet gas," which is also used for commercial purposes. This latter class forms the basis for the so-called "natural gasoline" industry.

The liquefaction of natural gas products is by compression. The process was recognized and put into practice about 1904 in Pennsylvania. The method of manufacture is briefly described in the following paragraphs from Technical Paper No. 10 of the Bureau of Mines, entitled, Liquefied Products of Natural Gas:

Up to the last two years the general practice in the manufacture of liquid natural gas was to make the product by compression of the gas in single-stage compressors operated at a pressure of 150 to 300 pounds per square inch. The one product thus obtained, so-called "natural gasoline," was run into a tank and "weathered." The weathering consisted in allowing the lighter portions to volatilize spontaneously and escape into the open air until such time as the boiling away of the liquid had practically ceased. Thus the process involved a loss of 25 to 50 per cent, or even more. This loss was an absolute waste, not only of power and of cost of operating the engines and compressors, but of the product itself.

The next step in the industry was to pass the waste gases (of which only the small quantity used for power had been utilized) from the single-stage compressor through a higher stage compressor, thereby getting a second and more volatile product—a "wilder" liquid—which was run back into the first tank and mixed with the first or heavier condensate. This mixture was then again weathered to a safe degree, whereby it lost the greater part of the more volatile product that had been condensed in the second stage.

Recently the process has been improved another step, in that the first-stage compressor product is run into one tank and handled as ordinary gasoline; the second-stage compressor product is run into a second tank and handled as a lighter gasoline, with which the heavy refinery napthas can be enriched or enlivened.

The last-mentioned method of using the second-stage compressor product should receive wide recognition, and a market for the product should develop that would be no mean factor in the industry. Blending in the proportions of, say, 1 part of the product to 4 or 5 parts of the refinery napthas makes these heavy napthas more volatile and of greater value as fuel for automobiles; it also greatly increases their general usefulness. The proportions to be used in blending, however, must be determined more definitely by test.

The natural gas of this country frequently contains light products that do not condense in the second-stage compressor, and for which it is practicable and necessary to install three, four, and even higher stage compressors. These light products—true gases at ordinary temperatures and pressures—can be compressed and liquefied, but the liquid gases so obtained must be handled as gases and not as oils. The mistake heretofore made in the "natural gas gasoline" industry, as some have recognized, has been the attempt to handle the light gaseous products as oils and not as gases. Until the manufacturers of this lightest third or fourth-stage compressor product recognize its gaseous nature, the absolute necessity for insuring the safety of the public involves certain restrictions in its transportation, and not until the realization that this extremely volatile liquid should be handled only in strong steel containers capable of withstanding high pressures will it be transported with safety.

The natural gas from some regions will yield no gasoline, while that from other localities produces as much as 8 to 10 gallons per thousand cubic feet, the average being about 3 gallons per thousand cubic feet. The gasoline thus manufactured is very different from that which is the product of the refineries. Some of the dry gases will produce gasoline under high pressure, and some of the wet gases will produce gasoline simply by cooling without compression.

Reports from producers of gasoline from natural gas indicate that approximately 400,000 gallons of gasoline were produced in 1911, not less than 144,629,000 cubic feet of gas being used and the average yield per thousand cubic feet was 2.68 gallons, the production varying from one-fourth gallon to 4 gallons. The gravity varied from 67° to 86° Baume. The average price was 5.4 cents per gallon. Eight plants were in operation.

In 1912 there was a remarkable increase in the production of natural gas gasoline. The total number of plants increased to 17 and the amount produced to 1,575,644 gallons, valued at $99,626.00. The average price increased to 6.3 cents. The advance in the price of gasoline for this year was less in Oklahoma than in any other state. The average yield was 2.25 gallons per 1,000 cubic feet.

At the close of 1913 the number of plants in the State had increased to 49 under the management of at least 20 different companies. The amount produced was 6,462,968 gallons, with a value of $577,944.00. The amount of gas used was 2,152,503,000 cubic feet, and the value of the gas used $82,742.00. The highest yield was 7½ gallons; the next 5 gallons; and the lowest one-half gallon to 1,000 cubic feet of gas used. The gravity ranged from 70° to 96° Baume.

During 1914 several additional plants were put in operation and some of the old plants doubled their capacity. The "casing-head" gas produced from the Glenn Pool district proved to be very

rich in gasoline, and the district leads in the number of plants October 1, 1914, there were over 60 plants in the State, and the production to date amounted to approximately 9,575,686 gallons.

After the gasoline has been extracted the residue, or "exhaust" gas, is utilized in various ways. In some cases it is run through the pipe lines to gas consumers for domestic and industrial purposes. In others it is used to drive gas engines or to run the gasoline plant, or in some cases returned to the original producer for field purposes, or allowed to waste.

The following list gives the number and location of the plants in operation during the past year:

Alluwe	3	Mounds	1
Bartlesville	1	Morris	1
Childers	1	Muskogee	7
Delaware	2	Okmulgee	2
Dewey	2	Cleveland	1
Drumright	3	Sapulpa (Taneha)	2
Glenn Pool and Kiefer	30	Tulsa	5
Lenapah	1	Watova	2

Some of the natural gas gasoline is sold as crude gasoline, or ordinary gasoline, but all the high gravity products are blended with various percentages of heavy naphtha, thus reducing the gravity to any degree desired. For example, an 87° Baume is mixed with 50 per cent naptha and the product sold for 9 to 10 cents per gallon. A 94° Baume is blended with heavy naptha so that the gravity is reduced to 69°.

Statistical Data Concerning Natural Gas Gasoline, 1913 and 1914. By Counties.

COUNTY Location of Plant—	No. of Operators		No. of Plants in Operation		Yield of Gasoline per Thousand Cubic Feet Gallons		Average Gravity of Gasoline as Produced and Before Blending	
	1913	1914	1913	1914	1913	1914	1913	1914
Creek	12	16	27	32	2.5-5.5	2.5-6.0	86°-94°	80°-90°
Muskogee	4	7	4	7	2.5-3.0	2.5-3.5	86°-90°	80°-90°
Nowata	3	8	3	8	3.0-7.5	3.5-8.0	80°-92°	80°-94°
Okmulgee	3	3	5	5	2.0-3.0	2.0-3.0	82°	82°-86°
Pawnee	1	1	1	1	0.5-	0.5-	70°-76°	68°-76°
Tulsa	3	4	7	8	2.0-3.0	2.0-3.0	82°-90°	80°-90°
Washington	1	2	1	3	2.5-	2.5-3.5	84°	84°-86°
Total	27	41	49	64	.....	.....	.....	.....

In the above table the figures for 1914 are complete to October 1st. The actual total production for the nine months can not be accurately stated, but the estimate given will be approximately correct. The list of operators as given in the county totals shows some duplication since the same operators have plants in more than one county. For 1913 the total number of operators is about 20 and for 1914 approximately 30.

NATURAL GAS EXHAUSTION.

Little was known regarding the natural gas industry when the laws to regulate the use of this fuel were enacted. So the consumer who knows little of gas except what he sees in consumption, thinks the supply inexhaustible. It is therefore difficult to convince him that when this fuel is once gone, it is gone forever, whether it be consumed usefully or wasted recklessly.

Our present methods of field operations waste enormous amounts of natural gas. As is generally known, gas wells are allowed to flow unchecked because of poor management or carelessness. Such practices as using the rock pressure of gas wells for power is common. Often when gas is encountered in the top of the sand it is allowed to flow unchecked in the hopes that it will drill into oil some day. Another common practice in the oil fields is the use of flambeau lights which cause a great waste of gas. The State has a law against such use of gas, except when such lights, not to exceed four in number, are used in and around drilling wells. Burning gas through the day is also prohibited by the State laws except when such use is regulated by a meter. But at present these laws are not strictly enforced and consequntly do not prohibit the waste of gas as they should. Sometimes wells that produce 5 to 20 million cubic feet of gas per day with a spray of 10 or 20 barrels of oil are allowed to flow unchecked for the oil produced. When it is considered that 6,000 cubic feet of natural gas equals one barrel of crude oil in fuel value, 6,000,000 cubic feet of gas will equal 1000 barrels of oil. So in order to obtain the 10 or 20 barrels of oil an equivalent of 1000 barrels is wasted. For this reason Oklahoma is losing thousands of dollars every day.

In Oklahoma's rapid development of the oil and gas industry, there has always been a greater supply of natural gas than was needed for the demand. So when some of the best gas fields have been exhausted, it causes no alarm, for there is plenty to spare from some new field. But it is needless to say that the new fields to be discovered in the future are numbered. We do not intend to speculate how many, nor yet how long our present supply of natural gas will last. But it should be remembered that our natural gas is valuable, whether it be consumed now or in the future and if it can not be consumed now, the best reservoir for its safe keeping for the years to come is in the earth.

ASPHALT.

VARIETIES.

Asphalt is a solid material derived from petroleum and may be divided into two general classes: (1) asphaltite—which represents the variety free from sandy and clayey impurities and is found in either fissures or basins. (2) bituminous rock—in which the asphalt material fills the pores of sandstone, limestone, or other rocks. The most important varieties of asphaltite are: Albertite, anthraxolite, ozokerite, grahamite, lake asphalt, gilsonite, impsonit, and manjak. Under the second class of asphalt material are shale asphalt, lime asphalt, and sand asphalt. The main deposits of Oklahoma asphalt fall under the second class, although rich deposits of gilsonite and grahamite are known.

Asphaltic materials are used for pavements when mixed with the proper amounts of crushed rock. The pure forms are used in the manufacture of candles, ointments, powders, as an adulterant for beeswax, for making paints and varnishes, such as are used for iron work, for lining chemical tanks, roofing pitch, insulating electric wires, as a substitute for rubber in garden hose, and as a binder for pitch in making coal briquetts.

LOCATION OF DEPOSITS.

The asphalts of Oklahoma, with one or two exceptions, occur in the southern one-third of the State, from the Arkansas line westward nearly the length of the State, the most westerly occurrence being in the northwestern part of the Wichita Mountains. The area divided into districts beginning at the west is as follows: The Wichita Mountains, Stephens and Jefferson counties, Ardmore district, Arbuckle Mountains, Ouachita Mountains, and Red River district.

The asphalts of commercial importance in the Wichita Mountain area occur in the vicinity of Lawton. They consist of sandstones saturated with asphaltic bitumen. Up to the present time the deposits have not been sufficiently prospected to give anything definite as to the exact area, thickness, or nature of the material. A quarry, near Elgin, was worked for paving material in Lawton some years ago, and has been reopened recently.

Deposits in Jefferson and Stephens counties consist of considerable areas of sandstone aphalt. In the northeastern part of Jefferson County 160 acres of segregated asphalt land is underlaid by a ledge of asphaltic sandstone 25 feet thick. This material has been shipped from Comanche and used for paving. Two other outcrops of this same material have been reported in this vicinity. In Stephens County the deposits occur in the southeastern part. In at least one instance the asphalt appears to have worked up along a fault and to have impregnated the sandstones on either side.

Although there are large amounts of material present the deposits have not as yet been utilized.

The Ardmore district is the most important one in the State both from the point of material present and of development. The asphalts are impregnations of sandstones by asphaltic bitumen of varying consistency and occur in the Glenn formation of Pennsylvanian age. The rocks are folded and the deposits of asphaltic sandstone usually dip very steeply, and in some cases are almost vertical. It is impossible to estimate the amount of the deposits. Those known number about 15.

The Arbuckle Mountains district which comprises parts of Murray, Johnston, and Pontotoc counties contains asphalt deposits of commercial importance.

Those of Murray County are chiefly rock asphalts, impregnations of limestone and sandstone of Ordovician age. They are confined to a small area lying east of Dougherty and south of Sulphur. The area is divided into two districts, the Buckhorn and the Brunswick.

Johnson County has only one deposit of asphalt in the Arbuckle Mountains region. This is at Ravia. The asphalt is a limestone, 5 to 6 feet thick, unevenly impregnated with bitumen. The material has been used in paving, but the quarry is not worked at present.

In Pontotoc County, asphalt deposits are known or reported at Fitzhugh, Ahloso, Franks, Ada, and Roff. Of these deposits only the last two have been developed. The deposit near Ada has an area of about 100 acres and prospect drilling shows the entire area to be underlaid with the asphaltic rock to a depth of 80 feet. The material is a coarse, calcareous sand, which lies nearly level. The product is quarried in hillside quarries and is hauled by wagon to Ada. Pavements have been constructed from this material in Ada, Lawton, Tulsa, Holdenville, and Hugo, Okla., and in Sherman and Paris, Texas, with marked success. The amount of this material available is very great. The deposit at Roff is a rich sandstone asphalt about 10 feet thick, dipping to the west. Only a small quarry has been opened, the distance from transportation preventing extensive development.

The asphalts of the Red River district occur principally in the Trinity sand, the basal formation of the Lower Cretaceous system. The rocks dip gently to the southeast and have remained practically unaltered since deposition. The sands of the Trinity are usually unconsolidated except where cemented by bituminous materials. This district includes parts of Love, Marshall, Bryan, and McCurtain counties, and the southern part of Johnston County. Seven occurrences of asphaltic material have been reported in Love County, but only one has been worked. Marshall County also reports seven occurrences of this material, principally lenticular bodies in

the sand. The deposits in the extreme southern portion of Johnston County seem to be quite extensive. Bryan and McCurtain counties contain deposits of sand asphalt, but nothing definite is known of their extent and character. In general these asphalts are soft and seem to contain considerable paraffin, making their use in paving questionable at present.

In the Ouachita Mountains region both rock and pure asphalt are present. The deposits of rock asphalt known are a few in Atoka County, and one in LeFlore County. The pure asphalt occurs as grahamite at Jumbo near Antlers and at Page near Poteau, and as gilsonite near Tuskahoma. The pure asphalts occur in veins, usually along fault lines. Some of these could be used for paving but they are more valuable for other purposes. This region like the others has not been sufficiently prospected to make any definite statement in regard to the extent of the deposits.

Value of asphalt in Oklahoma, 1903-1913.

Year.	Value.	Year.	Value.
1903	$28,150	1909	$48,130
1904	37,516	1910	65,244
1905	27,790	1911	.....
1906	18,461	1912	.....
1907	20,770	1913	91,416
1908	23,820	....	.....

GYPSUM.

OCCURRENCE.

Gypsum occurs in western Oklahoma in four general areas: (1) Kay County area; (2) the main line of gypsum hills, i. e., the outcrop of the Blaine formation; (3) the second line of gypsum hills on the eastern edge of the Greer formation, and (4) the southwestern area.

Kay County area.—Gypsum occurs in the central part of the county in the region between Newkirk and Blackwell. The deposits are small and not very pure, the greater portion being made up of gypsite, a mixture of clay and gypsum. It occurs in the Marion formation of the non-red Permian.

Main line of gypsum hills.—The main line of gypsum hills, following the outcrop of the Blaine formation, enters the State from Kansas on the south side of Salt Fork of Arkansas River, and continues through Woods County in a southwesterly direction to form a crescent-shape, then swings northwest to the Kansas line. Another outcrop of the same formation enters the State from Kansas on the southwest side of the Cimarron River and continues on that side of the river through portions of Woods, Harper, Woodward, Major, Dewey, Blaine, Kingfisher, and Canadian counties. There are three ledges of gypsum, two of which cap the so-called "Gyp Hills." The members are Ferguson, Medicine Lodge, and Shimer. The thickness varies from 5 feet to about 25 feet, and the color from white to pink. In Woods and Harper counties, the gypsum is usually selenitic, but in the counties to the southwest rock gypsum and anhydrite become prominent. Caves are numerous in Major County.

Second line of gypsum hills.—This area consists of parts of the following counties: Dewey, Ellis, Roger Mills, Custer, Washita, Kiowa, Caddo, Comanche, and Grady. This line of gypsum hills is formed by the eastern portion of the outcrop of the Greer formation, which usually consists of shales and sandstones with varying amounts of gypsum and dolomite or magnesian limestone. The gypsum ledges are not continuous over very large areas. Good exposures are rare. The gypsum outcrops vary in width from 5 to 30 miles. The hills are more rounded in comparison with those of the main line of hills. The ledges grade laterally into sandstone. The gypsum varies in thickness from a few feet to 60, as in eastern Washita County, in color from white to pink, and in texture from fine-grained to coarsely selenitic.

Southwestern area.—The southwestern area includes parts of Greer, Beckham, Harmon, and Jackson counties. The gypsum occurs in the Greer formation. The topography is similar to that of the main line of hills. The five ledges in the northern part of this area, are known as the Chaney, Kiser, Haystack, Cedartop, and Collingsworth. All are well defined and can be traced for many miles. The thickness varies in the Chaney from 3 to 5 feet, in the Kiser from 1 to 3 feet, in the Haystack from 18 to 25 feet, in the Cedartop from 18 to 20 feet, and in the Collingsworth from 18 to 20 feet.

FORMS OF GYPSUM.

Gypsum occurs in five forms: Rock gypsum, selenite, satin spar, gypsite, anhydrite, and concretionary.

Rock gypsum occurs in heavy ledges. It is fine-grained and frequently selenitic. The color varies from white to gray, bluish-white, and pink. The beds are often irregularly mounted or banded. Some of the beds attain a thickness up to 60 feet or more.

Selenite is a crystalline form of gypsum. The crystals may be thin, tabular, diamond-shaped, or have other variations. Pure selenite is transparent. A piece will split easily into thin sheets. It is usually found associated in bands or veins with the massive gypsum ledges or clays.

Satin spar is a form of gypsum in which the crystals are fibrous or needle-like. It is associated with the massive gypsum deposits, usually occurring as thin bands in the associated shales.

Gypsite is commonly called earth or dirt gypsum. The impurities are clay, sand, organic matter, and iron. The color varies from

white to pink or red, according to the amount of, and kind of impurities. The thickness varies from 2 to 12 feet over known areas.

Anhydrite is not classified as a gypsum, but is very closely related to it. It is gypsum without water of crystallization. The color varies from white to red or blue. It can be distinguished from gypsum because it is harder, usually whiter, and weathers with a pitted and jagged surface. Anhydrite occurs associated with gypsum.

GYPSUM INDUSTRY.

Twelve mills in the State handle some form of gypsum, some have been in operation for a long time, but in late years have been shut down, chiefly due to industrial depression. The supply of gypsum is said to be inexhaustible. Gould's estimates for some of the counties are as follows: Woodward, 8,000,000,000 tons; Major, 12,000,000,000 tons; Kingfisher, 50,000,000 tons; Dewey, 1,000,000,000 tons; Ellis and Roger Mills, 500,000,000 tons; Custer, 6,000,000,000 tons; Washita, 20,000,000,000 tons; Harmon, 15,000,000,000 tons.

Up to the present time only a small amount of the gypsum has been utilized. There are several reasons for this. The great distance of the gypsum area from fuel supply and market is the principal factor. Other factors are the wasteful methods of mining, competition with the mills of other states, and a lack of sufficient transportation facilities.

USES OF GYPSUM.

Raw gypsum is used as a fertilizer or land plaster, as a constituent in Portland cement to retard the setting, as an ingredient in cement, and as a basis for paints. Other uses are for carved ornaments, interior decorations, and adulterant for food stuffs, white lead, and drugs. The calcined products are made by heating the raw gypsum up to various temperatures to drive off water of crystallization. The products formed in this manner are plaster of Paris, cement plaster, flooring plaster, hard-finish plaster, and many other materials.

Value of gypsum products in Oklahoma, 1901-1913.

Year.	Value.	Year.	Value.
1901	$ 66,031	1908	$288,000(e)
1902	111,215	1909	370,000(e)
1903	234,521	1910	451,000(e)
1904	190,245	1911	293,203
1905	200,000(e)	1912	268,618
1906	356,000(e)	1913	330,416
1907	404,000(e)	....	.....

(e) Estimated.

SALT.

USES AND PRODUCTION.

Salt is used to form a glaze on pottery and other vitrified clay products, in enameling and pipe works, in many chemical and metallurgical industries, in refrigerating, for salting cattle, curing hides, curing fish, making pickles, preserving meats, dry-salting meats, preserving butter, cleansing oleomargarine, as well as for the more familiar culinary and preservative purposes.

Salt is produced in about 15 states. In addition to the domestic production of 33,324,808 barrels in 1912, there were imported 998,664 barrels. These imports were in part offset by exports amounting to 445,785 barrels. The total domestic production is thus brought up to 33,877,687 barrels. The United States is not dependent upon any foreign country for her salt.

It is well known that there is enough salt water going to waste every day in Oklahoma to make many barrels of salt, yet our salt supply comes from other states, and we pay $1.75 per barrel. The small production of salt in Oklahoma comes from Harmon and Blaine counties.

In 1910, Oklahoma produced 2,564 barrels of salt. In 1911, 500 barrels. The production of 1910 was divided as follows: Table and dairy salt, 107 barrels, common fine salt 180 barrels, coarse solar salt, 1,314 barrels. In 1911 the total shows 307 barrels of coarse solar salt and 193 barrels of other grades and brine. The production for 1912-1914 has dwindled to a very insignificant amount.

OCCURRENCE.

Salt is closely associated with gypsum in origin and occurrence. It is mined from beds of rock or obtained from brine by evaporation. There are several salt plains in the west and northwest part of the State. Wells and springs of salt water occur in all parts of Oklahoma. Salt water is often encountered in the deep drillings of the oil and gas fields.

Of the salt plains which occur in western Oklahoma in the region of gypsum hills, their location is as follows: One east of Cherokee in Alfalfa County; two on Cimarron River, in Woods, Harper and Woodward counties; one on Salt Creek, west of Ferguson in Blaine County; another on North Fork of Red River, south of Carter in Beckham County; two on Elm Fork of Red River in north Harmon County, and three on Sandy Creek, south of Eldorado in Jackson County.

The salt deposit east of Cherokee in Alfalfa County is the largest in the State, and also the only one which contains no large salt springs. The area is saturated with salt water and the surface is crusted with white salt crystals. The plain is level, white, and barren of vegetation. No salt has been manufactured from this

region, but conditions are such, and the percentage of salt high enough that it would offer profitable development at any time. The two saline deposits on the Cimarron River are known as Little and Big Salt Plains. The former lies just south of the Kansas line between Harper and Woods counties. The latter is 15 to 20 miles farther down the river, between Harper and Woodward counties on the southwest and Woods County on the northwest. The amount of saturated salt water going to waste from these two places is enormous. In the early days salt water was shipped from the area for many miles, but in late years practically no salt has been manufactured here.

The Blaine County salt deposit is on Salt Creek, about 4 miles west of Ferguson. Enough brine flows from this area to make a large amount of salt. The plain is so situated that development could easily be carried on. Several small plants have operated here; one with a capacity of 500 to 2,000 pounds per day. A few years ago a plant with a capacity of 450 barrels for 24 hours was erected at Ferguson, the nearest railroad point to this salt deposit. The brine was obtained from open and drilled wells and was carried 2 miles in a 2½ inch wrought iron pipe. The plant was well equipped but operated only a few months and has since been dismantled.

In the Beckham County salt plain more than 20 springs of water are said to unite to form a stream of water of considerable size. The brine is very strong. Salt has been manufactured here at various times.

The Harmon County salt plains are on the south side of Elm Fork of Red River. Several springs occur, the waters of which vary from fresh to very salt. The deposits from which salt has been manufactured for years are in a narrow canyon formed by the Greer gypsum. The areas are known locally as the Chaney or Salton Salt Plain, and the Kiser Salt Plain. Both are small. The water issuing from the springs comes from beneath the gypsum beds or boils up from the surface. The industry here carried on uses chiefly the solar evaporation process.

There are three salt flats in Jackson County, all on the west side of Sandy Creek, about 3 miles south of Eldorado. The water comes from springs and the sandy floor has an incrustation of salt.

The examination of the salt from the various deposits shows quite a variation in character. Some show a very high content of sodium chloride. The principal impurities are sodium and calcium sulphate, and aluminum oxide which have probably found their way into the deposit through the dust which has blown in.

Value of salt in Oklahoma, 1901-1913.

Year.	Value.	Year.	Value.
1901	$ 5,986	1908	$ 900
1902	7,562	1909	900
1903	2,070	1910	881
1904	1,961	1911	431
1905	2,145	1912	325
1906	4,965	1913	259
1907	910		

LEAD AND ZINC.

OCCURRENCE.

At present there are three areas in Oklahoma producing lead and zinc, the first one centering around Miami, and lying wholly in Ottawa County, the second in the Arbuckle Mountains in Murray County, and the third in eastern McCurtain County.

The northeastern area is the southwestward continuation of the Joplin district, and in general the geological and other conditions are the same as in the Missouri and Kansas part of the field.

Up to the present time three mining camps have been developed in this area. These are in order of age, the Peoria, Quapaw or Lincolnville, and Miami.

Mining operations were begun in the Peoria camp in 1890. Zinc silicate is the principal ore and is secured from a depth of less than 20 feet. The distance from market and lack of transportation facilities have hindered development. As a result mining since 1894 has been on a small scale and of an intermittent nature.

The Quapaw or Lincolnville camp is located a few miles southwest of Baxter Springs, Kansas. The ore occurs in runs, and as a sheet or blanket ground formation at a depth of 75 to 100 feet. The principal ores are galena (lead) and sphalerite (jack), in varying proportions. Some calamine (silicate) and cerussite (dry bone) are produced from the more open ground of some of the runs. Four mills are now operating in the camp, two other mines are worked part time, and a few hand jigs are in operation.

The first mine in the Miami camp was opened in 1907. The main ore body is a run extending in a direction slightly west of north. The run is 60 to 80 feet in width, and the face is from 12 to 25 feet in height. There are smaller runs to the west which are approximately parallel to the main body. In these the ore is not quite so rich but the zinc concentrates are higher grade. A deeper run has recently been opened and proved to underlie most of the

camp. This run is very rich and has already shown that it contains sufficient material for several years' operation.

The Davis zinc field lies in the heart of the Arbuckle Mountains. The ore bearing area is a belt from 500 feet to one-half mile wide and about 15 miles long. The principal ore of this area is sphalerite (jack), which has weathered to smithsonite (carbonate or dry bone) to a depth of 3 or 4 feet. Lead in the form of galena occurs in very small quantities. It is usually encrusted with a white coating, either the sulphate or carbonate or both. The best ore occurs in close proximity to a belt of iron ore of which boulders, some 6 feet in diameter lie on the surface. Most of the development consists of open pits and shallow prospects, a few of which reach a depth of 40 feet. The first body of ore appears to be 30 feet or less in thickness. One deep hole was reported to have passed through a thick body of ore at 100 feet. One mill has been built and several others planned. Surface quarry methods can be used in this area.

Lead and zinc have been found at Ravia, 25 miles southeast of Davis. About 30 shafts have been sunk to a depth of 30 to 90 feet, and many to more shallow depth.

Considerable quantities of lead are found in a few places in the granite near Lawton, in the Wichita Mountains. Some lead is also found in a sandstone near Ada. The Ravia and Lawton areas promise to become productive. Lead is reported from the Ouachita Mountains. Recently a considerable deposit has been found and development is now taking place. Samples of the ore show 10 per cent lead and 3 per cent zinc.

USES.

Lead and zinc in their metallic state and in compounds are used in a variety of ways. A few of them will be described below.

In the metallic form lead is used principally for pipes in plumbing and for surrounding electric wire cables. Sheet lead is used in large quantities for lining sulphuric acid chambers and tank cars for the shipment of the acid. Considerable quantities of this metal are used in the manufacture of tin foil, shot and bullets, and as a constituent in type metal, babbitt metal, and white metal. The principal use of lead compounds is as pigments for paint, and about one-half of the lead produced is used for this purpose.

Zinc, although not as important a metal as lead, has a great variety of uses. The principal use of zinc is in galvanizing sheet iron and wire. Zinc dust is used in large quantities in dyeing, fire works, manufacture of hydrogen, and as a means of precipitating gold and silver in the cyanide process of extraction of those metals. The compounds of zinc find many uses as a pigment for paint, as a preservative for wood, and in medicine.

Value of lead in Oklahoma, 1907-1913.

Year.	Value.	Year.	Value.
1906	$.....	1910	$ 158,840
1907	42,824	1911	173,250
1908	118,356	1912	304,920
1909	195,048	1913	548,064

Value of zinc in Oklahoma, 1907-1913.

Year.	Value.	Year.	Value
1906	$.....	1910	$ 248,076
1907	84,842	1911	256,158
1908	210,090	1912	796,122
1909	324,864	1913	1,306,368

GLASS SAND.

GENERAL.

Glass sand is derived from sandstone and sands and is distinguished from the common varieties by the fact that it contains a very small percentage of impurities, the most harmful of which, are: iron, clay, magnesia, and organic compounds. Iron is a strong colorizing agent, imparting to the glass a green, yellow, or red color, which varies with the amount and degree of oxidation of the iron. Aluminous substances (principally clay) lessen the transparency of the glass and for the higher grades their presence in excessive amounts must be avoided. The presence of magnesia raises the fusion point of the sand and thus more fuel must be used to melt the charge. Organic matter is a strong colorizing agent and produces a dark amber color.

To neutralize the colorizing effects of these impurities upon glass, decolorizing agents are sometimes used. The principal decolorizing agents are manganese, arsenic, antimony, potassium nitrate, nickel oxide, and cobalt oxide. These ingredients are used in small quantities, since in large quantities they become colorizers instead of decolorizers.

The percentage of impurities allowable in glass sand depends upon the grade and character of glass desired. For the finest flint ware, such as optical and cut glass, only the purest sand can be utilized, perfect transparency, great brilliancy, and uniform density of product being required. For manufacture of this ware the sand should not carry more than one-half of 1 per cent of iron, (ferric oxide, Fe_2O_3), or 1 per cent of alumina (Al_2O_3). Plate and window glass may contain as much as 2 per cent of each of iron and alumina without injury, while bottle glass and other cheap glass can be made from sand containing as much as 2 per cent of iron and 6 per cent of clayey material.

The prevailing opinion among glass sand experts is that the shape and size of the grains affect the quality of the sand. Some claim that the grains should be sharp and angular, while others contend that the finest grades of glass are being manufactured from sand composed entirely of rounded grains. There are also varied opinions as to the most desirable size of the grains. The prevailing sentiment is that to produce the best results the grain should not be larger than 30 mesh nor smaller than 120 mesh. If the sand is pure, however, the size of the grains may have a somewhat wider range and still good results be obtained, so long as the grains are comparatively uniform in size.

KNOWN DEPOSITS.

So far as is known the available glass sand deposits of Oklahoma occur in three regions, namely: the Arbuckle Mountains,

southeastern Oklahoma, and near Tahlequah in the northeastern part of the State. Beds of almost white sand, however, are reported near Tulsa, Bartlesville, Claremore, Ramona, Cleveland, Catoosa, Muskogee, and Holdenville. So far as has been determined no large deposits of easily accessible sand, in these regions, have been found to be of sufficient purity to be used for anything but the poorest grades of glass. All analyses show a large amount of iron oxide and other impurities which exclude them from consideration except for bottle glass.

The glass sand in the Arbuckle Mountatins occurs in the Simpson formation, of Ordovician age, which outcrops as a belt around the Arbuckle uplift. The Simpson is composed of 1200 to 2000 feet of sandstone and fossiliferous limestones with interbedded greenish clay shales, and marls. This formation is exposed in eight general areas in the Arbuckle Mountains, namely: the Southern Belt, which is a narrow strip along the south side of the mountains, the Delaware Creek area, the Roff area, the Hickory area, the Mill Creek area, the Nebo area, the Sulphur area, and the Davis area. Although the topography is somewhat rough and a few small streams traverse the formation, yet large amounts of the sand may be economically transported, which is the chief factor in determining the value of the glass sand deposits in the Arbuckle Mountains.

The second area in which glass sand occurs in quantity in Oklahoma is in the southeastern part of the State. The formation containing it is known as the Trinity sandstone which is the basal formation of the Cretaceous system exposed in this area. The Trinity sandstone enters Oklahoma from Texas just west of Marietta and extends north and east to near Ardmore, thence generally eastward into Arkansas, outcropping as a broad band 5 to 15 miles wide along the southern base of the Arbuckle and Ouachita mountains.

From a study of this area it is believed that in several places commercial quantities of good sand occur. The deposits at Greenville, northeast of Durwood, and at Madill are readily accessible, both being within a short distance of railroad facilities.

The third area in which glass sand abounds is in the northeastern part of the State, northeast of Tahlequah along the Illinois River. This sand is a part of the Bergen sandstone which is from 50 to 100 feet thick. The Bergen sandstone is correlated with the St. Peters sandstone which is one of the principal glass sand bearing formations in Minnesota, Wisconsin, Iowa, Illinois, and Missouri.

The workable portion of the Bergen sandstone occurs in a 50-foot bluff which is exposed for one-fourth mile along the north bank of the Illinois River. While the sand shows by analysis to be high grade, its remoteness from railroads and the high cost of

constructing a spur to the deposit, together with the fact that a heavy capping of limestone occurs above the sand renders it improbable that development will take place in the near future.

GLASS PLANTS.

The glass sand industry is in its infancy in Oklahoma, although within a little more than a year the number of glass plants has grown from 6 to 14 in number. They are distributed in the State as follows: The Sunflower Glass Plant, the Schram Glass Plant, and the Premium Glass Plant all at Sapulpa; the Tulsa Glass Company and the Neodesha Bottle and Glass Company, at Tulsa; the Graham Glass Company, Baker Brothers' Window Works, and two Skelton glass plants at Okmulgee; and one each at Blackwell, Ponca City, Bartlesville, Avant, and Poteau.

To give some idea of the volume of business of the glass industry in the State at the present time it might be well to note some figures from several of the Okmulgee plants. These statistics are given in as much as they are more up-to-date than any other information we have at hand at the present time.

The Skelton Glass Plants are now employing about 600 people, with a weekly pay roll of $15,000, and will employ 800 when running at full capacity. They will turn out about 1,000,000 boxes of glass this season, perhaps 1,250,000 boxes with a gross value of $2,000,000 to $2,500,000.

Baker Brothers employ 170 people, of whom 90 are skilled labor, with a weekly pay roll of about $3,500. Their season's output will be about 100,000 boxes with a gross value of something like $200,000.

The Graham Brothers Bottle Works employs 120 people, with a weekly pay roll ranging from $1,800 to $2,000. Their output last year was 50,000 gross of bottles, which may be doubled this season.

The 3 plants at Sapulpa employ a total of about 435 men, and manufacture window glass, fruit jars, and tableware. Another plant is to be built there which will be completed about April, 1915, and will employ 125 men. This plant will make tableware. The sand used by the glass plants at Sapulpa comes chiefly from the vicinity of Roff, Oklahoma.

These plants, together with those at Blackwell, Ponca City, and Poteau use Oklahoma glass sand with marked success, which leaves us to conclude that Oklahoma glass sands can compete favorably with those of other states and should in the near future, considering the cheaper freight rates on our home product, become the source of supply for all Oklahoma glass plants.

The Mid-Continent Glass Sand Company has a modern plant of 300 tons daily capacity at Roff, Oklahoma. The product is known in the trade as "washed and dried white sand." The sand is supplied

chiefly to glass plants within the State, and is used in the manufacture of window glass, bottle and fruit jars. An occasional car is shipped to foundries and iron works for molding and casting purposes. This sand is noted for its fineness and uniformity of grains.

BUILDING MATERIALS.

GENERAL.

The term building stone includes all stone for ordinary construction work, as well as for ornamental and special uses. The building stone industry in Oklahoma is yet in its infancy. Artificial products, such as cement, terra cotta, brick, etc., have been strong competitors in this industry. Most of the modern buildings in the cities are constructed of artificial products. Nevertheless, a large amount of stone is used in the trimmings, sills, and caps. Such being the case there will at least be a demand for stone building material as long as construction work continues.

The people of Oklahoma do not realize that this State has such great building stone resources. This is commonly shown by the surprise manifested by those who see for the first time the many varieties of granite, limestone, marble, and sandstone. These have been tested and proved to be among the best. Notwithstanding these facts, we are sending hundreds of thousands of dollars each year to other states for building stone. There are great opportunities for development of our own resources along this line.

LIMESTONE.

The chemical composition of pure limestone is calcium carbonate ($CaCO_3$). It usually contains more or less impurities, such as iron and silica. Iron is the chief source of discoloration. The chief varieties of limestone are chalk, marl, travertine, cave icicles (stalactites and stalagmites), compact limestone, dolomite, and the oolitic, hydraulic, and lithographic forms.

Limestone suitable for building purposes is found in great abundance in Oklahoma. The northeastern limestone area includes the following counties: Sequoyah, Adair, Cherokee, Mayes, Wagoner, Delaware, Craig, Ottawa, Kay, Osage, Pawnee, Creek, Tulsa, Rogers, Washington, Nowata, and Craig. Marble also occurs in some of these counties. Several quarries are in operation. The Wapanucka limestone in the southeastern part of the State is a valuable building stone and is quarried in several places, the chief quarries being at Bromide and Hartshorne. Three limestone formations between Red River and the Ouachita Mountains are quarried for building stone. The limestone deposits in the Arbuckle Mountains, which are the thickest if not the most extensive of any in the State, are suitable for good building stone, ballast, road material,

and cement. Two limestone formations in the Wichita Mountains could be utilized for building stone. Quarries which utilize this stone are located near Ft. Sill, Rainy Mountain, and Lawton.

Other uses of limestone besides building stone are road material, ballast, concrete, cement, glass, and minor uses.

OOLITIC LIMESTONE.

Oolitic limestone is made up of small, rounded grains of lime cemented into a mass. This limestone occurs in the limestone ridge between Bromide and Wapanucka. It is known as the Bromide Oolitic limestone and composed chiefly of a curious rock called "Oolite." A similar rock occurs at other places over the State. Oolitic limestone is popular, especially for ornamental work such as trimmings on fine buildings, and for monuments. One of the best deposits of this stone in the United States is at Bedford, in southern Indiana. The Oklahoma stone is similar in many respects and seems to be just as good as the Bedford stone. The quarry at Bromide has been equipped with modern machinery, both steam and electrical power being used, so that any sized contract can be quickly and easily handled.

Value of Limestone in Oklahoma, 1901-1913.

Year.	Value.	Year.	Value.
1901	$ 32,497	1908	$ 257,066
1902	50,541	1909	450,055
1903	56,140	1910	509,344
1904	101,516	1911	504,664
1905	168,924	1912	409,994
1906	171,983	1913	246,912
1907	189,568		

MARBLE.

Marble is limestone which has been subjected to heat and pressure to such an extent that it has become crystalline. The grain varies from fine to coarse. Impurities, especially organic matter, produce discolorations and lines which give the "marbled" effect. Any limestone which will take a polish is ordinarily called marble. Several limestones in the State have this characteristic. True marble occurs in Sequoyah County, the largest quarry in the State being located at Marble City, 10 miles north of Sallisaw. This marble is sound, of gray to pink color, good texture, and takes good polish. Care is necessary, however, in quarrying to avoid styolithic structure, which makes it practically unfit for decorative purposes. When used for interior work this marble retains the polish well, but on exposed surfaces it soon becomes dull. This rock is only partly metamorphosed, and in many places has the appearance and structure of ordinary limestone. A considerable amount of marble has been quarried at Marble City, and at present there are a number of buildings over the State in which this material has been used. As an ordinary limestone quarry, and as a source of much valuable marble, this location offers one of the best quarrying propositions in the State.

LIME.

One of the uses of limestone is for the manufacture of lime. The process is accomplished by burning limestone in furnaces or kilns. Water and carbon dioxide (CO_2) are expelled. Lime is used for making mortar, plaster, cement, bleaching powders, sand-lime brick, and many other products. The use of lime as a fertilizer has become of considerable importance. Agricultural chemists have shown that there are 5 or 6 different functions which lime may perform for the benefit of soil. The question whether lime should be applied to the soil as quicklime, hydrated lime, air-slacked lime, or ground limestone is still the subject of a great deal of controversy. In each case, however, the local conditions must be considered carefully before a final conclusion can be reached. The limestone from which lime is made should be fairly pure in order to obtain the best results.

The first record of lime production on a commercial scale in the State was in 1902 when an output of about 25 barrels was reported. The industry gradually developed until 1910 when there were 8 plants in the State, one in each of the following counties: Atoka, Coal, Comanche, Delaware, Dewey, Johnston, Nowata, and Pawnee. Since 1911 not more than 4 of the plants have been in operation, those reporting production for 1911 to 1914 being in Coal, Comanche, Delaware, and Johnston counties.

There are several limestone formations in the State which are admirably suited for the burning of lime. In the south and southeastern parts, the Arbuckle, Hunton, Viola, Wapanucka, and Goodland limestones have been used. In the north-central and northeastern part, the Mississippi lime or Boone chert is of value. In the Pennylvanian area of the State from 8 to 10 limestones would prove suitable, and in the Permian of Kay County 2 or 3 would be of value.

Value of lime in Oklahoma, 1902-1913.

Year.	Value.	Year.	Value.
1902	$ 25	1908	$ 5,500(e)
1903	4,800	1909	6,000(e)
1904	3,194	1910	9,700
1905	4,650	1911	14,603
1906	4,850	1912	13,538
1907	5,000(e)	1913	12,160

(e) Estimated.

SANDSTONE.

Sandstone is composed of sand cemented together, usually by lime, iron, or silica. Iron colors the sandstone black, red, or brown, and is better cementing material than lime. Sandstone cemented by silica is harder and more durable than either of the other. In the eastern part of the State light-colored sandstones prevail; in the southern part, brown and black are the more common; while red is the prevailing color to the west. It is the most widely distributed building stone in Oklahoma, occurring in almost every county. The general regions of occurrence are: (1) Arbuckle Mountains, (2) Wichita Mountains, (3) Ouchita Mountains, (4) Ozark Uplift in southern Adair and northern Sequoyah counties, (5) Coal Measures area, (6) Redbeds area, (7) Southern area, including Bryan, Marshall, and McCurtain counties, (8) in the Cimarron Valley, near Kenton in northwestern Oklahoma.

Value of sandstone in Oklahoma, 1901-1913.

Year.	Value.	Year.	Value.
1901	$ 5,000(e)	1908	$ 57,124
1902	24,200	1909	59,855
1903	6,500	1910	19,801
1904	2,995	1911	90,971
1905	15,112	1912	5,334
1906	40,861	1913	1,010
1907	43,403		

(e) Estimated.

BUILDING SAND AND GRAVEL.

Building sand in Oklahoma is derived from several sources:) The stream channels in the western part of the State are choked ith sand; (2) sand hills also occur near the streams; (3) some ndstone ledges disintegrate, or are so soft that the sand may be ıg directly from the ledge.

Sand is used in construction work as a constituent of mortar, ment, and plaster.

Gravel is made up of pieces of broken, water-worn rock of larger ze than grains of sand. When cemented together it is called nglomerate. Large quantities of gravel occur along the streams suing from the Ozark, Ouachita and Arbuckle mountains, and the lint Hills in the northern part of the State.

Gravel is used for concrete, railroad ballast, and road materials. It is locally abundant, while sand is scattered over the entire State.

Value of sand and gravel in Oklahoma, 1904-1913.

Year.	Value.	Year.	Value.
1904	$ 500	1909	$ 185,812
1905	17,937	1910	186,977
1906	8,000	1911	97,539
1907	22,506	1912	163,298
1908	35,971	1913	39,457

GRANITE.

Granite is an igneous rock composed of quartz, orthoclase feldspar, and mica, or hornblende, or both, and other minerals. Individual minerals can usually be seen with the naked eye, because of the crystalline nature of the rock. Granite occurs associated with gabbro, prophyry, and diabase in the Wichita and Arbuckle mountains.

Exposures of granite in the Arbuckle Mountains occur north of Tishomingo, between Mill Creek and Wapanucka, and in 2 small areas lying south and west of Davis, these areas being known as East and West Timber Hills. The Tishomingo granite is of excellent quality and appearance. It is coarse-grained, pinkish or grayish, and a very durable stone. It has been used in the construction of a number of buildings, and for columns, pillars, and cap stones for a number of other buildings in the State.

Granite makes up the greater part of the rock in the Wichita Mountains. These mountains cover an area of about 1200 square miles, and extend from Granite to Lawton. The peaks consist of a mass of granite. Quarries of importance are located at Granite.

Cold Springs, and Mountain Park. The quality, abundance, and accessibility of Oklahoma granite, with the increasing demand for ornamental and building stone, insure a steady development in this industry for the future. Conditions are such that more extensive quarries should be opened and finishing plants of large capacity built near the quarries. At the present time very little of the stone is finished in the State. One company which owns a large quarry near Granite ships the stone in the rough to Michigan City, Indiana, to be polished, and then such as is used in Oklahoma is shipped back into the State, thus adding a heavy additional freight rate and much other expense to the cost of the finished stone.

Value of Granite in Oklahoma, 1901-1913.

Year.	Value.	Year.	Value.
1901	$ 12,000(e)	1908	$ 23,239
1902	11,970	1909	67,584
1903	9,030	1910	102,566
1904	32,082	1911	20,244
1905	20,720	1912	14,460
1906	18,847	1913	30,678
1907	24,550		

(e) Estimated.

CLAY AND CLAY PRODUCTS.

PROPERTIES OF CLAY.

Clay is a complex mixture of various minerals which are derived from the decay of other rocks. It should contain enough of the mineral kaolinite to impart its characteristics to the mass. Clays were originally derived from igneous or crystalline rocks, which contain large quantities of feldspar. Other constituents of clay are quartz (sand), undecomposed feldspar, mica, iron oxide and carbonate, calcium carbonate and sulphate, magnesium carbonate and sulphate; and organic matter.

There are several different kinds of clays. Residual clay is that which remains where it is formed. It is usually pure, white in color, easily worked, and is used in the manufacture of pottery and high-grade ware. Small deposits are known in the Arbuckle and Wichita mountains and in eastern Oklahoma. Transported clays as alluvial, colluvial, and shale, have been removed from the place where decomposition took place. They are more or less impure. Another type, known as fire clay, is that found underneath coal beds. In many cases it is very pure and fine-grained.

Kaolin is the chief constituent in the mineralogical composition of clays. It gives the plastic property, which allows the clay to

be molded into any desired shape, and also the refractory or heat-resisting properties. Fire clays contain a very large per cent of kaolin. Of the impurities which usually occur in clay, iron oxide (Fe_2O_3) produces the red color. Too much lime and magnesium act as a flux, causing the clay to melt at a low temperature. Quartz increases the melting point in impure clays, but has the opposite effect on pure clays.

The important properties of burned clay are color, specific gravity, porosity, hardness, toughness, crushing strength, and tensile strength. In some clays color is not important. In structural clay products the crushing and tensile strength are the important factors. In face brick, paving brick, and sewer pipe, porosity is of chief importance.

PROCESSES OF MANUFACTURE.

Several processes are being used in the manufacture of clay-products. Clays and shales are usually quarried with hand shovels, wheelbarrows, scrapers, wagons, and steam shovels, and then hauled to the plant by various methods. The clays are molded by 3 processes: Namely, the soft mud process in which the clay is made into a soft mud to be molded by hand or machine into any desired shape; the stiff mud process in which the clay, after grinding, is mixed with water and then molded; and the dry process in which the clay is only moistened enough to retain its shape, then molded and subjected to great pressure. After being molded the ware must be dried and burned.

USES OF CLAY.

Some of the most common uses of clay are for common and front brick, paving brick, drain tile, sewer pipe, roofing tile, fire proofing and hollow block, terra-cotta, stoneware, porcelain ware, ornamental ware, paints, adulterants, fire brick, Portland cement, railroad ballast, and furnace and road material. Common brick can be made from almost any clay, but pottery and stoneware require a high degree of purity. Fire brick are made from clays that are very difficult to melt.

CLAY AND SHALE AREAS.

For convenience, the respective areas in which clay occurs may be divided as follows: (1) Arbuckle and Wichita mountains; (2) Ouachita Mountains; (3) Ozark Uplift; (4) Pennsylvanian region; (5) Redbeds or Western region.

In the Arbuckle Mountain region, in south-central Oklahoma there are several shales which could be utilized. Near Ravia a ledge of the Simpson shale is about 40 feet thick. It is suitable for common or front brick, fire proofing, or drain tile. The Sylvan shale, 100 to 300 feet thick, is a very pure clay shale. The Oklahoma Portland Cement Company at Ada uses this shale in the man-

ufacture of Portland cement, but so far no other clay products have been manufactured from the Sylvan shale.

In the Ouachita Mountain region, the Standley shale, reported to be 6,100 feet in thickness, is the only shale available for the manufacture of clay-products.

In the region of the Ozark Uplift, in the extreme northeastern part of the State, the Chattanooga and Fayetteville shales could be utilized for paving brick, sewer pipe, and fire proofing. Transportation facilities are good and fuel is near at hand.

The Pennsylvanian area includes that part of the State lying north of the Arbuckle and Ouachita mountains, west of Grand River, and east of the Redbeds. Shales make up about three-fourths of these rocks. Some of the principal shale formations are the Vinita formation, Labette shale, Nowata shale, the Coffeyville formation, and the "Copan member" of the "Wann" formation These beds are available to transportation and fuel. Most of the development in the clay industry has been in this section of the State. A large part of these shales can be used to make drain tile, common or building brick, paving brick, sewer pipe, and roofing tile. The clays underlying the coal beds are well suited for paving brick, sewer pipe, fire proofing, and fire brick. In many cases the roof material is a good grade of blue shale. The utilization of these clays and shales from the coal area could be made a very paying proposition.

The Permian or Redbeds area includes all of the State west of a line passing through or near Blackwell, Ponca, Pawnee, Stroud, Prague, Byars, and Davis, and west around the Arbuckle Mountains. The bids consist of about three-fourths of red clay-shale which can be used to make common and front brick, drain tile, and irrigation tile. None of the shales are suitable for refractory materials, on account of the high percentage of iron. Fuel is not easily obtained, hence development has been retarded in this area.

The Cretaceous area lying along Red River south of the Arbuckle and Ouachita mountains has a number of ledges of shale which can be used only in making common brick. Wood which is plentiful over much of this area is the only form of fuel easily available.

CLAY PLANTS.

In the development of the clay industry there are at least four factors to be taken into consideration. These are: First, the supply of raw material; second, fuel; third, transportation facilities; and fourth, markets. Oklahoma possesses all these essential factors. There are 35 clay-working plants in operation in the State. Brick plants are located at Bartlesville, Nowata, Clarmore, Vinita, Tulsa, Pawhuska, Broken Arrow, Collinsville, Cleveland, Sapulpa, Okmulgee, Wainwright, Boynton, McAlester, Poteau, Ada, Ardmore, Enid, Guthrie, Oklahoma City, Chickasha, Marlow, Addington, Comanche, Waurika, Alva, Geary, Hobart, Blackwell, Shawnee, and Mangum.

VALUE OF CLAY PRODUCTS.

The value of clay products in Oklahoma in 1912 was $535,318 and in 1913, $573,371. The increase of 1913 over 1912 was $38,053. In 1912 Oklahoma ranked thirty-second and in 1913, thirty-fourth in the United States. The amount of common brick manufactured in 1912 was 67,712,000, valued at $341,589, and that of vitrified brick, 18,805,000, valued at $175,900. The average price of common brick was $5.04 per thousand. In 1913 the number of common brick was 73,176,000, valued at $369,344, the average price being $5.05 per thousand; and that of vitrified brick was 14,912,000, valued at $149,844, the average price being $10.05 per thousand.

Value of clay products in Oklahoma, 1901-1913.

Year.	Value.	Year.	Value.
1901	$ 322,284	1908	$ 562,929
1902	403,649	1909	1,032,314
1903	534,977	1910	920,921
1904	531,024	1911	756,639
1905	596,299	1912	535,318
1906	540,901	1913	573,371
1907	664,512		

PORTLAND CEMENT.

MATERIALS.

One of the chief problems confronting the people today is to find some material that can be substituted economically and successfully in the place of wood as a building material. As a consequence Portland cement has come to the front along with natural stone and building brick. It has stood the test in all kinds of construction work, even where subjected to heat and earthquakes as it was in the great San Francisco disaster.

Within recent years the demands upon the production of Portland cement have increased, due to the facts mentioned above, and also because wood and other building materials are not always accessible, or are too high-priced because of heavy freight charges. It seems probable that this demand will increase rather than decrease in the future. The unlimited supply of raw material, cheap fuel, and good transportation facilities insures a steady and rapid growth for this industry within the State.

Materials used in the manufacture of Portland cement are limestone and shale, or argillaceous limestone. Limestone furnishes lime, some alumina, silica, ferric oxide, and magnesia. Shale furnishes alumina and some of the above constituents. It is necessary in order to prepare a good cement to have the proper proportions of the different materials. Too much lime weakens the cement and too much iron reduces the tensile strength and setting power. The percentages of the constituents should be: silica 19 to 26, lime 58 to 67, alumina 4 to 11, ferric ovide 2 to 5, magnesia not more than 4, and sulphuric anhydride not more than 1 per cent. Any natural products containing these ingredients in the proper proportions can be manufactured into Portland cement.

PROCESS OF MANUFACTURE.

The process of the manufacture of Portland cement is simple. The raw materials are quarried and then transported to the plant. They are then delivered to powerful crushers for the coarse grinding, after which they are elevated to storage bins and remain there until a chemical analysis has been made. From the bins the mixture passes through dryers into the intermediate crushers, then to bins where the necessary proportions of clay and limestone are added and mixed before the final grinding. After leaving the fine grinders, the material passes a hundred mesh sieve to storage bins. From here the product goes through the continuous rotary kilns, where it is fused into dark, greenish-black pieces about an inch in diameter. After cooling, the clinker is ground fine, and a little gypsum added to retard setting. The finished product is then conveyed to the stock room where it is packed.

LIMESTONE AND SHALE AREAS.

There are at least six areas where limestone and shale occur in large quantities. In northern and northwestern Oklahoma, in the region extending from the Arkansas River east to Craig County, there are about 20 ledges of limestone, varying in thickness from 10 to 40 feet, and interstratified with shale and sandstone. Not only are the necessary raw materials abundant, but the presence of coal, oil, gas, and adequate transportation facilities make the region suited to the building up of this industry. Two of the most prominent ledges of limestone, known as the Boone and Pitkin, are within 20 to 50 miles of the source of fuel, as well as being favorably located with regard to the necessary shale deposits

In the southeastern part of the State, the Wapanucka limestone outcrops along a line for nearly 100 miles, extending from the Arbuckle Mountatins past Atoka, east to the State line. Clays and shales are found in close proximity. Two coal beds parallel this ledge of limestone. Several other ledges of limestone outcrop in the region south of the Arbuckle and Ouachita mountains, but

so far, the lack of a nearby fuel supply has prohibited the use of these materials in the manufacture of Portland cement.

In southern Oklahoma, in the area of the Arbuckle Mountain uplift, there are four ledges of limestone: namely, the Arbuckle limestone, 6,000 feet thick; the Viola limestone, 800 feet thick; the Bois d'Arc; the Chimney hill; and the Sycamore limestones. Shale outcrops occur along with or in close proximity to these limestone ledges. As can readily be seen there is an abundant supply of raw materials. Fuel could be shipped, or oil and gas piped into this region from the Healdton field, which is only 30 odd miles distant.

In southwestern Oklahoma, in the Wichita Mountatin area, there are two ledges of limestone, namely the Arbuckle and Viola limestones. Shale is also found. Fuel in suitable quantities is not found in the region, consequently there is at present insufficient inducement for the development of this area for Portland cement.

CEMENT PLANTS.

At present there are three cement plants in the State, though several others have been projected. These plants are located at Ada, in Pontotoc County; at Dewey, in Washington County; and at Hartshorne, in Pittsburg County.

The plant at Ada is the pioneer in the development of the State's cement resources. It is located 1 mile southwest of Ada, in Pontotoc County, on 3 lines of railroads: the Missouri, Kansas, and Texas; the St. Louis and San Francisco, and the Oklahoma Central. The buildings are of reinforced concrete and cover about 10 acres of ground. The limestone and shale, found together, are quarried 6 miles south of the plant, and hauled to the quarry by a switch engine. There are four rotary kilns 125 feet in length. The mill has a daily capacity of 4,000 barrels. Powdered coal is the fuel used at present. The power is furnished by four Corliss steam engines. The cement manufactured is of a high quality.

The Dewey Portland cement plant is at Dewey, in Washington County, on the Atchison, Topeka, and Santa Fe, and Missouri, Kansas, and Texas railroads. The quarry is 1½ miles east of the plant. The shaly limestone ledge is about 22 feet thick. The extra amount of clay needed is obtained from a pit just to the north of the plant. There are five rotary kilns 100 feet in length. The plant is operated by electrical power, which is generated in 6 double-acting gas engines of 555 horsepower each. Natural gas is used. The daily capacity is 3,000 barrels. The cement is light in color, and very high grade.

The Choctaw Portland Cement plant is located 1½ miles south of Hartshorne, in Pittsburg County, on a spur of the Chicago, Rock Island and Pacific Railroad. The buildings are of reinforced concrete. The rock is obtained from an exposure of the Wapanucka limestone, which stands as a ledge 100 feet high near the plant.

Shale is secured underneath the limestone. The kilns are 8 feet in diameter and 110 feet in length. Powdered coal is the fuel used. At present the plant is not in operation for manufacturing cement.

Only two things can check the demand for cement. One would be the discovery of a better and cheaper material, and the other the cessation of all structural work. It seems unlikely that either of these contingencies will arise within the near future.

Value of Portland cement in Oklahoma, 1908-1913.

Year.	Value.	Year.	Value.
1908	$ 462,000	1911	$.....
1909	608,000	1912	1,029,834
1910	888,000	1913	1,258,676

ROAD MATERIALS.

GENERAL.

Good roads, as a social and financial asset to a community, state, or nation, stand in the first rank. While materially adding to the value of real estate they lessen the wear and tear upon man, beast, and vehicles. They also enable the farmers and truckmen to market their produce at any season of the year with the least waste of time and energy.

From the social point of view, as well as from the financial advantages derived, good roads deserve a place of prime importance. It is chiefly to the rural districts that these social advantages accrue. The increased attendance at rural gatherings, churches, and schools, and the rural free delivery, with the added attraction which such a community offers to the better class of home-seekers, all speak favorably for splendid systems of good roads.

Many of our early roads were nothing more than paths or trails which followed the most convenient lines of travel, and in most cases were more favorably located than the roads of the present. In some localities, where the roads follow the section lines (all section lines by the State law are public highways), much improvement has been necessary to place the road in good condition. Even then the road might not be as good as one constructed with less time and money by taking into consideration the topography and general land features.

MATERIALS.

The term road materials includes clay, sand, gravel, sandstone, limestone, asphalt, clinker from burned culm heaps of coal mines, and that produced when coal dust is burned with clay, and cinders from factories. Material for macadam roads may be obtained

from igneous, sedimentary, and metamorphic rocks. The best test for a road is actual use, hence some of the materials just mentioned have been found to be more satisfactory than others.

Sand as a road material has not been satisfactory. It is practically worthless except on extremely plastic or sticky clay roads. A mixture of sand and clay would be much better.

Clays are the chief constituents of most natural roadways. They are satisfactory in dry weather when properly graded, but on the contrary, in wet weather they are often almost impassable. Clay roads can be improved by the addition of sand, and sand roads by the addition of clay. Clay products, such as vitrified brick, are used in street paving, and in many cases country highways have been paved.

Gravel.—There are three kinds of gravel in Oklahoma; namely, granite, quartz, and limestone gravel. They have only fair wearing qualities, but have good cementing value and form a smooth, hard surface. The use of gravel as a road material is confined to the localities in which it occurs.

Asphalt and Bitumen.—The use of asphalt in a road or pavement is as a binder or cement for the mineral particles. Asphalts in Oklahoma are plentiful. They occur as impregnations in limestone, sandstone, or in the pure state. Rock asphalt, a physical combination of pure asphalt and rock, has been very successfully used, and is conceded to be a better paving material than can be made by artificial processes. Asphaltic oils are used in some localities on the roads and are said to have added much to their improvement.

Clinker.—The product left after the burning of culm piles has been used to some extent near the coal mines. It is not suited to heavy traffic on account of the softness of the material. However, it adds much to the improvement of the earthen road. Cinders from manufacturing plants have been utilized to improve sticky clay road.

Rocks for macadam.—There are many limestones which would furnish an unlimited supply of road materials. This kind of stone has been quarried at several places, but the output has been used chiefly for railroad ballast, Portland cement, and concrete rock. However, there is an enormous amount of material that can be used as a good road material. It has been very satisfactory and will probably be the future road material for macadam roads in Oklahoma. Portable crushers might be installed at localities near where work is to be done. Waste stone from building quarries might also be utilized. The railroads have used crushed rock from granite quarries for road beds. Such material could be utilized for the foundation of roads, but might not be satisfactory for the surface part.

Mill tailings.—In the region of the lead and zinc mines good roads could be built with a very small expenditure for the rock material. A large amount of chert and limestone is mined with the lead and zinc and is crushed to various degrees of fineness by the milling process. This material which is known as "mill tailings," or "chats," has accumulated in great heaps, and the companies are anxious to get rid of it. It can be loaded on the cars by the railroads at a cost of about 6 or 8 cents a ton. In some localities it sells at prices ranging from 50 cents to $1.00 a ton, but in the neighborhood of the mines it can be had for about 15 cents a ton. It is excellent road material and can be used to good advantage in many sections of the State. It is also of special value as concrete rock and railroad ballast. The material has been used in a very limited way on the roads in the immediate vicinity of the mining camps.

QUARRIES IN OKLAHOMA.

In the following table the locations of all the principal quarries in the State are given. The kind of stone, the use made of it, and the geological formation from which the rock is derived are indicated.

Quarries in Oklahoma.

Location.	Kind of stone.	Use.	Geological formation
Ada, ½ mile west	Lime asphalt	Paving	Viola limestone
Ada, near Lawrence	Limestone	Crushed stone	Viola limestone
Ardmore, 6 miles southwest	Sand asphalt	Paving	Glenn formation
Ardmore, 5 miles south	Sand and lime asphalt	Paving	Glenn formation
Avant, southeast	Limestone	Crushed stone	Avant limestone lentil
Bromide	Limestone	Lime	Viola limestone
Bromide	Limestone	Building stone	Wapanucka limestone
Cache	Granite gravel	Road material	Granite
Cement	Siliceous limestone	Crushed stone	Viola limestone
Chocie	Limestone	Crushed stone	Wapanucka limestone
Chilocco	Limestone	Crushed and building stone	Winfield limestone
Cold Springs	Black granite	Building stone	Cold springs granite.
Crusher	Limestone	Crushed stone	Arbuckle limestone
Crusher, ½ mile north	Limestone	Crushed stone	Arbuckle limestone

Location.	Kind of stone.	Use.	Geological formation.
Dougherty, 4 miles northeast (Brunswick district) 3 quarries	Sand and lime asphalt	Paving	Simpson formation and Viola limestone
Dougherty, Buckhorn district, 20 prospects and quarries	Sand and lime asphalt	Paving	Simpson formation and Viola limestone
Dewey, southeast	Limestone	Crushed stone	Dewey limestone
Fitzhugh	Limestone	Crushed stone	Viola limestone
Granite Reformatory	Granite	Crushed and building stone	Granite
Garnett	Limestone	Crushed stone	Oologah limestone
Granite, 1 mile northwest	Granite	Crushed and building stone	Granite
Hartshorne	Limestone	Crushed stone	Wapanucka limestone
Hotulka	Gravel	Concrete	
Keough	Limestone	Crushed stone	Pitkin formation
LeFlore	Sandstone	Crushed stone	Ouachita Mt. sandstone
Lenapah	Limestone	Crushed stone	Lenapah limestone
Lost City	Limestone	Crushed stone	Skiatook formation
Lester	Disintegrated granite	Ballast	Granite
Newkirk, 4 miles east	Limestone	Fence posts, building stone, etc.	Fort Riley limestone
Newkirk, 4½ miles northeast	Limestone	Flag stone and curbing	Winfield limestone
Ponca City	Limestone	Curbing and building stone	Wreford limestone
Ravia, 2 miles northwest	Granite	Crushed stone for ballast	Granite
Ravia	Lime asphalt	Paving	
Ripley	Limestone	Crushed stone for macadam roads	Neva limestone
Richard Spur	Limestone	Crushed and building stone	Arbuckle limestone
Tishomingo	Granite	Crushed and building stone	Tishomingo granite
Tishomingo, southeast	Granite gravel	Ballast	Granite

IRON.

Iron, as the most useful, and next to aluminum, the most abundant of metals, is mined and reduced in almost every country in the world. There is a general impression that the world's supply of iron ore is approaching exhaustion. The principal argument against this is that improved methods of smelting will enable the lower grade ores to be successfully used as a source of iron. The enormous deposits of iron ore in certain localities have held in check the discovery and development of smaller areas and leaner ores.

Oklahoma has no large deposits of iron ore, but some good ores occur in small quantities and future investigation may reveal considerable quantities of impure ore.

The iron present in rocks gives rise to the various colors which occur. Iron is widely diffused throughout the Redbed shales and sandstones in the central and western part of the State, and some of these contain as much as 15 to 20 per cent. Some of the ore occurs throughout the Coal Measures area, chiefly in the form of concretionary or kidney ore. These two sources are not likely to produce ore of value in large quantities. Some good iron occurs in the Ouachita and Arbuckle mountains. In the region of Roff, Mill creek, Davis, and Hunton, large bowlders are found scattered over the surface. In the vicinity of Sulphur and Bromide blocks of ore weighing several hundred pounds occur. This is chiefly a manganese iron ore. The analysis of a sample shows 10 per cent iron and 40 per cent manganese. During the summer of 1914 considerable work was done in exploiting the region about Bromide to determine the value and extent of this material. The work was done by private individuals interested because of holdings in that region. However, a Survey party doing work in the region of Wapanucka and Bromide investigated the region to some extent, but the results of their examinations are not ready to be published.

In the Wichita Mountains considerable ore is found scattered over the surface. Some manganese has been collected by Survey parties, and a number of good samples have been sent in from various parts of the State. A few tons of pyrites are shipped each year from the lead and zinc region. Two or three shipments of the low grade ores have been made from Hunton and Mill Creek.

Deposits of iron ore have been reported from many localities. Recently certain newspaper reports were published stating that large deposits of valuable iron ore have been found in the Coal Measures area and that the region would in a few years rival Pittsburg as an iron center. The Survey is not responsible for these statements as intimated, and while no systematic investigations of the iron ore deposits have been made, the field work over the State has revealed no conditions that lend encouragement to the finding of extensive deposits.

COPPER.

Copper is widely distributed among the rocks. It has been reported from many places in Oklahoma, but in all these localities it has been found in such small quantities that it is of no commercial importance. Copper stain is frequently found in rocks, and even pieces of metallic copper may be included in small fragments, but such are no indication of ore of value. The principal places from which copper is reported is from the Redbeds region, and from the mountain regions. Much prospecting has been done in a number of localities. In some places hundreds of shafts have been sunk, but in no case has the amount of copper justified the expense.

GOLD AND SILVER.

There is always a desire on the part of the prospector to search for the precious metals. Much prospecting has been done in Oklahoma for gold and silver. This search has been carried on for years, and up till the present time not enough has been found to be of any economic value. Some analyses of selected samples show high mineral content, but in quantity the ore-bearing rock proves to be practically worthless. Throughout the Arbuckle and Wichita mountain region numerous prospect holes have been sunk to depths verying from a few feet to 100 feet. In some cases material containing a very small percentage of gold, silver, and other precious metals has been found. An investigation of a large number of these prospects by the United States Geological Survey a few years ago showed that nothing of value had been discovered. Many people have been induced to invest in stockselling schemes and lake prospects without any returns for their money.

In August, 1913, 29 tons of ore were shipped from a surface working 5 miles west of Byars in McClain County. The smelter returns show that 1,300 ounces of silver were recovered, having a value of $785. The material is silver chloride in a soft, reddish sandstone. Several samples were collected from this locality by a representative of the Geological Survey and were assayed, but did not prove to be as rich as hoped.

Whether future prospecting may reveal valuable deposits cannot be said, but it is believed that representative places have been prospected over the State and these do not offer encouragement for additional investigations.

TRIPOLI.

Tripoli is a light, soft, porous, siliceous rock supposed to have resulted from the leaching of calcareous material from a siliceous limestone. It is usually white or cream colored, but often there is sufficient iron oxide present to give a decided pink to red color. It is of value for a number of purposes. The chief products are man-

ufactured from the flour which is prepared from the tripoli as quarried, in essentially the same manner as ordinary wheat flour is made. The rock is ground and sieved through silk wire bolting, is packed in barrels and sold in the market. Various grades of flour are made, depending on the purity of the material, and the fineness of the grinding. The chief use of the flour is as an abrasive or polisher in metal-working trades. The finer grades are used in jewelry polishing, and the coarse as brass and steel polishes. It is also used as an adulterant in the manufacture of gunpowder, a the body in dynamite, lagging for boiler, for making cement, water filters, wood filler, and wood polishes.

Illinois, Missouri, Arkansas, and Oklahoma are the states which produce tripoli. The principal seat of the industry is at Seneca, Missouri. Two mills owned by the same company are operating there. Much of the raw material comes from the Oklahoma side of the line. In 1912 a large deposit of value was found near Peoria, Okla., about 8 miles from Seneca, and a railroad spur was constructed and a mill site selected. A New York company expects to develop the deposit and furnish ground tripoli for abrasive purposes. It is difficult to obtain large pieces of the Oklahoma tripoli, such as are desired for filter manufacture, because of the cracks and bedding planes in the rock.

The rock exposed in the northeastern part of the State, where the tripoli occurs is the Boone chert, or Mississippi limestone. This formation consists of layers of pure limestone, limestone interbedded with chert, and layers of pure chert or flint. The deposits of tripoli owe their origin to the solvent action of water on this limestone or chert. The region is rough and hilly. The tripoli is found chiefly in the tops of the hills and along the sides of ravines. The extent of the deposit in Oklahoma is not known. Several small deposits of tripoli have been reported from various sections of the State. The source of the Missouri tripoli is probably the same as that of Oklahoma. The deposit in Arkansas consists in weathered, calcareous, siliceous rock. The calcareous material has been leached out, leaving a pure, fine-grained siliceous material. At various places novaculite beds have been altered to tripoli.

VOLCANIC ASH.

Volcanic ash is composed of fine dust and powdered lava blown from volcanoes. There are several localities in Oklahoma where considerable deposits of volcanic ash are known to exist. Only a few deposits are of great size. It is only recently that volcanic dust has been considered of commercial value. In the absence of any definite data the Geological Survey began field work in 1913 to investigate the deposits in the State. This work was assigned to Frank Buttram, then chemist and field assistant for the Survey.

During the progress of the work the known deposits were examined and a number of new deposits of value were found. It was also discovered that volcanic ash in greater or less quantities existed over a large part of the State, and when not found in distinct deposits it is found disseminated through the surface soil over large areas.

A report has been prepared and has just come from the press, which gives the result of these field investigations. In order to discuss properly the deposits in the State it was found necesary to gives something of the origin and probable source of dust in these deposits, and also to discuss the mean of its transportation, physical and chemical characteristics, and economic value. In order to deal with these phases of the subject properly, and to give the reader a general idea of volcanic phenomena the report was divided into three general chapters. The first chapter discusses briefly the different types of volcanoes, their distribution and origin. The second chapter deals with the origin, distribution, physical and chemical properties and economic value of volcanic dust, while the third deals with volcanic dust in Oklahoma.

The principal volcanic dust deposit in Oklahoma occurs in the northwestern and east central parts of the State. One of the principal occurrences is about 8½ miles northwest of Gate, near the boundary line between Harper and Beaver counties. Here a deposit 9 feet in thickness outcrops for a distance of 1800 feet or more and about 1¼ miles east of this location another deposit showing 10 feet in thickness has a considerable outcrop. Other small deposits occur in the same general locality. Another important deposit is about 8 miles northwest of Woodward, where there is an outcrop of about 600 feet, showing a thickness of 6 feet, and a little farther to the south the outcrop continues for some distance with a thickness of about 8 feet. The deposit considered most accessible and perhaps most important in the State is in section 15, just northeast of Custer City. A deposit of much value and considerably removed from the ones above described is found 8 miles northwest of Wetumka. This deposit is being developed to some extent and the material shipped from Okemah to Oklahoma City, where it is being used for various purposes. Another small deposit occurs 6 miles west of Okemah and another near Dustin. Near the north edge of the town of Stigler is a small deposit of impure ash 4 to 5 feet thick. Other deposits are known to occur over the general region from about Alva east to Newkirk and south to Watonga and Kingfisher. It is very probable that further investigations will lead to the discovery of many other deposits of greater or less extent over the northwest and central parts of the State.

Volcanic ash is used for abrasive purposes, chiefly in the form of polishing powders, scouring soaps, and cleansing powder. It is

also used in the manufacture of dynamite as a holder of nitro-glycerine. It is a good non-conductor of heat and is used for packing material for safes, steam pipes and boilers, and as fireproof building material. It is of value as a fertilizer in the natural state, and in addition is used as an absorbent of liquid manure in the preparation of artificial fertilizers. It is also used in the manufacture of cements, artificial stone, paper, sealing wax, fire works, and many other materials.

NOVACULITE.

Novaculite is an even-grained, gritty stone which is really a sandstone with the appearance of chert or flint. It has not been found in commercial quantities in Oklahoma, but since fine deposits occur in Arkansas in the Ouachita Mountains it is highly probable that the same materal may be found in the extension of these same mountains on the Oklahoma side of the line. The most likely localities would be along the hills east of Stringtown and Atoka, about Talihina and to the eastward. The workable stone is obtained usually in rather small pieces. The size of the block as quarried ranges from 1 to 1500 pounds. The stone is used for whetstones, razor hones, and jewelers' stones. In fact, it may be used by all workmen who use small-pointed or fine-edged tools.

WATER RESOURCES.

RIVERS.

Oklahoma has many streams of considerable size. Ten rivers cross the State. The two largest are the Arkansas, which with its tributaries drains the northern two-thirds of the State; and the Red River which receives the water from the southern third of the State. The Arkansas, which rises in the Rocky Mountains, flows a distance of 200 miles across the northeastern part of the State. The channel contains much sand. In Colorado and western Kansas much of the water is used for irrigation, so that in northern Oklahoma there is little water in the stream. In this State it is fed by many tributaries. From near Muskogee, where Verdigris and Grand rivers enter, the Arkansas is navigable for small boats part of the year. The principal tributaries from the south are Poteau, Canadian, Cimarron, and Salt Fork. The South Fork of the Canadian River rises in New Mexico, the North Fork has many tributaries rising in eastern New Mexico, and one in the Panhandle of Texas. Salt Fork flows through the salt plains of Alfalfa County and below that point the water is salty. The principal tributaries of the stream are Medicine, Mule, Sand, Chikaskia, Deer, Cottonwood, and Bois d' Arc creeks.

Red River forms the southern boundary of Oklahoma. The stream has a broad sand-choked channel. The principal streams

which empty into this river are the Washita, the only stream in western Oklahoma which has steep banks and little sand in the channel; Little and Kiamichi rivers which drain the Ouachita Mountains; Boggy Creek which drains the area between the Ouachitas and Arbuckles; Blue River in the eastern part of the Arbuckles; Mud and Beaver creeks which drain the area between the Arbuckles and Wichitas; and Cache Creek from the eastern part of the Wichita Mountains. The North Fork of Red River rises in the Panhandle of Texas. All of these streams have extensive, fertile valleys.

DOMESTIC WATER SUPPLY.

The water supply for household and domestic use in Oklahoma is good. There is no part of the State in which good water cannot be obtained. Springs are found in all parts of the State. In the northeastern part of the State springs are abundant and furnish the chief water supply. In the Ouachita, Arbuckle, and Wichita mountains are a great many good springs of pure water. Some springs are found in the sandstone regions of the eastern half of the State, and in the Flint Hills in the northern part there are many excellent springs. In the Redbeds region springs are common but usually contain gypsum or salt.

The purest spring water in western Oklahoma comes from springs in the sand hills and the high uplands. Some of the most noted of these springs are Cleo Springs, Elm Springs at Alva, Caddo Springs, north of El Reno, and several large springs near Moscow, Aline, Grand, and Woodward.

Good well water can be obtained in all parts of the State. In the mountain region but few wells have been put down. In the eastern and central parts of the State wells are common, and a good supply of water is usually found at 50 feet or less. In the Redbeds and Gypsum Hills region the wells are from 50 to 100 feet. In some of these wells the water is pure while in others there is considerable gypsum and salt. In the sand hills and high plains of the western part of the State, good pure water is obtained. The wells are often 300 feet or more in depth, and windmills are used to pump the water. In many parts of the State surface water is ponded for stock use.

Lawton's dam and reservoir impound 5,000,000,000 gallons of water. The height of the dam is 50 feet, and the area of the reservoir is 1082 acres.

For city water supplies the water is obtained either from deep wells, strong springs, mountain streams, or rivers.

WATER POWER.

The water power resources of the State are very great. There are a number of swiftly flowing streams, carrying constant volumes of water. In these areas the question of utilization is not a

difficult one. There are many other streams which have irregular flows. Water power has long been successfully used for practical purposes. Water power is inexpensive and perpetual, and requires little additional expense after once it has been put to use.

A proper development of the water power of the State would bring about several important results. Much cheap power would be secured, navigation facilities increased, less damage done by floods, and purer water supplied from large storage basins. Much of the water power of the State is not readily accessible under present conditions except by transmission in the form of electricity. Electricity can be successfully transmitted for 150 to 200 miles. Artificial light and heat are of special importance. When our ordinary fuels have been exhausted water must be the chief agent for supplying the needs. The water power might well be utilized as a means of conservation of other resources.

Power plants are now in operation in only a few places in the State. Many others are being considered. Along the Washita several projects have been investigated and in the eastern part of the State it is proposed to construct a dam across Grand River near Muskogee. The amount of power here generated would be enormous. Extensive reservoirs may also be formed from mountain streams. To say the least, there are all the good water power sites in Oklahoma that can ever be utilized for all purposes—water power, irrigation, and domestic uses. The reservoir constructed on Medicine Creek near Lawton, impounding an enormous supply of water, shows what may be accomplished by the utilization of natural storage basins.

MINERAL WATERS.

There are many mineral wells and springs in Oklahoma. Water is one of the essentials of life. The use of mineral water in the treatment of disease is an important one. As ordinarily understood, "mineral water" is applied to water which is used in the treatment of disease and differs from ordinary water in that it holds in solution certain solids or gases. The quantity of mineral matter contained varies greatly and many waters sold for medicinal or table use as mineral waters often contains smaller quantities of inorganic substances than that contained in many domestic and city water supplies. Mineral waters of commerce are both natural and artificial; that is, some water is put on the market in the natural state, while others are treated by concentration on the addition of organic or inorganic substaces for certain results.

Rain water as it falls upon the surface of the earth is practically pure. In passing through the soil and rocks it comes in contact with many mineral substances from which the mineral casts may be obtained. The kind of mineral and the quantity contained in the water depends upon several features and the classification of water on the basis of mineral contained is a very arbitrary one.

Platt National Park, a Government reservation, includes the mineral wells and springs in the vicinity of Sulphur.

There are several good sulphur and bromide springs near the town of Bromide, and the town was founded chiefly for the purpose of utilizing these waters for medicinal and bathing purposes. Several mineral springs of importance occur in the region of the Arbuckle and Wichita mountains. Others occur in the Ouachita and Ozark mountains.

In northeastern Oklahoma there are a great number of artesian wells which produce strong mineral waters, and at many places over the State in general mineral water has been found either in springs or in deep well borings. The term "artesian" was formerly applied only to wells which flowed, but in common use the term is now applied to any deep well. In prospecting for oil and gas in Oklahoma the drill often encounters mineral water. Some very important wells have been found in this manner. The utilization of both the pure and mineral waters which issue from the springs over the State will be given much fuller consideration in the future than they have in the past. The chief purpose is to find waters which are pure from the standpoint of not being contaminated with substances which would be detrimental to health. While waters which contain minerals are often of special benefit, it is also true that the greatest value is derived from the amount of water used, and as good results may be obtained from the use of pure water as from medicinal waters.

There was a decided advance in the mineral water trade of Oklahoma during 1911, the total output increasing from 150,000 gallons, valued at $4,950.00 in 1910, to 497,074 gallons with a value of $14,290.00 in 1911. In 1912 the output showed an additional gain both in quantity and value, amounting to 1,015,512 gallons sold, with a value of $32,971.00, an increase of 518,438 in gallons and in value of $18,681.00. The year 1913 showed a decline of more than one-half from the amount sold in 1912, but the value per gallon increased. The total amount sold was 502,439 gallons, valued at $26,231.00.

The following list gives the names and location of the springs and wells reporting sales during the past two years:

Altus Water Company	Altus
Beech Wells	Sulphur
Bromide and Eaton Wells	Claremore
Bromide Springs	Bromide
Brown Sulphur Springs	Granite
Claremore Radium Wells	Claremore
Comanche Mineral Wells	Comanche
Crystal Water Company	Oklahoma City

Excelsior Water Company.....Oklahoma City
Germicide Wells .....Wagoner
Green Well .....Chelsea
Guthrie Well .....Guthrie
Harper Artesian Bromide Wells.....Sulphur
"Hercules" and "Sooner".....Guthrie
Kallum Wells .....Faxon
Lewis Lithia Wells.....Oklahoma City
Nowata Radium Well.....Nowata
Old Government Springs.....Enid
Osage Spring .....Tulsa
Sand Springs .....Sand Springs
Sand Springs Water Company.....Sand Springs
Shannoan Springs .....Chickasha
Sulphur Bromide Well.....Sulphur
Tulsa Crystal Spring.....Tulsa
Work's Excelsior Wells.....Comanche
Zylite Water Company.....Oklahoma City

Production and value of mineral waters in Oklahoma, 1908-1913.

Year	Commercial Springs	Quantity Sold	Value.	Average price per gallon received
1908....	9	534,114	$52,779	9.9 cents
1909....	12	563,475	35,194	6.2 cents
1910....	4	115,000	4,950	4.3 cents
1911....	10	497,074	14,290	2.9 cents
1912....	10	1,015,512	32,971	3.2 cents
1913....	12	502,439	26,231	5.2 cents

The waters sold in the State are used for table, medicinal, and general commercial purposes. Several thousand gallons are used in the preparation of soft drinks and some for the manufacture of distilled water. Four of the firms reporting sales have bathing houses in connection with their springs or wells and a considerable amount is used at these places. Some of the resorts at the various springs have accommodation for several hundred guests. There are many excellent springs in the State from which the water is not sold and the real value of this mineral output would thus be much increased.

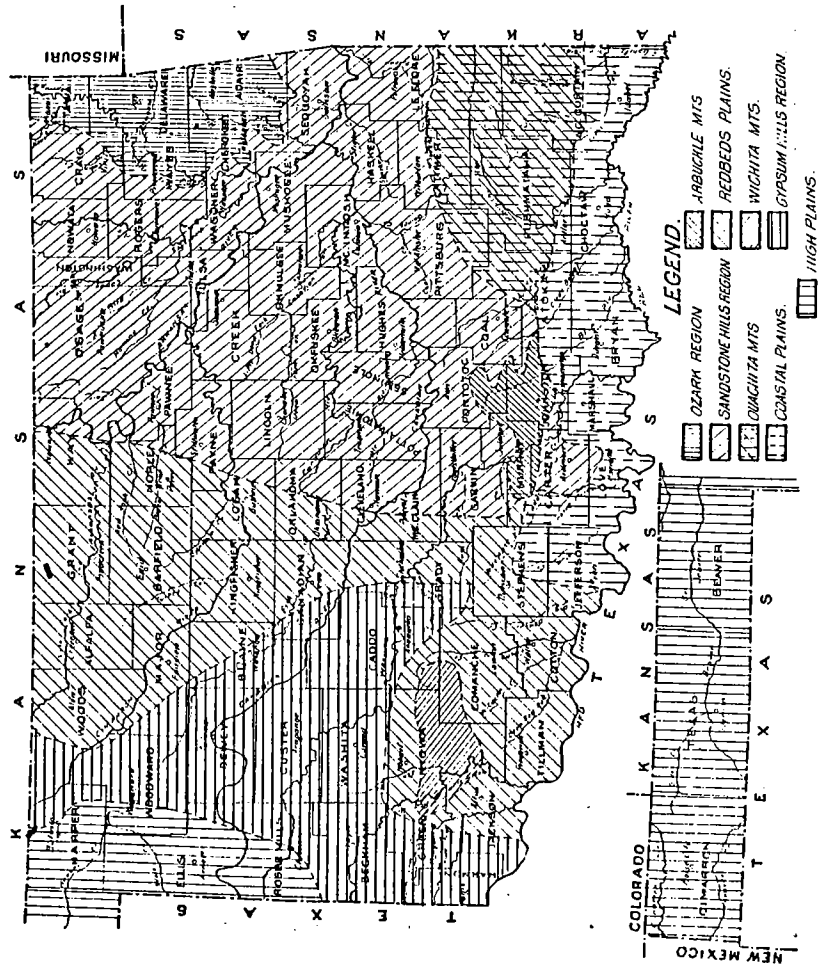


Fig. 3. Map of Oklahoma showing topographic or physiographic divisions of the state

SOILS.

Topographically the State is divided into 9 regions as follows (1) Ozark Plateau, (2) Sandstone Hills region, (3) Ouachita Mountains, (4) Coastal Plains, (5) Arbuckle Mountains, (6) Redbeds Plains region, (7) Wichita Mountains, (8) Gypsum Hills region, (9) the High Plains region.

There is no sharp line of division between these various regions. The general boundaries are shown in the accompanying sketch map, (fig. 3). These divisions coincide closely with the geologic divisions of the State. (See fig. 4).

The great variety of rock materials found in these regions produce soils differing much in character. The granite, limestone, sandstones, shales, and clay, each make different types of soil.

Soil is termed the loose mantle of material covering the surface of the earth. It consists of the disintegrated material of the earth's crust mixed with varying amounts of decayed organic matter. The earth's crust is composed of more than 70 elements, most of which are present in very small proportions, but, with the exception of 4 or 5, all have some important function in plant growth.

Immediately beneath the soil, or stratum of earth which affords nourishment to plants, is a mass of earth or rock unmixed with the decayed matter to which the term subsoil is applied.

The soils of the State would be grouped under the following heads: (1) Residual soils; (2) Transported soils. Under the second division are (a) colluvial soils, (b) alluvial soils, and (c) aeolian soils.

Residual soils are those which have been formed in the place where they are now found. The parent rock underlies the soil or subsoil at a greater or less distance, and the soil bears some of the characteristics of this rock. Th upper part of the rock's surface is generally somewhat broken and decayed with fragments scattered throughout the subsoil. A very large percentage of the upland soils of the State belong to this class.

Transported soils are those which have been moved by the action of water, wind, and ice. Very few residual soils remain undisturbed for any great length of time. The term colluvial soil indicates hillside soils, or those soils which have been removed only a little distance from the place of origin. They form a large part of the rolling and hilly uplands. The alluvial soils include those of the river valleys and the smaller stream bottoms. Many of the soils of this type in the State are of the very highest importance and are adapted to the growing of all sorts of crops. The aeolian soils are those which have been influenced by the action of the wind. The region of sand hills along our rivers are examples of this type. These regions are suited only to special crops. The greater part of these areas are stable, but in a few cases areas of shifting dunes are found.

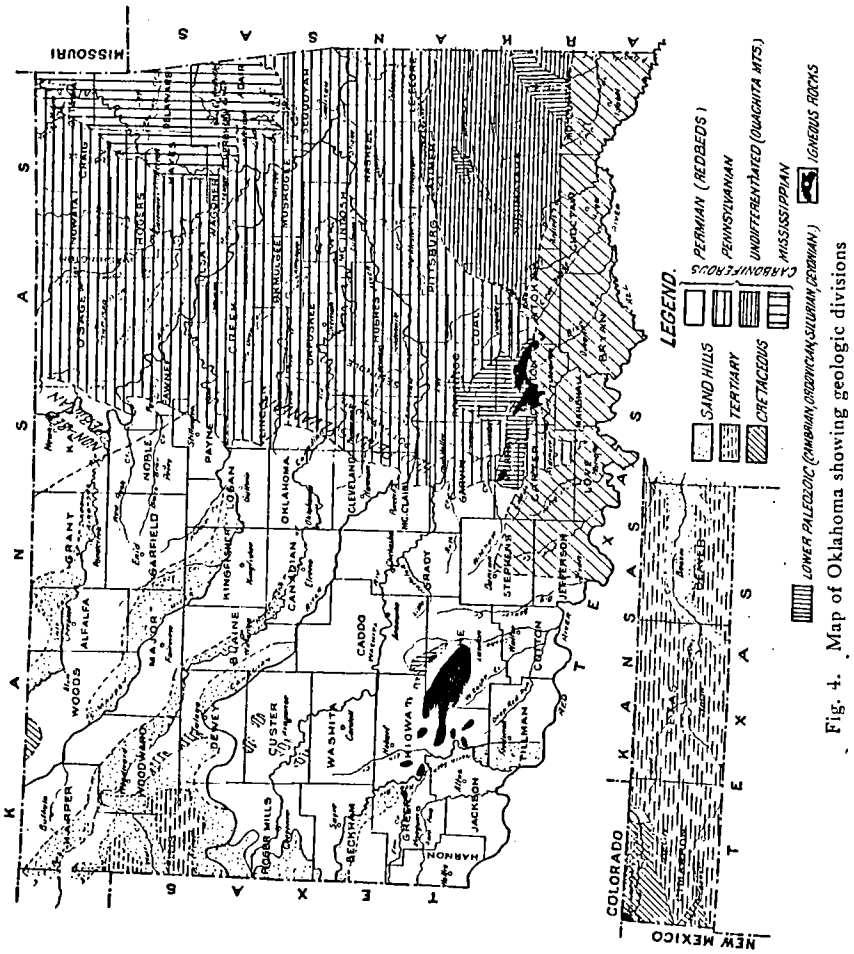


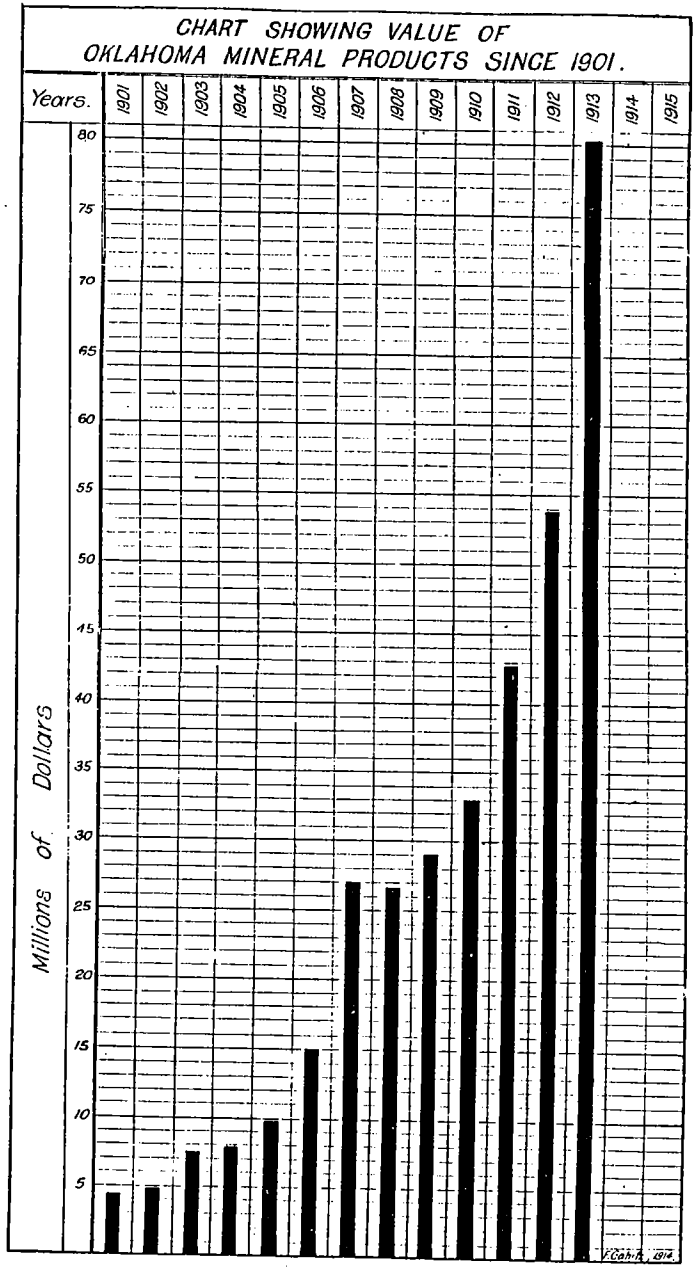
Fig. 4. Map of Oklahoma showing geologic divisions

Large areas in the State are not to be considered as agricultural regions. In the 5 mountainous districts there is little land of value except in the highlands of the Ozark Plateau. This region, while indicating a mountainous locality, is only the remnant of a worn down table land and is one of the important agricultural regions of the State, especially in the growing of hay and general forage crops. About the boundaries of the Arbuckle and Wichita Mountains some very fertile soils are found. The constituents derived from the granite and limestone make up good soils.

Only a small percentage of the agricultural lands of the State are now being utilized. The State is new and farming conditions have not reached the highest standard in any part. Hundreds of thousands of acres of Indian lands, segregated lands, and other tracts which are not open for settlement, have prevented growth from an agricultural standpoint. With proper care and cultivation the fertile soils should become the principal producing resource of the State. The soils are adapted to many crops. At the present time cotton, wheat, oats, corn, kaffir, prairie grass, and alfalfa are the principal crops.

The rainfall varies from place to place, from year to year, and from season to season. The highest rainfall is in the eastern part of the State, where the average for a period of 20 years was about 40 inches; in the central part of the State, 30 to 35 inches; and in the western one-third it decreases from 30 inches to about 15 inches in the western part of the Panhandle. With rainfall properly distributed throughout the growing season the soils show their high degree of fertility by the enormous crops which are produced.

The Geological Survey had made practically no investigation of soil conditions until during the field season of 1914. A bulletin will be prepared in the near future which will give considerable information concerning the origin, distribution, character, and fertility of the various soils of the State.



Value of mneral products of Oklahoma, 1902-1907.

	1902	1903	1904	1905	1906	1907
Coal	$ 4,265,106	$ 6,386,463	$ 5,532,066	$ 5,145,358	$ 5,482,366	$ 7,433,914
Petroleum	32,910	142,102	1,325,745	3,524,122	8,000,000	17,513,521
Natural Gas	360	1,000	49,665	130,137	259,862	417,221
Asphalt	.....	28,150	37,516	27,790	18,461	20,770
Granite	11,970	9,030	32,082	20,720	18,847	24,550
Sandstone	24,200	6,500	2,995	15,112	40,861	43,403
Limestone	50,541	56,190	101,518	168,921	171,983	189,568
Marble	.....	.....	.....	.....	.....	16,805
Lime	.....	4,803	3,194	4,650	4,850	5,250
Cement	.....	.....	.....	.....	.....	.....
Gypsum	111,215	234,621	190,245	(e)191,878	(e)356,441	(e)421,024
Clay Products	403,649	534,977	531,024	596,299	540,901	661,512
Sand & Gravel	.....	.....	(e)500	(e)3,000	(e)8,000	22,508
Lead	.....	.....	.....	.....	.....	42,824
Zinc	.....	.....	.....	.....	.....	84,849
Salt	7,562	2,070	1,961	2,145	4,965	910
Mineral Water	.....	.....	.....	(e)5,000	7,714	7,345
Other Products	.....	.....	1,000	.....	3,000	.....
TOTAL	$ 4,907,543	$ 7,406,153	$ 7,809,509	$ 9,835,135	$14,918,281	$26,908,968

(e) Estimated; (a) Included in "Other Products"; (b) Includes asphalt, marble, and cement; (c) Includes crushed stone; (d) Includes sand lime brick.

Value of mineral products of Oklahoma, 1908-1913.

	1908	1909	1910	1911	1912	1913
Coal	$ 5,976,504	$ 6,253,367	$ 5,867,947	$ 6,291,494	$ 7,867,331	$ 8,542,719
Petroleum	17,694,843	17,428,990	19,922,660	26,451,767	34,672,604	59,581,918
Natural Gas	860,159	1,806,193	3,490,704	6,731,770	7,406,528	7,436,389
Asphalt	23,820	48,130	65,244	(a).....	86,763	91,416
Granite	23,239	67,584	102,566	20,244	14,460	30,678
Sandstone	57,124	59,856	19,801	90,971	5,334	1,010
Limestone	257,066	450,655	509,344	594,661	409,994	246,912
Marble	.....	.....	.....	(a).....	.....	.....
Lime	.....	(e)6,000	(e)9,000	14,603	13,538	12,160
Cement	(e)121,971	(e)713,832	e)1,029,954	(a).....	1,029,834	1,258,676
Gypsum	(e)288,000	(e)100,000	(e)151,600	293,203	268,618	330,416
Clay Products	562,929	1,032,314	920,921	756,639	535,318	573,371
Sand & Gravel	35,971	185,812	186,977	97,539	163,298	39,157
Lead	118,356	195,018	158,840	173,250	304,920	548,064
Zinc	210,090	324,864	248,976	256,158	796,122	1,306,368
Salt	(e)900	(e)900	881	431	325	259
Mineral Water	52,779	35,194	4,950	11,290	32,971	26,231
Other Products	.....	.....	.....	891,324	(c)350,737	(d)5,527
TOTAL	$26,586,751	$29,008,138	$32,988,865	$42,678,347	$53,958,695	$80,631,630

(e) Estimated; (a) Included in "Other Products"; (b) Includes asphalt, marble,