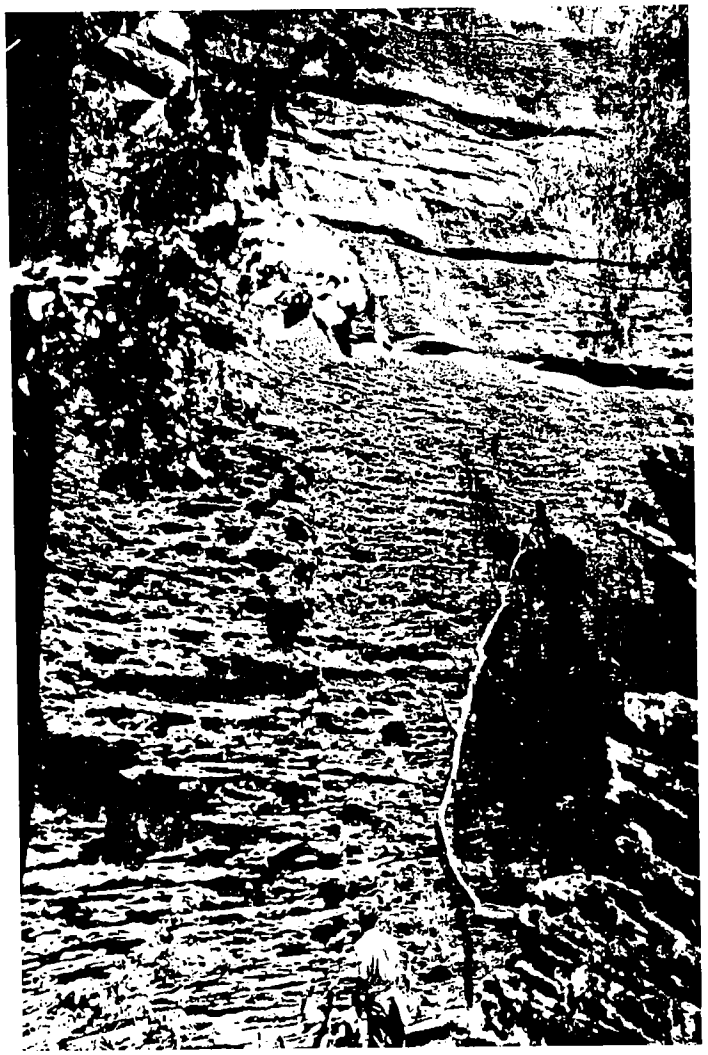


Cliff of calcareous sandstone of the Hale formation, fifty feet high, showing pitted weathering that is characteristic of the Hale formation in most of its eastern exposures. The pitted character results from leaching of calcareous material. Bunch Mountain, sec. 15, T. 14 N., R. 24 E., Adair County, Oklahoma. (Measured section No. 23).

OKLAHOMA GEOLOGICAL SURVEY

ROBERT H. DOTT, Director

BULLETIN NO. 66

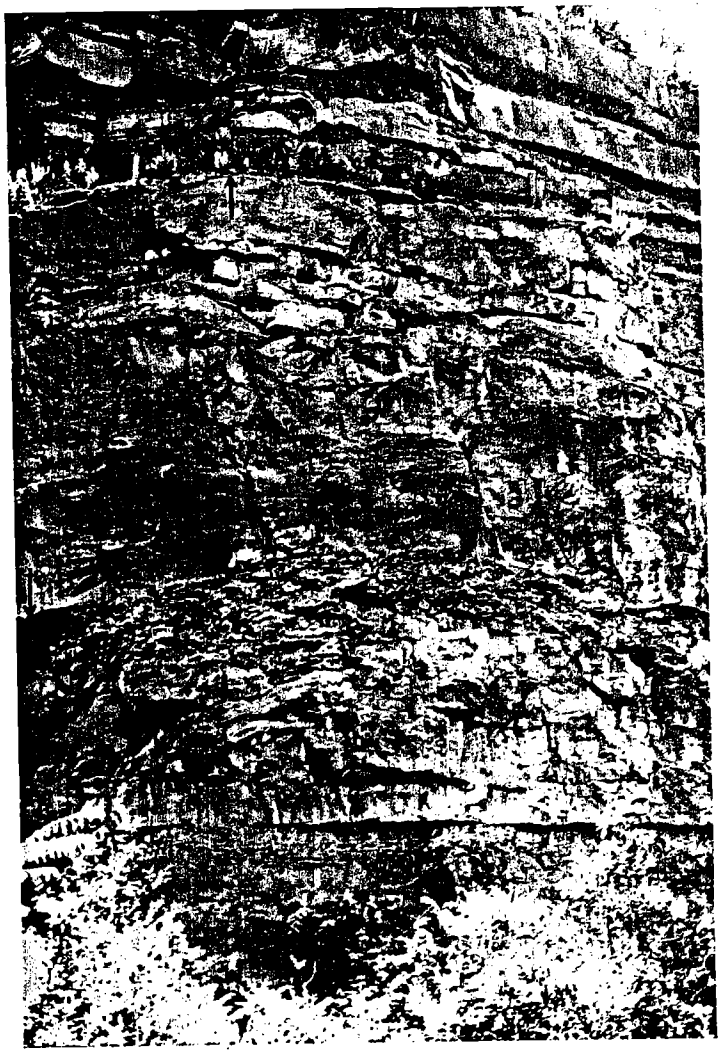
THE MORROW SERIES OF NORTHEASTERN OKLAHOMA

by

CARL A. MOORE

NORMAN

1947



Quarry face in Keough Quarry, sec. 25, T. 16 N., R. 19 E., Wagoner County, near Fort Gibson, Oklahoma. (Measured section No. 69). Arrows mark upper and lower limits of Hale formation, which here is 27 feet of relatively pure limestone, underlain by the Pitkin limestone (upper Mississippian) and overlain by alternating shales and limestones assigned to the Bloyd formation.

ILLUSTRATIONS

THE MORROW SERIES OF NORTHEASTERN OKLAHOMA

by

CARL A. MOORE

ABSTRACT

Detailed field work during the summers of 1938 and 1939, and subsequent study of insoluble residues of field samples, have yielded additional data on the character of the Morrow series, lower Pennsylvanian age, in northeastern Oklahoma. Sufficient information is at hand to permit the clear recognition of the major divisions of the Morrow in Oklahoma: the Hale formation at the base and the Bloyd formation above. The Bloyd formation in Oklahoma contains representatives of both the Brentwood and Kessler limestone lentils as recognized in the vicinity of the village of Morrow, Washington County, Arkansas.

The known western limit of the limestone that is thought to represent the Kessler member is about 4 miles west-southwest of Stilwell, Oklahoma. The limestone beds of the Hale and Bloyd formations can be differentiated by a study of their insoluble residues, as well as by their stratigraphic position.

There is a disconformable contact between the Pitkin limestone (Chester) and the Hale formation in almost all the sections in Adair County and in eastern Cherokee County. In central and western Cherokee County and in Muskogee County, this contact is poorly exposed and more difficult to find. At the base of the Hale in Adair County and in many sections in Cherokee County there is a highly ferruginous, calcareous, phosphatic, conglomeratic bed averaging less than 0.5 foot in thickness. This conglomeratic bed served as a marker between the somewhat similar beds of the Pitkin and Hale in Cherokee County.

The Morrow series is the basal Pennsylvanian in this area, and is considered middle Pottsville in age. The Morrow should be defined to include the beds between the Pitkin formation of the Chester series (Mississippian), and the Atoka formation of the Des Moines series, upper Pottsville (Pennsylvanian). There is evidence of a slight amount of eastward tilting of the Pitkin limestone and older formations before deposition of the Hale sandstone. The contact with the overlying Atoka sandstone is a well-marked erosional unconformity.

INTRODUCTION

Scope and Purpose of the Investigation. This report represents a detailed study of the outcrops of the Morrow series of rocks in northeastern Oklahoma, in an area lying generally north and east of the Arkansas River and east of the Neosho (Grand) River.

The primary purposes of this investigation were (1) to study the lithology of the Morrow series from the type section on Hale Mountain, Washington County, Arkansas, westward into Oklama; (2) to measure in detail the exposures of Morrow rocks in the area; (3) to collect samples, make and study insoluble residues; (4) to describe the subdivisions of the Morrow series of northeastern Oklahoma, and to present basic data, including characteristics of insoluble residues, for correlating these units where exposed in different parts of the area, with rocks of the same age encountered in wells drilled for oil and gas in other parts of the state.

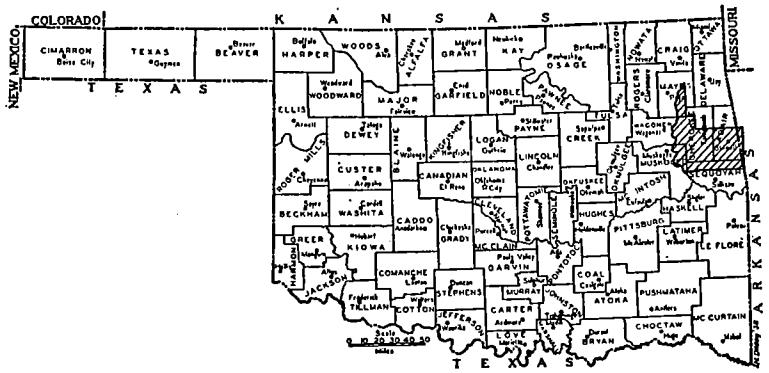


FIG. 1. Index map of Oklahoma showing location of area covered by this report.

Location of the Area. The outcrop area of the Morrow series in northeastern Oklahoma is around the southwest edge of the Ozark Plateau. (See figure 1.) This area includes the southern part of Adair County, much of Cherokee County, southern Mayes County, the eastern edge of Wagoner County, the eastern part of Muskogee County, and the northwestern part of Sequoyah County. In addition, 4 sections were measured in western Arkansas as a basis for a better understanding of the westward extension of this series of rocks into Oklahoma.

PREVIOUS INVESTIGATIONS

The first mention of rocks of Morrow age was by Simonds[1] in his report on the geology of Washington County, Arkansas. He recognized four subdivisions of what is now called the Morrow series the Washington shale and sandstone at the base, the Pentremital limestone, the Coal-bearing shale, and the Kessler limestone at the top. These subdivisions were erected solely on the basis of stratigraphy and lithology rather than on the basis of fossils, and Simonds himself realized that his subdivisions were subject to change when the fossils should be studied.

Simonds included these rocks in the lower Carboniferous (Mississippian) and assigned them to "Chester-St. Louis-Warsaw" age, following the classification of H. S. Williams.[2] The Marshall shale (Fayetteville) and the *Archimedes* limestone (Pitkin) were added to the above stratigraphic units and all of them were included by Branner[3] in the Boston group, named for the Boston Mountains where these rocks are best exposed. The Boston group was considered upper Mississippian in age, and equivalent to the Genevieve group of H. S. Williams.[4]

Credit for naming the Morrow, however, has been given to Adams and Ulrich.[5] They described the Morrow as a ". . . variable formation consisting of shales in which are some thin limestones and occasional sandstone beds. The basal portion is usually a sandstone or sandy shale. Above this there is the limestone . . . called the Pentremital limestone by the Arkansas survey . . . the name "Brentwood" is applied to it in this report. . . . The third member has usually been designated the Coal-bearing shale. In the vicinity of Fayetteville . . . a bed of coal is found in this shale. . . .

". . . there is a stratum of limestone above the Coal-bearing shale which forms a variable lens, and . . . has been described as the Kessler limestone. . . . Above it there are a few feet of shales

[1] Simonds, F. W., "The Geology of Washington County": *Geol. Survey of Ark. Ann. Rep. of* 1888, Vol. IV, pp. 75-105, 1891.
[2] Williams, H. S., "Correlation Papers, Devonian and Carboniferous": *U. S. Geol. Survey*, Bull. 80, 1891.
[3] Branner, John C., "The Geology of Washington County": *Geol. Survey of Ark. Ann. Rep. of* 1888, Vol. IV, table on p. xiii, 1891.
[4] Williams, H. S., *op. cit.*, 1891.
[5] Adams, George I., "Zinc and Lead Deposits of Northern Arkansas, with a Section on the Determination and Correlation of Formations," by E. O. Ulrich: *U. S. Geol. Survey Prof. Paper* 24, pp. 28; 109-113, 1904.

and sandstones which belong to the Morrow formation. The upper limit . . . is rather indefinite, but at many places is marked by the presence of heavy sandstones which carry quartz pebbles." The Morrow was classified as a formation at the base of the Pennsylvanian, and Ulrich regarded it as early Pottsville age.

Drake[6] contributed the first notable geological report dealing with northeastern Oklahoma, and although correct only in a broad sense, his map showed the distinction between the Mississippian and Pennsylvanian rocks.

In 1905[7] and 1906[8], Taff mapped the areal geology of Adair, Cherokee, and Muskogee Counties, and described each formation in considerable detail, in addition to outlining the geologic history of the area. Purdue[9] mapped the Winslow, Arkansas, quadrangle and delineated the Hale and Bloyd formations, and the Brentwood and Kessler members of the Bloyd.

Croneis[10] gave the name "Baldwin" to the thin coal in the "Coal-bearing shale" between the Brentwood and Kessler limestones.

Reports of a reconnaissance nature dealing with the stratigraphy and structure of northeastern Oklahoma were made by Snider,[11] Mather,[12] Aurin, Clark and Trager,[13] and Gould.[14] Only a few recent papers deal with the geology of the Morrow series of

[6] Drake, N. F., "A Geological Reconnaissance of the Coal Fields of Indian Territory": *Contributions to Biology from the Hopkins Seaside Laboratory* (Leland Stanford Jr. University) No. 14, 1897; also *Proc. Am. Phil. Soc.*, Vol. 26, No. 156, pp. 326-419, 1898.

[7] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Tahlequah Folio* (No. 122), 1905.

[8] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Muscogee Folio* (No. 132), 1906.

[9] Purdue, A. H. *U. S. Geol. Survey Geol. Atlas, Winslow Folio* (No. 154), 1907.

[10] Croneis, Carey, "Geology of the Arkansas Paleozoic Area": *Ark. Geol. Survey, Bull.* 3, p. 82, 1930.

[11] Snider, L. C., "The Geology of a Portion of Northeastern Oklahoma": *Okla. Geol. Survey Bull.* 24, 1915.

[12] Mather, Kirtley F., "The Fauna of the Morrow Group of Arkansas and Oklahoma": *Denison Univ., Sci. Lab., Bull.*, Vol. 18, pp. 59-284, 1915.

[13] 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. Petrol. Geol.*, Vol. 5, pp. 115-153, 1921.

[14] Gould, Chas. N., "Index to the Stratigraphy of Oklahoma": *Okla. Geol. Survey Bull.* 35, 1925.

the area in more detail: Cram,[15] Harlton, [16] and Newell.[17] In 1938, Harlton[18] applied the term Morrow series to the upper part of his "Bendian system."

PRESENT INVESTIGATION

Previous to the initiation of this project, the Morrow had been studied in Oklahoma principally in the vicinity of Muskogee and Fort Gibson, and the beds of this area were correlated with the type section of the Morrow in Arkansas on the basis of lithologic similarity.

Reconnaissance observations by some workers in Oklahoma raised doubts regarding correlations of the Morrow units in Oklahoma with those in Arkansas, and it was suggested by Mr. Dott that the Morrow series should be studied in detail across the area from the Arkansas-Oklahoma state line to the vicinity of Muskogee. He suggested that the study begin with the section on Hale Mountain, previously described in detail by Giles and Brewster,[19] and consist of detailed study and measurements of as many exposed sections as possible in Adair and Cherokee Counties. It was thought that the rocks could be correlated, section to section, across the area, and thus establish the identity of the units of the Morrow series near Muskogee.

About the same time, it was learned that Girty and Henbest, of the U. S. Geological Survey, were undertaking a study of the fauna of the Morrow, and Dott suggested that insoluble residues might offer diagnostic criteria, and thus give another approach for differentiation and correlation of the different units—an approach that would be applicable to subsurface geology in prospecting for oil and gas.

[15] Cram, Ira H., "Cherokee and Adair Counties," in "Oil and Gas in Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. III, pp. 531-586, 1930. This chapter also published as Bull. 40-QQ.

[16] Harlton, Bruce H., "Carboniferous Stratigraphy of the Ouachitas with Special Study of the Bendian": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 18, pp 1018-1049, 1934.

[17] Newell, Norman D., "Carboniferous Stratigraphy," in Wilson, Charles W., Jr., "Geology of the Muskogee-Porum District Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, 1937.

[18] Harlton, Bruce H., "Stratigraphy of the Bendian of the Oklahoma Salient of the Ouachita Mountains"; *Bull, Amer. Assoc. Petrol. Geol.*, Vol. 22, pp. 852-915, 1938.

[19] Giles, Albert W. and Brewster, Eugene B., "Hale Mountain Section in Northwest Arkansas": *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 14, pp. 121-128, 1930.

Field Procedure. This investigation was undertaken during the summers of 1938 and 1939. The mapping was done on State Mineral Survey culture base maps[20] for the Adair County portion of the work, on the scale of 1 inch to the mile, and on the U. S. Geological Survey topographic sheets of the Tahlequah and Muskogee quadrangles, scale 1:125,000. Where larger scales were needed to show details of sample locations, plats of 2 and 4 inches to the mile were used. Complete mapping of the area was not undertaken, and the mapping of Taff shown in the Tahlequah and Muskogee folios was followed in general. The reader is referred to the areal geologic map of Cherokee and Adair Counties, Oklahoma, compiled by Cram, and published with Oklahoma Geological Survey Bulletin 40-QQ.

As a general rule, the outcrops are fairly well exposed in creeks and in gulleys up the sides of the many outliers in the area. Underbrush is so thick at the bases of the outliers in Adair County that it is a task to reach the hills from the roads. Blank portions of the measured sections indicate covered intervals. The covered intervals are most commonly due to: (1) sandstone blocks fallen from the overlying Atoka formation; (2) clay, shale, and slope wash; (3) locally dense underbrush, especially at the bases of small cliffs. There are common evidences of recent landslides that have obscured outcrops. In many places it is difficult to determine whether beds are in place, especially the thin limestones interbedded with shales.

A section was measured on nearly every outlier in Adair County and averaged about 2 miles apart. In Cherokee County, sections were measured at selected points, roughly 4 to 6 miles apart. In areas of doubtful correlations, additional sections were studied. Series of stratigraphic sections from Arkansas westward to the Muskogee area, with one or more in every township, are shown graphically in the profiles (Plates XI-XV). These profiles illustrate the differences in the Morrow from the type section in Arkansas to the vicinity of Muskogee.

All sections were measured carefully by means of aneroid barometer, hand level, a 50-foot steel tape, and a 6-foot folding rule, graduated to 0.1 foot. Representative samples were collected from

[20] Works Progress Administration Project No. 65-65-538, sponsored and directed by the Oklahoma Geological Survey, 1936-1937.

nearly all measured sections at every exposed change in lithology for subsequent study of insoluble residues.

Laboratory Procedure. Each sample collected was given identical treatment, regardless of whether it was limestone, shale, sandstone, or conglomerate. The sample was crushed to ¼-inch size and two representative splits were placed in 2½-inch vials, one for acid treatment, the other for binocular examination. The large fragment size was used to preserve large individual insoluble fragments and structures. A sample averaging 17 to 20 grams was weighed, placed in a 400-cc beaker, digested in a 5 percent solution of commercial grade hydrochloric acid (HCl), and heated on a sand bath until all reaction had ceased. This procedure took from 30 minutes to more than 2 hours. As the acid became saturated with the soluble material and the residue had settled to the bottom of the beaker, the spent acid was decanted and fresh acid was added. Care was taken not to lose any of the fine particles of the residue.

Upon complete digestion, the contents of each beaker were filtered through a previously weighed filter paper; the filter paper and contents were dried in an oven, and the weight and percentage of residue were determined.

Following this, the residue was washed from the filter paper into another 400-cc beaker, using a small jet of water and a soft camel's hair brush. After thorough washing much of the clay and silt were decanted. The sample was covered with about 100 cc. of water, about 15 cc of 0.2 n KOH or NaOH was added, and this solution was brought just to a vigorous boil in order to deflocculate the clay in the residue.

Further washing at this stage made it possible to decant essentially all the clay and fine silt, leaving only grains above a 1/32 to 1/64 mm size grade in the residue. These grains were washed out of the beaker with acetone, dried and weighed in order to compute the percentage of grains to the original weight of the sample. Finally these mineral grains were returned to the vial for subsequent study with the binocular and petrographic microscopes.

These residues and their detailed descriptions are now on file in the offices of the Oklahoma Geological Survey at Norman, Oklahoma.

ACKNOWLEDGMENTS

The writer takes this opportunity to acknowledge his indebtedness to Mr. Robert H. Dott, Director of the Oklahoma Geological Survey, for fostering this work as a special project of that organization, for aid in the field, and for continued interest in the development of the project. Professor A. C. Trowbridge, of the State University of Iowa, guided the preparation of the first part of the work, dealing with Adair County. Dr. H. G. Hershey, of the Iowa Geological Survey, supervised the preparation and study of the insoluble residues of the first part of the work.

Through the kindness and cooperation of Professor G. Marshall Kay, space was provided in the sedimentation laboratory at Columbia University, New York City, for the preparation and study of the insoluble residues of the second part of the work. Dr. H. N. Coryell, of Columbia University, discussed the project with the writer and offered many valuable suggestions.

During the summer of 1938, Mr. Charles Burton Moore, Jr. assisted the writer in the field in Adair County. Mr. David Richards, then a student at the University of Oklahoma, ably assisted the writer during the summer of 1939 in Cherokee County and adjoining areas.

GEOGRAPHY

Topographic Features. The area of outcrop of the Morrow series is around the southwest part of the Ozark Plateau physiographic province,[21] east of the Illinois River and at the boundary of the Springfield Plateau sub-province and the Boston Mountains province west of that river.

The maximum regional relief of this area is about 1,300 feet, the altitudes ranging from 1,750 feet on the north end of Bugger Mountain, sec. 11, T. 16 N., R. 26 E., Adair County, to 450 feet along the Arkansas River in the northeast corner of T. 12 N., R. 20 E., Muskogee County. The common topographic expression of Morrow outcrops is in the buttes that rise above the plain of the Ozark Plateau, which is developed on the Boone chert (Osage) of

[21] Fenneman, Nevin M., "Physiography of Eastern United States," *McGraw-Hill Book Co., Inc.*, pp. 635-662, 1938.

Mississippian age. The buttes are capped by Atoka sandstone, or by upper Morrow beds where the Atoka has been removed.

In this area the Ozark Plateau slopes southwest and plunges beneath the Atoka sandstone of the Boston Mountains to the south, and beneath the Prairie Plains monocline to the west. The buttes average about 300 feet high along the Arkansas-Oklahoma line and in southern Adair County, but are only about 150 to 200 feet high in most of Cherokee County.

Because of the nature of the topography most of the detailed sections were measured on the buttes, and attempts were made to correlate the various formations from one butte to another.

In Adair County, the Atoka sandstone commonly caps and forms cliffs around the tops of the hills. The shales of the Bloyd formation are immediately below the sandstone, and commonly form a sloping area that is overgrown with brush, or one that has been converted into pasture land. Good outcrops are not abundant and diligent search was necessary in many areas to locate exposures for study.

The massive Hale sandstones and limestones form cliffs near the base of the outliers. These cliffs are easily visible from the roads in the area. For example, the cliffs on Stilwell Mountain, so clearly seen from the town of Stilwell, are made up of Hale limestones, with thin, interbedded sandstone members.

The Pitkin limestone underlies the Hale formation and becomes a part of the cliff. Many springs issue from the jointed Pitkin limestone at the contact with the underlying Fayetteville shale. The Fayetteville shale forms the long, gentle slopes that extend from the buttes to the Boone chert which underlies the Fayetteville in this area. Complete sections of the Fayetteville were not seen. The outcrop of the Fayetteville shale is perhaps the best farm land in the area.

Drainage. The area is well drained by two rivers, several large creeks, and innumerable smaller streams. The large creeks have permanent flow but some of the smaller streams are dry during part of the late summer. All drainage from the area is to the Arkansas River that borders the area on the southwest. The Neosho (Grand) River bounds the area on the west, and the Illinois River flows in a southwesterly direction through the central part.

Accessibility of the Area. The area is served by U. S. highways 59, 62, and 64, and state highways 10 and 51. Most parts are reached by good, all-weather roads. The highways are paved or gravelled and trunk county roads are gravelled. Due to the topography, there are very few section line roads except in the vicinity of Muskogee.

The Kansas City Southern Railroad extends in a general north-south direction across the eastern part of the area, connecting Westville, Stilwell, and Sallisaw. The Missouri Pacific Railroad connects Ft. Gibson and Sallisaw, generally paralleling the Arkansas River along the southwest part. The Missouri-Kansas-Texas Railroad passes just west of the area; and the Kansas, Oklahoma, and Gulf Railroad crosses the northwest corner.

Economic Development. Farming and ranching are the most important industries of the area. Nearly all the bottom land is devoted to farming and much of the upland is farmed or is devoted to pasture.

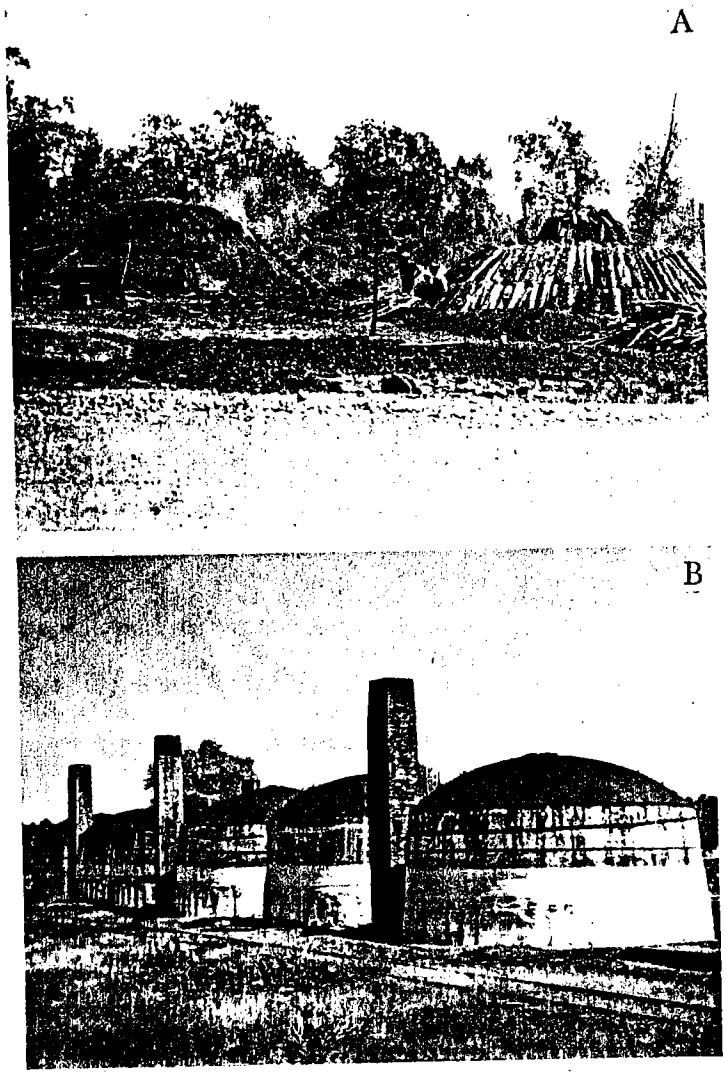
Land along the creek bottom is utilized to some extent for orchards.

Lumbering in the southern and eastern parts of the area formerly was important. The old lumber trails and log roads still may be found on the uplands and on steep slopes of the buttes. There is a large sawmill at Evansville, Arkansas, that uses considerable timber from the eastern edge of the area.

A series of primitive, earth-covered charcoal kilns were operated during the summer of 1938, along state highway 51 about 2 miles northwest of Stilwell. The charcoal was trucked to Baron, Oklahoma, and shipped by rail from there. At the present time a series of modern, brick, bee-hive type charcoal kilns is operating at Baron. (See Pl. I.)

Although considerable oil and gas have been produced west of the area in Muskogee and Wagoner Counties and some gas in Sequoyah County to the south, there has been no commercial production in this area. Several oil and gas showings have been reported in test wells. According to Cram[22] prospecting for oil and gas cannot be encouraged in this area.

[22] Cram, Ira H., "Cherokee and Adair Counties," in "Oil and Gas in Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. III, pp. 531-586, 1930. This chapter also published as Bull. 40-QQ.



Charcoal-making from native hardwoods is one of the principal manufacturing industries of the area. Charcoal kilns, Adair County, Oklahoma. A. Earth-covered kiln, northwest of Stilwell. B. Beehive type of kiln, at Baron.

STRATIGRAPHY

Rocks exposed in the Oklahoma portion of the Ozark Plateau range in age from pre-Cambrian to lower Pennsylvanian. Table I shows the stratigraphic relationships of the rock units of the area, and the position of the Morrow series in the section:

TABLE I

CLASSIFICATION OF ROCKS EXPOSED IN OKLAHOMA PORTION OF THE OZARK MOUNTAINS

System	Series	Formation
Pennsylvanian	Des Moines	Atoka formation
	Morrow	Bloyd formation
		Hale formation
Mississippian	Chester	Pitkin limestone Fayetteville shale
	Meramec*	"Grand River" limestone Batesville sandstone Hindsville limestone Moorefield shale
	Osage ("Boone")	Keokuk limestone Reeds Spring limestone St. Joe limestone
	Kinderhook	Chattanooga shale Sylamore sandstone
Devonian		Sallisaw sandstone Frisco limestone
Silurian		St. Clair limestone
Ordovician		Fernvale limestone Fite limestone Tyner shale Burgen sandstone Cotter dolomite
pre-Cambrian		Spavinaw granite

* "Mayes" of some authors. Divisions and names used by R. A. Brant, Tulsa Geological Society Field Trip: Tulsa, to Choteau and Grand River and return, October 18, 1941; Also Master's Thesis, University of Tulsa.

Gordon and Kinney regard the Batesville sandstone of the Batesville, Arkansas area as basal Chester ("The Mississippian formations of the Batesville district, Independence County, Arkansas": U. S. Geol. Survey, Oil and Gas Investigations, Preliminary Map 12, 1944.)

Heretofore the stratigraphy of the Morrow series in northeastern Oklahoma has been studied only in a general way. Very few detailed sections have been measured to determine its exact composition, limits, divisions, and lateral variations. As a result of the present study, the terms Hale and Bloyd formations are introduced into Oklahoma as subdivisions of the Morrow. The Hale is a thick calcareous sandstone in Arkansas and a sandy limestone to fairly pure limestone in the western part of the area near Muskogee, Okla. The Bloyd contains thin limestones interbedded with shale that probably represent the Brentwood limestone of Arkansas, and a limestone in eastern Adair County that is questionably correlated with the Kessler. A coal bed was found in the Bloyd shale at one locality that is thought to be approximately in the position of the Baldwin coal of Arkansas.

The Pitkin limestone underlies the Hale disconformably, and the Atoka formation overlies the Bloyd unconformably. The Pitkin and Atoka formations are included in the detailed discussion of this paper to show the general relations of the Morrow series to the adjacent formations.

MISSISSIPPIAN SYSTEM

Chester Series

Pitkin Limestone

The Pitkin limestone underlies the Morrow series in all measured sections, and a short description of this formation is pertinent here. The Pitkin is the youngest formation of the Chester series in northeastern Oklahoma. It rests on the Fayetteville shale apparently conformably, and is in turn overlain by the Hale formation of the Morrow series.

Distribution and Character. The Pitkin is characteristically a massive limestone, but two distinct lithologic zones have been observed. In addition to the massive beds, an argillaceous to granular zone may be recognized in many exposures in Adair County. (See fig. 2.) Texture of the limestone ranges from very coarsely crystalline to fine and sublithographic crystalline. (See table II.) It is light to dark blue gray in color.

Massive Zone. In the upper few feet of this zone the limestone is highly spotted and stained with limonite, is locally oolitic near the base, commonly carries resinous-appearing beds near the top, weathers blocky with a knobby surface, and is highly jointed in many places.

TABLE II

Textural Divisions of Limestone Used in This Report

over 3 mm — very coarsely crystalline
3 - 1 mm — coarsely crystalline
1 - $\frac{1}{2}$ mm — coarse medium crystalline
$\frac{1}{2}$ - $\frac{1}{4}$ mm — medium crystalline
$\frac{1}{4}$ - $\frac{1}{8}$ mm — fine medium crystalline
$\frac{1}{8}$ - $\frac{1}{32}$ mm — fine crystalline
Below $\frac{1}{32}$ mm — very fine crystalline
Visible with a 7X hand lens — sublithographic crystalline
crystalline.
(The size grade refers to either crystals or grains or both.)

The massive zone is the most common throughout the southern part of Adair County and all of Cherokee County. It is locally very fossiliferous and carries many forms such as *Stenoscisma* (*Camerophoria*) *explanata, Diaphragmus elegans,* and *Archimedes*

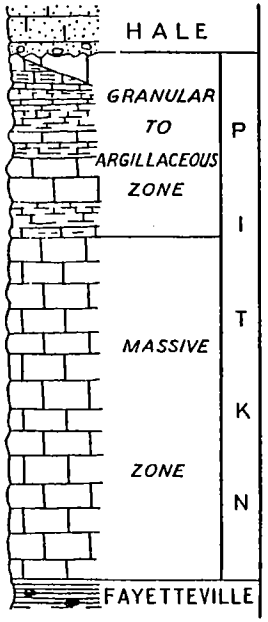


Fig. 2. Diagram showing the two lithologic zones that may be recognized in the Pitkin limestone, Adair County, Oklahoma.

s. l. spp. which were used as the Mississippian markers. William H. Easton discussed and described the fauna of the Pitkin limestone of Arkansas[23] in which he listed 130 genera and 208 species. Faunal studies of the Pitkin in Oklahoma show generic and specific similarities with the Pitkin of Arkansas, indicating the equivalency of the Pitkin rocks over the entire area of outcrop in the western part of the Ozark Mountains.

Argillaceous to Granular Zone. This zone is a succession of thin, knobby, blue gray, argillaceous limestones interbedded with dark blue, slightly calcareous shales; and in some places coarsely crystalline, granular limestone beds are present. It serves as a good marker where the conglomeratic base of the Hale formation is not exposed or is too thin to be noted. The zone averages less than 10 feet thick.

The calcareous shales of this zone are characterized by an abundance of large brachiopods and large mollusks: *Echinoconchus alternatus, Linoproductus prattenianus, Allorisma walkeri, Platyceras subrotundum.* The Mississippian index fossils, *Archimedes* s. l. spp., *Diaphragmus elegans,* and *Stenoscisma (Camerophoria) explanata,* were found but are not as abundant as in the lower, massive, zone. In general the massive and argillaceous zones carry identical faunas, the only variations are due to the inherent difference in ecological conditions during the deposition of massive limestone versus successive beds of argillaceous limestones and calcareous shales. The faunal study also points out the equivalence of the newly recognized upper zone of the Pitkin of northeastern Oklahoma to that of the type area around Pitkin, Washington County, Arkansas.

Coarsely crystalline, granular phases of this zone were noted in measured sections 22, 46, 51 and 52, all in Adair County. In these sections the argillaceous portion of the zone is not present and the massive zone is overlain by the granular limestones. On Gittin' Down Mountain, secs. 14, 15, 22 and 23, T. 15 N., R. 24 E. (No. 46),[24] the Pitkin is 64 feet thick and is composed entirely of massive bedded, very coarsely crystalline to rather granular, very crinoidal, blue gray limestone, spotted and stained with limonite.

[23] Easton, William H., "The Fauna of the Pitkin Formation of Arkansas": *Jour. Paleontology,* Vol. 17, No. 2, pp. 125-154, 1943.

[24] Numbers in parentheses denote numbers of measured sections. These sections are numbered from west to east and from south to north.

It weathers crinoidal and thin bedded, especially in the upper part, is fossiliferous, and carries a trace of phosphate.

At the top of the Pitkin and below the conglomerate of the Hale limestone, on the southeast end of Stilwell Mountain, secs. 1 and 2, T. 15 N., R. 25 E. (No. 52), beds of granular limestone were found in the top of this zone, with argillaceous limestones and calcareous shales beneath. This is an outcrop to study a complete section of the Pitkin limestone in eastern Oklahoma.

This upper zone of the Pitkin was not recognized in Cherokee County. Evidently it comprises the very top part of the Pitkin and was protected from the post-Pitkin erosion in local areas. The occurrence of this zone in Adair County points to a pre-Hale eastward tilting so that the Hale rests on older Pitkin beds in Cherokee County.

Thickness. The Pitkin limestone is generally well represented on outcrops in the entire area south and east of McBride, Oklahoma, where it averages about 30 feet thick.

In the profiles across T. 13 N., and T. 14 N., the Pitkin averages about 25 feet thick, ranging from a maximum of 40 feet at Davidson, Arkansas, secs. 14 and 23, T. 12 N., R. 33 W. (No. 4), to a minimum of 17 feet in the Terrapin Creek section, sec. 29, T. 14, N., R. 23 E. (No. 20).

In the profile across T. 15 N., however, the Pitkin is thicker and has a wider range of thickness. It is 21 feet thick on Hale Mountain, Arkansas; 70 feet on Goat Mountain, sec. 7, T. 15 N., R. 25 E. (No. 53); thins again in western Cherokee County, and thickens to a maximum of 82 feet in the River Bluff section, in sec. 32, T. 15 N., R. 20 E. (No. 33).

The Pitkin is fairly uniform in thickness and averages about 29 feet across T. 16 N.

Character of Insoluble Residues. Perhaps the most distinctive single character of the Pitkin residues is the low percentage of grain residue.[25] The amount of grain residue is commonly 0.5 percent, far below the percentage of error, and should be called a trace.

[25] The term "grain residue" is used here to designate the insoluble residue after the removal of the clay and fine silt size grades by treatment with KOH and/or NaOH, and by decantation.

The average major size grade of the quartz, which is the predominant mineral in the residues, is 1/8 to 1/16 mm., and it may be poorly sorted or well sorted. Euhedral secondary quartz crystals averaging 1/8 x 1/32 mm. in size were found in many Pitkin samples. (See Pl. II B.) These crystals characterize the massive zone.

In the argillaceous to granular zone the percentage of grain residues is larger, as much as 10 percent of the residues; a higher percentage of clay is present; and many residues are composed of as much as half limonite and limonitic-stained material.

Considerable material resembling organic substance was found in many of the Pitkin residues. This is a black, opaque, tar-like material, insoluble in carbon tetrachloride, alcohol, and gasoline, and has a high fusion point.

This study indicates that the Pitkin is not everywhere identifiable solely on the basis of the character of the insoluble residues, and it is necessary to depend primarily on field relationships to recognize this limestone formation.

PENNSYLVANIAN SYSTEM

Morrow Series

Historical Statement. The Morrow series is now considered to be lower Pennsylvanian in age. However, because it lies unconformably between typical Mississippian and typical Pennsylvanian, and because of the equivocal nature of its fossils, the age of the Morrow was long a moot question. In an early report by the Arkansas Geological Survey Branner[26] placed it in the Mississippian because there seemed to be a greater break between the Morrow and the overlying Atoka sandstone of Des Moines age, than between the Morrow and the underlying Pitkin limestone of Chester age. Early paleobotanists recognized the affinities of the Morrow flora with that of the lower Pennsylvanian, and shortly after the beginning of the present century, both Ulrich and Girty concluded that the Morrow fauna, like the flora, indicates a lower Pennsylvanian age. Mather's study[27] of the fauna tended to confirm this conclusion.

[26] Branner, John C., "The Geology of Washington County": *Geol. Survey of Ark. Ann. Rep. of* 1888, Vol. IV, table on p. xiii, 1891.
[27] Mather, Kirtley, F., "The Fauna of the Morrow Group of Arkansas and Oklahoma": *Denison Univ., Sci. Lab., Bull.*, Vol. 18, pp. 59-284, 1915.

This age assignment has been followed by all geologists, except that R. C. Moore suggested that the top of the Mississippian be raised to the top of the Morrow because of the very great magnitude of the unconformity above, as compared to the unconformity at its base. This suggestion was made in oral presentation at the sixteenth session of the International Geological Congress, Washington, 1933, and was published in 1936.[28] In a paper published in 1934, he retained the same age assignment, but stated in a footnote that "Study carried on since the completion of this paper leads to the conclusion that preponderance of evidence favors the classification of the Morrow and equivalent beds as Pennsylvanian."[29] He follows this classification in subsequent papers.

A recent study of the cephalopod fauna[30] from the Morrow series indicates that although the cephalopods are related to both the Mississippian and Pennsylvanian forms, they are more like the Pennsylvanian.

General Statement. The section on Hale Mountain, southwestern Washington County, Arkansas, along the road 1.5 to 2.0 miles southwest of the village of Morrow, and 5 to 6 miles east of the Oklahoma-Arkansas state line, is in the type area, and is one of the classic sections of the Morrow series. It has been described in detail by Giles and Brewster,[31] and was adopted as the starting point for the present investigation.

The Hale Mountain section differs somewhat from other sections of the Morrow in northwestern Arkansas, and the present investigation confirms earlier opinions that westward from Hale Mountain, in Oklahoma, the Morrow rocks are characterized by important lateral changes: the calcareous Hale sandstone grades laterally into massive limestone, the Brentwood limestone grades laterally into interbedded limestone and shale, and the Kessler has been removed by erosion west of the middle of Adair County. The

[28] Moore, R. C., "'Carboniferous' Rocks of North America": *Int. Geol. Cong., Rep. 16th Session,* 1933, Vol. 1, pp. 593-616, pls. 1-3, 1936.
[29] Moore, R. C., "The Origin and Age of the Boulder-Bearing Johns Valley Shale in the Ouachita Mountains of Arkansas and Oklahoma": *Am. Jour. Sci., 5th Ser.*, Vol. 27, pp. 432-453, 1934.
[30] Miller, A. K., and Moore, Carl A., "Cephalopods From the Carboniferous Morrow Group of Northern Arkansas and Oklahoma": *Jour. Paleontology,* Vol. 12, pp. 341-354, 1938.
[31] Giles, Albert W., and Brewster, Eugene B., "Hale Mountain Section in Northwest Arkansas": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 14, pp. 121-138, 1930.

massive limestone near Ft. Gibson, long thought by geologists to be Brentwood, has proved to be continuous with the Hale.

Attention should be called to the pronounced change in the Morrow rocks from Adair County into Cherokee County. In Adair County all the units of the Morrow are similar to those of the type area in Arkansas. A few miles west of the Cherokee-Adair county line, the Morrow is less than half its thickness on Hale Mountain, and about two-thirds the thickness of this series in the western part of Adair County. The Hale is represented in Cherokee County by a limestone formation that in many exposures, is difficult to distinguish from the Pitkin limestone. That this limestone of the Hale is equivalent to the sandstone farther east is evidenced by the similarity of the insoluble residues, by the thin conglomeratic bed at the base, and by the close similarity between the Hale limestone in Cherokee County and the limestone beds directly associated with the Hale sandstones in Adair County. A study of the stratigraphic profiles will also assist in understanding that this limestone is the equivalent of the sandstone.

The Bloyd formation thins progressively westward from Arkansas into Cherokee County, but maintains a more or less uniform thickness across Cherokee County to Muskogee. The Brentwood limestone member loses its identity in Oklahoma, being a succession of shales with discontinuous limestone beds. There is a local development of thin-bedded siltstone, which has been called a sandy shale, in several sections in Cherokee County. Locally the shales are calcareous and very fossiliferous.

The Kessler limestone is much thinner in Oklahoma, and is recognizable primarily on the basis of its insoluble residue. Studies indicate that it does not extend west of a north-south line roughly 4 miles west of Stilwell, Oklahoma. It has been removed by pre-Atoka erosion, and the sandstones of the Atoka rest on older beds of the Bloyd toward the west and north. This erosion also accounts for the irregular thickness of the Morrow series in Cherokee County.

HALE FORMATION

The Hale formation was named by Taff[32] from Hale Mountain, Washington County, Arkansas, to replace the preoccupied term "Washington" given this unit by Simonds in 1891. It is the oldest Pennsylvanian formation in this area, rests on the Pitkin limestone of Mississippian age and is overlain by the Bloyd formation.

[32] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Tahlequah Folio* (No. 122).

Distribution and Character. The Hale is present in every measured section in the area, and is generally the best exposed of all the formations studied. In the eastern and central part of the area it crops out in cliffs with the upper part of the Pitkin exposed and at the top, in some places, the limestones or shales of the Bloyd (probably equivalent to Brentwood) are exposed.

In all sections the Hale rests on the eroded surface of the Pitkin limestone, with the possible exception of a few of the sections in the northern part of the area near Pryor, Oklahoma, where the Pitkin was not found. There is a conglomeratic bed at the base of the Hale in most of the sections in the eastern and southeastern parts of the area. This conglomerate averages less than a foot in thickness, is made up of well rounded limonitic, shaly, limestone pebbles and phosphate nodules, contained in a very ferruginous and calcareous, yellow brown matrix. The matrix is generally phosphatic and weathers to a hematite-red color. Re-worked Pitkin fossils and pebbles have been found in the conglomerate.

The character and variations of the Hale formation in the different measured sections is discussed by townships. Names and numbers of measured sections give a cross reference to Appendix A and Plates.

PROFILE ACROSS TOWNSHIPS 13 AND 14 NORTH

(Plate X)

Starting from the measured section at Davidson, Arkansas, secs. 14 and 23, T. 12 N., R. 33 W. (No. 4), this profile extends westward through Bunch, Oklahoma, to Greenleaf Dam, south of Braggs, Oklahoma. At Davidson, Arkansas, the Hale is made up of a basal 6-foot bed of sandy, fissile shale, followed by 4 feet of calcareous sandstone, cross bedded and irregularly bedded, medium to fine grained. Above a thick concealed interval there is a well-exposed outcrop of typical calcareous Hale sandstone that weathers pitted and cavernous.

On the south end of Ross Mountain, secs. 34 and 35, T. 15 N., R. 26 E. (No. 68), the Hale is similar to that at Davidson, Arkan-

sas: a basal 7-foot sandstone, thin bedded, argillaceous, greenish, and essentially non-calcareous; followed by 6 feet of sandy, fissile shale, and a thick concealed interval. Next above is 29 feet of calcareous sandstone, thick-bedded, and weathering pitted in horizontal flutings. Above this sandstone is 24 feet of very sandy limestone that is very coarsely crystalline and very crinoidal in the lower part.

At the Salem School section, sec. 31, T. 15 N., R. 26 E. (No. 66), the Hale is thinner and consists of typical calcareous Hale sandstone.

On Welch Mountain, sec. 33, T. 15 N., R. 25 E. (No. 58), the Hale is entirely limestone except the basal conglomerate, which is calcareous and contains pebbles of Pitkin limestone and "Boone" chert. The limestones are generally medium to very coarse crystalline, and blue gray in color. There is one oolitic bed that was not found in place.

The sections on High Mountain, secs. 2, 3, 10 and 11, T. 14 N., R. 24 E. (No. 21), and Bunch Mountain, sec 15, T. 14 N., R. 24 E. (No. 23), exhibit the Hale composed of typically weathered calcareous sandstones with thin limestone beds that are crinoidal and very coarsely crystalline. (See frontispiece.)

In eastern Cherokee County, Elk Creek section, sec. 23, T. 14 N., R. 23 E. (No. 19), the Hale is made up of limestone that is light gray, locally very sandy, generally coarsely crystalline and crinoidal. There are three thin calcareous sandstone beds in the unit. Three miles to the west, in the Terrapin Creek section, sec. 29, T. 14 N., R. 23 W. (No. 20), the Hale is poorly exposed. It carries limestone beds that are sandy, that have a typical Hale grain residue and weather pitted and cavernous. In addition there is an 8-foot bed of sandy blue gray shale near the top.

One of the best exposed and most instructive sections in this part of the area is the Blackgum section, secs. 32 and 33, T. 14 N., R. 22 E., and secs. 4 and 5, T. 13 N., R. 22 E. (No. 11). The basal part of the Hale is irregularly bedded sandstone with thin shaly partings, medium to fine grained, and is essentially non-calcareous. (See Pl. III A.) The upper 10 feet of the Hale is of fine sandstone that is slightly calcareous, irregularly bedded, blue gray in color with a greenish cast. The limestone on top of this bed is assigned to the Bloyd on lithologic appearance and on the basis of the study of insoluble residues.

In neither the Linder Creek section, sec. 3, T. 13 N., R. 21 E. (No. 9) nor the Greenleaf Dam section, sec. 2, 13 N., R. 20 E. (No. 6), is the base of the Hale exposed. In the former the Hale is generally poorly exposed and is made up of irregularly bedded limestones that are light blue gray, coarsely crystalline, crinoidal, and weather granular. At Greenleaf Dam, at the lake level in 1939, there was a 3-foot bed of calcareous sandstone followed by generally thin bedded limestones that contain local sandy inclusions and crinoid stems replaced with orange calcite.

The McLain section, sec. 28, T. 13 N., R. 20 E. (No. 8), is difficult to correlate precisely with adjacent sections because of generally poorly exposed beds. A 1-foot bed of dark gray, fine, sandstone is called the base of the Hale. The bed is followed by 8 feet of blue gray fissile shale with limy concretions and lenses. The questionable top of the Hale is placed within a limestone-shale interval where the lithologic character of the limestone seems to change sufficiently to warrant a formation break.

PROFILE ACROSS TOWNSHIP 15 NORTH

(Plate XI)

This profile is perhaps the best in which to study the outcrop of the Morrow series of rocks in northeastern Oklahoma. It extends from the type section area on Hale Mountain, Washington County, Arkansas westward to the vicinity of Muskogee, Oklahoma. The attempt is made to correlate beds between adjacent measured sections to determine the facies changes from the type section westward. It is believed that in this way it is possible to correctly interpret the Morrow sections near Muskogee, and to correlate these beds with the type section.

The Hale is a mappable unit across the area of outcrop and can generally be differentiated upon close study of its lithology, the field relationships, and on the basis of the insoluble residues.

Giles and Brewster[33] described the Hale formation on Hale Mountain, Arkansas, and pointed out that the basal 16 feet is concealed. Above this concealed interval the Hale is composed of calcareous sandstone with a few thin shales and one limestone bed. See appendix A for detailed description of this section.

[33] Giles, Albert W., and Brewster, Eugene B., *op. cit.*

Across the middle of the southern part of Adair County the Hale contains more sandstone with a decrease in the amount of shale, and locally, limestone beds are well developed.

The Hale is entirely sandstone in T. 15 N., R. 26 E. Two sections were measured in this township but a full thickness of the Hale was not exposed in either. The basal part is thin bedded sandstone, gray on fresh exposures, weathering brown to buff, is somewhat cross bedded locally, and contains shaly beds. Massive beds of slightly calcareous sandstone are found in the middle of the measured sections.

Westward in T. 15 N., R. 25 E., the base of the Hale is marked by a calcareous conglomerate bed, ranging from 0.2 to 1.0 foot in thickness, directly overlain by a 1-foot bed of blue, non-calcareous, fissile shale. Both these beds show a positive test for phosphate. Above these basal beds the Hale is composed of massive, light brown sandstone, locally calcareous, commonly cross bedded, and invariably carrying typical "Hale weathered" beds. A yellow sandy shale is present in the Hale on Taylor Mountain, sec. 13, T. 15 N., R. 25 E. (No. 54).

The Hale is thinner in Gittin' Down Mountain, secs. 14, 15, 22, and 23, T. 15 N., R. 24 E. (No. 46), because of the locally thickened Pitkin that seems to have formed a pre-Hale topographic high. Here there is no conglomerate at its base, and the Hale consists entirely of massive-bedded and cross-bedded, non-calcareous to slightly calcareous sandstone. Local beds of typical "Hale weathering" are found in Bowles Mountain, secs. 22, 27 and 28, T. 15 N., R. 24 E., 2 miles south of Gittin' Down Mountain; however, the Hale is thicker and the calcareous conglomerate bed is found at its base. In this section, the upper part of the Hale is made up of light blue gray limestone, very coarsely crystalline and extremely crinoidal. Thin shale beds separate the limestone beds. These beds are assigned to the Hale chiefly on the character of the insoluble residues.

One of the best and most instructive exposures of the Hale formation in the western part of Adair County is in the Hungry Mountain District, E½ sec. 16, T. 15 N., R. 24 E. (No. 47), where 60 feet of Hale is well exposed in a road cut. The base is a 6-foot bed of very sandy limestone followed by a thin but persistent 6-inch bed of blue clay shale weathering yellow brown and buff, and carrying phosphatic pebbles that yielded 3.12 per cent phosphate on analysis.

Locally there is a second thin shale parting separated from the first by a 6-inch conglomeratic layer overlain by 12 feet of sandstones and shale. The sandstones are very thin and are interbedded with heavily limonitic-stained shales. Cross-bedded, calcareous sandstones are well developed. (See Pl. IV A). Limestone reefs, which are very sandy, and which appear cross-bedded and fluted on weathered surfaces, occur within this zone, (Pl. IV B). The syngenetic origin of these reefs is indicated by the fact that thin resistant sandstone beds may be traced laterally to a reef, thence up and through it, and back to their original level. This situation illustrates the extreme variability of the Hale, from limestone to sandstone within a very short distance. Evidently weathering removes most of the calcareous material from the reefs and the non-calcareous honeycombed exposures, typical "Hale weathering," remain. Thin-bedded sandstones with shaly partings, and a massive bed that weathers characteristically pitted and cavernous, complete the section.

On County Line Hill, sec 24, T. 15 N., R. 23 E. (No. 40), the Hale consists of massive bedded, very calcareous sandstone, and local limestone lenses. These limestone beds are typical of the Hale limestone in that they are coarsely crystalline, very crinoidal, and are of granular texture. In the Barber section, secs. 28 and 33, T. 15 N., R. 23 E. (No. 39), the entire exposed Hale is massive limestone, brown gray, locally oolitic and sandy, coarsely crystalline, and very crinoidal. This massive limestone is underlain by *Archimedes*-bearing Pitkin limestone, and the insoluble residues are very similar to the calcareous sandstone residues of the Hale farther east.

Two sections were measured in T. 15 N., R. 22 E. In both these the base of the Hale consists of sandy limestone. The North Pettit section, secs. 14 and 15, T. 15 N. R. 22 E. (No. 36), has a calcareous conglomerate at the base that is similar in all respects to the typical Hale basal conglomerate to the east. The Hale seems to grade upward into the limestones and shales of the Bloyd, and in neither section was the top of the Hale identified with certainty. The limestones in the Hale are light gray to cream gray, coarse to coarse-medium-crystalline, crinoidal, and weather in horizontal flutings, which seem to be characteristic of the Hale in many sections. The insoluble residues also indicate this limestone to be Hale.

In the West Zeb sections, secs. 3 and 10, T. 15 N., R. 21 E. (No. 34), the beds assigned to the Hale formation consist of lime-

stone. These limestone beds are locally sandy, locally oolitic, variably crystalline, and near the top weather in large horizontal flutings. Both the base and top of the Hale are questionable, but the limestones assigned to the Hale have typical insoluble residues.

The section in the eastern part of Nigger Hollow, sec. 7, T. 15 N., R. 21 E. (No. 35), may be used to illustrate the differentiation of the Pitkin and Hale limestones. Here the Pitkin is characteristically rubbly, sublithographic crystalline in texture and carries *Archimedes*. The insoluble residue is 4.8 per cent with a grain residue of 0.8 per cent. At its base the Hale limestone is very sandy: insoluble residue 41.7 per cent, grain residue 38.5 per cent, and the limestone weathers pitted and cavernous and in horizontal flutings. (See Pl. III B.) All of the lower and middle limestone beds of the Hale formation in this section have an insoluble residue of clean sand. The top of the Hale is placed at a 1-foot greenish, argillaceous, sandstone bed.

One of the best exposed sections of the Hale near Muskogee, Oklahoma, is along old state highway 10, up Braggs Mountain, sec. 29, T. 15, N., R. 20 E. (No. 32). In this section there is a calcareous conglomerate less than a foot thick at the base of the Hale. This bed is followed by 18 feet of massive, sandy limestone and 6 feet of thin bedded, very sandy greenish limestone, overlain by 28 feet of massive, blue gray limestones with thin shale partings. These limestones weather rather fluted near the top. A section was measured along the new road up Braggs Mountain, in secs. 21 and 28, T. 15 N., R. 20 E., from the Fayetteville to the Atoka (No. 31). This section is very similar to that along old state highway 10, (No. 32). The limestones in the lower part of the upper 28-foot zone have an insoluble residue of clean quartz sand with a high percentage of limonite. Blue gray, fissile shale overlies the upper limestone. Because of vertical continuity of the limestone beds, and the absence of any lithologic break, the zone from the base of the calcareous conglomerate to the base of the blue gray fissile shale is assigned to the Hale formation.

Goose Neck Bend section, SE¼ sec. 26, T. 15 N., R. 19 E. (No. 29), is the westernmost outcrop of the Morrow series in this latitude. To the west and southwest the Morrow dips beneath the Atoka sandstones. The Hale is fairly well exposed, except the base, which is covered by river alluvium. At the exposure, 34 feet

of massive blue gray limestone, very coarsely crystalline and very crinoidal, with numerous shale interbeds, and an upper 0.5-foot bed of conglomeratic limestone, are assigned to the Hale. The upper conglomeratic bed is considered to be the top of the Hale. Poorly exposed blue gray, fissile shale lies above the conglomeratic bed.

PROFILE ACROSS TOWNSHIP 16 NORTH

(Plate XII)

This cross section extends from Hale Mountain, Washington County, Arkansas, westward through Wauhillau, Parkhill, the hills south and west of Tahlequah and ends at the classic Keough Quarry section north of Ft. Gibson, Oklahoma. The abrupt thinning of the Morrow series from Adair into Cherokee County is graphically shown. Measured sections west of Parkhill contain less than 100 feet of Morrow, as compared to the thick sections of the series in Adair County which average over 100 feet. In these sections the Hale formation averages about 30 feet thick, and may be recognized at the base of the Morrow series.

To help in correlating from the type section on Hale Mountain into Oklahoma, a section was measured in sec. 10, T. 13N., R. 33 W., near Tolu, in Arkansas. In this section, the Hale is composed of calcareous sandstone, very sandy limestone, and massive, non-calcareous, medium-grained sandstone. By studying this particular section a satisfactory correlation is possible from the type section to the thinner section on Bugger Mountain in Oklahoma.

On Bugger Mountain, secs. 11 and 14, T. 16 N., R. 26 E. (No. 84), the Hale consists of a basal 1-foot shale member carrying a silty sandstone bed, followed by 12 feet of calcareous sandstone, 13 feet of locally oolitic, sandy limestone, and 8 feet of massive, calcareous sandstone.

The base of the Hale on Spade Mountain, secs. 1 and 12, T. 16 N., R. 24 E. (No. 78), consists of sandy shale with thin sandstone beds that appear to cut across the bedding planes of the shale. Above this, the Hale is made up of massive bedded sandstone. The non-calcareous portions make a steep cliff, (See Pl. V A.) and the calcareous portions weather typically pitted and cavernous. The Hale is 100 feet thick in Spade Mountain—the thickest in this part of the area.

At Wauhillau, secs. 19 and 20, T. 16 N., R. 24 E. (No. 79), the Hale is very similar to that on Spade Mountain except that it contains two shale beds.

On Sugar Mountain, sec. 21, T. 16 N., R. 23 E. (No. 77), the Hale is poorly exposed but there are 18 feet of massive bedded gray limestone at the top. This limestone is assigned to the Hale formation because of the character of the insoluble residues.

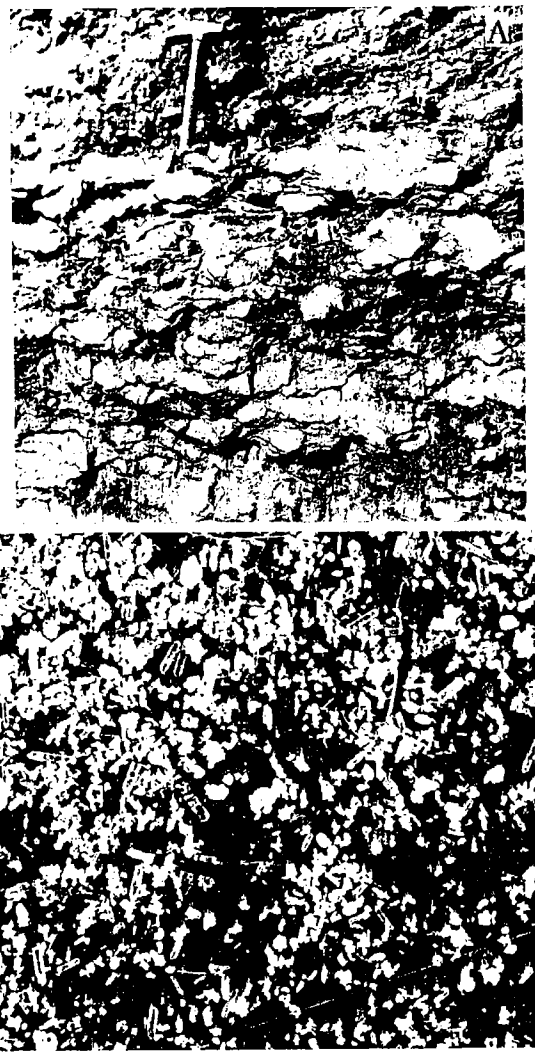
One of the best sections of the Hale near Tahlequah, Oklahoma, is the Parkhill section, sec. 27, T. 16 N., R. 22 E. (No. 76), where the entire Morrow series is well exposed along a new cut on the road toward Cookson, Oklahoma. The basal bed of the Hale is a sandy limestone (calcareous sandstone) that is massive, light gray, coarse medium to coarse crystalline, and weathers into cross bedded flutings (Pl. V B).

The three sections measured south and west of Tahlequah, Oklahoma, sec. 5, T. 16 N., R. 22 E. (No. 74), sec. 26, T. 17 N., R. 21 E. (No. 89), and sec. 6, T. 16 N., R. 22 E. (No. 75), all show the Hale to be entirely limestone, but in sec. 5, T. 16 N., R. 22 E. (No. 74), there is a sandy bed at the base. The limestone is generally massive bedded, of various shades of gray, variably crystalline, locally fossiliferous and weathers smooth and uneven. The individual beds form small benches around the sides of the low hills, and most outcrops are poorly exposed. In most samples, the insoluble residues are chiefly clean quartz sand, with traces of drusy quartz.

In the rather poor section on Bobtail Branch, sec. 8, T. 16 N., R. 21 E. (No. 72), there is a good contact of the Hale and Pitkin. Limestone that appears granular, that is, very coarsely crystalline and crinoidal, light gray in color, and highly fossiliferous, rests on the jointed, light blue limestone of the Pitkin formation. Beds assigned to the Hale are limestones with interbedded shales, locally oolitic, and locally weathering thin-bedded and fluted.

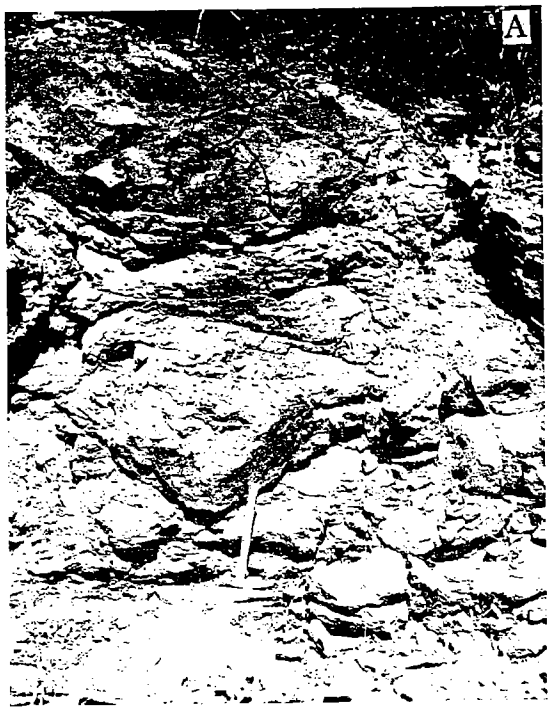
The Blacksmith section, sec. 10, T. 16 N., R. 20 E. (No. 70), is rather well exposed. The base of the Hale is placed above the highest *Archimedes,* where the insoluble residues consist of clean, white, crystalline quartz, largely secondary, with minor amounts of quartz sand grains. Alternating beds of limestone and shale make up the Hale section.

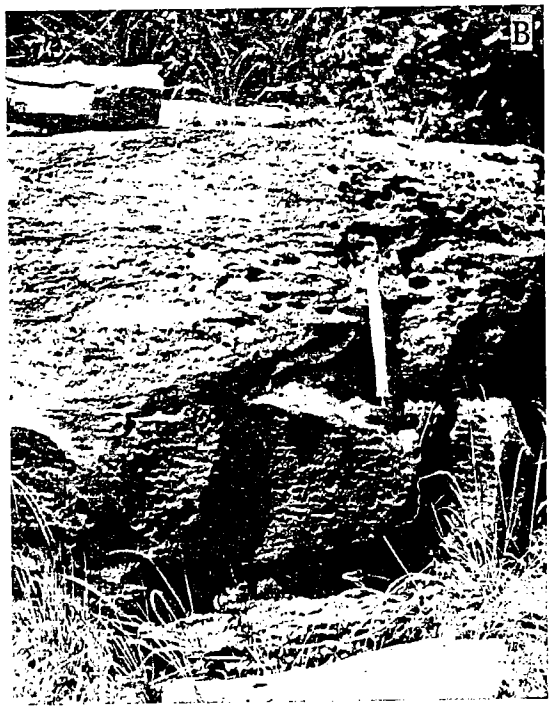
PLATE II.



A. Close-up view of argillaceous phase of Pitkin limestone. West side of southeastern extension of Stilwell Mountain, secs. 1 and 2, T. 15 N., R. 25 E., Adair County, Oklahoma. (Measured section No. 52).

B. Grain residue of Pitkin limestone showing abundance of secondary euhedral quartz crystals. Sample from Bunch Mountain, sec. 15, T. 14 N., R. 24 E., Adair County, Oklahoma. (Measured section No. 23).



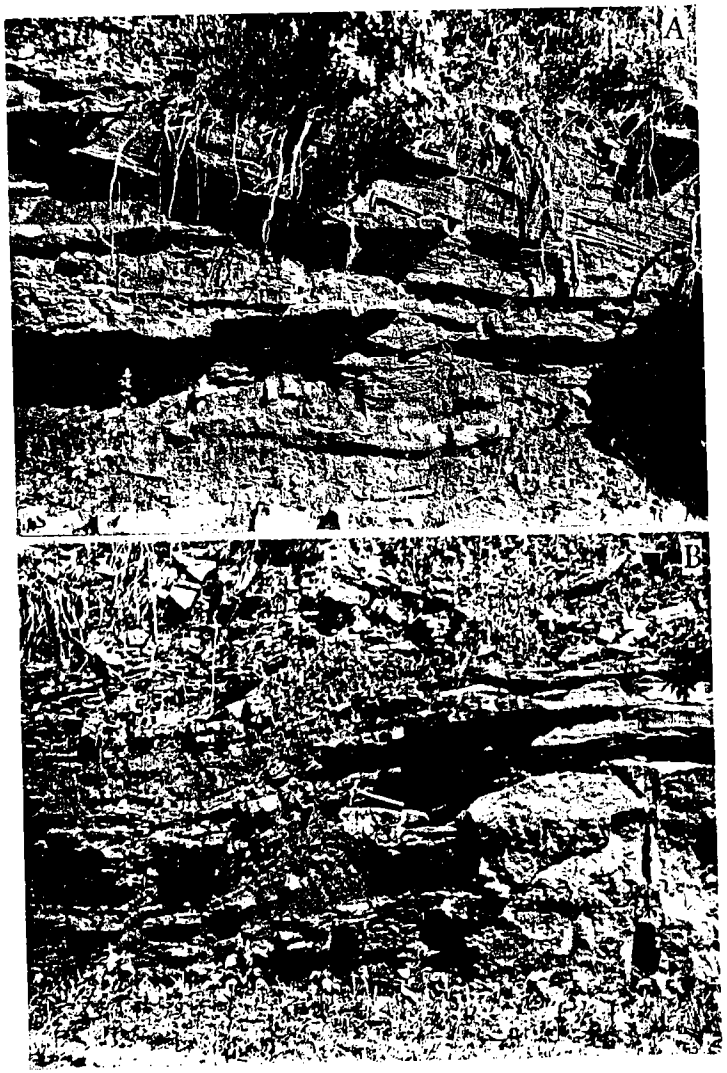


A. Basal sandstone bed of Hale formation, Blackgum section, secs. 32 and 33, T. 14 N., R. 22 E., Cherokee County, Oklahoma. (Measured section No. 11). Note the irregular bedding, and thin, shaly partings. The head of the hammer rests on Pitkin limestone.

B. Sandy limestone of the Hale, exposed in the east part of Nigger Hollow, secs. 7 and 18, T. 15 N., R. 21 E. (Measured section No. 35). Note the pitted and cavernous nature of the weathering.

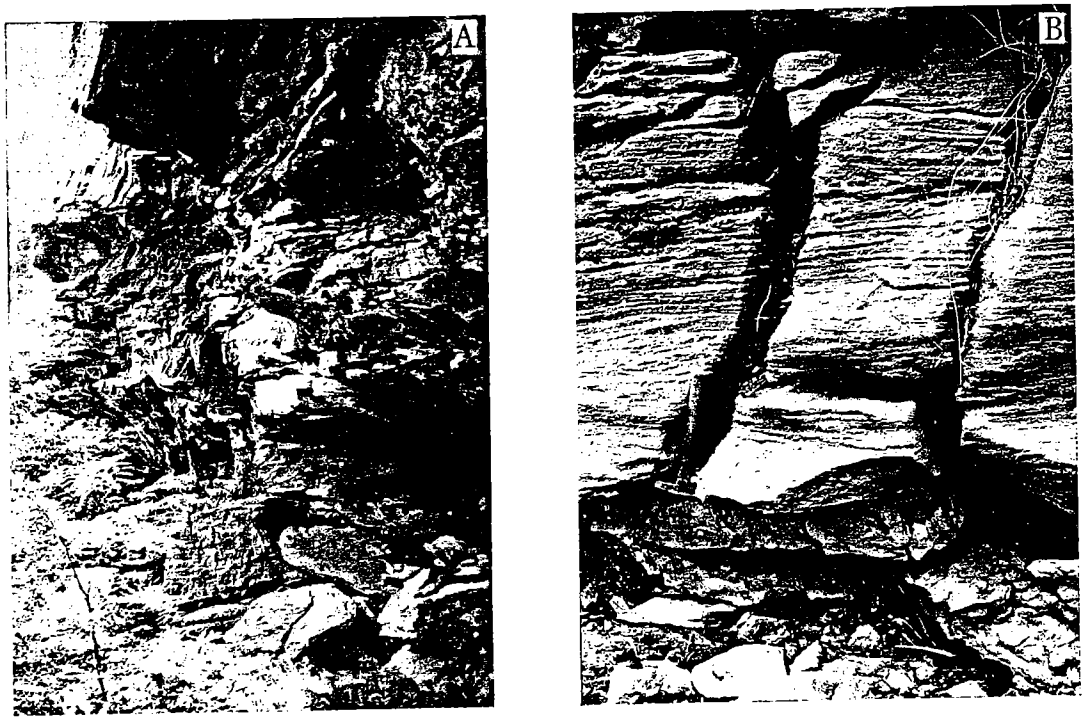
PLATE III.

PLATE IV.



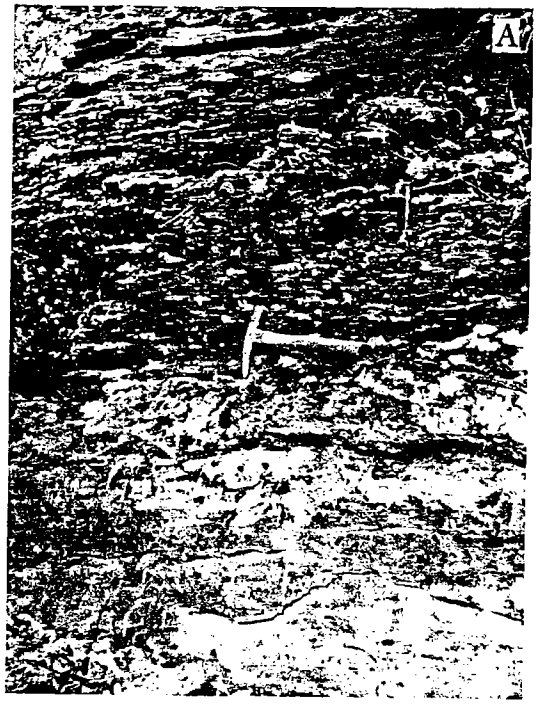
A. Cross-bedding in sandstone of the Hale formation, Hungry Mountain district, E½ sec. 16, T. 15 N., R. 24 E., Adair County, Oklahoma. (Measured section No. 47). This view is near the level of the limestone reefs shown below.

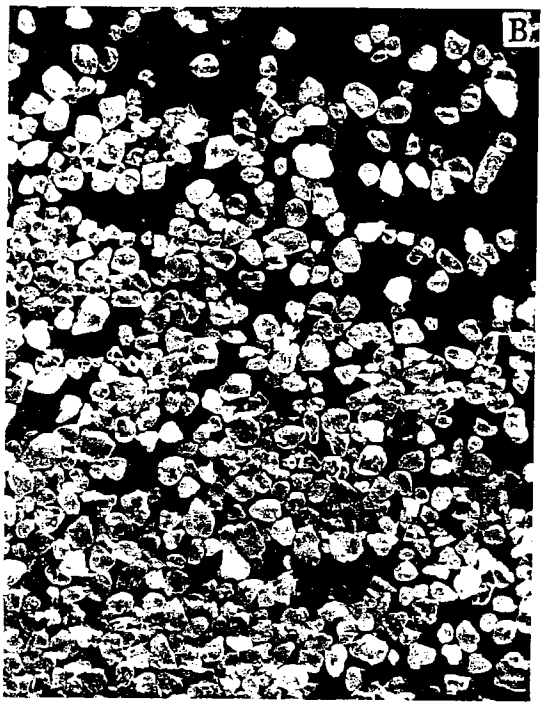
B. Limestone reef in Hale Formation, adjacent to view above. One of the resistant sandstone layers may be traced laterally up to, and through the upper part of the reef.



A. Cliff of massive sandstone in the Hale formation, southwest spur of Spade Mountain, sec. 11, T. 16 N., R. 24 E., Adair County, Oklahoma. The Hale in this exposure is much less calcareous than elsewhere.

B. Hale-Pitkin contact along road south of Parkhill. Head of hammer marks contact between finely crystalline Pitkin limestone, and coarse, sandy limestone of the Hale, showing fluted weathering. Parkhill section (Measured section No. 76), secs 26 and 27, T. 16 N., R. 22 E., Cherokee County, Oklahoma.

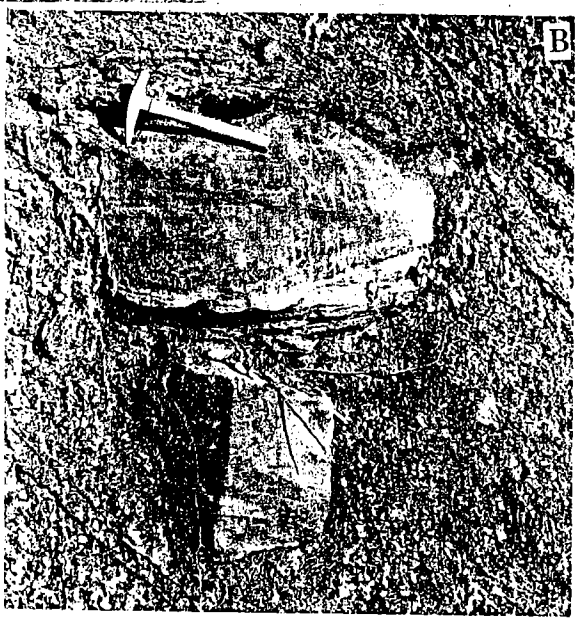




A. Contact of massive-bedded Pitkin limestone beneath thin-bedded calcareous sandstone of the Hale formation. Taylor Mountain section (measured section No. 54), sec. 13, T. 15 N., R. 25 E., Adair County.
B. Grain residue of Hale formation, sample from beds in upper part of above view (bed 5 of Measured section No. 54). Grains are angular, frosted, and are in the 1/4-1/8 mm size grade.

PLATE VI.

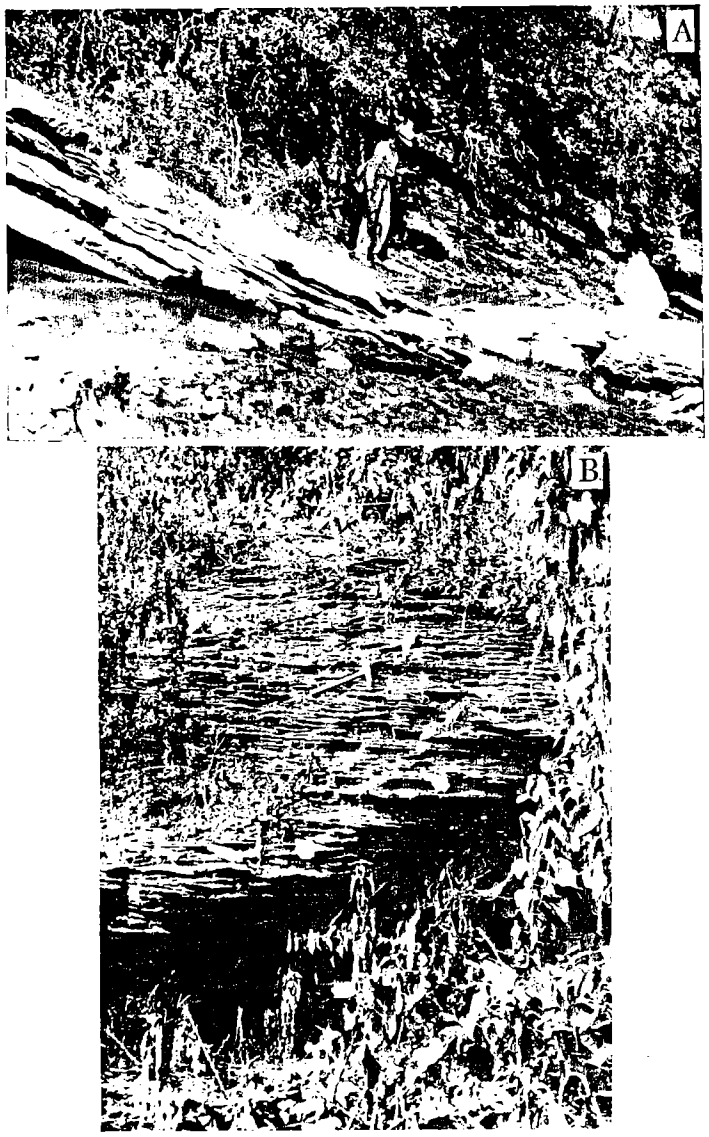
PLATE VII.



A. Coal in Bloyd formation 0.6 mile east of Bayou Manard, along Oklahoma State highway No. 10. The coal is 0.8 foot thick, and lies immediately below massive sandstone of the basal Atoka formation, and above typical dark shale of the Bloyd formation. This is the only known exposure of coal in the Morrow series in northeastern Oklahoma, and is of interest because of its possible relationship with the Baldwin coal of the Bloyd formation in northwestern Arkansas. NE¼ sec. 20, T. 15 N., R. 20 E., Muskogee County, Oklahoma.

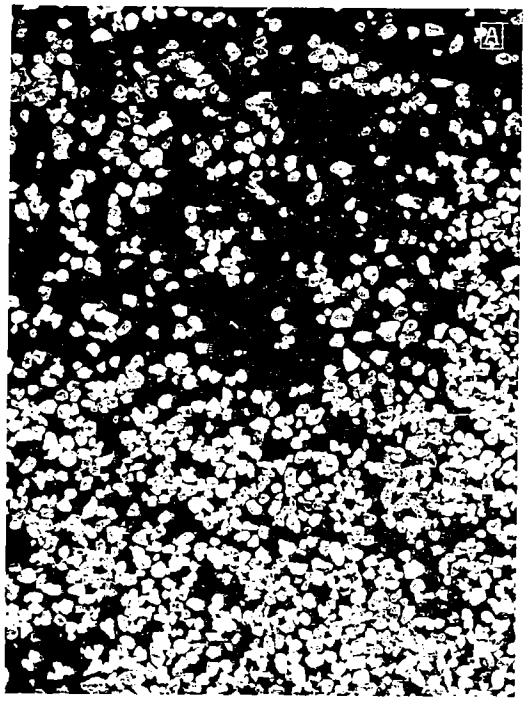
B. Typical exposure of thin limestone beds in the Bloyd shale. Ross Mountain, (Measured section No. 61), sec. 13, T. 15 N., R. 26 E., Adair County, Oklahoma.

PLATE VIII.



A. Kessler limestone member of Bloyd formation, northeast side of Salt Creek anticline. Beds dip approximately 25 degrees. (Measured section No. 15), sec. 18, T. 13 N., R. 26 E., Sequoyah County, Oklahoma.

B. Thin-bedded siltstone of the Atoka formation. South end of Welch Mountain, sec. 5, T. 14 N., R. 25 E., Adair County, Oklahoma.



A. Grain residue of limestone (Brentwood) member of lower Bloyd formation. Grains are angular, frosted, and are in 1/8-1/16 mm size grade. Sample from Spade Mountain (Measured section No. 78, bed 15), secs. 1, 2 and 12, T. 16 N., R. 24 E., Adair County, Oklahoma. X 25.

B. Grain residue of Kessler limestone member of Bloyd formation. Note casts of *Endothyra* sp. and the prominent 1/2-1/4 mm size grade of quartz grains. Sample from north end of Welch Mountain (Measured section No. 58, bed 26), sec. 33, T. 15 N., R. 25 E., Adair County, Oklahoma. X 25.

PLATE IX.

The Flower Creek section, sec. 19, T. 16 N., R. 20 E. (No. 71), was measured and studied as a check on the classic Keough Quarry section, sec. 25, T. 16 N., R. 19 E. (No. 69). In the Flower Creek section there is limestone conglomerate at the base of the Hale that carries a high percentage of phosphate. Above the conglomerate bed the Hale is composed of massive to thin bedded, light to cream gray limestone, locally sandy and locally very fossiliferous.

The Keough Quarry section has been visited and studied by a great number of geologists, principally because of the well known bed so rich in *Pentremites* that occurs in the Bloyd formation. As in other sections in this part of the area, the Hale here is principally limestone with thin shale partings, (see Frontispiece.) The lower 17 feet is massive, pink, coarsely crystalline limestone with a conglomeratic, uneven-bedded limestone, and greenish-gray, calcareous shale near the top. Insoluble residues indicate that these limestones all belong to the Hale formation.

NORTH-SOUTH PROFILE ALONG WESTERN EDGE OF AREA

(Plate XIII)

From south to north this profile includes the westernmost sections measured in the area, i. e., along the line at which the Morrow rocks dip beneath the Atoka sandstones and shales along the Neosho (Grand) River. It extends from south of Muskogee, T. 13 N., R. 19 E., northward to the last recognized Morrow outcrop in T. 22 N., R. 20 E.

The Hale is made up chiefly of limestone in this part of the area. At the south end it averages some 50 feet thick and contains several shale beds. Northward it becomes thinner, contains less shale, and is made up of irregularly bedded light blue gray limestone beds. The sections in the south half of the profile have been described in connection with the east-west profiles.

In the Hulbert section, sec. 34, T. 17 N., R. 20 E. (No. 87), the Hale has a 2-foot sandstone at its base, containing *Calamites* and other plant remains. Above the sandstone the Hale consists of limestones that are gray, very coarsely crystalline, and weather cross-bedded and uneven.

Differentiation between the limestones of the Pitkin and the Hale in the Clear Creek section, sec. 6, T. 17 N., R. 20 E. (No. 86),

is based principally on insoluble residues. The Hale is light gray, very coarsely crystalline limestone that is unevenly bedded and locally is sandy.

Two important and well exposed sections were measured near Yonkers: East Yonkers section, sec. 6, T. 18 N., R. 20 E. (No. 92), and Yonkers section, sec. 10, T. 18 N., R. 19 E. (No. 91). The East Yonkers section has 8 feet of very sandy limestone at the base. This bed is followed by generally uneven bedded, coarsely crystalline limestone that contains several shale beds. The insoluble residues are made up principally of clean quartz sand. Fourteen feet of Bloyd formation overlies the Hale in the East Yonkers section. The Yonkers section is unique in that it is the only section west and north of Parkhill, Oklahoma, in which the Hale consists of alternating thin beds of sandy shale, calcareous sandstone, and sandy limestone. Above the thin-bedded zone the Hale consists of sandy light gray limestone, thin, fissile, shale beds and an upper blue gray limestone. *Pentremites* were found near the top of this limestone. The Hale is overlain by the Atoka in this section.

Near Cedar Crest, Oklahoma, in sec. 8, T. 19 N., R. 20 E. (No. 94), the Morrow is represented by only 47 feet of Hale. It is gray and brown gray limestone, coarsely crystalline, and is sandy at the basal part.

The northernmost exposure of the Morrow was found in sec. 20, T. 22 N., R. 20 E., as reported by Snider.[34] In this study one boulder was found consisting of limestone, blue gray, coarse medium crystalline, crinoidal, weathering rather granular. The insoluble residue indicates a correlation with the Hale beds to the south.

NORTH-SIDE PROFILE THROUGH CENTRAL PART OF AREA

(Plate XIV)

This profile extends from Marble City, Oklahoma, in T. 13 N., R. 23 E., where the classic Quarry Mountain section was measured and studied, northward through Pettit, Tahlequah, to Gideon, Oklahoma, T. 18 N., R. 21 E.

In the Quarry Mountain section, sec. 14, T. 13 N., R. 23 E. (No. 12), near Marble City, a complete section is exposed from

[34] Snider, L. C., "The Geology of a Portion of Northeastern Oklahoma": *Okla. Geol. Survey Bull.* 24, 1915.

the St. Clair limestone (Silurian) into the Atoka formation. Here the Hale consists of a basal 1-foot bed of sandy oolitic limestone that seems to grade into the limestone above. The remainder of the Hale is made up of alternating limestones and shales, with a 3-foot bed of sandstone marking the top.

Northward this profile contains the following previously discussed sections: the Terrapin Creek section, sec. 29, T. 14 N., R. 23 E. (No. 20); North Pettit section, secs. 14 and 15, T. 15 N., R. 22 E. (No. 36); Parkhill section, secs. 26 and 27, T. 16 N. R. 22 E. (No. 76); south Tahlequah section, sec. 5, T. 16 N., R. 22 E. (No. 74); and Pecan Creek section, sec. 26 T. 17 N., R. 21 E. (No. 89). The Gideon section, sec. 36, T. 18 N., R. 21 E. (No. 93), at the north end of the profile is important because of its proximity to the north edge of the Morrow sea. Here the entire Morrow is only 36 feet thick compared with 93 feet in the Pecan Creek section and 56 feet in the Tom Patch section, sec. 3, T. 17 N., R. 21 E. (No. 88), the decrease probably being the result of non-deposition and overlap against the old shore line.

Thickness. The Hale has a wide range of thickness throughout the area, much of which is believed to be due to conditions of deposition rather than to widespread pre-Bloyd erosion.

Across T. 13 N., the Hale thickens from 30 feet in the Quarry Mountain section, sec. 14 T. 13 N., R. 23 E. (No. 12), to 58 feet in the McLain section, sec. 28 T. 13 N., R. 20 E. (No. 8), on the west bank of the Arkansas River.

From a thickness of 95 feet at Davidson, Arkansas, secs. 14 and 23, T. 12 N., R. 33 W. (No. 4), the Hale thickens to 104 feet on the south end of Ross Mountain, secs. 34 and 35, T. 15 N., R. 26 E., Oklahoma (No. 68). It is rather irregular in thickness in the western part of Adair County, averaging about 61 feet, and is somewhat thinner in eastern Cherokee County. Near Blackgum, Oklahoma, secs. 4 and 5, T. 13 N., R. 22 E., and secs. 32 and 33, T. 14 N., R. 22 E. (No. 11), the westernmost complete section of the Hale in this cross section, it is 35 feet thick.

Across T. 15 N., the Hale thickens from 89 feet on Hale Mountain, Arkansas, to 138 feet on Ross Mountain, secs. 12 and 13, T. 15 N., R. 26 E. (No. 61), and then thins to 69 feet on Taylor Mountain, sec. 13, T. 15 N., R. 25 E. (No. 54), and to 52 feet on Gittin' Down Mountain, secs. 14, 15, 22 and 23, T. 15 N., R. 24 E.

(No. 46), where the Hale is thinner over the topographic high in the Pitkin. In Cherokee County the Hale is 68 feet thick on County Line Hill, secs. 24, T. 15 N., R. 23 E. (No. 40), and then averages about 45 feet thick across the county.

The profile across T. 16 N., illustrates the westward thinning from Hale Mountain to Bugger Mountain, sec. 14, T. 16 N., R. 26 E. (No. 84). The Hale reaches its maximum thickness, 100 feet, in the northern part of the area on Spade Mountain, secs. 1 and 12, T. 16 N., R. 26 E. (No. 78), and it is more than 75 feet thick at Wauhillau, Oklahoma. Across Cherokee County to the Keough Quarry north of Ft. Gibson, the Hale averages only about 25 feet in thickness.

Across T. 17 N., and extending on northward along the Neosho (Grand) River, the Hale averages about 45 feet in thickness. North of Yonkers, erosion has removed the Bloyd so that the Atoka rests on the Hale formation.

Stratigraphic Relations. The Hale lies disconformably on the Pitkin limestone. (See Pl. VI A.) This contact, in all but a very few sections is marked by a change from limestone to sandstone or to sandy limestone and by a basal conglomerate. The difference between insoluble residues is generally especially well marked.

The Hale-Bloyd contact is conformable and the contact is generally drawn at the top of a continuous limestone or sandstone bed assignable to the Hale. Where the contact must be drawn between limestones there is less certainty.

In the eastern part of the area the Hale-Bloyd contact is commonly placed above a blue-gray limestone that is very coarsely crystalline, has a very crinoidal texture, and an insoluble residue in which the major grade of the quartz is 1/4-1/8 mm size; and below a brown gray, platy fossiliferous limestone with an insoluble residue that is characterized by the major grade of quartz being a very fine sand. This distinct change in lithology and in the character of the insoluble residues is apparent in nearly all places.

In the western part of the area the Hale-Bloyd contact is placed at the top of a persistent limestone above which interbedded shale and limestone beds come in. Below this contact the residues are generally made up of clean quartz sand, typical of the Hale. In the overlying beds the residues are smaller in percentage and contain large amounts of clay and drusy quartz.

Age and Correlation. The Hale formation contains the oldest Pennsylvanian rocks of northeastern Oklahoma. From a study of cephalopod fauna, Miller and Owen conclude that the Hale formation is of the same age as the Union Valley limestone at the base of the Morrow in the Arbuckle Mountains.

> . . . last May, John Owen and I completed a detailed study of the Union Valley cephalopods, which are fairly numerous and varied, and submitted it to the Journal of Paleontology for publication. We were able to recognize nine cephalopod species from the upper or arenaceous limestone portion of the Union Valley. The two most abundant forms in the Union Valley (*Cravenoceras? morrowense* and *Glaphyrites oblatus*) are also the most abundant cephalopods from the Hale. Furthermore, the Hale and Union Valley have other cephalopods in common: *Pronorites arkansasensis, Gastrioceras branneri, Lioceras* cf. *L. liratum* and *Mooreoceras? sp.* A direct comparison with Hale specimens convinced me that the similarity is genuine. In summary it can be said that all nine of the species of cephalopods known from the Union Valley are congeneric with Hale forms, and at least five or six of them are conspecific. These facts lead me inescapably to the conclusion that the upper or limestone member of the Union Valley formation should be correlated with the cephalopod-bearing portion of the Hale formation.[35]

The Union Valley limestone has been correlated with the Primrose calcareous sandstone formerly assigned to the upper part of the Springer formation in the Ardmore basin. It is now thought that the Hale formation is to be correlated with the entire Union Valley formation of the Arbuckle Mountains and with the Primrose sandstone of the Ardmore Basin.

Harlton[36] correlated the Union Valley limestone with a siliceous limestone formerly regarded as the base of the Wapanucka formation in the frontal Ouachita Mountains, to which he applied the name Primrose because of its probable equivalence to the Primrose

[35] Miller, A. K., Personal Communication. Miller, A. K., and Owen Britt, "The Cephalopod Fauna of the Pennsylvanian Union Valley Formation of Oklahoma": *Jour. Paleontology*, Vol. 18, No. 5, pp. 417-428, 1944.

[36] Harlton, Bruce H., "Stratigraphy of the Bendian of the Oklahoma Salient of the Ouachita Mountains": *Bull. Amer. Assoc. Petro. Geol.*, Vol. 22, pp. 852-915, 1938.

sandstone of the Ardmore basin. He also assigned the upper 400 to 500 feet of beds formerly classified as upper Jackfork to the Union Valley sandstone, and placed this unit at the base of the Morrow.

Hollingsworth[37] stated that ". . . he might go so far as to correlate the limestone at the top of the Union Valley with the lower 'Johns Valley' shale of the Ouachita Mountains."

Character of Insoluble Residues. The most distinctive feature of the Hale residues is the clean quartz sand, the small amounts of clay, and the general absence of drusy quartz. (See figs. 3-8.)

In the eastern part of the area the Hale residues are characterized by quartz grains 1/4-1/8 mm in major grade size, generally well frosted and ranging from angular to curvilinear in shape. The residues contain very small percentages to a complete absence of secondary euhedral quartz or drusy quartz. The percentage of insoluble and grain residues is characteristically much higher than either the Pitkin or Bloyd residues. (See Pl. VI B.)

In the western part of the area, however, it is more difficult to distinguish the Hale and the Bloyd residues. The Hale residues are generally characterized by the presence of clean quartz sand as elsewhere, and by the lack of drusy quartz and secondary euhedral quartz crystals. Muscovite may be present in the Hale residues but is not necessarily diagnostic. In this part of the area the percentage of insoluble residue may be quite low and the major grade of the quartz in the residues will range from 1/8-1/16 mm to 1/2-1/4 mm, with the coarser grades predominating.

BLOYD FORMATION

The Bloyd formation was named by Purdue[38] from Bloyd Mountain, 9 miles south of Fayetteville, Washington County, Arkansas. At the type locality, the previously named Brentwood limestone was recognized as a lower limestone lentil and the Kessler limestone was recognized as an upper limestone lentil. No name was given the shale between the Brentwood and Kessler, other than the term "Coal-bearing" shale, as used by Simonds in his early report.[39] Croneis[40] has applied the name Baldwin to the coal bed in this shale. At the type locality, 6 to 10 feet of calcareous, black shale intervenes between the top of the Hale formation and the base of the Brentwood limestone; and on Bloyd Mountain, and on Hale Mountain as well, there is an upper shale, between the Kessler and the base of the overlying Atoka formation.

[37] Hollingsworth, R. V., Personal communication.
[38] Purdue, A. H., *U. S. Geol. Survey Geol. Atlas, Winslow Folio* (No. 154), 1907.
[39] Simonds, F. W., "The Geology of Washington County": *Geol. Survey of Ark. Ann, Rep. of* 1888, Vol. IV, pp. 75-105, 1891.
[40] Croneis, Carey, "Geology of the Arkansas Paleozoic Area": *Ark. Geol. Survey Bull.* 3, 1930.

This description fits the sections in Washington County, Arkansas, very well, and all five units are easily recognizable. To the south, in secs. 14 and 23, T. 12 N., R. 33 W., near Davidson, Arkansas, and in Oklahoma, this clean-cut distinction is not at all apparent. From data gathered from a large number of detailed sections, it is evident that the Brentwood loses its identity in Oklahoma, and becomes indistinguishable in a sequence of alternating thin, discontinuous limestones and interbedded shale of the lower Bloyd. The equivalents of the "Coal bearing" shales become locally calcareous, with discontinuous limestone beds. Hence, a given measured section may show an almost continuous limestone outcrop, and an adjacent section consist of shale with a very few thin limestone beds.

Giles and Brewster[41] in the Hale Mountain section, described three limestone beds, that they assigned to the Kessler, as massive, locally sandy, somewhat cross-bedded, fossiliferous, variably crystalline in texture, and weathering shaly, fluted, and with a chocolate brown color. Above these limestones is 64 feet of thin bedded to fissile, gray clay shale with two 1-foot limestone beds, and a 1-foot sandstone bed.

The extent of the Kessler limestone in Oklahoma has never been determined satisfactorily. Newell[42] tentatively assigned to Kessler(?) a "3-foot bed of hard bluish-gray limestone" in the midst of 68 feet of shale, in his section 79, along highway 10, over the Braggs Mountain escarpment, in sec. 29, T. 15 N., R. 20 E. This particular bed is believed by the writer to be one of the limestone beds in the position of the Brentwood member.

The Kessler limestone member was questionably recognized in Adair County, Oklahoma, as far west as the west line of

[41] Giles, Albert W. and Brewster, Eugene B., "Hale Mountain Section in Northwest Arkansas": *Bull. Amer. Assoc. Petrol. Geol.*, Vol 14, pp. 121-138, 1930.
[42] Newell, Norman D., "Carboniferous Stratigraphy," in Wilson, Charles W., Jr., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, 1937.

R. 25 E., beyond which, pre-Atoka erosion has cut into the Bloyd below the horizon of the Kessler. In eastern Adair County, a limestone near the top of the Morrow is probably equivalent to the limestone called Kessler on Hale Mountain, although in only one place does it resemble that unit as described by Giles and Brewster. Generally it is gray to brown-gray, medium to coarsely crystalline, and is fossiliferous. Its maximum thickness is less than 12 feet. The unit considered Kessler in this study contains a characteristic insoluble residue that is a good guide in correlation, and in distinguishing it from the limestone of the middle and lower Bloyd.

The shale above the Kessler is well developed and exposed on Hale Mountain, but occurs only in isolated places in Oklahoma, and is poorly exposed. In many sections in the eastern part of the area, the Kessler limestone lies immediately below the Atoka sandstone, and is commonly covered by slope wash and rubble from the overlying Atoka.

COAL IN THE BLOYD FORMATION

A new highway cut between Muskogee and Camp Gruber, Oklahoma, has revealed the only coal observed by the writer in the Morrow series of rocks in Oklahoma. It is located in the NE¼ sec. 20, T. 15 N., R. 20 E., Muskogee County, 1.75 miles east of the Missouri Pacific Railroad underpass, and 0.6 miles east of Bayou Manard, on the south side of state highway 10. The coal lies above a thick section of Bloyd shale and below the massive Atoka sandstone, and is therefore one of, if not the oldest, coal in Oklahoma. (See Pl. VII A.) The following section was measured in company with A. H. Hanson and J. O. Beach in the summer of 1944.

The maximum thickness of coal, and the place where it is best exposed, is approximately in the center of the small hill and about 20 feet above the level of the highway. The lateral extent of the coal outcrop is only about 300 feet because both the east and west slopes of the hill are deeply weathered and mantle rock and soil obscure the coal beyond the limits of the outcrop.

SECTION OF UPPER BLOYD SHALE, ROAD CUT ALONG HIGHWAY 10, NE¼ SEC. 20, T. 15 N., R. 20 E.

		THICKNESS (feet)
DES MOINES SERIES		
ATOKA FORMATION		
9.	Pope Chapel sandstone, very fine grained, iron stained, fossiliferous ..... caps the hill	
8.	Shale, covered, estimated at ..... On top of Braggs Mountain, southeast of the coal outcrop, about 2 miles along the highway, this shale is silty, green to gray green and locally is carbonaceous; and carries a small coal bed less than 3 feet in areal extent in the road cut.	15
7.	Coody sandstone, light gray, fine grained with medium grains toward the base; few thin papery carbonaceous streaks; locally calcareous. Lower 2 inches is greenish brown, carbonaceous with included coaly particles, fairly soft, medium grained with a few coarse grains. The lower 12 feet forms the prominent cliff above the coal	18
MORROW SERIES		
BLOYD FORMATION		
6.	Coal, carries impurities of pyrite and shale	0.8
5.	Shale, thin bedded, highly carbonaceous	0.4
4.	Shale, gray, soft sandy. Resembles underclay on weathering	0.5
3.	Sandstone, fine to very fine grained, thin bedded, soft; gray and green in color; locally very shaly with the amounts of shale varying along the strike. Carries plant remains	3.0
2.	Shale, blue gray, fissile, ironstone concretions; thin sandstone streaks in the upper 2 to 3 feet	25.0
1.	Limestone in south road ditch, east of coal outcrop, blue gray, medium crystalline, crinoidal and granular; fossiliferous; *Pentremites*, crinoid stems, arms, plates, and calices, Bryozoa, Brachiopods, at least	6.0
	Residue: approximately 1 per cent. Quartz major grades 1/16-1/32 mm, principal subsidary grade 1/8-1/16 mm. Angular. Some glauconite.	

Coal in the upper Morrow in Oklahoma was observed by Taff. In the Tahlequah folio, he states:

> "The shale between the main limestone and the thinner beds of limestone near the top of the (Morrow) formation contain a thin bed of coal at one locality in the Muskogee quadrangle and at a number of places in northwestern Arkansas, some of which are in the Fayetteville quadrangle . . ."[43]

In the Muskogee folio,[44] under the heading "Shale of the Morrow formation" he states:

> "The deposits above the main limestone consist of blue and black shale, with thin beds of limestone and sandstone locally developed and more rarely with thin coal in the lower part . . ."

[43] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Tahlequah Folio* (No. 122), p. 2, 1905.
[44] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Muscogee Folio* (No. 132), p. 6, 1906.

A direct correlation with the Baldwin coal of Arkansas is not certain, though at the time of writing the Tahlequah Folio, Taff certainly was of that opinion, and it seems reasonable to conclude that these coals are of approximately the same age.

Distribution and Character. Much new information is available on the character of the Bloyd formation from this study. In order to interpret these data more clearly, this formation is described by profiles of measured sections in order to evaluate the relationship between the adjacent sections and thereby facilitate correlation of this part of the Morrow series westward across northeastern Oklahoma from the section on Hale Mountain, Washington County, Arkansas.

PROFILE ACROSS TOWNSHIPS 13 AND 14 NORTH

(Plate X)

The Bloyd is 191 feet thick on the Arkansas-Oklahoma State line at Davidson, Arkansas, secs. 14 and 23, T. 12 N., R. 33 W. (No. 4), and is made up of blue gray fissile clay shale with thin limestone beds. It is poorly exposed at the top.

The upper shale of the Bloyd formation, above the Kessler limestone, is doubtfully recognized along a tributary of Little Lee Creek, in sec. 8, T. 14 N., R. 26 E., Adair County, Oklahoma (No. 28), and farther south in sec. 24, T. 14 N., R. 25 E.

There is very little change in the lithology of the Bloyd westward through Adair County into eastern Cherokee County. Being predominantly a shale formation, it is poorly exposed, and the top is generally difficult to determine. A good Bloyd-Atoka contact was studied on High Mountain, secs. 2, 3, 10, and 11, T. 14 N., R. 24 E. (No. 21), where 10 feet of dirty black, fissile shale is overlain by a thick bed of massive, somewhat cross-bedded, Atoka sandstone.

In the Blackgum section, secs. 32 and 33, T. 14 N., R. 22 E., and secs. 4 and 5, T. 13 N., R. 22 E. (No. 11), a complete section of the Bloyd was studied. Attention should be called to the prominent bed of siltstone approximately in the middle of the section.

A typical western Cherokee County section is well exposed at Greenleaf Lake, sec. 2, T. 13 N., R. 20 E. (No. 6). The thick uneven-bedded, medium to coarsely crystalline limestone beds are very typical of the Bloyd of this area.

PROFILE ACROSS TOWNSHIP 15 NORTH

(Plate XI)

This profile extends westward from the classic section on Hale Mountain, south of Morrow, Washington County, Arkansas, (No. 1), where the Brentwood limestone member consists of massive, fossiliferous, gray to brown, medium- to coarse-grained limestone, 76 feet thick. Next above it is fissile, blue gray shale, with clay-ironstone concretions, 89 feet thick, overlain by 3 limestones and interbedded shales aggregating 30 feet, which Giles and Brewster[45] assign to the Kessler. Above the Kessler is 64 feet of thin-bedded to fissile gray clay shale with two 1-foot limestone beds, and a 1-foot sandstone.

The Bloyd is well exposed on the north end of Muskrat Mountain, sec. 21, T. 15 N., R. 26 E. Oklahoma, (No. 64). In this area the Bloyd consists of a thick shale with thin limestone beds. (See Pl. VII B.) The limestones are generally blue-gray to dark gray, variably crystalline, locally crinoidal, and typically weather platy and crinoidal. On the southwest side of Muskrat Mountain in secs. 28 and 29, T. 15 N., R. 26 E. (No. 65), 5 feet of limestone near the top of the Bloyd was assigned to the Kessler. It is followed by 15 feet of shale.

South of Stilwell, on Taylor Mountain, sec. 13, T. 15 N., R. 25 E. (No. 54), the limestones of the lower Bloyd are well exposed. These limestones are medium to coarsely crystalline, gray to black, rather fossiliferous, locally very crinoidal, and weather platy.

On Soap Mountain, secs. 24 and 25, T. 15 N., R. 25 E. (No. 56), two upper limestone beds are assigned to the Kessler. These limestone beds are massive, buff to gray, oolitic, locally very crinoidal and otherwise fossiliferous, and weather more or less smooth and even. Above the upper limestone bed is 6 feet of the upper shale, and above the shale the base of the Atoka sandstone.

On the north end of Welch Mountain, sec. 33, T. 15 N., R. 25 E. (No. 58), a brown to blue-gray, variably crystalline limestone bed, 7.6 feet thick, with a basal conglomerate, was assigned to the Kessler. It weathers thin-bedded and brown. No overlying shale was observed, and the Atoka sandstone probably rests on the Kessler.

[45] Giles, Albert W. and Brewster, Eugene B., *op. cit.*

The upper part of the Bloyd was studied on the south end of Double Mountain, sec. 24, T. 15 N., R. 25 E. (No. 59), where 2 feet of limestone assigned to Kessler was observed, separated from the Atoka sandstone by an estimated 2 feet of shale.

In the western part of Adair County the Bloyd is fairly well exposed, and on Bowles Mountain, secs. 27 and 28, T. 15 N., R. 24 E. (No. 50), consists of an alternating series of limestone and shale. The Kessler limestone has been removed by pre-Atoka erosion in this part of the area, and the Atoka sandstone rests on the shales of the Bloyd. The contact is generally obscured by sandstone blocks from the Atoka, and by slope wash.

The Bloyd is poorly exposed in T. 15 N., R. 23 E., where it consists of shale and thin limestone beds.

In T. 15 N., R. 22 E., however, the Bloyd is fairly well exposed and includes limestone beds, and a buff-brown siltstone, averaging less than 10 feet thick. Near the top the limestone is tough, brown-gray, and weathers very rubbly and uneven. Some of the limestones show large blue splotches on weathered surfaces, a characteristic of many of the limestones of the Bloyd in this area.

In the South Pettit section, sec. 28, T. 15 N., R. 22 E. (No. 37), the Bloyd is thicker than elsewhere in the vicinity, and the Atoka sandstone rests directly on a limestone of the Bloyd. This limestone is uneven-bedded, dark blue-gray to brown-gray, with a somewhat greenish cast, coarse medium to coarse crystalline, weathers uneven-bedded to almost fissile. The grain residue is very coarse: major grade of quartz ½-¼ mm, with a prominent 1-½ mm grade; it is very poorly sorted. The large quartz grains resemble vein quartz and have a velvety finish. There is some question as to whether this bed is Kessler or older. The residue and position suggest the Kessler, but the locality is almost 18 miles west of exposures in which Kessler is more confidently identified, and the presence of Kessler at this place could be accounted for only as an erosion remnant on the pre-Atoka surface. The writer concludes that the limestone belongs to the pre-Kessler portion of the Bloyd.

Practically all the exposed Bloyd in the East Nigger Hollow section, sec. 7, T. 15 N., R. 21 E. (No. 35), is limestone. Due to the low slope of the hill the shales are covered by alluvium and by slope wash. The limestones are generally variably crystalline in texture, locally fossiliferous, gray to blue-or brown-gray in color, and weather smooth with some light blue beds.

The Bloyd is thicker here than in any of the adjacent sections, due either to faulting, which was not observed, or to preservation of a local hill in the Morrow during the period of pre-Atoka erosion.

Perhaps the best exposed sections of the Bloyd near Muskogee, Oklahoma, are along old route of state highway 10, up Braggs Mountain, sec. 29, T. 15 N., R. 20 E. (No. 32) and East Braggs Mountain section, secs. 21 and 28, T. 15 N., R. 20 E. (No. 31). Here the Bloyd consists of blue gray fissile clay shale with 1- to 3-foot beds of blue gray to buff, fine crystalline limestone. There is a 2-foot bed of buff to greenish thin-bedded siltstone 20 feet above the base.

Two and a half miles west of Braggs Mountain, in Goose Neck Bend section, sec. 26, T. 15 N., R. 19 E., west of Arkansas River (No. 29), there is a fairly good exposure of the Bloyd. It is the typical shale series with thin, fine to medium crystalline blue-gray limestones.

PROFILE ACROSS TOWNSHIP 16 NORTH

(Plate XII)

The Bloyd is well exposed on Bugger Mountain, sec. 14, T. 16 N., R. 26 E. (No. 84). Here it is 102 feet thick with a basal limestone section 35 feet thick that probably corresponds to the lower limestone member (Brentwood) of the Bloyd formation on Hale Mountain, Washington County, Arkansas. Above the predominantly limestone section the formation consists of blue gray, fissile clay shales with thin limestone beds.

The 3-foot limestone capping West Stilwell Mountain, sec. 33, T. 16 N., R. 25 E. (No. 82), is assigned to the Kessler.

On Spade Mountain, secs. 1 and 12, T. 16 N., R. 24 E. (No. 78), a good section of the Bloyd was obtained. A 1-foot sandstone bed occurs about 30 feet below the top of the formation. In general the limestones are thin, uneven bedded, locally fossiliferous, and weather platy to knobby and uneven.

The best exposure of the Bloyd near Tahlequah, Oklahoma, is the Parkhill section along the road up the mountain in sec. 27, T. 16 N., R. 22 E. (No. 76). There the Bloyd is 77.8 feet thick

and consists of argillaceous limestone beds at the base, a thick interval of buff colored siltstone, a few limestone beds, and 23 feet of shale at the top.

The Bloyd is thin in the sections immediately south and west of Tahlequah where it consists of the common sequence of interbedded limestones and shales. The limestones are variably crystalline, and locally argillaceous. There is a 2-foot very calcareous sandstone bed near the top in the Pecan Creek section, sec. 26, T. 17 N., R. 21 E. (No. 88).

In the Blacksmith section, sec. 10, T. 16 N., R. 20 E. (No. 70), the Bloyd is shale and siltstone. It is made up, from bottom to top, of greenish to buff siltstone; and 21 feet of blue gray, fissile, clay shale.

In the classic Keough quarry section, north of Fort Gibson, sec. 25, T. 16 N., R. 19 E. (No. 69), the Bloyd is 85 feet thick, well exposed, and contains the famous *Pentremites* zone. The exposure is predominantly shale with thin gray, coarsely crystalline, fossiliferous limestone beds. (See frontispiece.)

NORTH-SOUTH PROFILE ALONG WESTERN EDGE OF AREA

(Plate XIII)

This profile extends along the Neosho (Grand) River, contains the westernmost sections measured in the area, and yields information on the nature and thickness of the Bloyd where this formation dips beneath the Atoka sandstones. Most sections were measured along road cuts where the Bloyd is well exposed. Here again, the measured sections comprising the south half have already been described in the east-west profiles.

The Bloyd section south and west of Hulbert, Oklahoma, sec. 34, T. 17 N., R. 19 E. (No. 85), is one of the best exposed sections in this part of the area. It consists of blue gray, fissile shale with three blue gray, medium to very fine crystalline limestone beds. It is well exposed along the road cut.

Only 14 feet of Bloyd is present in the East Yonkers section, sec. 6, T. 18 N., R. 20 E. (No. 92). The upper part was removed by pre-Atoka erosion. It consists of limestones and shale beds, the limestones being brown to gray, argillaceous, and locally quite fossiliferous. No beds assignable to the Bloyd were found north of this measured section.

NORTH-SOUTH PROFILE THROUGH CENTRAL PART OF AREA

(Plate XIV)

Although not a part of this profile, the measured section on the Salt Creek Uplift, sec. 18, T. 13 N., R. 25 E., (No. 15), is the southeasternmost outcrop of Morrow rocks in the general area. Alternating argillaceous limestones, with coarse crystalline masses in an amorphous matrix, and blue gray fissile clay shales, are assigned to the Kessler member of the Bloyd, (See Pl. VIII A.) The limestones are fossiliferous, and a few poor specimens of *Pentremites* were found.

In the Quarry Mountain section, sec. 14, T. 13 N., R. 23 E. (No. 12), the Bloyd consists of blue gray, fissile clay shale with some limonite concretions, and thin limestone beds. The limestones are blue gray, medium to fine crystalline, uniformly crystalline, and are moderately fossiliferous.

Measured sections north of Marble City have already been discussed in connection with the east-west profiles. Only 13 feet are questionably assigned to the Bloyd in the Gideon section, sec. 36, T. 18 N., R. 21 E. (No. 93). A 4-foot buff to greenish siltstone bed may correlate with the siltstone beds in adjacent measured sections. This abnormally thin section is believed to be due to non-deposition of the complete Bloyd section, and, in part, to pre-Atoka erosion.

Thickness. The maximum thickness of the Bloyd is in the eastern part of the area, along the Arkansas-Oklahoma line. From there it thins progressively westward. In general the Bloyd maintains a rather uniform thickness to the middle of Adair County, and then it thins abruptly in eastern Cherokee County. It is thin westward to Muskogee where it dips beneath the Atoka sandstones. Abnormally thin sections are found in the northern part of the area north and east of McBride, Oklahoma.

In each of the profiles, the Bloyd has a minimum thickness about the middle of the area, and thickens both eastward, and toward the west edge of the area.

Across T. 13 N., the Bloyd is 132 feet thick in the Quarry Mountain section, sec. 14, T. 13 N., 23 E. (No. 12) and thins to 107 feet and 66 feet respectively, in the Bluffs section, secs. 26 and 27, T. 13 N., R. 20 E. (No. 7), and the McLain section, sec. 28, T. 13 N., R. 20 E. (No. 8).

The Bloyd is considerably thicker across T. 14 N., being 191 feet thick at Davidson, Arkansas, secs. 14 and 23, T. 12 N., R. 33 W. (No. 4).

In the north end of Welch Mountain, sec. 33, T. 15 N., R. 25 E. (No. 58), the Bloyd is 118.6 feet thick and averages 147 feet westward to the eastern part of Cherokee County. At Blackgum, Oklahoma, it is only 103.8 feet thick but thickens to 115.2 feet in the Greenleaf Lake section, sec. 2, T. 13 N., R. 20 E. (No. 6).

From the section on Hale Mountain, Washington County, Arkansas, in the profile across T. 15 N., the Bloyd averages 176 feet in thickness as far west as the Taylor Mountain section, sec. 13, T. 15 N., R. 25 E. (No. 54). From here it thins rather abruptly westward and is very irregular in thickness westward to Muskogee, averaging 108 feet.

Across T. 16 N., the Bloyd is greatly thinned. On Hale Mountain, Arkansas, it is 260 feet, and thins to 120 feet on Bugger Mountain, secs. 14 and 23, T. 16 N., R. 26 E. (No. 84). On Spade Mountain, secs. 1 and 12, T. 16 N., R. 24 E. (No. 78), the Bloyd is 150 feet thick and then thins westward into Cherokee County where it maintains a more or less uniform thickness of about 60 feet. At the Keough Quarry, sec. 25 and 26, T. 16 N., R. 19 E. (No. 69), the Bloyd is 85 feet thick.

From McBride, Oklahoma, northward, the Bloyd is greatly thinned probably because of non-deposition adjacent to the old shore line of the Morrow Sea. In places the Bloyd was removed by pre-Atoka erosion, and is missing north of Yonkers, Oklahoma. In this general area the Bloyd averages about 32 feet in thickness ranging from a trace to 62 feet where present.

Stratigraphic Relations. The Bloyd formation is conformable with the underlying Hale formation, but is separated from the overlying Atoka formation by a pronounced erosional unconformity that accounts for much of the variation in thickness of the Bloyd across the area. Pre-Atoka erosion cut progressively deeper into the formation from east to west, indicating a regional eastward tilting prior to Atoka deposition.

Character of Insoluble Residues. The percentage of insoluble residue in the limestones of the lower Bloyd (Brentwood equivalent) averages around 5 per cent, with a grain residue of less than 1 per cent. In the eastern part of the area, the quartz grains generally are in the 1/8-1/16 mm size grade, are angular, moderately frosted, and generally secondary euhedral crystals of quartz are present. (See Pl. IX A.) This feature of secondary euhedral quartz crystals in this part of the area is an important factor in distinguishing between residues of the Hale and limestones of the Bloyd. (See figs. 3-8.) The euhedral crystals generally average about 1/4x1/16 mm in size, with a length to width ratio of 4:1. Drusy quartz is present in some of the residues in this part of the area.

In the western part of the area the residues of the Bloyd limestones almost invariably contain drusy quartz and a considerable amount of clay. The major grade of quartz is 1/8-1/16 mm. The percentage of quartz grains varies inversely with the combined percentage of drusy quartz and secondary euhedral and subhedral quartz crystals.

The insoluble residues of the Kessler limestone member are different from those of the limestone of the lower Bloyd. The Kessler on Hale Mountain has percentages of insoluble residues ranging from 20 per cent to 50 per cent, and there is a prominent 1/2-1/4 mm size grade of quartz grains. (See Pl. IX B.) The grains are poorly sorted, mostly angular, with varying degrees of frosting, and many of the subhedral secondary quartz crystals have smaller euhedral authegenic crystals (average 1/16 x 1/64 mm in size) growing on them.

All limestones referred to the Kessler have a higher percentage of insoluble residues than the limestones assigned to the lower Bloyd, and the residues contain a prominent 1/2-1/4 mm, or a 1-1/2 mm size grade, of quartz grains. Secondary euhedral crystals may or may not be present.

An arenaceous foraminifera, *Endothyra* sp., occurs in the Kessler samples from Soap Mountain, secs. 24 and 25, T. 15 N., R. 25 E. (No. 56), and from the north end of Welch Mountain, sec. 33, T. 15 N., R. 25 E. (No. 58). These foraminifera were not found in any other samples in Adair County or in the area of the Kessler outcrop, and may be used as a local index fossil for the Kessler. This criterion, however, does not hold true farther to the west because similar foraminifera are found indiscriminately through many of the residues of limestones of the lower Bloyd.

Des Moines Series

General Statement. In the present classification of Pennsylvanian rocks of Oklahoma, all strata between the top of the Morrow series, and the base of the Missouri series are referred to the Des Moines series. In the Ardmore basin, equivalent rocks are included in the upper Dornick Hills and Deese formations.

ATOKA FORMATION

All sections measured in the Morrow series of rocks in northeastern Oklahoma were carried at least to the base of the Atoka sandstone, and where possible, to the tops of hills, so as to include a portion of the Atoka formation. Locally thin-bedded, generally medium- to coarse-grained, cross-bedded sandstone rests on the upper part of the Bloyd in all parts of the area except northward from Yonkers, where the Bloyd was removed by pre-Atoka erosion, and the Atoka is in contact with the Hale formation.

In the area adjacent to Ft. Gibson and Muskogee, this basal Atoka sandstone probably is equivalent to the Coody sandstone member of the Atoka formation, as defined and recognized by Wilson and Newell in the Muskogee-Porum district.[46] Whether the Coody or some other member of the Atoka is represented by the basal Atoka sandstones in parts of the area more distantly removed from the Muskogee-Porum district, remains for future study to determine.

These post-Morrow beds in Adair and most of Cherokee Counties formerly were called Winslow,[47] and in Wagoner and Mayes counties, have been referred to the Cherokee. Cronies[48] first used the term Atoka for the beds called Winslow in Arkansas, and Wilson[49] recognized Atoka, Hartshorne, McAlester, and Savanna formations in the Muskogee area, replacing the general term Winslow.

Distribution and Character. The Atoka formation consists of interbedded shale, siltstone, and sandstone (Pl. VIII B). It caps

[46] Newell, Norman D., "Carboniferous Stratigraphy," in Wilson, Charles W., Jr., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma": *Okla. Geol. Survey Bull.* 57, 1937.
[47] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Tahlequah* Folio (No. 122), 1905; and, *Muscogee Folio* (No. 132), 1906.
[48] Croneis, Carey, "Geology of the Arkansas Paleozoic Area": *Ark. Geol. Survey Bull.* 3, 1930.
[49] Wilson, C. W., Jr., "Geology of the Muskogee-Porum District, Muskogee and McIntosh Counties, Oklahoma," with a chapter on "Carboniferous Stratigraphy," by Norman D. Newell: *Okla. Geol. Survey Bull.* 57, 1937.

most of the hills in the area, and crops out extensively immediately to the south.

Atoka sandstone blocks have slumped down and covered the slopes of the hills, in many places mantling the shale outcrops below. This is especially true in the eastern part of the area where the Morrow series is thickest, and contains more shale in the upper part of the Bloyd formation. The lower contact of the Atoka was seen in only a few places in Adair County, but was studied in nearly all sections measured in Cherokee County and adjoining areas.

In the southern part of the area, the basal Atoka consists of 18 to 20 feet of massive bedded, non-calcareous, light gray, locally crossed-bedded sandstone that weathers yellow-brown.

In the Parkhill section, sec. 27, T. 16 N., R. 22 E. (No. 76), the exposed Atoka consists of the following, from top to bottom:

	Feet
Shale: brown; with clay seams. Poorly exposed	20.0
Sandstone; thin bedded with thin clay and shaly beds	15.0
Sandstone: massive bedded, non-calcareous; medium grained; rather cross-bedded; heavily iron stained	2.0
Total	37.0

Very commonly the basal few inches of the Atoka sandstone is slightly calcareous because of reworked limestone and calcareous material from the underlying Bloyd formation that is incorporated in the sandstone.

Along old state highway 10 up Braggs Mountain, sec. 29, T. 15 N., R. 20 E., Newell called the 45-50 feet of exposed sandstone above the Morrow series, Coody sandstone. Here the sandstone is massive bedded, with several thin-bedded layers; it is cross-bedded, and contains a few plant fossils.

Southwest of Tahlequah, sec. 5, T. 16 N., R. 22 E., (No. 74), the lowest sandstone bed of the Atoka is a very fine sand with the major size grade of quartz 1/8-1/16 mm.

A good exposure of the Atoka in the Blacksmith section, sec. 10, T. 16 N., R. 20 E. (No. 70), shows the following section:

	Feet
Sandstone: massive bedded	11.0
Shale: sandy (siltstone); weathers very red	7.0
Sandstone: massive and thin bedded; yellow brown and gray; fine to medium grained; heavily iron stained	5.0
Total	23.0

A similar section may be studied along Flower Creek, sec. 19, T. 15 N., R. 20 E. (No. 71):

	Feet
Sandstone: massive bedded, medium grained; few local coarse lenses	20.0
Siltstone: blue black with a greenish hue; well jointed. Major grade of quartz, 1/32-1/64 mm, principal subsidiary grade 1/16-1/32 mm, trace of fine sand grains	4.0
Sandstone: massive bedded; fine grained; ripple marked and cross bedded	6.0
Total	30.0

There is an excellent continuous exposure of the Atoka sandstone in successive cliffs from the NW¼ sec. 25, T. 13 N., R. 22 E., at the Indian school house, thence down the main tributary to Vian creek in sec. 23, T. 13 N., R. 22 E.

Stratigraphic Relations. The Atoka formation rests unconformably on the members of the Morrow series. In the eastern part of the area it rests on the upper Bloyd limestone member; in the western part on the lower Bloyd, and in the northern part, on the Hale, depending on the amount of pre-Atoka erosion.

At no place in the area is the top of the Atoka present. The upper part of the formation as described in the Muskogee-Porum area has been removed by erosion.

Character of Insoluble Residues. The basal Atoka sandstone is composed of poorly sorted sand, the major size grade of the quartz grains is 1/8-1/16 mm, or a very fine sand; the grains are angular and appear freshly broken with no signs of frosting or abrasion.

Residues from the overlying siltstone are composed almost entirely of quartz of coarse silt grade; major grade size 1/16-1/32 mm, well sorted, angular, with very little frosting.

SUMMARY OF RESULTS OF STRATIGRAPHIC AND INSOLUBLE RESIDUE STUDIES

(Figures 3-8)

The primary purpose of this investigation was to discover criteria whereby rocks of the Morrow series of northeastern Oklahoma could be correlated with equivalent rocks in the type area of northwestern Arkansas. The problem was approached in a twofold manner: the measurement and study of all exposures, beginning at the classic Hale Mountain section near Morrow, Washington County, Arkansas; and the collection of samples and preparation and study of insoluble residues from the Morrow beds of Oklahoma.

Comparison of the various sections brought out certain definite relationships and marked variations. The upper Mississippian Pitkin limestone is easily distinguished from the basal Morrow. The Hale formation is a definite lithologic unit that can be recognized throughout the area. In Oklahoma it is much more calcareous than in Arkansas, being increasingly so from east to west. In the vicinity of Fort Gibson and Muskogee, it is a fairly pure limestone, and for this reason, the Hale formation in that area formerly was believed to be Brentwood (lower Bloyd).

The Bloyd formation in Oklahoma, on the other hand, has little resemblance to the Bloyd of many of the Arkansas exposures. It is principally shale, with thin, lenticular limestone ledges interbedded. Although the Brentwood limestone member is doubtless represented in a zone of interbedded shale and limestone, very few exposures contain thick, massive limestones so characteristic of the Brentwood in Arkansas. A limestone in the upper part of the Bloyd in eastern Adair County is thought to be the equivalent to the unit on Hale Mountain that has been assigned to the Kessler, although its character in Oklahoma exposures is considerably different.

Insoluble residue studies had not been attempted in this series before, on any large scale. Hence, it was necessary to determine if there are any significant differences in the residues of the Pitkin, Hale, Bloyd, and Atoka formations. Such proved to be the case; distinctive differences in the residues were noted, and when insoluble data were plotted graphically beside the detailed lithologic

section, they were found to be of great value in correlating adjacent measured sections. (See figs. 3-8.)

The residues, (fig. 3) of the beds on Hale Mountain show well marked differences between the Pitkin, Hale, Bloyd, and Atoka formations and between the Brentwood and Kessler members of the Bloyd. Similarly, in eastern Oklahoma, the same differences were noted. Westward, however, as the lithology of each formation changes, insoluble residues change also but to a lesser degree. (See figs. 3-8.) These changes were easily determined and correlations were carried forward.

From this rather complete study of insoluble residues of the Morrow series and adjacent formations both below and above, it may be stated that this method of detailed study has considerable merit, and when properly used, provides clear and usually unquestionable criteria for making correlations. No one feature of the residues alone, however, is diagnotic.

Differences in percentage of residues, amount of clay in the residues, and the nature and size of the quartz grains, served to separate the Hale and Bloyd residues.

In a like manner the percentage of residues and the occurrence of euhedral quartz crystals differentiate the Pitkin and Hale residues. The percentage of residues, absence of clay in the residues, the nature of the quartz grains, the absence of secondary or subhedral quartz crystals, and the almost universal presence of heavy limonite staining, serve to separate the Atoka residues from any of the other residues. All these differences in the residues, when plotted graphically besides the detailed lithologic section, provide good evidence on which to make correlations.

STRUCTURE

(Plate XV)

Structure of the rocks of the area was studied only incidentally in the course of this investigation. General features have been described by Taff,[50] Snider, [51] Cram,[52] and Wilson[53] and are shown on the Geologic Map of Oklahoma.

The area of outcrop of the Morrow series is along the southwest flank of the Ozark dome. In the northeastern portion of the area the rocks are flat-lying and this portion is characterized by a number of buttes, consisting of outliers of younger rocks rising above the relatively flat plain underlain by the Osage (Boone). Most of these buttes, locally called "mountains," are capped by rocks of the Morrow series, and it is in them that many of the data for this report were obtained.

Southwest of an arc drawn roughly through Church, Lyons, Barber, Parkhill, and Tahlequah, the dip of the rocks is much greater. In this part of the area, the regional south and southwest dip is modified by a system of nearly parallel faults and folds that trend N. 45° E. to N. 60° E., giving a broad pattern of fault blocks or slices, most of which have been tilted southeast. There are several exceptions wherein the rocks have been elevated or depressed without notable tilting, and a few have been downwarped medially, with corresponding elevation of the rocks along the margins, resulting in shallow, faulted synclines. One block contains a subsidiary anticline.

All the faults terminate to the east and northeast, or are unrecognized, in the thick limestones and cherts of the Osage (Boone). Only one, that in the valley of Bayou Manard, seems definitely to pass beyond the Arkansas River valley, and probably is continuous with the Muskogee fault (south) as mapped by Wilson.[54] Many of the others pass into anticlinal folds before reaching Arkansas River,

[50] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Tahlequah Folio* (No. 122), 1905; and, *Muscogee Folio* (No. 132), 1906.
[51] Snider, L. C., "The Geology of a Portion of Northeastern Oklahoma": *Okla. Geol. Survey Bull.* 24, 1915.
[52] Cram, Ira H., "Cherokee and Adair Counties," in "Oil and Gas in Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. III, pp. 531-586, 1930. This chapter also published as Bull. 40-QQ.
[53] Wilson, C. W., Jr. *op. cit.*
[54] Wilson, C. W., Jr., *op. cit.*

and several of the folds associated with faults in the Ozark area appear to be related to structural features of the Muskogee-Porum district, west of Arkansas River. For identification in the following discussion, local names are proposed for the individual fault blocks.

The entire region was subjected to southward tilting and probably some local folding prior to Mississippian time, resulting in progressively deeper erosion from south to north, the truncation of all beds from Sallisaw sandstone (Devonian) to Cotter dolomite (Ordovician) between Marble City and Spavinaw, and overlap by the Chattanooga Shale.[55] However, in general, the regional faults and associated folds resulted from Pennsylvanian deformation. It is believed that the faulting and folding of this area, together with similiar structural features of the Arkansas Valley syncline, to the south, are genetically related, in some manner, to the extensive deformation of the Ouachita Mountains.

MAJOR FEATURES

The southernmost of the major fault blocks, called Blackgum, extends from Tps. 12 and 13 N., R. 22 E., northeastward to T. 15 N., R. 24 E., being bounded on the southeast by a fault, or series of faults extending from near Vian, through Marble City and Bunch, to near Lyons. In the vicinity of Marble City, this fault shows more stratigraphic displacement than any other in the region, for the St. Clair limestone (Silurian) has been brought into contact with Atoka sandstone (Pennsylvanian). The North bounding fault extends from the NE corner T. 13 N., R. 21 E., to sec. 25, T. 15 N., R. 23 E. The rocks in this block are elevated by both bounding faults, with corresponding depression of the medial portion, resulting in a shallow, faulted syncline, which, by its alignment, may be continuous with the Porum syncline of southern Muskogee County.

Adjacent to, and northwest of the Blackgum fault block is the Cookson block, divided into two segments by a short fault in the vicinity of Cookson. The northern segment has been elevated with respect to adjacent blocks, and also has been arched to a sufficient extent near the town of Cookson that the Illinois River has cut

[55] Cram, Ira H., "Cherokee and Adair Counties," in "Oil and Gas in Oklahoma": *Okla. Geol. Survey Bull.* 40, Vol. III, pp. 531-586, 1930. This chapter also published as Bull. 40-QQ.

through the entire Osage (Boone), exposing the underlying Chattanooga shale. The southern segment has been depressed with respect to both the Blackgum and the northern segment of the Cookson blocks, and tilted slightly to the south. Southwest from Cookson, the faults disappear, and the areal geology indicates that the Cookson block and the north limb of the Blackgum block merge into an anticline which extends southwest to the Arkansas River. Its trend and alignment suggests a continuation with the Warner uplift of the Muskogee -Porum district.

Northwest of the Cookson fault block is the Pettit fault block which appears to have been subjected to simple southward tilting, though there is a suggestion in the areal geology of slight downward wraping in its medial portion, with the further implication that this downwrap may be related to the Rattlesnake Mountain syncline of the Muskogee-Porum district. The north bounding fault passes into an anticlinal fold in the vicinity of Greenleaf, and this fold extends to the Arkansas River. There is no marked anticlinal feature in the Muskogee-Porum district to correspond with this anticline, but there is a striking relationship between the north bounding fault of the Pettit block and the Keefeton fault of the Muskogee-Porum district. Both bear the same apparent relation to the anticline just described, and both are upthrown in the same direction.

The fault block north of the Pettit block, which is called the Braggs fault block, is likewise tilted southward, and contains, near its northern margin, an anticlinal fold that is named the Nigger Hollow anticline. It is bounded on the north by the Muskogee fault (south) whose trace lies near and parallel to Bayou Manard, extending from the vicinity of Parkhill and Tahlequah, across the Arkansas River valley, to the vicinity of Muskogee.

North of Ft. Gibson, is a series of faults, and tilted blocks not named on the map, whose regional relations are more obscure, owing partly to imperfect knowledge of the structure of rocks west of Neosho (Grand) River, in Wagoner County. The best description of the structure of this area is given by Cram.[56]

[56] Cram, Ira H., *op. cit.* pp. 575, 578.

MINOR FEATURES

A few minor features were noted in the course of this investigation which have not been described heretofore, and are worthy of mention.

The north and south Davidson faults, named for Davidson, Arkansas, extend about 2 miles into Oklahoma, in secs. 7 and 18, T. 14 N., R. 27 E., and secs. 12 and 13 T. 14 N., R. 26 E. The Atoka is faulted down against the Hale, and the upper part of the Bloyd formation is in contact with the Fayetteville shale, indicating a throw of 125 to 150 feet. Both faults are downthrown to the south, and the intervening block is tilted northward.

Three miles east of Stilwell, Oklahoma, is a short, east-west fault that brings the Wedington sandstone member of the Fayetteville shale in contact with Osage (Boone) chert. This small fault may continue eastward, either as a minor fold, or a fault concealed by chert rubble, and join the Evansville fault in Arkansas.[57]

Particular attention should be called to the steep monoclinal dip south of Church, Oklahoma, along the northern part of T. 14 N., R. 26 E, where the general southward dip from the Ozark dome increases abruptly from about 30 feet per mile to over 70 feet per mile. Westward, in T. 14 N., R. 25 E., this flexure passes into a fault which probably was produced by local failure of the rocks along the line of increased dip. The fault is downthrown to the south and Atoka sandstone is in contact with Osage (Boone) chert, indicating a stratigraphic displacement of at least 300 feet. Many small springs issue along this fault trace.

Nigger Hollow anticline, in secs. 12 and 13, T. 15 N., R. 20 E., extending into secs. 7 and 18, T. 15 N., R. 21 E., is a small, well-defined fold near the north margin of the Braggs fault block. Meremec ("Mayes") limestone, mapped as Boone, but described as part of the Fayetteville, by Taff[58] is exposed in the crest of the structure. A sharp syncline intervenes between the Nigger Hollow anticline and the Muskogee fault.

[57] Croneis, Carey, "Geology of the Arkansas Paleozoic Area": *Ark. Geol. Survey Bull.* 3, 1930.

[58] Taff, J. A., *U. S. Geol. Survey Geol. Atlas, Muscogee Folio* (No. 132), 1906.

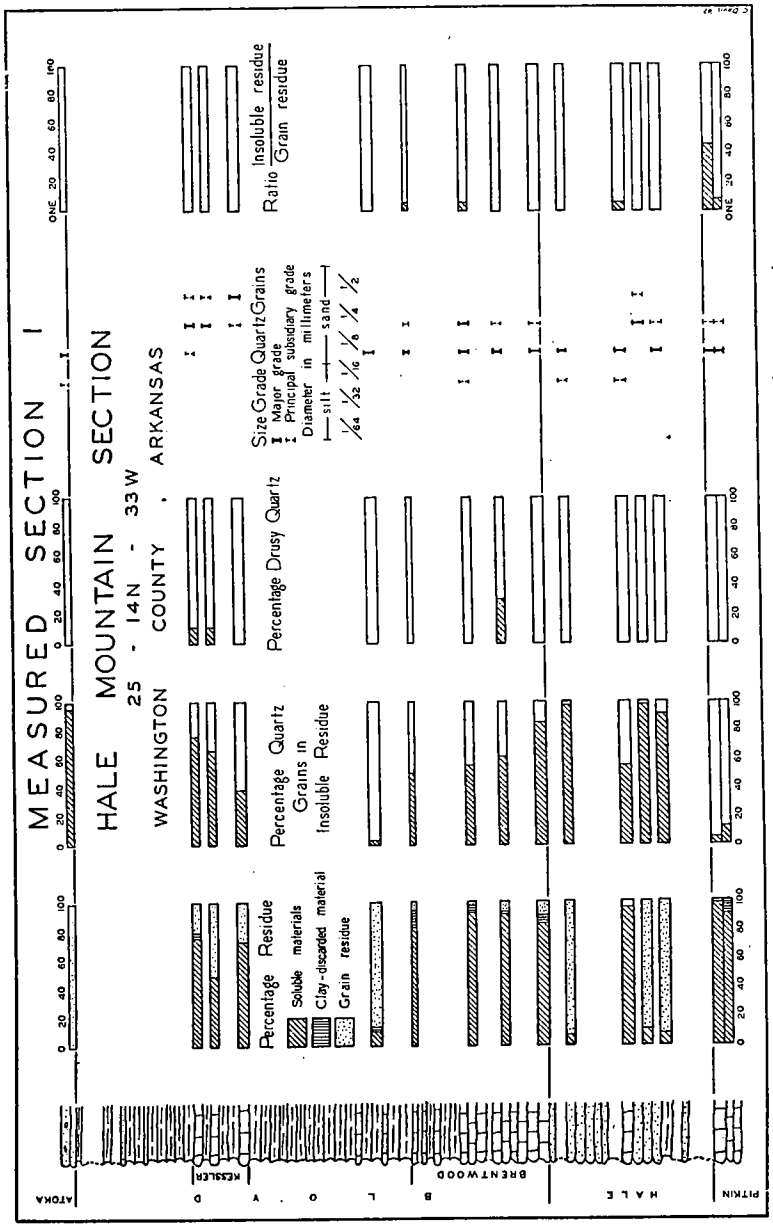


FIG. 3. Correlation of insoluble residue data with stratigraphic section measured on Hale Mountain, (measured section No. 1) sec. 25 T. 14 N., R. 25 W., Washington County, Arkansas.

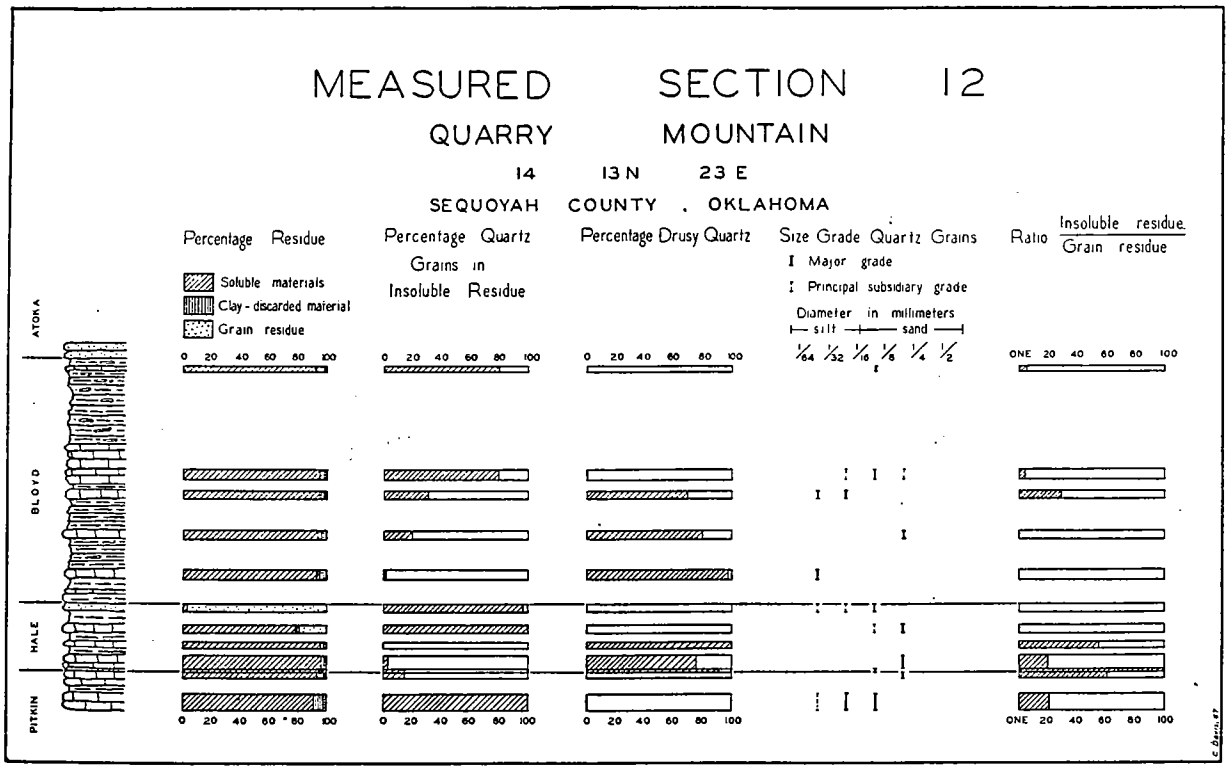


FIG. 4. Correlation of insoluble residue date with stratigraphic section measured on Quarry Mountain, (measured section No. 12) sec. 14, T. 13 N., R. 23 E., Sequoyah County, Oklahoma.

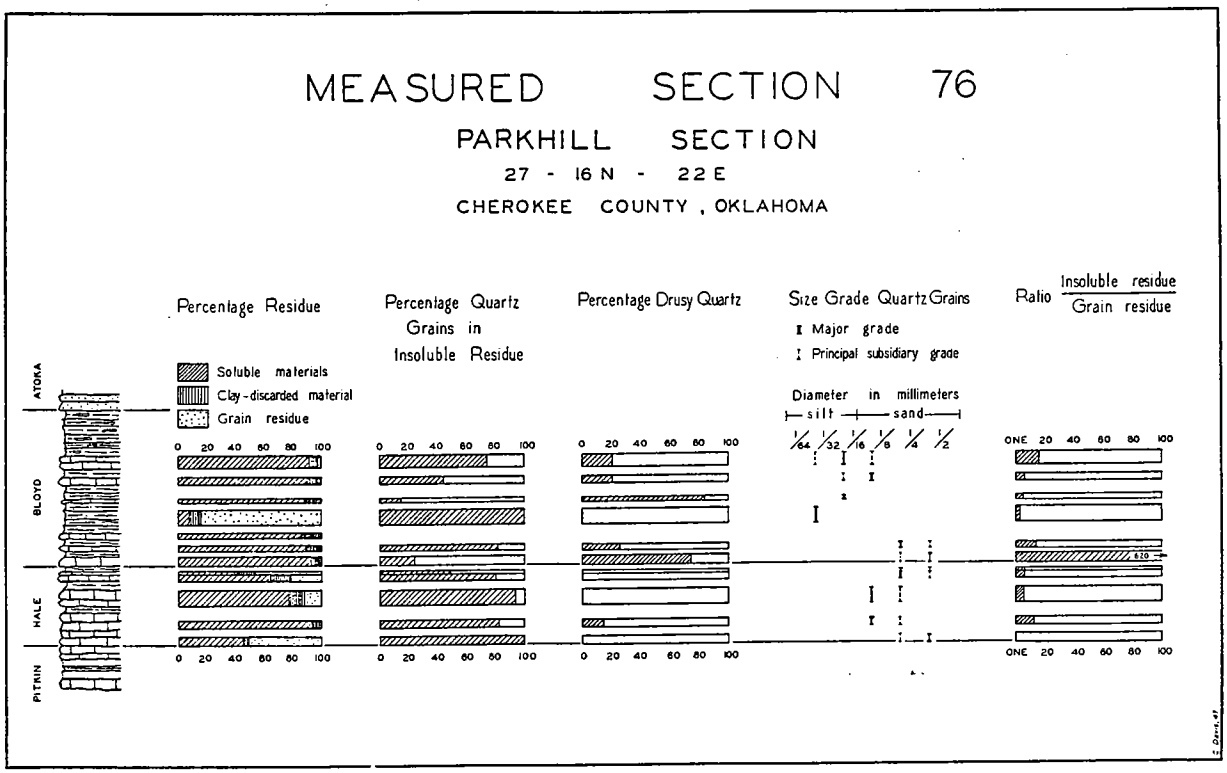


FIG. 5. Correlation of insoluble residue data with stratigraphic section measured along road south of Parkhill, (measured section No. 76) sec. 27, T. 16 N., R. 22 E., Cherokee County, Oklahoma.

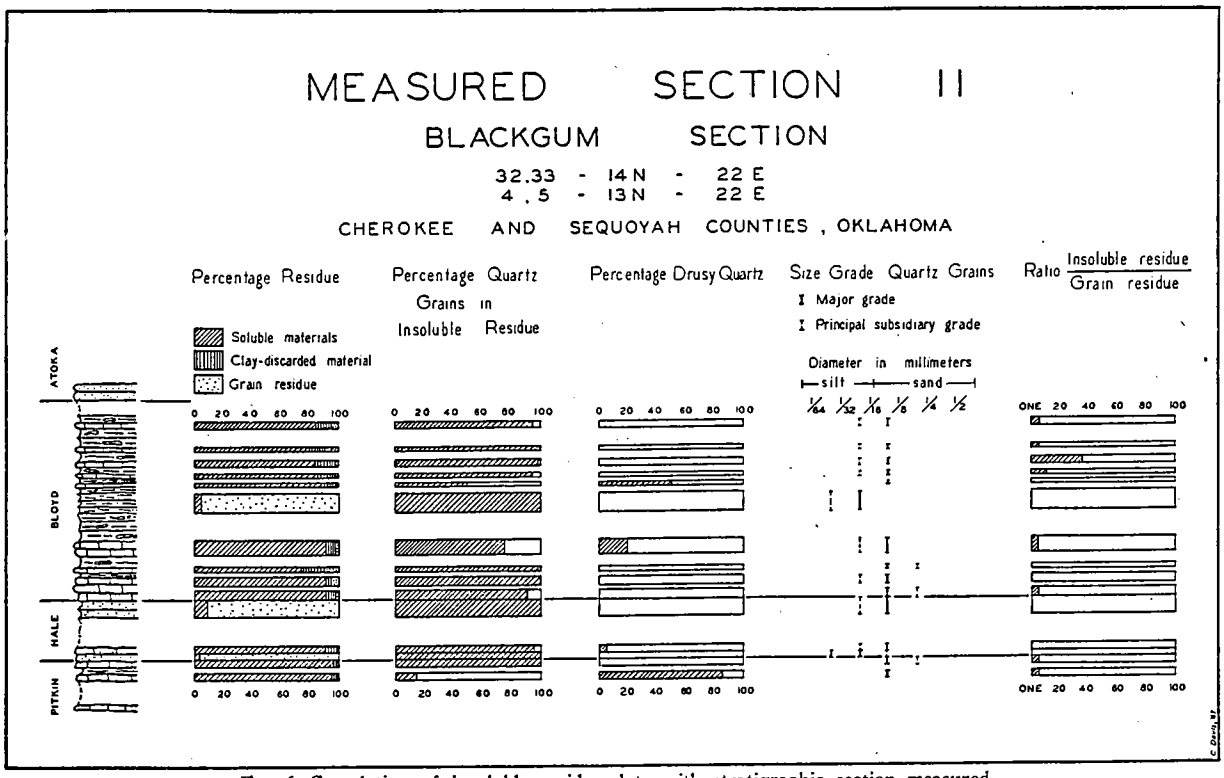


FIG. 6. Correlation of insoluble residue data with stratigraphic section measured near Blackgum, (measured section No. 11) secs. 32 and 33, T. 14 N., R. 22 E., and secs. 2 and 5, T. 13 N., R. 22 E., Cherokee and Sequoyah Counties, Oklahoma.

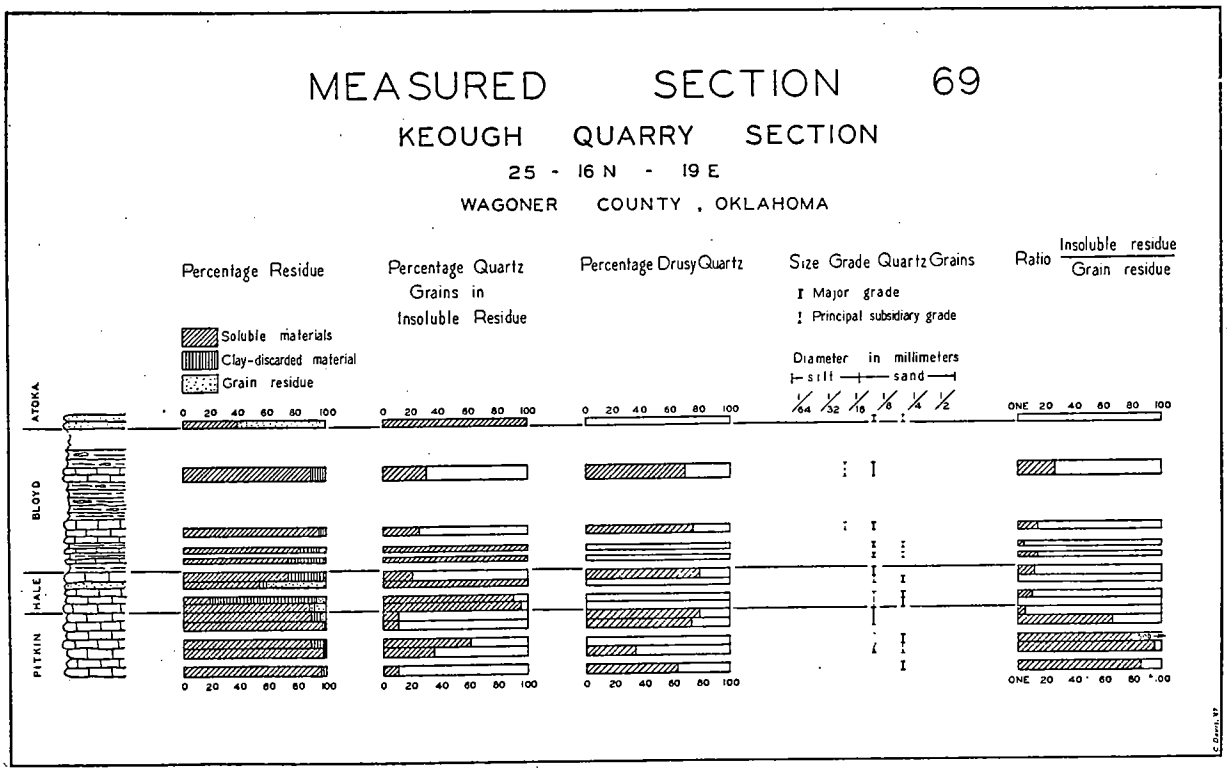


FIG. 7. Correlation of insoluble residue date with stratigraphic section measured in Keough Quarry, (measured section No. 69) sec. 25 T. 16 N., R. 19 E., Wagoner County, Oklahoma.

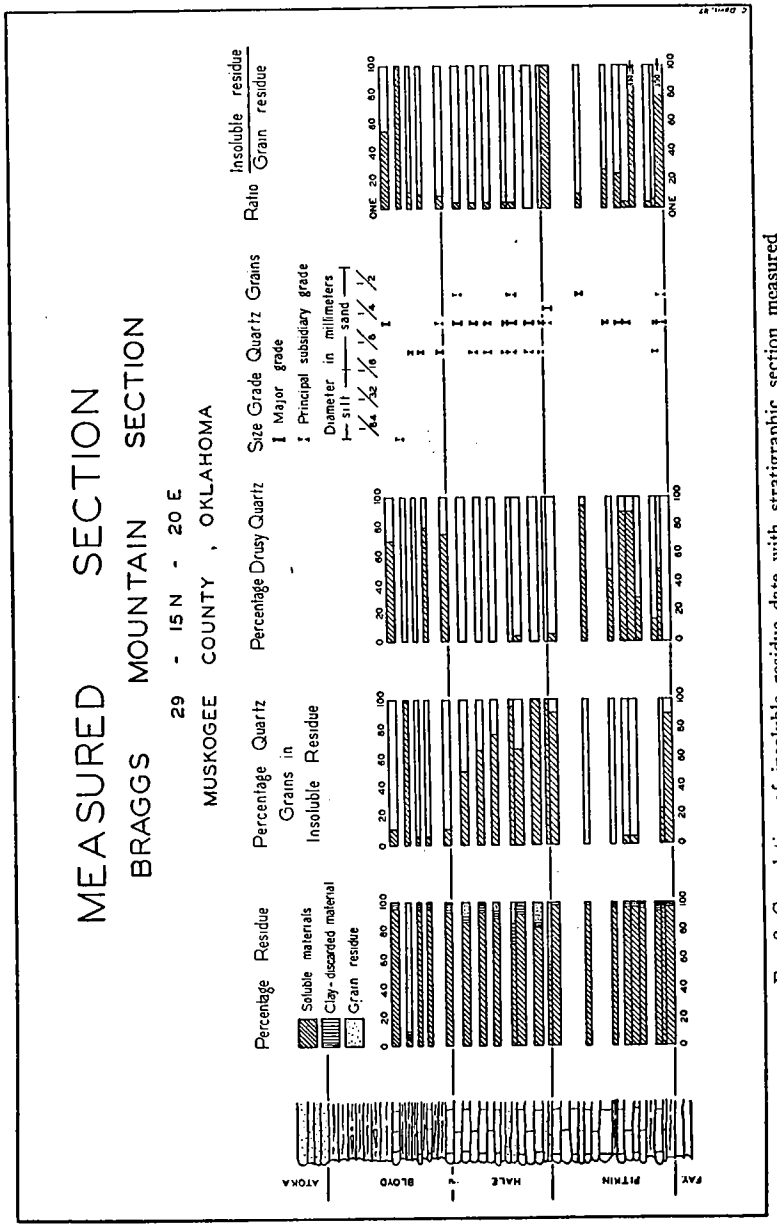


Fig. 8. Correlation of insoluble residue date with stratigraphic section measured along old route of Oklahoma State Highway No. 10, on Braggs Mountain, (measured section No. 32) sec. 29, T. 15 N., R. 20 E., Muskogee County, Oklahoma.

APPENDIX

MEASURED STRATIGRAPHIC SECTIONS OF THE MORROW SERIES IN NORTHEASTERN OKLAHOMA

1. HALE MOUNTAIN SECTION, WASHINGTON COUNTY, ARK.

(From Giles, A. W., and Brewster, Eugene B., Hale Mountain section in northwest Arkansas: Am. Assoc. Petroleum Geologists, Bull., vol. 14, pp. 121-138, 1930).

		Feet
	(Winslow) Atoka formation	
112.	Conglomerate with small white quartz in a matrix of coarse-grained, dark brown sandstone with limonite concretions	0.7
111.	Coarse-grained, friable, yellowish brown, iron-stained, cross-bedded sandstone	25.0
	Thickness of the (Winslow) Atoka	25.7
	Bloyd shale above Kessler limestone	
110.	Concealed	1.0
109.	Thin-bedded, fissile, gray clay shale	1.5
108.	Concealed probably shale	12.5
107.	Thin-bedded, fissile, gray clay shale	5.0
106.	Concealed, probably shale	5.5
105.	Hard, fine-grained, light yellowish gray rippled sandstone	1.0
104.	Thin-bedded, fissile, gray clay shale	8.0
103.	Sandy, limonitic, concretionary leached limestone, weathering yellow to chocolate-brown	0.5
102.	Thin-bedded, fissile, gray clay shale	5.0
101.	Sandy, cross-bedded, fossiliferous, brownish, medium-grained limestone, weathering to chocolate-brown with fluted surface	0.5
100.	Thin-bedded fissile, gray clay shale	23.5
	Thickness of Bloyd shale above Kessler	64.0
	Kessler limestone member of Bloyd shale	
99.	Massive, sandy, cross-bedded, fossiliferous, brownish, medium-grained limestone, weathering to chocolate-brown with fluted surface	4.0
98.	Fissile, gray clay shale with clay-iron concretions	3.0
97.	Massive, locally sandy and micaceous, fossiliferous, dark gray to brownish, medium grained limestone, weathering shaly and chocolate-brown	6.0
96.	Gray to brown clay shale with clay-iron concretions	11.0
95.	Fossiliferous, sandy, ferruginous limestone weathering brown, soft, and porous	0.5
94.	Gray to brown clay shale with clay-iron concretions	1.0
93.	Massive and thin-bedded, very fossiliferous, dark gray, fine to coarse-grained, conglomeratic limestone with limonite concretions, weathering shaly	4.5
	Thickness of the Kessler	30.0
	Bloyd shale below Kessler limestone	
92.	Gray to brown clay shale with clay-iron concretions	20.5
91.	Gray, sandy, micaceous platy shale	2.5
90.	Gray to brown clay with clay-iron concretions	5.5
89.	Gray to brown clay shale with clay-iron concretions	33.0
88.	Fossiliferous, sandy, ferruginous limestone weathering brown soft, and porous	0.5
87.	Gray to brown clay shale with clay-iron concretions	12.0

		Feet
86.	Massive, coarse-grained, very fossiliferous, medium gray limestone	1.5
85.	Ferruginous, sandy clay limestone weathering brown, very fossiliferous, with trilobites	0.5
84.	Gray to brown clay shale with clay-iron concretions	13.0
	Thickness of Bloyd shale below Kessler	89.0
Brentwood limestone member of Bloyd shale		
83.	Massive, fossiliferous, brownish gray conglomeratic limestone weathering brown and limonitic	0.5
82.	Massive, fossiliferous, dark gray, coarse-grained limestone	3.0
81.	Concealed	1.0
80.	Massive, fossiliferous, medium gray, medium-grained limestone	1.0
79.	Massive, fossiliferous, dark gray, fine-grained limestone	1.0
78.	Massive, fossiliferous, dark gray, fine- to medium-grained limestone	1.0
77.	Thin-bedded, bluish gray, fissile clay shale	3.5
76.	Massive, very fossiliferous, coarsely crystalline gray limestone weathering brownish	4.0
75.	Thin-bedded, bluish gray, fissile clay shale	11.0
74.	Massive, fossiliferous, dark gray, bituminous fine-grained limestone	0.5
73.	Massive, fossiliferous, dark gray, fine-grained limestone	2.0
72.	Concealed	1.0
71.	Massive, fossiliferous, brownish, very coarse-grained limestone with large calcite crystals	1.0
70.	Concealed, probably limestone	1.5
69.	Massive, fossiliferous, brownish, very coarse-grained limestone with large calcite crystals	1.5
68.	Concealed	0.5
67.	Massive, fossiliferous, medium-grained brownish limestone with calcite crystals	1.5
66.	Massive, fossiliferous, dark gray, medium- to coarse-grained limestone with calcite crystals	4.5
65.	Concealed, probably shale	3.5
64.	Massive, fossiliferous, brownish gray, coarse-grained limestone	1.5
63.	Massive, fossiliferous, light gray crystalline limestone	1.0
62.	Massive, fossiliferous, medium gray, very coarse-grained limestone	3.5
61.	Massive, fossiliferous, sandy, brown fine-grained limestone	1.5
60.	Massive, fossiliferous, medium gray, coarse-grained limestone	3.0
59.	Concealed, probably limestone	0.5
58.	Massive, fossiliferous, gray to pink, coarse-grained limestone	2.5
57.	Concealed	0.5
56.	Massive, fossiliferous, gray to pink, coarse-grained limestone	1.0
55.	Massive, very fossiliferous, brownish, coarse-grained limestone	2.5
54.	Massive, fossiliferous, dark gray, fine-grained limestone	0.5
53.	Massive, fossiliferous, pink, very coarse-grained limestone	1.0
52.	Massive, fossiliferous, dark gray fine-grained limestone	0.5
51.	Massive, fossiliferous, brownish limestone	0.5
50.	Massive, fossiliferous, dark, bituminous fine-grained limestone	0.5
49.	Massive, very fossiliferous, brownish limestone	1.5
48.	Massive, fossiliferous, light gray coarse-grained limestone	1.5
47.	Massive, fossiliferous, pink coarse-grained limestone	0.5
46.	Massive, fossiliferous, light gray coarse-grained limestone	2.0
45.	Massive, fossiliferous, dark gray, medium- to coarse-grained limestone	7.0
	Thickness of the Brentwood	76.5

		Feet
Hale formation		
44.	Massive, fossiliferous, yellowish brown, medium- to fine-grained, closely jointed sandstone	3.0
43.	Concealed	5.5
42.	Massive, brown, cross-bedded, fine-grained calcareous sandstone with calcite crystals, weathering yellowish brown, pitted and cavernous	23.0
41.	Concealed	8.0
40.	Massive, fossiliferous, brownish limestone with large calcite crystals, weathering reddish and forming a steep bluff on outcrop	4.5
39.	Massive, fossiliferous, brown, calcareous, medium- to fine-grained sandstone, locally conglomeratic and with calcite crystals in some beds, weathering to fluted surface	13.0
38.	Gray clay shale with clay-iron concretions	1.0
37.	Brownish gray, fine-grained sandstone	0.5
36.	Gray clay shale with clay-iron concretions	2.5
35.	Sandy, micaceous, brownish gray shale	3.5
34.	Concealed	6.5
33.	Thin-bedded, brown, rippled coarse- to medium-grained sandstone	2.0
32.	Concealed	16.5
	Thickness of the Hale	89.5
Pitkin limestone		
31.	Massive, fossiliferous, gray, coarse-grained crinoidal limestone with *Archimedes* and calcite crystals	3.5
30.	Massive, fossiliferous, dark gray limestone with *Archimedes* and calcite crystals	1.5
29.	Concealed	1.5
28.	Dark gray, fossiliferous limestone	1.0
27.	Dark gray, fossiliferous limestone with large calcite crystals	1.5
26.	Massive, non-fossiliferous, dark gray medium-grained limestone	1.0
25.	Dense, non-fossiliferous, light gray cherty limestone	0.5
24.	Coarse-grained, fossiliferous gray limestone	1.0
23.	Massive, fossiliferous, gray medium-grained limestone	3.0
22.	Massive, fossiliferous, gray cherty limestone	1.0
21.	Concealed	3.0
20.	Massive, fossiliferous, gray, coarsely crystalline limestone	3.0
	Thickness of the Pitkin	21.5
Fayetteville shale		
19.	Gray clay shale with small clay concretions	5.5
18.	Concealed	2.0
17.	Gray clay shale with small clay concretions	0.7
16.	Concealed	0.5
15.	Gray clay shale with small clay concretions	4.5
14.	Concealed	0.5
13.	Gray clay shale with small clay concretions	9.0
12.	Concealed	9.0
	Thickness of shale above Wedington member	31.7
Wedington sandstone member		
11.	Topmost bed massive, brown coarse- to medium-grained micaceous sandstone	2.5
10.	Brown, flaggy sandstone	2.5
9.	Gray clay shale with clay concretions and with 5 sandstone layers ½ inch to 2 inches thick interbedded with the shales	3.0
8.	Concealed	5.0
	Exposed thickness of Wedington	13.0
Fayetteville shale		
7.	Concealed, probably dark gray clay shale	27.5
6.	Dark gray clay shale with clay concretions	19.5
5.	Concealed, probably shale	25.5

	Feet
4. Black, fissile clay shale	30.5
3. Concealed, probably black shale	7.7
2. Black, fissile clay shale	1.2
Thickness of shale below Wedington member	112.0
Boone limestone	
1. Blue to bluish gray, fossiliferous, coarse-grained crystalline limestone with large ripple marks	5.0
Exposed thickness of Boone	5.0

2. TOLU, ARKANSAS SECTION, SEC. 3, T. 13 N., R. 33 W.

	Feet
Pennsylvanian	
Des Moines series	
Atoka formation	
25. Sandstone to top of hill	26.0
Exposed thickness of Atoka	26.0
Morrow series	
Bloyd formation	28.0
24. Covered	4.0
23. Shale	2.2
22. Limestone: black, medium crystalline, sandy; thin, bedded, and cross-bedded	
(Note: Beds 22-24 correlated with Kessler member of Bloyd Formation. Total thickness 34 feet.)	14.0
21. Shale: blue gray, fissile, limonite concretions	14.0
20. Covered	6.0
19. Shale: blue gray, fissile, limonite concretions	12.0
18. Covered	8.0
17. Shale: poorly exposed	32.0
16. Covered	2.0
15. Limestone: blue gray to green gray, medium with large calcite masses; platy, crinoidal fossiliferous	2.0
14. Covered	4.0
13. Shale	2.0
12. Limestone: blue gray, medium with coarse crystals; weathers platy and brown; *Pentremites*	4.0
11. Shale	4.0
10. Limestone: blue gray, medium, with large calcite masses; uneven bedded; weathers iron stained and platy	20.0
9. Covered	158.0
Estimated thickness of Bloyd	
Hale formation	
8. Sandstone: yellow brown, medium grained, iron stained; tough, slightly calcareous	6.0
7. Covered: includes some poorly exposed, thin cross-bedded sandstone beds	24.0
6. Sandstone: heavily stained; weathers pitted and cavernous	10.0
5. Covered, probably sandstone	24.0
4. Limestone with thin sandy lenses: coarse, crinoidal, iron stained	4.0
3. Covered	4.0
2. Sandstone: yellow brown, calcareous, medium grained; cross-bedded, thin to uneven bedded; with gray medium crystalline limestone lenses	8.0
Thickness of Hale	80.0
Mississippian	
Chester series	
Pitkin limestone	
1. Limestone: gray, fine; jointed	22.0
Covered below	
Exposed thickness of Pitkin	22.0

3. EVANSVILLE, ARKANSAS, SECTION. STARTS 0.5 MILE SOUTHEAST OF EVANSVILLE AND EXTENDS UP THE HILL IN SEC. 27, T. 13 N., R. 33 W.

	Feet
Pennsylvanian	
Morrow series	
Bloyd formation	
28. Covered	5.6
27. Limestone: gray black, coarse medium; weathers smooth and in parallel flutings; fossiliferous, crinoidal	16.8
26. Shale: blue gray, fissile; weathers yellow brown buff	4.0
25. Conglomerate: mostly limonitic pebbles with limestone; large *Pleurodictyum* (*Michelinia*) and large crinoid stems	2.5
24. Limestone: dark blue gray and brown gray; fossiliferous	6.6
23. Shale: blue gray, fissile	4.5
22. Limestone: light gray; very coarse, crinoidal; weathers yellow with a bumpy surface	14.0
21. Covered: probably limestone	2.0
20. Limestone: Light gray, very coarsely crystalline; weathers smooth; crinoidal	13.2
Exposed thickness of Bloyd	69.2
Hale formation	
19. Shale: yellow brown buff, sandy	4.0
18. Sandstone: greenish gray, ferruginous; grades into limestone below	1.5
17. Limestone: light blue gray, coarsely crystalline; some sandy beds; weathers evenly; fossiliferous	2.0
16. Sandstone: blue gray on slightly weathered surface; thin-bedded; weathers red and slightly pitted	8.5
15. Covered	4.0
14. Shale: blue gray, fissile	5.5
13. Limestone: black to gray, coarse medium; weathers platy; fossiliferous	1.0
12. Shale: blue gray, fissile	1.0
11. Limestone: gray black to brown, very coarse crystalline; weathers smooth and crinoidal	11.5
10. Shale: blue gray, fissile	10.6
9. Limestone: black, very coarsely and evenly crystalline; weathers crinoidal and platy; fossiliferous	1.0
8. Shale: blue gray, fissile	2.0
7. Shale: blue gray, massive bedded	2.0
6. Covered	4.6
5. Shale: yellow brown; weathers light yellow and limonite stained	13.0
4. Limestone: dark blue gray, very coarsely crystalline; weathers crinoidal and in big pittings; fossiliferous	5.5
3. Covered	4.0
2. Sandstone: dirty yellow green color; very shaly	0.5
1. Shale: blue gray	4.0
Covered below	
Exposed thickness of Hale	86.2

4. DAVIDSON, ARKANSAS SECTION, SECS. 14, 23, T. 12 N., R. 33 W.

	Feet
Pennsylvanian	
Des Moines series	
Atoka formation	
38. Covered to top of hill, sandstone rubble	11.0
37. Sandstone: yellow brown with light gray streaks, fine grained; thin to uneven bedded	13.0
Exposed thickness of Atoka	24.0

		Feet
Morrow series		
Bloyd formation		
36.	Covered	14.0
35.	Shale: blue gray, fissile	20.0
34.	Covered	22.0
33.	Shale: blue gray, fissile, limonite concretions; contains two sandy beds	32.0
32.	Limestone: blue to blue gray, fine with sublithographic lenses, oolitic; weathers platy with crossing calcite veins	8.0
31.	Limestone	10.0
30.	Limestone: blue gray, fine crystalline, well jointed; weathers light blue splotched with brown; fossiliferous, *Spirifer, Productids*	3.0
29.	Shale: blue gray, fissile; limonite concretions	20.0
28.	Shale: dirty blue gray, iron stained; weathers fissile	1.0
27.	Shale: blue gray, fissile; limonite concretions	22.0
26.	Limestone: brown, thin-bedded; poorly exposed	0.5
25.	Shale: blue gray, fissile; limonite concretions	4.0
24.	Limestone: blue gray to brown gray, very coarse, uneven bedded; locally fossiliferous and crinoidal	4.0
23.	Shale: blue gray, fissile, limonite concretions	10.0
22.	Limestone: blue to blue gray, fine with sublithographic crystalline lenses; weathers platy and with crossing calcite veins; fossiliferous	1.0
21.	Shale: blue gray, fissile, limonite concretions	11.0
20.	Limestone: brown gray, coarse; iron stained red; crinoidal, fossiliferous, bryozoans, brachiopods	4.0
19.	Shale: blue gray, fissile, limonite concretions	5.0
	Thickness of Bloyd	191.5
Hale formation		
18.	Sandstone: thin-bedded, calcareous	5.0
17.	Sandstone, very calcareous: yellow brown, fine grained; cross-bedded and thin-bedded; weathers pitted and cavernous	34.0
16.	Limestone, sandy: light gray medium, even crystalline; thin-bedded, cross-bedded	6.0
15.	Covered	34.0
14.	Shale: poorly exposed	6.0
13.	Sandstone, calcareous: yellow brown, medium to fine grained; cross bedded, irregularly bedded	4.0
12.	Shale: blue gray, fissile with few sandy shale beds	6.0
	Thickness of Hale	95.0
Mississippian		
Chester series		
Pitkin limestone		
11.	Limestone: at top, gray, coarse even crystalline; uneven bedded, crinoidal; at base, brown gray, coarse, crinoidal, uneven bedded; weathers irregular, fluted and spalls off	36.0
10.	Limestone: gray, medium, well jointed; weathers light blue; fossiliferous	4.0
	Thickness of Pitkin	40.0
Fayetteville shale		
9.	Covered and shale	100.0
	Estimated thickness of Fayetteville	100.0
Meramec? series		
8.	Limestone: dark blue gray, very fine to sublithographic crystalline; weathers jointed and light blue	6.0
7.	Shale: black	5.0
6.	Limestone: thin-bedded to fissile, shaly	1.0
5.	Shale: black	6.0
4.	Limestone: dark gray to black, coarse even crystalline; fossiliferous	2.0

		Feet
3.	Shale: black, fissile, well jointed	18.0
2.	Limestone, few shale breaks: brown gray, coarse medium crystalline; weathers light blue and uneven	18.0
	Estimated thickness of Meramec?	56.0
Osage series		
1.	Chert:	38.0
	Covered below	

5. LOWER VIAN CREEK SECTION. SEC. 9, T. 12 N., R. 22 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
4.	Covered and poorly exposed sandstone to top of hill	
3.	Sandstone: massive bedded	6.0
	Exposed thickness of Atoka	6.0
Morrow series		
Bloyd formation		
2.	Shale	4.0
1.	Limestone with few shale beds; blue gray to brown gray, very coarse; weathers granular; fossiliferous	50.0
	Covered below	
	Exposed thickness of Bloyd	54.0

6. GREENLEAF DAM SECTION. SEC. 2, T. 13 N., R. 20 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
20.	Covered, sandy soil	64.0
19.	Sandstone: light gray to yellow brown, medium grained; thin-bedded	8.0
	Exposed thickness of Atoka	72.0
Morrow series		
Bloyd formation		
18.	Covered	12.0
17.	Shale: blue gray, fissile, limonite concretions	10.0
16.	Limestone: brown gray, fine even crystalline; weathers smooth and light blue splotched, brittle	3.5
15.	Limestone: at base gray to brown, medium; thin-bedded	16.8
14.	Shale, poorly exposed: blue gray, fissile, limonite concretions	15.2
13.	Limestone: blue gray, coarse, iron stained red; uneven and thin-bedded, cross-bedded	13.2
12.	Shale: blue gray, fissile, limonite concretions	1.0
11.	Limestone, conglomeratic: brown gray, fine medium matrix; weathers sandy; fossiliferous, *Pleurodictyum* (*Michelinia*), cephalopods; carries limonite pebbles with trace phosphate	1.0
10.	Shale: poorly exposed	3.5
9.	Limestone: blue gray, very coarse; uneven bedded; weathers granular and thin-bedded; crinoidal	5.6
8.	Shale: blue gray, fissile, limonite concretions; few covered intervals	33.4
	Thickness of Bloyd	115.2
Hale formation		
7.	Limestone: blue gray in lower part and gray in upper half; thin-bedded in lower half	12.0
6.	Shale: calcareous, buff	0.5
5.	Limestone, very sandy: gray, earthy to fine crystalline; weathers sandy and iron stained	0.5
4.	Shale: blue gray, fissile, limonite concretions	1.5

		Feet
3.	Limestone: blue gray, fine medium; weathers thin-bedded, spalls off and is uneven bedded; crinoid stems replaced by orange calcite	3.5
2.	Limestone: blue gray, very coarse crystalline; granular and cross-bedded; fossiliferous, crinoidal	5.0
1.	Sandstone, calcareous: medium grained; weathers pitted and cavernous. Seems to grade into limestone above	3.0
	Covered below by water of Greenleaf Lake.	
	Exposed thickness of Hale	26.0

7. BLUFFS SECTION. SEC. 26, T. 13 N., R. 20 E.

Pennsylvanian
Des Moines series
Atoka formation

34.	Covered to top of hill	26.0
33.	Sandstone: thin-bedded, forms cliff	6.0
32.	Covered	14.0
31.	Sandstone: massive bedded	3.0
30.	Covered	19.0
29.	Sandstone: yellow brown, coarse grained; cross-bedded, thin- to massive-bedded	6.0
28.	Sandstone, calcareous: buff to gray, medium to fine, even grained; thin-bedded; weathers buff brown, calcareous	4.0
	Exposed Thickness of Atoka	78.0

Morrow series
Bloyd formation

27.	Limestone: gray, very coarse; uneven bedded and cross-bedded; weathers granular. Upper 1-foot fine crystalline and weathers rubbly	6.0
26.	Shale: poorly exposed	20.0
25.	Limestone: poorly exposed	2.0
24.	Shale	7.0
23.	Limestone: poorly exposed	1.0
22.	Shale	6.0
21.	Limestone, poorly exposed: rubbly limestone pebbles on slope, blue gray with greenish lenses; fossiliferous	2.0
20.	Shale: poorly exposed	9.0
19.	Limestone: gray with greenish streaks, sublithographic; weathers smooth and in big pittings	3.0
18.	Shale: poorly exposed	2.0
17.	Limestone, few shale breaks; brown to brown gray with greenish lenses, very coarse; uneven-bedded; weathers fluted; coarsely crinoidal	14.0
16.	Limestone: gray with greenish argillaceous streaks, sandy; weathers rubbly	2.0
15.	Shale: poorly exposed	12.0
14.	Limestone: very rubbly	4.0
13.	Shale: poorly exposed	2.0
12.	Limestone: brown gray, fine even crystalline; uneven bedded; weathers rubbly	10.0
11.	Shale: poorly exposed, includes a 1-foot limestone bed	5.0
	Thickness of Bloyd	107.0

Hale formation

10.	Limestone: blue gray with brown gray lenses; uneven bedded, rubbly	3.0
9.	Shale: blue gray, fissile, limonite concretions; includes two thin argillaceous limestone beds 0.5 foot thick	8.0
8.	Limestone, sandy: blue gray with brown lenses, fine; uneven bedded	4.0

		Feet
7.	Shale: blue gray, fissile, sandy	4.0
6.	Limestone, sandy: buff gray to brown gray; grades into shale above	2.0
5.	Shale: blue gray, fissile; somewhat calcareous near top and fossiliferous	4.0
4.	Covered: may include two thin argillaceous beds	9.0
3.	Shale: blue gray, fissile	8.0
2.	Limestone, sandy: blue gray, fine, argillaceous; weathers very sandy	5.0
1.	Limestone: brown gray, coarse medium; weathers brown, smooth, and spalls off. Grades into limestone above	4.0
	Covered below	
	Exposed thickness of Hale	51.0

8. McCLAIN SECTION. SEC. 28, T. 13 N., R. 20 E.

Pennsylvanian
Des Moines series
Atoka formation
Poorly exposed to top of hill

34.	Sandstone	3.0
	Exposed Thickness of Atoka	3.0

Morrow series
Bloyd formation

33.	Shale: blue gray, fissile; limonite concretions	8.0
32.	Limestone: dark gray to blue gray, fine medium with few coarse crystals; uneven-bedded; weathers smooth, pitted and well jointed	3.0
31.	Shale	3.0
30.	Limestone: weathers thin-bedded	6.0
29.	Limestone: light gray, very fine to sublithographic; weathers rubbly and uneven bedded	3.0
28.	Shale	15.0
27.	Limestone: neutral gray, coarse, well jointed; weathers uneven bedded and smooth; fossiliferous, *Hustedia*	2.0
26.	Shale	4.0
25.	Limestone: yellow gray, coarse with large calcite masses; weathers uneven bedded and granular	6.0
24.	Shale	4.0
23.	Limestone: buff to gray, very coarse, large calcite masses; weathers granular; crinoidal, large brachiopods	3.0
22.	Shale	3.0
21.	Limestone: gray, fine medium to fine; uneven bedded, well jointed; weathers smooth; fossiliferous	3.0
20.	Shale	4.0
	Estimated thickness of Bloyd	67.0

Hale formation

19.	Limestone: blue gray to brown gray, coarse medium with very coarse crystals, large calcite masses; weathers very sandy on surface	2.0
18.	Shale	4.0
17.	Limestone: blue gray with brown gray lenses, medium with large calcite masses; weathers in light blue splotches and rubbly; fossiliferous	2.0
16.	Shale: sandy	3.0
15.	Limestone: blue gray; weathers granular and thin bedded; crinoidal, fossiliferous	3.0
14.	Shale	4.0
13.	Limestone: blue gray, fine crystalline to sublithographic; weathers buff	4.0

		Feet
12.	Shale	8.0
11.	Shale: poorly exposed, may include some limestone	18.0
10.	Shale: blue gray, fissile, limy concretions and limy lenses	8.0
9.	Sandstone, calcareous: dark gray, fine-grained, argillaceous; weathers limonite stained	1.0
	Estimated Thickness of Hale	57.0
Mississippian		
Chester series		
Pitkin limestone		
8.	Limestone: gray, fine medium; weathers fluted; fossiliferous	2.0
7.	Limestone, granular: very coarse crystalline with some sublithographic beds, few shale breaks	10.0
6.	Covered	16.0
	Estimated thickness of Pitkin	28.0
Fayetteville shale		
5.	Covered	14.0
4.	Limestone: blue gray to gray, very coarse, large calcite masses; uneven bedded; weathers locally thin bedded; fossiliferous, *Archimedes*	8.0
3.	Shale: dark gray to black	8.0
2.	Covered	32.0
1.	Limestone: blue, sublithographic; jointed, brittle	1.0
	Exposed thickness of Fayetteville	63.0

9. LINDER CREEK. SEC. 3, T. 13 N., R. 21 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
17.	Covered: sandstone rubbly and sandy soil	14.0
16.	Sandstone: massive bedded	8.0
15.	Covered	14.0
14.	Sandstone: poorly exposed	6.0
	Exposed thickness of Atoka	42.0
Morrow series		
Bloyd formation		
13.	Shale: blue gray, fissile, limonite concretions	4.0
12.	Covered	18.0
11.	Shale: blue gray, fissile, limonite concretions	8.0
10.	Limestone: dark blue gray, very coarse, calcite veins, brittle; weathers brown and smooth	3.0
9.	Shale: poorly exposed	22.0
8.	Limestone: brown gray, very fine even crystalline; weathers buff brown and knobby; fossiliferous	1.0
7.	Shale: blue gray, fissile; limonite concretions	4.0
6.	Limestone: includes granular, knobby and thin-bedded beds; lower few feet brown gray, fine even crystalline	10.0
5.	Shale: blue gray, fissile, limonite concretions	8.0
4.	Covered	20.0
	Estimated thickness of Bloyd	98.0
Hale formation		
3.	Limestone: at top, blue to blue gray, fine medium; uneven bedded, well jointed; weathers in light blue splotches and somewhat rubbly; lower part is light blue gray, very coarse; weathers granular, crinoidal, iron stained red	20.0
2.	Covered	6.0
1.	Sandstone, calcareous: gray to brown gray, fine grained; weathers rough and iron stained; residue shows 51% insoluble	1.0
	Exposed thickness of Hale	27.0

10. TENKILLER SECTION. NE¼ SEC. 15. T. 13 N., R. 21 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
	Covered to top of hill	
26.	Sandstone; massive bedded	3.0
25.	Covered	20.0
	Exposed thickness of Atoka	23.0
Morrow series		
Bloyd formation		
24.	Shale: poorly exposed	16.0
23.	Limestone: gray to blue gray, very fine with sublithographic lenses, greenish argillaceous streaks; weathers iron stained buff and rubbly	3.0
22.	Shale: blue gray, fissile, limonite concretions	8.0
21.	Limestone: gray, medium to very fine, argillaceous bands and streaks; weathers thin-bedded and iron stained	1.0
20.	Shale: blue gray, fissile, limonite concretions	5.0
19.	Shale: greenish buff; grades into shale above and below	2.0
18.	Shale: blue gray, fissile, limonite concretions	5.0
17.	Limestone: gray, fine with coarse crystals; uneven-bedded; weathers smooth and locally thin-bedded; oolitic, crinoidal	2.0
16.	Shale: blue gray, fissile, limonite concretions	6.0
15.	Shale, calcareous: blue to buff gray, fissile, travertine-like concretions on surface; seems to grade into shale above	1.0
14.	Shale: blue gray fissile, limonite concretions	13.0
13.	Limestone	1.0
12.	Shale: blue gray, fissile, limonite concretions	4.5
11.	Limestone: gray to blue gray, fine with coarse medium crystals; weathers smooth and fluted	1.5
10.	Shale: blue gray, fissile, limonite concretions	8.0
9.	Limestone: blue gray, fine to very fine crystalline; uneven bedded, well jointed; weathers rough and rubbly	2.0
8.	Shale: blue gray, fissile, limonite concretions. Includes a 2-foot shaly limestone bed that is slightly conglomeratic	18.0
	Thickness of Bloyd	97.0
Hale formation		
7.	Limestone: blue gray to brown gray on weathering, fine with few coarse crystals; uneven bedded; weathers cross-bedded; fossiliferous	2.0
6.	Shale: blue gray, fissile, limonite concretions	10.0
5.	Siltstone: brown to buff, well jointed, iron stained	2.0
4.	Limestone: gray, medium with coarse crystals; weathers smooth; fossiliferous, crinoidal	2.0
3.	Shale	5.0
2.	Limestone: gray, fine to very fine; weathers smooth; fossiliferous	3.0
1.	Shale: poorly exposed	5.0
	Covered below	
	Exposed thickness of Hale	29.0

11. BLACKGUM SECTION. STARTS IN SECS. 32, 33, T. 14 N., R. 22 E., AND ENDS IN SECS. 4, 5, T. 13 N., R. 22 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
31.	Sandstone: thin-bedded	8.0
	Exposed thickness of Atoka	8.0

		Feet
Morrow series		
Bloyd formation		
30.	Covered	9.0
29.	Shale: blue gray, fissile, limonite concretions	4.0
28.	Limestone: dark blue gray, fine, even crystalline with few coarse medium crystals; platy; moderately fossiliferous	2.0
27.	Shale: blue gray, fissile; well jointed; poorly exposed in lower part	11.2
26.	Limestone: blue to purplish blue gray, fine; uneven bedded, sandy, argillaceous streaks; brachiopods	1.5
25.	Shale: blue gray, fissile, limonite concretions	4.0
24.	Limestone: blue gray to purplish blue gray, sublithographic to fine crystalline, argillaceous; uneven bedded; bryozoans, productids, *Composita, Spirifer*	2.0
23.	Shale: blue gray, fissile, limonite concretions	4.5
22.	Limestone: blue gray, unevenly crystalline; uneven bedded; weathers sandy and moderately iron stained buff	2.0
21.	Shale: blue gray, fissile, limonite concretions	3.0
20.	Limestone: gray to blue gray, coarse with sublithographic crystalline lenses; weathers smooth and with rubbly beds; fossiliferous, crinoidal	2.0
19.	Shale: blue gray, fissile, limonite concretions	3.0
18.	Siltstone: buff, iron stained, fissile; seems to grade into shale above	11.0
17.	Shale: blue gray, fissile, limonite concretions, some sandy beds; poorly exposed near base	15.6
16.	Limestone: blue to blue gray, fine; uneven bedded; weathers pitted, glauconitic	8.0
15.	Shale: blue gray, fissile, limonite concretions	6.0
14.	Limestone: blue gray, medium, sandy and argillaceous, heavily iron stained; thin-bedded	2.0
13.	Shale: blue gray, fissile, limonite concretions	2.5
12.	Limestone: gray with purplish cast, coarse medium to coarse crystalline; uneven bedded, one thin shale break	7.0
11.	Shale	1.0
10.	Limestone: light blue, very fine with coarse crystals, greenish calcite masses; weathers smooth, uneven bedded, and rubbly at top; crinoidal	2.5
	Thickness of Bloyd	103.8
Hale formation		
9.	Sandstone: blue gray with a greenish cast, calcareous, trace phosphatic	10.2
8.	Covered	16.2
7.	Limestone, sandy: dark blue with greenish streaks; fossiliferous	2.0
6.	Sandstone: medium- to fine-grained; irregularly bedded, thin shaly partings and streaks, disconformable contact on limestone	6.5
	Thickness of Hale	34.9
Mississippian		
Chester series		
Pitkin limestone		
5.	Limestone: gray to light gray, coarse; uneven bedded; fossiliferous, crinoidal	3.0
4.	Shale: blue gray to purple, rather fissile	3.0
3.	Limestone: dark blue gray, coarse; fossiliferous and crinoidal, large crinoid calyx, 3 by 2.5 inches, *Pentremites, Linoproductus*	4.5
2.	Covered	13.0
1.	Limestone: blue gray	2.0
	Covered below	
	Exposed thickness of Pitkin	25.5

12. QUARRY MOUNTAIN SECTION. SEC. 14, T. 13 N., R. 23 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
49.	Covered: Sandy and shaly soil	54.0
48.	Sandstone: massive bedded	8.0
47.	Covered	6.0
46.	Sandstone: massive bedded, in a cliff	16.0
45.	Covered	14.0
44.	Siltstone: greenish, thin-bedded	6.0
43.	Covered	26.0
42.	Sandstone: massive bedded	8.0
	Exposed thickness of Atoka	138.0
Morrow series		
Bloyd formation		
41.	Shale	4.0
40.	Limestone: greenish gray, coarse medium, sandy, thin-bedded and granular; weathers platy	2.0
39.	Shale: blue gray, fissile, limonite concretions	40.0
38.	Limestone: fine crystalline; weathers rubbly at top; few shale breaks	19.0
37.	Limestone: blue gray, very coarse; weathers granular; very crinoidal, extremely fossiliferous, bryozoans, productids, *Composita,* gastropods	4.0
36.	Shale	3.0
35.	Limestone: blue gray, fine medium; uneven bedded, hard; weathers rubbly; moderately fossiliferous	4.0
34.	Shale: poorly exposed	16.0
33.	Limestone: blue gray, medium even crystalline; weathers smooth and jointed; fossiliferous, Productids, *Spirifer*	5.0
32.	Shale: poorly exposed	17.0
31.	Limestone: blue gray, coarse even crystalline; weathers jointed and granular; crinoid stems replaced by buff calcite	6.0
30.	Shale	6.0
29.	Limestone	2.0
28.	Shale	4.0
	Thickness of Bloyd Formation	132.0
Hale formation		
27.	Sandstone: light gray, medium grained; casts of crinoid stems, *Hustedia*	3.0
26.	Shale	7.0
25.	Limestone: light gray, medium even crystalline; weathers into thin beds and granular beds; fossiliferous	4.0
24.	Shale	4.0
23.	Limestone: gray, well jointed; weathers smooth and buff	3.0
22.	Shale	3.0
21.	Limestone, poorly exposed: light gray to buff gray, fine even crystalline, locally coarse crystalline	5.0
20.	Limestone: sandy, medium crystalline, oolitic; crinoidal, *Pentremites* abundant, bryozoans; seems to grade into limestone above	1.0
	Thickness of Hale	30.0
Mississipian		
Chester series		
Pitkin limestone		
19.	Limestone: dark gray, very fine with coarse crystalline lenses; weathers light blue and well jointed; fossiliferous	2.0
18.	Limestone	10.0
17.	Shale	4.0
16.	Limestone	8.0

		Feet
	15. Limestone: gray, very fine to sublithographic, brittle; weathers light blue; moderately fossiliferous	2.0
	Thickness of Pitkin	26.0
	Fayetteville shale	
	14. Covered, probably shale	12.0
	13. Limestone	1.0
	12. Shale	2.0
	11. Limestone	1.0
	10. Shale: calcareous, trace phosphatic	4.0
	Thickness of Fayetteville	20.0
Meramec? series		
	9. Limestone: dense at top, shaly below, fossiliferous	4.0
	8. Covered	5.0
	7. Limestone: dark gray at base, lighter gray near top, coarse, even crystalline, glauconite specks; carbonaceous odor when struck with a hammer; many thin shale breaks	15.0
	Thickness of Meramec	24.0
Osage series		
	6. Chert; gray, well jointed	28.0
	Thickness of Osage	28.0
Kinderhook series		
	Chattanooga shale	
	5. Shale: blue black, fissile, well jointed	40.0
	Thickness of Chattanooga	40.0
	Sylamore sandstone	
	4. Sandstone, poorly exposed: brown black pebbles and few chert fragments	8.0
	Thickness of Sylamore	8.0
Devonian		
	Sallisaw sandstone	
	3. Sandstone: even grained	4.0
	Thickness of Sallisaw	4.0
	Frisco limestone	
	2. Limestone:	6.0
	Thickness of Frisco	6.0
Silurian		
	St. Clair limestone	
	1. Limestone: light gray to pink; very coarse; base concealed by fault	96.0
	Exposed thickness of St. Clair	96.0

13. WEST QUARRY MOUNTAIN SECTION. W½ SEC. 15, T. 13 N., R. 23 E.

Pennsylvanian		
	Des Moines series	
	Atoka formation	
	52. Covered to top of spur of hill	18.0
	51. Sandstone: poorly exposed	1.0
	50. Covered	16.0
	49. Shale: poorly exposed	7.5
	48. Sandstone: poorly exposed	2.0
	Exposed thickness of Atoka	44.5
	Morrow series	
	Bloyd formation	
	47. Shale: blue gray, fissile, limonite concretions	11.2
	46. Shale: poorly exposed	11.2
	45. Shale: blue gray, fissile, limonite concretions	5.6
	44. Limestone: greenish in upper part, coarse, shaly inclusions; cross-bedded and thin-bedded; fossiliferous, corals, bryozoans, *Pentremites, Composita*	8.0

		Feet
	43. Shale: poorly exposed	15.2
	42. Limestone: dark blue gray, medium; lower part weathers uneven bedded and rubbly; Dielasma, productids, *Composita*....	4.0
	41. Shale: poorly exposed	3.0
	40. Covered	11.2
	39. Limestone: dark blue gray, sublithographic bands in medium crystalline matrix; weathers with fossil markings on surface; *Composita*	2.0
	38. Covered	5.6
	37. Shale: blue gray, fissile, limonite concretions	1.0
	36. Covered (spring issues at base)	10.2
	35. Shale	3.5
	34. Limestone: gray, coarse even crystalline, glauconitic; weathers uneven; crinoidal	2.0
	33. Covered	9.0
	32. Limestone: blue gray with brown lenses; cross-bedded; weathers fluted; *Pentremites* abundant	2.0
	31. Shale	2.0
	30. Limestone: gray, medium with coarse crystals; uneven bedded; weathers rubbly and crinoidal	2.0
	29. Shale: poorly exposed	5.5
	28. Limestone: light gray, coarse medium, glauconite spotted; crinoidal	2.0
	27. Shale: poorly exposed	11.2
	26. Limestone: purplish gray, coarse medium with large blue green argillaceous bands; weathers smooth with iron stained inclusions	1.0
	25. Shale: blue gray, fissile, limonite concretions	4.5
	24. Siltstone: fissile, iron stained on bedding planes	3.0
	23. Shale: blue gray, fissile, limonite concretions	5.6
	22. Siltstone: fissile, iron stained on bedding planes	3.0
	21. Shale: blue gray, fissile, limonite concretions	4.0
	Thickness of Bloyd	148.5
	Hale formation	
	20. Limestone: gray to blue gray, coarse medium; weathers smooth; crinoidal, fossiliferous	4.0
	19. Shale: poorly exposed	2.0
	18. Limestone, very sandy: gray, medium with black calcite crystals; grades laterally into a sandstone; weathers fluted; fossil casts	4.0
	17. Shale	0.5
	16. Limestone: gray to black, black calcite crystals, coarse; crinoidal	4.0
	15. Shale: poorly exposed	4.0
	14. Limestone, very sandy, especially in lower part: blue gray with greenish hue, very coarse to coarse crystalline, heavily iron stained	10.0
	Thickness of Hale	28.5
Mississippian		
	Chester series	
	Pitkin limestone	
	13. Limestone: brown gray, coarse to coarse medium; weathers blue gray; coarsely crinoidal, *Archimedes;* disconformable contact with limestone above	1.0
	12. Limestone	8.0
	11. Limestone: blue gray, medium to coarse medium; granular and uneven beds; *Archimedes* and *Pentremites* abundant	1.0
	10. Covered: probably shale	8.0
	9. Limestone: dark blue gray, rubbly	2.0
	Estimated thickness of Pitkin	20.0

		Feet
Chester-Meramec? series		
8.	Limestone and shale: limestone sublithographic crystalline, averaging 4 inches thick; thin, uneven, calcareous shale seams, with slightly calcareous black pebbles	14.0
7.	Limestone and shale: limestones average 3 inches thick; shaly, blue gray sublithographic; weather rubbly. Shale; black, well jointed, carbonaceous	10.0
6.	Shale	6.0
5.	Chert and cherty limestone	6.0
4.	Shale	4.0
3.	Limestone: grades into shale above	2.0
2.	Limestone: black to blue black, shaly, thin-bedded	8.0
	Estimated thickness of Chester-Meramec? series	50.0
Osage series		
1.	Chert	

14. CIRCLE A RANCH SECTION. SEC. 30, T. 13 N., R. 23 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
	Covered to top of hill	
24.	Sandstone: poorly exposed	4.0
23.	Shale: sandy	8.0
22.	Covered	50.0
	Exposed thickness of Atoka	62.0
Morrow series		
Bloyd formation		
21.	Shale: poorly exposed	4.0
20.	Limestone: blue, fine; weathers yellow buff, smooth and in big pittings	2.0
19.	Shale: blue gray, fissile, limonite concretions	6.0
18.	Siltstone: blue gray, calcareous; weathers fissile, peculiar "worm" impressions	3.0
17.	Shale: blue gray, fissile, limonite concretions	9.0
16.	Limestone: gray to blue gray; crinoidal, fossiliferous	2.0
15.	Shale	2.0
14.	Limestone: blue, coarse medium; uneven bedded; weathers brown and crinoidal, and rubbly in upper part	10.0
13.	Shale: calcareous	3.0
12.	Limestone: blue gray	1.0
11.	Covered	10.0
10.	Limestone with few shale breaks	29.5
9.	Shale: buff, calcareous; very fossiliferous, abundant *Pentremites*	0.5
8.	Limestone, few discontinuous shale breaks: gray blue in the upper part, fine medium with very coarse crystals; uneven and irregular bedded, cross-bedded; very crinoidal, extremely fossiliferous, *Pleurodictyum* (*Michelinia*), bryozoans, *Pentremites, Composita, Spirifer*	12.0
7.	Covered	13.0
6.	Limestone; very coarse; weathers granular and fluted; crinoidal, bryozoans abundant; seems to grade into limestone below	3.0
5.	Limestone: blue gray, buff bands and streaks; carries banded "algal" pebbles; weathers buff and rubbly	2.0
4.	Shale	10.0
3.	Covered	12.0
	Thickness of Bloyd	134.0
Hale formation		
2.	Limestone: dark gray with black calcite crystals, medium with very coarse crystals; weathers brown gray, thin-bedded and platy; crinoidal	4.0
1.	Limestone: granular; few thin shale streaks	14.0
	Covered below	
	Exposed thickness of Hale	18.0

15. SALT CREEK SECTION. SEC. 18, T. 13 N., R. 26 E., SEC. 13, T. 13 N., R. 25 E.

		Feet
Pennsylvanian		
Morrow series		
Bloyd formation		
	Covered above by sandstone rubble	
11.	Limestone: brown gray, coarse medium to medium; weathers smooth and jointed; crinoidal, fossiliferous	1.5
10.	Shale	5.0
9.	Limestone: blue gray, coarse to coarse medium; weathers "chocolate brownish" and shaly; very fossiliferous especially on weathered surface, crinoidal with large crinoid stems	3.0
8.	Shale with thin limestone beds	8.0
7.	Limestone: blue, earthy matrix with coarse and very coarse crystalline masses, shaly; very fossiliferous, *Pentremites*	0.5
6.	Shale	4.0
5.	Limestone	0.5
4.	Shale	7.0
3.	Limestone: blue, coarse crystalline masses; thin-bedded; very fossiliferous, *Composita*	0.8
2.	Limestone: blue to blue gray, variably crystalline; unevenly bedded, conglomeratic at base; very fossiliferous, *Pleurodictyum* (*Michelinia*)	2.2
	(Beds 2-11 correlated with Kessler member.)	
1.	Shale, poorly exposed, may be referable to Bloyd below Kessler member	10.0
	Exposed thickness of Bloyd	42.5

16. W. QUALLS SECTION. SEC. 11, T. 14 N., R. 21 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
27.	Sandstone: poorly exposed	6.0
26.	Sandstone: medium grained, cross-bedded, heavily iron stained	10.0
	Exposed thickness of Atoka	16.0
Morrow series		
Bloyd formation		
25.	Shale	10.0
24.	Limestone: brown gray, very coarse; weathers thin bedded and granular; crinoidal, fossiliferous	3.0
23.	Shale	5.0
22.	Limestone: light blue on weathering, poorly exposed	1.0
21.	Shale: blue gray, fissile, limonite concretions	5.0
20.	Limestone: blue gray, fine medium, few coarse crystals, well jointed; weathers thin bedded	6.0
19.	Limestone: gray, very coarse; weathers granular and rubbly; crinoidal; many thin shale beds	20.0
18.	Limestone: gray, sublithographic, with black calcite crystals; very fossiliferous, *Pleurodictyum* (*Michelinia*), productids, *Spirifer*, immature *"Gastrioceras"*	2.0
17.	Limestone: some is granular, some thin bedded to knobby	8.0
16.	Shale	2.0
15.	Limestone: gray, fine with sublithographic lenses, brittle;	

		Feet
	weathers smooth; fossiliferous, *Pentremites*	3.0
14.	Covered	15.0
13.	Shale	12.0
	Estimated thickness of Bloyd	92.0
	Hale formation	
12.	Limestone: blue gray-black, coarse; weathers smooth; moderately crinoidal, fossiliferous	2.0
11.	Covered	2.0
10.	Limestone: very coarse, crinoidal	1.0
9.	Covered	3.0
8.	Sandstone: light gray, medium grained, slightly calcareous, heavily iron stained	1.0
7.	Covered	3.0
6.	Limestone: dark gray, coarse; fossiliferous; granular bed near middle	7.0
5.	Limestone: light gray to cream gray, fine even crystalline; weathers platy; moderately fossiliferous	1.0
	Estimated thickness of Hale	20.0
	Mississippian	
	Chester series	
	Pitkin limestone	
4.	Covered	12.0
3.	Limestone: blue gray, fine; weathers jointed and smooth; fossiliferous, crinoidal	6.0
2.	Limestone: blue gray, fine medium; weathers crinoidal iron stained buff; fossiliferous	2.0
1.	Limestone: blue gray, fine, well jointed; very fossiliferous, *Archimedes, Pentremites, Linoproductus*	6.0
	Covered below	
	Estimated exposed thickness of Pitkin	26.0

17. S. QUALLS SECTION. SEC. 13, T. 14 N., R. 21 E.

	Pennsylvanian	
	Des Moines series	
	Atoka formation	
	Covered above	
31.	Sandstone: massive bedded, fine to medium grained, yellow brown, iron stained	8.0
	Exposed thickness of Atoka	8.0
	Morrow series	
	Bloyd formation	
30.	Covered	9.6
29.	Shale: poorly exposed, sandy; buff on weathering	5.6
28.	Shale: blue gray, fissile, limonite concretions	16.8
27.	Limestone: blue gray with greenish argillaceous bands, streaks and lenses, very coarse; reddish on weathering; coarsely crinoidal	2.0
26.	Shale: sandy, fissile	1.0
25.	Shale: poorly exposed	8.1
24.	Limestone: gray, coarse; very fossiliferous, bryozoans, *Pentremites*, productids, *Rhipidomella?*, *Spirifer*, gastropods	3.0
23.	Covered	13.2
22.	Shale: poorly exposed, blue gray, fissile	11.2
21.	Covered	22.4
20.	Limestone: very coarse, crinoidal, granular, few sandy inclusions; weathers thin-bedded	3.0
19.	Covered	2.0
18.	Limestone: light gray, coarse even, crinoidal; weathers smooth; fossiliferous	3.0

		Feet
17.	Shale: poorly exposed	10.0
16.	Limestone: blue gray, coarse even crystalline; weathers smooth; crinoidal	2.0
15.	Shale: poorly exposed	3.5
14.	Limestone: light gray, fine with many coarse crystals; fossiliferous, crinoidal	2.5
13.	Shale	2.0
	Estimated thickness of Bloyd	120.9
	Hale formation	
12.	Sandstone: medium grained, soft, friable, agrillaceous, heavily ironed stained, spongy, honeycombed; casts of bryozoans, corals, *Spirifer, Composita,* trilobite pygidium	1.0
11.	Covered	1.0
10.	Limestone: blue to purplish gray; thin and uneven bedded; weathers crinoidal; very fossiliferous	3.5
9.	Covered	2.0
8.	Shale: buff, iron streaked	3.0
7.	Sandstone: yellow brown, medium grained, iron stained	6.0
	Estimated thickness of Hale	16.5
	Mississippian	
	Chester series	
	Pitkin limestone	
6.	Covered	9.1
5.	Limestone: blue to blue gray with blue agrillaceous bands and lenses, fine with coarse crystals; weathers rubbly; fossiliferous, crinoidal	2.0
4.	Covered	2.5
3.	Limestone: dark blue gray, coarse even crystalline; weathers smooth; moderately fossiliferous, crinoidal	2.0
2.	Covered	6.5
1.	Shale: heavily iron stained and streaked	3.5
	Covered below.	
	Estimated exposed thickness of Pitkin	25.6

18. GREENLEAF CREEK SECTION. SEC. 30, T. 14 N., R. 21 E.

	Atoka formation	30.0
	Bloyd formation	62.0
	Hale formation	18.0
	Pitkin limestone	28.0
	Covered below.	

19. ELK CREEK SECTION. SEC. 23, T. 14 N., R. 23 E.

	Pennsylvanian	
	Des Moines series	
	Atoka formation	
49.	Covered: sandstone rubble	30.0
48.	Sandstone: thin-bedded	10.0
47.	Covered: may be mostly sandstone	30.0
46.	Sandstone	8.0
	Exposed thickness of Atoka	78.0
	Morrow series	
	Bloyd formation	
45.	Covered: probably shale	10.0
44.	Shale	7.0
43.	Limestone, very sandy: thin-bedded; weathers iron stained	1.0
42.	Shale	4.0
41.	Limestone: gray, sublithographic, compact; weathers smooth and in light blue splotches; fossiliferous	2.0

		Feet
40.	Covered	18.0
39.	Shale: blue gray, fissile, limonite concretions	8.0
38.	Limestone: gray, medium with coarse crystals; weathers rubbly and spalls off	2.0
37.	Covered	4.0
36.	Limestone: blue to blue gray, very fine to sublithographic; uneven bedded; weathers buff and rubbly	2.0
35.	Covered	4.0
34.	Limestone: gray to blue gray, fine to very fine, few coarse crystals; weathers rough and moderately iron stained buff; fossiliferous, crinoidal	2.0
33.	Covered, poorly exposed shale in lower few feet	25.5
32.	Limestone: blue gray, heavily iron stained buff, very argillaceous; extremely fossiliferous, corals, *Pentremites,* crinoid base	0.5
31.	Shale	2.0
30.	Limestone: dark blue gray, medium, with coarse crystals; weathers smooth and moderately iron stained buff	3.0
29.	Shale, poorly exposed	14.0
28.	Limestone: dark neutral gray, very fine to sublithographic; conchoidal fracture, uneven bedded; weathers smooth; moderately fossiliferous	1.0
27.	Shale: poorly exposed	12.0
26.	Limestone: blue gray, fine medium; uneven bedded, jointed, thin-bedded on weathering; fossiliferous, *Aulopora, Spirifer, Dictyoclostus*	2.0
25.	Limestone	11.0
24.	Limestone: black, coarse medium with very coarse crystalline lenses; weathers granular and crinoidal	2.0
23.	Shale	7.0
22.	Limestone: dark blue gray, coarse, iron spotted; weathers smooth; crinoidal	4.0
21.	Shale	6.0
	Thickness of Bloyd	154.0
Hale formation		
20.	Limestone: locally sandy; weathers thin-bedded	6.0
19.	Limestone: blue gray, medium to fine medium, with coarse crystals, oolitic, iron spotted; weathers in light blue splotches and rubbly	4.0
18.	Limestone, very sandy: light gray; thin uneven bedded; highly glauconitic	2.0
17.	Sandstone, calcareous: light gray, iron spotted, fine grained; cross-bedded	1.0
16.	Limestone	1.0
15.	Shale: poorly exposed	2.0
14.	Limestone: light gray, medium, sandy streaks, uneven bedded; weathers rough and rubbly; fossiliferous, abundant bryozoans	4.0
13.	Limestone: blue gray, very coarse, large calcite masses; granular on weathering; very crinoidal, fossiliferous	8.0
12.	Limestone: light gray, medium grained; uneven bedded; weathers thin-bedded; fossiliferous	2.0
11.	Limestone	10.0
10.	Limestone, very sandy: dark blue gray, medium, with lenses of very coarse crystals, argillaceous streaks, iron spotted	2.0
9.	Sandstone, calcareous: yellow brown, fine grained; cross bedded; few thin beds of pitted and cavernous weathering; iron spotted and stained	1.0
8.	Limestone, sandy: heavily iron stained, very coarse; thin-bedded; extremely crinoidal	5.0
	Thickness of Hale	48.0

Mississippian

		Feet
Chester series		
Pitkin limestone		
7.	Limestone: many shale breaks; upper part light blue, jointed; lower part neutral gray, very fine to sublithographic; well jointed; weathers smooth and knobby; *Archimedes, Pentremites*	20.0
	Thickness of Pitkin	20.0
Fayetteville shale		
6.	Covered	4.0
5.	Shale: black, clayey at base; carries thin 3- to 4-inch limestone beds	2.0
4.	Limestone: fossiliferous, corals, *Archimedes,* large crinoid stems, *Composita*	1.0
3.	Covered	7.0
	Estimated thickness of Fayetteville	14.0
Meramec? series		
2.	Limestone: with few thin shale beds	25.0
	Thickness of Meramec?	25.0
Osage series		
1.	Chert	

20. TERRAPIN CREEK SECTION. SEC. 29, T. 14 N., R. 23 E.

Pennsylvanian

		Feet
Des Moines series		
Atoka formation		
32.	Sandstone: cross-bedded, thin beds, ripple marks ranging from 4 to 5 inches from crest to crest. Poorly exposed in upper 8 feet	28.0
31.	Covered	50.0
	Estimated thickness of Atoka	78.0
Morrow series		
Bloyd formation		
30.	Covered; evidences of blue gray shale in upper part	54.0
29.	Limestone: neutral gray, medium to fine medium; weathers into massive granular beds in upper part and thin-bedded in lower part; almost a fossil coquina, small spired gastropods abundant	5.0
28.	Shale and covered	10.0
27.	Shale: blue gray, fissile, limonite concretions	8.0
26.	Limestone: light gray to light blue gray, medium, with many large calcite masses; weathers with light blue splotches and pitted; very fossiliferous	3.0
25.	Shale: blue gray, fissile, limonite concretions	14.0
24.	Limestone: blue gray, coarse; weathers smooth and locally thin-bedded and granular; fossiliferous, crinoidal, *Spirifer*	3.0
23.	Covered	7.0
22.	Limestone: compact, poorly exposed	2.0
21.	Covered	13.0
20.	Limestone: blue gray to brown gray, very coarse; very thin-bedded on weathering; very crinoidal	3.0
19.	Limestone: gray, very fine; uneven bedded; weathers yellow buff with blue splotches; fossiliferous, *Pentremites*	2.0
18.	Limestone-shale: thin limestone beds, blue, sublithographic, crystalline, rubbly	18.0
17.	Covered	5.0
16.	Limestone: blue gray, very coarse; crinoidal	2.0
15.	Shale: blue gray, fissile, limonite concretions	7.0
	Estimated thickness of Bloyd	156.0

	Feet
Hale formation	
14. Limestone: gray with purplish hue, medium to fine medium; weathers honeycombed	3.0
13. Covered	5.0
12. Shale, sandy: blue gray	8.0
11. Shale: blue gray, fissile, limonite concretions	6.0
10. Limestone: blue to purplish gray, medium to fine medium; uneven bedded; weathers thin-bedded	4.0
9. Covered	13.0
8. Limestone: blue gray, medium; fossiliferous	4.0
7. Sandstone: very calcareous; blue gray, medium grained; weathers fluted, pitted, and cavernous. Insoluble residue shows 59% sand grains	3.0
6. Covered	2.0
5. Limestone: gray with black crystals, medium to fine medium; weathers smooth	3.0
Thickness of Hale	51.0
Mississippian	
Chester series	
Pitkin limestone	
4. Limestone and shale	17.0
Thickness of Pitkin	17.0
Fayetteville shale	
Shale and covered	20.0
Thickness of Fayetteville	20.0
Meramec? series	
2. Limestone, with few thin shale beds: gray brown, very coarse, platy, crinoidal; weathers granular. Well exposed, disconformable, contact on Boone chert	20.0
Osage series	
1. Chert and cherty limestone	

21. HIGH MT. SECTION. SECS. 2, 3, 10 AND 11, T. 14 N., R. 24 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
27. Sandstone: partly concealed	14.0
26. Covered	18.0
25. Siltstone: thin-bedded	5.0
24. Covered	52.0
23. Siltstone: thin-bedded	3.0
22. Sandstone: light gray; somewhat cross-bedded; weathers yellow brown	18.0
Exposed thickness of Atoka	110.0
Morrow series	
Bloyd formation	
21. Shale: dirty black, fissile; good contact with overlying sandstone	10.0
20. Covered	82.0
19. Limestone: gray, very coarse, granular, tough; weathers smooth and crinoidal; fossiliferous	2.0
18. Covered	32.0
17. Limestone: light gray to yellowish gray, medium to coarse medium, some very coarse crystals; weathers smooth and buff	4.0
16. Covered	3.0
15. Limestone: blue gray, fine to fine medium with coarse black crystals; weathers yellow brown and rough	9.0
Thickness of Bloyd	142.0
Hale formation	
14. Limestone: dark blue gray to gray black, fine to sublithographic; weathers knobby and rubbly; appears to cap the calcareous sandstone below	2.0
13. Sandstone: calcareous	4.0
12. Covered	12.0
11. Limestone, very sandy: light gray; weathers in parallel horizontal flutings	5.0
10. Limestone: gray, very coarse; weathers light blue, smooth to pitted	12.0
9. Sandstone, calcareous	33.0
Thickness of Hale	68.0
Mississippian	
Chester series	
Pitkin limestone	
8. Limestone: dark blue to dark blue gray, fine medium with very coarse black crystals; weathers crinoidal, rough and jointed; fossiliferous	5.0
7. Covered	16.0
Estimated thickness of Pitkin	21.0
Fayetteville shale	
6. Covered	29.0
5. Limestone: brown; very fossiliferous, many *Archimedes*	2.0
4. Covered	19.0
3. Shale: blue black, limonite concretions	8.0
Estimated thickness of Fayetteville	58.0
Meramec? series	
2. Limestone: blue gray, variably crystalline; some thin shale breaks	21.0
Thickness of Meramec?	21.0
Osage series	
1. Chert	

22. BEAVER MT., SECS. 8 and 17, T. 14 N., R. 24 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
26. Covered; sandy soil and siltstone rubble	17.0
Estimated thickness of Atoka	17.0
Morrow series	
Bloyd formation	
25. Shale: blue gray, fissile, limonite concretions	16.0
24. Limestone: blue to brown gray, fine to sublithographic; weathers pitted; slightly fossiliferous; locally conglomeratic	5.0
23. Covered	20.0
22. Shale: blue gray, fissile, limonite concretions	6.0
21. Limestone: brown gray and gray to black, very coarse, tough; weathers smooth and slightly crinoidal	3.0
20. Limestone and shale	10.0
19. Covered	2.0
18. Limestone: dark blue brown gray, coarse medium; weathers into well jointed blocks; fossiliferous	4.0
17. Covered	3.0
16. Limestone: blue gray, fine medium to fine, some coarse crystals; weathers rough and somewhat pitted; moderately fossiliferous	3.0
15. Limestone: gray, fine; weathers smooth	2.0
14. Covered	3.0
13. Limestone: dark blue black, much orange calcite, coarse; well bedded; weathers in thin horizontal flutings; includes several thin shale beds	28.0

		Feet
	12. Limestone: brown gray, very coarse; weathers rough with some thin bedded intervals	5.0
	Thickness of Bloyd	110.0
Hale formation		
	11. Limestone: similar to bed 9; weathers with sandy inclusions	3.0
	10. Covered	2.0
	9. Limestone: gray with purplish tints, coarse; weathers rough light blue gray; fossiliferous	5.0
	8. Covered	6.0
	7. Limestone: light gray to white or cream gray, coarse, glauconitic; weathers yellow brown, sandy and pitted	6.0
	6. Covered	22.0
	5. Sandstone: some beds slightly calcareous; beds average 0.5 to 1 foot thick	14.0
	4. Sandstone: slightly calcareous; thin-bedded; average ¼ to 1-inch thick, irregularly bedded, ripple marked, thin shale partings	6.0
	3. Conglomerate, calcareous; very coarse, trace phosphatic, few limonite pebbles	0.2
	Thickness of Hale	64.2
Mississipian		
Chester series		
Pitkin limestone		
	2. Limestone: blue gray to gray black, very coarse; weathers granular; crinoidal	2.5
	1. Limestone: brown gray, sublithographic, breaks with a subconchoidal fracture; weathers light blue and somewhat blocky.	14.0
	Covered below	
	Exposed thickness of Pitkin	16.5

23. BUNCH MT., SEC. 15, T. 14 N., R. 24 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
	33. Covered: shale and sandstone rubble	42.0
	32. Sandstone: massive bedded	3.0
	Estimated thickness of Atoka	45.0
Morrow series		
Bloyd formation		
	31. Covered: few poor exposures of shale	63.0
	30. Limestone: blue gray, fine medium to medium; weathers smooth with light blue splotches on surface; fossiliferous	3.0
	29. Covered	12.0
	28. Limestone: brown gray, coarse to very coarse, granular; weathers thin-bedded; fossiliferous	7.0
	27. Limestone: blue gray brown, fine medium with very coarse crystals; weathers buff and light blue and knobby	3.0
	26. Shale: blue gray, fissile, limonite concretions	5.0
	25. Covered	4.0
	24. Limestone: blue gray with black crystals, fine medium; weathers smooth and crinoidal	3.0
	23. Covered	4.0
	22. Limestone: gray, coarse; weathers smooth and platy; fossiliferous	6.0
	21. Covered	11.0
	20. Limestone: brown gray, coarse; weathers crinoidal; fossiliferous	3.0

		Feet
	19. Covered	25.0
	Estimated thickness of Bloyd	149.0
Hale formation		
	18. Limestone: blue gray black, fine compact, tough; weathers platy, in big pits and crinoidal	2.0
	17. Covered	2.0
	16. Limestone: blue gray, medium with larger crystals; weathers rough, pitted, and platy; fossiliferous	6.0
	15. Covered	11.0
	14. Limestone: light gray, very coarse; weathers yellow brown with horizontal parallel flutings	3.0
	13. Sandstone: locally very calcareous	16.0
	12. Limestone: very coarse: crinoidal	8.0
	11. Sandstone, very calcareous: blue black, fine medium; weathers pitted, cavernous and yellow brown	9.0
	Thickness of Hale	57.0
Mississippian		
Chester series		
Pitkin limestone		
	10. Limestone: dark blue gray, coarse; thin-bedded and flaky to platy; fossiliferous, trace phosphatic	1.0
	9. Limestone: gray, fine to medium, locally oolitic; grades into bed above	2.5
	8. Limestone: dark blue gray, fine to fine medium; fossiliferous, grades into bed above	1.0
	7. Limestone: gray, fine medium and medium, oolitic near top; weathers rough, blocky and buff	3.0
	6. Covered	12.0
	Estimated thickness of Pitkin	19.5
Fayetteville shale		
	5. Covered	19.0
	4. Limestone: brown; many *Archimedes*	2.0
	3. Covered	38.0
	Estimated thickness of Fayetteville	59.0
Meramec? series		
	2. Limestone: blue gray, variably crystalline	12.0
	Estimated thickness of Meramec?	12.0
Osage series		
	1. Chert	

24. BEAVER MT., SEC. 18, T. 14 N., R. 24 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
	20. Sandstone: thin-bedded	10.0
	19. Covered	52.0
	18. Sandstone: beds average 1 inch thick	6.0
	17. Covered	66.0
	Estimated thickness of Atoka	134.0
Morrow series		
Bloyd formation		
	16. Covered	16.0
	15. Shale: blue gray, fissile, limonite concretions	4.0
	14. Limestone: brownish blue gray, fine, tough; weathers in light blue splotches	3.0
	13. Shale: blue gray, fissile, limonite concretions	4.0
	12. Covered	62.0
	11. Limestone: weathers thin-bedded	4.0
	10. Covered: includes several poorly exposed limestone beds	45.0

	Feet
9. Limestone: blue gray and brown gray, very coarse; weathers smooth and brown	3.0
8. Covered	6.0
Estimated thickness of Bloyd	147.0
Hale formation	
7. Limestone, sandy: very coarse; weathers in horizontal flutings	6.0
6. Covered	21.0
5. Limestone: gray, fine medium, oolitic; weathers thin-bedded	3.0
4. Covered	10.0
3. Limestone, sandy: fossiliferous	4.0
2. Covered	17.0
Estimated thickness of Hale	61.0
Mississippian	
Chester series	
Pitkin limestone	
1. Limestone, poorly exposed: more massive near the base	7.0
Covered below	
Exposed thickness of Pitkin	7.0

25. BEAVER MT., SECS. 19 AND 20, T. 14 N., R. 24 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
32. Sandstone	4.0
31. Covered	28.0
30. Siltstone: greenish, thin-bedded, heavily limonite stained	18.0
29. Covered	15.0
Estimated thickness of Atoka	65.0
Morrow series	
Bloyd formation	
28. Covered: includes some shale	15.0
27. Limestone: gray and blue gray, fine to sublithographic, some coarse crystals, tough; weathers light blue and pitted	5.0
26. Covered	17.0
25. Limestone: thin-bedded	2.0
24. Covered	4.0
23. Limestone: dark blue gray, very coarse; weathers crinoidal and smooth	2.0
22. Shale: blue gray, fissile, limonite concretions	11.0
21. Limestone: weathers light blue	3.0
20. Covered	6.0
19. Limestone	3.0
18. Covered	12.0
17. Limestone and shale: the limestone in the upper part is thin-bedded and weathering buff, with light blue splotches	30.0
16. Covered	11.0
15. Shale: blue gray, fissile, limonite concretions	7.0
14. Limestone: gray to brown gray, very coarse, even crystalline; few shale beds	12.0
13. Covered, probably shale	5.0
Estimated thickness of Bloyd	145.0
Hale formation	
12. Limestone: light gray, sandy; weathers light blue gray	10.0
11. Covered	11.0
10. Sandstone: calcareous; fossiliferous	4.0
9. Covered: probably sandstone	10.0
8. Sandstone: calcareous; weathers pitted and cavernous	5.0
7. Covered	6.0

	Feet
6. Sandstone: very calcareous	4.0
Thickness of Hale	50.0
Mississippian	
Chester series	
Pitkin limestone	
5. Limestone: gray, medium, with coarser crystalline beds; weathers light blue and somewhat blocky	20.0
Thickness of Pitkin	20.0
Fayetteville shale	
4. Covered	16.0
3. Shale: blue black; contains two thin limestone beds in upper part	24.0
Thickness of Fayetteville	40.0
Meramec? series	
2. Limestone: blue gray, variably crystalline; few thin shale streaks in upper part	22.0
Thickness of Meramec?	22.0
Osage series	
1. Chert and cherty limestone	

26. BEAVER MT., SEC. 30, T. 14 N., R. 24 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
38. Covered, sandy soil and sandstone rubble	23.0
37. Sandstone: thin-bedded, beds average 1 inch in thickness	4.0
36. Covered: includes poorly exposed sandstone and siltstone; sandstone rubble and sandy soil	115.0
Estimated thickness of the Atoka	142.0
Morrow series	
Bloyd formation	
35. Covered	78.0
34. Limestone: gray, medium; weathers buff and light blue splotched	2.0
33. Covered	8.0
32. Limestone: gray brown, medium; weathers buff and light blue splotched	2.0
31. Covered	16.0
30. Limestone: gray, fine with coarse crystals; weathers smooth and crinoidal; fossiliferous	2.0
29. Covered	11.0
28. Limestone: blue gray, very coarse; weathers thin-bedded and crinoidal; fossiliferous	3.0
27. Covered	4.0
26. Limestone: gray to brown gray, very coarse, glauconitic; weathers smooth; crinoidal	3.0
25. Shale: blue gray, fissile, limonite concretions	4.0
24. Limestone: dark blue to blue black, medium; weathers buff and smooth; many crinoid stems replaced by orange calcite, fossiliferous	4.0
23. Covered	3.0
Estimated thickness of Bloyd	140.0
Hale formation	
22. Limestone: very coarse, crinoidal, granular	8.0
21. Covered	8.0
20. Limestone: gray, coarse medium; weathers sandy; fossiliferous	3.0
19. Sandstone: weathers pitted and cavernous	2.0
18. Covered	7.0
17. Shale: yellow brown	6.0

		Feet
	16. Sandstone, calcareous; weathers yellow brown, pitted and cavernous; fossiliferous	5.0
	15. Covered	3.5
	14. Limestone: gray, fine medium to medium, rubbly; weathers smooth, pitted and in large flutings; fossiliferous	5.0
	13. Limestone: gray with parallel black bands, fine medium with coarse crystals, highly glauconitic; weathers in horizontal flutings	1.0
	12. Covered	3.0
	11. Sandstone, calcareous: light gray, medium; weathers yellow brown and cross bedded	7.6
	10. Covered	4.5
	9. Sandstone, calcareous: weathers pitted, cavernous and in horizontal flutings	1.5
	8. Covered	3.0
	7. Limestone: brown gray; thin-bedded to platy; weathers flaky; fossiliferous	1.0
	Thickness of Hale	69.1
Mississippian		
Chester series		
Pitkin limestone		
	6. Limestone: blue gray to brown gray, coarse medium; weathers smooth, in big pittings and blocky	10.0
	5. Covered	10.0
	Estimated thickness of the Pitkin	20.0
Fayetteville shale		
	4. Covered, probably shale	44.0
	Estimated thickness of Fayetteville	44.0
Meramec? series		
	3. Covered	30.0
	Estimated thickness of Meramec?	30.0
Osage series		
	2. Chert and cherty limestone, generally poorly exposed	186.0
	Thickness of Osage	186.0
Kinderhook series		
Sylamore sandstone		
	1. Sandstone: light gray glassy, medium even grained	2.0
	Covered below	
	Exposed thickness of Sylamore	2.0

27. CANTRELL MT., SEC. 6, T. 14 N., R. 25 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
	18. Sandstone: yellow brown; massive bedded	8.0
	17. Covered	49.0
	16. Siltstone: brown buff with greenish hue; thin-bedded	16.0
	15. Sandstone: thin-bedded	8.0
	Exposed thickness of Atoka	81.0
Morrow series		
Bloyd formation		
	14. Covered: includes some blue gray fissile shale	127.0
	13. Limestone: light blue gray, resinous appearance, coarse; weathers smooth and crinoidal	3.0
	12. Covered	10.0
	11. Limestone: blue to purplish gray, coarse medium with larger crystals; weathers smooth, crinoidal, and buff; fossiliferous	2.0
	10. Covered	5.0
	9. Limestone: light gray to dark gray, coarse medium, locally sandy; weathers pitted and rough; fossiliferous	7.0

		Feet
	8. Covered	11.0
	7. Limestone: similar to bed 5 below	2.0
	6. Covered	5.0
	5. Limestone: gray to black with some brown coloring, medium to coarse medium, large blue black shaly inclusions with *Pleurodictyum* (*Michelinia*); weathers rough, dirty brown, and crinoidal; fossiliferous	2.0
	Estimated thickness of Bloyd	174.0
Hale formation		
	4. Covered	18.0
	3. Sandstone, calcareous: cross-bedded near the base	37.0
	2. Covered	5.0
	Estimated thickness of Hale	60.0
Mississippian		
Chester series		
Pitkin limestone		
	1. Limestone: blue gray; very fossiliferous, *Archimedes*	14.0
	Covered below	
	Exposed thickness of Pitkin	14.0

28. SECTION ON A TRIBUTARY TO LITTLE LEE CREEK, SEC. 8, T. 14 N., R. 26 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
	Covered to top of hill	
	24. Shale and siltstone: dirty yellow with greenish hue	11.0
	23. Covered	39.0
	Estimated thickness of Atoka	50.0
Morrow series		
Bloyd formation		
	22. Shale and covered: blue gray, fissile, limonite concretions	17.0
	21. Limestone: blue gray to brown gray, variably crystalline; weathers platy and crinoidal; upper half fossiliferous	7.0
	(Note: Beds 21, 22 correlated with Kessler member of Bloyd formation. Total thickness 24 feet.)	
	20. Covered: few shale indications	17.0
	19. Shale and covered: blue gray, fissile, limonite concretions	25.0
	18. Limestone: blue gray; weathers even and granular; extremely crinoidal, many crinoid stems replaced with orange calcite	5.0
	17. Covered	6.0
	16. Limestone: dark blue gray; platy to massive bedded; crinoidal	2.0
	15. Covered	15.0
	14. Limestone: brown gray, coarse; platy to massive, crinoidal	2.0
	13. Covered	4.0
	12. Shale: blue gray, fissile, limonite concretions	4.0
	11. Limestone: gray black, coarse; weathers smooth; fossiliferous and crinoidal	3.0
	10. Shale: blue gray, fissile, limonite concretions	5.0
	9. Covered	13.0
	Estimated thickness of Bloyd	125.0
Hale formation		
	8. Sandstone: thin-bedded, limonite stained	1.0
	7. Covered	8.2
	6. Limestone: light blue gray, coarse; fossiliferous, very crinoidal, crinoid stems replaced by orange calcite	16.8
	5. Limestone: dark blue gray, limonite and glauconite spotted	1.5
	4. Shale, very sandy: steel blue black, somewhat fissile	8.0

		Feet
3.	Sandstone; calcareous	3.0
2.	Limestone: gray, very coarse; forms small benches in the cliff; crinoids	5.5
1.	Sandstone, calcareous	4.0
	Covered below by bed of stream	
	Exposed thickness of Hale	48.0

29. GOOSE NECK BEND. SEC. 26, T. 15 N., R. 19 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
20.	Sandstone: massive bedded	6.0
19.	Sandstone, calcareous: iron stained buff; cross-bedded and thin uneven bedded	8.0
	Exposed thickness of Atoka	14.0
Morrow series		
Bloyd formation		
18.	Covered	8.0
17.	Shale: blue gray, fissile, limonite concretions; poorly exposed	6.0
16.	Limestone: blue gray, medium, heavily iron stained; thin and uneven bedded; weathers platy and spalls off	4.0
15.	Covered	16.0
14.	Shale: blue gray, fissile, limonite concretions	4.0
13.	Limestone: gray, fine medium crystalline, coarse in lower part; fossiliferous, crinoidal; few thin shale beds	16.0
12.	Shale: poorly exposed	14.0
11.	Limestone: blue gray, heavily iron stained, very coarse to coarse; thin-bedded; weathers into small platy boulders; crinoidal, fossiliferous	2.0
10.	Shale: poorly exposed, includes a limestone bed that is light blue on weathering	10.0
9.	Limestone: blue gray to brown gray, medium crystalline with coarse crystals and calcite masses; massive- to thin-bedded; weathers brown buff; *Pentremites*	4.0
8.	Shale: poorly exposed	10.0
7.	Limestone: gray, heavily iron spotted, coarse with very coarse crystals; massive and thin, uneven bedded; crinoidal, fossiliferous, bryozoans	2.0
6.	Shale: poorly exposed	11.0
5.	Limestone: gray, coarse medium; crinoidal	3.0
4.	Shale: poorly exposed	10.0
	Estimated thickness of Bloyd	120.0
Hale formation		
3.	Limestone: conglomeratic	0.5
2.	Limestone	30.0
1.	Limestone: blue gray, heavily iron stained, very coarse with large calcite crystals; weathers granular; crinoidal	4.0
	Covered below	
	Exposed thickness of Hale	34.5

30. WEST NIGGER HOLLOW SECTION. SEC. 12, T. 15 N., R. 20 E.

	Feet
Atoka formation	14.0
Bloyd formation	114.0
Hale formation	46.0
Pitkin limestone	66.0

31. EAST BRAGGS MOUNTAIN SECTION. SECS. 21 and 28, T. 15 N., R. 20 E. ALONG NEW ROAD CUT ON HIGHWAY 10 BETWEEN MUSKOGEE AND BRAGGS

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
45.	Sandstone: stained tan and buff, fine grained at base; locally cross bedded. There is a trace of coal smut at base	8.0
	Exposed thickness of Atoka	8.0
Morrow series		
Bloyd formation		
44.	Sandstone and sandy shale: fine, stained brown to tan	3.0
43.	Shale: blue gray, fissile, seems to grade into sandy beds above	5.0
42.	Limestone: blue gray, medium crystalline; weathers brown gray; crinoidal, fossiliferous. Seems to occur as a lens in the shale	5.5
41.	Shale: blue gray, fissile	8.5
40.	Limestone, poorly exposed: rubbly on weathering, weathers into pseudo cross beds; extremely crinoidal	3.0
39.	Shale, poorly exposed	9.0
38.	Limestone: blue gray, very fine crystalline, few shale breaks; crinoidal on weathering	6.0
37.	Shale: fine silty, gray and buff with greenish cast	4.0
36.	Covered, probably shale	3.0
35.	Limestone: blue gray; weathers buff; *Pentremites*	3.5
34.	Shale: blue gray, poorly exposed, fissile	5.0
	Estimated thickness of Bloyd	55.5
Hale formation		
33.	Limestone: poorly exposed, blue gray, medium to fine crystalline; thin bedded, platy, may include some shale	8.0
32.	Shale: calcareous, marly buff; fossiliferous nodules at top, *Composita,* crinoid stems	2.0
31.	Limestone as below, few thin shale beds	3.0
30.	Limestone: brown gray, coarse to medium crystalline, crinoidal; massive bedded in lower part, locally platy in upper part	11.0
29.	Shale: blue gray, fissile, weathers buff	10.0
28.	Limestone: brown gray, fine sandy; weathers into pseudo cross beds; upper part is platy; crinoidal	8.0
27.	Shale: blue gray, fissile; weathers iron stained buff; *Pleurodictyum* (*Michelinia*)	1.5
26.	Limestone: blue gray, very fine to sublithographic; fossiliferous, brachiopods, fenestellids	2.2
25.	Limestone: light blue gray, locally very sandy, fine granular, fine crystalline; weathers into honeycombed sandy beds. Conglomerate beds 3 to 6 inches at base, red, very limy. (At the time this section was measured the arrow on the highway curve sign pointed to lower contact)	11.0
	Estimated thickness of Hale	56.7
Mississippian		
Chester series		
Pitkin limestone		
24.	Limestone: light blue gray, fine crystalline; weathers porous and in pseudo cross beds; coquina-like beds of fossil fragments, crinoidal. Basal 2 to to 3 feet is dense concretionary limestone. Upper 3 feet oolitic, few glauconite specks; weathers porous and in pseudo cross beds; *Archimedes*	11.0
23.	Limestone, with thin dark shale breaks: rubbly, beds average 1-inch thick; concretionary, crinoidal	2.0

		Feet
22.	Limestone: blue gray, very fine to dense crystalline; brown gray on weathering; fossiliferous streaks, fenestellids, *Diaphragmus*, crinoidal	6.0
21.	Shale: dark gray, with thin concretionary limestone beds that average 2½ inches thick; *Archimedes;* a 3-inch limestone bed at top	6.0
20.	Limestone: brown blue gray, fine crystalline; fossiliferous, *Diaphragmus*	6.0
19.	Shale	0.3
18.	Limestone: blue gray, medium crystalline; appears cross bedded, limonite staining accentuates the cross bedding; crinoidal	4.5
17.	Shale: dark gray, soft	0.3
16.	Limestone: light blue gray, dense, tiny calcite inclusions; breaks with conchoidal fracture; weathers light gray, buff	17.0
15.	Limestone: gray, blue gray, lithographic, appears rubbly locally, concretionary; upper part is more massive bedded; medium crystalline; crinoidal, extremely fossiliferous, *Diaphragmus, Arichimedes*	6.5
	Estimated thickness of Pitkin	55.6
	Fayetteville shale	
14.	Shale and limestone: gray, concretionary; limestone beds average 4 inches thick, upper 6 inches is limestone; fossiliferous, gastropods, productids	7.5
13.	Limestone: gray brown; very fine crystalline; fossiliferous, *Composita*, productids	1.2
12.	Limestone: light blue gray, coarse to medium crystalline; brown gray on weathering; carries a wedging shale bed in top 2 feet; very crinoidal, *Archimedes*	10.0
11.	Limestone: blue gray, concretionary, dense, many thin shale beds	7.0
10.	Shale, with beds of concretionary limestone averaging 4 inches thick: blue gray, dense; weathers buff tan	18.0
9.	Shale: gray to dark gray, fissile	11.0
8.	Limestone as below	0.3
7.	Shale: gray, fissile, silty	0.3
6.	Limestone: gray brown to brown, shaly, silty, concretionary; iron stained on weathering	0.3
5.	Shale: gray to black, fissile; hard concretions with finely disseminated pyrite in few beds; buff in basal part on weathering	45.0
4.	Limestone: gray; beds average 1 foot thick; weathers buff yellow; very fossiliferous, *Composita* abundant, *Punctospirifer, Diaphragmus*	5.0
3.	Shale: gray to black, fissile-jointed; weathers iron stained	17.0
2.	Shale: tan, buff, soft, well jointed	12.0
	Estimated thickness of Fayetteville	134.6
	Meramec? series	
1.	Limestone: light gray to brownish, very fine (Mayes type), shaly; fossiliferous	4.0
	Covered below	

32. WEST BRAGGS MT. SECTION ALONG OLD ROUTE OF HIGHWAY 10. SEC. 29, T. 15 N., R. 20 E.

		Feet
	Pennsylvanian	
	Des Moines series	
	Atoka formation	
53.	Sandstone: cross-bedded, several thin-bedded layers, few fossils	45.0
	Exposed thickness of Atoka	45.0

		Feet
	Morrow series	
	Bloyd formation	
52.	Shale: blue gray, fissile, concretions; few covered intervals	36.6
51.	Limestone: blue, with black calcite crystals, coarse medium to fine medium; weathers iron stained buff	3.0
50.	Shale and covered	6.0
49.	Shale: buff with greenish cast, sandy; thin-bedded	2.0
48.	Shale: plastic, iron streaked	3.0
47.	Limestone: blue and buff mottled, fine medium; weathers buff; moderately fossiliferous	2.0
46.	Shale: blue gray	2.0
45.	Limestone: blue gray, fine medium to fine; weathers rather purplish, in thin uneven beds and rather rubbly	2.5
44.	Shale: blue gray, fissile, poorly exposed	9.6
43.	Limestone: blue, fine with medium crystalline bands and lenses; even bedded; weathers uneven and rather rubbly; moderately fossiliferous	1.0
	Thickness of Bloyd	67.7
	Hale formation	
42.	Limestone: blue gray, fine medium matrix with coarse crystals, has argillaceous streaks, crinoidal; weathers rather fluted; upper few inches shaly and extremely fossiliferous, bryozoa, *Pleurodictyum* (*Michelinia*), *Pentremites,* crinoid remains, *Punctospirifer*	20.2
41.	Shale: blue gray	0.4
40.	Limestone, sandy: light gray, very coarse to coarse; weathers in uneven and fluted beds; crinoidal, fossiliferous	4.5
39.	Limestone: blue to blue gray, fine crystalline; thin-bedded; moderately fossiliferous	2.5
38.	Covered	3.0
37.	Sandstone: slightly calcareous, medium- to fine-grained, heavily iron stained; thin-bedded	6.0
36.	Limestone: blue to blue gray with greenish hue, heavily iron stained, very coarse, very crinoidal, trace phosphatic; thin-bedded; grades into limestone below	0.3
35.	Limestone: dark blue, coarse; weathers smooth and spalls off; very fossiliferous, coarsely crinoidal	3.0
34.	Limestone: blue to blue gray, very coarse; moderately iron stained, small lenses appear very sandy; upper part rather uneven bedded and thinner bedded; weathers smooth, extremely crinoidal; very fossiliferous	10.0
33.	Limestone: very sandy, medium grained, ferruginous	5.0
32.	Limestone: lower half is good conglomerate, upper half conglomeratic sandy limestone, contains limonite pebbles, iron spotted and stained	1.0
	Thickness of Hale	55.9
	Mississippian	
	Chester series	
	Pitkin limestone	
31.	Limestone: light blue gray, fine medium to fine; weathers smooth	2.0
30.	Limestone: blue to blue gray, coarse; weathers with large crinoid stems on surface and fluted; coarsely crinoidal, *Ethelocrinus* (*Eupachycrinus*) base	16.2
29.	Limestone: rubbly with thin shale partings	1.0
28.	Limestone: blue to blue gray, coarse; weathers rubbly and knobby; *Archimedes* common	5.5
27.	Limestone: neutral gray, variably crystalline, fine medium lenses in very coarse crystalline masses; very uneven bedded; weathers in cross bedded flutings and crinoidal; moderately iron spotted, extremely crinoidal, somewhat oolitic	10.0

		Feet
26.	Shale: black, fissile	0.5
25.	Limestone: dark blue gray with black crystals, fine; weathers iron stained; somewhat oolitic	1.0
24.	Shale: blue gray, fissile, sandy, calcareous	1.5
23.	Limestone: blue to brown, very argillaceous; thin-bedded; fossiliferous; seems to grade into shale above	0.5
22.	Limestone: very coarse with large black calcite masses, somewhat oolitic, carries lenses of crinoidal material, 10 to 22 mm thick	2.5
21.	Limestone: brown gray, fine, brittle	0.5
20.	Limestone: gray to brown gray, coarse; even bedded; fossiliferous, brown crinoid remains	2.5
19.	Limestone: blue gray and brown gray, very coarse; coarsely crinoidal, very fossiliferous; trace phosphatic	0.2
18.	Shale: slightly calcareous	0.3
17.	Limestone: rubbly and knobby	4.0
16.	Limestone: dark neutral gray, brittle, rubbly and knobby; thin uneven bedded, thin calcite veins; light blue buff on weathering; *Diaphragmus*	4.0
15.	Shale: black, fissile	4.0
14.	Limestone: extremely crinoidal, extremely oolitic in lower few inches, black calcite crystals; uneven bedded; weathers rough and crinoidal; *Archimedes*	5.0
13.	Limestone: and shale interbedded	1.0
12.	Shale: black, contains black calcite veins; buff on weathering	5.0
	Thickness of Pitkin	67.2
	Chester series	
	Fayetteville shale	
11.	Shale and covered: black shale, poorly exposed	20.4
10.	Limestone: gray, sublithographic	0.5
9.	Shale: black, fissile	5.6
8.	Shale: poorly exposed	11.2
7.	Shale: black, fissile, well jointed, trace phosphatic	9.2
6.	Shale: blue black, calcareous	2.0
5.	Shale: black, fissile, well jointed	5.6
4.	Shale: poorly exposed, many covered intervals	11.2
3.	Limestone: poorly exposed	2.0
2.	Covered	14.0
1.	Limestone: dark blue gray, very fine; weathers jointed, knobby, and buff	2.0
	Covered below	
	Exposed thickness of Fayetteville	83.7

33. RIVER BLUFF SECTION. W½ SEC. 32, T. 15 N., R. 20 E.

		Feet
	Pennsylvanian	
	Des Moines series	
	Atoka formation	
23.	Covered to top of hill, bed of sandstone	13.0
22.	Sandstone, poorly exposed	6.0
	Exposed thickness of Atoka	19.0
	Morrow series	
	Bloyd formation	
21.	Limestone: blue gray; uneven bedded; rubbly on weathering	3.0
20.	Covered	24.0
19.	Limestone: blue gray to brown gray, fine medium, with very coarse crystals; thin-bedded; appears sandy on weathering; fossiliferous, crinoidal	2.0
18.	Covered	45.0

		Feet
17.	Limestone: gray, very fine to sublithographic; weathers uneven bedded and rather rubbly	5.0
16.	Covered	28.0
	Estimated thickness of Bloyd	107.0
	Hale formation	
15.	Limestone:	6.0
14.	Limestone: blue gray, medium, sandy lenses and stringers; weathers red and purplish; fossiliferous	4.0
13.	Sandstone: upper 3 feet well exposed, calcareous, fossiliferous, phosphatic, fine-grained; sandy limestone lenses that are crinoidal	20.0
12.	Shale: blue gray, fissile	3.0
11.	Limestone, very shaly: blue gray to brown gray, coarse medium; extremely fossiliferous, bryozoans, *Pleurodictyum* (*Michelinia*), crinoid stems; carries peculiar white and black chert-like pebbles average 5 mm diameter, very iron stained	0.5
	Thickness of Hale	33.5
	Mississippian	
	Chester series	
	Pitkin limestone	
10.	Limestone: blue gray to brown gray, fine; many thin-bedded layers, grades laterally into oolitic, light buff gray limestone, fine, with some coarse crystalline crinoidal; weathers uneven and in cross-bedded flutings and spalls off	39.0
9.	Shale	2.0
8.	Limestone	2.0
7.	Limestone: gray to blue gray, sublithographic crystalline; weathers smooth; crinoidal, fossiliferous, bryozoans, brachiopods	7.0
6.	Shale: carries *Archimedes*	0.3
5.	Limestone: rubbly; weathers light blue	4.0
4.	Limestone: lower part, brown gray, fine to very fine; weathers buff and uneven; forms cliff	24.0
	Thickness of Pitkin	78.3
	Fayetteville shale	
3.	Covered	90.0
2.	Shale	20.0
1.	Limestone; poorly exposed	2.0
	Covered below	
	Exposed thickness of Fayetteville	112.0

34. WEST ZEB SECTION. SECS. 3 AND 10, T. 15 N., R. 21 E.

		Feet
	Pennsylvanian	
	Des Moines series	
	Atoka formation	
18.	Sandstone: poorly exposed to top of hill, cross-bedded	25.0
	Exposed thickness of Atoka	25.0
	Morrow series	
	Bloyd formation	
17.	Covered	6.0
16.	Shale: poorly exposed	4.0
15.	Covered	25.0
14.	Shale: poorly exposed	8.0
13.	Covered	12.0
12.	Limestone: Light blue gray and brown gray, fine with coarse crystals and large calcite masses; weathers rubbly, fossiliferous	3.0
11.	Covered, poorly exposed shale at top	22.0
	Estimated thickness of Bloyd	80.0

	Feet
Hale formation	
10. Limestone: blue gray, medium with very fine crystalline lenses; uneven bedding; weathers quite rubbly	5.0
9. Limestone: upper part light blue gray; uneven bedded; weathers in large horizontal flutings in some beds; fossiliferous; lower part blue gray and brown gray; much limonite staining, very coarse; weathers smooth and crinoidal	16.0
8. Covered: may be limestone	9.0
7. Limestone: blue gray, fine; uneven bedded; weathers uneven and in big pittings; moderately crinoidal, fossiliferous, bryozoa, *Orthotetes, Phricodothyris* (*Squamularia*), trilobite pygidium	1.0
6. Limestone	5.0
5. Limestone, very sandy: yellow to brown gray, fine medium with coarse crystals; weathers smooth, somewhat oolitic	1.0
4. Limestone	7.0
Thickness of Hale	44.0
Mississippian	
Chester series	
Pitkin limestone	
3. Limestone: dark blue gray, very coarse to coarse; weathers rather fluted, considerable iron staining, crinoidal; oolitic beds	9.0
2. Limestone: light blue, sublithographic	2.0
1. Limestone: blue gray, coarse medium to medium; massive bedded; weathers smooth; coarsely crinoidal, very fossiliferous, *Archimedes, Pentremites*	18.0
Concealed below	
Exposed thickness of Pitkin	29.0

35. EAST NIGGER HOLLOW SECTION. SECS. 7 and 18, T. 15 N., R. 21 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
45. Covered to top of hill: shaly soil and sandstone blocks	2.0
44. Covered	8.0
43. Sandstone	4.0
42. Covered	12.0
41. Sandstone: conglomeratic	2.0
Exposed thickness of Atoka	28.0
Morrow series	
Bloyd formation	
40. Covered	2.0
39. Limestone: dark gray with black calcite crystals, fine; weathers smooth; fossiliferous	2.0
38. Covered	8.0
37. Limestone	2.0
36. Covered	8.0
35. Covered: probably shale	1.5
34. Limestone: similar to bed 33 but more rubbly on weathering	4.0
33. Limestone: brown gray with a greenish cast, variably crystalline, medium to very fine with sublithographic lenses; tough; weathers smooth; many small brachiopods, *Punctospirifer*, young Athyridae	3.0
32. Covered: probably shale	3.5
31. Limestone	4.6
30. Limestone: poor exposure	7.6
29. Covered: may include a 1-foot limestone bed	14.8
28. Limestone: light blue on weathered surface	4.6
27. Covered: limestone rubble, probably shale	18.8

	Feet
26. Limestone: lower part contains thin-bedded lenses; upper part has some sublithographic crystalline beds	11.2
25. Shale: blue gray, calcareous	1.5
24. Limestone: brown gray, fine medium to fine with few coarse crystals, tough	6.5
23. Covered	1.0
22. Limestone	4.0
21. Covered, poorly exposed shale at base	20.0
20. Limestone: blue gray with purplish hue, fine with few large crystalline masses; weathers smooth and in pittings, jointed; moderately fossiliferous	3.0
19. Covered	9.0
18. Limestone: blue gray, fine medium to fine; uneven bedded; weathers buff and very rubbly with smooth massive lenses; fossiliferous	3.0
17. Covered	8.0
Estimated thickness of Bloyd	151.6
Hale formation	
16. Sandstone, calcareous; greenish, medium to fine grained, very agrillaceous; uneven bedded; weathers iron stained buff and red	1.0
15. Limestone: similar to bed 14, very coarse; extremely crinoidal, fossiliferous	2.0
14. Limestone: blue gray with a purplish hue, coarse medium with very coarse crystals; thin-bedded lenses that are very fossiliferous, uneven bedded; weathers iron stained buff; crinoidal	4.0
13. Covered	4.0
12. Sandstone: medium grained, somewhat pitted; *Calamites*, (poorly exposed)	1.0
11. Covered	1.0
10. Limestone (may not be in place): coarse, granular, coarsely crinoidal	3.0
9. Covered	3.0
8. Limestone	1.0
7. Covered	12.0
6. Limestone: light gray with buff colored surfaces, medium with very coarse crystalline masses; uneven bedding; weathers in irregular beds; fossiliferous, *Crurithyris* (*Ambocoelia*)	8.0
5. Shale	6.0
4. Limestone, very sandy: light gray to cream gray, medium to fine medium; weathers in horizontal flutings, pitted and cavernous, slightly iron spotted; fossiliferous, large crystalline crinoid masses	6.0
Thickness of Hale	52.0
Mississippian	
Chester series	
Pitkin limestone	
3. Limestone: sublithographic; weathers in rubbly boulders; carries *Archimedes*	6.0
2. Limestone: very coarse crystalline, granular; some beds almost fissile on weathering, moderately iron spotted; crinoidal	4.0
1. Covered, probably limestone	18.0
Covered below	
Exposed thickness of Pitkin	28.0

36. NORTH PETTIT SECTION. E½ SEC. 15 AND W½ SEC. 14, T. 15 N., R. 22 E.

	Feet
Pennsylvanian	
Des Moines series	
Atoka formation	
32. Sandstone	8.0
31. Covered	14.0
30. Sandstone	2.0
29. Covered	14.4
28. Sandstone: very thin-bedded	1.0
27. Sandstone: coarse and medium grained, heavily iron stained	4.6
26. Sandstone: coarse to medium grained; cross-bedded	1.0
25. Shale: sandy, slightly calcareous; very thin-bedded	1.0
Exposed thickness of Atoka	46.0
Morrow series	
Bloyd formation	
24. Limestone: blue gray, fine with irregular sublithographic crystalline beds; uneven-bedded; weathers rubbly with blue splotches; moderately fossiliferous, *Spirifer rockymontanus*	6.0
23. Covered	8.0
22. Shale: blue gray, fissile	4.0
21. Covered	29.0
20. Shale: blue gray, fissile	6.0
19. Covered	20.0
18. Shale	6.0
17. Limestone (may not be in place): brown gray, fine to very fine; weathers rough, irregular bedded and reddish	3.0
16. Shale: blue gray, fissile	4.0
15. Covered	8.0
14. Shale: brown, sandy	4.0
13. Covered	13.0
Estimated thickness of Bloyd	111.0
Hale formation	
12. Limestone: dark gray, flakes of glauconite, coarse and granular; weathers iron spotted; coarsely crinoidal, moderately fossiliferous	3.0
11. Shale: blue gray, fissile	8.0
10. Covered	7.0
9. Limestone: light gray, fine to very fine, appears sandy; weathers rough and uneven	6.0
8. Covered	8.0
7. Limestone: gray to light brown gray, coarse to coarse medium with some large crystalline masses; crinoidal, well jointed; some beds very coarse, crinoidal, granular, uneven, heavily iron stained, buff	6.0
6. Covered	1.0
5. Limestone: rubbly; weathers thin-bedded and spalls off	3.0
4. Limestone: conglomeratic and sandy, much iron staining; fossiliferous, *Pleurodictyum* (*Michelinia*), *Nuculana* (Leda), *Chonetes*, large clams; trace phosphatic	2.0
Thickness of Hale	44.0
Mississippian	
Chester series	
Pitkin-Fayetteville formation	
3. Limestone: light blue, fine crystalline	6.0
2. Covered	15.0
Thickness of Pitkin-Fayetteville	21.0
Meramec? series	
1. Limestone: blue gray, variably crystalline; rounded chert pebbles at base	33,0
Concealed below	
Exposed thickness of Meramec?	33.0

37. SOUTH PETTIT SECTION. NE¼ SEC. 28, T. 15 N., R. 22 E.

	Feet
Pennsylvanian	
Des Moines series	
Atoka formation	
28. Sandstone: medium grained, beds average 2 to 3 inches thick, basal 2 inches calcareous	5.0
Exposed thickness of Atoka	5.0
Morrow series	
Bloyd formation	
27. Limestone: dark blue gray to brown gray with greenish cast, coarse medium to coarse; weathers uneven bedded and quite fissile; thin-bedded; iron spotted buff with greenish shale-like masses included	2.0
26. Covered	10.0
25. Shale	3.0
24. Limestone: brown gray and blue gray, very fine to sublithographic; weathers fissile, rubbly, and uneven bedded; tough, many thin-bedded layers averaging 6 to 8 inches thick	8.0
23. Covered	22.0
22. Shale	4.0
21. Limestone: dark blue gray to dark gray black, coarse; weathers thin-bedded to almost fissile; very crinoidal, granular	6.0
20. Covered	13.0
19. Shale	4.0
18. Limestone: blue gray, very fine to sublithographic crystalline; weathers in blue splotches and rubbly	3.0
17. Concealed	16.0
16. Shale	4.0
15. Limestone: light blue gray to dark blue gray, medium; weathers rubbly and uneven; black calcite crinoid masses, very fossiliferous	3.0
14. Covered	9.0
13. Limestone: upper 6-feet, blue gray, fine medium with sublithographic crystalline masses; weathers rubbly and in horizontal flutings; fossiliferous; lower 2-feet, blue gray and brown gray, coarse; fossiliferous	8.0
12. Covered	12.0
11. Limestone: (may not be in place) dark gray, very fine to sublithographic with coarse crystals; weathers smooth (loose block of limestone carrying *Pentremites*)	3.0
10. Covered	6.0
9. Shale	3.0
Thickness of Bloyd	139.0
Hale formation	
8. Limestone: light gray, fine to sublithographic; weathers rough, iron stained buff and brown; fossiliferous	6.0
7. Shale	2.0
6. Limestone: light gray with a faint greenish cast, medium to fine medium, with sublithographic crystalline beds; weathers rubbly	14.0
5. Limestone: blue gray with a faint greenish cast; weathers rubbly and in knobby masses	2.0
4. Limestone: light gray to cream gray, coarse to coarse medium, carries large crystalline calcite masses and stringers; weathers smooth; fossiliferous, crinoidal	4.0
3. Limestone: poorly exposed, sandy, tan to light gray, coarse; thin-bedded to platy; weathers thin-bedded and rather cross-bedded; fossiliferous; trace phosphate	8.0
Thickness of Hale	36.0

	Feet
Mississippian	
Chester series	
Pitkin limestone	
2. Limestone: poorly exposed	15.0
Estimated thickness of Pitkin	15.0
Meramec? series	
1. Covered to approximate top of Boone	25.0
Estimated thickness of Meramec?	25.0

38. STANDING ROCK SECTION. SEC. 36, T. 15 N., R. 22 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
Covered to top of hill	
8. Sandstone	6.0
Exposed thickness of Atoka	over 6.0
Morrow series	
Bloyd formation	
7. Shale: blue gray, fissile, clay seams a few inches thick limonite concretions; well jointed	22.4
6. Limestone: gray to greenish gray, sublithographic, rather argillaceous; uneven-bedded; weathers rubbly	5.0
5. Shale: greenish, fissile, limonite concretions, calcareous streaks; fossiliferous	4.0
4. Limestone and shale. Shale: greenish, fissile, thin clay seams. Limestone: blue gray and greenish, fine; argillaceous streaks and bands	3.0
3. Limestone: gray, very fine to sublithographic; weathers light blue and rubbly	2.0
2. Shale: greenish, fissile, clay seams, heavily iron stained; well jointed	4.0
1. Shale: blue gray, fissile, limonite concretions	4.0
Covered below	
Exposed thickness of Bloyd	44.4

39. BARBER SECTION. SECS. 28 AND 33, T. 15 N., R. 23 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
33. Covered to top of hill	12.0
32. Sandstone (in a cliff): gray, medium grained, heavily iron stained	5.0
Exposed thickness of Atoka	17.0
Morrow series	
Bloyd formation	
31. Covered, some shale indications	17.0
30. Limestone: blue gray on fresh surface, sublithographic with fine crystalline areas, few calcite masses; weathers with blue splotches; moderately crinoidal	2.5
29. Shale	4.0
28. Covered	30.0
27. Limestone: brown gray, subilthographic crystalline, (may not be in place)	1.0
26. Limestone: blue gray, fine medium few coarse crystals; weathers iron stained and jointed; very fossiliferous	2.0
25. Shale	6.0
24. Covered	7.0
23. Shale	2.0
22. Covered	15.0

	Feet
21. Shale	3.0
20. Limestone: blue, coarse medium to medium; weathers smooth and reddish, well jointed; crinoidal	2.0
19. Covered	17.0
18. Shale	6.0
17. Limestone: blue to brownish blue, fine medium; some thin-bedded, well jointed; weathers iron stained	2.5
16. Covered	9.5
Estimated thickness of Bloyd	126.5
Hale formation	
15. Limestone: light gray, fine medium; weathers thin-bedded; very fossiliferous	3.0
14. Covered	35.0
13. Limestone: light blue gray, fine medium, few larger crystals; weathers uneven; fossiliferous	6.0
12. Limestone: light gray, coarse; weathers smooth, coarsely crinoidal, granular	10.0
11. Limestone: light brown gray, fine medium to fine crystalline, oolitic, appears sandy	13.0
Estimated thickness of Hale	67.0
Mississippian	
Chester series	
Pitkin limestone	
10. Covered	18.0
9. Limestone: gray, fine to very fine; well jointed; fossiliferous, bryozoa, *Archimedes, Linoproductus*	13.0
Thickness of Pitkin	31.0
Fayetteville shale	
8. Covered	2.0
7. Shale	12.0
6. Covered	4.0
5. Limestone: gray, very fine; well bedded; moderately fossiliferous	7.0
4. Covered	13.0
3. Shale: black, fissile	2.0
Thickness of Fayetteville	40.0
Meramec? series	
2. Limestone: top 3 feet gray, fine to very fine with few coarse crystalline calcite masses; weathers smooth, well jointed; moderately fossiliferous. At base it is gray to blue gray, coarse medium; weathers smooth, granular; fossiliferous, *Moorefieldella, Syringothyris*	35.0
1. Covered down to estimated top of Boone	10.0
Estimated thickness of Meramec?	45.0

40. COUNTY LINE HILL, SEC. 24, T. 15 N., R. 23 E.

Pennsylvanian	
Morrow series	
Hale formation	
15. Covered	10.0
14. Limestone: light gray to cream gray, coarse medium; weathers rough, dark dirty blue, and pitted; fossiliferous	3.0
13. Sandstone, calcareous	10.0
12. Covered, probably calcareous sandstone	6.0
11. Sandstone, calcareous	8.0
10. Limestone: very coarse, crinoidal, and granular	3.0
9. Sandstone: calcareous; many beds weather pitted and cavernous	28.0
Exposed thickness of Hale	68.0

	Feet
Mississippian	
Chester series	
Pitkin limestone	
8. Limestone: dark blue gray, very coarse; fossiliferous	8.0
7. Limestone: gray, brittle, fine, subconchoidal fracture; weathers in parallel grooves and shaly	2.0
6. Limestone: gray, fine medium with much very coarse material; grades into shaly layer below; weathers brown and light blue	12.0
5. Shale: black, some pebbles show trace phosphate; upper part knobby limestone; gray, with thin shaly partings	0.8
4. Limestone: characteristically blocky and jointed on weathering	12.0
Estimated thickness of Pitkin	34.8
Fayetteville shale	
3. Covered to indications of brown limestone carrying *Archimedes*	27.0
2. Shale: dark gray to black, fissile. Poorly exposed at top	24.0
Estimated thickness of Fayetteville	51.0
Meramec? series	
1. Limestone: blue gray, variably crystalline; several thin shale beds. Poorly exposed in lower few feet to top of Boone	38.0
Estimated thickness of Meramec? series	38.0

41. SMALL HILL IN SW¼ SEC. 2, T. 15 N., R. 24 E.

Pennsylvanian	
Morrow series	
Hale formation	
8. Covered: sandstone rubble and sandy soil	34.7
7. Sandstone: yellow brown, calcareous; characteristically weathered	16.8
Exposed thickness of Hale	51.5
Mississippian	
Chester series	
Pitkin limestone	
6. Limestone: brown gray to cream gray, very coarse; brittle, oolitic	5.0
5. Limestone: gray to black, argillaceous; thin shale streaks	1.0
4. Shale: blue to black, fissile, very calcareous, trace phosphatic	0.5
3. Limestone: gray to black, fine medium to fine; weathers knobby	2.0
2. Covered	32.0
1. Limestone: dark gray, fine to sublithographic, well jointed; weathers smooth	6.0
Covered below	
Exposed thickness of Pitkin	46.5

42. ROCKY MOUNTAIN, SEC. 4, T. 15 N., R. 24 E.

Pennsylvanian	
Morrow series	
Hale formation	
15. Sandstone: massive bedded, heavily limonite stained; weathers red	32.0
14. Sandstone: slightly calcareous; cross-bedded	12.0
Exposed thickness of Hale	44.0
Mississippian	
Chester series	
Pitkin limestone	17.0
13. Limestone	
12. Limestone: gray to brown gray; some thin-bedded, some jointed zones and crinoidal layers; weathers thin-bedded to platy; trace phosphatic	8.0

	Feet
11. Covered	20.0
10. Limestone: upper part, blue gray, very coarse; crinoidal and fossiliferous	11.0
9. Limestone: blue gray, platy	2.0
Thickness of Pitkin	58.0
Fayetteville shale	
8. Covered	20.0
7. Shale: gray to black, fissile	6.0
6. Covered	32.0
Estimated thickness of Fayetteville	58.0
Meramec? series	
5. Limestone, poorly exposed: blue gray, fine to sublithographic crystalline; well jointed; some crinoidal	21.0
4. Limestone: brown gray, coarse medium with several larger crystals; trace phosphatic	0.5
3. Limestone, silty: blue gray, coarse; thin-bedded to platy; trace phosphatic	1.5
2. Limestone: dark blue gray to black, very coarse; massive bedded, tough; weathers evenly; crinoidal	1.5
1. Covered to estimated top of "Boone"	16.0
Estimated thickness of Meramec?	40.5

43. HUNGRY MOUNTAIN SECTION, E½ SEC. 9, T. 15 N., R. 24 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
28. Sandstone	9.0
27. Sandstone and covered: probably includes some shaly beds	28.0
Exposed thickness of Atoka	37.0
Morrow series	
Bloyd formation	
26. Covered	7.0
25. Shale: yellow brown to buff	2.0
24. Conglomerate: rounded limestone and limonitic pebbles; one large *Pleurodictyum* (*Michelinia*) in the limestone; some of the limonitic pebbles show traces of phosphate. May not be in place	1.0
23. Shale: blue gray, fissile	1.0
22. Limestone: dark blue gray, medium, tough; weathers buff and smooth	3.0
21. Shale and covered: blue gray, fissile, limonite concretions	18.0
20. Limestone: blue gray, coarse, tough, well jointed; weathers platy and crinoidal; fossiliferous	3.0
19. Shale and covered: blue gray, fissile, limonite concretions	18.0
18. Limestone	3.0
17. Shale and covered: blue gray, fissile, limonite concretions	19.0
16. Limestone: blue gray, coarse; weathers smooth; crinoidal	3.0
15. Shale: blue gray, fissile, limonite concretions	2.0
14. Limestone: blue, platy in part; fossiliferous	2.0
13. Shale: blue gray, fissile, limonite concretions	2.0
12. Limestone and shale, poorly exposed: limestone purplish dark blue gray, very coarse; weathers evenly and platy; fossiliferous and crinoidal	26.0
Thickness of Bloyd	110.0
Hale formation	
11. Covered: sandy soil	8.0
10. Sandstone: massive bedded	2
9. Limestone: blue gray, very coarse; granular; weathers even and in parallel flutings; very crinoidal	5.0

		Feet
8.	Sandstone: lower 3 feet in beds 3 inches thick, typically weathered; next 7 feet are limy sandstone, weathering in horizontal parallel flutings. Rest of the cliff is thick-bedded sandstone weathering pitted and cavernous	49.0
7.	Limestone: blue gray, coarse; fossiliferous	1.5
6.	Sandstone, calcareous: fossiliferous, trace phosphatic; weathers in horizontal parallel flutings and rather cross-bedded; seems to grade into bed above	3.0
5.	Conglomerate: limonitic, calcareous; weathers red	0.5
	Thickness of Hale	69.0
	Mississippian	
	Chester series	
	Pitkin limestone	
4.	Limestone: blue gray, jointed; fossiliferous; upper 2 inches shows trace phosphate	7.0
3.	Limestone: dark gray, fine to sublithographic; weathers knobby; *Allorisma walkeri*	0.5
2.	Shale: blue gray, fissile; phosphatic	0.3
1.	Limestone: gray, darker in upper 1 foot, medium; weathers smooth and fluted	4.0
	Covered below	
	Exposed thickness of Pitkin	11.8

44. SMALL HILL IN SW¼ SEC. 11, NW¼ SEC. 14, T. 15 N., R. 24 E.

	Pennsylvanian	
	Morrow series	
	Bloyd formation	
19.	Limestone: blue gray, medium to fine medium, tough; weathers smooth and platy	3.0
18.	Covered	7.0
17.	Limestone	3.0
16.	Shale: blue gray, fissile, limonite concretions	10.0
15.	Covered	6.0
14.	Limestone: blue gray, very coarse; platy; extremely crinoidal	3.0
13.	Covered: limestone rubble, some coarse, some sublithographic	18.0
12.	Shale: blue gray, fissile, limonite concretions	5.0
11.	Covered	7.0
10.	Limestone: blue gray, medium to coarse medium, tough, granular; fossiliferous	2.0
9.	Covered: a sandstone boulder observed	6.0
8.	Limestone: blue gray, very coarse; weathers smooth; crinoidal, fossiliferous	2.0
7.	Covered	6.0
	Exposed thickness of Bloyd	78.0
	Hale formation	
6.	Covered: sandstone rubble and sandy soil	42.0
5.	Sandstone: yellow brown; massive bedded; characteristic Hale weathered	31.5
4.	Sandstone, very calcareous: weathers cross-bedded; fossiliferous	2.5
	Estimated thickness of Hale	76.0
	Mississippian	
	Chester series	
	Pitkin limestone	
3.	Limestone: gray, medium	1.0
2.	Limestone: similar to bed 1; fossiliferous, abundant capuloid-type gastropods	1.0
1.	Limestone: blue to brown gray, fine medium to fine	1.0
	Covered below	
	Exposed thickness of Pitkin	3.0

45. LITTLE ROCKY MOUNTAIN, SEC. 12, T. 15 N., R. 24 E.

		Feet
	Pennsylvanian	
	Morrow series	
	Hale formation	
5.	Covered: sandstone rubble and sandy soil	37.8
4.	Sandstone: medium grained; weathers pitted cavernous, in reddish and purplish bands	18.2
3.	Covered	10.0
	Exposed thickness of Hale	66.0
	Mississippian	
	Chester series	
	Pitkin limestone	
2.	Covered	8.0
1.	Limestone: light blue gray, coarse; crinoidal	5.0
	Exposed thickness of Pitkin	13.0

46. GITTIN' DOWN MOUNTAIN, SW¼ SEC. 14, SE¼ SEC. 15, NE¼ SEC. 22, NW¼ SEC. 23, T. 15 N., R. 24 E.

	Pennsylvanian	
	Des Moines series	
	Atoka formation	
24.	Covered: sandstone and siltstone rubble	62.0
23.	Sandstone: massive bedded, forms cliff	10.0
	Exposed thickness of Atoka	72.0
	Morrow series	
	Bloyd formation	
22.	Shale: dark blue, gray fissile, limonite concretions; good exposure of contact with overlying Atoka	8.0
21.	Covered	25.0
20.	Limestone: blue gray, very coarse; weathers platy; fossiliferous	3.0
19.	Covered	37.0
18.	Shale: blue gray, fissile, limonite concretions	4.0
17.	Limestone: dark blue gray, medium to coarse medium, tough; weathers rubbly and knobby; fossiliferous, trilobite pygidium	5.0
16.	Shale: blue gray, fissile, limonite concretions	14.0
15.	Limestone: blue gray, coarse medium; weathers smooth and crinoidal; crinoid stems replaced by orange calcite	6.0
14.	Covered	20.0
	Estimated thickness of Bloyd	122.0
	Hale formation	
13.	Covered	46.0
12.	Sandstone: calcareous; characteristically weathered; one stack of very peculiar weathering—thin-bedded, pitted, with joints inclined about 45 degrees to the vertical, crossing all beds	23.5
11.	Sandstone: cross-bedded; gray to yellow brown on weathering	5.0
	Thickness of Hale	74.5
	Mississippian	
	Chester series	
	Pitkin limestone	
10.	Limestone: blue gray, very coarse; crinoidal, weathers thin-bedded, especially in upper part, and granular, trace phosphatic	64.0
	Thickness of Pitkin	64.0
	Fayetteville shale	
9.	Covered	18.0
8.	Shale: blue gray, fissile	9.0
7.	Limestone: blue gray, medium; massive bedded	5.0
6.	Shale: blue gray, fissile	10.0
5.	Covered: probably shale	16.0
	Estimated thickness of Fayetteville	58.0

		Feet
Meramec? series		
4.	Limestone: blue gray; massive bedded	1.0
3.	Siltstone: gray, calcareous; beds average 0.5 inch to 1-inch thick; trace phosphatic	7.0
2.	Limestone: gray blue gray, medium; beds 3 to 4 inches thick with few thin-bedded zones; fossiliferous	6.0
1.	Covered to estimated top of "Boone"	10.0
	Estimated thickness of Meramec?	24.0

47. THE SADDLE IN THE HUNGRY MOUNTAIN DISTRICT, E½ SEC. 16, T. 15 N., R. 24 E.

Pennsylvanian		
Morrow series		
Hale formation		
20.	Covered: probably sandstone	8.0
19.	Sandstone: massive bedded, ferruginous; weathers pitted, cavernous and red	14.0
18.	Sandstone: yellow gray; thin bedded; weathers red; yellow brown shale partings that also weather red	2.5
17.	Sandstone: yellow brown; massive bedded	3.0
16.	Sandstone: yellow gray; thin bedded; weathers red; many yellow brown shale partings	13.7
15.	Sandstone and limestone: zone of limestone reefs. Limestone, sandy: weathers cross-bedded, pitted, and cavernous. Sandstone: thin beds with prominent yellow brown shale partings, some thin blue gray shale partings 1 to 2 mm thick that weather red	12.0
14.	Shale and conglomerate: blue gray; weathers yellow brown, buff, and whitish buff; contains pebbles that yielded 3.12 per cent phosphate on analysis. There are two thin shale beds separated by a thin conglomerate bed of limonitic pebbles in a matrix of limestone	0.5
13.	Limestone: very sandy	6.0
	Exposed thickness of Hale	59.7
Mississippian		
Chester series		
Pitkin limestone		
12.	Limestone: blue gray; with gray shale beds and shale partings; fossiliferous on bedding planes, *Chonetes, Archimedes.* Shale bed 0.5 foot at top carries limestone pebbles 1-inch in diameter	20.0
11.	Limestone: blue gray, very coarse; fossiliferous and crinoidal; few thin blue gray shale partings near top	4.5
10.	Limestone: blue gray, fine to sublithographic; weathers knobby. A spring issues at the base of this limestone, over shale	1.0
	Thickness of Pitkin	25.5
Fayetteville shale		
9.	Shale: blue black, fissile, limonite concretions	35.0
8.	Shale: blue black, fissile, clay	23.0
7.	Covered, probably shale	10.0
6.	Shale: blue black, fissile	4.5
	Thickness of Fayetteville	72.5
Meramec? series		
5.	Limestone: blue, very coarse; weathers yellowish and crinoidal; fossiliferous	7.5
4.	Limestone: gray, fine to sublithographic; weathers yellowish and smooth	1.0

		Feet
3.	Limestone: blue, very coarse; weathers yellowish and crinoidal	12.5
2.	Siltstone: yellowish brown, slightly calcareous; thin bedded	9.0
1.	Covered to estimated top of "Boone"	18.0
	Estimated thickness of Meramec?	48.0

48. JACKSON MOUNTAIN, SEC. 17, T. 15 N., R. 24 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
17.	Covered	16.0
16.	Sandstone: yellow brown, heavily limonite stained; two shaly beds in lower part	23.0
	Exposed thickness of Atoka	39.0
Morrow series		
Bloyd formation		
15.	Covered	98.0
14.	Shale: blue gray, fissile, limonite concretions	5.0
13.	Covered	8.0
12.	Limestone: dark blue gray, very coarse; weathers crinoidal, thin-bedded, and in grooves	5.0
11.	Limestone: blue gray, variably crystalline; weathers smooth; fossiliferous	5.0
	Estimated thickness of Bloyd	121.0
Hale formation		
10.	Covered	13.0
9.	Sandstone: massive bedded	2.0
8.	Limestone: blue to brown, very coarse; weathers evenly, crinoidal, granular; represented by calcareous sandstone on east side of hill	6.0
7.	Limestone: light buff to light blue gray, oolitic; weathers smooth and crinoidal; fossiliferous	10.0
6.	Covered	6.0
5.	Sandstone: yellow brown, slightly calcareous; locally thin-bedded; weathers smooth to pitted and cavernous	10.0
4.	Covered	15.0
3.	Limestone: blue gray	5.0
2.	Conglomerate: matrix of limestone, heavily limonite stained, phosphatic	0.5
	Thickness of Hale	67.5
Mississippian		
Chester series		
Pitkin limestone		
1.	Limestone: dark gray, fine medium to fine, jointed, top part somewhat knobby; fossiliferous	5.5
	Covered below	
	Exposed thickness of Pitkin	5.5

49. BILL SANDERS MOUNTAIN, SECS. 21, 28, AND 29 T. 15 N., R. 24 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
30.	Covered: sandstone rubble and sandy soil	52.0
29.	Sandstone: yellow brown; massive bedded	12.0
	Exposed thickness of Atoka	64.0
Morrow series		
Bloyd formation		
28.	Covered	29.0

		Feet
27.	Shale: blue gray, fissile, limonite concretions	4.0
26.	Covered	20.0
25.	Limestone: blue gray, coarse medium, tough; weathers crinoidal	5.0
24.	Shale: blue gray, fissile, limonite concretions	1.0
23.	Limestone: blue gray, coarse medium; weathers crinoidal, smooth and rather sandy; many of crinoid stems replaced by orange calcite, trace phosphate	10.0
22.	Limestone: dark blue gray, with black calcite crystals, very coarse; weathers crinoidal, fossiliferous; may not be in place	2.0
21.	Shale: sandy, carries a thin sandstone lens near the middle	10.0
20.	Covered	52.0
	Estimated thickness of Bloyd	133.0
	Hale formation	
19.	Covered	36.0
18.	Sandstone: similar to bed 16	5.0
17.	Limestone: purplish blue, coarse medium, tough	1.0
16.	Sandstone: yellow gray to yellow brown, calcareous; weathers with many cross-bedded layers; fossiliferous	8.0
15.	Covered	18.0
	Estimated thickness of Hale	68.0
	Mississippian	
	Chester series	
	Pitkin limestone	
14.	Covered	49.0
13.	Limestone: includes few thin shale beds	12.0
12.	Limestone: gray to black, coarse even crystalline; weathers knobby and rather fluted	5.0
	Estimated thickness of Pitkin	66.0
	Fayetteville shale	
11.	Covered	18.0
10.	Limestone: gray blue gray, medium to coarse, tough; weathers smooth	2.0
9.	Covered	5.0
8.	Limestone, poor outcrop: dark blue gray, medium to very coarse; weathers brown and crinoidal	2.0
7.	Covered	27.0
	Estimated thickness of Fayetteville	54.0
	Meramec? series	
6.	Limestone: blue gray, coarse; crinoidal	5.0
5.	Shale: blue black, fissile	8.0
4.	Limestone, poor outcrop: blue gray, one bed is very fine to sublithographic crystalline; weathers smooth; fossiliferous	10.0
3.	Covered	37.0
2.	Limestone, poorly exposed	4.0
1.	Covered to estimated top of "Boone"	18.0
	Estimated thickness of Meramec?	82.0
	(Pre-Hale is too thick, probably due to local structure)	

50. BOWLES MOUNTAIN, W½ SEC. 27, E½ SEC. 28, T. 15 N., R. 24 E.

		Feet
	Pennsylvanian	
	Des Moines series	
	Atoka formation	
37.	Covered: includes some sandstone and shale	29.0
36.	Sandstone: yellow brown; massive bedded	5.0
	Exposed thickness of Atoka	34.0

		Feet
	Morrow series	
	Bloyd formation	
35.	Covered, probably shale	39.0
34.	Limestone: blue gray, very coarse; weathers light tan and platy; fossiliferous	3.0
33.	Covered: may include some shale	23.0
32.	Limestone: blue, very coarse; weathers smooth and platy; fossiliferous	2.0
31.	Shale: blue gray, fissile	3.0
30.	Limestone: yellow gray, oolitic; weathers red and pitted	5.0
29.	Shale: blue gray, fissile	6.0
28.	Limestone: blue, fine, tough	2.0
27.	Shale: blue gray, fissile	5.5
26.	Limestone	3.5
25.	Shale: blue gray, fissile	0.5
24.	Limestone: dark blue gray, extremely coarse	2.5
23.	Shale; blue gray, fissile	2.0
22.	Limestone	6.0
21.	Covered	14.0
20.	Limestone: light blue gray, coarse, extremely crinoidal; weathers even	5.0
19.	Shale: fissile, poorly exposed	2.0
	Thickness of Bloyd	124.0
	Hale formation	
18.	Limestone: similar to bed 17, irregular limonite content, contains thin shale beds	24.0
17.	Limestone: light blue gray, very coarse; weathers even; extremely crinoidal	2.0
16.	Covered: probably mostly sandstone	22.0
15.	Sandstone: with limy beds and limestone "reefs"; much cross bedding	28.0
14.	Conglomerate: limestone matrix, rounded limonite pebbles, trace phosphatic; weathers red	0.4
13.	Sandstone: similar to bed 15, contains a 1-foot bed of limy sandstone and calcareous limonitic concretions, trace phosphatic	2.0
12.	Sandstone: very calcareous, local limonitic concretions that carry some phosphate	3.0
11.	Shale: blue gray, fissile	0.3
10.	Conglomerate: heavily limonite stained, limonite concretions, trace phosphatic; fossiliferous	0.5
	Thickness of Hale	82.2
	Mississippian	
	Chester series	
	Pitkin limestone	
9.	Limestone: brown gray, fine medium to fine, tough, slight trace phosphate; appears to grade upward into the calcareous conglomerate above	1.5
8.	Limestone: light gray, medium with some crystals 4-12 mm in size, tough, highly oolitic, especially 3 feet above the base; weathers thin-bedded to platy	8.0
7.	Covered	38.0
6.	Limestone and shale: some of the limestone is sublithographic; very fossiliferous	15.0
5.	Limestone: blue gray, tough; contains few thin shale beds; weathers limonite yellow; fossiliferous, *Archimedes*	5.0
	Thickness of Pitkin	67.5
	Fayetteville shale	
4.	Shale: blue black, fissile, limonite concretions. One limestone bed 2 feet thick near middle	26.0
	Thickness of Fayetteville	26.0

		Feet
Meramec? series		
3.	Limestone and shale: limestone light gray, coarse; weathers even and pitted; crinoidal and fossiliferous. Lower few feet darker in color and rather granular	28.0
2.	Shale: blue black to black fissile; poorly exposed in lower part	15.0
1.	Covered to estimated top of "Boone"	5.0
	Estimated thickness of Meramec?	48.0

51. BEAVER MOUNTAIN, SEC. 31, T. 15 N., R. 24 E., EXTENDING INTO SEC. 6, T. 14 N., R. 24 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
29.	Covered	40.0
28.	Siltstone: yellow brown with a greenish hue; thin-bedded	8.0
27.	Covered	42.0
26.	Sandstone	8.0
25.	Covered	54.0
	Estimated thickness of Atoka	152.0
Morrow series		
Bloyd formation		
24.	Covered	10.0
23.	Limestone: blue gray and brown, medium, tough, very sandy, some black shale partings; weathers brown with ironstone bands	3.0
22.	Covered	5.0
21.	Limestone: gray with purplish tint, medium, tough	3.0
20.	Covered	65.0
19.	Limestone, some shale beds: blue gray, very coarse	25.0
18.	Covered	7.0
17.	Limestone: dark blue gray, very coarse; weathers smooth, crinoidal and brownish	6.0
16.	Covered	4.0
	Estimated thickness of Bloyd	128.0
Hale formation		
15.	Limestone: similar to bed 13; weathers pitted and fluted	6.0
14.	Covered, probably limestone	2.0
13.	Limestone: light gray to white gray, medium to coarse medium; weathers buff and gray; fossiliferous	3.0
12.	Covered	29.0
11.	Sandstone: calcareous	8.0
10.	Limestone, sandy: light gray, coarse medium; beds average 2 to 3 inches thick	4.0
	Thickness of Hale	52.0
Mississippian		
Chester series		
Pitkin limestone		
9.	Limestone: dark blue gray, very coarse; weathers thin-bedded	4.0
8.	Limestone: light gray with black crystals, medium; weathers well jointed	0.5
7.	Limestone: gray to black, very coarse; weathers light blue	4.0
6.	Limestone: gray, fine to sublithographic, subconchoidal fracture	20.0
	Thickness of Pitkin	28.5
Fayetteville shale		
5.	Covered	20.0
4.	Limestone: brown; abundant *Archimedes*	2.0
3.	Covered	58.0
	Estimated thickness of Fayetteville	80.0

		Feet
Meramec? series		
2.	Limestone: gray to blue gray, coarse	10.0
1.	Covered to estimated top of "Boone"	5.0
	Estimated thickness of Meramec?	15.0

52. STILWELL MOUNTAIN, ACROSS SOUTHEAST EXTENSION, SEC. 1, T. 15 N., R. 25 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
21.	Sandstone: medium to coarse; beds average 3 feet thick	8.0
20.	Covered: sandstone rubble and sandy soil	33.0
	Exposed thickness of Atoka	41.0
Morrow series		
Bloyd formation		
19.	Covered	19.0
18.	Limestone: gray brown with dark crystalline inclusions, fine to sublithographic; weathers blue gray and in small fluted surfaces	5.0
17.	Covered	28.0
16.	Shale: blue gray, fissile, limonite concretions; weathers yellow brown	8.0
15.	Covered	10.0
14.	Limestone: dark blue gray to brown gray, coarse, oolitic; weathers somewhat platy	5.0
13.	Covered	93.0
	Estimated thickness of Bloyd	168.0
Hale formation		
12.	Covered	25.0
11.	Sandstone: slightly calcareous, heavily limonite stained; massive bedded; weathers red	10.0
10.	Covered, probably sandstone	7.0
9.	Sandstone: calcareous with thin, sandy limestone beds (forms cliff); weathers pitted and cavernous	26.0
8.	Conglomerate: pebbles and concretions, sandstone cemented with silica, pebbles rounded; weathers red	1.0
	Estimated thickness of Hale	69.0
Mississipian		
Chester series		
Pitkin limestone		
7.	Limestone: dark blue gray, very coarse, even crystalline, heavily limonite stained. Seems to occur as a discontinuous wedge above the argillaceous limestone below and the conglomeratic bed of the Hale above	1.5
6.	Limestone: blue gray to dark blue gray; weathers knobby	2.5
5.	Shale: with knobby limestone layers, trace phosphatic	1.0
4.	Shale, very calcareous: dark blue, in part slightly phosphatic; fossiliferous, large, *Pleurodictyum* (*Michelinia*), mollusca, almost a crinoid stem coquina	1.0
3.	Limestone and shale: limestone beds 2 to 3 inches thick, with thin shale bands and partings that average 0.5 to 1 inch thick	2.5
2.	Limestone: dark gray, fine to sublithographic with large black crystals, tough; grades into bed above	3.0
1.	Limestone: gray blue gray, very coarse, fossiliferous, crinoidal; upper 2 to 3 feet much finer and almost non-fossiliferous; there is a thin-bedded zone 1 foot thick 2 feet above base; weathers gray	22.0
	Covered below	
	Exposed thickness of Pitkin	33.5

53. GOAT MOUNTAIN, SE¼ SEC. 7, T. 15 N., R. 25 E.

		Feet
Pennsylvanian		
Morrow series		
Bloyd formation		
32.	Shale: blue gray, fissile	7.0
31.	Limestone: purplish and brown, fine; some thin shale beds	15.0
	Exposed thickness of Bloyd	22.0
Hale formation		
30.	Sandstone: ferruginous; massive bedded	1.0
29.	Limestone: dark blue gray, very coarse; weathers smooth; many crinoid stems replaced by orange calcite	5.0
28.	Limestone: light blue gray, very coarse; crinoidal	14.0
27.	Limestone: very coarse; weathers into a crinoid stem coquina; extremely fossiliferous	5.0
26.	Sandstone: calcareous; cross-bedded; weathers in parallel horizontal flutings	21.0
25.	Sandstone: coarse, calcareous; weathers reddish and in characteristic Hale-weathered beds	13.0
24.	Limestone: blue gray; weathers thin-bedded near base; fossiliferous	2.0
23.	Conglomerate: similar to bed 21	0.5
22.	Shale: blue gray, fissile	0.5
21.	Conglomerate: sandy pebbles and rounded limonite pebbles, highly calcareous; weathers red	1.0
	Thickness of the Hale	63.0
Mississipian		
Chester series		
Pitkin limestone		
20.	Limestone: dark blue gray, tough; top 1 foot fossiliferous and crinoidal, Capuloid-type snails	2.5
19.	Limestone: argillaceous, many thin shale partings that show traces of phosphate; large mollusca, *Allorisma walkeri*	2.0
18.	Shale: blue gray, highly calcareous; trace phosphate	0.4
17.	Limestone: brownish blue gray, fine to sublithographic; top 1 foot knobby	13.0
16.	Limestone: blue gray, very coarse; crinoidal	2.0
15.	Limestone: blue gray, coarse medium to coarse; massive- to thin-bedded and platy	3.0
14.	Covered: probably blue gray fissile shale	6.0
13.	Limestone	11.0
12.	Limestone: light blue gray; fossiliferous	3.0
11.	Limestone	9.0
10.	Limestone: light blue gray, coarse medium; weathers light gray; extremely crinoidal, almost a crinoid stem coquina	4.0
9.	Limestone	14.0
	Thickness of the Pitkin	69.9
Fayetteville shale		
8.	Shale: blue gray, fissile	24.0
7.	Limestone	3.0
6.	Shale: blue gray, fissile	9.0
5.	Limestone	8.0
4.	Shale: blue gray, fissile	14.0
3.	Limestone	5.0
2.	Shale: blue gray, fissile; poorly exposed in lower part	8.0
1.	Covered to estimated top of "Boone"	12.0
	Estimated thickness of Fayetteville	83.0

54. TAYLOR MOUNTAIN, SEC. 13, T. 15 N., R. 25 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
34.	Covered: sandstone rubble and sandy soil	32.0
33.	Sandstone: yellow brown, somewhat cross-bedded; beds average 3 to 5 inches thick	14.0
32.	Covered	13.0
31.	Siltstone: gray with greenish hue; thin-bedded; weathers platy	14.0
30.	Covered	9.0
	Exposed thickness of the Atoka	82.0
Morrow series		
Bloyd formation		
29.	Covered	35.0
28.	Limestone: blue gray, brownish hue, medium, many of the crinoid stems replaced by orange calcite; weathers buff and red; fossiliferous. Lower part more coarsely crystalline and more fossiliferous	8.0
27.	Covered and shale	5.0
26.	Limestone: blue gray, medium; weathers buff and platy; fossiliferous	4.0
25.	Covered	17.0
24.	Shale: blue gray, fissile	8.0
23.	Covered	16.0
22.	Limestone: dark gray to black, coarse, crinoid stems replaced by orange calcite; weathers fluted and platy; fossiliferous	6.0
21.	Covered	16.0
20.	Limestone: light gray to buff brown, coarse; weathers smooth and in big pittings; fossiliferous, large crinoid stems abundant	13.0
19.	Shale: blue gray, fissile, limonite concretions	4.0
18.	Covered: probably mostly shale	18.0
17.	Shale: blue gray, fissile	2.0
16.	Limestone: blue gray, coarse medium to medium, limonitic inclusions, tough; weathers smooth; fossiliferous	2.0
15.	Shale: blue gray, fissile	2.0
14.	Limestone: gray to black, very coarse; crinoidal, upper part more fossiliferous	10.0
13.	Covered	3.0
	Estimated thickness of the Bloyd	169.0
Hale formation		
12.	Covered	8.0
11.	Shale: yellow brown, very sandy, heavily stained and banded with limonite	8.0
10.	Sandstone, calcareous: light gray with dark gray bands 2 to 3 mm thick; weathers thin-bedded and in parallel horizontal flutings	18.0
9.	Sandstone: yellow brown; massive bedded and cross-bedded	13.0
8.	Sandstone, very calcareous: brown; weathers thin-bedded and in thin cross-bedded beds; fossiliferous, crinoidal	5.7
7.	Covered, probably shale	2.0
6.	Sandstone, calcareous: light gray, medium	1.0
5.	Limestone, very sandy especially at top: light gray, coarse; weathers thin-bedded and in parallel horizontal flutings, resistant ironstone beds 1 inch thick; slightly phosphatic; fossiliferous	14.0
4.	Shale: dirty gray with black seams, fissile, trace phosphatic	1.3
3.	Conglomerate: brown, limonite pebbles in a limestone matrix, trace phosphatic	0.2
	Estimated thickness of the Hale	71.2

Mississippian
Chester series
Pitkin limestone

		Feet
2.	Limestone: brown gray, coarse medium; weathers evenly; crinoidal	28.0
1.	Limestone: blue gray to light blue gray, fine medium with large crystals, some fine to sublithographic beds; weathers smooth and jointed; fossiliferous	5.0
	Covered below	
	Exposed thickness of the Pitkin	33.0

55. DOUBLE MOUNTAIN (NORTH END), SEC. 23, T. 15 N., R. 25 E.

Pennsylvanian
Des Moines series
Atoka formation

17.	Covered	46.0
	Estimated thickness of Atoka	46.0

Morrow series
Bloyd formation

16.	Covered, few poorly exposed shale beds	103.0
15.	Shale: blue gray, fissile, limonite concretions	3.0
14.	Limestone: lower half, dark blue gray to almost black, very coarse; weathers smooth and crinoidal; upper half blue gray; weathers in parallel horizontal flutings	2.5
13.	Shale: blue gray, fissile, limonite concretions	3.5
12.	Limestone: light brown gray to black, very coarse; weathers smooth; crinoidal, moderately fossiliferous, much orange calcite replacement	3.0
11.	Covered	6.0
10.	Limestone: blue gray, very coarse, appears granular, iron stained red; extremely crinoidal	8.0
9.	Covered, may be shale	6.0
	Estimated thickness of Bloyd	135.0

Hale formation

8.	Limestone: gray with black crystals, coarse medium; weathers even and jointed; crinoidal	9.0
7.	Covered	6.0
6.	Limestone: brown, medium with very coarse crystals; weathers platy; fossiliferous, large *Pleurodictyum* (*Michelinia*)	4.0
5.	Covered	5.5
4.	Limestone: light gray, very coarse; weathers friable, extremely crinoidal, granular	22.4
3.	Sandstone, very calcareous: dark gray to black, medium to coarse. (This bed is a sandy limestone in less than 50 feet along the outcrop)	17.0
2.	Conglomerate: very thin, or absent in places, considerable phosphate, calcareous, limonite pebbles; weathers red	0.2
	Estimated thickness of Hale	64.1

Mississippian
Chester series
Pitkin limestone

1.	Limestone: blue gray, coarse; weathers jointed and fractured	17.0
	Covered below	
	Exposed thickness of Pitkin	17.0

56. SOAP MOUNTAIN, SECS. 24 and 25, T. 15 N., R. 25 E.

Pennsylvanian
Des Moines series
Atoka formation

		Feet
39.	Covered, sandstone and siltstone rubble	20.0
	Estimated thickness of Atoka	20.0

Morrow series
Bloyd formation

38.	Covered	6.0
37.	Limestone: buff gray, coarse medium; weathers even; moderately fossiliferous	4.0
36.	Covered	5.0
35.	Limestone: blue gray, coarse; thin-bedded; weathers smooth; fossiliferous, crinoidal	3.0
	(Note Beds 35-38 correlated with Kessler member of Bloyd formation. Estimated thickness of Kessler 18 feet.)	
34.	Covered	34.0
33.	Shale: blue gray, fissile, few limonite concretions	6.0
32.	Limestone: blue gray, very coarse, much orange calcite replacement; locally thin-bedded; weathers smooth and crinoidal; fossiliferous	13.0
31.	Covered	10.0
30.	Limestone: light gray, coarse; weathers smooth; fossiliferous	3.0
29.	Covered: much limestone rubble	17.0
28.	Limestone: smoky gray, fine medium; some platy beds, some beds well jointed; locally fossiliferous	11.0
27.	Limestone: brown gray and blue gray, fine to sublithographic; weathers blue, smooth, and platy	3.0
26.	Limestone: brown to blue gray, fine with coarse crystals; fossiliferous	6.0
25.	Covered	3.0
24.	Limestone: blue gray, coarse; fossiliferous, many crinoid stems replaced by orange calcite	2.0
23.	Covered	2.0
22.	Limestone: blue gray, fine; weathers smooth, (may not be in place)	3.0
21.	Shale: blue gray, fissile, limonite concretions	4.0
20.	Covered	14.0
19.	Shale: blue gray, fissile, limonite concretions	2.0
18.	Limestone: black, medium; weathers smooth; fossiliferous, crinoidal	2.0
17.	Shale: blue gray, fissile, some limonite concretions	8.0
	Thickness of Bloyd	161.0

Hale formation

16.	Limestone: blue gray to brown gray, medium; weathers in large pittings and somewhat jointed	4.0
15.	Sandstone, calcareous: characteristic Hale weathering near top; partly concealed	31.0
14.	Sandstone: calcareous, thin-bedded	10.0
13.	Sandstone: calcareous, large limy inclusions	15.0
12.	Limestone: yellow gray, coarse; fossiliferous, crinoidal	1.5
11.	Conglomerate: yellow brown, calcareous matrix, slight trace phosphate, limonite pebbles; weathers buff and red; the upper half of this bed contains rounded pebbles of blue shale and grades upward into the next bed	0.8
	Thickness of Hale	62.3

Mississippian
Chester series
Pitkin limestone

10.	Limestone: gray blue gray, coarse medium, appears sandy,	

		Feet
	fossiliferous; upper 2 feet gray, fine to sublithographic, with large crystals, weathers smooth and in large pits; fossiliferous	18.0
9.	Covered to where a spring issues over shale	20.0
	Estimated thickness of the Pitkin	38.0
	Fayetteville shale	
8.	Shale: blue black	6.0
7.	Covered	16.0
6.	Shale: blue gray, limonite concretions	10.0
5.	Shale: black to blue black	21.0
4.	Limestone	4.0
3.	Shale: black	7.0
2.	Limestone	6.0
1.	Shale: black	4.0
	Covered below	
	Exposed thickness of Fayetteville	74.0

57. NORTH END OF DAHLONEGAH HILL. SEC. 30, T. 15 N., R. 25 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
17.	Sandstone: massive bedded	8.0
16.	Covered: sandstone rubble	16.0
15.	Sandstone: massive bedded	7.0
14.	Covered	33.0
13.	Sandstone: thin-bedded, in cliff	5.0
	Exposed thickness of the Atoka	69.0
Morrow series		
Bloyd formation		
12.	Covered: includes a few blue fissile shales with limonite concretions	118.0
11.	Shale: blue gray, fissile, limonite concretions	4.0
10.	Limestone: dark blue gray, medium with very coarse crystals; weathers smooth and crinoidal; fossiliferous, many *Pentremites*	5.0
9.	Limestone: poor outcrop, includes a 2- to 3-foot very sandy limestone bed; fossils preserved as casts	17.0
8.	Covered	6.0
	Estimated thickness of Bloyd	150.0
Hale formation		
7.	Sandstone, calcareous: yellow brown; beds range up to 1 inch thick; weathers in big pits	7.0
6.	Limestone: similar to bed 4	7.0
5.	Covered	5.0
4.	Limestone: blue gray, granular, very coarse; weathers in horizontal parallel flutings and sandy; crinoidal	20.0
3.	Sandstone, calcareous: cross-bedded in lower 2 feet, beds average 1 to 2 inches thick, prominent ironstone bands; weathers pitted and cavernous, especially in the upper part	15.0
2.	Conglomerate: calcareous, phosphatic nodules	0.1
	Thickness of Hale	54.1
Mississippian		
Chester series		
Pitkin limestone		
1.	Limestone: dark blue gray, fine medium; weathers jointed and rough; fossiliferous	15.0
	Exposed thickness of Pitkin	15.0

58. NORTH END OF WELCH MOUNTAIN, SEC. 33, T. 15 N., R. 25 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
35.	Covered: sandstone rubble and sandy soil	20.0
34.	Sandstone: yellow brown, medium; weathers red	2.0
33.	Shale: thin-bedded to fissile, yellow brown	3.0
32.	Covered	3.0
	Estimated thickness of Atoka	28.0
Morrow series		
Bloyd formation		
31.	Covered	2.0
30.	Limestone: brown and blue gray, fine; weathers blue and pitted. Similar to bed 29, but differs markedly on weathering	2.5
29.	Limestone: brown with few blue gray bands and inclusions, fine to sublithographic; thin calcite veins across the bedding; weathers yellow and light yellow brown; fossiliferous	0.6
28.	Limestone: gray, coarse medium, sandy; weathers thin-bedded to almost fissile, and brown; fossiliferous, trace phosphatic	4.0
27.	Conglomerate: yellow brown, limestone matrix, limonitic; limestone pebbles tested 1.62 per cent phosphatic on analysis	0.5
26.	Limestone: brown gray, coarse medium to medium; weathers red and yellow brown; moderately crinoidal	2.0
	(Note: Beds 26-31 correlated with Kessler member of Bloyd formation. Estimated thickness of Kessler 11.6 feet.)	
25.	Covered: some poorly exposed blue gray, fissile shale beds	40.5
24.	Limestone: upper 5 feet blue gray to brown gray, very coarse; weathers "chocolate" brown; fossiliferous, crinoidal	12.0
23.	Covered	9.0
22.	Limestone (may not be in place): gray to black, very coarse; weathers rough and somewhat thin-bedded; extremely crinoidal	2.0
21.	Covered	5.0
20.	Limestone: upper 3 feet brown gray, coarse, medium; weathers rough and somewhat thin-bedded	12.0
19.	Covered	10.0
18.	Shale: blue gray, fissile, limonite concretions	5.0
17.	Limestone: blue gray with a brownish hue, coarse medium with very coarse crystals; weathers crinoidal; fossiliferous	3.0
16.	Covered	3.0
15.	Limestone: (may not be in place) blue gray, fine medium with coarse crystals; weathers smooth	2.0
14.	Covered and shale	6.0
	Estimated thickness of the Bloyd	121.1
Hale formation		
13.	Limestone: brown gray, very coarse, granular, black shaly inclusions; weathers smooth and crinoidal; fossiliferous	2.0
12.	Covered	7.0
11.	Limestone: blue gray, medium with very coarse crystals; weathers rough and jointed; crinoidal	5.0
10.	Covered	7.0
9.	Limestone: light gray to buff, fine and medium; weathers pitted	5.0
8.	Covered	13.0
7.	Limestone: lower 5 feet black, very coarse, some orange calcite replacement; upper 6 feet blue gray to purplish, medium; thin-bedded; weathers crinoidal and smooth; fossiliferous	11.0
6.	Limestone: extremely coarse, weathers granular and thin-bedded; fossiliferous; extremely crinoidal	6.0

	Feet
5. Conglomerate: calcareous, rounded chert pebbles and some limestone pebbles with crinoid stems; weathers yellow brown and red; fossiliferous	2.0
Thickness of Hale	58.0
Mississippian	
Chester series	
Pitkin limestone	
4. Limestone: blue gray and brown gray, coarse to very coarse; upper 5 feet smoky blue gray to blue, brittle, fine to sublithographic; knobby beds with thin blue black shale partings; cliff forming	19.5
Estimated thickness of Pitkin	19.5
Fayetteville shale	
3. Shale: blue gray, fissile	4.0
2. Covered	40.0
Estimated thickness of Fayetteville	44.0
Meramec? series	
1. Limestone, occurs in a continuous outcrop: blue gray; some thin beds, some shaly beds; fossiliferous	48.0
Covered below	
Exposed thickness of Meramec?	48.0

59. DOUBLE MOUNTAIN, (SOUTH END), SEC. 34, T. 15 N., R. 25 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
24. Covered, sandstone rubble and sandy soil	25.0
Estimated thickness of Atoka	25.0
Morrow series	
Bloyd formation	
23. Covered	58.0
22. Limestone: brown gray, rather platy, medium, glauconitic; weathers shattered, buff	2.0
21. Covered: few indications of blue gray fissile shale	57.0
20. Limestone	3.0
19. Covered	4.0
18. Limestone: gray to black, very coarse; weathers red, fossiliferous; crinoidal	4.0
17. Covered: some limestone rubble	31.0
Estimated thickness of Bloyd	159.0
Hale formation	
16. Limestone: blue gray, medium; weathers thin-bedded to platy	4.0
15. Limestone: blue gray, fine medium to medium; weathers smooth; very fossiliferous, bryozoans	3.0
14. Shale: blue gray, fissile, limonite concretions	4.0
13. Covered	11.0
12. Limestone: blue gray and gray black, very coarse; weathers smooth to pitted; fossiliferous, crinoidal	3.0
11. Covered	20.0
10. Shale: blue gray, fissile, limonite concretions	3.0
9. Sandstone: deeply weathered, some characteristic Hale weathering	2.0
8. Covered	4.0
7. Limestone: gray, very coarse, crinoidal, some granular beds	11.0
Thickness of Hale	65.0
Mississippian	
Chester series	
Pitkin limestone	
6. Limestone: upper 2 feet gray, fine medium to fine; weathers smooth; sparsely fossiliferous; lower foot is argillaceous	4.0
5. Limestone: blue gray, coarse medium; weathers fluted; fossiliferous	4.5
4. Covered	27.0
Estimated thickness of Pitkin	35.5
Fayetteville shale	
3. Shale: blue black, limonite concretions; few covered intervals	30.0
Estimated thickness of Fayetteville	30.0
Meramec? series	
2. Limestone, in continuous outcrop: light blue, generally coarse; some thin bedded, cherty inclusions in lower 1 foot	58.0
Thickness of Meramec?	58.0
Osage series	
1. Chert and cherty limestone	

60. NORTHEAST SPUR OF MUSKRAT AND ROSS MOUNTAINS, SEC. 11, T. 15 N., R. 26 E.

Pennsylvanian	
Morrow series	
Hale formation	
6. Sandstone: ferruginous; massive bedded near top with some thinner beds below	31.0
5. Covered: probably sandstone	3.0
4. Sandstone, calcareous: yellow brown; weathers pitted with grooves and ridges	5.0
3. Shale: yellow brown, plastic	4.0
2. Covered	60.0
Exposed thickness of the Hale	103.0
Mississippian	
Chester series	
Pitkin limestone	
1. Limestone: blue gray, medium with sublithographic crystalline beds; fossiliferous, *Linoproductus*, *Aviculopecten*	12.8
Exposed thickness of Pitkin	12.8

61. NORTH END OF ROSS MOUNTAIN. SECS. 12 AND 13, T. 15 N., R. 26 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
27. Covered to top of hill	32.0
26. Shale: yellow brown, ferruginous	4.0
25. Sandstone: yellow brown; massive beds 1.5 to 2 feet thick	8.0
Estimated thickness of Atoka	44.0
Morrow series	
Bloyd formation	
24. Covered: sandstone rubble	52.0
23. Shale: blue gray, fissile	2.0
22. Covered	3.0
21. Shale: blue gray, fissile	3.0
20. Covered: sandstone rubble	46.0
19. Sandstone: poor outcrop, gray to black, medium grained; some conglomeratic blocks observed at this level around the hill	2.0
18. Shale: blue gray, fissile, limonite concretions (includes many covered intervals)	37.0
17. Sandstone: may not be in place	1.0
16. Shale: blue gray, fissile, limonite concretions	3.0

		Feet
15.	Limestone: dark blue gray, coarse medium to coarse, hard, tough; weathers somewhat cross-bedded	3.0
14.	Shale: blue gray, fissile, limonite concretions	8.0
13.	Limestone and shale: limestone is gray blue gray, coarse; weathers platy, reddish brown, crinoidal, and cross-bedded; carries a prominent pebble bed 4 feet from top	22.0
12.	Shale: blue gray, fissile, limonite concretions	12.0
11.	Covered	38.0
	Estimated thickness of the Bloyd	232.0
	Hale formation	
10.	Covered	28.0
9.	Sandstone: similar to bed 7	3.0
8.	Covered	2.0
7.	Sandstone: gray, tough; massive-bedded	8.0
6.	Covered	13.0
5.	Sandstone: yellow brown to gray; very thin-bedded	5.0
4.	Covered	23.0
3.	Shale: yellow brown, sandy	6.0
2.	Covered	22.0
1.	Sandstone: gray thin-bedded, one to two inches thick, ripple marks, somewhat cross bedded; weathers ferruginous; near top becomes more thin-bedded and shaly	28.0
	Estimated thickness of the Hale	138.0

62. NORTH SPUR OF MUSKRAT MOUNTAIN. SEC. 14, T. 15 N., R. 26 E.

Pennsylvanian		
Morrow series		
Hale formation		
7.	Covered to top of hill	10.0
6.	Sandstone: massive bedded	5.5
5.	Covered	5.5
4.	Sandstone: beds average 3 to 4 inches thick; characteristic Hale weathering	10.0
3.	Covered	5.5
2.	Sandstone: thin bedded, partly covered	10.0
	Exposed thickness of the Hale	46.5
Mississippian		
Chester series		
Pitkin limestone		
1.	Limestone: blue gray, lower 6 to 8 feet fine to sublithographic, upper part medium; upper few inches very argillaceous with trace of phosphate; fossiliferous	28.0
	Covered below	
	Exposed thickness of the Pitkin	28.0

63. NORTHERN POINT OF MUSKRAT MOUNTAIN. SEC. 15, T. 15 N., R. 26 E.

Pennsylvanian		
Morrow series		
Hale formation		
13.	Sandstone: in part thin bedded with beds 0.5 to 1 inch thick	14.0
12.	Sandstone: massive bedded	3.0
11.	Covered	10.0
10.	Sandstone: thick- and thin-bedded, highly cross bedded; characteristic Hale weathering	15.8
9.	Sandstone: massive bedded	3.5
8.	Covered: red sandy and clayey soil	10.0

		Feet
7.	Sandstone: massive bedded	3.0
6.	Sandstone: thin bedded	10.5
5.	Sandstone: yellow brown; massive bedded, and cross bedded; weathers bright yellow ochre color	12.5
4.	Shale: blue gray, fissile, plastic (a spring issues over this shale)	8.0
3.	Shale: yellow brown, heavily stained with limonite; many limonite pebbles that show trace phosphate	3.5
2.	Sandstone: somewhat argillaceous; massive and thin-bedded	6.0
	Exposed thickness of Hale	99.8
Mississippian		
Chester series		
Pitkin limestone		
1.	Limestone: blue to light blue gray, sublithographic to fine medium; fossiliferous, *Archimedes*, locally crinoidal	8.0
	Exposed thickness of Pitkin	8.0

64. MUSKRAT MOUNTAIN, SEC 21, T. 15 N., R. 26 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
25.	Covered: slope covered with loose sandstone blocks and sandy soil	56.0
24.	Sandstone: white, fine grained; massive bedded	3.0
	Estimated thickness of Atoka	59.0
Morrow series		
Bloyd formation		
23.	Covered	49.0
22.	Shale: blue gray, fissile, limonite concretions; many concealed intervals	56.0
21.	Limestone: dark gray, coarse, tough	2.0
20.	Shale: blue gray, fissile, limonite concretions	18.0
19.	Shale: bluish to yellow brown, sandy; thin-bedded; weathers ferruginous	2.0
18.	Shale: blue gray, fissile, limonite concretions	2.0
17.	Limestone: very platy	1.0
16.	Shale: blue gray, fissile, limonite concretions	10.0
15.	Limestone and shale: limestone is dark blue to black, coarse medium; weathers platy; top bed rich in bryozoans	16.0
14.	Shale: blue gray, fissile, limonite concretions	18.0
13.	Limestone: black to blue black, tough; weathers light brown and smooth; crinoidal and fossiliferous	3.0
12.	Shale: blue gray, fissile	1.0
11.	Limestone	4.0
10.	Shale: blue gray, fissile	1.0
9.	Limestone: light blue gray, coarse medium to coarse; weathers smooth and even; slightly fossiliferous	5.0
8.	Shale: blue gray, fissile, limonite concretions	10.0
7.	Limestone: dark blue gray, coarse medium; fossiliferous	2.5
6.	Shale: blue gray, fissile	2.0
5.	Limestone: dark blue gray, coarse medium with some 2 to 3 mm crystals; weathers platy and crinoidal; fossiliferous	4.0
4.	Shale: blue gray, fissile	7.5
	Estimated thickness of Bloyd	214.0
Hale formation		
3.	Limestone: blue gray, very coarse, typical upper Hale limestone, extremely crinoidal; weathers smooth and pitted	10.0
2.	Covered	3.0
1.	Sandstone	6.0
	Covered below	
	Exposed thickness of the Hale	26.5

65. SOUTHERN PART OF MUSKRAT MOUNTAIN AND NIGGER JOE POINT, SECS. 28 AND 29, T. 15 N., R. 26 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
26.	Covered: sandstone and siltstone rubble	33.0
25.	Sandstone: gray and brown, argillaceous; thin-bedded	3.0
24.	Covered: sandstone and siltstone rubble, sandy soil	21.0
	Estimated thickness of Atoka	57.0
Morrow series		
Bloyd formation		
23.	Shale: blue gray, fissile, limonite concretions	15.0
22.	Limestone: brown, fine medium; capped by a thin-bedded to platy layer; weathers chocolate brown; fossiliferous (Note: Beds 22 and 23 correlated with Kessler member of Bloyd formation. Total thickness 20 feet.)	5.0
21.	Shale and covered: blue gray, fissile, limonite concretions	23.0
20.	Limestone: blue gray to gray, fine; fossiliferous	5.0
19.	Shale and covered: blue gray, fissile, with limonite concretions	40.0
18.	Limestone: blue gray, very coarse; weathers smooth; fossiliferous	6.0
17.	Covered	72.0
	Estimated thickness of Bloyd	166.0
Hale formation		
16.	Covered	60.0
15.	Sandstone: (at top of Nigger Joe Point, SE¼ sec. 29, T. 15 N., R. 26 E.) white and gray with yellow brown bands; thin bedded; weathers ferruginous	3.0
14.	Covered	10.0
13.	Sandstone: calcareous, many limy inclusions, trace phosphatic; 8 feet below top is 0.5-foot limestone bed, crinoidal and very coarse	31.0
12.	Limestone, very sandy: blue gray; weathers ferruginous	5.0
11.	Limestone: thin-bedded, trace phosphatic, lower 0.5 foot argillaceous with blue pebbles	2.8
10.	Conglomerate: calcareous, limonitic pebbles that weather red, trace phosphatic; grades upward into limestone	0.5
	Estimated thickness of Hale	112.3
Mississippian		
Chester series		
Pitkin limestone		
9.	Shale: blue gray	0.3
8.	Limestone: blue gray to brown gray, coarse medium to coarse; fossiliferous	2.0
7.	Limestone: partly covered, blue gray, chiefly fine to sublithographic	16.0
	Thickness of the Pitkin	18.3
Fayetteville shale		
6.	Shale: blue gray, fissile, limonite concretions; contains one thin limestone bed	30.0
5.	Sandstone: yellow brown, well jointed. This is Wedington sandstone member of Fayetteville	10.0
4.	Shale: black to blue black, few limonite concretions; poorly exposed near base	94.0
	Thickness of Fayetteville	134.0
Meramec? series		
3.	Covered, some poorly exposed limestone	26.0
2.	Limestone: blue gray, coarse medium to medium; weathers smooth and buff; fossiliferous, abundant small algal-like discs	5.0
1.	Covered to estimated top of "Boone"	8.0
	Estimated thickness of Meramec?	39.0

66. SALEM SCHOOL SECTION, SEC. 31, T. 15 N., R. 26 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
22.	Covered: blocks of massive bedded sandstone and thin-bedded siltstone cover the slope	28.0
	Estimated thickness of Atoka	28.0
Morrow series		
Bloyd formation		
21.	Covered, few shale indications at top	21.0
20.	Shale: blue gray, fissile, limonite concretions	8.0
19.	Limestone: brown gray, fine; weathers with big shallow pittings	3.0
18.	Shale and covered: blue gray, fissile, limonite concretions	18.0
17.	Limestone: blue gray, very coarse; weathers granular	2.0
16.	Shale and covered: blue gray, fissile, limonite concretions	31.0
15.	Limestone: blue gray, very coarse; weathers smooth; fossiliferous	10.0
14.	Shale and covered: blue gray, fissile, limonite concretions	44.0
13.	Limestone: black, coarse, crinoid stems replaced by orange calcite; weathers platy	5.0
12.	Shale: blue gray, fissile	4.0
11.	Limestone: blue gray with black crystals; weathers smooth	5.0
10.	Covered	3.0
	Estimated thickness of Bloyd	154.0
Hale formation		
9.	Sandstone: massive bedded	1.0
8.	Covered	14.0
7.	Limestone: gray black, very coarse, crinoidal and sandy	1.5
6.	Sandstone, calcareous: yellow tan buff with blue gray limy inclusions; weathers cross-bedded, pitted and cavernous, and in horizontal flutings; slightly phosphatic	24.5
5.	Covered	6.0
	Estimated thickness of Hale	47.0
Mississippian		
Chester series		
Pitkin limestone		
4.	Covered	5.0
3.	Limestone: blue gray; thin shale partings; fossiliferous	3.0
2.	Covered	11.0
1.	Limestone: light blue gray, coarse medium; weathers knobby; crinoidal	10.0
	Covered below	
	Exposed thickness of Pitkin	29.0

67. BELL SCHOOLHOUSE KNOB, SEC. 32, T. 15 N., R. 26 E.

		Feet
Pennsylvanian		
Morrow series		
Hale formation		
6.	Sandstone: calcareous; massive bedded; poorly exposed	25.0
5.	Covered	20.0
4.	Limestone, very sandy: blue gray; thin-bedded, trace phosphatic	1.0
3.	Covered	3.0
2.	Conglomerate: with dark shale, limonite pebbles, sandy, calcareous cement, trace phosphatic	0.3
	Exposed thickness of Hale	49.3

Mississipian
Chester series
Pitkin limestone

		Feet
1.	Limestone: blue gray, medium with sublithographic beds; weathers even and rubbly	17.0
	Exposed thickness of Pitkin	17.0

68. SOUTH END OF ROSS MOUNTAIN, SECS. 34 AND 35, T. 15 N., R. 26 E.

Pennsylvanian
Des Moines series
Atoka formation

31.	Covered: sandstone and siltstone rubble	25.0
30.	Siltstone: light yellow brown with greenish hue; thin bedded, beds average less than 1 inch thick, cross bedding on a small scale	8.0
29.	Covered: siltstone rubble	20.0
	Estimated thickness of Atoka	53.0

Morrow series
Bloyd formation

28.	Covered	46.0
27.	Limestone: brown, blue gray, coarse; weathers smooth; fossiliferous	3.0
26.	Shale: blue gray, fissile, limonite concretions	30.0
25.	Limestone: brown, fine and medium; weathers smooth and blue; fossiliferous	5.0
24.	Shale: blue gray, fissile, limonite concretions	5.0
23.	Limestone	2.0
22.	Shale: blue gray, fissile, limonite concretions	12.0
21.	Limestone: dark blue gray, very coarse; weathers even and crinoidal; fossiliferous	2.0
20.	Shale: blue gray, fissile, limonite concretions	10.0
19.	Limestone: blue gray, coarse medium; platy beds; weathers thin-bedded; fossiliferous	1.0
18.	Shale: blue gray, fissile, limonite concretions	11.0
	Estimated thickness of the Bloyd	127.0

Hale formation

17.	Sandstone: gray to blue gray, very calcareous with limestone inclusions; weathers pitted and ferruginous	24.0
16.	Covered	5.0
15.	Sandstone: limy inclusions; weathers cross-bedded and in horizontal parallel flutings	29.0
14.	Covered	31.0
13.	Sandstone: yellow buff, calcareous; massive bedded	2.0
12.	Sandstone: argillaceous, calcareous, and silty; trace phosphate	6.0
11.	Sandstone: greenish, argillaceous, few limonite pebbles; thin-bedded; weathers ferruginous	7.0
	Thickness of Hale	104.0

Mississipian
Chester series
Pitkin limestone

10.	Limestone: blue gray, sublithographic	8.0
9.	Limestone: gray brown, jointed, fossiliferous	10.0
8.	Shale with knobby limestone; fossiliferous, in part slightly phosphatic. Limestone; blue gray, very coarse, very crinoidal	1.0
7.	Limestone: gray blue gray, fine, tough; weathers smooth and pitted	11.0
6.	Limestone: few thin shale beds	29.0
	Thickness of Pitkin	59.0

Fayetteville shale

		Feet
5.	Covered	87.0
4.	Shale: iron stained, sandy	7.0
3.	Covered: few indications of shaly soil	66.0
	Estimated thickness of Fayetteville	160.0

Meramec? series

2.	Limestone: blue gray; fossiliferous, small algal-like discs on weathered surface	6.0
1.	Covered to top of Boone	11.0
	Estimated thickness of Meramec?	17.0

69. KEOUGH QUARRY, SEC. 25 T. 16 N., R. 19 E.

Pennsylvanian
Des Moines series
Atoka formation

29.	Sandstone: massive bedded	6.0
28.	Covered: sandy and shaly soil and sandstone rubble	26.0
27.	Sandstone: fine to medium grained, iron stained; cross-bedded, ripple marked, some thin beds	8.0
	Exposed thickness of Atoka	40.0

Morrow series
Bloyd formation

26.	Covered	12.0
25.	Shale: blue gray, fissile, limonite concretions	10.0
24.	Limestone: gray to brown gray, medium, some coarse crystals; uneven-bedded; weathers thin-bedded to platy; fossiliferous, crinoidal	8.0
23.	Shale: poorly exposed	20.0
22.	Limestone: argillaceous, iron stained buff; thin-bedded; fossiliferous, bryozoans abundant	3.0
21.	Limestone: Similar to bed 19	1.0
20.	Shale: *Pentremites* zone, unfossiliferous along strike	0.5
19.	Limestone: brown gray, very fine with coarse crystals; coarsely crinoidal, fossiliferous; few thin shale breaks	8.0
18.	Shale: buff to gray, calcareous, limestone concretions; fossiliferous, crinoid remains, corals	1.5
17.	Limestone with two shale breaks: light gray, very coarse; fossiliferous, *Dentalium*, crinoidal and with poorly preserved calyces	7.5
16.	Shale: similar to bed 14	0.5
15.	Limestone: dark blue black, argillaceous with coarse crinoidal material; thin-bedded	2.0
14.	Shale: with thin limestone beds; very calcareous, crinoidal; trace phosphatic	6.0
13.	Limestone: dark gray, coarse with very coarse crystals, large calcite masses; crinoidal, fossiliferous	1.5
12.	Shale: blue black to black, fissile, calcareous; includes a 6-inch hard, iron-stained bed; fossiliferous; trace phosphatic	3.5
	Thickness of Bloyd	85.0

Hale formation

11.	Limestone: gray, coarse medium; sandy beds and sandy inclusions that are greenish buff, medium grained, uneven bedded; not so sandy in upper part	10.0
10.	Shale: gray with greenish cast, calcareous	0.3
9.	Limestone: similar to bed 7	2.0
8.	Limestone: uneven bedded, conglomeratic; trace phosphatic	0.5
7.	Limestone: pink, very coarse with large calcite crystals; thin greenish sandy beds that show trace of phosphate, few black, small, low grade calcareous phosphatic pebbles in the limestone	

	Feet
and especially in sandy lenses; extremely crinoidal, *Pleurodictyum (Michelinia)*, large corals, crinoidal bases, *Composita, Dictyoclostus, Hustedia*	14.5
Thickness of Hale	27.3
Mississippian	
Chester series	
Pitkin limestone	
6. Limestone: gray with greenish hue, fine medium with coarse crystals, greenish argillaceous streaks near top; extremely rubbly and uneven bedded; few small black low grade phosphatic calcareous nodules near upper part of bed	2.5
5. Limestone: gray, fine with large calcite masses, jointed; fossiliferous, *Linoproductus, Composita*	9.5
4. Limestone and shale: shale, calcareous, fissile; irregularly bedded; limestone in thin beds, gray, sublithographic; light blue on weathering, knobby; *Pleurodictyum (Michelinia.)*	2.0
3. Limestone: gray, fine to sublithographic; brittle, conchoidal fracture	8.5
2. Limestone: poorly exposed below top; reddish brown on weathering	6.0
1. Limestone: on floor of quarry, brown with dark calcite crystals, fine with coarse crystals, jointed; weathers by spalling off locally; *Archimedes*, bryozoans, brachiopods	2.0
Covered below	
Exposed thickness of Pitkin	30.5

70. BLACKSMITH SECTION, E½ SEC. 10, T. 16 N., R. 20 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
35. Sandstone: on top of hill	11.0
34. Shale: sandy, weathers red	7.0
33. Sandstone: yellow brown and gray, heavily iron stained, fine to medium grained; massive- and thin-bedded	5.0
Exposed thickness of Atoka	23.0
Morrow series	
Bloyd formation	
32. Shale: blue gray, fissile; weathers buff	10.6
31. Shale: poorly exposed	9.2
30. Shale: buff, plastic, seems to grade into bed below	2.0
29. Siltstone: green to buff brown, moderately iron stained along bedding planes, thin-bedded, jointed, carbonaceous	6.5
28. Shale: poorly exposed	20.4
Thickness of Bloyd	48.7
Hale formation	
27. Limestone, argillaceous: blue gray, coarse medium; large coral, extremely crinoidal, *Composita*	2.0
26. Shale: poorly exposed	3.5
25. Limestone: similar to bed 23, lower 1 foot glauconitic; *Composita, Spririfer*	5.5
24. Shale	2.0
23. Limestone: blue gray, medium matrix with coarse crystals; weathers thin and uneven bedded and crinoidal; fossiliferous	5.0
22. Shale: poorly exposed	3.0
21. Limestone: blue gray, iron spotted, coarse; upper part uneven bedded; crinoidal	2.5
20. Shale: poorly exposed	3.5
19. Limestone: light gray to cream gray, fine, some 2-inch calcite masses, jointed; weathers crinoidal; *Pentremites* abundant,	

	Feet
large *Pleurodictyum (Michelinia)*	7.6
Thickness of Hale	34.6
Mississipian	
Chester series	
Pitkin limestone	
18. Shale: dirty blue gray, iron stained; fossiliferous, *Crurithyris (Ambocoelia)*	2.0
17. Limestone: dark blue gray, coarse, iron spotted and stained; locally a crinoid stem coquina, isolated plates of *Agassizocrinus* calyces, *Archimedes*	4.0
16. Limestone: gray to buff gray, fine medium; includes blue sublithographic beds a few inches thick, some thin shale partings, iron spotted; weathers smooth	3.5
15. Shale	0.5
14. Limestone: gray to blue gray, coarse with very coarse crystals, brown calcite masses; tough iron stained; *Composita?*	2.0
13. Shale: poorly exposed	0.5
12. Limestone: similar to bed 10; weathers rough and irregular; top bed carries abundant large *Archimedes*	7.0
11. Shale: poorly exposed	1.0
10. Limestone: lower part blue, fine to sublithographic; thinner bedded and rubbly near top; crinoidal, very fossiliferous, abundant *Pentremites, Archimedes*	4.0
9. Shale: blue gray, plastic, calcareous	2.0
8. Limestone: dark blue black, fine with coarse crystals, tough, sandy, emits carbonaceous odor when struck with hammer; few black nodules that contain trace phosphate	1.0
7. Limestone: light blue; knobby on weathering	0.5
6. Shale: poorly exposed	2.0
5. Shale: blue gray, fissile, plastic	1.0
4. Limestone: alternating beds of blue gray, very fine to sublithographic, and gray, very coarsely crystalline; massive bedded; fossiliferous, crinoidal, *Agassizocrinus*, iron spotted	3.6
Thickness of Pitkin	34.6
Fayetteville shale	
3. Shale: poorly exposed	2.0
2. Limestone: thin-bedded	1.0
1. Shale: black, fissile	7.0
Covered below	
Exposed thickness of Fayetteville	10.0

71. FLOWER CREEK SECTION. SEC. 19, T. 16 N., R. 20 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
24. Sandstone: medium grained, few coarse grained lenses	20.0
23. Shale: blue black, greenish hue; well jointed, sandy	4.0
22. Sandstone: fine grained, iron stained; ripple marked, cross-bedded	6.0
Exposed thickness of Atoka	30.0
Morrow series	
Bloyd formation	
21. Covered	24.0
20. Shale: blue gray, fissile	3.0
19. Limestone: gray, medium, even; weathers light blue	2.0
18. Shale	2.0
17. Limestone: blue gray, iron spotted; upper 3 inches sandy; weathers thin-bedded; fossiliferous	2.0

	Feet
16. Shale, poorly exposed	5.0
Estimated thickness of Bloyd	38.0
Hale formation	
15. Limestone: gray with greenish calcite masses, very fine with coarse crystals	1.0
14. Limestone: rough, irregular, and knobby, very sandy, green argillaceous streaks and shaly partings, limonite concretions; *Pleurodictyum* (*Michelinia*), bryozoans, *Hustedia, Composita, Derbyia?, Spirifer,* trilobite pygidium	1.0
13. Limestone: light to cream gray, coarse to coarse medium; glauconitic	4.5
12. Limestone: light gray, fine medium to medium; weathers thin-bedded	15.0
11. Limestone	5.0
10. Limestone: coarse with large calcite masses, heavily iron stained, granular; weathers knobby; crinoidal, fossiliferous, *Pleurodictyum* (*Michelinia*) common	2.0
9. Limestone: light gray, very coarse	2.0
8. Limestone conglomerate: pebbles of shale, limonite and limestone in limestone matrix, very sandy, phosphatic; weathers thin-bedded and uneven bedded	1.0
Thickness of Hale	31.5
Mississippian	
Chester series	
Pitkin limestone	
7. Limestone: light neutral gray, sublithographic, oolitic	1.5
6. Limestone: light gray, fine medium, moderately iron stained buff; weathers rubbly and uneven	3.5
5. Shale	1.0
4. Limestone: gray, coarse, granular, iron stained; weathers smooth	6.0
3. Shale	3.0
2. Limestone: blue gray, crinoidal; fossiliferous	5.0
1. Limestone and shale	10.0
Covered below	
Exposed thickness of Pitkin	30.0

72. BOBTAIL BRANCH SECTION. SEC. 8, T. 16 N., R. 21 E.

Pennsylvanian	
Des Moines series	
Atoka formation	16.0
Morrow series	
Bloyd formation	74.0
Hale formation	32.0
Mississippian	
Chester series	
Pitkin limestone	30.0

73. EUREKA SECTION. SEC. 21, T. 16 N., R. 21 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
16. Sandstone: thin-bedded, poorly exposed	9.0
Exposed thickness of Atoka	9.0
Morrow series	
Bloyd formation	
15. Covered	46.0

	Feet
14. Limestone: blue gray, thin-bedded; weathers thin-bedded and rough	3.0
13. Covered	7.0
12. Limestone: light gray, coarse medium; weathers smooth; coarsely crinoidal, some black crinoidal material	2.0
11. Covered	5.0
10. Sandstone: yellow brown, coarse to medium grained, very slightly calcareous, heavily iron stained (may not be in place)	2.0
9. Covered	3.0
Estimated thickness of Bloyd	68.0
Hale formation	
8. Limestone: gray, coarse medium; weathers rough and thin-bedded	2.0
7. Covered	12.0
6. Shale	3.0
5. Limestone: light blue gray, fine with sublithographic lenses; weathers in light blue splotches; moderately crinoidal, fossiliferous	2.0
4. Limestone: dark blue gray to purplish, buff on bedding planes; very thin-bedded and platy	1.0
3. Limestone: light gray to gray brown, oolitic in upper part; weathers smooth	6.0
Thickness of Hale	26.0
Mississippian	
Chester series	
Pitkin limestone	
2. Limestone: gray, fine medium with coarse crystals; weathers jointed and rather rubbly	6.0
1. Limestone with few thin shale beds	12.0
Covered below	
Exposed thickness of Pitkin	18.0

74. SOUTH TAHLEQUAH SECTION. SEC. 5, T. 16 N., R. 22 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
14. Sandstone: medium to coarse grained	6.0
13. Covered	12.0
12. Sandstone: fine to medium grained; massive bedded	2.0
Exposed thickness of Atoka	20.0
Morrow series	
Bloyd formation	
11. Covered	18.0
10. Limestone: blue gray and dove gray, fine with sublithographic crystalline lenses; weathers light blue and rubbly, with local granular beds	5.0
9. Covered, poorly exposed shale near base	27.0
Estimated thickness of Bloyd	50.0
Hale formation	
8. Limestone: dove gray, fine even crystalline; weathers rough	4.0
7. Limestone: upper part light gray, fine with coarse crystals; very uneven bedded; weathers smooth and uneven; moderately fossiliferous	18.0
6. Limestone: coarse crystalline, trace phosphatic; weathers very sandy	2.0
Thickness of Hale	24.0

	Feet
Mississippian	
Chester series	
Pitkin limestone	
5. Limestone: blue gray to drab gray, sublithographic crystalline; some thin shale beds at the base	18.0
Estimated thickness of Pitkin	18.0
Fayetteville shale	
4. Covered	23.0
3. Bed of Septarian concretions	1.0
2. Covered	24.0
1. Shale: poorly exposed, dark gray to black	6.0
Covered below	
Exposed thickness of Fayetteville	54.0

75. WEST TAHLEQUAH SECTION. SEC. 6, T. 16 N., R. 22 E. (INTO SEC. 1, T. 16 N., R. 21 E.)

Pennsylvanian	
Des Moines series	
Atoka formation	
30. Sandstone: yellow brown, medium to fine grained, well jointed	3.0
Exposed thickness of Atoka	3.0
Morrow series	
Bloyd formation	8.0
29. Covered	3.0
28. Shale	
27. Limestone: blue to blue gray, sublithographic with black calcite veins and small masses; uneven bedded, jointed; weathers rubbly and in light blue splotches	4.0
26. Shale	4.0
25. Covered	16.0
24. Shale	4.0
23. Limestone: blue to blue gray, fine medium with few coarse crystals; weathers smooth; fossiliferous, moderately crinoidal	2.0
22. Shale	4.0
21. Limestone: blue gray, medium to fine medium; thin-bedded and granular; crinoidal	2.0
20. Shale	2.0
Estimated Thickness of Bloyd	49.0
Hale formation	
19. Sandstone: yellow brown, medium to fine medium grained; slightly calcareous; heavily iron stained	2.0
18. Limestone: weathers in light blue splotches, rubbly	3.0
17. Covered	2.0
16. Limestone: blue gray, medium with very coarse and coarse crystals; thin bedded; granular on weathering	2.0
15. Covered	4.0
14. Limestone: gray, very coarse to coarse, granular; weathers smooth; crinoidal	3.0
13. Limestone: thin-bedded; weathers rough and irregular	4.0
12. Limestone	5.0
11. Limestone: neutral gray, sublithographic; weathers jointed, rubbly and light blue	3.0
10. Limestone: gray, coarse to coarse medium; weathers buff and crinoidal; fossiliferous, crinoidal	2.0
9. Limestone: light gray to gray black, coarse even crystalline, oolitic; weathers rough	10.0
Thickness of Hale	40.0

	Feet
Mississippian	
Chester series	
Pitkin limestone	
8. Limestone	6.0
7. Limestone: dark blue gray and brown gray, iron stained along bedding planes, very coarse; crinoidal and fossiliferous	2.0
6. Limestone: light blue, sublithographic; jointed	2.0
5. Limestone: neutral gray, fine with sublithographic crystalline lenses; jointed, uneven bedded; weathers thin-bedded and rubbly; fossiliferous, *Diaphragmus*	2.0
4. Covered	7.0
3. Shale	3.0
2. Limestone	14.0
1. Limestone and interbedded shales: grades downward into Fayetteville shale	4.0
Covered below	
Exposed thickness of Pitkin	40.0

76. PARKHILL SECTION. SECS. 26 AND 27, T. 16 N., R. 22 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
35. Covered: brown shale and clay soil	20.0
34. Sandstone: thin-bedded, shaly	15.0
33. Sandstone: medium grained, heavily iron stained; rather cross bedded	2.0
Exposed thickness of Atoka	37.0
Morrow series	
Bloyd formation	
32. Shale: fissile; weathers buff	3.5
31. Shale: buff with greenish hue	0.5
30. Shale: blue, fissile, limonite concretions	19.2
29. Limestone: rubbly	1.0
28. Limestone: very fine to sublithographic; uneven bedded and rubbly, fossiliferous lenses and discontinuous shaly beds	5.0
27. Shale: buff to yellow brown, includes a 0.3-foot limestone similar to bed 26	3.5
26. Limestone: light blue gray, coarse medium; weathers smooth; moderately crinoidal	4.5
25. Siltstone: similar to bed 23	6.0
24. Limestone: purplish blue gray, coarse medium; weathers smooth and iron stained, coarsely crinoidal; discontinuous along strike	0.5
23. Siltstone, with limy stringers; buff with greenish hue, appears sandy and gritty	19.8
22. Limestone: blue medium with coarse crystals; upper 3 inches shaly and fossiliferous	1.5
21. Shale: gray, plastic; includes 6-inch shaly limestone bed that is very fossiliferous, *Amplexus, Productids, Spirifer rockymontanus*	2.5
20. Limestone: dark blue gray, coarse to coarse medium; weathers buff; crinoidal and fossiliferous, *Pleurodictyum* (*Michelinia.*) *Pentremites, Composita*	3.0
19. Shale: brown with greenish cast, blocky, ferruginous; includes a 6-inch sandstone bed, heavily iron stained that weathers pitted	2.0
18. Limestone: shaly, rubbly, and contains 1- to 2-inch shale beds; crinoidal on surface, *Pentremites*	2.0
17. Limestone: gray with blue gray bands, very fine to sublithographic; fossiliferous; grades into limestone above	3.0
Thickness of Bloyd	77.5

		Feet
Hale formation		
16.	Shale: plastic, buff to light blue, somewhat variegated	1.0
15.	Sandstone, calcareous: heavily iron stained; weathers pitted and cavernous; fossiliferous	1.0
14.	Limestone: purplish blue to blue green, very fine, some coarse crystals, clay inclusions and sandy; this seems to be reef-like, grades laterally into a fissile shaly sandstone	2.5
13.	Shale: sandy, fossiliferous; weathers buff	2.0
12.	Shale: mostly covered	2.0
11.	Limestone: light gray, very coarsely crystalline; crinoidal; upper 3 feet shaly	10.1
10.	Shale: buff with greenish cast, fissile	2.0
9.	Limestone: gray, coarse medium to coarse, some black calcite masses; weathers buff and in uneven beds	14.7
8.	Limestone, sandy: light gray, coarse medium with large calcite masses; uneven bedded, crinoidal	6.5
	Thickness of Hale	41.8
Mississippian		
Chester series		
Pitkin limestone		
7.	Limestone: similiar to bed 5	0.5
6.	Shale: calcareous, trace phosphatic; very fossiliferous, bryozoans	0.5
5.	Limestone: blue, fine medium to fine; conchoidal fracture; top bed contains many *Archimedes* and a pebble layer	6.0
4.	Covered	3.0
3.	Shale	5.0
2.	Covered	3.0
1.	Limestone: blue, jointed, sublithographic; fossiliferous, *Diaphragmus*	6.0
	Covered below	
	Exposed thickness of Pitkin	24.0

77. SUGAR MOUNTAIN SECTION, SE¼, SEC. 21, T. 16 N., R. 23 E.

Pennsylvanian		
Des Moines series		
Atoka formation		
19.	Sandstone: on top of hill	2.0
18.	Covered	12.0
17.	Sandstone: fine-grained; thin-bedded	1.0
16.	Covered	7.0
15.	Sandstone: blue gray, thin-bedded, calcareous; weathers iron stained brown	3.0
14.	Sandstone: fine-grained	3.0
13.	Sandstone: blue black, very fine grained, hard, carbonaceous, well jointed	1.0
	Estimated thickness of Atoka	29.0
Morrow series		
Bloyd formation		
12.	Covered	41.0
11.	Limestone: blue gray to brown gray, fine with coarse medium crystals; weathers smooth, buff colored with light blue splotches; crinoidal, very fossiliferous	2.0
10.	Covered	48.0
9.	Shale: blue gray, fissile	2.0
8.	Limestone: blue gray, very coarse, crinoidal, granular, iron spotted; weathers smooth and granular	4.0
7.	Covered	10.0
	Estimated thickness of Bloyd	115.0

		Feet
Hale formation		
6.	Limestone: lower part, neutral gray, fine medium, hard; uneven bedded	18.0
5.	Covered	4.0
4.	Sandstone: light gray, fine-grained, iron stained buff; weathers red; abundant plant remains, *Calamites*	4.0
3.	Covered to approximate top of Pitkin, few indications of calcareous sandstone that may be in place	26.0
	Estimated thickness of Hale	52.0
Mississippian		
Chester series		
Pitkin limestone		
2.	Covered: evidences of limestone, blue gray, coarse; massive bedded; crinoidal	32.0
	Estimated thickness of Pitkin	32.0
Fayetteville shale		
1.	Covered: to estimated top of "Boone," evidences of shale black, fissile, probably includes some beds assignable to the Meramec?	43.0
	Estimated thickness of Fayetteville	43.0

78. SPADE MOUNTAIN. SECS. 1 AND 12, T. 16 N., R. 24 E. SECTION STARTS ON EAST LINE OF SEC. 11, ABOUT 1/8 MILE NORTH OF SOUTH LINE OF THE SECTION.

Pennsylvanian		
Des Moines series		
Atoka formation		
37.	Sandstone: occurs as deeply weathered loose blocks	2.0
	Exposed thickness of Atoka	2.0
Morrow series		
Bloyd formation		
36.	Limestone: blue gray, fine medium; weathers bumpy and platy; fossiliferous, crinoidal	3.0
	(Note: Bed 36 correlated with Kessler member of Bloyd formation. Thickness 3.0 feet.)	
35.	Shale: fissile, limonite concretions	19.0
34.	Limestone: blue gray, coarse with large calcite masses; weathers iron stained buff; fossiliferous, crinoid base, *Pleurodictyum* (*Michelinia*)	1.0
33.	Shale: fissile, limonite concretions	7.0
32.	Sandstone: fine-grained, very calcareous, trace phosphatic, heavily iron stained	2.0
31.	Shale: fissile, limonite concretions	5.0
30.	Limestone: light gray to dark gray, medium to fine medium; weathers bumpy	3.0
29.	Covered: probably shale	5.0
28.	Limestone: gray to blue gray, coarse medium with very coarse crystals, locally granular beds; weathers knobby and rubbly; fossiliferous	4.0
27.	Covered: probably shale	10.0
26.	Limestone: blue gray and brown gray, fine medium; platy; weathers iron stained brown	2.0
25.	Covered: probably shale	12.0
24.	Limestone: blue gray, fine medium to medium; uneven bedded; weathers buff and smooth; fossiliferous, crinoidal	4.0
23.	Covered: probably shale	6.0
22.	Limestone: similar to bed 19, locally thin-bedded	3.0
21.	Covered: probably shale	6.0
20.	Shale: fissile, limonite concretions	2.0

		Feet
19.	Limestone: blue gray and brown gray, medium with coarse crystals; weathers iron stained; crinoidal	2.0
18.	Shale: fissile, limonite concretions	7.0
17.	Limestone: blue gray, coarse medium to medium crystalline; fossiliferous and crinoidal	4.0
16.	Shale: fissile, limonite concretions	7.0
15.	Limestone: brown gray with black argillaceous streaks, very sandy; thin-bedded; *Pentremites*	1.0
14.	Limestone: blue gray, medium; weathers in thin uneven beds; fossiliferous, crinoidal	2.0
13.	Shale: fissile, limonite concretions	6.0
12.	Limestone	10.0
11.	Limestone: neutral gray, sublithographic with black calcite crystals, contains peculiar "limonite concretions" about 1 inch in diameter; weathers smooth and light blue	4.0
10.	Limestone: gray, medium with coarse crystals; weathers smooth; coarsely crinoidal	6.0
	Thickness of Bloyd	140.0
	Hale formation	
9.	Sandstone: light gray, calcareous; weathers pitted and cavernous	11.0
8.	Covered: includes many beds of calcareous sandstone	70.0
7.	Shale: similar to bed 4	2.0
6.	Shale: blue black, fissile	1.0
5.	Sandstone: yellow brown, medium grained; thin-bedded; high in phosphate	2.0
4.	Shale: yellow brown, ferruginous; carries thin sandstone beds, average about 2 inches thick, extending across the shale bedding	11.2
3.	Shale: yellow brown; weathers fissile; fossiliferous	1.0
2.	Shale: blue black, fissile, poorly exposed	2.0
	Thickness of Hale	100.2
	Mississippian	
	Chester series	
	Pitkin limestone	
1.	Limestone: blue gray, poorly exposed	20.0
	Covered below	
	Exposed thickness of Pitkin	20.0

79. WAUHILLAU SECTION. SEC. 19, T. 16 N., R. 24 E.

		Feet
	Pennsylvanian	
	Morrow series	
	Hale formation	
10.	Sandstone: massive beds up to 6 and 8 inches thick weathers red	16.6
9.	Shale: dirty yellow	4.6
8.	Sandstone: dirty yellow; beds average 2 or 3 inches thick	2.0
7.	Shale: blue gray, fissile, limonite concretions; weathers yellowish brown and light colored	17.8
6.	Covered: probably sandstone	2.5
5.	Sandstone: thin-bedded, beds average less than 1 inch thick	2.0
4.	Sandstone: beds 2 to 3 inches thick, well jointed	21.4
3.	Covered	11.2
2.	Shale: yellow brown; with thin sandstone beds, maximum 2 inches thick, extending across the shale bedding	7.0
1.	Shale: blue gray, fissile; weathers yellow brown to buff	3.0
	Covered below	
	Exposed thickness of the Hale	88.1
	(This section may be too thick because of structure)	

80. COON MOUNTAIN. SEC. 35, T. 16 N., R. 24 E.

		Feet
	Pennsylvanian	
	Morrow series	
	Bloyd formation	
24.	Limestone: on top of hill, fossiliferous	5.0
23.	Shale: blue gray, fissile, limonite concretions	6.0
22.	Limestone: blue gray, fine medium to medium, tough; fossiliferous	5.0
21.	Covered	17.0
20.	Shale: blue gray, fissile, limonite concretions	10.0
19.	Covered: limestone rubble	4.0
18.	Limestone: blue gray, fine; well jointed	5.0
17.	Covered	5.0
16.	Shale: blue gray, fissile, limonite concretions	3.0
15.	Limestone: blue gray, fine, tough; weathers smooth	10.0
14.	Shale: blue gray, fissile, limonite concretions	8.0
13.	Limestone: blue gray, coarse medium to coarse; extremely fossiliferous, bryozoans	3.0
12.	Covered	10.0
	Exposed thickness of Bloyd	91.0
	Hale formation	
11.	Limestone: blue gray and brown gray; weathers platy	5.0
10.	Sandstone: thin-bedded	6.0
9.	Covered	18.0
8.	Sandstone: typically weathered	43.0
7.	Sandstone: yellow brown; massive (in a single bed); weathers red	6.0
6.	Limestone: yellow gray with a resinous appearance, medium; weathers smooth	1.5
5.	Conglomerate: calcareous, coarse limestone matrix, with limonitic and jasperoid pebbles; weathers red, considerable phosphate	1.0
	Thickness of Hale	80.5
	Mississippian	
	Chester series	
	Pitkin limestone	
4.	Limestone: blue gray, tough, fine; occurs in knobby layers	1.0
3.	Shale: dark black to black, calcareous, sandy; fossiliferous, crushed brachiopods, *Spirifer rockymontanus;* trace phosphatic	1.0
2.	Limestone: blue gray to buff with black calcite masses, fine medium	5.0
1.	Limestone: dark gray, very coarse, tough; beds average 1 to 3 inches thick; weathers platy	16.0
	Exposed thickness of Pitkin	23.0

81. WALKINGSTICK MOUNTAIN, SECTION MEASURED IN SEC. 4, T. 16 N., R. 25 E.

		Feet
	Pennsylvanian	
	Morrow series	
	Bloyd formation	
13.	Limestone: massive, light blue gray, coarse medium, crystalline; weathers evenly; fossiliferous, crinoidal	2.0
	Exposed thickness of Bloyd	2.0
	Hale formation	
12.	Covered	4.0
11.	Limestone: light blue gray, coarse medium; weathers evenly; fossiliferous and crinoidal, carries an abundance of capuloid snail shells	3.0
10.	Covered	20.0

	Feet
9. Limestone: light blue gray, tough, medium; weathers evenly	4.0
8. Covered	7.5
7. Limestone: blue gray, very coarse; fossiliferous	4.5
6. Limestone: similar to bed 7 but carries prominent green streaks and trace of phosphate	1.0
5. Limestone: blue gray, extremely coarse and crinoidal; fossiliferous, many crinoid stems replaced by limonite	6.0
4. Limestone: cream gray to light blue gray, oolitic, coarse medium, glauconitic; weathers evenly; fossiliferous	5.0
3. Covered	23.0
Estimated thickness of Hale	78.0
Mississippian	
Chester series	
Pitkin limestone	
2. Covered and black shale	27.0
1. Limestone: gray to brown, medium to fine; weathers smooth	5.0
Covered below	
Estimated exposed thickness of Pitkin	32.0

82. MOUNTAIN WEST OF STILWELL, OKLAHOMA, SEC. 33, T. 16 N., R. 25 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
17. Sandstone: thin-bedded, some shaly beds; poorly exposed	5.0
Exposed thickness of Atoka	5.0
Morrow series	
Bloyd formation	
16. Limestone: brownish blue gray, fine medium with larger crystals, tough; weathers rough and pitted	3.0
(Note: Bed 16 correlated with Kessler member of Bloyd formation.)	
15. Covered	52.0
14. Limestone: brown gray, coarse; massive bedded in upper and lower part, middle friable and granular on weathering; upper and lower parts weather smooth; fossiliferous and coarsely crinoidal	8.0
13. Covered: may include two poorly exposed limestone outcrops	28.0
12. Limestone: blue gray, coarse medium to coarse; weathers smooth and crinoidal	4.0
11. Covered: probably shale with some limestone	21.0
10. Limestone: blue gray, coarse; weathers smooth with few pittings and flutings; extremely crinoidal	4.0
9. Covered	3.0
8. Limestone: blue gray, very coarse and medium, rather sandy; weathers red	3.0
7. Covered	17.0
Estimated thickness of Bloyd	143.0
Hale formation	
6. Limestone: gray, very coarse; thick bedded; fossiliferous, crinoidal	3.0
5. Limestone: light blue gray to cream gray, medium to fine medium; massive to platy; weathers shingly and some cross-bedded, includes limy sandstone and sandy limestone members. All weather fluted and cross-bedded with some very sandy beds	70.0
4. Limestone, conglomeratic: reddish brown to black, coarse; weathers sandy, crinoidal, some limonite pebbles, trace phosphatic	1.5
Thickness of the Hale	74.5

	Feet
Mississippian	
Chester series	
Pitkin limestone	
3. Limestone: dark blue gray to brown, fine medium, some sandy inclusions; thick and thin bedded; weathers knobby	2.5
2. Covered: limestone rubble and shaly soil	34.0
1. limestone: blue gray to brown gray, coarse medium, some sandy inclusions	4.5
Covered below	
Exposed thickness of Pitkin	41.0

83. STILWELL MOUNTAIN (NORTH END), SEC. 35, T. 16 N., R. 25 E.

Pennsylvanian	
Morrow series	
Hale formation	
13. Covered: calcareous sandstone rubble and sandy soil	22.0
12. Limestone, very sandy: dark blue gray with greenish streaks, coarse medium; weathers fluted and pitted; fossiliferous	8.6
11. Covered: limestone rubble	8.0
10. Limestone: light gray to buff, coarse medium, oolitic; thin bedded	11.2
9. Limestone: blue gray, coarse medium; thick-bedded; fossiliferous	11.4
8. Sandstone, calcareous: yellow brown, medium grained; somewhat cross-bedded	3.9
Exposed thickness of Hale	65.1
Mississippian	
Chester series	
Pitkin limestone	
7. Limestone: dark blue gray	3.0
6. Limestone: dark blue gray, medium coarse; one bed quite fossiliferous; trace phosphatic	5.0
5. Shale: with knobby limestone beds 2 to 3 inches thick, very irregular; shale similar to bed 3 below; limestone similar to bed 2 below	1.0
4. Limestone: blue gray, coarse medium to coarse; weathers smooth	0.5
3. Shale: dark blue, fissile, very calcareous; highly fossiliferous, crinoidal, a microscopic coquina, trace phosphate	1.5
2. Limestone: blue gray, coarse; massive-bedded	6.0
1. Covered down to where a spring issues over Fayetteville shale	23.0
Covered below	
Thickness of Pitkin	40.0

84. BUGGER MT., SECS. 11, 14 AND 23, T. 16 N., R. 26 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
54. Covered sandstone rubble and sandy soil	11.0
Estimated thickness of Atoka	11.0
Morrow series	
Bloyd formation	
53. Shale	2.0
52. Limestone: blue gray, fine medium crystalline; weathers buff to orange; extremely fossiliferous, many brachiopods	4.0
51. Covered	5.0
50. Limestone: brownish blue gray, medium crystalline with	

		Feet
	coarse crystals; weathers chocolate brown; fossiliferous	3.0
	(Note: Beds 50-53 correlated with Kessler member of Bloyd formation. Total thickness 14 feet.)	
49.	Covered	17.0
48.	Shale: blue gray, fissile	1.0
47.	Covered	19.0
46.	Shale: blue gray, fissile	2.0
45.	Limestone: gray, fine medium crystalline with coarse crystals; weathers platy; fossiliferous	2.0
44.	Shale: blue gray, fissile	4.0
43.	Limestone: gray black and brown gray, medium crystalline with coarse crystals; weathers rough and crinoidal; fossiliferous	3.0
42.	Shale: blue gray, fissile	7.0
41.	Limestone: dark gray, tough, very coarse even crystalline; weathers crinoidal and platy; fossiliferous	3.0
40.	Shale: blue gray, fissile	7.0
39.	Limestone: blue gray, fine medium to fine crystalline; weathers limonite stained buff	3.0
38.	Shale: blue gray, fissile	2.0
37.	Limestone: gray to gray black, medium to fine medium; weathers smooth and buff	3.0
36.	Limestone	12.0
35.	Limestone: gray, coarse medium to coarse; weathers light blue; fossiliferous	2.0
34.	Limestone	10.0
33.	Limestone: dark blue gray, very coarse, even crystalline; weathers smooth and dirty brown	2.0
32.	Limestone	4.0
31.	Limestone: dark blue gray to brownish, coarse medium to coarse; weathers smooth, crinoidal, limonite stained dirty brown	2.0
	Thickness of Bloyd	119.0
Hale formation		
30.	Covered	1.0
29.	Sandstone: cross-bedded, calcareous; weathers pitted and cavernous	8.0
28.	Limestone: cream gray with green streaks, medium crystalline; trace phosphate	0.5
27.	Limestone	9.5
26.	Limestone: medium crystalline, oolitic; thin-bedded to platy, beds average 2 inches thick	3.0
25.	Sandstone: light gray, calcareous; weathers yellow brown.....	12.0
24.	Clay: blue to purple, variegated when wet, plastic	2.0
23.	Sandstone: yellow brown; thin-bedded	1.0
22.	Shale: yellow brown, fissile	3.0
21.	Sandstone: similar to bed 19	6.0
20.	Sandstone: light gray, medium grained, very slightly calcareous; weathers yellow brown	3.0
19.	Sandstone: shaly, calcareous; very thin-bedded, irregularly bedded, ripple marks	2.0
18.	Sandstone: light gray, medium grained, calcareous; weathers yellow brown	1.0
17.	Covered	2.0
16.	Shale: blue gray, fissile	5.0
15.	Sandstone: brown with bluish streaks, micaceous, few limonitic pebbles	1.5
	Thickness of the Hale	60.0

		Feet
Mississippian		
Chester series		
Pitkin limestone		
14.	Shale: blue gray, fissile	1.5
13.	Limestone: light gray to brown, coarse medium to coarse; weathers blocky; fossiliferous	6.0
12.	Limestone: brown, coarse with some fine crystalline inclusions; weathers smooth and thin-bedded	6.0
	Exposed thickness of the Pitkin	13.5
Fayetteville shale		
11.	Covered: includes some Pitkin in upper part	140.0
	Estimated thickness of Fayetteville	140.0
Meramec? series		
10.	Limestone: light blue gray, very coarsely crystalline	2.0
9.	Covered	2.0
8.	Limestone: brown, some reddish brown crystals, fine medium crystalline; weathers pitted and brown buff	2.0
7.	Covered	2.0
6.	Limestone: blue gray, very coarsely crystalline	2.0
5.	Covered	18.0
4.	Limestone: blue gray, coarse medium crystalline; crinoidal; massive bedded and thin bedded, somewhat platy in upper few feet	8.0
3.	Covered	8.0
2.	Limestone: blue gray, coarse medium crystalline, glauconitic, iron spotted; weathers crinoidal and yellow brown	8.0
1.	Covered to estimate top of "Boone," heavily covered by slope wash	32.0
	Estimated thickness of Meramec?	84.0

85. McBRIDE SECTION. SEC. 36, T. 17 N., R. 19 E.

		Feet
Pennsylvanian		
Des Moines series		
Atoka formation		
24.	Covered: sandy soil	4.0
23.	Sandstone: medium grained, poorly exposed; few fossil casts	6.0
22.	Covered	10.0
	Estimated thickness of Atoka	20.0
Morrow series		
Bloyd formation		
21.	Shale: poorly exposed	6.0
20.	Limestone: greenish gray, coarse; weathers smooth and massive bedded; crinoidal, fossiliferous, bryozoans	2.0
19.	Shale: includes 0.5-foot limestone bed that is fossiliferous and argillaceous	4.0
18.	Sandstone: greenish with a yellow hue, very fine grained, calcareous; weathers pitted and iron stained	3.0
17.	Shale: poorly exposed	7.0
16.	Limestone: blue to blue gray, fine medium; uneven bedded; weathers buff; *Spirifer*	2.0
15.	Shale; poorly exposed	8.0
14.	Limestone: light gray, fine; uneven bedded; weathers jointed and rough; crinoidal	2.0
13.	Shale: poorly exposed	2.0
12.	Limestone, poorly exposed: blue gray, coarse to coarse medium; platy; crinoidal, *Aulopora* common	2.0
11.	Shale: poorly exposed	2.0
	Thickness of Bloyd	40.0

	Feet
Hale formation	
10. Limestone: gray with greenish argillaceous lenses, coarse to coarse medium; weathers rough	2.0
9. Shale: poorly exposed	2.0
8. Limestone: some beds poorly exposed	8.0
7. Limestone: blue gray, coarse medium to medium, coarsely crinoidal	14.0
6. Limestone: blue gray; thin-bedded to platy; weathers brown gray	2.0
Thickness of Hale	28.0
Mississippian	
Chester series	
Pitkin limestone	
5. Limestone: upper part gray, sublithographic with coarse black calcite crystals; weathers greenish gray; crinoidal; basal part is brittle, gray to blue gray, very fine with coarse crystalline lenses; uneven bedded, jointed; becomes sandy along strike	11.0
4. Limestone: gray, coarse medium with coarse crystals; weathers in massive beds and jointed	3.0
3. Limestone: dark blue gray to gray, fine; weathers in massive beds	2.0
2. Limestone	4.0
1. Limestone: gray, fine medium with sublithographic crystalline areas; weathers in massive beds	2.0
Covered below	
Exposed thickness of Pitkin	22.0

86. CLEAR CREEK SECTION. SEC. 6, T. 17 N., R. 20 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
19. Covered: sandstone rubble and sandy soil	34.0
18. Sandstone: yellow brown iron stained, medium grained; thin bedded and cross bedded	8.0
Exposed thickness of Atoka	42.0
Morrow series	
Hale formation	
17. Limestone: blue gray, coarse medium; thin bedded and platy, well jointed; weathers brown	4.0
16. Limestone: gray, coarse medium, carries green argillaceous streaks and lenses; uneven bedded; moderately crinoidal and fossiliferous; many thin shale breaks	36.0
15. Limestone: light gray, very coarse; weathers smooth and massive bedded	6.0
14. Limestone: very coarse; extremely uneven bedded, cross bedded; weathers thin and granular	6.0
13. Limestone: light gray, medium even crystalline; appears cross bedded; weathers granular and tends to spall off; one bed very sandy and carries black pebble-like inclusions	8.0
Thickness of Hale	60.0
Mississippian	
Chester series	
Pitkin limestone	
12. Limestone: poorly exposed. Includes some thin shales	14.0
11. Limestone: blue gray; massive bedded	6.0
10. Covered	12.0
9. Limestone: gray, coarse medium; weathers rough and rubbly; fossiliferous	4.0
8. Limestone: gray, very fine with coarse crystals; crinoidal, fossiliferous in upper part. Poor outcrop	8.0

	Feet
7. Limestone: gray, sublithographic crystalline with some very coarse beds; *Linoproductus*	8.0
Thickness of Pitkin	52.0
Fayetteville shale	
6. Covered	50.0
Estimated thickness of Fayetteville	50.0
Meramec? series	
5. Limestone: gray, coarse medium; uneven bedded; fossiliferous, *Archimedes*, *Diaphragmus*, productids, *Eumetria*, *Spirifer*, pelecypods, gastropods, trilobite pygidium	4.0
4. Covered	8.0
3. Limestone: black to dark gray, sublithographic lenses in coarser matrix; crinoidal, fossiliferous, *Archimedes*, large *Bellerophon*	2.0
2. Covered	8.0
Estimated thickness of Meramec?	22.0
Osage series	
1. Chert and cherty limestone	16.0
Covered below	
Exposed thickness of Osage series	16.0

87. HULBERT SECTION. SEC. 34, T. 17 N., R. 20 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
Covered above	
18. Sandstone: thin bedded, poorly exposed	6.0
Exposed thickness of Atoka	6.0
Morrow series	
Bloyd formation	
17. Shale: poorly exposed	4.0
16. Limestone: blue gray, very fine to sublithographic; thin-bedded to platy, uneven bedded; fossiliferous	3.0
15. Shale: blue gray, fissile, limonite concretions	8.0
14. Shale: blue gray to buff, sandy, fissile	6.0
13. Shale: poorly exposed	10.0
12. Limestone: blue gray, fine with sublithographic crystalline lenses; weathers buff; fossiliferous	1.0
11. Shale	2.0
10. Limestone: blue gray, medium with very coarse crystalline bands; thin-bedded and uneven bedded; weathers iron stained; crinoidal	10.0
9. Shale: blue gray, stained buff	3.0
8. Shale: blue gray, locally very calcareous, fossiliferous	4.0
7. Shale: poorly exposed	2.0
Thickness of Bloyd	53.0
Hale formation	
6. Limestone: light blue and gray, very coarse; weathers smooth and granular; very crinoidal, fossiliferous	21.0
5. Shale: blue gray to buff, calcareous, fissile	1.0
4. Limestone: gray, very coarse; cross-bedded and uneven bedded; crinoidal	17.0
3. Shale: sandy	0.5
2. Sandstone: iron stained; *Calamites* and other plant remains	2.0
Thickness of Hale	41.5

	Feet
Mississippian	
Chester series	
Pitkin limestone	
1. Limestone: dove gray; weathers light blue, poorly exposed	4.0
Covered below	
Exposed thickness of Pitkin	4.0

88. TOM PATCH SECTION. SEC. 3, T. 17 N., R. 21 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
8. Sandstone rubble and sandy soil to top of hill	15.0
Exposed thickness of Atoka	15.0
Morrow series	
Bloyd formation	
7. Shale: poorly exposed	5.0
6. Limestone: blue gray; weathers shaly; very fossiliferous, bryozoans, *Pentremites* abundant, *Composita*, gastropods	2.0
5. Shale: blue gray, fissile, limonite concretions	8.5
4. Limestone: gray, coarse crystals in very fine crystalline matrix; weathers brownish, shaly and in big pittings	1.0
3. Shale: blue gray, fissile, limonite concretions	3.0
Thickness of Bloyd	19.5
Hale formation	
2. Limestone: gray, coarse with sublithographic crystalline areas; cross bedded; fossiliferous, crinoid plates and arms, *Pentremites*	22.4
1. Sandstone: heavily iron stained, medium to coarse grained; thin-bedded, cross-bedded; weathers pitted and cavernous	14.0
Covered below	
Exposed thickness of Hale	36.4

89. PECAN CREEK SECTION. SEC. 26, T. 17 N., R. 21 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
32. Sandstone, medium grained	2.0
Exposed thickness of Atoka	2.0
Morrow series	
Bloyd formation	
31. Covered	6.0
30. Shale	12.0
29. Limestone: dark blue gray, fine even crystalline; weathers rough and rubbly	3.0
28. Covered, probably shale: may include a thin limestone bed	11.0
27. Sandstone: brown, medium grained, very calcareous, trace phosphatic; limonite stained; fossiliferous	2.0
26. Limestone: dove gray with black calcite crystals, very fine with sublithographic crystalline lenses; weathers rubbly	4.0
25. Limestone: neutral gray with greenish cast, coarse with large crystalline masses; weathers buff and argillaceous; very fossiliferous	3.0
24. Covered	5.0
23. Limestone: similar to bed 21	4.0
22. Covered	6.0
21. Limestone: dark blue gray to purplish blue, fine medium with coarse crystals; uneven and thin beds; moderately fossiliferous	1.0
20. Shale	3.0

	Feet
19. Limestone: gray to blue gray, fine even crystalline with few coarse medium crystals; weathers buff and rough	2.0
18. Shale	2.0
Thickness of Bloyd	64.0
Hale formation	
17. Limestone	4.0
16. Limestone: light gray, coarse; weathers iron stained buff and brown; oolitic, crinoidal, very fossiliferous	3.0
15. Limestone	8.0
14. Limestone; neutral gray, fine even with coarse medium crystals; weathers iron stained buff and rubbly; moderately crinoidal	8.0
13. Limestone, sandy: light gray, granular, coarse; uneven bedded, buff to light brown on weathering; fossiliferous, crinoidal	1.0
12. Limestone: light gray, granular, very coarse; extremely crinoidal, crinoid stems white to cream gray	1.0
11. Limestone	4.0
Thickness of Hale	29.0
Mississippian	
Chester series	
Pitkin limestone	
10. Limestone: neutral gray, very fine crystalline; weathers rough and rubbly	2.0
9. Covered	6.0
8. Shale	3.0
7. Limestone: gray, very fine crystalline to earthy, well jointed; weathers rough; moderately crinoidal	2.0
6. Limestone: dark blue gray, fine with small sublithographic crystalline lenses and large crystalline masses, jointed; weathers iron stained buff	6.0
5. Covered	4.0
4. Shale	3.0
3. Limestone: similar to bed 1	2.0
2. Limestone	6.0
1. Limestone: blue gray, coarse to coarse medium; weathers iron stained buff and rough; fossiliferous, productids, *Composita*	1.0
Covered below	
Estimated thickness of Pitkin	35.0

90. CRITTENDEN SECTION. SEC. 30, T. 17 N., R. 21 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
23. Sandstone, poorly exposed	12.0
Exposed thickness of Atoka	12.0
Morrow series	
Bloyd formation	
22. Covered	6.0
21. Shale: poorly exposed	6.0
20. Limestone: gray with greenish streaks, coarse; weathers light blue and light buff; fossiliferous	4.0
19. Shale	4.0
18. Limestone	1.0
17. Shale	3.0
16. Limestone: blue gray to brown gray, coarse; thin-bedded; fossiliferous	4.0

		Feet
15.	Covered	12.0
14.	Limestone: thin-bedded, argillaceous, very granular	2.0
13.	Limestone, poorly exposed: brown and greenish gray; weathers rubbly and uneven; fossiliferous	10.0
12.	Limestone: blue gray, crinoid stems replaced by orange calcite; uneven bedded; weathers brown and rough	2.0
11.	Shale: poorly exposed	8.0
	Thickness of Bloyd	62.0
	Hale formation	
10.	Limestone: blue gray; uneven bedded to platy at top, cross bedded, thin-bedded	15.0
9.	Limestone: granular	2.0
8.	Shale	1.0
7.	Limestone	22.0
6.	Limestone, argillaceous and sandy: blue gray to brown, medium with very coarse crystals; weathers rough and jointed; fossiliferous, crinoidal	0.5
	Thickness of Hale	40.5
	Mississippian	
	Chester series	
	Pitkin limestone	
5.	Limestone: light blue and brown gray, fine; weathers rough and jointed	10.0
4.	Covered	22.0
	Estimated thickness of Pitkin	32.0
	Fayetteville shale	
3.	Covered	21.0
2.	Limestone	1.0
1.	Shale and covered to estimated top of Meramec? limestone	4.0
	Estimated thickness of Fayetteville	26.0

91. YONKERS SECTION. SEC. 10, T. 18 N., R. 19 E.

	Pennsylvanian	
	Des Moines series	
	Atoka formation	
22.	Covered: sandy soil	20.0
	Estimated thickness of Atoka	20.0
	Morrow series	
	Hale formation	
21.	Limestone: blue gray, coarse medium; weathers rubbly and light blue; fossiliferous, *Pentremites,* corals, bryozoans; few thin shale breaks	16.0
20.	Limestone: blue gray with greenish argillaceous lenses, medium; fossiliferous	1.0
19.	Limestone: blue gray, fine with sublithographic lenses; uneven bedded; weathers smooth	10.0
18.	Shale	0.5
17.	Limestone, very sandy: light gray, medium; weathers pitted, uneven bedded and cross bedded	7.0
16.	Shale: discontinuous along strike	1.5
15.	Limestone: light gray, sandy pockets; weathers fluted and cross bedded	6.0
14.	Shale: heavily iron stained	0.5
13.	Alternating sandy shale, limy sandstone and sandy limestone beds, 0.5 to 1 inch thick	4.0
12.	Covered	2.0

		Feet
11.	Sandstone: yellow brown, fine-grained; massive bedded; some weather pitted	2.0
	Thickness of Hale	50.5
	Mississippian	
	Chester series	
	Pitkin limestone	
10.	Limestone: blue gray, sublithographic; *Archimedes, Diaphrogmus, Derbyia,* thin shale bed 5 feet above base	16.0
9.	Covered	6.0
8.	Limestone: brown gray, coarse medium; weathers uneven bedded and granular; heavily iron spotted	4.0
7.	Limestone: gray, sublithographic; calcite veins; weathers light blue	2.0
	Thickness of Pitkin	28.0
	Fayetteville shale	
6.	Shale: black	34.0
5.	Limestone: blue to blue gray, fine with large orange calcite veins; weathers rough, crinoidal	1.0
4.	Shale	13.0
3.	Bed of septarian concretions	1.0
2.	Shale: black, well jointed	21.0
1.	Limestone: weathers buff iron stained and irregular	1.0
	Covered below	
	Exposed thickness of Fayetteville	71.0

92. E. YONKERS SECTION. SEC. 6, T. 18 N., R. 20 E.

	Pennsylvania	
	Des Moines series	
	Atoka formation	
21.	Sandstone: light gray; abundant fucoids	6.0
20.	Shale: sandy, platy; carries a sandstone bed; grades upward into sandstone	12.0
	Exposed thickness of Atoka	18.0
	Morrow series	
	Bloyd formation	
19.	Limestone: brown to green gray, very fine with coarse crystals, argillaceous; fossiliferous, productids, *Strobeus* (*Sphaerodoma*)	2.0
18.	Shale: poorly exposed	8.0
17.	Limestone: poorly exposed	2.0
16.	Shale	2.0
	Thickness of Bloyd	14.0
	Hale formation	
15.	Limestone: yellow gray; very argillaceous; weathers rubbly; fossiliferous	4.0
14.	Limestone	4.0
13.	Limestone: light gray, coarse medium even crystalline; weathers in thin, uneven beds	2.0
12.	Limestone: few shale beds	16.0
11.	Limestone: blue gray, coarse even crystalline; weathers thin-bedded and granular; crinoidal, fossiliferous, bryozoans	2.0
10.	Limestone: light blue gray, medium with coarse crystals, few argillaceous beds; fossiliferous, large *Thamnopora* (*Pachypora*), *Pentremites*	4.0
9.	Limestone	14.0
8.	Limestone: gray, coarse medium with very coarse calcite masses; uneven bedded; weathers smooth and irregular; crinoidal, *Hustedia*	2.0
7.	Limestone: sandy, iron stained	2.0

	Feet
6. Limestone, sandy: gray, fine; thin-bedded; fossiliferous, *Hustedia,* productids	6.0
5. Sandstone: yellow brown, calcareous	2.0
Thickness of Hale	58.0
Mississippian	
Chester series	
Pitkin limestone	
4. Covered	16.0
3. Limestone: gray, sublithographic to medium crystalline; fossiliferous, fenestellids, *Archimedes,* blastoids, productids, *Composita*	4.0
Estimated thickness of Pitkin	20.0
Fayetteville shale	
2. Covered	20.0
1. Limestone: gray, medium crystalline; *Agassizocrinus* base	4.0
Covered below	
Exposed thickness of Fayetteville	24.0

93. GIDEON SECTION. SEC. 36, T. 18 N., R. 21 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
13. Sandstone and sandstone rubble, poorly exposed	31.0
12. Sandstone: massive bedded	6.0
Exposed thickness of Atoka	37.0
Morrow series	
Bloyd formation	
11. Covered	9.0
10. Shale: buff to greenish, sandy; thin-bedded to fissile, iron-stained brown	4.0
Estimated thickness of Bloyd	13.0
Hale formation	
9. Covered	13.0
Estimated thickness of Hale	13.0
Mississippian	
Chester series	
Pitkin limestone	
8. Limestone: light gray to white gray, fine to very fine; weathers light blue; fossiliferous	4.0
7. Limestone: blue gray, very coarse, large calcite masses; weathers granular	4.0
6. Limestone: blue gray, very coarse; weathers jointed and light blue; crinoidal, *Archimedes*	2.0
5. Limestone: light gray fine even crystalline, brittle; thin-bedded	4.0
4. Limestone: blue gray, *Archimedes*	6.0
Thickness of Pitkin	20.0
Fayetteville shale	
3. Shale: black, fissile	4.0
2. Limestone: dark blue gray, sublithographic; rubbly	1.0
1. Shale, poorly exposed	4.0
Covered below, shaly soil	
Exposed thickness of Fayetteville	9.0

94. CEDAR CREST SECTION. SEC. 8, T. 19 N., R. 20 E.

Pennsylvanian	
Des Moines series	
Atoka formation	
13. Sandstone: poorly exposed	14.0

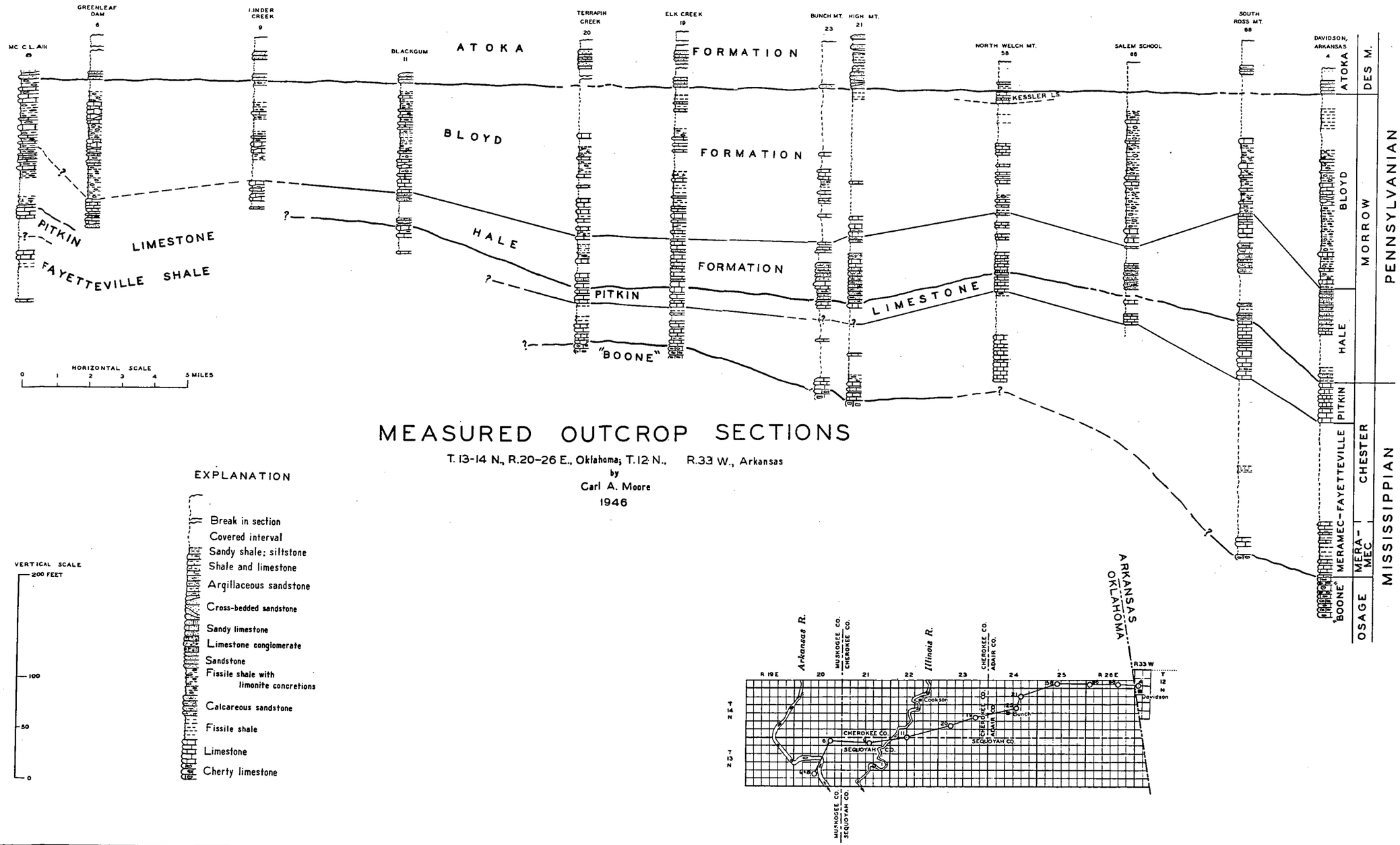
	Feet
12. Sandstone: coarse and medium grained; thin-bedded and cross-bedded	2.0
Exposed thickness of Atoka	16.0
Morrow series	
Hale formation	
11. Limestone, in a cliff: very uneven bedded and cross-bedded; at base, gray, fine medium with few coarse crystals; weathers cross-bedded; fossiliferous, crinoidal	28.0
10. Covered	12.0
9. Limestone: brown gray, very coarse, sandy; weathers massive bedded and thin-bedded, upper 4 feet cross-bedded	6.0
8. Limestone, poorly exposed: light gray, coarse medium; weathers light blue and smooth; crinoidal, fossiliferous	1.0
Thickness of Hale	47.0
Mississippian	
Chester series	
Fayetteville shale	
7. Covered	11.0
6. Shale: blue black, well exposed	17.0
Thickness of Fayetteville	28.0
Meramec? series	
5. Limestone: gray, sublithographic, brittle, conchoidal fracture, argillaceous	1.0
4. Limestone	8.0
3. Shale blue black, fissile	4.0
2. Limestone: dark gray, coarse medium, granular; few shale beds	30.0
Exposed thickness of Meramec?	43.0
Osage series	
1. Chert	40.0
Covered below	
Hale formation	
Exposed thickness of Osage series	40.0

95. PRYOR SECTION. SEC. 20, T 21 N., R. 19 E.
1½ MI. E. AND 1½ MI. S. OF PRYOR IN CREEK

Covered above	
Hale formation	
Limestone, poorly exposed: blue gray and greenish gray, coarse medium to coarse; thin bedded, uneven bedded and rubbly in lower part; weathers brown gray; fossiliferous, corals, *Pleurodictyum* (*Michelinia*), crinoid remains, fenestellids, bryozoans, *Dictyoclostus, Spirifer*	6.0
Covered below, black shale indications	

96. GREENBRIAR SECTION. SEC. 20, T. 22 N., R. 20 E.

Hale formation	
One limestone bed, poorly exposed, occurs as boulders around small hill: blue gray, coarse medium, even crystalline; weathers granular; crinoidal	2.0



MEASURED OUTCROP SECTIONS

T. 13-14 N., R. 20-26 E., Oklahoma; T. 12 N., R. 33 W., Arkansas

by

Carl A. Moore

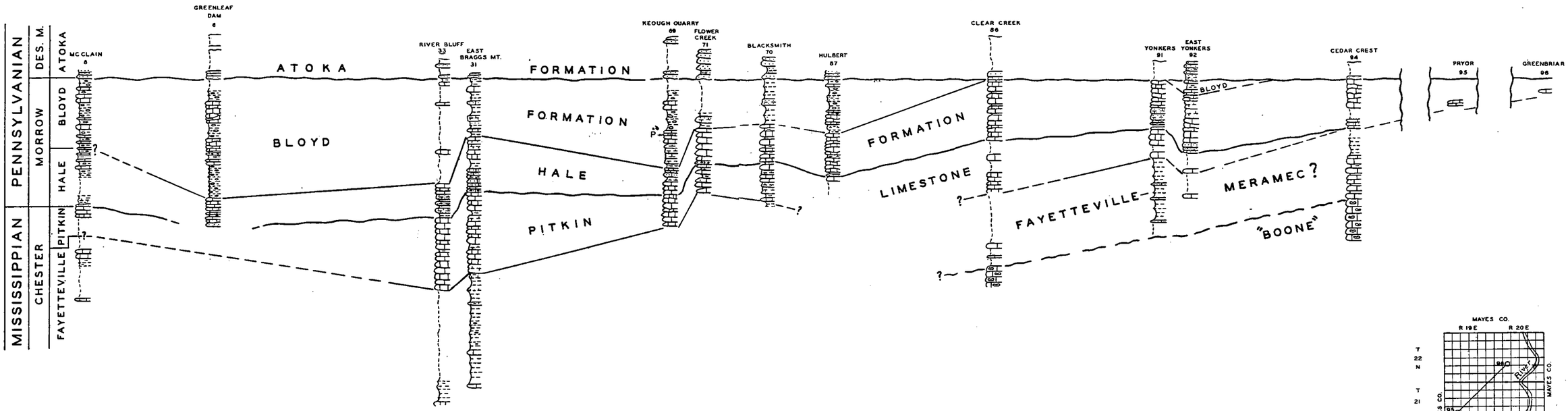
1946

EXPLANATION

- Break in section
- Covered interval
- Sandy shale; siltstone
- Shale and limestone
- Argillaceous sandstone
- Cross-bedded sandstone
- Sandy limestone
- Limestone conglomerate
- Sandstone
- Fissile shale with limonite concretions
- Calcareous sandstone
- Fissile shale
- Limestone
- Cherty limestone

VERTICAL SCALE

200 FEET
100
50
0



HORIZONTAL SCALE

0 1 2 3 4 5 MILES

MEASURED OUTCROP SECTIONS

T. 13-22 N., R. 19, 20 E., Oklahoma

by

Carl A. Moore

1946

VERTICAL SCALE

200 FEET

100

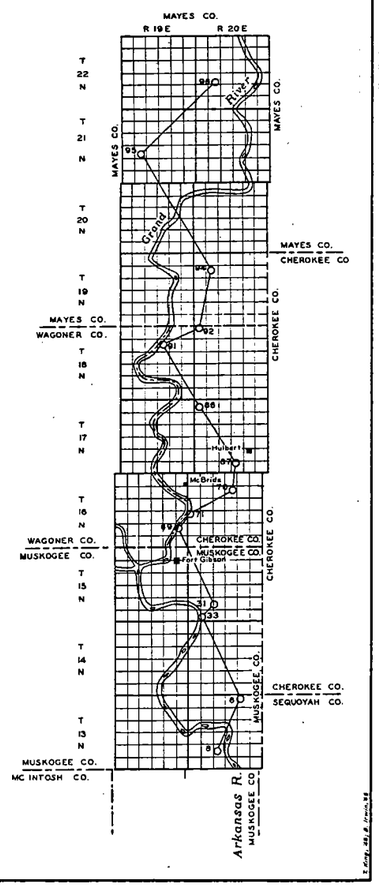
50

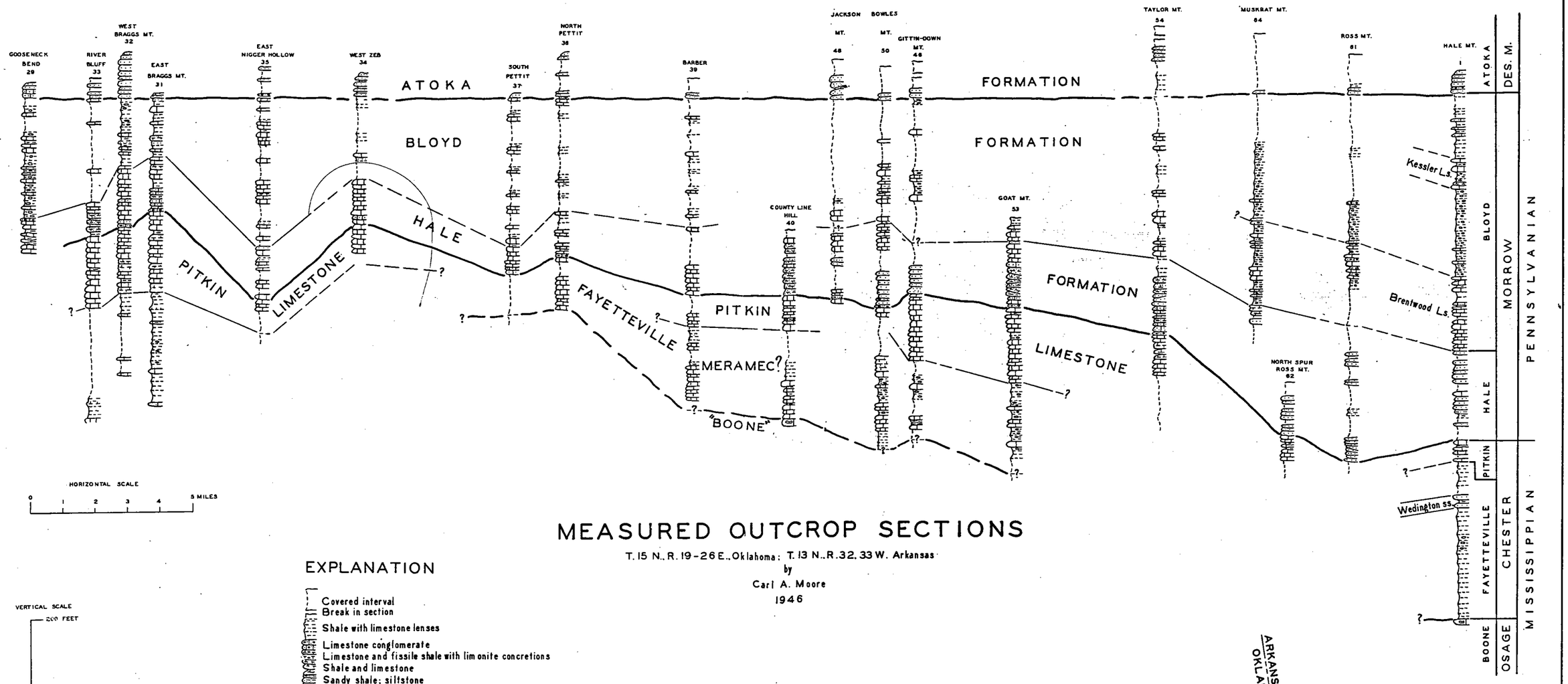
0

EXPLANATION

- Break in section
- Covered interval
- Calcareous sandstone with shale lenses
- Fissile shale
- Sandstone
- Sandy shale
- Shale and limestone
- Limestone conglomerate
- Fissile shale with limonite concretions
- Shale with limestone lenses
- Calcareous sandstone
- Sandy limestone
- Limestone
- Cherty limestone

P Pentremites zone





MEASURED OUTCROP SECTIONS

T. 15 N., R. 19-26 E., Oklahoma; T. 13 N., R. 32, 33 W. Arkansas

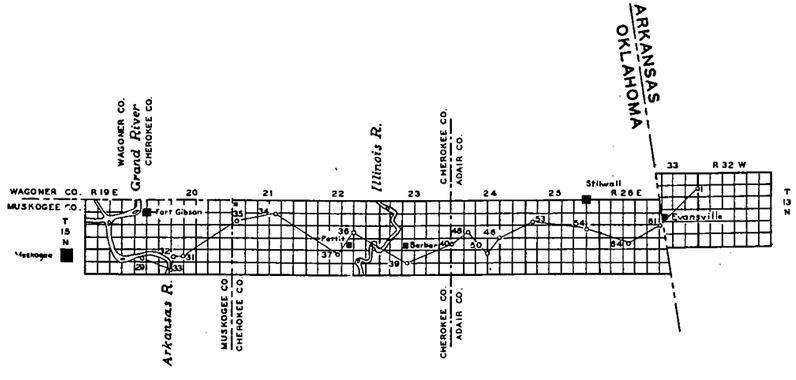
by

Carl A. Moore

1946

EXPLANATION

- Covered interval
- Break in section
- Shale with limestone lenses
- Limestone conglomerate
- Limestone and fissile shale with limonite concretions
- Shale and limestone
- Sandy shale; siltstone
- Cross-bedded sandstone
- Sandy limestone
- Conglomerate with clay iron-stone concretions
- Sandstone
- Fissile shale with limonite concretions
- Calcareous sandstone
- Sandy shale
- Fissile shale
- Limestone
- Cherty limestone



KEOUGH QUARRY 69 · FLOWER CREEK 71 · BLACKSMITH 70 · PECAN CREEK 89 · WEST TAHLEQUAH 75 · SOUTH TAHLEQUAH 74 · PARKHILL 76 · SUGAR MT. 77 · SPADE MT. 78 · 79 WAUHILLAU · WALKINGSTICK MT 81 · BUGGER MT. 84 · TOLU, ARKANSAS 2 · HALE MT.

ATOKA FORMATION

BLOYD FORMATION

HALE FORMATION

PITKIN LIMESTONE

"BOONE" FAYETTEVILLE SHALE

Kessler Ls.

Kessler Ls.

Brentwood Ls.

Wedington Sandstone

MERAMEC SERIES

P

MEASURED OUTCROP SECTIONS

T. 16 N., Rs. 19 – 26 E., Oklahoma, and T. 13 N., R. 33 W., Arkansas

by

Carl A. Moore

1946

HORIZONTAL SCALE

0 1 2 3 4 5 miles

VERTICAL SCALE

200 feet

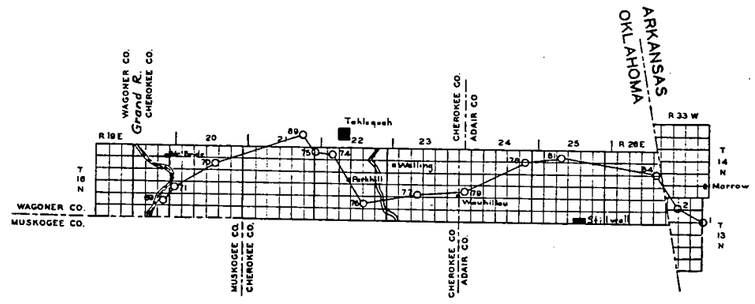
100

50

0

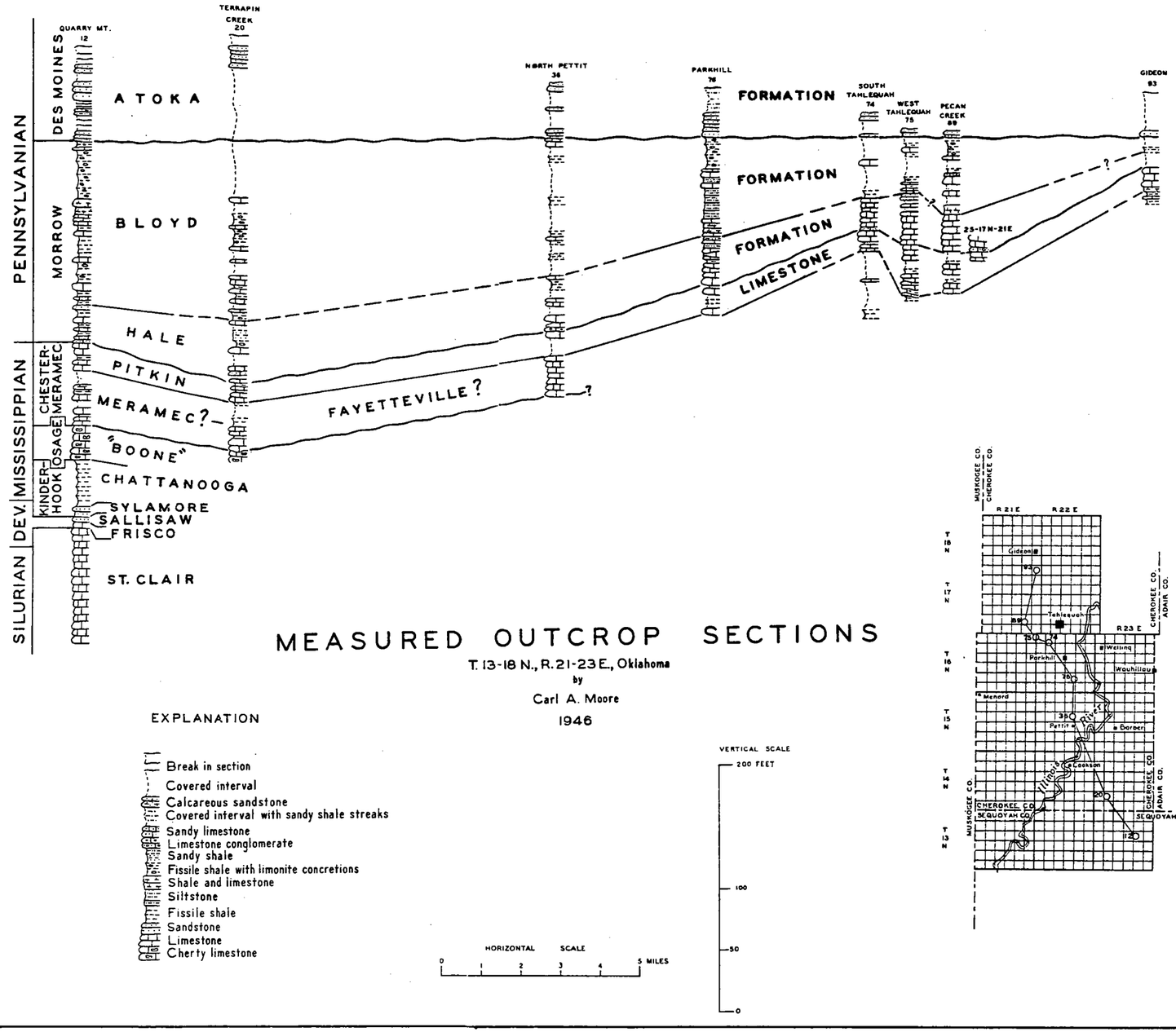
EXPLANATION

- Covered interval
- Sandy shale; siltstone
- Shale and limestone
- Argillaceous sandstone
- Cross-bedded sandstone
- Sandy limestone
- Limestone conglomerate
- Sandstone
- Fissile shale with limonite concretions
- Calcareous sandstone
- Fissile shale
- Limestone
- Cherty limestone
- P Pentremites zone



PENNSYLVANIAN: ATOKA · DES MOINES · MORROW · BLOYD · HALE · PITKIN

MISSISSIPPIAN: CHESTER · FAYETTEVILLE · "BOONE" · OSAGE



MEASURED OUTCROP SECTIONS

T. 13-18 N., R. 21-23 E., Oklahoma

by

Carl A. Moore

1946

EXPLANATION

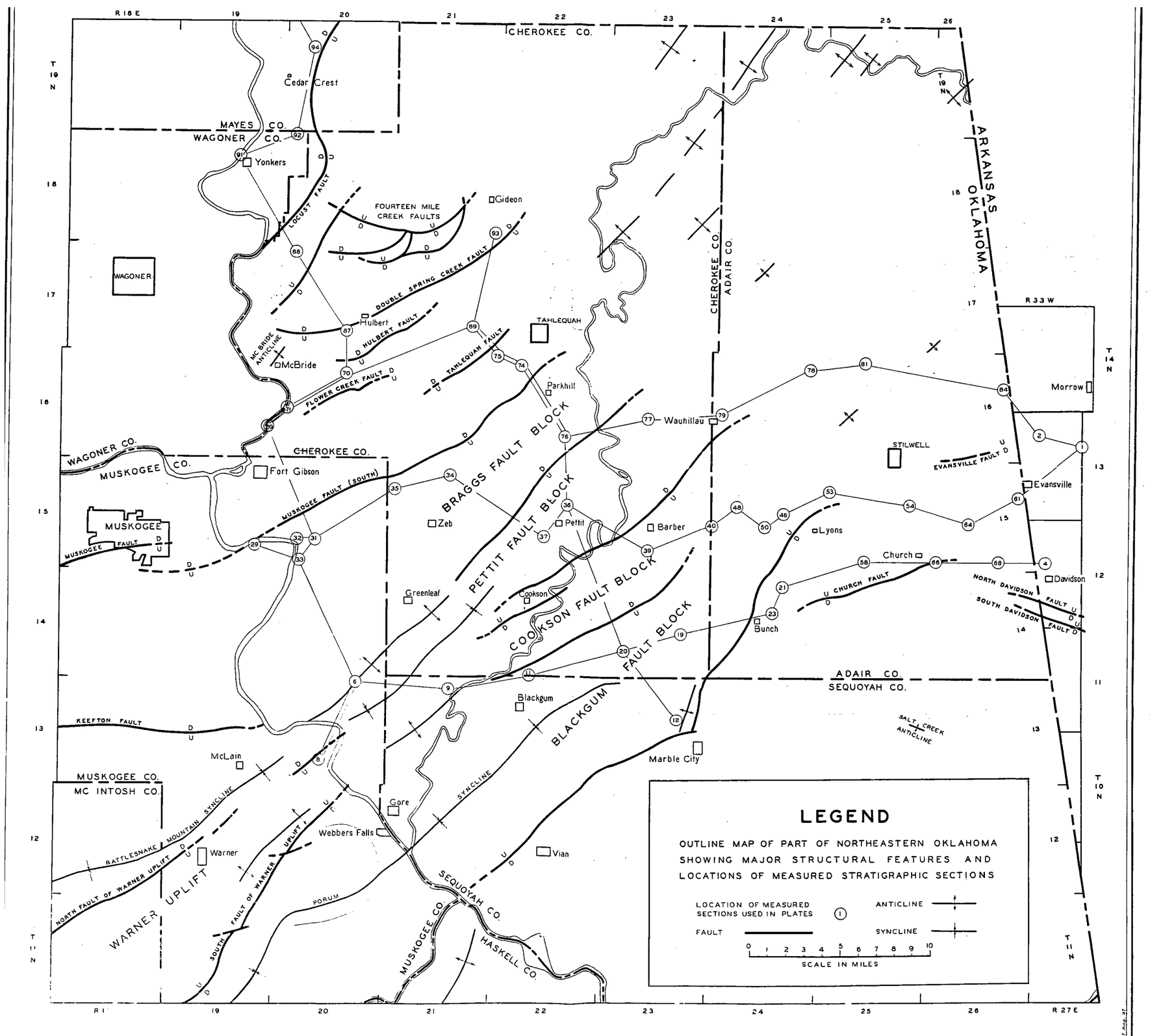
- Break in section
- Covered interval
- Calcareous sandstone
- Covered interval with sandy shale streaks
- Sandy limestone
- Limestone conglomerate
- Sandy shale
- Fissile shale with limonite concretions
- Shale and limestone
- Siltstone
- Fissile shale
- Sandstone
- Limestone
- Cherty limestone

HORIZONTAL SCALE

0 1 2 3 4 5 MILES

VERTICAL SCALE

200 FEET
100
50
0


R 18 E
19
20
21
22
23
24
25
26
R 33 W
R 27 E
R 1
T 19 N
T 14 N
T 13 N
T 12 N
T 11 N
T 10 N
CHEROKEE CO.
MAYES CO.
WAGONER CO.
ADAIR CO.
SEQUOYAH CO.
MUSKOGEE CO.
MC INTOSH CO.
HASKELL CO.
ARKANSAS
OKLAHOMA
Cedar Crest
Yonkers
WAGONER
Gideon
FOURTEEN MILE CREEK FAULTS
LOCUST FAULT
DOUBLE SPRING CREEK FAULT
Hulbert
HULBERT FAULT
MC BRIDE ANTICLINE
McBride
FLOWER CREEK FAULT
TAHLEQUAH
TAHLEQUAH FAULT
Parkhill
Wauhillau
Morrow
STILWELL
EVANSVILLE FAULT
Evansville
Fort Gibson
MUSKOGEE
MUSKOGEE FAULT
MUSKOGEE FAULT (SOUTH)
BRAGGS FAULT BLOCK
PETTIT FAULT BLOCK
Zeb
Pettit
Barber
Lyons
Church
Davidson
NORTH DAVIDSON FAULT
SOUTH DAVIDSON FAULT
U CHURCH FAULT
Bunch
Greenleaf
Cookson
COOKSON FAULT BLOCK
BLACKGUM FAULT BLOCK
Blackgum
Marble City
KEEFTON FAULT
McLain
SALT CREEK ANTICLINE
Gore
SYNCLINE
Webbers Falls
Vian
RATTLESNAKE MOUNTAIN SYNCLINE
NORTH FAULT OF WARNER UPLIFT
Warner
WARNER UPLIFT
SOUTH FAULT OF WARNER UPLIFT
PORUM
LEGEND
OUTLINE MAP OF PART OF NORTHEASTERN OKLAHOMA SHOWING MAJOR STRUCTURAL FEATURES AND LOCATIONS OF MEASURED STRATIGRAPHIC SECTIONS
LOCATION OF MEASURED SECTIONS USED IN PLATES
ANTICLINE
FAULT
SYNCLINE
0 1 2 3 4 5 6 7 8 9 10
SCALE IN MILES