OKLAHOMA GEOLOGICAL SURVEY

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BULLETIN NO. 1.

PRELIMINARY REPORT ON THE MINERAL RESOURCES OF OKLAHOMA

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NORMAN
November, 1908

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INTRODUCTION.

Few states have either as many kinds of mineral or as much mineral of a kind as has Oklahoma, but at the present time not one half of one per cent of it has been developed. The state has deposits, which for all practical purposes are inexhaustible, of the following valuable minerals: Coal, oil, gas, asphalt, gypsum, salt, lead, zinc, shale, clay, glass sand, granite, gabbro, limestone, sandstone, building sand, gravel, and Portland cement rock, besides smaller deposits of iron, copper, tripoli, novaculite, volcanic ash, and a little gold and silver.

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

Another thing which the Survey endeavors to do is to discourage useless prospecting for minerals in regions where geological conditions are such that no mineral need be expected. To cite a single instance, during the past ten years at least $50,000 a year has been spent in prospecting for oil in the Redbeds of Western Oklahoma, where the conditions are such that there is not one chance in a thousand of finding anything of value. The members of the staff of the Survey are always glad to advise with anyone who plans to undertake drilling or prospecting in the state, as to the advisability of their action and their chances for success.

This bulletin has been written for the purpose of calling attention to the state's dormant resources. It is issued in response to requests which are constantly coming into the Survey office for information regarding Oklahoma's minerals. Its aim is to present in the briefest possible form a bare outline of the subject. At the present time preliminary reports are being written on the following subjects:

1. Building stone.
2. Road material.
3. Oil and gas resources.
4. Mineral resources of the Arbuckle Mountains.

It is expected that these reports will be published during the coming winter.

The Survey hopes to publish during the coming year additional preliminary reports as follows:

5. Coal.
6. Asphalt.
7. Portland cement rock.
8. Gypsum.
9. Clays and shales.
10. Lead and zinc.

These preliminary reports having been published it is hoped that the more strictly scientific work of the Survey may be accomplished, and reports prepared on the geological structure of the state, together with more detailed information concerning various mineral resources.

The conclusions given in this report need not necessarily be accepted as final, but rather as the results of such investigations as have been made up to the present time. There is little doubt that new localities will be discovered which will yield a number of economic products. For instance the limits of the oil field may be extended beyond the area indicated on the map herein given, or deposits of lead or volcanic ash may be found in regions not now known. In the preparation of the maps and the printed descriptions care has been taken to be conservative in order not to encourage useless prospecting or the needless waste of money. The members of the Survey staff are always glad to be of any assistance possible to the people of Oklahoma in all matters connected with the development of the state's mineral resources.

COAL.

(By Chas. N. Gould.)

The coal fields of Oklahoma cover about 20,000 square miles, in the Eastern part of the state (see fig. 1) and fall naturally into two divisions; namely, one north of the Canadian River, which is usually known as the Cherokee-Creek field, and one south of that

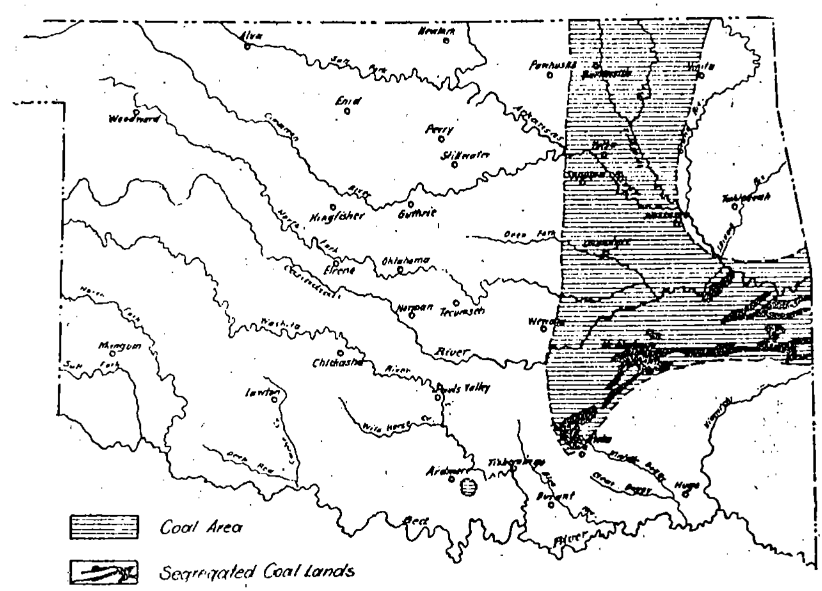

FIGURE 1.

Map of Oklahoma, showing the area underlaid with coal and the location of the seggregated coal lands.

river, or the Choctaw field. The Cherokee-Creek coal lies at a higher level, geologically, than the Choctaw coal, but is on about the same level as the Kansas coal. The coal in Arkansas is a direct continuation of the Oklahoma field, but only the lower beds are exposed in that state. The Texas coal area west of Fort Worth is a part of the same field, but is cut off from the Oklahoma fields by the Arbuckle uplift.

The coal beds dip slightly to the west, forming the eastern side of a large synclinical basin, the western border of which flanks the Rocky Mountains. In the southern part of the field the rocks have been much folded so that the veins often stand on edge, but the folding becomes much less intense northward (see fig. 2) and in the Cherokee-Creek field the beds are more nearly level. The rocks also become much thinner towards the north, many sandstones pinching out, while others are replaced by limestones.

The Choctaw coal fields are bounded on the north by the Canadian and Arkansas rivers, on the South by the Choctaw fault, which

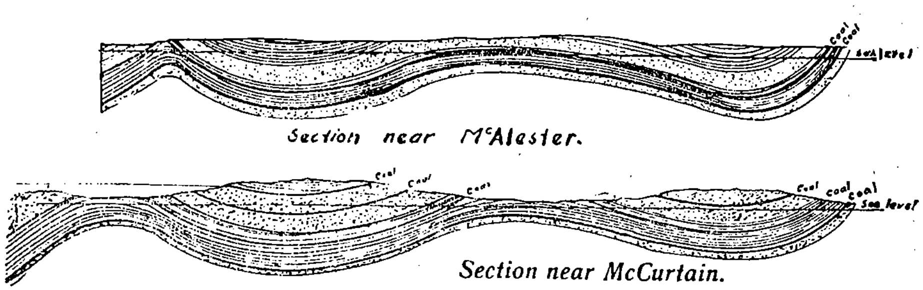

FIGURE 2.

Two cross sections of the Choctaw coal fields. The rocks have been folded, and the veins of coal dip steeply into the ground, or even stand on edge.—After Taff.

runs from Atoka to the Arkansas line, and the Arbuckle uplift, and on the west by an indefinite, irregular line. The whole region is folded very sharply near the Choctaw fault line, but much less so near the Canadian river.

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

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

spent going over the ground, checking up and verifying his previous work.

The total amount of land segregated is nearly half a million acres—437,743 acres to be be exact. This land lies in what is now LeFlore, Haskell, Latimer, Pittsburg, Atoka, Coal and Carter counties, Oklahoma. The main body extends uninterruptedly southwestward from the Arkansas line, near Fort Smith, for a distance of 125 miles as far as Lehigh and Atoka.

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

It is but just to say that doubt has been thrown on the accuracy of Mr. Taff's estimates by a number of mining men, and particularly by Mr. Wm. Cameron, who was for a number of years the mine inspector for Indian Territory. Mr. Cameron is of the opinion that Mr. Taff over-estimated the number of acres underlaid with coal, as well as the average thickness of the veins and the depth to which the coal can be profitably worked. He estimated that 4,000 tons per acre is a fair average for the amount of coal that can be secured, and that one-third of the land can never be mined on account of the depth and pitch of the coal. According to his estimate, the total amount of available coal on the segregated land is 1,252,916,000 tons.

The value of the coal is also a mooted question. Senator LaFollette in a speech in the United States Senate March 28, 1906, stated that the coal was worth $2 a ton at the mouth of the mine, and therefore estimated the value of the coal to be $4,337,000,000. It is obvious, however, that $2 a ton is too high an estimate for the value of the coal in the ground. Perhaps no better estimate can be made at the present time than that which is based upon the royalty that the mine operators pay the Indians, eight cents per ton. Taking Mr. Taff's estimate of the amount of the available coal, 2,954,138,000 tons, the value at eight cents a ton would be $236,331,040. Taking Mr. Cameron's estimate of 1,252,916,000 tons, the coal would be worth $100,233,280.

The apparent discrepancies between the estimates of the two gentlemen, both of whom are privileged to speak with authority, may be reconciled when we remember that Mr. Cameron evidently bases his conclusions on the present wasteful methods of mining in vogue in the region, whereby only about two-thirds of the coal is utilized. He also discards a number of veins from two to three feet thick which Mr. Taff included. Mr. Taff, on the other hand, has looked into the future and attempted to include all the available coal in the region. Judged by present mining methods Mr. Cameron is probably not far from correct in his estimate. Judged by the future, Mr. Taff is certainly right.

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

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

The rocks of the region consist of alternating layers of sandstone and shale. Mr. Taff has named the following formations, the lowest being given first: Atoka, Hartshorne, McAlester, Savanna and Boggy. The thickness of these formations and the relative location of the various veins of coal in them are indicated on the accompanying diagram, figure 3.

The upper and lower Hartshorne, or, as they are sometimes called, the Grady coals, are the lowest in the series, and are separated by about fifty feet of shale. The lower vein is just above a heavy ledge of sandstone known as the Hartshorne sandstone, and as the outcrop of this sandstone always forms a distinct ridge it makes an excellent marker for the coal, so that the vein can be easily located. Both veins are continuous, of a fairly good quality, and extend over a large area. In the eastern part of the field the upper ledge nearly pinches out. The Hartshorne coal is generally bituminous, but in places semi-anthracite, and varies in thickness from two and one-half to seven feet. Near Atoka it is called the Atoka coal, while in the Cavanal Mountain region it goes by the

name of Panama coal. It is being mined at a large number of places, among which are Wilburton, Hartshorne, McAlester, Krebs, Cherryvale, Heavener, Lehigh, Panama, and McCurtain.

The McAlester coals, or as they are called in other parts of the state, the Lehigh or Stigler coals, occur in the upper part of the McAlester formation nearly 2,000 feet, geologically, above the Hartshorne coal. They are separated by about sixty feet of shale.

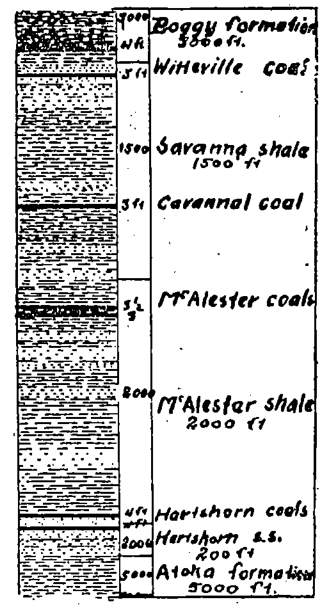

FIGURE 3.

A section of the rocks of the Choctaw coal field. Showing the thickness of the formations and the location of the seven principle coal veins. —After Taff.

They are bituminous, but slightly harder than the Hartshorne coal. The veins vary in thickness from two feet to four and one-half feet. The McAlester coal is mined near Wilburton, McAlester, Hartshorne, Red Oak, Hughes, Stigler, Sansbois, Coalgate and Lehigh.

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

The Witteville coals, known also as the Jones' Creek coals, are, geologically, the highest ones south of the Canadian River. There are two main veins, the lower of which is at the top of the Savanna formation, while the upper one is found in the Boggy shales. The beds are from two and one-half to four feet in thickness, but their value is decreased in many places on account of partings of bony coal. The Witteville coals are mined at Witteville, Sutter, Massey and Blocker.

In the eastern part of Carter County, just south of Ardmore, a small vein known as the Ardmore coal has been worked for some time, but it is of very little importance and has not yet been correlated.

The Cherokee-Creek coal, as has been said before, occurs in the upper part of the coal measures in the same formation as does the Kansas coal. The Cherokee shales, in which the Weir-Pittsburg coal of Kansas is found, extends into Oklahoma, increasing towards the south both in thickness and in area.

In the southern part of the Cherokee-Creek field there are a number of small, un-named coal veins, some of which are correlated with the McAlester and Witteville coals. One of these veins has been mined, near Wagoner, by the strip pit system. Other beds are found near Council Hill and Boynton. On Cane Creek a thirty-inch vein has been discovered, which promises much for future development.

The most important ledge of coal in the field is known as the Henryetta coal, a vein about three feet thick, situated from 100 to 200 feet below the Fort Scott limestone. The outcrop has been traced from Henryetta northeast to the Kansas line. It is mined at Henryetta, Schulter, Morris, Broken Arrow and Catoosa.

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

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

In 1907 Oklahoma produced 3,642,658 short tons of coal, valued at $7,433,914. The state ranked fourteenth among twenty-eight coal-producing states. Only three other states showed a greater per centage of increase over the production in 1906. Eight thousand, three hundred and ninety-eight men were employed in the coal mines of Oklahoma. The average production per man was 434 tons.

OIL AND GAS.

(By L. L. Hutchison.)

The questions, Where and how do oil and gas originate? and Why are they found in certain favored localities? are ever recurring ones. It therefore seems desirable to give a brief resume of the theories concerning the origin, occurrence and accumulation of these minerals before going into a discussion of Oklahoma's oil and gas development.

There are, at present, two theories proposed to account for the ultimate origin of oil and gas; namely, the Organic, and the Inorganic thories. The Organic theory has rapidly gained favor in the last two or three decades, and is now almost universally accepted among geologists, and is recognized by the world's greatest chemists, as the most plausible and most probable theory

Organic Theory.

Oil and gas are found, with a few minor exceptions, either in or very near rock strata which contain large quantities of the petrified remains of plants and animals, and never, in paying quantities, in rocks of the granitic type. This, together with the fact that petroleum and natural gas have been formed by artificial distillation processes, makes it appear almost certain that these hydrocarbons, as found in nature, are distilled, by a yet un-explained process, from the remains of organic life deposited in the sedimentary rocks at the time of their formation.

Chemical analysis shows natural gas to consist of the more gasseous constitutents of the petroleum mixture; so it appears that the ultimate origin of natural gas is the same as that of petroleum. The natural gas which is found by boring seems to be of secondary origin, that is, it is a volatilization product from petroleum.

Chemists attacked the problem of the origin of petroleum even before geologists did, and attempted to produce crude oil by various synthetic chemical processes.

Inorganic Theory.

Chemists found that, under certain artificial conditions, they could cause inorganic matter to so react as to form a number of the compounds of the hydrocarbon series, the mixture of which forms petroleum. These reactions were, it appears, invariably induced at very high temperatures, under great pressure, and between carbides and water. But the nature of the carbides is such that their existence in sedimentary rocks is precluded. If carbides, and other compounds such as chemists used in their experiments, do exist in nature, they are to be expected in molten magmas. When these carbide-containing magmas are intruded into water-bearing formations, hydrocarbons, i. e., oil and gas, would doubtless be formed.

If, then, this were the method of oil and gas origin, we should find them collected in or near large granitic masses. The contrary, however, is the case, that is, oil and gas are found in regions so far removed from seats of igenenous activity, that there is no probable genetic connection between them and the granitic intrusions. Besides this, there are other reasons why the chemical theory is rejected. Those chemists who have come to know more about the geology of petroleum, have almost universally discarded the inorganic theory as the one which most probably explains the origin of oil and gas.

Occurrence.

Petroleum and natural gas occur in sedimentary rocks of all geologic ages. They are found most abundantly, however, in rocks of the Ordovician, Silurian, Carboniferous, and Tertiary ages: As a general rule the *older* the producing rocks, the *less* the *quantity,* but the *better* the *quality* of the oil.

Careful investigations, made in the various oil fields of the

world, have proved beyond reasonable doubt, that four conditions are essential in order to have oil and gas concentrated into paying "pools." These are:

1. A source of supply.
2. Reservoir rock.
3. Cap rock.
4. Catchment basin.

Highly fossiliferous or bituminous strata are evidence that great quantities of organic remains were buried in the rocks at the time of their formation, and hence prove a probable source of supply.

"Oil pools," are often spoken of. The term, however, does not mean that the oil occupies great underground caves or caverns, but merely that oil is found filling the pore spaces in certain rocks. The reservoir rock, then, is merely a porous formation in which the oil and gas collect, because it is more porous, than the surrounding strata.

Oil, gas, and water are found intimately associated in nearly all of the oil fields of the world. Since oil and gas are lighter than water they rise when in its presence, and would be forced to the surface and dissipated were there no rocks impervious to oil and gas, encountered between the seat of their origin and the surface. Such an impervious formation is called the "cap rock." Slaty or calcareous shale and fine grained limestone most commonly form the cap rock.

The earth's crust has been subjected to stresses and strains ever since the beginning of geologic times. When these forces are of sufficient magnitude, the rocks are thrown into undulations, like the waves of the sea, with alternating crests and troughs, or up-folds, called anticlines, and down-folds called synclines. (Fig. 4.) If there are oil, gas, and water in such folded rocks, and some of the strata are porous, while others are impervious, these three liquids will arrange themselves in the inverse order of their specific gravities, e. g., the one of the lowest specific gravity, (gas), will flow to the highest places, that is, the tops of the crests, or anticlines; the oil will collect beneath the gas, along the slopes of the anticlines, while the water will settle back into the down-folds, or synclines, (Fig 5.)

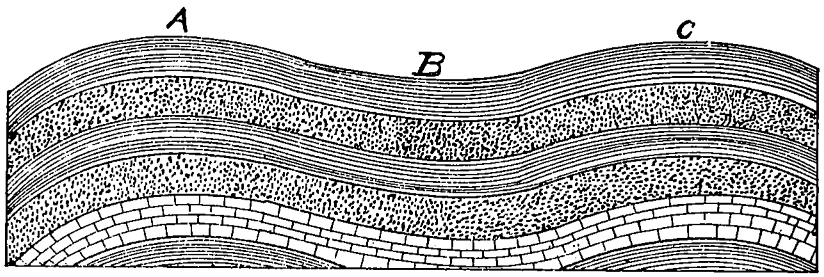

FIGURE 4.

An ideal section of the earth's crust which has been folded. A and C are anticlines and B is a syncline.

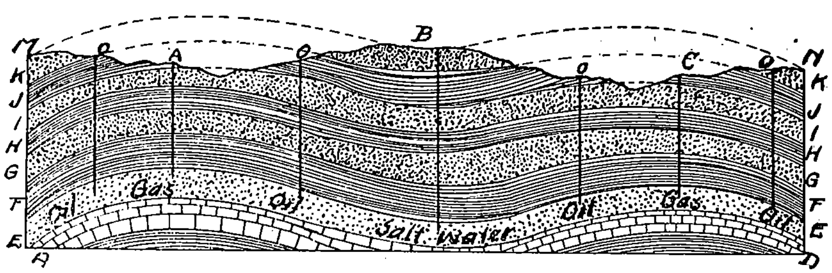

FIGURE 5.

The same section as Figure 4, after the tops of the anticlines have been worn away, but showing the relative positions which gas, oil, and salt water will assume in the folded strata. Wells drilled at A and C, at the crest of the fold, encounter gas; wells at O, O, O, O, on the sides of the fold will strike oil; while one at B in the syncline will produce salt water.

History and Development.

There is no authentic record of the earliest discovery of petroleum and natural gas in Oklahoma. Oil, it appears, was known to the earliest settlers near Mounds, and Adair, for there is a single oil spring that has been known for years, near each place. These springs yield small quantities of crude oil, while the "burning spring" northeast of McAlester, is a typical natural gas escapement. Shallow drilling near these so-called oil and gas springs failed to reveal economic deposits of either oil or gas, and they came to be considered of no consequence.

The greater part of the development to date, is in six general regions, namely: the Muskogee field, in and near the city of Muskogee; the Ninety-sixth Meridian field, which extends from the north line of the state to the Glenn Pool; the Coody's Bluff-Alluwe field, usually known as the Shallow field, east of the Verdigris, in Nowata and Rogers counties; the Cleveland field in a bend of the Arkansas River in eastern Pawnee county; the Hogshooter field, along Hogshooter creek in eastern Washington County; and the Bald Hill-Morris region, east and northeast of Okmulgee.

Of these regions, it seems that the Muskogee field was the first where oil was discovered by boring. The first development there was in 1894, when two wells were drilled within the present city limits. One was 800 feet deep and the other 1100 feet deep. These wells had respective initial productions of 12 and 60 barrels daily. Owing to local conditions, further development was deferred until 1904, when approximately 30 new wells were brought in with a total production of about 1000 barrels per day. The oil was of paraffine base and tested 42 degrees Baume. Development in the Muskogee region was confined to a small area near the city, until the winter of 1906-07, when a strong well of high grade oil was brought in a few miles southwest of town. Since that time, more than a hundred producing wells have been drilled and the development possibilities in the region seem to be only fairly entered upon.

The Ninty-sixth Meridian region, consists of a large number of small fields or so-called pools, the most prominent of which are those near Copan, Bartlesville, Dewey, Ramona, Skiatook, Tulsa, Redfork, and the word-renowned Glenn Pool. The first wells were drilled prior to the year 1901, at which time there were five producing just beyond the Osage reservation line west of Bartlesville.. The following year oil and gas were discovered at Redfork, south of Tulsa. This gave great impetus to prospecting from the Kansas line to Tulsa, and the attempts were so uniformly successful that in 1906 in driving from Caney, Kansas, to Beggs, Oklahoma, one need never be out of sight of producing wells for more than two hours together.

The first producing wells of the Coody's Bluff-Alluwe field were brought in a few miles west of Chelsea, about eight years ago. Prospecting proved that the producing area lay to the northward. Development went on rapidly, until at present the Coody's Bluff-Alluwe field covers a region six to ten miles wide and about twenty-five miles long. The depth to the oil sand, in this region, is variable, ranging from 150 feet in some places west of Chelsea, to nearly 600 feet at the northern end of the field.

The presence of oil and gas at Cleveland was first known in July of 1904, when the first well, known as "Uncle Bill No. 1," was finished on the William Lowrey farm, immediately south of the townsite. The entire country was soon under lease. Even town lots with residences, were leased and drilled, and the city council had to prohibit the erecting of oil derricks at the rear of stores, and on the vacant bits of ground in the business center. The original field is small, not covering over a half dozen square miles, and seems to have already passed its prime, for a number of wells, once good producers, have been abandoned and it is reported that none are now flowing. The field, though small, was very rich. Geological conditions are such, however, that it is believed that a new and larger field will be opened up southwest of the old one in the near future.

The Hogshooter field is situated along Hogshooter Creek, whence its name. The first producing wells were drilled in 1906. Some splendid flows of gas have been encountered; the largest reported was in the spring of 1907, when a well said to produce 60,000,000 cubic feet per day was brought in. Development has been continuous since the beginning. Conditions are such that it is believed, that much more productive territory will be found between the east line of Osage County and the Verdigris River.

The first well in the Morris field, about six miles east of Okmulgee, was drilled during the summer of 1906. This was soon followed by others, until at present there are more than fifty wells

producing either oil or gas in paying quantities. The Bald Hill field, about 10 miles north of Morris, is rapidly becoming important. The first well was brought in during the fall of 1907.

Successful wells have been drilled at various places in the Osage reservation, west of the Ninety-sixth Meridian. A number of wells which produce heavy fuel oil in paying quantities, have been drilled at Wheeler, about 20 miles northwest of Ardmore, in the southern part of the state. Both oil and gas in small amounts have been found at Gotebo, and Lawton, near the Wichita Mountains, and a small quantity of oil has been found at Granite, at the western extremity of the same range. Dry gas in sufficient quantities for local use is found at Blackwell, Ponca City, Coweta, Chelsea and Bristow. Coweta also produces some oil, and light producing wells have been brought in near Wewoka, Madill and Manford.

In 1906 the entire Mid-continent field produced, according to Government statistics, 21,718,648 barrels of crude oil, and Oklahoma was classed as the third state in the union in point of production. Development went forward with phenomenal rapidity and by the close of 1907 Oklahoma was easily the first producer among the states. The total production of the Mid-continental field for that year was 45,933,649 barrels. Of this amount, 44,300,149 barrels, worth over seventeen and three-quarter millions of dollars, are accredited to Oklahoma, while Kansas yielded only 1,633,500 barrels.

There is no way of even estimating the amount of gas produced in the state. Every city and hamlet in the field uses gas for manufacturing and domestic purposes. The Oklahoma Natural Gas Company is now delivering gas to Oklahoma City and to points between that city and the field for domestic use at 25 cents per thousand cubic feet. They are preparing to extend their lines to Chickasha, Lawton, El Reno, Kingfisher, Enid, Perry, Pawnee, Stillwater, Guthrie, and intermediate points. To supply such a patronage, requires a vast amount of gas, but the company now claims that it controls a supply sufficient for at least ten years.

The total cost of the development of the entire oil field to date, exclusive of pipe lines, approximates $25,000,000*. The gross income from the investment for 1907, was approximately $17,500,000.

*Petroleum Gazette, July, 1908.

Markets.

Until within the last eighteeen months, the Prairie Oil and Gas Company, a subsidiary of the Standard Oil Company, operat the only pipe line in Oklahoma, and therefore purchased all the oil sold, except such as was shipped to independent companies, which was relatively very little. During the year, 1907, the Gulf and Texas companies, each completed pipe lines from the Gulf coast to the Glenn Pool, in the southern end of the Ninty-sixth

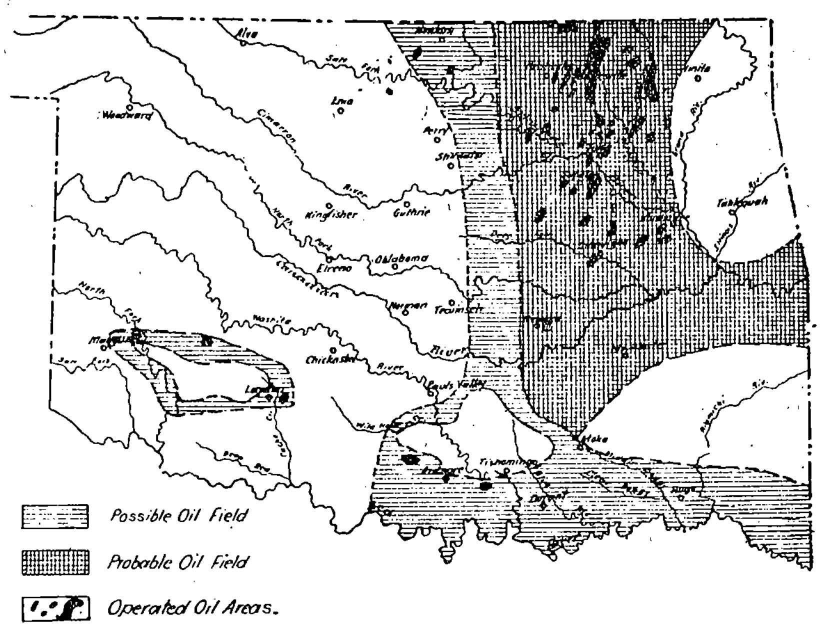

FIGURE 6.

Map showing the location of the developed oil fields of Oklahoma; the undeveloped area in which oil will probably be found; and the area of possible oil and gas production.

Meridian field, and built a number of large storage tanks about three miles south of Jenks. The completion of these lines, put three buyers in the field, instead of one, and gave considerable relief to market conditions. But even with this increase in facilities, the pipe line companies, have not grown as rapidly as the phenom-

enal increase in production warranted, and they are often unable to remove oil as fast as it is produced, and a slightly congested market sometimes obtains.

Refineries.

There are at present only two oil refineries in the state. One belongs to the Uncle Sam Oil Company, and is located at Tulsa; the other, an independent plant, is situated at Muskogee. Only the latter is in operation.

Conclusion.

Such, in brief, is a review of the present development of Oklahoma's oil and gas territory. It is, however, the opinion of the survey staff, that not one tenth of the probable oil field of the state has been touched, (fig. 6,) and that not one-tenth of what has been proved productive is yet developed. According to this estimate, not more than one per cent. of the state's oil and gas has been developed.

ASPHALT.

(By Chas. N. Gould.)

The asphalt deposits of Oklahoma are among the most extensive in the United States. The greater part of the deposits occur in the southern part of the State, in the region south of the Arbuckle Mountains, although exposures are found all the way from the Arkansas line to the Wichita Mountains (see fig. 7.) Practically all the asphalt in Oklahoma is found as rock asphalt; in other words, rock impregnated with asphalt. In a few cases, however, as near Atoka and Cornish the material is found in an almost pure semi-viscous state. Pure asphalt or bitumen is derived from the distillation of petroleum or rock oil. On the island of Trinidad, the asphalt comes to the surface in great quantities and spreads out, forming a so-called lake. The evaporation on the surface forms a hard crust, but beneath the crust the asphalt is soft and viscous.

The asphalt in Oklahoma occurs usually along faults which extend from the surface to a depth of sometimes many thousands of feet. Along these faults or fissures the rocks have slipped up on one side and down on the other. At some unknown depth these fissures have cut beds which carried the heavy petroleum, which came along the fault line and impregnated the rock on either side of the fissure. If the rock alongside the fissure happens to be a limestone the substance is called lime asphalt. So it will often happen that a bed of lime asphalt occurs beside a bed of sand asphalt or vice versa, the two beds being on opposite side of the fault line.

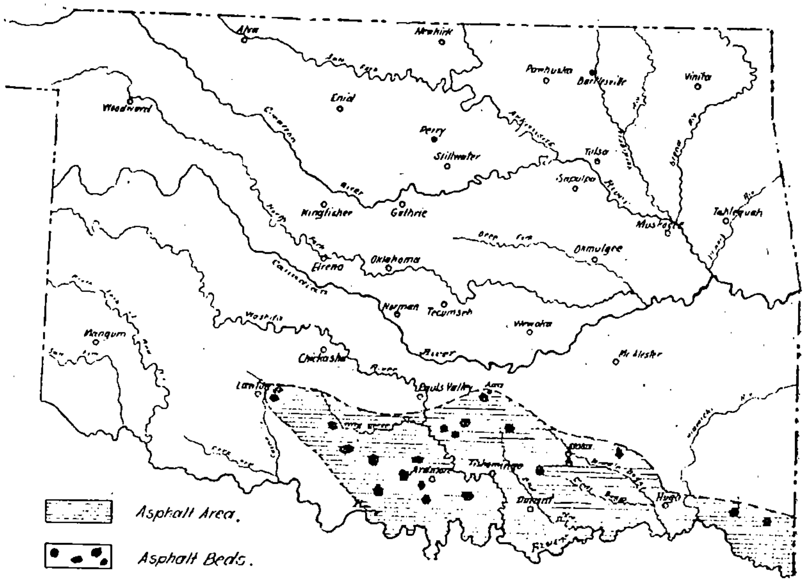

FIGURE 7.

Map of Oklahoma showing the asphalt deposits and the general region in which asphalt occurs.

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

ized. It is usually considered that a mixture of the lime and sand asphalt makes the best paving.

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

The faults often outcrop on the surface for a distance of a mile or more. The depth to which the fissures extend is unknown, but in some cases as shown by drilling it is at least 100 feet. When it is understood that several scores of the fault lines have already been discovered and that new ones are coming to light all the time, it will be seen that the deposits are, for all practical purposes, inexhaustible. It is no uncommon thing for a farmer breaking out new prairie to turn up a black rock and find that an asphalt vein crosses his field. Or perhaps a man digging post holes may throw up a piece of asphalt rock. No one knows how extensive the deposits are, but there need be no surprise if new beds are discovered for the next fifty years.

According to the terms of a treaty entered into between the Choctaw and Chickasaw Indians and the United States all the known valuable coal and asphalt lands in both nations were segregated, or set apart from allotment. The work was done by Mr. Joseph A. Taff, of the United States Geological Survey, in 1903 and 1904. Mr. Taff included in his segregation all the land containing asphalt that had been discovered up to that time, 7,240 acres in all, of which 6,880 acres had been leased by various companies and 360 acres not leased. This land is included in thirteen separate tracts, twelve of which are located in the Chickasaw Nation and one in the Choctaw Nation. The size of the tracts varies from 40 to 860 acres. According to the terms of the treaty, the leased land, 6880 acres, could not be sold without a special act of Congress, so that only 360 acres of unleased asphalt land were on the market. Bids for this land were opened August 7, 1906, but all were rejected by the Secretary of the Interior.

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

At various times several of these different deposits have been operated. Quarries have been opened on practically all the leases and several mills have been erected, located as follows: One at Gilsonite, three miles south of Sulphur; one at Brunswick mine near Dougherty, and one at Ardmore. In some cases the rock was simply crushed fine, and in other instances an attempt was made to distill out the asphalt from the rock matrix. At various times the rock has been used for paving in a number of cities such as Kansas City, Fort Worth, Ardmore and Shawnee.

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

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

GYPSUM.

(By Chas. N. Gould.)

The gypsum area of which the Oklahoma beds form a part is the largest in the United States. The area extends practically uninterruptedly from Southern Nebraska across Kansas, Oklahoma and Texas, nearly to the Pecos River. It is not to be understood, however, that the line of outcrops is entirely continuous, but that throughout this entire distance the rocks are more or less gypsiferous. Over a considerable part of the area outcrops are continuous, and one may travel 200 miles or more and at no time be out of sight of heavy gypsum ledges.

The line of outcrops from Southern Nebraska to West Central Texas is approximately 600 miles long. The width of the area containing gypsum varies from a few miles to more than 100 miles. Oklahoma is in the center of the region and the most extensive deposits

are in this state. The amount of gypsum in Oklahoma is practically inexhaustible. With perhaps two exceptions, every county west of the main line of the Rock Island railroad contains enough gypsum to make plaster to last an indefinite length of time.

For convenience of discussion all the deposits of the state may be roughly grouped under four general regions, (see fig. 9) as follows:

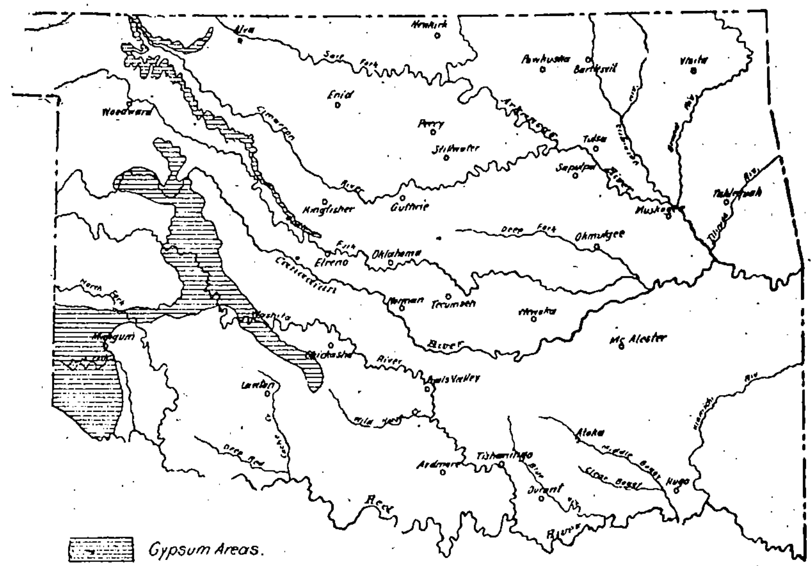

FIGURE 9.

May of Oklahoma, showing the three general regions in which gypsum occurs.

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

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

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

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

The Kay County Region.

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

The Main Line of Gypsum Hills.

The first considerable gypsum deposit encountered in crossing Oklahoma from east to west is along the main line of Gypsum Hills. These hills extend uninterruptedly from the vicinity of El Reno, Oklahoma northwest to Medicine Lodge, Kansas.

The hills are formed by two, sometimes three, ledges of massive white, rock gypsum, interstratified between beds of red clay-shale; that is to say, the gypsum ledges are members of the Redbeds formation. There are red clays below, above, and between the heavy ledges of gypsums. The clays and shales are usually soft, while the gypsums are relatively hard, and, following the universal law of erosion,—known as the survival of the hardest,—the gypsum beds often remain intact after the softer clays have all been eroded away. The various ledges of gypsum, with the interbedded clays and ledges of dolomite that are found below the gypsum ledges, aggregate from 60 feet to 90 feet in thickness.

Viewed from the east, the hills appear as a wall crowned with a white band. Nor is the skyline continuous, for numerous breaks occur where the gypsum ledge is gone, having been carried away by water. The general appearance is rather that of an uneven row of flat-topped buttes or mesas.

The line of outcrop of these hills extends from the north line of the state southeastward to El Reno. The ledge croses the Kansas line near the point where the Salt Fork enters Oklahoma. West of Alva the ledge outcrops near Whitehorse Creek and reaches the

Cimarron in northwestern Woods County. The gypsum forms the cap of the bluffs which enclose the canyon of Cimarron River from the Kansas line southeast for a distance of thirty miles. These bluffs vary from 50 feet in height near the state line to nearly 150 feet below the Big Salt Plain. The bluffs capped with gypsum are particularly well developed along the south side of the Cimarron River as far as the Glass Mountains in Major County. This line of hills is the region of bat caves and natural bridges. South of the Glass Mountains the ledge bears off to the south, gradually leaving the Cimarron, and approaches the North Canadian at Darlington and El Reno.

It is along this line, nearly 60 miles in length, from the Glass Mountains south that the hills rise as a wall west of the broad valley of the Cimarron. Some of the deepest canyons and most picturesque scenery in Oklahoma are found in this region.

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

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

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

Throughout Blaine County the various ledges of the gypsum are exposed, usually outcropping along the side of a hill or as the cap rock of a bluff or butte. In many places, however, the entire thickness of one of the ledges may be concealed beneath a load of debris, while in other localities the same ledge is entirely uncovered and may be exposed over an area of several acres.

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

The Second Line of Gypsum Hills.

To the west of the main line of the Gypsum Hills and at a higher level, geologically, there is a thickness of several hundred feet of red sandstones, shales and clays, with some included ledges of dolomite and magnesian limestones. These formations extend from Woodward County to Comanche, just back of, and paralleling the line of hills just discussed.

Still farther west and at a higher level than the sandstone, clay, and dolomite members, there is a second line of gypsum hills. In general the gypsum in this region differs both in form and stucture from that heretofore described. For one thing, it is not usually found in continuous ledges, that is, ledges of constant thickness do not extend for any great distance across the country. On the contrary, the stratification is very erratic. Sometimes practically all the thickness of the formation is composed of gypsum, while in nearby localities only sandstones and clays occur. Another point of difference is that the rocks of this region do not form conspicuous hills as do those farther east. In general these gypsums appear on the surface in the form of rounded knolls, or mounds, on the top of a divide between two streams, or as long, gently flowing

ledges along the side of a local bluff, or perhaps more frequently still, along the side of one of the rather deep canyons cut out by small streams into the soft rocks that make up the region.

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

Greer County Region.

The fourth general region of gypsum deposits in Oklahoma is in the southwestern corner of the state in Greer, Jackson and Southern Beckham counties. There is reason to believe that the deposits of this region belong to the same general level or geologic horizon as those just discussed under the name of Second Gypsum Hills; in fact, in a geologic classification, the rocks of these two regions would be described together. There is, however, a considerable area in Southwestern Washita County, lying between Cloud Chief and the North Fork of Red River, where the gypsum ledges are rarely exposed. This area separates the Greer and the Beckham County deposits from the main region and so differentiates the former region.

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

The deposits in Southeastern Beckham County are confined to a narrow belt, but in the area where exposures occur the finest examples of gypsum bluffs in the state are found. Along the north bank of the North Fork of Red River, extending upstream for a distance of ten miles or more from the extreme southwestern corner of the county, is a bluff which varies in height from 150 feet to 200 feet, composed of red clay shales interstratified with ledges of massive, white gypsum. There are four ledges of gypsum along the face of the bluff approximating 70 feet in thickness. The amount of available material along this bluff, estimating the deposits to be a mile wide, is more than one billion tons.

The ledges which outcrop on the North Fork in Beckham County cross under the bed of the river and appear at Haystack Mountain, some 20 miles northwest of the town of Granite. The same ledges that appear on the North Fork bluff and on Haystack Mountain also outcrop along all the streams tributary to Elm Fork. The various ledges appear on the cap of the bluff on both sides of Elm Fork far into Collingsworth County, Texas, and on the south side of this stream almost to the city of Mangum.

In Southern Greer and Western Jackson counties there are also extensive gypsum deposits, but in general the gypsum in this region does not occur in conspicuous ledges. The surface is level and few canyons have been cut into the plain, but the presence of the gypsum rock is often revealed by the numerous sinkholes that are found in the region and by an occasional exposure along a creek bank.

Amount of Gypsum in Oklahoma.

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

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

In arriving at results the plan has been, first, to estimate the number of square miles occupied by gypsum; and next, to approximate the combined thickness of the ledges. In both calculations care was constantly taken to make conservative estimates. The

number of square miles was multiplied by the thickness in feet and this by 2,000,000. This product is considered the number of tons of gypsum on the area under discussion.

Classified by counties the approximate amount of gypsum in Oklahoma is as follows: (This classification refers to the old counties of Oklahoma, before the boundaries had been changed by the recent constitutional convention.)

County.	Tons.
Canadian	50,000,000
Kingfisher	50,000,000
Blaine	2,500,000,000
Woods	14,000,000,000
Woodward	24,000,000,000
Comanche	200,000,000
Caddo	3,000,000,000
Washita	20,000,000,000
Custer	6,000,000,000
Dewey	1,000,000,000
Day	500,000,000
Roger Mills	1,000,000,000
Greer	53,000,000,000
Total	125,800,000,000

Classified by regions the amounts are:	Tons.
Main line of Gypsum Hills	40,200,000,000
Second line of Gypsum Hills	31,600,000,000
Greer County region	54,000,000,000
Total	125,800,000,000

Manufacture of Gypsum.

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

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

Investigations conducted last summer by F. A. Herald and Chester C. Clark, two of the Survey staff, show the presence of nearly 50 new deposits of gypsite. A little systematic work would doubtless reveal many more.

The fuel problem is more difficult. It is useless to look for coal anywhere in the gypsum region, and the geological structure precludes the probability of petroleum or natural gas being found in quantity. The nearest coal is 200 miles or more from the gypsum, and under existing conditions the railroads get the freight on both the coal and the finished plaster. A milling and transit rate to the gas fields of Eastern Oklahoma has been suggested as the solution of the difficulty. The fact, however, that gypsum is more than one-fifth water of crystallization presents grave difficulties to this plan, even if a suitable rate could be obtained from the railroad. The last resort is to pipe the natural gas to the gypsum. Gas mains are already laid as far as Oklahoma City, and they will probably soon be extended to El Reno, which is not more than 15 miles from the southern end of the gypsum hills. Whether or not a rate can be secured which will enable the plaster men to utilize the gas remains to be seen. To my mind this is the most practicable solution of the problem.

Analyses of Oklahoma Gypsums.

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

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

SALT.

(By Chas. N. Gould.)

Wells and springs containing salt water are found not only throughout the Redbeds area in Western Oklahoma, but also in the eastern part of the State, and in certain regions the water from the springs is so salty as to warrant the popular phrase "salt springs" or "salt plains." Leaving out of account the regions in Eastern Oklahoma in which the water is but slightly salty, it is proposed to describe the localities, particularly in the western part of the State, in which salt springs and salt plains are common. (See fig. —.)

There are two salt plains along the Cimarron River between Woods, Woodward and Harper counties, two in Northwestern Greer County, and one each in Alfalfa, Blaine and Beckham counties. These plains are widely separated and vary greatly both in size and amount of water which flows from them. While all the salt springs come from the rocks of the Redbeds, they do not all issue from the same geological horizon. The Alfalfa County plain is located thirty miles or more from the Gypsum Hills, but all the other plains are in these hills. The Cimarron River plains and Blaine County plain are supplied by springs that issue from not far below heavy gypsum members, and the Beckham and Greer county plains are found near the base of gypsum ledges.

Alfalfa County Plain.

This is the largest of any of the Oklahoma salt plains and also the only one that contains no large salt springs. It is located four miles east of Cherokee, just south of the Salt Fork of the Arkansas in the eastern part of Alfalfa County, and is about 30 miles from the nearest point of the Gypsum Hills. It includes an area of approximately 60 square miles, extending about 10 miles north and south and 6 to 8 miles east and west. The plain is as level as a floor, and on ordinary occasions as white as a snow field, from the incrusation of salt crystals which cover it. It is absolutely barren of vegetation, with only here and there a scattered bit of driftwood to break the monotony.

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

Cimarron River Plains.

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

Hills. The Little Salt Plain is two to three miles long and a mile or more wide.

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

The plain is flat, except for a few meandering channels of the Cimarron River, which in wet weather contain small streams of water, but are ordinarily dry. After a rain sometimes a stream of considerable volume flows down the channel across the plain, but during the summer months nearly all the water either evaporates or sinks into the sand. In places where a small stream still runs down the channel, the water is often so salty that a thin crust of crystal white salt, resembling a sheet of ice, forms on the surface of the stream. The entire plain, except just after a rain, is covered with a thin incrustation of snow-white crystals, which, in most places, do not exceed an eighth of an inch in thickness, but reflect the sunlight like a snow field.

In a large cove among the gypsum-covered hills, at the mouth of Buffalo Creek, near the south side of the plain proper there are a number of salt springs, which boil up from the flat surface of the plain. The water is crystal-clear, and it sometimes requires more than occular proof to convince one that it contains nearly 40 per cent of salt. There are scores, perhaps hundreds, of these springs on an area of but a few acres, some of which flow streams as large as a man's arm. The presence of a spring is always marked by a conspicuous white incrustation of salt, which forms around the spring and along the sides of the little stream that flows from it. Particles of grass or weeds blown into these springs or streams soon become covered with white salt crystals, thus forming strings which are often an inch or more in diameter, and look like rock candy. In places the incrustations around the springs are so thick that the salt may be scraped up and hauled away. In former years freighters came for hundreds of miles to haul this salt away for stock and for domestic use. Beds of rock salt are reported from this plain, but their presence has never been verified. The combined flow of the various springs which feed the plain will approximate several thousand gallons per hour. In former years there have been a number of primitive salt plants in this region. The water was dipped or pumped up from the springs or from shallow wells and evaporated in pans or kettles, sometimes by sun heat, sometimes by fire. At the present time no salt is being made.

Blaine County Plain.

Besides the two plains of the Cimarron, just described, the Salt Creek plain, in northern Blaine County, is also fed by springs which issue from below the gypsum ledges, and like the others, it is located in a canon at the foot of the Gypsum Hills. This plain is much smaller than the Big Salt plain of the Cimarron, just described. It is not more than a quarter of a mile wide at the widest place, and for the greater part of its extension is not more than 100 yards, with a length of perhaps three miles. The springs which supply the plains issue from the head of the main Salt Creek Canon. A ledge of red- and blue-mottled, cross-bedded sandstone, outcrops along the heads of several branches of the main canon, and springs issue from it. The flow is sufficient to form a small creek. Along the bottom of the canon the salt incrusations formed by evaporation, cover a narrow strip 100 yards wide along the sandy channel of the stream A mile below the springs the canon widens, the creek leaves the wall of hills and enters the flat country, and the salt plain spreads out and becomes, in one place, as much as a quarter of a mile wide.

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

A few years ago a plant with a capacity of 450 barrels per

twenty-four hours was erected at Ferguson, Oklahoma, the nearest railroad point to the plain. The brine was obtained from open and drilled wells and was carried two miles in a 2½-inch wrought iron pipe. Steam was employed to operate the rakes, elevators, conveyors, etc., the pans were of cement 12 by 150 feet and 20 inches deep. The plant remained in operation but a few months.

Beckham County Plain.

In the extreme southern part of Beckham County, near Carter, on sections 10, 11, 14, 15, Township 8 North, Range 22 West, is a salt plain occupying an area of about 40 acres. This plain, which is about half a mile distant from the North Fork of Red River, is located near the base of the Gypsum Hills. In places springs of salt water issue directly from beneath gypsum ledges, while in other instances the water boils up in the form of bold springs from the level surface of the plain. There are more than 20 springs, the waters of which unite to form a stream as large as a stove pipe. In view of the fact, however, that a great part of the water sinks into the sand, it is probable that this amount represents but a small part of the actual flow. Salt has been manufactured at this plain for many years. The water is said to contain a considerable proportion of gypsum, but not so much as to render it unfit for use.

Greer County Plains.

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

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

LEAD AND ZINC.

(By Gaylord Nelson.)

Lead and zinc are the only metals that are being mined, with profit, in Oklahoma at the present time, and in spite of the fact that among the mineral resources of the state they are perhaps the latest to be discovered, they occupy an important position among her economic minerals, and their importance will increase as the limits of the present productive area are extended.

The present known workable deposits of these minerals are all included in Ottawa County in the northeast corner of the State. (See fig. 10.) Prospecting has been done, however, over several widely separated areas, notably in the vicinity of Spavinaw Creek and around Tahlequah. In these localities many specimens of lead and zinc ore have been picked up on the surface, but no deposits of economic importance have been officially reported. Considerable prospecting has also been done, from time to time, in the Arbuckle Mountains where both lead and zinc occur on the surface. Several shallow shafts have been sunk at various places, and some good specimens of disseminated ore, said to come from Ada, have been sent to the Survey. What ore there may be in this region seems to disappear a short distance below the surface, at least none of the results have been encouraging enough to warrant extensive development.

In Ottawa County there are three well-developed camps; in the order of their establishment they are, Peoria, Quapaw and Miami. The first shaft was sunk in the Peoria district in 1891. Since then there has been a steady output of ore from the camp. In the

Quapaw district, the next district to be opened up, ore was first secured by shaft, in 1897. The Miami camp, probably the youngest camp in the whole Ozark region, has been in existence scarcely three years. The first steam concentrating mill was completed less than a year ago. But in spite of extreme youth, development has been pushed rapidly forward in this camp and it bids fair to be-

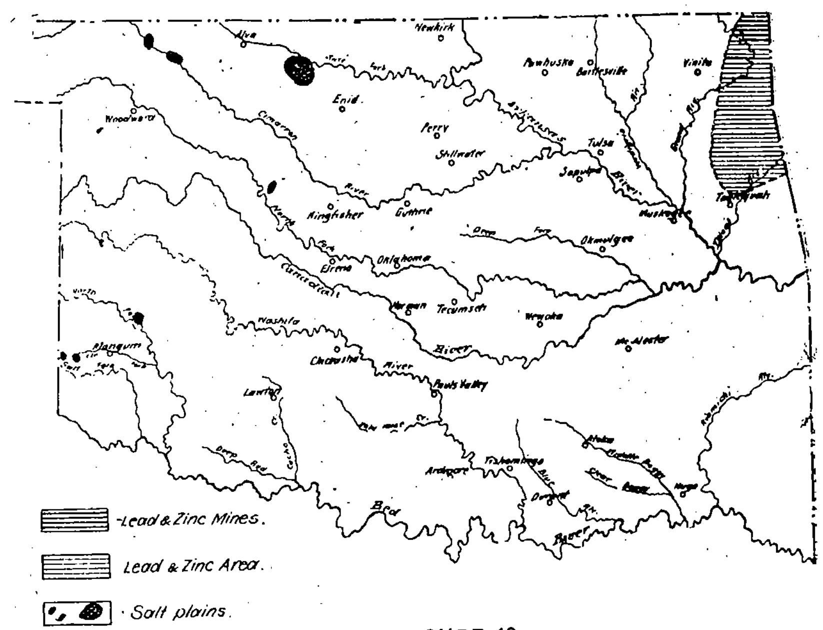

FIGURE 10.

Map of Oklahoma, showing: A, the northeastern part of the state, of zinc mines and the area in which the lead and zinc ococur, and B, the loocation of the seven salt plains in Western Oklahoma.

come, in a short time, the most important of the three. However, at the present time the Quapaw camp shows the most extensive development in the region, there being about twenty-five steam concentrating plants in operation, besides a number of hand jigs.

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

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

The geology of the district is simple, the surface formation being the black, carbonaceous shale of the Cherokee formation which is of Pennsylvanian age. Below these shales are the sandstones, limestones and shales of the Chester group. Beneath the Chester group is found the Boone chert which forms so much of the surface rock in the Peoria and Quapaw districts. Throughout the productive area a large part of the limestone of the Chester has been removed by underground solution allowing the insoluable sandstone to settle down on the Boone. In this process of settling the sandstone has been fractured and broken into angular fragments. The term brecciation is applied to this fracturing. The underground waters carrying these ores in solution have freely circulated in this breccia and in so doing the ore has been deposited filling the cracks and crevices and cementing the breccia into a solid mass.

Most of the ore mined in the district occurs in this manner. There are two other modes of occurrence of the ore in the district; as an impregnation of the sandstone itself and also as a pure ore mass filling small solution cavities in the limestone. The latter is relatively unimportant as a source of the ore.

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

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

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

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

There are a number of drawbacks to operations in the district, of which, probably, the greatest is the low grade of the ores caused by the presence of so much iron. Another great drawback at the present time is the lack of transportation facilities. A single wagon road connects the camp with Miami, four miles south, which is the nearest shipping point. All the heavy traffic to and from the mines must pass over this road, and the traffic is so heavy and incessant that the road has been worn full of ruts and holes thus rendering the hauling of a load extremely difficult. Lately there has been strong agitation for an electric road connecting Miami with the mines and the present indications are that the road will be built in the near future. If so, the transportation question will be settled in a satisfactory manner.

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

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

GLASS SAND.

(By Chas. N. Gould.)

Any sand that contains a large per cent. of silica and a small amount of iron is glass sand. One half of one per cent. of iron will render sand of no value for the manufacture of the best quality of glass. Bottle glass, and other cheap grades, may be made of sand containing as much as 2 per cent of iron.

The presence of iron in a rock can usually be determined by the color. Iron is the great coloring matter of the rocks. Such colors as red, brown, black and yellow, and all intermediate shades and tints are usually due to iron. Now, most sand and sandstone is slightly colored, the prevailing tint being gray, yellow, brown or red. In western Oklahoma the greater part of the sandstone is red, and this red sandstone sometimes contains as much as 20

per cent of iron. The sandstone in the eastern part of the state is usually light in color, either yellow, brown or gray, showing that the amount of iron is much less. Samples analyzed in the Survey laboratories show that this sandstone contains all the way from 5 to 15 per cent. of iron.

Glass sand, then, is sand without iron as coloring matter; in other words, white sand. There are several places in eastern Oklahoma where ledges of almost white sand occur. This, on analysis shows from one to three percent of iron, indicating that it would make a poor grade of glass. Ledges of this character are reported near Bartlesville, Tulsa, Ramona, Claremore, Catoosa, Holdenville, and Muskogee. So far as has been determined, however, no sand in this region has been found to be of sufficient purity to justify its use for anything but the poorest grades of glass.

So far as is now known the available glass sand in Oklahoma occurs in three regions, namely, near Tahlequah; in the Arbuckle Mountains, and in southern Oklahoma, north of Red River.

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

"The Bergen sandstone is a massive, moderately fine-grained light brown rock. The beds are thick and planes of stratification are usually indistinct. The rock consists of nearly pure siliceous sand of rounded grains, with a matrix scarcely sufficient to cement them together.

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

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

The glass sand in the Arbuckle Mountains is contained in the Simpson formation which consists of a great mass of sandstones, shales and limestones 2000 feet, or more, thick. The Simpson usually outcrops as a band surrounding the mountains, and the rocks as a rule stand on edge. There are, in this formation, three ledges of sandstones. Mr. Taff describes the sandstone members of the Simpson formation, in the Tishomingo Folio, United States Geological Survey, page 3, as follows:

"There are three sandstone members; one of local occurrence at the base, one near the middle, and another near the top of the formation. Many of the beds occurring in these sandstone beds are composed of massive, quartz sand. In places, such sandstone beds are without distinct bedding and are indurated, while at other localities they are composed of massive, friable sand. Occasionally there are calcareous beds and even limestone layers interbedded with the sandstone. These members range in thickness from thin strata to beds aggregating 100 feet."

In many places in the Arbuckle Mountains the sandstone outcrops in close proximity to a railroad. The road bed of the Santa Fe railway in the Washita Gorge, north of Ardmore was blasted, for a part of the way, through a sandstone ledge of the Simpson. There are a number of good exposures along the Frisco road between Fitzhugh and Mill Creek, and near the proposed line of the Missouri, Oklahoma and Gulf railroad.

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

The value of this sand to Oklahoma will be better understood when it is remembered that glass sand is often hauled for long distances to be manufactured. It is cheaper to ship the sand to the fuel, than the fuel to the sand. Much of the sand used in the glass factories of northern Oklahoma and southern Kansas comes from Illinois. The Oklahoma sand is as pure as any in the country, and much nearer to fuel than the Illinois sand. As soon as it is developed it will add another profitable source of income to the state's industries.

GRANITE.

(By Chas. N. Gould)

Granite is a composite rock made up, in the main, of three minerals, namely: quartz, feldspar and either mica or hornblende. In appearance it is usually mottled, the variation in color being

caused by the various minerals which compose it. There are in Oklahoma three general regions in which granite occurs. (fig. 11) namely: Wichita Mountains, Arbuckle Mountains, and along Spavinaw Creek, about a half-mile west of Spavinaw postoffice, in Mayes

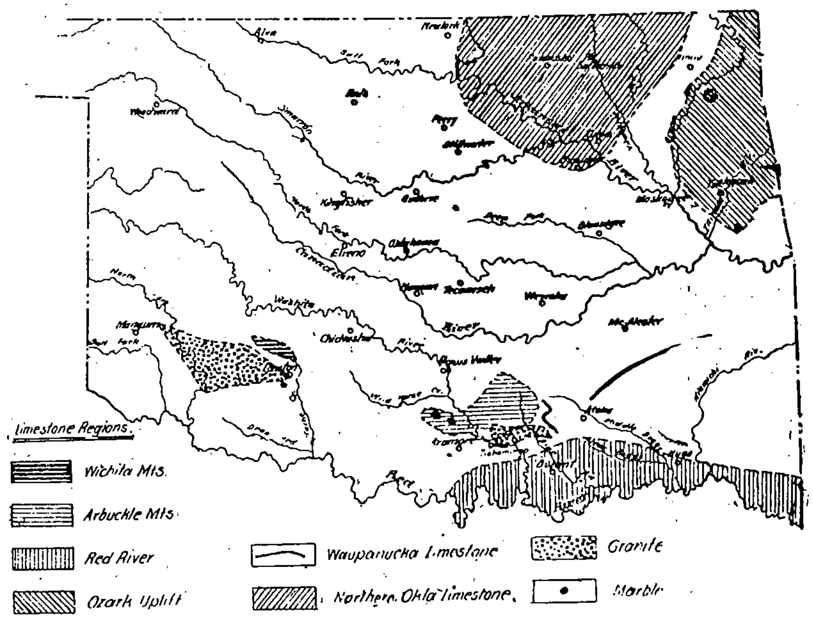

FIGURE 11.

Map of Oklahoma showing the location of the limestone, granite and marble deposits of the state.

County. The latter locality is very small and unimportant. In both the Wichita and Arbuckle Mountain ranges there are a number of other igneous rocks associated with the granite. The most abundant of these are gabbro, porphyry, and diabase.

Wichita Mountains.

The greater part of the rocks in the Wichita Mountains consists of granites. These mountains are sixty miles long; extending from near Lawton, the county seat of Comanche County, to Granite in Greer County. The average width is 20 miles. A number of peaks, such as Mount Scott, Sheridan, Baker, Quanah and some others, are from 1000 to 1200 feet above the level of the plain. Other peaks, such as Teepe, Headquarters, Longhorn and Devils Canyon mountains, stand 800 to 1000 feet high. All of these peaks and a number of others not mentioned, besides a great many scattering groups and ranges, consist of massive granite, usually red or pink in color.

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

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

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

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

Arbuckle Mountains.

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

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

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

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

Spavinaw Creek Granite.

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

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

Oklahoma should cease importing stone, when a product in every way superior can be obtained within her borders. The patronizing of home industries should be the watchword of the users of stone in our state.

LIMESTONE AND MARBLE.

(By L. L. Hutchison.)

Limestone occurs in inexhaustible quantities in six different regions in Oklahoma. Marble is known to occur in but one locality. (See Fig. 11.)

Limestone.

The largest of the limestone areas is in the northern part of the state. It extends from Newkirk and Pawnee on the west, to Chelsea and Catoosa on the east; and from the north line of the State southward as far as Jennings and Sapulpa. In this area, which comprises approximately 5,000 square miles, the rocks consist of heavy ledges of limestone, varying in thickness from ten to seventy-five feet, interbedded with sandstones and shales. There is scarcely a town in the entire region that is not convenient to limestone suitable for building purposes. Eight railroads either cross or border this region, and there are but a few stations on any road from which limestone could not be profitably shipped if the nearby ledges were but opened up by practical quarrymen.

The stone varies considerably in color and texture. In the vicinity of Newkirk, it is cream-colored, and even-textured, though coarse and full of small fossils. It makes a beautiful building stone and has been widely used throughout the state for public buildings. Near Pawnee some of the limestone is nearly blue, while near Tulsa and Avant it is usually light gray.

Quarries have been opened at Newkirk, Ponca City, Pawhuska, Pawnee, Bartlesville, Dewey, Claremore, Nowata, Tulsa, Skiatook,

Jennings, and many other places. Many of these quarries supply local demand only, but building stone is shipped to contractors from a few. Crushers which furnish crushed stone for railroad ballast and concrete work are located at Lost City, (near Tulsa), Avant, Uncas and Lenepah, but they by no means supply the demand for this grade of rock.

The limestone region next in size, in that part of the Ozark uplift which occupies northeastern Oklahoma. It lies east of Grand and north of Arkansas rivers. This region comprises an area of approximately 2,000 square miles. The rocks are mainly limestones, sandstones, and shales of Carboniferous age. Of these the limestones are of far greater importance industrially.

In the northern part of the area there are two ledges of limestone, the Boone and Pitkin, and in the southern part three, the Boone, Pitkin and Morrow. The Boone formation is the cherty limestone in which the lead and zinc of the Joplin and Miami districts are found. It contains, near its base, a ledge of very high grade stone, namely, the renowned Carthage limestone, so much sought for by architects and builders. The Pitkin is a hard, bluish limestone, very pure chemically. It dresses easily and takes good finish. The Morrow is also a very pure limestone, is readily dressed, and white in color.

None of the limestones of this region are developed at the present time. No rock is being shipped, either for building stone or concrete work, though the area is crossed by four lines of railroad. There is every reason to believe that a little diligent search would reveal a building stone as good in every essential as the Carthage limestone.

The limestone region third in importance, in point of size, is situated in the Red River region south of the Arbuckle and Ouachita mountain uplifts. The rocks of this region consist of alternating limestone, sandstone, and shale, with the limestone greatly predominating. The principle limestone formations are as follows: The Goodland limestone from 25 to 35 feet thick; it is massive and white and lies immediately above the Trinity sandstone; the Caddo limestone known to be as much as 150 feet thick at various places, is yellow and white in color, and interbedded with marls; the Bennington limestone is a blue rock composed largely of fossil shells and is from 10 to 15 feet thick. These three limestone members outcrop almost parallel to the Red River from the vicinity of Madill east to the Arkansas line.

Up to the present time there have been but few or no systematic attempts to develop the building stone possibilities of this region. Many quarries have been opened to supply local demand, and the limestones are found to make beautiful and durable buildings. The greater number of the business buildings at Madill are erected from the stone of the Caddo and Goodland formations. These are hard and fine-grained, but yield readily to the process of dressing. The shales which immediately underlie the thick marly Caddo limestone, appear to be very suitable for the manufacture of Portland cement when properly mixed with the limestone which is readily at hand. From general appearances, it is thought that the Caddo limestone is suitable for cement manufacture, but would generally be too friable for construction purposes.

The transportation facilities of the region are good. The St. Louis & San Francisco Railroad from Ardmore, Oklahoma, to Hope, Arkansas, divides the region in two almost equal parts, while three lines cross it from north to south. These four lines of railroad passing through the region give it transportation facilities second to none.

The limestone region fourth in size but possibly first in importance is the Arbucle Mountain uplift. There are four prominent ledges in the region. The lowest, geologically, and the most important one is the Arbuckle limestone which is 4,000 to 8,000 feet thick and consists of alternating massive and thin-bedded ledges. It varies in color from white to cream and carries occasional cherty concretions.

The only use to which this rock has so far been put is concrete work and railroad ballasting . It is believed that with careful investigation, good quarry sites for building and dimension stone could be found.

The Viola limestone lies from 1,500 to 2,000 feet above the Arbuckle limestone and is from 750 to 1,000 feet thick. This formation is usually white to bluish in color. It is much harder than the formations with which it comes in contact and, therefore, is invaribly well exposed, occuring as ridges and hills. It has been used for ballast and concrete work, but quarries for building stone will eventually be opened.

The Hunton limestone is white and yellowish in color and sometimes contains chert concretions. It is 200 feet thick in places and alternately thick and thin bedded. At some horizons the limestone

is shaly and marly, forming what appears to be natural cement rock.

The fourth limestone member of the Arbuckle region is the Sycamore formation. It has been worn away by erosion during a former geological age, in many places, and is often locally absent, but where it has its greatest development it is about 150 feet thick. This limestone thins out to the eastward, but becomes thicker toward the west.

The Arbuckle region is crossed from north to south by the main line of the Santa Fe and Frisco railroads. The line which connects these roads between Davis and Scullin is near the northern extension of the area. The big cuts along the Santa Fe are made through the Viola and the Arbuckle limestones. The possibilities for crushers and the opening up of building stone quarries are exceedingly good, so far as material and transportation are concerned, and it is believed that a little systematic work would enable one to find high grade building stone.

The region fifth in importance, in point of size, is situated along the northeastern side of the Wichita Mountain uplift, 10 to 30 miles northwest of Ft. Sill. This limestone is of about the same age and character as the massive Arbuckle limestone of the Arbuckle Mountains, and has every appearance of being a good building stone. It is being crushed near Richards to supply railroad ballast and stone for concrete work. Transportation facilities are not so good as in the regions previously described, but the Rock Island Railroad passes within three quarters of a mile of the southeastern extension of the ledge.

The sixth limestone area is that occupied by the Wapanucka limestone, which outcrops along a line extending from near Atoka to about LeFlore in western LeFlore County. The faulting and folding of the region in which the formation occurs, has turned the limestone on edge and its outcrops form what is known as the Limestone Ridge. This is the stone that is being crushed at Limestone Gap and has been quarried for local use at different localities throughout its extent. The beds at the top of the formation are white and massive, often having the appearance of marble. This character makes the stone at this horizon highly desirable for ornamental and finishing work. Near the center there is a horizon which is sandy and shaly. Lower ledges show cherts and flinty plates interbedded with silicious limestone which, it appears, would be suitable for ballast, concrete work, and paving.

The transportation facilities in this region are most excellent. The M. K. & T. railroad parallels the outcrop from Atoka to Reynolds, and the Rock Island from Reynolds to its eastern limit.

Marble.

Technically marble is limestone that has been changed, or metamorphosed, by the action of heat and pressure. In common parlance, however, any limestone that takes a good polish is a marble. The line between limestone and marble can never be sharply drawn. If we accept the latter definition there are a large number of ledges of marble in Oklahoma. For instance, the Arbuckle, Viola, Hunton, Boone, Pitkin and Wapanucka limestones are often so hard and fine grained that they take a good polish and in this sense are marbles.

There is, however, one region in Oklahoma where true marble, that is metamorphosed limestone, has been found. This region is near Marble City, on the Kansas City Southern Railroad in Sequoyah County.

The area containing the marble occupies four or five sections. The stone is known to be more than 200 feet in thickness, thus making the approximate amount of available marble to exceed 10,000,000,000 cubic yards.

The stone is principally calcium carbonate, but contains a small per cent of magnesium carbonate, thus making it slightly dolomitic. In color it ranges from a pure white to a pink and in places shows the characteristic mottled or marbled appearance of gray marble. A block of this stone subjected to pressure tests six months after it was removed from the quarry showed a crushing strength of 12,000 pounds to the square inch. When just removed from the quarry, however, it crushed at 8,000 pounds.

The occurrence of this stone near the Kansas City Southern Railroad which joins with several east and west roads gives splendid transportation facilities to operators.

Such is a brief resume of the limestone and marble possibilities of Oklahoma. It will be seen that very little development has been done. In a very few cases have the quarries been worked by companies with capital sufficient to develope their possibilities. In spite of this fact, however, the value of Oklahoma limestone marketed during the year 1907 amounted to $47,173, while the marble output is valued at $16,805. The rapid advance in the construction of concrete sidewalks, pavements, and reinforced concrete buildings

in the state has rendered it impossible for the crushers at present operating to supply the demand for crushed stone. During the past two years one county alone paid more than $90,000 to a single company outside of the state for limestone which is no better than much of the stone in Oklahoma. This is but one of many similar instances. The amount of Oklahoma money annually sent abroad to pay for building stone doubtless aggregates more than a million dollars. Obviously, then, it is the duty of every patriotic Oklahoman to insist on having native stone used whenever it is at all possible.

SANDSTONE.

(By Chas. N. Gould)

Sandstone is the most widely distributed building stone in Oklahoma, there being scarcely a county in the state where it is found in quantity. The color, texture and quality of the sandstone vary greatly in different regions.

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

Stone of this character is found in all parts of more than thirty counties including practically all of the old Cherokee Nation, all of the Creek, the northern part of the Choctaw, and northeastern part of the Chickasaw nations. Hundreds of cities and towns in this part of the state contain buildings constructed from local sandstone. Before the advent of gas-burned pressed brick from Kansas, a great part of the buildings were constructed of this stone. Such cities as Vinita, Chelsea, Claremore, Catoosa, Okmulgee, Muskogee, Eufaula, Sapulpa, Coalgate, McAlester, Wilburton, Hartshorne, Poteau, and Sallisaw may be cited as examples of cities containing sandstone buildings. There is scarcely a community east of the main line of the Santa Fe Railroad that does not contain ample stone for local use.

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

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

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

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

There are several regions in Oklahoma where little sandstone is found. One area which is bounded on the north by the Kansas line, on the east by the Santa Fe Railroad and on the south and west by the Gypsum Hills, has very little hard rock of any kind. A second area is in old Beaver County, or "No Man's Land", which now comprises Cimarron, Beaver, and Texas counties. This region is a part of the High Plains, where little stone of any kind is exposed. A third region containing but little sandstone lies along Red River from Love County east to the Arkansas line, including Marshall, Bryan, Choctaw, and southern McCurtain counties. The hard rocks of this region are largely limestones.

Quarries which supply stone for local use have been opened in sandstone ledges in many parts of the state but so far as known none of the product has been shipped abroad. Near practically all the towns which have been mentioned as containing buildings constructed of sandstone, quarries are found which furnish ample stone for local use. For instance, the greater part of the stone for the Muskogee buildings comes from the Standpipe Hill in the northern part of the city or from the quarry a mile to the east. There are several quarries within the city limits of McAlester from which sandstone is obtained. A quarry is being opened in the suburbs of Quinton from which is obtained some of the finest building stone in the state. The first contract for this stone will probably be let for buildings in Ft. Smith, Arkansas.

The Catlett Quarry near Pawnee is one of the best known quarries in northern Oklahoma.

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

In 1907, the value of sandstone production in Oklahoma was but $43,403. There is little doubt that with the opening of new quarries and the systematic development of the industry, the production will greatly increase.

CLAYS AND SHALES.

(By Chas. N. Gould)

Clay and shale are found in all parts of Oklahoma and in most places the quality is such that they may be used for brick and other ordinary clay products in which a red color is not objectionable. No attempt will be made in this article to enumerate all the localities in which clay and shale occur.

The rocks of the greater part of western Oklahoma consist of the so-called Redbeds which are made up of a great mass of red clay shales with a few intervening ledges of some other material, usually sandstone, gypsum or dolomite. The red color of this shale is due to the presence of iron. Chemical analyses show that in certain cases the amount of iron in the shale is as much as 15 to 20 per cent.

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

The chief difficulty in the way of manufacturing brick in the Red beds, is the lack of cheap fuel. There is no coal in the region, the nearest mines being at McAlester, 140 miles southeast of Oklahoma City. A little gas has been found at Gotebo and Lawton, but so far not in large amounts. There is little to warrant the hope that fuel of any kind will be found in anything like paying quantities in the Redbeds. Freight rates on coal have been high, while a very reasonable rate has been secured on gas-burned brick from Cherryvale and Coffeeville, Kansas, into Oklahoma. For these reasons a number of the plants in western Oklahoma have been abandoned.

The greater part of the rocks in eastern and northeastern Oklahoma consist of alternating layers of clay, and shale, with intervening strata of limestone and sandstone. This clay and shale is usually gray, yellow, or drab in color. The amount of iron contained is much less than in the region of the Redbeds and the amount of aluminum consequently greater. The greater part of the clay in this region is suitable for the manufacture of pressed brick, stiff mud brick, tile, hollowware, and certain grades of pottery. Pressed brick plants have been established at Bartlesville, Ramona, Ochelata, Tulsa, Redfork, Sapulpa, Cleveland, Okmulgee, Vinita, Claremore, Muskogee, and McAlester. Few of these plants do more than supply local demand, and so great has been the demand for brick the past few years that many towns have had to import brick from Kansas.

This is the fuel region of Oklahoma. Coal is found in every county in this part of the state and near practically every town. Oil and gas are present in the greatest abundance in many localities. Gas wells which furnish all the way up to 50 million cubic feet per day occur in many communities. Nothing is needed in this region but the establishment of tile and pottery works.

All the essentials for a number of profitable plants are found in eastern Oklahoma. Raw material is here in abundance; cheap fuel, of three kinds; coal, oil and gas, is in quantities, for all practical purposes, inexhaustible. Competing lines of railroad spider-web the region. A market is assured; for Oklahoma has now a million and a

half of people with comparatively few substantial buildings. No drainage has been done and few roads built. Drain tile will be used in constantly-increasing amounts, for drainage and culverts. The first plants on the ground will reap a harvest. A number of growing cities stand ready to give substantial encouragement to bonafide enterprises.

In the coal fields there are large deposits of fire clay. This material is known to exist in large quantities at Lehigh, Coalgate, Wilburton, McAlester, Hartshorne, and Blocker, while there is little doubt but that investigation will reveal its presence in many localities now not known.

Fire clay is usually found beneath coal veins and the large number of these veins in the state and the extensive area underlaid by them warrants the belief that the amount of fire clay is practically inexhaustible. At the present time none of this clay is being utilized. All the fire brick used in the state is shipped in.

In the region of the Ozark uplift in the northeastern part of the state and in the Arbuckle Mountain uplift in southern Oklahoma, there are a number of heavy beds of clay and shale which might be utilized in the manufacture of pressed brick, pottery, tile, terra cotta, etc. This shale is rich in aluminum and contains a relatively small amout of iron and other harmful ingredients so that the products should not burn red.

Kaolin, or fine potters clay, is reported from the Wichita Mountains and the region about Tahlequah in the northeastern part of the state, but no extensive deposits have been definitely located.

With the exception of the red clay-shales in west central Oklahoma all of the material heretofore described is suitable for use in the manufacture of Portland cement, which is made of limestone and shale, first ground, then mixed, burned and reground. Almost any kind of shale and any kind of limestone will make Portland cement, providing that certain injurious ingredients are not present.

There are six regions in Oklahoma where limestone is found in quantity. Practically all of northeastern and southern Oklahoma is covered with beds of limestone. Near these limestone ledges shale occurs, so that Portland cement may be manufactured over a great part of the northeastern and southern parts of the state. There are now two Portland cement mills at work, one at Dewey in northern Oklahoma, the other at Ada, near the south central part of the state.

With the inexhaustible amount of high grade raw material, the abundance of cheap fuel, the constantly increasing market and the ready means of transportation it should not be long until Oklahoma manufactures all her clay products.

PORTLAND CEMENT ROCK.

(By. Chas. N. Gould.)

It is only within the past few years that the people of the Southwest have begun to awaken to the realization of the fact that they must soon find some new supply of cheap and efficient building material. The timber in this part of the United States is nearly exhausted, and much of the lumber now used comes from the South Atlantic states or from the Pacific coast. The price of lumber is advancing every year, and will continue to increase indefinitely.

No one who has studied the trend of the times, however, can doubt that the coming building material for the great Southwest is Portland cement. Many persons now in middle life will live to see the day when a new wooden house in this part of the country will be a rarity.

The process of the manufacture of Portland cement is not complex. Nothing is needed in the way of raw material but shale, limestone and fuel. Almost any kind of shale or limestone may be utilized, provided certain injurious ingredients, notably iron and magnesia, are not present in large amounts. The limestone and shale are ground fine, mixed in the proper proportions, burned to a clinker and reground. The chief difficulty in the establishment of a Portland cement plant is not in the location of raw material, but the great initial cost of the plant. It is usually estimated that the amount of money necessary to equip a 1000-barrel plant is between $400,000 and $500,000, the amount depending upon the type of plant and the location.

There is perhaps no part of the United States today where there is more building in prospect within the next few years than in Oklahoma. With statehood a great impetus has been given to all kinds of development. Not only are there a number of public buildings, including schools, asylums, penitentiaries, etc., to be erected, but all sorts of business blocks and residences are to be built. The cities are growing rapidly, nor are the smaller towns behind in the matter of development. While it is true that a considerable number of these buildings will be erected of brick and stone, there can be no doubt that Portland cement will enter very largely into construction

in the western part of the state. As counties are being organized thousands of new bridges will be built, and there is a constantly-growing tendency among engineers and contractors to use Portland cement for bridge construction.

Oklahoma has deposits of Portland cement rock that never can be exhausted, and vast deposits of fuel, including coal, oil, gas. Limestone occurs in practically all parts of Oklahoma except the central and northwestern sections. There are at least six widely-separated regions in the state where limestone occurs in quantity. Shale is always present near the limestone. In the following paragraphs I shall discuss briefly the character and stratigraphy of the limestone and shale beds in the various regions and the occurrence of fuel which will be most suitable for the manufacture of Portland cement. The various regions are located on the map, page 47, Fig. 11.

The rocks in that part of Northern Oklahoma extending from the Arkansas river east to Craig County consist largely of alternating layers of shale, sandstone and limestone. There are in all in this region about 20 ledges of limestone, varying in thickness from 10 to 40 feet, which strike slightly west of south from the Kansas line about as far as the Arkansas River. The shales, which are interstratified with the limestones, are apparently suitable for the manufacture of Portland cement. Three veins of workable coal cross this region from north to south, and the region occupies the heart of the Oklahoma oil field. The amount of natural gas already in sight is sufficient to last for many years. Numerous wells yielding 5,000,000 to 10,000,000 cubic feet daily have been shut in, and a number of wells are reported to yield all the way up to 60,000,000 cubic feet. It is safe to say that not one per cent of the available gas in the region is now being utilized. For factory purposes gas may often be secured at two cents per thousand cubic feet. As an example of the conditions which are found in this region, I may cite a single instance where a hill which occupies a number of square miles is capped with a ledge of limestone, beneath which is a bed of shale and under the shale a vein of coal. Both the limestone and the shale are suitable for the manufacture of Portland cement. There is plenty of water convenient, gas is found near at hand, and two competing lines of rail road cross nearby. It will be seen that all that is necessary at this place is to dig down the hill and grind it up.

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

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

There is a region in southeastern Oklahoma lying between the south side of the Arbuckle and Ouachita mountains and Red River that contains a number of ledges of limestone and shale apparently suitable for the manufacture of Portland cement. The rock is practically the same quality as that being used in Dallas, Tex. The limestone ledges are from 10 to 40 feet thick, and are usually rather soft and consequently easy to crush. No fuel has been so far found in the region, so that coal would have to be hauled from the Lehigh-McAlester district or gas would have to be piped from a still greater distance. It is possible, however, that natural gas will be found by deep drilling. There are several lines of railroad and plenty of water.

The Arbuckle Mountain uplift in southern Oklahoma is 60 miles long and averages 20 miles wide. The rocks are largely limestones and shales. There are four ledges of limestone, namely the Arbuckle limestone, 6000 feet thick; the Viola limestone, 800 feet thick; the Hunton limestone, 200 feet thick, and the Sycamore limestone, 100 feet thick. Interstratified with the limestones are several ledges of shale. Coal is found east of the mountains at Nixon, Lehigh and Atoka, and south of the mountains at Ardmore. Oil and gas have been found at Wheeler, and it is possible that they may be found northeast of the mountains near enough to be available as fuel. Several lines of railroad cross the region.

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

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

The Dewey plant has a nominal capacity of 2000 barrels per day. Gas is used for both power and heat. 35,000,000 cubic feet of gas obtained from wells owned by the company is consumed daily. The power is generated by four four-cylinder, double-acting gas engines, of 500 horse power each, arranged in tandem. There are 5 kilns 8 feet in diameter and 100 feet long. The rock is brought from a 22 foot ledge of limestone a mile and a half away over a standard guage track. The shale is obtained from a pit 100 yards from the plant.

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

Taking into consideration all known conditions, including raw material, fuel, transportation facilities and market, it seems evident that the best locations for the establishment of new Portland cement plants are in the northern Oklahoma region or along the heavy ledge of Wapanucka limestone between Atoka and Hartshorne. There are still a number of choice sites available in these regions, although several of the best have been secured by options, within the past few months. Plants have been projected at or near Tulsa, Nowata, McAlester and Muskogee, near all of which points there is stone, clay and fuel. The recent financial depression and the cessation of activity in building operations will account largely for the fact that these plants have not been established.

There is little doubt but that the increased amount of building which will be brought about by statehood and the opening up of a vast amount of vacant land in Oklahoma will create a demand for building material sufficient to justify the erection of several additional cement plants in the new state. The abundance of limestone and shale, the cheapness of fuel and the constantly-increasing demand for Portland cement lead to the conclusion that no more profitable investment can be made than the establishment of such plants.

ROAD MATERIAL.

(By Chas. N. Gould)

A good road should be smooth and hard, as nearly level as possible, properly constructed, well drained, the road bed graded and shaped, and it should always be kept in good repair. The four chief things to be considered in building a road then, are location, materials, drainage and construction.

Good roads have a money value to farmers. Bad roads are the greatest drawback to rural life. Farmers suffer more from the lack of good roads than any other class of citizens. The difference between good and bad roads is often equivalent to the difference between profit and loss. Localities that have good roads become rich, while in regions that have bad roads, fertile farms are abandoned and rich lands go to waste.

In a new country the first roads built are usually of earth. As the country is developed the roads are gradually improved. In many of the older states stone roads have been built. These are expensive but experience has shown that permanent stone roads are the best investment that can be made.

Most roads in Oklahoma are located on section lines. This is in most cases a good thing, particularly in a level country. Straight roads are always best. In a hilly country, or one cut by streams, however, it is often difficult to built roads on section lines because of the steepness of the grade. When grades are 1 foot in 50 a horse can draw about three-fourths as much as on a level. Where the grade is 1 foot in 25 he can draw one-half as much, and on a grade of 1 foot in 10 he can draw only one-fourth as much. Grades should never exceed one foot in twenty-five. A road should always go around a hill rather than over it, and no hesitation should be made in leaving a section line to avoid a steep grade.

At the present time practically all the roads in Oklahoma are earth roads, and those in the eastern part of the state are poor. There are two reasons to account for this, namely, kind of material

which go to make the roads, and the length of time the roads have been worked.

In western Oklahoma most of the roads are made of sandy clay which packs well and forms a good road bed. In many cases these roads have been built for several years and now are in fairly good condition. In eastern Oklahoma, on the other hand, the roads are made largely of a sticky clay which becomes muddy in wet weather and dusty in dry weather and works badly. In this part of the state very few roads have been worked for more than a few years.

Broken stone is the best road material, but is usually expensive; not only because it has to be hauled for long distances, but because it requires much handling and rolling. Most country roads are made of material nearest at hand, generally earth. In some cases clay, shale, and gravel can be secured at little cost, and if so these materials should always be used, if crushed stone is impracticable. The best material that can be secured in most places is a mixture of sand and clay. If the road bed is sandy, clay should be hauled from some nearby locality. If clay is the material in the road, sand should be brought in to mix with it. Experience will show the proper proportion of the materials to be used.

Water will destroy a road quicker than anything else. Drainage alone will often change a bad road into a good one. The best roads will quickly go to ruin if undrained.

The great secret, therefore, of good roads is drainage. Most country roads are too flat to shed water. The middle of the road should be well rounded, in order to permit the water which falls during a rain to flow off quickly. If allowed to stand it soaks in and ruins the road bed. Side ditches should be broad rather than deep and large enough to carry the water from the heaviest rains. Water should never be permitted to flow for long distances in side ditches because it will wash deep gullies. Neither should it be allowed to collect in puddles by the roadside for it sinks into the soil and softens the foundation of the road, forming mud holes. Culverts of concrete, metal, or stone should cross the road at frequent intervals, and carry off the water from the side ditches.

The middle of the road should always be the highest part. It should always be made as hard and imprevious to water as possible, so that the rainfall will flow freely and quickly into the side ditches. The best shape for the cross section of the earth road is that of an arc of a circle with a gradual fall of about 1 in 20. The proper width of the roadway varies with conditions. Usually a graded road 15 to 30 feet wide will be sufficient. The right of way should be much wider. Sixty feet is the legal width of Oklahoma roads.

On flat prairies or bottom lands where the natural drainage is poor, it is often necessary to elevate the road bed two or three feet above the general level. This is most easily done by a road machine or grader. The material for building the elevated roadway is usually obtained from the side ditches along the road.

After the road bed has been made it should be rolled thoroughly. Unless this is done the first rain will wash away the loose dirt and spoil the road. If the surface is packed solid with a roller it will last much longer and give much better service.

Sand roads are never good except when wet, therefore, the more a sand road is drained the worse it becomes. Nothing will ruin a sand road quicker than to dig a ditch on either side and drain the water away. The best way to make such a road firm is to keep it damp. This can be done by planting shade trees along the road or by growing a thick turf of Bermuda grass.

Sand roads may be improved by the use of any tough fibrous material, such as the refuse of sorgum mills, or even straw or prairie hay. A road covered with some such substance will remain fairly hard and firm for several months. A better, but more expensive method is to cover the surface of the sand with tough clay, or mix the sand and clay together. In many parts of Oklahoma stiff red clay may be found not far from the sand roads.

One horse can pull more on a hard smooth stone road than four horses can on a good earth road. In building a stone road a foundation is prepared, rolled smooth and hard, and thoroughly drained. Upon this bed is spread a layer five or six inches thick of stone broken the size of a walnut. This layer is rolled until it is compact and firm. A layer an inch thick or more of fine screenings to serve as a binding material is placed on the broken stone, and the whole is then rolled until perfectly firm and smooth. The cost of such a road, under ordinary conditions, will be from $2,000 to $4,000 per mile.

The essential qualities of good road material are first, that when thoroughly packed the surface of the road shall be hard and firm, but not brittle; second, that it shall neither wear down into dust in the summer nor become muddy in the winter, and, third, that it will be durable and lasting. Experience in other countries has shown that the best material for surfacing roads is asphalt, which has been

described in another chapter under Asphalt, then come limestone, granite, flint, and gravel, in the order named. Sandstone and shale are almost worthless under ordinary conditions. Sandstone breaks up into sand and shale when ground fine becomes dust and in wet weather forms mud. A number of the rocks named above are found in [illegible] parts of the state. Trap rock is not very widely distr[illegible], although considerable ledges of this rock are found both in the Tishomingo region and the Wichita Mountains. The deposits are large enough that when crushers are established near them the material will supply a good part of southern and western Oklahoma.

Flint is found in the southern part of the Flint Hills region in Osage and Kay counties and in the Ozark uplift in Ottawa, Delaware, Adair, Cherokee, and Mayes counties. This material, broken fine, makes an excellent surfacing for roads. At the present time no crushers are in operation in the flint-producing localities but when they are established there will be an abundant supply of the material.

Limestone is the most widely distributed of all good road materials in Oklahoma. There are six widely scattered regions in Oklahoma where limestone of good quality is found. It occurs in the following counties: Kay, Osage, Pawnee, Washington, Tulsa, Nowata, Craig, Mayes, Ottawa, Adair, Delaware, Cherokee, Muskogee, Pittsburg, Coal, McCurtain, Choctaw, Bryan, Marshall, Johnston, Pontotoc, Murray, Carter and Comanche. Crushers are now in operation at Lenepah, Tulsa, Avant, Limestone Gap, Crusher, Richards and Uncas. Crushed stone may be obtained at any of these places. There are hundreds of other localities in the state where large crushers might be installed.

In the future every county in the region where limestone is abundant will own crushers and the stone will be used for the building of roads.

Granite is a fairly good road material. The objections to its are, first; it is very hard and therefore very difficult to crush; second, it contains little binding material and for that reason does not make a firm road bed. Granite is found in Comanche, Kiowa, Greer, Jackson, Johnston, Murray and Mayes counties, and will in the future contribute its part of the road material in these parts of the state.

In central and western Oklahoma where but little hard rock of any kind is exposed on the surface the cost of roads will be greater. Fortunately the dirt roads of western Oklahoma will always be fairly good. Stone for road building is found abundantly in these parts of the state where the earth roads are poorest.

The great need of common roads is daily or weekly care. A road receiving daily attention will not need expensive repairs, and the total cost of maintainance will be less, and instead of becoming worse the road will constantly improve. Ruts and holes form easily in earth roads and if not repaired at once they become filled with water and will be made deeper and wider by each passing wagon. A hole which might have been filled with a shovel full of material will soon need a cart load. Ruts and holes should never be filled with stone or other material harder than the road bed. If this is done the road wears unevenly and there will soon be two mud holes for every one repaired.

The road to meet the needs of the farmer must be hard and firm in all kinds of weather. Farmers should be able to do their heavy hauling when the fields are too wet to work, as their teams would otherwise be idle. On the other hand, the road must not be too costly. Stone roads are always best, but in most parts of Oklahoma the farmer must be satisfied for some years to come with well made, well drainer, earth, kept in good repair by careful attention.

SAND AND GRAVEL.

(By Chas. N. Gould).

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

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

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

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

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

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

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

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

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

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

In the Ozark region, the gravel is made up largely of rounded fragments of flint, chert, and hard limestone. It is found along the beds of the Illinois, Grand, Neosho, and Spring rivers, and Sallisaw, Vian, Greenleaf, Maynard, Clear, Spring, Saline, and Spavinaw creeks.

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

The gravel about the Wichita Montains is composed largely of granite pebbles. The principal granite gravel deposits of that region are found in the channels of Medicine Bluff, Cache, Blue Beaver, Oak, Otter, Elk and Rainy Mountain creeks. In those streams flowing from the limestone hills north of the range of the Wichitas limestone pebbles are found.

Creeks in northern Oklahoma which rise among the Flint Hills of Osage, Kay, and Pawnee counties, often carry pebbles composed of hard limestone and flint. Some of these streams are Bird, Hominy, Beaver, Walnut, Salt, Wolf, Turkey, Grayhorse, and Buck creeks.

Comparatively little gravel is being utilized in Oklahoma at the present time. Few states have more abundant supply or better quality of gravel but practically none of it has been developed. In most cases, the gravel is so located that it could be loaded with a steam shovel. Nothing is needed but the development of the industry.

TRIPOLI.

(By Gaylord Nelson)

Tripoli is one of the minerals that occurs in considerable abundance in Oklahoma but is comparatively rare elsewhere. The present seat of the tripoli industry is located at Seneca, Missouri, just east of the Oklahoma line, but a large share of the raw material comes from Oklahoma, so that tripoli should be considered among the mineral resources of the State.

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

The region is exceedingly rough and hilly. Most of the drainage of the region is to the southwest through Lost Creek into Grand River. The general dip of the rocks is to the west or northwest, but it is so gentle that its effect on the structure is unimportant.

The deposits that are being worked at the present time, occur in two localities, about eight miles distant from each other. One of these localities is in Oklahoma, the west half of section 33, T. 18 N, R 15 E. The state line passes through the middle of that section. There is one pit on the Missouri side of the line just east of the works in Oklahoma. The tripoli obtained from these localities is largely ground up into tripoli flour.

The other locality from which tripoli is now being obtained is eight miles east of Seneca. The product of these quarries is used in the manufacture of filters, and is called "filter stone." The tripoli is encountered at a depth of from three to six feet and the beds are usually from ten to twelve feet thick. None of the deposits are large so that they are worked out in a short time, and it is necessary to be constantly opening new pits. The tripoli found under practically the same conditions at all the quarries. Above the commercial deposits is a mixture of tripoli with many interbedded nodules of chert, and over all there is a red shale from one to two feet thick. The shale and impure tripoli have to be stripped off in order to expose the workable tripoli. In the pits from which the tripoli for grinding is obtained the rock is blasted off with black powder, but in the "filter stone" quarries, it is broken out with wedges. On being removed from the quarry, the material for grinding is stored in large open sheds until it is thoroughly dry, when it is hauled to the mill and ground, while the material from the "filter stone" quarries is hauled, by teams, direct to the mill and manufactured into filters without drying. The Oklahoma tripoli is not suitable for manufacturer of filters because it is full of cracks and contains frequent bedding planes, thus making it difficult to obtain large pieces. The stone from east of Seneca, however, does not contain these cracks and bedding planes so that it is possible to get the stone out in any desired size.

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

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

The flour is used for a variety of purposes but the larger part of it is used as an abrasive or polisher in the metal working trades. The very finest grades are used as a jewelry polish, while the coarser ones are used as brass and steel polishes. A large part of output of this particular mill is shipped abroad. No doubt the flour is used as an adulterant, as it is nearly pure appreciable grit and is very heavy.

pany, The American Tripoli Co., operates l at Seneca. This mill makes filter stones

of all sizes and descriptions. The machinery used for cutting stones is simple. The rocks are sawed into blocks by a circular saw resembling the saws in use in saw mills, but having small steel strips set at right angles to the plane of the saw, for teeth.

After sawing to the required size, the pieces are rounded by holding them against a rapidly rotating emery wheel from three to five feet in diameter. The inside of these cylinders is then drilled out and the stone is ready to be used in filters. The finishing work on certain kinds of filters is also done at this mill by casing the stones with nickel plated cylinder tubes.

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

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

IRON.

(By Chas. N. Gould)

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

In certain localities in Oklahoma the rocks contain relatively large quantities of iron. The shales of the Redbeds of the central and western parts of the state, for instance, sometimes contain as much as fifteen or twenty per cent. of iron. In certain places among the Redbeds rusty black rocks may be found scattered on the surface which look as if they had been burned. Many people imagine that they have been thrown out by volcanos, but this is not the case. The black color is caused by the large amount of iron contained in the rocks, which is oxidized by its exposure to the air. This black rock, usually a sandstone, is really a fair quality of iron ore, and if it could be found in large quantities near cheap fuel, it might pay to smelt it. As long, however, as deposits of iron ore are found in such immense quantities in other parts of the country, this will probably never be worth smelting.

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

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

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

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

In the Arbuckle region there are extensive iron ore deposits, but so far as known all are in the form of pockets among the limestone. In some cases the ore is still embedded in the rock while in other localities the limestone, which is more soluble than the iron ore, has been removed by erosion, thus leaving the iron boulders scattered over the surface. There are dozens of localities in the

mountains where large quantities of the massive black boulder sometimes as large as a tent, cover areas of several acres. Cases this kind occur near Davis, Roff, Mill Creek, Hunton, and Frank The ore is usually of high grade, some of it being manganese ir ore, which commands a fancy price on the market. Shipments the ore has been made from near Hunton and Mill Creek.

No estimates have been made of the amount of ore in t mountains nor is it possible to do more than approximate t amount.

It is quite probable that the ore in sight, scattered over t hills in widely separated areas, will amount to a number of millio of tons. The greater part of it is in localities difficult of acce Whether or not it will ever be found to be commercially valuab remains to be seen.

Fuel is abundant near McAlester and the Arbuckle Mountai If iron ore is ever found in quantities sufficient to justify develo ment there will be no lack of fuel with which to smelt it.

GOLD AND SILVER.

(By Chas. N. Gould.)

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

There is a widespread notion that gold and silver occur in pa ing quantities in Oklahoma. Much time, money and effort ha been spent in the hope of finding these metals. Many individu have spent years in a vain effort to discover something of val but so far as known neither gold nor silver from Oklahoma has be placed on the market.

There is perhaps not a county in the state in which the preci metals have not been sought. The greater part of the effort, ho ever, has been put forth in the Wichita and Arbuckle mountai Since the time of the Marcy expedition in 1852 ,prospectors a miners have been at work in the Wichitas. It is even claimed t the Spaniards sou ıt gold there and the cites of old Spanish mines are still pointed out. There is, however, no record that the Spaniards, or any one else, ever found anything of value.

At the time of the opening of the Kiowa and Comanche country to settleemnt in 1901, and for several years thereafter, there was much activitly in the Wichita Mountains. It has been estimated that at one time there were more than 2,000 miners at work in the region. The mountains were once bristling with claim notices, and honeycombed with mining shafts. Scores of camps were scattered throughout the mountains. According to various estimates all the way from half a million to a million and a quarter of dollars have been spent in sinking shafts in the Wichita Mountains. Some of the shafts reached a depth of 200 or 250 feet, although most of them were less than 25 feet deep. Several small smelters were erected, and a numbe of carloads of ore were shipped to large smelters at Pueblo and Denver. Hundreds of assays have been published, many of them claiming values running sometimes as high as several hundreds, or even thousands, of dollars per ton.

A number of reports have been published on the occurence of gold and silver in the Wichitas, the three most important of which will be cited.

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

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

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

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

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

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

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

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

"No. 94 showed 0.98 oz. of silver and 3.6 per cent. of lead. No. 20 contained 5 per cent.; No. 21, 3½ per cent.; No. 22, 6 per cent.; No. 23, 8 1-3 per cent.; No. 9, 5 per cent.; No. 10, 3 per cent., and No. 11, 3½ per cent. of copper.

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

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

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

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

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

Dr. Bain's conclusions are as follows:

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

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

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

During the summer of 1907 Mr. Arthur J. Collier, of the United States Geological Survey, visited the region, and collected samples from a number of localities. His report has not yet been published.

Prospecting in the Arbuckle Mountains never reached the stage atained in the Wichitas. The structure of the rocks in the two ranges is practically the same and there is as much reason to suspect the presence of gold in one as in the other.

A number of shafts have been sunk in the Arbuckles. The greater part of them are in the West Timbered Hills, south of old Fort Arbuckle. So far as is known nothing of value has ever been found.

Mr. Joseph A. Taff of the United States Geological Survey, has studied the problem more carefully than anyone else, and after reviewing the structure of the region concludes:

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

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

COPPER.

(By Chas. N. Gould.)

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

Copper has been reported in the Redbeds from the following counties: Pottawatomie, Lincoln, Logan, Noble, Garfield, Major, Woods, Kingfisher, Blaine, Caddo, McClain and Greer. In most cases nothing has been found but the greenish stain but in a number of instances, for instance near Perry, in Noble County, and Winnview, in Blaine County, small nuggets of native copper the size of a

hazlenut occur, in some localities, scattered through the reddish clay-shale. In several instances tunnels have been driven into the red clay banks for as much as fifty feet and several gallons of these small copper nuggets have been secured. In no case, however, has the amount of copper obtained justified the expenditure.

There is a region along the valley of the Cimarron River and Carisso Creek near Kenton, in the extreme northwestern corner of the state, where copper was mined for a number of years. Several hundred shafts have been sunk in this region. The rocks are the Redbeds similar to those which occur in central Oklahoma. These rocks are in many places vividly stained with copper. Some of the material obtained has been hauled to the railroad and shipped to smelters, but the investment did not prove profitable and at the present time all of these workings have been abandoned.

Copper mines were also opened, a number of years ago, in the vicinity of Byars, McClain County, and operated by primitive methods for a considerable time. But they too were not profitable and all that remains at the seat of operations is a few holes and old tunnels and a part of an old improvised horse power crusher for pulverizing the ore.

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

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

No. 31, U. S. G. S., Washington, D. C.

VOLCANIC ASH.

(By Chas. N. Gould)

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

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

Volcanic ash is used as an abrasive for polishing purposes, as a filter, and as an adulterant for soap, and certain other manufactured articles. Some of the beds in western Nebraska have been worked for a number of years, but so far as is known none of the Oklahoma material has ever been put on the market. As soon as the beds in western Oklahoma are opened, there is no doubt that this industry will become profitable to the operators.

NOVACULITE.

(By Chas. N. Gould)

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

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

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

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