A PRELIMINARY REPORT ON THE CRETACEOUS OF OKLAHOMA

A THESIS

submitted in part fulfillment

of the requirements for the degree of

Bachelor of Arts in Geology

by

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and

approved by

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1909

INTRODUCTION.

Location and Extent

The Cretaceous formations discussed in this paper occupy an area roughly rectangular in outline in the southeastern part of Oklahoma along the Red River. The region is limited on the north by the Ouachita and Arbuckle Mountains. The Arkansas-Oklahoma state boundary line forms the eastern limit and on the west the area extends slightly beyond the main line of the Athhison, Topeka and Santa Fe Railroad.

This strip of country is roughly one degree of latitude in width and three degrees of longitude in length. The thirty-forth parallel passes a little south of the

center of the region, while the meridian of ninetyfour degrees thirty minutes limits it on the east. More exactly it might be said that the area is about fifty miles wide north and south and about two hundred miles long. The whole of Bryan, Marshall and Choctaw Counties lie within it. Those counties which are partly within the region are Love, Carter, Johnson, Atoka, Pushmataha and McCurtain.

Historical Sketch.

The earliest Geographical and Geological history of our state is intimately connected with the Red River region. This may be due to at least two causes, first, the fact that the Red River was a National Boundary between French and Spanish possessions in America, and later

between Spain and the United States, then between Texas and the United States. The second cause for this interest in this stream was largely scientific, an attempt to reach its head waters. A number of expeditions were sent out by the Federal Government for this purpose. Strange as it may seem, it took these"pioneers of science" nearly fifty years to find the object of their search, for no less than three fruitless attempts were made during this time, each of which added something of value to the early knowledge of the country.

The first investigationsin the region were carried on by the Spaniards. Baron Frederick Henrich Alexander Von Humboldt was employed by the government of Spain from 1799 to 1804 to make a study of the geography and natural history of their possessions in America. The geology of

southern Oklahoma was not included in his report. He did not visit the Red River in person, but derived some knowledge of it from Spanish army officers. From information thus gained he made the first map of this region and its adjoining territory. It is said that a glance at this early map is enough to satisfy any one that the author did not take time to examine the country himself.

An Englishman, William Kenedy was the next man of any importance to mention this part of the country in scientific reports. He was sent, in 1836, on a diplomatic mission to Texas and while there wrote a two hundred-page book on the Geography of that state. He also made a map which included the Red River country and which was quite an improvement on the one made by Von Humboldt thirty years before.

This report was followed in 1841 by a map compiled by Mr. ~~G~~G. A. Scherpf, a German emigrant agent. His work was superior to that of the other two.

The first and in some respects the best Geological research that has been done on the Cretaceous along the Red River was accomplished by Dr. Ferdinand Von Roemer who came from Germany in 1845 and spent two years studying the Geology of Texas. He was especially interested in the Cretaceous formations of that state and adjoining territory, but he also spent some time on the Tertiary formations of the region. Upon his return to Europe he wrote an account of his work entitled "Die Kreidebildungen Von Texas und ihre Einschlusse. Mit einem die Beschreibung von Veisteinerungen aus Palaozoischen und Tertiaren Schichten enthaltenden Anhange und mit II von C. Hohe

nach der Nature auf Stein gezeichneten Tafelm," printed at Bonn, by Adolp Marcus, 1852.

Dr. Roemer's work constituted the last studies of any importance done by foreign students in southern Oklahoma and northern Texas. Shortly after the publication of his report in 1852, Texas organized a State Geological Survey and, as is usually the case among state surveys, investigations were pushed beyond the state borders into southern Oklahoma. But before this and other geological surveys of Texas are discussed it might be interesting to note what the Federal Government had been doing towards the exploration of the region up to this time.

After the acquisition of the Louisana Territory the Red River or the height of

land south of it became the boundary between Spanish and American possessions from the ninetyforth to the one hundredth meridian. The United States became vitally interested at once and Major Pike was sent out in 1806 to follow the Arkansas River to its source and then to cross over to the headwaters of the Red River and descend that stream to Natchitoches. Unfortunately he mistook the Rio Grande for the Red River and while descending that stream was captured by the Spaniards near Santa Fe.

In 1807 Lieutenant Freeman was sent to explore the Red River but was also captured by the Spanish near Childress Texas. Another exploring expedition under Major Long was sent out in 1819 by way of the Arkansas to its headwaters for the purpose of descending the Red River. This party

missed the Red River as Major Pike had done but descended the South Canadian instead of the Rio Grande.

It was not until 1852 that a well equipped exploring expedition finally made its way to the headwaters of the Red River. Captain R. B. Marcy was in command with Captain George B. McClellan as assistant, Dr. G. G. Shumard accompanied the expedition as geologist. The party came into Oklahoma by way of Ft. Smith Arkansas and first met with Cretaceous rocks at Ft. Washita, now a mass of ruins on a high bluff overlooking the Washita River in Johnson County. This party in some respects did the best geographical work that had been done up to that time and numerous specimens of the Flora and Fauna of the region were collected and taken east when the expedition

returned. Dr. Shumard made several mistakes which are excusable considering the fact that his studies were carried on hurriedly. The unconformity between the upper and lower Cretaceous he placed between the Fredericksburg and Washita divisions. He mistook the Silo formation for Tertiary and failed to recognize the Red River Fault Zone.

In 1852 and 1853 Mr. Julius Marcou was geologist in Major Whipples party which surveyed the thirtyfifth parallel. Marcou devoted some time to the study of the Cretaceous formations of Oklahoma. It is unfortunate however that he quarreled with the Secretary of War who demanded his notes and gave them to Mr. W. P. Blake to be written up. Marcou's chief error regarding the Cretaceous was somewhat similar to Shumard's in placing the Washita in the upper Cretaceous.

In 1858 Dr. Shumard was appointed State Geologist of Texas and began the study of the rocks in the vicinity of the Red River; before he could make any extended investigations in the region, the Civil War broke out, The Capital at Austin Texas was converted into an Armory and percussion caps for Confederate guns were manufactured in his office. He went to St. Louis and remained there till after the war but never returned to Texas. A few of his notes were published after his death but they throw little or no light on the region in question.

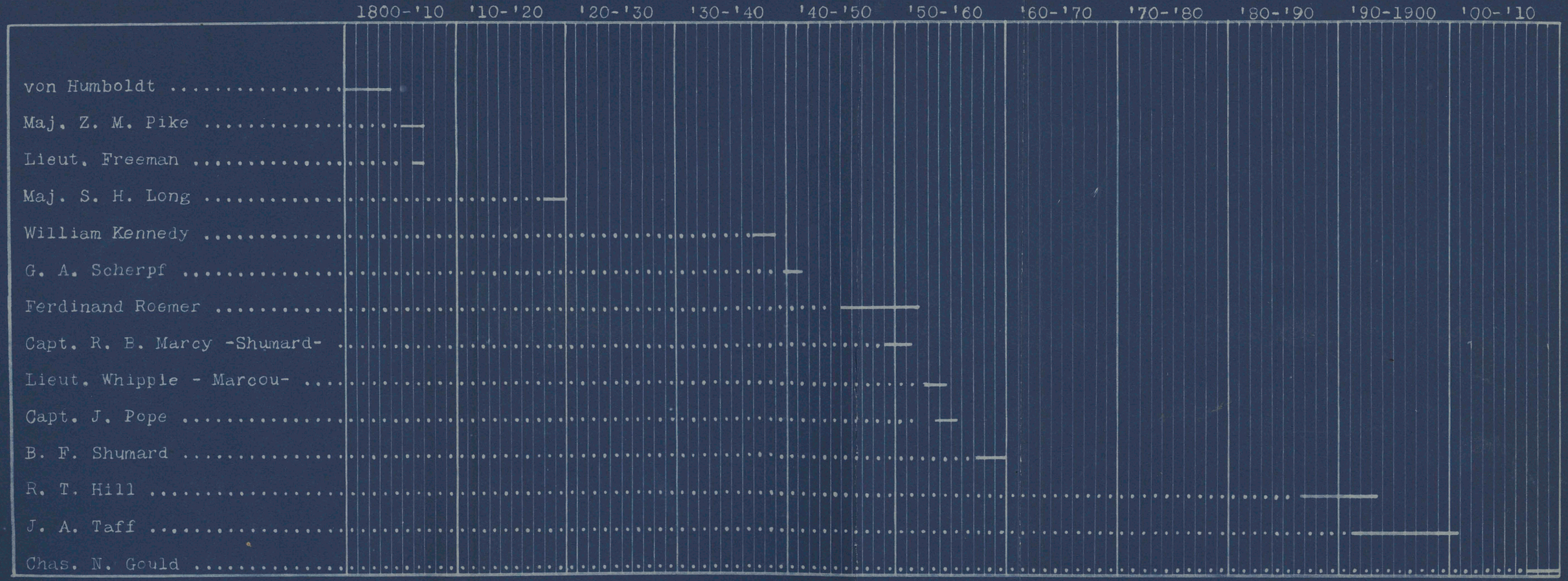
In 1867 Texas again organized a State Geological Survey with John W. Glenn, State Geologist. Mr. Glenn resigned in 1874 and Dr. S. B. Buckley who was assistant geologist under Dr. Shumard was appointed in his place. This is popularly known as

the Glenn-Buckley Survey. The work accomplished by this survey had very little material value especially for southern Oklahoma.

Mr. Robert T. Hill has probably done more work on the Cretaceous of the Red River region than any other man, unless Mr. Joseph Taff may be considered his equal in this respect. Both of these men worked on the State Geological Survey of Texas. Later they made special studies of various parts of the Red River region for the Federal Government. Hill's, report on the Black and Grand Prairies is one of the notable publications which resulted from this work. Two folios, the Atoka and the Tishimingo, published by the United States Geological Survey each containing large areas of

Cretaceous rocks, were worked out by Mr. Taff.

This is a brief account of over a century of investigations in the vicinity of the Red River and the region occupied by Cretaceous rocks in the state. Since Oklahoma has been admitted into the union the Oklahoma Geological Survey has had several men at various times working on the Cretaceous formations of this and adjoining states, examining carefully their economic resources and collecting material for a more thorough report than has as yet been made.



ONE HUNDRED YEARS OF GEOLOGIC AND GEOGRAPHIC INVESTIGATION IN THE RED RIVER REGION.

PHYSIOGRAPHY.

Drainage

The region is well drained and owing to the character of some of its rocks abundant water is supplied to keep strong currents flowing continually in all of the larger streams. Some of the formations are composed almost entirely of sand and as the rainfall of the country averages more than forty inches, the water level stands rather near the surface, so that springs occur along every small creek that has succeeded in cutting its channel deep enough to reach the ground water.

The streams of the region may be divided into three groups: Those that rise on the High Plains to the west, those that head in the Ouachita and Arbuckle

Mountains, and those whose sources are within the area occupied by the Cretaceous rocks. Red River and Washita belong to the first class. Those which belong to the secondclass are Blue River, Boggy Creek, Kiamichi River and Little River. To the third class belong a number of smaller and less important streams which are too numerous to be mentioned but all of which rise in the Cretaceous rocks.

The Red River rises on the High Plains of western Texas and flows east forming the southern boundary of Oklahoma. This river has had a greater influence on the topography and physiography of this area than any other stream. Its valley is broadly U shaped. In the eastern part of the state the channel meanders back and forth apparently engaged in broadening the valley rather than cutting it deeper.

The counties of this region bordering on the river are Love, Marshall, Bryan, Choctaw and McCurtain. Along the southern border of the latter county the Red River takes on the unmistakable evidence of old age.

The Washita River rises on the High Plains of the Panhandle of Texas and flows southeast across the western part of Oklahoma. It cuts a gorge through the heart of the Arbuckle Mountains, and after leaving them crosses Cretaceous formations for about fifty miles to join the Red River. The Washita does not receive any tributaries of importance from the Cretaceous. Its course after it first reaches these formations is roughly with the strike of the rocks. The Cretaceous rocks however are not sufficiently massive to interfer seriously with a

stream as large as the Washita and after it turns south cuts across the strike at almost right angles. The channel of the Washita differs from that of the Red River in that it is not choked by sand and is engaged more in cutting downward.

Blue River and Boggy Creek rise in the Arbuckle Mountains and flow in a general southeasterly direction across the Cretaceous formations to the Red River. Both carry clear pure water and furnish a constant supply. It is from the former that the City of Durant gets its water.

The Kiamitia River rises in the Ouachita Mountains in western Arkansas and flows southwest until it reaches the Cretaceous formation when it changes its course and flows southeast and becomes a tributary of the Red River. It has a

broad deep channel and can be forded only at but few points and then only during low water.

Little River rises in the Kiamitia Mountains, a range of the Ouachita in La Flore County, and like the Kiamitia River takes a general southwesterly course until it reaches the Cretaceous formations. This stream however differs in two ways from the others mentioned. First it does not cross the Cretaceous formations in Oklahoma but flows around the end of the Goodland Limestone in Arkansas and enters the Red River in that state. Again, after it crosses the Trinity formation of the Cretaceous it becomes unmistakably a strike stream. For forty miles it is compelled to flow due east along the base of the Goodland Limestone

and turns southward as noted above only when it has flowed around the end of this formation. Little River is the only stream of this area that seems to have been affected permanently by the arrangement of rock strata of the region. All of the other rivers and creeks, some of them much smaller and much less important, have been able to cut their way across the general slope of the country. This stream has a broad deep channel that is fordable locally only at low water.

Stream Piracy.

The geological conditions of the regiom are of a nature that would tend to foster stream piracy. There is a number of alternating resistant and non-resistant ledges across which the streams of the

region flow. If for any reason the Red River should begin deepening its channel rather rapidly there would doubtless be some important and interesting re-adjustment of the drainage of the region. Boggy Creek is already encroaching on the Blue River and has sent out a strike branch- Caney Creek- which is threatening Blue River. The Kiamitia also has some strike streams which seem to be developing rapidly because of the softness of the rocks through which they flow. No direct evidence bearing on the subject was observed but judging from conditions there can be but little doubt that the western part of Little River is a diverted stream. Numerous gravel beds in the vicinity of Garvin in McCurtain

County show from their composition that the material was derived from the Ouachita Mountains and that they are not of the character which the Red River deposited a little further south. At the time these gravels were laid down some stream must have been entering the Red River not far south of this point. Similar gravel deposits also occur high on the divide south of Little River opposite the mouth of Mountain Fork indicating that a stream occuping approximately its position crossed the divide at this point. Since these deposits were laid down these streams have been beheaded by a westward-working strike stream from Arkansas.

Oxbow Lakes.

The topography along the Red River

throughout most of its course in this region is nearing maturity. This is especially true in Choctaw and McCurtain Counties. The river meanders considerably in its broad flood plain and has already formed numerous oxbow lakes. The depths of these lakes vary probably none of them exceed thirty feet. In some instances these bodies of water have been partly filled with sediment carried down by creeks which flow into them. In such cases swamps choked with heavy growths of plant life are formed. A few of these lakes are out on the border of the present flood plain or in the lower part of the first terrace above and are now at such an elevation that the river does not flow through them in time of flood.

Roubuck Lake lying a few miles southwest of Hugo in Choctaw County belongs to this class. The analysis of a sample of water from this lake shows the following results:

Calcium Carbonate	5.43	Gr.	per gal.
Magnesium Carbonate	1.17	"	" "
Calcium Sulphate	.21	"	" "
Oxides of iron, Aluminium and Silicon	.15	"	" "
Alkali Chorides	1.16	"	" "
Alkali Sulphates	.73	"	" "
Solids	8.85	"	" "
Incrusting Solids	6.94	"	" "
Pounds of Solid per 1000 gal	.99	"	" "

River Terraces.

Along the Red River there are at least

three and sometimes four distinct river terraces with possible traces of others which have been almost obliterated by erosion. These terraces may be divided into two classes, low-lying alluvium terraces and high gravel terraces. One or more of these are always present.

The higher-lying terraces are composed of sand and course gravel with large water-worn pebbles, altogether different from anything that the river is carrying now. Certain pebbles in these clastic formations below the mouth of the Washita River obviously came from the granites and limestones of the Arbuckle Mountains. Above the mouth of the Washita, the debris is composed of material which bears unmistakable evidence of having come from the high plains region to the west. These terraces seem to

diverge from the river as one goes eastward in the vicinity of Garvin and Idabel, remnants of them appear on the divide between Red River and Little River.

The alluvium terraces are composed of material similar to that which the river is carrying at present. The lower ones contain fine sandy loame with a deep rich soil. Traces of the old river channel are still present in places occupied by marshes or swamps as noted above or sometimes by creeks which make their way into the river by following the old channel at the foot of one of the terraces.

Owing to the limited time devoted to the Cretaceous it was not possible to make a thorough systemic study of these formations, and for two reasons no attempt was made to corelate the various terraces. However, each in the series in a given place seemed

to have a marked resemblance to the same one in another locality, in so far as material and height above the present channel are concerned. The higher terraces present the greatest difficulty as they are rather fragmental and are absent over large areas. Further study however will probably demonstrate that these terraces bear definite relation to corresponding periods of aggradation and degradation or to periods of activity and inactivity while the stream was deepening its valley.

Prairies and Forests.

Some of the Cretaceous rocks are of such a nature that timber grows readily on soils formed from them, while other formations weather into a soil wholly unsuited to forest growth. As these formations outcrop in broad bands across this part of

Oklahoma it follows that band-like strips of forest and prairie will also be a feature of the region. These conditions exist throughout the area occupied by Cretaceous rocks and consequently two great prairie regions and two great timber regions extend across Texas and southern Oklahoma. This feature of the region is so conspicious that it was noted even before there was any explanation for it; and the local terms East and West Cross Timbers were used and afterwards found their way into the geological literature of Texas and Oklahoma. Lying between the two timbered regions is the Grand Prairie and east of the East Cross Timbers is the Black Prairie. These belts take roughly an east and west direction in Oklahoma but in Texas their trend is almost north and south. The

direction in both states corresponds to the direction of strike of the rocks.

The Grand Prairie in Oklahoma consists of about twentyfive hundred square miles of territory lying in Love, Marshall, Bryan, Choctaw and McCurtain Counties. The soil is heavy and black and not adapted to the growth of trees except where there is very abundant rainfall. It is typically a limestone soil resulting from the weathering and disintigration of lime and marly clay formations. As the amount of rainfall increases eastward across this region one would expect to find forest trees encroaching on the prairie, this in fact occurs, and causes,(together with a geological factor which will be discussed later) the prairie to become narrower eastward until it diminishes in width from twenty miles

to a series of small prairies south of Little River.

The Grand Prairie is broken in a number of places by forest areas which grow in the alluvial deposits and connect the Upper and Lower Cross Timber, thus producing a disjointed effect which results in isolating the various divisions of the prairie. These lacal prairies were all named by Hill, except the most easterly. The prairie lying to the west of the Washita is the Marietta, the one between the Blue and the Washita is named the Washita Prairie. The Caddo Prairie lies between Blue River and Boggy Creek. The Goodland Prairie is between Boggy Creek and Kiamichia River, and Little River Prairie is between the stream which bears that name and Kiamichi River. It is

proposed by the writer of this paper, that the prairie lying south of Little River and extending eastward to the Arkansas line be called the Idabel Prairie. This last named Prairie consists of a number of glades in the Gulf Timber Belt which extends into Oklahoma from Texas and Arkansas. The other Prairies are less broken in character.

The timber seems to be encroaching slowly on the prairie. At Fort Towson and several places east of that point the trees surrounding these glades are usually young seldom showing a greater age than fifty years. Sometimes a belt of this timber a mile or more in width will be found growing in places where there probably was not moisture enough half a century ago to support such vegetation.

	Atlantic Coast	Eastern Gulf	Oklahoma	Western Gulf	Interior	Pacific Coast	Europe
Upper Cretaceous	Manasquan 60 Rancocas 180	Wanting	Wanting	Wanting	Denver, Livingston, ect. ? 1500 Laramie 1000	Wanting	Danian
	Monmouth 150 Matawan 400	Ripley 275 Selma 300 Eutaw 1000	Wanting	Montana Navarro 940	Montana Fox Hills 1000 Ft. Pierre 1000	Chico 400	Senonian
			Colorado Austin ? Eagle Ford ?	Colorado Austin 410 Eagle Ford 150	Colorado Niobrara 700 Benton 700		Turonian
	Wanting	Wanting	Silo 250	Woodbine 250	Dakota	Wanting	Cenomanian
	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity	Unconformity
Lower Cretaceous	Wanting	Wanting	Washita Bennington 25 Bokchito 140 Caddo 60 Kiamichi 125	Washita Buda 45 Del Rio 80 Georgetown 80	Wanting	Horsetown 6000	Aptian
	Wanting	Tuscaloosa 1250	Fredricksburg & Goodland 20 Comanche Pk. 6 Walnut ? 10	Fredericksburg Edwards 300 Comanche Pk. 40 Walnut 15	Kootenay and Morrison 200	Knoxville 20000	Urgonian
Jurassic?	Potomac 700	Wanting	Trinity 500	Trinity Paluxy 150 Glenn Rose 450 Travis Peak 150	Wanting?	Wanting?	Neocomian Wealdon 1500

Pierce Larkin

Old Fort Towson, now a mass of ruins, was built on a prairie with a wide view in all directions but now it is shut in with a forest of young oaks and hickories, some have been cleared away to prepare the land for agriculture. Forest trees a foot in diameter are now growing inside the officers quarters at the old fort.

GENERAL DIVISIONS OF THE CRETACEOUS

The area of the Red River Region of Oklahoma is so small compared with the deposits of Cretaceous age in other parts of the world that it is necessary to make, in a general way, a review of these formations. The Cretaceous deposits of the state are not sufficient to make a complete section of the rocks of that period, and one section requires the later overlying formations of Texas to complete it. From

this it will be seen that our state possesses only a part of the Cretaceous, either Geographically or Geologically considered, and that to make a complete study of the rocks of this period we will have to draw upon other states.

By considering Geological conditions in America which gave rise to the various deposits during Cretaceous times we find that at the beginning of this period there was a general and widespread though gradual warping of the central part of the continent which was closely followed by the encroachment of the waters of the Gulf of Mexico on the land. It was during this time that the Trinity Sands were deposited in Texas and Oklahoma, and the Morrison Beds in Cimarron County and elsewhere along

the eastern slope of the Rocky Mountains.

At first the Ouachita Uplift and an arm of land connecting it with the Central Mineral Region of Texas held this onward movement of the sea in check but after some time the waters spread rapidly over the western part of the state and extended beyond its borders toward the Arctic Ocean. This movement in Oklahoma was largely from the west. The eastern limit of the invasion is not known. The greater part of deposits has been removed by erosion until at present they occur only in the western counties of the state. The formations which were laid down in this central region at this time are comparatively thin and consist largely of calcareous shale and impure limestone.

In Texas and in the Red River Region of Oklahoma the latter part of the formations of this time are largely very pure limestones. This is usually referred to as the Fredricksburg group of the Cretaceous.

Following this there was a rather rapid withdrawal of the water from the interiors of the continent with the deposition of shale and impure limestone in the southern part of Oklahoma and Texas corresponding in general, geographically to the outline of the region occupied by the Trinity. These deposits are called the Washita group of the Cretaceous.

The retreat of the waters continued until most of the deposits previously made were subject to erosion making thus an unconformity between these formations


An Outline Map of OKLAHOMA Showing the Occurence of Cretaceous Rocks in the State
Morrison and Dakota
Fredericksburg
North
Salt Fork
Cimarron
Canadian
River
South
Canadian
ARKANSAS
RIVER
Washita
River
RED
RIVER
Trinity, Fredericksburg, Washita, Dakota, and Colorado.

and those following. These deposits constitute the Comanche series of the Cretaceous. The unconformity is very general and this part of the period just discussed is usually referred to as the lower Cretaceous.

The Gulf of Mexico again advanced and gradually a larger area was submerged in the central part of the Continent than at the time of the first encroachment. The waters at this time extended from the western part of Gulf of Mexico northward to the mouth of the Mackenzie River and connected the Arctic Ocean with the Atlantic by a Mediterranean Sea which divided North America into two parts. While this sea was forming an extensive deposit was being laid down along its shores. The Dakota Sandstone, as this formation is

usually called, is present in the northwestern part of Cimarron County. The Silo Sand of southern Oklahoma and the Woodbine of Texas are contemporaries of the Dakota.

A long period of deposition followed, but by referring to the chart it will be seen that deposits did not occur to any great extent in Oklahoma during this time. A small portion of the southern part of Marshall, Bryan and McCurtain Counties were possibly under water during a part of this time. After this there were no more Cretaceous rocks deposited in Oklahoma. In several of the northwestern states however as well as in Texas and along the Atlantic and Gulf coasts there are extensive deposits which were laid down at this time and which are known as the Colorado

Series, the Montana Series and the Laramie Series.

Following this there was a general retreat of the sea from the interior and along the borders of the Continent, and the upper Cretaceous period was at an end.

THE TRINITY DIVISION

Character and Mode of Deposition.

As noted elsewhere in this paper it is a difficult matter to discuss the Cretaceous rocks of Oklahoma without touching upon those of this age in other states. The Trinity Series of this period were first studied in Texas where it reaches its greatest development. A very brief statement as to the character and structure of rocks of this age in that

state may not be out of place.

Mr.Robert T. Hill has refersed three distinct formations of the lower Cretaceous of Texas to the Trinity series. The lowest of these is often referred to as the Basal Sands or the Travis Peak formation. It consists of a series of sandstones and conglomerates severl hundred feet in thickness. Just above the Travis Peak is the Glen Rose which is a calcareous formation, consisting of limestones interstratified with marly clays. Above these beds is another sand, the Poluxy, which is composed principally of cross-bedded pack sand, and is the highest formation of the Trinity.

Towards the north the Glen Rose looses its calcareous character and changes

gradually into sand, until there is no distinguishing characteristic by which it can be separated from the Arenaceous formations above and below. In regions where these conditions predominate Mr. Hill has called this formation the Antlers, deriving the name from Antlers the county seat of Pushmataha County, where the formation is well developed. Mr. Taff of the U. S. Geological Survey and Mr. Branner former State Geologist of Arkansas have retained the term Trinity for the Basal Sands of the Cretaceous in Oklahoma and Arkansas and the term Antlers has not been generally accepted. It appears that unless this formation is composed of differentiated and mapable divisions it should be called the Antlers, otherwise there will arise confusion of terms.

The Trinity Division of the Cretaceous in Oklahoma consists principally of more or less unindurated sand. There also is much clay present which is usually quite arenaceous. None of these sand and clay members are continuous over large areas, but are usually cross-bedded and interstratified with lenticular beds rarely more then thirty feet in thickness. The sand often grades into clay in very short distances and it is rare indeed that one would be able to follow a ledge of either sand or clay for more then a mile without finding its character changed or entirely altered. The grains of sand of this formation are water worn, and during periods of continued wet weather the entire area is more or less boggy.

Besides these lentils of loose sand and clay there are conglomerates at the base, and indurated sandstones are scattered at wide intervals throughout the formation. The basal conglomerates are always composed of fragments of older formations near at hand. East of Atoka where the Trinity lies upon the Jack Fork Sandstone there are numerous deposits composed of rounded fragments derived from this formation. West of Atoka these conglomerates are composed of fragments of limestone or granite accordingly as one finds them near limestone or granite areas. The heaviest deposits are in the region where the Washita River enters the Cretaceous area. Along Boggy Creek and Kiamichi

River there are also abundant deposits of boulders evidently brought down by these streams or streams which corresponded roughly to these of the present.

The indurated members of the Trinity noted above are rather rare. They usually consist of lentils of sandstones cemented with iron. Northeast of Caddo there is a rather heavy ledge of this character near the top of the Trinity. South of Atoka is another ledge and in the vicinity of Antlers several such indurated ledges occur. There are also heavy ledges of sandstone in the Trinity northeast of Marietta.

At only one place has limestone been reported from the Trinity in Oklahoma. This was said to have been found in a well drilled at Madill, Marshall County,

where a ledge four feet thick, three hundred forty two feet below the surface is said to have been encountered. There are two unsettled questions connected with this however. In the first place there is a question in the drillers mind as to the exact nature of the rock; and second it is quite difficult to say whether this ledge is in the Trinity or in underlying Carboniferous formations.

Every characteristic of the Trinity would lead one to conclude that it was deposited near the shore. In the first place its heterogenous composition shows constantly changing conditions under which it was laid down. If it had been deposited in the deeper areas of the sea where changes were more gradual and less frequent one would expect to find an

entirely different formation. A horizontal shifting or a filling in of a few feet in the brackish water areas along the shore however would change materially the character of the local deposits while such shifting further out would scarcely effect sedimentation. There is no definite break in the character of the formations of the Trinity of Arkansas, Oklahoma and Texas, except the Glen Rose Beds of the latter state which indicate quiet water throughout a long period of time, and along with this a subsidence of the ocean bottom to permit the collection of such a great thickness of calcareous material. The condition however, may be considered as local, and it evidently did not affect the general shallow water conditions in Oklahoma; for the contemporaneous beds

in our state show no trace of such conditions, and like the rest of the rocks of this division in Texas point to exactly opposite conditions.

Another point which indicates shallowness of water at the time that the Trinity was being laid down is the presence of both salt and gypsum. Neither of these salts is as abundant in the Cretaceous deposits of Oklahoma as in those of Arkansas but they are not entirely wanting. Gypsum often occurs in the water of the Trinity in small quantities as is shown by the analysis of water from some of the wells at Hugo, Oklahoma. There is also a salt spring which flows from near the top of the Trinity four miles northeast of this town, and several other salt springs have been reported, it

is a well known fact that salt and gypsum are both formed in brackish water areas. So that there can be no doubt as to the origin of these salts in the Trinity of this state.

Another indication of the shore deposition of the Trinity is the abundance of lignitic and silicified wood found. In a dozen or more places in this state lignite has been reported from the Trinity. Petrified wood is also very common. There is no reason to believe that wood carried out to sea was buried in the sediment forming there. The timber which gave rise to these formations either grew in swamps along shore or else was washed down by streams and buried in the sand below the level of the water. Stumps

have been found in situ. Ancient swamps may also be traced by dark colored bituminous shales containing impure lignite, which occur over areas of several square miles in places.

The presence of dinosaur remains in the Trinity is also a good indication of the origin of these rocks. A single bone, a coracoid has been found so far in Oklahoma but remains of this nature have been reported in Texas and Arkansas. These dinosaurs were land animals which may have frequented the shore, or their carcases may have been carried down by some stream and deposited in the sand at its mouth. In no instance could they be considered as animals which frequented deep waters.

Stratigraphic Relations.

There is an unconformity everywhere at the base of the Trinity. In Love County and part of Carter County this formation rests upon rocks of supposed Permian age. East of this it lies upon the Pennsylvanian and in Johnson and Atoka Counties it rests upon granite or rocks of the lower Paleozoic. Still farther east for a few miles it again comes in contact with formations of undoubted Pennsylvanian age. From a few miles east of Atoka to the Arkansas line the Trinity rests upon the Jack Fork Sandstone the age of which is n now thought to be Pennsylvanian. It will be seen from this that the youngest rocks upon which the Trinity rests are of Permian age and that there can be no continuity of sedimentation between the two formations; in fact there is

abundant evidence of unconformity. It might be interesting to note in this connection that near Caddo, Bryan County at a distance of at least fifteen miles from the point where granite is exposed on the surface granite was encountered in a well at a depth of about five hundred feet. Rock of presumably Pennsylvanian age was found at about the same depth at Madill, Marshall County, about twelve miles from any outcrop of that formation.

Age of the Trinity.

The base of the Trinity of Oklahoma may possibly represent a transition from the Jurasic to the Cretaceous, as do the lower part of the Potomac Beds in the east and the Morrison, Como or Kootenay formations in the northwest. This point

was suggested by Mr. Hill in his report on Cretaceous, regarding the Trinity of Arkansas but he possibly places the Potomac Beds too high in the Cretaceous. The coracoid of a dinosaur found well towards the top of the Trinity near Caddo, Oklahoma, gives rather conclusive evidence to the fact that in point of age the upper part of this formation, the Potomac Beds, and the Morrison are all of approximately the same age. Since the Morrison Beds and the lower part of the Potomac series have been usually considered as transitional formations the lower clays and sands of the Trinity will undoubtedly fall in the same class. So far no fossils have been found in the lower Trinity in Oklahoma so there is little or no direct

evidence on this point. Some fossils found by Hill, in Arkansas appear to be rather more nearly Jurasic than Cretaceous in age. Others in Texas seem to indicate that the formation is Cretaceous.

Thickness.

The thickness of the Trinity varies. Along the line of the Frisco Railroad from Antlers to Goodland, Hill estimates it to be about 1500 feet. This is possibly too great. A careful section taken along the line of the Missouri, Kansas and Texas Railroad from Caddo to Atoka shows six hundred sixty one feet of Trinity. The dip however is so easily confused with cross-bedding that possibly this may be only approximate. Wells mentioned above, which were drilled

several miles west of Caddo, and in the vicinity of Durant, show this formation to be about five hundred feet thick. The same thickness holds good for the wells at Madill. Northeast of Marietta the formation is thinner than at any other place so far known in the state. It is not over three hundred fifty feet thick in this loc locality.

Section from Caddo to Atoka.

No.1, yellow clay with local lenses of conglomerate containing large waterworn boulders.....10 ft.

No.2, grayish yellow sandy clay which grades downward through many thin lentils of course, waterworn and angular gravels..30 ft.

No.3, fine conglomerate in beds of

gray sandy clay.....30 ft.

No. 4, yellow and brown pack sand.....10 "

" 5, yellow sandy clay.....10 "

" 6, gray sandy clay with
yellow streaks.....40 ft.

No. 7, hiatus, bottom land.....80 "

" 8, yellow clay streaked with red
and containing lenses of
gray indurated sandstone.....40 ft.

No. 9, grayish yellow clay, sandy
at the base.....20 ft.

No.10, reddish yellow sand in
Matrix of clay.....20 ft.

No.11, hiatus, valley of Davis and
Boggy Creek.....80 ft.

No.12, grayish white sand.....20 ft.

" 13, blue arenaceous clay
streaked with yellow.....10 ft.

No.14, reddish yellow sand cross bedded.12 "

No.15, grayish blue sand with
clay matrix.....12 ft.
No.16, green colored arenaceous clay....22 "
No.17, pack sand reddish brown with
iron stone concretions
at the base..... 8 ft.
No.18, grayish yellow clay red in
places and containing
occassional lenses of sand.....32 ft.
No.19, blue arenaceous clay with
lenses of white sand.....10 ft.
No.20, yellow pack sand.....10 ft.
No.21, yellow clay changing into white
sand, much cross-bedded then
into yellow sand in matrix of
fine yellow clay in one of which
was found the dinosaurian
coracoid.....40 ft.
No.22, yellow clay arenaceous

in places.....12 ft.

No.23, arenaceous clay grayish yellow clay iron stone concretions present with it.....15 ft.

No.24, reddish gray sand unidentified with species of gryphaea and ostrea.....12 ft.

No.25, grayish yellow sand in matrix of clay very argilaceous in places.....32 ft.

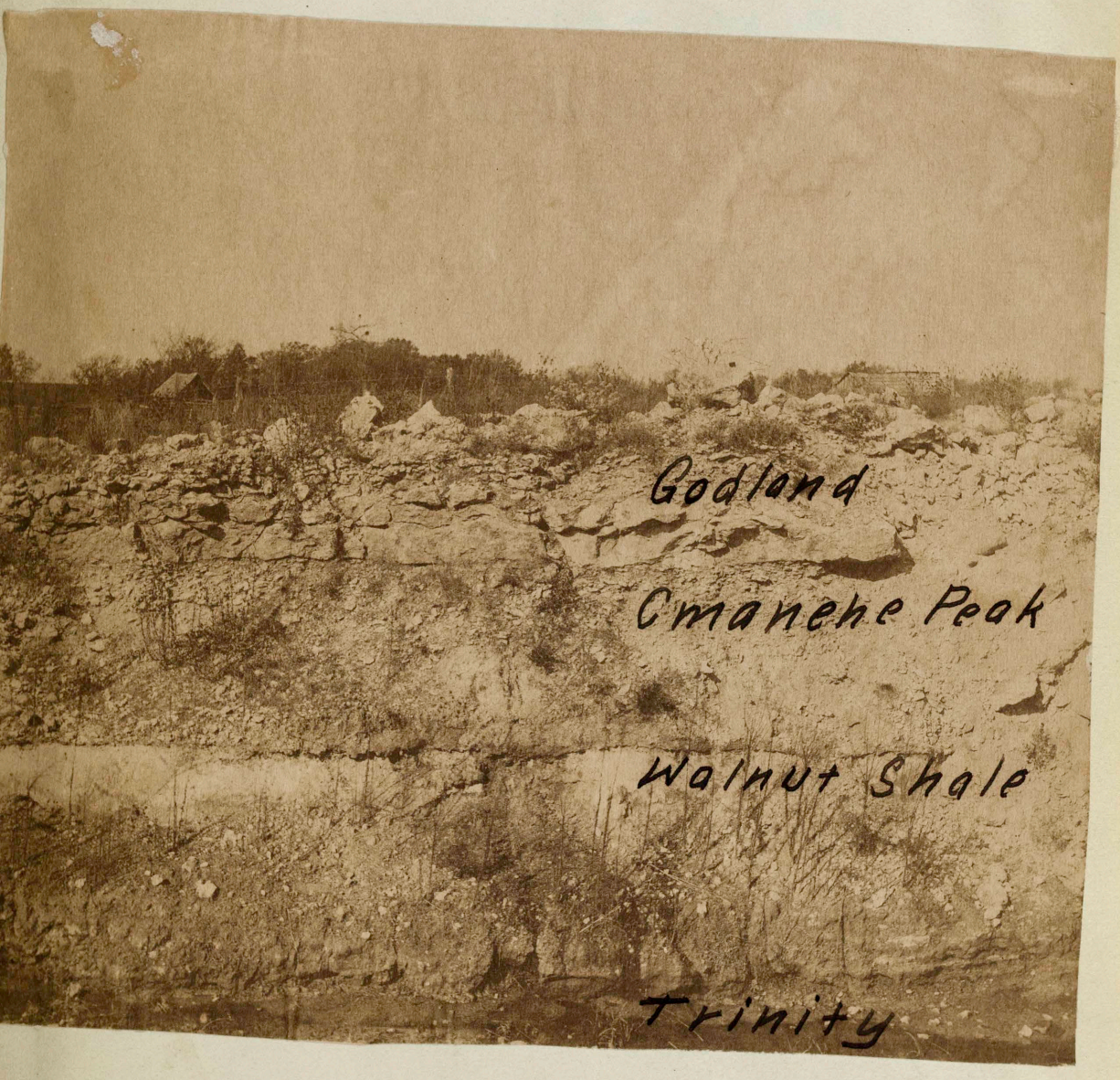
No.26, yellow clay streaked with blue sand in places..... 6 ft.

No.27, yellow pack sand cross bedded....10 ft.

Total.....633 ft.

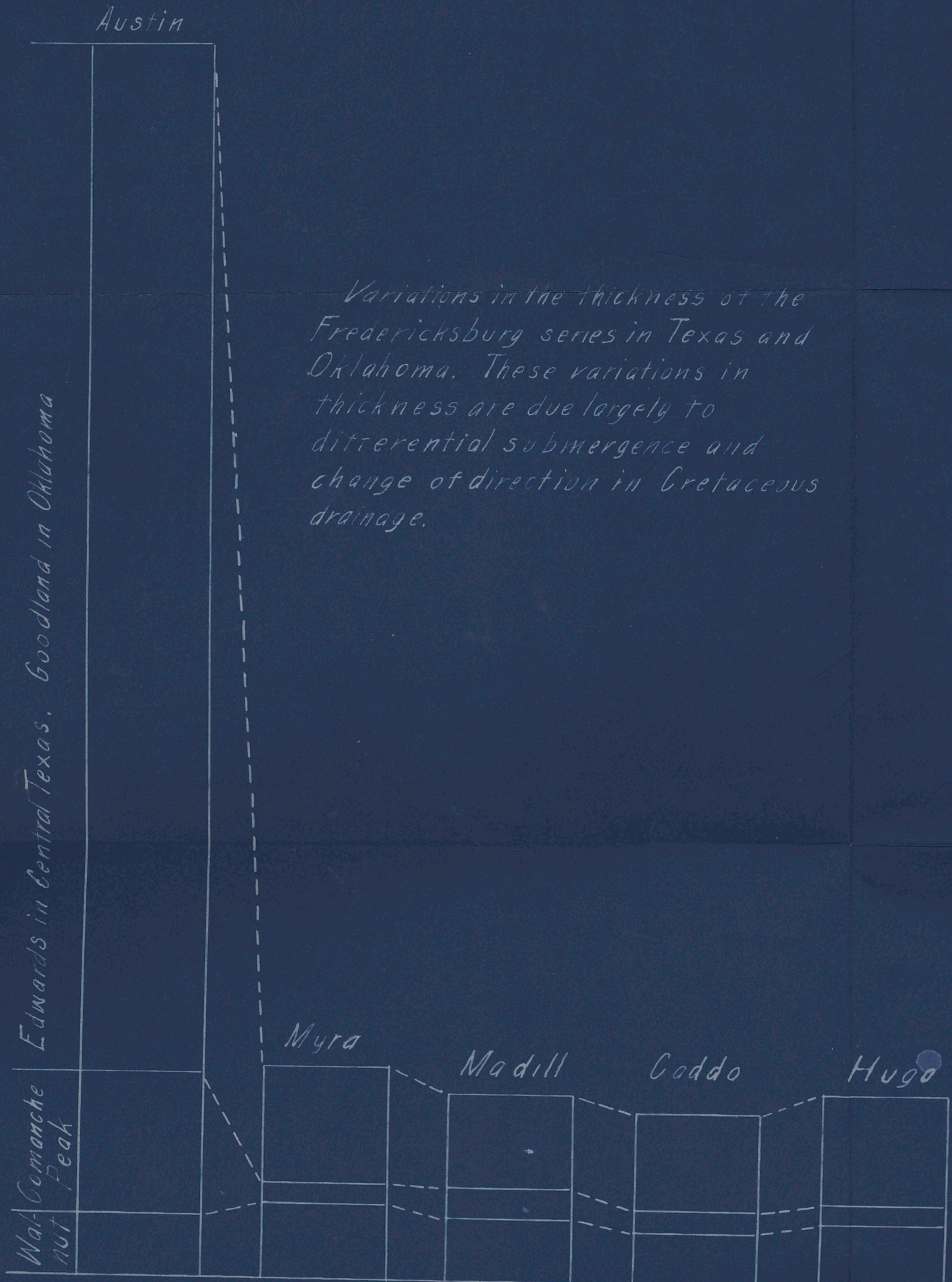
Fredericksburg Division.

At the end of the Trinity time there was a wide spread deepening of the Cretaceous sea. At least conditions were


Godland
Comanche Peak
Walnut Shale
Trinity

such that the turbulent shallow-water forces that were at work during the deposition of the sand ceased, and quieter waters suitable for the deposition of shale and limestone over large areas followed. The depositions which occured at this time were greater over the Texas region than in Oklahoma. Thickness aggregating four hundred feet at Austin, Texas, are represented in the Red River Region by only forty feet. The Fredericksburg, like the Trinity further south, consists of three formations. The Walnut shale, Comanche Peak and Edwards limestone . The Goodland limestone in Oklahoma has usually been considered by Taff and others the representative of these formations. There are some traces however of both the Walnut clay

and Comanche Peak formations below the Goodland. While these formations are naturally very thin and very different in character from the heavier deposits further south it is quite plain that there were at least two distinct changes in sedimentation between the top of the Trinity and the base of the Goodland proper. From six to eight feet of marl at the base of the Goodland contains several species of fossils which abound in the Comanche Peak beds. Besides the stratigraphic relations and structure of these rocks are very similar to the Comanche Peak. Below the gray calcareous marl is a yellow sandy shale varying in thickness from three to twelve feet. Near Madill there are Exogyra texana present



Variations in the thickness of the Fredericksburg series in Texas and Oklahoma. These variations in thickness are due largely to differential submergence and change of direction in Cretaceous drainage.

Pierce Larkin

in this formation. In general appearance at Madill and further east it resembles the Walnut shale and its stratigraphic position is the same. From all appearances these marl and shale members below the Goodland are representatives of the thicker and better characterized Comanche Peak and Walnut shale of Texas.

The absence of pronounced sedimentation in Oklahoma during the early Fredericksburg was probably due partly to the warping which brought about the invasion of the sea over the western part of the state. During Trinity times the source of clastic material in the state came from southward-flowing streams. When the region was tilted to the west during Comanchean times the supply of

sediments was turned westward. This left the Red River Region without rock forming sedimentation and consequently meager representatives of the thick formations deposited elsewhere at this time.

Another factor which was potent in minimizing these deposits was the nearness of the axis of least depression. This was not far from the eastern end of the Ouachita uplift. There are two structural characteristics which indicate that there was not equal submergence in this region from east to west. In the first place the Walnut shales of Texas are represented by increasingly arenaceous deposits from west to east in Oklahoma and northern Texas. In the second place the strikes of the various formations of Lower and Upper Cretaceous converge

eastward and this occurs with little or no difference in the dip of the beds. Resulting from this more or less constant shallowness of the water in this region and the diversion of the sediments to western seas there would be thin formations, pinching out or growing thinner eastward. If calcareous deposition occurred the water would be too shallow for the collection of beds of great thickness. Fossils of all the northern outcrops of the Cretaceous are more or less littoral while the fossils brought to the surface by the Red River faults are of a character that would indicate deeper water and they bear greater resemblance to the fauna of the same formations further south in Texas

than to these in Oklahoma.

Austin Section of the Fredericksburg.

Edwards Limestone.....300 ft.

Comanche Peak..... 40 "

Walnut Clay..... 15 "

Total.....355 ft.

Myra Texas.

Section of the Fredericksburg.

Goodland-

Massive white limestone.....30 ft.

Comanche Peak-

Gray marl..... 6 ft.

Walnut Clay-

Yellow clay..... 8 ft.

Yellow impure limestone

stratified with clay..... 8 ft.

Yellow clay..... 4 ft.

Black carbonaceous clay..... 2 ft.

Total.....58 ft.

Madill Oklahoma.

Section of the Fredericksburg.

Goodland limestone.....20 ft.

Comanche Peak-

Gray marl..... 8 ft.

Walnut Clay-

Yellow shale.....10 ft.

Blue shale..... 6 ft.

Total.....44 ft.

Caddo Oklahoma.

Section of the Fredericksburg.

Goodland limestone.....20 ft.

Comanche Peak-

Gray marl..... 6 ft.

Walnut Clay-

Yellow sandy clay..... 8 ft.

Blue marl with sand..... 4 ft.

Total.....38 ft.

Goodland Oklahoma.

Section of the Fredericksburg.

Goodland limestone.....20 ft.

Comanche Peak-

Gray marl.....4 ft.

Walnut clay-

Yellow sandy clay.....12 ft.

blue marl..... 3 ft.

Total.....39 ft.

The Goodland Limestone.

Structure and Lithologic character.

The highest member of the Fredericksburg Division of the Cretaceous in Oklahoma is the Goodland limestone. It corresponds to the Glen Rose formation in Texas, and extends such a short distance

into Arkansas that it has never been named in that state. In most places it consists primarily of three members as follows: first at the top a hard more or less thin-bedded limestone usually varying from ten to twenty feet in thickness; second below it a soft marly limestone which cannot always be detected, but which has a usual thickness of about six feet; third, below this there is a limestone resembling the upper member but ordinarily more compact and crystaline, the thickness varying from four to eight feet.

The harder members are white , massive, homegenous ledges of almost wholly crystaline limestone, which breaks with conchoidal fracture. Wherever exposed to the weather the slope is covered with sharp-edged fragments of limestone which

are separated from the ledge in the process of weathering. This formation rarely forms cliffs, owing to this peculiarity, while in many places bluffs fifty or sixty feet in height are found the particular part of the escarpment occupied by the Goodland limestone will usually have a slope of forty five degrees or less. Gullies in this rock are typically V shaped and have strikingly uniform slopes on both sides.

Extent and Area.

The Goodland crosses the Red River a few miles west of the main line of the Atchison, Topeka and Santa Fe Railroad in Love County and leaves Oklahoma just south of Little River where that stream enters Arkansas from McCurtain County. At this point the formation passes under

Tertiary Gravels and does not reappear in Arkansas. It is not only one of the most persistant ledges in Oklahoma but also is probably the most uniform in character.

The area over which the Goodland limestone is exposed is comparatively limited considering the persistency of the formation. It narrows down in many places to a mere scarp ledge and in its widest extent is not more than two or three miles across. The soil of the area where the Goodland forms the surface rock is usually stony. The surface rock in such cases is more or less honeycombed due to differential erosion.

Physiography.

The topography resulting from the

Goodland formation is always striking. With a well prepared contour map one would have little trouble in tracing its outcrop. Everywhere it forms a north-facing escarpment, due to the fact that it is more resistant than the underlying formation and dips to the south under the higher overlying shales and limestone. There are also a number of outlying hills, some of them several miles north of the main outcrop capped with this limestone. The dip plane usually forms south-sloping valleys but as a rule the Goodland is not exposed and the overlying formations form the floor of the valleys.

The Washita Group.

The Washita Group opened with thick deposits of oyster shells and of shale.

In some places the shell banks are ten feet deep and are composed of almost one solid mass of shells. In Oklahoma there are four distinct formations which belong to this group, two are shale, one is limestone and shale, and the fourth limestone and marl. The whole evidently represents quiet conditions of the sea and also changes in variety of sediments and sedimentation. The Goodland limestone, the upper member of the Fredericksburg Division of the Cretaceous in this region represents a period of clear water. But the following division shows varying changes from turbid to clear water. Caused probably by numerous oscilations of the ocean bottom. Throughout the shale there are highly silicified ledges of thin limestone.

The formations of the Washita division in Oklahoma are the Kiamichi, the Caddo, the Bokchito and the Bennington. At Austin, Texas, the Georgetown limestone is the apparent representative of the Kiamichi Caddo and Bokchito formations of Oklahoma. The Del Rio and Buda limestone of Texas are represented in Oklahoma by the Bennington limestone.

Kiamichi Formation.

Structure and Lithologic Character.

The Kiamichi is primarily a laminated clay formation of a dark blue color. Interbedded with the clay are ledges of limestone which are more or less lenticular and have widely different characteristics at different localities. Near the base these ledges are sometimes composed of solid masses of shells mostly

Gryphaea corrugata. The thickness of these shell beds varies greatly. In some places the shells have been broken and shattered resulting in the formation of so called coquina. At Goodland and Caddo this basal formation is largely shale. But east of the Kiamichi River the shell beds are prominent while west of that stream this characteristic is practically absent. Higher up in the formation numerous ledges of more or less siliceous limestone occur, these likewise reach their greatest developement east of the Kiamichi River and produce in that region a different topography rom that which is present in the western part of the area.

Topographic Features.

West of the Kiamichi River this formation is usually occupied by valleys. The small streams which flow with the strike have valleys whose long slope is toward the notth. In some cases the Goodland limestone is exposed in these valleys but this is the exception rather than the rule. From Hugo eastward this rather even topography is interrupted by the presence of thin lenticular limestones which are interbedded with the clay. The relief becomes in this region more rugged and irregular. In the vicinity of Little River there is an entirely different topography . The area of Kiamichi shale is narrow here and most of the small streams tend to cut back through it almost at right angles to its strike.

Another peculiar feature which occurs in these clays is the presence of what is locally termed Edge Rocks. These consist of tabular pieces of the interbedded limestone which have left their original almost horizontal position and are very often found standing more or less perpendicularly. This is due to at least two causes: first, the underlying clay will be eroded away from the downhill side of a protruding ledge and the stone breaks loose and topples over; second subsequent freezing and thawing of the moist clay on the uphill side will eventually succeed in turning the stone beyond the vertical into an inclining position from which the same process will be repeated

until the rock either weathers away or else reaches a more or less stable position at the bottom of the hill. The two succeeding formations of the Washita also exhibit this peculiarity.

Life of the Kiamichi.

The life of the Kiamichi was characterized by the abundance of individuals rather than of species. The great shell beds of the eastern part of the formation are practically composed of one species namely, Gryphaea corrugata. It is almost impossible to find a representative of any other species in the region. The fossils of the Kiamichi which have been brought to the surface in the vicinity of Denison, Texas, by

faulting are more varied.

The following fossils are found in Oklahoma:

Gryphaea corrugata- Hill.

Gryphaea navia- Hill.

Schlaenbochia belkuapia- Marcou.

Exogyra texana- Hill.

Hamites fremontii- Marcou.

Ammonites brazoensis- Hill.

The last two named are known to occur only at the bluff on the north side of Red River where the main line of the Missouri, Kansas and Texas Railroad crosses that stream.

Thickness of the Kiamichi.

There is no data for determining exactly where the line should be drawn

between the Kiamichi and Caddo Formations. The lithologic and faunal changes from the one to the other are almost complete but they are so gradual that it is impossible to say just where the line of division should occur. The thickness of the Kiamichi has been variously estimated from forty to one hundred eighty feet, the greatest being probably at Hugo, which is shown by the sections. The average thickness is estimated by Mr. Taff to be one hundred fifty feet but this seems to be too great. At Goodland Mr. Hill estimates the thickness at one hundred eighty feet. Well records and a section at this place shows it to be much thinner.

The Caddo Formation.

Structure and Character.

The Caddo formation consists of white and yellow limestone interstratified with blue and gray calcareous marls. The limestone is rather impure and the individual ledges vary from a few inches to four feet in thickness. The marl beds are seldom more than a foot thick. The Caddo has the most persistent characteristics of all formations of the Cretaceous in Oklahoma and Texas. Its appearance and structure are the same at Austin, Texas where it constitutes the major part of the Georgetown formation, in the northern part of Texas, at Ft. Worth, where the formation received its name in that part of the state, and at Caddo Oklahoma where it was studied and named by Mr. Taff. The strata perhaps are a little more massive at Austin than at

points further south but no one who has studied the formation there would be liable to mistake it for any other formation in Oklahoma.

Life.

The Caddo has the most varied fauna of all Cretaceous formations in the state. It is rich both in species and in abundance of individuals. The most abundant fossils are Ammonites. These large coiled shells are usually very plentiful locally but in some places they are almost wanting. Just east of Soper in Choctaw County there are outcrops of the Caddo formation where one could collect hundreds of these forms, ranging from an inch or two to twenty inches in diameter. After two days work on the Caddo and adjoining

formation south of Fort Towson only a single specimen was found. North of Denison, Texas, where these beds have been brought to the surface by faulting collecting is exceptionally good.

The following is a partial list of Caddo Fossils:

Schlaenbachia geniculata - Conrad.

Schlaenbachia leonensis - Conrad.

Epiaster elegans - Shumard.

Ostrea carinata - Lamarck.

Gryphaea washitaensis - Hill.

Nautulus texanus - Shumard.

Pectan texana - Roemer.

Pectan quadracostata - Roemer.

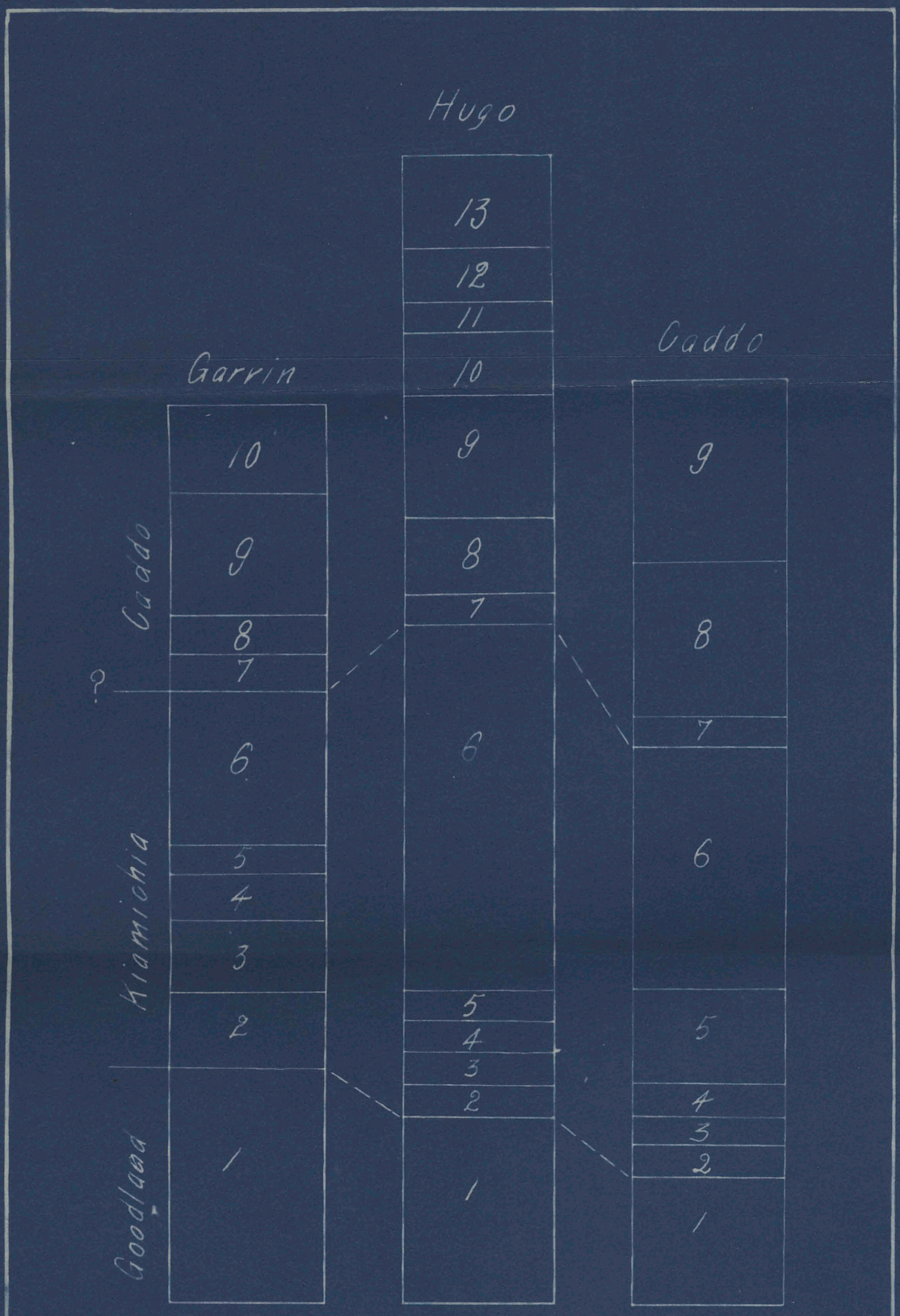
Gryphaea pitcheri - Shumard.

Extent.

The Caddo enters the state a little west of Marietta and forms the bluffs on the south side of Red River where the Atchison, Topeka and Santa Fe crosses that stream. Thence it extends across the state in an almost east and west line and passes under the Pleistocene deposits near Idabel in McCurtain County. Rather large areas of the formation are exposed in Bryan and Choctaw Counties. The width of the area occupied by these rocks is greatest in the western part of the region. To the eastward, especially in McCurtain County they form merely a line of outcroping limestones.

Topography.

The Caddo limestone, like the Goodland, forms a line of north-facing



Goodland, Kiamichia and Caddo Sections.

escarpments in Oklahoma and is often found in a position of caprocks on outlying hills. On the south of the outcrop it forms long slopes corresponding with its dip. The valley of Blue River south of Caddo is a good example of this form of topography.

Sections of Caddo and Kiamichi.

Well at the Light and Ice Plant, at Hugo, Oklahoma.

Bokchita-

Blue shale.....40 ft.

Caddo and Kiamichi-

Limestone..... 2 ft.

Shale..... 5 ft.

Hard rock.....13 ft.

Shale and thin rock.....136 ft.

Goodland-

Hard white limestone.....20 ft.

Marl and sand.....15 ft.

Total.....249 ft.

Section at Garvin.

Caddo-

Number 10 white limestone containing many marine shells .....14 ft.

Number 9 yellow marly shale forming deep black soil.....20 ft.

Number 8 yellow shale with thin bedded limestone.....11 ft.

Number 7 yellow limestone with shale containing Gryphaea pitcheri and G. mucronata..... 6 ft.

Kiamichi-

Number 6 yellow clay.....25 ft.

Number 5 yellow silicified limestone enter bedded with

yellow shale..... 5 ft.

Number 4 heavy ledges of white and yellow limestone silicified at the top..... 8 ft.

Number 3 yellow and blue shale.12.ft.

Number 2 shell limestone interstratified with blue shale containing large numbers of G. corragottal.....12 ft.

Goodland-

Number 1 hard massive white limestone.....30 ft.

Total.....203 ft.

Section at Hugo.

Caddo-

Number 13 white limestone interbedded with blue marly clay....12 ft.

Number 12 yellow calcareous clay8 ft.

Number 11 siliceous limestone

interstratified with yellow clay..... 5 ft.

Number 10 arenaceous marl with yellow and white limestone..... 9 ft.

Number 9 yellow shale.....18 ft.

Number 8 silicified limestone with blue and gray shale.....11 ft.

Number 7 yellow limestone and shale ..... 5 ft.

Kimmichi-

Number 6 yellow and blue shale with thin lentils.of.shell limestone containing G. corragotta.....60 ft.

Number 5 shell limestone..... 4 ft.

Number 4 yellow clay with thin shell limestone..... 5 ft.

Number 3 blue calcareous clay.. 5 ft.

Number 2 blue shell

limestone with clay..... 6 ft.

Goodland-

Number 1 massive white

limestone.....25 ft.

Section at Caddo.

Caddo-

Number 9 gray and yellow

limestone.....20 ft.

Number 8 yellow and blue

marly clay.....24 ft.

Number 7 soft marly limestone...4 ft.

Kiamichi-

Number 6 blue and yellow

clay with very little

limestone.....40 ft.

Number 5 limestone interstratifi-

ed with yellow shale.....12 ft.

Number 4 yellow shale..... 4 ft.

Number 3 blue and yellow shale with limestone..... 4 ft.

Number 2 blue shale..... 4 ft.

Goodland-

Number 1 massive white limestone.....20 ft.

Total.....295 ft.

The Bokchito.

The Bokchito is the next formation above the Caddo. Primarily it is composed of shale and, like the Kiamichi, it contains many ledges of impure limestone but unlike it this shale is quite arenaceous and in places contains much iron. Locally there are sand ledges, that show cross bedding. the stratification would seem to indicate that at the time of deposition there was

shoaling of the waters and that conditions were not stable but that there was a general tendency towards alternating elevation and depression. The limestones and sandstones are all highly ferruginous and throughout the formation iron concretions abound.

Extent.

The Bokchito formation enters the state south of Marietta where it correspends to the middle part of the Denison beds of Texas. It is well exposed in the vicinity of Robers Roost, and also about two miles north of Durant where the formation is cut up by small branches of Blue River. The town of Hugo is built upon this formation. A mile south of this place the Bokchito is covered with Pleistocene and the formation is not

known to appear again in Oklahoma east of this point with the exception of a small a area south of Idabel, and a somewhat larger exposure along the state line little south of Cerrogordo, Arkansas. A closer investigation southeast of Hugo along Red River might reveal it. The outcrop must pass into Texas somewhere in this region or it is absent at Maggs Ferry southeast of Fort Towson where the bluff on the north side of the Red River is composed of Caddo limestone.

Topography.

The Bokchito is primarily a valley-forming formation but locally where hard ledges of sandstone or silicious limestone prevent rapid erosion a rough and uneven topography is developed. Some of the

Caddo Hills are capped with this formation and the rough country to the northwest of Hugo is due to the same cause. Where escarpments occur they are usually northward-facing. The valleys are usually broad and slightly sandy due to the more rapid erosion and transportation of the clay element in the formation.

The Bennington.

After the Bokchito formation had been deposited there followed a short interval of quite waters during which the deposition of marls and limestones occurred. To the south, in Texas, shales and limestones were formed. This was really the calm before the storm for the Bennington is the highest formation of the lower Cretaceous in thisregion and was laid down just before

the transition period which ushered in the Upper Cretaceous.

The Bennington is composed of a white and blue limestone with arenaceous mr marl. It is about twenty five feet thick. The lower ten or twelve feet is composed of several ledges of hard, compact limestone interstratified with layers of shaly marl. This breaks with conchoidal fracture and is inclined to be crystalline in places. The heaviest single ledges are about four feet thick. The intervening shale beds are usually not more than a foot in thickness and in places only a few inches. Marl occupies about twelve feet of the upper part of the formation. In places considerable sand is mixed with this marl especially at the top. The marl is not always present but its absence is generally due to erosion

which occurred at the end of the lower Cretaceous.

Life.

The fauna of the Bennington is abundant. The first ledge which is about five feet thick contains Ostrea quadriplicata. Following this ledge are several alternating shale and limestone members which contain Exogyra arietina. These little shells are so plentiful that in places the ledges are composed entirely of them. Along with these fossils are considerable numbers of Terebratula wacoensis. They are more abundant in the stratified shales than in the limestones and are present in larger numbers than in the Georgetown limestone of Texas, the equivalent of this formation.

The marl has an abundance of echinoidea gastropods, pelecypods and cephalopods but the number of varieties in each case is not large.

The following is a partial list of fossils:

Exogyra arietina - Roemer.

Gryphaea mucronata - Roemer.

Terebratula wacoensis - Roemer.

Ostrea quadriplicata -Shumard.

Turrilites brazoensis - Roemer.

Nautulus -sp.

Exogyra - sp.

Ammonites leonensis -Roemer.

Extent.

The Bennington enters Oklahoma southeast of Marietta where it forms the cap rock of some high bluffs along Red River?

The formation then swings around to the northeast and reaches its northern most extension in the vicinity of Robbers Roost. From there it takes a southeasterly course to near the mouth of Boggy Creek where, presumably, it passes across into Texas. The rocks of this formation are best developed in the region of Robbers Roost, Durant and Bennington in Bryan County. They were first studied and named at the latter named place by Mr. Taff.

Topography.

The Bennington like the Caddo and Goodland forms northward-facing escarpments wherever it appears on the surface. It is the cap rock of many outlying bluffs, notably the highest of the Caddo Hills and also occurs on Sugar

Loaf Mountain in the northeastern part of Bryan County.

Meade Oklahoma.

Section of the Bennington.

No.8,	marl with beds of soft limestone..	15 ft.
" 7,	soft marly limestone.....	2 "
" 6,	marl with Terebratula wocoensis...	1 "
" 5,	hard gray limestone.....	1 "
" 4,	shattered limestone.....	1 "
" 3,	gray limestone containing E. arietina.....	4 "
" 2,	gray marl containing G. quadraplicata.....	1 "
" 1,	massive blue limestone near the bottom of Newberry Creek.....	5 "
Total.....		31 ft.

Upper Cretaceous.

With the deposition of the Bennington the Lower Cretaceous closed and turbulent times began. The sea withdrew from the land but did not remain absent long for there is but little evidence of unconformity between the Bennington and the following formation. Locally there seems to be a gradual transition through the marl of the Bennington into the shale and sand of the Upper Cretaceous which would indicate that there were places where erosion had not taken place. The formations of the Upper Cretaceous in Oklahoma are the Silo, Eaglefod and the Austin.

The Silo.

There is no other formation in the Cretaceous of Oklahoma so much like the Trinity as is the Silo. Its characteristics are more constant however and the sand and shales which form it are more evenly

deposited. The lower part of the formation is clay and its upper part consists esentially of sand. The clay is highly arenaceous so much so that it weathers into a sandy soil. The sand at the top of the formation is often very much cross-bedded but is usually not indurated. Mr. Taff has divided the formation south of Red River in Texas into three divisions; namely the Basal Clay, the Dextor Sand and Timber Creek Beds. It may be found that a division of this nature may also attain in Oklahoma, after the formation has been more thoroughly studied. The thickness of the Silo is about two hundred feet. In point of time it is a contemporary of the Woodbine of Texas and Dakota of the western plains.

The Silo is strongly ferruginous. The iron is present in the beds as a glanconite or pyrite and upon coming in contact with oxidizing agents it gives the rocks of the formation a reddish brown color. At the base of the formation near the top of the marl beds of the Bennington, there is a ledge of strongly ferruginous sandstone. This part of the formation is one of the most common characteristics and always marks its base or occurs slightly above it. The shales which are present higher up in the formation interbedded with sandstone are as a rule carbonaceous and lignite beds of a few inches in thickness in connection with these are not uncommon. Lignitic and pyritized wood

are found in many places scattered throughout the formation, one bed of lignite four feet thick is reported near Bennington.

Extent.

The Silo crosses the Red River in the eastern part of Love County and leaves the state not far west of the mouth of Kiamichi River. It has its greatest development in the state in the region of Durant along the Missouri, Kansas and Texas Railroad. At the points where it enters and leaves the state it is easily confused with the Pleistocene.

List of fossil plants from the Woodbine formation of Texas.

Diospyros steenstrupi - Heer

Lindera venusti - Lesq.

Diospyrus primaeva - Heer.

Andromeda pfaffiana - Heer.

Cinnamomum - Heeri-Lesq.

Salix hayei - Lesq.

Myriea longa - Heer.

None of these plant remains have been found in Oklahoma as yet but fossil leaves are reported as occuring a mile northeast of Kiersey Oklahoma.

Topography.

Where there is no excess of clay the Silo is typically a sand hill country and presents all the monotony of relief which is found in such regions. The clay erodes into large rounded knobs usually covered with sand. Along the northern contact of the formation there is a series of hills and knobs which have resulted

from the protecting influence of the ferruginous sandstone near the base of the Silo. These hills are especially well developed in the vicinity of Silo, Durant and Bennington.

The Eagleford.

The Eagleford has not been identified in Oklahoma up to the present t time although it is probably present along the Red River in Bryan County.

The Austin Chalk.

In the southwestern part of Arkansas there is an exposure of white friable limestone protruding out of the Pleistocene sand and gravel which forms the surface rock of the region. This formation is

the Austin Chalk. The upper part of it is marly. Only a very small area of this marl, not to exceed half a square mile has so far been found in Oklahoma, this occurs along the Arkansas line a few miles north of Red River. This is the highest Cretaceous formation in the state and is interesting only on that account.

Life.

The fossils discovered in the Austin are, Radialites austinensis, Exogyra ponderosa and Gryphia ancella. At first it was thought that Exogyra ponderosa and E. costata existed here together in these beds but it was found later that the specimen with faint costata was only a ponderosa at that

stage in its developement where these markings had not disappeared. Strong concentric lamella are present on all these shells. Even the costata on the younger individuals give way to concentric lamellae along the outer edges of the shell.

Pleistocene.

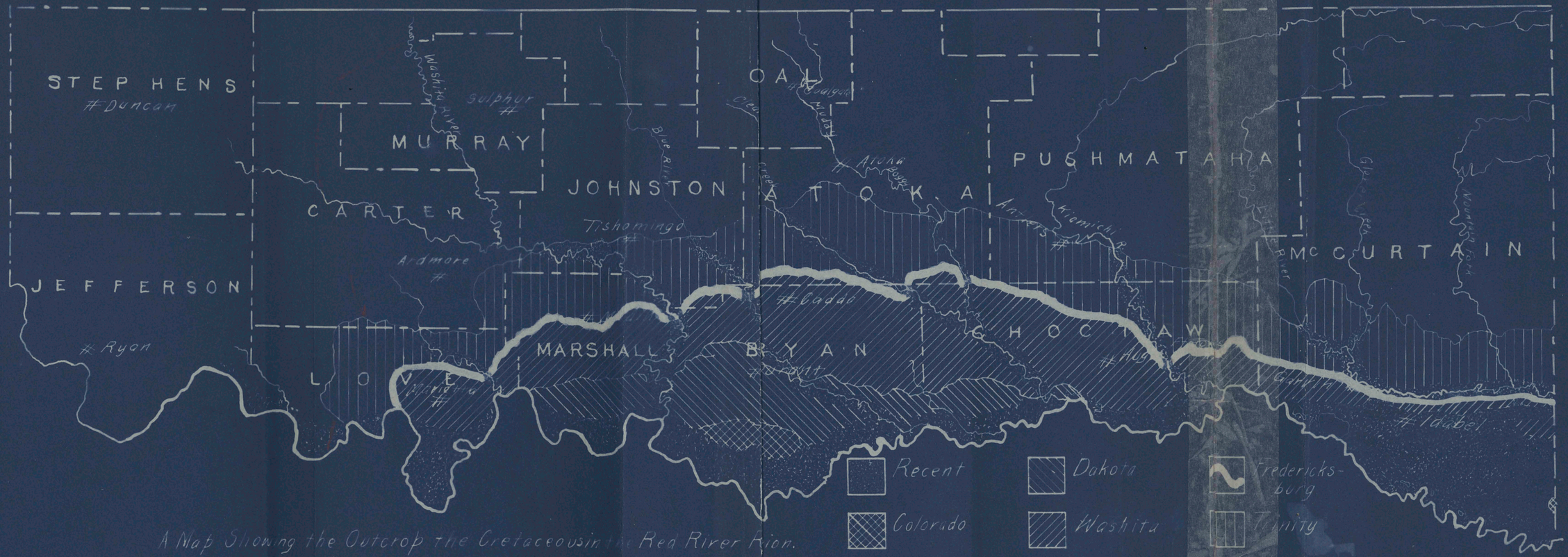
Satisfactory work in the eastern part of the Cretaceous area was impossible owing to the presence of Pleistocene deposits. Between Little River and Red River only occassional glimpses of the Cretaceous formation may be had. The Pleistocene consists primarily of sand and gravel most of which seems to have been deposited by the Red River and by

tributary streams which brought detritus down out of the Ouachita Mountains. A study of these deposits along with the river terraces would throw considerable light on the early drainage of this part of the state.

Faulting.

In the southern part of Bryan and Marshall Counties there is a fault which takes the general direction of north 60 degrees west. The throw is about six hundred feet and brings the Goodland limestone up into contact with the Silo formation. The down-throw is on the north side. There is another fault about seven miles south of this one and roughly

parallel to it with a down-throw of two hundred feet on the south side. This fault just enters Bryan County and the northwestern end of it must appear in the southern part of Marshall County. A block of the Cretaceous and underlying rocks 40 by 7 miles has been lifted up six hundred feet on the north side and tilted so that the corresponding lift on the south has been only two hundred feet. A peculiar and interesting feature of this fault zone is that it stands at nearly right angles to the Balconies fault line which runs roughly north 30 degrees east of south across the Cretaceous of Texas. The State Geological Survey has not had time to investigate and map this fault zone but some interesting



A Map Showing the Outcrop the Cretaceous in the Red River Rion.

Pierce Larkin

features will undoubtedly develop.

Economic Resources.

Water.

This region has an abundant water supply. The two sandstone areas form great catchment basins which give inexhaustible supplies of water. At depths ranging from twenty five to three hundred feet abundant water can be had in any part of the Cretaceous area,

Character of the Water.

Water from the Trinity usually contains slight amounts of gypsum and hydrogen sulphide. Occassionally iron is present in large quantities or even common salt but for the most part the

supply furnished by this formation is potable and healthful and can be used in boilers without scaling. Water of the Silo is not so good since it usually contains a large percentage of salts especially iron and magnesium sulphates. Wells which find water near the surface are not so liable to be impregnated with these chemicals as are the deeper ones which pass down through overlying formations into the Silo. In the first case the supply of fresh water is so great that it carries the soluable salts downward deeper in the formation.

Analysis of water from wells at Hugo. The supply in all these wells is taken from the Trinity.

Well No.1- at the ice plant-depth.....256 ft.

" " 2- at the handle factory three quarter's of a mile south of well No.1- depth.....297 ft.

" " 3- at Walton and Roger's mill a half mile east of well No.2- depth.....286 ft.

	1	2	3
Calcium carbonate	9.79	12.82	11.12
Magnesium carbonate	2.79	1.79	2.13
Calcium sulphate		.16	.23
Magnesium sulphate		.27	.78
Oxides of iron aluminum and silicon	.19	.29	.19
Alkali chlorides	.99	.75	.99
Alkali sulphates	1.84	2.37	1.64
Grains of solid matter per gallon	15.10	18.45	17.08

Artesian Water.

It is these two great sand belts that give Texas its flowing well area to the south of these formations in Oklahoma. Artesian wells have not been reported from any part of the Oklahoma Cretaceous but they are found in abundance in Texas along the Red River and further south. There apparently is no reason why flowing wells should not occur any where along this river below the mouth of the Washita and as high as the third terrace and in some places above this point. All the conditions necessary for Artesian wells are present in this valley.

Asphalt.

Asphaltic sands occur in the Trinity

just below the Goodland limestone in a number of localities. The deposits consist of sand saturated with a stiff, tarry bitumen. In some places the rocks are beyond saturation and a thick liquid asphalt oozes out of the sand.

Thickness.

Section at Madill.

No.4- Goodland limestone.....22 ft.

" 3- yellow shale containing a few Gryphaea marcoui and Exogyra texana.....10 ft.

" 2- blue shale .....6.ft.

" 1- asphalt bearing sand.....4-15 ft.

These bitumenous beds occur locally all along the outcrop of the Goodland limestone from Marietta in Love County to Idabel in

McCurtain County. They vary in area from a few acres to several hundred acres. One at Madill must have nearly a thousand acres in it. This however is not all in one body but in detached areas. There is another near Woodville of unknown size which will doubtless prove to be connected with the faulting of the region. In the vicinity of Caddo there are several large fields; northeast of Hugo is another, and there are also deposits at Garvin and at Idabel.

Origin.

There has been considerable conjecture as to the origin of these bitumenous deposits. Two theories have been proposed both supported by good arguments. One

is that the asphalt is due to leakage from underlying oil bearing formations beneath the Cretaceous; the other and apparently more plausable would explain its presence by evaporation from local oil beds in the Trinity. The latter probably is the better explanation for it has been demonstrated by drilling that the asphalt beds near Caddo are underlain at no great distance with granite. Those fields near Hugo, Garvin and Idabel are undoubtedly over the Jackfork sandstone which is not an oil bearing formation. A well drilled at Madill through the Trinity into the Glenn formation below to a depth of 1800 feet came in contact with no oil although it was drilled almost in the center of the Madill asphalt region.

The presence of oil and gas in what may be near the base of the Trinity at Madill shows that it is not improbable that these minerals might exist elsewhere in this formation.

Oil and Gas.

An oil field near Madill is now being developed by the Red River Oil Company. Both oil and gas are present in the field. In March 1909 a well producing 1500 barrels was brought in in this field. The gas well is weak. The field will undoubtedly be enlarged and new ones developed in the vicinity. The quality of hte oil is excellent, being high in gasoline and kerosene and low in asphalt. In addition to the wells at Madill considerable drilling has been done in the

Cretaceous, but so far as known all other attempts have been without success. Oil possibly occurs throughout the whole region but there is no clue by means which its presence may be discovered. Promiscuous drilling here and there is the only way of determining whether the mineral is in a particular locality. It is altogether possible that good fields will eventually be developed in this region but they will be found only through good fortune or persistant prospecting of the people interested.

Building and Road Material.

This section of Oklahoma is particularly fortunate in having two good ledges of building stone crossing almost the entire length of the region.

These are the Goodland and Bennington limestones. At places the Caddo limestone also presents ledges homogeneous enough to make a good quality of quarry stone. Of those the Goodland is undoubtedly the best for it is the whitest, easiest worked and contains less iron than the others and consequently will not be discolored when exposed to the weather.

Madill has utilized these rocks more for building purposes than has any other town in the region. There are several city blocks besides the Oil Mill constructed from Goodland limestone. These buildings are all in good condition and show no tendency to either disintegrate or to become discolored. Some old walls that have passed through a fire are still standing, are apparently in as good

condition as when erected. Fort Towson built some time in the early forties was constructed largely of this rock. The fort was burned by Confederate soldiers during the Civil War and since that time trees a foot in diameter have sprung up inside of the building, yet parts of the walls are still standing while the rock in them is not discolored and is as white as the day it came from the quarry.

Lime.

Lime used in the construction of Fort Towson was burned from the Goodland limestone. Later lime was burned near the town of Goodland from the same formation and near Meade from Bennington limestone. At present there is a company at Fort Towson burning small quantities of

excellent lime. The industry is very small whenecompared with what it might be if sufficient capital were invested. There is an almost unlimited amount of fuel at all points where it would be convenient to burn lime. Fort Towson could easily make one of the chief lime producing cities of the state. Madill with the gas for fuel could soon become another producing point of note.

Brick and Tile Clay.

Brick and tile clay abounds on all hands yet pressed brick is shipped from Kansas and Texas to all these growing towns of this section of Oklahoma. Hugo should have a plant, Durant and Madill should each have large plants to supply the demand of southeastern

Oklahoma and northern Texas for brick and tile. There is an abundance of good clay near each of these towns and it is only a question of utilizing it. So far no clay has been found in this section of the country that will burn buff, for most of it contains too much iron or an excess of iron over lime and consequently the iron oxide produces a red color in the brick. Bricks that were burned by the federal government when it built Fort Towson are still in good condition and although hand made and very porous still they are but very little effected by half a century of weathering. Mr. J.B. Robinson a contractor who is constructing some buildings at Idabel burned a kilm of brick just east of the town. They

were made from a sticky red Pleistocene clay which is abundant at that place. The quality of the brick is good.

Sources of Information.

The sources of information of this thesis are of three kinds, individual work done on the Cretaceous formation of Oklahoma and Texas, suggestions by others who are familiar with the region, and publications.

The writer spent about nine weeks studying the Cretaceous rocks of south-eastern Oklahoma during the summer and autumn of 1908. For six weeks during the latter part of the summer and two weeks at holiday time were spent for the state. About a week was spent at other times working for oil and gas companies. The work in Texas consisted largely of a number of short field trips

made in the region surrounding Austin while the writer was Tutor in Geology at the State University of Texas. Some collecting was done for the State Geological Survey of Oklahoma at Dennison and later a trip to St. Joe, Nacomas and Spanish Fort, Texas was made to determine the point where the Trinity sands across Red River. Some work was also done on the Cretaceous at Hood, Texas for the Cook County Oil and Coal Company.

The writer is indebted to a number of friends who have made suggestions and furnished much valuable information. The work was done under the direction of Dr. Chas. N. Gould who is Director of the State Geological Survey of Oklahoma. Dr. R. W. Ohern has read the manuscript

and added a number of suggestions. Prof. T. L. Eyerly and Ben C. Belt did some good work during the latter part of December 1908 mapping the Goodland and higher formations in Love County.

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