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THE REAGAN SANDSTONE

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IN CANDIDACY FOR THE DEGREE OF

MASTER OF SCIENCE

SCHOOL OF GEOLOGY

BY

RAY L. SIX

NORMAN, OKLAHOMA

1929

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by

Ray L. Six.

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THE REAGAN SANDSTONE

A Petrographic Description

By

Ray L. Six

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INTRODUCTION

Purpose

The purpose of this paper is to present a detailed description of the Reagan sandstone of the Wichita and Arbuckle mountains with emphasis being laid upon the Reagan of the Wichita mountains. This description is based upon the petrologic and petrographic character of the component parts of the sandstone.

Previous work on the Reagan sandstone was published by J. A. Taff, of the United States Geological Survey, Chester A. Reeds, of the United States National Museum, C. N. Gould and others whose contributions will appear in the Bibliography on pp.96 to99 .

The work of these men has been in the form of general regional reports which by nature were brief. From time to time various members of the faculty of the School of Geology of the University of Oklahoma have led brief field excursions in order to study the formations composing the exposed rocks of the Arbuckle and Wichita mountain areas.

Method

After the thesis subject was approved and filed with the dean of the graduate school the work was carried out as follows:

1. Consultation with Professor Samuel Weidman under whose direction

the work was carried out.

2. All available literature describing the Reagan sandstone or the areas in which it occurs was read.

3. Five weeks were spent in field work, collecting hand specimens, making detailed geologic sections, collecting fossils, studying the relationship of underlying and overlying strata and in general examination of the geologic conditions of the whole area wherein the Reagan sandstone occurs.

4. These field notes, samples and maps were brought back to the laboratory and there studied and described in detail. Thirty-six thin sections were made of the most representative specimens. The work was carried out during the latter part of the summer of 1927 and the following autumn, winter, spring and summer of 1928. The specimens have been described macroscopically and microscopically.

5. The preliminary results of this study were incorporated in this thesis.

The writer has used all geologic maps available and such instruments as the alidade, hand-level, Brunton compass, aneroid, tape, petrographic microscope and camera in carrying out this study.

Acknowledgements

The writer is greatly indebted to Dr. Samuel Weidman of the School of Geology of the University of Oklahoma, under whose supervision this research was done. He wishes to thank the following for valuable suggestion during the preparation of this thesis: Dr. V. E. Monnett, Dr. C. E. Decker, Dr. A. J. Williams, Dr. G. E. Anderson, Dr. F. A. Melton, and Dr. C.A. Merritt, of the School of Geology and Dr. C. N. Gould and Mr. C. L. Cooper of the Oklahoma Geological Survey. Mrs. Gladys A. Six has made valuable suggestions and criticisms.

General Statement

Geologic time has been divided into a number of major subdivisions for the sake of reference and study of the events that have transpired

during our earth's existence. Back of this somewhat arbitrary subdivision of time are two of the fundamental premises of geological study, namely, chronological order and superposition. With these in mind it is reasonable to believe that most of the first and oldest rocks are covered by others of later age. Our field studies have proven this supposition to be correct, consequently there are but few windows thru which we may look back at the events of the ancient past.

The earliest formations of the continent will perhaps never be observed, being removed by erosion long before the intrusives which dissected them were brought to the surface.

The oldest observable rocks of the western interior region of the United States are igneous intrusives, composed of a complex series of aplites, granites, diorites, gabbros and rhyolites in great variety of form. These are cut by dike intrusions of later age tho all pre-Cambrian. We may observe these oldest rocks along the eastern flank of the Southern Rockies; in the Central Mineral Region of Texas; in the Black Hills of South Dakota; in the St. Francis Mountains of southeastern Missouri; on Spavinaw Creek in Mayes County, in northeastern Oklahoma; in the Arbuckle Mountain area of southern Oklahoma and in the Wichita Mountain area of southwestern Oklahoma. In addition to the places where one can actually observe these pre-Cambrian intrusives, the driller's bit has encountered the same or similar rocks beneath overlying strata, in the petroleum industry's search for oil and gas.

These first igneous rocks were subjected to the same agencies of erosion and deformation as our present earth surface. The result was that mountains were uplifted and leveled, plains were built, plateaus

were formed and dissected, rains and snow fell, and streams came into being which eroded, transported, deposited and reworked sediments in an almost endless cyclic series. In the Wichita Mountain area near Meers we find a metamorphosed sandstone of pre-Cambrian age. It is known as the Meers quartzite. This represents the oldest sedimentary rock known in Oklahoma. Its parent rocks are as yet unknown.

Thus, when the first Cambrian seas began their advance from the southwestern part of the continent thru the broad, shallow, slowly deepening troughs they encountered a terrane not unlike that of the present, except for the absence of vegetation. The surface was barren and offered almost ideal conditions for the progressive disintegration of the mantle rock. The isolated highlands became islands within the advancing Cambrian seas. Down from these islands and adjoining land masses came streams with loads of sediment, dropping it at the edge of the sea, there to be worked and reworked, deposited and redeposited by wave and current. Where deposited they form the first sediments surrounding the ancient islands and running parallel with the shorelines of the old land masses. Invariably a profound unconformity separates them from the underlying igneous and metamorphic pre-Cambrian rocks. The length of time represented by this lost interval is unknown except to say it was sufficient for the hills and mountains to be peneplained. This interval marks the end of the pre-Paleozoic eras and the beginning of the Paleozoic era. During succeeding times the remaining pre-Paleozoic highlands remained as islands and land masses separating the larger bodies of water, except when disturbed by diastrophism and vulcanism with the resultant shifting of shorelines and change in topographic features.

A perusal of the columnar sections given on pp. 25 and 39 of this paper will show briefly these changes.

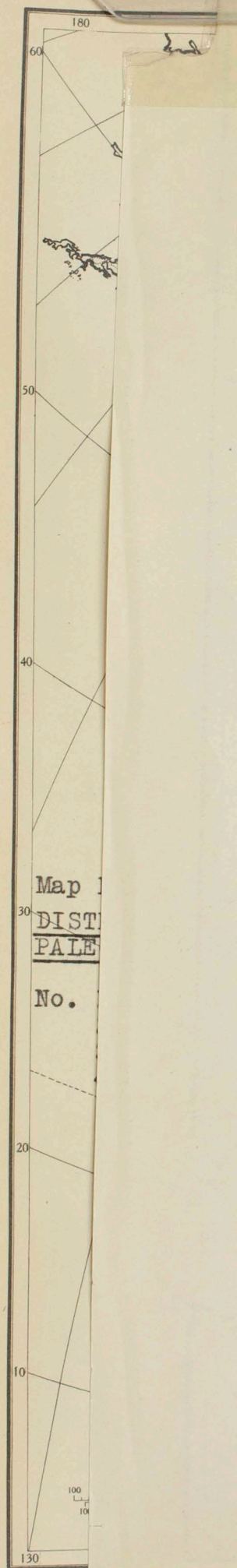
THE REAGAN SANDSTONE

This is the oldest Paleozoic sedimentary formation known in Oklahoma. It was first called Reagan sandstone by J. A. Taff of the United States Geological Survey during his study of the Arbuckle and Wichita mountains in 1901 and 1902. It derived its name from the village of Reagan, located about ten miles north of the city of Tishomingo, Johnston County, Oklahoma. The outcrop of Reagan sandstone just east of the village of Reagan in sec. 20 and 29, T. 2 S., R. 6 E. has long been considered the type locality. It is the type locality for those outcrops east of the Washita river in the Arbuckle mountains but is somewhat different from other exposures in the Arbuckle and Wichita mountains. It is similar to the other outcrops only in color and quartz content.

Age of the Reagan Sandstone

Taff, Reeds and others considered the Reagan sandstone to be of Middle Cambrian age. E. O. Ulrich of the United States Geological Survey in recent unpublished papers assigns it to the Upper Cambrian.

The following correlation table indicates the geographic location and stratigraphic position of the Reagan and other formations of Cambrian age.



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GENERAL CORRELATION TABLE(1)

Basal Paleozoic Formations of Southern and Central United States

Pre-Cambrian	Cambrian	Ordovician	Area
Granite	Tonto ss. 400 ft.		Grand Canyon, Ariz.
Granite	Bliss ss. 0-300 ft.	El Paso ls.	El Paso, Quadrangle
Granite	Van Horn ss. (0-700 ft.)	El Paso ls.	Van Horn, Quadrangle
Granite	Wilberns Cap Mountain Hickory ss.	Ellenberger ls.	Llano District, Tex.
Granite-porphyry	Reagan ss. (0-987 ft.)	Arbuckle ls.	Wichita mountains, Okla.
Tishomingo gr. Colbert porphyry	Reagan ss. (0-500 ft.)	Arbuskle ls.	Arbuckle mountains, Okla.
Granite	La Motte ss.		St. Francis mountains SE. Mo.
	Weisner quartzite		Alabama and Georgia
	Deadwood formation		Wyoming
	Potsdam or St. Croixan ss.		Wisconsin

The above table shows that the basal formations of the Paleozoic are of clastic orgin and rest upon the pre-Cambrian rocks igneous intrusives. It has already been stated that the pre-Cambrian rocks had been exposed to erosion long enough to produce a peneplain upon which at a much later date the Cambrian clastics were deposited unconformably. This unconformity represents the Lipalian interval. The clastics deposited in the southwestern portion of the United States and in the southern portion of the Applachian trough were Lower Cambrian while those of New Mexico and Western Texas are Middle Cambrian and those of central Texas, Oklahoma and Missouri are Upper Cambrian. The physical and faunal evidence indicate that there was

(1) Compiled from U. S. G. S., P. P. No. 71.

an encroachment of the Lower Cambrian seas into the Cordilleric trough from the Pacific ocean and into the Applachic trough from the Gulf of Mexico region. Water from the Cordilleric trough continued to progress eastward over the land until it met, in Upper Cambrian time, the westward moving waters from the Applachic trough in the Missouri, Arkansas, Oklahoma and central Texas region. We thus have clastic materials being deposited along the edges of these encroaching seas and calcareous materials further off shore. The Upper Cambrian rocks of the Cordilleric trough in Arizona and Nevada are limestone and those of the Oklahoma region are highly calcareous but containing also an abundance of clastic materials.

In each case noted deposition continued unbroken from Upper Cambrian on into Lower Ordovician time and the seas became more and more favorable to the deposition of calcareous deposits. The record of events of any one area are somewhat similar to those of the others.

In some areas the basal sandstones have been changed into quartzites by one or more of three causes: first, induration as a result of weight of overlying sediments; second, cementation of the sand by quartz carried in by water; third, metamorphism by igneous intrusions. The first two of these possibilities for the origin of the quartzite of the Reagan are much more plausible than the latter.

Fauna and Flora of the Reagan Sandstone

The fossils of the Reagan sandstone have not been worked out in detail. Only the megascopic forms having been studied. Some micro-fauna is present but is as yet unstudied. The published works of Taff[9], Reeds[8],

Gould,[3] Decker[1] and others give the following list of forms:

Actotreta microscopia Shumard.

Agraulos convexus Whitfield.

Chariocephalus tumifrons Hall.

Chariocephalus tumifrons Whitfield.

Eorthis remnicha.

Eorthis wichitaensis.

Linnarssonella girtyi Walcott.

Obolus tetonensis Walcott.

Obolus tetonensis ninus.

Obolus (Lingulella) similis Walcott.

Obolus (Lingulepis) acuminatus Conrad.

Orthis (?) indianola Walcott.

Orthis (?) wichitaensis Walcott.

Orthis (?) remnicha Wenchell.

Pterocephalia sancti-sabae Roemer.

Ptychoparia roemeri Schumard.

Ptychoparia affinis Walcott.

Ptychoparia (?) cf. pernasutus Walcott.

These are only the most representative forms present in the Reagan sandstone but detailed paleontological studies will reveal many more.

In addition to the above, the writer has observed fucoids, ostracods and crinoids (stems) in the formation. Fucoids are very abundant in one of the lower members of the Reagan in section A, described on page 50 of this paper. Ostracods were observed in the shaley phases around the western

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4, 8, 3, 1. See Bibliography.

extremity of the West Timbered Hills in the Arbuckle mountains.

The lower phases of the formation are not highly fossiliferous due to the coarse clastic nature of the material. As one ascends the section the material passes thru argillaceous to calcareous materials with an increasing abundance of fossils present. In some places the individual beds are largely fragmentary remains of trilobites. The top of the Reagan is very definitely defined by a Ptychaspis deckeri zone in both the Arbuckle and Wichita mountain regions. This Ptychaspis zone is one of the recent additions to the faunal knowledge of the lower Paleozoics by E. O. Ulrich and C. E. Decker, described in unpublished reports.

The flora of the Reagan sandstone is confined to the fucoids. However, detailed study will no doubt discover numerous algae forms. The fossil content of the Reagan is difficult because of the lenticular character of the fossil bearing strata. In the upper phases the fossil bearing beds seem fairly regular, but in the lower and middle phases the fossil bearing horizons are non-continuous zones, difficult of location, due to the forest vegetation covering the Reagan.

Pre-Reagan Formations

There are six pre-Reagan formations in Oklahoma. In the Wichita mountains are the granite, gabbro, Meers quartzite and an unnamed group of pre-Cambrian quartzite and sandstone. In the Arbuckle mountain area are the Tichomingo granite and the Colbert Porphyry. To some extent each of these has contributed to the material now deposited as Reagan sandstone. In some cases we are very sure of the source of the material in the Reagan, that is, we know the parent rock from which the fragments were derived.

Wichita Mountain Area

The pre-Reagan sedimentaries and quartzites found in the Wichita mountain area were first described briefly by C. H. Taylor in his paper on the "Granites of Oklahoma", issued by the Oklahoma Geological Survey as Bulletin No. 20, 1915. These are unnamed. He states that they are older than the gabbro or granite. Little is known of these except that which Taylor has written.

The pre-Reagan igneous materials are composed of a series of intrusives, granites and gabbros. The intervals between these intrusions is not known. The ascending order of these granite intrusions as determined by C. H. Taylor is as follows: Headquarters granite, Reformatory granite, Lugart-Mt. Scott granite, Cold Springs granite and Elk Mountain granite. These granite masses have been cut by numerous dikes of pegmatite, quartz, diabase, granite, gabbro, and quartz-diorite. For detailed descriptions of these the reader is referred to the bulletin by C. H. Taylor, above referred to. The igneous rock underlying the Reagan sandstone on the north side of the Wichita mountains is a granite porphyry. Under microscopic description/p, the reader will find detailed descriptions of this rock under S-2, S-33, and S-54. See pages 78, 79 and 81.

Macroscopically these granite-porphyries are reddish brown in color with occasional grey masses of orthoclase feldspar present at large phenocrysts. The size of the particals vary from 0.1 mm. to 0.5 mm. The chief mineral is feldspar (microcline and orthoclase, the latter being least abundant) as large phenocrysts in a ground mass of fine grained rock. A dark greenish mineral, pyroxene, is present associated with black hornblende. Quartz is present in great abundance but is mostly confined to the groundmass as very fine grains.

Microscopically, the texture of the rock is porphyritic. The groundmass crystalline with quartz as the chief constituent, composing as much as 40 per cent of the rock. These quartz grains are usually clear but some have abundant bubble inclusions. The quartz averages 0.05 mm. in diameter. Felspar composes in a few cases as much as 55 per cent of the rock, occuring as euhedral and acicular crystals of 0.07 mm. size. A few are much larger as phenocrysts which show very little alteration and twinning is very common. See picture No. 14, S-2, page 78 for photomicrograph of this condition. Pyrite and magnetite occur as dark opaque, irregular grains 0.1 mm. in size and composing 3 to 5 per cent of the rock. Some of these fragments are altering to limonite.

Arbuckle Mountain Area

In the Arbuckle mountains the Colbert porphyry serves as the source of the Reagan sandstone around the East and the West Timbered hills. These hills are composed of Colbert porphyry badly cut by dike intrusives and composed of quartz and pegmatite. Macroscopically the Colbert porphyry is a reddish brown, being very similar in appearance to the granite porphyry in the northeast side of the Wichita mountain area. The size of the crystals is greater than 0.1 mm. and less than 5.0 mm. Quartz, feldspar and an undetermined green mineral compose the rock. The feldspar is light pink, well twinned and where exposed to the elements, is altering to kaolin. The quartz is clear, glassy and in very small crystals.

Microscopically, pyrite shows up as disseminated grains 0.1 mm. to 2.0 mm. in size. Occasionally magnetite is present as inclusions within the spherulites of quartz. These are very beautiful structures and are

quite common in Colbert porphyry samples. It is one of the characteristic optical and physical anomalies of this rock as yet not observed in any of the other pre-Reagan rocks. Apatite is found as acicular crystals arranged as zoned inclusions within the quartz. The feldspar is microcline, beautifully twinned. The texture is quite porphyritic. See page 79 , S-54 for photomicrograph of the sperulitic structure of the porphyry. Two pictures will be noted, No. 64 is the same as No. 65 except under higher magnification.

On the eastern side of the Washita river in the Arbuckle mountains the source rock of the Reagan sandstone was the Tishomingo Granite with its numerous vein and dike materials. The Tishomingo granite is a very coarse grained granite with a pink color due to the high feldspar content. Large amounts of quartz are also present. Large amounts of quartz-monzonite, aplite, granite porphyry and basic dikes are found as intrusives cutting the granite. In the western part of the larger granite exposure the Tishomingo is only a few tens of feet thick and below this is a dark bluish-black granitic rock of great hardness which is known locally as black granite and is encountered in wells dug into the rock for water. When this strata is reached, drilling or digging ceases as it has not been known to contain water. The thickness of this dark, hard intrusive is unknown and dikes of it cut the Tishomingo granite trending in a northwest-southeast direction. In spite of its superior hardness as compared to the Tishomingo granite, it has less resistance to the agencies of weathering. Thus, many of the dikes are traceable not as ridges but as depressions. The thickness of these dikes ranges from tiny veinlets to 3 feet thick.

In the area just west of Troy, Oklahoma, there are large numbers of quartz dikes containing traces of gold and silver. Several fortunes have been expended thus far in a vain effort to find these precious metals in commercial quantity. The granite is covered with a heavy growth of scrub oak and the surface is peneplained and but slightly dissected since Lower Cretaceous (Comanchean) time.

Pre-Reagan Unconformity

In all places where the base of the Reagan sandstone is exposed it rests unconformably upon older rocks, mainly pre-Reagan, pre-Cambrian igneous, intrusives. This unconformity is profound and in the regions of the Arbuckle and Wichita mountains represents the lost time interval commonly entitled the Lipalian. Its length of time was great enough to allow very complete peneplaination of the land mass. The scarcity of the topographic highs on this surface plus the deep zone of weathered material, substantiate this great length of time. Here and there within this peneplained surface are found sharp undulations which were monadnocks, standing out as small hills within the otherwise little-dissected plain. The old stream courses are marked by valleys. The uneven character of this eroded surface accounts for the varying thickness of the Reagan sandstone and the great variation in the thickness of the basal conglometate. The best example of a hill or old monadnock within this peneplained surface is found in sec. 18 and 19, T. 2 S., R. 4 E. Here we find a mass of Tishomingo granite protruding thru the basal portion of the Arbuckle limestone, the first overlying formation above the Reagan sandstone. This hill was several hundred feet high extending up thru the Reagan sandstone

and well up into the basal Arbuckle limestone. At the present time it protrudes above the surface of the Rock Prairie as a low, wood covered hill several acres in extent. Its present height above the surrounding area is about twenty-five feet. This hill stood out as an island in the Upper Cambrian and Lower Ordovician seas.

The best places to observe this unconformity are from the northeast side of the Wichita mountains at the locations of sections A, B and C, and the west bank of Honey creek in the East Timbered Hills. Here a tributary of Honey Creek has cut a valley parallel with the strike of the Reagan and along the contact of the Reagan sandstone and the Colbert porphyry showing in great detail the nature of the unconformity and the overlying basal conglomerate. Many localities in the West Timbered Hills show the same condition. See Plate XII for the character of this conglomerate.

In the areas east of the Washita river in the Arbuckle mountains the nature of the unconformity is harder to observe because, in every case, a broad valley partially filled with alluvium and covered by a growth of trees and undergrowth or soil under cultivation, precludes the direct observation of the contact. In a few places one can see that the top portion of the igneous intrusives was completely disentegrated into a kind of granite wash. This is the case in the outcrop of Reagan sandstone and the Tishomingo granite just south of Mill Creek. The material composing the basal breccia and conglomerate of the Reagan is in every case composed of the underlying igneous intrusives.

Thus, the old surface upon which the basal Reagan was deposited, was very level except for isolated monadnocks and small stream incisions.

These depressions served as collecting grounds for the greater thicknesses of the conglomerate of the basal Reagan and weathering was very pronounced on this old surface. The encroachment of the Reagan seas was such that the surface features were preserved without much destruction on the part of the waves.

Post-Reagan Formations

In both the Arbuckle and Wichita mountains the Arbuckle limestone is the first overlying formation. The Reagan sandstone grades into the Arbuckle thru a transition zone composed of calcareous beds separated by shale layers. The Arbuckle limestone is some 8,000 feet thick. It was first separated into sub-divisions by Decker and Ulrich. Appendix A, page 100 gives in tabular form the results of their work up thru the summer of 1928. Due to the tentative nature of this classification of Arbuckle rocks the results have not been incorporated in this manuscript. It will be noted from this table that two new periods have been introduced between the Cambrian and the Ordovician sections of the Paleozoic.

Thus the Arbuckle limestone rests conformably upon the Reagan except in the case of section B, sec. 21, T. 4 N., R. 12 W. along the northeastern flank of the Wichita mountains. Here we have a local unconformity marked by a basal conglomerate. The character of the Arbuckle limestone is a series of limestones, dolomites, marbles, sandstones and shales, the shales often acting as partings of the other members.

In the Arbuckle and Wichita mountains we find Permian Red Beds lying unconformably upon the Reagan sandstone. We find also Trinity

sands lying upon the Reagan in the area just east of Ego in the Region east of the Washita River in the Arbuckle mountains. In a few isolated cases we find recent alluvium and slightly older quaternary gravels lying unconformably upon Reagan sandstone.

After the Arbuckle limestone come the Simpson formation, Viola limestone, Sylvan shale, Chimneyhill limestone, Henryhouse shale, Haragan shale, Bois d' Arc limestone, woodford chert, Sycamore limestone and the Caney shale.

Distribution of the Reagan

The Reagan sandstone occurs in two regions, namely, the Wichita Mountain area in the southwest portion of Oklahoma (See Map No. 1) and the Arbuckle Mountain area in the south central portion.

The Wichita Mountain Area

This area lies in the southwestern part of the state of Oklahoma. It is distributed thru the following counties: Comanche, Caddo, Kiowa, Greer and Jackson. See Map No. 1, page 22 . In terms of the United States Geological Survey system of quadrangles it is located in the following quadrangles: Granite, Roosevelt, Cooperton, Meers, Apache, Lawton, Cache, Snyder, Headrick and Altus. The Wichita Mountain Area forms the visible portion of a buried mountain system extending from the vicinity of Duncan northwestward thru the Wichitas and the Panhandle of Texas and connects with the southern Rockies in New Mexico. It is perhaps a part of the first or ancestral Rockies. This ridge forms one of the major structural features of that region. The core is igneous intrusive material cut

by later intrusives in the form of dikes and batholiths, all of which are faulted and broken in a very confusing manner.

To the south of these mountains are to be found a few outcrops of the Paleozoics represented by the Reagan sandstone, Arbuckle limestone and undifferentiated Permian red beds. The Reagan rests unconformably upon the older pre-Cambrian igneous intrusives. The Arbuckle limestone rests conformably upon the Reagan. Lying unconformably upon these are a series of Red Bed (Permian) deposits which completely surround the mountains on all sides. Here and there these Permian deposits are covered over by more recent alluvial material derived from the present mountains.

In the northern part of the Wichita mountains we find the Meers quartzite which represents the oldest sedimentary formation in the state. Lying unconformably upon this quartzite and the igneous intrusives is found the Reagan sandstone. Above the Reagan and conformable upon it comes the Arbuckle limestone series which is approximately eight-thousand feet thick. In places the Simpson and Viola formations are found. These, with the much later Permian, mark the latest Paleozoics to be found on the surface in this area. Thru drill cuttings from prospect holes drilled in the search for petroleum the Reagan and some of the older formations are known to occur further from the mountains.

The structural features of the area which affect the Reagan sandstone include faulting and folding. The faulting consists of thrust, normal and oblique types. The folding is complex, composed of anticlines and synclines of symmetrical and assymmetrical types in series with an occasional over-turned fold. The axes of these folds are parallel to the main trend

of the mountains. This is northwest-southeast. The first major uplift of this region came in pre-Permian time, the last in post-Permian time.

Plates I, II, III, IV, V, VI, VII, VIII, and IX show the character of the Wichita Mountain Area.

On the following page is a tabulated geologic section of the Wichita Mountains showing the relationship of the Reagan sandstone to the other formations of the region.

The largest and most important area of the Reagan sandstone occurs on the northeast flank of the Wichita mountains. Here it has been brought to the surface by faulting and folding with subsequent erosion. This area is divided into two sub-areas. The first lies east of the Blue Creek fault and north of Mounts Scott and Cummins, the second lies to the northwest. The strike of the Reagan sandstone of this first sub-area is N. 55° N. In this area there are a number of faults in the Reagan and associated formations. The most important of these is a strike fault in the northeast corner of T 4 N, R 13 W. The dip of this fault plane is generally about 40° and the strike of the fault plane N. 20° W. This parallels the Blue Creek fault. Here the Reagan is faulted down against the granite porphyry. The branching character of this fault causes a repetition of beds. The dip of the Blue Creek fault is 25° to the southwest. In each of these two faults the southwest side has been thrust up over the northeast side.

Northwest of the Blue Creek fault in the second sub-area there are three other outcrops of the Reagan sandstone. All these are on the northeast east limb of an anticline whose axis parallels the major axis of the mountain uplift. The first of these outcrops is found in sections 36, 35, 26 and 27 of T 6 N, R 14 W. The strike of this outcrop is N 47° W, dip

GENERALIZED SECTION OF THE FORMATIONS OF THE WICHITA MOUNTAINS [1]

Age	Formation	Thickness
Pleistocene	Gravels, sand and Alluvium	?
	Unconformity	
Permian	Red Beds (sandstones, shales, limestones, evaporation products.)	?
	Unconformity	
Pennsylvanian Mississippian Devonian Silurian	These are not exposed on surface but thesese are known to be present.	?
Ordovician	Viola limestone	200-300 ft.
	Simpson formation	150 ft plus.
	Arbuckle limestone (upper part)	circa 8,000 ft.
	Arbuckle limestone (lower part)	
Cambrian	Reagan sandstone	0-983 ft.
	Great Unconformity	
pre-Cambrian	Granites, porphyries, gabbros, diabase, monzonite as massive intrusives.	
	Granite, pegmatite, and quartz as vein materials.	
	Meers quartzite.	

(1) U. S. G. S.--Tentative correlation chart of Formations in Oklahoma, Southern Kansas and Northern Texas--1925.

101482 : cop. 2.

NE 49°. The second outcrop is in the NW¼ of section 21, T 6 N, R 14 W. The third outcrop is further to the northwest in section 17, T 6 N, R 14 W. The dip and strike of the second and third outcrops is the same as that of the first.

According to one of the field geologists of the Roxana Petroleum Corporation, Reagan sandstone was encountered in a well drilled by his company to the northwest of the third outcrop mentioned above. The writer has not had the opportunity for examining cuttings from this well. If Reagan was encountered in this well at the depth indicated, the dip of the formation flattens out very rapidly.

South of the Wichita mountains in T 2 N. R 13 W. is to be found a series of isolated patches of Reagan sandstone. These are southwest of Signal mountain and west of the main mass of Arbuckle limestone. They are just outside of the southern boundary of the Ft. Sill Military Reservation. The dip of these outcrops is south and the strike due east and west.

Map No. 2.

Distribution of Reagan sandstone in Wichita mountains.
(after Taff, Gould & others with modifications)

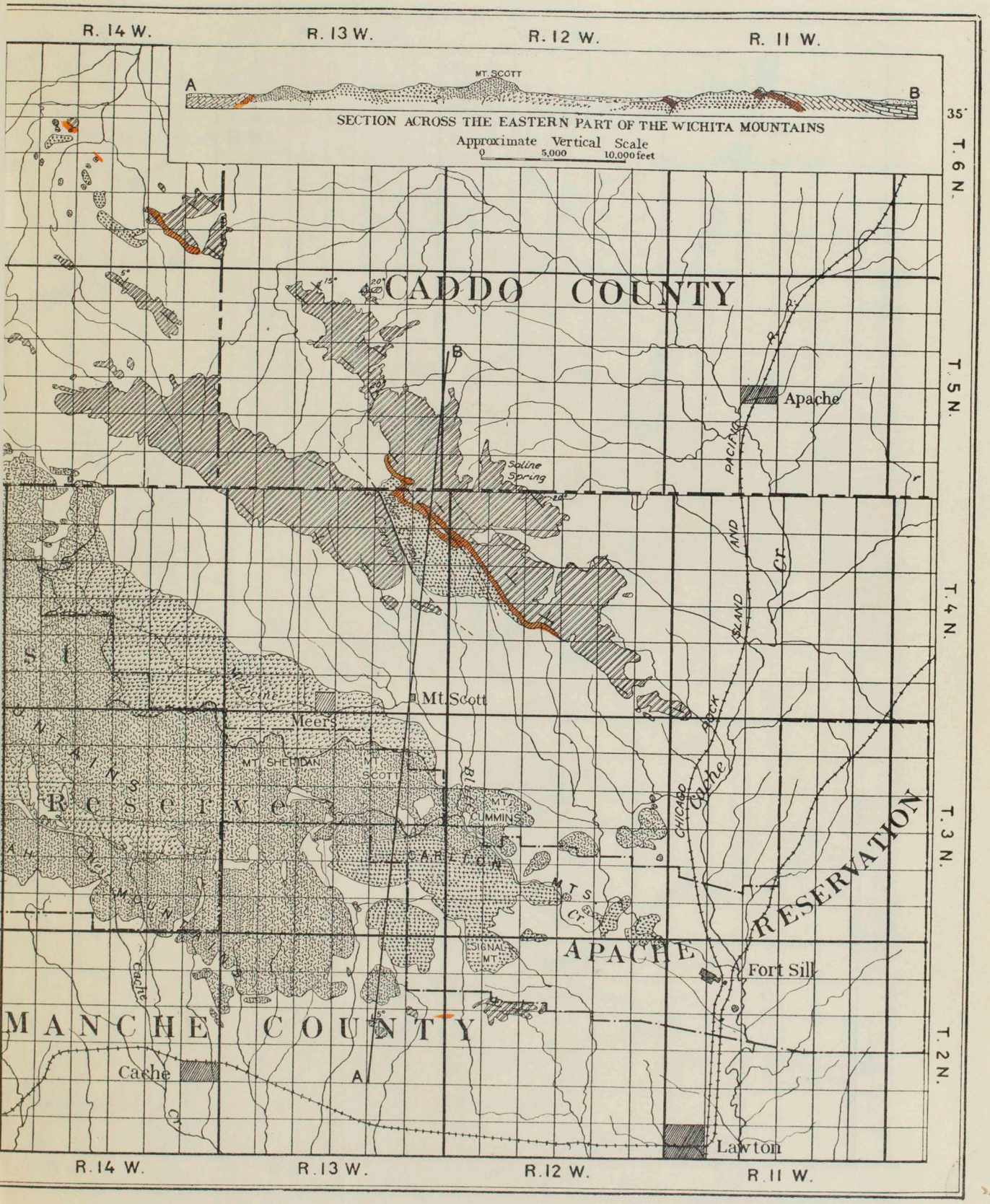


PLATE I.



A. Northeast front of the Wichita mountains. Parent rocks for the Reagan sandstone and other sediments surround these mountains. Note the flat top of Mt. Scott.



B. Mt. Scott from the east side of Lake Lawtonka.

PLATE II.

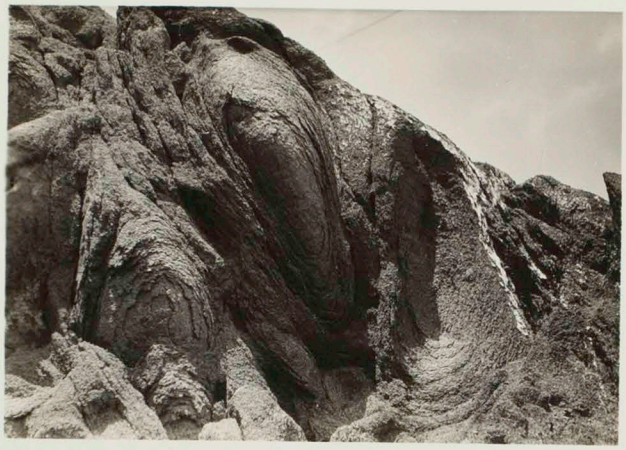


A. Mt. Sheridan. Note flat top similar to that of Mt. Scott. This is a remnant of an old peneplain. The top portion above timber line is granite; timbered portion is gabbro. The Meers quartzite is found to the north of this mountain.

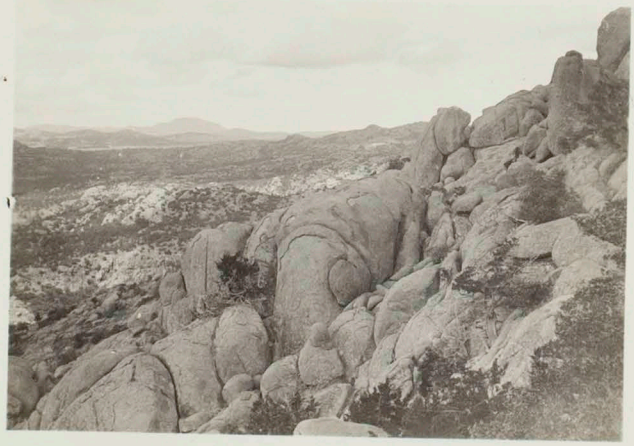


B. Saddle mountain.

PLATE III.



A. Exfoliation of Gabbro in Hazel's quarry. Location: east face of Mr. Sheridan.



B. View looking northeast from northwest spur of Eagle mountain toward Mt. Scott. Shoulder of Eagle mountain in left foreground. Note excellent exfoliation of granite.

PLATE IV.

THE REAGAN OF THE WICHITA UPLIFT.



a. Scene at Section A. Sec. 7, T. 4 N., R. 12 W. showing basal quartzite member, just above basal conglomerate.



b. Scene at Section A. Sec. 7, T. 4 N., R. 12 W. Shows the escarpment formed as result of erosion of Reagan Formation. Heavy brown porous member prominent in center of escarpment. Scarp top is Arbuckle limestone. View looking northwest.

PLATE V.

THE REAGAN OF THE WICHITA UPLIFT.



a. Fucoids from the next member above the Quartzite stratum at section A. Sec. 7, T. 4 N., R. 12 W. At this station this layer is severd hundred yards long.



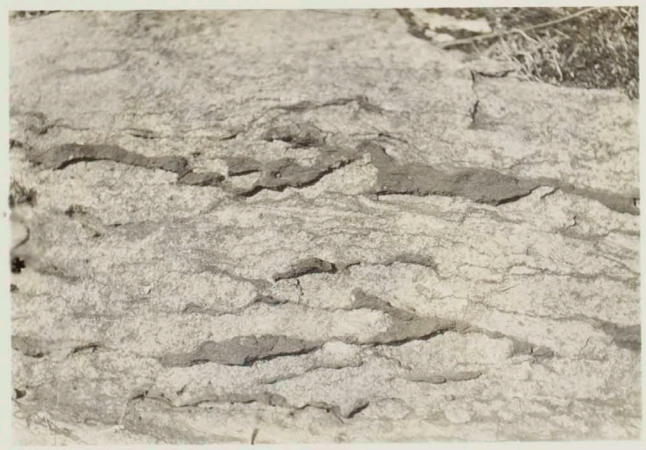
b. Porous character of the heavy brown sand member of Reagan at Section A, Sec. 7, T. 4 N., R. 12 W. This form face of escarpments and is very prominent. Chert stringers in underlying member may be seen in base of picture.

PLATE VI.

THE REAGAN OF THE WICHITA UPLIFT.



a. Detail view showing the honeycomb nature of the calcareous cherty member near the middle of the heavy brown porous member of the Reagan at Section A, Sec. 9, T. 4 N., R. 12 W.



b. Detail view showing character of the chert stringers in the calcareous member near the topoof the Reagan at Section A, Sec. 7, T. 4 N., R. 12 W.

PLATE VII.

THE REAGAN OF THE WICHITA UPLIFT.



a. General view of one of the interformational conglomerates at Section C, NW¼, Sec. 26, T. 6 N., R. 14 W.



b. Detailed view of the interformational conglomerate shown above.

PLATE VIII.

THE REAGAN OF THE WICHITA UPLIFT.



a. Looking northwest parallel with the strike of the rocks near the top of the Reagan section showing the Arbuckle - Reagan contact. This view includes the middle member of the Reagan. This at Section B., Sec. 21, T. 4 N., R. 12 W.



b. Detail at Section B, showing the character of the upper calcareous phase of the Reagan. There are 29 thin layers of alternating shales and limestones. Many show much arenaceous material. Sec. 21, T. 4 N., R. 12 W.

PLATE IX.

THE REAGAN OF THE WICHITA UPLIFT.



a. View at Station B, Sec. 21, T. 4 N., R. 12 W., showing the Reagan-Porphyry contact and the character of the valleys eroded into the softer more shaly lower middle members of the formation.

a. Porphyry.
b. Porphyry contact. A Profound unconformity.
c. Basal quartzite member. Hard very resistent. Forms a row of hog-backs parallel to main escarpment.
d. Softer shaly members of lower middle portion.
e. Heavy brown porous beds forming main portion of scarp.
f. Upper calcareous phase of Reagan.

Arbuckle Mountain Area

The Arbuckle mountain area is located in the south-central part of the state of Oklahoma, within Garvin, Pontotoc, Atoka, Johnston and Carter counties. According to the quadrangle system of the United States Geological Survey this area lies in the following quadrangles: Pauls Valley, Stonewall, Coalgate, Atoka, Tishomingo, and Ardmore. Topographis maps have been issued for all of these and Geologic Atlases in folio size have been issued for the Tishomingo, Atoka and Coalgate areas. The Stonewall area has been well described by George Morgan in Bulletin No. 2 of the Bureau of Geology, Norman, Oklahoma.

The Arbuckle mountains form a topographic highland some 1500 feet above sea level at its maximum elevation. It is badly dissected by stream erosion. According to Dr. F. A. Melton two areas of the East and West Timbered Hills stood out as monadnocks in the Triassic peneplain; above which they projected less than one-hundred feet. These Timbered hills are composed of Colbert Porphyry, an intrusive of pre-Cambrian age. See description of this rock and the Tishomingo granite in section on pre-Reagan formations on page **15.** . These hills are covered with a growth of scrub oak. In the eastern part of the mountains the Tishomingo granite presents a peneplain now covered with scrub oak and badly dissected by streams.

The Colbert porphyry and Tishomingo granite compose the core of the mountains and, structurally, occupy the axis of the mountain folding. The trend of the mountains is northwest-scutheast and presents a broad geanticline with Paleozoic rocks dipping away to the north-east and to the southwest. These are distorted into a series of parallel folds and troughs affecting only the preupper Pennsylvanian rocks. The folding then took place

during late Pennsylvanian time. The Permian seas came in around the mountains, depositing the Red Beds. After Permian time the area was uplifted and eroded until the beginning of Comanchean time when the seas again encroached depositing the Trinity group now observed on the south flank of the mountains. This was followed in turn by a regional uplift which has continued down to the present time. The gorge of the Washita is an excellent example of this rejuvination.

Faulting is complex and widely distributed thru the Arbuckle mountains resulting in the usual omission and repetition of beds. It is possible to find practically any type of structural feature desired in these mountains.

Plates X, XI, XII, XIII show some of the topographic features of this region.

On the following page is a generalized geologic section of the Arbuckle mountains, showing the relationship of the Reagan sandstone to the other formations found.

In the Arbuckle mountains there are two regions in which Reagan sandstone is found. One east and the other west of the Washita river. The region west of the Washita can be subdivided into two areas, one around the West Timbered Hills and the other around the East Timbered Hills. The region east of the Washita river can be subdivided into four areas.

In the West Timbered Hills there are three exposures of the Reagan sandstone. The first and largest lies on the southwest flank of the hills, extending from sec. 28, T. 1 S., R. 1 E. northwest thru sec. 29, 30, and 18 of the same township into sec. 24, 23, 22, 15 and 14 of T. 1 S., R. 1 W. The dip is to the southwest with strike northwest and southeast. The second occurs in sec. 13 and 14, T. 1 S., R. 1 E. The dip

1

GEOLOGIC SECTION OF THE ARBUCKLE MOUNTAINS

Recent and Pleistocene:	
Gravels, alluvium and sand.	
Unconformity	
Lower Cretaceous	
Trinity group.	
Unconformity	
Permian	
Red beds.	
Unconformity	
Pennsylvanian.	
Franks and Seminole conglomerates.	
Unconformity	
Mississippian	
Caney shale	800-1600 ft.
Sycamore limestone	0-200 ft.
Devonian	
Woodford chert	600-650 ft.
Bois d' Arc limestone	0-90 ft.
Haragan marl and shale	0-166 ft.
Silurian	
Henryhouse shale	0-223 ft.
Chimney Hill limestone	0-55 ft.
Ordovician	
Sylvan shale	0-300 ft.
Viola limestone	500-800 ft.
Simpson formation	1200-2000 ft.
Arbuckle limestone (upper part)	7800 ft.
Cambrian	
Arbuckle limestone (lower part)	
Reagan sandstone	0-500 ft.
Unconformity	
Pre-Cambrian	
Intrusives-pegmatite dikes	
Colbert porphyry	
Tishomingo Granite	

(1) After Oklahoma Geological Survey.

Map No. 3. Distribution of Reagan sandstone in Arbuckle mountains.
(After Taff, Gould & others with modifications)

is to the northeast with strike northwest southeast, parallel to the main axis of the mountains. This exposure is small and very incomplete. The third outcrop lies around the northwest end of the hills in sec. 2, 3, 9, 10, 11 and 14 of T. 1 S., R. 1 W. Here the dip is 25° to the northwest with the outcrop paralleling the base of the Colbert porphyry hills. Near the south end of this outcrop, faulting has dislocated the position of the Reagan. In one case overthrust has placed it on top of the basal Arbuckle limestone and at another it has placed it in contact with it.

In the East Timbered Hills the Reagan sandstone is to be found on the southwest slopes of the hills paralleling the base of the Colbert porphyry. At the east end of the outcrop it is recurved around the hills to the northeast flank to the great fault between the Arbuckle limestone and the porphyry. Heretofore this recurved portion has been marked as a fault with no Reagan present. Map No. 5 shows this new area curving around the end of the East Timbered Hills to the fault zone. During the summer of 1928, C. E. Decker of the School of Geology, University of Oklahoma, found the same condition. This marks a correction in previous maps of Reagan exposures. A geologic crossection of this part of the mountains is given in Plate XI-B. The fault here indicated does not extend as far to the southeast as is indicated on older maps of the area. This outcrop of Reagan occurs in sec. 35 and 26, T. 1 S., R. 1 E. extending on into sec. 1 and 12, T. 2 S., R. 1 E.

On the east side of the Washita river there are four outcrops of the Reagan sandstone. The first is found along the western side of the Tishomingo granite and begins at the fault along the south side of the

Mill Creek syncline in sec. 10, T. 2 S., R. 4 E., extending in a southeast direction thru sec. 14, 15, 23, 26, 35 and 36 of same township into sec. 1, 12, 13, 23, 24 of T. 3 S., R. 4 E. Here the strike changes to east-west, the outcrop continuing on into sec. 19, 30 of T. 3 S., R. 5 E. An oblique fault which offsets and slightly overlaps the Reagan sandstone extends from sec. 2, T. 3 S., R. 4 E. into sec. 30, T. 3 S., R. 5 E.

The second outcrop, which is the type locality, is just east of the village of Reagan, for which the formation was named, in sec. 20 and 29 of T. 2 S., R. 6 E. This outcrop is very small and lies in a down faulted graben block between two faults whose strike is N. 20° W. The dip of the Reagan is 12° and parallel to the strike of these faults and the strike is at right angles to these faults.

The third outcrop is located in sec. 4 and 5, T. 3 S., R. 7 E. and lies between two faults in a graben block. The writer doubts if this outcrop is true Reagan even tho mapped as such on all maps of this area. It occupies the approximate stratigraphic position of the Reagan but is so little exposed and of such a physical nature as to be more like one of the Ozarkian or Canadian sandstones mentioned by E. O. Ulrich of the United States Geological Survey in an unpublished manuscript. Detailed faunal studies, as yet unmade, will be needed to decide this point. This area is $7\frac{1}{2}$ miles north and $1\frac{3}{4}$ miles west of the village of Milburn on the east side of the Blue River. The dip is to the northwest and the strike to the northeast.

The fourth area of Reagan sandstone is found three miles east of the hamlet of Ego, in sec. 28, 32 and 33, T. 3 S., R. 9 E. Here the Reggan sandstone lies around the north and northwest edge of an area of

Tishomingo granite upon which it lies unconformably. On the east it is cut off abruptly by a fault and on the west is overlaid unconformably by the Trinity sand. This is the basal member of the Trinity Group, of Comanchean age.

The afore mentioned series of outcrops of the Reagan sandstone are thought to be all that occur. However, further studies may reveal others. The following table of Reagan outcrops briefly summarizes these outcrops:

Table of Reagan Sandstone Outcrops in Oklahoma

I. Wichita Mountain Area: (See map No. 1)

A. North of the Mountains: (See map No. 2.)

1. East of Blue Creekfault:
   a.----sec. 26, T. 4 N., R. 12 W.; sec. 27, 22, 21, 20, 17, 18 and 7, T. 4 N., R. 12 W.; sec. 12, 1 and 2, T. 4 N., R. 13 W.; sec. 35, 36, and 26, T. 5 N., R. 13 W.

2. West of Blue Creek Fault:
   a.----sec. 26, 27, 35 and 36, T. 6 N., R. 14 W.
   b. NW¼, sec. 21, T. 6 N., R. 14 W.
   c.----sec. 17, T. 6 N., R. 14 W.

B. South of the Mountains: (See map No. 2)

1. SW. Signal Mountain:
   a.----T. 2 N., R. 13 W.

II. Arbuckle Mountain Area: (See map No. 3.)

A. West of the Washita River:

1. West Timbered Hills Region. (T. 1 S., R. 1 W. & 1 E.)
   a.----sec. 18, 28, 29 and 30 of T. 1 S., R. 1 E.; sec. 14, 15, 22, 23 and 24, T. 1 S., R. 1 W.
   b.----sec. 13 and 14, T. 1 S., R. 1 E.
   c.----sec. 2, 3, 9, 10, 11 and 14, T. 1 S., R. 1 W.

2. East Timbered Hills Region: (T. 1 S., R. 1 E.; R. 2 S., R. 1 E.)
   a.----sec. 36 & 36, T. 1 S., R. 1 E.
   sec. 1 & 2, T. 2 S., R. 1 E.)

B. East of the Washita River:
(T. 2 S., R. 4 E.; R. 3 S., R. 4 E.; T. 3 S., R. 5 E.; T. 2 S., R. 6 E.; T. 3 S, R. 7 E.; T. 3 S., R. 9 E.)

1. West of Tishomingo Granite, south of Mill Creek.
a.----sec. 10, 14, 15, 23, 26, 35, 36, T. 2 S. R. 4 E.; sec. 1, 12, 13, 23, 24, T. 3 S.; R. 4 E.; sec. 19, 30, T. 3 S., R. 5 E.

2. East of Reagan (type locality)
a.----sec. 20, 29, T. 2 S., R. 6 E.

3. North of Milburn.
a.----sec. 4, 5, T. 3 S., R. 7 E.

4. East of Ego.
a.----sec. 28, 32, 33, T. 3 S., R. 9 E.

PLATE X.

SCENES IN THE ARBUCKLE UPLIFT.



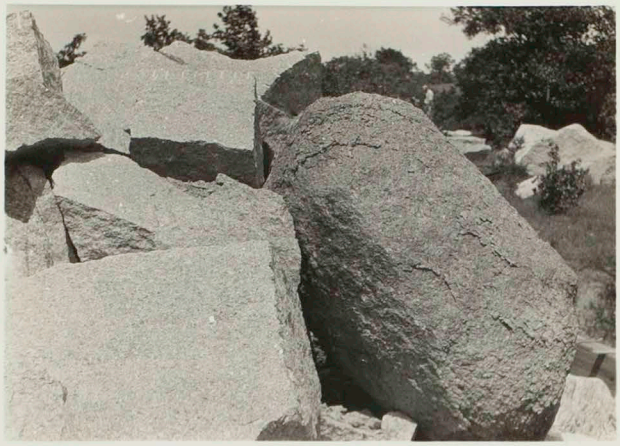
a. View of the Tishomingo Granite as seen 1½ miles from Troy, Oklahoma, at the Capitol Quarry. This rock forms the parent rock for the Reagan for the area east of the Washita River. It is much dissected by later intrusives. Weathering along joints is very pronounced. Exfoliation is noticable.



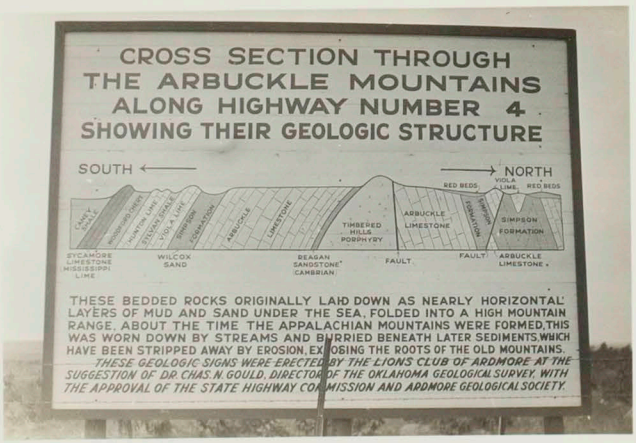
b. View from the southwest end of the West Timbered Hills, showing the remains of Cretaceous peneplain atop the Colbert porphyry. This porphyry is wooded, resistant, and cut by many dikes. In the foreground of the picture is the Arbuckle limestone. Between the Porphyry and the Arbuckle is the Reagan valley. Toward the right of the picture the Reagan is faulted out, leaving Arbuckle in contact with Porphyry. The view is toward the East.

PLATE XI.

SCENES IN THE ARBUCKLE UPLIFT.



a. View showing the way in which the Tishomingo Granite weathers. Exfoliation is prominent.



b. Picture of signboard erected on top of the Arbuckle Mountains which graphically illustrates the structure of the mountains in a north and south direction thru the East Timbered Hills region.

PLATE XII.

THE REAGAN OF THE ARBUCKLE UPLIFT.



a. View showing nature of the breccia at the base of the Reagan on Honey Creek in East Timbered Hills, Section D.



b. Basal Conglomerate in Reagan on Honey Creek, Section D.

PLATE XIII.

THE REAGAN OF THE ARBUCKLE UPLIFT.



a. Detail of mold of large boulder in the basal conglomerate shown in Plate XII-b.

DESCRIPTIONS OF GEOLOGIC SECTIONS

Four geologic sections are described. Sections A, B and C are on the northeast flank of the Wichita mountains. (See Map No. 2) Section D is along Honey Creek, east Timbered Hills region of the Arbuckle mountains. (See Map No. 3).

Section A., sec. 7, T. 4 N., R. 12 W.

This section was made up the face of the escarpment shown in Plate IV-B (see page 31), in sec. 7, T. 4 N., R. 12 W. on the north flank of the Wichita mountains. (See Map No. 2) It was measured at right angles to the strike which is N. 45° W. and parallel with the dip which is NE. 35°. The lithologic, petrologic and petrographic character of the rocks composing this section are very similar to those in section B taken further east along the same outcrop. Section A has a total thickness of 248.6 feet while section B has a thickness of 983.7 feet.

This escarpment is due largely to erosion of the Reagan and adjoining granite porphyry along a fault plane. This is an oblique reversed fault lacking only a few degrees of being a strike fault. At the east end of the fault the Reagan is only partly exposed but at the west end one gets the complete Reagan section. This fault comes in from the granite porphyry, perhaps as a component of the Blue Creek fault to the west, and continues east until it unites with another oblique fault which causes offset and overlap of the Reagan sandstone. This fault strikes northwest-southeast. One quarter of a mile northwest of the intersection of these two faults the second one unites with another oblique fault paralleling the strike of the first one. This gives an inverted Z-pattern. Erosion has been very pronounced along this third fault and a deep canyon

is the result. Near the east end of the second fault the Reagan is faulted out and Arbuckle limestone is in contact with the granite porphyry. In each case the block on the south or southwest side of the fault planes is the overthrust component and the block on the north or northeast side the down thrown one.

Section B., sec. 21, T. 4 N., R. 12 W.

This section was measured up the north wall of a Reagan valley which was eroded out along the contact of the Reagan sandstone and the underlying granite porphyry, in sec. 21, T. 4 N., R. 12 W. This is east of section A, in sec. 21, T. 4 N., R. 12 W. (See Map No. 2) The strike of the Reagan sandstone at station B is N. 55° W and the dip northeast 45°.

Here the Reagan sandstone rests unconformably upon a pink granite porphyry whose upper surface was badly weathered and somewhat dissected by streams prior to the deposition of the basal Reagan. For detailed descriptions of this porphyry see page 78 , S-19 and S-2. Above this unconformity is a basal conglomerate of variable thickness, composed of rounded and subangular microscopic and macroscopic fragments of the underlying granite porphyry. The thickness is as much as 12 feet and as little as 2 feet. This conglomerate is present at the base of the Reagan sandstone throughout the Wichita area and in it is some brecciatic material. The greater thicknesses sometimes found in this basal conglomerate is due to the stream channels and shallow valleys which have been filled with the conglomerate prior to the general distribution of the gravels over the divides between. Some of the thicknesses indicate that they are

alluvial deposits at the mouth of streams or perhaps deposition at a change in the gradient of the pre-Reagan streams which flowed over the old peneplain.

Above this basal conglomerate is a very persistant layer of quartzite which often merges with the conglomerate making a combined thickness of 34.2 feet. This quartzite in conjunction with the overlying sandstone member makes a series of low hogback ridges running parallel to the main Reagan escarpment at its base and near to the Reagan granite-porphyry contact. See page 92 ; S-20 and S-21 for detailed descriptions of this member. This quartzite is reddish in color, very hard and resistant, and the upper part of the conglomerate is a bed of hematite of considerable commercial importance. These deposits have been known for some time but were only utilized locally as a source for pigment in the manufacture of red and yellow barn paint.

Above this quartzite member is a very persistant brown sandstone member 114.2 feet in thickness and containing a very widespread layer of hemetite. The hematite deposit at times extends downward and merges with the one mentioned above in the quartzite and the conglomerate. The upper member of this sandstone is very resistant and has unusually well developed joints which produce large oblong blocks in the process of weathering which are used locally for building stone and often transported long distances.

Above this sandstone member is 63.0 feet of soft yellowish shale which erodes rapidly into a valley, leaving the underlying more resistant strata as an escarpment. Plate IX-A shows the valley eroded out in

this shaly phase. Due to the badly weathered condition of this member, good samples were unobtainable but some contained organic forms thought by H. E. Vanderpool to be ostracods, similar to some found in this shaly phase in the West Timbered Hills section of the Arbuckle mountains. The upper surface of the shaly phases is covered by luxuriant grasses and occasional shumac bushes.

Above this member comes 172.0 feet of heavy beaded, porous, brown sandstone which produces a very pronounced escarpment. It is very coarse grained and contains chert stringers in abundance, particularly in the basal portion. Plate V-B shows the character of the same member in section A a short distance to the west. See S-24 on page 91, for a detailed description of this material, photomicrographs are given also. Where this member is highly arenaceous and glauconitic it weathered to a greenish brown and where it is highly calcareous the weathered product is greenish grey. The greenish granules of glauconite is distinctly visible to the eye. Thin sections of this material reveal the following minerals: quartz, 80 per cent; glauconite, 10 per cent; pyrite, 5 per cent; apatite, 5 per cent; open spaces and undeterminable fragments 2 to 3 per cent. The quartz occurs as rounded grains, sometimes frosted and others have acicular crystals of apatite inclusions in abundance. The glauconite occurs in rounded grains .1 mm. diameters. It is interesting to note that the glauconite is without exception badly weathered and is often altering to calcite. This seems to be a characteristic of the Reagan glauconite, regardless of the geographic location of the deposit or the stratigraphic position within the Reagan sandstone.

The next member in this section marks the beginning of the calcareous phase of the formation which extends with minor breaks to the top of the section. Here it consists of 45.0 feet of calcareous sandstone having a brownish grey color. This is sometimes modified to a greenish cast due to the glauconite present in this member of the Reagan and which is generally banded, but is also widely disseminated, both vertically and laterally.

This is followed by 160.0 feet of very porous, quite resistant, brown sandstone which is separated from the lower member of somewhat similar character by shale partings and some very argillaceous strata which may bear micro-fauna. Plates VI-A & B show the physical character of this member on weathered surfaces. See S-26 and S-27 on pages 92 and 93 for detailed descriptions of the microscopic and petrologic character of this member. Photomicrographs accompany these descriptions. S-26 is from near the middle of this member.

Above this comes 206.0 feet of thin bedded calcareous sandstones and shales. As one progresses upward thru the section from this point the Reagan becomes more and more calcareous in nature. This calcareous member is quite fossiliferous. The trilobites are fragmental consisting of genial spines, portions of free cheeks and pygydiums which are most abundant. In some places one is desirous of calling it a trilobite breccia.

The next 223.0 feet are calcareous beds composing the transition between the Arenaceous Reagan sandstone and the highly calcareous Arbuckle limestone series above. At the top of the transition zone in this locality there is an unconformity representing a short period of erosion.

Above this hiatus is a fine conglomerate composed of the igneous materials from the highlands to the southwest which form the core of the Wichita mountains lying to the southwest.

From the foregoing description of station A and B it seems evident that the Reagan sandstone on the north side of the Wichita mountains divides itself naturally into four phases. First, the basal conglomerate and quartzite; second, the highly argillaceous material of the lower central portion; third, the heavy, porous, brown sandstones forming pronounced escarpments; fourth, the calcareous upper phases marking the transition to the Arbuckle limestone above and separated from it by a slight unconformity. The total thickness of section B is 983.7 feet.

Section C, NW. ¼, sec. 26, T. 6 N., R. 14 W.

This section was measured up the face of the Reagan sandstone escarpment in the NW. ¼, sec. 26, T. 6 N., R. 14 W. (See map No. 2) The strike of the Reagan outcrops here is N. 47° W., and the dip is NE. 49°. Just south of this escarpment across a small valley is a large granite porphyry hill known locally as Old Baldy. This igneous mass forms the axis of an anticline whose axis is northwest-southeast. The physical character of this granite porphyry is the same as that of the granite porphyry further to the southeast in sections A and B. On the northeast limb of this anticlinal fold the exposure of the Reagan sandstone is perfect. It should normally appear on the southeast limb also, but due to erosion and deposition of alluvium which later has been subjected to

intensive cultivation, the Reagan sandstone is not visible. In parts of this valley south of Old Baldy one finds Red Bed deposits indicating marked erosion in pre-Permian time. Beyond the natural position of the Reagan one finds 7,000 to 8,000 feet of Arbuckle limestone exposed. In this, folding has been very pronounced. The Arbuckle limestone extends on toward the southwest to the valley which parallels the igneous core of the Wichita mountains. This valley is filled with granite wash from the mountains thus covering up any Reagan that might be present in this area.

In the NW. $\frac{1}{4}$, sec. 26, T. 6 N., R. 14 W. the basal Reagan rests unconformably upon the granite porphyry. The top of the igneous material was deeply weathered prior to the deposition of the Reagan sandstone upon it and the character of this contact is the same as that in the sections A and B previously mentioned.

The basal member of the Reagan sandstone is a conglomerate of a thickness varying from a few inches to three feet. The component of this conglomerate are rounded and subangular fragments of the underlying granite porphyry. The conglomerate member is highly arkosic grading upward into a quartzite similar in character to that mentioned in sections A and B. The combined thickness of both conglomerate and quartzite is rarely over 6 feet in this locality. See page 80 , S-37 for detailed description of the parent granite porphyry from which this was derived.

Above the quartzite lies 74 feet of arenaceous shale, with lenses of calcareous shales. The calcareous phases are often highly fossil-

iferous. The upper portions of this argillaceous unit of the Reagan sandstone contain thin beds of a brown sandstone separated by shale partings and containing some glauconite which imparts to it a greenish cast. The chief mineral constituent is quartz.

Just above this arenaceous unit of the argillaceous member and 80 feet from the base of the Reagan is an interformational conglomerate. Its thickness varies from a few inches to 4 feet. See Plate VIII-A for picture of this conglomerate. The lower portion of this conglomerate is composed of much finer materials than the upper portion. The constituent pebbles and boulders are smooth and well rounded, indicating considerable transportation on the part of the streams moving them. The basal part of this conglomerate contains a high percentage of glauconite which imparts a greenish tint to the rock. Here as elsewhere in the Reagan the glauconite is in a highly altered condition.

Above this interformational conglomerate is 37 feet of very coarse arkosic sandstone. This weathers very easily and usually leaves a valley. Above this is the brown, porous, heavy bedded sandstone, having in the basal portion chert stringers and lintils. This sandstone is more porous here at section C than at either A or B further to the southeast beyond the Blue Creek fault.

Above this brown sandstone lies a very fossiliferous zone of calcareous material. The fossils are largely fragments of trilobites with some brachiapods.

Above this fossiliferous zone is 68.8 feet of rock composed of interbedded calcareous and arenaceous material. Microfauna should be present in this zone. Above this is 6 feet of calcareous sandstone con-

taining fossils which are largely fragmentary.

Next above is 120 feet of massive brown sandstone which composes the major portion of the escarpment and is similar to that found in Section A.

The calcareous zone of the Reagan is here composed of 250 feet of thin bedded sandstone, limestone and shales, the latter acting as partings between the other two components. Here again this calcareous phase serves as the transition zone into the overlying Arbuckle limestone. The total thickness of the Reagan at Section C is 500.1 feet.

Section D, SE. $\frac{1}{4}$, sec. 35, T. 1 S., R. 1 E.

This section was made at right angles to the strike and parallel to the dip of the rocks along the west side of the valley of Honey Creek in the SE. $\frac{1}{4}$, sec. 35, T. 1 S., R. 1 E. located on the southwest flank of the East Timbered Hills. (See Map No. 3) The strike of the outcrops is N. 30° W. and the dip is SW. 43°. This is one of the best exposures of the Reagan sandstone in the Arbuckle mountains. Here the creek has cut back by headwater erosion into the plateau of Arbuckle limestone thru the Colbert porphyry and the Reagan sandstone. Thru the porphyry it has cut a narrow canyon-like valley. Once thru the resistant porphyry it worked rapidly thru the Reagan and on into the Arbuckle plateau the surface of which is the Jurassic peneplain. Tributaries to this valley of Honey Creek in the porphyry are controlled by joints; those developed in the Reagan by the strike and dip of the beds. This stream dissection has exposed the Reagan to the best possible advantage.

Unconformably underlying the Reagan sandstone in this section is the

Colbert porphyry which is pink in color. The phenocrysts in the poryphyry are orthoclase and microcline and they are in a groundmass of very fine material, consisting principally of quartz, feldspar, magnetite and pyrite. The quartz often contains abundant acicular crystals of apatite. The Colbert porphyry is characterized by large numbers of quartz spheurlites with magnetite and pyrite grains disseminated thru them which present beautiful forms which remind one of echinoids with all spines and spicules in place.

The upper surface of the porphyry was badly weathered and very irregular before the deposition of the basal Reagan sandstone upon it and numerous stream channels were carved upon it.

The first Reagan sandstone to be deposited upon this irregular, weathered surface of the porphyry was a coarse conglomerate. The basal portion is much coarser than the upper part and grades into a finer sand phase just above the conglomerate. The sizes of the rounded and subangular boulders in the conglomerate range from 12 to 17 inches with finer material filling the spaces between. The component parts of this conglomerate are fragments of the underlying porphyry and separate crystals of feldspar from the same source. The larger fragments are well worn stream or wave bowlders. Plates XII and XIII show detail photographs of this member. Thickness of this basal conglomerate ranges from 2.5 feet to 11.2 feet.

Next in order above this conglomeratic member lies 6 feet of quartzite which forms the south wall of a tributary valley carved out along the contact of the Reagan and the porphyry. It is a very hard resistant rock, pink in color and containing quartz and some feldspar grains. The

contacts between these different members at the base of the Reagan can be well observed in this valley wall.

Above the quartzite comes 171 feet of friable sandy beds with lintils of calcareous and argillaceous material. This portion of the Reagan is densely wooded and cut up by small tributary valleys and in it no fossils were found. At the top of this member the dip changes from 43° to 37°. The succeeding beds continue to flatten out for some distance and then abruptly increase to very steep dips of 85°.

Above the sandy phase is 74.5 feet of calcareous sandstone with lintils of very argillaceous materials and in local areas very fossiliferous. Quartz is the chief constituent with glauconite disseminated thru it as stringers having a green hue.

The succeeding 62.4 feet are of similar material, followed by 95 feet of alternating beds of shale and limestone with occassional sandstones. This marks the lower part of the calcareous phase of the Reagan sandstone above which is 28.5 feet of heavy bedded sandstone composed of well rounded quartz grains. The next 137.7 feet is composed of thin bedded limestone and markes the top of the calcareous phase which is likely to be differentiated from the Reagan sandstone and termed the Honey Creek formation if the suggestion of E. O. Ulrich and C. E. Decker is followed.(1) The basal part of the Honey Creek formation is the Ptychaspis zone of trilobites and just above it comes the sponge beds. Above these sponge beds the overlying Arbuckle becomes dolomitic and finally grades into the Royer marble.(2) The Reagan sandstone at section D is 575.3 feet in thickness.

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(1) Unpublished manuscripts.
(2) In unpublished manuscripts. See Appendix A.

Reagan West of the Washita River

The Reagan sandstone around the West Timbered Hills is essentially the same as that found in section D of the East Timbered Hills region. It is so similar that to describe the sections made here would be but a repetition of that given under section D of the Honey Creek section. There are three outcrops of Reagan around the West Timbered Hills as mentioned under the section of distribution of the Reagan sandstone, page 22. The one on the south flank of the hills is perhaps the best of the three. The one around the west and northwest end of the hills presents some interesting studies in structure, combinations of dip and thrust faults. The outcrop on the northeast flank of the hills is very incomplete.

Reagan East of the Washita River

East of the Washita River there are four outcrops of the Reagan sandstone as listed on page 43 under the section of distribution of the Reagan. Each is very similar in character to those east of the Washita River. The first of these is found along the western edge of the Tishomingo granite upon which it lies unconformably. This granite underlies each of the Reagan outcrops in this area. In the area west of the Tishomingo Granite and south of Mill Creek the Reagan dips to the west and southwest 12°. The thickness is less than 300 feet and contains at the base a phase high in feldspar content which is altering. Above this are two hard quartzitic members. At the top the usual calcareous phase is missing and it grades directly into marble similar in

character to the Royer found south of the East Timbered Hills. The arkosic sands at the base take the place of the conglomerates found farther to the west.

In the Area east of Reagan we have only the sand phase with a little of the calcareous phase which merges with the basal Arbuckle limestone. The calcareous phase here is much thinner than in the Timbered Hills region west of the Washita. This area has long been known as the type locality and is so described by Mr. Taff of the United States Geological Survey. The strike of the outcrop is N. 45° E, and the dip is NW. 22°.

The next outcrop lies to the north of the village of Milburn on the east side of the Blue River. This is a sandstone area lying between two faults. The Reagan outcrops in a grauben block. Due to the fragmental character and the absence of faunal evidence the writer doubts if this is true Reagan sandstone. If it is Reagan it should be the middle arenaceous member. The dip is northwest beneath the Arbuckle limestone. On the other three sides are found the Tishomingo granite upon which it rests unconformably. Erosion and resultant deposition of alluvium have covered the place where the contact occurs.

The last outcrop east of the Washita River lies just east of the hamlet of Ego southeast of Coleman and southwest of old Boggy Depot. It consists of a narrow belt between the Tishomingo granite on the southeast side and faults on the east and west sides, while on the northeast the Reagan dips beneath the Arbuckle limestone. In many places it is partially overlaid by the Trinity sand which is the basal member of the

Trinity Group. Only the middle portion of the Reagan is here present and is a thin, calcareous phase where it merges with the overlying Arbuckle limestone.

From this it will be seen that the Reagan reaches its maximum thickness in the Wichita mountains and thins out to the west and the east. The easternmost outcrop is less than 100 feet in thickness.

Lithology of the Reagan

Lithologically the Reagan sandstone divides itself into seven units. These units are conglomerate, sandstone, quartzitic phase, shaly phase, limestone phase, glauconite and iron oxide.

Conglomerate

There are two types of conglomerate, one basal and the other interformational. The basal conglomerate is not present in the Reagan outcrops south of the Wichita mountains and east of the Washita river in the Arbuckle mountains. The thickness of the basal conglomerate varies from 0 to 34.2 feet. The absence and thinner deposits of this conglomerate are on and around topographic hights in the surface of the pre-Reagan peneplain upon which it was laid down by streams flowing into encroaching Reagan seas. The greater thickness is found in accumulations of conglomerate in valleys carved in the surface of the old eroded surface. In stream valleys which have been cut in the present surface of the land and at right angles to the strike of the Reagan outcrops marked thinning is noted on the seaward side of the shore line. One would expect to find local thickening of the conglomerate about the mouths of

pre-Reagan streams but field work has not revealed such a condition. In a few instances the basal conglomerate is entirely absent. One in sec. 21, T. 4 N., R. 12 W. just east of section B and again in the east central part of T. 2 S., R. 3 E. where the Reagan is entirely absent.

South of the Wichita mountains the base of the Reagan is not exposed hence we were not able to examine the basal members of the formation, or the rocks underlying Reagan sandstone.

In all cases the basal conglomerate is composed of subangular and rounded fragments of the underlying igneous formations. The sizes vary from sub-microscopic pieces to one 3.5 feet in diameter. The majority of the larger fragments are 4 inches to 9 inches in size. (See pages 15 and 50 section B on pre-Reagan formations for detailed descriptions of these pre-Reagan formations) In the Wichita area it is composed of Colbert porphyry and fragments of dikes which cut the porphyry. Plate XII-A & B and XIII shows the character of this conglomerate in the Honey Creek section in the East Timbered hills. S-54, page 79 shows the microscopic nature of the Colbert porphyry and S-2, page 78 shows the character of the granite porphyry of the Wichita area. There is much quartz in the finer phases of the conglomerate. Locally one finds considerable orthoclase and microcline which is indicative of the proximity of the source of the material. In the top phases of the conglomerate where it grades into the finer zones considerable glauconite is found.

In section C, NW $\frac{1}{4}$, sec. 26, T. 6 N., R. 14 W. 80 feet above the base of the Reagan sandstone is an interformational conglomerate from a few inches to 4 feet in thickness. See Plate VIII-A for pictures of this

conglomerate. The member below this is 74 feet arenaceous shales, the top members of which contain much glauconite. In Plate VIII-A the dark bands in the strata just below the conglomerate is glauconite. The lower portion of the conglomerate is composed of very fine materials grading upward into coarse rounded bowlders 4 to 6 inches in diameter. The size of the pieces continues to decrease as one nears the top of the conglomerate and gradually merges with the compact sandstone layer just above. Glauconite is abundant enough in the basal portion of the conglomerate to impart a green color. The pebbles and sand of this conglomerate are smooth, well rounded fragments indicating considerable transportation from their place of origin. Their source was the igneous core of the mountains to the southwest which,at that time, was higher than the region to the north where streams carried them. This conglomerate indicates one of two possibilities. Either, the sea became shallower, thus allowing deposition of coarser materials, of a mountain freshet resulting from a torrential down pour of rain during a thunder storm or a period of continued precipitation might have developed currents strong enough to carry the coarser materials further to sea than would be the case in normal periods of rainfall. The change in depth of sea water indicated under the first possibility might happen under one of two conditions; first, the emergence of the coast line; second, a retreat of the shore line seaward. This set of conditions may have been developed by local warping of the coast line, or adjustment by faulting of local stresses. The galuconite contained in this interformational conglomerate is highly altered to calcite.

The petrographic and petrologic character of these fragments can be noted in detail in S-2, page 78 . Further studies of these conglomerates may reveal traces of pre-Reagan rocks other than the igneous and metamorphics known and described under Pre-Reagan Formations in the Wichita mountains.

Sandstone

The Reagan sandstone is highly arenaceous except in the topmost members where it grades into a calcareous zone of transition into the overlying Arbuckle limestone. There are in the Wichita mountain area two zones of sandstone within the Reagan sandstone, one of which lies just above the quartzite member and the other just above the argillaceous member.

The thickness of the sandstones vary from place to place within a single outcrop which is accounted for by the lenticular character of individual beds. The color is a brownish grey excepting where there is enough glauconite to give it a greenish hue or a dark green color. Some of the stringers and lintils are nearly pure glauconite. The texture of the sandstones is uneven and the diameter of the grains varies from 0.1 mm. to 1.5 mm.

Macroscopically the following minerals can be observed: quartz, feldspar, calcite, glauconite and hematite with occasional small fragments of rock. The quartz occurs as clear or frosted grains subangular and angular in shape, having a diameter of less than 1.5 mm. and is the natural cement that indurates the rock. Feldspar is present as fragmental crystals of orthoclase and microcline and weathering of the angular fragments is not pronounced which indicates that they have not

been transportated far. Glauconite is present in considerable abundance, both as disseminated and concentrated groups. In stippled dissemination it often imparts a greenish hue to the rock but where concentrated it lends a dark green color. The grains are rounded and under a hand lens show alteration to calcite. See page 83 S-4 for detailed description and photomicrograph of a thin section of this condition. The dark, opaque grains are glauconite. Calcite is present in association with the glauconite and as replacement produced in fossils. See page 92 S-26 for photomicrograph showing calcite in fossils. Note, in each case, that the calcite outside the fossil is highly twinned. Calcite also occurs as vein material. See page 88 S-10 for photomicrograph of this condition. Iron oxide occurs as hematite in the basal members of the Reagan sandstone in sections A and B on the north side of the Wichita mountains. In any of the Reagan outcrops one can find individual mineral grains that have an encasement of iron oxide. Photomicrographs of S-21, page 91 illustrate this point. In surface exposures the hematite is often altering to limonite.

Petrographic study reveals the physical character of the mineral grains in greater detail. The quartz grains occur as clear, frosted grains, subangular and rounded. The frosted character indicates that the grains have been transported for considerable distances or that they have been subjected to severe mechanical abrasion locally. Many of the grains are encased with alayer of iron oxide which is very difficult to remove. Boiling for 20 minutes in a 10 per cent solution of HCl fails to remove all of it. The quartz contains numerous inclusions, the most

abundant being acicular crystals of apatite, disseminated grains of magnetite, gas and liquid cavities. Some of the quartz is drusy, particularly those samples from the region east of the Washita river in the Arbuckle mountain region. The photomicrograph in S-8, picture No. 48, page 86 shows an excellent example of reticulated rutile commonly known as Venus' hair. This is noted in the large, clear grain occupying the center of the field. The quartz is uniaxial and positive in character and in size the grains average 1.0 mm. and compose from 3 per cent to 85 per cent of the rock.

Chlorite occurs as brown tabular, acicular crystals and fragments of crystals in 0.5 mm. sizes, composing in some cases as much as 4 per cent of the rock. In two cases chlorite was found as stringers and veinlets.

Feldspar as orthoclase and microcline occur widely in the sandy phases of the Reagan, as crystals and fragmental crystals, often grey in color and tabular in shape, showing very little alteration. The fragments are often beautifully twinned, particularly in the case of the microcline. The sizes of the feldspar fragments vary from 0.1 mm. to 2.0 mm. and compose as much as 10 per cent of the rock.

Glauconite occurs in varying sizes up to 1.5 mm. in diameter and may compose as much as 60 per cent of the rock. The glauconite is in a highly altered condition, calcite being the alteration product. The presence of leucoxene in some of the grains indicate that there was some ilmenite present in the rock. The calcite may give the key to the origin of the glauconite. In some of the present glauconite materials, viz., those of New Jersey, it seems that Foraminifera has been largely

responsible for the condition. The question then arises as to whether foraminifera existed during Reagan time in the seas occupying the region now known as the Arbuckle and Wichita mountains. Faunal studies indicate that Foraminifera were present in the Cambrian.

Iron oxide is present in different forms, sometimes as coating over the surface of mineral grains. The quartz grains have been covered in this manner more than the others. Hematite occurs in irregular and small globular masses in the basal portions and in two cases in commercial quantities. In sections A and B the hematite amounts to 30 per cent of the rock. Iron occurs in magnetite grains disseminated thru the rock and as inclusions within the quartz. Pyrite is present as interstitial grains, 0.5 mm. in size and in some cases composing 2 per cent of the rock. Pyrite is altering to the limonite also.

Rock fragments composed of fine conglomeratic and brecciatic material are present in the basal part of the lower sandstone member of section A. The size of these rock fragments is greater than 0.4 mm. and less than 1.0 mm. diameter. In two specimens they compose 5 per cent of the rock. The origin of these is sediment older than the Reagan sandstone. Where these are located and from whence they came is unknown. It is safe to suppose that they were derived from the material composing the igneous core of the mountains or highlands which served as a partial source of the Reagan itself. Later uplift and consequent erosion carried these away and utilized their fragments in the building of the Reagan sandstone. C. H. Taylor in his bulletin on the Granites of Oklahoma, issued by the Oklahoma Geological Survey, mentions some pre-Reagan sedi-

mentary quartzite, the Meers quartzite and sandstone older than the granite and gabbro which now compose the core of the Wichita mountains. Probably the Meers quartzite was the material from which these rock fragments were derived.

The sandstones of the upper arenaceous phase contain the same series of minerals with a number of calcareous and cherty stringers.

Quartzitic Phase

The part of the Reagan sandstone at the bottom is a hard, resistant, scarp-forming quartzite in certain localities. Generally a brownish red in color and very fine grained. Below it is either a conglomerate, arkose sand or the underlying pre-Reagan rocks. This quartzite is best developed on the northeast flank of the Wichita mountains. Here the quartzite forms a low escarpment at the base of the main Reagan escarpment. Plate IV-A, shows the nature of this quartzite in the outcrop. In thickness this member varies from 2.5 feet to 30.0 feet in thickness. The component parts are 0.1 mm. to 5 mm. in diameter, and are composed of quartz, feldspar and fragments of porphyry. The quartz is rounded and some of it shows secondary enlargement. Macroscopically it is glassy. Under the microscope some of it is clear and some drusy. Bubble inclusions are abundant. Some grains are frosted, others twinned. The rock fragments are angular and vary in size from 0.3 mm. to 4.0 mm. In the lower and upper phases of this quartzite we have glauconite and feldspar, the latter being but little weathered. The glauconite is highly altered. Quartzite is normally formed under two sets of conditions; first, by metamorphism of the sandstone thru heat and pressure; second, by cemen-

tation of the grains by quartz. The latter method is most plausible in this case since we find that the cement used by nature in indurating this rock is quartz. The agent carrying out the cementation was without doubt water containing silica.

This quartzite occurs also in the East and West Timbered Hills sections of the Arbuckle mountains. The character of the stratum is the same as that described from the Wichita mountain section. In the West Timbered Hills section the quartzite rarely exceeds 6 feet in thickness. In the region east of the Washita no quartzite is known to occur.

Shaly Phase

The shale strata of the Reagan sandstone is very disappointing for it is very soft, weathers easily and since it occurs in a valley fresh specimens are almost impossible to obtain. The writer was not able to procure a single fresh specimen of this shale, therefore, the petrographic character is unknown. In the upper part of the calcareous section are found the thin, paper-like beds of shale which serve as parting strips between the heavy, calcareous beds of arenaceous limestones. This shale member in the lower middle part is persistant thruout the northern part of the Wichita mountains and around the West Timbered hills section. In the rest of the Reagan areas the shale is either absent or covered by erosion of other beds, which have left it buried beneath a load of alluvium and is now covered with a dense growth of vegetation.

These shales indicate a change in the sedimentary conditions of the borders of the Reagan seas. Where sandstone is the underlying strata the seas were deepened, with the resultant deposition of the shale. If lime-

stone is the underlying formation then there was a marked shallowing of the seas. In the upper calcareous Reagan we have some fourteen highly calcareous beds separated by as many argillaceous members. In upper Reagan time there is positive proof of considerable oscillation of the shoreline of the Reagan seas. This oscillation may have been due to the beginning tremors of the Applachian revolution or it may have been due to some local adjustment of forces affecting only this portion of the North American continent. However, the former seems the more logical deduction since we have, during the Ordocician period, a general advance of the sea over the continent of North America.

Iron Oxide

These deposits are well distributed thruout the Reagan sandstone. In the basal members of the formation the accumulation is markedly greater than in the upper. In the Wichita mountains on the northeast flank at section A and B we have an accumulation of iron oxide in the form of hematite that is commercially valuable. It had, for a long period of time, been worked by the natives of the neighborhood as a source of pigment for cheap paint manufactured for their own use. At the present time a mining company is mining the ore by the strip method. It has been estimated by one of their engineers that there are 500,000 tons of the ore immediately available. From whence came this hematite? Under the microscope we find that a great deal of it is oolitic in nature. This suggests an accumulation of the ore along a coast line. Perhaps it was the accumulation of the iron secretions from some organism. Or was it a chemical precipitate? Mr. Shead of the School of Chemistry is strongly inclined to believe that oolites are chemical precipitates. The writer is inclined to believe that

this particular accumulation of hematite is due to ground water concentration. However, the writer does not rule out the other possible causes. Under the conditions present, the ground water theory seems to be the most plausible. When the extent and exact nature of the deposit is known it will be possible to deduce more correct conclusions regarding its genesis. To date, not even the core drill has been employed to determine the extent of the ore body. It is interesting to note that the basal Reagan wherever exposed along the north side of the Wichita mountains, contains a high content of hematite.

Glauconite

Glauconite is one of the most common of the opaque minerals found within the Reagan sandstone. It is distributed thru the entire formation and its concentration is slightly greater in the middle members. The character of the glauconite is always the same, being highly replaced by calcite and occasionally altered to leucoxene. Its characteristic green color imparts a greenish hue or a dark green color to the rocks in which it occurs. It is often concentrated in bands imparting a graphic character to the sandstone layers. This anomoly usually occurs just below a layer of coarser material. See Plate VII-A. The sizes of the glauconite grains vary from submicroscopic to large grains 1.5 mm. in diameter and sometimes compose as much as 60 per cent of the specimen examined.

The presence of leucoxene bespeaks the presence of ilmenite associated with the grains of glauconite before alteration began. The calcite occurs both as primary and secondary mineral. Where it is secondary,

ground water has had a large part in its formation. Where it is primary the theory of Murray and Renard offers the best explanation of its presence.

Glauconite is a hydrated silicate of potassium and ferric iron. Chemical analyses vary from sample to sample. It is being formed at the present time near the mud line off continental shores. It occurs as granules within rocks of all ages from Cambrian to the most recent and within present arable soils. See L. Cayeux, Annales Soc. geol. du Nord, Vol. 34, 1905, p. 146 for full description of this condition.

The origin of glauconite has been the subject of much discussion on the part of chemists and geologists for a number of years. The Challanger Reports give its location as being most abundant in the sea, "just beyond the limits of wave and current action or, in other words, where fine muddy particles commence to make up a considerable portion of the deposits." It is developed principally in the interior of shells and the mode of formation is obscure. Murray and Renard argue that after death of the organism the shell becomes filled with fine mud, upon which, in the presence of the sulphates of sea water, the organic matter of the organism may act. The iron of the mud is reduced to sulphide, which afterward oxidizes to ferric hydroxide, the alumnia being removed at the same time in solution, and colloidal silica set free. The latter, acting upon the hydroxide, in the presence of potassium salts derived from adjacent minerals, finally produces glauconite. This theory is supported by observation that glauconitic shells are always associated with the detritus of terrigenous rocks which contain orthoclase, muscovite, and other minerals from which potassium can be obtained. This explanation

of the formation of glauconite is sufficient for most of the glauconite found in sediments but some glauconite is obviously not formed in this manner.

L. Cayeux, in Mem. Soc. geol. du Nord, Vol. 4, pt. 2, 1897, pp. 163-184 has shown that in certain instances glauconite was formed subsequent to the consolidation of its rocky matrix. He admits that glauconite can be formed in the manner described above, from organisms, but insists that it may be formed in quite another manner. He does not indicate the nature of this mode of formation. He notes that ferric hydroxide and pyrite are formed during the decomposition of glauconite and this seems to substantiate the contention of Murray and Renard.

Another mineral, celadonite, is regarded by Dana and others as having the same composition as glauconite, and being very difficult to distinguish from glauconite has no doubt been confused with glauconite by the casual observer. This mineral is monoclinic, generally non-crystalline, yet having distinct cleavage and regarded by Lacroix as analogous to the micas. It occurs as a decomposition product of augite in various basaltic rocks. It is green in color, earthy in texture and never granular as in glauconite. It is similar to some of the chloritic minerals and identification should be reserved until complete chemical analysis has been obtained.

The final reactions in the formations of glauconite, regardless of the genesis, are the same. Potassium and soluble silica being absorbed by colloidal ferric hydroxide. In the ocean these materials are produced by the action of decaying animal matter upon ferruginous clays and fragments of potassium bearing silicate minerals. In sedimentary deposits where the glauconite is secondary, the action of percolating waters upon

the hydroxide would account for its formation. In igneous rocks the hydroxide is derived from the augite, or perhaps olivine, percolating water again playing an important role.

The formation of glauconite and celadonite thus become, in the words of Clarke, Data of Geochemistry, U. S. G. S. Bull. No. 770, p. 522, "the results of a single process, which is exactly equivalent to that in which potassium compounds are taken up by clays."

Limestone Phase

The limestone phases of the Reagan sandstone occur at the top of the formation. Here the limestone is almost as hard tho not quite as blue as that of the overlying Arbuckle limestone. Beginning at the base of the Reagan the formation is highly arenaceous but the nearer the top is reached the more calcareous it becomes. The color of the calcareous phases is light grey. It is compact and crystalline. The chief constituent is calcite as fossils and as twinned crystals the latter occupying veins evidently having been brought in by ground water. The calcite is often euhedral, grey in color and composes 80 per cent of the rock and in 1.0 mm. sizes.

Chlorite is present, as acicular crystals 0.2 mm. long, composing 5 per cent of the rock. Glauconite is present in as much as 5 per cent of the rock, in a highly altered condition and in 0.1 mm. sizes. Quartz occurs in finely disseminated grains with glauconite inclusions. Occasionally a rock fragment is found which is subangular in shape and as much as 1.5 mm. in size. These fragments contain quartz, feldspar and pyrite. Fossils are very abundant in the calcareous phases. Some zones

contain brecciated trilobites and brachiapods. See page 87 S-9, S-13, and S-26 for detailed descriptions and photopicrographs of thin section of the calcareous phases of the Reagan.

Microscopic Descriptions and Photomicrographs of the Pre-Reagan and Reagan Rocks

S-2, Granite Porphyry.
Wichita Mts.
Sec. A.





MACROSCOPIC:

Color reddish-brown, weathering to dark reddish-brown or dark grey.

Crystals vary in size from 0.1mm. to 0.5 mm.

Chief minerals present in hand specimen are:

1. Feldspar, as large pink phenocrysts in a fine grained groundmass in which is a considerable quantity of a
2. Dark, greenish mineral which in turn is associated with
3. A dark grey to black mineral (Hornblende ?) and
4. Quartz in great abundance as fine grains within the ground mass.

MICROSCOPIC:

Texture of the rock is porphyritic. The ground mass is crystalline with quartz as chief mineral. The minerals present are:

1. Quartz:
   composing about 40 per cent of the rock; occuring as clear irregular grains 0.05 mm diameters. Many grains have numerous bubble inclusions.

2. Feldspar:
   composing about 55 per cent of the rock; occuring as euhedral and acicular crystals in 0.07 mm sizes. Many are much larger and are in the form of phenocrysts showing very little alteration. Twinning is very common.

3. Pyrite or Magnetite (?):
   composes about 5 per cent of the rock occuring in the form of opaque, irregular grains averaging 0.1 mm in diameter. Some pieces seem to be altering to limonite.

S-54, Colbert Porphyry.
Section D,
Arbuckle mountains.





MACROSCOPIC:

Color of rock is red weathering to brownish red. Texture is porphyritic.

Crystals vary in size from 0.1 mm. to 5.0 mm.

Chief minerals present are:

1. Feldspar as phenocrysts, 0.1 mm. to 5.0 mm in size.
2. Quartz as fine grains within the ground mass.
3. Kaolin as an alteration product of feldspar.

MICROSCOPIC:

The texture of the rock is porphyritic, the ground mass contains numerous grains and spheurlites of quartz. The minerals present are:

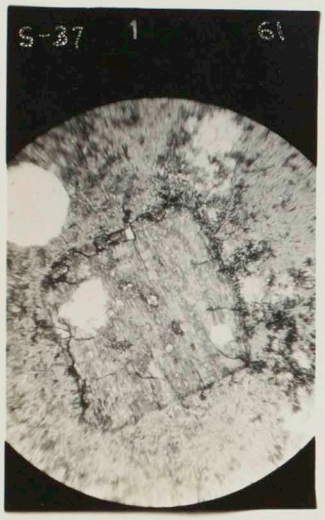
1. Feldspar:
   as microcline in tabular phenocrysts, altering to kaolin. These average 0.8 mm. in size.

2. Quartz:
   as grains and spherulites containing numerous grains of magnetite, pyrite and acicular apatite. These spherulites average 0.6 mm. in diameter. These are characteristic of the ground mass structure of the Colbert porphyry.

3. Magnetite and pyrite:
   as grain inclusions 0.08 mm in size within the spherulites of quartz.

4. Apatite:
   as acicular crystals 0.01 mm. in size within the ground mass and quartz spherulites

S-37, Granite porphyry,
Weathered specimen,
Section C,
Wichita mountains.





MACROSCOPIC:

This rock is pink and red in color with a porphyritic texture composed of crystals 0.1 to 3.0 mm. in size.

Minerals present are:

1. Feldspar:
   as large pink phenocrysts.
2. Quartz:
   as clear irregular masses within the ground mass.
3. Pyroxene: (?)
   as a dark green mineral.

MICROSCOPIC:

The rock is porphyritic in texture, with ground mass very fine grained. The color is red, opaque or green, depending upon which mineral is dominant.

Minerals present are:

1. Feldspar:
   as 2.5 mm. phenocrysts, in crystals containing quartz inclusions and altering to kaolin. It composes 40 per cent of the rock.
2. Quartz:
   as irregular masses within the ground mass.

S-38, Granite Porphyry,
Section C,
Wichita mountains.



MACROSCOPIC:

This porphyritic rock varies from red to dark pink in color and weathers to light pink or brown. The component parts are 0.1 mm. to 5.0 mm. in size.
Minerals present are:

1. Feldspar:
   as large, pink phenocrysts within a groundmass of fine, compact and even textured material.

MICROSCOPIC:

Texture porphyritic with very fine grained groundmass.
Minerals present are:

1. Quartz:
   as tabular grains and crystals 2.0 mm. in size and containing abundant inclusions.
2. Feldspar:
   as tabular crystals altering to kaolin in 2.0 mm. size.
3. Chlorite:
   as bluish, green acicular crystals 1.0 mm. in size.

S-3 - Reagan sandstone
Wichita Mts.,
Sec. A.



MACROSCOPIC:

Color is grey, weathering to a light lead grey.
Texture is coarse. Altered in places to a quartzite.
Sizes of grains 0.1 to 0.2 mm.
Chief minerals present are:

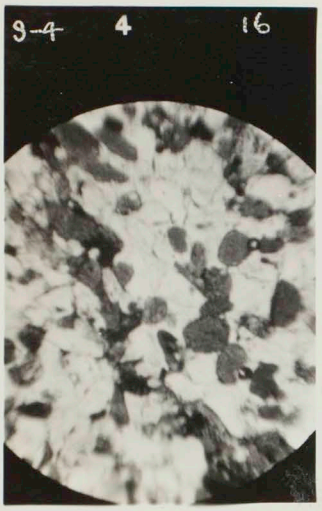
1. Quartz:
   as grains well rounded and subangular.
2. Feldspar:
   pink, subangular grains, some slightly rounded; very little alteration or weathering present.

MICROSCOPIC:

Texture of the rock is coarse; composed of rounded grains.
Minerals present are:

1. Quartz:
   as rounded, frosted, fractured grains of 2.0 mm. size. Some show secondary enalrgement. Composes 90 per cent of the rock.
2. Pyrite:
   as opaque rounded and irregular grains of 0.05 mm. size. Some seem to be of secondary origin. Composes 1 per cent of the rock.
3. Feldspar:
   as weathered material, perhaps from this source.
4. Chlorite:
   composing a few per cent of the rock, occuring as acicular brown fragments 0.2 mm. long.

S-4, Reagan sandstone,
Wichita Mts.,
Sec. A.





MACROSCOPIC:

Color grey, weathering to a lighter grey.
Texture is medium grained; some portions being fine others grading into very coarse material. Grains are subangular and well rounded, sizes of grains 0.5 mm to 1.5 mm.
Minerals present are:

1. Quartz:
   as angular, subangular and rounded grains well cemented together.
2. Glauconite:
   as green, rounded irregular grains.

MICROSCOPIC:

Texture of the rock is medium, grains cemented.
Minerals present are:

1. Quartz:
   as angular, rounded, and subangular clear and frosted grains 1.5 mm in size; having feldspar inclusions. Composes 90 per cent of the rock.
2. Glauconite:
   as green irregular grains of 0.5 mm size, generally altering to calcite. Composes 5 per cent of the rock.
3. Pyrite or Fe. oxide:
   as opaque interstitial grains in 0.5 mm. sizes. Composing about 2 per cent of the rock. Some of it altering to limonite.
4. Chlorite:
   as brown tabular, acicular crystals and fragments in 0.5 mm. sizes, composing 2 per cent of the rock.
5. Feldspar:
   ?

S-5, Reagan sandstone,
Wichita Mts.,
Sec. A.

MACROSCOPIC:

Grey in color, weathering to a brownish-black.
Texture is fine. Sizes of grains less than 1 mm.
Minerals present are:

1. Quartz:
   as glassy rounded, subangular grains less than 1 mm. in size.
2. Glauconite:
   as a green, rounded and granular grains, disseminated in stippled fashion thruout the specimen.
3. Calcite:
   as fragments of organic materials, perhaps brachiopods.(?)

MICROSCOPIC:

Texture of the rock is fine.
Minerals present are:

1. Quartz:
   as clear, rounded, frosted grains of 1 mm. size composing 80 per cent of the rock. Some of the grains are enclosed in a layer of iron oxide.
2. Glauconite:
   as green, rounded grains of 0.2 mm. size composing 10 per cent of the rock. Often altering to calcite.
3. Feldspar:
   as grey, angular and tabular fragments of 0.2 mm. size, showing very little alteration.
4. Chlorite:
   as stringers and veinlets of opaque or brown color, in 0.9 mm. sizes composing about 4 per cent of the rock.

S-6, Reagan sandstone,
Wichita Mts.,
Sec. A.



MACROSCOPIC:

Color dark greenish grey, weathering to black or brown.
Texture is fine with sizes of grains less than 1.0 mm. in size.
Minerals present are:

1. Glauconite:
   as a green, granular mineral in sufficient quantity to give dominant color to the rock.
2. Quartz:
   as fine rounded grains in great abundance.
3. Oxide of iron in form of limonite.

MICROSCOPIC:

Texture of rock is granular, in sizes as indicated above.
Color of specimen in thin section grey stippled with green.
Minerals present are:

1. Glauconite:
   as rounded irregular grains of green color in 0.8 mm. sizes, often altering to calcite and composing about 60 per cent of the rock.
2. Quartz:
   as rounded, clear grains of 0.5 mm. size, composing 30 per cent of the rock.
3. Feldspar:
   as subangular fragments 0.1 in size and composing about 10 per cent of the rock.

S-8, Reagan sandstone,
Wichita Mts.,
Sec. A.

MACROSCOPIC:

Color greenish-black, weathering to a dark greenish grey.
Texture is medium to very fine, with sizes of grains between 0.01 mm. and 0.9 mm.
Minerals present are:

1. Quartz:
   as rounded, angular and subangular grains.
2. Glauconite:
   as rounded irregular grains in sufficient abundance to give color to the rock.
3. Iron oxide stains present.

MICROSCOPIC:

Texture and color of rock as described above.
Minerals present are:

1. Quartz:
   as clear, irregular, twinned, drusy grains of 1.0 mm. size, composing 33 per cent of the rock. Some of the grains are encased in iron oxide.
2. Glauconite:
   as green irregular grains of 0.4 mm. size altering to calcite, and composing about 30 per cent of the rock.
3. Calcite:
   as irregular grains showing cleavage and twinning, occurs in 1.0 mm. sizes, composing 30 per cent of the rock. Perhaps altered from aragonite.
4. Feldspar: (?)
   as angular fragments of 0.3 mm. size.
5. Rock Fragments:
   composed of rounded and subangular fragments of a fine conglomeratic breccia in 0.4 mm. sizes and composing 5 per cent of the rock.

S-9, Reagan sandstone,
Wichita Mts.,
Sec. A.

MACROSCOPIC:

Color light grey, weathering to a dark grey.
Texture hard crystalline, thin bedded, off times laminated and may be very friable. Sizes of grains less than 20 mm.
Minerals present are:

1. Calcite:
   as angular fragments showing cleavage and sometimes twinning. Derived from alteration of aragonite. (?)
2. Glauconite:
   in thin bands parallel to the bedding planes. Altering to Calcite.
3. Calcite:
   in the form of fragments of trilobites. Glabella cephalon and genial spine portions very abundant.

MICROSCOPIC:

Texture of the section is granular.
Minerals present are:

1. Glauconite:
   as green colored irregular grains of 0.2 mm. size composing 3 per cent of the rock.
2. Calcite:
   as clear irregular twinned fragments altered from aragonite and in 2.0 mm. sizes, composing 85 per cent of the rock.
3. Quartz:
   as clear gray sometimes drusy grains of 1.0 mm. size comprising 15 per cent of the rock.
4. Chlorite:
   as brown, acicular fragments of 1.0 mm. size composing 2 per cent of the rock.

S-10, Reagan sandstone,
Wichita Mts.,
Sec. A.



MACROSCOPIC:

Color reddish-brown with green bands, weathering to a brownish grey with occasional green tints.
Texture fine, associated with lamination and cross-bedding.
Sizes of grains less than 2.0 mm.
Minerals present are:

1. Quartz:
   as rounded grains arranged in bands.
2. Glauconite:
   as green grains rounded and irregular, in bands between laminae of quartz.

MICROSCOPIC:

Color alterating bands of green and grey.
Texture of section is fine.
Minerals present are:

1. Glauconite:
   as green irregular grains 0.1 mm. size, and comprising 8 per cent of the rock.
2. Quartz:
   as frosted rounded, subangular and secondarily enlarged grains of 0.1 mm. size, composing 85 per cent of the rock.
3. Chlorite:
   as brownish tinted tabular fragments and stringers of 1.0 mm. length, composing about 5 per cent of the rock.
4. Pyrite:
   as opaque irregular grains of 0.1 mm. to 2.0 mm. size.

S-11, Reagan sandstone,
Wichita Mts.
Sec. A.



MACROSCOPIC:

Color brownish-grey weathering to dark grey or black.
Texture fine crystalline quartzitic. Size of grains sub-macroscopic.
Minerals present are:

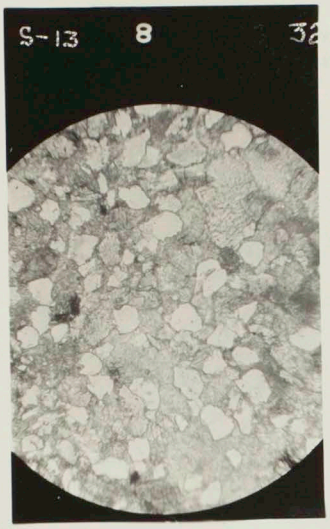
1. Quartz:
   as very fine grains, rounded and subangular.
2. Calcite:
   as irregular grains and interstitial forms.
3. Glauconite:
   as fine rounded irregular grains in bands.

MICROSCOPIC:

Texture very fine.
Minerals present are:

1. Glauconite:
   as irregular grains altering to calcite.
   0.1 mm. in size and composing 5 per cent of the rock.
2. Pyrite:
   as opaque grains irregular in form, less than 0.1 mm. in size and composing 5 per cent of the rock.
3. Quartz:
   rounded, sometimes frosted grains of 0.1 mm. in size and composing 25 per cent of the rock.
4. Calcite:
   as irregular, angular and subangular grains of 0.1 mm. in size and smaller, comprising 45 per cent of the rock. Calcite derived (?) from altered aragonite.
5. Rock Fragments:
   as brownish, subangular fragments of 2.2 mm. in size composed ofquartz and feldspar, the latter altering to kaolin. These fragments compose about 20 per cent of the rock.

S-13, Reagan sandstone,
Limestone phase,
Section A,
Wichita mountains.



MACROSCOPIC:

The rock is hard, compact and weathers to a dirty grey color. The grains are largely submicroscopic in size.

Minerals present are:

1. Calcite:
   as individual grains disseminated thru rock and as replacement products in organic remains.
2. Quartz:
   present as grains.
3. Fossils:
   present as trilobite remains, free cheeks, glabellas, with genial spines predominating.

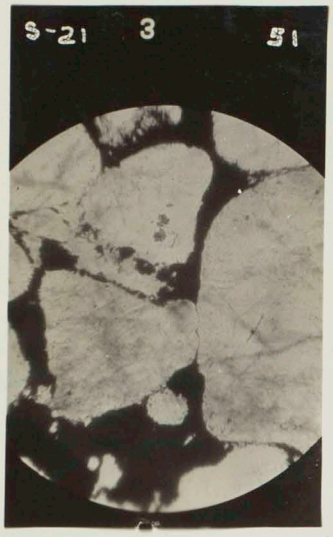
MICROSCOPIC:

The texture is very fine and even grained.

Minerals present are:

1. Glauconite as altered, rounded, green grains, 0.1 mm. in size composing 2 per cent of the rock.
2. Quartz:
   as grey colored, rounded grains 0.1 mm. in size, composing 80 per cent of the rock.
3. Calcite:
   as irregular grains, 0.2 mm. in size, composing 10 per cent of the rock.
4. Chlorite:
   as acicular crystals and stringers, 0.5 mm. in size composing 10 per cent of the rock.
5. Pyrite: (?)
   as irregular, opaque grains 0.01 in size and composing about 1 per cent of the rock.

S-21, Reagan sandstone,
Section B,
Wichita mountains.



MACROSCOPIC:

Fresh specimens of the rock are red in color, altering to a lighter red, with numerous solution cavities in the surface. The material is coarse and composed of subangular and rounded fragments, 0.1 mm. to 2.0 mm. in size.

Minerals present are:

1. Quartz:
   as irregular and rounded grains.
2. Hematite:
   as coatings over the grains which imparts the reddish color to the stone, and as oolitic concretions.
3. Fossils:
   as small brachiapods.

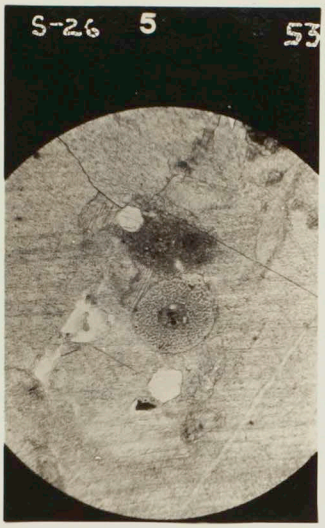
MICROSCOPIC:

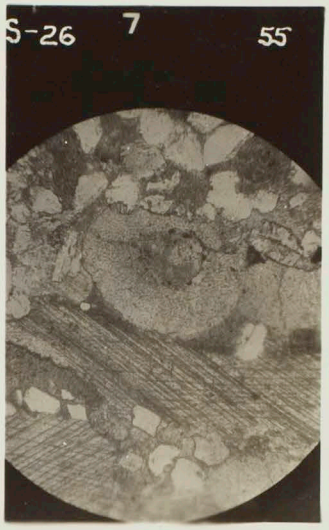
The texture of the rock is very uneven.

The minerals present are:

1. Quartz:
   composing 60 per cent of the rock, as clear, rounded grains 0.4 mm. in size with numerous bubble inclusions.
2. Pyrite:
   as irregular, black and opaque grains 0.1 mm. in size composing 2 per cent of the rock. Some alteration to limonite is noticable.
3. Hematite:
   composing about 2 per cent of the rock.
4. Glauconite:
   as 0.1 mm. grains, irregular in size and composing about 1 per cent of the rock. Replacement by calcite is common.
5. Feldspar:
   composes about 10 per cent of the rock and is rounded in form, grey in color and 0.25 mm. in size.

S-26, Reagan sandstone,
Calcareous phase,
Section B,
Wichita mountains.





MACROSCOPIC:

Specimens are grey in color weathering to a lighter grey, very compact and crystalline, composed of crystals 0.1 mm. to 0.5 mm. in size.

Minerals present are:

1. Calcite:
   as abundant grains and replacement material in fossils.
2. Glauconite:
   very abundant and arranged in bands.
3. Fossils are very abundant, being replaced by calcite. Trilobites cephalons, glabellas, genial spines and small brachiapods in casts and molds.

MICROSCOPIC:

It is a medium grained, crystalline, colorless to grey rock.

Minerals present are:

1. Calcite:
   as altered aragonite, grey in color, euhedral in shape 1.0 mm. in size and composing 80 per cent of the rock.
2. Chlorite:
   as brown acicular grains 0.2 mm. in size and composing about 5 per cent of the rock.
3. Glauconite:
   as highly replaced by calcite, green irregular grains 0.1 mm. in size composing 5 per cent of the rock.
4. Quartz:
   clear and grey irregular grains 0.7 mm. in size, with glauconite inclusions and composing 5 per cent of the rock.
5. Rock fragments containing feldspar and quartz in 1.5 mm. subangular pieces composing 5 per cent of the rock.
6. Fossils are very abundant as calcite. Crinoid stems and brachiapods are most abundant.

S-27, Reegan sandstone,
Section B,
Wichita mountains.

MACROSCOPIC:

Rock is greenish grey, weathering to dark grey upon exposure. The texture is fine, very compact and with laminated bands of cross-bedded sandstone. Ripple marks are occasionally observed.

Minerals present are:

1. Quartz:
   as rounded and irregular grains.
2. Glauconite:
   as irregular bands and disseminated grains.

MICROSCOPIC:

Texture is fine and compact with a mottled coloration.

Minerals present are:

1. Glauconite:
   as green, altered, rounded grains 0.2 mm. in size and composing 10 per cent of the rock.
2. Pyrite:
   altering to limonite, as opaque, rounded grains 0.1 mm. in size composing 1 per cent of the rock.
3. Quartz:
   clear, rounded grains 0.1 mm. in size with round and square inclusions, composing 80 or more per cent of the rock.
4. Chlorite:(?)
   as brownish hued, acicular crystals and stringers 0.2 mm. in size composing 5 per cent of the rock.

Summary and Conclusions

As determined upon a faunal basis by Dr. E. O. Ulrich of the United States Geological Survey, the Reagan sandstone is Upper Cambrian and as indicated by the fragmental character of its composition, it is of clastic sedimentary origin.

The sources of the material composing the Reagan sandstone were, first; the underlying, older, igneous rocks; second, sedimentary material occuring as mantle rock on the old Pre-Cambrian surface; third, the Meers quartzite on the north flank of the Wachita Mountains; fourth, calcareous precipitates from the Upper Cambrian seas and fifth, calcareous algal secretions or possibly bacterial secretions such as Bacterium calcus.

The first and second source mentioned seem the most plausible original sources of this clastic material. To these were added the materials from the remaining sources as Upper Cambrian time progressed. In as much as the coarse clastics grade upward through argillaceous into calcareous phases, it seems reasonable to suppose that the Reagan sandstone was laid down in an advancing sea.

The surface upon which the Reagan was deposited was a peneplain whose dissection continued on into Reagan time. The monadnocks and topographic highs of this surface produced an irregular contact with the overlying formations, thus making the basal conglomerate variable in thickness. The maximum thickness is on the north side of the Wichita mountains. Where the projections from the old peneplained surface are

higher than the thickness of the Reagan deposits, the Reagan sandstone is absent.

In the eastern area of the Reagan outcrops the calcareous phases are entirely absent and the aranaceous phase more prominent. This seems to indicate either a shallower sea and a nearer coast line or a progression of the sea to the eastward. Consequently, the calcareous phase is best developed in the Wichita mountain region. The small, rounded and frosted character of the clastic material in the Lower and Middle portions of the Reagan indicate that the material suffered considerable displacement and transportation on the part of streams and waves, the latter, perhaps, being the more common process. Some of the material may be mantle rock reworked.

The conglomerate found 80 feet above the base of the formation at Station C in sec. 26, T. 6 N., R. 14 W. indicates that there may have been periods of heavy precipitation which produced large accumulations of debris at the mouth of streams or that there may have been periods of great storms whose excessive wave action produced accumulations of boulders along the coast.

If the glauconite is of the same origin as that in New Jersey, its wide distribution indicates that much of the material was laid down in shallow, near shore deposits and perhaps along a sinking land mass.

The formation reveals a distinct scarcity of fauna and flora but of the life types which do exist, the trilobites and brachiapods are most numerous.

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3. Geologic Map of Carter County, Oklahoma, O.G.S.

4. Geologic Map of Arbuckle Mountain Region, O.G.S.

5. Geologic Map of the Wichita Mountain Group, U.S.G.S. & O.G.S.

6. Geologic Map of parts of Caddo, Commanche, Greer, and Kiowa Counties, Oklahoma, O.G.S.

7. Personal reconnaissance and detail maps of areas in which Reagan Sandstone outcrops.

8. Maps in various publications referred to in first part of bibliography.

APPENDIX

The following series of tables show the progress of the classification of the rocks of the Arbuckle and Wichita mountains:

Taff's Correlation, 1903.

Devonian:
- Woodford Chert.
- Bois d' Arc limestone.
- Haragan marl.

Silurian:
- Hunton limestone.
- Sylvan shale.

Ordovician:
- Viola limestone.
- Simpson formation.

Cambrian-Ordovician:
- Arbuckle limestone.

Cambrian:
- Reagan sandstone.

Pre-Cambrian:
- Porphyryr(Colbert)
- Granite (Tishomingo)

U.S.G.S. Correlation, June, 1925.

Upper Ordovician:
- Sylvan shale (Richmond fossils)

Middle Ordovician:
- Viola limestone.

Lower Ordovician:
- Simpson formation.
- Upper most Arbuckle limestone.

Upper Cambrian:
- Reagan sandstone.

Pre-Cambrian:
- Colbert Porphyry.
- Tishomingo granite.

Tentative Correlation and Classification, November, 1928.

ORDOVICIAN:

Viola Group:
Fernvale limestone
Rainy Mountain limestone

Simpson Group:
Bromide formation (Coarse sandstone at the base)
Criner formation (Upper ss. of Davis-Ardmore road section)
McLish formation (Soft sandstone at the base)
Tulip Creek formation. (Wilcox sandstone at the base)
Falls Creek formation. (Bergen sandstone at the base)
Nebo formation (20-100 ft. sandstone at the base)
Joins formation (Conglomerate at the base)

UPPER CANADIAN:

West Springs Creek formation. (Upper shaly limestone beds)
Alden limestone (Ceratopia beds)

MIDDLE & LOWER CANADIAN:

Arbuckle Group:

Cool Creek limestone (Oolites near the top)

OZARKIAN:

Wolf Creek dolomite. (?)
McKenzie Hill limestone.
Chapman's Ranch dolomite.
Signal Mountain limestone.
Royer Marble.
Ft. Sill limestone. (Sponge beds)

CAMBRIAN:

Timbered Hills Group:

Honey Creek formation (Ptychaspis zone at the top)
Cap Mountain sandstone
Reagan sandstone.

PRE-CAMBRIAN:

Granites and porphyries.

(After Decker and Ulrich)

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