OKLAHOMA GEOLOGICAL SURVEY
Chas. N. Gould, Director

Circular No. 16

OKLAHOMA
THE
GEOLOGISTS' LABORATORY

By
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Norman
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GATEWAY TO THE ARBUCKLE MOUNTAINS—WASHITA RIVER GORGE, MURRAY COUNTY

OKLAHOMA, THE GEOLOGISTS' LABORATORY*

INTRODUCTION

We are living in a laboratory age. No longer do men accept as true, statements which have as their basis nothing but the dignity of antiquity and the weight of authority. Today *Ipse Dixit* is not the court of last resort. On the other hand, in order to be believed, a thing must be proved. All statements of facts are subject to test; some are proved to be true; others false.

As the years have come and gone, each science has evolved its own laboratory technique. The chemist pours things into a test tube; the physicist manipulates his mirrors and his balances; the biologist peers through his microscope; the bacterioligist cultivates his cultures. And usually all of these experiments take place within the four walls of the laboratory.

But the geologist cannot always so do. Geology is essentially an outdoor science. For many of the branches of geology there can be no such thing as a complete indoor laboratory. Neither a Shaler, a Kemp, a Salisbury, nor a Branner has ever devised a completely satisfactory geological laboratory in physiography or structural geology. These men, giants though they were, and hundred of others, with equal zeal and great knowledge, have wrought earnestly in the endeavor to build up indoor laboratories, and devise methods of work that would in a measure bring home to the student of geology something of what it is all about. But it is very doubtful if they succeeded. In the very nature of things, neither teaching genius, however brilliant, nor enthusiasm, however contagious, can supply that which is not. I need not remind the teacher of geology that it is the common thing not the unusual thing, for young men to go out from four years of laboratory and class room experience with but a hazy notion of what it is all about, and it is not until these same young men have had actual field experience that they really wake up to the importance of the whole subject.

Those of us who have been in the thick of the fight for some years know well that for many divisions of the science of geology, the only practical geological laboratory is the field. If I may be pardoned for injecting personal opinions, it is my deliberate judgment that neither text-book illustrations, blackboard diagrams, high-priced charts, models of wood or of plaster, nor any other similar makeshifts, ever taught a student, however earnest, to recognize a fault in the field. It is very doubtful if

*Address of retiring president. Oklahoma Academy of Science Norman, Oklahoma, November 25, 1927.

any amount of instruction ever taught a young man to tag an unconformity if he met one coming down the road. These things are not so accomplished.

My experience of something like three decades has lead me to believe that only by means of field work are geologists made, and that unless one wears out shoe leather on the rocks, vain is the help of man. I can cite you to a score of men now in middle life, and perhaps a hundred more in younger life, men who are today making a name and fame for themselves, who, had it not been for the instruction gained on field trips to the Arbuckle Mountains in the first decade of this century, would in all probability today have been shoe salesmen or automobile mechanics. Many of these men you know; Larkin, Reeds, Kirk, Belt, DeGolyer, Buttram, Eckes, Wood, Monnett, Hareld, Aurin, Carpenter, Clark, Trout, Loomis, Hamilton. What a galaxy of geologists. Most of these men came to the University of Oklahoma with no definite purpose in life, just as hundreds are coming today. But these men first had their feet set in the right path, and their goings established, on field trips into the Arbuckle Mountains.

And what a geological laboratory we have in Oklahoma. Not only the Arbuckle Mountains, which stand out *par excellence,* but this entire state of which we are all so proud, Oklahoma. I verily believe that I am stating a sober, demonstrable truth when I say that no other state in the Union can equal Oklahoma in this respect. From whatever angle you approach the subject, Oklahoma ranks high, and in many cases it stands supreme. I do not believe that there is an equal area in North America in which so many different kinds of geological phenomona can be seen as the area within ten miles of the little town of Dougherty, Murray County, Oklahoma.

I can at this time do little more than sketch with rather bold strokes the outlines of the subject; to possibly open up vistas, down which you may be able to see. It will be my endeavor to outline the subject, very briefly, from the following angles: physiography; areal geology; historical geology; stratigraphy; structure; paleontology and economic geology. I shall omit at this time subjects like petrography, sedimentation and geography, which might profitably be discussed.

PHYSIOGRAPHY

First, take physiography. Physiographically, Oklahoma is chiefly a plain sloping from an altitude of about 5,000 feet on the lava-covered hill, known as Black Mesa, in the northwest corner of Cimarron County, to an altitude of about 325 feet along

TURNER FALLS
On Honey Creek, Arbuckle Mountains

Red River in southeastern McCurtain County. Down this sloping plain the rivers run. But the State is not all plain. Four mountain areas and several ranges of hills interrupt.

The Wichita Mountain type of topography consists of jagged granite peaks, like the Rockies or the Andes in miniature, rising abruptly from the surrounding plain. In fact, the Wichitas are but the tops of a buried range projecting above a sea of surrounding plain. The Arbuckle Mountains consist of a comparatively level plateau surrounding porphyry monadnocks. The alternation of hard and soft rocks, standing on edge, which make up the greater part of the mountains, into which streams have cut their valleys, produce a variety of erosion forms most unique. The Ouachita Mountains in southeast Oklahoma consist of long, narrow, parallel, battlement ridges, composed chiefly of hard resistant sandstone, separated by valleys of softer and more easily eroded shale. The Ozark Mountains in northeastern Oklahoma consist of a westward-sloping plateau, held up by a resistant formation, the Boone chert, or, as the oil drillers have it, the Mississippi lime, minutely dissected in places by streams, producing a peculiar topography which differs entirely from the topography of either of the other mountain areas in the State.

In northern Oklahoma one finds the stair-step topography of Kansas, formed by the west dipping monocline of Pennsylvanian rocks. In the western part of the State is the east-facing, mansard scarp of the Gypsum Hills. In the Panhandle counties we encounter the flat, even expanse of the High Plains where the landscape stretches away for unnumbered miles, the horizon a circle, the sky a dome. And intermingled with it all there are in various parts of the State such types as bad lands, sand hills, and stream valleys, all conspiring to make Oklahoma the physiographer's paradise.

AREAL GEOLOGY

Notice next the areal geology of the State. The new colored geologic map prepared by Mr. H. D. Miser and published as a bit of cooperative work between the United States Geological Survey, the Oklahoma Geological Survey, and the geologists of Oklahoma, is said by those who know, to be in many ways, the most complete and most comprehensive state geological map ever published in America.

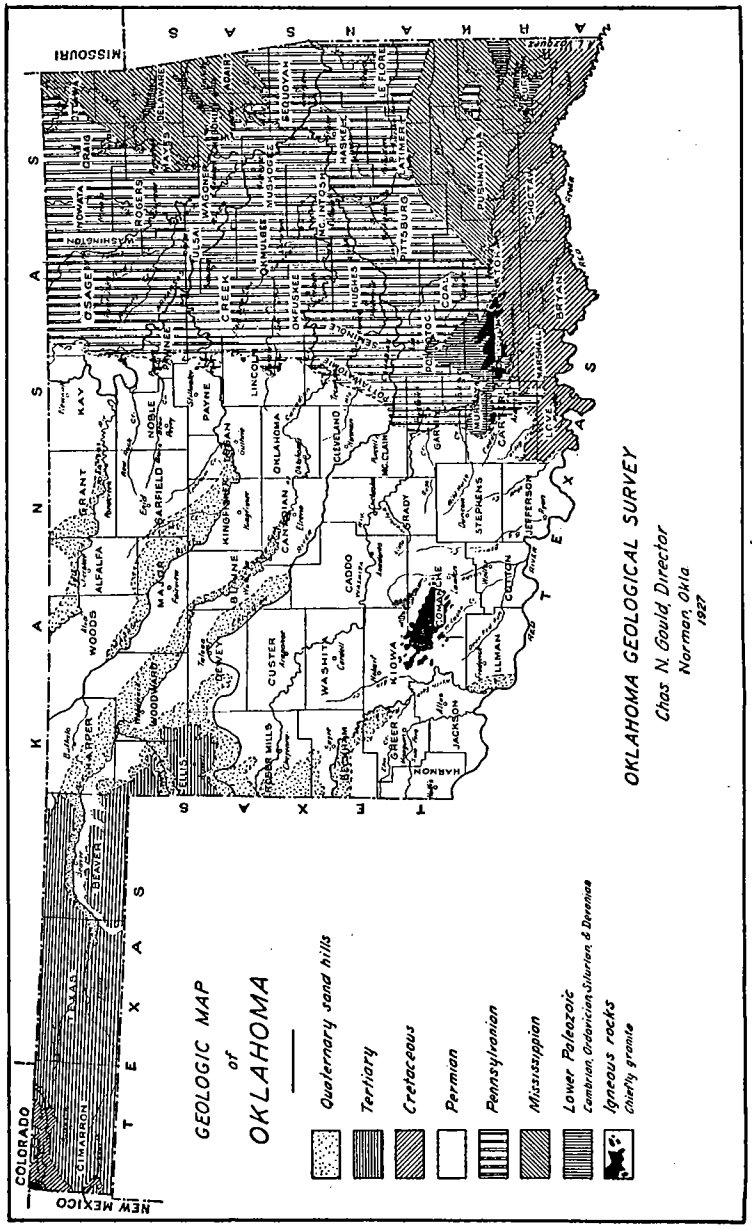
This map shows graphically, in colors and symbols, the surface outcrops of the 125 different geologic formations of the State. The area of surface outcrops of a formation as shown on a map, depends, primarily, on two things, the thickness of the bed, and the slope or angle of inclination. In the Arbuckle Mountains, which consist chiefly of an elevated, truncated dome, the formations stand practically on edge and circle the mountains like the slices of an onion, so that the area of outcrop is restricted and often shows on the maps as a single narrow line. In one instance, six formations, Woodford chert, Bois d' Arc limestone, Haragan shale, Henryhouse shale, Chimneyhill limestone, and Sylvan shale ranging in age from Ordovician to Mississippian, are indicated by a single symbol. In central and western Oklahoma, on the other hand, where the beds lie more nearly level, the areal extent of a formation occupies a much larger surface, sometimes covering almost an entire county.

One of the striking things about the geologic map, which attracts the attention of both the geologist and the layman, is the sunburst effect around the Arbuckle Mountains. A glance at the map will disclose this unique feature. From the lower Pennsylvanian to the upper Permian the formations radiate out from the Arbuckles on the east, northeast, north and northwest like spokes of a wheel, of which the mountains form the hub. The narrow ribbon-like zones formed by the outcrop of the various formations extend from the Arbuckles to the Kansas line. Farther west the more gently dipping beds of the Permian show by their outcrop the presence of the Anadarko Basin.

In the southern counties one may note the area occupied by the northern extent of a Cretaceous sea which once lapped the southern flanks of the Ouachita and Arbuckle Mountains. In the western part of the State scattered polka-dot colored patches on the map show the presence of certain oyster-shell beds which were deposited in this area when this Cretaceous sea extended uninterruptedly from the Gulf of Mexico to the Arctic Ocean. Great areas of Tertiary rocks in the extreme western counties are reminders of the time when the Rocky Mountains were being washed down and their debris spread out in great alluvial fans on the Great Plains.

STRATIGRAPHY

In the matter of stratigaphy Oklahoma as a state has few equals and possibly no superiors. The new colored map lists about 125 separate formations. These formations range in thickness from the Chattanooga shale and Chimneyhill limestone, which average less than 50 feet thick, all the way up to the Arbuckle limestone now known to be 7,800 feet thick, and the Stanley shale which is probably still thicker. All kinds of sedimentary rocks are represented in Oklahoma, shales of various kinds and colors, limestones of different textures, dolomites, sandstones, and conglomerates. The total combined maximum



thickness of the various sedimentary beds exposed on the surface is approximately 84,000 feet, but, of course, the total thickness of the formations at any one place is very much less.

One might write and speak at length regarding this phase of the subjcet, the stratigraphy of Oklahoma. So little has been done, and so much still remains undone. As the years come and go much must eventually be written. Let me cite only three examples out of the note book of 1927, which strike us in the face. It is only this year, a quarter of a century after Taff and Ulrich did their classic work in the Arbuckle Mountains that Decker and Merritt have finally carefully measured the thickness of the Arbuckle limestone, divided it into units, and found it to be approximately 7,800 feet thick. It is only this year, more than 20 years after Taff discovered the erratic masses of Ordovician limestone in the Caney shale in John's Valley, in the Ouachita Mountains, that Miser and Cooper found erratic limestone boulders 269 feet long, 65 feet wide and 20 feet thick which probably must have been transported for more than 50 miles, embedded in the Caney, and Miller has prepared a map of the Caney shales in the Valley. It is only this year, 74 years after Marcou first saw the Cretaceous outliers, the oyster shell beds, in western Oklahoma, and 27 years after I first attempted to map them, that Bullard and Redfield have accurately mapped these beds. Truly the harvest is great and the laborers few.

HISTORICAL GEOLOGY

Where can the student of historical geology find a more prolific field than Oklahoma? If the Morrison formation is Jurassic, as is believed by many American geologists, and if certain beds in Cimarron County are of Triassic age, then Oklahoma has rocks representative of every geologic period. Pre-Cambrian granites occur on the surface in the Wichita Mountains, the Arbuckle Mountains, and on Spavinaw Creek in the Ozark Mountains. Quartzites believed to be older than this granite, probably Proterozoic in age, are found in the Wichita Mountains. The Arbuckle Mountain Paleozoic section is one of the most complete on the continent. Something like 12,000 feet of sediments from Cambrian to Mississippian in age occur in the Arbuckle Mountains. Resting unconformably upon the igneous granite and porphyry is the Reagan sandstone of upper Cambrian age. This is soon replaced by the Arbuckle limestone, one of the thickest known ledges of limestone in the world. The work of Decker and Merritt the past summer has shown that the Arbuckle is over 7,800 feet thick. The age is Ozarkian and Canadian. Then in regular sequence come the Simpson, Viola and Sylvan of Ordovician age. The Chimneyhill and Henryhouse are

Silurian, the Haragan and Bois d' Arc are Devonian, and the Woodford, Sycamore and Caney are Mississippian. The same formations are believed to occur in the Wichita Mountains also, although so far as known only the Reagan, Arbuckle, Simpson, and Viola are exposed on the surface.

In the Ozark Mountains rocks of the same age as the Arbuckle, Simpson, Viola, and Henryhouse are exposed on the surface. The Chattanooga shale takes the place of the Woodford chert. The Boone is the approximate equivalent of the Sycamore.

In the Ouachita Mountains the lower part of the Paleozoic section is very different stratigraphically from the section exposed in the other three mountain uplifts, the sediments being chiefly clastics, including both shales and sandstones, rather than calcareous rocks.

Upper Paleozoic or Carboniferous rocks, as exposed on the surface, occupy nearly 80 per cent of the area of Oklahoma. Mississippian formations occur in the Ozark, Ouachita, and Arbuckle Mountains, while Pennsylvanian rocks occupy much of the eastern part of the State. Permian formations, chiefly red beds, occur in the western counties.

As has already been indicated, rocks which may be of Triassic and Jurassic age occur in Cimarron County. Cretaceous beds ranging from Trinity to Eagle Ford occur along Red River, while in western Oklahoma the Cretaceous ranges from Purgatoire to Benton. Tertiary formations cover several of the western counties. Pleistocene deposits, chiefly sand hills, valley alluvium, and gravel beds are found in many parts of the State. One of these Pleistocene beds, an ancient river channel, near Frederick, has recently yielded a number of fossil remains, including bones of three species of elephants, three horses, two camels, *Mylodon*, *Megalonyx* and *Glyptodon*. Certain human artifacts, including seven metates, or grinding stones, two arrowheads and beads are said to have been found in the same undisturbed river gravel 10 to 20 feet beneath the surface. The age is said by Oliver P. Hay, our best authority, to be Aftonian, or the first inter-glacial epoch.

STRUCTURE

For the student of structural geology our State forms a very excellent laboratory. Oklahoma's most interesting and spectacular geological phenomona are the direct results of structural deformations. Oklahoma's chief source of mineral wealth, petroleum, occurs along anticlines, faults, and other structural

features. The four mountain ranges are elevated, truncated domes, exposing upturned strata along the flanks. In the Arbuckle Mountains especially there are several places where one may stand on a hill and see spread out before him in panorama a series of anticlines and synclines—Appalachian-type structure in miniature. The Anadarko Basin in western Oklahoma and the Arkansas Valley syncline in the eastern part of the State are great structural troughs. In the north-central part of the State there are more than one hundred very peculiar short *en echelon* faults arranged in several rows, the cause of which is not at this time thoroughly understood.

In fact there are very many things not now known about Oklahoma's fault systems which await solution. Why do the structural trends in eastern Oklahoma run northeast-southwest, while the trends in western Oklahoma are northwest-southeast? Do the Ouachita Mountains consist essentially of a great, exotic overthrust block, brought in from the southeast, somewhere in Arkansas, Texas, or Louisiana, as is believed by Van der Gracht and others? What is the age and the cause of the Criner-Wichita-Amarillo uplift and what is its relation to the Arbuckle Mountain orongeny? These and many other questions today remain unanswered. Where and when will arise the structural geologist with the training, the ability, the inclination, and the time to solve for us these and other equally important, vexing questions?

PALEONTOLOGY

And the fossils! Where can the American paleontologist find better collecting than here? For wealth of material and variety of forms, Oklahoma is unexcelled. Starting with the Reagan and Arbuckle formations of Cambrian age in the Arbuckle and Wichita Mountains running the entire geological gamut to the Pleistocene deposits along our rivers, Oklahoma abounds with fossils. Great men, masters of the science, have collected here. Starting with Marcou in 1853, witness the procession; Cope, Stephenson, Hill, Williston, Vaughan, Stanton, Wood, Taff, Ulrich, Girty, David White, Beede, Case, Decker, Romer; men whose business it is to read the geologic clock in the endeavor to unravel Nature's hidden mysteries.

I very much doubt if any single small area in North America has yielded more fossils, or has been visited by more collectors, than has the diminutive hill, not much larger than an ordinary haystack, known as White Mound, near Dougherty, in the Arbuckle Mountains. More than 50 species of invertebrates occur there; corals, trilobites, sponges, cephalopods, but

chiefly brachiopods. I first collected there in 1901, and Professor Monnett has estimated that since that time more than 5,000 students from the University of Oklahoma have collected fossils from White Mound. The specimens have gone to practically all the larger museums of the world and to most universities in North America and Europe. Yet, so abundant are the fossils at this place, that any one of us might start tomorrow collecting inveterbrates from White Mound, and spend the rest of his natural life at the task, but at the close of a long and more or less useful life, there would still be fossils uncollected. Each rain washes out more specimens.

The Pennsylvanian formations of eastern Oklahoma yield uncounted millions of fossils of various kinds. The veterbrates of the Permian red beds of Oklahoma and Texas are the very earliest of the reptilian bones found anywhere in the world and represent the transition from amphibian to reptilian forms of life.

Dinosaurs have been found in the Trinity near Atoka and in the Morrison near Kenton. In southern and western Oklahoma there are hills composed of great reefs of oyster shells, and gigantic, coiled cephalopods known as *Ammonites* which weather out and cover the slopes. Fosil horses, elephants, mastodons, camels, bears, sloths, armadillos, and other strange prehistoric beasts that bogged down in quicksand during pleistocene times and are now being exposed by erosion, occur chiefly in the western counties.

Fossil plants of the coal age, limbs with strange pit-like markings, which represent leaf scars, abound in the Pennsylvanian of eastern counties. Peculiar forms of ferns, some of them with fronds a foot wide, occur in the Permian red beds. Dicotyledons, including leaves of the broad leaved plants such as willow, oak, sassafras, and elm are found in the Cretaceous of Cimarron County. Leaves very like those on our living trees are common in rocks of Tertiary age in Beaver County.

So that the fossil hunter, whether he be interested in plants, invertebrates, or vertebrates, may find in Oklahoma abundant material to occupy a busy life.

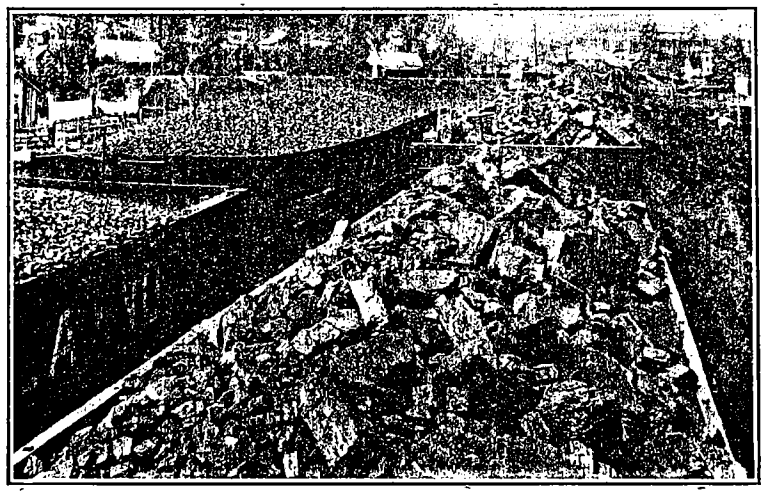
ECONOMIC GEOLOGY

In conclusion let us glance for a brief moment at the economic geology of Oklahoma, a thing which many people who pose as pure scientists are frequently prone to either overlook entirely, or at least pass by rather lightly, but which, after all, is the basis of a large part of our material prosperity as a State.

It is an axiom of economics that all wealth comes originally from the earth, and, taking the matter by and large, there are but three sources of new wealth, namely, wealth from the soil, wealth from the mine, and wealth from manufactures.

In wealth from the mine and oil well, Oklahoma stands unique. In a quarter of a century she has increased her mineral wealth from $4,000,000 a year in 1901, to $570,000,000 a year in 1926, and has advanced from 35th place to second place among the States in the Union in new mineral wealth per year.

In basic raw minerals upon which modern civilization rests, namely, fuels, structural material, and certain of the metals, Oklahoma stands supreme. Among fuels, Oklahoma produces each year 150,000,000 to 180,000,000 barrels of oil valued at $350,000,000 to $400,00 0,000. She also produces 275,000,000 thousand cubic feet of natural gas valued at $40,000,000; and 400,000,000 gallons of natural gas gasoline, usually spoken of as casing head gasoline, valued at $40,000,000. And the end is not in sight. Five years ago grave scientists were predicting the amount of oil and gas in reserve in Oklahoma. Today none would be so foolhardy. During the past few months, a single field in Oklahoma, Seminole, three years ago unknown, has been producing from 450,000 to 500,000 barrels of oil daily. On July 30, 1927 this field produced 527,000 barrels oil. This establishes a record for the United States.



OKLAHOMA COAL READY FOR SHIPMENT

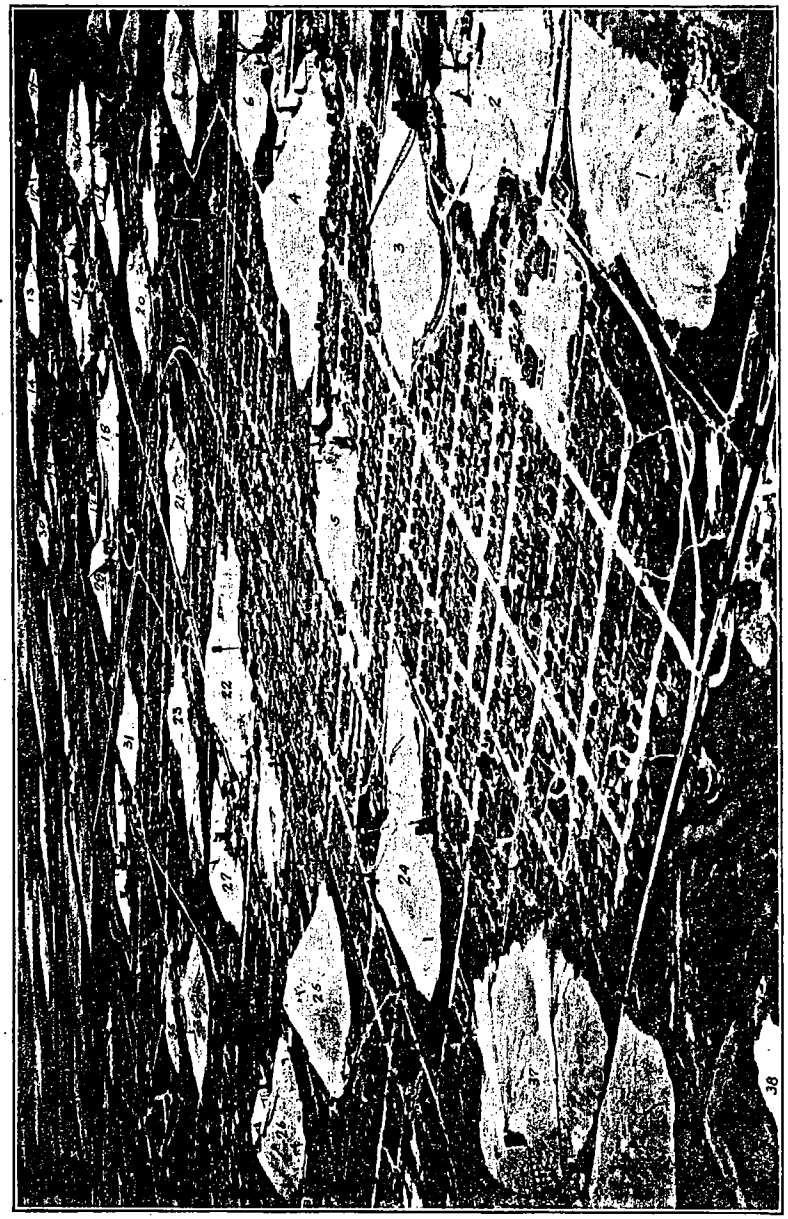
But when and if the oil and gas are all gone, there remain in Oklahoma, according to government estimate, 79,000,000,000 tons of coal, enough at the present rate of mining to last over 25,000 years.

Oklahoma has structureal materials to supply the world: mountains of granite, great ledges of limestone, whole counties of sandstone, clays and shales in inexhaustable quanity, asphalt in unknown amounts, 123,000,000,000 tons of gypsum, enormous beds of glass sand, besides marble, volcanic ash, tripoli, novaculite, and many others.

GYPSUM HILLS, WESTERN OKLAHOMA

A small part of a single county, Ottawa, in northeastern Oklahoma, produces each year over 250,000 tons of zinc worth $40,000,000, which is more than is produced in all the rest of the country combined, and $12,000,000 worth of lead. Western Oklahoma has enough saltwater going to waste to make an estimated amount of 100 car loads of salt a day.

What does this mean to the geologist? Simply this! Our fair State possesses enormous amounts of a very large number of the minerals upon which modern civilization is built: namely;



MAN-MADE HILLS
Chat piles, Picher Lead and Zinc District, Ottawa County

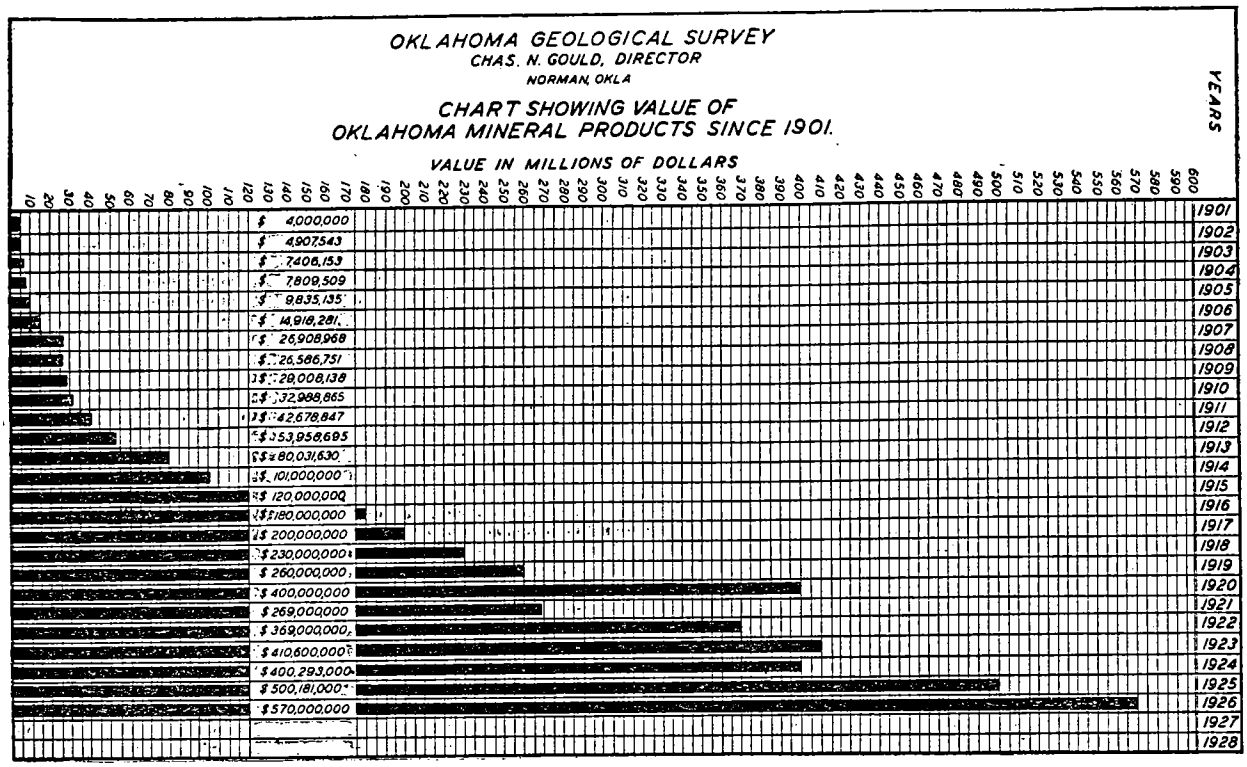
metals, structural materials, and fuels. With the exception of petroleum, natural gas, zinc, lead, and coal, few of these minerals are now being developed, but for the most part, are laying dormant. These dormant minerals do not today increase the revenues of the State, nor do they add to our taxable wealth. What better object might be sought, what more potent task might be accomplished, how can we as scientists better serve our State and our generation, than by girding ourselves like men and doing everything that lies in our power looking toward the winning of these raw materials and shaping them into articles for the use and comfort of man?

OUR OPPORTUNITY

To the student of earth science, Oklahoma offers an unique opportunity. It matters not whether one is interested in physiography, areal geology, historical geology, stratigraphy, structure, paleontology, or economic geology, he can find here abundant material to engage his best talents.

We have already accomplished a few things. Earnest men have wrought faithfully, and certain foundations have been laid. Time, the great arbiter, must judge whether or not these foundations are to endure. We have done a certain amount of qualitative work. We know a few, and only a few, of the more obvious things about Oklahoma geology. For more than a quarter of a century geology has been taught on the campus of the University of Oklahoma. We have turned out our quota of workers and we certainly have no cause to be ashamed of our output.

But, after all, we realize that our work has been crude work. In the very nature of the case, all pioneer work is crude work. We who are on the stage of action this year, 1927, are only like advance scouts, men in deer skin and coon skin, with moccasined feet, peering through the forest and across the plains, trying to discover what manner of land is this—the land of Oklahoma. It is for the younger generation, men who come after us, men whose grandfathers will not be born for another hundred years, to do the constructive work, the quantitative work, on the geology of Oklahoma.


OKLAHOMA GEOLOGICAL SURVEY
CHAS. N. GOULD, DIRECTOR
NORMAN, OKLA
CHART SHOWING VALUE OF
OKLAHOMA MINERAL PRODUCTS SINCE 1901.
VALUE IN MILLIONS OF DOLLARS
YEARS
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$ 4,907,543
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$ 180,000,000
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