OKLAHOMA GEOLOGICAL SURVEY

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BRIEF STATEMENT

OF THE

GEOLOGICAL HISTORY

OF

OKLAHOMA

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Classes of Rocks

Geologists divide the rocks on the earth's crust into three general classes, igneous, sedimentary, and metamorphic.

Igneous or crystalline rocks are those which were part of the original earth's crust, or which have come up from the interior of the earth. Some of the chief types of igneous rocks are granite, basalt, porphyry, gabbro, diorite and rhyolite.

Sedimentary or stratified rocks are those which were originally laid down as sediments, usually in some large body of water. The material which makes up the sedimentary rocks was derived originally either from igneous rocks or from some other sedimentary rocks. These rocks have been deposited usually in regular layers or strata, hence the term stratified. The chief classes of sedimentary rocks are shales, sandstones and limestones.

Metamorphic rocks are those that have been metamorphosed or changed from their original condition by the action of heat and pressure. Limestone, when changed, becomes marble, shale becomes slate, and sandstone becomes quartzite.

Rocks of all the kinds mentioned above occur in Oklahoma. Igneous rocks, chiefly granite and porphyry, are found in the Wichita and Arbuckle mountains and in a small area along Spavinaw Creek in eastern Mayes County. On the map the areas occupied by igneous rocks are shown in solid black.

Sedimentary rocks, consisting of shale, sandstone and limestone occupy more than ninety percent of the area of Oklahoma Metamorphic rocks, usually marble and slate, occur in the mountain regions.

During geologic time that part of North America now included in the State of Oklahoma has been alternately submerged below the ocean and elevated above it many times. During the periods of submergence beneath the water, various kinds of deposits were laid down on the ocean bottom. When the country was raised above the water these deposits hardened and became solid rock. When the land stood out of the water for any length of time, the action of the elements rain, wind, water and frost, wore away the rocks and carried them through rivers into the ocean.

Geologic Time Scale

Geological time is divided by geologists into the following eras: Archean, Algonkian, Paleozoic, Mesozoic and Cenozoic. These eras are again subdivided into periods and the periods into minor subdivisions. The rocks deposited during a period of time are called a system. The rocks deposited during the Cambrian period make up the Cambrian system. In the following table, the systems and such minor subdivisions as are well represented in Oklahoma are shown. The oldest rocks are placed below:

Cenozoic	Quartenary	Pleistocene
	Tertiary	Pliocene
		Miocene
Mesozoic	Cretaceous	Upper (Dakota)
		Lower (Comanche)
	Jurassic	
	Triassic?	
Paleozoic	Carboniferous	Permian
		Pennsylvanian
		Mississippian
	Devonian	
	Silurian	
	Ordovician	
	Cambrian	

Archean

Rocks Exposed in the Arbuckle and Wichita Mountains

The oldest rocks in Oklahoma are the granites, presumably of Archean age, and are exposed in the Wichita and Arbuckle mountains. Granite is usually considered a part of the original crust of the earth, and granite or some form of igneous rock, underlies all the stratified rocks; that is to say, if a hole were drilled deep enough anywhere on the surface of the earth it would encounter the igneous rock. We may assume that all of Oklahoma is underlain with some form of igneous rock, probably granite, which, however, is now exposed in but a few places. About the middle of Cambrian times the sea surrounded the granite peaks and a deposit of sand derived from the granite was laid down along the shore line. This sand now appears as a ledge of coarse-bedded sandstone, known as the Reagan sandstone. Lying upon the granite, in the Wichita and Arbuckle Mountains, the sandstone is composed largely of coarse feldspar and quartz-fragments and is generally too coarse to make a good building stone.

The sea in which the Reagan was deposited, deepened, or the

land surface was lowered so that the granite was entirely submerged. In this sea a great mass of limestone and dolomite was deposited, which so far as known is one of the thickest limestone formations in the world. This is known as the Arbuckle limestone. Its exact thickness is unknown, but is estimated by Mr. Taff, formerly of the United States Geological Survey, who has studied the formation, to be somewhere between 6,000 and 8,000 feet. Limestone of the same age as the Arbuckle, very similar to it in character and almost equal to it in thickness occurs in the Appalachian Mountains and in other parts of the country. These deposits are believed to be continuous although they are so deeply buried under younger formations as to make it impossible to trace any connections. If this is true, Oklahoma at the time of the deposition of the Arbuckle limestone, must have been a portion of a great sea which covered most of the United States. These conditions must have endured for an immense length of time, probably for hundreds of thousands or even millions of years, to permit the accumulation of such a great thickness of limestone and dolomite which, necessarily, is deposited very slowly.

Early in Ordovician time, after the deposition of the Arbuckle limestone conditions changed from that of a deep sea to a shallow sea, and a deposit consisting of shale, sandstone, and thin-bedded limestone was laid down. This formation, which is about 2,000 feet thick is known as the Simpson formation.

About the middle of Ordovician time conditions again changed this time from a shallow to a deep sea and another heavy ledge of limestone was deposited. This formation, known as the Viola limestone, is about 800 feet thick, and consists of heavy bedded white or blue limestone.

During the early part of the Silurian period the Sylvan shale was deposited. It is 100 to 200 feet thick and may be used for the manufacture of Portland cement or for various other clay products.

Above the Sylvan is a formation known as the Hunton limestone, which consists of three members, a limestone at the base, then a shale member, then another limestone at the top. The upper and middle portions of the Hunton are of Helderbergian or lower Devonian age . The entire thickness of this formation is usually less than 200 feet.

After the deposition of the Hunton limestone, the region was elevated above the ocean and erosion took place. In many places much of the upper part of the Hunton was carried away, and occasionally all of it has been removed. Then, in late Devonian time, the region again sank and there was laid down in still water a deposit of mud and silt, which, on hardening, became a hard, brittle shale, containing many concretions and bands of chert. The formation is known as the Woodford chert. Limestone, known as the Sycamore, was deposited locally on top of the Woodford chert.

Above the Sycamore are shales and sandstones of Carboniferous age, which will be described later.

The formations so far described are well exposed in the Arbuckle Mountains, in Murray, Johnston and Pontotoc counties. The Reagan, Arbuckle and Viola formations are exposed in the Wichita Mountains also, and the others are almost certainly present although deeply buried and not now exposed.

After these rocks had been deposited there occurred one of those periods of emergence, which have occured at intervals throughout geologic time. The regions occupied by the Arbuckle and Wichita Mountains were elevated in the form of two vast domes, each about 60 miles long and 20 miles wide. The amount of upheaval was probably about two miles above their present level. As soon as this uplift occurred and the rocks stood out of water, the agents of erosion, wind, rain, frost, and heat began to wear down the mountains. The upper rocks were first destroyed, and carried into the ocean. Afterward the rocks more deeply buried were attacked and carried away. In time all the sedimentary formations were worn away in places exposing the granite core of the mountains. This granite now stands out as high, jagged peaks in the Wichita Mountains, while in the Arbuckles it is exposed in the country around Tishomingo, and in the East and West Timbered Hills south and west of Davis. Surrounding the granite and flanked upon all sides of it are the various sedimentary formations mentioned above lying in regular order, beginning with the Reagan and ending with the Sycamore. In passing from the Washita River near Davis to the East Timbered Hills, a distance of four miles, one will walk over the uplifted cut-off edges of about two miles of sedimentary rocks.

Rocks Exposed in the Ozark Uplift

The regions heretofore described are in southern Oklahoma. In the northeastern part of the State, conditions were somewhat similar. In this region which is the southwestern extension of the Ozark Uplift, a number of formations, consisting of limestone, sandstone and shale, were laid down under varying conditions, either in the ocean or along the shore. The Yellville limestone and dolomite (not exposed in Oklahoma but near by in Arkansas) was deposited about the same time as the Arbuckle limestone.

The Burgen sandstone was laid down about the same time as the Simpson formation, the St. Clair marble about the same time as part of the Hunton limestone, while the Chatanooga shale corresponds in age to the Woodford chert.

The most important formation in this part of the State, however, is a ledge of limestone and chert, some 300 feet thick, known as the Boone chert, which was deposited in Mississippian time. It is of about the same age as the Sycamore limestone in the Arbuckle Mountains. This is the formation in which the lead and zinc of the Joplin and Miami districts occur. The limestone quarried at Carthage, Missouri, comes from this formation also. The Boone formation is exposed on the surface in Ottawa, Delaware, Adair, Cherokee and Mayes counties, where it forms the surface of the upland plateau lying between Grand River and the Arkansas-Missouri line.

Above the Boone is a shale formation, the Fayetteville shale, and above the Fayetteville a limestone known as the Pitkin limestone. This limestone is hard and durable and would make a splendid building stone. The Fayetteville and Pitkin are both thought to be of Mississippian age.

After the deposition of the formations just described which occupy much of southern Missouri as well as northeastern Oklahoma and northern Arkansas, there occurred an upheaval, very similar to the one which brought up the Arbuckle and Wichita Mountains. The rocks were elevated in the form of an immense dome. Erosion immediately began its work on the uplift and in many places the Pitkin, Fayetteville and much of the Boone formation have been removed, while in some of the deeper valleys along the White River in Arkansas the older formations down to the Yellville limestone are exposed.

Rocks Exposed in the Ouachita Mountains

The Ouachita (Wa-she-taw) Mountains are located in southeastern Oklahoma, extending from near Atoka east to the Arkansas line. They consist chiefly of long narrow ridges, composed of thick ledges of sandstone standing on edge, with intervening shale valleys. The various ridges have received names such as Winding Stair, Kiamichi, Jack Fork, Pine and Buffalo mountains. There are no igneous rocks exposed in the Ouachita Mountains, as is the case in the Arbuckles and Wichitas. The oldest rocks in this part of the State consist of certain exposures of chert and shale of Ordovician age which outcrop in three localities, namely, in the Potato Hills west of Talihina; in Atoka County between Stringtown and Atoka, and along Mountain Fork and Glover Creek in eastern McCurtain County.

Lying above these older rocks are immense deposits of sandstone and shale which were laid down during early Carboniferous times. The exact age of these rocks is not known, but they are probably early Pennsylvanian. Three separate formations have been described; the Standley shale, 6000 feet thick, which lies on the Ordovician rocks; the Jackfork sandstone, 5000 feet thick; and the Caney shale, 1500 feet thick. The Caney shale is also exposed in the country surrounding the Arbuckle Mountains. All these rocks have been tilted and now stand on edge. It is the heavy, persistent Jackfork sandstone that now makes up the long ridges of the Ouachita Mountains, while the Standley and Caney shales, being softer have worn away forming valleys.

Pennsylvanian Rocks

All the depositions and upheavals heretofore described occurred in early geologic time, before the close of the middle Carboniferous or Pennsylvanian time. In the Arbuckle Mountains, the Sycamore limestone is probably of Carboniferous age and in the northeastern part of the State the Boone, Fayetteville and Pitkin are Mississippian in age. In the Ouachita Mountains the Jackfork and Caney formations are Mississippian or Pennsylvanian.

About the time that these uplifts occurred, or possibly earlier, there was a great shallow basin or arm of the ocean occupying what is now east-central Oklahoma. This basin seems to have been connected with another arm which extended north through what is now central Oklahoma, Kansas and Nebraska. The basin must have extended far to the west, but we have no means of knowing just how far. The streams rising in the uplifted mountain regions just described, emptied their accumulated sediments into this basin so that in time there were laid down immense deposits of sand and mud. Great plants grew in the swamp-like basin and the vegetation accumulated in immense quantities. As time went on the mass of vegetation which was laid down in the basin became coal. The sand hardened into sandstone and the mud formed shale. These formations are more than ten thousand feet in thickness and belong to the Pennsylvanian or Coal Measures age. The rocks of this age now occupy about one-third of the State and consist largely of alternate ledges of shale, sandstone and coal, although in the northern part of the State, farther from the mountain uplifts, there are a number of ledges of limestone. The shales are much more abundant than the other rocks, and occupy perhaps three-fourths of the thickness of all the formations.

The Pennsylvanian area is separated from the Ouachita Mountain uplift by the Choctaw fault. North of this fault lies the Wapanucka limestone, the only limestone ledge in this part of the State. Above the Wapanucka the formations, in ascending order, are, Atoka formation, Hartshorne sandstone, McAlester shale, Savanna sandstone, Boggy shale, Thurman sandstone, Senora formation, Stuart shale, and Calvin sandstone. The combined thickness of these various formations is about 8500 feet. These rocks are exposed in that part of the State extending from the Choctaw fault north to the Arkansas River, and nearly as far west as the Sapulpa-Denison branch of the St. Louis & San Francisco Railroad.

Among the Pennsylvanian rocks of northern Oklahoma there are a number of ledges of limestone which lie interbedded among the sandstones and shales. Great numbers of shells and other forms of marine life, preserved as fossils, make up the greater part of the limestone ledges . These ledges enter Oklahoma from Kansas and pass southward, usually bearing off a little to the west,

about as far as the Arkansas River, where they usually thin out and finally disappear. Only a very brief description of the various ledges need be given here.

The lowest limestone of Pennsylvanian age enters Oklahoma a few miles west of Grand River in central Craig County, and passes southwestward near the towns of Centralia, Chelsea, Claremore and Catoosa and crosses the Arkansas River south of Broken Arrow. This formation was formerly known as the Fort Scott limestone, but is now called the Claremore. Above this formation shales occur and above the shales is another ledge of sandstone known as the Pawnee, which parallels the Claremore a few miles to the west, passing southward toward the Arkansas River. Then come other shales and a ledge of limestone known as the Altamont, which unites with the Pawnee at Oolagah and the two are known as the Oolagah limestone. Above is another thick bed of shales, which is succeeded by another limestone—the Lenapah, which passes from Kansas southwest through Nowata, Lenapah and Tulsa as far as North Canadian River. Other limestone ledges lying west of the Lenapah are known as the Hogshooter, Dewey, Avant and Piqua. Eastern Osage County is occupied largely by ledges of shale and sandstone and no other important limestone is found while passing westward until a point four miles west of the town of Pawhuska is reached where there is a very heavy limestone formation known as the Pawhuska formation, composed of three members which cap the hills of that region.

Western Osage County is occupied by the southern part of the Flint Hills of Kansas. The rocks consist of alternating layers of limestone and shales and sandstone all of which dip westward. There are a number of ledges of limestone in western Osage and eastern Kay counties, the most important of which are the Wreford, Fort Riley, Winfield, and Herrington limestones. These formations cannot be traced farther south than Noble County.

Permian Rocks

Lying west of, and above the sandstone, shale and limestone of Pennsylvanian age, is a great series of red shales known as the Redbeds. This series of rocks, consist of unknown thicknesses of red clay shales, containing occasional ledges of some other material, usually gypsum. sandstone, or dolomite. These rocks occupy all the country from about the eastern line of old Oklahoma westward across the State, surrounding the Wichita Mountains, and extending across the Panhandle of Texas, as far as New Mexico. The Redbeds seem to have been deposited during a time of withdrawal of the sea and also of extremely arid climate. They contain very few fossils and their red color is apparent proof that little organic matter was buried with them. Very few ledges can be traced for any distance, so that the thickness of the Redbeds is

not known. The extensive gypsum deposits in western Oklahoma belong to the Permian Redbeds.

While it is generally true that the Permian rocks in Oklahoma are red and the Pennsylvanian rocks non-red, there is a strip of country extending north and south through central Oklahoma where conditions are otherwise. In other words, it seems that the line of change in color in the rocks does not coincide with the line of separation between the Pennsylvanian and Permian. This condition is shown on the map where the areas of red Pennsylvanian and non-red Permian are shown. The actual line of contact between the Pennsylvanian and Permian as shown on the map has not been accurately located.

The Permian rocks of Oklahoma have been divided into five formations as follows: The Enid formation consists largely of red shale and includes all the lower part of the series as exposed in the country east of the main line of Gypsum Hills. The Blaine formation consists of heavy ledges of white massive gypsum, which make up the main line of the Gypsum Hills, and outcrops along a line extending from near El Reno north to Kansas. The Woodward formation lies west of the Gypsum Hills and consists of red shales and sandstones. The Greer formation is made up of several ledges of massive gypsum. It is exposed in a number of counties in western and southwestern Oklahoma and crosses Red River into Texas. The Quartermaster formation which lies above the Greer is made up largely of soft sandstone. It is exposed chiefly in Beckham, Washita, Custer and Roger Mills counties.

Triassic or Jurassic Rocks

After the rocks of the Pennsylvanian and Permian age had been deposited, all that part of America now occupied by Oklahoma was raised above the ocean and for a long period of time remained out of the water, in fact so far as we know, only the southeastern part and certain regions of western Oklahoma have again been submerged since Permian time.

With the possible exception of a few unimportant formations of doubtful age which outcrop along the Cimarron River in the extreme northwestern part of Cimarron County, there are no rocks of either Triassic or Jurassic age in the State, which indicates that all of Oklahoma was a land area through those periods.

Cretaceous Rocks

During the Cretaceous period, that part of Oklahoma which lies south of the Arbuckle and Ouachita Mountains, all of eastern Texas, and southern Arkansas were submerged and a number of different formations were deposited.

The oldest Cretaceous formation in Oklahoma is known as the Trinity sandstone, and is composed largely of coarse sand and clay. The Trinity, which is from 400 to 600 feet thick, was probably deposited along the margin of a sea which at one time marked the southern base of the Arbuckle Mountains. This formation, as exposed on the surface, extends from near Ardmore to the Arkansas line and dips south passing beneath the next younger formations. After the deposition of the Trinity the water deepened and a limestone formation was deposited. It is about twenty-five feet thick, usually white in color and is known as the Goodland limestone. After the deposition of this limestone there was a shallowing of the sea and a series of mud and calcareous shell rock was deposited to a depth of thirty to fifty feet.

The sea again deepened and the Caddo limestone was deposited. This formation is about 150 feet thick and consists of clay, calcareous marls and white or yellow limestones. There was another shallowing of the sea and a series of clays and sand, with thin beds of limestone were laid down. This formation is known as the Bokchito and is about 150 feet thick. The sea again deepened and the Bennington limestone 80 to 100 feet thick was laid down. Above the upper limestone members there was laid down a deposit of sand and clay. This sandstone is known as the Silo sandstone.

At the time that southeastern Oklahoma was covered by a Cretaceous sea, there seems to have been an embayment of another sea extending from Kansas and Colorado south across the western part of the State. In a number of the western counties there are deposits of shell rock containing fossils of Cretaceous age lying on the unevenly-eroded surface of the Redbeds. These were probably laid down at about the same time as the Goodland or Caddo limestone of southern Oklahoma. There is no means of determining just how far this sea extended but deposits have been found in Woods, Harper, Woodward, Dewey, Custer, Roger Mills and Washita counties.

In the extreme northwestern part of Oklahoma along the valley of the Cimarron River there are rocks of Cretaceous age also. These consist largely of sandstone and shales, the upper members being the Dakota sandstone of the same age as the Silo. This formation is found very abundantly in Kansas, Nebraska, and other states in the northern part of the Great Plains.

Tertiary Rocks

During late Cretaceous times Oklahoma stood out of the water and so far as we are able to learn it has remained a part of the unsubmerged continent ever since. During Tertiary times, however, the Rocky Mountains, which were then much higher than at the present time, were being eroded and washed away, and the material derived from them, consisting of sand, clay and gravel, was carried by streams and spread out on the western part of what is now the Great Plains. Much of western Dakota, Nebraska, Kansas and Oklahoma, northern Texas and eastern New Mexico, Colorado, Wyoming and Montana contain deposits of Tertiary age

derived from the waste of the Rocky Mountains. In Oklahoma Tertiary deposits occur in the three western counties, Cimarron, Texas, and Beaver, and in a number of other counties in the western part of the State. These formations are exposed as white cliffs or banks along the streams. The sheet water of the Plains is found usually near the base of the Tertiary, and the many perennial springs in this region obtain their supply from the same rocks.

There are many places in western Oklahoma where sand hills occur, but they are usually found most abundantly north of such streams as Salt Fork, Cimarron, North Canadian and South Canadian. It is believed that much of the sand which goes to form these hills was derived principally from Tertiary deposits, and that the hills have been shaped by the winds. A considerable amount of the sand was undoubtedly carried from the various streams by strong south winds.

In the extreme northwest corner of the State there is a deposit 150 feet thick and some 10 miles in area of black volcanic lava. The rock came originally from a volcano, which in Tertiary times was located just west of what is now the Oklahoma line, in southeastern Colorado.

Quarternary Rocks

The Quarternary or Pleistocene deposits of Oklahoma consist largely of the alluvial soil or bottom land along the streams, and fine silt and soil forming the so-called black upland on many of the divides. The deposits do not form rock, as the term is popularly understood.

Minerals in the Rocks

Many of the formations described above contain various minerals some of them in immense quantities; many of them extremely valuable.

Some of the finest granite in the world is found in the Arbuckle and Wichita mountains. These granite rocks also contain small quantities of gold and silver, but so far as known these minerals have not been found in paying quantities in Oklahoma.

Limestone is found widely distributed in the State, chiefly in the mountain regions, and in the Pennsylvanian area in the northern counties. The greater part of this limestone is suitable for building stone, for burning into lime, for the manufacture of Portland cement, for concrete rock, road material, and for many other uses.

Sandstone is widely distributed, being found in rocks of practically all ages. The best sandstone is found in Pennsylvanian and Cretaceous rocks. The Simpson sandstone in the Arbuckle Mountains and the Burgen sandstone near Tahlequah, contain vast deposits of glass sand. Clays and shales suitable for a very large

variety of clay products occur in all formations and widely distributed.

Coal occurs chiefly in the Pennsylvanian rocks of eastern Oklahoma where at least ten workable beds are found. The government estimates that Oklahoma contains 79,000,000,000 tons of coal.

The greater part of the petroleum and natural gas so far found in the State comes from the Pennsylvanian rocks also. The amount of these fuels is so great that it cannot now be estimated.

Asphalt occurs widely distributed in southern Oklahoma, chiefly in the Arbuckle and Wichita mountains and in the Pennsylvanian rocks surrounding those mountains.

Lead and zinc occur chiefly in the Boone chert of Mississippian age in the northeast corner of the State, and in the Arbuckle limestone in the Arbuckle Mountains.

Iron ore occurs most abundantly in the Arbuckle, Viola and Hunton formations of the Arbuckle Mountains. Deposits are reported from the Wichita Mountains and from the Pennsylvanian rocks near McAlester.

Gypsum, of which it is estimated that Oklahoma contains 125,000,000,000 tons, occurs as members of the Permian Redbeds in the western part of the State. Salt occurs in large quantities in the same general region.

Among the minerals of minor importance, tripoli occurs in the Boone chert in the northeastern counties; novaculite or razor hone rock is found in the Ouachita Mountains, and beds of volcanic ash are stratified among the Tertiary deposits of the Plains.

LIST OF PUBLICATIONS

The following publications of the Oklahoma Geological Survey are either now available or will be off the press within the next few months:

Bulletins

Bulletin No. 1. Preliminary Report of the Mineral Resources of Oklahoma. Postage 3 cents.

Bulletin No. 2. Rock Asphalt, Asphaltite, Petroleum and Natural Gas in Oklahoma. Postage 10 cents.

Bulletin No. 3. Geology and Mineral Resources of the Arbuckle Mountains. Postage 6 cents.

Bulletin No. 4. Coal of Oklahoma (To be issued in December). Postage 6 cents.

Bulletin No. 5. Structural Materials of Oklahoma. Postage 6 cents.

Bulletin No. 6. Director's Report and Brief Chapters on twenty Oklahoma Minerals. Postage 3 cents.

Bulletin No. 7. Clays and Clay Industries of Oklahoma. Postage 10 cents.

Bulletin No. 8. Road Materials and Road Conditions in Oklahoma. (To be issued in September). Postage 7 cents.

Bulletin No. 9. Lead and Zinc in Oklahoma. (To be issued in November). Postage 8 cents.

Bulletin No. 10. Oklahoma Mineral Waters. (To be issued in November). Postage 8 cents.

Circulars

Circular No. 1. Origin, Scope and Purpose of the Oklahoma Geological Survey. (Edition Exhausted).

Circular No. 2. Brief Statement of the Geological History of Oklahoma. Postage 1 cent.

Circular No. 3. Oklahoma Among the Southern States. Postage 1 cent.