OKLAHOMA GEOLOGICAL SURVEY

BULLETIN No. 6

PART I
DIRECTOR'S BI-ENNIAL REPORT
TO THE
GOVERNOR OF OKLAHOMA, 1910

PART II
BRIEF CHAPTERS ON OKLAHOMA'S MINERAL RESOURCES

NORMAN
December, 1910.

SCIENTIFIC STAFF

Chas. N. Gould.....Director
L. C. Snider.....Assistant Director
Frank Buttram .....Chemist

LETTER OF TRANSMITTAL

To His Excellency, Governor C. N. Haskell.

Sir:

In compliance with section four of the law establishing the Oklahoma Geological Survey, I present herewith the first biennial report of the Survey covering the time from the date of its organization July 25, 1908, to December 31, 1910.

This report includes also, as Part II, brief chapters on some twenty of the most common mineral products of the State.

Respectfully submitted

CHAS. N. GOULD, Director.

Norman, Oklahoma, December 31, 1910.

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PART I.

DIRECTOR'S BIENNIAL REPORT
TO THE
GOVERNOR OF OKLAHOMA

THE AUTHORITY

The authority for the establishment of the Geological Survey, is contained in Section 37 of Article 5, of the Constitution of Oklahoma:

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

THE LAW

The Survey was established by the first legislature of Oklahoma. The bill providing for its establishment follows:

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 Commisison 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 ($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 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 seven 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 co-operation.

That the Director of the Survey be authorized in the name of the Commission, to solicit the friendly aid and co-operation of all the citizens of Oklahoma, and particularly all teachers, and other professional men of the State.

That in conformity with Article three of Section three 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 may think 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.

The following general instructions to the Director of the Geological Survey were adopted by the Commission.

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 co-operate 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 of the Geological Survey 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 field of Oklahoma. Also to prepare and present to the Commission, reports fully illustrated setting forth the facts relating to these subjects.

APPROPRIATIONS 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 30, 1911.

Senate Bill No. 318

An Act

Making an appropriation to pay the expenses of the Oklahoma Geological Survey, for the fiscal year 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 ($34,650.00) dollars, 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 year ending June 30, 1910;	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
Stationary, 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	
Traveling expenses for Director and assistant	800.00	800.00
	$3,390.00	$3,425.00

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

	For the fiscal year ending June 30, 1910;	June 30, 1911.	
Printing reports.			
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	
Grand total	$17,245.00	$17,405.00	$34,650.00

March 27, 1909.

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

C. N. HASKELL, Governor.

Itemized lists of the expenditures of the Survey since the date of its organization have been submitted to the governor semi-annually and are on file at his office. These lists may be found in the office of the State Superintendent of Public Instruction, who is secretary of the Commission; in the office of the President of the State University, the Executive Officer of the Survey; in the office of the State Auditor and in the office of the Director of the Survey.

STAFF

Since the organization of the Survey the personnel of the force has been as follows:

Director, Chas. N. Gould.

Assistant Director, L. L. Hutchison, from Sept. 1, 1908, to Nov. 11, 1910. L. C. Snider since Nov. 11, 1910.

Chemist, L. C. Snider from July 1, 1909, to Nov. 11, 1910. Frank Buttram since Nov. 11, 1910.

Draftsman, Frank Gahrtz and others have served intermittently.

Assistant Geologists, D. W. Ohern, Chas. H. Taylor, Chester A. Reeds and J. W. Beede.

Stenographers, Mary E. Marsh, C. W. Rose, Robt. H. Wood, Florence Marsh, and M. A. Cox.

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

THE OFFICES

The law establishing 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.

On account of the loss, by fire, of the main building of the State University in 1908, neither rooms nor laboratories were available for the use of the Survey. It was necessary, therefore, for more than a year, to secure offices in private residences, which arrangement proved quite unsatisfactory. The completion of the Engineering building at the University, and the removal of the Department of Engineering to this building, left vacant, on the campus, a frame building, which has been assigned to the use of the Survey. Office and rooms have been fitted up as follows:

1. Office of director.
2. Office of assistant director.
3. Library.
4. Museum and exhibit room.
5. Draftsman's office.
6. Chemical laboratory.
7. Work and preparation room.
8. General store room.

The work of the Survey is now being conducted in this suite of rooms, which are fairly well adapted to the requirements of the bureau.

FIELD WORK

Field work is the basis of all geological investigation. Before reports can be written it is necessary that detailed studies be made of specific areas. It has been the policy of the Survey at all times to keep as many parties in the field as the appropriations available would permit. The work of the different years will be taken up in detail.

Field Work in 1908: In pursuance with the instructions of the Commission, the Director organized a number of parties for field work, as follows:

L. L. Hutchison was in charge of a party consisting of Ben C. Belt, Artie C. Reeds, W. J. Cross, and T. R. Corr, which organized at Tulsa, and spent the season in Tulsa, Creek, Okmulgee, Muskogee and Wagoner counties, investigating the oil and gas fields in that region.

A party was organized at Ponca City, and placed in temporary charge of H. A. Everest. E. Z. Carpenter and H. G. Powell were assistants. Later in the season Dr. D. W. Ohern, Professor of Mineralogy at the State University, assumed charge of this party. The party traveled east across Osage, Washington, Nowata and Craig counties, then south and west across Rogers, Tulsa, and Osage counties, to Ponca City. The work consisted in mapping the limestone, sandstone, and clay beds and studying oil and gas conditions and the occurrence of coal.

Pierce Larkin was assigned to work in the Cretaceous rocks in southern Oklahoma. Starting from Atoka, he worked south and east across Atoka, Bryan, Pushmataha, Choctaw and McCurtain counties, as far as the state of Arkansas. He mapped a number of formations and made extensive studies of building stone, road material, and Portland cement rock.

Chester A. Reeds spent the season investigating the mineral resources of the Arbuckle Mountains. Mr. Reeds had already spent three seasons in this region and was more familiar with the country than any other man in the State. His report on the subject is in press.

Dr. J. W. Beede, Professor of Geology at the Indiana University, spent four weeks in the northern part of the State, studying the limestone and shale of Kay, Osage, and Noble counties, with reference to their geological structure and the occurrence of building stone and Portland cement rock.

Frank A. Herald and Chester C. Clark, were assigned to work in the gypsum region in western Oklahoma. During the summer they visited Blaine, Beckham, Greer, Jackson, Caddo and Grady counties searching for deposits of gypsum and mapping the occurrence of gypsum and salt.

G. W. Kneisly undertook the study of the granite rock of the State. He spent three weeks in Greer, Jackson, Kiowa and Comanche counties, and made good collections of granite and gabbro from the Wichita Mountains. He then visited Murray and Johnson counties and made extensive collections from the Tishomingo region.

Gaylord Nelson was assigned work on Portland cement beds in the eastern part of the State. He visited several localities and collected material from Ottawa, Craig, Mayes, Adair, Cherokee, Sequoyah, Muskogee, Wagoner, Rogers, Washington and Pontotoc counties. He visited and took extensive notes on the two Portland cement mills in the State, one at Ada and one at Dewey. He also spent several days in the Miami lead and zinc region, in the tripoli region in the eastern part of Ottawa County, near Seneca, Missouri, and at the marble quarries near Marble City, in Sequoyah County.

Key Wolf was assigned to the work of tracing out a ledge of limestone in southeastern Oklahoma, known as the Wapanucka limestone. He followed this ledge from Coal County, north and east across Atoka, Pittsburg, and Latimer counties. During the latter part of the season, he assisted Chester A. Reeds in the Arbuckle Mountains.

During the fall and winter of 1908, H. A. Everest, E. L. DeGolyer, and John Bennett, were employed in the eastern part of the State, mapping the outcrops of coal and limestone in that region.

Field Work, 1909: Owing to the lack of appropriation available for field work beginning July 1, 1909, it was found necessary to discontinue a considerable amount of investigation which had been contemplated. During the summer but two field parties were at work.

Prof. D. W. Ohern, of the Department of Geology of the State University, was placed in charge of a party to investigate the coal, oil, gas, limestone, clays and shales and Portland cement rock in northeastern Oklahoma. Associated with him were E. Z. Carpenter, Frank A. Herald, Key Wolf, Artie C. Reeds, W. J. Hazeltine and later in the season Robert H. Wood and Ben C. Belt. Frank A. Herald left the party the first of July to take up work with the United States Survey in Colorado and near the end of the season, E. Z. Carpenter joined a government party near Pawhuska.

Prof. Ohern's party outfitted at Tulsa and worked east to Broken Arrow and north past Catoosa, Claremore, Chelsea and Centralia to the Kansas line, west to Lenapah, south to Nowata and Talala, then along Bird Creek in the vicinity of Ramona, Skiatook, Bartlesville and Copan and finally west past Avant to Pawhuska and south through Hominy to Cleveland.

L. L. Hutchison spent the greater part of the summer in investigating the occurrence and amount of asphalt in southern Oklahoma. He was assisted during part of the year by Ben C. Belt who studied the asphalt deposits of Carter County.

Field Work, 1910: Owing to lack of appropriations it was not found feasible to undertake any extensive field work during 1910. Arrangement was made with the U. S. Geological Survey, however, as will be discussed later under Co-operation, for work in the Bartlesville-Nowata region in northern Oklahoma. Prof. Ohern again had charge of this work and was assisted by E. Z. Carpenter, R. H. Wood, J. C. Thompson, C. W. Hamilton, John Herald, and Fred Capshaw. Mr. Wood later joined a government party in Colorado.

Dr. Chester A. Reeds, Professor of Geology at Bryn Mawr College, who had already spent several years studying the geological formations of the Arbuckle Mountains, continued his work in

that region under the direction of this Survey. He was assisted by Lloyd Maxwell.

EXAMINATIONS OF SPECIAL REGIONS

The Survey is paid for by all the people of Oklahoma and is administered for their benefit. It can undertake the examination of private projects and enterprises only in so far as such examination will advance the public welfare, and aid in the development of the State's dormant resources.

Two mistaken ideas are prevalent, namely: first, that the Survey will examine free of charge any so-called mineral prospect in the State; and second, that the Survey maintains a free assay bureau. Both these notions are erroneous. So many requests of this character are constantly coming in that if all were granted, the staff of the Survey would do nothing else but investigate so-called mines and assay worthless material.

The Survey has no desire to engage in the work which properly belongs to the practical geologist and mining engineer, and for that reason cannot ordinarily undertake the examination of private enterprises. All prospectors, miners, and private companies, engaged in promoting individual enterprises should secure the services of a competent, scientific expert.

On the other hand the Survey is ready to examine regions supposed to contain deposits of value, provided that a sufficient number of people are interested in the matter to justify the expenditure of State appropriation. To cover cases of this kind, a special form of petition has been prepared, which will be sent on application to the Director.

The petition is worded as follows:

.....Oklahoma, ...19....

To the Director of the Oklahoma Geological Survey:

We, the undersigned freeholders of the County of.....State of Oklahoma, do hereby petition that a competent Geologist be sent to this County to examine and report upon the following described lands, to-wit: .... We have reason to believe that the following minerals may be found upon these lands: ....

When this petition is signed by fifty tax-payers of a community and properly certified by the county clerk, a geologist will be sent to examine the region.

During the past two years petitions, properly signed and certified, have been received from the localities listed below. In each case an examination was made and a report submitted to the interested parties.

Afton
Antlers
Ardmore
Bartlesville
Bennington
Mangum
Mead
Mill Creek
McAlester
Okeene

Caney
Chickasha
Comanche
Cowlington
Davis
Drummond
Florence
Grove
Heavener
Howe
Inola
Longdale
Madill
Pawnee
Porum
Poteau
Roff
Sapulpa
Sallisaw
Stigler
Sweetwater
Tahlequah
Tishomingo
Vinita
Wagoner

EXAMINATION AND ANALYSIS OF SPECIMENS

The Survey was not organized for the purpose of furnishing free assays to prospectors, and the Director much prefers that material to be assayed be sent elsewhere. On request, he will gladly furnish a list of names of parties whom he considers to be reliable assayers.

The Survey is willing, however, to undertake the determination of rocks and minerals found in Oklahoma under the following conditions:

1. Any rock or mineral sent to the Director will be examined and if its mineral content can be determined without an assay, the same will be furnished free of cost.

2. In case the Director believes that the specimen contains valuable mineral and that its determination will be of value to the work of the Survey, or aid in the development of the resources of the State, it will be analyzed free of cost.

3. All samples sent in must comply with the following conditions:

(a) Each sample must weigh at least 6 ounces, but not more than two pounds.

(b) Each sample must be enclosed in a canvas bag or strong wrapper, carefully labeled.

(c) The parcel must be forwarded prepaid to

The Director of the Oklahoma Geological Survey,
Norman, Oklahoma.

(d) A letter must be sent at the same time to the same address giving necessary information regarding the specimen.

(e) The exact locality where the sample was found (which must be in the State of Oklahoma) must be accurately disclosed.

4. The Director of the Survey reserves the right of publishing at any time the results of any assay made at public expense.

The Survey is constantly in receipt of requests for examination and analysis of specimens from all parts of Oklahoma, and even

from adjoining states. In some cases the examination may be made with little trouble. In the majority of instances, however, it is necessary to spend considerable time in making the analysis. Many samples that come in are obviously not worth analyzing. During the past two years more than three hundred specimens have been examined.

CLAY INVESTIGATION

Ever since the organization of the Survey, the importance of the development of the clay industry of the State has been constantly kept in mind. The citizens of Oklahoma are sending out of the State more than one million dollars a year for pressed brick, tile, pottery, and other clay products, all of which might be manufactured at home. Oklahoma has the raw material, the fuel, the transportation and the market for all sorts of clay products, but very little of this material has been developed. In 1909 arrangements were made with the Federal Survey for co-operation in the matter of testing clays, and Mr. L. C. Snider, then chemist for the Oklahoma Survey, was detailed to work at the government testing laboratories in Pittsburg, Pa. Beginning July 1, 1909, the work was carried on until the latter part of September of the same year. Something like thirty samples of clay were tested. During the winter of 1909-10 an extensive correspondence was carried on with all parts of the State, and samples were collected by members of the Survey from several localities. As a result about 75 samples of Oklahoma clay were sent to Pittsburg. Mr. Snider left Oklahoma for Pittsburg in April, 1910, and was employed in the government laboratories until August testing these clays.

The following properties were determined for each clay:

1, Water of plasticity; 2, Linear and volume drying shrinkage; 3, The linear and volume burning shrinkage; 4, The per cent of absorption and per cent of porosity of the burned ware at ten different burning temperatures; 5, The specific gravity of the raw clay; 7, General working, drying and burning behavior.

These determinations require, besides grinding and making up the clays, pressing the discs and burning six kilns, about sixty weighings, forty measurements, eighteen volume determinations and sixty numerical calculations for each sample.

Clays were forwarded to Pittsburg from the following towns in Oklahoma. The results of the tests have been sent to the owners and a report on the subject of Oklahoma Clays by Mr. Snider, is now ready for the press:

Alderson 2
Altus 1
Antlers 3
Ardmore 2
Atoka 2
Madill 1
Mangum 1
Marlow 1
McAlester 5
Meeker 2

Avant 2
Binger 1
Big Heart 1
Bartlesville 1
Blackwell 2
Bristow 1
Boynton 1
Cleveland 3
Coalgate 3
Claremore 2
Comanche 2
Calvin 2
Doxey 2
Durant 1
Enid 3
Garvin 5
Hartshorne 2
Lindsay 1.
Midway 2
Miami 2
Muskogee 3
Nelagony 2
Oklahoma City 2
Perry 2
Poteau 2
Quay 3
Ramona 1
Rush Springs 1
Stigler 2
Sparks 1
Sweetwater 2
Vinita 2
Waurika 3
Woodville 2
Wilburton 3

HIGH SCHOOL COLLECTIONS

In conformity with Section 5, of the law establishing the Survey:

All material 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.

And instructions given by the Commission:

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

the Survey has endeavored to provide high schools, normal schools and the various educational institutions of the State with free collections of rocks, fossils and minerals. A type set contains approximately 75 speciments including the following materials:

Samples of building stone, including granite, gabbro, marble and limestone.

Samples of minerals: lime asphalt, sand asphalt, shale asphalt, galena and sphalerite.

Samples of gypsum, selenite, satin spar, and massive gypsum.

Samples of one Portland cement series.

Several samples of sand-barite crystals, some silicious geodes, glacial boulders, and carbonetes.

A number of fossils, including stigmaria, ammonites, oyster shells, echinoderms, and two specimens of coral. Each specimen is labeled and numbered.

Up to the present time the following institutions have received collections:

High Schools

Alva	Lawton
Ada	Miami
Altus	Newkirk
Bartlesville	Nowata
Blackwell	McAlester
Cherokee	Medford
Comanche	Muskogee
Checotah	Oklahoma City
Caddo	Okmulgee
Coalgate	Okeene
Durant	Okemah
Duncan	Purcell
El Reno	Perry
Enid	Ramona
Foraker	Stigler
Fairview	Shawnee
Frederick	Snyder
Granite	Sulphur
Geary	Tulsa
Hugo	Wynnewood
Hartshorne	Walters
Henryetta	Westville
Lone Wolf	

State Schools and Officials

Agricultural & Mechanical College, Stillwater; Northwestern State Normal, Alva; East Central State Normal, Ada; Central State Normal, Edmond; Oklahoma School for Deaf, Sulphur; Southwestern State Normal, Weatherford; University Preparatory School, Tonkawa. President State Board of Agriculture, Guthrie; State Superintendent Public Instruction, Guthrie.

Other collections are being packed as rapidly as funds at the disposal of the Survey will permit. It is hoped that within the next year, more than fifty additional collections may be available for the school children of the State of Oklahoma.

It is the policy of the Survey to lend these collections to the various schools and to add to them from time to time. In this way it is believed that a good typical collection, representing Oklahoma's minerals, rocks, and fossils, will be placed in the museums of the high schools, normal schools and colleges of the State.

STATE FAIR.

In conformity with the idea of advertising the State's resources, arrangements were made with the authorities of the

Oklahoma State Fair at Oklahoma City to place on exhibition collections illustrating the mineral wealth of the State. This collection was begun in 1908, when only a small amount of money was available, and little time could be taken for the assembling of the minerals. The only available space for the collection that year was on the second floor of Exposition Hall. The mineral collection was immediately so popular, and attracted so much attention, that it was deemed advisable to enlarge the exhibit space. This was done in 1909, but even then the space available was inadequate.

During the past year the State Fair Association has erected a separate mineral building, 50 by 100 feet in size. In it has been installed the most comprehensive collection of the mineral resources of Oklahoma ever gotten together in one place, and one of the best collections ever assembled at any state fair. It is the plan to make this a permanent collection, open to the public at all times, and to add to it from year to year. The State Fair authorities pay the transportation on the collections, but the Survey superintends their installation.

In addition to collections at the State Fair, the Survey has sent out a number of smaller special collections for various congresses and gatherings. Several collections have been sent out on private cars.

GOOD ROADS.

The Survey has continually kept in mind the matter of the location and utilization of the road-building material in the State, and has at all times endeavored to co-operate in every way possible with state, county and city officials in the matter of locating suitable material for the construction of roads.

As a result of co-operation between the Survey, the office of Public Roads of the Department of Agriculture, at Washington, and the Park Commission of Oklahoma City, Mr. L. C. Snider, Chemist of the Survey, and Mr. James T. Voshell of the office of Public Roads, in March, 1910, visited something like thirty of the most important limestone and granite quarries of the State, and collected samples of road-building material. The localities are the following:

Locality	No. Specimens	Material
Ada	2	Limestone and Asphalt.
Ardmore	2	Asphalt.
Cache	1	Gravel.
Cement	1	Limestone.
Cold Springs	1	Granite.
Fitzhugh	1	Limestone.
Granite City	1	Granite.
Hartshorne	2	Limestone.

Harjo	1	Gravel.
Keough	1	Limestone.
Limestone Gap	1	Limestone.
Newkirk	1	Limestone.
Ponca City	2	Limestone.
Ripley	1	Limestone.
Ravia	2	Granite and Asphalt.
Richards Spur (P. O. Apache)	1	Limestone.
Sulphur	3	Asphalt.
Tishomingo	3	Asphalt and Granite.
Uncas	1	Limestone.
Wapanucka	1	Limestone.

This material was sent to Washington and tested in the laboratories of the Office of Public Roads. The results of the tests have been sent to the owners of the quarries and Mr. Snider has prepared a report embodying the results of the tests, which will be published as soon as funds are available for that purpose.

The office is constantly in receipt of inquiries from all parts of the State regarding road material, and it is believed these official tests, which are made without cost, will be of great benefit to the State.

It is planned during the next two years to further enlarge the scope of this work. Oklahoma is in great need of good roads. At the same time the State possesses a large amount of road-building material. It is the work of the Survey to discover the location of this material and aid in its utilization.

LECTURES.

In pursuance with the instructions of the Commission:

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

The Director and his assistants have taken every opportunity to deliver public addresses in Oklahoma. These addresses have been given chiefly before commercial organizations, but, in a number of cases, before popular audiences, congresses, and associations of various kinds, and often before high schools.

Some member of the Survey staff has delivered addresses at each of the following cities in Oklahoma:

Antlers
Atoka
Bennington
Bartlesville
Chelsea
Cherokee
Clinton
McAlester
Mangum
Madill
Nashville
Okmulgee
Pauls Valley
Poteau

Comanche
Cowlington
Dewey
Duncan
Edmond
Eufaula
Guthrie
Granite
Howe
Holdenville
Henryetta
Idabel
Jet
Lehigh
Lindsay
Lenapah
Miami
Mill Creek
Pawnee
Ponca
Roff
Sulphur
Shawnee
Stillwater
Sweetwater
Tulsa
Tahlequah
Vinita
Wagoner
Wewoka
Weleetka
Wapanucka
Weatherford
Wilburton
Woodward
Wynnewood

WATER SUPPLY

During the past year, the continuous drought in Oklahoma has brought vividly to the minds of the people in many of the cities of the State, the importance of an adequate future water supply, and a great many inquiries have come to this office for assistance in this matter. In every case, steps have been taken to aid the interested municipality. It is believed that the advice which has been furnished by the Survey within the last few months, has aided, or will aid in the saving of many thousands of dollars to the various towns in the matter of securing an efficient water supply.

In several cases information furnished regarding the probable absence or presence of artesian water, has resulted either in the finding of good supplies of water, or the saving of money in needlessly prospecting in localities where there was no chance of finding water.

At the present time the Survey is in correspondence with the officials of a number of cities in the various parts of the State regarding water supply, and it is believed that in several cases plans now in operation will still further aid in securing abundant water.

CO-OPERATION.

Acting upon the instructions given by the Commission:

"To co-operate 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 has constantly endeavored to secure co-operation with the various scientific bureaus at Washington, particularly with the U. S. Geological Survey, as well as with other state surveys. Several trips to Washington have been made with this end in

view. During the past year co-operation has been arranged along a number of different lines, as follows:

The United States Geological Survey is co-operating with the Oklahoma Survey in the matter of preparing a geological folio of the oil fields in northern Oklahoma. During the summer of 1909 a government party, in charge of Carl D. Smith, prepared a geological map of the Pawhuska quadrangle in eastern Osage County. He was assisted in this work by men already trained by the Oklahoma Survey. During the field season of 1910, as explained above, Prof. D. W. Ohern, who had already spent two summers in the région, had charge of a party preparing a map of the Nowata quadrangle, which joins the Pawhuska quadrangle on the east, and includes the greater part of the Washington and Nowata counties, as well as part of northern Rogers County. The maps prepared by Messrs. Smith and Ohern will be published jointly by the U. S. Geological Survey and the Oklahoma Geological Survey. For the carrying out of the work of mapping the Nowata quadrangle for the past summer, the Federal Survey alloted the sum of $1500.00, which was spent by Dr. Ohern and his assistants.

The work of L. C. Snider during the past two summers, in the matter of testing clays at Pittsburg, has already been referred to. It is estimated that the amount of co-operation furnished by the the past summer, the Federal Survey allotted the sum of $1500.00

In the matter of testing road material, which has already been explained, the office of Public Roads furnished the services and expenses of an expert road engineer for one month. The Park Board of Oklahoma City paid the travelling expenses of L. C. Snider, Chemist of the Survey, and the Oklahoma Survey paid Mr. Snider's salary. Tests of about 25 samples were made by the office of Public Roads. The results of the work have already been mentioned. It is estimated that the amount of money spent by the government co-operating in the matter of testing road material in Oklahoma has been approximately $500.00.

During the summer of 1910 the Federal Survey employed in various field parties in Oklahoma and other states, twelve men, students of the University of Oklahoma, most of whom had been trained on the Oklahoma Geological Survey. The total salaries paid these men for this work will approximate $1500.00.

The amount of money expended during the past year by the general government in the matter of co-operation with the Oklahoma Survey and persons connected therewith, will approximate $4,000.00.

Plans are being made for even a more extensive co-operation next year. There is a large amount of economic work yet to be done on the minerals of Oklahoma which must be accomplished by specially trained experts. Men of this kind may often be secured at little or no expense to the people of the State. If the plans now in contemplation are carried out, Oklahoma should, during

the next few years, receive the benefit of the experience of a number of trained scientists in the matter of the development of the State's dormant mineral resources.

CORRESPONDENCE.

The correspondence of the office has constantly increased from the day of organization of the Survey. The people of the State as well as interested parties in the East have learned to look to the Geological Survey for information regarding the State's resources and industries. Not a day passes that inquiries are not received regarding the location of certain minerals. Every letter which reaches the desk of the Director or his assistants receives a courteous reply and as a result of information disseminated during the past two years, a number of industries have already been established in the State, and at the present time a number of others are contemplating locating here.

This is consistent with one of the most important functions of the Survey, namely "to disseminate accurate and precise knowledge regarding the location of minerals," and as the work of the Survey develops, it is believed that this phase will become more and more important.

PUBLICATION.

In order to bring the mineral resources of Oklahoma to the attention of those most likely to be interested in the various products, it has been the policy of the Survey to publish, in trade journals and popular magazines, articles dealing with the minerals of the State. Scarcely a month has passed that one or more such articles has not been published. Some of the trade journals in which articles have appeared are:

Mining and Scientific Press; Mining Science; Mines and Minerals; Mining World; Engineering and Mining Journal; Rock Products; Stone; American Stone Trade; Clay Worker; Clay Record; Brick; Cement Age; Cement Record; Petroleum; Oil Investor's Journal; Gas Journal; National Petroleum News; Oil and Gas; Engineering News; Good Roads; and Manufacturer's Record.

A number of semi-popular articles have appeared in the following magazines:

Science; Taylor-Trotwood; Sturms; Southwest; Farm and Ranch; Frisco.

In addition to articles in magazines and trade journals this office has constantly endeavored to keep the State press informed regarding any authentic discoveries, or the development of any mineral products of Oklahoma. Several hundred articles have been furnished the daily papers, and many of the weekly papers of the State, and a number of special articles have appeared in the

metropolitan press of such cities as St. Louis, Chicago, Memphis, Pittsburg and New York.

REPORTS.

The work of the Survey is known to the general public chiefly by the reports issued, therefore it has been the policy to send out as many reports as possible. It must be remembered, however, that before reports can be written it is necessary to secure a large amount of data. This usually necessitates extensive field work, much correspondence and the compilation of information of various sorts. Particularly is this true in the case of a new state like Oklahoma where little previous work has been done and where everything has to be built up from the beginning.

During the past two years the Director and his assistants have devoted all the time which it was possible to spare from other duties more pressing, to the preparation of reports. At the time of this writing, Dec. 1, 1910, the following work has been accomplished:

Bulletin No. 1: 3,000 copies, Preliminary Report on the Mineral Resources of Oklahoma, was issued November, 1908.

Bulletin No. 2: 2,500 copies, by L. L. Hutchison, Oil, Gas and Asphalt in Oklahoma. Manuscript submitted in April, 1910, not yet off the press.

Bulletin No. 3: 2,500 copies, by Chester A. Reeds, Mineral Resources of the Arbuckle Mountains. Manuscript submitted August 1910, not yet off the press.

Bulletin No. 4: 2,500 copies, by Chas. N. Gould, and L. L. Hutchison; Coal in Oklahoma, contract let for printing, in preparation.

Bulletin No. 5: 2,500 copies, by Chas. N. Gould, and others. Portland Cement, and Building Materials of Oklahoma; in preparation, contract let for printing.

Bulletin No. 6: 4,000 copies. Director's Biennial Report. This bulletin.

Bulletin No. 7: 3,000 copies, Clays of Oklahoma, by L. C. Snider. Ready for the press.

In addition to the above listed reports, which are either now being printed or are in preparation, the following reports have been begun:

Road Materials, L. C. Snider (Ready for the press).
Gypsum, Chas. N. Gould (In preparation.)
Salt, Chas. N. Gould (In preparation.)
Lead and Zinc, L. C. Snider (In preparation.)
Glass Sand, Frank Buttram (In preparation.)
Granite, Chas. H. Taylor, (In preparation.)

For the publication of the reports on gypsum, salt, and lead and zinc, funds have already been appropriated.

All the reports listed above must be considered in the nature of

preliminary reports, and all deal with economic subjects. Practically nothing has yet been published on the general geology of the State. It is the purpose to publish, as rapidly as funds permit, two series of bulletins, one dealing with the general geology of Oklahoma, the other including comprehensive reports on the State's mineral resources.

The publications of the Survey are for free distribution not only to the people of Oklahoma, but to interested parties living outside the State. Requests for copies should be sent to the Director, Oklahoma Geological Survey, Norman, Oklahoma.

PART II.

BRIEF CHAPTERS
ON
OKLAHOMA'S MINERALS.

INTRODUCTION

In November, 1908, shortly after the organization of the Survey, Bulletin No. 1 was published, containing brief descriptions of the occurrence and amount of some twenty of the most common minerals in Oklahoma. This little book met with such favor and has been in such constant demand that two editions have been exhausted. Advantage is taken of this opportunity to republish a considerable part of the former report. In some cases the article has scarcely been revised. In most instances, however, the advance in our knowledge of the subject and the development of the mineral has necessitated a complete revision of the chapter. In several cases it has been found necessary to entirely rewrite the article.

So little has been done in the way of the development of the mineral resources of the State that no one can yet even estimate either their amount or their value. This is the work which the Geological Survey is now attempting to accomplish. It endeavors to locate the various valuable minerals in the State, and to determine as nearly as possible their amount and approximate value. It endeavors in every way possible to bring these minerals to the notice of investors and to interest capital in their development. To this end the Survey most earnestly invites the aid and co-operation of the people of the State, in calling the attention of capitalists and manufacturers to our vast undeveloped resources.

COAL

(By Chas. N. Gould)

The coal fields of Oklahoma occupy an area of about 20,000 square miles, in the eastern part of the State. The largest deposits lie in the following counties: Pittsburg, Coal, Atoka, Latimer, LeFlore, Haskell, Sequoyah, MacIntosh, Wagoner, Mayes, Craig, Nowata, Washington, Rogers, Tulsa, Okmulgee, Okfuskee and Hughes. Coal has also been mined in Carter County.

The coal mined in Kansas and in Arkansas belongs to the same general field as the Oklahoma coal. The Texas coal area west of Fort Worth is a part of the same field, also, but is cut off from the Oklahoma area by the Arbuckle uplift.

The rocks containing the coal beds in northern Oklahoma dip slightly to the west, forming the eastern side of a great synclinal basin, the western border of which flanks the Rocky Mountains.

In the southern part of the field the rocks have been much folded, so that the coal often stands on edge.

The greater part of the coal in Oklahoma lies in that part of the State which was originally the Choctaw Nation, namely in Pittsburg, Coal, Atoka, Latimer, LeFlore and Haskell counties. To this area the name Choctaw coal field is often applied. It is bounded on the north by the Canadian and Arkansas rivers, on the south by the Choctaw fault, (which runs from Atoka north and east to the Arkansas line) and the Arbuckle uplift, and on the west by an indefinite, irregular line. The whole region is folded very sharply near the Choctaw fault line, but much less so near the Canadian River.

Before the Choctaw and Chickasaw Indians took their allotments of land they made a treaty with the Government whereby the land that was underlaid with coal was segregated, or set apart, for the benefit of the nations as a whole; that is, land containing coal could not be allotted by any individual citizen of either nation.

The government assigned the segregation of this coal to the United States Geological Survey, and the director of the Survey detailed Mr. Joseph A. Taff to perform the work. Mr. Taff had already spent five years in studying and mapping the coal deposits of the Indian Territory. A year's additional time was spent going over the ground, checking up and verifying his previous work.

The total amount of land segregated is nearly half a million acres: 437,743 acres to be exact. The main body extends uninterruptedly southwestward from the Arkansas line, near Fort Smith, for a distance of 125 miles, as far as Lehigh and Atoka.

Mr. Taff estimated that this area was underlaid with veins of coal, the combined thickness of which approximated seven feet, and that the average output for the entire region may be placed at 7000 tons per acre. This amount, multiplied by the number of acres uderlaid with coal, gives a total of approximately 3,000,000,000 tons of coal on the segregated land.

Others, however, consider this estimate too high. Mr. William Cameron, who was for many years the government mine inspector for the Indian Territory, estimates that the total amount of available coal on the segregated land is 1,252,916,000 tons.

The value of the coal is also a mooted question. Estimates as high as $4,337,000,000 have been made. This is obviously too high. Perhaps no better estimate can be made at the present time than that which is based upon the royalty that the mine operators pay the Indians, eight cents per ton. Taking Mr. Taff's estimate of the amount of available coal, 2,954,138,000 tons, the value at eight cents a ton would be $236,331,040. Taking Mr. Cameron's estimate of 1,252,916,000 tons, the coal would be worth $100,233,280.

According to the provisions of the treaty made with the Indians, the Government was to sell the segregated coal land. Mr. Taff divided the entire area into tracts of approximately 960 acres each, and the Secretary of the Interior advertised for bids, which were opened August 7, 1906. All bids were rejected because, in the opinion of the Secretary all were too low. A second attempt was made to sell the land, with the same fate, so at the present time none of the land has been sold.

Much of the coal land has been leased to mining companies, who are engaged in placing the coal on the market. None of the segregated land is open to settlement, so that at the present time there are nearly half a million acres of land lying idle. Much of it is capable of a high state of cultivation. This land supports no population and pays no taxes. Many efforts have been made to have the surface of the segregated land opened to settlement, but so far without avail. It is obvious that, until this is done, a great hardship is being worked upon the counties in which this land is located. Efforts to have Congress take action in the matter and provide for the sale of the land have so far been unavailing.

There are at least seven veins of commercially valuable coal in the Choctaw coal field, besides a number of thin veins and lentils which are at present not worked. Those of commercial value are known as the upper and lower Hartshorne coals, the upper and lower McAlester coals, the Cavanal coal and the two Witteville coals.

The upper and lower Hartshorne, or, as they are sometimes called, the Grady coals, are the lowest, geologically, in the State. The two beds are separated by about fifty feet of shale. The lower bed is just above a heavy ledge of sandstone, known as the Hartshorne sandstone, and as the outcrop of this sandstone always forms a distinct ridge, it makes an excellent marker for the coal, so that the position of the bed can be easily located. Both beds consist of coal of a fairly good quality and extend over a large area. In the eastern part of the field the upper bed nearly pinches out. The Hartshorne coal is generally strictly bituminous, but in places it is a semi-anthracite. It varies in thickness from two and one-half to seven feet. The extensive folding of the rocks have tilted the formations so that the coal often stands on edge. It is noticed that as a general rule the coal that is most highly tilted, approaches more nearly an anthracite than that which lies level. Near Atoka it is called the Atoka coal, while in the Cavanal Mountain region it goes by the name of the Panama coal. It is being mined at a large number of places, among which are Wilburton, Hartshorne, McAlester, Krebs, Cherryvale, Heavener, Lehigh, Panama and McCurtain.

The McAlester coals, or as they are called in other parts of the State, the Lehigh or Stigler coals, occur nearly 2,000 feet, geologically, above the Hartshorne coal. The two beds of the McAlester coal are separated by about sixty feet of shale. The coal is bituminous and is slightly harder than the Hartshorne coal. The beds vary in thickness from two feet to four and one half feet. The Mc-

Alester coal is mined near Wilburton, McAlester, Red Oak, Hughes, Stigler, Sansbois, Coalgate and Lehigh.

The Cavanal coal occurs only in the eastern part of the field. It is from two to three feet thick, and is a fairly good bituminous coal. The Cavanal vein is the least important one in the field, and is being mined only on the south and east sides of Cavanal Mountain, between Wister and Poteau.

The Witteville coals, known also as the Jones' Creek coals, are geologically, the highest ones south of the Canadian River. There are two principal beds which average from two and one-half to four feet in thickness, but their value is decreased in many places on account of partings of bony coal. In places this coal contains so large a percentage of sulphur as to materially decrease the value of the coal.

In the eastern part of Carter County a few miles southeast of Ardmore, a small vein known as the Ardmore coal has been worked for some time, but it is of relatively little importance.

Several of the beds already described extend across the Canadian River and have been mined locally in MacIntosh, Muskogee and Wagoner counties. Strip pits have been operated at or near Muskogee, Wagoner, Boynton, Council Hill, Coweta, Checotah, Porum and Keefeton. The beds are much thinner in this region than farther south, however, and the quality of the coal is not so good. The thickest bed known in this region is about thirty inches, being located on Cane Creek in western Muskogee County.

There are two beds of considerable importance in northern Oklahoma, both being located at a higher level than the coal in the Choctaw field.

The most important ledge of coal in this part of the State, known in different localities as the Henryetta, Broken Arrow and Catoosa coal is about three feet thick. The outcrop has been traced from near Calvin northeast to the Kansas line. It is mined at Lamar, Dustin, Henryetta, Morris, Schulter, Broken Arrow, Catoosa, Claremore, Chelsea and Centralia.

The highest coal of any importance in the State is found in Tulsa and Creek counties and is known as the Dawson coal. It occurs about ninety feet below a characteristic light blue limestone which serves as an excellent marker in tracing its outcrop and location. Its known outcrop extends from near Bird Creek in Tulsa County, to a point just southwest of Beggs as a ledge from two and one-half feet to three and one-half feet in thickness, of very clean and pure bituminous coal. It is mined at Dawson, Mohawk, Tulsa, and Redfork. It is thought that the coal mined at Collinsville belongs to this bed also.

The amount of coal in the State is unknown. Mr. Taff estimated the amount on the segregated land to be about 3,000,000,000 tons. This is certainly not half the coal in the State. On this basis, the coal in Oklahoma would be somewhere between 6,000,000,000 and

10,000,000,000 tons. On the other hand the United States Geological Survey estimates the amount of coal in the State to be 75,000,000,000 tons. This estimate, however, seems to be entirely too high.

The first mining of coal on a commercial scale in the Indian Territory was carried on near McAlester in 1872. Since that time a number of railroads have been built through the coal region and with their aid the coal industry has developed rapidly.

In 1907 Oklahoma produced 3,642,658 short tons of coal, valued at $7,433,914. The State ranked fourteenth among twenty-eight coal-producing states. Only three other states showed a greater percentage of increase over the production in 1906. Eight thousand, three hundred and ninety-eight men were employed in the coal mines of Oklahoma, during that year.

Since 1907 the amount of coal mined has decreased. The chief cause for this condition of affairs is the great increase in the amount of natural gas. Such cities as Muskogee, Tulsa, Sapulpa, Oklahoma City, Chandler and Shawnee, not to mention scores of others that formerly employed coal for fuel, now use natural gas obtained from the wells in northern Oklahoma. Coal from the Oklahoma fields still supplies the western and the southern parts of the State, but even there gas is making an inroad. The amount of gas in Oklahoma is very great and bids fair to remain a formidable competitor to coal for many years.

PETROLEUM

(By Chas. N. Gould)

More money has been spent in the development of petroleum and more has been received from that source than from any other mineral industry in Oklahoma.

The Oklahoma oil fields have been developed gradually southward from Kansas. As early as 1882 drillers had discovered small quantities of gas in the State, but it was not until 1893 and 1894 that anything like extensive operations began. After oil had been found in the southern counties of Kansas, the drillers began to venture across the line into the Cherokee and Osage nations. Many of the first wells were failures, partly because they were drilled in regions where no oil existed, and partly because the wells were not carried deep enough. For the past ten years the drillers have been slowly and cautiously working south until at the present time they have reached several points seventy-five to one hundred miles south of the Kansas line.

So far the greater part of the development in Oklahoma has been in five general regions. Probably more than two-thirds of all the oil produced in the State has been found along the 96th meridian, which is the dividing line between Cherokee and Osage nations. Wells drilled within a few miles east and west of this meridian have almost invariably found large quantities of oil

or gas. In Kansas the wells at Caney and Peru are located near this line. The most prominent fields near the 96th meridian in Oklahoma are those at or near Copan, Dewey, Bartlesville, Ramona, Skiatook, Tulsa, Red Fork, Glenn Pool, Tanaha, Hamilton and Henryetta.

A second oil-producing region lies along the Verdigris River some twenty-five miles east of the 96th meridian. This is usually known as the Coody's Bluff-Alluwe field, although the name Shallow field is sometimes applied to it for the reason that the oil is found at a comparatively shallow depth. The greater part of the wells are from 400 to 600 feet in depth, and on account of this fact development in this field is not expensive. The area of the proved territory extends for thirty miles or more north and south and is six to ten miles wide. Within the past year a northwestern extension of this field has been developed near Delaware in central Nowata County.

A third productive region is at Cleveland in eastern Pawnee County, some twenty-five miles west of the 96th meridian. The Cleveland field is small, occupying not more than half a dozen square miles but it has produced a large amount of oil. Development in this field has about ceased, and the output is fast decreasing.

A field has been developed at Muskogee. The most productive wells are located from one to three miles southwest of the city. The oil is of good quality, and it is probable that the area of the field will be still farther extended.

The Bald Hill-Morris field is a large and rather poorly defined field extending from near the Arkansas River at Haskell in western Muskogee County, southwest some 25 miles to the vicinity of Morris. Only a small part of the field has been prospected, but it is altogether probable that future development will reveal the presence of a large amount of oil in the region.

There are a number of small fields in various parts of Oklahoma which show promise of future development. Several wells near Madill have produced some extremely high grade petroleum. At Wheeler there is a low grade asphaltic oil, an excellent fuel oil. East of Duncan the same kind of oil has been found. Gas, which is usually associated with petroleum, has been found at Poteau in the extreme eastern part of the State, at Lawton and Gotebo in the vicinity of the Wichita Mountains, and at Blackwell and Ponca near the Kansas line.

The depth to the oil sand varies in different localities. The shallowest wells are those in the Coody's Bluff-Alluwe region east of the Verdigris River, where the average depth is about 600 feet. Farther west, near Bartlesville, wells are 1,000 to 1,200 feet deep. Near Tulsa and in the Glenn Pool the greater part of the oil and gas is found at a depth of 1,500 to 1,700 feet. At Cleveland the oil

is found in a higher sand than at Bartlesville or Tulsa, but the depth is approximately the same as in these localities.

The greater part of the oil produced in Oklahoma is purchased by three companies, the Prairie Oil & Gas Company, which is a subsidiary of the Standard Oil Company, the Texas Company and the Gulf Company. The pipe lines of the Prairie Company lead into Kansas and thence northeast. The lines of the Texas and Gulf companies lead directly to the Gulf of Mexico. A fourth pipe line is now being laid to Baton Rouge. Much oil is hauled in tank cars, and several train loads leave the various fields daily. The facilities for transportation have always been inadequate, however, and on this account production has been greatly curtailed. It is hoped, that with additional pipe lines, all the oil produced may be disposed of.

Refineries are now in operation at Tulsa, Sapulpa, Oklahoma City, Muskogee and Chelsea, but they are able to use only a very small part of the oil now being produced.

It is difficult to ascertain the exact amount of production in Oklahoma for the reason that all the oil from the Mid-Continent field, which includes both Kansas and Oklahoma, is grouped together. The following figures, however, may be of interest as showing the relative amount. In 1906 the world's production of petroleum was, in round numbers, 214,000,000 barrels, of which the United States produced 126,000,000 barrels. Of this amount the Mid-Continent field produced 22,000,000 barrels. It is estimated that Oklahoma produced approximately three-fourths of this amount. In 1907 the Mid-Continent field produced 46,846,267 barrels of petroleum and in 1908 48,323,810 barrels. During these two years Oklahoma led the United States in the production of oil. In 1909 California exceeded Oklahoma and probably will do so in 1910.

There is no geological connection whatever between the oil found in the Mid-Continent field and that found in other parts of the United States. The statement is frequently made that if the oil fields were traced far enough south they would finally connect with the Corsicana or the Beaumont fields of Texas. This is a geological impossibility. Oil and gas occur in rocks of all ages, from those which are very old to the most recent. The oil and gas obtained in the Kansas and Oklahoma fields are found in rocks of Carboniferous age. The greater part of the oil from Pennsylvania and West Virginia comes from rocks a little older than those which contain oil in Oklahoma. The oil from western Ohio and Indiana is derived from the Trenton limestone, a very much older rock. The oil from Corsicana, on the other hand is obtained in Upper Cretaceous rocks which were deposited at a much later date, geologically, than the Carboniferous formations. The oil at Beaumont, Texas, and Los Angeles, California, comes from a series of still younger rocks, known as the Tertiary.

The origin of oil and gas is not definitely known. A number of theories, both chemical and geological, have been proposed at

different times by various men to account for the formation of these substances. According to one theory oil has been formed by the chemical action of hot water on certain metals contained in the rocks. This theory, however, is not now accepted by practical geologists.

After studying the matter from every conceivable standpoint, geologists have gradually come to believe that both oil and gas have been formed within the earth, by the very slow and long-continued distillation of plants and animals, which were buried in the rocks during former geological ages. If an animal or plant dies on the surface of the earth it decays or rots and the organic material is dissipated and disappears into the atmosphere. But if the animal or plant is buried out of contact with the air, the organic compounds will be distilled very slowly, and will form series of complex hydrocarbons. Petroleum consists of several hydrocarbons which are liquid under ordinary conditions, while natural gas contains those which have lower boiling points so that they are gases under the same conditions. Many rocks contain large numbers of fossils, and fossils are but the remains of animals and plants entombed in the rocks. As the organic matter which originally formed the animals and plants now represented by the fossils, was slowly distilled, it usually penetrated through the rocks and escaped into the air. Oil springs and bubbling gas in shallow wells, which are common in certain regions, are believed to originate in this way. In many localities, however, the conditions of stratification and structure are such that the oil and gas, instead of escaping, have been stored up in the rocks. It is in these regions that oil and gas may be found by deep drilling.

In order for oil and gas to occur in paying quantities at least three conditions are necessary, namely: first, a source of supply; second, a reservoir, and third, a cap-rock or impervious stratum through which the oil and gas cannot pass. If any one of these three conditions is wanting in any particular region oil and gas in quantity will not be found there.

The source of supply for oil and gas is present in the rocks of most regions. It is simply a stratum of sandstone, limestone or shale, which when deposited in some former ocean, contained the remains of plants and animals. The substances formed from the slow distillation of this organic matter are volatile and obeying the laws of gases and liquids, tend to pass upward and to escape to the surface. In many cases, however, before reaching the surface they encounter a porous rock which acts as a reservoir or receptacle in which they are collected.

The second essential, the reservoir, is usually a coarse sandstone, or in the driller's parlance, the "oil sand." Any sand filled with oil is an "oil sand," and it often happens that a certain sandstone ledge contains oil in one locality, while a short distance away it contains none. Sometimes the reservoir is a conglomerate and

perhaps less frequently, a porous limestone or a coarse grained shale.

The third essential is a cap rock, so dense or impervious that it will not permit the passage of oil or gas. This rock is in almost all cases a stratum of fine-grained clay or shale, which the driller usually calls "slate." If the shale is not sufficiently dense to prevent the passage of oil or gas or if it contains crevices, as is frequently the case, these volatile substances have probably been escaping for ages and are perhaps all gone. Under such conditions oil springs may occur on the surface or gas may be found issuing from the rocks, but the presence of oil springs or escaping gas are no indication of large amounts of oil and gas beneath the surface. On the contrary any practical geologist knows that it is almost useless to drill for oil or gas near an oil spring, for there is usually no connection between the escaping oil or gas and a deep-seated supply. The fact that oil or gas is escaping goes to show that the conditions which would cause them to collect in large bodies are absent.

From what has been said it will be understood that while oil and gas are present in small quantities in many regions, it is only under definite conditions of stratification and structure that these products occur in sufficient quantities to be of commercial value; for it is only in the localities where there is a source of supply, a porous reservoir and an impervious cap rock, that these substances have ever been found in paying quantities.

In connection with these three essentials there should be mentioned another factor which is of the greatest practical importance in the determination of the location of oil and gas. Assuming that there are present in any particular region a source of supply, a reservoir, and a cap rock, how may one discover the most likely place in which to drill for oil and gas?

The rocks on the earth's crust do not all lie level, but in many cases have been folded into a great series of wave-like arches and troughs. An upfold or arch is known as an **anticline** and a downfold as a **syncline.**

Now geologists have found that in regions of folded rocks, where the three essentials, viz, source of supply, reservoir, and cap rock, are all present, the oil and gas almost invariably occur along the lines of anticlines, that is, under the arch. If salt water is also present in the reservoir sand, as is often the case, it will usually be found in the syncline or trough. So it is often no difficult matter to locate with some degree of certainty the oil and gas-producing localities in a region of folded rocks, for the oil, gas and salt water, obeying an elementary law of physics, will arrange themselves in order of their specific gravities.

Conditions of structure such as have been described occur in a number of states. By far the greater part of the oil and gas found in Pennsylvania, West Virginia, Ohio, Indiana and Illinois, have been secured along anticlinal folds. The anticlinal theory of the

location of oil and gas is now regularly taught in classes in economic geology in most American universities, and the more up-to-date oil men are everywhere accepting it as a basis for prospecting and development. No one believes that the theory is infallible. It sometimes happens that neither oil nor gas are found in anticlines, in localities where surface conditions appear favorable, and on the other hand oil and gas have occasionally been found in synclines. The fact remains, however, that careful investigations in a number of widely separated fields, not only in the United States, but in other parts of the world as well, have shown that by far the greater part of the productive oil and gas wells are found along anticlinal folds.

The question may be asked: What is the bearing of all this on the oil industry in Oklahoma? Simply this: the greater part of all the oil and gas so far found in this State occurs along anticlines. In every region in which these substances have been found there are indications of disturbances in the rocks and in most cases well-marked anticlines may be determined.

Another factor which must always be taken into consideration in Oklahoma, as well as other known oil fields, is the shape and lithologic character of the oil and gas-bearing sands. If the sand is thin, it can hold little oil or gas; if it is thick, it can hold much larger deposits. If the sand is fine-grained and practically impervious, but little oil or gas can pass through it. If it is coarse-grained and porous, large amounts of oil and gas may be stored up. So that other things being equal, the thicker the sand and the more porous the material, the larger the amount of oil or gas contained therein. Thin beds of fine-grained sand can carry but little if any oil or gas. From this it will be readily understood that the most prolific oil or gas fields must necessarily occur in regions where a thick bed of porous sand is located along an anticline. These conditions seem to obtain at Glenn Pool, where the sand is more than 100 feet thick, as well as at Bartlesville, in the Muskogee field, and at a number of other prominent fields in the State. Wherever a pumpkin-seed-shaped bed of porous sand occurs in a region where the rocks either lie level or where there is an anticlinal fold, oil and gas have usually been found. On the other hand, in several cases, dry sands of considerable thickness have been found along anticlines, while along others only thin sands carrying a small amount of oil have been encountered.

Nor are the developed oil fields all the anticlines known to exist in the State. The rocks in the southern part of the old Creek Nation, the northern part of the Choctaw and the southeastern part of the Cherokee Nations are folded into a series of anticlines and synclines. From a geological standpoint there is no reason why these regions should not contain as large deposits of oil and gas as those that have already been discovered farther north.

It need occasion no surprise if oil and gas is found in many

parts of Sequoyah, McIntosh, Okfuskee, Hughes, Coal, Pittsburg, Haskell, Latimer and LeFlore counties, in regions where no prospecting has been done. There is also a possibility of finding oil and gas in any of the Red River counties as far west as Jefferson, as well as in several of the counties lying just west of the present developed fields, particularly Osage, Pawnee, Creek, Seminole and Pontotoc.

There are five general regions in Oklahoma where it is very probable that neither oil nor gas will ever be found in paying quantities, namely: in the heart of the four mountain uplifts, and the Redbeds region in the western part of the State. Much money has been spent in vain attempts to find oil and gas in these regions and doubtless as the years go on still greater amounts will be squandered. Those intending to drill for oil or gas should always secure the opinion of a competent geologist regarding the possibilities of finding these products. He may not always be able to tell where to drill, but he should be able to tell where not to drill.

NATURAL GAS

(By Chas. N. Gould)

In Oklahoma, as in most other regions, natural gas is found associated with petroleum. While it is true that there are in the State a few gas wells in which the amount of petroleum produced is negligible, and there are some oil wells which produce but little gas, the fact remains that in at least 90 per cent. of the wells, both substances are found. This is only what might be expected when the nature of the two products is understood. Petroleum and natural gas are but two manifestations of the same series of chemical compounds, one being the gaseous, the other the liquid form.

This being true it naturally follows that a discussion of the geology and occurrence of petroleum would include also the subject of natural gas. Inasmuch as these topics have been rather fully discussed in the chapter on petroleum, page .... to ...., it is unnecessary to take them up here.

The most important problem connected with natural gas in Oklahoma, is an estimate of the amount already available or in prospect. This is a question that can not now be answered intelligently.

All that we can say is that the deposits are enormous, but at the present time there are not sufficient data to enable us to estimate accurately their possible amount. Practically every oil well so far drilled in the State produces gas, while at the same time many of the strongest gas wells do not contain oil. The daily capacity of an Oklahoma gas well varies from a few cubic feet per day up to millions of cubic feet. The average sized well in the Tulsa or Bartlesville region runs all the way from 1,000,000 to 10,000,000 cubic feet per day. Wells in various parts of the State have been

reported to produce 40,000,000; 50,000,000 and even 60,000,000 cubic feet per day.

According to the statistics of the United States Geological Survey, there were, at the close of 1908, 474 gas wells in Oklahoma. This is probably not more than half the actual number now in existence. Gas wells are strung all along the 96th meridian from the Kansas line to Henryetta. Some of the strongest wells with a capacity running up into the tens of millions of feet per day are located in the Hogshooter field, the Shallow field, the Morris field, the Bald Hill field and the Muskogee field, while other wells equally good are located at Wainwright, Pawhuska, and in the Preston Pool. Smaller amounts have been found in dozens of localities scattered throughout the State.

Any estimate of the amount of gas actually in sight in Oklahoma is little better than a guess. There are no accurate data and even an approximation may of necessity be misleading. Taking into account all known facts, however, and estimating as nearly as possible the amount from the various wells, including those now being utilized, those shut in, and those going to waste, the amount of gas already discovered in Oklahoma should be somewhere between 1,500,000,000 and 3,000,000,000 cubic feet per day. A conservative approximation would probably be 2,000,000,000 cubic feet daily.

But if we attempt to go a step further to form a conjecture as to the amount of gas which may yet be discovered in Oklahoma, we are at once confronted with the inadequacy of language and the paucity of figures. Those of us who have traveled over the developed fields of Oklahoma, studying the problem from a scientific standpoint, believe that at the present time not one-fifth, or possibly not one-tenth of the gas in those fields has yet been touched. In many cases only a single well to the square mile has been drilled in search of oil. Gas having been found, for which there is no demand, the entire territory has been condemned, and the field abandoned.

In the region south of Muskogee and Okmulgee there has been practically no drilling as yet, but this is a region in which the geologist believes that there should be vast untapped reservoirs of gas and oil. Even the geologist with his well-known inclination to estimate things in hundreds of millions, stands aghast before the unknown possibilities of the future development of the Oklahoma gas field.

Natural gas is now being utilized to a limited extent for manufacturing and domestic purposes in the region in which it is produced. Such towns as Bartlesville, Dewey, Cleveland, Collinsville, Mounds, Wagoner, Claremore, Morris, Boynton, Wann, Blackwell, Chelsea, Bigheart, Pawhuska, Tanaha, Ochelata, Ramona, Tulsa, Skiatook, Nowata, Talala, Lenapah, Sapulpa, Okmulgee, Muskogee, Ponca and Coweta use gas, produced usually within a few miles of the city, for lighting and heating purposes. In a number of cases,

gas is used for industrial purposes. For instance, Bartlesville has zinc smelters, Dewey has a Portland cement mill and a number of towns in the gas fields have brick plants that use gas. A pipe line from the Tulsa-Glenn Pool region supplies Oklahoma City, Edmond, Guthrie, Chandler and Shawnee. Ardmore uses gas piped from the Wheeler field 20 miles distant.

Within the past few months a gas well with a reported capacity of 5,000,000 cubic feet daily, has been discovered at Poteau, in the extreme eastern part of the State. Gobeto and Lawton in the southwest corner of the State are supplied with gas from local wells.

The price of fuel varies directly with the distance it has to be piped. In Tulsa and Bartlesville, to cite two examples, where the gas is produced near at hand, prices are about ten cents per thousand cubic feet for domestic use and two to four cents for manufacturing purposes. Several towns in this region have advertised two cent gas and one and one-half cent gas for factories. In Oklahoma City, where the gas is piped over a hundred miles, the price is twenty-five cents per thousand for domestic use and ten cents for factory use.

It is obviously impossible to accurately estimate the life of the oil and gas fields of Oklahoma. Ordinarily these substances are exhausted within a few years after the reservoir containing them has been tapped. It is well known that the life of the ordinary oil well or gas well does not usually exceed five years. Some of the wells are exhausted in a year or two, others produce a small quantity of oil for ten, twenty, or even forty years. Some of the first wells drilled in Pennsylvania in the late 60's are still producing. On the other hand, the famous Beaumont field, which was at one time the wonder of the world, is now practically exhausted. The Indiana gas field is nearly exhausted. Many of the first wells drilled in southern Kansas and northern Oklahoma have already ceased to produce oil or gas in paying quantities.

It must be remembered, however, that as I have already stated, only a relatively small part of the oil and gas region of Oklahoma has ever been prospected and a still smaller part developed. There is enough prospective territory untouched in Oklahoma to keep the drillers busy for the next fifty years. Counting fifty years more for the last wells brought in, and assuming that the greater part of the gas will be utilized and not permitted to go to waste, we may approximate 100 years as the life of the oil and gas field of Oklahoma. This estimate is probably under, rather than over the actual time limit.

At a conservative estimate not to exceed 10 per cent., possibly not more than 5 per cent. of the gas so far discovered is now being utilized. Part of it is shut in waiting a chance for utilization, but much of it is going to waste. One can not drive anywhere through the gas field of northeastern Oklahoma without being shocked at the prodigal waste of fuel now going on. In hundreds of places,

gas is permitted to burn day and night without ceasing. Scores of wells are permitted to flow unchecked, and this priceless fuel is being dissipated into the air. A law which was passed by the last legislature, the object of which was to attempt to conserve the natural gas, has done much to check this waste, but in many sections it is yet more honored in the breach than in the observance. At the present time in Oklahoma a vast amount, possibly hundreds of millions of cubic feet a day of the best fuel the world has ever known, is permitted to escape into the air.

In territorial days little attempt was made to save the gas. To cite but one instance out of a hundred; when gas was first encountered in Bartlesville, it was permitted to escape unchecked. The roaring of the gas was so persistent that people in the town could not sleep at night, and so the gas was carried in pipes outside of the city limits, where it might escape without the noise disturbing the sleepers.

The following paragraphs from a current periodical will give some idea of present conditions in the State:

"The party took a run down to the new Preston oil field. While there accurate measurements were made of the gas well recently brought in, and it was shown to be good for 36,000,000 cubic feet per day. This is the largest gas well ever developed in the southern Creek country and one of the largest that has been completed recently in Oklahoma. Its magnitude was a surprise, even to the owners of the well. It has been running wild ever since it was brought in and the roar of the escaping gas can be heard for miles. The owners are purposely allowing the gas to go to waste with the belief that the well will finally drill itself into oil."

The following quotation from a letter to the Director of the Survey April 4th, 1910, by a practical gas man, will give an idea of the situation from the view point of an interested citizen:

"There are millions of feet of natural gas going to waste in this State, due largely to carelessness and neglect by the many producers in drilling for oil. It seems their sole aim is to drill through the gas bearing strata in order to secure the oil, as the oil can be marketed more readily and the gas has a very limited market. While this is being done the gas is allowed to go to waste; in fact very little attention is paid to it. In many cases the well is drilled into salt water, which destroys it entirely as a gas well. Only recently in the new Hamilton Switch pool there have been no less than fifty to seventy million cubic feet of gas blowing away, in [illegible] to supply the whole State of Oklahoma, every day, with apparently no effort on the part of the producer to prevent it. There are some of the wells in this Pool which came in having a capacity as large as 36,000,000 cubic feet per day. We feel that the gas is just as marketable and valuable a product as the oil and that a well which is drilled in having a capacity of from two to four million cubic feet per day should be shut in to save the gas, as it looks like a crime to allow the gas to go to waste in this

It is greatly to be regretted that some really effective plan has not been devised to curtail the prodigal waste of this valuable fuel, which has been going on in eastern Oklahoma for the past ten years, and which is still in progress. For this there is no excuse except the cupidity of man. The well having been drilled, in search of oil, and gas having been encountered, for which there is no immediate demand, it is easier to pull the tools, letting the well stand open, permitting the escape of the gas, than it is to plug the well. In many cases, as the one above cited, a gas well with a capacity of many millions of cubic feet per day is permitted to flow unchecked in the hope that it will some day drill into oil. In scores of instances

wells which produce ten or twenty barrels of oil and say 5,000,000 or 10,000,000 cubic feet of gas a day are permitted to flow unchecked. The gas is all wasted to save the small amount of oil. When it is remembered that 6000 cubic feet of gas has a fuel value equivalent to a barrel of oil, it will be understood that 6,000,000 cubic feet of gas equals a thousand barrels of oil. So in the case cited the equivalent of 1000 barrels of oil, is permitted to go to waste each day in order to save ten or twenty barrels. For these reasons, Oklahoma is day after day losing hundreds of thousands of dollars worth of valuable fuel, which should be saved for future generations. This waste is nothing short of criminal, and it is high time that the people of Oklahoma, as of other gas-producing states, were awakening to a realization of conditions.

One point should be clearly kept in mind, namely, that these fuels, once gone, are gone forever. You may take all the water from a well and the rainfall will restore the water. You may exhaust the fertility of the soil, but by careful cropping and fertilizing, the fertility may be renewed. You may cut down the forests, and new forests will grow, but when you take from the earth the minerals, the oil, the gas, the coal, contained therein these minerals are never replaced.

In this connection it may not be out of place to quote a statement made by Dr. White, State Geologist of West Virginia, at the congress of governors at Washington two years ago:

"For just as sure as the sun shines, and the sum of two and two is four, unless this insane riot of destruction and waste of our fuel resources which has characterized the past century shall be speedily ended, our industrial power and supremacy, will, after a meteor-like existence, revert, before the close of the present century, to those nations that conserve and prize at their proper value their priceless treasures of carbon."

We are trying to keep our gas at home. We need it. It is true that we have been wasting it about as fast as we could, but at the same time, we don't want any body to take any of it away. What we want is to locate factories here that will utilize our fuel. We have a plenty and to spare. If the gas fields are ever exhausted, we have a few billion tons of coal to fall back on; (The United States Geological Survey says we have 75,000,000,000 tons) but we are not worried about the gas failing for several years yet. But right in the gas fields or within short piping distance, there are inexhaustible deposits of as good clay as that found in Ohio or New Jersey; of as fine glass sand as that of Illinois or Pennsylvania; of Portland cement rock as good as can be found anywhere in the world. There is also limestone for burning into lime; lead and zinc deposits among the most prolific on the continent, besides sandstone, marble, granite and asphalt, all in enormous quantities. A little farther away, there are 123,000,000,000 tons of gypsum, and salt water enough going to waste to make 100 car loads of salt a day.

We need these things developed. We must have them developed before Oklahoma comes to her own, and we believe that if we can keep our gas at home the development will come all the sooner.

If the gas is piped out of the State, Oklahoma will derive very little benefit from it. If it is utilized at home, it means the establishment here of hundreds of industrial plants and factories and the opening of scores of mines and quarries, all of which go toward the development of our State.

ASPHALT

(By Chas. N. Gould)

The asphalt deposits of Oklahoma are among the most extensive in the United States. The greater part of the deposits occur in the southern part of the State, in the region south of the Arbuckle Mountains, although exposures are found all the way from the Arkansas line to the Wichita Mountains. Practically all the asphalt in Oklahoma occurs as rock asphalt; in other words, as rock impregnated with asphalt. In several cases, however, the material is found in an almost pure semi-viscous state. In other cases it is a hard, brittle substance known as grahamite or impsonite, having the general appearance of anthracite coal.

Pure asphalt or bitumen is derived from the natural distillation of petroleum or rock oil. It is the last distillation product, the part that remains after all the volatile oil and gases have been distilled away. On the island of Trinidad, the asphalt comes to the surface in great quantities and spreads out, forming a so-called lake. The evaporation on the surface forms a hard crust, but beneath the crust the asphalt is soft and viscous.

The asphalt in Oklahoma occurs usually along faults which extend from the surface to a depth of sometimes many thousands of feet. Along these faults or fissures the rocks have slipped up on one side and down on the other. At some unknown depth these fissures have cut beds which carried petroleum. This oil, being volatile and tending to escape to the surface, came up along the fault line. The lighter oils and gases have long since escaped while the heavy asphalt has remained behind and impregnated the rock on either side of the fissure. If the rock alongside the fissure happens to be a limestone the substance is called lime asphalt; if it is a sandstone, the material is a sand asphalt. So it will often happen that a bed of lime asphalt occurs beside a bed of sand asphalt or vice versa, the two beds being on opposite sides of the fault line.

Analyses of the asphalt made by Professor DeBarr of the State University of Oklahoma show that the composition of the material varies considerably. The so-called lime asphalt contains all the way from two to ten per cent bitumen, the remainder being calcium carbonate or limestone. The sand asphalt runs usually from ten to twenty per cent of bitumen. The shale asphalt usually contains less than five per cent of bitumen and is rarely utilized. It is usually considered that a mixture of the lime and sand asphalt makes the best paving.

The thickness of the so-called veins on either side of the fault lines varies from two or three feet to more than fifty feet. Usually the sandstone, which is a porous rock has been filled to a greater distance from the fissure than has the dense shale and limestone. Limestone is often impregnated with the material for a distance of twenty-five to fifty feet from the fault, depending upon the porosity of the rock.

The faults often extend on the surface for a distance of a mile or more. The depth to which the fissures extend is unknown, but in some cases as shown by drilling it is at least 100 feet. When it is understood that several scores of the fault lines have already been discovered, and that new ones are coming to light all the time, it will be seen that the deposits of asphalt are, for all practical purposes, inexhaustible. It is not an uncommon thing in Carter, Murray and Stevens counties, for a farmer breaking out prairie to turn up a black rock and find that an asphalt vein crosses his field. Or perhaps a man digging post holes may throw up a piece of asphalt rock. No one knows how extensive the deposits are, but there need be no surprise if new beds are discovered for the next fifty years.

According to the terms of a treaty entered into between the Choctaw and Chickasaw Indians and the United States Government, all the known valuable coal and asphalt lands in both nations were segregated, or set apart from allotment. The work was done by Mr. Joseph A. Taff, of the United States Geological Survey, in 1903 and 1904. Mr. Taff included in his segregation all the land containing asphalt that had been discovered up to that time, 7,240 acres in all, of which 6,880 acres had been leased by various companies, and 360 acres had not been leased. This land is included in thirteen separate tracts, twelve of which are located in the Chickasaw Nation and one in the Choctaw Nation. The size of the tracts varies from 40 to 860 acres. According to the terms of the treaty, the leased land, 6,880 acres, could not be sold without a special act of Congress, so that only 360 acres of unleased land were on the market. Bids for this land were opened August 7, 1906, but all were rejected by the Secretary of the Interior.

As has been said, since the time the land was segregated a number of additional deposits of asphalt have been discovered. The greater part of these are on land which can now be sold. Some of this land lies near railroads and some of it is twenty miles away from transportation.

At various times several of these different deposits have been operated. Quarries have been opened on practically all the leased land and several mills have been erected, located as follows: One at Gilsonite, three miles south of Sulphur; one at the Brunswick mine near Dougherty, and one at Ardmore. In some cases the rock was simply crushed fine, and in other instances an attempt was made to distill out the asphalt from the rock matrix.

At various times the rock has been used for paving in a num-

ber of cities such as Kansas City, Fort Worth, Ardmore, Shawnee, Paris, Sulphur, Lawton, and Norman. When properly laid it makes a most excellent pavement, hard, firm and durable.

The city of Ardmore, which used asphalt obtained almost within the city limits has today what are believed to be the best paved streets in America. While the greatest amount of the street paving in Oklahoma today is being done with so-called Trinidad or Bermuda asphalt, which is in fact only the discarded oil residue from oil refineries, and which will last but a short time, some of the most valuable material in the world lies dormant in the hills of Oklahoma, awaiting development.

The chief difficulties in the way of profitable utilization of the asphalt deposit of Oklahoma are as follows: First, the attitude of the asphalt trust. Following well-known methods, the trust has underbid independent operators and used either asphalt imported from Trinidad or an inferior manufactured product derived from oil refineries. It is claimed that practically all the leases in the Chickasaw Nation are now held by the asphalt trust. Second, the lack of economical methods of utilizing the rock asphalt. The crushed rock is bulky and transportation charges often prohibitive. The methods of refining the product on the ground have not always been satisfactory. Third, the cost of transportating the raw product from the mines to the railroad.

In spite of these objections the fact remains, however, that there are in Oklahoma vast deposits of asphalt, enough to pave all the streets of all the cities in the State and to last for untold generations.

LEAD AND ZINC

(By Chas. N. Gould)

While it is true that Oklahoma possesses a large amount of mineral wealth, it must be remembered that the greater part of it consists of non-metalliferous deposits. At the present time lead and zinc are the only metals that have been mined with profit.

There are two general regions in Oklahoma in which lead and zinc are known to occur in sufficient quantity to justify development, namely in the northeastern counties and in the Arbuckle Mountains. These two localities will be discussed separately.

Northeastern Oklahoma Lead and Zinc Region

The lead and zinc deposits of northeastern Oklahoma occur in the same rocks in which the lead and zinc of the Joplin region are found. This is the southwestern extension of the Ozark uplift. The same series of rocks outcrop in Ottawa, Delaware, Adair, Cherokee and eastern Mayes counties. Both lead and zinc have been found in small quantities in all of these counties, but it is only

in Ottawa, the northeastern county in the State, that extensive development has been attempted.

The following paragraphs from the report of Mr. Gaylord Nelson published in 1908 as a part of Bulletin No. 1 of this Survey, will outline the general geology of the region, and give a comprehensive idea of the development which had then been accomplished.

"In Ottawa County there are three well-developed camps; in the order of their establishment they are, Peoria, Quapaw and Miami. The first shaft was sunk in the Peoria district in 1891. Since then there has been a steady output of ore from the camp. In the Quapaw district, the next district to be opened up, ore was first secured by shaft, in 1897. The Miami camp, probably the youngest camp in the whole Ozark region, has been in existence scarcely three years. The first steam concentrating mill was completed less than a year ago. But in spite of extreme youth, development has been pushed rapidly forward in this camp and it bids fair to become, in a short time, the most important of the three. However, at the present time the Quapaw camp shows the most extensive development in the region, there being about twenty-one steam concentrating plants in operation, besides a number of hand jigs.

"The ore is found under practically the same conditions in the Peoria and Quapaw camps and a few general remarks will cover both. In these two districts the Boone chert of Lower Carboniferous or Mississippian age forms the greater portion of the surface rocks. In places small patches of sandstone and limestone of the Chester group are found above the Boone chert, but the greater part of the Chester has been dissolved and carried away by surface waters. It is under these patches, or blankets, of sandstone and limestone that the ore bodies are found, these relatively impervious formations, it appears, having prevented the water from exerting its solvent power on the ore. From the nature of the formations in the districts the ore may be encountered at any depth, or as the miners aptly express it: "At Quapaw and Peoria the ore is found from the grass roots down." In fact at Quapaw on the holdings of the Cherokee Lead and Zinc Mining Company, just southwest of Lincolnville, several wagon loads of calamine (zinc silicate) were picked up from the surface where it had been plowed up and left through ignorance of its value. Both of these districts are very rough. Many of the hills are of sandstone and limestone covered with small pieces of residual chert. The topography taken as a whole is what we would naturally expect in a mining region.

"The geology and topography of the Miami district stand out in marked contrast to that of the above-mentioned regions. The country for several miles in every direction from the camp is a level grass-covered prairie. Low hills to the east and west can be seen in the distance, but the camp itself has the appearance of a fertile farming country. There are no exposures of rock on the surface except the short line of bluffs along the east bank of the Neosho

River, immediately west of town, and small exposures of limestone in the bed of Tar Creek one mile east of town.

"The geology of the district is simple, the surface formation being the black, carbonaceous shale of the Cherokee formation which is of Pennsylvanian age. Below these shales are the sandstones, limestones and shales of the Chester group. Beneath the Chester group is found the Boone chert which forms so much of the surface rock in the Peoria and Quapaw districts. Throughout the productive area a large part of the limestone of the Chester has been removed by underground solution allowing the insoluable sandstone to settle down on the Boone. In this process of settling the sandstone has been fractured and broken into angular fragments. The term brecciation is applied to this fracturing. The underground waters carrying these ores in solution have freely circulated in this breccia and in so doing the ore has been deposited filling the cracks and crevices and cementing the breccia into a solid mass. Most of the ore mined in the district occurs in this manner. There are two other modes of occurrence of the ore in the district; as an impregnation of the sandstone itself and also as a pure ore mass filling small solution cavities in the limestone. The latter is relatively unimportant as a source of the ore.

"Among the minerals found associated with the ore bodies the most important and troublesome to the miners is the sulphide of iron known as marcasite. This mineral being nearly as heavy as the sphalerite, makes separation by jigging difficult and it lowers the grade of the ore as there is a penalty of $1 per point for iron. Much heavy oil or bitumen is found impregnating the rocks and crevices in the same manner as the ore. This oil is also a source of trouble to the miners as it tends to ball up the crushed ore in the jigs and prevents a good separation. Little or no calcite (tiff) or dolomite (spar), which are so common in the Joplin region are found with the Miami ores. The ores mined are practically all sphalerite, (zinc sulphide or resin jack) and galena, (lead sulphide). There is but an insignificant amount of silicate or carbonate ore.

"At the time of the writer's visit to the camp, the second week in August, 1908, there were only four concentrating mills in operation, but two others were rapidly approaching completion and are probably now handling ore. Aside from these milling properties there are a number of shafts sunk down to the ore and many other shafts are in process of being sunk. These shafts vary in depth from 90 to 130 feet. The shallower ones are to the east and the deeper to the west of the town. The depths of the shaft about represents the thickness of the overlying shale.

"The present operations are confined to sections 1 and 12, Township 28 North, Range 22 East, and sections 6 and 7, Township 28 North, Range 23 East, but prospecting is being rapidly extended far to the west and south. Several good strikes have been reported, so that it is probable that the district will soon be enlarged to embrace considerable territory to the west and south of the Neosho River.

"The ores are easily mined and only the most simple methods are employed in raising and separating them from the gangue minerals. In the mines, the ore is shot off by dynamite, in faces, and hoisted to the surface in buckets operated by donkey engines. This material is then crushed and the ore separated from the gangue minerals by the use of water jigs. This separation is easily effected, owing to the wide difference in the specific gravity of galena.

"There has not been enough development or prospect work in the district to give any idea of the amount of ore in the field but it is probable that better ore will be found below the level of the present workings. But without that hope there is enough ore in sight to make the Miami camp one of the most productive of the whole Ozark region, and in time it may rival Joplin itself as a producing camp.

"From all indications Oklahoma will soon be one of the great lead and zinc producing states of the Union and become a close rival to Missouri in the matter of production."

During the past two years, development was steadily increased until now there are 25 mines in operation. The production for 1910 was $700,000. The greater part of the zinc concentrate is sme'ted in Iola, Kansas, and Bartlesville, Oklahoma. Within the past few months there has been considerable prospecting outside the deve'oped field and there is little reason to doubt that more extensive deposits will eventually come to light.

Arbuckle Mountain Lead and Zinc Region

In the Arbuckle Mountains lead and zinc ore are found in limestone also, but the conditions under which these minerals occur are somewhat different from those in the northeastern counties. Prospecting has been carried on in these regions for many years, and much money spent in sinking shafts.

The Arbuckle Mountains occupy an area sixty miles long and twenty miles wide. In but one locality, so far as is known to the Survey, are conditions such as to justify the expenditure of time and money in development. This region is located in the heart of the mountains some eight miles southwest of Davis. A report on this region submitted by the Director, April 29, 1910, outlines our present knowledge of conditions in that region.

Extracts from the report follow:

"This region is located near the heart of the Arbuckle Mountains. In the southwestern part of the region are located the West Timbered Hills, composed largely of porphyry and granite rocks. The main part of the region, however, is occupied by heavy, massive limestone some 6,000 feet thick, known as the Arbuckle limestone. Between the limestone and the porphyry is a zone from a

quarter to a mile wide in which the rocks are largely coarse sandstones and conglomerates, known as the Reagan sandstone.

"The mines which were visited are located on sections 17, 20 and 21, T. 1 S., R. 1 E, 8 miles southwest of Davis, and are all on the Arbuckle limestone and at a distance of from a few hundred yards to a mile and a half northeast of the outcrop of the granite and Reagan sandstone along the West Timbered Hills.

"The ore consists largely of zinc carbonate and zinc sulphide, or sphalerite, popularly known as jack. In general the zinc carbonate occurs on the surface or within a few feet beneath the surface in the form of more or less porous or honeycombed, yellow or brown masses. It seems to follow old solution channels extending from the surface downward. In many places the sphalerite or jack outcrops on the surface, passing downward this ore increases in richness and amount.

"Five general groups of mines were visited, namely: the Hope and Sober mines, the Brown mines, the McGuire-Robnett mines, the Ansell and Toop mine and the Heinman mines. Of these, the Ansell and Toop and the Heinman mines are shafts, which have gone down to a depth of 40 to 60 feet. In the case of the Hope and Sober, the Brown, and the McGuire-Robnett mines, the shafts have not penetrated a greater depth than 10 to 15 feet.

"In this connection I do not desire to discuss the relative richness of the ore in the various mines. No chemical analyses have been made under my direction and I have no definite knowledge regarding the value of the different ores. This is a matter with which the owners are much better acquainted than I.

"At various times carloads of ore have been shipped to the smelters at Bartlesville and other points and according to reports, much of this shipment has been profitable. As nearly as I can learn, somewhere between 10 and 15 cars of ore have gone out from the camp. The best returns have been obtained, I understand, from the Hope and Sober mines.

"The problem which most vitally concerns the future of the camp is the definite knowledge regarding deep seated ores. There is no doubt but there is a considerable amount of both carbonate and jack within a few feet of the surface in a number of localities on the sections named above, as well as in other parts of the mountains. With regard to the conditions at a greater depth, we have no means of knowing. In other places in the mountains, namely, near Dougherty, near the East Timbered Hills, and in the vicinity of Mill Creek and Ravia, where shafts have been gone down in the Arbuckle limestone, the same formation in which the mines under consideration are located, no values have been found so far as I am able to learn, at a greater depth than 20 feet beneath the surface. In these shafts all the pay ore is located within 10 or 15 feet of the surface. What the conditions may be in the region under discussion, we have no means of knowing until a number of shafts have penetrated to a depth of 50 feet or more.

"Sufficient study has not been made to form a definite opinion as to the origin of the ore, but so far as I know, all reputable geologists and mining engineers who have made an examination of the region, are now agreed that the ore found on or near the surface was brought there by descending water. My interpretation is that the ore now collected, either as carbonate or sulphide in crevices or solution channels, on or near the surface, was concentrated there by descending water. We know that during former geological times, something like a mile and a half of rock has been worn away from above the present level of the mountain range. The probabilities are that a small amount of lead and zinc was scattered throughout all these rocks. The limestone, being more soluble, has been carried away. The lead and zinc, being less soluble, has remained behind. It has from time to time accumulated either as a carbonate or sulphide in the cavities which it now occupies. How far down this ore was carried, we have no means of knowing, and as stated above, we shall not be able to determine this until the drill, or better still, a number of shafts have penetrated a considerable depth beneath the surface.

"The popular fallacy of "blow outs" which is widespread in the mountains, has really no foundation in fact. There is a small amount of iron scattered around over the hills and the popular idea is that this was at one time thrown up from beneath. In point of fact, however, the iron was at one time disseminated through the rocks which lay at a higher level than the present surface of the mountains and as the limestone has been worn away, it has dropped down and is now scattered around as boulders on the limestone.

"There is no evidence whatever of volcanic or any other similar action in these mountains. The present conditions were brought about by long continued erosion of the limestone and granite rocks."

IRON

(By Chas. N. Gould)

Iron is a very widely distributed mineral. There are few rocks anywhere on the earth's crust that do not contain it in at least small quantities. Iron is the great coloring matter of the rocks, and gives rise to the greater part of the reds, yellows, browns, blacks, and intermediate tints seen in stone.

In certain localities in Oklahoma, the rocks contain relatively large quantities of iron. The shales of the Redbeds of the central and western parts of the State, for instance, contain sometimes as much as fifteen or twenty per cent. of iron. In certain places among the Redbeds rusty black rocks, which look as if they had been burned may be found scattered on the surface. Many people imagine that these rocks have been thrown out by volcanoes, but

this is not the case. The black color is caused by the large amount of iron contained in the rocks, which is oxidized by its exposure to the air. This black rock, usually a sandstone, is really a fair quality of iron ore, and if it could be found in large quantities near cheap fuel, it might pay to smelt it. As long, however, as deposits of iron ore are found in such immense quantities in other parts of the country where conditions for manufacture are more ideal, this Oklahoma iron will probably never be worth smelting.

Deposits of iron ore have been reported from various localities in eastern Oklahoma. Some of these deposits have been examined and found to be of little or no commercial value.

There are three general regions in the State from which large deposits of iron ore are reported, and which may repay investigation, namely, near McAlester, in the Wichita Mountains, and in the Arbuckle Mountains.

For several years there have been persistent rumors to the effect that large deposits of iron ore are found in the mountains south of McAlester. It has been stated on what seems to be good authority that mining experts have examined these deposits in the interests of wealthy corporations and have made extremely favorable reports. The localities where this ore is reported to be found have not been visited by members of the Survey. Specimens reported to have been obtained in these localities which have been examined, appear to be low grade iron ore. The Survey does not now desire to express an opinion as to the value of the reported iron ore from the McAlester region.

Considerable deposits of high grade iron ore, chiefly magnetite, occur in the Wichita Mountains. Large boulders of this ore are scattered on the surface in several localities, particularly in a region 10 to 15 miles northeast of Mountain Park. So far as known no systematic surveys of the deposits have been made, and until this is done there is no way of arriving at an estimate regarding their value.

In the Arbuckle Mountains there are rather extensive iron ore deposits, but so far as known all these deposits are in the form of pockets among the limestone. In some cases the ore is still embedded in the rock while in other localities the limestone, which is more soluble than the iron ore, has been removed by erosion, thus leaving the iron boulders scattered over the surface. There are dozens of localities in the mountains where large quantities of the massive black boulders, sometimes as large as a tent, cover areas of several acres. Cases of this kind occur near Davis, Roff, Bromide, Mill Creek, Hunton, Ravia, and Franks.

This ore is usually of high grade, some of it being manganese iron ore, which commands a fancy price on the market. Shipments of the ore have been made from near Hunton and Mill Creek. No estimates have been made of the amount of ore in the mountains nor is it possible in the present state of our knowledge to even approximate the amount.

It is quite probable that the ore in sight, scattered over the hills in widely separated areas in Oklahoma amounts to several millions of tons. The greater part of it is in localities difficult of access. With good transportation facilities and the certainly increasing demand for iron ore, it should be a question of but a short time until Oklahoma iron ore is developed.

Fortunately, fuel is abundant near McAlester and the Arbuckle Mountains. If iron ore proves to be in quantities sufficient to justify development there will be no lack of fuel with which to smelt it.

COPPER

(By Chas. N. Gould)

Copper is widely distributed among the rocks of Oklahoma. There is hardly a county from which it has not been reported. In practically every county, however, it has been found in such small quantities that it is not of commercial importance. Its presence is usually denoted by the green and blue stain which it makes in the rocks. Generally speaking, all the reds, yellows, browns, blacks and intermediate shades and tints are caused by the presence of iron, but the blues and greens are often caused by copper. A little copper will color so large an area that the miners have a saying that "a pound of copper will stain a square mile of rock." This being true it will readily be understood that a small area containing rocks which have been colored blue or green by copper does not necessarily indicate the presence of copper in paying quantities.

Copper has been reported in the Redbeds from the following counties: Pottawatomie, Lincoln, Logan, Noble, Garfield, Major, Woods, Kingfisher, Blaine, Caddo, Dewey, Harmon, Harper, McClain and Greer. In most cases nothing has been found but the greenish stain, but in a number of instances, for instance near Perry, in Noble county, and Winnview, in Blaine County, small nuggets of native copper the size of a hazelnut occur, scattered through the reddish clay-shale. In several instances tunnels have been driven into the red clay banks for as much as fifty feet and several gallons of these small copper nuggets have been secured. In no case, however, has the amount obtained justified the expenditure.

There is a region along the valley of the Cimarron River and Carisso Creek, near Kenton, in the extreme northwestern corner of the State, where copper was mined for a number of years. Several hundred shafts have been sunk in this region. The rocks which are Redbeds similar to those in central Oklahoma are in many places vividly stained with copper. Some of the material obtained has been hauled to the railroad and shipped to smelters, but the invest-

ment did not prove profitable and at the present time all of these workings have been abandoned.

Copper mines were opened, a number of years ago, in the vicinity of Byars, McClain County, and operated by primitive methods for a considerable time. But they, too, were not profitable and nothing remains at the seat of operations but a few holes and old tunnels and a part of an old improvised horse power crusher for pulverizing the ore.

Copper has been reported from the Kiamichi Mountains in the southeastern part of the State. There is a region not far from Hochatown in east central McCurtain County where small quartz dikes have cut the sandstones and shales. Along the contact of these dikes the rock is stained with copper but so far as is now known it has not been found in marketable quantities.

Copper occurs in igneous rocks in both the Arbuckle and the Wichita mountains. A number of shafts have been sunk in each region and a considerable amount of ore taken out. One government assay has been made which shows 10.81 per cent of copper. It is possible that if improved mining methods were employed and a sufficiently large body of ore outlined the venture might be made profitable. Up to the present time, however, all the money invested in copper mining in Oklahoma has been lost.

GOLD AND SILVER

(By Chas. N. Gould)

Gold is one of the most widely distributed of substances but it is usually in such minute quantities as to be of no commercial value. Not only is gold present in most solid rocks, but there is probably not a cubic foot of soil that does not contain very small traces of it. It is said that every cubic mile of sea water contains $200.00 worth of gold, and strange as it may seem, companies have been formed and money invested in vain efforts to extract it from sea water.

There is a widespread notion that gold and silver occur in paying quantities in Oklahoma. Much time, money and effort have been spent in the hope of finding these metals. Many individuals have spent years in a vain effort to discover something of value, but so far as known neither gold nor silver from Oklahoma has been placed on the market. There is perhaps not a county in the State in which the precious metals have not been sought. The greater part of the effort, however, has been put forth in the Wichita and Arbuckle mountains. Since the time of the Marcy expedition in 1852, prospectors and miners have been at work in the Wichitas. It is even claimed that the Spaniards sought gold there and the sites of old Spanish mines are still pointed out. There is, however, no record that the Spaniards, or any one else, ever found anything of value.

At the time of the opening of the Kiowa and Comanche country to settlement in 1901, there was much activity in the Wichita Mountains. It has been estimated that at one time there were more than 2,000 miners at work in the region. The mountains were once bristling with claim notices, and honeycombed with mining shafts. Scores of camps were scattered throughout the mountains. According to various estimates all the way from half a million to a million and a quarter dollars have been spent in sinking shafts in the Wichita Mountains. Some of the shafts reached a depth of 200 to 250 feet, although most of them were less than 25 feet deep. Several small smelters were erected, and a number of car loads of ore was shipped to large smelters at Pueblo and Denver. Hundreds of assays have been published, many of them claiming values running sometimes as high as several hundreds, or even thousands, of dollars per ton. Several reports have been published by government and other officials on the occurrence of gold and silver in the Wichitas, the most important of which will be cited.

In 1904 Prof. E. G. Woodruff, then professor of Mineralogy at the State University of Oklahoma, now a member of the U. S. Geological Survey, spent several weeks in the Wichita Mountains, visited practically all the camps then active, and wrote a paper entitled "Present Status of the Mining Industry in the Wichita Mountains of Oklahoma." He sums up his conclusions as follows:

"The mining industry of the Wichita Mountains is still in the prospecting stage. A conservative estimate places the number of claims located at about two thousand five hundred. On many of these claims no work whatever has been done. It is probable that five hundred openings are from ten to fifteen feet deep. The number of shafts ranging from twenty to twenty-five feet deep does not exceed one hundred. Possibly fifty are more than thirty feet deep. A few have gone beyond one hundred feet, and in one case the shaft was more than two hundred feet deep.

"Two cars of ore have been shipped, one from the Wildman district and one from the Oreana district. In addition to these shipments, a number of sample shipments have been made. At this time no ore is leaving the region. In one district a small smelter is being constructed to separate the bullion from the gangue.

"A word should be added concerning the damage which unscrupulous assayers have inflicted upon the region. With premediated purpose they have, in many cases, issued false certificates, thus buoying up the hope where it already existed, and creating undue excitement. In many cases the unsuspecting miner has been led to continue his search for the metal in the most impossible places. No one thing has contributed more harm to the industry than have these unprincipled assayers.

"Development is now in a quiescent state. At the time this investigation was made, five prospects were actually being sunk, two in the Meers district, two in the Cache district and one in the Oreana district."

Dr. Edwin DeBarr, professor of chemistry at the State University of Oklahoma, visited the region during the summer of 1904 and collected 197 samples which were afterwards assayed. Dr. DeBarr's conclusions are as follows:

"All samples were assayed by fluxes and by the cyanide processes and the heavy sulphides were assayed by the chlorination process, and all save No. 136 showed no trace of gold.

"No. 136 was obtained from washing placer material south of Brushy and Bald mountains and Gold Hill, in the creeks and in Deep Red, in which material there is a very small quantity of exceedingly fine gold in a limited area. The lack of water and the black iron in which it is found, together with the limited amount of gold therein, renders it unprofitable for working.

"No. 94 showed 0.98 oz. of silver and 3.6 per cent. of lead. No. 20 contained 5 per cent.;

No. 21, 3 1-2 per cent.; No. 23, 8 1-3 per cent.; No. 9, 5 per cent.; No. 10, 3 per cent.; and No. 11, 3 1-2 per cent. of copper.

"In collecting and sampling the above ores the greatest care was taken to secure a good sample free from contamination, and with a view to revealing the true condition of values from the supposed mineral-bearing material. Whenever possible the samples were taken from the shafts."

Dr. H. Foster Bain, of the United States Geological Survey, visited the region in October, 1904, and collected 95 samples, 71 of which were assayed by E. T. Allen, chemist to the Survey. Mr. Allen reported as follows:

"After the usual cupellation and parting, gold was looked for most carefully, but not a trace was found in any of the samples.

"Ten of the above samples were examined for silver as prescribed for gold, but no silver was found except in Nos. 41 and 48, which showed 0.14 and 0.92 ounces per ton, respectively.

"Nos. 57 and 73 were also assayed for copper and No. 48 for lead. No. 57 gave 0.35 per cent. copper; No. 73 gave 10.81 per cent. copper; No. 48 yielded 3.63 per cent. lead."

Dr. Bain's conclusions are as follows:

"In view of the precaution taken in collecting the samples and the great care with which they were assayed, the absolutely uniform absence of even a trace of gold, and only the occasional presence of a small quantity of silver, copper, or lead, allows but one conclusion to be drawn, namely, that none of the prospects examined show any ore in the proper sense of the term, nor does any one of them have any present or probably future value.

"Whether future prospecting may reveal other occurrences which do have value cannot, it is true, be stated. It is believed, however, that the prospects examined were fully representative and have, in many cases at least, been developed enough to allow a proper judgment as to their value to be made, and in no case do they offer any encouragement whatever for additional prospecting."

Very little work has been done in the mountains during the past six years and at the present time the greater number of the shafts are filled with water. A few persistent prospectors are still at work, but there seems to be little promise of renewed activity.

Prospecting in the Arbuckle Mountains never reached the stage attained in the Wichitas. The structure of the rocks in the two ranges is practically the same and there is as much reason to suspect the presence of gold in one as in the other. A number of shafts have been sunk in the Arbuckles. The greater part of them are in the West Timbered Hills, south of old Fort Arbuckle. So far as is known nothing of value has ever been found.

Mr. Joseph A. Taff, formerly a member of the United States Geological Survey, has studied the problem more carefully than anyone else. In a published report, after reviewing the structure of the region, he concludes:

"All the fault contacts between the igneous and stratified rocks have been carefully traced, but no indication of the mineralization of the rocks or the occurrence of ore deposits of any consequence along them have been noted.

"Many of the dikes, chiefly those of biabase, cutting the granite have been prospected at various times for the precious metals without any show of profit, and the sum of all information obtained gives no assurance that ore or metal deposits of any value can be found in the region."

GYPSUM

(By Chas. N. Gould)

The gypsum area of which the Oklahoma beds form a part, is the largest in the United States. The area extends almost uninterruptedly from central Iowa across Kansas, Oklahoma and Texas, nearly to the Pecos River. Over a considerable part of the area outcrops are continuous and one may travel 200 miles or more and at no time be out of sight of heavy gypsum ledges.

The line of outcrop from southern Nebraska to westcentral Texas is approximately 600 miles long. The width of the area containing gypsum varies from a few miles to more than 100 miles. Oklahoma is in the center of the region and the most extensive deposits are in this State. The amount of gypsum in Oklahoma is practically inexhaustible. With very few exceptions, every county west of the main line of the Rock Island railroad contains enough gypsum to make plaster to last an indefinite length of time.

For convenience of discussion all the deposits of the State may be roughly grouped under four general regions as follows:

1. The Kay County region occupies the central part of Kay County.

2. The main line of Gypsum Hills extends from Canadian County northwest through Kingfisher, Blaine, Major, Woods, Harper and Woodward counties to the Kansas line.

3. The second line of Gypsum Hills lies along a line parallel to the main range, and from 50 to 75 miles farther southwest, and extends from the Keechi Hills, in southeastern Caddo County, northwest through Caddo, Washita, Custer and Dewey, and into Woodward and Roger Mills counties.

4. The Greer County region occupies the greater part of western Greer County, practically all of Harmon, as well as the southern part of Beckham and western part of Jackson counties.

The Kay County Region: In the central part of Kay County, in the region between Newkirk and Blackwell, particularly along Duck, Bois d'Arc and Bitter creeks, that flow south into Salt Fork, there are a number of local deposits of gypsite or gypsiferous earth. These deposits are "pockety" and of comparatively small importance. There was formerly a plaster mill in Kay County, but it ceased operations on account of lack of material. The rocks are soft shales and clays, gray to blue in color, with a few beds of gray, impure limestone. Whether or not there are gypsum deposits of any magnitude along the line of this formation farther south than Kay County is not known.

The Main Line of Gypsum Hills: The first considerable gypsum deposit encountered in crossing Oklahoma from east to west is along the main line of Gypsum Hills. These hills are formed by two, sometimes three, ledges of massive white, rock gypsum, interstratified between beds of red clay-shale; that is to say, the gypsum ledges are members of the Redbeds formation. There are red clays below, above and between the heavy ledges of gypsum. The clays and shales are usually soft, while the gypsums are relatively hard, and, following the universal law of erosion, known as the survival of the hardest, the gypsum beds often remain intact after the softer

clays have all been eroded away. The various ledges of gypsum with the interbedded clays and ledges of dolomite that are found below the gypsum ledges, aggregate from 60 to 90 feet in thickness.

Viewed from the east, the hills appear as a wall crowned with a white band. The skyline is not continuous, for numerous breaks occur where the gypsum ledge is gone, having been carried away by water. The general appearance is rather that of an uneven row of flat-topped buttes or mesas.

The line of outcrop of these hills extends from the north line of the State southeastward to El Reno. The ledge crosses the Kansas line near the point where the Salt Fork enters Oklahoma. West of Alva the ledge outcrops near Whitehorse Creek and reaches the Cimarron in northwestern Woods County. The gypsum forms the cap of the bluffs which enclose the canyon of Cimarron River from the Kansas line southeast for a distance of thirty miles. These bluffs vary from 50 feet in height near the State line to nearly 150 feet below the Big Salt Plain. The bluffs capped with gypsum are particularly well developed along the south side of the Cimarron River as far as the Glass Mountains in Major County. This line of hills is the region of bat caves and natural bridges. South of the Glass Mountains the ledge bears off to the south, gradually leaving the Cimarron, and approaches the North Canadian a few miles north of Darlington and El Reno.

The upper ledge of gypsum which usually caps the hills is known as the Shimer gypsum. Below the Shimer, and separated from it by a ledge of red clay-shales, is the Medicine Lodge gypsum. A third ledge, known as the Ferguson gypsum, is found in the southern part of this range of gypsum hills.

The following section taken on the south canyon at the head of Salt Creek at the Rubey Stucco-Plaster Company's mill in northern Blaine County, will illustrate the character and thickness of the ledges in this region:

No.	Description	Feet
7	Massive white gypsum, the Shimer	15
6	Soft gray dolomite sandstone	1
5	Red gypsiferous clay	27
4.	Massive white gypsum, the Medicine Lodge	17
3	Red gypsiferous clay with green bands of selenite	25
2	Pinkish, mottled gypsum, irregularly stratified, the Ferguson	4
1	Red gypsifeous clay with thin green and white selenite bands and layers	86
	Total	175

Throughout Blaine County the various ledges of gypsum are exposed, usually outcropping along the side of a hill or as the cap rock of a bluff or butte. In many places, however, the entire thickness of one of the ledges may be concealed beneath a load of

debris, while in other localities the same ledge is entirely uncovered and may be exposed over an area of several acres.

In the region around the head of Salt Creek and its tributary, Bitter Creek, the Medicine Lodge gypsum, the middle of the three ledges, assumes a peculiar form. The lower half of the ledge, usually consisting of a thickness of 8 feet to 10 feet, is much harder than the rest of the ledge, or, in fact, of any other ledge of gypsum, so far as known, in the State. As seen from below this part of the ledge is pure white and breaks with an even fracture into cubical blocks of such unusual form that the unique structure may often be distinguished a mile away. On close examination the gypsum is found to be very hard and fine-grained, usually pure white, but with an occasional bluish or reddish tint. It takes a good polish and has the general appearance of marble, being known locally as the Salt Creek marble. A chemical analysis reveals the fact that the rock is an anhydrite, and that it contains a very small percentage of water of crystalization. Ordinary gypsum contains from 20 to 21 per cent of water bound up in the crystal. In the rock from this ledge the amount of water is sometimes as low as 2 per cent. An analysis of the rock—No. 2 in the table at the close of the chapter—will give an idea of the composition of the rock.

The Second Line of Gypsum Hills: From 50 to 75 miles west of the main line of the Gypsum Hills and at a higher level, geologically, there is a second line of gypsum hills. In general the gypsum in this region differs both in form and structure from that heretofore described. For one thing, it is not usually found in continuous ledges, that is, ledges of constant thickness do not extend for any great distance across the country. On the contrary, the stratification is very erratic. Sometimes practically all the thickness of the formation is composed of gypsum while in nearby localities only sandstones and clays occur. Another point of difference is that the rocks of this region do not form conspicuous hills as do those farther east. In general these gypsums appear on the surface in the form of rounded knolls, or mounds, on the top of a divide between two streams, or as long, gently flowing ledges along the side of a local bluff, or perhaps more frequently still, along the side of one of the rather deep canyons cut out by small streams into the soft rocks that make up the region.

This range of hills extends from the southeastern corner of Caddo County northwest through Washita and Custer counties as far as Dewey, Ellis and Roger Mills counties. The width of the gypsum outcrops of this region from east to west varies from a few miles to nearly 30 miles.

Greer County Region: The fourth general region of gypsum deposits in Oklahoma is in the southwestern corner of the State in Greer, Harmon, Jackson and southern Beckham counties. There is reason to believe that the deposits of this region belong to the same general level or geologic horizon as those just discussed under

the name of Second Gypsum Hills; in fact, in a geologic classification, the rocks of these two regions would be described together. There is, however, a considerable area in southwestern Washita County, lying between Cloud Chief and the North Fork of Red River where the gypsum ledges are rarely exposed. This area separates the deposits in the southwestern counties from the main region and so differentiates the former region.

In the Greer County region, both in Beckham County, along the North Fork of Red River, and in northern Greer and southern Beckham counties, near the line of the Panhandle of Texas, the gypsum ledges are well defined and persist for long distances. In this regard they are like the ledges of the main line of Gypsum Hills in Blaine, Major and Woodward counties, rather than like the second line of hills in Caddo, Washita, Custer and Dewey counties. In the greater part of the region there are five well defined ledges.

Amount of Gypsum in Oklahoma: Not long since the writer had occasion to prepare an estimate of the amount of gypsum available in Oklahoma. After some consideration as to the best method to be employed, the following plan was adopted: A ledge of gypsum a foot thick and a mile square was used as a basis. The specific gravity of gypsum was estimated at 2.32 and the weight of a cubic foot of water at 62.5 pounds. Hence, a cubic foot of gypsum would weigh 2.32 times 62.5 pounds, or 145 pounds. From this it would be found that a ledge of gypsum of the thickness and area given would weigh 2,021,184 tons. In the calculation of the amount of gypsum in a region the odd numbers, 21,184 tons, were discarded and the weight of a ledge a mile square and a foot thick has been considered as 2,000,000 tons.

In estimating the amount of gypsum in any particular region, care has been taken to include only available material. No deposits have been considered in these calculations that are at a greater depth than 100 feet beneath the surface and, in general, the ledges discussed are less than 50 feet under ground.

In arriving at results the plan has been first, to estimate the number of square miles occupied by gypsum; and next, to approximate the combined thickness of the ledges. In both calculations care was constantly taken to make conservative estimates. The number of square miles was multiplied by the thickness in feet and this by 2,000,000. This product is considered the number of tons of gypsum on the area under discussion.

Classified by counties the approximate amount of gypsum in Oklahoma is as follows:

County	Tons
Canadian	50,000,000
Blaine	2,500,000,000
Woods	8,000,000,000
Woodward	8,000,000,000
Major	12,000,000,000
Harper	10,000,000,000
Comanche	200,000,000
Caddo	3,000,000,000
Washita	20,000,000,000
Custer	6,000,000,000
Dewey	1,000,000,000
Ellis	500,000,000
Roger Mills	1,000,000,000
Greer	14,000,000,000
Beckham	12,000,000,000
Harmon	15,000,000,000
Jackson	13,000,000,000
Total	126,300,000,000

The Manufacture of Gypsum: There are at the present time ten gypsum mills in western Oklahoma, located as follows: one each at Okarche, Cement, Marlow, Bickford, Ferguson, Southard, El Dorado and Alva, and two at Watonga. There is also one mill at McAlester in the eastern part of the State. The capacity of the various mills ranges from 40 to 100 tons each, per day. In the majority of cases the material used is gypsite, or dirt gypsum. Coal is the fuel used, the greater part of which comes from the McAlester region, 200 to 250 miles distant. The price of coal at the mill ranges from $4 to $6.50 per ton. The market for gypsum products is largely to the east. Much of it goes direct to Kansas City and Memphis. For several years the demand has exceeded the supply.

There are two problems to be solved in connection with the gypsum plaster industry of Oklahoma, namely, the location of available gypsite deposits, and the securing of cheaper fuel. The plaster men believe that the greater part of the gypsite has been located and that the supply will soon be exhausted. There are geological reasons, however, for believing that there are vast undiscovered deposits of gypsite in each of half a dozen of the western counties, and that all that is needed is systematic prospecting. It is my conviction, based on ten years of careful study of conditions, that at a conservative estimate not 10 per cent of the available gypsite deposits have yet been found.

The fuel problem is more difficult. It is useless to look for coal anywhere in the gypsum region, and the geological structure precludes the probability of petroleum or natural gas being found in quantity. The nearest coal is 200 miles or more from the gypsum, and under existing conditions the railroads get the freight on both the coal and the finished plaster. A milling and transit rate to the gas fields of eastern Oklahoma has been suggested as a solution of the difficulty. The fact, however, that gypsum is more than one-fifth water of crystallization, presents grave difficulties to this plan, even if a suitable rate could be obtained from the railroad. The

last resort is to pipe the natural gas to the gypsum. Gas mains are already laid as far as Oklahoma City, and they will probably soon be extended to El Reno, which is not more than 15 miles from the southern end of the gypsum hills. Whether or not a rate can be secured which will enable the plaster men to utilize the gas remains to be seen. To my mind this is the most practical solution of the problem.

Analyses of Oklahoma Gypsums: The following table shows analyses of material taken from various parts of Oklahoma, and will illustrate the general character of the gypsum:

	Lower Ferguson	Marble Gypsum (Anhydrite Ledge) Ferguson	Selenite Flakes Mr. Heman Woods Co.	Gypsum from Caves Near Weatherford
Calcium sulphate	80.09	94.83	76.76	75.57
Calcium carbonate	.....	.....	.....	1.11
Magnesium sulphate	.....	1.93	.....	.....
Magnesium carbonate	.....	.....	.85	.40
Water	19.82	2.74	19.80	20.22
Oxide of iron and aluminum	.....	.....	1.45	.45
Insoluble residue	.65	.....	.95	1.66
Totals	100.56	99.50	99.80	99.41

SALT

(By Chas. N. Gould)

Wells and springs containing salt water are found in all parts of Oklahoma. There are in the Redbeds and in the western part of the State, however, seven salt plains—that is, regions where springs are located—as follows: two along the Cimarron River between Woods, Woodward and Harper counties, two in northwestern Harmon County, and one each in Alfalfa, Blaine and Beckham counties. These plains are widely separated and vary greatly in size and amount of water which flows from them. While all the salt springs come from the rocks of the Redbeds, they do not all issue from the same geological horizon. The Alfalfa County plain is located thirty miles or more from the Gypsum Hills, but all the other plains are in these hills. The Cimarron River plains and Blaine County plain are supplied by springs that issue from not far below heavy gypsum members, and the Beckham and Harmon county plains are found near the base of gypsum ledges.

Alfalfa County Plain: This is the largest of all of the Oklahoma salt plains and also the only one that contains no large salt springs on its surface. It is located four miles east of Cherokee, just south of the Salt Fork of the Arkansas. It includes an area of approximately 60 square miles, extending 10 miles north and south and 6 to 8 miles east and west. The plain is as level as a floor, and

on ordinary occasions as white as a snow field from the incrusation of salt crystals which cover it. It is absolutely barren of vegetation, with only here and there a scattered bit of driftwood to break the monotony.

The origin of the salt on this plain is somewhat obscure. About the margin of the plain are a few weak salt springs, but they rarely furnish sufficient water to form a running stream. On digging a hole a few feet deep in any part of the plains, however, salt water begins to run in and in ten minutes the hole will fill up to a point within 6 inches of the top. The plain is composed of loose reddish-brown sand and clay, which is apparently everywhere saturated with salt water. The surface evaporation of this water gives rise to the white salt incrustations which render the surface of the plain white, except after a rain, when the salt crystals are dissolved. The best explanation of the origin of the salt water is to suppose that it comes from a large number of small springs which issue from the Redbeds beneath the plain. There is a theory in the community that the plain is underlaid with rock salt. There is no evidence to support this theory, however, and it seems more reasonable to suppose that the shale beneath the plain is highly saliferous, that is, impregnated with salt, and that water penetrating this salty shale dissolves the salt. There is no way of estimating the amount from these plains but there is doubtless enough to supply a hundred salt plants. None of it is being utilized.

Cimarron River Plains: Along the Cimarron River between Woods, Woodward and Harper counties, there are two salt plains that are fed by springs which issue from red shales 50 to 100 feet below a heavy ledge of gypsum. Locally these plains are known as Big Salt Plain and Little Salt Plain, the latter being just south of the Kansas line, where the Cimarron River first breaks through the line of Gypsum Hills. The Little Salt Plain is two to three miles long and a mile or more wide.

The Big Salt Plain is located 15 or 20 miles farther down the Cimarron, and extends for 8 miles or more along the river. In width it varies from half a mile to 2 miles. On the south bank the bluffs of red shale and sandstone capped with gypsum rise directly from the edge of the plain to a height of 100 feet or more. North of the plain these hills are not so steep and are at a distance of half a mile or more from the plain, but even here the sinuous white line of gypsum may be traced along the tops of the bluffs as far as the eye can reach. In other words, the plain lies in a broad canon of the Cimarron River, inclosed on both sides by gypsum-capped hills.

The plain is flat, except for a few meandering channels of the Cimarron River, which in wet weather contain small streams of water, but are ordinarily dry. After a rain a stream of considerable volume sometimes flows down the channel across the plain, but during the summer months nearly all the water either evapor-

ates or sinks into the sand. In places where a small stream still runs down the channel, the water is often so salty that a thin crust of crystal white salt, resembling a sheet of ice, forms on the surface of the stream. The entire plain, except just after a rain, is covered with a thin incrustation of snow-white crystals, which, in most places, do not exceed an eighth of an inch in thickness, but reflect the sunlight like a snow field.

In a large cove among the gypsum-covered hills, at the mouth of Buffalo Creek, near the south side of the plain proper, there are a number of salt springs, which boil up from the flat surface of the plain. The water is crystal-clear, and it sometimes requires more than occular proof to convince one that it contains nearly 40 per cent. of salt. There are scores, perhaps hundreds, of these springs on an area of but a few acres, some of which flow streams as large as a man's arm. Beds of rock salt are reported from this plain, but their presence has never been verified. The combined flow of the various springs which feed the plain will approximate several thousand gallons per hour. In former years there have been a number of primitive salt plants in this region. The water was dipped or pumped up from the springs or from shallow wells and evaporated in pans or kettles, sometimes by sun heat, sometimes by fire. At the present time no salt is being made.

Blaine County Plain: This plain is not more than a quarter of a mile wide at the widest place, and for the greater part of its extension is not more than 100 yards, with a length of perhaps 3 miles. The springs which supply the plain issue from the head of the main Salt Creek Canon, which is located among the Gypsum Hills. A ledge of red and blue mottled, cross-bedded sandstone outcrops along the heads of several branches of the main canon, and springs issue from it. The flow is sufficient to form a small creek. Along the bottom of the canon, the salt incrustations formed by evaporation cover a narrow strip 100 yards wide along the sandy channel of the stream. A mile below the springs the canon widens, the creek leaves the wall of hills and enters the flat country and the salt plain spreads out and becomes, in one place, as much as a quarter of a mile wide.

From the standpoint of economic importance, the Salt Creek plain bids fair to exceed all others in the State, as it is nearer to both the coal fields and to market than the others. A inumber of primitive salt plants have at different times been located along the edge of the plain. The methods employed in securing the salt are extremely simple. A well is dug in the sand of the plain and the water pumped by hand into vats and evaporated by boiling. Fuel, chiefly cedar and oak wood, was formerly obtained from the canons near by. It is stated that three buckets of brine will make one bucket of salt. The capacity of one of the plants is said to have been from 500 to 2,000 pounds per day. The salt was hauled in wagons to supply local trade, and the demand is said to have exceeded the supply for a number of years.

A few years ago a plant with a capacity of 450 barrels per twenty-four hours was erected at Ferguson, Oklahoma, the nearest railroad point to the plain. The brine was obtained from open and drilled wells and was carried two miles in a 2 1-2 inch wrought iron pipe. Steam was employed to operate the rakes, elevators, conveyors, etc. The pans were of cement 12 by 50 feet and 20 inches deep. The plant remained in operation but a few months, when it was purchased by the salt trust and shut down. It has since been dismantled.

Beckham County Plain: In the southeast corner of Beckham County, near Carter, on sections 10, 11, 14, 15, Township 8 North, Range 22 West, is a salt plain occupying an area of about 40 acres. This plain, which is about half a mile distant from the North Fork of Red River, is located near the base of the Gypsum Hills. In places, springs of salt water issue directly from beneath gypsum ledges, while in other instances the water boils up in the form of bold springs from the level surface of the plain. These are more than 20 springs, the waters of which unite to form a stream as large as a stove pipe. In view of the fact, however, that a great part of the water sinks into the sand, it is probable that this amount represents but a small part of the actual flow. Salt has been manufacured at this plain at various times.

Harmon County Plains: The two Harmon County plains are located in small canons which have been carved in the Gypsum Hills, south of Elm Fork of Red River, about five miles east of the Texas line. From the names of the owners these plains are known locally as the Chaney Salt Plain and the Kiser Salt Plain. Neither covers an area of more than an acre and they are not more than a mile apart. Both are fed by springs that issue from the shales below heavy ledges of gypsum. Springs boil up from the level floor, and the water flows out of the canon to mingle with the water of the river. A flourishing local industry has been carried on at these plains for twenty years, and some years as much as 600,000 pounds of salt have been manufactured at each one. Since the timber, which formerly grew in the canons, has been exhausted, solar evaporation has been largely employed to produce salt. The average combined flow from each plain forms a stream larger than a man's arm. In a number of canons emptying into Elm Fork in this region, there are salt springs, but no others have sufficient strength of flow to warrant the establishment of salt plants.

Utilization: Salt has been manufactured at various times on all of the salt plains of Oklahoma, except the large plain in Alfalfa County, which as stated above, contains no springs of any size. With the exception of the plant at Ferguson, primitive methods only have been employed and no considerable amount of capital has been invested. It goes without saying that salt springs of this character will ultimately develop into properties of much value. It is estimated that there is enough salt water going to waste in Oklahoma to make 100 carloads of salt daily.

GRANITE

(By Chas. N. Gould)

Granite is a composite rock made up chiefly of three minerals, namely: quartz, feldspar, and either mica or hornblende. In appearance it is usually mottled, the variation in color being due to the colors of the various minerals which compose it. Granite is a very hard rock and is difficult to work but it makes extremely valuable building stone.

There are in Oklahoma three general regions in which granite occurs, namely: Wichita Mountains, Arbuckle Mountains, and along Spavinaw Creek. In both the Wichita and Arbuckle mountains ranges there are a number of other igneous rocks associated with the granite, the most abundant of which are gabbro, porphyry, and diabase.

Wichita Mountains: The greater part of the rocks in the Wichita Mountains in southwestern Oklahoma, consists of granites. These mountains are 60 miles long; extending from near Lawton, the county seat of Comanche County, northwest to Granite in Greer County. The average width is 20 miles. A number of peaks, such as Mount Scott, Sheridan, Baker, Quanah, and some others, are from 1,000 to 1,200 feet above the level of the plain. Other peaks, such as Teepe, Headquarters, Longhorn, and Devils Canyon mountains, stand 800 to 1,000 feet high. All of these peaks and a number of others not mentioned, besides a great many scattering groups and ranges, consist of massive granite, usually red or pink in color.

Certain ranges and peaks in the central part of the system consist largely of gabbro, which is an igneous rock belonging to the basalt family. As exposed in the Wichita Mountains it is a hard, black, crystalline rock, sometimes known as black granite. It frequently has a greenish tint, or may be grayish in color, and weathers into rough, lumpy surfaces.

Near the eastern part of the main range a number of high peaks are composed of porphyry, which is a hard, massive rock, much like granite, but differs from it in texture. The porphyry of the Wichitas is composed of a fine grayish or brownish ground mass in which is embedded reddish or pinkish crystals, which give a reddish-gray tint to the rock.

The principal quarries in the Wichita Mountains are at Granite and Cold Springs. At the town of Granite there are several quarries from which is obtained a very high grade of red and pink stone. The state reformatory was located at this place on account of the extensive deposits of granite. This material is used for columns, monuments, and building stone and has been extensively shipped to eastern markets. At Cold Springs and Roosevelt black granite or gabbro is quarried. The rock found there is grayish black on fresh fracture and takes a high polish. This stone is largely used for monumental purposes and practical monument cutters say that it takes a better and more lasting polish than the famous Quincy granite of Massachusetts.

So far as known the porphyry in the Wichita Mountains has never been used. There are many localities where both the granite and porphyry might be quarried. The chief difficulty at the present time is lack of transportation. Two lines of the Frisco road and one line each of the Rock Island and Orient, pass through the mountains. Good quarries might be opened near Lugart, Roosevelt, Mountain Park, Snyder, Cache, and Fort Sill on existing lines. No finer building or ornamental stone exists anywhere in America, and it is a question of but a few years until this material will be much more extensively quarried than at the present time.

Arbuckle Mountains: The granite rocks exposed in the Arbuckle Mountains occur in three general regions: first, a large area covering perhaps 100 square miles, lying north of Tishomingo between Mill Creek and Wapanucka; and second and third, in two smaller areas lying south and west of Davis in the heart of the main range. These areas are known as the East Timbered Hills and West Timbered Hills. The rocks in these two latter localities are largely porphyry, rather than granite, and being so far from transportation, have never been quarried. At the present time there are no indications that it will be utilized soon.

In the larger, or Tishomingo area, the granite rocks are being quarried at or near Mill Creek, Troy, and Tishomingo. The stone varies in color and texture, in different quarries. The typical Tishomingo granite is a coarse-grained, pinkish, or grayish stone which takes an excellent polish and is very durable. It has been used in the construction of a number of buildings, notably the Chickasaw council building at Tishomingo, and for columns, pillars, and cap stones for a number of other buildings in Oklahoma and eastern states. No handsomer stone than the Tishomingo granite occurs anywhere.

The granite as exposed near Troy, Ravia, Mill Creek, and Wapanucka, is, as a rule, different in texture from that at Tishomingo. The former is usually fine-grained and grey or red, but some times rose-colored.

The great variety of texture as well as the uniform superior quality of the stone in the various quarries, warrants the conclusion that the granite in the Tishomingo area will be found adequate for all demands of the State for the highest grade building stone.

Spavinaw Creek Granite: There is a small granite dike along Spavinaw Creek, about one-half mile west of the postoffice of Spavinaw. During some former geologic age this dike has been thrust up from below, penetrating the softer rocks. These rocks have been worn away and have left the granite exposed for nearly half a mile. If a railroad is ever built along Spavinaw Creek this stone will become commercially important.

There is no reason why Oklahoma should import a cubic foot of granite. There is as good stone in the State as can be found anywhere in the world, and the great variety of color makes it desirable for all sorts of architectural and monumental purposes. For example, the gabbro and black granite from Cold Springs is much superior in quality and texture to the greater part of the Quincy granite and imported Scotch black granite now being used for monuments. The coarse-grained granite from Tishomingo is as handsome as is found in the United States. The dark red granite from the town of Granite takes a most lustrous polish and is suitable for all sorts of structural purposes. Oklahoma should cease importing stone, when a product in every way superior can be obtained within her borders.

LIMESTONE

(By Chas. N. Gould)

Limestone is found widely distributed in Oklahoma, particularly in the eastern and southern counties. Central, western, and northwestern Oklahoma have very little limestone. For convenience of discussion the deposits of limestone in Oklahoma may be divided into six general areas.

The largest limestone area in Oklahoma is located in the northern part of the State. It extends from Newkirk and Ponca on the west, to Claremore on the east, and from the Kansas line south to Tulsa and Pawnee. In this region the rocks consist of alternate layers of sandstones, shales, limestones, lying level or dipping slightly to the west. There are 8 or 10 heavy ledges of limestone varying in thickness from 10 to 60 feet, extending north and south across the region. There is scarcely a town throughout this area that is not near limestone. Quarries have been operated at or near Pawnee, Bartlesville, Nowata, Tulsa, Avant, Foraker, Newkirk, Ponca, Uncas, and Chilocco. Some of this stone is nearly blue. In general, however, it is light gray in color. Crushers, which furnish crushed limestone for ballast and concrete have been located at Uncas, Ponca, Lost City (west of Tulsa), Lenapah, Ripley, Avant and Garnett.

The second largest limestone area in Oklahoma is located in the northeastern part of the State, in the country lying east of Grand River and north of the Arkansas River. There are in this region three heavy ledges of limestone, the Boone, Pitkin, and Morrow. The Boone which is the thickest, and most extensive, contains near its base some heavy ledges which near Carthage, Mo., are quarried for building stone. The Pitkin is fine textured and suitable for building. None of this stone is now being quarried for building stone and so far as known only two crushers have been in operation. One is at Keough, near Ft. Gibson, the other south of Stilwell. At Grove a lime kiln has been in successful operation

for several years. The amount of material for building stone, for concrete, and for the manufacture of lime is practically inexhaustible and only waits development.

A third area of limestone is along Red River in the southern part of the State, extending from Love County east to McCurtain. The rocks are of Cretaceous age and include three prominent limestone ledges, namely, the Goodland, 30 feet thick, the Caddo, which is 100 feet or more thick and the Bennington, 10 feet thick. While considerable quarrying has been done for local use, there has been little systematic attempt to develop the limestone resources of this part of the State. Such towns as Madill, Marietta, and Caddo, contain limestone buildings and small quantities of lime have been burned at various points, but no extensive operations have ever been started.

A fourth limestone area in eastern Oklahoma is the Wapanucka limestone, a formation some 400 feet thick, standing on edge, which extends from near Wapanucka east along the northern flank of the Ouachita Mountains, nearly to the Arkansas line. Throughout this area the limestone forms what is known as Limestone Ridge. In places the limestone is oolitic, as for instance, along Delaware Creek near Bromide. A crusher at Limestone Gap has for many years furnished ballast for the M. K. & T. railroad, and is now supplying crushed limestone for concrete. The rock used in the penitentiary at McAlester, was secured here. At Hartshorne, where a Portland cement plant has been built, the stone comes from this ledge. Lime kilns at Wapanucka use the upper member of the ledge for burning into lime. Other industries have been projected at Pittsburg and Reynolds.

The most important limestone region in Oklahoma from a commercial standpoint is the Arbuckle Mountain uplift, in southern Oklahoma. This area, which is 60 miles long and 10 to 30 miles wide, contains four heavy ledges of limestone. The lowest geologically, and the most important one, is the Arbuckle limestone which is 4,000 to 6,000 feet thick. It varies in color from white to cream and carries occasional cherty concretions. The only use to which this rock has so far been put is for concrete work and railroad ballasting. Two stone crushers at Crusher in Murray County, have supplied crushed stone for many of the buildings in Oklahoma City and other cities in Oklahoma and Texas. It is possible that good quarry sites for building and dimension stone may be found.

The Viola limestone is from 750 to 1,000 feet thick, the rock being usually white to bluish in color. It has been used for ballast and concrete work, particularly along the Frisco railroad near Lawrence. At this place the limestone used for making Portland cement at the Oklahoma Portland Cement Company's plant at Ada, is obtained from the Viola. Near the same place there is a large stone crusher. At Bromide an excellent lime is burned from this formation.

The Hunton limestone is white and yellowish in color and sometimes contains chert concretions. It is 200 feet thick in places and is alternately thick and thin bedded. At some horizons the limestone is shaly and marly, forming what appears to be natural cement rock. No quarries have been opened in this rock and so far as known no attempt has been made to utilize this stone.

The fourth limestone member of the Arbuckle region is the Sycamore formation. This limestone thins out to the eastward, but becomes thicker toward the west. It has been quarried for building stone at Dougherty.

Another limestone region is situated along the northeastern side of the Wichita Mountain uplift, 10 to 30 miles northwest of Ft. Sill. This limestone is of about the same age and character as the massive Arbuckle limestone of the Arbuckle Mountains. In most places it has been so thoroughly crumpled that it would not make good building stone. A quarry was opened on the Fort Sill reservation some years ago from which was obtained the stone for the buildings at the old fort. This stone is crushed for concrete rock at Richard's Spur north of Lawton.

With all this limestone lying dormant in our hills, the people of Oklahoma are each year sending hundreds of thousands of dollars out of the State to buy building stone not so good for structural purposes. As soon as our own quarries have been developed the money now sent abroad will remain at home to build up home industries.

MARBLE

(By Chas. N. Gould)

Limestone that has been changed or metamorphosed, by the action of heat and pressure is a marble. In common parlance, however, marble is any limestone that will take a good polish. The distinction between limestone and marble cannot be sharply drawn. For instance, the Arbuckle, Viola, Hunton, Boone, Pitkin, and Wapanucka limestones are often so hard and fine grained that they take a good polish and in this sense are marbles. The limestones of many of the ledges in the northern part of the State are of the same nature.

The only place in Oklahoma where true marble has been quarried is at Marble City in northern Sequoyah County. At this place a ledge 200 feet or more thick has been brought to the surface by a fault. It is exposed over an area of perhaps two square miles. The stone is white to gray or pinkish in color, and when polished makes a handsome and durable building stone. The Pioneer Telephone building at Oklahoma City was constructed of this stone.

The quarry has been idle for several years but it is reported that it has recently been purchased by eastern capitalists with the intention of developing the stone on a large scale. The quarry is

located near the Kansas City Southern Railroad, and is thus accessible to market.

SANDSTONE

(By Chas. N. Gould)

Sandstone is the most widely distributed building stone in Oklahoma, there being scarcely a county in the State where it is not found in quantity. The color, texture, and quality of the sandstone vary greatly in different regions.

Generally speaking, the best sandstone in the State is found in the region of the coal fields in eastcentral Oklahoma. The greater part of the rock in this region consists of massive beds of shale and sandstone with occasional ledges of limestone. The sandstone is usually light brown to gray in color, regularly bedded and of fine texture, all of which qualities render it a handsome building stone. It outcrops usually along the sides of bluffs and cliffs and on top of high hills.

Sandstone of this character is found in all parts of more than thirty counties including practically all of the old Cherokee Nation, all of the Creek and Seminole, the northern part of the Choctaw, and northeastern part of the Chickasaw nations. Hundreds of cities and towns in this part of the State contain buildings constructed from local sandstone.

Before the advent of gas-burned brick from Kansas, a great part of the buildings were constructed of this stone. Such cities as Vinita, Chelsea, Claremore, Catoosa, Okmulgee, Muskogee, Eufaula, Sapulpa, Coalgate, McAlester, Wilburton, Hartshorne, Poteau, and Sallisaw may be cited as examples of cities containing sandstone buildings. There is scarcely a community east of the main line of the Santa Fe railroad that does not contain ample stone for local use.

There is an area in central Oklahoma about fifty miles in width and extending from the Kansas line south to Arbuckle Mountains, in which the sandstone varies in color from grey to red. This area contains all or part of the following counties: Osage, Kay, Noble, Pawnee, Payne, Logan, Lincoln, Oklahoma, Cleveland, Pottawatomie, Pontotoc, McClain, and Garvin. Buildings at Stillwater, Pawnee, Perry, Orlando, Guthrie, Jennings, Prague, Shawnee, Chandler, Norman, Purcell, Byars, and Tecumseh, have been constructed principally of this red or gray sandstone.

In the western part of the State, sandstone suitable for building is usually not abundant. This is the region of the Redbeds, and practically all the sandstone is red. Ordinarily, it is rather soft and often unsuited for good building stone, but occasional ledges occur in many of the central and western counties from which durable building stone is obtained. Such towns as Anadarko, Elk City, Weatherford, Mangum, Cheyenne, Sayre, Woodward, Alva,

and Taloga, contain buildings which have been constructed of red sandstone.

There is little sandstone in the Wichita Mountains, the rocks in this region being granite or limestone. The Arbuckle Mountains contain one formation, the Simpson, which includes several ledges of sandstone but the material is usually so soft that it cannot be used for construction purposes. It is, however, a good quality of glass sand.

The rocks in the Ouachita Mountain region in the southeastern part of the State contain a number of massive ledges of sandstone, usually standing on edge. Much of this sandstone will make good building stone, but very little of it has yet been utilized.

There is a region in southern Oklahoma where dark red or black sandstone is abundant, the color being due to the presence of iron in the rock. Buildings at Durant, Bokchito, Woodville, and Bennington have been constructed of this dark red stone.

There are several regions in Oklahoma where little sandstone is found. One area which is bounded on the north by the Kansas line, on the east by the Santa Fe railroad and on the south and west by the Gypsum Hills, has very little hard rock of any kind. A second area is in old Beaver county, or "No Man's Land," which now comprises Cimarron, Beaver, and Texas counties. This region is a part of the High Plains, where little stone of any kind is exposed.

Quarries which supply stone for local use have been opened in sandstone ledges in many parts of the State, but so far as known none of the product has been shipped abroad. Near practically all the towns which have been mentioned as containing buildings constructed of sandstone, quarries are found which furnish ample stone for local use. For instance, the greater part of the local stone for the Muskogee buildings comes from the Standpipe Hill in the northern part of the city or from the quarry a mile to the east. There are several quarries within the city limits of McAlester from which sandstone is obtained. A quarry has been opened in the suburbs of Quinton from which is obtained some of the finest stone in the State. The Catlett Quarry near Pawnee is one of the best known quarries in northern Oklahoma.

From what has been said, it will be understood that the sandstone industry is practically undeveloped. No large quarries have been opened and very little capital has been invested. The great number of railroads which now cross Oklahoma in all directions, provide ample transportation facilities. There are hundreds of localities in the State where quarries that should produce high grade building stone, which should be in good demand, not only in Oklahoma, but in other states as well, might be opened. Oklahoma sandstone will not suffer from comparison with the best building stone in the country. The stone at Quinton for instance, is superior in many ways to the famous sandstone from Berea, Ohio.

CLAY AND SHALE

(By L. C. Snider)

In the development of any center of the clay industry there are at least four essential factors to be noted. These are: first, the supply of the raw material; second, fuel; third, transportation facilities; and fourth, markets. Oklahoma possesses advantages in all of these essential features which should make it one of the great centers of the clay working industries.

In the matter of raw material, Oklahoma is certainly as well supplied as any other state. The eastern portion of the State, except the extreme southern part, is underlaid by the sandstones and shales of the Carboniferous system. These shales are of the same age as those of Ohio and Pennsylvania and some of them are the continuation of the beds that are worked with excellent results at Cherryvale and Coffeyville, Kansas. The beds are often many feet in thickness and easily accessible. The few tests that have been made show that practically all these shales are suitable for building and front brick, paving block, drain tile, or hollow ware. These shales are usually gray to black in color and have fine working and burning properties, and practically all of them burn to a good red color.

Plants are already installed in this region at Cleveland, Pawhuska, Vinita, Claremore, Nowata, Bartlesville, Tulsa, Okmulgee, Sapulpa, Boynton, Collinsville, Wainwright, Muskogee, Poteau and McAlester. All of these factories make common and building brick; several of them produce sidewalk brick, and a few manufacture paving brick.

Among the places where similar shales are exposed but are not being worked are Wann, Avant, Nelagony, Big Heart, Ramona, Ochelata, Henryetta, Miami, Coalgate, Atoka, Antlers and many other towns.

The clay veins underlying the coal beds are usually called "fire" clays, and in the eastern states are truly fire clays, but in Oklahoma the condition at the time of deposition seem to have been different and the clays contain too much iron to be called No. I fire clays.

Several of these veins have been tested. The underlying clays from the mines at McAlester, Alderson, Coalgate and Poteau prove to be what are known as No. III fire clays. They are excellent material for face brick, sewer pipe, paving brick, fire-proofing, etc. Some of these burn to a rich dark red and the others to a very dark buff or chocolate. The underlying clays tested from Midway and Hartshorne, unfortunately have so much carbon distributed in them in the form of plant impressions and very thin veins of coal that it would be impossible to oxidize them in commercial kilns.

Several fine ledges of shale occur in the Simpson and Sylvan formations of the Arbuckle Mountains. There are good exposures

at Lawrence and Ravia along the Frisco railroad and at Crusher along the Santa Fe. The shale at Ravia burns to a peculiar mottled reddish buff color which should be attractive for front brick.

The rocks of the greater part of western Oklahoma consist of the Redbeds which are made up of a great mass of red clay shales with a few intervening ledges of some other material, usually sandstone, gypsum or dolomite. The red color of this shale is due to the presence of iron.

Chemical analyses show that in certain cases the amount of iron in the shale is as much as 15 to 20 per cent. The clays from the gypsum region often contain sufficient gypsum to cause them to whitewash badly when made by the stiff mud or soft mud process and also show a pronounced tendency to puff and swell during burning. The chief difficulty in the way of manufacturing brick in the Redbeds, is the lack of cheap fuel. There is no coal in the region, the nearest mines being at McAlester, 140 miles southeast of Oklahoma City. A little gas has been found at Gotebo and Lawton, but so far not in large amounts. There is little to warrant the hope that fuel of any kind will be found in anything like paying quantities in the Redbeds. Freight rates on coal have been high, while a very reasonable rate has been secured on gas-burned brick from Cherryvale and Coffeyville, Kansas, into Oklahoma. For these reasons a number of the plants in western Oklahoma have been abandoned.

Pressed brick plants have been established in a number of cities in the Redbeds region. Oklahoma, Chandler, Guthrie, Purcell, Chickasha, El Reno, Kingfisher, Enid, Alva, Geary, Mangum, Gotebo, Hobart, Comanche, Marlow, Addington, Altus, and Waurika have each had plants; most of them are still in operation, but some have shut down for various causes.

In the southern portion of the State, along Red River east from Marietta, the shales occur usually in thinner beds than in the eastern portion but there are many localities with beds of workable thickness, well situated with regard to fuel and transportation. Many of these ledges are suitable for clay products but some of them contain so much lime that they are very difficult to work. The shale should be carefully tested before an attempt is made to locate a plant in this region.

In regard to the second essential factor, the fuel, it is only necessary to state that the northeastern portion where the Carboniferous shales occur in greatest abundance, is in the midst of the world's greatest oil and gas field. The gas can be obtained for manufacturing purposes at a few cents per thousand feet. The gas field is being constantly enlarged and shows no signs of failure of supply. There are also smaller fields in the southwest and southcentral parts of the State. Just south of the oil and gas belt lie the coal fields which will supply an abundance of cheap fuel for years to come. The western portion is not so fortunate in this respect but in no part would the cost of fuel be prohibitive.

All parts of Oklahoma are well supplied with railroads, especially the eastern portion, where the better shales and the fuel are most plentiful. The main lines of the M. K. & T. and the Frisco systems traverse this portion of the State from the north to south and each system has many branches or cross lines which connect the two systems at several points. The Iron Mountain has a line from Coffeyville to Ft. Smith, and the Midland Valley crosses the field from northwest to southeast. The Fort Smith and Western and the Rock Island give east and west connections through the coal fields. Through the Redbeds region, the Santa Fe, Rock Island, Frisco and Orient give excellent connections in all directions.

In regard to the markets it should be noted that the rapid growth of such cities as Oklahoma City, Muskogee, Tulsa, McAlester, Enid, Ardmore, Durant and many others creates a demand, which is much larger than the supply. Several plants have been installed in the State but the greater portion of the clay products used are still imported from the older states. No one who has investigated the conditions doubts that the era of permanent building in the State is just beginning and that the demand for all sorts of architectural clay products will steadily increase. No drainage has been done and few roads built. Drain tile and sewer pipe will be used in constantly-increasing amounts, for drainage and culverts on roads and for draining farm lands. There is also a new field opening in the use of tile for subirrigation.

The combined product of all the plants at present does not supply the local demand for building and paving brick; and hundreds of thousands of brick are imported from Kansas into the region each year. These brick are hauled in some cases two or three hundreds of miles through a country having just as good shale as that from which the brick was made and having inexhaustible quantities of cheap fuel. All of the sewer pipe, drain tile, hollow block, fire proofing or terra cotta used in Oklahoma is manufactured outside the State, although it has the clay and the fuel required to make such products as cheaply as they can be made elsewhere.

With very few exceptions all the clays tested from the State are red—or very dark buff—burning clays and at present no deposits of high grade fire or pottery clay are known. The tests made have covered only a small portion of the deposits and it is probable that such deposits will be found.

Even if these materials should not be found in the State, the abundance of shales suitable for building and paving brick, drain tile, sewer pipe, etc., combined with the advantages in the way of fuel and transportation, and markets should make Oklahoma one of the great centers of the clay industry.

GRAVEL AND BUILDING SAND.

(By Chas. N. Gould)

Building sand is widely distributed in Oklahoma. There is not a county in which it does not occur, and usually it is found in unlimited quantities. Gravel is very abundant in certain localities, but it is not so widely distributed as sand.

The sand in Oklahoma may be roughly divided into two kinds, namely, transported sand, and residual sand. Transported sand is that which has been carried to its present place by wind or water. The sand along the stream beds and valleys is generally brought there by water, while much of the sand in the sand hills is wind blown.

The streams in western Oklahoma are choked with sand which has usually been derived from the plains near their sources, and carried down stream. Such streams as the Arkansas, Salt Fork, Cimarron, North Canadian, South Canadian and Red rivers, have typical sand-choked channels.

A chain of sand hills from 2 to 20 miles wide, is found north of several of the above named streams. Along the Salt Fork, the sand hills extend from near Tonkawa, west past Alva; along the Cimarron they begin near Guthrie, and are found all the way to the Big Salt Plains near the Kansas line; along the North Canadian, they extend from El Reno to the head of the River, and they flank the valley of the South Canadian from Bridgeport to the Panhandle of Texas, and with some minor exceptions, extend as far east as Purcell; while the sand hills of the Red River region are confined to Beckham, Greer and Tillman counties.

All this sand may be called transported sand. Much of it is wind-blown from the stream channels, but some was doubtless carried from the Rocky Mountains by the creeks and rivers of a former geologic age. Some of the sand has been worn round, and is not considered the best quality for building. There is, however, hardly a locality in western Oklahoma, that will not furnish an abundance of sand for common mortar, cement and plaster.

The greater part of the sand in eastern Oklahoma is residual, and has been derived from the disintegration of sandstone in place or near at hand. The principle rocks in the eastern part of the State are alternating ledges of clay and sandstone. The sandstone breaks down by the action of wind, water, heat, cold, etc., and the sand grains collect, either on the site of the ledges, or along small stream channels. In places the sandstone is so soft and friable that it may be dug directly from the ledge.

Owing to the fact that the greater part of the sand in eastern Oklahoma has never been carried for great distances, it is usually sharp, that is, the individual grains have never been worn round. There is scarcely a community where an ample amount of sand for ordinary use may not be obtained.

Gravel consists of fragments of broken rock. Usually the pebbles which make up the gravel have been worn smooth on account of having been carried by water. These pebbles are in most cases composed of relatively hard rock, such as some form of granite, limestone or flint.

Sometimes, the pebbles have been cemented together, thus forming a solid stone, and the rock is known as conglomerate or pudding stone. If the pebbles of conglomerate are not rounded, but are angular, that is, having sharp corners, the rock is called breccia. If the cementing material which holds the conglomerate or breccia together is dissolved, the pebbles fall apart, forming gravel.

The largest deposits of gravel in Oklahoma are found in those regions which contain hard rocks, particularly in the section where granite and limestone abound. The majority of streams which flow from the Ozark uplift, the Wichita and Arbuckle mountains, and the Flint Hills, carry gravel.

In the Ozark region, the gravel is made up largely of rounded fragments of flint, chert, and hard limestone. It is found along the beds of the Illinois, Grand, Neosho and Spring rivers, and Sallisaw, Vian, Greenleaf, Maynard, Clear, Spring, Saline and Spavinaw creeks. Near Muskogee the stream gravel from the bed of the Grand River is loaded on cars and shipped for concrete rock.

The Franks conglomerate is a geological formation which nearly surrounds the Arbuckle Mountains. It is composed largely of rounded limestone boulders and pebbles, varying in size from sand grains to fragments as large as a gallon measure, cemented together. When this conglomerate is disintegrated, the pebbles and boulders are washed down the streams, as for example, Rock, Sulphur, Oil, Blue, Mill, Cool, Caddo, Wild Horse, and Boggy creeks, which flow from the mountains. In the region between Tishomingo and Wapanucka, many of the streams contain pebbles composed of fragments of granite, weathered from the Tishomingo granite. Stream gravel shipped from Tishomingo and Rea is derived from this granite. Stream gravel and sand is also shipped from near Wynnewood and from Cache Creek west of Lawton.

PORTLAND CEMENT ROCK.

(By L. C. Snider)

Portland hydraulic cement is composed of a mixture of finely ground limestone and clay or shale. It differs from natural hydraulic cement in that the latter is produced from natural mixtures of the two substances, such as clayey limestones or limey clays and is not made by artificial mixing. It is evident that by artificial mixing a much more uniform and satisfactory product can be obtained than occurs in the natural mixtures. On this ac-

count Portland cement has in a great measure replaced the natural cement for structural purposes.

Artificial hydraulic cement was first manufactured by Joseph Aspdin, in Leeds, England, in 1824 and named Portland cement because the artificial stone produced from it was very similar in appearance to the building stone from the well known quarries on the Island of Portland in Dorsetshire. The process which he invented is used practically unchanged today except for the introduction of machinery which makes possible the production of the cement on a very large scale.

In the manufacture of Portland cement, the limestone and shale are crushed in rock crushers and then thoroughly dried in long rotary dryers. They are then ground separately to an impalpable powder and mixed in the proper proportions, which must be determined by the chemical analysis of the limestone and the shale or clay. This mixture is burned in long rotary kilns at a temperature at which it is partially fused. This semi-fused material or clinker, after cooling, is ground again to an extremely fine powder and is ready for use.

Almost any shale and limestone may be used for the manufacture of the cement provided that certain ingredients, notably iron, magnesia and sulphur are not present in too large amounts. From a study of many cements under different conditions, Bleininger decides that the raw mixture of the two rocks should show a composition corresponding to the formula $(2.8CaO)\ SiO_2$, $(2\ CaO)\ Al_2O_3$. He considers that the following factors should be considered in the selection of the limestone and clay: (Geol. Surv. of Ohio, 4th Series, Bull. 3.)

Clay

"1. The clay must have a percentage ratio of silica to alumina of from 3:1 to 4:1. A clay should be found, if possible, which is naturally fine; but if such a material cannot be found, either a coarse clay of the proper composition must be selected and ground fine, or an addition of ground sand or sandstone must be given a more aluminous but otherwise suitable clay."

"In examining many Portland cements this point seems to be the chief difficulty with a number of brands. Owing to the high content of alumina, the cement not only sets too fast, but also shows an inherent weakness. Matters are made still worse by the addition of gypsum, which is a grave source of deleterious influences. At the same time, the clay should not be too silicious, but should lie between the above limits. The sum of the silica and alumina percentages in the hydrous clay should not exceed 87 per cent; thus leaving at least 13 per cent for combined water and fluxes like ferric oxide, potash and soda.

2. The clay must not contain so much magnesia that the magnesia content of the cement rises above 3 per cent.

3. The clay should contain at least 3 per cent of ferric oxide,

but not sufficient to raise the ferric oxide content of the cement over 4 per cent.

4. The clay should be low in sulphur and should not contain more than 1 per cent of sulphur in any form.

5. The material should be free from any irregularly distributed matter, be it concretionary nodules of ferrous carbonate, calcium carbonate as found in the older sedimentary clays, or lumps of these or similar materials as found in glacial clays."

Limestone and Calcareous Materials

"1. These should be fine grained and uniform in composition and structure.

2. The magnesia should be low enough so that in the cement a content of 3 per cent of magnesia is not exceeded.

3. The alumina content should not be high enough to disturb the proper silica-alumina ratio in the cement.

4. The content of ferric oxide must not be so high as to increase the amount of ferric oxide in the cement beyond 4 per cent.

5. It should be low in sulphur and free from concretionary iron sulphide."

Oklahoma has deposits of Portland cement rock that never can be exhausted, and vast deposits of fuel, including coal, oil and gas. Limestone occurs in practically all parts of Oklahoma except in the central and northwestern sections. There are at least six widely-separated regions in the State where limestone occurs in quantity. Shale is always present near the limestone. In the following paragraphs the character and stratigraphy of the limestone and shale beds in the various regions and the occurence of fuel which will be most suitable for the manufacture of Portland cement will be discussed.

The rocks in that part of northern Oklahoma extending from the Arkansas River east to Craig County consist largely of alternating layers of shale, sandstone and limestone. In this region about 20 ledges of limestone, varying in thickness from 10 to 40 feet, extend slightly west of south from the Kansas line about as far as the Arkansas River. The shales, which are interstratified with the limestones, are apparently suitable for the manufacture of Portland cement. Three veins of workable coal cross this region from north to south, and the region occupies the heart of the Oklahoma oil field. The amount of natural gas already in sight is sufficient to last for many years. Numerous wells yielding 5,000,000 to 10,000,000 cubic feet daily have been shut in, and a number of wells are reported to yield all the way up to 60,000,000 cubic feet. It is safe to say that not five per cent of the available gas in the region is now being utilized. For factory purposes gas may often be secured at two cents per thousand cubic feet. As an example of the conditions which are found in this region, a single instance may be cited where a hill which occupies a number of square miles is capped with a ledge of limestone, beneath which is a bed of

shale and under the shale a vein of coal. Both the limestone and the shale are suitable for the manufacture of Portland cement. Plenty of water is convenient, gas is near at hand, and two competing lines of railroad cross nearby. All that is necessary at this place is to dig down the hill and grind it up.

The northeastern part of Oklahoma is occupied by a series of rocks, largely limestone and shale, which includes the southwestern extension of the Ozark Mountains in Missouri. There are in this region, two prominent ledges of limestone, known as the Boone and Pitkin, interstratified with shale. Practically all the limestone and shale might be used for the manufacture of Portland cement. All the fuel, either coal, oil or gas, needed for manufacturing purposes in the region can be had from the oil and coal fields 20 to 50 miles to the west. There is plenty of water and there are several competing lines of railway.

In southeastern Oklahoma is a ledge of limestone, 500 feet in thickness, known as the Wapanucka, which stands on edge, and outcrops for nearly 100 miles. It extends from the eastern end of the Arbuckle Mountains near Wapanucka, past Atoka and along the northern side of the Ouachita Mountains near Hartshorne and Wilburton. Beds of clay and shale lie both above and below the limestone. Throughout nearly its entire outcrop the limestone ledge is paralleled by two veins of coal each four feet thick. Natural gas will probably be found in the region north and northwest of the limestone. Several lines of railroad intersect the ledge and the Rock Island parallels it from Reynolds to Hartshorne.

A number of ledges of limestone and shale apparently suitable for the manufacture of Portland cement occur in southeastern Oklahoma in the region lying between the south side of the Arbuckle and Ouachita Mountains and Red River. The rock is practically the same quality as that being used in Dallas, Texas. The limestone ledges are from 10 to 40 feet thick, and are usually rather soft and consequently easy to crush. So far, little fuel has been found in the region, so that coal would have to be hauled from the Lehigh-McAlester district or gas would have to be piped from a still greater distance. It is possible, however, that natural gas will be found by deep drilling. There are several lines of railroad and plenty of water.

The Arbuckle Mountain uplift, composed largely of limestone and shale extends for 60 miles, in the southern part of the State, with an average width of 20 miles. There are four ledges of limestone, namely: the Arbuckle limestone, 6,000 feet thick; the Viola limestone, 800 feet thick; the Hunton limestone, 200 feet thick, and the Sycamore limestone, 100 feet thick. Interstratified with the limestone are several ledges of shale. Coal is found east of the mountains at Nixon, Lehigh and Atoka, and south of the mountains at Ardmore. Oil and gas have been found at Wheeler, and it is possible that they may be found northeast of the mountains near

enough to be available as fuel. Several lines of railroad cross the region.

North of the main range of granite peaks of the Wichita Mountains is a ridge some 30 miles in length and five miles in width composed of massive hard limestone. A few small knobs composed of the same rock outcrop south of the Mountains. Shale is found near the limestone. It is doubtful if fuel in suitable quantities for manufacturing will ever be found in the region. Oil and gas in small quantities have been found at Gotebo, Lawton and Granite, but there is little to warrant the hope that these products will ever be found in large amounts. Owing to these conditions, it is very unlikely that the cement rock of the Wichitas will soon be developed.

At the present time there are two Portland cement plants in operation in Oklahoma. One is located at Dewey near the Kansas line, the other at Ada in the southeast central part of the State.

The Dewey plant has a nominal capacity of 3,000 barrels per day. Gas is used for both power and heat. Thirty-five million cubic feet of gas obtained from wells owned by the company is consumed daily. The power is generated by six four-cylinder, double-acting gas engines, of 500 horse power each, arranged in tandem. There are five kilns 8 feet in diameter and 100 feet long. The rock is brought from a 22 foot ledge of limestone a mile and a half away over a standard gauge track. The clay is obtained from a pit 100 yards from the plant. The limestone used is quite argillaceous and the clay is used principally for its silica content.

All the materials used in the Ada Portland Cement plant are hauled 6 miles over the Frisco Railroad from the company's quarries located near Parkhill. Both the limestone and shale are very pure. Coal, the fuel used, is obtained usually at Lehigh 30 miles away.

A plant is being constructed at the side of a limestone ledge near Hartshorne which will use the upper part of the Wapanucka limestone. Sufficient shale occurs in the lower part of the hill to supply the plant. The finished product will be handled over a switch from the Rock Island railroad which is about one mile distant. Coal which occurs near at hand will be used for fuel.

The demand for Portland cement in Oklahoma for the last few years has been enormous, and the two local mills have been able to supply only a small part of it. There is no evidence of a decrease of building or development in the State and it seems probable that more cement will be required in Oklahoma in the next few years than in any equal length of time in the past.

Several conditions aid in tending to make Portland cement the principal building material of the future. The price of all kinds of lumber is rapidly increasing. It is impossible to lower the cost of production of clay products or of building stone much below the present level. In contrast to these conditions must be considered

the cheapness of Portland cement, its adaptability for all sorts of construction work and its durability. These considerations have especial weight in a region such as the western half of Oklahoma where there is no timber at hand, no fuel for burning clay products, and very little stone suitable for building purposes.

A list of localities where gravel and crushed stone which is suitable for use in connection with cement for concrete work can be obtained is given on page 93 in connection with the article on Road Materials.

GLASS SAND.

(By Frank Buttram)

Any sand that contains a large per cent of silica and a small amount of iron and argillaceous material is glass sand. Iron and argillaceous material—alumina, lime, soda, and potash—constitute its principal impurities.

Iron is a very strong colorizing agent, and if found in excess of one-half of one per cent in sand renders it of no value for the manufacture of the best quality of glass. Such colors as red, brown, black and yellow, and all intermediate shades and tints that are found in rocks are usually due to iron.

On the other hand the argillaceous materials in the sand give the glass manufactured from it a cloudy appearance, and render the glass more or less opaque according to the percentage of the impurities found in the sand. Bottle glass, and other cheap glasses, may be made of sand containing as much as two per cent of iron and six per cent of argillaceous materials.

So far as is known the available glass sand in Oklahoma occurs in three regions, namely: near Tahlequah; in the Arbuckle Mountains; and in southeastern Oklahoma.

In western Oklahoma the greater part of the sandstone is red, due to the large per cent of iron oxide that it contains. In eastern Oklahoma there are several places where ledges of almost white sand occur. Ledges of this character are reported near Tulsa, Bartlesville, Claremore, Ramona, Catoosa, Muskogee and Holdenville.

So far as has been determined, no sand in this region has been found to be of sufficient purity to justify its use for anything but the poorest grades of glass, as all analyses made of the samples taken from these different places show from one to three per cent of iron.

The glass sand near Tahlequah occurs along the bend of the Illinois River. Mr. Joseph A. Taff, of the United States Geological Survey, in the Tahlequah folio, page 2, describes the formation as follows:

"The Bergen sandstone is a massive, moderately fine-grained light brown rock. The beds are thick and planes of stratification are usually indistinct. The rock consists of nearly pure silicious

sand of rounded grains, with a matrix scarcely sufficient to cement them together.

In natural exposure the rock breaks readily under the stroke of the hammer, crumbling into loose sand. The formation varies in thickness from a thin stratum to beds aggregating more than 100 feet. It is exposed in the Tahlequah quadrangle, in but a single area, on the Illinois River northeast of Tahlequah, where it rises in bluffs to a height of nearly 100 feet, and the base is not exposed. The full thickness, therefore, is certainly not less than 100 feet."

Unfortunately the glass sand in this region is found in the bottom of the narrow valley of the Illinois River, without available railroad connections.

The glass sand in the Arbuckle Mountains is contained in the Simpson formation which consists of a great mass of sandstones, shales and limestones 2,000 feet, or more, thick. The Simpson usually outcrops as a band surrounding the mountains, and the rocks as a rule stand on edge. There are, in this formation, three ledges of sandstones, any of which contains sand of sufficient purity to be designated as glass sand. Some of the localities where this formation outcrops near lines of railroad are as follows: Davis, Dougherty, Crusher, Berwyn, Ravia, Mill Creek, Roff and Bromide. Near any one of these towns enough glass sand may be secured to make all the glass Oklahoma would use in a thousand years.

The third area in which glass sand occurs in quantity is in the southeastern part of the state. The formation is known as the Trinity sandstone, and outcrops as a broad band five to fifteen miles wide along the southern base of the Arbuckle and Ouachita mountains, extending from Marietta to the Arkansas line. The formation consists largely of reddish and yellowish sandstone, but in a number of localities it is almost pure white. Localities near Marietta, Atoka and Antlers are said to yield good glass sand.

The factors on which a deposit of sand depends for its possible value for glass making are, (1) chemical composition, (2) physical character, (3) amount available, (4) location with respect to fuel supplies, (5) condition of quarrying or mining, and (6) location with respect to markets.

Operator	Location of Mine or Quarry	per cent. Silica	per cent. Iron	per cent. Argillaceous Material
Millington White Lead Co.	Millington, Ill.	99.42	.02	.56
Pacific Glass Co.	Pacific, Mo.	99.20		.76
Pittsburg Plate Glass Co.	Pittsburg, Pa.	99.21	.003	.5 .21 volatile
	Crusher, Okla.	99.95	.08	very slight trace

From the above analyses it is seen that our glass sand compares very favorably with that of the three leading states in its production. In fact, our glass sand is as pure as any in the United States.

We not only have as good a grade of glass sand, and as great a quantity of it as any other state in the Union, but we have more fuel and cheaper fuel than any other state with which to work it up into glass, and sufficient railroad facilities and markets to dispose of it after it is manufactured. As soon as this industry is developed it will add another profitable source of income to the State.

ROAD MATERIALS.

(By L. C. Snider)

For the consideration of the road material the State may be divided into eight districts, (1) the Mississippian area or northeastern portion, (2) the east-central portion north of the Arkansas River, (3) the eastern portion south of the Arkansas River, (4) the Ouachita Mountain region, (5) the Arbuckle Mountain region, (6) the Wichita Mountain region, (7) the Cretaceous area or extreme southern portion, and (8) the central and western portion or Redbeds area.

The northeastern portion, comprising all of Ottawa, Adair, Cherokee and Delaware counties, and parts of Craig, Mayes, Wagoner and Sequoyah counties, is underlaid with limestone and cherts of Mississippian age; consequently macadamized roads are the logical improved roads in this district. Almost any hillside in the area will furnish a good site for a road material quarry. Where these rocks have been broken up under traffic the natural roads are among the best in the State.

The region lying west of the area previously mentioned is also well supplied with limestone. Several ledges cross the State line from Kansas, some of which extend to the Arkansas River, and some beyond. Among these are the Claremore, Pawnee, Altamont, Lenapah, Hogshooter, Dewey, Avant, Pawhuska and Wreford limestones.

Most of these limestones are suitable for road material and no part of the area is so far removed from limestone as to make the construction of macadamized roads impossible. Care should be exercised, however, in the selection of the material as some of the ledges are of rather soft stone and it will be found more economical in the long run to import a harder, more resistant stone than to use a soft stone which is close at hand.

South of the Arkansas River the limestones give place to sandstones and shales, and this area is almost without material for improved roads as neither sandstone nor shale can be considered as road material. There are some deposits of gravel at Harjo and Konawa. The Wapanucka limestone crosses the extreme southeastern portion of the area from Reynolds to the Arkansas line. There are also local beds of limestone and chert which may be utilized.

The Ouachita Mountain region in Pittsburg, Pushmataha, McCurtain and LeFlore counties is very rough and hilly. Owing to the nature of the country it is thinly settled and the demand for improved roads is not so great as in the other portions of the State. The only road material in this region is the chert exposed near Talihina, and some deposits of pure asphalt near Tuskahoma and Antlers. The latter can scarcely be considered as available for roads.

The Arbuckle Mountains in Murray, Johnston, Pontotoc and Atoka counties and the Wichita Mountains in Comanche, Swanson and Kiowa counties contain a wealth of macadam material. Granite can be secured at Tishomingo, Ravia, Mill Creek and other localities in the Arbuckles and at Granite, Cold Springs, Snyder and Lawton and other places in the Wichitas. Inexhaustible deposits of limestone occur along the Santa Fe and Frisco railroads which cross the Arbuckles from north to south. This limestone is quarried and crushed at Ada, Fitzhugh and Crusher. The same limestone outcrops along the north side of the Wichitas and is quarried at Richards Spur near Apache. The streams from both mountain systems carry large quantities of sand and gravel which make an excellent top dressing for clay roads. Immense deposits of asphalt occur in these mountains, but this is not at present an available material for country roads.

The Cretaceous area or the extreme southern portion has several ledges of limestone which run almost parallel to Red River from Marietta eastward. The principal one of these is the Goodland limestone which is well exposed at Madill, Goodland and near Idabel. It always outcrops as a steep bluff and can be easily quarried. The asphalts of this region are very soft sand asphalts and it is believed that they can be utilized as a top dressing for clay roads. This, however, has not yet been demonstrated.

The western half of the State is underlaid with the sandstones and shales which are known as the Redbeds. Except for a few local limestones as at Cement and for a few thin ledges of dolomite exposed near Geary, Watonga, Mangum and Altus the whole region is without material for macadamized roads, and the sand-clay road is the logical road of this section.

As is well known a sand road is good when wet while a clay road is better when dry. By mixing sand and clay in the proper proportions a road can be built which in this region will give probably better satisfaction than a macadamized road, and for about one-tenth the cost. In many localities the shales are sandy and the natural roadway contains about the proper proportion of sand and clay to form a good sand-clay road. All that is necessary in this case is to keep the road well graded and drained. Where the roads

are so clayey as to become very muddy in wet weather, sand should be spread over them and mixed with the clay by traffic or by "puddling" with plows and harrows after a rain. If the road is still muddy after one application of sand, more sand should be added until the proper mixture results. Clay should be spread over sandy roads in a similar manner to render them solid in dry weather.

Value of Good Roads: The advantage of good roads may be classified under the following heads:

(1) They save time and labor in transportation.

(2) They make it possible to market the crop at any time during the year.

(3) They save wear and tear on horses, harness and vehicles.

(4) They make the marketing of perishable products, such as fruit and vegetables possible.

(5) They bring great improvement in the social condition of the country.

(6) They increase the value of the land along them.

The last item is the result of the other five and may be taken as a measure of the benefits derived from road improvement.

Road Conditions in Oklahoma: At present there are very few permanently improved roads in the State. This condition is due to several reasons, among which may be mentioned the recent opening of most of the land to purchase; the large amount of land which is not taxed; the expenses incident to formation of counties; the re-establishment of roads on section lines; and the low price of land in some sections of the State which makes the taxes insufficient for road improvement. All of these conditions, however, are improving and in a short time the matter of road improvement will receive the attention it deserves.

Road Construction: Since the construction of any form of improved road implies the construction of a good earth road as a foundation and since an earth road properly graded and drained will give a smooth hard surface for the greater part of the year in this climate, the construction of an earth road is a matter of great importance.

The most important feature of a good earth road is the drainage. The under ground water must be removed by tile or board drains and the surface water carried away by side ditches. The road must be kept free from ruts and holes as water standing on the road rapidly softens and destroys it. No attempt should be made to grade the whole 60 feet of roadway, but attention should be concentrated on a good grade about 16 feet wide. Bridges and culverts must, of course, be provided where needed. An earth road well constructed and drained and well maintained is a fairly good road especially in a climate like that of Oklahoma where the rainfall is not excessive and where there is little freezing. A community which will not keep up good earth roads is not ready for permanently improved roads.

Sand roads may be improved by any method which will keep them moist. They should not be drained and the surface should be level or slightly concave instead of crowned. The growth of trees and bushes along the roadway should be encouraged as well as the growth of grass over the road. Straw or weeds spread over the surface give temporary improvement. The addition of clay to form a sandclay road as previously mentioned gives a permanently is proving to be the most economical of any surfacing material improved road.

The construction of any form of permanently improved road is simply the addition of a protective covering to a good earth road. For macadamized roads, four to eight inches of crushed stone is added. The stone is usually broken so that it will pass a two inch ring. The screenings below 1-2 inch are removed and later added as a top dressing one or two inches thick. The stone for a macadam road must be hard and tough so as to resist the grinding action of the wheels and the blows from the horses' hoofs.

The bituminous road has been widely introduced in recent years under such names as "bitulithic" and "petrolithic." These roads seem to be successful but cannot be said to have fully passed the experimental stage. Paving brick is used for heavy traffic roads in the eastern states and, although the initial cost is heavy, are proving to be the most economical of any surfacing material when the life of the road and small cost of maintenance is considered.

The following is a list of the principal localities where macadam road material and concrete rock can be obtained at present.

Localities in Oklahoma Where Crushed Stone or Concrete Rock May be Obtained

Wynnewood—Garvin County, Stream gravel.
Granite—Greer County, Crushed granite.
Cold Springs—Swanson County, Crushed granite.
Muskogee—Muskogee County, Stream gravel.
Rea—Johnston County, Stream gravel.
Cache—Comanche County, Stream gravel.
Tishomingo—Johnston County, Stream gravel.
Limestone Gap—Atoka County, Crushed limestone.
Uncas—Kay County, Crushed limestone.
Avant—Osage County, Crushed limestone.
Hartshorne—Pittsburg County, Crushed limestone.
Crusher—Murray County, Crushed limestone.
Apache—Comanche County, Crushed limestone.
Lenapah—Nowata County, Crushed limestone.
Cement—Caddo County, Crushed limestone.
Ripley—Payne County, Crushed limestone.
Lost City—Tulsa County, Crushed limestone.
Keough—Muskogee County, Crushed limestone.
Garnett—Rogers County, Crushed limestone.
Fitzhugh—Pontotoc County, Crushed limestone.

TRIPOLI

(By Chas. N. Gould)

Tripoli is a soft, porous, silicious rock, usually white or cream colored, used chiefly for water filters and for polishing powder. It occurs in considerable abundance in Oklahoma but is comparatively rare elsewhere. The present seat of the tripoli industry is located at Seneca, Missouri, just east of the Oklahoma line, but a large share of the raw material comes from Oklahoma, so that tripoli should be considered among the mineral resources of the State.

The only rock exposed in this part of the State is the Boone formation or Mississippi limestone. This formation is made up of alternating strata of pure limestone, limestone interbedded with chert, a fine-grained, hard, silicious rock, and pure chert or flint. Where these chert beds lie in favorable position for surface water to exert its solvent action, the limestone is dissolved out and the residue remains a white porous, and comparatively soft rock. To this disintegrated chert or flint the name of tripoli is applied. Owing to the method of its formation commercial tripoli is found only on the summits of hills and the tops of ridges, for it is impossible to free the pores of the rock of the impurities which the surface waters continually wash into it at the lower levels.

The deposit in Oklahoma now being worked is located on the west half of section 33, T. 18 N, R. 15 E. The State line passes through the middle of that section. There is one pit on the Missouri side of the line just east of the works in Oklahoma. The tripoli obtained from these localities is largely ground up into tripoli flour. Oklahoma tripoli is not suitable for the manufacture of filters because it is full of cracks and contains frequent bedding planes, thus making it difficult to obtain large pieces.

There are two mills at Seneca owned by the same company. One is for the grinding of tripoli flour and the other is for the manfacturing of filter stones. At the present time this company is the only one operating in the field.

The machinery of the flour mill is essentially the same as that of the ordinary wheat flour mill. The rock first passes through light crushers in the basement, is then elevated to bins from which it passes through reels to ordinary upright stone mills, is sieved through silk wire bolting and is packed in barrels and sacks ready for the market. Several grades of flour are made depending on the amount of iron present and on the fineness of the grinding. The iron oxide imparts a red color to the stone, so the flour is graded into the "Rose" and "Cream" according to the amount of iron present.

The flour is used for a variety of purposes but the larger part of it as an abrasive or polisher in the metal working trades. The very finest grades are used as a jewelry polish, and the coarser ones as brass and steel polishes. A large part of the output of this particular mill is shipped abroad. No doubt some of the flour is used as an adulterant, as it is nearly pure white, without appreciable grit, and is very heavy.

There seems to be no reason why tripoli deposits should be confined to this one small spot in Oklahoma. The same formation that is found in the vicinity of Seneca also covers a large part of the region east of Spring and Grand rivers and north of the Arkansas River. It is probable that if a careful and systematic search were made of this area other workable deposits of tripoli would be brought to light. The great essential for successful working of the tripoli deposits is their proximity to transportation. Small specimens of tripoli have been found near Tahlequah and in the vicinity of Spavinaw Creek, but no larger deposits were noted. Systematic prospecting will doubtless reveal the presence of tripoli in commercial quantities.

The value of the output of the two mills at Seneca is about $50,000 per year. These are the largest works of the kind in the United States and a large part of their material comes from Oklahoma. Oklahoma is, therefore, the largest producer of tripoli in the Union, and in view of the fact that she has unparalleled resources in that material, there appears to be no reason why she should relinquish her supremacy in the tripoli industry.

VOLCANIC ASH

(By Chas. N. Gould)

Volcanic ash is composed of fine dust and powdered lava blown from volcanoes. During a former geological age there were a great many volcanoes in what is now northeastern New Mexico, and southeastern Colorado. When these volcanoes were in eruption the fine dust, and powdered pumice or lava carried by westerly winds drifted east and settled in such quantities that it often formed beds several feet thick, which covered a number of acres. These deposits of volcanic ash, so called, occur at various locations over the plains. Beds have been reported from western Nebraska, and Kansas, eastern Colorado and the Panhandle of Texas. In Oklahoma, deposits are known to occur in Beaver, Harper, Ellis, Woodward and Woods counties and will probably also be found in Texas and Cimarron counties.

Volcanic ash is usually a soft, gritty, grayish or light colored material which usually occurs in regular beds outcropping along the side of a hill. When the soil or rock which covers it is removed by the action of water the volcanic ash is rapidly eroded and carried away.

Volcanic ash is used as an abrasive, for polishing purposes, as a filter, and as an adulterant for soap, and certain other manufactured articles. Some of the beds in western Nebraska have been worked for a number of years, but so far as is known none of the

Oklahoma material has ever been put on the market. As soon as the beds in western Oklahoma are opened, there is no doubt that this industry will become profitable to the operators.

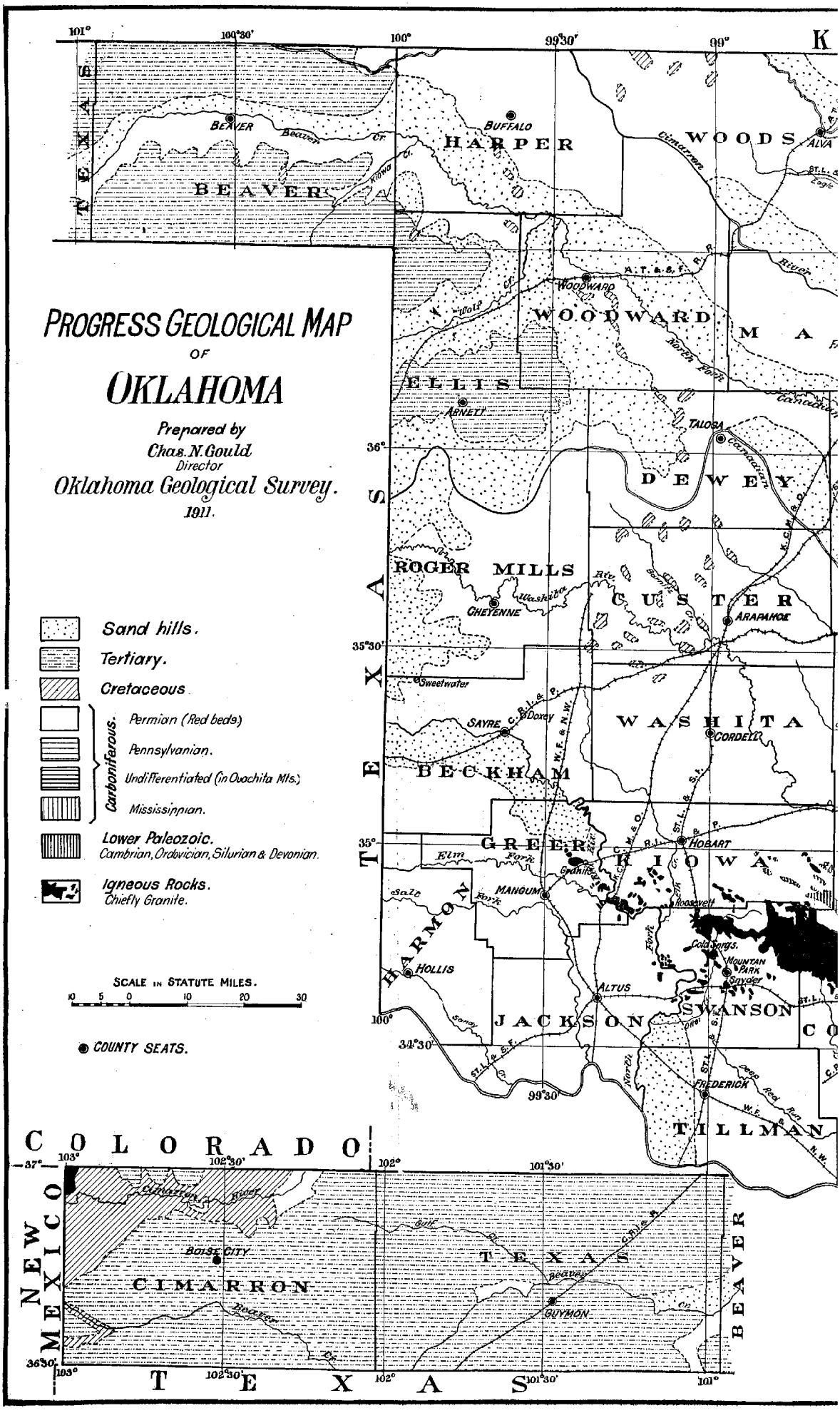
NOVACULITE

(By Chas. N. Gould)

Novaculite is a very fine-grained sandstone, so fine indeed that it looks like chert or flint. It is used for razor hones, jeweler's stones and other fine abrasives.

Some of the finest deposits of novaculite in the United States occur near Hot Springs, Arkansas, in the eastern end of the Ouachita Mountains. The same formation which contains the novaculite at Hot Springs passes westward into Oklahoma and is exposed in a number of places, for instance, near Talihina and Atoka.

At the present time no localities have been reported in Oklahoma where novaculite is exposed under conditions which would render it profitable to quarry, but there is little doubt that systematic search would reveal profitable localities. The best place to look for it is along the range of hills just east of the M. K. & T. railroad between Stringtown and Atoka, and in a range of hills known as Potato Hills, lying east of Talihina and north of Tuskahoma.


PROGRESS GEOLOGICAL MAP
OF
OKLAHOMA
Prepared by
Chas. N. Gould
Director
Oklahoma Geological Survey.
1911.
Sand hills.
Tertiary.
Cretaceous.
Carboniferous.
Permian (Red beds.)
Pennsylvanian.
Undifferentiated (in Ouachita Mts.)
Mississippian.
Lower Paleozoic.
Cambrian, Ordovician, Silurian & Devonian.
Igneous Rocks.
Chiefly Granite.
SCALE IN STATUTE MILES.
10 5 0 10 20 30
COUNTY SEATS.
BEAVER
HARPER
WOODS
ALVA
BUFFALO
WOODWARD
ELLIS
ROGER MILLS
CUSTER
DEWEY
BECKHAM
WASHITA
GREER
KIOWA
HARMON
JACKSON
SWANSON
TILLMAN
COLORADO
NEW MEXICO
TEXAS
CIMARRON
BEAVER
BOISE CITY
GUYMON
ARNETT
TALOGA
CHEYENNE
ARAPAHOE
SWEETWATER
SAYRE
CORDELL
HOBART
MANGUM
HOLLIS
ALTUS
COLD SPRINGS
MOUNTAIN PARK
SNYDER
FREDERICK
101°
100°30'
100°
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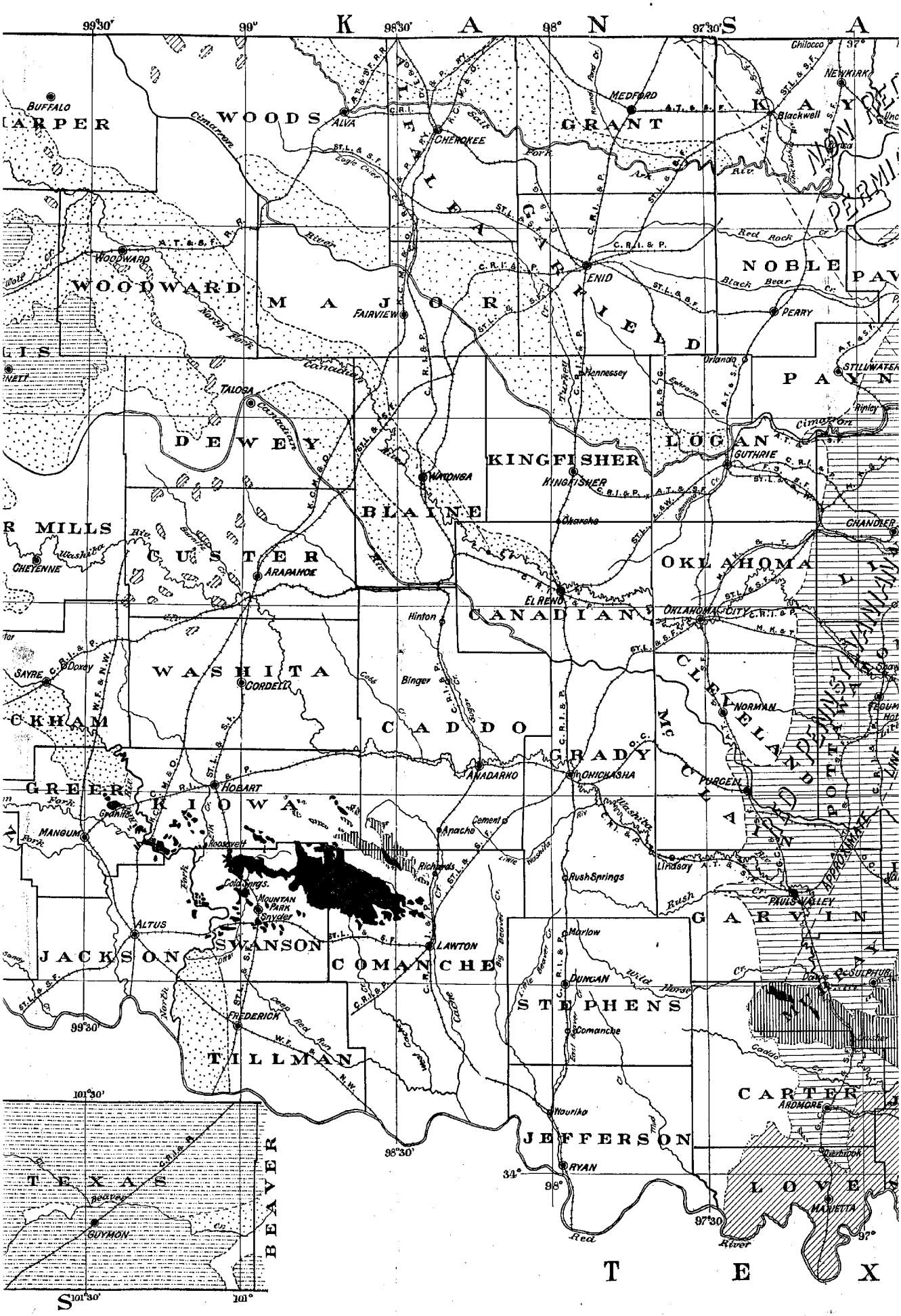
99°
36°
35°30'
35°
34°30'
103°
102°30'
102°
101°30'
37°
36°30'


KANSAS
TEXAS
WOODS
ALFALFA
GRANT
KAY
NOBLE
WOODWARD
MAJOR
GARFIELD
PAWNEE
DEWEY
LOGAN
KINGFISHER
BLAINE
CUSTER
OKLAHOMA
CANADIAN
WASHITA
CADDO
GRADY
GREER
KIOWA
JACKSON
SWANSON
COMANCHE
TILLMAN
STEPHENS
CARTER
JEFFERSON
LOVE
GARVIN
MCCLAIN
CLEVELAND
PAYNE
LINCOLN
BEAVER
ALVA
CHEROKEE
MEDFORD
Blackwell
NEWKIRK
Chilocco
ENID
FAIRVIEW
PERRY
Orlando
Hennessey
STILLWATER
TALOGA
WATONGA
KINGFISHER
GUTHRIE
Ripley
Cimarron
Okarche
CHANDLER
CHEYENNE
ARAPAHOE
EL RENO
OKLAHOMA CITY
Hinton
SAYRE
Doxey
CORDELL
Binger
NORMAN
ANADARKO
ONICHASHA
PURCELL
HOBART
MANGUM
Granite
Apache
Cement
Richards
Cold Springs
Mountain Park
Snyder
ALTUS
LAWTON
Rush Springs
Lindsay
PAULS VALLEY
Marlow
DUNCAN
Comanche
SULPHUR
FREDERICK
Wurika
ARDMORE
RYAN
MARIETTA
Quanah
GUYMON
Red River
99°30'
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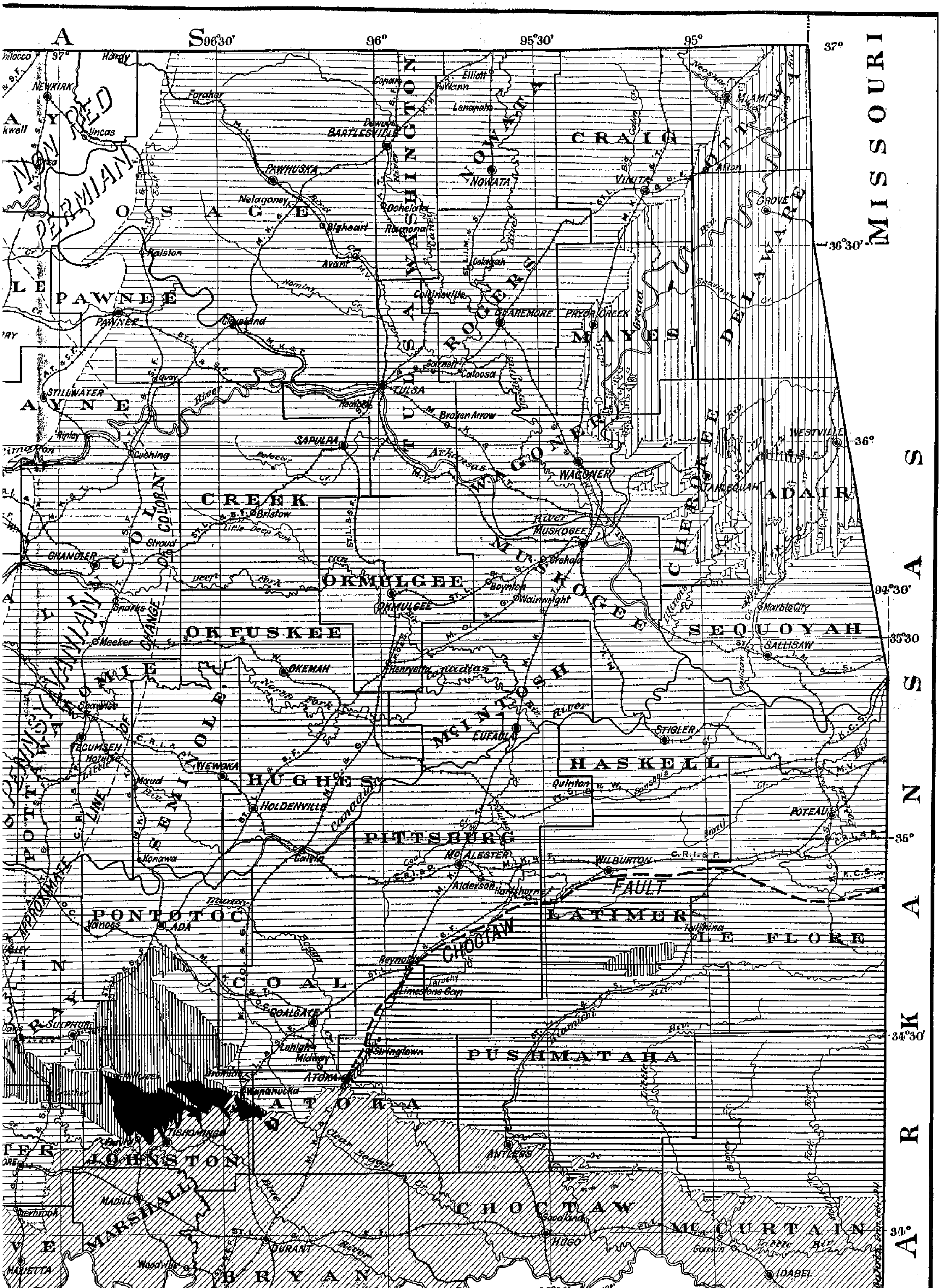
98°
97°30'
97°
34°
101°30'
101°



MISSOURI
ARKANSAS
TEXAS
CRAIG
OSAGE
PAWNEE
NOWATA
WASHINGTON
ROGERS
MAYES
DELAWARE
OTTAWA
TULSA
WAGONER
CHEROKEE
ADAIR
CREEK
OKMULGEE
MUSKOGEE
SEQUOYAH
OKFUSKEE
McINTOSH
HASKELL
HUGHES
SEMINOLE
PITTSBURG
LATIMER
LE FLORE
PONTOTOC
COAL
PUSHMATAHA
ATOKA
JOHNSTON
MARSHALL
BRYAN
CHOCTAW
McCURTAIN
PERMIAN
PENNSYLVANIAN
CHOCTAW FAULT
NEWKIRK
PAWHUSKA
BARTLESVILLE
NOWATA
VINITA
MIAMI
GROVE
PAWNEE
CLAREMORE
PRYOR CREEK
STILLWATER
TULSA
SAPULPA
WAGONER
TAHLEQUAH
WESTVILLE
MUSKOGEE
CHANDLER
OKMULGEE
SALLISAW
OKEMAH
EUFAULA
STIGLER
WEWOKA
HOLDENVILLE
POTEAU
McALESTER
WILBURTON
ADA
COALGATE
SULPHUR
ATOKA
TISHOMINGO
ANTLERS
MADILL
DURANT
HUGO
IDABEL
MARIETTA
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