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MINERAL RESOURCES IN OKLAHOMA

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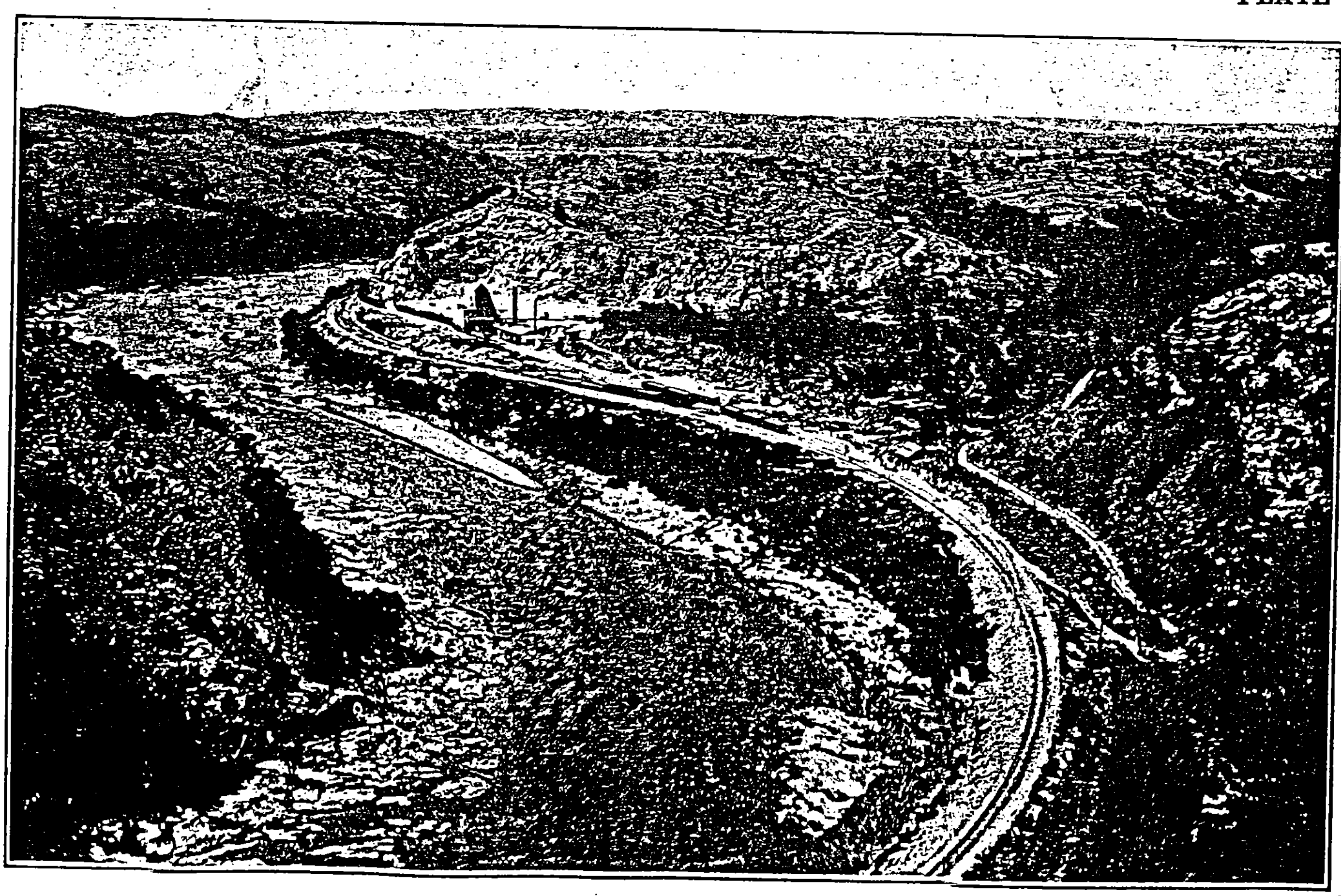


GATEWAY TO THE ARBUCKLE MOUNTAINS
The Washita River gorge at Crusher, Murray County, Oklahoma

MINERAL RESOURCES IN OKLAHOMA

INTRODUCTION

In this bulletin attention is called to the remarkable variety, total valuation and distribution of Oklahoma's mineral resources. The importance of this State as a producer of commercial minerals among the states of the Union is unquestioned, because Oklahoma ranks second in valuation of annual new mineral wealth.

The general distribution of the more important mineral deposits is described in the text and shown on the maps which make up this report. Such information is of interest to all Oklahomans and to many out-of-state inquirers.

The numerous requests which are received at the office of the Oklahoma Geological Survey for data concerning the mineral resources and mineral products of the State cannot in all cases be met by the special publications on the various resources, or by individual correspondence. So it is the purpose of this bulletin to give some general information that will meet these requests. In collecting the data for this report the publications of the Survey were drawn upon freely, since the present paper represents a revised edition of certain chapters of Bulletin 27, Geography of Oklahoma, and a pamphlet published some time ago entitled, "Handbook on the Natural Resources of Oklahoma," both of which publications have been out of print for several years. Most of the statistics of production have been obtained from the U. S. Bureau of Mines reports on Mineral Resources of the United States.

Chapter I

GENERAL GEOGRAPHY OF OKLAHOMA

LOCATION AND BOUNDARIES

Oklahoma is located a short distance south of the geographical center of the United States. The adjoining states were laid out and the remaining territory, known as Indian Territory, was left to the Indian tribes. A tract of land near the center of the United States remained unallotted to the Indians, and this area was called Oklahoma. The accepted interpretation of the meaning of the word Oklahoma is that it came from two Choctaw words meaning "red men"—Okla (people), and homma or humma (red). By various treaties with the Indian tribes, the territory known as Oklahoma, open to settlement by the whites, was increased until it included practically the western half of the present State. The eastern half remained as Indian Territory until 1907. Oklahoma Territory and Indian Territory together were admitted into the Union as the 46th state, and were designated as the State of Oklahoma.

The main portion of the State of Oklahoma lies between 37° N. latitude on the north, and Red River (approximately the 34th parallel on the south, and from about 94° 30′ west longitude on the east to the 100° meridian on the west, with the Panhandle of Oklahoma, lying between the parallels of 36° 30′ and 37° and reaching west to 103° west longitude, as a northwestward extension. The greatest length of the State along the north line, including the Panhandle of Oklahoma, is about 470 miles. The greatest length of the main portion of the State is about 320 miles, and the greatest breadth is about 225 miles. The area is 70,470 square miles, so that Oklahoma is larger than any state east of the Mississippi River and is equal in size to Ohio and Indiana combined.

Oklahoma's only natural boundary is Red River on the south. This river was established as the boundary between the Spanish possessions and the Louisiana Purchase. There was a dispute as to whether the South or North Fork of Red River was meant in this treaty, and for many years the territory between the two forks, now including the southern part of Beckham, and all of Greer, Harmon, and Jackson counties, was claimed by Texas. The Supreme Court of the United States decided in 1896 that this territory was part of the Louisiana Purchase, and it was added to Oklahoma, thus establishing the present southern boundary of the State.

The western boundary of the main portion of the State was established at the 100th meridian at the time of the Louisiana Purchase. When Texas was admitted as a slave state, a strip along the north end of the Panhandle of Texas was north of the parallel of 36° 30′, and according to the terms of the Missouri Compromise, could not be admitted to the Union as slave territory. It was therefore ceded to the Federal Government, and in 1896 was added to the Territory of Oklahoma. The southern boundary of this strip was established by the admission of Texas. As just mentioned, the western boundary had already been established by the organization of the Territory of New Mexico in 1820, and the northern boundary was fixed at the 37th parallel by the organization of the Territory of Colorado.

The remainder of the northern boundary of Oklahoma was established at the 37th parallel by the organization of the Territory of Kansas. According to the Missouri Compromise, Kansas should have extended south to 36° 30′ but this would have made it include part of the lands already granted to the Cherokee Nation and would have divided these lands into free and slave territory, so the boundary was placed at 37°

The eastern boundary of Oklahoma consists of three straight lines. The western boundary of Missouri was fixed when that State was admitted to the Union in 1820, at a line drawn due south from the junction of the Kansas and Missouri rivers. This established the eastern boundary of Oklahoma between the parallels of 37° and 36° 30′. In 1824 the western boundary of Arkansas was defined as a line running due south from a point 40 miles west of the southwest corner of Missouri. This line passed very near the present sites of Muskogee and Wilburton. Part of the territory included in Arkansas by this boundary had, however, been granted previously to the Choctaw Nation, and in 1828 the boundary was shifted to the east. It was then defined as beginning at the point where the eastern line of the Choctaw Nation crossed Red River and running due north to Arkansas River, thence in a straight line to the southwest corner of Missouri.

PUBLIC LAND SURVEYS

The Federal Government has surveyed all of the land of Oklahoma by a system of public land surveys. This work was begun in 1870 from a point a mile south of old Fort Arbuckle, eight miles west of Davis, Murray County. This point is marked by a stone pillar about four feet high and a foot square. On one side are carved the letters I. P. (meaning Indian Principal); on the other side is the date, 1870. This is the point from which all the public land in Oklahoma, except the Panhandle of Oklahoma comprising Beaver, Texas and Cimarron counties, has been surveyed.

Principal Meridian and Range Lines

From the Initial Point the surveyors ran a true north and south line extending north to Kansas and south to Texas. This line is called the Indian Meridian. They then went six miles east of the principal meridian and surveyed another true north and south line parallel with it. This is known as a range line and all land between the principal meridian and this line is said to be in Range 1 East. Six miles farther east is a second range line and the land between the first and the second range lines is in Range 2 East. In like manner, running north and south, range lines were laid out every six miles apart all the way to the Arkansas line. Other range lines were surveyed west of the principal meridian and the land lying between these lines is known as Range 1 West, Range 2 West, and so on.

Base Lines and Township Lines

Going back to the Initial Point a line was surveyed east and west from Arkansas to the western part of the territory. This is known as the Base Line. At intervals of six miles apart north and south of the base line, other lines were surveyed, known as township lines. The strip of land six miles wide running east and west between two township lines is known as a township. Thus the six mile strip north of the base line and between it and the first township line is known as Township 1 North. The strip between the second and third township line south of the base line is Township 2 South.

Congressional Townships*

By this method all the territory was cut into blocks six miles square, known as congressional townships. There are in Oklahoma about two thousand congressional townships.

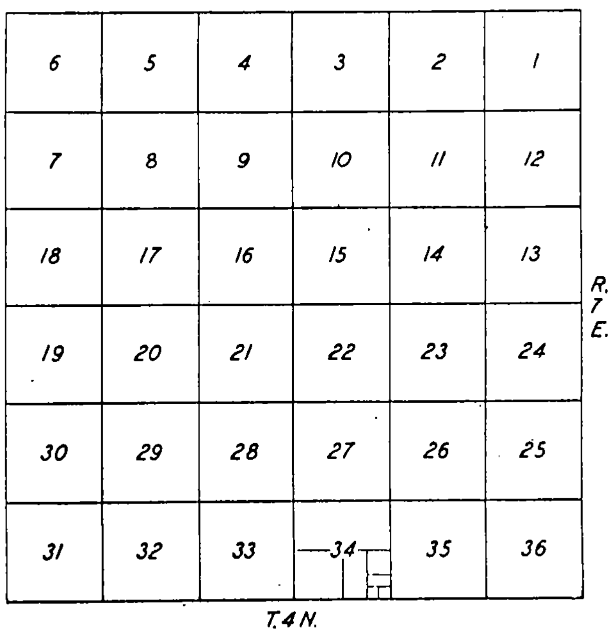


Figure 1. Diagram of a township showing location of sections.

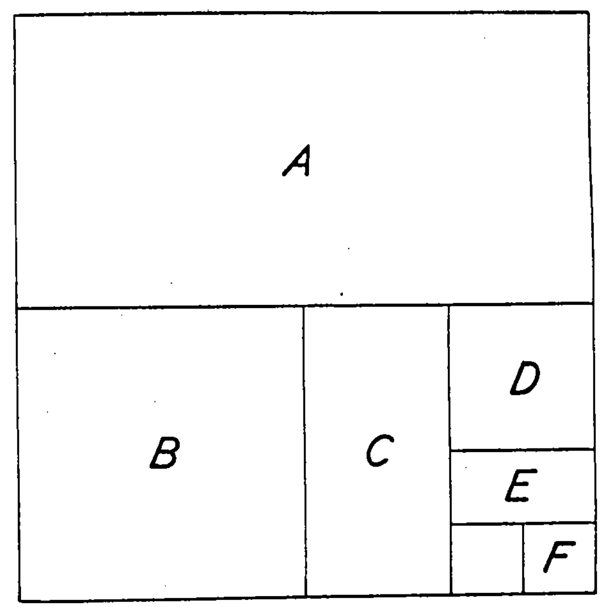
*It is unfortunate that the word township is used in three senses in the United States:
First: A township is a strip of land running east and west six miles wide, parallel to a base line.
Second. A congressional township is a tract of land six miles square containing thirty-six sections, bounded by range lines and township lines.
Third. A municipal or political township is a subdivision of a county which has its own local government and elects its own officers. It may contain only a part of a congressional township or it may include several congressional townships.

Each congressional township contains 36 square miles known as sections, each containing 640 acres. These sections are numbered consecutively from 1 to 36, beginning on the northeast corner as shown in Fig. 1.

Sections

Each section is usually divided into quarter sections containing 160 acres. The quarter section is the unit of sub-division in granting land to settlers. No person can homestead more than 160 acres; so that many farms, particularly in the western part of the State, are of this size.

The section, however, may be divided into tracts of any size as shown in Fig. 2, which represents a section divided into tracts of 320, 160, 80, 40, 20 and 10 acres. The description of tract numbered **B** would read the southwest quarter of section thirty-four, Township four North, Range seven East, usually abbreviated to SW. ¼ sec. 34, T. 4 N., R. 7 E., containing one hundred and sixty acres. The description of tract numbered **F** would be the southeast quarter of the southeast quarter of the southeast quarter of section thirty-four, Township four North, Range seven East, usually abbreviated to SE. ¼ SE. ¼ SE. ¼ sec. 34, T. 4 N., R. 7 E., containing ten acres.



Fegure 2. A section subdivided (See Fig. 1).

Corner Stones

A stone has been placed in the ground at each section corner, and usually one at the corner of each quarter section. These stones have been marked so that by reading the marks one can locate the section.

It is easy to learn to read the marks on a corner stone if the following rules are observed.

Along a range line, that is, on the east or west side of a township, the marks are on the NORTH and SOUTH sides of the stone. There will be as many marks on the north side of the stone, for instance, as the number of miles to the next township corner. On the southeast corner of section 12, there will be two marks on the north side of the stone and four marks on the south side. On the northeast corner of section 36 there will be five marks on the north and one on the south.

Along township lines, the marks are on the EAST and WEST sides of the stone and there are as many marks as the number of miles to the next township corner. The northeast corner of section 2 will have one mark on the east and five on the west.

Except along township and range lines the marks are on the EAST and SOUTH sides of the stone, and there are as many marks as the number of miles to the east or south line of the township. For instance, the stone at the corner of sections 10, 11, 14, and 15, will have two marks on the east and four on the south because this stone is two miles from the east line of the township and four miles from the south line. In the center of the township at the corner of sections 15, 16, 21, and 22, there will be three marks on the east and three on the south.

In the eastern part of the State, that is in old Indian Territory, there is at each township corner an iron pillar, standing about three feet above the ground, with a brass cap, on which is given the number of the township and range as well as the elevation above sea level. In the timbered country section lines may be followed by blazes on the trees, and at each section corner the number of the land is cut on four trees, one in each section, known as witness trees, or bearing trees.

In the prairie country there are of course no blazed or witness trees. The corner stones are marked, however. In the older settled parts of the state where roads have been opened upon section lines, the marks on the corner stones have usually been rubbed off by passing wheels, and in many cases the corner stones themselves have been broken down.

Cimarron Meridian

The land in Cimarron, Texas, and Beaver counties, which counties occupy what was formerly known as No Man's Land or the Neutral Strip, was not surveyed from the same principal meridian or base line as the remainder of the State. This area, which is about 135 miles long east and west, and 35 miles wide, was surveyed from the Cimarron Meridian, which is the extreme western line of the State. The Base Line is the southern line of the area, which is also the northern line of the Texas Panhandle.

TOPOGRAPHY

Oklahoma has a topography characterized as rolling to hilly. In general the surface of Oklahoma is a plain which slopes to the southeast; and since the average slope is about eight feet to the mile, it is so slight that one can hardly see that the country slopes at all.

The highest point in Oklahoma is on Black Mesa, in the extreme northwestern corner of the State, near Kenton, Cimarron County, where the elevation above sea level is about 5,050 feet. The lowest points in the State are along the eastern line where Arkansas and Red rivers leave Oklahoma. The Arkansas River flows from Oklahoma at Fort Smith, Arkansas, and the Red River at the extreme southeast corner of the State, southeastern McCurtain County. At these places the elevation above sea level is between 300 and 400 feet.

It is interesting to note a comparison of altitudes in Oklahoma with those of North America. The extremes in elevations for North America are Mount McKinley, Alaska, which is 20,300 feet above sea level, and Death Valley, California, which is 276 feet below sea level. The mean (average) elevation for North America and for Oklahoma is the same, being 1,300 feet above sea level.

The principal areas of hilly land are the Ozark Mountains in the northeastern part of the State, the Ouachita Mountains in the southeastern part, the Arbuckle Mountains in the south-central portion and the Wichita Mountains in the southwest part. Another prominent topographic feature is Black Mesa in northwestern Cimarron County, a flat-topped hill capped by black lava rock which was poured out from a volcano long ago.

In parts of western Oklahoma the streams have cut deep channels into the rocks, thus breaking the usually smooth surface of the plain. In fact, only in the western portion and in a belt through the central part of the State from north to south, is the surface very level. The greatest inequalities of surface, that is, the greatest differences in levels between the tops and bottoms of the hills, are in the southeastern part of the State, in the Ouachita Mountain ranges, where some of the so-called mountain peaks rise as high as 1,500 feet above their bases.

The altitudes of some of the various towns given below show the variations in elevations in different parts of Oklahoma:

Altitudes of Oklahoma Towns

Town and County	Elevation (Feet)
Idabel, McCurtain County	474
Poteau, LeFlore County	500
Miami, Ottawa County	800
Ardmore, Carter County	880
Oklahoma City, Oklahoma County	1,207
Newkirk, Kay County	1,148
Alva, Woods County	1,332
Lawton, Comanche County	1,096
Watonga, Blaine County	1,522
Altus, Jackson County	1,383
Sayre, Beckham County	1,810
Shattuck, Ellis County	2,232
Woodward, Woodward County	1,893
Goodwell, Texas County	3,286
Kenton, Cimarron County	4,500

DRAINAGE

Because Oklahoma lies entirely in the Mississippi River Basin, all of its surface drainage finds its way to the Mississippi River through the two major streams, Arkansas River and Red River. The Arkansas River and its branches drain about three-fourths of the area of the State. Its principal branches from the north are the Verdigris, Grand, and Illinois rivers, and Sallisaw Creek. Those from the south and west are Salt Fork, Cimarron, North Canadian, South Canadian, and Poteau rivers. Red River drains the southern and southwestern parts of the State. The principal branches named from west to east are North Fork of Red River, Cache Creek, Beaver Creek, Mud Creek, Washita River, Blue River, Boggy Creek, Kiamichi River, and Little River. In the following paragraphs the streams are considered somewhat in detail.

Arkansas River Drainage System

Arkansas River is the largest stream which flows across the territory included in Oklahoma. It enters the State near the middle of the north boundary and flows in a general southeastern direction, but with a very winding course. As is the case with all the other rivers which flow across the Great Plains, the bed of the Arkansas is sand-choked. The water is always heavily charged with sediment, and is of a red color, although this color is not so

marked in the Arkansas as in the streams farther south. During flood times the waters carry large quantities of sand, and shift it and roll it along the bottom in enormous quantities. Sand bars and islands of sand are formed with each flood, only to be destroyed and built up in different localities with the next flood. During the dry seasons the river is almost or, in places, entirely dry, and the sand is left to the mercy of the winds which shift it about from place to place, building large sand dunes. Some of these reach for a considerable distance back from the river. This feature is not nearly so pronounced along Arkansas River as along the Cimarron and Canadian rivers.

Through the greater part of its course Arkansas River has a wide flood plain. Vast quantities of silt are deposited over this plain in times of highwater. This river bottom soil is very rich, especially in the lower course of the river in Wagoner, Muskogee, and Haskell counties, and it forms one of the richest farming regions in the State.

As has been said, the entire channel of Arkansas River is filled with sand. The depth of this sand at different places is not accurately known, but it probably averages over 30 feet. A large percentage of the water carried by the river probably moves down through this sand. Even at times when the river bed is dry, water will rise almost to the tops of holes dug in the sand.

Tributaries

Verdigris River joins Arkansas River from the north, near the city of Muskogee. This river rises in Kansas and flows with a very winding course in a southerly direction through Nowata, Rogers, and Wagoner counties. It flows through most of its course on a bedrock of clay shale, so that the collovial material which predominates is mud. It is markedly different from the Arkansas in the absence of sand bars and the sand-choked channel. The banks are usually steep. The waters are often muddy, but not so heavily charged with sediment as those of the Arkansas.

Grand River is formed by the junction of Spring River and Neosho River, near the town of Miami in Ottawa County.

These rivers rise respectively in Missouri and Kansas. From the junction of the two streams, Grand River (called Neosho by the United States Geological Survey) flows in a direction slightly west of south, through the northeastern corner of Delaware County, through Mayes County, and between Wagoner and Cherokee counties, joining the Arkansas a few miles southeast of the mouth of the Verdigris River, near Fort Gibson. The region drained by Grand River is one of chert and limestone hills which are for the most part heavily forested. The soil covering of the hills is usually thin, and contains sufficient fragments of chert to make it very porous, so that the rainfall soaks rapidly through the soil without washing much of it into the streams. The rocks of the region are very porous, and great quantities of water flow through underground courses and emerge as springs. As a result of these conditions the water in Grand River is very clear, and the channel contains very little mud and practically no sand. Large bars and islands of coarse chert and limestone gravel are built up in times of high water. There is a marked difference between the tributaries entering Grand River from the west and those entering from the east. Those from the west, of which Big Cabin and Pryor creeks are the most important, drain a region underlain by clay shale. They are able to wear their valleys down faster than Grand River, which flows on the resistant chert, and consequently have broad, flat flood plains, and very gentle gradient. They are muddy streams with steep banks, much more nearly resembling the Verdigris than the Grand, which they enter. The tributaries from the east, Cowskin River and Spavinaw, Spring, and Clear creeks, like Grand River, flow almost entirely through the chert hills region, and are clear streams with steep gradients. They carry practically no mud, but flow throughout their course over gravel bottoms.

Illinois River and Sallisaw Creek are streams which resemble the Grand in almost every particular. They drain the greater part of Cherokee and Adair counties. Both streams rise in Arkansas and take a western and southern course, joining Arkansas River where it forms the southern boundary of Sequoyah County.

The principal streams joining the Arkansas from the south and west, the Salt Fork, Cimarron and Canadian rivers, are streams very similar to the Arkansas itself. They are all typical streams of the Great Plains, and all have their source in the foothills of the Rocky Mountains, far to the west of Oklahoma. The three rivers are sand-choked and have great series of sand dunes built up along their courses, usually along the northern side of the stream. The sand dunes of the Cimarron reach as far as 15 miles from the river. The water of these rivers is of a very red color, due to the material that is carried in suspension. All of them go almost or entirely dry during dry seasons, and all are subject to very rapid "rises". The valleys of all three streams are very narrow in proportion to the length of the rivers, and they have very few important tributaries in Oklahoma. The source of the water which flows through these streams is largely in the foothills of the Rocky Mountains, where the rainfall is much heavier than it is in the lower portion of the courses of the rivers. It is this fact which

accounts for the "rises" which have been mentioned. Heavy rains far up the rivers, and also the snow melting in the spring on the mountains, throw vast quantities of water into the rivers through the narrow channels, and in spite of the fact that it is not increased by contributions from tributaries, it rushes down the channel of the river with great force. Often a wall of water ten feet or more in height will advance very rapidly down the river and cause great destruction. The water of all of these rivers carries some salt in solution. This is especially true of the Cimarron which flows across two large salt plains between Harper and Woods counties. These plains are fed by salt springs, and the water of the Cimarron for some distance below the plains is so salty that cattle will not drink it. North Canadian River is the only important tributary of the Canadian in Oklahoma. It is a stream similar to the Canadian itself, and flows through a narrow valley between the valleys of the Canadian and Cimarron. It is very similar to these two streams, but is considerably smaller.

PLATE II

RED RIVER AT ROCK BLUFF FERRY, NEAR LEON, LOVE COUNTY

Red River Drainage System

Red River forms the southern boundary of Oklahoma. It is also a typical plains river, is largely sand-choked, and in the upper part of its course has a great development of sand dunes. The water is very red, but not much more so than that of the Canadian or Cimarron. The amount of water carried in the dry seasons is very small and at times the river is almost dry, although large quantities of water are moving slowly through the sand in the river's bed.

Tributaries

The principal tributary to Red River in Oklahoma is Washita River, which, while a river of the plains, differs considerably from those already described. It carries much less sand, and usually has steep mud banks. It enters the State about the middle of the western boundary, and flows in an easterly direction through Roger Mills, Custer, Washita, Caddo, Grady, and Garvin counties. Near the center of Garvin County, it turns almost directly south through Murray County, flowing through a gorge across the narrow portion of the Arbuckle Mountains (See Plate I). From the south line of Murray County it flows east through a corner of Carter County and the southern part of Johnston County, and then south through Marshall and Garvin counties. The valley of the Washita is wide, and the bottom lands form probably the largest and richest river valley region in the State. The North Fork of Red River drains the extreme southwestern portion of the State. It more nearly resembles the Cimarron and Canadian than it does the Washita. It is a river carrying much sand and has large areas of sand dunes along its course. Kiamichi River and Little River drain the southeastern corner of the State into Red River. These streams, with their numerous tributaries, more nearly resemble Grand and Illinois rivers than they do any of the others described. They flow through a very rough country in which the soil is usually very thin. The water comes largely from sandstone areas, and is therefore very clear. They are probably the best streams in the State for fish, and hundreds of hunters and fishers visit this section of the State every year. Kiamichi River forms the only important break or gap in the western part of the Ouachita Mountains, and on this account one line of the St. Louis & San Francisco Railroad has been built along it for many miles.

WEATHER AND CLIMATE

By weather is meant the combined effects of different factors on the atmosphere at a given time and place. The principal factors affecting the weather are temperature and humidity, or amount of moisture in the atmosphere. The amount of motion of the air (wind) may be regarded as another factor of the weather, although it is due primarily to variations in temperature. Climate may be regarded as the average weather of a given locality.

In general the climate of Oklahoma is temperate, although there are many extremes of weather both hot and cold, wet and dry. The seasonal changes in temperature are rather great, ranging from below 0° in winter to above 100° in summer. As a whole the State is subject to rather strong winds, the result of great cyclonic movements of the atmosphere which are typical of this part of the country. The causes and mechanics of these movements are described in all texts of Physical Geography and need not be discussed here.

Most of these movements cross the State from northwest to southeast, but some of them have their origin over the Gulf of Mexico and advance toward the north.

Chapter II

GEOLOGY AND GEOLOGIC HISTORY OF OKLAHOMA

GENERAL STATEMENT

In dealing with the geology of any region we are concerned principally with the study of the rocks, that is, their nature and composition, and the position in which they lie. The first subject—the study of the kinds of rocks and the relation of the different rocks to each other, is known as stratigraphy, or stratigraphic geology. In addition to these two, a third subject may be considered—the history of the conditions under which the rocks were deposited, and under which they have come into their present form, or historical geology.

The study of the rocks of any region is extremely important in connection with the study of its development in any line. The nature of the surface, the characteristics of the drainage, and most important of all, the soils of a region are dependent primarily on the nature of the underlying rocks. On this account it is necessary to give considerable attention to the rocks of Oklahoma. In this chapter the different kinds of rocks are described briefly, the distribution of the different kinds in Oklahoma is noticed at some length, and finally, a brief geologic history of the region now known as Oklahoma is given.

ROCKS AND MINERALS

Classification

Rocks are materials which form the earth's surface. They are of many kinds, according to their composition and physical characteristics. However, they may be divided into two great classes—the igneous and sedimentary.

The igneous rocks are those which have been formed by the cooling of a molten mass or magma. They are the crystalline rocks and are composed of interlocking crystals of a great number of minerals. The best known type of the igneous rocks is granite, which occurs in enormous quantities, and which is well known as a building material. There are a great number of other varieties of igneous rocks, but they are of very small importance in Oklahoma and need not be noticed here.

Granite

Granite is usually of a gray to red color, is a very hard, compact rock, and occurs in great masses which are not separated into layers. The masses are often cracked so that the rock may be quarried in blocks of small dimensions, but nothing resembling regular bedding of the rocks occurs in granite. Granites occur principally as the cores of mountain ranges, as masses which were intruded into older rocks at considerable depth, and which have since been exposed by erosion.

Conglomerates, Sandstones, Shales, and Limestones

The sedimentary rocks, as their name indicates, are formed as sediments, layer on layer, either under water or from the air. The aereal or wind-blown deposits are of some importance in Oklahoma, but the rocks deposited in water predominate. They are easily divided into three or four distinct classes. When material is washed down from the earth's surface into the water, the coarse material is deposited very close along the shore, while the finer material is carried farther and farther from the shore and deposited far out in the large bodies of water. Rocks which have been formed near the shore will, as a rule, consist of boulders, gravel, and sand. The proportion of gravel and sand will depend upon the nearness of high land, the amount of run-off of the streams, and the presence or absence of strong currents in the water in which the materials are deposited. Farther out from shore only sand and mud are deposited, and the material is finer as the distance from the shore increases. Far out from shore (or even close to shore near very low lands) there will be little or no deposit of fragmental materials brought down from the lands, but only a limy mud which may be formed from the material brought down from the land in solution. This lime may be precipitated from solution by chemical reaction, but is very largely taken out by the shell-bearing life forms of the sea and built up into their shells. When the animals die the shells, or the materials derived from them, sink to the bottom and are built up into considerable layers.

In case the sea withdraws from a certain area the gravels, sands, muds, and limy muds or marls are gradually consolidated

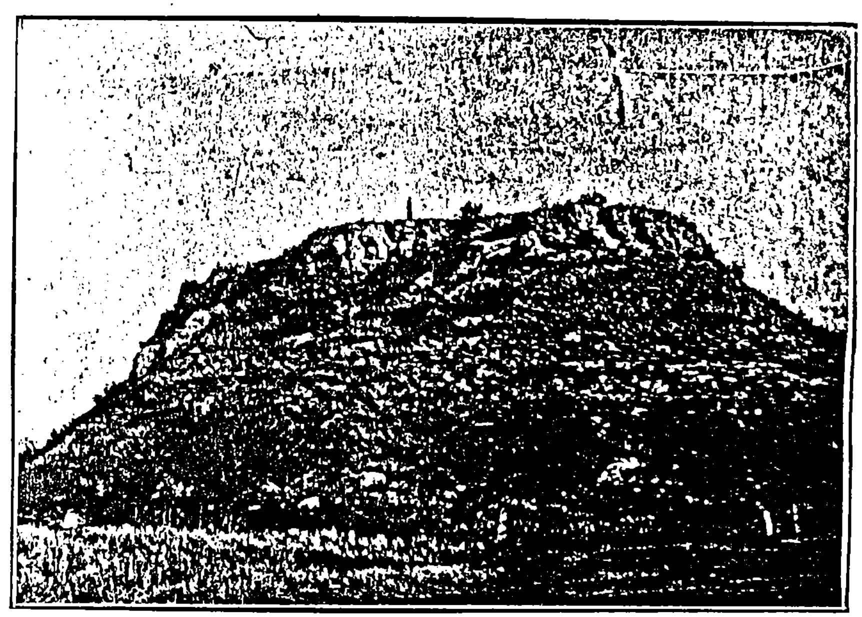
and cemented into hard rock. A gravel cemented into hard rock is called a conglomerate; a sand, a sandstone; a mud, a shale or slate; and a limy mud a marl or limestone.

It is evident from the nature of the formations of these rocks that there is no hard and fast line separating the different varieties. Some sand will be mixed with the gravel, and the gravel will grade outwards from the shore or beach, from coarse to fine gravel, and finally into sand without any sharp line of demarcation. Some fine sand will be deposited with the mud and some of the finest mud may extend far out where the principal deposit is limestone. We have, then, all gradations between the different types. For instance, we may have the conglomerate with pebbles so fine that it may be a question whether to call it conglomerate or a sandstone; we may have sandy shales or shaly sandstones; we may have calcareous (limy) clays and clayey limestones. However, this does not interfere with a general classification of the sedimentary rocks into conglomerates, sandstones, shales, and limestones.

Chert or Flint

Still another variety of sedimentary rocks which is of considerable importance in Oklahoma is chert or flint. While the quantity of this rock is in general very much less than that of the other types, locally it is very abundant. It is a very hard, brittle, and extremely fine-grained rock composed entirely of silica. It is probably formed by precipitation of the colloidal silica from solution.

PLATE III



GYPSUM BLUFF, NORTHERN HARMON COUNTY

Gypsum

Gypsum is another type of sedimentary rock. It is composed of calcium sulphate, is very soft, and usually white in color. It occurs as lumps or nodules in other rocks, and also as definite beds which may extend over large areas. Where it occurs in beds it was produced probably by the evaporation of sea water in enclosed or partially enclosed basins. It is an important economic resource, being used largely for the manufacture of plaster. Large deposits of gypsum occur in western Oklahoma, where iron oxide has given most of the rock exposures a red color.

Coal

Coal is a rock which is produced by the gradual alteration of immense beds of plant matter buried with the rocks. It is thought that at different times in the earth's history swamp conditions existed over large areas. These swamps were near sea level and were surrounded by very low lands. As the plants which grew in the swamp fell they were protected from decay by the water, and collected in enormous quantities in an almost pure condition, since very little sand or mud was carried into the swamps. After a considerable thickness of this plant material accumulated, a subsidence of the swamps permitted the sea to encroach and deposits of mud and sand covered the layers of plant material—or a rise of the surrounding lands may have caused the swamps to be covered with mud and sand. After the plant material was covered, the pressure of the overlying beds gradually changed it into coal. Coal beds occur in eastern Oklahoma and are an important economic resource.

Soils

When rocks have been exposed for a great length of time to the action of the weather, the cementing material is dissolved and the rocks break down into what is known as mantle rock. The mantle rocks, while forming an extremely small part of the earth's crust, are of first importance from an economic standpoint. The upper surface of the mantle rocks becomes covered with vegetation. The materials from the decaying vegetation penetrate the upper portion of the loose mantle rock and form soils. The nature of the soils in Oklahoma depends more upon the character of the underlying rock from which it was formed than upon any other single factor. A soil derived from a conglomerate is a gravelly soil; the soil from a sandstone is a loose, sandy loam; the soil from a shale is a "tight" clay soil, usually very hard to drain. Limestone usually produces a rich, fertile soil. The lime is almost, or quite, dissolved and the soil is formed entirely from the clay and sand which exist as impurities in the limestones. Most lime-

Metamorphic rocks

In addition to the two great classes of rocks, the igneous and sedimentary, a third class, the metamorphic, is sometimes recognized. These are either igneous or sedimentary rocks which have been so changed by heat or pressure, or both, that they have lost their original characteristics. Thus granite may be metamorphosed into schist, limestone into marble, sandstone into quartzite, and shale into slate or schist. These rocks are of little importance in Oklahoma. Some of the shales in the southeastern part of the State are somewhat slaty, and some limestone is changed to marble.

DISTRIBUTION OF ROCKS IN OKLAHOMA

Igneous Rocks

Igneous rocks occur in Oklahoma principally in two areas, the Arbuckle Mountains in the south-central part of the State; the Wichita Mountains in the southwestern part. There are also two very small areas, one in Mayes County, and the other in the northwestern corner of the State in Cimarron County. In the Arbuckle Mountains east of Washita River there is an area of over 100 square miles which is underlain by a coarse-grained gray to pink granite. This area lies to the north of Tishomingo, and the granite is known as the Tishomingo granite. The granite area extends east and west almost across the middle part of Johnston County. West of Washita River are two small areas of granite porphyry known as East and West Timbered Hills. The combined area of the Timbered Hills is not more than 2 or 3 square miles. All of the peaks of the Wichita Mountains are composed of granite or related igneous rocks, such as diorite, gabbro, porphyry, and other varieties. These granite peaks are distributed from Lawton, in Comanche County, northwestward across Kiowa County to Granite, Greer County, a distance of about 60 miles. The granite of the Wichita Mountains varies in color from a gray to almost black to a rather dark red. Much of it is suitable for building purposes, and several quarries have been operated from time to time in this area. The third area of igneous rock is in northwestern Mayes County, along Spavinaw Creek near the town of Spavinaw. This area is only a few hundred feet long and about 100 feet wide. The rock is a pink granite which was forced up into a crack in the sedimentary rocks and cooled into its present condition. The fourth area is in the extreme northwestern corner of the State in Cimarron County. Black Mesa, the highest elevation in the State, is composed of a black lava of comparatively recent geologic age.

PLATE IV

GRANITE HILL NORTHWEST OF GRANITE, GREER COUNTY

PLATE V

FRANKS CONGLOMERATE NEAR INITIAL POINT, MURRAY COUNTY

Sedimentary Rocks

Conglomerates are not of common occurrence in Oklahoma. Around the Arbuckle Mountains there are considerable areas

where the bed rock is a conglomerate of limestone pebbles and boulders cemented together. The town of Sulphur is built on this conglomerate, and anyone who has visited the town will remember the conglomerate in the cuts for streets, and in the railroad cuts between Davis and Sulphur. This formation is known as the Franks conglomerate.

Another conglomerate, which is of some importance as a source of gravel, exists north from the Arbuckle Mountains, passing a short distance east of Shawnee, where the gravel from the conglomerate has been worked. Some of the hills in an area near Red River in southwestern Love and southeastern Jefferson counties are capped by a conglomerate consisting of quartz pebbles of various colors, very firmly cemented. These conglomerates are of value for ballast, road material, and concrete fillers.

Sandstones are well distributed in almost all parts of the State. In most places the shales and sandstones are interbedded, that is, beds of sandstone are separated by beds of shale, and a great thickness of rock may be made up of alternating beds of

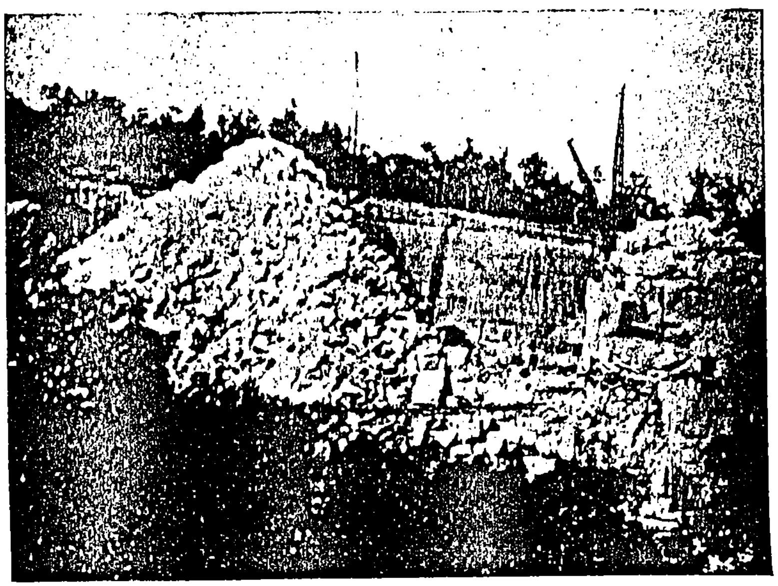
PLATE VI

SANDSTONE QUARRY AT COALGATE

shale and sandstone. In some regions, however, the sandstones are so abundant that they may be called sandstone areas. The mountains in the east-central and southeastern parts of the State, such as the Sansbois, Cavanal, Sugar Loaf, Winding Stair, Jackfork, Kiamichi, and Pine, are composed very largely of sandstone. Thick sandstone beds form the hills in a large area in the north-central part of the State, which includes most of Seminole, Hughes, Okfuskee, and Creek counties. Thinner sandstone beds are present farther to the northeast, and are of much less importance than in the region just mentioned. Thin sandstones also occur in the western part of the State, where they are of a red color, but they form a small proportion of the rocks in this region.

Shales occur interbedded with the sandstones in all the regions mentioned, but are of most importance in the western half of the State. Practically all the surface west of the main line of the Atchison, Topeka, & Santa Fe Railway is underlain by red shales with some red sandstones and some important beds of gypsum. This whole region is known as the red beds area and is described more fully in another part of this report.

PLATE VII



WAPANUCKA LIMESTONE QUARRY AT BROMIDE

Limestones occur in five rather distinct areas. The extreme northeastern portion of the State, including all of Delaware, and the greater parts of Ottawa, Mayes, Cherokee, and Adair counties, is underlaid by a thick formation of limestone with a large amount

of chert. When the rock weathers the limestones dissolve and the chert remains as a mantle rock, so that the region is called the Chert or Flint Hills region, but the quantity of the limestone in the bedrock is much greater than of the chert or flint. To the west of this area, across Rogers, Nowata, and Washington counties, there are several beds of limestone, some occurring as far west as Newkirk and Blackwell in Kay County. A third area in which limestones are important is the belt along Red River in the southeastern part of the State, south of the Arbuckle and Ouachita Mountains. A single limestone formation of considerable importance, economically, outcrops from Wapanucka and Atoka north and east almost to the Arkansas line. Several limestone formations are present in the Arbuckle Mountains. One of them is more than a mile thick. The same formation outcrops along the north side of the Wichita Mountain region.

Chert has already been mentioned as occurring with the limestone in the northeastern part of the State. It also occurs in the limestones in the north-central limestone area. One formation in the Arbuckle Mountains consists largely of chert. In two areas in the Ouachita Mountains, one along the line between Latimer and Pushmataha counties, and another in central McCurtain County, chert is very abundant. Important beds of gypsum are interbedded with the red shales in the western part of the State. Coal beds are present in the east-central and northeastern parts of the State.

Large areas of wind-blown sand which give rise to sedimentary rock formations occur along the streams of the red beds region in the western part of the State.

STRUCTURAL GEOLOGY OF OKLAHOMA

The structure of Oklahoma may be best thought of by picturing the four mountain areas of the State, the Ozark Mountains in the northeastern part, the Ouachita Mountains in the southeastern, the Arbuckle Mountains in the south-central, and the Wichita Mountains in the southwestern part of the State. The rocks in each of these areas are greatly folded and, especially in the Ouachita Mountains, faulted. Between the Ozark Mountains on the northeast and Ouachita and Arbuckle mountains on the south and southwest, is the Arkansas Valley trough in which the rocks are thrown into strong folds, but with only a minor amount of faulting. In the central part of the State the rocks have a gentle dip in a general westerly direction away from the Ozark and Arbuckle uplifts. The general westward dip is interrupted in many places by very gentle folding. The westward dip continues nearly to the western border of the State, becoming more and more gentle as the distance from the mountains increases. Along a line extending in a general north-south direction, about the longitude of Alva and Arapaho, the rocks are very nearly level, and from there on west have a very slight eastward dip due to the influence of the Rocky Mountains to the west. This, of course, indicates a trough or basin condition.

HISTORICAL GEOLOGY

General Discussion

Geologists divide the time included in the history of the earth into great eras, or periods of time, in which certain great events took place, in the same way as historians divide the history of a nation into the era or period of discovery, era of settlement, and so on. In geology the great eras are established on the basis of the remains of life (fossils) found in the rocks which were formed during that period.

It has already been noted in the discussion of rocks and minerals that there are two great classes of rocks, the igneous, or those which have cooled from a molten condition, and the sedimentary, or those which were deposited as sediments from water or from the atmosphere. The sedimentary rocks which were deposited in water usually contain the remains of living organisms which were buried in the sediments at the time they were deposited, and which remain in the rocks to tell us of the kind of life which was maintained on the earth at the time the rocks were formed. Any remains or evidence of life forms which are found buried in rocks are called fossils. Among these fossils those of the animals living in the sea are the most common, since most of our sedimentary rocks were deposited in the sea or arms of the sea. However, land animals were often buried in swamps, or their skeletons washed down into the beds of streams and covered by sand and gravel so that they have been preserved. Naturally, only the hard parts of the animals are preserved, and animal fossils consist almost entirely of the shells of sea animals and the teeth and bones of land animals. From a study of these hard parts the trained observer can determine the nature and many of the characteristics of the animals to which they belonged. The science dealing with the ancient life of the earth, that is, the study of fossils, is called paleontology. Plants are also often preserved, the woody part being replaced by stone which preserves the original structure of the wood, or the impression of leaves, bark, or stems remains in the sand or mud in which they were buried. The study of plant fossils is called paleobotany.

In the early part of the earth's history the animal and plant life included only the more simple forms, and the more complex forms developed from the simpler forms with the passing of time. Consequently if the study of the fossils in certain rocks shows that

only the simpler ancestral forms of life are present, these rocks can safely be said to be older than other rocks which contain the remains of more highly developed forms of animal or plant life. Paleontology, then, forms the principal basis for the division of the earth's history into eras.

The great eras into which the earth's history is divided are as follows, beginning with the youngest and progressing downward to the oldest:

The Cenozoic (recent life) era.
The Mesozoic (middle life) era.
The Paleozoic (early life) era.
The Proterozoic (earlier life) era.
The Archeozoic (ancient life) or Archean era.

Eras are divided into periods, which are in turn divided into epochs.

Divisions of Geologic Time

Eras	Periods	Epochs
Cenozoic	Quaternary	Recent Pleistocene
	Tertiary	Pliocene Miocene Oligocene Eocene
Mesozoic	Cretaceous Lower Cretaceous or Comanchean Jurassic Triassic	
Paleozoic	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian	

The divisions of the Archeozoic and Proterozoic apply to only small areas and are not important in Oklahoma.

The rocks deposited during each period of time are called a system of rocks, and the same name is applied to the system as to the period. For example, the Pennsylvania system includes all the rocks which were deposited in the time included in the Pennsylvanian period. The names of the systems (and periods) of the Paleozoic era are taken from places where the rocks were first studied, or where they are well developed. The names Cambrian, Ordovician, and Silurian are taken from Wales; Devonian comes from Devonshire, England; Mississippian and Pennsylvanian from the Mississippi River and the State of Pennsylvania; and Permian from Perm, a province of Russia. To say that rocks are of Pennsylvanian age simply indicates that they are of the same age of (were deposited at the same time as) the great coal-bearing series of rocks in the State of Pennsylvania.

In Oklahoma, the rocks range in age from Archeozoic to Recent. All the systems of the Paleozoic, the Comanchean and Cretaceous systems of the Mesozoic, and the Miocene and Pliocene, Pleistocene, and Recent of the Cenozoic, are found.

GEOLOGIC HISTORY OF OKLAHOMA

We know little about the history of the region now included in Oklahoma before Paleozoic time, since the rocks of the Archeozoic are exposed only in small areas in the Arbuckle and Wichita Mountains. We are safe in saying that the area of the State appears to have been a land surface for a great length of time before the Cambrian period and during the early part of that period. After the middle of Cambrian time the sea advanced over most or all of the area, and sand and mud were deposited in the shallow waters which covered the old land surface. During the Ordovician, Silurian and Devonian periods the area of Oklahoma was mostly covered by shallow waters, but at times portions of the area were elevated into land so that there are many breaks in the history of the rocks as shown by the fossils. During the Mississippian period the sea probably covered all of the region, and rocks of considerable thickness were deposited. During Pennsylvanian times the region now included in Oklahoma stood near sea level so that there were great swamps in which the vegetation accumulated to considerable thickness. From time to time the sea advanced over the area, and beds of mud and sand were deposited over the beds of vegetable matter, thus preserving them to form coal beds. At or near the close of the Pennsylvanian period there were great movements of the earth's crust which resulted in the folding of the sedimentary rocks which had been deposited in a level position. In some places the force was sufficient to cause breaks (faults) in the rocks and to shove them over each other for some distance. The Ozark, Ouachita, Arbuckle, and Wichita Mountains are the remnants of domes which were made in the rocks at this time, and the rocks in the areas between the Ozark Mountains and the Ouachita Mountains and between the Ouachita Mountains and the Arbuckle Mountains were tilted and thrown into great folds at the same time. These mountain regions are described more fully in another section.

During the Permian period the eastern part of the State was probably land. Great thicknesses of deposits were laid down over the western part of the State. These rocks are of a deep red color and are known as the red beds. It is certain that a part of these rocks were deposited in bodies of water, but it is probable that at least some of the red beds are land (wind-blown) deposits.

At the close of the Paleozoic era, the area of Oklahoma was all land and remained so during the Triassic and Jurassic periods of the Mesozoic. During lower Cretaceous (Comanchean) time the sea advanced from the south and covered the eastern part of the State north to the Ouachita and Arbuckle Mountains, and probably the whole western third of the State. This submergence was comparatively short and before the end of Cretaceous times all of Oklahoma was land and has remained so to the present, so that erosion has been continuously at work reducing the rocks to soils as we know them in Oklahoma today.

During a part of the Cenozoic era (Tertiary) the Rocky Mountains stood higher, relative to the land to the east of them, than they do now, and vast quantities of gravel were carried down from them by floods. The streams spread this material out as a blanket over the lowlands. Considerable deposits of these Tertiary gravels, as they are called, are found in the northwestern counties of Oklahoma. The gravels are made up of water-rounded quartz pebbles and coarse sands.

During Pleistocene and Recent times the area of the State was probably in much the same condition as at present. The deposits of these periods consist of alluvium along the streams.

Areal Geology of Oklahoma

The geologic map of Oklahoma shows the areas in the State where rocks of different age are found on the surface.

As has been said, the rocks of the Archeozoic era occur at the surface in only small areas in Oklahoma. What may be called the cores of the Arbuckle and Wichita Mountains are composed of igneous rocks (granites and similar rocks) which are Archeozoic in age. Such rocks undoubtedly underlie the whole State as a basement foundation supporting all younger sedimentary formations. Most of the hills of the Wichita Mountains are made up of these old rocks. In the Arbuckle Mountains they occur in three areas—one east and two west of Washita River.

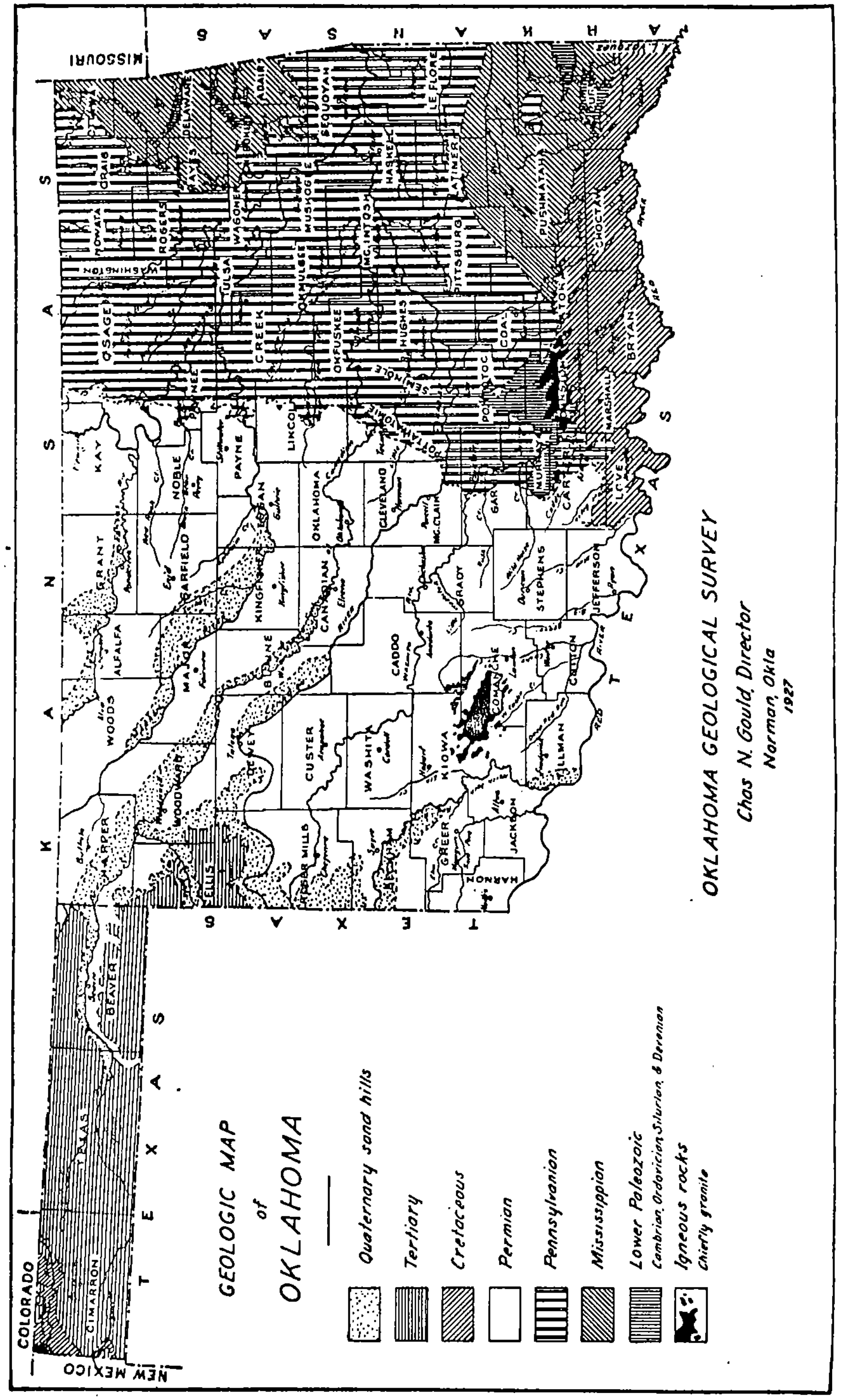


Figure 3. Geologic map of Oklahoma.

The older Paleozoic rocks, the Cambrian, Ordovician, Silurian, and Devonian, also occur on the surface in the Arbuckle and Wichita Mountains, where they lie steeply upturned against the older granite cores. Ordovician, Silurian, and Devonian rocks are present also in the Ozark Mountains, in the bottoms of the deeper valleys which the streams have cut through the younger rocks lying above them. Rocks older than Mississippian are also shown in two or three areas in the Ouachita Mountains.

Mississippian rocks occur in two large areas, the Ozark Mountain region in the northeastern corner of the State, and the Ouachita Mountains in the southeastern. The principal formation in the Ozark region is a mass of limestone and flint or chert about 300 feet thick. The rough, angular pieces of flint which cover the hillsides in this region give the area the name of Flint Hills by which it is commonly known. The Mississippian rocks of the Ouachita Mountains consist of shales and sandstones about 10,000 feet thick. One heavy bed of sandstone about 3,800 feet thick is responsible for the ranges of high hills or mountains of this region, such as the Kiamichi, Jackfork, and Winding Stair Mountains.

The Pennsylvanian rocks occupy a broad L-shaped area in the eastern part of Oklahoma. They are continuous with rocks of the same age in Arkansas on the east and in Kansas on the north. In the southern and eastern parts of this area the rocks are entirely of sandstone and shale in alternate layers and have a total thickness of about 14,000 feet. To the north the rocks thin considerably and there are several limestone beds with the shales and sandstones interbedded. This system of rocks is very important from an economic standpoint, since it contains all the coal beds of the State, and a large portion of the oil and gas deposits. The shales of the system furnish much of the raw material used in the State for clay products, building and paving brick, and the limestones are valuable for building stone, for burning into lime, and for crushed rock for concrete work, railroad track ballast, and road material. The Pennsylvanian rocks of the east-west limb of the L are folded into broad arches and troughs which extend generally in a northeast-southwest direction. Those of the north-south limb dip or slope gently to the west and pass under the younger Permian rocks above them. A small outcrop of Pennsylvanian rocks is mapped south of the Arbuckle Mountains mainly in Carter County.

The Permian rocks outcrop over most of the western half of the State. In general these rocks are soft red shales and sandstones, and in a rough way the area of Permian rocks may be considered as the red beds area. However, some of the uppermost Pennsylvanian rocks in central Oklahoma are red, and there is a small area of non-red Permian rocks in Kay and adjoining counties. The Permian rocks are soft and weather easily, forming a deep, rich soil. The red beds probably attain a maximum thickness of over 3,000 feet. Besides the soil, the economic products of the Permian system in Oklahoma are gypsum, which occurs in thick ledges in the western part of the State, and shales, which are used in the manufacture of brick. Some oil and gas production has been discovered in Permian rocks. The Permian rocks have not been much disturbed since they were deposited, and lie nearly level.

The lower Cretaceous (Comanchean) rocks form the surface rocks of the southern portion of the State, between the Arbuckle and Ouachita mountains on the north and Red River on the south. The area is continuous with a much larger area of these rocks in Texas. Small patches of lower Cretaceous limestone are found on the hills in some of the western counties of the State, and these are probably the remnants of a continuous body connecting the lower Cretaceous areas of Texas and Kansas, the greater part of which has been removed by weathering agencies. The lower Cretaceous rocks in southern Oklahoma consist of limestones and soft shales with sandstones at the bottom and top of the series. The economic products are the soils, which are very rich, especially on the shale and limestone outcrops; the limestones and some oil, gas, and asphalt. The limestone could be utilized as crushed rock and building stone, but little use has been made of it as yet. All of these rocks are nearly level, dipping very gently to the southeast.

The Tertiary rocks are soft, unconsolidated clays, sands, and gravels, which form a covering a few hundred feet in thickness over the red beds in parts of the northwestern portion of the State. The Panhandle counties, Cimarron, Texas, and Beaver, have most of their area covered by these rocks, and there are also large areas in Harper, Ellis, and Roger Mills counties. In the valleys of the streams the washed-in or alluvial soil is often of sufficient depth to be classed as a distinct formation—the Recent alluvium. Along the rivers in the western part of the State there are large areas of sand hills. The hills are composed of sand thought to have been blown by the wind from the river beds.

The areas of the different rock systems are shown on the accompanying map (Fig. 3). The areas of igneous rocks are shown in solid black, and those of the sedimentary rocks in patterns or lines. The areas occupied by the Paleozoic systems older than the Mississippian are too small to be shown for each system on a map of so small a scale. Consequently the Cambrian, Ordovician, Silurian, and Devonian are all mapped together as pre-Mississippian. The belts of alluvium are not shown, but the larger areas of sand hills are indicated by a distinct pattern.

Chapter III

PHYSIOGRAPHIC PROVINCES OF OKLAHOMA

GENERAL STATEMENT

On account of the differences in the character of the surface bedrock and soils, and in consequent differences in industries and population, it is possible to divide Oklahoma into a number of fairly distinct regions. In most cases the boundaries between these regions are sharp, but in some cases two adjoining regions grade into each other imperceptibly. In a general way, the State can be divided into mountains or hilly areas and plains or valley regions. Of the mountain or hilly areas there are four. The great plains and valley regions may be separated into six divisions.

Physiographic Divisions of Oklahoma

Ozark Mountains in northeastern Oklahoma.
Ouachita Mountains in the southeastern part of the State.
Arbuckle Mountains in the south-central part.
Wichita Mountains in the southwestern part.
Red River or Cretaceous region south of the Arbuckle and Ouachita Mountains.
Sandstone Hills region lying to the west of the Prairie Plains.
Prairie Plains along the west side of the Ozark Mountains.
Red Beds Region occupying a broad strip north and south through the middle part of the State, with an extension to the west along the southern border.
Gypsum Hills lying to the west of the Red Beds Plains.
High Plains in the extreme northwestern part of the State.

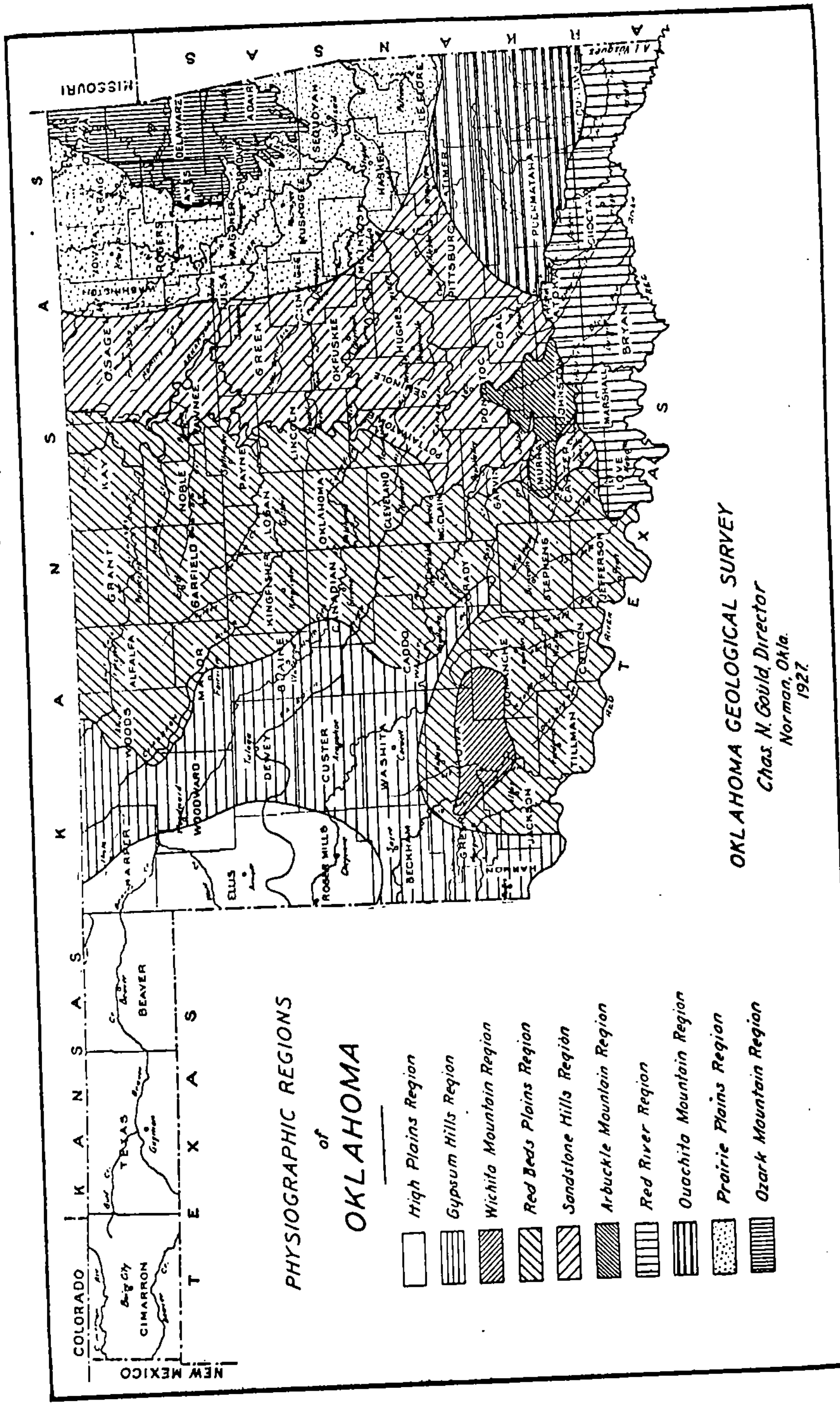


Figure 4. Physiographic regions of Oklahoma.

OZARK UPLIFT OF MISSISSIPPIAN REGION

The Ozark Uplift includes a large area in southern and southwestern Missouri, northwestern Arkansas, southeastern Kansas, and extends a distance of several miles into the northeastern part of Oklahoma. The area includes all of Delaware, the greater parts of Ottawa, Mayes, Cherokee, and Adair, with small portions of Wagoner and Craig counties.

The rocks underlying this portion of the State belong principally to what is known as the Boone formation, a series of cherts and limestones of Mississippian age. On weathering the limestone is dissolved from the formation and the chert remains as a covering of mantle rock several feet deep over the tops of the flat hills and the slopes. It is this fact which has given the well known name of Flint Hills to the region. Locally, the larger streams have cut down into older rocks lying beneath the Boone formation. The principal areas of these older rocks lie north and northeast of Tahlequah on Illinois River and Barren Forks. Around the edge of the uplift is a fringe composed of the outcrops of Mississippian rocks. These do not attain a very great thickness in Oklahoma, and the width of their outcrop is in most places less than one mile. The entire section as exposed in the region is described in "Index to the Stratigraphy of Oklahoma", by Chas. N. Gould, Bulletin 35, Oklahoma Geological Survey.

The structure of the Ozark region is rather complex. A series of folds extends in a general northeast-southwest direction. In places the folds are broken by longitudinal faults. Some cross-folding and doming is present. The details of the structure are given in Bulletin No. 24 of the Oklahoma Geological Survey, and portions of the area are described in Folios 122 and 132 of the Geologic Atlas of the United States published by the United States Geological Survey.

The surface of the region consists of a plain into which the streams have cut narrow V-shaped valleys, leaving between them broad flat-topped hills. Many of these flat areas are treeless and are called prairies. The larger ones are given distinctive names, such as Cowskin Prairie in northern Delaware County. The hillslopes are steep and covered with a mantle of loose chert, which in many places reaches a depth of 20 to 30 feet. The surface as a whole slopes to the southwest, away from the center of the uplift. The greatest elevation on the ridges in the northeastern corner of the area is about 1,000 feet, while that of the streams in the southeastern part is about 600 feet. The maximum heighth of the hills above their base is about 400 feet and the average about 250 feet.

The entire region lies in the drainage basin of the Arkansas River. The greater part of the drainage is carried into Arkansas River through Grand River and its tributaries. Grand River is formed by the junction of Spring and Neosho rivers near Miami in Ottawa County and flows southwest and south into Arkansas River at Fort Gibson. The principal tributaries of the Grand within this area are Lost Creek, Cowskin River, Honey, Drowning, Spavinaw, Salina, Spring, Coal, Fourteen Mile, and Ranger creeks. The southern portion of the area is drained directly into Arkansas River through Bayou Manard, and Greenleaf creeks, Illinois River, Vian, Sallisaw, and Lee creeks, and several smaller streams. All the streams of the area are clear and rapid-flowing. Their bottoms are gravely, and they carry practically no mud.

On account of the solution of the limestones much of the drainage is underground. Sink-holes are numerous on the broad, flat-topped hills, and springs abound in the valleys and along the streams.

The soils of that portion of the area underlaid by Boone chert consist of loose, cherty material. On the flat-topped hills there is in most cases a considerable thickness, as much as 10 or 15 feet, of soil with very little chert, but below this depth it grades rapidly into loose chert, and shortly into solid rock. On the slopes of the hills there is little or no soil at the surface, but there is sufficient soil in the lower part of the mantle or loose chert to support good tree growth. The Boone chert soil, where it is of sufficient thickness, is very fertile and is especially adapted to the raising of fruits. The famous Ozark Mountain fruit region of southwestern Missouri and northwestern Arkansas is in this same physiographic region and has the same soil as that which covers the hills in northeastern Oklahoma. However, the lack of transportation facilities has prevented any great development of the fruit raising industry in Oklahoma. Farming is carried on to a considerable extent on the flat-topped hills and prairies, but the principal crop on these areas is hay, made from the native grasses. As a rule, it is not possible to cultivate the hill slopes.

The valley soils are fertile, although usually quite stony. The ordinary farm crops are raised in the valleys, but the area of this soil is very small in proportion to that of the hill land. The valleys and slopes, as well as the tops of many of the ridges, are covered with timber. Lumbering was formerly an industry of considerable importance, but the larger timber has been removed and at present the principal lumber industry is the production of railroad ties and cord-wood. The forests consist principally of blackjack and post oak. In the southern part of the region some pine is found. There are practically no manufacturing industries in the area.

The principal mineral resources of the region are lead, and zinc, which occur only in the extreme northern part, near Miami in Ottawa County. The conditions of their occurrence and the mining industry near Miami are described in the chapter on mineral resources. The chert or flint of the area furnishes an inexhaustible supply of road material, but very little use has been made of it as yet. Limestone has been quarried for crushed stone near Fort Gibson. The Kansas City Southern Railway has a large chert gravel pit north of Stilwell. The material is used for ballast. The chert "tailings" or chats from the mines at Miami have been used with considerable success upon the roads of that vicinity. The main line of the St. Louis & San Francisco Railroad crosses the north end of the area. The main line of the Missouri, Kansas & Texas Railway nearly parallels the western margin of the area. The Okmulgee-Fayetteville branch of the St. Louis & San Francisco Railroad crosses the southern portion; the Kansas City Southern Railroad touches the southeastern corner; and the Rogers-Grove branch of the St. Louis & San Francisco Railroad penetrates the northern portion at Grove. A large central area consisting of southern Delaware, eastern Mayes, and northern Cherokee counties is without railroad facilities. The roads are on the section lines only in the leveler parts. In the more hilly regions it is not feasible to open up section lines. Many of the highways are fairly good on account of their natural surfacing of chert.

The region as a whole is sparsely populated. Most of the land belongs to Cherokee Indians and the greater part of the inhabitants of the hillier districts are Cherokees. Around the edges of the uplift and in the larger valleys there are numerous white settlers. The important towns within the area are Tahlequah and Westville in the southern part, and Grove in the northern part. Miami, Afton, Vinita, and Pryor Creek are located on the prairie plains just off the edge of the chert hills.

OUACHITA MOUNTAIN REGION

The Ouachita Mountains lie in southwestern Arkansas and southeastern Oklahoma. The region in Oklahoma includes southern LeFlore, southern Latimer, southeastern Pittsburg, northeastern Atoka, practically all of Pushmataha, and the northern two-thirds of McCurtain counties. The Ouachita Mountains are called Kiamichi Mountains by many Oklahomans.

The bedrocks of the region consist of a great thickness of shale and sandstone with considerable chert. Limestones are almost absent from this area. The section as exposed in the region is as follows:

Geologic Section, Ouachita Mountains, Oklahoma

1. Stringtown shale (Ordovician) consists of black and blue shales with some chert. It is about 600 feet thick with the base not exposed.

2. Talihina chert (Ordovician) consists principally of bluish, greenish, and white chert with thin, cherty, and clayey shales, and some thin lentils of blue limestone. It is about 1,150 feet thick.

3. Stanley shale consists of bluish, greenish, black, slaty shale with thin sandstones and considerable chert. It is about 6,100 feet thick.

4. Jackfork sandstone consists of heavy, massive beds of brown sandstone separated by much thinner bands of shale. It is about 3,800+feet thick. The age of the Jackfork and Stanley is not established, but judging from the evidence of some poorly preserved plant remains found near the base of the Stanley they are probably Mississippian. During the summer of 1916 a field party of the Oklahoma Geological Survey collected several specimens of fossil plants from the Jackfork sandstone, and while these have not been studied in detail, they show some evidence that the Jackfork may be Pennsylvanian.

5. Caney shale consists of greenish to black clay shale, and has a thickness of about 1,600 feet. It is probably lower Pennsylvanian in age.

By far the greater portion of the area is underlain by the Stanley shale and Jackfork sandstone. Rocks older than the Stanley shale are known in three areas: a narrow strip extending northeast from Atoka a distance of about 10 or 15 miles; an area in the southern part of Latimer County extending across into Pushmataha County; and in a broad belt extending from northeast to southwest through McCurtain County. In the last named area the rocks below the Stanley shale, that is, those equivalent to the Talihina shale, may be divided into several formations which have been recognized and mapped in the larger portion of the Ouachita Mountains in Arkansas. These are, named from the top down, Arkansas novaculite, Missouri Mountain slate, Blaylock sandstone, Polk Creek shale, and Bigfork chert. Still older shales, sandstones, and limestones are exposed in the central part of this area, a complete description of which can be consulted in Bulletins 32 and 35 of the Oklahoma Geological Survey. The structure of the region is very complex. A series of strong folds extends northeast-southwest across the region. The largest of these exposes the large area of Ordovician and older rocks mentioned above. On the flanks of these major folds are numerous minor folds, many of which are overturned. Faulting is common.

No detailed description of the geology or structure of the entire region in Oklahoma has been published. The Atoka Folio

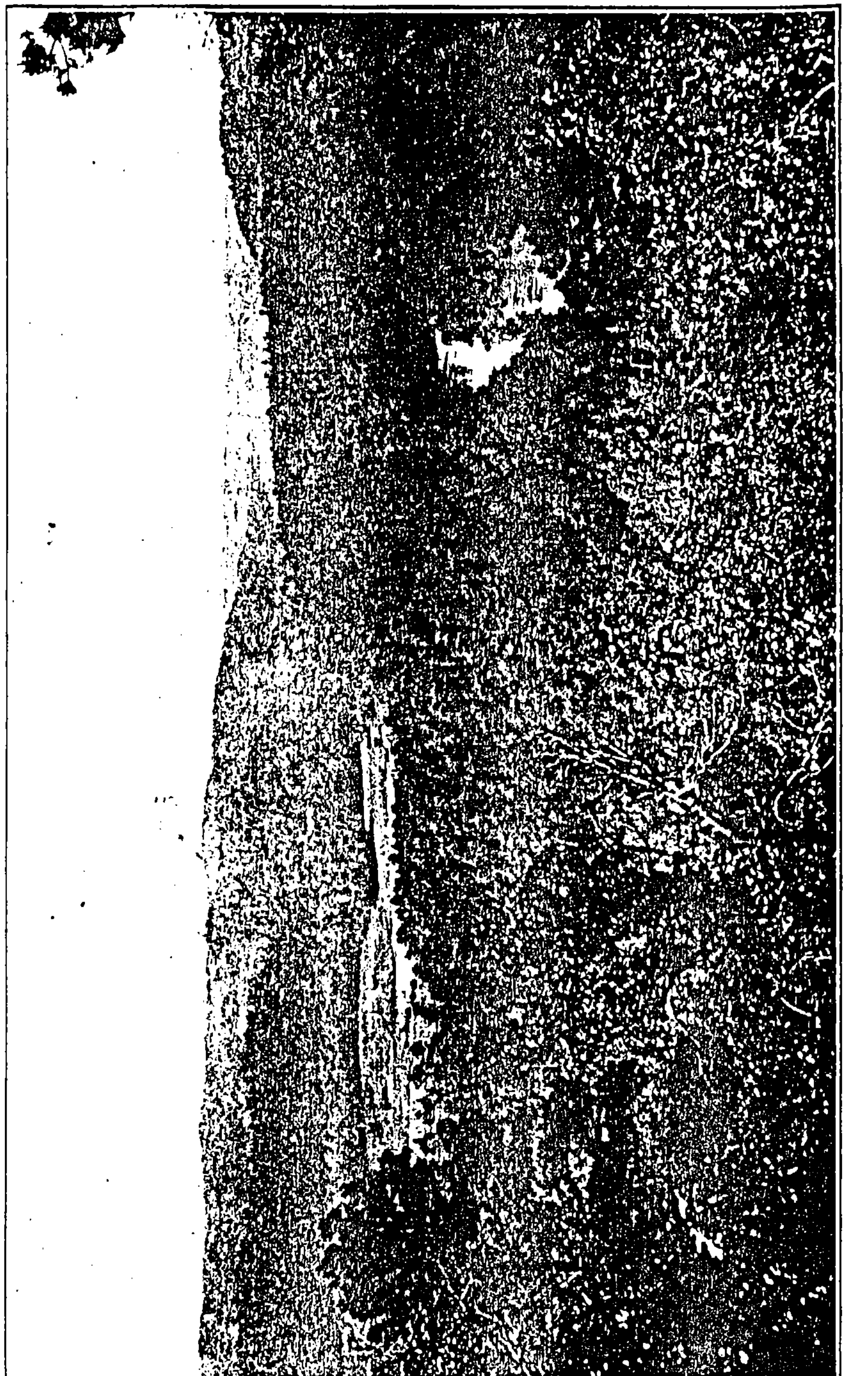
(No. 79) of the U. S. Geological Survey, describes a small area on the western margin. A description of the region in Arkansas may be found in a bulletin of the Arkansas Geological Survey, entitled Slates of Arkansas.

The surface of the region is very much rougher than that of any other part of Oklahoma. The thick Jackfork sandstone is very resistant to weathering and forms high, rugged ranges of hills which are known locally as mountains. On account of the duplication of the outcrop, due to the folding and faulting which the rocks have undergone, there are several of these mountains. The principal ones have distinctive names, such as Winding Stair, Kiamichi, Jackfork, Pine, Rich, and Blackfork mountains. Rich Mountain, in the southeastern part of LeFlore County, is the highest of these hills, reaching an elevation of over 3,000 feet above sea level, and an elevation of almost 2,000 feet above the streams at its base. The general slope of the region from this high point is to the south. The southern margin along the boundary between this region and the Red River area has an elevation of about 500 feet.

The principal streams of the region rise near the northern boundary and flow south to Red River. The resistant layers of rock and the complicated structure cause the streams to flow in very winding courses. Kiamichi River, the principal stream, rises in Arkansas, flows west in a winding course through the southern part of LeFlore and northwestern part of Pushmataha counties, then swings south and back to the southeast through the eastern part of Choctaw County. Little River rises in the extreme southwestern part of LeFlore County, flows first west, then south, then southeast, in a course nearly parallel to that of Kiamichi River, to near Garvin in McCurtain County, where it turns almost directly east and crosses the Arkansas line some distance before it joins Red River. Glover Creek, Lukfata Creek, and Mountain Fork River are important tributaries of Little River flowing nearly south and joining Little River in its eastward course. A narrow strip along the northern part of the area is drained northward into Poteau River through several tributaries, of which the most important are Black Fork and Fourche Maline rivers. All the streams of the Ouachita Mountains are clear and rapid-flowing.

The soils of this region are in general thin and poor. There is practically no soil on the mountains and hills of the Jackfork sandstone. The broad flats of Stanley shale are covered to a thickness of several feet with soil which is very "tight" and poorly drained. The soil of the Talihina chert area is somewhat better than that of the Jackfork or Stanley, but is in most places very thin. Only in the stream valleys is agriculture of any importance.

PLATE VIII



OUACHITA MOUNTAINS

The whole area is covered with a thick growth of timber and lumbering is the most important industry. The pine forests which cover most of the area have been worked over, but considerable good virgin timber remains. Some attempts have been made at mining lead and zinc, some of which still bear promise of being successful. Manganese ore occurs in nodules in the Arkansas novaculite, but not in sufficient quantity to be of economic importance. The reported discovery of gold and silver near Albion a few years ago caused great excitement, but nothing has resulted from it. Some cattle are grazed in the forests and small prairies, but the industry is of no great importance.

The region is very poorly provided with railroads. Only one railroad crosses the area, the Paris line of the St. Louis & San Francisco Railroad, which crosses in a north-south direction following the course of Kiamichi River for a long distance. The main line of the Chicago, Rock Island & Pacific Railroad runs within a few miles of the northern border of the area, and the Ardmore branch of the same road almost touches the northwest border. The main line of the Missouri, Kansas & Texas Railway touches the region on the west. The country roads are in general mere trails through the forests. The surface of the region is so rough that it is not feasible to lay out the roads on section lines. State Highway No. 10, which traverses this region, is one of the most scenic routes in the State. Its construction is of gravel and crushed rock on a wide roadbed. This road is a genuine achievement in making the district much more accessible. In the rougher portions none of the streams are bridged, and in fact there is very little traffic of any kind.

The region is by far the most sparsely settled of any portion of Oklahoma. None of the towns within the area has as many as 1,000 inhabitants, and there are only a few villages of more than 100 inhabitants. In the valleys of the principal streams there are small farms, but most of the land has been allotted to Choctaw Indians and no improvements have been made upon it. The majority of the inhabitants outside the villages are Choctaws.

ARBUCKLE MOUNTAIN REGION

The Arbuckle Mountain region lies in the south-central part of the State. It contains nearly all of Murray County, the northern half of Johnston County, the southern part of Pontotoc County, and the southwestern part of Coal County. The area is roughly triangular in shape with the base of the triangle to the southeast, and contains approximately 860 square miles. This region is geologically one of the most interesting in the State and the United States, and more material has been published about this area than about any other of equal size in the State.

The rocks of the Arbuckle Mountains consist of a central core of pre-Cambrian granites and related rocks surrounded by steeply-dipping strata of Paleozoic sedimentaries. The stratigraphic section as exposed in the mountains is as follows:

Geologic Section, Arbuckle Mountains, Oklahoma

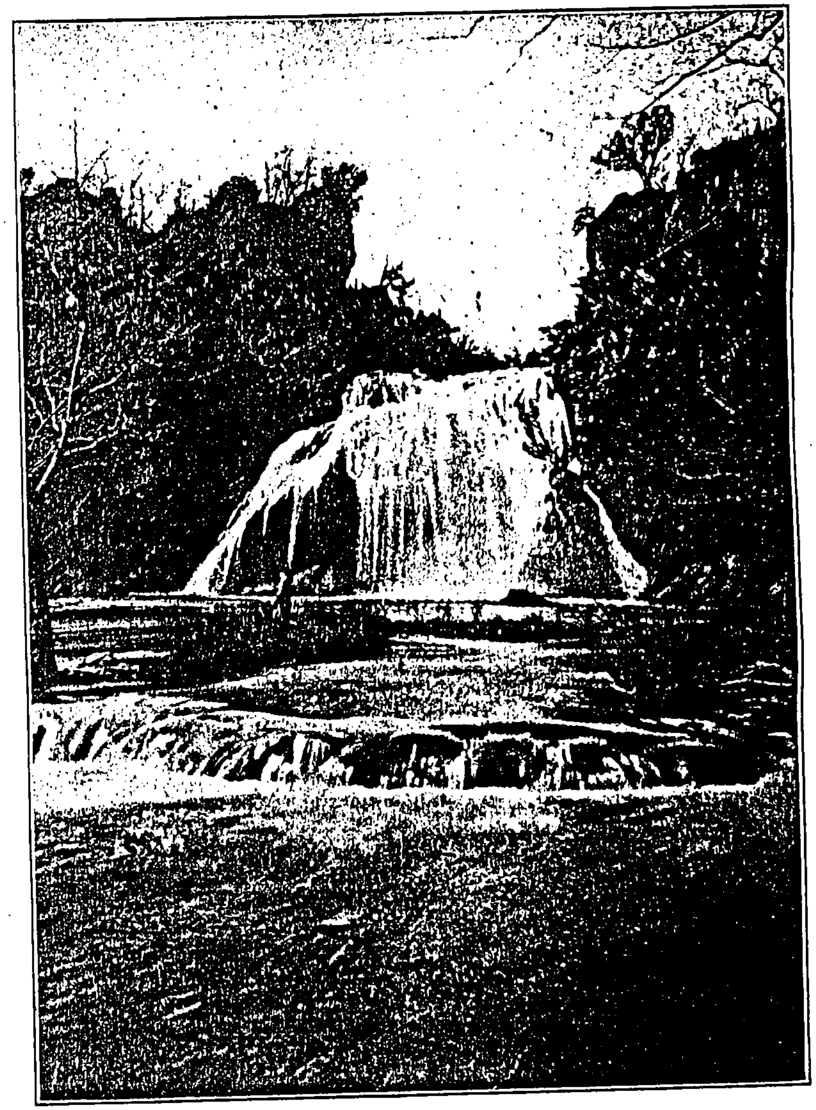
	Thickness in feet
Caney shale, (Mississippian-Pennsylvanian), black and green clay shale	1,600
Sycamore limestone, (Mississippian), lenticular mass of blue limestone	0 to 200
Woodford chert, Devonian (?), black shale and brown chert in alternating layers	650
Frisco limestone, Devonian, massive bedded coquina-like	20
Bois d'Arc limestone, Devonian	0 to 190
Haragan shale, Devonian	0 to 166
Henryhouse shale, Silurian	0 to 228
Chimneyhill limestone, Silurian	0 to 53
Sylvan shale, Silurian	60 to 300
Viola limestone, Ordovician	500 to 700
Simpson formation, Ordovician shales, sands and limestones	1,200 to 2,000
Arbuckle limestone, Cambrian and Ordovician	4,000 to 6,000
Reagan sandstone, Cambrian	0 to 500
Granite and related rocks, pre-Cambrian age.	

The surface of the Arbuckle Mountain region is in general a plateau, sloping from an elevation of 1,350 feet in the western part to one of 750 feet in the eastern. The plain is considerably dissected by erosion. The effects of the erosion are greatly influenced by alternation of hard and soft strata, and by the structure of the rocks. The hard formations stand out as mountains or ridges, and the softer ones form valleys. The width of the ridge or valley produced by a given formation depends upon the position of the strata, which varies from nearly horizontal to vertical. The highest elevations in the region are two mountains of granite porphyry west of Washita River, known as East and West Timbered Hills. These hills reach an altitude of about 400 feet above their bases. The hills and ridges are mostly grasslands, while the valleys are timbered.

The drainage of the Arbuckle Mountain region is into Washita River, which flows almost directly across the region from north to south. In the lower part of its course through the mountains the river has cut a narrow gorge between hills of limestone rising about 300 feet above the water level. (See Pl. I). The principal tributaries of the Washita from the west are Colbert, Honey, Falls, Cool, and Caddo creeks. The last named creek flows entirely outside the mountain area but receives from the north the drainage

from the southern slope of the mountains through Dalton, Spring, Hickory, Henryhouse, and Tulip creeks. From the east and northeast the Washita receives the waters of Mill, Rock, Pennington, and Cedar creeks, and of Blue River, all of which have the major portions of their courses within the mountian area. All the streams of the region are clear and rapid-flowing. Many of them, especial-

PLATE IX



TURNER FALLS IN THE ARBUCKLE MOUNTAINS
Note the cliffs of travertine on both sides of the falls.

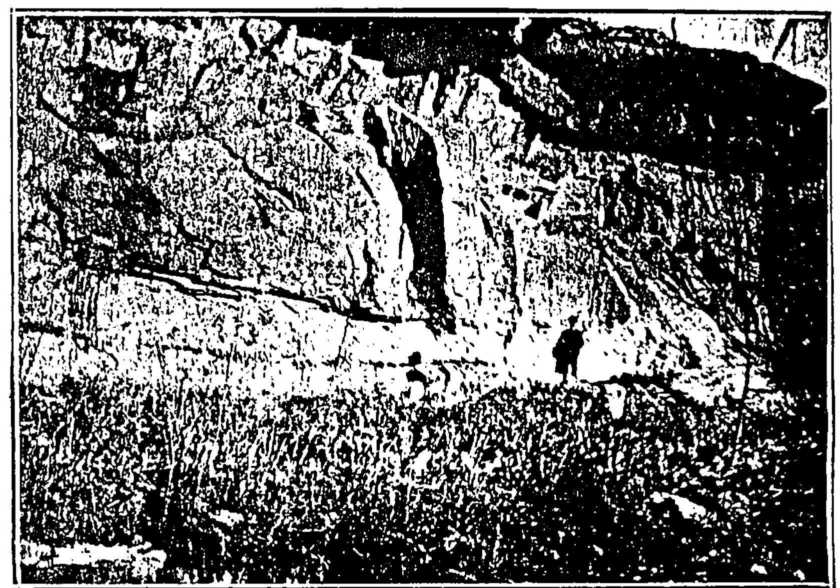
ly those west of the mountains, have many beautiful waterfalls. Turner Falls on Honey Creek and Price's Falls on Falls Creek, southwest of Davis, are probably the best known of these falls. The drainage of the area underlaid by Arbuckle limestone is largely underground. Sinkholes are numerous, and very large springs, the mouths of underground streams, occur along the principal drainage channels. In its underground course through the Arbuckle limestone the water dissolves large quantities of calcium carbonate, which is precipitated as travertine when the streams flow on the surface. Especially large deposits of travertine have been formed at Turner Falls on Honey Creek, and at the numerous small falls on Falls Creek. In general, the larger tributaries of the Washita in this region flow across the strike of the rocks, while the secondary streams flow in the valleys formed parallel to the strike of the softer formations. Artesian water conditions are found in several localities, due to the steep dip of the formations. The artesian water is generally highly charged with minerals, as is also the water of many of the true springs of the region. The best known mineral waters occur in wells and springs at Sulphur and Bromide.

The soils of the region are generally thin. Locally, on the granite areas, the soil is of sufficient depth to permit farming and is quite fertile. The limestone outcrops are in most places washed almost clear of soil and are suitable only for grazing land. The shale outcrops and the narrow stream valleys have a fairly deep soil and support a small farming population.

Agriculture and grazing are the principal industries. As has been stated, the valleys are farmed to a considerable extent, while practically all of the hill land is pastured. Efforts have been made to develop the mining industry ever since white men settled in the region. Gold and silver have been reported in paying quantities at several localities and considerable excitement has been produced at different times by these reports. However, up to the present time, no paying deposits of gold, silver, or copper have been found, although all three metals certainly exist in very small quantities. Zinc has been found in commercial quantities near the West Timbered Hills west of Davis. This zinc is, as a rule, finely disseminated through the rock making the ore difficult and expensive to mine. This, and the distance from transportation and fuel supplies, makes the utilization of the ores impracticable except at times when the price of zinc is unusually high. The mountains contain inexhaustible supplies of limestone and granite for building purposes. However, the limestone is not especially adapted to quarrying and in most places is so badly jointed and cracked by the movements which the strata have undergone that it cannot be obtained in large blocks. It is utilized for crushed

stone at two plants near Crusher on the Gulf, Colorado & Santa Fe Railway in the gorge of Washita River. (See Pl. I). The granite has been quarried for building stone north of Tishomingo and for crushed stone at Ravia. Granite gravel and "rotten" granite have been used at Tishomingo and near Mill Creek. Some of the sandstone members of the Simpson formation are practically pure quartz sand and are well adapted for use as glass sand. The quantity of this substance available in the region is enormous but it has been utilized so far only at Roff and Hickory, where sand washing plants have been operated for the past few years. Large deposits of asphalt occur in the mountains and also in the rocks immediately surrounding the mountains. The deposits at Buckhorn and Gilsonite near Sulphur, and at Woodford, northwest of Ardmore and near Ada, have been worked intermittently for several years. The limestone and shales are locally adapted for use as materials for the manufacture of Portland cement. The cement plant at Ada secures its material from the Viola limestone and Sylvan shale southwest of that town.

PLATE X



GLASS SAND IN THE SIMPSON FORMATION, BROMIDE

Transportation facilities in the region are poor. The Gulf, Colorado & Santa Fe Railway crosses the mountains from north to south through the gorge of Washita River. A main line of the St. Louis & San Francisco Railroad crosses from north to south, an average distance of about 20 miles to the east of the Gulf, Colorado & Santa Fe line. For the greater part of its course through the mountains it utilizes the divide between Mill Creek and Rock Creek. The Ardmore branch of the Chicago, Rock Island & Pacific parallels the southeastern edge of the mountains between Olney and Randolph, crossing the extreme southeastern extension between Wapanucka and Fillmore. State Highway No. 4, (U. S. National Highway No. 77), is a direct route across the Arbuckle Mountain region of south-central Oklahoma. The completion of this important road will mark an advancement in making more complete the highway which is the most direct route across the State from north to south. Country roads are, in general, unimportant lanes, on section lines only in the flatter portions of the region. The population of the region as a whole is sparse. There are no large towns within the mountains. Davis, Sulphur, Ada, Wapanucka, and Tishomingo are located around the margin of the region and draw a considerable portion of their trade from the mountain area.

WICHITA MOUNTAIN REGION

The Wichita Mountains consist of ranges and groups of hills extending from Lawton in Comanche County north and west across Kiowa County to Granite in Greer County. The length of the area from east to west is about 60 miles, and the width from north to south is about 25 miles. The long axis of the Wichita Mountains is in approximately the same direction as that of the Arbuckle Mountains and the two uplifts were undoubtedly produced by the same set of forces.

The rocks of the Wichita Mountain region are of the same general nature as those in the Arbuckle region. However, the red beds were deposited much higher, relatively, on the Wichita Mountains than on the Arbuckle Mountains, so that nearly all of the Paleozoic rocks are covered and only the highest portions of the granite mountains protrude above the plain formed by the level line of the red beds. Nearly all of the hills forming the group are composed of granite or other igneous rock. In the northeastern part of the region there are small areas of Reagan sandstone hills, of Arbuckle limestone covering considerable area, and three small mountains or knobs of Viola limestone. These formations are, in general, very similar to the formations of the same name in the Arbuckle Mountains, so it is presumed that the other formations of the Arbuckle region are present in the Wichita region, but buried beneath the red beds.

The Wichita Mountains proper comprise a considerable area extending from Fort Sill north of west to Cooperton. The moun-

PLATE XI

WICHITA MOUNTAINS, NEAR FORT SILL

tains are composed principally of a granite which is fine to medium-grained, and generally of a pink color. The extreme southeastern portion of the mountains is composed of porphyry, and considerable areas along the northern boundary and some isolated areas within the mountains are composed of gabbro or closely related igneous rocks. The mountains rise abruptly from the flat red beds plains. Some of the higher peaks have received distinctive names, such as Mount Scott, Mount Sheridan, Saddle Mountain, Haystack Mountain, and Mount Baker. These rise from 700 to 900 feet above their bases. To the west of the Wichita Mountains proper are many isolated peaks and ridges of granite and gabbro or related rocks rising above the red beds plains. The most important area of gabbro west of the Wichita Mountains lies around the town of Cold Springs, while the largest granite area is near the town of Lugert. Many of these isolated peaks or ridges have been given local names, among which are Navajo, Twin, Little Bow, Teepee, Dome, Devil's Canyon, Quartz, and Headquarters mountains. Some of these rise to elevations of 300 to 500 feet above the plains, but no one of them is so high as the more important peaks of the Wichita Mountains proper. The central portion of the Wichita Mountain group is sometimes called the Raggedy Mountains.

The drainage of the region is south into Red River. The North Fork of Red River crosses the western part of the area and receives the drainage of a considerable area. Its principal tributaries in the region are Teepee and Elk creeks. The northeastern portion of the mountains is drained south through a number of small streams into Red River, while a small area in the northern part of the mountains is drained north through tributaries of

Washita River. All these streams lie partly in the mountains proper and are in the granite areas, but the greater part of their courses is in the red bed plains surrounding the granite.

The soils of the greater part of the whole region belong to the red beds plains rather than to the mountains, strictly speaking. The granite peaks are, in general, washed almost or quite free from soil. In the large granite area of the Wichita Mountains proper some of the stream valleys contain sufficient soil for farming, but in general the hills are bare, or support a scanty growth of trees. The greater part of the Wichita Mountains proper is included in the Wichita National Forest and Game Reserve. Considering the region as a whole, agriculture is by far the most important occupation; but if only the granite or limestone areas are considered, agriculture is not of very great importance. The soil from the gabbro and related rocks is much deeper and richer than that of the granite and in these areas farming is of more importance. Reports of the finding of gold and silver in commercial quantities have been circulated at various times and the mountains have been the scenes of great excitement. The amount of money expended in attempting to find gold and silver in this area probably totals hundreds of thousands of dollars, but so far no returns have been received from this expenditure. Gold, silver, and copper are known to occur in small quantities at various localities, but, so far, none of the deposits have proved to be of commercial importance. The granites and gabbros have been quarried for building and monumental stone at several localities near railroads. The quarrying industry is described fully in Bulletin 20 of the Oklahoma Geological Survey.

The main line of the Chicago, Rock Island & Pacific Railway passes near the eastern end of the mountains, one branch of the St. Louis & San Francisco Railroad parallels the southern border of the area, and another branch of the same system crosses it from north to south, west of the center. The Kansas City, Mexico & Orient, and the Mangum branch of the Chicago, Rock Island & Pacific cross the northwest portion of the area. The granite and limestone areas of the region are very sparsely settled. The flat land between the ranges and peaks supports a good farming population, but these areas are a part of the red beds plains rather than of the mountains themselves.

RED RIVER (CRETACEOUS) REGION

This area lies in the southeastern part of the State, between the Arbuckle and Ouachita mountains on the north and Red River on the South. The length of the area from east to west is about 170 miles, and its greatest width is about 45 miles, although the

average width is considerably less than that amount. The area includes all of Marshall, Bryan, and Choctaw counties, nearly all of Love County, and parts of Carter, Johnston, Atoka, Pushmataha, and McCurtain counties.

The rocks of the Red River area belong to the lower Cretaceous or Comanchean system. They are the northeastward continuation of the great belt of rocks of this area which extends southward through central Texas and far into Mexico. They consist of sands, shales, and limestones. The complete section is as follows:

Geologic Section, Red River Region, Oklahoma

	Thickness in feet
Silo or Woodbine sandstone, brown fr'able sandstone, locally hardened by iron cement with some shale and shaly limestone	500
Bennington limestone. Blue shell limestone	10-15
Bokchito formation. Red and blue shale with thin limestone and soft sandstones	140
Caddo limestone. Yellow and white limestone with thin, marly beds	60
Kiamichi formation. Soft blue shale with thin beds of shell limestone in the lower part	150
Goodland limestone. Massive white limestone	25
Trinity sand. Fine gray to yellow unconsolidated sands with conglomerate beds locally at the base	200-1,528

The rocks outcrop in parallel east-west belts.

The general structure of this region is that of a monocline dipping very gently to the south and southeast. The rocks lie on the sharply upturned edges of the much older rocks of the Arbuckle and Ouachita mountain regions which pass southward under the nearly level-lying lower Cretaceous rocks. The general dip to the south and southeast is about 20 to 30 feet to the mile. This dip is interrupted locally by gentle folding. While the region has not been worked in detail, at least two folds are known in the region. One anticlinal fold extends north of west from the vicinity of Madill, and another parallels it at a distance of 6 or 8 miles to the south. Further work in the region is likely to show the presence of more of these folds. The surface of the region is comparatively smooth. The alternation of hard and soft strata produces stairstep topography, with the limestones forming steep northward-facing escarpments and having gently-dipping slopes to the south and southeast. In the broad belt of Trinity sand around the northern margin there are several deep canyons.

The drainage is entirely to the south and southeast into Red River, which forms the southern boundary of the region. Washita, Blue, Kiamichi, and Little rivers, and Boggy Creek are the principal streams. The streams in this region have rather a low gradient and as a rule fairly steep mud banks. Underground water is found principally in the Trinity sand, which forms a great artesian reservoir for the southern part of this region and over large areas southward into Texas. The water in this sand is usually of exceptional purity.

The soils of the region are principally deep, black soils, formed by the decomposition of the limestones and marly shales which comprise the greater part of the geologic section. Around the northern margin is a belt of as much as 10 miles in width, of very sandy soil, the product of the Trinity sand. In the extreme southern part, along Red River, are considerable areas of very red, sandy clay soils which have been deposited by, or have been blown from, Red River in comparatively recent times.

The deep, black limestone soils make this region one of the most fertile in the State and agriculture is by far the most important industry. Even the sandy soils on the outcrop of the Trinity sand are quite fertile and are farmed to a large extent. Cotton is the principal crop, although corn and some wheat are grown profitably. The sandier portions of the region are timbered and lumbering is an industry of some importance. Several of the smaller towns are important lumbering centers, but the majority of the timber comes from the Ouachita region to the north rather than from the limestone area. The mineral industries are of little or no importance. The limestones are used on a small scale for local purposes, but have not been quarried and shipped. Most of the clays contain too much lime to be of value in clay products. Some asphalt deposits are known but none of sufficient size to be commercially important. Oil was found several years ago at Madill, but the pool proved to be very small. The oil is exceptionally high grade and in spite of the small production the wells at Madill are still being pumped. Some gas has been found at Enos and Lark in the southern part of Marshall County. Small quantities of a very heavy oil have been discovered near Mannsville.

Two lines of the St. Louis & San Francisco and the main lines of the Missouri, Kansas & Texas, of the Gulf, Colorado & Santa Fe, and of the Missouri, Oklahoma & Gulf railways cross the region from north to south. A line of the St. Louis & San Francisco extends east from Ardmore nearly the full length of the region. A short line of railroad extends from Valliant to Broken Bow. In wet weather the roads over the limestone belts off of the main highways are almost impassable, but the area can boast of a fine system of paved and graveled highways connecting the important centers of population.

This region is comparatively thickly populated on account of the agricultural value of the territory. A great deal of the land belongs to the members of the Choctaw and Chickasaw Indian tribes, and a large portion of it is not highly improved.

SANDSTONE HILLS REGION

The Sandstone Hills region is not sharply marked off from the surrounding areas. The limestones, whose outcrops form the Prairie Plains region to the east, die out to the south and west and their place is taken by shales and sandstones. The amount of sand, both relative and absolute, increases tremendously to the south. There is thus a transition from the Limestone Hills region to the Sandstone Hills region. To the west the region grades imperceptibly into the Red Beds plains, so this boundary must also be arbitrary. For practical purposes the line of the eastern Oklahoma branch of the Atchison, Topeka & Santa Fe from Pauls Valley to Shawnee, and a line drawn from Shawnee to Pawnee and thence north to the State line may be taken as the western boundary. To the south the region is set off rather sharply from the Arbuckle Mountain region. The area as thus outlined includes all or parts of Coal, Pittsburg, Latimer, McIntosh, Garvin, Pontotoc, Hughes, Okmulgee, Tulsa, Creek, Okfuskee, Osage, Pawnee, Payne, Lincoln, Seminole, and Pottawatomie counties.

The rocks of the region consist principally of alternating sandstones and shales. Detailed sections of stratigraphy of the region are given in Bulletin 35, Oklahoma Geological Survey. The formations thin to the north and the sandstones disappear, while limestones come into the section.

The rocks of this region have a general westward and northwestward dip which increases gradually from the Kansas-Oklahoma line to the south. Along the State line the amount of dip is probably not over 30 or 40 feet per mile. The westward dip is interrupted in many places by gentle folding, many of the folds being important reservoirs for oil and gas. Of these the best known is that east of Cushing, the famous Cushing oil and gas field.

The surface of the region is rough. The shales weather very rapidly leaving the sandstone ledges forming pronounced escarpments and hills. The sandstones are of sufficient thickness to produce large blocks which cover the tops and slopes of the hills. The hill lands have elevations of from 300 to 1,500 feet above the lowlands. The soils of the region are as a rule fairly fertile, though the soils of the region outside of the larger stream valleys are rather poor. The hills in the southern part of the region which are composed largely of the Savanna sandstone and are entirely too rough for farming purposes, so are of value only for grazing. All except the very roughest portions are covered with timber, but the growth is too scrubby to be of much value. The broad flat outcrop of the McAlester shale and the more level portions of the outcrop of the Atoka formation give a prairie country, but the natural drainage is poor and the soils are very tight clay soils of low fertility. Although farming is carried on to considerable extent on this flat plain, the poorer portions are left in pasture. The broader stream valleys and some of the narrower valleys in rougher parts have fairly fertile soil and practically all such areas are in farms.

While agriculture and grazing must be considered as important industries of the region as a whole, locally the mining of coal is far more important. Important beds of workable coal are present in the McAlester and Hartshorne formations, and less important beds in the Boggy shale. All these beds are mined at different localities, and practically all of the coal mining industry of the State is centered in this region and the Prairie Plains region. The Wapanucka limestone, which extends along the southern boundary of the region, is used for crushed stone at Limestone Gap and Hartshorne. Natural gas has been found at Coalgate, near McAlester, at Red Oak, Stigler and Poteau.

The principal mineral resources are oil and gas which are found in enormous quantities. The Cushing pool, which has already been mentioned, the Paden pool in Okfuskee County, the many pools in Osage County, pools in the vicinity of Sapulpa and Tulsa, including the famous Glenn Pool, and many other fields, are all located within this area. The shales are in many places suited for the manufacture of clay products and have been utilized for brick at Sapulpa, Tulsa, Pawhuska, Ada, Cleveland, and other places. The sandstone has been used in local buildings but is not of great value as a building stone.

Transportation facilities are good. The lines of the Chicago, Rock Island & Pacific; St. Louis & San Francisco; Missouri, Kansas and Texas; Atchison, Topeka & Santa Fe; Fort Smith & Western; and the Midland Valley afford connections in all directions. The highways are practically all hard surfaced or improved.

The population is sparse in the hilly regions and comparatively dense in the level regions of good farming lands. The distribution of the population is affected rather markedly by oil and gas, and the cities in the area owe a great part of their growth to the petroleum development in their neighborhood. Tulsa, Sapulpa, Cushing, and Drumright are outstanding examples. Ada has natural gas and some important factories. The towns in the southern portion of the area are trading places supported by the population of their immediate vicinity.

PRAIRIE PLAINS REGION

This region comprises a narrow belt on the west side of the Ozark Mountains and to the north of the Ouachita Mountains. It is the eastern portion of the area of Pennsylvanian rocks. It comprises all or parts of Nowata, Craig, Washington, Tulsa, Rogers, Mayes, Wagoner, Muskogee, McIntosh, Sequoyah, Haskell and Le Flore counties.

The rocks of the region consist principally of shales and limestones, with some sandstones of Pennsylvanian age. The stratigraphy is rather complicated on account of the dying out of the limestones southward from the Kansas line, and the increase in the thickness of the shales, and the coming in of sandstone in the same direction. The structure is in general a monoclinal slope to the west and northwest, away from the Ozark Mountains. The average dip varies from about 30 feet to the mile near the Kansas line to 50 to 60 feet to the mile in the southern portion of the region. The general dip is interrupted in many localities by gentle folding and terracing. Practically all the anticlinal folds have proved to carry oil and gas and these have been studied in great detail.

The surface slopes to the south and east. The alternation of hard and soft strata, combined with the prevailing west dip, gives rise to a stairstep topography with the limestones and sandstones forming eastward facing escarpments with gentle slopes to the west and with broad valleys underlain by shale separating the limestone ridges. The drainage is into Arkansas River. Practically all of the area is drained into the Arkansas through the Verdigris and Caney, its principal tributaries. These are rather sluggish streams with steep mud banks through the greater part of their courses. Ground water is not very abundant, but is found in the sandstone beds which occur in the shales in sufficient quantities for local use.

The soils are fairly deep and of moderate fertility. On the limestone scarps the soil is very thin, but there is usually a sufficient amount to support a good growth of grass.

Farming is the principal permanent industry of the region. The flat prairies on the shale outcrops are especially noted for their production of a fine grade of prairie hay or native wild grass. This is the principal agricultural industry in eastern Rogers, Nowata, and western Mayes counties, and the greater part of Craig County. Cotton is raised in the southern portion.

RED BEDS PLAINS REGION

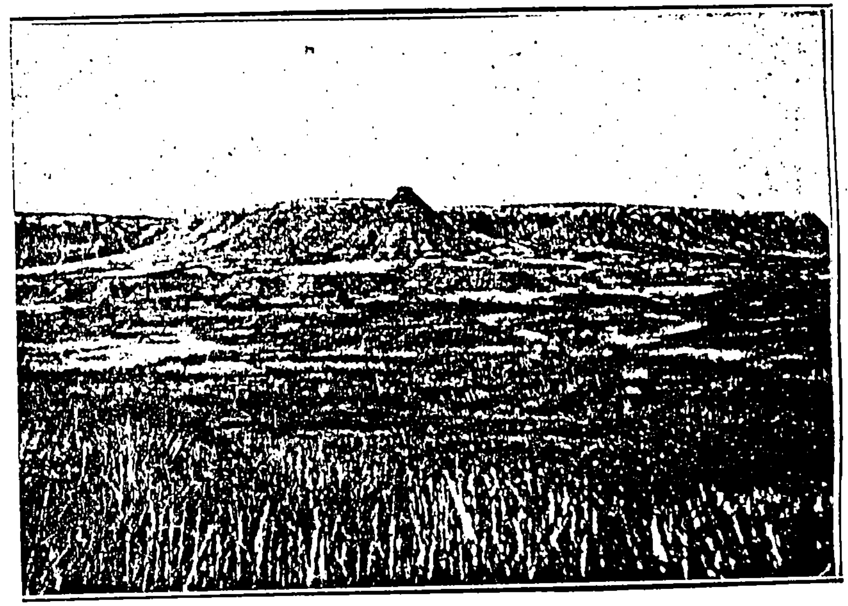
This region is limited on the east by the Sandstone Hills region and on the west by Gypsum Hills. It extends entirely across the State in a north-south direction, widening toward the south and entirely surrounding the Wichita Mountain region which has been described. As considered here, the region includes all or parts of Kay, Pawnee, Noble, Payne, Lincoln, Logan, Pottawatomie, Oklahoma, Cleveland, McClain, Garvin, Carter, Jefferson, Stephens, Cotton, Tillman, Comanche, Kiowa, Caddo, Grady, Canadian, Kingfisher, Blaine, Major, Garfield, Grant, Alfalfa, and Woods counties. This region has not been investigated geologically to the extent that the areas to the east have been. United States Geological Survey Water Supply Paper No. 148, by Chas. N. Gould, deals with the stratigraphy and water resources of a considerable portion of the area. New available information in regard to the geology of the region is to be had in Oklahoma Geological Survey, Circ. 13, The Permian of Western Oklahoma and the Panhandle of Texas, by Chas. N. Gould, and Frank E. Lewis.

The rocks of the region are soft red shales with thin red sandstones, which are, as a rule, quite soft and do not produce pronounced escarpments. The greater part of the area is included in the outcrop of the Enid formation of the Permian system, which formation consists of a great thickness of red clay and soft shales with thin sandstones. The exact thickness is not known but varies probably between 1,200 and 1,600 feet. In the lower part of the formation, that is, the eastern part of the area, sandstones are much more abundant than higher in the section. Some red sandstones with smaller proportions of shales in the eastern part of the area belong to the Pennsylvanian system and are equivalent to non-red formations of the Sandstone Hills region farther north. An area comprising most of Kay County is included in this region. The general physiographic features are the same as in the rest of the region. The rocks, however, are non-red limestones and shales of Permian age. To the south these grade into red rocks.

The surface slopes to the south of east. In general it is a slightly rolling plain. The streams have cut only shallow, narrow channels and the ridges between the stream courses are broad and flat-topped. Only in the eastern portion (in the area where the Red Beds Plains region grades into the Sandstone Hills region) is there any great relief. Over most of the area the elevation of the hills above the streams at their base is not much more than 100 feet. The extreme eastern portion is covered by a growth of blackjack oak. Over the most of the area trees, principally elms and cottonwoods, occur only along the streams.

The drainage of the greater part of the area is to the south of east into Arkansas River through Salt Fork, Cimarron, North Canadian, and Canadian rivers. The streams are typical plains streams, flowing in broad, shallow valleys with sand-choked chan-

PLATE XII



BAD LANDS TOPOGRAPHY IN THE RED BEDS PLAINS REGION

nels. All of them have considerable areas of sand dunes along their courses. The streams are closely spaced and their tributaries within this areas are short and unimportant. The southern portion of the area is drained into Red River through several small tributaries, among which are Deep Red Run, Cache, Big Beaver, and Mud creeks, and Walnut Bayou. An area in the south-central part is drained by Washita River and its tributaries, Little Washita, Rush, Wildhorse and Caddo creeks.

The soils of the regions are in general of considerable depth and of medium to great fertility. Practically the whole region is in farms. All the standard farm crops are raised in abundance, cotton being the principal crop in the southern portion and wheat in the northern. Corn is grown throughout the area, but is not so dependable a crop as it is farther east on account of the lighter rainfall. The sorghums (cane, kafir, milo maise, and feterita) are grown extensively. The proportion of these crops to corn increased across the area from east to west. Stock raising is an important industry throughout the area, and considerable acreage in the rougher portions is devoted to pasturage. Oil and gas are found in most of the counties located within the region and prospecting is being carried on in other parts. There are no mineral industries except the manufacture of brick from the red clay shale in a few localities.

Railroad transportation is afforded by the lines of the Atchison, Topeka & Santa Fe; Chicago, Rock Island & Pacific; and the St. Louis & San Francisco railways in a north-south direction, and by branches of the same systems to the east and west. The country roads are laid out on section lines and are among the best in the State. The red clay soil usually contains a sufficient proportion of sand to produce a natural sand-clay road, which is good at almost all times in the year. With a very moderate amount of work these roads can be kept in first class condition. The local transportation in the Sandstone Hills region is a difficult problem, but no part of the region is far enough removed from clay banks to make the claying of the roads expensive.

This region is the longest settled portion of the State, and the population is fairly dense and well established. It is almost entirely an agricultural community and the towns are principally trading centers. Oklahoma City, Guthrie, El Reno, Lawton, Shawnee, and Enid are the only cities within the area with any important manufacturing industries. Newkirk, Chickasha, and Blackwell are near oil and gas fields and have some industries located on this account. Other important county seat towns and trading centers are Alva, Cherokee, Perry, Stillwater, Kingfisher, Chandler, Anadarko, Altus, Hobart, Norman, Pauls Valley, Purcell, and Duncan.

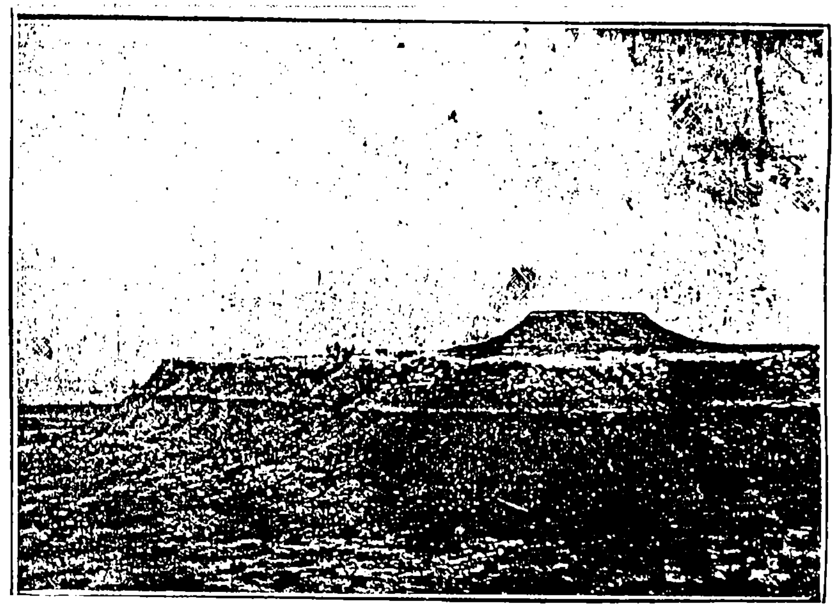
GYPSUM HILLS REGION

This region lies immediately west of the Red Beds Plains region, and in general characteristics is very similar to that region. It is separated from it on account of the presence of important ledges of gypsum which produce somewhat rougher topography than prevails in the Red Beds Plains region. It contains all or parts of the following counties: Woods, Harper, Woodward, Major, Dewey, Blaine, Canadian, Custer, Washita, Beckham, Greer, Harmon, Jackson, Kiowa, Comanche, and Caddo.

The rocks of the region, belonging to the red beds of the Permian system, are described in Circular 13, Oklahoma Geological Survey.

The structure of the region is not complex. In the eastern portions the rocks have a very gentle westward dip. Over the greater part they are practically level, and in the western portion have a gradual eastward dip. In other words, this region lies at the bottom of the great geosyncline between the Arbuckle and

PLATE XIII



GYPSUM HILLS TOPOGRAPHY IN THE BLAINE FORMATION
Three distinct beds of gypsum are exposed in this area

Ozark Mountains on the east and the Rocky Mountain uplift on the west. In the southern portion of the area the Wichita Mountains interrrupt the general structure and the red beds dip gently away from the mountains in all directions.

The Anadarko Basin is the major structural feature of this area. It is a broad trough or basin occurring north of the Wichita Mountains in western Oklahoma. The axis of this basin reaches from northeastern Stephens County, a few miles northwest of the west end of the Arbuckle Mountains, in a southeast-northwest direction across Grady, Caddo, Washita, Beckham and Roger Mills counties and on into the Panhandle of Texas.

The surface of this region is in general a plain into which the streams have cut channels which are not of great depth, but are deeper than the channels in the Red Beds Plains region to the east. The greatest relief is in the northern portion, where the streams have cut narrow canyons varying from 200 to 400 feet in depth in the gypsum formations, which rise as very sharp, flat-topped scarps, facing to the northeast above the level plain of the Red Beds region. In the central portion of the gypsum region the surface is rolling, the irregular gypsums producing round hills rather than the steep, continuous escarpments such as are described above. In the southern portion the gypsums are continuous and give a steep escarpment which is especially noticeable along North and Elm Forks of Red River.

The surface as a whole slopes to the southeast, rising gradually from the eastern margin of the area to the westward.

The drainage of most of the area is through the same streams as that of the Red Beds Plains region. The Salt Fork of Arkansas River, Cimarron, North Canadian, Canadian, and Washita rivers drain the greater part of the region. All except the Washita are typical plains streams with sand-choked channels and broad belts of sand dunes along their courses. The Washita carries much less sand, and as a rule has steep mud banks. The southwest portion of the Gypsum Hills region is drained south into Red River through North Fork, with Elm Fork and Salt Fork as its principal tributaries. The underground water in the Gypsum Hills region as well as in the Red Beds Plains region is of irregular occurrence and generally of poor quality, except in the sand hills areas where springs are abundant, especially at the contact of the sand and the red beds.

The soils of the Gypsum Hills region are very similar to those of the Red Beds Plains region. On the outcrop of the gypsum formations the soil usually contains a considerable percentage of gypsum but seldom sufficient in amount to be harmful.

Agriculture and grazing are the only important industries. The crops are in general the same as those in Red Beds Plains region farther east, but the decrease in average rainfall to the west causes more of the land to be devoted to pasture. Dry farming is practiced extensively and corn is largely replaced by sorghums, especially toward the northwestern part of the area where milo maize is the principal grain and forage crop. Cotton is the staple crop in the southern part of the area, and wheat in the northern part. The important mineral resources are gypsum and salt. The gypsums are suitable for the manufacture of plaster, and several plants have been established in the region, located at Watonga, Southard, Bickford, Okeene, Darrow, Alva, Rush Springs, and Eldorado. The supply of gypsum is inexhaustible, but the distance of the deposits from large building centers and adequate fuel supply makes the marketing conditions difficult.

Large springs of salt water come from the red beds rocks below the gypsum ledges at several localities in the region. At a few localities the springs supply sufficient brine to produce enormous quantities of salt if it were utilized. Cherokee salt plain in Alfalfa County, Little and Big Salt Plains on Cimarron River between Woods and Harper counties, the salt plain near Carter in

Beckham County, and the Chaney and Kiser salt plains on Elm Fork of Red River in Harmon County are the most important of these localities. The salt at each of these places forms incrustations over the valley floors, sometimes to a thickness of several inches. The amount of brine furnished by the springs is difficult to estimate but it is sufficient to make many carloads of salt daily. However, the larger plains on Cimarron River and Elm Fork are far removed from railroads and the salt is utilized only in a small local way. The Blaine County plain on Salt Creek is only four or five miles from the railroad and could be utilized. A plant was erected at Ferguson several years ago but has been abandoned and dismantled.

PLATE XIV

SALT PLAIN IN WESTERN WOODS COUNTY

The population of the Gypsum Hills region is somewhat more sparsely distributed than that of the Red Beds Plains region. Aside from the county seats, there are few towns of over 1,000 inhabitants. With the exception of the gypsum mills and several brick plants, there is practically no manufacturing industry and the towns are simply trading centers for their surrounding neighborhoods. Altus, Mangum, Hobart, Clinton, Fairview, and Woodward are the principal towns. The St. Louis & San Francisco, the Kansas City, Mexico & Orient, and the Wichita Falls & Northwestern railroads cross the region in a north-south direction; and two branches of the Chicago, Rock Island & Pacific, one of the St. Louis & San Francisco, and one of the Atchison, Topeka & Santa Fe cross the region from east to west.

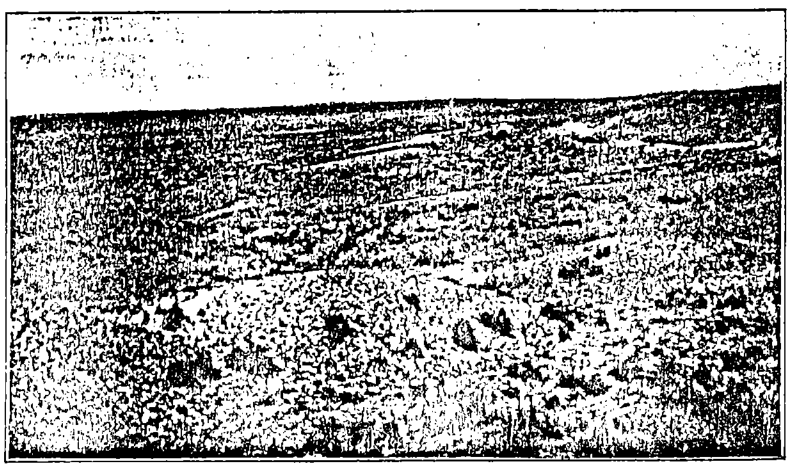
HIGH PLAINS REGION

The High Plains region occupies the extreme northwestern portion of the main part of the State, and all of the Panhandle of Oklahoma. The counties included are Roger Mills, Ellis, Harper, Woodward, Woods, Beaver, Texas, and Cimarron.

The rocks of the region consist of formations of the Permian system, and loose sands, clays, and gravels of Tertiary age. These are rather irregularly distributed and are generally not very thick. Locally they reach a thickness of 400 to 500 feet. Within the Tertiary rocks the distribution of the clay, sand, and gravel is very irregular. The sands and gravels are sometimes well cemented, forming what is known as the "mortar beds" or conglomeratic rock.

The area is located on the eastward-dipping monocline of the eastward slope from the Rocky Mountains. This dip is, however, very moderate. The surface is a plain into which the streams have cut narrow V-shaped canyons. The areas between the streams are broad and flat-topped. The general slope is to the southeast. This is the highest region, topographically, in the State, the maximum elevation being in Black Mesa the extreme northwest portion of Cimarron County. The drainage is through the branches of North Canadian River. Springs are abundant in the Tertiary rocks and the ground water is of excellent quality.

PLATE XV



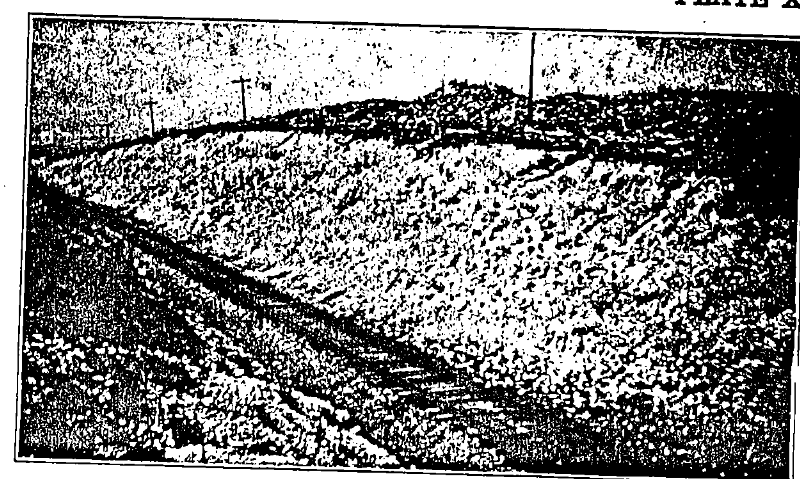
TOPOGRAPHY OF HIGH PLAINS REGION SOUTH OF GUYMON

The soils are of sufficient thickness and fertility to be excellent farming land, but the rainfall is too light to permit extensive farming. The greater part of the region is in pasture. Milo maize is the principal forage and feed crop. Wheat is grown extensively, especially in the eastern portion of the region. Broom corn is one of the leading crops and this section is one of the important producers of this product in the United States. There are no manufacturing industries in the region. The finding of gas in Texas County and oil in Cimarron County will undoubtedly lead to much exploration for these resources from now on in this district.

The region is sparsely settled. Transportation facilities are gradually becoming adequate. The Atchison, Topeka and Santa Fe Railway crosses the southeastern portion of the area; the Missouri, Kansas and Texas Railroad serves eastern Beaver County; the Beaver, Meade and Englewood Railroad extends from Forgan to Beaver and Turpin in Beaver County; and the Elkhart and Santa Fe Railway extends southwestward from the Kansas line to Felt in Cimarron County.

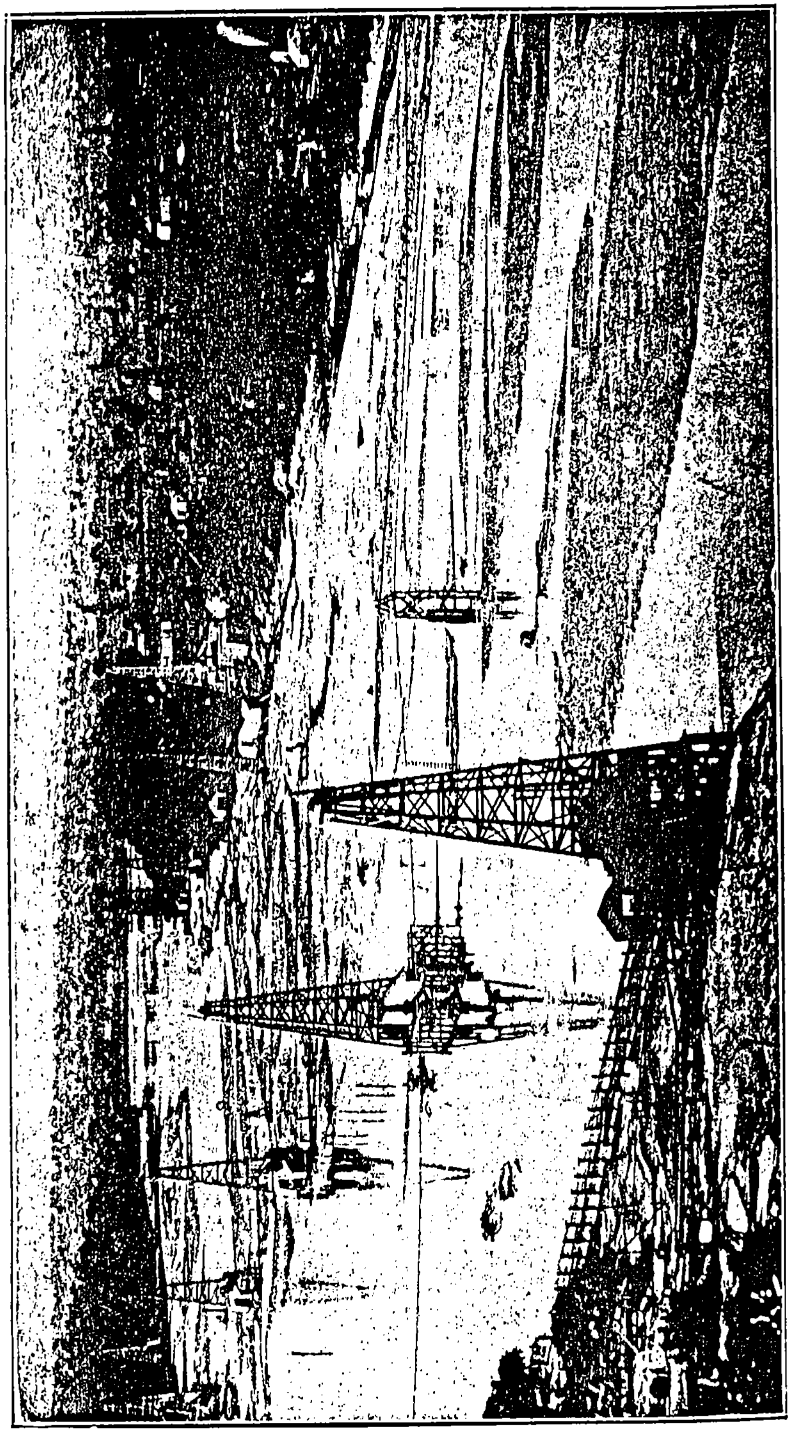
The country roads are mostly on section lines, but many of the section lines have not been opened as highways. The sandy clay soil, together with the caliche, or calcareous clay, of the region, makes a good natural roadbed and with very little work the roads can be kept in good condition. In fact, this region is noted for its excellent natural roads.

PLATE XVI



CALICHE IN RAILROAD CUT BETWEEN GUYMON AND OPTIMA, TEXAS COUNTY

PLATE XVII



CUSHING FIELD

Chapter IV

MINERAL RESOURCES OF OKLAHOMA

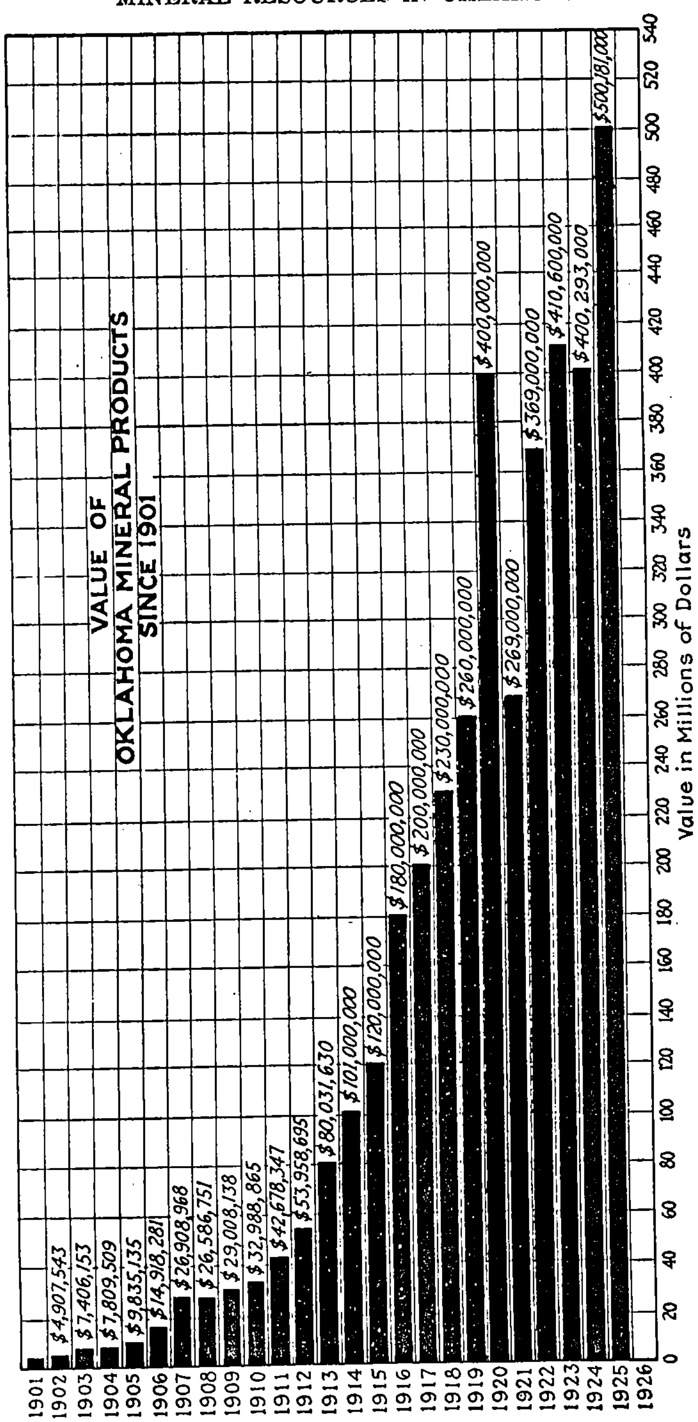
GENERAL STATEMENT

The mineral resources of Oklahoma which are now of greatest economic importance are the non-metallic minerals. Lead and zinc are the only metals which are produced in quantities sufficient to make them of great value, although iron ore occurs in some quantity, and small amounts of manganese, copper, silver, and gold have been found. Petroleum, natural-gas gasoline, natural gas, and coal are the main sources of Oklahoma's mineral wealth. Other non-metallic products, now largely undeveloped, are clay and shale, building stone, crushed stone for concrete and road materials, gravel and sand, Portland cement materials, gypsum, salt, asphalt, and mineral waters. The value of the mineral production from 1901 to 1926 is shown by the accompanying chart.

PETROLEUM

The source of the oil is almost undoubtedly plant or animal matter, or both, which was buried in the rocks as they accumulated at the bottom of the ancient seas. As the muds and sands were hardened by pressure, and finally elevated to their present position, the organic matter in them, being shut off from the air, was subjected to a process of distillation and the series of compounds forming natural gas and petroleum resulted. The small particles making up these compounds, distributed throughout the rocks, gathered together in porous rocks which serve as reservoirs The common porous rocks which contain oil and gas are sandstone and cavernous limestone. Later the folding of the rocks created places in the arches of the folds where the gas and petroleum could collect.

The collection into large bodies is due probably to the difference in the specific gravity (weight) of the gas and oil particles and that of the salt water with which they were associated. The gas and oil, being lighter than water, collect in the highest places they can reach. These are the crests of arches of the gentle folds which are present in the rocks of almost all regions. To accomplish this accumulation, there must be above the porous rock containing the gas and petroleum a tight-grained rock through which they cannot pass. This rock is in most places a shale and is called a cap rock. The arches or crests of the folds in which gas and petroleum may be collected are called anticlines, and the troughs between anticlines are called synclines. The porous rock in which the gas and



(Courtesy of Chemical and Metallurgical Engineering)

petroleum collect is the reservoir rock or oil sand. All these features are shown in the accompanying figure (Fig. 5). In general, the gas accumulates in the tops of the folds, that is, along the crests of the anticlines; the petroleum is found farther down the slope; and the salt water still farther down the slope, and in the synclines. This regular arrangement may be greatly complicated by the difference in thickness and porosity of the oil sand, and other factors.

From the foregoing discussion there appear three qualifications which an area must have before it becomes probable oil and gas area; namely, a source rock, a reservoir rock, and a trap to hold the oil.

Petroleum and natural gas are obtained by drilling wells. The outfit used in Oklahoma is called the standard or "churn-drill" rig. It consists of a derrick 80 feet high or higher, with pulleys at the top, and large windlasses at the base to handle the wire or rope cable. The tools consist of a long drill stem, at the lower end of which is fastened the bit. This is sharpened so that as the stem is raised and lowered a short distance in the hole the rock at the bottom of the hole is chipped or ground away. The ground rock or "drillings" is removed by a bailer, which is a long cylindrical bucket with a valve at the bottom. Besides the derrick there is an engine and boiler to furnish power and gearing, and beams to raise and lower the tools and bailer, and to give an up and down motion to the tools when drilling. Water is kept from entering the hole and the walls kept from caving by "strings" of iron pipe or casing. Wells in Oklahoma are started with casing 12 to 16 inches in diameter. As the well is deepened, the difficulties of drilling increase and strings of smaller casing are placed inside the larger one. There are usually four or more strings of casing in a well when it is finished.

In rotary drilling mud-laden water is pumped under high pressure downward within the rotary drill pipe and forced out through two small openings in the rotary bit against the bottom of the hole. This fluid then returns outside the drill pipe to the surface and brings the borings with it, plastering with mud the unlined walls of the bore-hole en route. The power plant of a rotary outfit, by means of sprocket chains, draw works, geared turntable and drill pipe, gives to the rotary bit a continuous rotary motion. No cessation of drilling operations to bail out the detritus is necessary, as it is with cable tools, because the rotary cuttings are washed out while drilling proceeds.

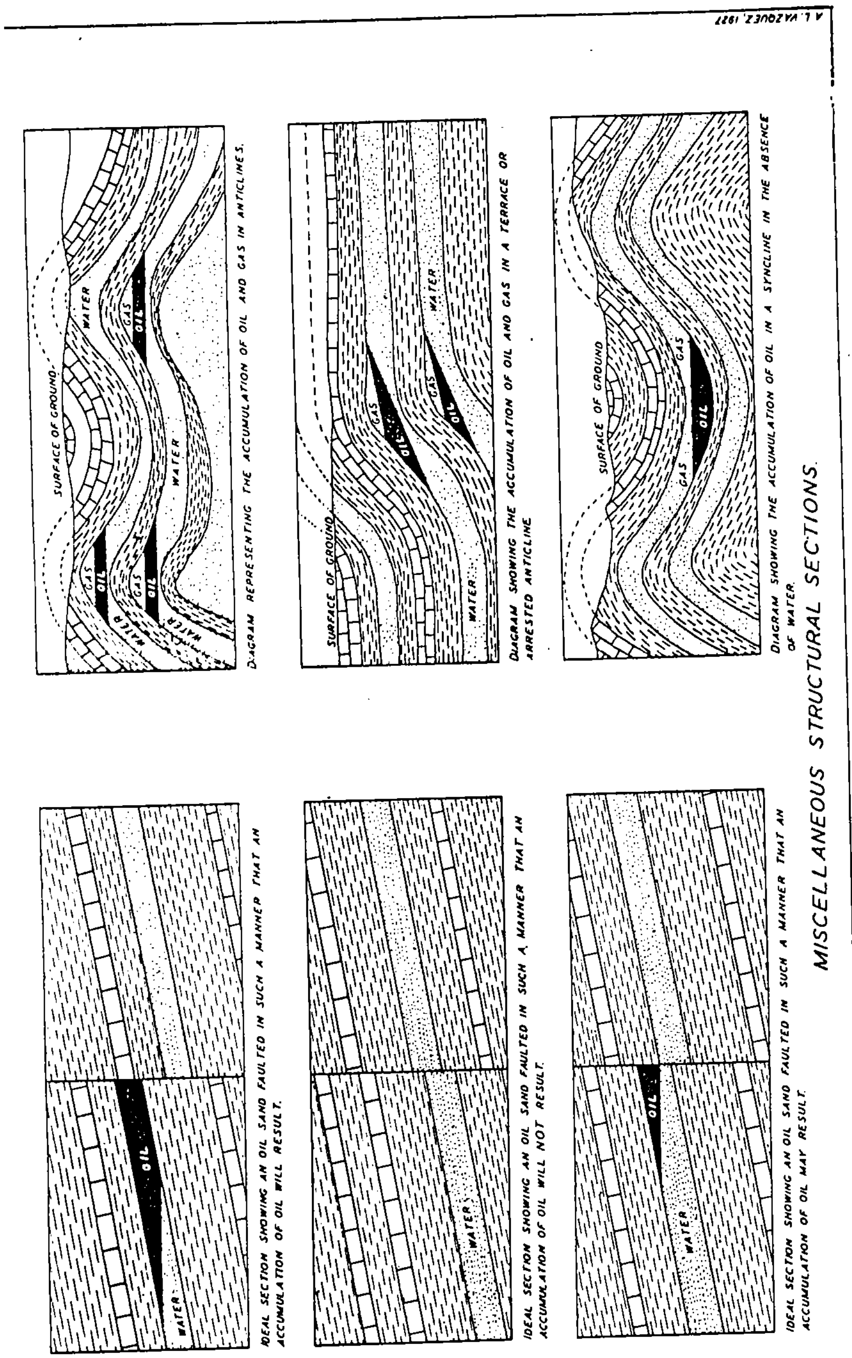


Figure 5. Miscellaneous structure sections.

Wells drilled with rotary machinery require less casing than if drilled with cable-tools, the plastering of the walls being a substitute, in part, for casing. This condition makes it difficult to observe proficiently all changes in formations drilled through, and thus makes the hazard of passing by or mudding off some productive horizon of importance. However, rotary drillers are becoming skilled in detecting slight changes in formations and in evaluating any information obtained from the drillings or from the intonation of the engine and machinery, thus making this hazard negligible.

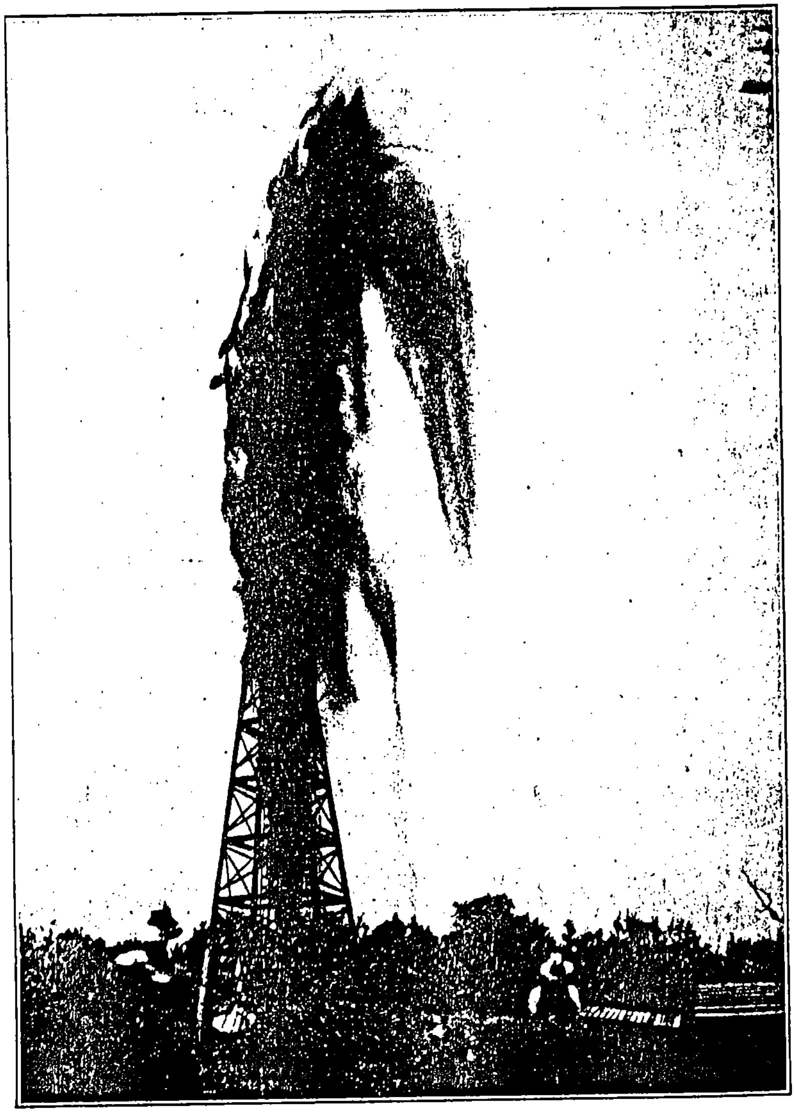
When petroleum is encountered it may flow from the well with great force, making a gusher or flowing well. (Pl. XVIII). Other wells may not flow and may have to be pumped by pumps especially built for this purpose. From the wells the petroleum flows or is pumped into 2-inch pipes which conduct it to large storage tanks or to loading racks along a nearby railroad. From the larger storage tanks it is pumped into large pipe-lines, through which it is conducted to refineries which may be hundreds of miles distant.

The principal petroleum fields of Oklahoma are in the northeastern and east-central parts of the State, in the region of Pennsylvanian rocks. These rocks consist of shales, sandstones, and limestones, which have a general westward dip away from the Ozark uplift in the northeastern corner of the State. The general dip is interrupted in many places by gentle folds, in the anticlinal parts of which the petroleum accumulates. Some of the sandstones and limestones are porous and form the reservoir rocks or "oil sands". The shales are fine-grained and tight and form the cap rocks. Some of the oil sands are of considerable extent. For instance, the Bartlesville sand is known to extend over hundreds of square miles, while others are relatively small, lenticular masses, which are productive only in a single locality.

The productive petroleum and natural gas pools are shown on the map showing location of oil and gas fields, Figure 6, page 74.

The specific gravity of Oklahoma oils varies from 22° to 48° Baume'. The heavier oils are found in the southwestern producing areas of the State. While the amount of oil produced in the Madill region is small, its quality is the highest of any produced in the State. The price of oil is dependent to a large degree upon the specific gravity and the base of the oil; that is, whether the base is asphalt or paraffin, the latter being the more valuable for refining purposes. The oils from the Wheeler and Healdton

PLATE XVIII



FLOWING OIL WELL NEAR TULSA

districts have an asphaltic base, while those of the northeastern part of the State are chiefly of paraffin base. This accounts for the difference in price of crude oil from the two sections.

The Oklahoma petroleums are in general fairly light oils of good refining quality. A large part of the production is refined at plants located within the State. Much of Oklahoma's oil production is carried through pipe lines to refineries in Texas, Kansas, Missouri, Indiana, and New Jersey. For several years Oklahoma ranked second to California in the production of petroleum, but, on account of the greater value of the Oklahoma oil, has stood first in the value of production. However, Oklahoma is now ranking first in production as well as in value.

History of Petroleum Development in Oklahoma

The discovery of oil in Kansas created excitement on the Indian Territory side of Oklahoma, and in 1884 the Choctaw Oil and Refining Company was formed "for the purpose of finding Petroleum, or Rock Oil, and thus increasing the Revenue of the Choctaw Nation". One well was begun about 20 miles north of Tahlequah and another on Clear Boggy Creek, about 14 miles west of Atoka. Neither produced more than showings of either oil or gas. In 1894, the Cudahy Oil Company (fostered by Michael Cudahy of Omaha) drilled two wells at Muskogee, each of which showed good prospects, but no active development took place in this field until 1904.

In 1886 Edward Bird secured a lease on a tract of land west of Chelsea where eleven producing wells were completed during 1891.

The first records of Oklahoma as an oil producing state show that in 1891 thirty barrels of crude oil were produced for the market; but from this beginning production has increased greatly, attaining a daily output of more than 725,000 barrels as of April 9, 1927. During the period 1891 through 1926, covering 37 years, the total production has been over two billion barrels of oil.

In 1891, when the first oil operations were under way in Oklahoma, to 1896, a period of five years, the total output was only 531 barrels. Then came a marked and rapid increase in oil production. In 1897 the yield was 625 barrels; up to this year only 27 wells had been drilled in the entire state and practically all the activity was confined to the Cherokee Nation. The largest field then was near the town of Chelsea in Nowata County, having 16 wells ranging in depth from 350 feet to 1,200 feet and producing a dark heavy oil. From here the activity extended southward. At Muskogee, a well was brought in at

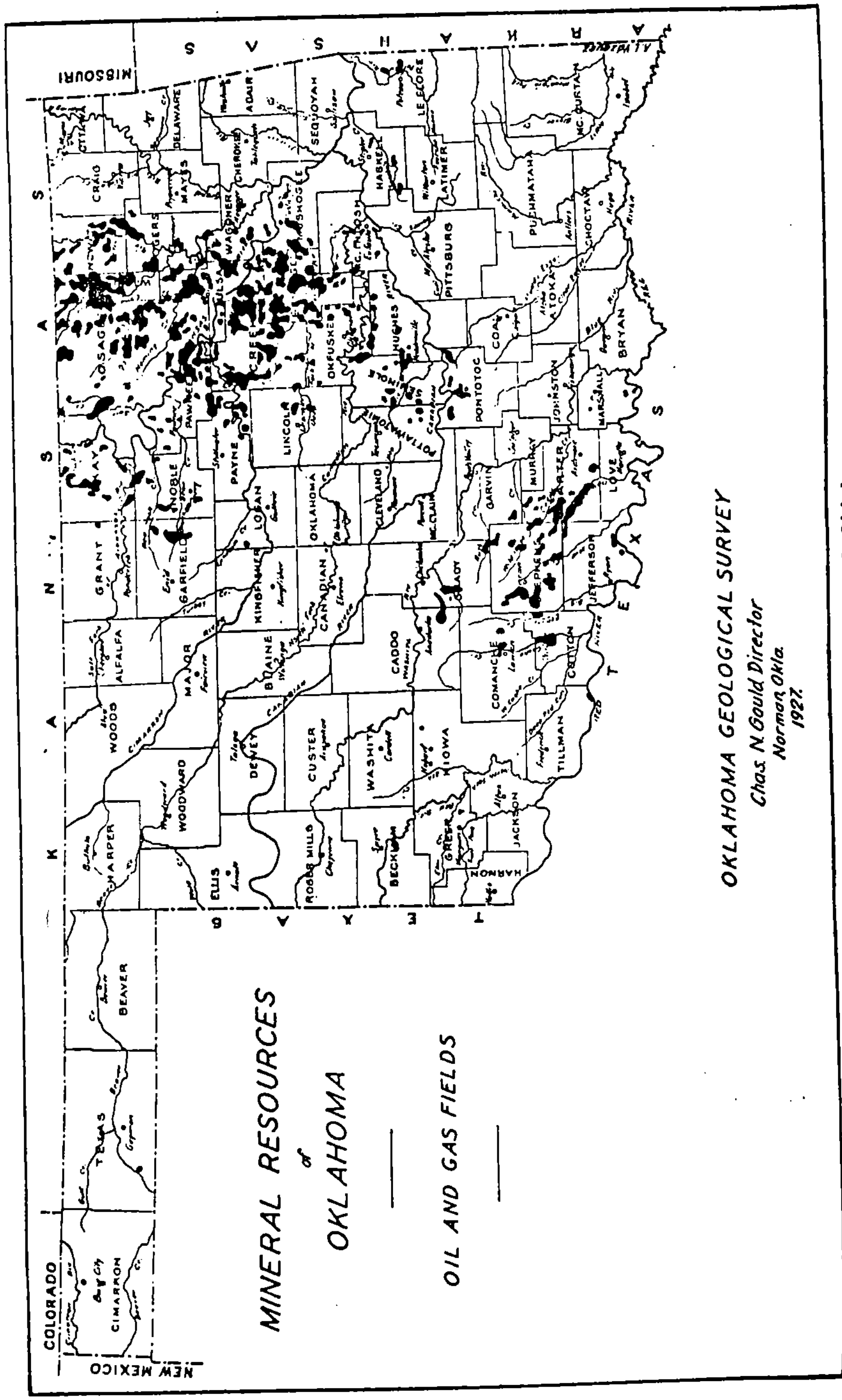


Figure 6. Oil and gas fields of Oklahoma

a depth of 1,100 feet which yielded a light greenish oil, 38° Baume'; this was the highest grade of oil produced in Oklahoma at that time. From 1898 to 1899 very little drilling was promoted because of the land and lease complications and entanglements with the Department of the Interior at Washington, D. C.

In 1900 activity was again resumed. Four definite fields were established and the production for that year was 75,000 barrels. Compare this figure with 700,000 barrels or more which are produced daily in the state today. It was known at that time that numerous springs and water wells gave evidence of the presence of petroleum. Asphalt in liquid as well as in solid form was found in scattered localities over Oklahoma. In 1901 the Red Fork-Tulsa area came in with its big initial production; in 1903 the Bartlesville pool and several others in that general vicinity were opened. The wells in these newer fields produced a product of such high quality that the future of the industry in Oklahoma gained high esteem among the oil men from the Pennsylvania region. Of the 100 wells brought in in 1903, only 3 produced as much as 110 barrels per day.

The Wheeler field, northwest of Ardmore, was discovered in 1905. In 1905, in addition to active development, the famous Glenn Pool was opened. The nearest pipe line in the state at this time ended at Bartlesville and the immense quantities of oil produced in this new field had to be stored in earthen vats. This pool reached its maximum production in October 1907, when 2,441,662 barrels were produced. Oil sold for about 40 cents per barrel and thousands of barrels were sold at 25 cents under private contract. The year 1905 saw the establishment of 25 fields for the State and a total production of 8,000,000 barrels of oil.

As early as 1906 Oklahoma lead Kansas in the number of wells drilled and very soon in the amount of production. Pipe lines were extended through the State from Kansas to the Gulf of Mexico. The drill continued to reveal good oil wells in many parts of Oklahoma; this was a period of testing and wildcatting all over the state and 10 new fields were discovered. During 1910, 35 fields were defined and established in the state, and production was 52 million barrels. The chief centers of new activity were Henryetta and Osage; gas was discovered at Poteau, and the Ponca City field was opened.

In 1912 the Cushing field was discovered, but not until 1914 did it reach its high production, when it turned into the market 22 million barrels of crude oil. Early in 1912 the price of oil advanced from 50 cents to 83 cents per barrel. Drilling was greatly stimulated, and as a result old fields were extended and much wildcatting was done which, in some cases, proved successful. Other important developments, in addition to the finding of the Cushing field, were the discovery of deeper sands in the Cleveland field; the eastward extension of the Glenn pool; the opening of the Adair pool, west of Nowata; renewed activities in the Ponca City field; and new work in Okmulgee County. Activity in Stephens County near Duncan and Loco was encouraging also.

In 1913 the price of oil advanced to $1.05 per barrel, with a premium of 20 to 50 cents per barrel additional for certain light grade oils. During this year 635 wells were completed in Oklahoma, of which 494 were oil producers, 52 were gas wells, and 88 were failures or dry holes. The principal new development was the opening of the Healdton field, in which field the first well was drilled in August, and by the close of the first year more than 300 wells had been drilled, with 270 of these as producers. Several shallow wells were drilled in the vicinity of Lawton, and numerous wildcatting adventures were made throughout central and southwestern Oklahoma. Activity was renewed in the Madill region. Several new fields were added to the list early in the year by the bringing in of good producers in localities outside of the proved fields. During 1913 and the early part of 1914 drilling operations reached a high point of activity. When the drop in price came in the early part of 1914 the state was producing over 250,000 barrels of oil daily.

In 1915 production in vast quantities poured into pipelines from every section of the state totalling 123 million barrels, and the State of Oklahoma was producing one-third of the oil of the world. At the end of this period 110 fields had been established in the state, the principal features of development being extensions to the Cushing and Healdton fields, new discoveries at Bixby, Boynton, and Blackwell, and drilling of many wildcat wells, several of which opened new areas of production. In the Cushing field the drilling campaign which began in the early part of 1914 continued, and as a result a prolific production was obtained. In the Healdton field there was renewed activity, the daily production increasing to almost 90,000 barrels by January 1, 1915.

The years from 1916 to 1920 were periods of steady drilling, producing, refining and marketing of crude oil in Oklahoma. During 1916, 9,100 wells had been completed in the state of which seventy-five per cent (75%) were productive. During this period the number of fields increased by 60, or a total of 170 producing areas; and at the close of 1920, after two decades of producing, Oklahoma had produced one billion barrels of oil valued at one billion dollars.

Despite the fact that the year 1921 got under way in face of one of the most disastrous reactions yet experienced by the oil industry, crude oil prices dropping from $3.50 a barrel to $1.00 in a period of a few months, Oklahoma, while caught with a large overproduction, had one of the most remarkable years in its history insofar as field development and production were concerned. At the beginning of the year approximately 50,000 producing wells in Oklahoma were turning about 314,000 barrels into the pipelines daily. The further development of the Okmulgee, Okfuskee, Creek and Stephens county fields, together with the Hewitt pool in Carter County and the Burbank field of western Osage County, and the discovery of a number of new producing sections in both the northern and southern parts of the State, briefly summarize the field work for this period. Total production for the year amounted to 115,679,576 barrels.

In 1922 there was a total of 6,148 completed wells; new producing areas were being established almost daily while many of the oil areas were extended, and 148 million barrels of crude oil were produced.

Although the business depression was greatly felt in the oil industry in 1923, Oklahoma broke all of her previous production records with 165 million barrels of crude oil. By this time a total of 242 oil fields had been established in Oklahoma.

The outstanding features of 1924 in the history of oil production in Oklahoma were the low number of wells completed (4,814), the increase of the average initial production per well, the remarkably rapid development of the Cromwell field in Okfuskee County, and the new pools at Wewoka and Stroud. Breaking its past production records is an old story with Oklahoma. In this year (1924) it surpassed all its past performances with a total crude output of 176,206,397 barrels.

For 1925, Oklahoma declined very little from its peak of oil development in 1924, producing 173,270,000 barrels compared with 176,206,397 barrels in 1924. It retained its rank of second place in the oil-producing states, with 22½ per cent of the total production of the United States. The major pools of Oklahoma in 1924 were still the principal producers throughout 1925. The day of greatest production was Nov. 22 when the production went slightly above 500,000 barrels. The peak was due to the production from the Garber deep sands. Of the major pools, Tonkawa led in the State, with Burbank second and Cromwell third. The average initial production per well decreased in 1925, and was 177.08 barrels. This was the smallest average since 1921, when the figure per well was 103.11 barrels; 1924 had the best average per well with 251.65 barrels. In percentage of dry holes drilled, 1925 also failed to establish a good figure for 32 per cent of the holes drilled were failures; 1924 held the best average in this respect also, for during that year 27.6 per cent of the holes drilled were dry and abandoned. The average gravity of oil produced in Oklahoma increased almost 1 degree Baume' in 1925, and was 37.5 degrees, an increase from 36.6 degrees, the average for 1924. The gravity of Oklahoma oil has steadily increased with the extended scope of operations, and the first oil found in Oklahoma had a gravity of 32.3 degrees.

During 1926, Oklahoma fields surpassed all past production records of crude oil by giving a yield of 177,651,198 barrels. The largest producing field was Burbank, which yielded over sixteen million barrels, with Tonkawa second with an output of nearly fourteen million barrels. The Seminole district in east-central Oklahoma, embracing the area south and west of Wewoka in Seminole and Pottawatomie counties, and including Seminole, Wewoka, Searight, Earlsboro and "8-6" (Bowlegs) fields, was the outstanding development of the year because of gushers in the Wilcox sand. Activity in the greater Seminole area is still increasing, which will undoubtedly result in the finding of a greater part of new production for 1927.

NATURAL GAS

Natural gas occurs closely associated with petroleum and many wells produce both substances. In a considerable area in eastern Oklahoma gas is produced in several localities where petroleum has not been found, as at Spiro, Poteau, Red Oak, Stigler, and Quinton.

In the early days of the petroleum industry in the State, there was little or no market for the gas and enormous quantities were wasted. However, this practice has changed because the oil industry is coming to realize more and more the important role which natural gas plays in the economic recovery of petroleum from the oil fields. Recent experiments and tests have proved that the conservation of the natural gas within the oil sands is of great importance to the oil operator if he is to secure the maximum length of producing life and maximum total production of oil from his wells. Natural gas is now being utilized by re-introducing it into the oil-bearing strata in a number of cases where the original gas has been dissipated and where the wells had long ceased to flow. Other important uses of natural gas are for domestic, commercial and industrial purposes; as well as direct usage at wells for heating, lighting, driving gas engines and firing the boilers of steam driven machinery.

Oklahoma is the leading user of natural gas for field purposes, that is, for drilling, pumping, and operating natural-gas gasoline recovery plants. In production of natural gas Oklahoma ranks first, California second, West Virginia third, Louisiana fourth and Texas fifth.

In 1925 the amount of natural gas produced and delivered to consumers, including deliveries in other States, from Oklahoma wells was 249,285,000 M. (M. is thousand) cubic feet, or 21 per cent of the total for the United States. The estimated value at the wells of this gas production was $18,447,000 based on an average price per thousand cubic feet of 7.4 cents; but the average price per thousand cubic feet is 14.5 cents at points of consumption which would amount to $36,121,000.00 in value.

Natural gas produced in Oklahoma and delivered to consumers, in thousands of cubic feet, 1914-1925, was as follows:

Natural Gas Production, 1914-1925

Year	M. cu. ft.
1914	78,167
1915	87,517
1916	123,517
1917	137,384
1918	124,317
1919	163,649
1920	154,467
1921	124,058
1922	140,631
1923	203,082
1924	214,452
1925	249,285

The most important gas producing areas of Oklahoma are Chickasha, Blackwell, Quinton, Poteau, Burbank, Sayre, Ada, Walters, Hogshooter, and many other pools which are more prominent because of their oil production.

Some 160 towns in Oklahoma are supplied with natural gas and millions of cubic feet are piped daily to towns and cities in Arkansas, Kansas, Texas and Missouri. The rapid drawing of the gas from the wells causes them to decline very rapidly and some of the older fields are nearing exhaustion. By statutory provision, under the control of the Corporation Commission, any company is prohibited from taking more than twenty-five (25) per cent of the daily natural flow of any gas well.

HELIUM

Helium is the lightest of the so-called inert gasses which do not combine with oxygen or any other substance and therefore cannot explode or burn. This quality of inertness, coupled with its high lifting power, makes helium gas of great value in aeronautics for both commercial and war purposes. While the whole balloon or dirigible filled with ordinary hydrogen gas bursts into flame when hit by an explosive shell, the explosive shell effects only the compartment actually hit in a helium filled bag. With the fire hazard completely eliminated by the use of helium, the risks of ballooning are greatly decreased and many new possibilities open up. The power plant of the airship may be placed as close as desired to the gas bag without fear of sparks, and by thus making the design more compact, and so reducing the wind resistance, the speed and cruising radius of the craft may be increased materially.

By means of the spectroscope helium was discovered on the sun in 1868. It was not until 1895, however, that it was known to exist on the earth, and it was then believed to be a very rare element. It was when helium was discovered in 1903 to constitute between one and two per cent of the millions of cubic feet of natural gas going to waste in Kansas, that its use for inflating balloons first became a possibility; but no one seems to have thought of such a use for the newly-found gas until after the beginning of the World War.

Helium is found in the gases of mineral springs. It is also found in natural gas in a large number of localities in the United States, particularly in Texas, Oklahoma, Kansas and Ohio. The government has established helium reserves in the Rocky Mountain region especially in Utah. The Eldorado pool in Butler County, Kansas and the Petrolia and Nocona pools of northern Texas yield gas containing more than 1 percent helium. Oklahoma occurrences of helium gas are common. Analyses of gas from the Blackwell, Bristow, Cement, Fox, Ingalls, Keyes, Loco, Myers, Osage City, Pawhuska, Pearson and Ponca City fields of Oklahoma have been made, and all show varying amounts of helium. (See Professional Paper 121, U. S. Geological Survey; or Oklahoma Geological Survey Bulletin 14.)

The only plant in operation for the extraction of helium is located at Fort Worth, Texas. The plant is owned jointly by the Army and Navy Departments, and is operated by engineers of the Linde Air Products Company, the owners of the process. It has been operating almost without interruption since early in 1921, and has been using gas from the Petrolia and Nocona fields of north-central Texas. The government is taking all of the helium gas produced.

Natural gas to be valuable as a source of supply of helium should contain at least 0.50 per cent of the gas. It is probable that even this quantity will offer great difficulty in the extraction work, although with experience in the process and cheaper methods which will come with practice, even smaller quantities may be valuable. The largest quantity ever discovered in natural gas was something over 2 per cent. The highest helium-content gas known in Oklahoma was from the Pearson field, Osage County, and the amount was 0.71 per cent. It is hoped that further investigation and sampling with analyzing of natural gases in Oklahoma will reveal commercial supplies and sources of helium.

NATURAL GAS GASOLINE

The natural gas which accompanies petroleum in the oil fields of the State carries varying amounts of gasoline. In 1925 there were 352 plants with a rated daily capacity of 1,525,825 gallons, in operation in Oklahoma, recovering gasoline by compression or absorption from this "casing-head" gas. After the gasoline is extracted the remaining "dry gas", so far as practicable, is taken into pipe lines, and is distributed to domestic and commercial consumers.

In this connection it is to be noted that the U. S. Bureau of Mines has conducted experiments and tests to find out if gasoline extraction methods lessened the heating value of natural gas, as is popularly believed. Their findings show that the loss from extracting the gasoline from natural gas in insignificant when compared to the advantages attained, not only to the producer and distributor of gas, but also for the domestic consumer of natural gas; and the conclusion was evident that such a practice is a benefit to the consumers and to the whole country rather than a detriment.

The usual recoveries of gasoline from natural gas vary from one-half gallon to 3 gallons per 1,000 cubic feet of gas handled, the average being about 1 gallon per 1,000 cu. ft. Some concerns market the natural gas gasoline (casing-head gasoline) separately, others blend it with refinery gasoline, while others turn it into the oil pipe lines thus mixing this high-gravity gasoline with the crude oil for transportation to the refinery where it is later regained. The value of natural gas gasoline to the consumer is that it aids in starting the motor and means less knocking of the engine. To the refiner it adds a very valuable constituent to the motor fuel, and enables him to utilize more advantageously his heavier naphthas from the crude. The natural gas gasoline industry is one which is comparatively young in importance, but it is so very necessary in meeting present day requirements for motor fuels that it should prosper and continue to expand.

Natural gas gasoline produced in Oklahoma, in thousands of gallons was as follows:

Natural gas gasoline production, 1911-1925

Year	M. Gallons
1911	388
1912	1,575
1913	6,463
1914	17,278
1915	31,666
1916	48,360
1917	115,123
1918	163,701
1919	189,995
1920	178,857
1921	185,341
1922	189,404
1923	270,249
1924	301,062
Total	1,699,462
Percentage of Total for U. S.	40.5

Oklahoma's production of natural-gas gasoline in 1925 was approximately 394,000,000 gallons valued at $43,500,000.00. In the period of time between 1911 and 1924, Oklahoma, the leader in the natural-gas gasoline industry, produced 40.5 per cent of the total production for the United States, representing an output of 1,699,462,000 gallons in 14 years.

Compression Method

The compression method of recovering gasoline from natural gas utilizes the property of a gas to liquefy at certain critical temperatures and pressures. The gas to be treated is subjected to pressures up to 250 pounds per square inch, and is later chilled and expanded.

The usual procedure is to place the casing-head gas under a pressure of 40 to 50 pounds to the square inch, and then cool to a temperature sufficiently low to cause the gasoline to liquefy. This initial treatment yields about 15 to 25 per cent of the total recovery and runs between 72° and 75° B′. The gas is then passed to the high pressure compressors where it is further compressed to 200 to 250 pounds per square inch. After compression it is sent to a second set of cooling coils where more of the gasoline is recovered, about 50 per cent of the total recovery. This gasoline is extremely volatile, and is known as "wild-gasoline" (80°-90°B′). The remainder of the recovery is obtained in a series of heat-exchanging coils and expansion engine, where the pressure is reduced to 0 to 60 pounds and the temperature to 40° to 60° below zero. The gasoline recovered at this point often runs as high as 100° B′, and is therefore extremely volatile.

Absorption Method

The principle on which this process is operated is the affinity of solutions of gases and liquids for each other. This mixing or absorption of the natural gas to be treated and the absorption medium, usually mineral seal oil, is introduced. The gas enters the tower near the bottom and passes through the tank to the top, encountering on its ascent the oil which is introduced through spray nozzles near the top. The gasoline in the gas is absorbed by the oil and is later recovered by distillation.

If the gas is "lean", or in other words, contains only 0.2 to 0.3 gallons of gasoline per 1,000 cubic feet of gas, the towers used are 30 to 50 feet high, 20 to 30 inches in diameter and capable of withstanding pressures of 100 to 350 pounds. The richer gases are treated at lower pressures, about 30 pounds, and in towers about 50 feet high and 12 feet in diameter.

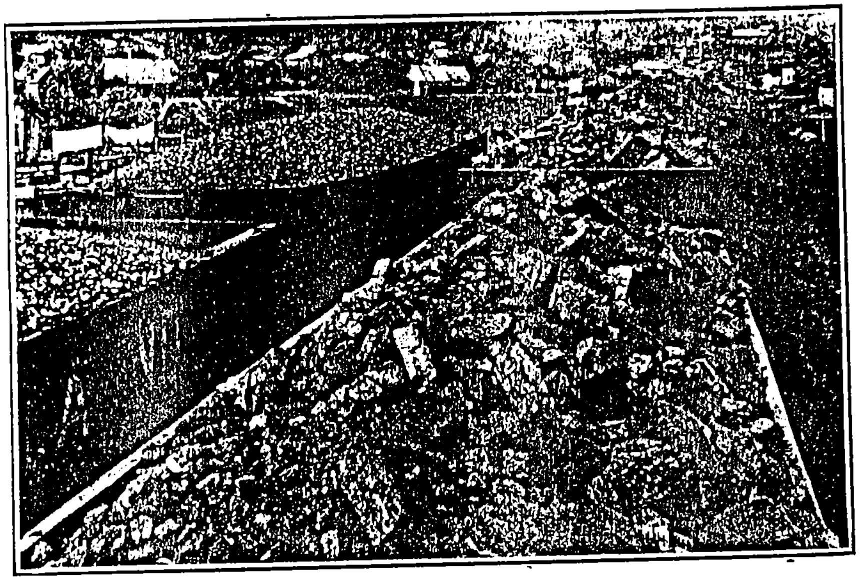
The product of the absorption process is more easily handled because of its lower Baume′ gravity (70° to 78° B′.) with an end point of 375°F. as compared with 92°B′, and 350°F. end point for compression gasoline.

COAL

The coal fields of Oklahoma are in the east-central and northeastern parts of the State. (See Fig. 8, page 97.) The area actually underlain by the coal amounts to approximately 12,000 square miles, located in Atoka, Coal, Craig, Haskell, Latimer, LeFlore, Muskogee, Okmulgee, Pittsburg, Rogers, Tulsa and Wagoner counties. According to estimates of the United States Geological Survey, this coal reserve contains 79,000,000,000 tons of coal. The coal bearing formations of Oklahoma consist chiefly of sandstone and shale with some limestone, especially north of Arkansas River. The formations are of Pennsylvanian (Allegheny) age.

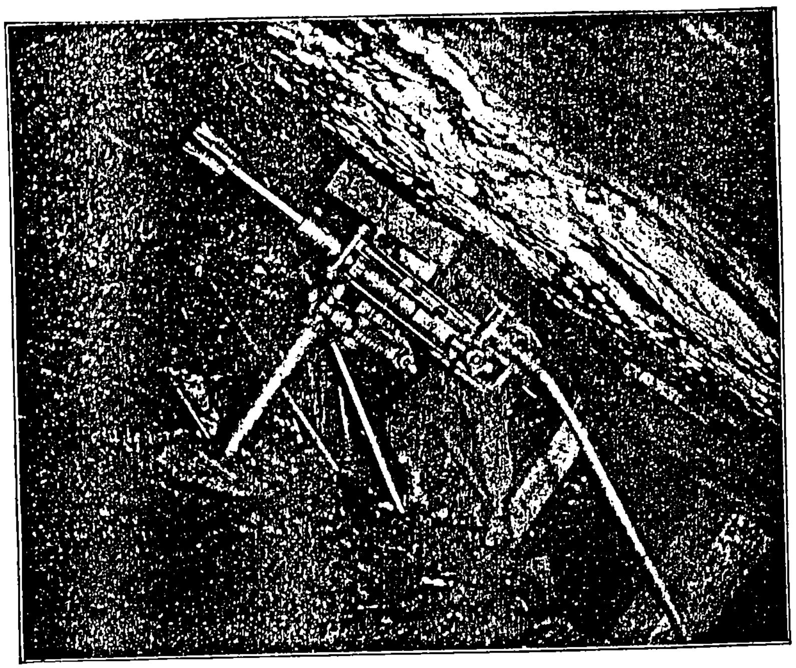
In the east-central part there are seven workable veins of coal, the two Hartshorne coals, the two McAlester coals, the Cavanal coal, and the two Witteville coals. The workable beds range in thickness from two to six feet and locally are seven or eight feet thick. Except in a few places there are only one to three beds available in a given area. Owing to the steep dip of the rocks the McAlester and Hartshorne coals, although separated by 2,000 feet stratigraphically, often outcrop within a short distance of each other, and both are mined at several towns such as McAlester, Hartshorne, Wilburton, Atoka, and Lehigh. In a part of the workings of Mine No. 19, Wilburton, the two Hartshorne beds come together, having the appearance of a single bed separated by a thin clay parting, and giving a total thickness of nine feet of coal.

PLATE XIX



OKLAHOMA COAL READY FOR SHIPMENT

PLATE XX



MINE ROOM SHOWING COAL DIPPING 38°

The great majority of Oklahoma coal is bituminous, although there is considerable semi-anthracite coal in the State. The latter coal has a greater value than anthracite for heating purposes because of more rapid combustion, and is extensively used for steam coals.

The coal in east-central Oklahoma is in the territory formerly owned by the Choctaw and Chickasaw Indians, and before the land was opened to settlement the coal lands were surveyed and segregated. It was planned to sell the lands to the highest bidder, but the Secretary of the Interior rejected all bids, so that the title remains in the Indian tribes. The lands are leased to the operating companies on a royalty basis. Some of the thinner outcrops, and the coal to the north, were not segregated and are owned principally by the operating companies.

In the northeastern region there are three veins of coal, the Cherokee, Fort Scott and Dawson coal beds. These veins are worked, principally by the strip-pit method rather than shaft-tunnel method, at Tulsa, Dawson, Collinsville, Red Fork, Henryetta, Schulter, Broken Arrow, Morris and Catoosa.

At the date of the earliest record of coal production in Oklahoma (1880) the production amounted approximately to 121,000 short tons. From that date to the beginning of 1927, the state has produced approximately 96,000,000 short tons of coal, with an almost steady increase from the date of the first recorded production.

Some factors which have curtailed the production of coal in Oklahoma are: labor situation: the competition of coal from other states (Colorado, Kansas); substitution of other fuels, chiefly natural gas and fuel oil, in place of coal; increased economy in the use of coal for both industrial and commercial purposes.

Recently some railroads in the southwest have eqiupped their locomotives with automatic mechanical stokers that carry coal from the tender and feed it into the fire entirely by mechanical processes and with great economies. The Harrah plant of the Oklahoma Gas and Electric company; the Southwest Power company at McAlester, and the Morris Packing company of Oklahoma City are equipped for the burning of coal in pulverized form. Under this process coal is reduced to a powder as fine as flour and carried with a current of air into combustion chambers, and the resultant fire, it is stated, can scarcely be told from burning oil. Under this process any kind of coal can be burned without a change of equipment. It is on their faith in these improved methods of burning coal and the results obtainable therefrom, and upon better mining methods now in effect that the coal industry of the state is hoping for a better future.

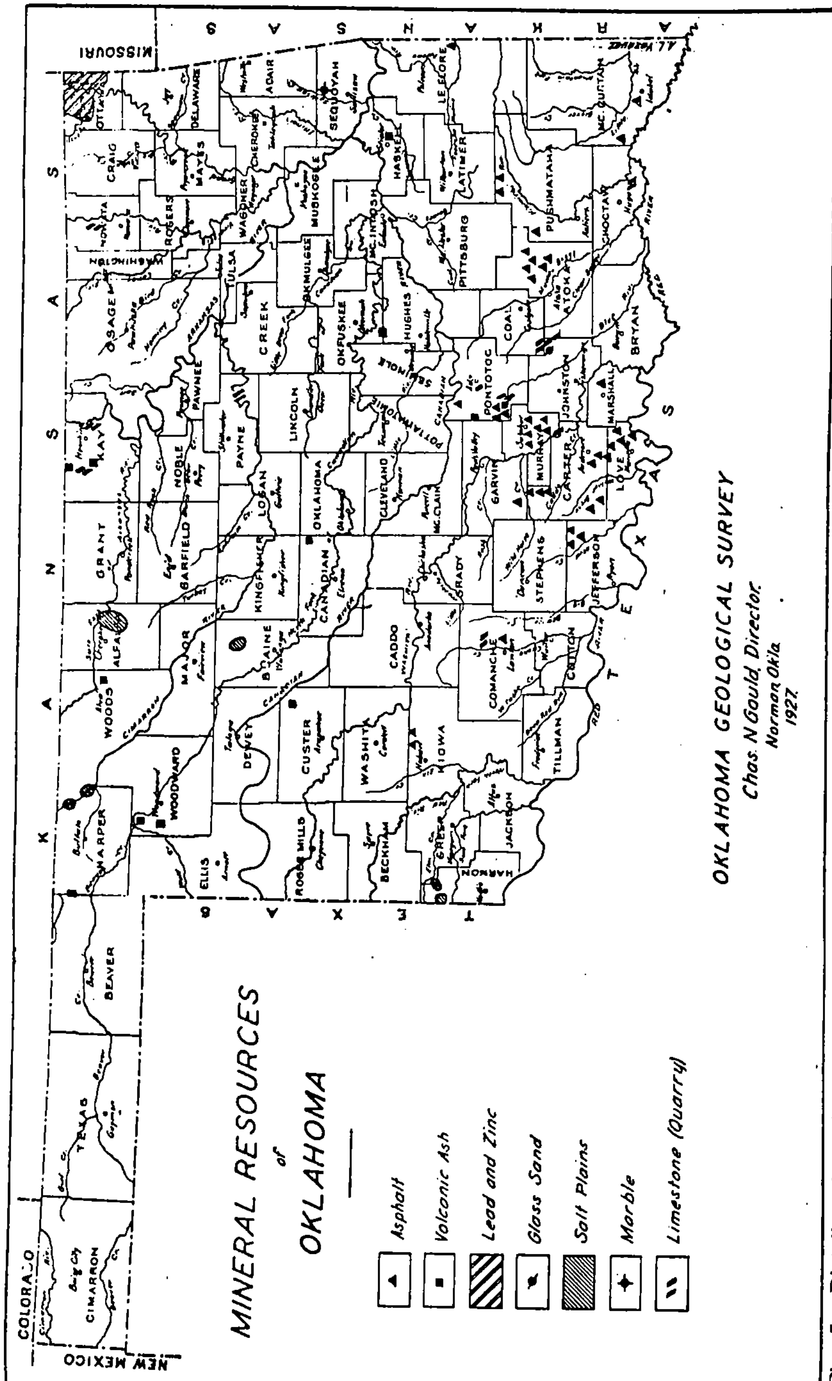


Fig. 7. Distribution of asphalt, volcanic ash, lead and zinc, glass sand, salt plains, marble and limestone quarries.

Available figures for county production of coal show that in 1924 the distribution was: Coal county, 29,249 tons; Haskell, 72, 874; Latimer, 254,024; LeFlore, 163,139; Okmulgee, 919,683; Pittsburg, 717,794; Tulsa, 176,976; Craig, Muskogee, Rogers and Wagoner counties, 96,903.

Amount and Value of Coal Produced in Oklahoma[3]—1885-1926

Year	Short Tons	Value
1885	500,000	$ 800,000*
1886	534,580	855,328
1887	685,911	1,286,692
1888	761,986	1,432,072
1889	752,832	1,323,807
1890	869,229	1,579,188
1891	1,091,032	1,897,037
1892	1,192,721	2,043,479
1893	1,252,110	2,235,209
1894	969,606	1,541,293
1895	1,211,185	1,737,254
1896	1,366,646	1,918,115
1897	1.336.380	1,787,358
1898	1,381,466	1,827,638
1899	1,537,424	2,199,785
1900	1,922,300	2,788,224
1901	2,421,781	3,915,268
1902	2,820,666	4,265,106
1903	3,517,388	6,386,463
1904	3,046,539	5,532,066
1905	2,924,427	5,145,358
1906	2,860,200	5,482,366
1907	3,624,658	7,433,914
1908	2,948,116	5,976,504
1909	3,119,377	6,253,367
1910	2,646,226	5,867,947
1911	3,074,242	6,921,494
1912	3,675,418	7,867,331
1913	4,165,770	8,542,748
1914	3,988,613	8,204,015
1915	3,693,580	7,435,906
1916	3,608,011	7,525,427
1917	4,386,844	12,335,413
1918	4,813,447	17,508,884
1919	3,802,113	14,544,401
1920	4,849,288	23,294,000
1921	3,362,623	15,546,000
1922	2,802,511	11,527,000
1923	2,885,038	10,874,000
1924	2,329,615	8,590,000
1925	2,438,400	8,261,910
1926	2,492,129	8,500,000*
Totals	103,662,428	$262,989 367

3. From Mineral Resources, U. S. Geol. Survey.
*Estimated.

Mining Methods.

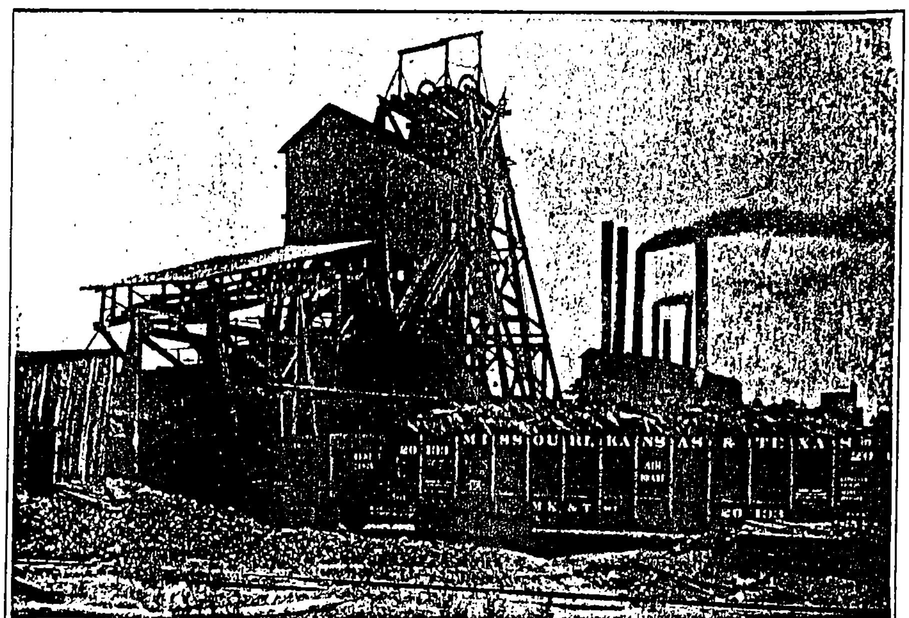
Oklahoma coals are obtained by stripping and underground mining. There are about as many shaft mines as there are slope mines. In the larger ones the double-entry, room-and-pillar system is used, while in the small slope mines the single-entry system is practiced.

Most of the coal that is obtained from underground mines is taken out from entries which are driven down the dip of the coal bed in slope mines. In the case of the shaft mines, the shaft is sunk from the surface until the coal bed is penetrated and then the cross headings are driven from the base of the shaft.

In the northeastern part of the State practically all of the coal is produced by stripping. This is done by the use of steam shovels for removing the overburden and the coal is removed by "pinning" and loaded by hand either into wagons or cars to be transported to the railroad shipping point. In some strip-pits the working is done by teams.

In 1925, 100 coal mines were operated in Oklahoma, furnishing employment to 5,631 men.

PLATE XXI



TYPICAL SHAFT COAL MINE IN OKLAHOMA

ASPHALT.

Asphalt, which usually contains considerable oil, is a residuum left by the escape and evaporation of bodies of asphaltic base crude petroleums formerly contained in the sedimentary rocks. Asphalt is made commercially when asphaltic base petroleums are refined, and it seems reasonable to believe that the natural deposits are made in a similar manner. That is, a bed of rock containing oil is brought so near the surface or is cut by a fault so that the oil can escape to the surface. The gases and lighter constituents of the oil escape into the atmosphere leaving the residual deposit of the heavier, more viscous components of oil. These form what we know as asphalt. Asphalt occurs widely distributed in southern Oklahoma in rocks of different ages. (See Fig. 7, page 86.) In the Arbuckle Mountains the deposits are found in the Simpson and Viola formations of Ordovician age.

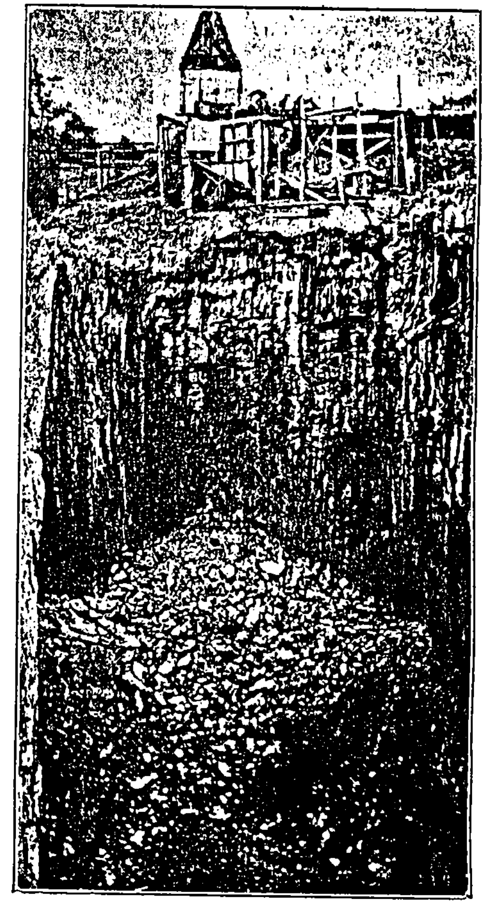
In these deposits the asphalt is found impregnating sandstones, limestones, and shales. Southwest of the Arbuckle Mountains, near Woodford, and also south of Ardmore, are some important deposits in which the asphalt impregnates the sandstones which stand almost perpendicular. Other important deposits are in southeastern Stephens and northeastern Jefferson counties, near Loco. Around the Wichita Mountains several deposits are known, there being large quantities near Lawton, Hobart, and Gotebo. Deposits of commercial value are known at various localities in the Trinity sand (Comanchean age) area of the Red River region. Several deposits of pure asphalt are known in the Ouachita Mountain region of southeastern Oklahoma. One deposit known as the Jumbo mine is northwest of Antlers, another is near Tuskahoma and a third not far from Page. In these deposits the asphalt occurs as a vein which was probably formed along a fault plane. It is presumed that the fault cut petroleum-bearing beds beneath, and that the escape to the surface gave rise to the residuum of asphalt now forming the vein. These asphalts have undergone considerable metamorphism and stand in the same relation to other asphalts that anthracite does to coal; that is, most of the volatile matter has escaped and the substance remaining is very high in fixed carbon. Material from the Jumbo deposit near Tuskahoma has the characteristic glassy lustre and conchoidal fracture of anthracite coal. In general appearance it greatly resembles hard coal, but has a greenish lustre and a much less specific gravity.

PLATE XXII

STRIPPING COAL WITH STEAM SHOVEL NEAR BROKEN ARROW

The rock asphalts, that is, limestone and sandstone impregnated with asphalt, have been used on a considerable scale for paving. The streets of many of the towns in Oklahoma and northern Texas, as well as some towns of Missouri and southeastern Kansas, are paved wholly or in part with this material. For use in paving the materials are assorted so as to give the proper bitumen content. The sandstone asphalt and limestone asphalts are ground, mixed together in the right proportions, heated and rolled on to a proper base, as is done with Trinidad or artificial asphalts. In general the pavements have given ex-

PLATE XXIII



ASPHALT MINE NEAR WOODFORD, CARTER COUNTY

cellent satisfaction, although in some cases the percentage of asphalt carried by the rocks seems to have been too small to give long life to the pavement. The natural variation in the texture of the rock which the asphalt imparts and the variation in percentage of asphalt carried by the rocks makes it difficult to secure a uniform composition in the finished product. The pure asphalts from the Ouachita Mountain region are not fit for use as paving materials, being too low in volatile constituents and consequently too brittle. This type of asphalt is used principally in the manufacture of asphalt varnishes, paints, waterproofing, and insulating materials.

LEAD AND ZINC

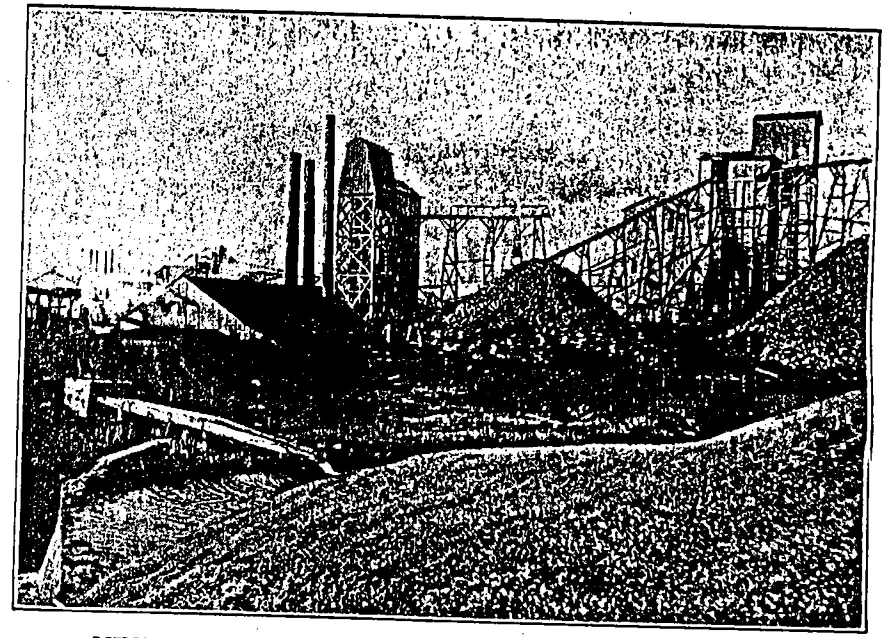
Ores of lead and zinc have been found in several localities in Oklahoma, but in only two places have there been sufficient amounts discovered to make it profitable to mine them. (See Fig. 7, page 86.) The most important locality is in Ottawa County, the northeasternmost county of the State, where the lead and zinc mining has become an important industry. The other district, which produces only zinc, is in the Arbuckle Mountains, west of Davis in Murray County. Small quantities of lead have been found near Lawton in Comanche County, near Ada in Pontotoc County, and in some of the counties in the Ouachita Mountain region.

Lead and zinc do not occur in nature as the metals themselves, but as ores or compounds with other substances. The principal lead ore is galena, a compound of lead and sulphur which has the color of lead, but which is brittle, breaking readily into small cubical blocks instead of being soft and malleable as the metal is. In this region the lead ores are almost free from silver, and the lead produced from them is known as soft lead. The principal zinc ore is a compound of zinc and sulphur known to geologists as sphalerite or zincblende, and to the miners as "jack". It is a substance having a resemblance to resin, and no resemblance to either zinc or sulphur.

Lead and zinc ores are not generally evenly distributed throughout very large bodies of rock, but are found in veins or "runs". These are bodies of rock in which the cracks and crevices are filed with ore, while the rock around the run contains little or no ore. The runs may be almost any shape or size, but those in Oklahoma are generally nearly straight. The thickness varies from 4 to 5 to 30 feet, or even more, and the width from a few feet to 100 yards or more. The longest run known in Oklahoma, the principal run of the Miami camp in Ottawa County, is over 2 miles long, but most runs are much shorter than this.

The runs of ore sometimes occur at the surface and are found there by prospectors. This is the case with the Arbuckle Mountain zinc ore. In Ottawa County, however, the ore bodies are at considerable depths, 100 to 400 feet, beneath the surface. The first step in developing a mine in a region which is supposed to contain lead and zinc is to prospect or determine whether any runs of ore are present and, if so, their thickness and extent. Prospecting is usually done by drilling a large number of holes with a well drilling machine. The rock cuttings removed from the well are observed closely, and in this way the thickness of the ore body and nature of the ore can be told. A large number of holes will show whether the ore body is wide enough and long enough to make mining of it profitable.

PLATE XXIV

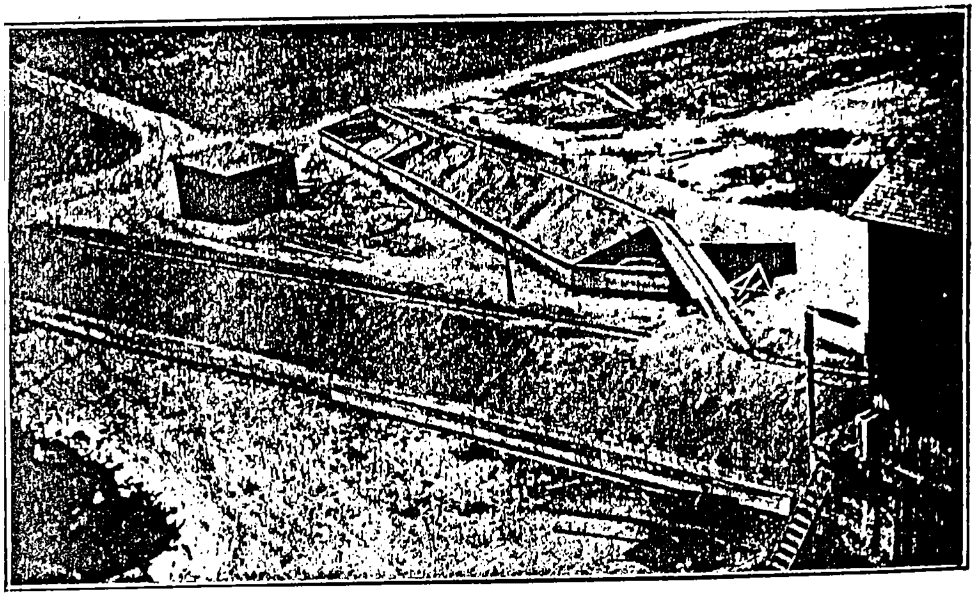


MINE IN THE TRI-STATE LEAD AND ZINC DISTRICT, OTTAWA COUNTY

After an ore body has been located a shaft is sunk to it. This shaft is merely a large dug well, 8 or 10 feet square. Then from the bottom of the shaft the rock with its ore is lifted out of the top of the shaft in large buckets fastened to a wire rope which is wound up on a winding drum stationed in a building several feet above the top of the shaft. Large entries or rooms are made in the ore body, beginning at the bottom of the shaft, by drilling holes into the rock, filling them with dynamite and blasting the rock to pieces. The broken rock is shoveled into the large buckets and hauled to the foot of the shaft in small cars on steel tracks, and elevated.

At the top of the shaft is a large building equipped with crushing, grinding, and screening machinery. The rock is crushed and ground until the largest pieces are less than an inch in diameter. This breaks out the small bodies of ore which are scattered through the rock. The small pieces of ore are then separated from the pieces of rock by washing both together over screens with a strong stream of water. The ore is heavier than the rocks and works down and falls through the screens, while the rock pieces are carried on faster by the water, washed over the screens and into an elevator, which carries them to a dump outside of the mill.

PLATE XXV



STORAGE BINS OF ZINC CONCENTRATE NEAR MIAMI

If mining conditions are favorable, rocks containing only a small percentage of ore can be worked with a profit. Some of the mines produce only 2 or three tons of ore from 100 tons of mined rock, and 10 tons of ore from 100 tons of rock is a very good yield.

Lead and zinc in their metallic state and in compounds are used in various ways. In the metallic form, lead is used principally for pipes in plumbing and for the surrounding of electric wire cables. Sheet lead is used in large quantities for lining sulphuric acid containers and tank cars for the shipment of acids. Considerable quantities of this metal are used in the manufacture of tin-foil, shot and bullets, and as a constituent in type metal, Babbitt metal and white metal. However, the principal use of lead compounds is for pigment in paint.

Zinc is used principally in galvanizing sheet iron and wire. Zinc dust is used in dyeing, fire-works, manufacture of hydrogen, and as a means of precipitating gold and silver in milling processes of recovery. It may also be utilized as a preservative for wood, as a pigment for paint, and in medicine.

The great mining region known as the Joplin district, from its principal town, includes the southwestern portion of Missouri, southeastern Kansas, and northeastern Oklahoma. Recently the area has been known as the Tri-State District.

The Oklahoma portion of the Joplin district lies in the northern part of Ottawa County, in the extreme northeastern part of the State. Miami is the principal town of the county and the region is often called the Miami district, although other towns have been built in the fields. Cardin, Picher, Quapaw, Hockerville, Douthat, and Century are some of the towns which have sprung up in that region on account of the ore industries. Commerce is connected with Miami by a short independent railroad, and is an important center of mining operations.

The oldest mining camp in Ottawa County is at Peoria, where mining operations took place as early as 1890. At that time the distance from market and the transportation facilities so hindered the business that little work was done. Later, when the railroad passed nearer Peoria, operations were renewed. Some good lead ore and one kind of zinc ore were found in shallow diggings. However, operations here are not as extensive as they are a few miles to the west.

The camp at Lincolnville was opened in 1903 and was strongly "boomed" prior to 1907. However, about that time the main deposits were worked out and the town decreased in population from 1,200 to 200. Since the beginning of the World War the price of both zinc and lead has been so high that exploration has been very active, and renewed prospecting by drilling has taken place.

Many new and promising ore bodies have been opened and numerous large mills are now operating.

The Miami camp was opened in 1907 and very rapidly became the most important camp in the county, and for some years past has been one of the leaders in the whole Joplin district. The ore occurs in a series of runs extending in a general north-south direction from about 4 miles north of Miami to the Kansas line. The grade of the ore, i.e., the percentage of concentrates, is the highest of any large camp in the Joplin district, but the concentrates themselves are of rather low grade, containing considerable iron. The history of the camp since its opening has been one of steady progress northward from the original shafts at the south end of the camp.

The rocks in the lead and zinc bearing region of northeastern Oklahoma consist chiefly of Boone chert of Mississippian age, which in the process of settling, fractured and broke into angular fragments. Solution cavities were also formed, and underground water, carrying the ores in solution, circulated freely in the breccias and thus deposited the ore, filling the cracks and crevices.

Average ore in the Ottawa County mines runs about 7 per cent in zinc. Lead is very irregular in the average mine, there being only a small amount, but once in a while, rich pockets are struck. Most of the tailing piles will run about 1 per cent. This small percentage seems to be brought about by the condition that considerable of the zinc occurs as fine particles in secondary chert.

The Tri-State District, comprising the area in southwestern Missouri (Joplin), southeastern Kansas, and northeastern Oklahoma, ranks first in importance of production and reserves among the lead and zinc deposits of the world.

In 1925 the total crude ore mined and milled in Oklahoma amounted to 10,605,200 short tons. The recoverable metal was 79,946 short tons of lead valued* at $13,910,604; 283,371 short tons of zinc valued at $43,072,392; with total value of $56,982,996.00 for lead and zinc produced. This high value of lead and zinc placed Oklahoma as leader among the states of the Union, with Missouri second, Michigan third, and Kansas fourth.

Besides the Ottawa County deposits lead has been reported from various localities in southeastern Oklahoma, from Ada, and from near Lawton. Some shipments of zinc ore have been made from mines in the Arbuckle Mountains west of Davis. None of these localities have proved to be commercially important.

BUILDING STONE

General Statement.

Oklahoma is well supplied with building stones of several varieties. Practically all of the better materials which may be used for building stone are confined to the eastern half of the State. The Wichita Mountain region is the only territory in the western part of the State which has any great supply of building material. (See Figs. 7 and 8, pages 86 and 97.)

The qualities desired in a building stone vary greatly with the use which is to be made of the stone. For such work as foundations, bridge piers, and abuttments, the color is of little importance, but for exterior work in large buildings the color may be the deciding factor in the choice of the stone. Naturally, pleasing color must be associated with other qualities which fit the stone for use, but it does not matter how durable, nor what other good qualities the stone may possess, if it does not have a pleasing color it will not be considered a very valuable building stone. Besides the color, other important qualities are: hardness, which greatly affects the cost of quarrying and dressing the stone; and porosity, which influences the durability or life of the stone in buildings.

*Value computed at the following average prices for 1925: lead, $0.087 per pound; zinc, $0.076 per pound; lead at $117.13 per short ton and zinc at $50.64 per short ton. U. S. Bureau of Mines Statistics.

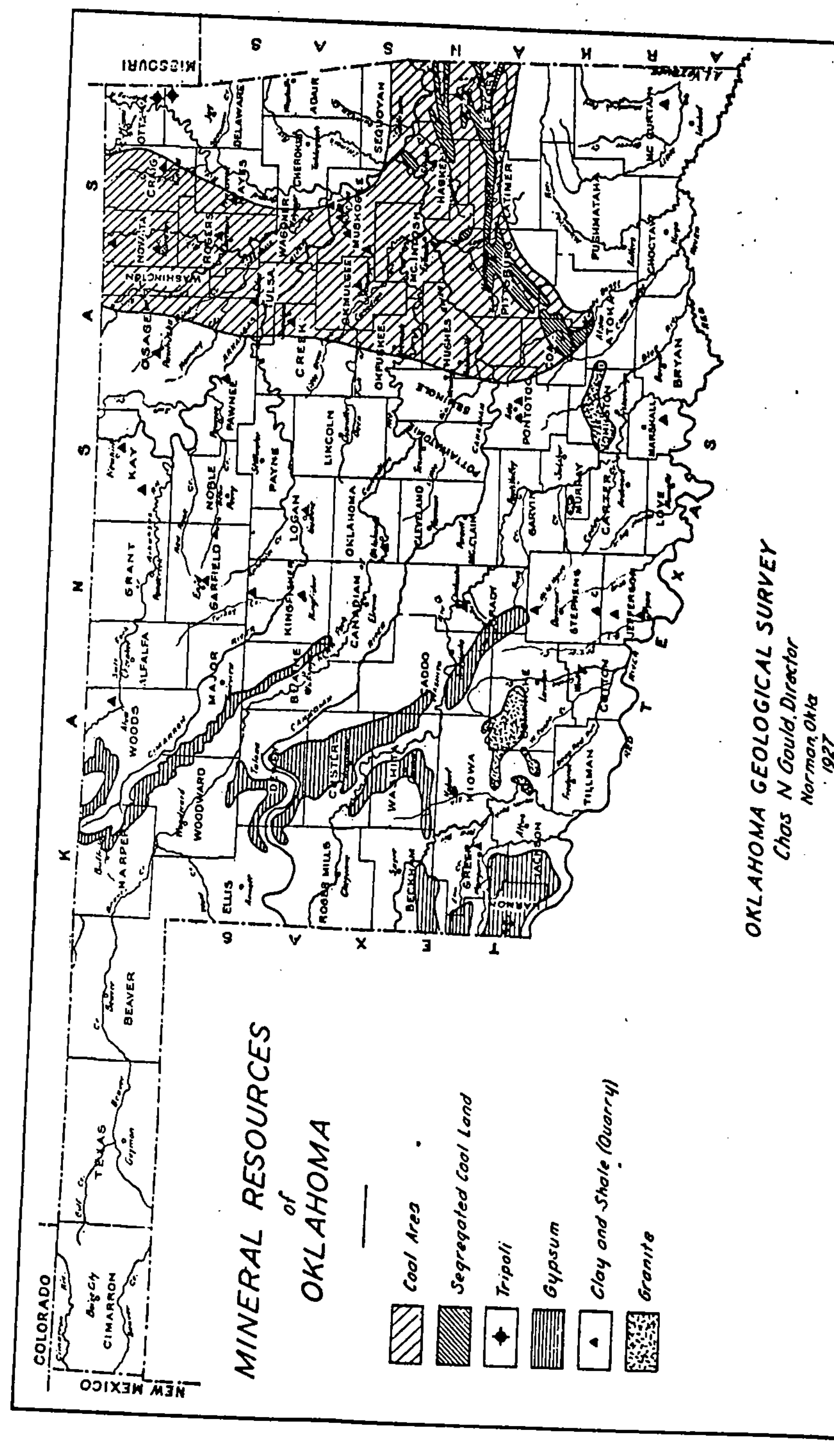


Figure 8. Distribution of coal, tripoli, gypsum, clay and shale quarries, and granite.

The greatest cause of deterioration of stone in buildings is the freezing of water in the pores of the rock. A rock may be quite porous and yet be durable if the pores are large, so that when the water freezes the ice may easily push out from the pores. Thirdly, the crushing and tensile strength must be sufficient for any use which may be made of the stone. Very few stones fail in this respect.

The different varieties of building stone which occur in Oklahoma are the granites, limestones, marbles and sandstones.

Granites.

Granites* occur in enormous quantities in the Arbuckle and Wichita Mountains. (See Fig. 8, page 97.) The granites of the Arbuckle Mountains occur largely in the portion of the mountains east of Washita River. The commercial granites of the region are chiefly in Johnston County, but an area of a few square miles is located in Atoka County. There are two distinct types of granite in this district. In the central portion, bounded roughly by Blue River on the east and Rock Creek on the west there is a coarse-grained, pinkish-gray, biotite granite. The remainder of the main area is composed of a fine-grained, pinkish-gray, biotite granite. The granite is generally fresh within a short distance of the surface, and quarrying conditions are favorable. Only a small portion of the granite area is near transportation. Little use has been made of this granite so far, although quarrying has been conducted on a small scale at Tishomingo and Troy. The Capitol Quarry from which stone was quarried for the State Capitol building basement is near Troy.

The granites of the Wichita Mountains vary greatly in color and texture. In the main portion of the mountains extending northwest from Lawton the granite is a medium-grained pink granite. No use has been made of the granite from the Wichita range proper up to the present time. In the vicinity of Cold Springs the granite is light to dark gray in color. Some of the rock is really gabbro and diabase rather than granite. This stone has been quarried at Cold Springs and near Roosevelt. A bright rose-red granite has been quarried to a limited extent near Mountain Park. The largest granite quarries in the Wichita Mountains are at Granite on Headquarters Mountain. The granite here is a very uniform, medium-grained, brownish-red stone. It occurs under conditions very favorable for quarrying, and has been used in the State to a considerable extent for building and monumental purposes.

*For full discussion of the granites of Oklahoma, see Bull. 20, Oklahoma Geological Survey, by C. H. Taylor.

PLATE XXVI

QUARRY IN TISHOMINGO GRANITE NEAR TROY

Plans have been made at different times to quarry the granite from a small dike near Spavinaw in Mayes County, but the stone is so far removed from a railroad that it is almost impossible to utilize it under present conditions.

Limestone

Limestones occur in five distinct areas: (1), in the northeastern portion of the State, a large, irregular area; (2), the Red River or Comanche-Cretaceous limestone area in the southeastern part; (3), the Arbuckle Mountain region; (4), the Wichita Mountain region; and (5), a single formation extending north and east from the Arbuckle Mountains to the Arkansas state line. (See Fig. 7, page 86.)

Almost any of the limestones in the northeastern region are suitable for use in local structure, but none of them possess any striking qualities of appearance or workability which would make them of any great importance.

The limestones in the Red River area are rather irregular in bedding and most of them contain a considerable percentage of clay which lessens their durability. It is not probable that any important industry can develop in this limestone area, although the stones are, and will be, used considerably for local purposes.

The Wapanucka limestone, which extends from the Arbuckle Mountains northeast to the State line, is one of the most important limestones, economically, in the State. (See Pl. VII, page 28.) It is the subject of Bulletin No. 23 of the Oklahoma Geological Survey, by B. F. Wallis. Locally, near the town of Wapanucka this limestone resembles very closely in appearance, texture, and hardness, the Bedford limestone of Indiana and Kentucky. This stone has been quarried on considerable scale between the towns of Bromide and Wapanucka.

Marble

Marble has been quarried near Marble City in Sequoyah County. (See Fig. 7, page 86.) The marble occurs here in a very thick bed from which it may be quarried in blocks as large as may be desired. This formation is the St. Clair marble of Silurian age. The material is a gray to pinkish white, coarsely crystalline limestone of very pleasing effect when polished. When left with a rough surface it makes an excellent building stone for exterior work, but is too soft to retain a polish when used this way. When polished it is a very excellent material for ornamental and decorative interior work.

Sandstone

The sandstones of the eastern portion of the State are generally uniformly grained, fairly well cemented, and of a neutral brown color. They have been used for a good many buildings locally, and also for bridges and foundations. None of them possess any striking features of texture or color which would make them of especial importance. No large quarries have been opened and it is very improbable that the sandstone industry will attain much importance in the State, although the value of the sandstone for local use is very great. The sandstones of the western half of the State are generally brick- to deep-red in color and very fine-grained and quite soft. Although they have been used to some extent locally they are not to be recommended when better material is available, as it generally is.

Building Sand and Gravel.

Building sand is widely distributed in Oklahoma. All of the streams of the western part of the State have their channels choked with sand. Rows of sand hills also occur along these streams.

In eastern Oklahoma and in the mountain regions the sand has been derived from the decay of the sandstone in those regions. Some of the sandstone ledges are so soft that sand may be dug directly from the ledge. There is enough good sand throughout the State to furnish an abundant supply for all mortar, cement, and plaster work that might be undertaken.

Gravel consists of pieces of broken stone. Much gravel is found in the State cemented together into masses, and this form of material is called conglomerate. Large quantites of gravel occur along the streams from the Ozark, Wichita, and Arbuckle Mountains, and the Flint Hills in Osage County. Much of the gravel from these regions is being used over the State. It is excellent material for concrete work, railroad ballast, and road metal.

Lime

One of the uses of limestone is for the manufacture of lime. The process is accomplished by burning limestone in furnaces or kilns. Water (H_2O) and carbon dioxide (CO_2) are expelled. Lime is used for making mortar, plaster, cement, bleaching powders, sandlime brick, and many other products. The use of lime as a fertilizer has become of considerable importance. Agricultural chemists have shown that there are 5 or 6 different functions which lime may perform for the benefit of soil. The question whether lime should be applied to the soil as quicklime, hydrated lime, air-slacked lime, or ground limestone is still the subject of a great deal of controversy. In each case, however, the local conditions must be considered carefully before a final conclusion can be reached. The limestone from which lime is made should be fairly pure in order to obtain the best results.

The first record of lime production on a commercial scale in the State was in 1902 when an output of about 25 barrels was reported. The industry gradually developed until 1910 when there were 8 plants in the State, one in each of the following counties: Atoka, Coal, Comanche, Delaware, Dewey, Johnston, Nowata, and Pawnee. Since 1911 not more than 4 of the plants have been in operation; those reporting production for 1911 to 1916 being in Coal, Comanche, Delaware, and Johnston counties. During the first half of 1916, only two were in operation, one at Grove, Delaware County, and the other near Bromide, in Coal County.

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

CLAY PRODUCTS

Clay and shales occur abundantly in nearly all parts of the State. (See Fig. 8, page 97.) In general the shales in the eastern half of the State are clay shales of dark gray to green or black in color. Many of these shales are of good working properties and burn at comparatively low temperatures to some shade of red. No high grade fire clays or pottery clays have been found. Some of the shales associated with the coals in the east-central part of the State are of sufficiently high grade for the manufacture of sewer pipe or terra cotta. This section of the State is well supplied with railroads and with abundant and cheap fuel. Several brick plants have been established and have met with a fair degree of success, but the clay industry has not attained the importance that the advantages of the section in transportation and fuel seem to warrant. The principal plants are at Nowata, Vinita, Pawhuska, Sapulpa, Henryetta, Ada, Holdenville, Hartshorne, Dawson, Claremore, Cleveland, Collingsville, Boynton, Muskogee, Tulsa, Bartlesville, Okmulgee, and McAlester. Smaller plants are located at several towns and villages.

The shales in the western part of the State are all fine-grained clay shales of a red color. These possess good working properties, although the plasticity and drying shrinkage are rather high.

At various times plants have been in operation at many towns in western Oklahoma, particularly at Oklahoma City, Guthrie, Perry, Chandler, Stillwater, Enid, Kingfisher, El Reno, Chickasha, Duncan, Lawton, Mangum, Hobart, Elk City, Alva, and Woodward, and several other smaller towns. These plants have supplied the local demand. Not all of them are now in operation. The material in this part of the State is inexhaustible but, except in a few cases near gas fields, fuel must be brought in. The only clay products produced in the State are common building and paving brick. The annual production is over 70 million bricks, valued at $3,000,000.00.

PORTLAND CEMENT MATERIALS

Portland cement is a mixture of mineral substances, which, on the addition of water, hardens to an artificial stone. It is seldom used pure but is added to sand, gravel, or crushed stone, when it forms a bond uniting the larger particles into a solid

mass. Portland cement has the advantage over other cements of hardening or "setting" under water. It was first made in England and the name came from the resemblance of the hardened cement to the famous building stone from Portland in that country.

PLATE XXVII

QUARRY IN VIOLA LIMESTONE SOUTH OF ADA

Portland cement is made essentially of a calcareous material, generally limestone, and clay or shale. Any fairly pure limestone and shale or clay will make Portland cement; but, naturally, the quality of the product is dependent on that of the materials. To make the best Portland cement the raw materials must be low in silica, magnesia, and sulphur, must contain some iron, but not enough to make the iron content in the finished cement over 4 per cent. Too much iron gives the cement a dark color. In addition to the proper chemical composition, the materials should be physically suitable, for the expense of preparing the materials depends on their physical characters. For instance, a hard, crystalline limestone and a slaty shale would be much harder to grind, and, consequently, much more expensive to prepare than a soft limestone or marl and a soft clay.

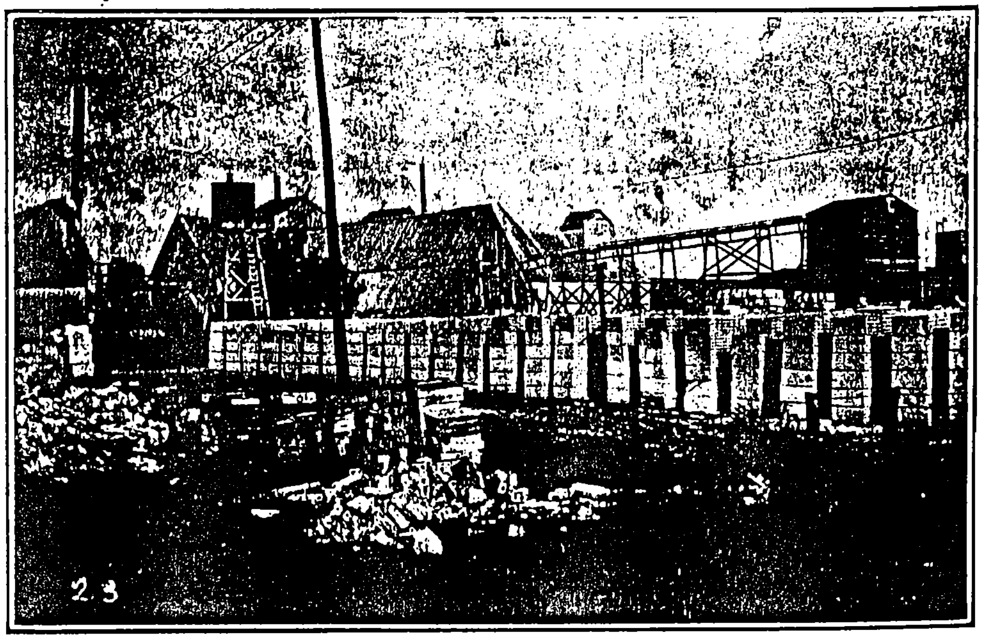
The process of making Portland cement is quite simple, but when conducted on a large scale requires a very expensive equipment of machinery. The limestone from the quarry and the clay from the pit are carefully dried, then ground separately to extreme fineness, mixed in the proper proportions—determined by their composition—and burned in large rotary kilns to a semi-vitrified mass or "clinker". The clinker is cooled and ground to extreme fineness, then packed in barrels or sacks ready for market.

Portland cement is manufactured at two localities in Oklahoma, Dewey in Washington County, and Ada in Pontotoc County. The value of the production is over $3,000.000 annually.

GYPSUM

Gypsum is used principally in the manufacture of wall plasters. Chemically, gypsum is hydrous calcium sulphate ($CaSO_4 \cdot 2H_2O$). When heated it loses part of the water and becomes $CaSO_4 \cdot H_2O$. That is, it loses one-half of its water of crystallization. The resulting substance is a white powder which is known as plaster of Paris. This has the property, when mixed with water, of taking up again the same amount of water as it lost when heated and recrystalizing to form gypsum. It is thus very valuable for the formation of casts and molds. Gypsum in nature is generally impure and the plaster made from it has usually a greenish or pinkish tinge. When mixed with sand and hair it makes the ordinary wall plaster of commerce.

PLATE XXVIII



GYPSUM PLANT IN WESTERN OKLAHOMA
Manufactured product in the foreground

Gypsum occurs in nature in three distinct forms: a non-crystalline or very finely crystalline form, rock-gypsum, a crystalline form with the crystals platy, selenite; and a crystalline form in which the crystals are needle-shaped, satinspar. Gypsum is a very soft mineral, usually white or slightly colored by impurities to gray, blue, red, or green. It may easily be distinguished from other common minerals by softness, being easily scratched by the thumb nail.

The manufacture of gypsum products is quite simple. The material is quarried or mined, crushed and ground to a fine powder, fed into large iron kettles, and heated until the proper amount of water is driven off. If heated to too high a temperature all of the water is driven off and the resulting plaster is said to be "dead burned". It then takes up water with extreme slowness and is of no value as plaster.

All the forms of gypsum occur in abundance in western Oklahoma. (See Fig. 8, page 97.) The distribution has already been noted in the section on physiographic provinces under Gypsum Hills region. Persistent ledges of gypsum form pronounced escarpments along the south side of Cimarron River from north of El Reno northwest to the Kansas line with a considerable area north of the Cimarron in Woods County. The amount of gypsum in this region is inexhaustible, although much of it is unavailable at the present time on account of lack of transportation. In the south and southwest gypsum regions there is also an enormous amount of gypsum, but in most cases it is not so well situated in regard to transportation and quarrying as several localities in the north along the main line of Gypsum Hills. Associated with the Gypsum Hills are considerable deposits of a gypsiferous clay which is known as gypsite. This usually lies in valleys or flats below the gypsum ledges. It is probably formed by the water which percolates through the gypsum coming down to the floor of the valley and evaporating from the surface, leaving its colluvial gypsum in a very fine crystalline form mixed with the clay of the valley floor. This gypsite is of great value in the manufacture of plaster, since it is very easily obtained and requires no grinding before it is heated. Large gypsite deposits are found in Blaine, Custer, and Jackson counties. Mills for the manufacture of plaster are located at Eldorado in Jackson County, at Rush Springs in Grady County, at Watonga, Okeene, Bickford, Southard, and Darrow in Blaine County, and at Alva in Woods County.

PLATE XXIX

GYPSUM BLUFFS ALONG NORTH FORK OF RED RIVER NEAR CARTER, BECKHAM COUNTY

While the deposits of gypsum in Oklahoma are inexhaustible and the raw materials can be very easily obtained, the high cost of fuel in the region and the distance from important building centers make competition with more favorably located deposits very difficult. None of the plants in Oklahoma have been running to capacity for considerable time and some of them have not been operated for the last four or five years. Gypsum production in Oklahoma in 1924 amounted to 316,134 short tons valued at $2,600,081.

SALT

Salt may be obtained commercially from the salt plains in the western part of the State. (See Fig. 7, page 86.) A large area on Salt Fork of Arkansas River east of Cherokee in Alfalfa County is known as the Cherokee Salt Plain. It is a flat plain about 30 square miles in area. Except at very wet times the entire surface of the plain is covered by a thin crust of salt.

Brine is encountered in the plain at depths ranging from a few inches to two feet. The amount of salt which could be obtained from this plain is very difficult to estimate, since no tests have been made in the way of sinking wells to determine the amount of brine which could be pumped from them. However, there is no question that vast amounts of salt could be obtained here.

PLATE XXX

VIEW OF SALT PLAIN IN HARMON COUNTY

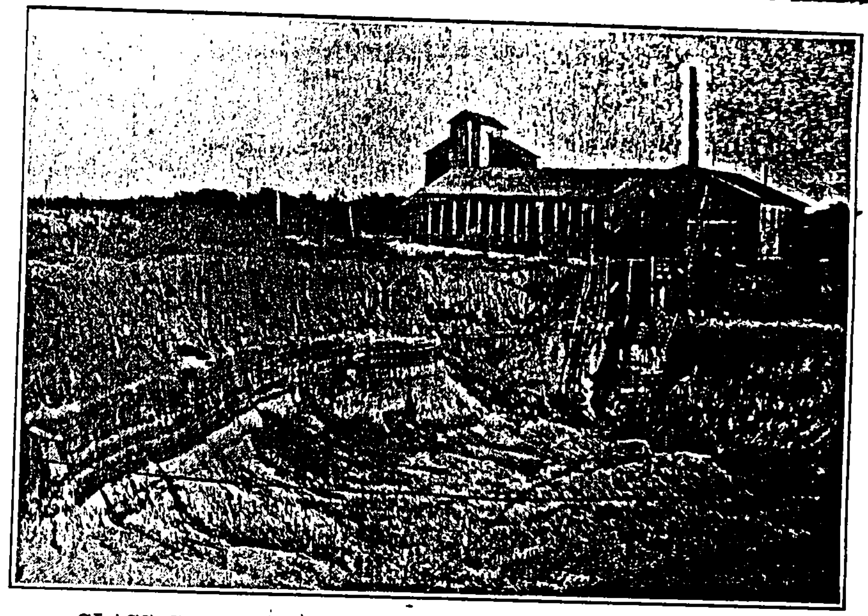
A short distance south of the Kansas line there are two important salt plains, one on the Woods County and one on the Harper County side of Cimarron River. These are known as the Little and Big Salt plains. Both are fed by brine springs. The Big Salt Plain on the Harper County side is more important and is fed by springs of large volume. One spring flows thousands of gallons per minute, and there are several smaller ones. On this plain, especially during dry weather, a crust of pure salt sometimes forms in the vicinity of the springs to a depth of six inches or even more. The quantity of salt available here is undoubtedly sufficient to supply a large plant, but it is so far removed from transportation that it is impossible to utilize it at present.

The Ferguson Salt Plain is on Salt Creek west of Ferguson in Blaine County. This is fed by springs coming from the red beds beneath the heavy gypsums of the Blaine formation. The brine is not so thoroughly saturated as is that at the Big Salt Plain and the crust of salt over the surface of the plain is much thinner. However, a very large amount of salt is going to waste at this locality. A few years ago a small plant was built at Ferguson to utilize this brine. Water was carried to Ferguson in pipes and a small but complete plant was arranged. However, it was abandoned after a short time and the machinery removed. Another similar, though smaller, plant is near Carter in Beckham County. The springs come from red beds beneath gypsum ledges. There are two large salt plains on Elm Fork of Red River in the extreme northwestern part of Harmon County. The conditions here are similar to those of Carter Salt Plain; that is, the salt plains issue from the red beds below the gypsums. Each of these plains, which are known as the Chaney and Kiser, could supply a very large quantity of salt; but like the plains on Cimarron River they are too far from transportation to permit them to be used. Salt is manufactured in a small way for local use by solar evaporation.

GLASS SAND.

Almost any sand may be used for the manufacture of glass, but sand containing very much impurity produces cloudy or colored glass. For a clear glass a pure siliceous sand is required. Such sand occurs in great abundance in the Arbuckle Mountains. (See Fig. 7, page 86.) Locally three ledges of sandstone in the Simpson formation are composed of practically pure sand which is so loosely cemented that the rock is very easily crushed. The only quarries utilizing this sand are at Roff and Hickory where the sand is washed and shipped to glass plants in the gas fields. This sand is of a very good grade. There is no doubt that increasing use of this sand will be made as long as the supply of cheap fuel can be secured in the State. The sands in many other localities in Oklahoma could be used for colored glass, but in general no industry of importance can be built up except with the pure sand. A ledge of sand northeast of Tahlequah is of sufficient purity for the manufacture of glass, but is too far removed from transportation to make it available. Some beds in the Trinity sands in the southeastern part of the State may also be suitable for glass sand.

PLATE XXXI



GLASS SAND QUARRY AND WASHING PLANT AT ROFF

ROAD MATERIALS.

The term road materials includes clay, sand, gravel, sandstone, limestone, asphalt, clinker from burned culm heaps of coal mines, and that produced when coal dust is burned with clay and cinders from factories. Material for macadam roads may be obtained from igneous, sedimentary, and metamorphic rocks. The best test for a good road is actual use, hence some of the materials just enumerated have been found to be more satisfactory than others.

The various building stones which have been mentioned, with the exception of the sandstones, may be utilized for material for macadam roads. So far, however, practically no macadam roads have been built in the State and it is doubtful whether this type of road, unless treated with some form of bituminous binder, is well adapted for our conditions and climate. The native asphalts might possibly be used as a binder for the material in macadam roads, but this should be tested thoroughly on a small scale before it is used extensively for building roads of this kind.

The eastern part of the State is fairly well supplied with road materials. In all localities stone could be secured by means of a short railroad haul, and an additional truck haul of a very short distance not more than 10 to 15 miles. The western part of the State, with the exception of the Wichita Mountain region and various local deposits of gravel, has little material for permanently improved roads. Fortunately, however, the sandy clay soil of this part of the State forms an excellent roadway almost the entire year. If properly graded and if dragged occasionally the country road in the western half of the State can be classed as good roads. The only exceptions are the sand hills area along the streams, but in most of these localities clay can easily be secured and a fairly good road may be made by the claying of the sand.

IRON.

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

The iron present in rocks gives rise to the various colors which occur in rock.

Oklahoma has no large deposits of iron ore, but some good ore occurs in the State, and there are reasons to believe that further investigations may reveal considerable quantites of ore. Iron is widely diffused through the red beds shales and sandstones in the central and western part of the State, and some of the formations contain as much as 20 per cent iron. Iron occurs throughout the coal measures area; chiefly in concretionary or kidney ore. These two sources are not likely to produce any ore of commercial value. Some good ore occurs in the Ouachita and Arbuckle Mountains; and in the region of Roff, Mill Creek, Davis, and Hunton, are found large boulders of low grade iron. In the vicinity of Sulphur and Bromide, blocks of ore weighing several hundred pounds are found. This is chiefly a manganese iron ore. The analysis of a sample of this ore shows 10 per cent iron and 40 per cent manganese. Shipments of ore have been made from near Hunton and Mill Creek.

In the Wichita Mountains considerable iron ore is found scattered over the surface. Some of this iron ore is magnetite. Some pyrites (iron sulphide) are shipped each year from the lead and zinc region.

Deposits of iron ore have been reported from many localities, but the Survey has not made any systematic investigation of the iron ore deposits and their true value cannot now be stated.

MANGANESE.

Explorations are now going on in Oklahoma to determine the extent of some manganese ore deposits. Investigations are being carried on about 3 miles north of Bromide and near Springbrook, about 5 miles southwest of Bromide.

The exploration near Springbrook was examined in considerable detail by a member of the Survey. Chemical analysis show this ore to run as high as 40 percent manganese. This ore occurs in irregular masses in an east-west fault zone which dips south at an angle of 80°. These irregular masses of ore vary in size from quite small to very large, one mass having been taken out which was 50 feet long, averaging 5 feet wide and 5 feet deep. The fault has brought in contact the Viola limestone and the Arbuckle limestone which are normally 1,400 feet apart in the geologic section. The vertical displacement is therefore more than 1,400 feet. The downthrow is on the north side of the fault. The strata on both sides dip towards the fault zone. About a mile southwest of the ore deposits is the Arbuckle-granite contact. The Arbuckle limestone dips away from the granite and towards the fault zone. The fault may be of sufficient magnitude to penetrate the granite which underlies the Arbuckle limestone. The Viola strata, dipping steeply towards the fault zone, acts as a barrier to the northward movement of the ground water that moves along the top slope of the Arbuckle limestone. Consequently there is movement of water upward in the fault zone. This idea is checked up by the fact that a spring is located on the fault zone.

The ore in the fault zone is a secondary concentration, the original source of which is the Arbuckle limestone, probably this Reagan sandstone which may underlie the Arbuckle limestone, and the granite which underlies both the Arbuckle limestone and the Reagan sandstone.

The structure here is such as to cause the groundwater to flow through the Arbuckle limestone and possibly on the contact of the granite with either the Reagan sandstone or the Arbuckle limestone or both. These formations may contain manganese which could be taken up by the groundwater, carried to the fault zone and deposited. The ore occurs in irregular masses because the fault zone is irregular, some parts of it permitting better circulation of the groundwater.

It is quite probable that there is a deposit of ore extending to considerable depth.

The fact that manganese ore is found in the Arbuckle region and on a fault zone opens up the possibility of additional deposits in this region. There are, no doubt, other localities where faulting has brought about similar conditions to those that prevail near Springbrook, Oklahoma.

COPPER.

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

NOVACULITE.

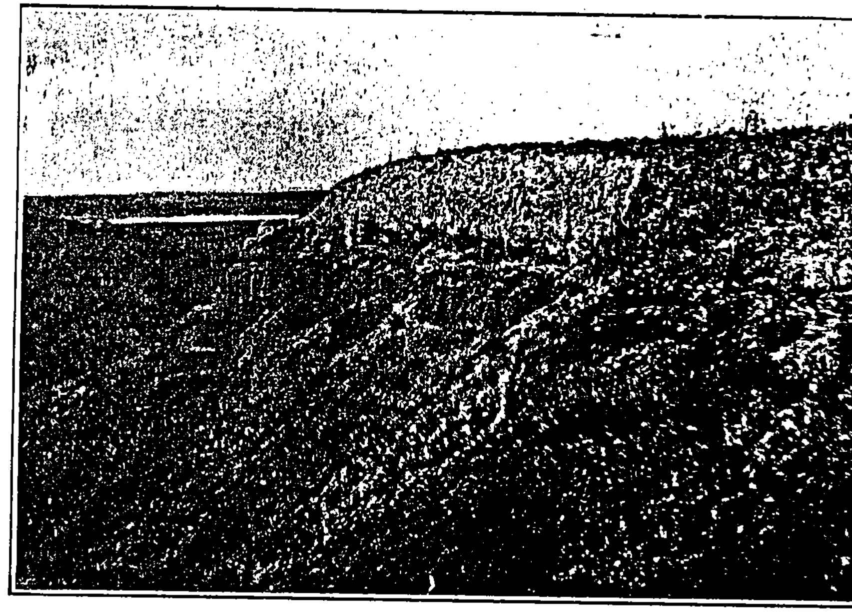
Novaculite is an even grained, gritty stone which is really a sandstone with the appearance of chert or flint. It has been found in commercial quantities in Oklahoma in the Ouachita Mountains, along the hills east of Stringtown and Atoka, about Talihina and to the eastward. The workable stone is obtained usually in rather small pieces. The size of the block as quarried ranges from 1 to 1,500 pounds. Novaculite is used for whetstones, razor hones, and jewelers' stones. In fact, it may be used by all workmen who use small-pointed or fine-edged tools.

VOLCANIC ASH.

Volcanic ash is composed of fine dust and powdered lava blown from volcanoes. There are several localities in Oklahoma where considerable deposits of volcanic ash are known to exist. (See Fig. 7, page 86.) Only a few deposits are of great size. It is only recently that volcanic dust has been considered of commercial value. It has been discovered that volcanic ash in greater or less quantities exists in several areas of the State, and when not found in distinct deposits it is found disseminated through the surface soil over large areas.

The principal volcanic dust deposits in Oklahoma occur in the northwestern and east central parts of the State. One of the principal occurrences is about 8½ miles northwest of Gate, near the boundary line between Harper and Beaver counties. Here

PLATE XXXII



VOLCANIC ASH DEPOSIT NORTHEAST OF GATE

a deposit 9 feet in thickness outcrops for a distance of 1,800 feet or more and about 1¼ miles east of this location another deposit showing 10 feet in thickness has a considerable outcrop. Other small deposits occur in the same general locality. Another important deposit is about 8 miles northwest of Woodward, where there is an outcrop of about 600 feet, showing a thickness of 6 feet, and a little farther to the south the outcrop continues for some distance with a thickness of about 8 feet. The deposit considered most accessible and perhaps most important in the State is in sec. 15, T. 14 N., R. 16 W., just north of Custer City, Custer County. A deposit of much value, and considerably removed from the ones above described, is found 8 miles northwest of Wetumka. This deposit is being developed to some extent and the material shipped from Okemah to Oklahoma City, where it is being used for various purposes. Another small deposit occurs 6 miles west of Okemah and another near Dustin. Near the north edge of the town of Stigler is a small deposit of impure ash 4 to 5 feet thick. Other deposits are known to occur over the general region from about Alva east to Newkirk and south to Watonga and Kingfisher. It is very probable that further investigations will lead to the discovery of many other deposits of greater or less extent over the northwest and central parts of the State.

Volcanic ash is used for abrasive purposes, chiefly in the form of polishing powders, scouring soaps, and cleansing powder. It is also used in the manufacture of dynamite and nitro-glycerin. It is a good non-conductor of heat and is used for packing material for safes, steam pipes and boilers, and as fireproof building material. It is of value as a fertilizer in the natural state, and in addition is used as an absorbent for liquid manure in the preparation of artificial fertilizers. It is also used in the manufacture of cements, artificial stone, paper, sealing wax, fireworks, and many other materials.

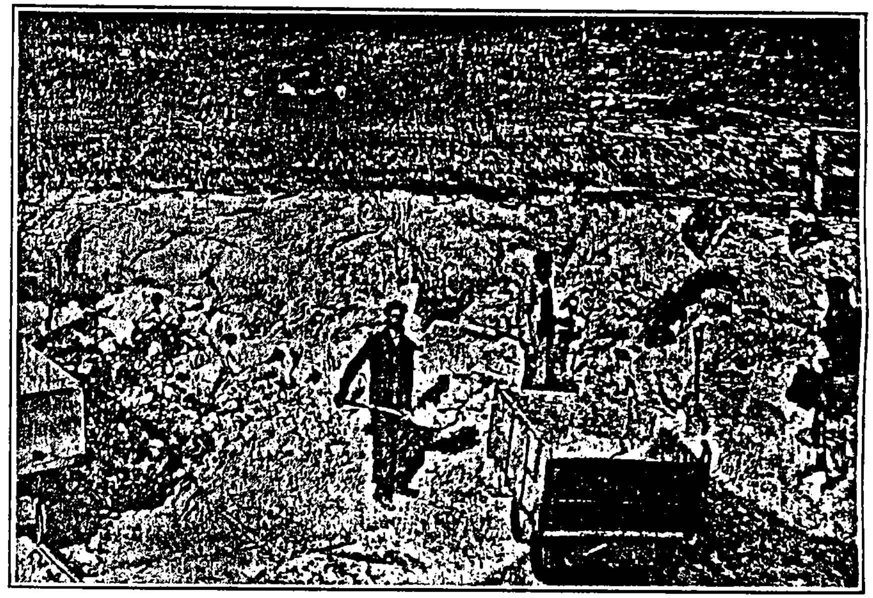
TRIPOLI.

Tripoli is a slight, soft, porous, siliceous rock supposed to have resulted from the leaching of calcareous material from a siliceous limestone. It is usually white or cream colored, but often there is sufficient iron oxide present to give a decided pink to red color. It is of value for a number of purposes. The chief products are manufactured from the flour which is prepared from the tripoli as quarried, in essentially the same manner as ordinary wheat flour is made. The rock is ground and sieved through silk wire bolting, is packed in barrels and sold on the market. Various grades of flour are made, depending on the purity of the material, and the fineness of the grinding. The chief use of the flour is as an abrasive or polisher in metal-working trades. The finer grades are used in jewelry polishing, and the coarse as brass and steel polishes. It is also used as an adulterant in the manufacture of gunpowder, as the body in dynamite, bagging for boilers, for making cement, water filters, wood filler, and wood polisher.

Illinois, Missouri, Arkansas, and Oklahoma are the states which produce tripoli. The principal seat of the industry is at Seneca, Missouri. Two mills owned by the same company are operating there. Much of the raw material comes from the Oklahoma side of the line. (See Fig. 8, page 97.) In 1912 a large deposit of value was found near Peoria, Oklahoma, about 8 miles from Seneca, and a railroad spur was constructed and a mill site selected. A company has considered developing the deposits and furnishing ground tripoli for abrasive purposes. It is difficult to obtain large pieces of the Oklahoma tripoli, such as are desired for filter manufacture, because of the cracks and bedding planes in the rock.

The rock exposed in the northeastern part of the State, where the tripoli occurs, is the Boone chert or Mississippi limestone. This formation consists of layers of pure limestone interbedded with layers of pure chert or flint. The deposits of tripoli owe their origin to the solvent action of water on this limestone or

PLATE XXXIII



TRIPOLI QUARRY, NORTHEASTERN OKLAHOMA

chert. The region is rough and hilly. The tripoli found is chiefly on the tops of the hills and along the sides of ravines. The extent of the deposits in Oklahoma is not known. Several small deposits of tripoli have been reported from various sections of the State. The source of the Missouri tripoli is probably the same as that of Oklahoma. The deposits in Arkansas consists of weathered, calcareous, siliceous rock. The calcareous material has been leached out, leaving a pure fine-grained siliceous material. At various places novaculite beds have been altered to tripoli.

GOLD AND SILVER.

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

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

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

DOMESTIC WATER SUPPLY.

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

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

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

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

MINERAL WATERS.

There are many mineral wells and springs in Oklahoma. The use of mineral water in the treatment of disease is an important one. As ordinarily understood, "mineral water" is applied to water which is used in the treatment of disease and differs from ordinary water in that it holds in solution certain solids or gases. The quantity of mineral matter contained varies greatly and many waters sold for medicinal or table use as mineral waters often contain smaller quantities of inorganic substances than are

PLATE XXXIV

ARTESIAN WELL CONTAINING SULPHUR WATER, SULPHUR contained in many domestic and city water supplies. Mineral waters of commerce are both natural and artificial, that is, some waters are put on the market in the natural state, while others are treated on the addition of organic or inorganic substances for certain results.

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

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

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

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

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

cline of more than one-half from the amount sold in 1912, but the value per gallon increased. The total amount sold was 502,439 gallons, valued at $26,231.00.

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

APPENDIX

Oil and Gas Producing Counties of Oklahoma, 1927.

County	Area in sq. mi.	County	Area in sq. mi.
Beckham	948	Murray	424
Caddo	1,296	Muskogee	876
Carter	832	Noble	764
Cimarron	1,850	Nowata	588
Coal	522	Okfuskee	617
Comanche	1,083	Oklahoma	720
Cotton	640	Okmulgee	684
Craig	770	Osage	2,350
Creek	963	Pawnee	617
Garfield	1,080	Payne	716
Garvin	814	Pittsburg	1,375
Grady	1,115	Pontotoc	716
Greer	624	Pottawatomie	819
Haskell	616	Rogers	751
Hughes	790	Seminole	626
Jefferson	767	Sequoyah	734
Kay	979	Stephens	891
Kiowa	1,089	Texas	2,065
LeFlore	1,637	Tillman	862
Lincoln	990	Tulsa	555
Logan	742	Wagoner	580
Marshall	442	Washington	420
Mayes	684		
McIntosh	742	Total number of Counties	46

Mineral Production of Oklahoma, 1920-25

Year	1920		1921		1922	
Mineral	Amount	Value	Amount	Value	Amount	Value
Petroleum a	106,206,000	$356,439,000	114,634,400	$183,135,000	149,571,000	$258,160,000
Natural Gas b	154,467,200	25,805,000	124,058,000	23,429,000	140,631,000	33,475,800
Natural-gas gasoline c	178,856,929	31,334,493	185,340,742	22,066,014	189,403,670	24,914,048
Zinc d	219,727	35,595,774	121,372	12,137,200	209,682	23,903,748
Lead d	65,394	10,463,040	41,552	3,739,680	62,856	6,914,160
Coal d	4,849,288	23,294,000	3,362,623	15,546,000	2,802,511	11,527,000
Cement e	1,484,698	3,284,412	1,596,566	3,420,093	(h)	(h)
Gypsum d	135,279	816,768	209,201	1,289,226	242,932	1,651,837
Clay products f		2,769,013		1,796,666		1,935,570
Stone d	875,560	1,056,136	878,350	1,023,514	1,156,950	1,327,370
Sand and ravel d	875,677	626,099	881,849	686,507	1,357,272	903,043
Other Minerals g		2,500,000		2,000,000		2,000,000
Total		$496,363,652		$270,318,900		$366,712,576

Year	1923		1924		1925	
Mineral	Amount	Value	Amount	Value	Amount	Value
Petroleum a	160,929,000	$279,700,000	173,538,000	$272,450,000	176,760,000	$347,000,000
Natural Gas b	203,082,000	31,214,000	211,452,000	31,045,700	215,000,000	32,000,000*
Natural-gas gasoline c	270,249,000	23,012,000	301,062,000	23,338,000	390,800,000	41,600,000
Zinc d	242,421	32,969,256	269,137	34,987,810	280,668	42,662,000*
Lead d	66,904	9,366,560	71,358	11,417,280	82,775	14,271,000*
Coal d	2,885,038	10,874,000	2,329,615	8,590,000	2,239,000	8,384,000*
Cement e	(h)	(h)	(h)	(h)	2,300,000	3,500,000
Gypsum d	290,121	2,248,895	316,134	2,600,081	342,000	2,737,000*
Clay products f		1,870,436		1,963,484		2,000,000
Stone d	1,265,900	1,427,920	1,303,030	1,499,297	1,340,000	1,527,000
Sand and gravel d	1,404,185	974,461	1,846,268	894,455		1,000,000*
Other Minerals g		5,500,000		4,600,000		3,500,000*
Total		$399,157,528		$393,386,107		$500,181,000

a, barrels; b, M. cubic feet; c, gallons; d, short tons; e, barrels; f, figures obtained through cooperation with Bureau of the Census; g, include values of asphalt, coke, lime, manganese ore, mineral paints, mineral waters, tripoli and miscellaneous minerals, some of which are estimated; h, included under "other minerals."
*Estimated.

Production of Petroleum in Oklahoma (in Barrels).

Year	Barrels	Year	Barrels
1891	30	1911	56,069,637
1892	80	1912	51,427,071
1893	10	1913	63,579,384
1894	130	1914	73,631,724
1895	37	1915	97,915,243
1896	170	1916	107,071,715
1897	625	1917	107,507,471
1898	none	1918	103,347,070
1899	none	1919	86,911,000
1900	6,472	1920	106,206,000
	7,554		853,666,315
1901	10,000		
1902	37,100		
1903	138,911		
1904	1,366,748		
1905 (Approx.)	8,000,000	1921	113,978,000
1906 (Approx.)	16,000,000	1922	150,000,000
1907	43,524,128	1923	161,000,000
1908	45,798,765	1924	176,760,000
1909	47,859,218	1925	173,270,063
1910	52,028,718	1926	177,651,198
	214,763,588		952,659,261

Total petroleum production for Oklahoma, 1891-1926 inclusive:

1891-1900	7,554
1901-1910	214,763 588.
1911-1920	853,666,315
1921-1926	952,659,261
	2,021,096,718

At the close of 1920 a total of over one billion barrels of oil had been produced in Oklahoma, with a total value of more than one billion dollars—the average price for oil being one dollar per barrel.

Since 1920 the average price for crude oil produced in Oklahoma has been about $1.75 per barrel. The amount of oil production in the State since 1920 has been 952,659,261 barrels; so that the value of production of Oklahoma oil since 1920 would therefore be about $1,667,153,706.75. Add to this the value of oil produced in Oklahoma prior to 1921 (one billion dollars) and a total valuation of $2,667,153,706.75 is obtained.

Oil Refineries, with Statistics on Capacity, etc.*

Status	Company	Railroad	Location	Daily Capacity	Type of Plant
Op.	Anderson-Prichard Oil Corp.	Frisco	Cyril	1,000	Skim
SD	Atwood Rfng. Co.		Oklahoma City	1,000	S. & L.
Op.	Barnsdall Refineries, Inc.	MV	Barnsdall	6,000	*Comp.
Op.	Barnsdall Refineries, Inc.	Frisco ON	Okmulgee	10,000	*Skim
Op.	Bell Oil & Gas Co.	RI MKT	Granfield	2,500	*Skim
Op.	Bolene Rfng. Co.	Santa Fe RI. Frisco	Enid	4,000	*Skim
Op.	Cameron Rfng. Co.	RI, GC, Frisco and SF.	Ardmore	3,500	Skim
Op.	Canfield Rfng. Co.	MKT Santa Fe	Yale	500	Skim
SD.	Carter Oil Co.	MKT Santa Fe	Cartoco	1,500	Top
Op.	Champlin Rfng. Co.	RI SF Frisco	Enid	16,000	*Wax
SD	Chestnut & Smith Corp.	Sands Springs R. R.	Sand Springs	5,000	Skim
SD	Constantine Rfng. Co.		W. Tulsa	3,000	Skim
Op.	Cushing Rfng. & Gasoline Co.	Santa Fe .	Blackwell	1,500	Skim
Op.	Cushing Rfng. & Gasoline Co.	MKT Santa Fe	Cushing	1,800	Skim
Rebldg.	Empire Refineries	MKT Santa Fe	Cushing	5,000	*Skim
SD	Empire Refineries		Oklahoma City	2,000	Skim
Op.	Empire Refineries	ON, Frisco	Okmulgee	3,000	*Wax
Op.	Empire Refineries	Santa Fe, RI.	Ponca City	7,500	*Wax
Op.	Garber Refinery, Inc.	Rock Island	Garber	4,500	Skim
SD	Gilmer Oil Co.	ONM & P	Ringling	1,000	Skim
Op. G.	Globe Oil & Rfng. Co.	Santa Fe	Blackwell	5,000	*Skim
Op.	Illinois Oil Co.	Santa Fe	Cushing	2,000	Skim
Op.	Imperial Rfng. Co.	RI. Frisco, GC & S. F.	Ardmore	6,000	*Skim
Op.	Independent Oil & Gas Co.	ON FRISCO	Okmulgee	6,000	*S. & L.
Op.	Interocean Oil Co.	OS Frisco	Bristow	2,000	Skim
Op.	Johnson Oil Rfng. Co.	MKT	Cleveland	3,500	*Skim
SD	Lawton Rfng. Co.		Lawton	1,000	Skim
Op.	Marland Rfng. Co.	Santa Fe	Ponca City	25,000	*Wax
SD	Mecca Rfng. Co.	KO & G	Allen	2,000	Skim
Op.	Mid-Continent Pet. Corp.	Frisco MV.	W. Tulsa	40,000	*Comp.
SD	Mid-Continent Pet. Corp. (Inland)		Cushing	2,500	Skim
Op.	Miller Bros. 101, Ranch	Santa Fe	Marland	100	Skim
SD	Newkirk Rfng. Co.	Santa Fe	New Kirk	2,000	Skim
SD	Nyamza Rfng. Co.	ONM & P.	New Wilson	2,500	Skim

*Hopkins, G. R., Petroleum refineries in the United States; U. S. Bur. of Mines Jan. 1, 1927.

Oil refineries, with statistics on capacity, etc.

Status	Company	Railroad	Location	Daily Capacity	Type of Plant
SD	Oil State Rfng. Co. (Bolene)	RI, Frisco, Santa Fe.	Enid	1,800	Skim
Op.	Oil State Rfng. Co. (Pontotoc)	KO & G	Allen	800	Skim
SD	Pawhuska Rfng. Co.		Pawhuska	1,000	Skim
Op.	Peppers Gasoline Co.	Frisco	Covington	700	Skim
Op.	Pierce Pet. Corp.	Sand Springs RR	Sand Springgs	8,000	*Wax
Op.	Producers Oil Co.	Frisco	Bristow	1,500	Skim
SD	Producers and Refiners Corp.	Santa Fe	Blackwell	3,000	Skim
Op.	Producers and Refiners Corp.	Frisco	W. Tulsa	6,000	*Skim
Op.	Pure Oil Co.	RI, GC, and Santa Fe.	Ardmore	7,000	*Skim
Op.	Pure Oil Co.	MKT	Muskogee	5,000	*Wax
SD	Red Seal Rfng. Corp.		Oklahoma City	2,000	S. & L.
Op.	Riley Pet. Corp.	Frisco	Bristow	500	Skim
Op.	Rock Island Rfng. Co.	RI	Beckett	2,500	Skim
Op.	Sapulpa Rfng Co. (Continental)	Frisco	Sapulpa	6,500	*Skim
Op.	Sayre Oil & Rfng. Co.	RI	Sayre	200	Skim
Op.	Shaffer Oil & Rfng. Co.	Santa Fe. MKT	Cushing	10,000	*Comp.
SD	Sinclair Rfng. Co.	Santa Fe. MKT	Cushing	6,000	Skim
Op.	Sinclair Rfng. Co.	Frisco	Muskogee	1,000	S. & L.
SD	Southern Oil Corp.	Santa Fe. MKT	Yale	5,500	Skim
Op.	The Sun Co.	Santa Fe. MKT	Yale	3,000	Skim
SD	Superior Oil Corp. (Okla.-Texas)	MKT, RI	Grandfield	2,500	Skim
Op.	The Texas Company	MV Frisco	West Tulsa	10,000	S. & L.
Op.	Texas-Pacific Coal & Oil Co.	Santa Fe	Wynnewood	2,500	*Skim
Op.	Tidal Rfng. Co.	Santa Fe	Drumright	6,000	*Skim
Op.	Tonkawa Pet. Corp.	Santa Fe	Tonkawa	2,000	Skim
Op.	Transcontinental Oil Co.	Frisco	Boynton	3,000	*Wax
Op.	Transcontinental Oil Co.	Frisco	Bristow	6,000	*Skim
SD.	Wagoner Rfng. Co.	MKT, MOP	Wagoner	100	Skim
Op.	Western Oil Corp.	RI	Comanche	1,500	Skim
SD.	Yale Asphalt Co.	Santa Fe, MKT	Yale	1,200	Asph.
Op.	Yale Oil Corp.	Santa Fe, MKT	Yale	1,200	Skim
				287,900	

EXPLANATION OF SYMBOLS

STATUS:

1. Op. denotes operating on January 1, 1927.
2. SD. denotes shut down on January 1, 1927.
3. Bldg. denotes building on January 1, 1927.
4. * denotes possession of cracking equipment.

LOCATION:

Location given is the plant location, which does not always correspond with the office address of the company. This directory is issued primarily as an adjunct to refinery statistics for the purpose of recording the growth of refinery equipment. For mailing addresses, the standard catalogues of the petroleum industry are better references.

DAILY CAPACITY

The capacity given represents the average daily crude throughput of the plant in complete operation, expressed in barrels of 42 U. S. gallons. There is no hard and fast rule governing size of plants, for in cases where refineries are partially or completely shut down, the rated capacity often varies with personal opinion. Furthermore, crude throughput fluctuates with the nature of the products that are produced. For example, the crude oil capacity of a plant engaged in skimming operations is much greater than when lubricating oils are being produced.

TYPE OF PLANT:

Six types of plants are recognized in this directory and are listed below, together with the products commonly produced. It should be borne in mind that, as with capacity, there is no hard and fast rule governing type of process for, the products produced are governed to some extent by the grade of crude oil used.

Skimming plant (Skim.)	Skimming and lube (S. & L.)	Wax plant (Wax)	Complete plant (Comp.)	Asphalt plant (Asph.)	Topping plant (Top.)
Gasoline Kerosene Gas and fuel oils	Gasoline Kerosene Gas and fuel oils	Gasoline Kerosene Gas and fuel oils Lubricating oils Wax	Gasoline Kerosene Gas and fuel oils Lubricating oils Wax Petroleum coke Asphalt, or both coke and asphalt.	Distillates Gas and fuel oils Asphalt	Tops Distillates Gas & Fuel oils

RAILROADS:

This denotes the different railroad connections over which tank cars have access to the refinery. This is a new phase of the work and, though composed in part of unofficial information, is believed to be essentially correct.

Name and Location of Oil and Gas Producing Areas in Oklahoma

Field	County	Twp. & Range
Ada	Pontotoc	4 N., 6 E.
Adair	Nowata	26 N., 14 E.
Agra	Lincoln	17 N., 5 E.
Alabama	Hughes	9 N., 11 E.
Alcorn	Kay	25 N., 2 W.
Allen	Pontotoc	5 N., 8 E.
Alluwe	Nowata	23-25 N., 16-17 E.
Alma	Stephens	2 S., 4 W.
Amabel	Payne	18 N., 5 E.
Asphaltum	Stephens	3 S., 4 W.
Atlantic	Osage	25 N., 8 E.
Avant	Osage	23 N., 11-12 E.
Baird	Cotton	1 S., 9 W.
Bald Hill	Okmulgee	14-15 N., 14-15 E.
Baltimore	Okmulgee	12 N., 11 E.
Barnes	Garfield	23 N., 3 W.
Barnsdall	Osage	23-24 N., 10-12 E.
Bartlesville	Washington	26 N., 12-14 E.
Bartlett	McIntosh	12 N., 14 E.
Bayou	Carter	4-5 S., 2 W.
Bearden (gas)	Okfuskee	10 N., 9 E.
Beaver	Comanche	2 N., 9-10 W.
Bebee	Pontotoc	5 N., 5 E.
Beggs	Okmulgee	15 N., 12 E.
Beland	Muskogee	14 N., 17 E.
Bilbo	Marshall	5 S., 5 E.
Billings	Noble	23 N., 2 W.
Billings, east	Noble	24 N., 1 W.
Billingslea	Creek	15-16 N., 8 E.
Bird Creek	Tulsa	20-21 N., 13 E.
Bixby	Tulsa	16 N., 13 E.
Blackwell	Kay	27-28 N., 1 E., 1 W
Boston	Osage	21-22 N., 7 E.
Bowlegs	Seminole	8 N., 6 E.
Boynton	Muskogee	13-14 N., 15-16 E.
Brinton	Okmulgee	13 N., 12 E.
Bristow	Creek	16 N., 9 E.
Brock	Carter	5 S., 1 E.
Broken Arrow	Tulsa	18 N., 14 E.
Bruner-Vern	Tulsa	19 N., 12 E.
Buck Creek	Osage	29 N., 9 E.
Buckner	Seminole	8 N., 8 E.
Burbank	Osage	26-27 N., 5-6 E.
Bu-Vi-Bar	Noble	21 N., 2 W.
California Creek	Nowata	27 N. 15 E.
Cameron (gas)	LeFlore	7-8 N., 26 E.
Canary (gas)	Washington	29 N., 13 E.
Caney (gas)	Washington	28 N., 12 E.
Carter-Knox	Stephens-Grady	2-3 N., 5 W.
Catoosa (gas)	Rogers	20 N., 14-15 E.
Cement	Caddo-Grady	5-6 N., 8-9 W.
Chandler	Lincoln	14 N., 5 E.
Chelsea	Rogers-Craig	24 N., 18 E.

Name and Location of Oil and Gas Producing Areas in Oklahoma (Cont'd.)

Field	County	Twp. & Range
Chickasha (gas)	Grady	4-5 N., 8 W.
Chicken Farm	Muskogee	14 N., 18 E.
Claremore	Rogers	21 N., 15-16 E.
Cleveland	Pawnee	21 N., 7-8 E.
Coal	Coal	2 N., 10 E.
Coalton	Okmulgee	12 N., 13 E.
Collinsville	Tulsa-Rogers	21-22 N., 14 E.
Comanche	Stephens	2 S. 7-8 W.
Continental	Creek	16 N., 9 E.
Coodys Bluff	Nowata	26 N., 16 E.
Copan	Washington	28 N., 13-14 E.
Council Hill	Muskogee	13 N., 16 E.
Country Club	Tulsa	20 N., 12 E.
Coweta	Wagoner	17 N., 16 E.
Cox	Carter	2 S., 2 W.
Crescent	Logan	18 N., 4 W.
Cromwell	Seminole	10-11 N., 8 E.
Cruce	Stephens	1 N., 6 W.
Cushing	Payne	18 N., 5 E.
Davenport	Lincoln	14 N., 5 E.
Dawson	Tulsa	20 N., 13-14 E.
Deaner	Okfuskee	11 N., 11 E.
Deep Rock	Payne	18 N., 3 E.
Deer Creek	Grant	27 N., 3 W.
Deleware	Nowata	27 N., 15-16 E.
Depew	Creek	15 N., 8 E.
Devonian	Okmulgee	15 N., 13 E.
Dewar	Okmulgee	11 N., 13 E.
Dewey	Washington	27 N., 12-14 E.
Dilworth	Kay	29 N., 1 E.
Dix	Okmulgee	15 N., 11 E.
Domes	Osage	27 N., 11 E.
Donahoe	Pawnee	23 N., 4 E.
Donnelly	Okfuskee	14 N., 10 E.
Doyle	Stephens	1 N., 5 W.
Drumright	Creek	17 N., 7 E.
Duncan	Stephens	1 N., 1 S., 8-9 W.
Duquesne	Pawnee	21 N., 6 E.
Dustin	Hughes	9 N., 12 E.
Earlsboro	Seminole-Pottattomie	9 N., 5 E.
Empire	Stephens	1-2 S., 8 W.
Enos	Marshall	7 S., 5 E.
Eram	Okmulgee	13 N., 15 E.
Eufaula	McIntosh	10 N., 16 E.
Evan	Okmulgee	13 N., 15 E.
Fairfax	Osage	25 N., 6 E.
Fisher	Tulsa	19 N., 11 E.
Foraker	Osage	27 N., 7 E.
Fox	Carter	2 S., 3 W.
Francis	Pontotoc	5 N., 7 E.
Frankfort	Osage	29 N., 6 E.
Fuhrman	Hughes	9 N., 9 E.

Name and Location of Oil and Gas Producing Areas in Oklahoma (Cont'd.)

Field	County	Twp. & Range
Garber	Garfield	22 N., 3-4 W.
Garrison	Okfuskee	10 N., 9 E.
Gilliland	Osage	23 N., 7 E.
Glenpool	Tulsa	17 N., 12-13 E.
Glenoak	Nowata	26 N., 14 E.
Gotebo	Kiowa	7 N., 16 W.
Graham	Carter	2-3 S., 2-3 W.
Grainola	Osage	29 N., 6 E.
Granite	Greer	6 N., 21 W.
Hallett	Pawnee	20 N., 7 E.
Hamilton Switch	Okmulgee	14 N., 12 E.
Hanbury	Comanche	2 N., 9 W.
Hanna	McIntosh	9 N., 13 E.
Harness (gas)	Grady	5 N., 7 W.
Haskell	Muskogee	15-16 N., 15 E.
Healdton	Carter-Stephens	3-4 S., 3-4 W.
Hector	Okmulgee	16 N., 13 E.
Hewitt	Carter	4 S., 2 W.
Hickory Creek	Osage	29 N., 11 E.
Hoffman	McIntosh-Okmulgee	12 N., 14 E.
Hogshooter	Washington	26-27 N., 13 E.
Holdenville	Hughes	7 N., 8 E.
Homer	Carter	1 S., 2 W.
Hominy	Osage	22 N., 8-9 E.
Hubbard	Kay	26 N., 2 W.
Humble (gas)	Jefferson	7 S., 5-6 W.
Independent	Okmulgee	16 N., 12 E.
Ingles	Payne	19 N., 4 E.
Inola	Rogers-Wagoner	19 N., 16 E.
Jenks	Tulsa	18 N., 13 E.
Jennings	Pawnee-Creek	19-20 N., 7 E.
Jolly-Ogg	Okmulgee	15 N., 14 E.
Jolly-Patton	Muskogee	14 N., 18 E.
Josey	Okfuskee	12 N., 11 E.
Kellyville	Creek	17-18 N., 10 E.
Kendrick	Lincoln	15 N., 6 E.
Keystone	Pawnee	20 N., 9 E.
Kiefer	Creek	17 N., 11-13 E.
Kilgore	Stephens	1 N., 5 W.
Kinta	Haskell	8 N., 20 E.
Kusa	McIntosh	11 N., 14 E.
Lark	Marshall	8 S., 5 E.
Lauderdale	Pawnee	20-21 N., 8 E.
Lawton	Comanche	2 N., 11 W.
Leonard	Tulsa	16-17 N., 14 E.
Lima	Seminole	8 N., 6 E.
Loco	Stephens	3 S., 5 W.
Lucky	Okmulgee	13 N., 13 E.
Lyons-Quinn	Okfuskee- Okmulgee	11 N., 12 E.
Madalene	Osage	21 N., 10 E.
Madill	Marshall	5 S., 5 E.
Magnolia	Stephens	1 S., 9 W.

Name and Location of Oil and Gas Producing Areas in Oklahoma (Cont'd.)

Field	County	Twp. & Range
Major	Okmulgee	16 N., 14 E.
Manion	Osage	23 N., 8-9 E.
Manford	Creek	19 N., 9 E.
Maramec	Pawnee	20 N., 6 E.
Marsh	Payne	18 N., 5 E.
Maud	Pottawatomie	7 N., 4 E.
Mervine	Kay	27 N., 3 E.
Micawber	Okfuskee	13 N., 8 E.
Midwest	Okfuskee	11 N., 10 E.
Milroy	Stephens	2 S., 4 W.
Mission	Wagoner	17 N., 15-16 E.
Morris	Okmulgee	13 N., 14 E.
Mose Carr	Okmulgee	14 N., 15 E.
Mounds	Creek	16 N., 11-12 E.
Myers Dome (gas)	Osage	26 N., 8 E.
Natura	Okmulgee	15 N., 13 E.
Nelagony	Osage	25 N., 10-11 E.
Nellie	Stephens	1 N., 9 W.
Newkirk	Kay	28 N., 3 E.
Newman	Hughes	8 N., 12 E.
New York	Creek	16 N., 11 E.
North Braman	Kay	29 N., 1 W.
Nowata-Clagget	Nowata	25-26 N., 15-16 E.
Nuyaka	Okmuulgee	13 N., 11 E.
Oak Grove	Wagoner	19 N., 15 E.
Ochelata	Washington	25 N., 13 E.
Oilton	Creek	18-19 N., 7 E.
Okemah	Okfuskee	11 N., 9-10 E.
Okesa	Osage	26 N., 11-12 E.
Okfuskee	Okfuskee	13 N., 10 E.
Oklahoma-Central	Okmulgee	15 N., 11 E.
Okmulgee	Okmulgee	13 N., 12-13 E.
Olean	Okmulgee	15 N., 12 E.
Olive	Creek	18 N., 8 E.
Onapa	McIntosh	11 N., 17 E.
Oolagah	Rogers	23 N., 14-15 E.
Osage	Osage	21 N., 8-9 E.
Oscar	Jefferson	7 S., 5 W.
Otoe	Noble	23 N., 2 E.
Otestot	Kay	27 N., 1 W.
Owasso	Tulsa-Rogers	20-21 N., 13-14 E.
Paden	Okfuskee	12 N., 7 E.
Panhandle	Texas	1 N., 12 E. C. M. and 4 N., 14 E. C. M.
Papoose	Okfuskee-Hughes	9-10 N., 9 E.
Pawhuska	Osage	25-26 N., 9-10 E.
Pawnee	Pawnee	22 N., 4 E.
Pearsonia	Osage	27 N., 8 E.
Pearson Switch	Pottawatomie	7 N., 5 E.
Pemeta	Creek	18 N., 7 E.
Perry	Noble	21 N., 1 W.
Pershing	Osage	24-25 N., 10 E.
Petit	Osage	23 N., 8 E.

Name and Location of Oil and Gas Producing Areas in Oklahoma (Cont'd.)

Field	County	Twp. & Range
Phillipsville	Okmulgee	14 N., 11 E.
Pine Pod	Okmulgee	14 N., 13 E.
Pine Smith	Okmulgee	13 N., 13-14 E.
Pollyanna	Okmulgee	15-16 N., 11-12 E.
Polo	Noble	22 N., 2 W.
Ponca City	Kay	
So. oil		25 N., 2 E.
No. gas		26 N., 2-3 E.
Pond Creek	Osage	28-29 N., 10 E.
Porter	Wagoner	16 N., 16-17 E.
Poteau (gas)	LeFlore	6-7 N., 26 E.
Prairie	Creek	16 N., 10-11 E.
Preston	Okmulgee	14 N., 12 E.
Prue (gas)	Osage	21 N., 10 E.
Quapaw	Osage	25 N., 11 E.
Quay	Pawnee	20 N., 5-6 E.
Quinton (gas)	Pittsburg	7 N., 18-19 E.
Rainola	Stephens	1 S., 8 W.
Ralston	Pawnee	23 N., 5 E.
Ramona	Washington	24 N., 12 E.
Ramsey	Cimarron	5 N., 5 E., C. M.
Red Fork	Tulsa	19 N., 12 E.
Red Oak (gas)	Latimer	6 N., 21 E.
Red River	Tillman	5 S., 14 W.
Retta	Kay	26 N., 2 W.
Rex	Wagoner	16 N., 19 E.
Ripley	Payne	18 N., 4 E.
Riverland	Okmulgee	14 N., 11 E.
Robberson	Garvin	1 N., 2-3 W.
Roff	Pontotoc	2 N., 4 E.
Rood	Seminole	9 N., 8 E.
Round-up	Carter	2 S., 2 W.
Roxana	Okmulgee	13 N., 14 E.
Sageeyah	Rogers	22 N., 16 E.
Salt Creek	Okmulgee	13 N., 11 E.
Sapulpa	Creek	18 N., 11-12 E.
Sayre	Beckham	9 N., 23 W.
Schulter	Okmulgee	12 N., 13 E.
Scott	Creek	16 N., 10 E.
Searight	Seminole	10 N., 6 E.
Seminole	Seminole	9 N., 6 E.
Shamrock	Creek	16-17 N., 7 E.
Sheridan	Okmulgee	16 N., 12 E.
Sholem-Alechem	Carter-Stephens	1-2 S., 3-4 W.
Skiatook	Osage-Tulsa	21-22 N., 12-13 E.
Slick	Creek	15 N., 10 E.
South Beggs	Okmulgee	14 N., 11 E.
South Braman	Kay	28 N., 1 W.
South Coffeyville	Nowata	29 N., 15 E.
South Elgin	Osage	29 N., 9 E.
Spencer	Okmulgee	15-16 N., 14 E.
Sperry	Tulsa	21 N., 13 E.
Spiro	LeFlore	9 N., 25 E.

Name and Location of Oil and Gas Producing Areas in Oklahoma (Cont'd.)

Field	County	Twp. & Range
Stidham	McIntosh	11 N., 15 E.
Stigler	Haskell	9 N., 21 E.
Stonebluff	Wagoner	16 N., 14-15 E.
Stroud	Creek-Lincoln	14 N., 6-7 E.
Sunray	Tulsa	18 N., 12 E.
Tabor	Creek	15 N., 10 E.
Talala	Rogers	24 N., 16 E.
Tatums	Carter	1 S., 3 W.
Terlton	Pawnee	20 N., 8 E.
Texhoma (gas)	Texas	1 N., 12 E., C. M.; 4 N., 14 E., C. M.
Thomas	Kay	25 N., 2 W.
1000 Acre Lake	Okmulgee	13 N., 12 E.
Tiger Flats	Okmulgee	12 N., 12 E.
Tonkawa	Kay-Noble	24-25 N., 1 W. 1 E.
Turkey Mountain	Tulsa	18 N., 12 E.
Turkey Pen Hollow	Okmulgee	12 N., 12 E.
Turley	Tulsa	20 N., 13 E.
Tuskegee	Creek	14 N., 10 E.
Tulsa	Tulsa	19 N., 13-14 E.
Twenty-one eleven	Osage	21 N., 11 E.
Twenty-one ten	Osage	21 N., 10 E.
Velma	Stephens	1-2 S., 5 W.
Vera	Washington	23 N., 12 E.
Vernon	Kay	29 N., 1 E.
Vian (gas)	Sequoyah	12 N., 22 E.
Vines (asphalt)	Murray	1 S., 2 E.
Vinita	Rogers-Craig	24 N., 18-19 E.
Wagoner	Wagoner	17-18 N., 17-18 E.
Walters	Cotton	1-3 S., 10-11 W.
Wann	Nowata	28 N., 14 E.
Watchorn	Pawnee	22-23 N., 3 E.
Webb	Grant	27 N., 3 W.
Webster	Wagoner	19 N., 15 E.
Weleetka	Okfuskee	10 N. 11 E
West Beggs	Okmulgee	15 N., 11 E.
Wetumka	Hughes	9 N., 10 E.
Wewoka	Seminole	7-8 N., 7-8 E
Wheeler	Carter	3 S., 2 W.
Wicey	Tulsa	16 N., 12 E.
Wigton	Okmulgee	13 N., 12 E.
Wimer (gas)	Craig	27 N., 17 E
Wilcox	Okmulgee	15 N., 11 E.
Wildcat Jim	Carter	2 S., 2 W.
Wildhorse	Osage	21-22 N. 10-11 E.
Woolsey	Stephens	2 S., 6 W.
Wynona	Osage	24 N., 9-10 E.
X-686	Osage	20 N., 10 E.
Yahola	Muskogee	15 N., 16 E
Yale	Payne	19 N., 5-6 E.
Yeager	Hughes	8 N., 10 E.
Young	Wagoner	18 N., 16 E.
Youngstown	Okmulgee	13-14 N., 11-12 E.
Y-686	Osage	28 N., 10 E.
Z-686	Osage	26-27 N., 11-12 E.