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PROGRESS REPORT
on the Classification of the
TIMBERED HILLS AND ARBUCKLE GROUPS OF ROCKS
Arbuckle and Wichita Mountains, Oklahoma

By
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CLASSIFICATION OF THE TIMBERED HILLS AND ARBUCKLE GROUPS OF ROCKS

By Charles E. Decker

ABSTRACT

This paper is a progress report on the subdivision, classification and correlation of two groups of lower Paleozoic rocks, aggregating nearly 8,000 feet in thickness, and formerly classified as Reagan sandstone, Honey Creek limestone, and Arbuckle limestone. It presents a number of detailed measured sections, from which fossils were collected by zones. An unnamed, basal limestone, the Reagan sandstone, Cap Mountain formation, and Honey Creek limestone are considered formations, and together make up the Timbered Hills group of upper Cambrian age. The Arbuckle limestone, as originally defined by Taff, is raised to the rank of group, and on the basis of faunal and lithologic evidence, is divided into 9 formations. In ascending order, these formations are: Fort Sill limestone, Royer dolomite, Signal Mountain formation, and Butterly dolomite, of upper Cambrian age; and McKenzie Hill formation (divided into the Chapman Ranch limestone and McMichel limestone members), Strange dolomite, Cool Creek limestone and chert, Kindblade limestone, and West Spring Creek limestone, all of Ordovician age. Graphic sections, showing thicknesses, faunal zones, and correlations of exposures in different areas, are shown in a chart, and outcrops in the Arbuckle and Wichita Mountains are shown by maps.

A carbonaceous and asphaltic zone occurs near the base of the Arbuckle limestone, and the upper part has been an important oil and gas producing formation for many years. There is considerable interest at present in prospecting for oil and gas in the area around and adjacent to the Wichita Mountains, and information contained in this report on character and thickness of the different subdivisions, should be of help to geologists engaged in this exploratory work.

A small deposit of red iron ore is present in the Reagan sandstone in the northeast part of the Wichita Mountains, and some limonite is found in the Arbuckle limestone. Both the Reagan sandstone and Arbuckle limestone have been utilized for dimension stone. The Arbuckle has supplied immense quantities of crushed stone for concrete aggregate and road metal, from both mountain areas. Extensive bodies of dolomite give promise of commercial value in the future.

INTRODUCTION

Purpose and Scope. Interest in the older Paleozoic formations of the Arbuckle and Wichita Mountains has been largely academic rather than practical. The Reagan sandstone has seemed to give little promise of economic use except for the one ferruginous deposit which has been exploited to some extent as a pigment for paint. More recently the basal even beds have been used as dimension stone in the building of bridges. The Arbuckle limestone has been of interest because of its great thickness and supposed uniformity of composition and texture. It has long been used for concrete aggregate and road metal and to some extent for building stone. Since numerous commercial uses for dolomite have been developed in recent years, the very extensive bodies of dolomite in the Arbuckle limestone give promise of great commercial value in the near future.

The Arbuckle limestone was formerly thought to be barren of oil and gas in the vicinity of the Wichita Mountains, and in 1922, Howell[1] stated: "In the vicinity of the Wichita Mountains the petroliferous sands of the Simpson, the lowest known oil bearing horizon, are immediately above the Arbuckle * * * *. Hence the Arbuckle may be considered the 'farewell rock,' below the top of which it is useless to drill * * * *."

Oil had been produced from the Arbuckle limestone in north central Oklahoma and southern Kansas for many years previously, and its identification as an important producing horizon was recognized by Aurin, Clark, and Trager in 1921,[2] who state (p. 148): "Some of the production in T. 23 N., R. 7 E., the Boston Pool and several other localities in Osage County, sec. 16, T. 29 N., R. 3 E., Kay County, in Oklahoma and in the Augusta and Eldorado fields, and possibly the Elk County fields in Kansas, is obtained from the uppermost part of this formation," (the Arbuckle limestone). Since 1922, important production has been found in the Arbuckle limestone in the Garber and Oklahoma City fields, and elsewhere in Oklahoma, and over a large area in western Kansas, so that today, the Arbuckle limestone is of great economic importance to the oil industry.

1. Howell, J. V., "Notes on the Pre-Permian Paleozoics of the Wichita Mountain Area,"; *Bull. Amer. Assoc. Petro. Geol.*, Vol. 6, pp. 421-22, 1922.
2. Aurin, F. L., Clark, G. C., and Trager, E. A.: "Notes on the Sub-Surface Pre-Pennsylvanian Stratigraphy of the Northern Mid-Continent Oil Fields"; *Bull. Amer. Assoc. Petro. Geol.*, Vol. V, pp. 117-153, 1921.

Within the past few years, considerable interest has developed regarding the oil-producing possibilities of the areas around and adjacent to the Wichita Mountains. It therefore becomes important to recognize the general structure and the parts and thickness of the Arbuckle group in the different areas, particularly because a carbonaceous and asphaltic zone has recently been found well down toward the base of the group. Numerous isolated outcrops occur in the Wichita and Arbuckle Mountain regions, so it is important to identify these parts and correlate them properly in the widely separated regions.

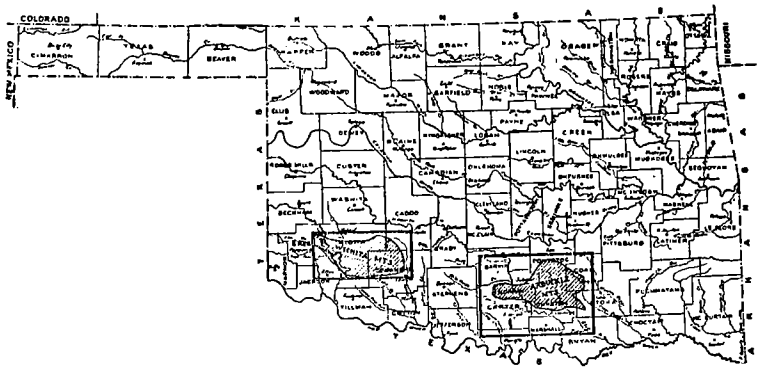


Fig. 1. Index Map of Oklahoma, showing location of Arbuckle and Wichita Mountains.

It is the purpose of this progress report to present as briefly as possible the results of a recent field study in the Arbuckle and Wichita Mountains, together with some data secured by the writer in his earlier studies in these mountains. It will include a discussion of stratigraphy in which the lower Paleozoic formations are divided into two groups of 12 formations; the details of a number of measured sections will be presented, including the information secured in collecting fossils by zones; the general structure will be noted; a graphic table will be shown correlating the formations of the Wichita Mountains with those of the Arbuckles; and the basis for the correlation will be presented in a discussion of the evidence secured from various groups of fossils.

Distribution and Area. This report covers those regions in which the lower Paleozoic rocks crop out in the Arbuckle and Wichita Mountains of south-central and southwestern Oklahoma.

It includes an area of about 370 square miles in the Arbuckle Mountains, 3 square miles in the Criner Hills to the south, and 75 square miles in the Wichita Mountains.

Previous Investigations. While a number of geologists, especially from Texas, made brief reconnaissance trips into the Wichita Mountains, Bain[3] was the first to recognize the general relations of igneous and sedimentary rocks which are shown in an excellent manner on his sketch map. He divided the sedimentary rocks into the Blue Creek series and the Rainy Mountain limestone, the former including sandstone and associated upper limestones of the present Reagan formation, and the latter the Arbuckle limestone. Though conformable on the lower series, he erroneously thought that this limestone (Arbuckle) had been folded and metamorphosed by the granite. He assigned the Blue Creek series to the Cambrian and the Rainy Mountain limestone to the Ordovician. The general geology of the Arbuckle and Wichita Mountains was worked out in an excellent manner by Taff[4], who differentiated and described the formations, determined their general structural relations, and mapped their outcrops. He embodied the results of his studies in three important publications.

In his report on the "Geological and Mineral Resources of the Arbuckle Mountains, Oklahoma," Reeds[5] did not add to the information on stratigraphy given by Taff, but did describe the structure in greater detail.

Ulrich[6] recognized that the Reagan was Upper Cambrian instead of Lower Cambrian, as originally assigned, and he separated the upper calcareous limestones of the Reagan into a separate member to which he gave the name Honey Creek. He indicated that the Arbuckle limestone could be divided into four parts, which were assigned in an indefinite manner to Upper Cambrian, Ozarkian, and Canadian, though the upper part was definitely assigned to the Canadian.

3. Bain, H. F., "Geology of the Wichita Mountains"; *Bull. Geol. Soc., Amer.*, Vol. 11, pp. 127-144, (map, p. 129), 1900
4. Taff, J. A., *U. S. Geol. Surv. Atlas, Atoka Folio* (No. 79), 1902. *U. S. Geol. Surv. Atlas, Tishomingo Folio* (No. 98), 1903. Geology of the Arbuckle and Wichita Mountains, Indian Territory, Oklahoma, *U. S. Geol. Surv. Prof. Paper* 31, 1904. (Reprinted as *Okla. Geol. Survey Bull.* 12, 1928.)
5. Reeds, C. A., *Okla. Geol. Survey Bull.* 3. 1910.
6. Ulrich, E. O., "Revision of Paleozoic Systems"; *Bull. Geol. Soc. Amer.*, Vol. 22, pp. 641-642, 1911.

The igneous rocks on which the sedimentary rocks lie in both the Arbuckle and Wichita Mountains were studied and differentiated by Taylor[7] who studied them in thin sections as well as megascopically and gave detailed mineral composition of the various types of rock.

Wallis[8] gave a brief statement of the general geology and structure of the Arbuckle Mountains and a table with generalized section for North America and correlation of formations in the Sandstone Hills and Arbuckle Mountains with those of the Ouachita Mountains.

Dake[9] described the Arbuckle limestone very briefly and stated that the basal part is Cambrian and "* * * it is variously estimated that from 1,200 to 3,000 feet of the upper portion is Ordovician."

From surface and subsurface information Howell[10] described the Arbuckle limestone as remarkably uniform and indicated the importance of differentiating it from other formations. Because at that time no oil had been found in it, in the Wichita Mountains area, it was designated the "farewell rock", below the top of which it was useless to drill. Also, he described megascopic and microscopic characteristics of well-cuttings and thin sections and noted that much of the limestone carries from 2 to 10 per cent magnesium. He gave a thickness of 6,000 feet for the Arbuckle limestone in the Wichita Mountains which is considerably more than recent measurements indicate.

The relatively large outcrop of the Arbuckle limestone in the southern part of the Stonewall quadrangle was described briefly by Morgan[11] who indicated that the lower part of the formation was not exposed in that area. He noted the presence of coarse conglomerates at several horizons in different parts of the outcrop.

7. Taylor, Charles H., "Granites of Oklahoma"; *Okla. Geol. Survey Bull.* 20, 1915.
8. Wallis, B. F., "The Geology and Economic Value of the Wapanucka Limestone"; *Okla. Geol. Survey Bull.* 23, pp. 24-35, 1915.
9. Dake, C. L., "The Problem of the St. Peter Sandstone"; Missouri Univ., School of Mines and Met., Bull., Tech. ser., Vol. 6, no. 1, pp 55-56, and pl. 2, op. p. 12, 1921.
10. Howell, J. V., "Notes on the Pre-Permian Paleozoics of the Wichita Mountain Area"; *Bull. Amer. Assoc. Petr. Geol.* Vol. 6, pp. 421-422, 1922.
11. Morgan, George D., "Geology of the Stonewall Quadrangle, Oklahoma"; *Bureau of Geol. Bull.* 2, pp. 21-25, 1924.

Gould[12] briefly described and gave thickness, distribution, age, and correlation of the Reagan sandstone and Arbuckle limestone, and the writer supplied lists of most common fossils for each formation.

In a discussion of the Paleozoic formations on the flanks of the Arbuckle dome Ulrich[13] presented a table of formations in which he placed only the Reagan formation, with the Honey Creek member at the top, in the Upper Cambrian, the basal Arbuckle limestone in the Ozarkian and the middle and upper parts in the Canadian. He named the lower dolomite of the Arbuckle "Royer marble" and attributed a fauna to it. This probably was an error, for he later indicated that no fossils had been found in the Royer. Possibly he had in mind the numerous fossils which occur in the limestones beneath the Royer and above the top of the Honey Creek formation.

Decker and Merritt[14] gave a detailed section of the Arbuckle limestone along U. S. Highway 77, noting the megascopic, microscopic, and chemical characteristic by zones, together with an extended bibliography. Because of complex structural relations it was necessary to shift the line of measurement several times and it seems certain now that there is duplication of beds at the south end of the East Timbered Hills. A more recent measurement, starting from the west edge of those hills, gave a thickness for the Arbuckle limestone of 7,292.7 feet as compared with the earlier measurement of 7,992 feet.

Hoffman[15] studied in detail the igneous rocks of the Wichita Mountains and divided them into 3 groups: gabbro and anorthosite, granophyres, and dike rocks. The results of his study are important here because it is upon the Carlton granophyre that the unnamed basal limestone, Reagan, or Honey Creek formations rest in all the exposed contacts with the pre-Cambrian, and fragments of this granophyre are included in the basal beds of these formations.

12. Gould, C. N., "Index to the Stratigraphy of Oklahoma"; *Okla. Geol. Survey Bull.* 35, pp. 11-14, 1925.
13. Ulrich, E. O., "Fossiliferous Boulders in the Ouachita 'Caney' Shale and the Age of the Shale Containing Them"; *Okla. Geol. Survey Bull.* 45, pp. 28-31 and fig. 3, 1927.
14. Decker, C. E., and Merritt, C. A., "Physical Characteristics of the Arbuckle Limestone"; *Okla. Geol. Survey Circ.* 15, pp. 3-55, 1928.
15. Hoffman, Malvin G., "Geology and Petrology of the Wichita Mountains"; *Okla. Geol. Survey Bull.* 52, pp. 4 (contents), 39, 40, 1930.

Later Ulrich[16] raised the Honey Creek from a member to a formation, and characterized three divisions in the lower part of the Arbuckle limestone as formations: Fort Sill, Royer, and Signal Mountain.

In a talk before the Tulsa Geological Society the writer[17] presented a table of most of the Ordovician and Cambrian formations, divided into four groups. The two lower groups, Timbered Hills and Arbuckle, with some substitutions and minor changes in formations and formation names, have been adopted for the classification of these lower Paleozoic formations of Oklahoma, and a paper by the writer, Bulletin of the Geological Society of America, vol. 50, 1939, gives the formations of these groups with a brief description and the assignment of a type section for each.

In supplying evidence concerning the position of the Cambro-Ordovician contact in the Arbuckle limestone, Bridge[18] gave a table of formations in which he placed the Honey Creek in the base of the Arbuckle, and named in ascending order above it, the following formations: Fort Sill, Royer, Signal Mountain, Unnamed unit, Chapman Ranch, and McKenzie Hill, leaving about 4,300 feet of undifferentiated Arbuckle at the top. He placed the Cambro-Ordovician contact at the base of the Chapman Ranch and at the top of the upper dolomite, a position that is accepted by the writer.

In two tentative correlation papers, the writer[19] recognized two important graptolite zones in the Arbuckle, approximately 800 and 4,600 feet respectively below the top. The upper was designated the *Didymograptus protobifidus* zone which has wide disribution in this country, Europe and Australia; and the lower one

16. Ulrich, E. O., "Preliminary Description of Honey Creek, Fort Sill, Royer and Signal Mountain Formations, Oklahoma"; *Bull. Geol. Soc. Amer.*, Vol. 43, pp. 742-747, 1932.
17. Decker, C. E., "Early Paleozoic Stratigraphy of the Arbuckle and Wichita Mountains"; *Tulsa Geol. Soc. Digest*, p. 55, 1933.
18. Bridge, J., "Position of the Cambrian Ordovician Boundary in Section of Arbuckle Limestone Exposed on Highway 77, Murray County, Oklahoma"; *Bull. Amer. Assoc. Petr. Geol.*, Vol. 20, pp. 980-984, 1936.
19. Decker, C. E., "Some Tentative Correlations on the Basis of Graptolites of Oklahoma and Arkansas"; *Bull. Amer. Assoc. Petr. Geol.*, Vol. 20, pp. 303-305, 1936 .

"Table of Tentative Lower Paleozoic Correlations on Basis of Graptolites"; *Bull. Amer. Assoc. Petr. Geol.*, Vol. 20, pp. 1252-1257, 1936.

was called the Middle Arbuckle or lower graptolite zone. This zone has been important in the correlation of this horizon in various outcrops of the Arbuckle and Wichita Mountains. The graptolites of the lower zone are dendroid, and some of them closely resemble species illustrated and described by Ruedemann[20] from the Upper Cambrian of Wisconsin, Minnesota, and Tennessee. Because of the close resemblance of some of these forms to the Upper Cambrian forms described and illustrated by Ruedemann, it was thought that the zone should be placed in the Cambrian. However, on the evidence of a number of other invertebrate fossils, it seems necessary now to place the zone in the lowest part of the Ordovician.

Present Investigation. The writer has spent three short summer seasons with one or two assistants primarily in the study of the Arbuckle limestone of the Arbuckle and Wichita mountains. However, he has given some attention to the older formations, (Reagan and Honey Creek), having measured some sections and collected fossils from them, in detail by zones. This more specific information is added to that secured by the writer through many years of study and collecting of fossils.

Acknowledgments. Grateful acknowledgment is made to Robert H. Dott for suggestions with reference to the manuscript and for assistance in assembling the material for correlation; to Josiah Bridge and G. Arthur Cooper for identification of Ceratopeas, sponges and brachiopods; to Ray Six, the late John Flynn, Bill Gwin, Brooks Pierce, Edward Frederickson, and Alfred Leoblick for assistance in the field; and to Helen Tappen for assistance in the laboratory. While the major part of the expenses were paid by the Oklahoma Geological Survey, minor items of expense for collection and preparation of materials were met by parts of grants by the American Association for the Advancement of Science and the University of Oklahoma research funds.

20. Ruedemann, Rudolf, "The Cambrian of the Upper Mississippi Valley, Part 3, Graptoloidea"; *Bull. of the Public Mus. of the City of Milwaukee*, Vol. 12, no. 3, pp. 307-348, pl. 46-55.

STRATIGRAPHY

General Statement

In order to compare in a systematic way the outcrops in the widely separated regions, the Cambrian and lower Ordovician formations of the Arbuckle and Wichita Mountains are classified in two groups—Timbered Hills below and Arbuckle above. Table I shows the subdivisions of each group, the Cambro-Ordovician contact in the midst of the Arbuckle group, the general distribution, and the range in thickness of the units in each of the two mountain regions. Also, zone numbers are given for the formations of the Arbuckle group corresponding to those in Oklahoma Geological Survey Circular 15, and Section No. 2 in the appendix of this report.

Groups, formations, and members. The classification used in this table agrees rather closely with the one given by the writer[21] before the Tulsa Geological Society in 1933. The names of the groups remain the same, but one unit, a basal limestone, is added at the bottom of the Timbered Hills group which contains in addition, the Reagan, Cap Mountain, and Honey Creek formations. In the Arbuckle group there are nine formations and two members. Six of the formations—Fort Sill, Royer, Signal Mountain, McKenzie Hill, Cool Creek, and West Spring Creek—remain unchanged. Butterly is substituted for Chapman Ranch as the name for the upper dolomite, and Chapman Ranch is placed as the basal member of the McKenzie Hill formation, while the upper member of that formation is called McMichel. Since Wolf Creek and Alden were preoccupied, Strange is substituted for the former, and Kindblade for the latter.

The twelve named formations, two members and a recently discovered basal limestone occurring in the Timbered Hills and Arbuckle groups are characterized in succession from oldest to youngest. They include rocks of Cambrian and Ordovician age.

Cambrian

THE TIMBERED HILLS GROUP

General Statement. The group was named because the Reagan and Honey Creek are well exposed adjacent to the East and West Timbered Hills in the Arbuckle Mountains. In addition to these

21. Decker, C. E., *Tulsa Geological Society Digest*, p. 55, 1933.

TABLE I

TABLE OF FORMATIONS

SHOWING AGE, DISTRIBUTION, THICKNESS AND ZONES

Periods	Groups	Formations and Members	Thickness (feet)		Zones of Section No. 2
			Arbuckles	Wichitas	
ORDOVICIAN	ARBUCKLE GROUP	West Spring Creek	1611-1620	250	1-134
		Kindblade	1216-1536	956	135-153
		Cool Creek	1513-1687	1015	154-181a
		Strange	Wanting	80	182-184
		McKenzie Hill McMichel Chapman Ranch	674-1122 144	223-1019	182-183 184
CAMBRIAN		Butterly	286-374	Wanting	185-206
		Signal Mountain	114-478	290-350	207-208
		Royer	675-771	195-219	209-218
		Fort Sill	120-283	224-369	219-221
	TIMBERED HILLS GROUP	Honey Creek	51-90	44-266	
		Cap Mountain	126	Wanting	
		Reagan	200-460	0-134	
		Basal limestone	Wanting	98	

two formations Cap Mountain from the eastern end of the Arbuckle Mountains is placed between them, and an unnamed, basal limestone from the north side of the Wichita Mountains is placed at the bottom of the group.

Basal Limestone. A basal limestone beneath the Reagan was discovered recently by the writer at the south end of Blue Creek Canyon. It crops out at the southeast edge of the isolated limestone hill in sec. 24, T. 4 N., R. 13 W., about 4 miles north of Mount Scott, where the exposure extends along the strike for several hundred feet until it is covered by Permian overlap to the west. This is the type section for the unit and constitutes the only known outcrop. It has a much more distinct contact with the Reagan than has the Honey Creek, and as a whole it differs far more markedly from the Reagan than do parts of the Honey Creek. If evidence of wider distribution is secured it may well be named as a formation.

It consists of 98 feet of dense gray limestone with some pinkish tints, and dips 45° to the north. A detailed section (No. 12), with eleven zones is shown in the appendix. Of these zones, numbers 1, 2, and 11 were measured with a tape horizontally and the thickness calculated, and zones 3 to 10 inclusive were measured directly at right angles to the dip.

While beds in the lower and upper parts of the basal limestone unit are moderately thin (3 to 12 inches), near the middle occur several individual beds 2.4, 3.0, 3.0, and 5.2 feet thick. The limestone has not been searched thoroughly for other fossils, but the only ones discovered were numerous small calcareous algae, most abundant in the lower part.

The basal limestone rests on the uneven surface of the Carlton granophyre, and contains fragments of that igneous rock, not only in the lower part, but well up toward the top. At the top it grades from a limestone through sandy limestone into the basal part of the Reagan sandstone. Being beneath the Reagan and grading into it, it is tentatively placed with that formation in the upper Cambrian. It is considered now to be the oldest known sedimentary unit in Oklahoma, though the metamorphic Meers quartzite, antedates it by millions of years, having been intruded and probably metamorphosed by the Pre-Cambrian igneous rocks.

The Reagan Formation. This formation takes its name from the town of Reagan in the Tishomingo quadrangle, Johnston County. A small outcrop occurs northeast of Reagan, but the type section is about five miles southwest of the village of Mill Creek, Johnston County, where Taff[22] measured a section and found it to consist of conglomerates, arkoses, and sandstones aggregating 460 feet in thickness. In some places the conglomerates are coarse, including pieces of the igneous rocks up to 6 inches or more in diameter. Locally the sandstones have been highly indurated so that they are called quartzites. As a rule the sandstones are coarse, but in some localities they are fine-grained and thinly banded, and locally become shaley, with beds of coarse limestone, especially toward the top. In many places the Reagan contains glauconite and locally in sec. 17, T. 4 N., R. 12 W., Comanche County, a marked concentration of hematite.

In the Arbuckle Mountains the Reagan crops out not only in the Tishomingo area, but also adjacent to both the East and West Timbered Hills. There is one outcrop on the southeast flank, and several on the northeast flank of the Wichita Mountains.

At the base it generally rests unconformably on the igneous rocks, but in one exposure about 98 feet of dense limestones separate it from the igneous rocks. In a few places there seems to be a fairly sharp contact with the Honey Creek formation above, but more commonly there is a gradation zone at the top, especially on the northeast flank of the Wichita Mountains. Here, an alternation of sandstones and coarse limestones makes it impossible to choose a distinct plane of separation between the two formations. No fossils have been found in the sandstone, but the interbedded limestones carry representatives of an upper Cambrian fauna.

Cap Mountain Formation. This formation is exposed at only one locality, secs. 23 and 26, T. 2 S., R. 4 E., in the eastern part of the Arbuckle Mountains southwest of the village of Mill Creek. Ulrich[23] considers it an extension of the formation by the same name in the Llano-Burnet area in Texas. The thickness secured

22. Taff, J. A., "Geology of the Arbuckle and Wichita Mts., Indian Territory and Oklahoma"; *U. S. Geol. Survey, Prof. Paper* 31, p. 21, 1904; *Okla. Geol. Survey Bull.* 12, p. 18, 1928.

23. Ulrich, E. O., "Preliminary Description of the Honey Creek, Fort Sill, Royer, and Signal Mountain Formations of Oklahoma"; *Geol. Soc. Amer. Bull.*, Vol. 43, p. 742, 1932.

from a paced measurement is 126 feet. It is a very tough, resistent rock, gray or pinkish gray in color, and in part rather coarsely crystalline. It seems to be highly magnesian or sandy magnesian limestone, or semi-dolomite, and is unfossiliferous.

Honey Creek Formation. This formation is named for Honey Creek which flows across one of its exposures in the Arbuckle Mountains at the west side of the East Timbered Hills in sec. 1, T. 2 S., R. 1 E., about 8 miles southwest of Davis. It was named and described by Ulrich[24] and raised from a member to the rank of formation. Both Bridge and Ulrich[25] included it in the lower part of the Arbuckle. In the earlier literature it was considered a phase or a member of the Reagan. It is here associated with the Reagan in the Timbered Hills group, because in some sections it resembles the coarse limestones in the upper part of the Reagan; like the Reagan it contains marked concentrations of glauconite (far more than occurs in the Arbuckle); it is generally more siliceous and frequently more ferruginous than the Arbuckle; it is nearly always more coarsely crystalline than the basal Arbuckle; and it carries a fauna distinct from that in the lower part of the Arbuckle.

The Honey Creek crops out in the Arbuckle Mountains on both sides of the West Timbered Hills, and in two places on the southeast flank and five on the northeast flank of the Wichita Mountains.

In most places it rests directly upon the Reagan, and in a number of places there seems to be a gradation phase from the upper part of the Reagan into the basal part of the Honey Creek. However, along the west edge of Blue Creek Canyon, the Honey Creek overlaps the Reagan and rests directly upon pre-Cambrian igneous rock, some fragments of which are included in its basal bed.

In most localities it is very fossiliferous. Trilobites occur in several zones, crinoid stems are common, locally making a coquinoid limestone, and two brachiopods, *Eoorthis remnicha*, *E. wichitaensis* are common. *Plectostrophia bridgei,* characteristic of the Wilberns of Texas, occurs in the upper part of the Honey Creek on

24. Ulrich, E. O., "Preliminary Description of the Honey Creek, Fort Sill, Royer, and Signal Mountain Formations of Oklahoma"; *Geol. Soc. Amer. Bull.*, Vol. 43, pp. 742-745, 1932.

25. Ulrich, E. O., and Cooper, G. A., "Ozarkian and Canadian Brachiopoda"; *Geol. Soc. Amer. Special Papers*, No. 13, p. 23, 1938. Bridge: footnote 33.

the northwest slope of McKenzie Hill, south of Signal Mountain in the Wichita area.

In the last article referred to above, Ulrich placed the Honey Creek in the upper Cambrian, correlating it with the Wilberns of Texas, the Davis of Missouri, and the Franconia of Wisconsin. The type section of the Honey Creek and several other sections are given in the appendix.

THE ARBUCKLE GROUP

General Statement. The Arbuckle Group gets its name by raising Arbuckle from a formation to a group name. The Arbuckle limestone was named for the Arbuckle Mountains and they in turn from old Fort Arbuckle near their northern edge, 7 miles west of Davis. The Arbuckle group comprises a great body of rocks consisting of limestones, sandstones, shaly limestones, and conglomerates, with a maximum thickness of nearly 7300 feet. The rocks of this group crop out over wide areas in the Arbuckle and Wichita Mountains and a lesser area in the Criner Hills, in numerous exposures, some of which are separated by considerable distances. Several sections are shown in a graphic table and detailed sections are shown in the appendix. The formations are described in succession, beginning with the oldest.[26]

Fort Sill Formation. This formation was named for the Fort Sill military post where a part of the formation is exposed in a quarry near the south edge of the post. However, the type section of the formation is located 6 miles west of this quarry on the west end of McKenzie Hill, in secs., 7 and 8, T. 2 N., R. 12 W. It was named, described, and measured by Ulrich,[27] who calculates a thickness of 150 feet, based on a dip of 10°. More recent measurement of dip in small quarries, some of which are new, indicate 13° to 15° instead of the lower angle used by Ulrich, and the thickness is now determined to be 224 feet. Detailed section No. 5. (Appendix) shows that the formation consists chiefly of thin beds of limestone, though thick beds occur at intervals. An oolitic

26. For distribution of formations, location of sections, and places to which reference is made, the reader is referred to Plate I of this report, the Geologic Map of the Arbuckle Mountains, *Okla. Geol. Survey Bull.* 55, 1931 (available at Okla. Geol. Survey), and Special Military (topographic) map of Fort Sill Military Reservation, War Department, Corps of Engineers, U. S. Army (2 sheets) 1927.

27. Ulrich, E. O., *op. cit.*, pp. 743-746, 1932.

zone occurs about 35 feet below the top and *Billingsella corrugata* occurs 87 feet below the top. A number of trilobite zones and one gastropod zone occur in the formation. Sponge spicules, so characteristic of the formation in some outcrops, are rare at this locality. The spicules are most abundant in the Arbuckle Mountains at the northwest edge of the West Timbered Hills, sec. 9, T. 1 S., R. 1 W. At the east end of the Arbuckles, in sec. 23, T. 2 S., R. 4 E., the Fort Sill includes arkose at a number of horizons and near the top. This indicates the presence of a granite hill near the site of the coarse deposits. The Fort Sill at the type locality is underlain by 44 feet of Honey Creek limestones, and is overlain by the fine conglomerates of the Signal Mountain. This upper contact doubtless marks a hiatus, because in the northwest part of the Wichita Mountains the Fort Sill and Signal Mountain formations are separated by about 200 feet of Royer dolomite, and in the Arbuckle Mountains by 675 to 771 feet of Royer.

Royer Formation. This formation was named for the old Royer ranch on the west side of the East Timbered Hills in the Arbuckle Mountains, and the type section for the formation is in the SE cor. sec. 36, T. 1 S., R. 1 E. However, all vestiges of the Royer ranch buildings have been removed and the property is now included as a part of the much larger Chapman Ranch. This formation was named by Ulrich[28] and assigned a thickness of 100 to 600 feet. The formation is 771 feet thick at the type locality. The formation is nearly as thick in the eastern end of the Arbuckle Mountains but is absent in the Wichitas except near the northwest edge, southwest of Carnegie, where it attains a thickness of about 200 feet. It consists chiefly of thick masses of dolomites separated by 5 zones of limestone. Most of the dolomite is coarsely crystalline and some of it is marble-like in texture. The details of the type section are given in section No. 2 (Appendix) and other descriptions occur in sections Nos. 1, 4, and 13. In all of its outcrops the Royer is underlain by the Fort Sill formation and it is followed above by the limestones of the Signal Mountain formation. When dolomites come into more extensive commercial use, these enormous deposits may have great value.

Signal Mountain Formation. This formation was named by Ulrich[29] for Signal Mountain, an igneous peak along the southwest edge of the Fort Sill Military Reservation, sec. 5, T. 2 N., R. 12 W.,

28. Ulrich, E. O., *op. cit.*, p. 744, 1932.

29. Ulrich, E. O., *op. cit.*, p. 746, 1932.

and the type section is located about a mile south of that peak on the west slope of McKenzie Hill, secs. 8 and 9, T. 2 N., R. 12 W. In the above reference Ulrich assigned a thickness of 185 feet to this formation in the type section, and more in the section on the north side of the mountains. The more recent measurement calculated with a higher dip, gives a thickness of 290 feet for the type section.

About 30 feet of the basal part of the formation consists of calcareous, sandy pebbles. However, the major part consists of thin beds of limestones which are separated into a series of zones by a large number of coarse limestone conglomerates. Some of the limestones and many of the limestone conglomerates contain many fragments of trilobites. The formation is about 60 feet thicker on the north than on the south side of the Wichita Mountains. In the Arbuckle Mountains it attains a thickness of 114 to 478 feet.

On McKenzie Hill, the Signal Mountain rests with apparent conformity on the Fort Sill limestone, but doubtless a hiatus occurs at this locality, because the Royer formation lies between it and the Fort Sill in the northwestern part of the Wichitas, and in all of its exposures in the Arbuckle Mountains. In the latter region it is overlain by the Butterly formation and occupies a position between two dolomites; the Royer below and the Butterly above. The detailed type section is given in section No. 5 (Appendix) and other sections are given in Nos. 1, 2, 4, 7, and 13.

Butterly Formation. This formation is named by the writer for ranches owned by John Butterly and Butterly brothers at the southeast end of the West Timbered Hills, secs. 28 and 29, T. 1 S., R. 1 E. However, the type section is on the east side of U. S. Highway 77 in sec. 18, T. 2 S., R. 2 E., southeast of the Chapman ranch buildings where it attains a thickness of 286 feet. On the west side of the East Timbered Hills it has a thickness of 374 feet. The formation has not been recognized in the Wichita Mountains.

The Butterly formation consists of dolomite, coarse for the most part, with large quartz grains and thin quartz conglomerates in the upper part. It ranges from pink to yellow and gray in color. It is resistant to weathering so that rough masses stand in relief, 4 to 6 feet above the general level. The type section measured in detail by the writer has been published[30]. The Butterly is limited

30. Decker, Charles E., and Merritt, Clifford A., "Physical Characteristics of the Arbuckle Limestone"; *Okla. Geol. Survey Circ.* 15, pp. 34, 35, zones 185-203, 1928.

by the limestones of the Signal Mountain formation below and the McKenzie Hill formation above.

Cambro-Ordovician Boundary

Taff[31] originally placed the Cambro-Ordovician boundary about 700 feet above the base of the Arbuckle limestone. Falling as it does within a thick series of rather uniform limestone, without evidence of physical break, this division must be made entirely on paleontological evidence, and has been the subject of considerable controversy.

Ulrich[32], in 1911 revised the Paleozoic systems, and combined the upper part of the series of rocks then called Cambrian, and the lower part of the Ordovician, into his Ozarkian. This revision was not generally accepted by stratigraphers, and the top of the Cambrian as drawn by Ulrich is many hundreds of feet lower than the Cambro-Ordovician boundary of other authors. The writer adheres to the more conventional classification, though he is still in some doubt as to what horizon should be chosen to exactly mark this boundary.

Bridge[33] discussed in some detail evidences for placing this boundary at the top of the upper dolomite (Butterly), and the position chosen by him is tentatively accepted by the writer and used in this paper. Thus, in addition to the entire Timbered Hills group, four formations of the Arbuckle group—Fort Sill, Royer, Signal Mountain, and Butterly—are placed in the upper Cambrian. According to the most recent figures on thickness of formations, as given in section No. 2 (Appendix), the Cambro-Ordovician boundary now is placed 1656 feet above the base of the Arbuckle group.

Ordovician

McKenzie Hill Formation. This formation is named for McKenzie Hill, a limestone hill about 7 miles northwest of Lawton and a mile south of Signal Mountain in secs. 8 and 9, T. 2 N., R. 12 W. The type section is near the top of McKenzie Hill on

31. Taff, J. A., "Description of the Tishomingo Quadrangle"; *Geol. Atlas of United States, Folio* No. 98, p. 3, 1903.

32. Ulrich, E. O., "Revision of Paleozoic Systems"; *Bull. Geol. Soc. Amer.*, Vol. 22, pp. 627-646, 1911.

33. Bridge, Josiah, "Position of Cambrian-Ordovician Boundary in Section of Arbuckle Limestone Exposed on Highway 77, Murray County, Oklahoma"; *Bull. Amer. Assoc. Petr. Geol.*, Vol. 20, p. 983, 1936.

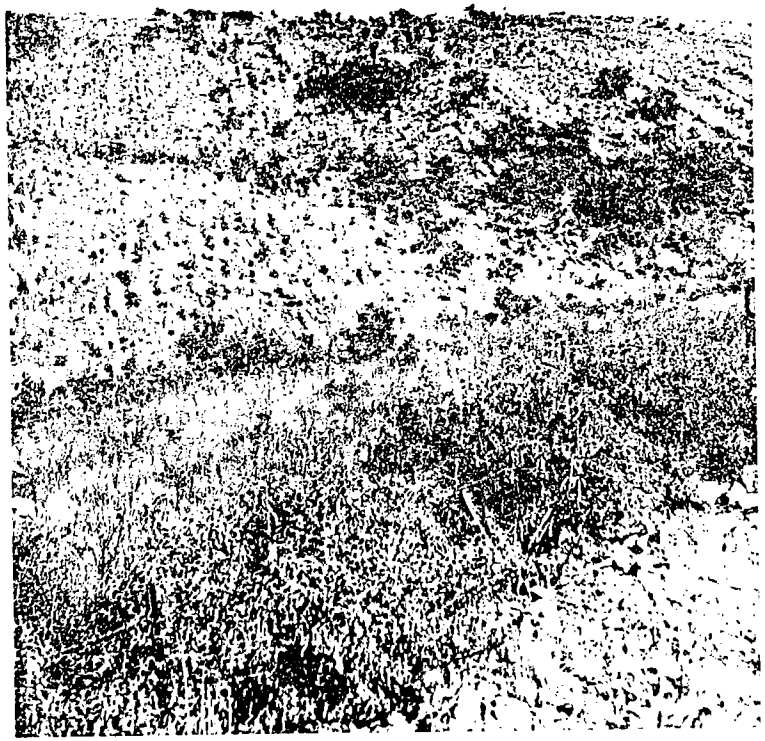
its western slope, where the formation has a thickness of 223 feet. About 8 feet of coarse limestone conglomerates occur at the base, succeeded by thin and thick limestones with numerous limestone conglomerates. About 40 feet of even-bedded limestones, called the "quarry beds" occur near the middle. Four quarries have been opened in these beds on McKenzie Hill, a fifth about 3 miles to the southwest, a sixth in Quarry Hill east of the Fort Sill railway station, and the Dolese quarry at Richard's Spur includes these beds. On McKenzie Hill the "quarry beds" are succeeded by thick beds of limestone containing many cylindrical chert nodules, and above them occur thin beds of weathered limestone to the base of the overlying Strange dolomite. On the north side of the Wichitas and in the Arbuckle Mountains a thickness up to 1,100 feet is assigned to the formation, though the contacts are uncertain. Parts of the "quarry beds" are very shaly and carbonaceous, and in the Dolese quarry and at Quarry Hill liquid asphalt has seeped along the bedding and joint planes. In the shaly phases of the "quarry beds" of this formation many fucoids and dendroid graptolites occur, and they have helped in identifying and tracing these beds in two localities in the Arbuckle Mountains, and in correlating numerous exposures in the Wichita Mountains. The brachiopod *Apheoorthis ornata* occurs widespread at some distance below the dendroid graptolite zone, and in the top of the Signal Mountain formation.

The McKenzie Hill formation has been divided into two members—Chapman Ranch below and McMichel above. The name Chapman Ranch member has been assigned by Bridge[34] to 144 feet of thick resistant limestones above the Butterly dolomite and at present is considered the basal unit of the Ordovician. The McMichel member includes the limestones of the McKenzie Hill formation above the Chapman Ranch member, and is well developed in both the Arbuckle and Wichita Mountains. While the Chapman Ranch member doubtless occurs in the Wichita Mountains, its typical gastropod and cephalopod faunule has not been distinguished there.

Strange Formation. This formation is named by the writer for the Strange ranch along the southern edge of McKenzie Hill. The type section is the exposure at the top of McKenzie Hill in secs. 8 and 17, T. 2 N., R. 12 W., where the formation consists of coarse massive dolomite, pink to gray in color. The outcrop has a thickness

34. Bridge, Josiah, "Position of the Cambrian-Ordovician Boundary in Section of Arbuckle Limestone Exposed on Highway 77, Murray County, Oklahoma"; *Bull. Amer. Assoc. Petr. Geol.*, Vol. 20, p. 983, 1936.

PLATE III.



Lower West Spring Creek formation, upper part of Arbuckle group, showing "tombstone" or "furrow" effect, produced by differential erosion on alternating hard and soft beds. South flank of Arbuckle anticline, along U. S. Highway 77, about sec. 6, T. 2 S., R. 2 E., Carter County, looking east.

of 80 feet but the upper part may be eroded. Three other outcrops occur, one about 0.5 mile to the east, sec. 9, T. 2 N., R. 12 W., and two a mile to the southeast in sec. 20, T. 2 N., R. 12 W. No other exposures of this formation have been recognized either in the Wichita or Arbuckle Mountains. An immense amount of dolomite is available and readily accessible in these outcrops. The Strange dolomite rests upon the limestones of the McKenzie Hill formation and constitutes the youngest rocks of the Arbuckle group on the south side of the Wichita Mountains.

Cool Creek Formation[35]. This formation is named for Cool Creek, the head waters of which flow across it 2 miles east of U. S. Highway 77, along the east side sec. 21, T. 2 S., R. 2 E., about 6 miles northeast of Springer. However, the type section is in sec. 18, T. 2 S., R. 2 E., along U. S. Highway 77 about 4 miles north of Springer, where it includes zones 154 to 181a of section No. 2 (Appendix). At this locality it has a thickness of 1,687 feet, and in section No. 1, southeast of Sulphur (Nebo section), the thickness is 1,513 feet. In the Wichita Mountains the Cool Creek occurs only on the north side, about 11 miles southwest of Carnegie, where it has a thickness of 1,015 feet. The formation consists primarily of thin beds of limestone, some of which are shaly and sandy. Zones of thick limestones occur in both mountain regions, although the thick beds are more conspicious in the Arbuckles than in the Wichitas. The formation is characterized by the large amount of chert present, and the wide-spread siliceous oolite. Black chert occurs near the base of the formation in the Wichita Mountains. *Hyolithes* and a few unidentified fossils have been found in the upper part of the formation in the Arbuckle Mountains, but it is largely unfossiliferous in both regions except for several zones of calcareous algae. The algal structures reach the large size of 3 to 4 feet in diameter, and are characteristic of the formation in both regions. No very definite boundaries have been chosen for this formation. It was extended downward to include most of the easily weathered limestones containing siliceous oolites, and upward to the base of the main *Ceratopea* zone.

Kindblade Formation. This formation was named by the writer for the Kindblade ranch about 10.5 miles southwest of Car-

35. For previous use of the term Cool Creek see: Wilmarth, M. Grace, "Lexicon of Geologic Names of United States"; *U. S. Geol. Survey Bull.* 896, p. 511, 1938; and Bassler, R. S., and Kellett, Betty, "Bibliographic Index of Paleozoic Ostracoda"; *Geol. Soc. Amer., Special Paper* 1, p. 48, 1934.

negie, along the northeast edge of which the formation is well-exposed. The outcrop at that locality, E½ sec. 26, T. 6 N., R. 14 W., is designated as the type section. It extends from the top of the outcrop southward, including 956 feet of limestones. In the Arbuckle Mountains the thickness aggregates 1,216 to 1,536 feet. The formation can be divided readily into numerous zones because of the spacing of the thick beds which are separated by 10 to 30 feet of intervening thin beds. Many chert nodules occur, especially in the middle and lower part of the formation. Many silicified fossils are preserved on the exposed surfaces, generally in the thicker beds. The most characteristic fossils are the operculum-like *Ceratopeas,* the major zone of which extends through nearly the entire formation, from bottom to top. A sponge, *Archaeoscyphia*, occurs near the base of the formation in both mountain regions. Species of brachiopods which are found wide-spread in this formation, include *Tritoechia delicatula, T. subacquiradiata* and *T. typica.* Among the gastropods, the most important for correlation are *Orospira bigranosa, Machurea affinis,* and *Hormotoma artemesia.* The first and last named of these gastropods are common in the Newalla limestone of Alabama. The limits of this formation are indefinite, as they were placed to include the upper and lower limits of the main *Ceratopea* zone. Accordingly, the formation grades into the Cool Creek below and the West Spring Creek above.

West Spring Creek Formation. This formation is named for West Spring Creek at the west end of the Arbuckle Mountains (sec. 31, T. 1 S., R. 1 W.) where it flows across the moderately dipping beds of the formation. However, the type section occurs along U. S. Highway 77 a little over 3 miles north of Springer (sec. 19, T. 2 S., R. 1 E.). In the type section the thickness is 1,611 feet and in the Nebo section to the east, 1,620 feet. In the Wichita Mountains rocks as young as those of the West Spring Creek formation have been recognized in only one locality, sec. 18, T. 5 N., R. 14 W., 14 miles south and 2 miles east of Mountain View. Here 250 feet of beds, belonging to the middle of the formation, occur in a syncline, and part of the beds are exposed in a road cut.

The formation is characterized chiefly by many zones of thin shaly limestones separated by thick resistant limestone beds. The uneven weathering of these beds has produced the noteworthy "tombstone" topography so noticeable on the south hill slopes along U. S. Highway 77. That some of these beds were deposited in

shallow water is evidenced by the reverse of mud cracks discovered by the writer[36] on the under side of a bed 740 feet below the top of the formation. More thick beds of limestone occur in the lower part of the formation.

Several sandstones occur in the upper part of the formation. Northeast of Woodford (sec. 24, T. 2 S., R. 1 W.) there are five sandstones ranging from about 8 to 12 feet in thickness. Southeast of Sulphur (sec. 1, T. 3 S., R. 3 E.) a number of sandstones, one 50 feet thick, are exposed. In the eastern part of the Arbuckle Mountain area this formation also contains much sandstone, as at Mill Creek. The bed being mined for glass sand at Mill Creek, (sec. 6, T. 2 S., R. 4 E.), is thought by the writer to belong to the West Spring Creek formation.

Dolomite occurs in several zones alternating with the sandstones in the upper few hundred feet of the West Spring Creek formation in the eastern part of the Arbuckle Mountains. Among the localities where these dolomites were observed are: sec. 36, T. 2 S., R. 3 E., and sec. 1, T. 3 S., R. 3 E., southeast of Nebo; in secs. 13, 23, and 24, T. 1 N., R. 4 E., east, southeast, and south of Hickory; in sec. 6, T. 2 S., R. 5 E., north of Mill Creek; in sec. 34, T. 2 N., R. 6 E., Byrds Mill Spring southwest of Franks; and in secs. 13 and 24, T. 1 S., R. 6 E., northeast of Connerville. In the vicinity of Hickory large quantities of high grade dolomite are accessible to railroad transportation.

As noted above, the upper Arbuckle has been an important oil producing horizon for many years, and the petroliferous rocks in both quarries at Crusher, sec. 30, T. 2 S., R. 3 E., Murray County, are in the West Spring Creek formation.

Many fossiliferous zones occur in this formation, but the most significant are those containing graptolites. The *Didymograptus protobifidus* zone occurs 808 feet below the top, on U. S. Highway 77. This zone was discovered on the east side of Washita River south of Crusher and in both Crusher quarries. It has been identified by the writer from the Marathon, Texas, and Smithville, Arkansas, regions, and is thought to occur in the Deep Kill of New York. It occurs in England, Europe, and Australia. At 845 feet, or 27 feet below the *D. protobifidus* zone, *D. protobifidus praecursor* occurs. This variety is significant in that it was found in the Wich-

36. Decker, C E., and Merritt, C. A., *op. cit.*, p. 11, pl. II-B, 1928.

ita Mountains and supplied the evidence to indicate that the middle part of the formation was present there. Previously it was thought that this formation was not represented in the exposures in those mountains. Some excellent dependent graptolites have been found in a zone 100 feet or more above the *D. protobifidus* zone, but these have not been worked up in detail.

The important *Hormotoma* gastropod bed is usually 20 to 35 feet below the top. Often several feet of limestones are crowded with gastropods, the most common of which is *Hormotoma*. The upper calcareous algal *Cryptozoon* zone is generally about 20 feet below the gastropod bed. Brachiopods include *Diparelasma transversum, Tritoechia planodorsata, Pomatotrema magnum, P. murale, P. oklahomense,* and *P. transversum* all by Ulrich and Cooper. Large numbers of ostracodes occur in the upper part of the formation and extend down for a distance of 1,000 feet or more. Some very fragmental trilobites have been found about 900 feet below the top.

No definite boundary has been placed at the bottom of the formation where it extends approximately to the top of the main *Ceratopea* zone. Its top is marked by the base of the basal conglomerate of the Joins formation of the Simpson group.

STRUCTURE

Structure In The Arbuckle Mountains

Major Folds. The structure of the rocks in the Timbered Hills and Arbuckle groups in the Arbuckle Mountain area are related to two large anticlinal folds: the Arbuckle anticline and the Hunton-Tishomingo anticline[37], which trend northwest-southeast, and in whose axes Pre-Cambrian granite and porphyry are exposed.

Minor Folds. Numerous smaller folds are present, some with axes normal to those of the major folds. Some of these smaller folds extend for 3 or 4 miles, while others are only part of a mile long.

Major Faults. Several very large faults occur, some with a throw of many thousand feet and some of them are of the scissors type. They trend northwest-southeast, but the trace does not follow the strike of the beds of the large folds.

37. Dott, Robert H., "Overthrusting in Arbuckle Mountains, Oklahoma," *Bull. Amer. Assoc. Petro. Geol.*, Vol. 18, pp. 567-602, 1934.

Minor Faults. Numerous small faults have a throw varying from a few feet to several hundred feet, and the traces of these faults run in various directions. So numerous and complex are the folds and faults that very extended and detailed studies would be necessary to work them out in any adequate way. Any one who is interested in the structure of the Arbuckle Mountain area is referred to the writings of Taff, Reeds, Moore, Morgan, and Dott[38].

Structure In The Wichita Mountains

Major Folds. The major elements of structure in the Wichita Mountains are two large anticlines whose axes trend in a general northwest-southeast direction. These axes make an angle of about 20° with each other, and may converge a little east of Fort Sill. Between these two anticlines is an irregular syncline. The larger southern anticline is 12 to 15 miles wide at its southeastern end and widens rapidly to the northwest where it seems to control the northeast dip of the Viola and Simpson formations in the Rainy Mountains south of Gotebo. None of the older sedimentary formations are exposed at the west end nor on the southwest side of the mountains. The northern anticline is less than half as wide as the southern one, and the central igneous axis is exposed only at intervals. The possible location of the northwest-plunging end of the northern anticline is suggested by the outcrop of Arbuckle limestone dipping 50° toward the northwest in sec. 30, T. 7 N., R. 15 W., about 4 miles southeast of Gotebo. In a similar manner the gently east-dipping Arbuckle limestone in Quarry Hill, a short distance east of the Fort Sill railway station, seems to mark the eastern end of the larger southern anticline, and the south-dipping limestones in McKenzie Hill 7 miles northwest of Lawton seem to mark the southeastern edge of this major fold.

There is significant evidence that the structure of the sedimentary rocks is intimately related to the igneous masses away

38. Taff, J. A., "Geology of Arbuckle and Wichita Mountains of Indian Territory and Oklahoma"; *U. S. Geol. Survey Prof. Paper* 31, pp. 37-46, 1904.
Reeds, C. A., "A Report on the Geological and Mineral Resources of the Arbuckle Mountains, Oklahoma"; *Okla. Geol. Survey Bull.* 3, pp. 43-53, 1910.
Moore, R. C., "The Relation of Mountain Folding to the Oil and Gas Fields of Southern Oklahoma"; *Bull. Amer. Assoc. Petr. Geol.*, Vol. 5, pp. 32-48, 1921.
Morgan, George. "The Geology of the Stonewall Quadrangle, Oklahoma"; *Bureau of Geology, Bull.* 2, pp. 24, 30, 34, 42, 48, 56, etc., 1924.
Dott, Robert H., *op. cit.*, pp. 567-602, 1934.

from which they dip as a general rule. The sudden changes in strike around some of these igneous masses suggest strongly their local influence on minor structure. There is also evidence that the early sediments were laid down on an irregular igneous surface with peaks of the igneous rocks supplying fragments through nearly 100 feet of the basal sediments. On the north side of the mountains in Blue Creek Canyon there seems to have been separation and isolation of the lowermost Upper Cambrian deposits on the two sides of an igneous mass. A basal limestone found at the south is not present at the north, and fine-textured, laminated sandstone on the south is in contrast with coarse-textured sandstone on the north. Along the west edge of Blue Creek Canyon (sec. 11, T. 4 N., R. 13 W.) both the basal limestone of the Timbered Hills group and Reagan sandstone are absent, so that the Honey Creek limestone beds overlap directly upon the igneous mass, and the basal beds of the Honey Creek enclose large pieces of igneous rock.

On the northern side of the northern anticline coarse conglomerates extend up a considerable distance in the Reagan, especially in sec. 26, T. 6 N., R. 14 W., where some of the zones contain igneous boulders 4 to 6 inches in diameter. Also, quartz and feldspar grains are found in the Honey Creek formation above the Reagan, indicating the presence of an exposure of igneous rocks in that region, well toward the close of deposition of the formations of the Timbered Hills group.

On the south side of the mountains no contact of lower Paleozoic with igneous rocks is exposed, and the Reagan sandstone crops out at only one locality at the north edge of sec. 13, T. 2 N., R. 13 W., but there arkosic fragments extend up through the Reagan into the base of the Honey Creek, indicating that conditions of early sedimentation in the south part of the mountains were similar to those in the north part. As no arkose has been discovered in the lower formations of the Arbuckle group, the igneous masses which now form the axes of the anticlines must have been covered throughout Arbuckle time. If the axes of these two anticlines represent the remnants of two Pre-Cambrian ridges, the relief in them could not have been more than a few hundred feet at the beginning of Cambrian deposition and they were soon completely submerged. Even though they were low, there is a suggestion that where they were close together they formed resistant buttresses between which the sedimentary beds were compressed and folded and faulted.

The structure of the sedimentary rocks between these two igneous masses, especially at the west side of Blue Creek Canyon, seems to indicate that when elevation and crustal shortening took place, these sedimentary beds were folded and contorted as though they had been caught in the jaws of a great vise. As the axes of the two folds diverge toward the northwest, the folding between them is not nearly so intense and dips are much lower. The axis of the southern anticline seems to broaden toward the northwest so as to control the northeast dip of the Viola limestone in Rainy Mountains 6 to 9 miles southeast of Gotebo. Although the northwest end of the northern anticline seems to plunge sharply and die out southeast of Gotebo, other minor structures may extend beyond it.

Minor Folds. In the highly folded area west of Blue Creek Canyon there are a number of smaller folds several hundred feet in width, and in the area northeast of Blue Creek Canyon upper Arbuckle beds have been folded into fairly large open folds. Still smaller folds 20 to 100 feet in width occur in exposures on both the north and south sides of the mountains.

Major Faults. Some of the faults are of considerable size, but none are known that compare in size with the larger ones in the Arbuckle Mountains. One of the larger faults passes through Blue Creek Canyon, and another about a mile to the northeast has a trace nearly parallel to it, but these are not known to extend more than 2 or 3 miles, and they have displacement of only 100 feet or so. Other faults of similar size cut beds in the upper part of the section to the east of these.

Minor Faults. A small fault, a few hundred feet long, cuts across McKenzie Hill in almost a north-south direction on the south side of the mountains in the west edge of sec. 9, T. 2 N., R. 12 W. Many others occur in the outcrop of the limestones on the north side of the mountains. One of these smaller faults has its trace extending westward, parallel with the strike in the upper part of the Arbuckle limestone, a short distance south of the edge of the exposure at the northwest edge of Blue Creek Canyon.

Minor Movements. On McKenzie Hill, on the south side of the mountains in secs. 7 and 8, T. 2 N., R. 12 W., many minor changes during deposition are suggested by the numerous conglomeratic horizons in the Fort Sill, Signal Mountain, and McKenzie Hill formations. In the Fort Sill formation, in which conglomerates

are least numerous, the typical edgewise conglomerates occur. In the basal part of the Signal Mountain formation the conglomerates are rather fine and are made up of small, rounded, brownish pebbles.

In the beds succeeding these basal conglomerates in the Signal Mountain, and extending well up toward the middle of the McKenzie Hill formation, numerous coarser conglomerates occur at intervals. They are limestone conglomerates in which most of the fragments are irregular and not of the flattened type that occur in edgewise conglomerates. Some fragments appear to have been partially rounded.

The numerous conglomerate zones suggest shoal conditions with many temporary breaks in deposition. Possibly the conditions noted above may explain at least in part the relatively thin section at that locality. There the Signal Mountain and McKenzie Hill formations together have a thickness of 514 feet, whereas, on the north side of the mountains, in sec. 26, T. 6 N., R. 14 W., the same two formations have a thickness of 1,369 feet, and in the Arbuckle Mountains in sec. 18, T. 2 S., R. 2 E., their combined thickness is 1,600 feet.

These figures show that the combined thickness of the Signal Mountain and McKenzie Hill formations on McKenzie Hill is a little more than one-third their combined thickness on the north side of the Wichita Mountains, and less than one-third their combined thickness in the Arbuckle Mountains.

ECONOMIC GEOLOGY

Oil and Gas. The upper part of the Arbuckle limestone has long been a very important horizon for the production of oil and gas in the Oklahoma City field and in areas to the north and northeast as well as in Western Kansas. The writer has found a highly carbonaceous horizon with asphalt seeps in two quarries in rocks of the McKenzie Hill formation about 600 to 900 feet above the base of the Arbuckle. If this zone is penetrated under proper structural conditions it may become a new source of oil and gas.

Crushed Rock. An immense amount of crushed rock from the Arbuckle limestone is used in concrete for structural work in foundations and walls of buildings, paving roads, and in building bridges and dams. It is used also as ballast for railroads and as a foundation in macadam roads.

Building Stone. Locally the Reagan sandstone is evenly bedded and highly indurated. A short distance northeast of Blue Creek Canyon a rectangular system of closely spaced joints has broken the 6 to 10 inch beds into pieces which need relatively little trimming. The stones have been used in building bridges and culverts on the newly graded highway through Blue Creek Canyon.

Much building stone has been secured from the McKenzie Hill formation from the quarries on the south side and at the east end of the Wichita Mountains. A large amount of stone has been secured from several quarries on McKenzie Hill. Two are located near the top of the west face, two others near the east end of the hill, and another in the same zone, at the south end of the hill on the McMichel ranch. There is considerable demand for building stones from these quarries, so they are being actively worked, at least part of the time. Some building stone has been quarried from the two Dolese quarries in the Arbuckle Mountains, and from the one at Richard's Spur in the Wichita Mountains. From smaller quarries in the Wichita Mountains special limestones are chosen for their ornamental value for building homes in Oklahoma City and elsewhere.

Dolomites. Dolomite is important in a number of technical and industrial processes and enormous masses of dolomites occur in several formations of the Arbuckle group in both mountain regions. With its wide distribution and the extremely large masses, it would seem to give promise of developing into an economic resource.

Zinc. A small amount of disseminated zinc has been found both to the northwest and to the southeast of the East Timbered Hills, in the Arbuckle Mountains. At one time, a concentrating plant was built at the former of the two localities and milling was attempted on a rather large scale.

Hematite. Hematite is concentrated in a noteworthy manner for several miles along the strike in sandstones of the Reagan formation east of Blue Creek Canyon in the Wichita Mountains, but seems to be most highly concentrated near the west side of sec. 17, T. 4 N., R. 12 W. Even here, however, the iron content is low. Spasmodic attempts, however, have been made to mine it for use as a paint pigment. Merritt[39] has recently discussed the nature and extent of this deposit.

Limonite. Large pieces of limonite are scattered over the surface of the limestones in the Arbuckle group, often along the trace of the fault planes. The largest deposit noted was in the Arbuckle Mountains on the west side of U. S. Highway 77 in sec. 12, T. 2 S., R. 1 E., where several tons of high grade ore lie in piles around a shallow pit. Some other limonite occurrences are listed below:

NE NW NE sec. 1, T. 1 S., R. 4 E. Limonite masses exposed over an area of 325 x 225 feet on the top of a low hill of Arbuckle.

Sec. 6, T. 1 N., R. 5 E. Limonite mass covering an area of 325 x 300 feet on a low Arbuckle hill.

S½ sec. 21, T. 1 S., R. 6 E. Limonite masses exposed over an area 250 x 350 feet on a low Arbuckle hill. A shaft 10 feet deep was sunk in the hill and was still in ore at the bottom.

Sec. 11, T. 1 S., R. 6 E. Limonite deposit covers an area of 2.5 acres on an Arbuckle hill.

Chemical analyses of hand samples from these deposits shows a high iron content, some specimens having 57 percent iron. These deposits have not been studied in detail and no definite information is available concerning their origin, size, and economic possibilities.

Glass Sand. As noted above, a number of sandstone beds are present in the upper part of the West Spring Creek formation of

39. Merritt, C. A., "Iron Ores of Wichita Mountains, Oklahoma"; *Economic Geology*, Vol. 34, No. 3, pp. 282-286, 1939; Iron Ores; *Oklahoma Geol. Survey, Mineral Report*, No. 4, 1939.

the Arbuckle group, in the Arbuckle Mountain area. These sandstones increase in thickness from west to east, and may have some economic importance as sources of glass sand. The quarry located just north of the town of Mill Creek, sec. 6, T. 2 S., R. 5 E., where glass sand is being mined at present, is thought to be in the upper part of the West Spring Creek formation.

Water Resources. Formations of the Arbuckle group furnish abundant supplies of ground water in both the Arbuckle and Wichita Mountain regions. The broad areas of outcrop, and the relatively high permeability resulting from fractures, joints and solution channels, provide ideal conditions for the accumulation and rather ready circulation of large quantities of water through the rocks.

Springs abound in the area of outcrops of the Arbuckle group in the Arbuckle Mountains, of which Byrd's Mill Spring, near Franks, which furnishes the city of Ada with its water supply, is perhaps the most famous. Such perennial streams as Blue River, Pennington Creek, Mill Creek, Falls Creek, and Honey Creek, are fed by springs that issue from the Arbuckle limestone. Owing to smaller areas of outcrop and lower rainfall, springs are less common in the Wichita Mountains.

There are a number of deep wells that draw water from the Arbuckle limestone in the vicinity of Lawton and Fort Sill, at the eastern end of the Wichita Mountains, and the water in several of these is under sufficient artesian head to flow at the surface. The rocks dip so steeply away from the Arbuckle Mountains, that wells drilled on the flanks of that uplift obtain water from formations younger than the Arbuckle.

SUMMARY

In the three summer field seasons attention was directed primarily to the study of the Arbuckle limestone, but a minor amount of time was spent in the study of the older formations beneath that limestone. Selected sections were measured in considerable detail, physical characteristics were noted and fossils were collected by zones.

Of the fossils identified a sponge, two zones of graptolites, numerous brachiopods, several gastropods, some calcareous algal structures, and some oolitic textures have supplied excellent evidence on which to correlate various parts of the different formations in

the Arbuckle and Wichita Mountain regions. A detailed study is still being made by Josiah Bridge of *Ceratopeas* and by Edward Frederickson of the trilobites from the lower limestones in the Arbuckle and Timbered Hills groups. A zone of dendroid graptolites was found in the U. S. Highway 77 section, and in the Nebo section in the Arbuckle Mountains, and in Quarry Hill, McKenzie Hill, Dolese quarry, and in outcrops extending several miles to the northwest of that quarry, in the Wichita Mountains. The combined evidence from the fossils indicates that 1,600 to 1,800 feet of the limestones belonging to the upper part of the Arbuckle group in the Arbuckle Mountains, are not generally exposed in the top of the sections in the Wichita Mountains. It is only on the evidence of the small graptolite *Didymograptus protobifidus praecursor* that the presence of the middle part of the West Spring Creek formation was established in the syncline about 14 miles south and 2 miles east of Mountain View.

The details of the study are presented in the 17 measured sections in the Appendix, and the measurements given there are in general probably the most accurate made to the present. The new measurements of the Arbuckle group along U. S. Highway 77 is 7,292 feet. The thickness given for the Nebo section seems too small, due perhaps to inaccuracies in pacing across the upper part. When the thickness is calculated from dips taken and the width of outcrop at right angles to the strike, a thickness is secured practically the same as that on U. S. Highway 77. The longest measured section of the Arbuckle group in the Wichita Mountains, located about 11 miles southwest of Carnegie, has an exposed thickness of 3,770 feet. The restored thickness secured by assigning 1,600 to 1,800 feet to the upper Arbuckle that are covered or absent, is 5,370 to 5,570 feet. This indicates 1,700 to 1,900 feet less thickness for the Arbuckle group in the Wichita Mountains than in the Arbuckle Mountains.

The position of the Cambro-Ordovician boundary, concerning which there has been much uncertainty, is here placed at the base of the McKenzie Hill formation, on the best evidence now available. This boundary is thus placed 1,656 feet above the base of the Arbuckle group along Highway 77 in the Arbuckle Mountains, 779 feet above the base of that group on the north side of the Wichita Mountains and 515 feet above the base of that group on the south side of the Wichita Mountains.

In connection with this study it seemed desirable to divide the very thick Arbuckle limestone into formations, so "Arbuckle" was raised to a group name which was divided into 9 formations and 2 members. A paper giving this newest classification and brief descriptions of formations, with locations of type sections, was submitted by the writer[40] to H. D. Miser and Josiah Bridge, of the United States Geological Survey, for criticism and for approval of new formation names.

A new basal limestone was discovered below the base of the Reagan with a thickness of 98 feet resting upon an unmapped outcrop of igneous rock. This limestone is thought to represent the oldest sedimentary deposit in the state.[41]

A new carbonaceous zone, locally asphaltic, was discovered from 600 to 900 feet above the base of the Arbuckle group in the Wichita Mountains.[42]

A graphic chart is presented showing in a distinct manner the correlation of the various zones in two sections in the Arbuckle Mountains with those in several sections of the Wichita Mountains.

A new geologic map of part of the Wichita Mountain area is presented. On it are shown the axes of the two major anticlines and the irregular syncline between them, together with dips to indicate the general structure. Noteworthy errors in the location of some igneous and sedimentary outcrops were corrected, but sufficient time was not available to check the location and outlines of all the outcrops. Future more detailed studies will doubtless necessitate still further changes in the map.

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40. Decker, C. E., "Two Lower Paleozoic Groups, Arbuckle and Wichita Mountains, Oklahoma"; *Bull. Geol. Soc. Amer.*, Vol. 50, pp. 1311-1322, 1939.
41. Decker, C. E., "Basal Sedimentary Formations in the Wichita Mountains"; read before twenty-fourth Annual Meeting, *Amer. Assoc. Petro. Geol.*, Oklahoma City, March, 1939. *Bull. Amer. Assoc. Petr. Geol.* Vol. 23, pp. 1094-1098, 1939.
42. *Idem.*, "Carbonaceous and Asphaltic Material in the Lower Arbuckle Limestones of the Wichita Mountains"; *loc. cit.*

APPENDIX

1. SECTION OF ARBUCKLE AND TIMBERED HILLS GROUPS

East of Nebo Store, 10 miles southeast of Sulphur at south edge of sec. 24, T. 2 S., R. 3 E., and of secs, 19 and 20, and the north edge of sec. 26, 27, and 28, T. 2 S., R. 4 E., Murray and Johnston Counties. Dip 15° NW, strike N. 10° E., near top of the formation.

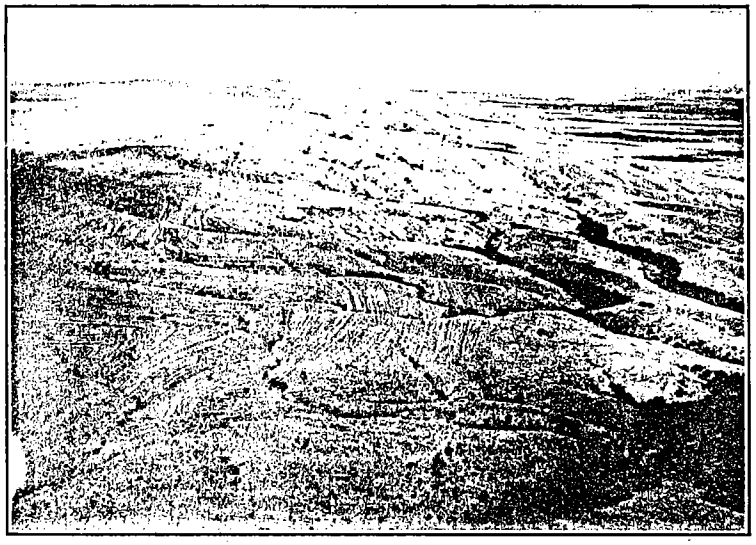
Zones	Thickness (feet)		Description
	Zone	Cumulative	
			ORDOVICIAN
Arbuckle Group.			
			West Spring Creek formation, 1,620.84 feet thick.
1.	slight		Conglomerate at base of Joins formation of Simpson group and uppermost Arbuckle not exposed.
2.	39.00	39.00	Thin limestones down to main gastropod bed.
3.	64.74	103.74	Thin limestones.
4.	341.64	445.38	Over ridge of loose sand with scattered fragments of sandstone, limestone, and breccia on the surface. A few limestones and sandstones crop out in lower third of zone.
5.	117.00	562.38	Shifted ¼ mile to north to secure better outcrops. 40′ of sandstone at top of zone, the rest alternating thin and thick limestones. Strike shifted N. 40° W. Dip SW.
6.	179.40	741.78	Covered across swale, sandy soil.
7.	78.00	819.78	Heavy yellowish-brown limestones.
8.	87.36	907.14	Soil covered across ravine.
9.	234.00	1141.14	Limestone beds slope towards southwest.
10.	234.00	1375.14	Shifted southward about ⅛ mile. Dip 15° SW. Strike N. 10° W. A zone of alternating thin and thick limestones.
11.	132.60	1507.74	Heavy beds of limestone alternate with zones of thinner beds. Limestones cherty toward base.
12.	54.60	1562.34	Soil covered on slope.
13.	58.50	1620.84	Gray limestones.
			Kindblade formation, 1,538.5 feet thick.
14.	167.70	1788.54	Heavy bedded limestones with sandy zone at base. Uppermost *Ceratopea* zone at top.
15.	15.60	1804.14	Gray limestones. *Ceratopea* abundant at base of zone.
16.	128.70	1932.84	Mostly heavy gray limestones with a few thin beds. *Tritoechia delicatula* U. and C. at base of zone.
17.	132.60	2065.44	Alternating thick and thin limestone beds with flat gastropods at base.
18.	120.80	2186.24	Thick and thin beds of limestone. Brachiopods, many gastropods, and a few *Ceratopea*.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
19.	62.40	2248.64	To N-S fence. Limestones with small brachiopods, *Tritoechia typica* U. and C., at base of zone.
20.	23.40	2272.04	Thick bedded gray limestones. Brachiopods, *Tritoechia typica* U. and C., gastropods, and trilobites.
21.	48.80	2320.84	Thick bedded gray limestones. Good gastropods, *Maclurea affinis*. This form is abundant in zone 7 of section 4, (235 feet below exposed top), 10½ miles south of Carnegie on the north side of the Wichita Mountains, where the upper part of the Arbuckle limestone is not exposed.
22.	288.60	2609.44	Light gray limestones with very thick beds at base. Gastropods present.
23.	85.80	2695.24	Massive limestones which are weathered rough and irregular.
24.	156.00	2851.24	Thick beds of limestone in upper part, last 80 paces soil covered in valley.
25.	42.90	2894.14	Thick limestone beds with *Ceratopea* at base of zone.
26.	179.40	3073.54	*Ceratopea* in thick beds of limestone. Many large gastropods present. Breccia at base.
27.	85.80	3159.34	Massive gray limestones. *Ceratopea* at base of zone.
	Cool Creek formation, 1,513.5 feet thick.		
28.	460.20	3619.54	Massive gray limestones to second fence, N-S.
29.	206.70	3826.24	Gray limestones at top, dolomitic marble-like toward base. Shifted south about ½ mile.
30.	15.60	3841.84	Partly covered with soil. Some thick gray limestones.
31.	831.00	4672.84	Much sandy soil, some heavy chert zones.
	McKenzie Hill formation, 674.2 feet thick.		
31a.	200.00	4872.84	A few outcropping limestones to lower Arbuckle Graptolite zone.
32.	15.75	4888.59	Dip 20° to 22° W. Strike N. 30° W. Lower Arbuckle Graptolite zone. Thin yellowish-brown limestones 1.5 to 6 inches thick, two of which are edgewise limestone conglomerates. In these and in some of the thinly splitting limestones the graptolites are sparsely scattered, some trilobites. Fucoids on some beds. Some cherty limestone and chert in joints.
33.	79.18	4967.77	Thin gray and brown limestones .4 to 1 foot thick.
34.	157.25	5125.02	Covered by grassy pasture cover.
35.	85.10	5210.12	Rather fine grained yellowish gray dolomite.
36.	136.90	5347.02	Soil and grass covered, some heavy chert masses scattered over the surface.

PLATE IV.

Reagan sandstone, Cambrian age, resting on pre-Cambrian porphyry. Contact in valley at left. Limestone Hills northeast Wichita Mountains. (U. S. Army Air Service.)

PLATE V.



Aerial view of limestones of the Arbuckle group, Limestone Hills, northeast Wichita Mountains (U. S. Army Air Service.)

Zones	Thickness (feet)		Description
	Zone	Cumulative	
			CAMBRIAN
			Butterly formation, 374.7 feet thick.
37.	53.28	5400.30	To algal bed, individual algae 2 to 4 inches in diameter in coarse pinkish-gray dolomite. Heavy cherts especially in upper two-thirds of zone.
38.	131.95	5532.25	Dolomites of above zone continue with many large siliceous oolites scattered through the zone.
39.	8.05	5540.30	Thin grayish yellow limestones, beds 1 to 3 inches thick.
40.	86.90	5627.20	Scattered outcrops, white to gray and yellow dolomites.
41.	94.52	5721.72	Massive coarse gray dolomites with erosional remnants standing 2 to 3 feet above the surface.
			Signal Mountain formation, 114.6 feet thick.
42.	114.60	5836.32	Soil and grass covered in swale.
			Royer formation, 675.28 feet thick.
43.	120.00	5956.32	Heavy gray dolomites. Dip 17° W. in middle of zone.
44.	30.00	5986.32	Soil and grass covered.
45.	129.90	6116.22	To N-S fence. Heavy dolomites.
46.	315.60	6431.82	Shifted north along the strike about 200 feet. The dolomites of zone above continue in yellow and pink coarse masses standing 2 to 3 feet above the surface of the ground.
47.	26.00	6457.82	Fine grained yellowish brown dolomites in beds .8 foot to 2 feet thick. Dip 15° W. Some sand grains on surface.
48.	38.48	6496.30	Rough surfaced beds of limestone with some quartz and feldspar grains in them, 8 to 14 inches thick.
49.	15.30	6511.60	Fine grained grayish brown dolomite, bedded.
			Fort Sill formation, 283.63 feet thick.
50.	15.90	6527.50	Dark gray limestone with rough surfaces on beds.
51.	128.70	6656.20	Fine grained gray magnesian limestones, but mostly thick beds with many quartz grains and some feldspar. About 12 feet conglomeratic at base of zone with quartz and feldspar grains. Seems to rest unconformably on a somewhat uneven surface of limestone beneath.
52.	48.25	6704.45	Pink to gray limestone with rough surfaces like sponge beds. Dip 18° to 20°.

Zones	Thickness (feet) Zone	Cumulative	Description
53.	90.78	6795.23	White marble mottled with buff, coarse crystals in parts. About 75 feet of it covered across the road region.

Total thickness 6795.23*

Timbered Hills Group.

Honey Creek formation, absent.

Cap Mountain formation, 126 feet thick.

54.	126.00	6921.23	Pinkish gray sandy dolomites with some quartz and feldspar grains toward base.

Reagan formation, 430 feet thick.

*Zones 1 to 31 were measured by pacing and 32 to 53 by tape, and the thickness was calculated from dips read at intervals.

Calculating outcrop distance from contacts:

West 3¼ miles at 15°, 26′ per 100′ for 17,160′ = 4461′
East 1¾ miles at 18°, 30′ per 100′ for 9,240′ = 2772′
Thickness from outcrop figures = 7233′

Taff[43] has given the following record of the thickest section of the Reagan sandstone as it occurs at the western end of the granite area (south of the village of Mill Creek in the Arbuckle Mountains).

"Section of Reagan Sandstone"

	Feet
"Thin-bedded and laminated sandstone, becoming calcareous in its upper part.	60
Coarse grit and sand, with some clay and green sand in upper part generally well stratified.	370
Quartzite and arkose conglomerate, composed of poorly sorted granitic materials."	30
Base rests on Pre-Cambrian Tishomingo granite.	
Total thickness	460

2. SECTION OF ARBUCKLE AND TIMBERED HILLS GROUPS

From top northward along U. S. Highway 77 to top of hill then northeastward at right angles to strike on the east side of highway to the top of the Royer formation. West part of T. 2 S., R. 2 E., Murray and Carter Counties. Measured by tape. Dip 55° SW, strike N. 55° W. Royer and Fort Sill formations measured by pacing southwestward from the west side of the East Timbered Hills. Dip 40°, strike N. 40° W. Measurements of zones 1-208 are taken from Oklahoma Geological Survey Circular 15. Descriptions are condensed, and some fossil zones are added.

43. Taff, J. A., "Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma"; *U. S. Geol. Survey Prof. Paper* 31, p. 21, 1904; *Okla. Geol. Survey Bull.* 12, p. 18, 1928.

Zones	Thickness (feet) Zone	Cumulative	Description
			ORDOVICIAN
			Arbuckle Group.
			West Spring Creek formation, 1,611.75 feet thick.
1-4	20.50	20.50	Thick and thin, dark gray limestone and some sandstone. Ostracodes and gastropods, with *Hormotoma* gastropod bed at base.
5-9	22.00	42.50	Thin sandy and shaly limestone. Ostracodes present.
10-11	10.25	52.75	Thick limestone at top. Sandstone thin shaly limestone. Main cryptozoon algal bed at top.
12-20	19.00	71.75	Several thick beds of limestone with zones of thin limestone, shaly and sandy limestones and breccia. Ostracodes.
21-28	20.75	92.50	Dark banded limestone shaly and calcareous sandstone conglomerates, and breccia at base.
29-35	116.00	208.50	Thick limestone, thin sandy limestone and shale, with much sandstone and sandy limestone at base.
36-45	133.00	341.50	Numerous thick limestones, with zones of thin limestones between. Some lens-shaped cherty bands. Much sandy, shaly limestone. Gastropods, brachiopods, *Pomatotrema magnum*, *Syntrophopsis*, *laevicula* and crinoid stems.
46-59	115.75	457.25	Thin beds of limestone alternate with thick resistant beds and much thin sandy limestone. Brachiopods, *Diparelasma typicum*.
60-76	172.25	629.50	Sandy and argillaceous limestone, reverse of mud cracks on lower surface of one bed. Some thin and thick even-bedded limestone, some chert nodules. Two algal zones. Some forms in lower bed are 2½ feet in diameter.
77-88	90.00	719.50	Much sandy and argillaceous limestone in thin beds between a number of thick dense limestones. Some large dependent graptolites near base of zone.
89-95	63.25	782.75	Mostly thick beds of limestone separated by several zones of thin sandy and shaly limestone.
96-102	169.75	952.50	Mostly thick limestone with several zones of thin shaly limestone between. *Didymograptus protobifidus* zone at 808 feet from top and *D. protobifidus praecursor* at 845 feet. Some ostracodes.
Graptolite Zones 808 and 845			
103-115	319.00	1271.50	Thick beds of dark gray limestone separated by zones of thin sandy and shaly limestone. Cherty toward base of zone. Low and high spired gastropods near top of zone.

Zones	Thickness (feet) Zone	Cumulative	Description
116-134	340.25	1611.75	Mostly wide zones of thick limestone with several zones of thin limestone, and sandy limestone. Some beds are dark chocolate but most of them are gray. Some are thinly banded.
Kindblade formation, 1,216.15 feet thick.			
135-142	239.15	1850.90	Mostly thick beds of limestone in upper and middle part of zone with thin gray limestones in lower part.
Top of Ceratopea zone.			
143-147	246.45	2097.35	Mostly thick limestone with three narrow zones of thin shaly limestone. *Ceratopea* runs nearly through the zone. Brachiopods are present and *Maclurea affinis* occurs near base of zone.
148-150	573.00	2670.35	Alternating zones of thin limestone with several thick beds. *Maclurea affinis, Orospira bigranosa, Hormotoma artemesia* near top of zone. Gastropods and *Stromatocerium* in middle. Sponge, *Archaeoscyphia* 2,457 feet below top of Arbuckle group.
151-153	157.20	2827.55	A few thick beds of limestone alternating with zones of thin limestone. *Ceratopea* in several horizons. Worm burrows and trails, algae and trilobites.
Base of Ceratopea Zone.			
Cool Creek formation, 1,687 feet thick.			
154-167	336.80	3164.35	Dark gray to black crystalline limestone, some asphaltic. Some zones of thin sandy limestone. Breccia near base of zone. *Stromatocerium, Hyolites* and several algal zones. One algal bed 4 feet thick.
168-176	210.70	3375.05	Numerous 4-foot beds of limestone separated by zones of thin limestone. More thin-bedded toward base of zone. *Oligorthis arbucklensis.*
177-179	683.00	4058.05	Thin bedded chocolate limestone at top of zone. Scattered edges of limestone scattered over pasture. Siliceous oolites abundant through the zone.
180-181a	456.00	4514.05	Limestone exposed only at intervals over pasture, siliceous oolites extend to base of zone. New zone 181a is 36 feet thick.
McKenzie Hill formation, 1,122 feet thick.			
McMichel member, 978 feet thick.			
182	483.00	4997.05	Heavy beds of limestone with one more argillaceous zone—graptolites at 4,605 below top, some trilobites in zone. Brachiopods near base of zone. *Apheoorthis* cf. *oklahomensis.*
Graptolite Zone, 4,605			
183	495.00	5492.05	Numerous thin limestones alternate with thicker beds, and lower part of zone is grass covered, but limestones crop out up the hill to the east.

Zones	Thickness (feet) Zone	Cumulative	Description
Chapman Ranch member, 144 feet thick.			
184	144.00	5636.05	Thick massive beds of limestone. Two thin zones look dolomitic. Gastropods and cephalopods 40 feet above base of zone. Dip 57°.
CAMBRIAN			
Butterly formation, 286 feet thick.			
185-203	82.30	5718.35	Narrow zones of coarsely crystalline dolomite alternate with thin zones, thin-bedded, fine-grained dolomite.
204-206	203.90	5922.25	Mostly coarsely crystalline dolomite with one thin zone in the center of thin-bedded, fine-grained dolomite.
Signal Mountain formation, 478.8 feet thick.			
207	376.00	6298.25	Resistant crystalline limestones in beds 4 to 12 inches thick. Contain numerous trilobite zones, and some brachiopods and gastropods near top of zone. *Apheoorthis ornata.*
208	102.25	6400.50	Mostly thin-bedded limestone with some looking more magnesian in character.
Royer formation, 771 feet thick.			
209	170.40	6570.90	Light gray coarse dolomite.
210	29.40	6600.30	Fine-grained, gray limestone, looks highly magnesian.
211	27.30	6627.60	Light colored, coarse-grained dolomite.
212	42.00	6669.60	Thick beds of dark gray limestone 2 to 4 feet thick.
213	42.00	6711.60	Coarse, light almost white, and pink dolomite.
214	10.50	6722.10	Fine textured, gray limestone.
215	37.80	6759.90	Coarse light colored dolomitic marble.
216	8.40	6768.30	Dark gray limestone in beds 3 to 8 inches thick.
217	288.00	7056.30	Yellowish-brown coarse dolomite. Weathers to rough masses which stand several feet above the surface.
218	115.20	7171.50	Yellowish-brown, pink and gray magnesian (well-bedded) limestones or dolomites.
Fort Sill formation, 120.88 feet thick.			
219	26.88	7198.38	Thick gray limestones.
220	4.00	7202.38	Massive bed of dark gray limestone.
221	90.00	7292.38	Mostly light colored grayish limestone in beds about 8 inches thick. Parts are poorly exposed, but a few rods to the south on the west bank of a creek 20 feet of alternating thin limestones and shales occur low in the zone.

Total thickness of Arbuckle group, 7,292.78 feet.

Zones	Thickness (feet) Zone	Thickness (feet) Cumulative	Description
Timbered Hills Group.			
			Honey Creek formation, 90.14 feet thick.
			West edge of East Timbered Hills, sec. 1, T. 2 S., R. 1 E., Murray County. Dip 36° SW, strike N. 30° W., figuring 60 feet per hundred.
222	17.96	7310.34	Irregularly bedded crystalline limestone with much ferruginous material. More dense than usual. Much glauconite and weathers irregularly.
223	24.96	7335.30	Grayish coarsely crystalline limestone with irregular shaly lenses. Evenly bedded. Much glauconite. Trilobite zones at base and 5 feet above base.
224	7.44	7342.74	Several crystalline limestone beds exposed. Trilobites at base of zone.
225	19.20	7361.94	Upper half coarsely crystalline grayish-brown limestones with glauconite. Lower half shaly and sandy beds alternate with limestone. Trilobites at base of zone.
226	4.38	7366.32	Crystalline gray limestone. Trilobites at base.
227	16.20	7382.52	Sandstones and limestones alternate in upper part with shaly zone at base resting on coarse Reagan sandstone. Below this about 200 feet of coarse Reagan sandstone, becoming very arkosic toward the base, rests on the irregular surface of the Pre-Cambrian Colbert porphyry.

Note: Species of brachiopods listed in this section were named and described by E. O. Ulrich and G. Arthur Cooper.

3. SECTION OF ARBUCKLE GROUP

Upper Arbuckle Ridge with *D. protobifidus praecursor* zone. Dip 15° S., strike varies N. 80° E. to N. 80° W. East edge sec. 18, T. 5 N., R. 14 W., Kiowa County. Fourteen miles south and 2 miles east of Mountain View, Oklahoma.

Zones	Thickness (feet) Zone	Thickness (feet) Cumulative	Description
			ORDOVICIAN
Arbuckle Group.			
			West Spring Creek formation.
1.	5.00	5 00	Thick beds limestone.
2.	5.00	10.00	Thick bed weathers in thin beds. *Didymograptus protobifidus praecursor* zone.
3.	63.70	73.70	Mostly thick limestones with a few thin beds between.
4.	24.18	97.88	Mostly thin limestone beds somewhat twisted.
5.	24.18	122.06	Thin limestone, large gastropods, *Hyolithes.*
6.	58.50	180.56	Alternating thick and thin limestones.
7.	78.00	258.56	Limestones with numerous chert fragments loose on surface.
			Rest covered to north by soil and Permian deposits.

4. SECTION OF ARBUCKLE AND TIMBERED HILLS GROUPS

Ten and one-half miles south of Carnegie on the north side of the Wichita Mountains, secs. 25 and 26, T. 6 N., R. 14 W., Kiowa County. Dip at top, 23° to 25° NE. Strike N. 45° W. Dip at base 45°.

Zones	Thickness (feet) Zone	Thickness (feet) Cumulative	Description
			ORDOVICIAN
Arbuckle group.			
			Kindblade formation, 957.05 feet thick.
1.	66.00	66.00	Thick bedded gray limestones containing small cherty nodules. At top of zone cephalopods, brachiopods, and gastropods.
2.	30.00	96.00	Moderately heavy beds of limestone. *Ceratopea* at top. Gastropods, cephalopods, a few *Hyolithes* present.
3.	36.00	132.00	Gray limestones. *Tritoechia typica* U. and C., and gastropods.
4.	42.00	174.00	Gray limestones in beds 1 to 3 feet thick. Gastropods and cephalopods.
5.	18.20	192.20	Gray limestones in beds 3 to 12 inches thick. *Ceratopea* and gastropods.
6.	36.00	228.20	Massive limestones. Brachiopods, gastropods, *Hyolithes.*
7.	7.56	235.76	Gray limestones. *Ceratopea, Maclurea affinis* abundant. *Tritoechia typica* U. and C. This zone equals zone 21 east of Nebo (section 1) where the same gastropod is abundant, giving evidence that about 1,800 feet of upper Arbuckle is not exposed in this Wichita section.
8.	20.16	255.92	Massive gray limestones, 6 inches to 2 feet thick. *Ceratopea, Maclurea affinis,* brachiopods.
9.	18.90	274.82	Gray limestones, gastropods, *Ceratopea.*
10.	20.16	294.98	Dark gray limestones in beds 2 to 6 inches thick. Brachiopods, gastropods, *Ceratopea* and others. Dip 35°,
11.	54.00	348.98	Heavy beds of gray limestone. *Ceratopea, Hormotoma artemesia,* cephalopods and *Tritoechia subaequiradiata* U. and C.
12.	74.55	423.53	Thick gray limestones. *Ceratopea, Hormotoma artemesia, Orospira bigranosa, Finkelnburgia scenidioides* U. and C., and *Hyolithes* at base of zone.
13.	27.00	450.53	Thick gray limestones. Sponge-like forms, *Hormotoma artemesia, Orospira bigranosa,* trilobite.
14.	18.90	469.43	Gray limestone in beds 2 to 12 inches thick. *Stromatocerium, Hormotoma artemesia.*

Zones	Thickness (feet) Zone	Cumulative	Description
15.	90.00	559.43	Limestones enclosing considerable chert. *Ceratopea* and other gastropods at base of zone.
16.	30.00	589.43	Gray limestones. Many *Stromatocerium*, *Ceratopea*, and *Orospira bigranosa* and *Orthoceras* at base.
17.	27.00	616.43	Limestones containing many chert nodules. *Ceratopea* 15 feet above base. Small *Stromatocerium* at base.
18.	48.00	664.43	Limestones with chert nodules in thick beds. *Ceratopea*, *Orospira bigranosa*, and other gastropods, *Hyolithes*.
19.	19.08	683.51	Gray limestones in beds 4 to 12 inches thick. Brachiopods, *Ceratopea* and other gastropods.
20.	34.98	718.49	Gray thick limestones. *Ceratopea* and other gastropods and *Hyolithes* at base.
21.	31.80	750.29	Thick limestone beds much fractured. *Stromatocerium*, *Hyolithes*, *Ceratopea*, *Orospira bigranosa*.
22.	69.96	820.25	Much fractured limestone in beds 6 to 12 inches thick with many chert nodules present. Brachiopods, marked algal bed. *Orospira bigranosa* and *Ceratopea*.
23.	136.80	957.05	Thick limestone beds at top, thin ones at base. Chert band 8 paces below top. Three breccia conglomerates in this zone. Sponge, *Archaeoscyphia*. This is zone 21, 24 miles southeast of Carnegie (section 11), 1,088' from the top.
	Cool Creek formation, 1,014.72 feet thick.		
24.	82.37	1039.42	Mostly thin beds of limestone with oolitic cherts. Algal bed just above base. Breccia at base.
25.	25.65	1065.07	Thin limestones and dolomitic zone 15 feet wide with chert in center.
26.	85.50	1150.57	Gray limestones in alternating thick and thin beds. Gastropods, *Hyolithes*, cephalopods.
27.	75.24	1225.81	Limestones with thick breccia conglomerate at base. Zone of large algae and chert above base.
28.	126.00	1351.81	Mostly thin beds of limestone alternating with a few beds 10 to 15 inches thick. Several algal zones, gastropods badly weathered. Some dark resistant beds look dolomitic.
29.	201.60	1553.41	To N-S fence. Thick beds of gray limestone part looks dolomitic. Much oolite and chert in lower part of zone.
30.	418.36	1971.77	Large algal structures near top, thin gray limestone with much chert and siliceous oolite.

Zones	Thickness (feet) Zone	Cumulative	Description
	McKenzie Hill formation, 1,020.30 feet thick.		
31.	517.56	2489.33	Gray to brown even bedded limestones, some cylindrical cherts in them. Large *Eccyliomphalus* type of gastropod as near top of McKenzie Hill near Signal Mountain.
32.	31.92	2521.25	Very thick beds dark gray limestone. Large trilobites at base of zone.
33.	96.90	2618.15	Very thick beds of gray limestone.
34.	104.88	2723.03	Mostly thin bedded limestone. Light to dark gray. Brachiopod zone. *Apheoorthis ornata* U. and C., and zone in which lower Arbuckle graptolites occur in the sections to the southeast.
35.	269.04	2992.07	A few thick, but mostly thin dark gray limestones.
	CAMBRIAN		
	Signal Mountain formation, 350 feet thick.		
36.	350.00	3342.07	Mostly thin gray to brown limestones.
	Royer Dolomite, 195.6 feet thick.		
37.	195.60	3537.67	Gray, brown, pink, massive dolomite, weathers rough and gives name of "Ragged Mountains" to the outcrop.
	Fort Sill formation, 233.14 feet thick.		
38.	45.60	3583.27	Fairly thin limestones.
39.	74.40	3657.67	Thick beds dark gray limestone.
40.	33.00	3690.67	Massive iron stained limestones, cliff makers, yet weather to thin platy beds.
41.	74.64	3765.31	Very thick bluish gray limestones.
42.	5.50	3770.81	Covered, shale or shaly limestone ?
Base Arbuckle is		3770.81	Base exposed, top overlapped by Permian.

Timbered Hills group.

Honey Creek formation, 138.13 feet thick. About 12 miles southwest of Carnegie at southwest edge of excellent Arbuckle outcrop. Sec. 26, T. 6 N., R. 14 W., Kiowa County; dip 50° NE. Strike N. 30° W. Figure 77 feet of strata per 100 feet.

43.	14.93	3785.74	Coarsely crystalline gray to brown limestone with much glauconite in thin layers in the limestones. Trilobites and brachiopods at base.
44.	41.58	3827.32	Coarsely crystalline limestones with more sandy material and much glauconite. Beds lenticular and show gnarled cross-bedded appearance. *Eoorthis remnicha* at base.
45.	29.26	3856.58	Limestones like those above, but more iron-stained and rough weathering. Trilobites at base.

Zones	Thickness (feet) Zone	Thickness (feet) Cumulative	Description
46.	52.36	3908.94	Rough resistant, less soluble coarsely crystalline beds thicker than those above. Small trilobite 10 feet below top and trilobite zone at base.
	Reagan formation, 92.39 feet thick.		
47.	30.80	3939.74	Fine grained sandstone at top, coarser toward base. Thin beds at top more massive toward base, some calcareous cement especially in upper part.
48.	28.10	3967.84	Coarsely crystalline glauconitic limestone, green to black from test pit. Others calcareous pinkish-gray with dark bands. Three feet of sandy glauconitic, calcareous beds at base.
49.	8.85	3976.69	Conglomeratic and calcareous at top with pebbles up to 6 inches. Sandy at base.
50.	24.64	4001.33	Resistant coarse sandstone at top and bottom with coarse conglomerate at base. Pebbles up to 10" in diameter. Some coarsely crystalline dark calcareous beds in middle of zone. Base rests on Pre-Cambrian igneous rock.

Calculated from paced measurements and dip in zones 1 to 29.
Calculated from taped measurements and dip in zones 30 to 41.
Zone 7 of this section 235.2'=zone 146 U. S. Highway 77 Arbuckle Mountain section 2071.74' from top: difference of 1836.14, this plus 3769.78 feet totals 5605.92, restored thickness.

5. SECTION ARBUCKLE AND TIMBERED HILLS GROUPS

McKenzie Hill, one mile south of Signal Mountain, secs. 7 and 8, T. 2 N., R. 12 W., Comanche County. Dip 15° SE, strike N. 40° E.

ORDOVICIAN

Arbuckle group.

	Strange formation, 80 feet thick.		
1.	80.00	80.00	Gray to pink coarsely crystalline dolomite. Finer near base, coarser toward top.
	McKenzie Hill formation, 233.08 feet thick.		
2.	43.94	123.94	Thin bedded limestones, badly weathered. Fucoids on surface.
3.	39.78	163.72	Thick beds crystalline gray limestones with numerous cylindrical cherts at top.
4.	37.44	201.16	Bluish gray limestones, some dark with carbonaceous material. Beds .25 to 2 feet thick. Quarry beds in quarry. Fucoids abundant, a few dendroid graptolites.
5.	76.44	277.60	Thin dense limestones gray to yellow. Beds ⅛ to ½ foot thick. Several breccia conglomerates in lower part and 9 inch conglomerate at base.

Zones	Thickness (feet) Zone	Thickness (feet) Cumulative	Description
6.	9.10	286.70	Four zones of thin bedded limestones separated by three heavier beds of coarsely crystalline limestone somewhat conglomeratic. Contains 6 trilobite zones. Zones given in horizontal and vertical distances above the base: (1) 3' (.78'); (2) 12.6' (3.27'); (3) 15' (3.90'); (4) 21' (5.46'); (5) 25.3' (6.57'); (6) 32' (8.32).
7.	8.44	295.14	Thick beds at top and base with thin beds of limestone between. Trilobites at top and base.
8.	10.01	305.15	Mostly thin beds of dense limestone, a few conglomerates.
9.	7.93	313.08	Thick beds of limestone conglomerates. Beds .8 to 1.5 feet thick. Dip 15°.

CAMBRIAN

	Signal Mountain formation, 290.46 feet thick.		
10.	26.00	339.08	Five thick limestone conglomerates, with numerous thin limestones and breccias between.
11.	130.00	469.08	Thin bedded limestones and conglomerates with some dense limestones. Much of surface covered.
12.	15.34	484.42	Massive conglomerate of limestone at top contains trilobites. Thin limestones in middle. Four feet of more resistant limestones at base. Trilobite zones at base and 2 feet above.
13.	4.52	488.94	Mostly thin limestones with 8 inch coarsely crystalline bed at base with a few trilobites.
14.	24.18	513.12	Four coarsely crystalline limestones .8 to 1.5 feet thick with thin limestones between. Trilobite zone at 5 and 10.5 feet above base.
15.	22.10	535.22	Five zones of thick limestones with thin limestones between. Trilobite zones at base and 10 feet above.
16.	11.44	546.66	Mostly covered, 3 narrow limestone zones exposed. Some are conglomeratic. Trilobites at base and 6.25 feet above.
17.	13.00	559.66	Five zones of thin yellow limestones exposed, rest covered. Trilobites at base and 7.8 feet above.
18.	10.60	570.26	Thin limestones in upper part, 1.25 feet coarse conglomerate at base.
19.	33.28	603.54	Mostly thin conglomeratic limestones, with small brown pebbles.
	Fort Sill formation, 223.84 feet thick.		
20.	33.02	636.56	Light gray dense sandy limestones. Beds thicker in lower part. Weathered gastropods near top of zone.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
21.	19.76	656.32	Ten and a half feet of heavy beds of limestone at top. Oolitic 12.5 feet below top. Sponge spicules scattered through zone.
22.	21.84	678.16	Grayish-brown crystalline limestones. Dip 15°, some folding to the north.
23.	26.76	704.92	Thin bedded, platy limestones .05 to .2 feet thick. Gastropods 5.5 feet above base and *Billingsella corrugata* U. and C., (as at Fort Sill), 14.5 feet above base.
24.	53.82	758.74	Mostly thin platy limestones with 5 feet of heavier beds at top, and several heavy beds scattered through with 3 foot bed at base.
25.	29.90	788.64	A few thick coarsely crystalline limestone conglomerates with thin limestones between. Tiny trilobites 13 feet above base and large one 25.5 feet above.
26.	38.74	827.38	Much coarsely crystalline grayish-brown limestone. Heavier beds in lower part, one bed 2 feet thick. Brachiopods 15 feet above base. Conglomerate at base.
Timbered Hills group.			
			Honey Creek formation, 44.54 feet exposed.
27.	9.24	836.62	Coarsely crystalline gray limestone much glauconite. Six inch breccia at base.
28.	11.88	848.50	Mostly thin, coarsely crystalline limestones, some thin yellowish beds.
29.	4.40	852.90	Coarsely crystalline yellowish-gray conglomerate at base. Trilobites at base and a few feet above base.
30.	11.66	864.56	Gray and yellow coarsely crystalline limestones in thin beds. Three trilobite zones near middle at 4, 5, and 6 feet above base.
31.	7.36	871.92	Coarsely crystalline yellow and gray limestones, with scattered glauconite. Brachiopod zone at top. Beds 4 to 9 inches thick. Trilobites at base 6 inches above base and 1.5 feet above base.
			Rest of formation covered by Permian.

6. QUARRY HILL

About ¼ mile east of Fort Sill railway station, sec. 8, T. 2 N., R. 11 W., Comanche County. Dip 3° to 5° SE.

ORDOVICIAN

Arbuckle group.

			McKenzie Hill formation.
1.	3.0	3.0	Thin limestones greatly weathered.
2.	4.0	7.0	Limestones mostly 3 to 8 inches thick, a few inch beds.
3.	2.0	9.0	Thin shaly limestones with many fucoids.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
4.	4.3	13.3	Massive limestone.
5.	1.5	14.8	Thin shaly limestones.
6.	11.0	25.8	Massive limestones with shaly partings, gray on fresh, buff on weathered surface.
7.	5.0	30.8	Dark gray limestones in beds 5 to 10 inches thick, shaly partings. Many fucoids.
8.	9.5	40.3	Dark gray shaly limestones. Carbonaceous and asphaltic. Dendroid graptolites and many fucoids.
			Base not exposed.

7. POST FIELD QUARRY

North edge of Post flying field, sec. 7, T. 2 N., R. 11 W., Comanche County.

CAMBRIAN

Arbuckle group.

			Signal Mountain formation, 26.8 feet exposed.
1.	5.0	5.0	Thin beds of gray limestone.
2.	6.0	11.0	Thick beds of limestone, many trilobites. *Dikellocephalus* present.
3.	3.5	14.5	Limestones 5-8 feet thick with .4 foot shale included.
4.	3.0	17.5	Even-bedded, platy limestones, dense to finely crystalline.
5.	4.0	21.5	Rough, coarsely crystalline limestones, yellow and pink. Some beds wedge-shaped. Glauconite and some trilobite fragments.
6.	3.5	25.0	Massive beds weather to thin platy condition. Dense. Platy, shaly zone .4 foot thick at top.
7.	1.8	26.8	Yellowish-brown limestones, conglomeratic at base and looks as though it were channeled. Base not exposed.

8. FORT SILL QUARRY

East of main North-South highway through post worked by prison labor, sec. 1, T. 2 N., R. 12 W., Comanche County.

CAMBRIAN

Arbuckle group.

Fort Sill formation, (named from quarry at Fort Sill) not measured. About 40 feet of limestones and shaly limestones are exposed in the quarry. Beds dip southeast and are contorted at east edge. *Billingsella corrugata* and trilobites occur at top of quarry. Edges of limestone beds exposed up the hill to the south aggregating a thickness of 30 to 40 feet. Base of formation not exposed. Though named from this quarry the type section of the formation is about 6 miles to the west on the west end of McKenzie Hill.

9. SECTION OF HONEY CREEK FORMATION OF TIMBERED HILLS GROUP

Northwest edge of West Timbered Hills. Southeast cor. sec. 4, T. 1 S., R. 1 W., Murray County. Dip 25° NE, strike N. 80° W.

About 300 feet of Arbuckle limestones form the upper part of the outcrop. A zone at the base, of about 100 feet of thin limestones is followed by thick beds, then a zone which is complexly folded.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
			CAMBRIAN
			Timbered Hills group.
			Honey Creek formation, 51.31 feet exposed.
1.	5.75	5.75	Coarsely crystalline pinkish gray to buff limestones. No glauconite. Trilobites at top.
2.	4.62	10.37	Like above with lower part covered. Trilobites at top of zone.
3.	14.70	25.07	Thin beds typical of Honey Creek. Glauconite present. Trilobites at base and 8 feet above.
4.	9.61	34.68	Thin dark yellow-gray limestones. Much glauconite. Fine grained limestone. Trilobites at base.
5.	6.13	40.81	Moderately crystalline limestones, little glauconite. Trilobites at base and 1.5 feet above.
6.	2.52	43.33	Upper part covered, lower part coarsely crystalline gray to brown limestones with much glauconite. Trilobites at base and 8 inches above base.
7.	3.78	47.11	Coarse crystalline yellowish-brown limestones. Much glauconite. Trilobites at base. 1 foot above, and 2 feet above base.
8.	4.20	51.31	Very glauconitic gray and brown crystalline limestones. Trilobites at base, 2 feet above and 3.5 feet above base.
			Covered to exposed top of Reagan sandstone, estimated about 50 feet.

10. SECTION OF TIMBERED HILLS GROUP

South side West Timbered Hills, Arbuckle Mountains, sec. 23, T. 1 S., R. 1 W., Murray County. Dip 17° SW, strike N. 80° W. Starting at base of Royer dolomite which at this locality weathers in smooth rounded knobs.

			CAMBRIAN
			Timbered Hills group.
			Fort Sill formation, 102.60 feet thick.
1.	63.00	63.00	Mostly dense gray limestone with some cherty beds.
2.	39.60	102.60	Dense purplish limestones. Some have a rough ferruginous surface.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
			Honey Creek formation, 25.11 feet exposed.
3.	11.40	114.00	Coarsely crystalline gray to yellow and brown iron stained limestone with much glauconite. Trilobites at base.
4.	5.04	119.04	Major part coarse but some finer with much glauconite. Trilobites at base.
5.	2.07	121.11	Similar to above but with brachiopods and small trilobites in middle and at base of zone.
6.	6.60	127.71	Some parts fine grained limestone, large trilobite fragments up from base.
			Flood plain of creek.

11. PARTIAL SECTION OF ARBUCKLE GROUP

Twenty-four miles southeast of Carnegie, on the north side of the Wichita Mountains. Dip 24° NE. strike N. 60° W. Top part of the Arbuckle covered. Secs. 29 and 32, T. 5 N., R. 12 W., Caddo County.

			ORDOVICIAN
			Arbuckle group.
			Kindblade formation, 1,139.74 feet exposed.*
1.	42.84	42.84	Gray and buff, fine grained limestones. Brachiopods, *Ceratopea*, gastropods, cephalopods 5 paces from top.
2.	31.50	74.34	Buff to yellow limestone in upper part, badly weathered and light to dark gray in lower part. A few brachiopods, *Ceratopea*, chert nodules.
3.	40.32	114.66	Dark gray limestones in beds 3 to 6 inches thick, cherty. *Tritoechia typica* U. and C., *Hyolithes.*
4.	44.10	158.76	Gray limestones in beds 1 to 3 inches thick. *Tritocchia typica* U. and C., *Ceratopea* cephalopods. Beds badly broken.
5.	42.58	201.34	Light to dark gray limestones with chert nodules. *Ceratopea* and other large and small gastropods.
6.	31.50	232.84	Limestones with *Ceratopea, brachiopods, Hyolithes*, and cephalopods.
7.	31.50	264.34	Dark gray limestones. *Ceratopea*, and other gastropods. *Maclurea affinis.*** (This equals zone 7 of section 4, 10½ miles south of Carnegie, 235 feet from the top; zone 21 of section 1, east of Nebo, 2318 feet from the top; and zone 21 of section 2, U. S. Highway 77, 2154 feet from the top.)
8.	46.62	310.96	Light to dark gray limestones in thick beds. *Ceratopea* and other gastropods. *Hypseloconus ozarkensis.* Van Buren formation.

Zones	Thickness (feet) Zone	Cumulative	Description
9.	63.00	373.96	Dark to light gray shattered beds of limestone 2 to 15 inches thick. Brachiopods at top, cephalopods, *Ceratopea*.
10.	50.40	424.36	Dark gray limestones in beds 3 to 12 inches thick. Brachiopods, *Tritoechia typica* U. and C., *Ceratopea*, *Orospira Bigranosa*, *Hormotoma artemesia*.
11.	12.60	436.96	Limestone with brachiopods and *Ceratopea* at top and base.
12.	51.92	488.88	Gray limestone beds 1 to 2 feet thick. *Tritoechia typica* U. and C., *Ceratopea* and other gastropods.
13.	104.88	593.76	Dark gray limestones, beds 6 inches to 2 feet thick. *Stromatocerium*, brachiopods, *Hyolithes*, chert nodules.
14.	44.10	637.86	Dark gray limestones, beds 1 to 3 feet thick. *Ceratopea* and other gastropods.
15.	148.20	786.06	Much jointed dark gray limestones, beds 1 to 2.5 feet thick. Brachiopods, *Ceratopea*, *Orospira bigranosa*, *Stromatocerium*.
16.	27.36	813.42	Gray thin to massive beds of limestones. *Ceratopea* at base.
17.	45.60	859.02	Gray limestones, 3 to 12 inches thick. *Ceratopea* scarce.
18.	86.64	945.66	Limestones thin bedded, buff at top, more massive resistant beds below. *Ceratopea*, *Hyolithes* at base.
19.	57.28	1002.94	Gray limestones in thick beds. *Ceratopea* and other gastropods. Cephalopods. Sponge, *Archaeoscyphia*.
20.	79.80	1082.74	Gray limestones, beds thin to thick, marked algal bed.
21.	57.00	1139.74	Thin to thick beds of gray to buff limestones. Reef of broad algae at base each 6 feet or more in diameter. Complexly folded limestones below this zone.

* Calculated from paced measurement and dip.

***Maclurea affinis* zone shows 2071, less 264 or 1807 feet missing from the top of the Arbuckle here. At base zone 21 encountered a big fold with complex structures below.

12. SECTION OF TIMBERED HILLS GROUP

Signal Mountain, Fort Sill, Honey Creek, Reagan and Basal Limestone

North side of Wichita Mountains, isolated hill 4 miles north of Mt. Scott, sec. 24, T. 4 N., R. 13 W., Comanche County.

CAMBRIAN

Arbuckle group.

Signal Mountain formation, about 300 feet exposed.

1.	300	300	Mostly very thick beds of gray limestones.

Zones	Thickness (feet) Zone	Cumulative	Description
	Fort Sill formation, 191.57 feet thick.		
2.	61.77	361.77	Dense gray limestones in thick beds.
3.	38.34	400.11	Thin platy iron-stained limestones. Non-resistant at this locality.
4.	48.86	448.97	Dark gray dense limestones in alternating thick and thin beds.
5.	2.13	451.10	Brownish platy limestones.
6.	21.30	472.40	Reddish-gray limestones thick beds at top and bottom, thinner beds in middle.
7.	1.42	473.82	Yellowish-brown shaly limestone with glauconite.
8.	17.75	491.57	Dense even-bedded reddish and gray limestones.
Timbered Hills group.			
	Honey Creek formation, 58.93 feet thick.		
9.	5.68	497.25	Covered strip probably shale or thin limestones.
10.	35.50	532.75	Limestones red on fresh, dark gray on weathered surface. Glauconite abundant.
11.	17.75	550.50	Coarse grained light gray limestone. Crinoid stems, trilobites, and brachiopods common in lower half of zone.
	Reagan formation, 134.19 feet thick.		
12.	134.19	684.69	Yellowish-brown sandstone, mostly fine grained, coarser in the middle and toward the top. Clearly laminated near base.
	Basal limestone, 97.97 feet thick.		
13.	4.26	688.95	Sandy limestone, grades into sandstone above.
14.	34.08	723.03	Gray limestones 3 to 12 inches thick. Contain fragments of chert and igneous fragments, conglomeratic near top with fragments up to 2 inches in diameter. Part of surface soil-covered.
15.	3.00	726.03	Gray dense limestone, igneous fragments in basal part.
16.	5.20	731.23	Bed of dense gray limestone; igneous fragments up to 1.5 inches in diameter.
17.	3.50	734.73	Four beds of limestone, contain igneous fragments.
18.	2.40	737.13	Dense limestone bed with igneous fragments up to 1.5 inches.
19.	6.00	743.13	Thin limestone, contain igneous fragments.
20.	3.00	746.13	Bed of dense gray limestone with igneous fragments.
21.	3.00	749.13	Thin limestones.
22.	3.00	752.13	Bed gray dense limestone with igneous fragments and cherts up to ¾ inches in diameter.
23.	30.53	782.66	Beds of dense gray limestone, some with pinkish tint; 3 to 6 inches thick. Contain igneous fragments and calcareous algae. Lie unconformably on the porphyritic Pre-Cambrian igneous rock.

13. SECTION OF ARBUCKLE GROUP

Sec. 16, T. 6 N., R. 14 W., Kiowa County, about 11 miles southeast of Mountain View, north side of Wichita Mountains. Dip 45° NE, strike N. 35° W.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
			CAMBRIAN
Arbuckle group.			
			Signal Mountain formation, 292.52 feet thick (top overlapped by Permian).
1.	95.85	95.85	Dark gray with some yellow blotches in limestone beds .6 to .8 foot thick.
2.	128.51	224.36	Mostly thin dark gray limestones, yellow blotches in upper part of zone.
3.	23.43	247.79	Gray limestones in beds .5 to 1 foot thick.
4.	44.73	292.52	Very massive gray limestone beds 2 to 5 feet thick.
			Royer formation, 219.39 feet thick.
5.	219.39	511.91	Dolomite, lower 44.7 feet bedded and weather smooth, 156.7 feet resistant weathers rough, 17.7 feet at top weather smooth.
			Fort Sill formation, 267.09 feet thick.
6.	10.65	522.56	Thin gray limestones.
7.	9.94	532.50	Thin platy limestones, 2 feet of dolomite at top.
8.	2.84	535.34	Dark gray limestones with algal structures.
9.	17.04	552.38	Thin platy limestones.
10.	53.25	605.63	Thick gray limestones.
11.	23.56	629.19	Thin gray limestones.
12.	21.30	650.49	Thick gray limestones.
13.	48.99	699.48	Platy ferruginous limestone. Trilobites 30 feet above base.
14.	4.26	703.74	Thick gray limestones.
15.	8.52	712.26	Platy gray limestones.
16.	44.73	756.99	Massive gray limestones.
17.	7.10	764.09	Covered, shales, or thin limestones.
18.	14.91	779.00	Massive crystalline limestones.
			Base of Arbuckle rests on typical Honey Creek beds.
Timbered Hills group.			
			Honey Creek formation, 142.71 feet thick.
19.	44.73	823.73	Coarsely crystalline, lenticular cross-bedded limestones.
20.	27.69	851.42	Sandy limestones, somewhat platy.
21.	14.91	866.33	Sandy limestones and calcareous sandstones, finer than usual.
22.	44.73	911.06	Coarse crystalline limestones, glauconite very abundant.

Zones*	Thickness (feet)		Description
	Zone	Cumulative	
23.	10.65	921.71	Glauconitic sandy calcareous beds with 6 inches of shale included.
			Reagan formation, 74.55 feet thick.
24.	74.55	996.26	Resistant thick Reagan sandstone. Glauconitic in parts. Rests upon Pre-Cambrian igneous rock.

14. SECTION ARBUCKLE LIMESTONE

North side of Wichita Mountains, 2 miles south of Rainy Mountains, 9 miles southeast of Gotebo. Secs. 30, 31, T. 6 N., R. 15 W., Kiowa County. Dip at north edge of outcrop 24° NE, strike N. 70° W. Dip decreases in middle to 15°.

			ORDOVICIAN
Arbuckle group.			
			Kindblade formation, base questionable. 1,013.72 feet exposed.
1.	67.20	67.20	Thick beds of gray limestones separated by many thinner beds. Gastropods and algal structures.
2.	18.00	85.20	Mostly thin limestones. Large algal structures at base similar to those at base of section No. 11, 24 miles southeast of Carnegie.
3.	36.00	121.20	Thin bedded gray limestones.
4.	9.60	130.80	Dark gray dolomite.
5.	16.00	146.80	Fine textured gray limestones, some appear high in magnesium.
6.	9.60	156.40	Banded sandstones and limestones or dolomites.
7.	68.00	224.40	Thin bedded limestone with much chert.
8.	36.00	260.40	Thick beds dark gray fine grained limestones.
9.	12.00	272.40	Dark gray fairly coarse dolomites.
10.	21.60	294.00	Yellow and gray coarse sandstone, some parts banded, others cross-bedded.
11.	36.00	330.00	Dark gray thick limestones with some interbedded dolomites.
12.	30.00	360.00	Gray limestones with many large cherts.
13.	64.80	424.80	Gray limestones with many large cherts.
14.	18.00	442.80	Mostly dark gray dolomite.
15.	24.00	466.80	Gray limestones, much chert in upper part.
16.	6.00	472.80	Dark pink and gray dolomite.
17.	38.00	510.80	Light gray limestones with much chert.
18.	10.80	521.60	Gray sandstones and sandy limestones.
19.	30.00	551.60	Dark gray limestones, part appears dolomitic.
20.	10.00	561.60	Thin gray limestones with much chert.
21.	8.40	570.00	Light gray banded sandstone.
22.	28.80	598.80	Thin gray limestones, some chert.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
23.	39.00	637.80	Dark pinkish-gray dolomite with many large cherts in upper part.
24.	17.94	655.74	Thin bedded light gray platy limestones.
25.	9.36	665.10	Dark gray limestones.
26.	3.90	669.00	Coarse pink and gray dolomite.
27.	5.46	674.46	Thin bedded light gray limestones.
28.	3.12	677.58	Coarse grained dolomite.
29.	22.62	700.20	Thin gray limestones with one 10-inch sandstone included.
30.	5.20	705.40	Coarse dolomite containing very large masses of chert.
31.	14.04	719.44	Light gray limestones.
32.	5.46	724.90	Coarse gray dolomite.
33.	6.50	731.40	Light gray limestones at top grades into 4 feet of sandstone at base.
34.	19.50	750.90	Dark gray limestone and dolomite with 3 feet of sandstone at base.
35.	23.40	774.30	Dark gray limestone and dolomite, 3 feet of light gray sandy limestone at base.
36.	12.48	786.78	Pink and gray dolomite. 1.5 feet sandy limestone at base.
37.	11.70	798.48	Thin dark gray limestones with 5 feet of banded coarse sandstone at base.
38.	9.36	807.84	Coarse pinkish-gray dolomite.
39.	7.80	815.64	Dark gray limestone and dolomite.
40.	23.40	839.04	Dark gray dolomitic limestone. It appears sandy. Two feet of dolomite at base.
41.	39.00	878.04	Thin gray limestones with thin sandy limestones at base.
42.	11.70	889.74	Fine grained gray dolomites. Top bed contains *Ceratopea* large *Maclurea*-like gastropods and cephalopod siphuncles.
43.	26.78	916.52	Gray thin bedded limestones.
44.	11.70	928.22	Coarse crystalline limestone or dolomite, appears magnesian, massive at base.
45.	6.50	934.72	Dark coarse dolomite.
46.	14.00	948.72	Dark gray limestones.
47.	18.00	966.72	Light gray dolomite.
48.	35.00	1001.72	Dark pinkish-gray dolomite.
49.	12.00	1013.72	Gray to pink dolomite.

Covered in pasture below this zone. Zone 1 to 45 inclusive measured horizontally by pacing and calculated from dip. Zones 46 to 49 measured normal to the beds.

15. SECTION OF ARBUCKLE AND TIMBERED HILLS GROUP

Fort Sill, Honey Creek and Reagan Formations

South side of Wichita Mountains, secs. 12 and 13, T. 2 N., R. 13 W., Comanche County. Dip 17° S. at top.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
			CAMBRIAN
Arbuckle group.			
			Fort Sill formation, 21 feet exposed.
1.	21.0	21.0	Basal Arbuckle exposed.
Timbered Hills group.			
			Honey Creek formation, 180 feet thick.
2.	20.4	41.4	Light gray coarse crystalline limestone.
3.	48.0	89.4	Coarse gray crystalline limestone upper part covered with soil.
4.	31.2	120.6	Gray and pink crystalline limestone weathers to a calcitic sand.
5.	20.4	141.0	Brown gray pink coarse crystalline limestone.
6.	24.0	165.0	Brown and pink crystalline limestone. Trilobites at top of zone.
7.	36.0	201.0	Coarse crystalline limestone.
			Reagan formation, 40 feet exposed.
8.	40.0	241.0	Sandstone and sandy limestone. Glauconitic. Greenish-brown in color.
			Basal Reagan covered to the north by Permian.

16. SECTION OF ARBUCKLE GROUP

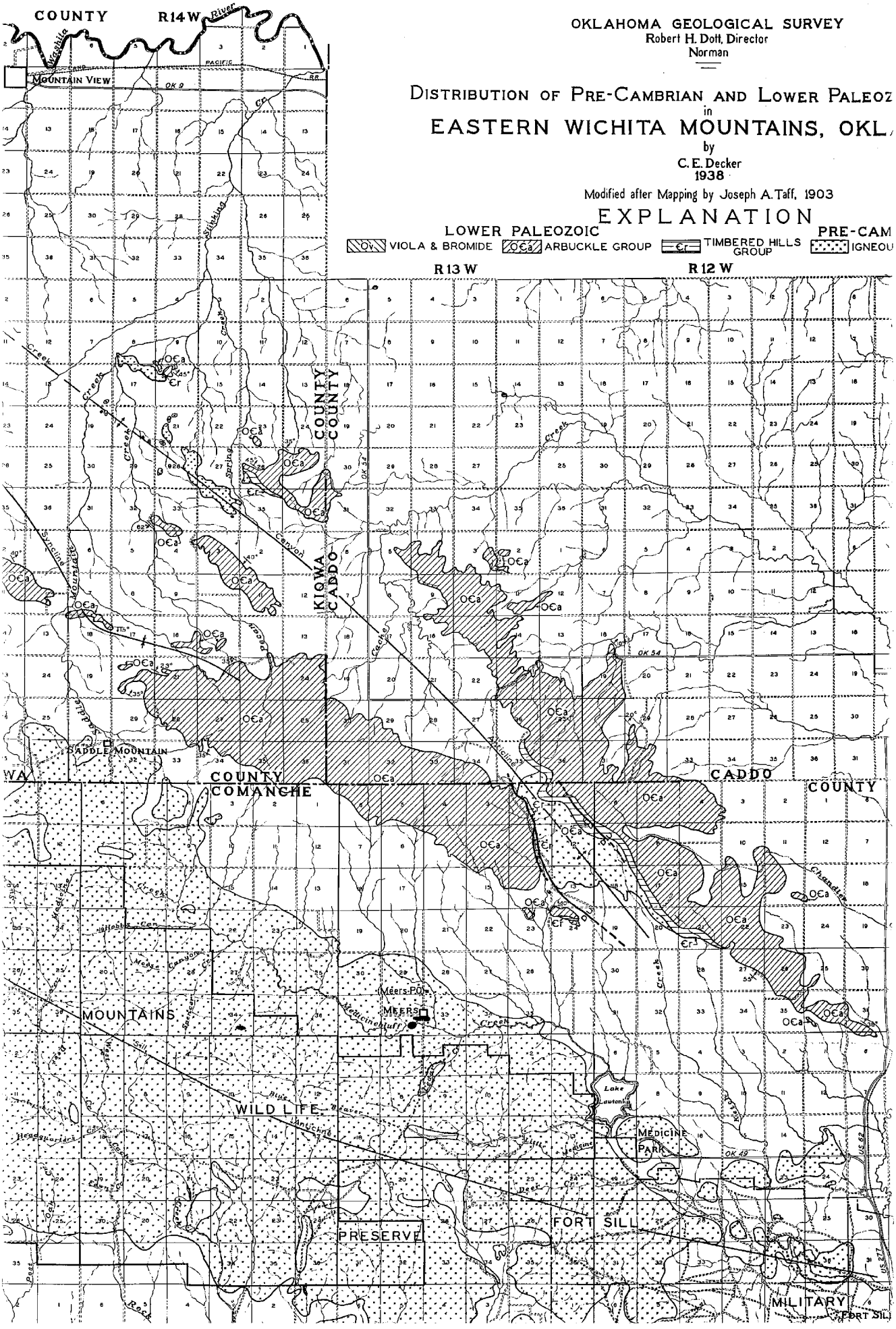
Southeast hill in sec. 14, T. 2 N., R. 13 W., Comanche County. Dip 24° SW, strike N. 75° W. Beginning near quarry at south end of hill.

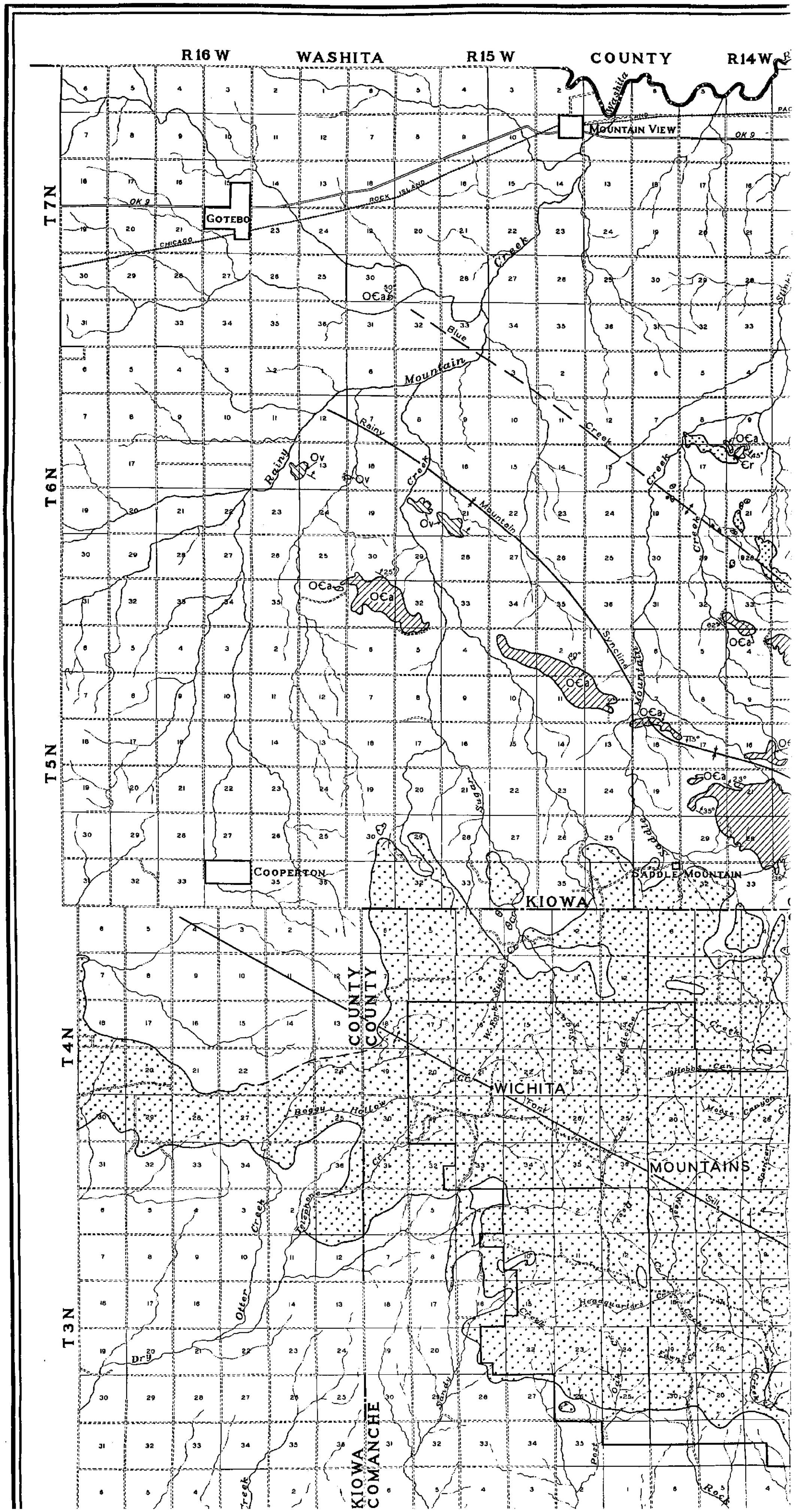
			ORDOVICIAN
Arbuckle group.			
			McKenzie Hill formation, 186 feet exposed.
1.	60.0	60.0	Quarry beds as at top of McKenzie Hill.
2.	20.4	80.4	Thin gray limestones.
3.	32.4	112.8	Thin gray limestones separated by 3 massive beds.
4.	37.2	150.0	Thick limestones at top, thinner ones in most of zone.
5.	36.0	186.0	Resistant heavy limestone beds.
			Signal Mountain formation, 177.20 feet exposed.
6.	81.6	267.6	Many conglomerates and thin limestones. Large round trilobite hypostomas at base.
7.	95.6	363.2	Numerous coarse limestone conglomerates and thin limestones.
			Covered to north by Permian.

17. SECTION OF ARBUCKLE GROUP

South side of Wichita Mountains, northwest hill, sec. 14, T. 2 N., R. 13 W., Comanche County. Beginning at the south end. Dip 20° SW at top, 13° near base. Strike N. 75° W.

Zones	Thickness (feet)		Description
	Zone	Cumulative	
			CAMBRIAN
			Arbuckle group.
			Signal Mountain formation, base questionable.
1.	27.84	27.84	Thin buff to gray limestones. Trilobites with large hypostoma.
2.	32.64	60.48	Thin limestones with a few heavier conglomeratic beds. Trilobites at base.
3.	32.64	93.12	Thin limestones, thicker in lower part.
4.	45.24	138.36	Yellowish limestones and conglomerates. Small trilobite 20 feet below top.
5.	102.00	240 36	Numerous conglomerates with thin limestones between. Two zones of iron-stained limestones.
6.	34.20	274.56	Very thin dense limestones. Brachiopods at base.
7.	59.70	334.26	Limestone conglomerate at top and base, thin gray limestones between.
8.	39.60	373.86	Yellowish buff limestones and conglomerates. Large trilobites at base.
9.	25.20	399.06	Thin yellowish limestones and conglomerates. Brachiopod and trilobites at base.
10.	42.30	441.36	Thin yellowish-brown limestones and conglomerates. Trilobites at base.
11.	16.20	457.56	Mostly thin yellow limestones, a few conglomerates. Trilobites at base.
12.	17.40	474.96	Thin yellow limestones and a few conglomerates. Trilobites at base and 3 feet above base.
13.	57.00	531.96	Thin yellow limestones. A few conglomerates.
			Grass-covered to north with Permian overlap.


OKLAHOMA GEOLOGICAL SURVEY
Robert H. Dott, Director
Norman
DISTRIBUTION OF PRE-CAMBRIAN AND LOWER PALEOZ
in
EASTERN WICHITA MOUNTAINS, OKL
by
C. E. Decker
1938
Modified after Mapping by Joseph A. Taff, 1903
EXPLANATION
LOWER PALEOZOIC
Ov VIOLA & BROMIDE
Oꞓa ARBUCKLE GROUP
Cr TIMBERED HILLS GROUP
PRE-CAM
IGNEOU
R14W
R13 W
R12 W
COUNTY
KIOWA COUNTY
CADDO COUNTY
COMANCHE COUNTY
MOUNTAIN VIEW
SADDLE MOUNTAIN
MOUNTAINS
WILD LIFE
PRESERVE
MEERS
Meers-PO
MEDICINE PARK
FORT SILL
MILITARY
OK 9
OK 54
OK 49
Oꞓa
Cr
Cr1
Cr2
Cr3


R16 W
WASHITA
R15 W
COUNTY
R14 W
T 7 N
T 6 N
T 5 N
T 4 N
T 3 N
MOUNTAIN VIEW
GOTEBO
COOPERTON
SADDLE MOUNTAIN
KIOWA
COUNTY
COUNTY
WICHITA
MOUNTAINS
KIOWA
COMANCHE
ROCK ISLAND
CHICAGO
OK 9
Washita
Blue
Mountain
Creek
Rainy
Syncline
Sugar
Otter
Dry
Headquarters
Post
Rock
Boggy
Hollow
Hobbs
Saddle Mountain
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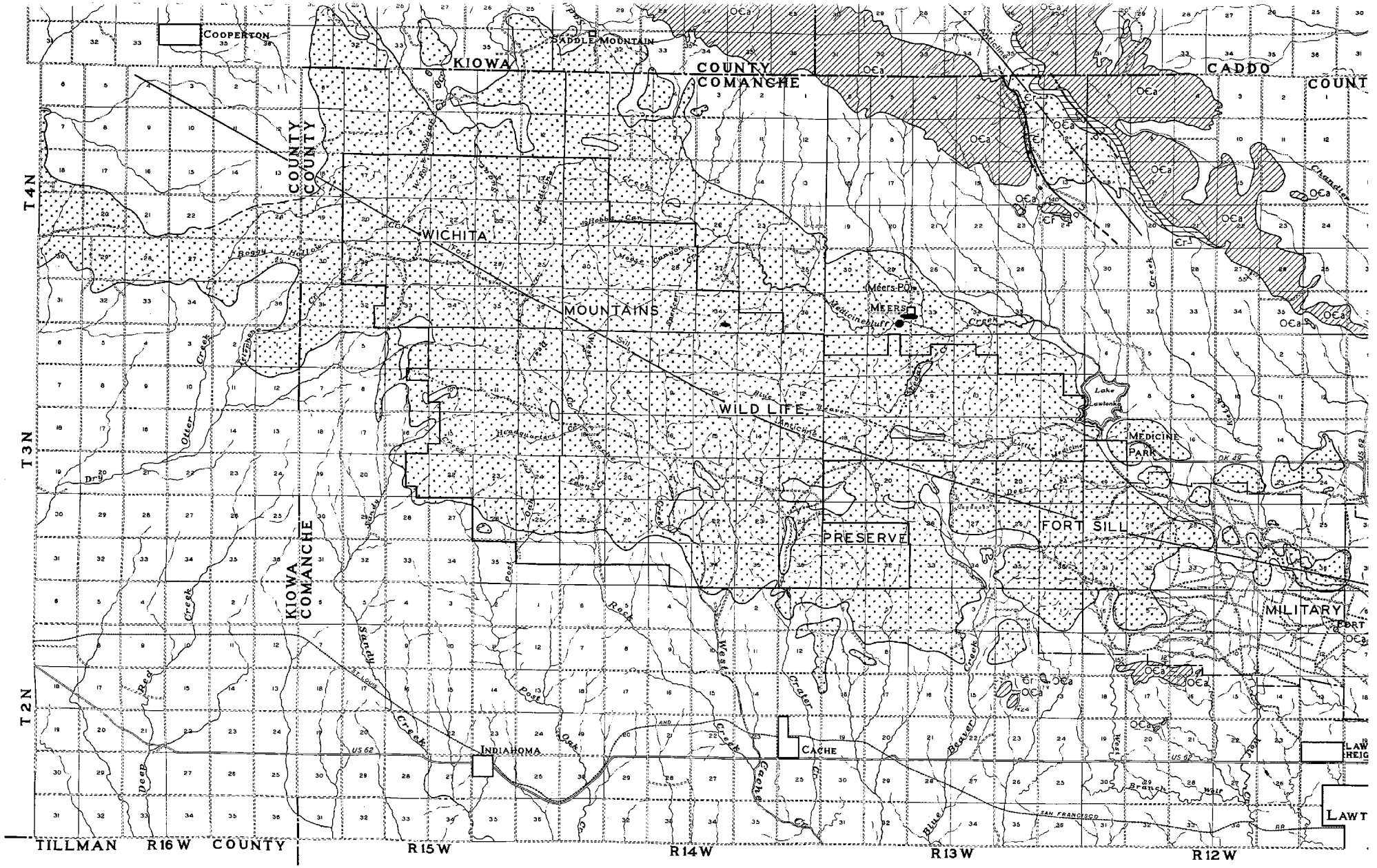

Fig. 1 Index Map of Oklahoma, showing location of Arbuckle and Wichita Mountains, discussed in this report.

OKLAHOMA GEOLOGICAL SURVEY
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DISTRIBUTION OF PRE-CAMBRIAN AND LOWER PALEOZOIC ROCKS in EASTERN WICHITA MOUNTAINS, OKLAHOMA

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C. E. Decker
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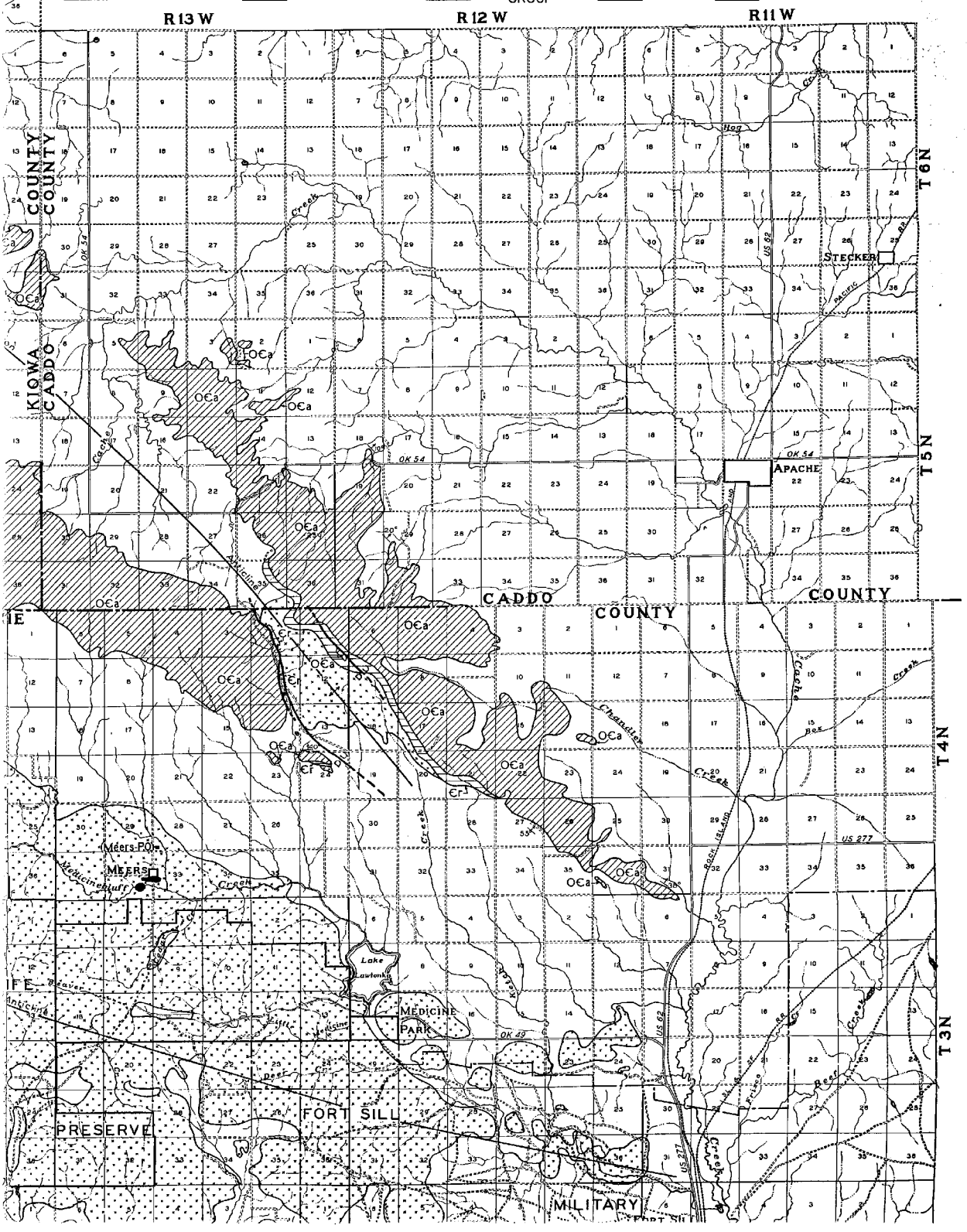
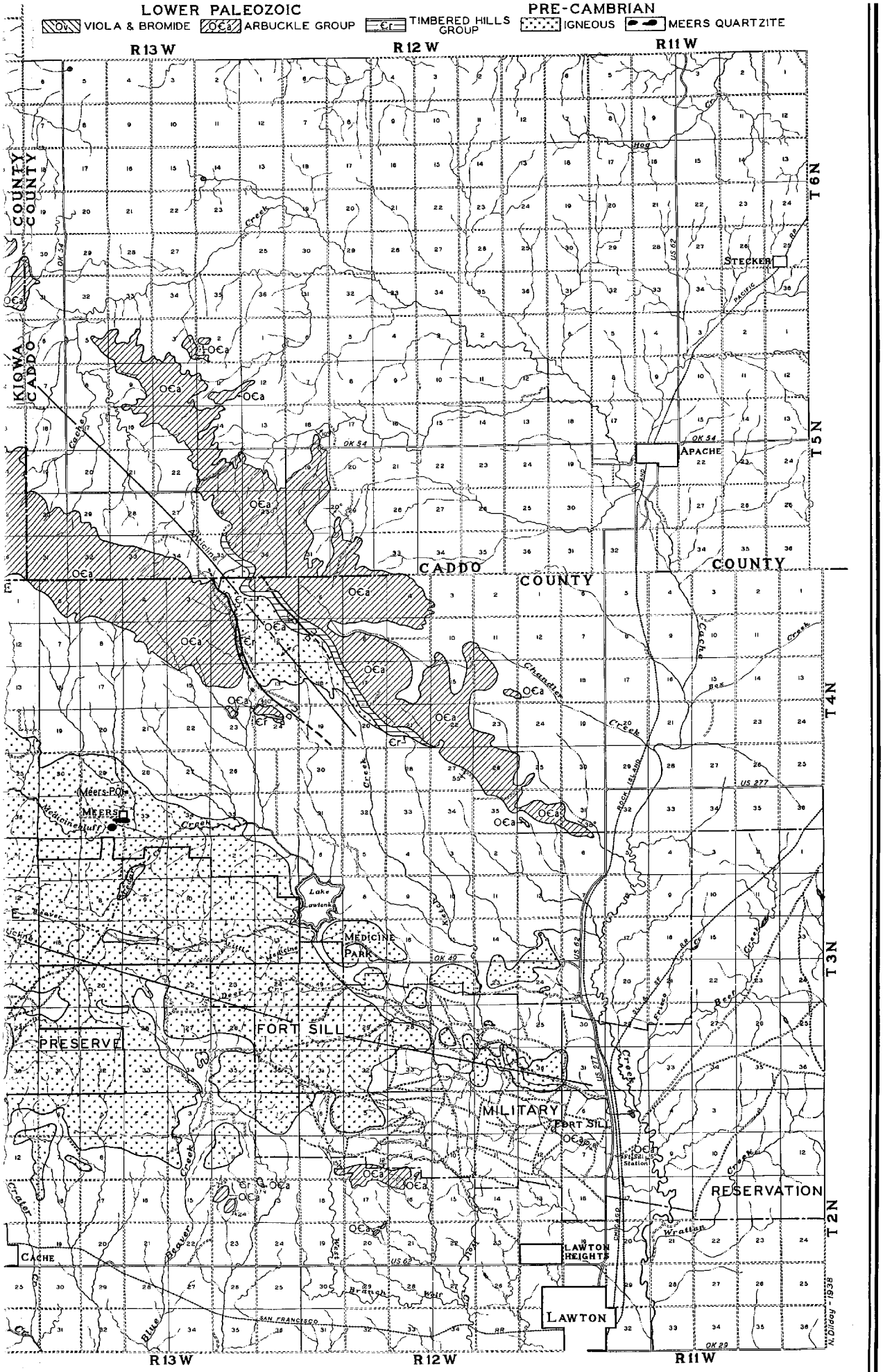
EXPLANATION

LOWER PALEOZOIC
- Ok VIOLA & BROMIDE
- OCa ARBUCKLE GROUP
- Cr TIMBERED HILLS GROUP

PRE-CAMBRIAN
- IGNEOUS
- MEERS QUARTZITE





of Arbuckle and Wichita Mountains, discussed in this report.

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EXPLANATION

LOWER PALEOZOIC: Ov VIOLA & BROMIDE; OCa ARBUCKLE GROUP; Cr TIMBERED HILLS GROUP

PRE-CAMBRIAN: IGNEOUS; MEERS QUARTZITE