Reconnaissance for uranium in northern Texas and southern Oklahoma

By Edward J. McKay

Trace Elements Investigations Report 689

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

IN REPLY REFER TO:

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

February 18, 1958

AEC -

Mr. Robert D. Nininger
Assistant Director for Exploration
Division of Raw Materials
U. S. Atomic Energy Commission
Washington 25, D. C.

Dear Bob:

Transmitted herewith are three copies of TEI-689, "Reconnaissance for uranium in northern Texas and southern Oklahoma," by Edward J. McKay, and a section on "Lithology and radioactivity of the Magnolia Petroleum Company No. 78 Honaker well in the Electra field, Wichita County, Texas," by D. H. Eargle, August 1957.

We plan to publish this report as a Geological Survey bulletin.

Sincerely yours,

John H. Eric

for W. H. Bradley
Chief Geologist

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

RECONNAISSANCE FOR URANIUM IN NORTHERN TEXAS AND SOUTHERN OKLAHOMA*

By

Edward J. McKay

and a section on "Lithology and radioactivity of the Magnolia Petroleum Company No. 78 Honaker well in the Electra field, Wichita County, Texas," by D. H. Eargle

August 1957

Trace Elements Investigations Report 689

This preliminary report is distributed without editorial and technical review for conformity with official standards and nomenclature. It is not for public inspection or quotation.

*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

USGS - TEI-689

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By Edward J. McKay

And a section on "Lithology and radioactivity of the Magnolia Petroleum Company No. 78 Honaker well in the Electra field, Wichita County, Texas," by D. H. Eargle

ABSTRACT

Uranium has been found in two stratigraphic zones in rocks of Permian age in northern Texas and south-central Oklahoma. These zones are in rocks of Wichita age in the Red River area and in the Rush Springs sandstone of the Whitehorse group in the Anadarko basin. In the Red River area, the radioactivity anomalies have a geographic distribution of about 6,000 square miles and a stratigraphic range of about 700 feet. Recognizable yellow uranium minerals are present at 3 of the 19 radioactive localities for which analyses are available. In the Anadarko basin, a vein deposit containing carnotite and tyuyamunite is in or near fractures in the Rush Springs sandstone on the Cement anticline.

Radioactivity anomalies in the Red River area are associated with carbonaceous material in scattered red feldspathic sandstone lenses. The thin sandstone lenses are in strata composed dominantly of shale, claystone, and mudstone. The Rush Springs sandstone in the Anadarko basin is a thick, festoon-bedded, red, feldspathic, well-sorted sandstone.

The distribution of radioactive localities in the Red River area has no apparent spatial relation either to regional structures, the Red River and Wichita Mountains uplifts, or to subsidiary folds on those

uplifts. The uranium deposit on the Cement anticline is genetically related to folding in the Anadarko basin.

Integration of geologic data in the Red River area suggests that mobilization of uranium in solution and concentration by carbonaceous material in sandstones in the upper half of the Wichita group is favored by "red bed" facies. In contrast, the adjacent marine facies of limestone and drab shale farther south in the Permian Basin and thick channel-fill sandstones and drab shales in the lower half of the Wichita group are barren. Apparently mobilization and movement of uranium in solution is favored in a sedimentary environment of high redox potential and inhibited by low potential. However, concentration of uranium as ore deposits in the upper half of the Wichita group appears to be limited to sandstone lenses which are discontinuous and relatively few in number. Generally these sandstone lenses are less than five feet thick and less than 300 feet across.

The association of uranium with fractures on the Cement anticline, the presence of similar fractures on other anticlines in the Anadarko basin and the presence of rocks suitable as hosts for large volumes of ore should encourage exploration in this region.

INTRODUCTION

Purpose of the investigation

The occurrence of uranium in asphaltic pellets near the Wichita Mountains in southern Oklahoma was first reported by Hill (1952, 1953) and Beroni (1954). Discoveries of uranium in "red beds" of Permian age

in the Red River Valley area during 1954 were reported by Beroni (personal communication). Further discoveries were reported in the Anadarko basin in 1956 by Beroni (personal communication). The present investigation appraises the uranium resources of the region by reconnaissance study of the stratigraphic distribution of radioactive deposits and the relationship of these deposits to geologic structure and sedimentary environment.

Previous work

The geology of the region has been described by many workers of whom only a few are referred to in this report. Most of the work was done in connection with exploration for oil and was confined to oil field districts. Comprehensive studies, which include references to district studies, and stratigraphic and paleontologic studies were made by Sellards and others (1932), and Cheney (1940) in northern Texas, by Gouin (1956) in southern Oklahoma, and by Reeves (1921) and Paschal (1941) in the Anadarko basin.

Present work and acknowledgments

The present study began in the fall of 1955 and terminated in the spring of 1957. Field work consisted of examining, sampling, and mapping of radioactive localities. A field examination was made of each sandstone and limestone marker bed mapped by previous workers, and traverses were made across the strike in search of zones of thick sandstone. A contribution to the stratigraphy of the Wichita group was made by D. H. Eargle who logged the core of the Magnolia Company's Honaker No. 78 well. The core description is the appendix of this report. Published subsurface data in the form of

well logs, cross-sections, and descriptions in the geologic literature were used in the study of the relation between sedimentary environment, as reflected by rock facies, regional structure, and the distribution of radioactivity anomalies.

The work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission. Sample analyses and thin sections were made by the Denver laboratories of the U. S. Geological Survey. The writer is indebted to Messrs. Beroni, Blair, and Meek of the Atomic Energy Commission; to John Kay, consultant; Robert Drake, North Texas Well Log Company; and Robert and Michael Carpenter, Mineral Detector Company, for their courtesy and cooperation.

Location and topography

The parts of northern Texas and southern Oklahoma that are included in the report area (figs. 1 and 2) are in the northern part of the Osage Plains section of the Central Lowland Province of Fenneman and others (1931) and are characterized by a slightly undulating land surface ranging in elevation from about 900 to 2,400 feet above sea level. Gently rolling plains are broken by the Red River and its tributaries, by the Wichita Mountains, and by hilly terrain in the Anadarko basin. Relief is slightly more than 200 feet in a few places along the Red River, although about 100 feet of relief is average; generally the relief is less than 30 feet on the tributaries. Relief in the Wichita Mountains is about 1,000 feet and in the Anadarko basin about 500 feet. Exposures of bed rock are limited mostly to road cuts and drainage areas. Mesquite trees, scrub oak, fields of cotton, and red soil cover most of the region.

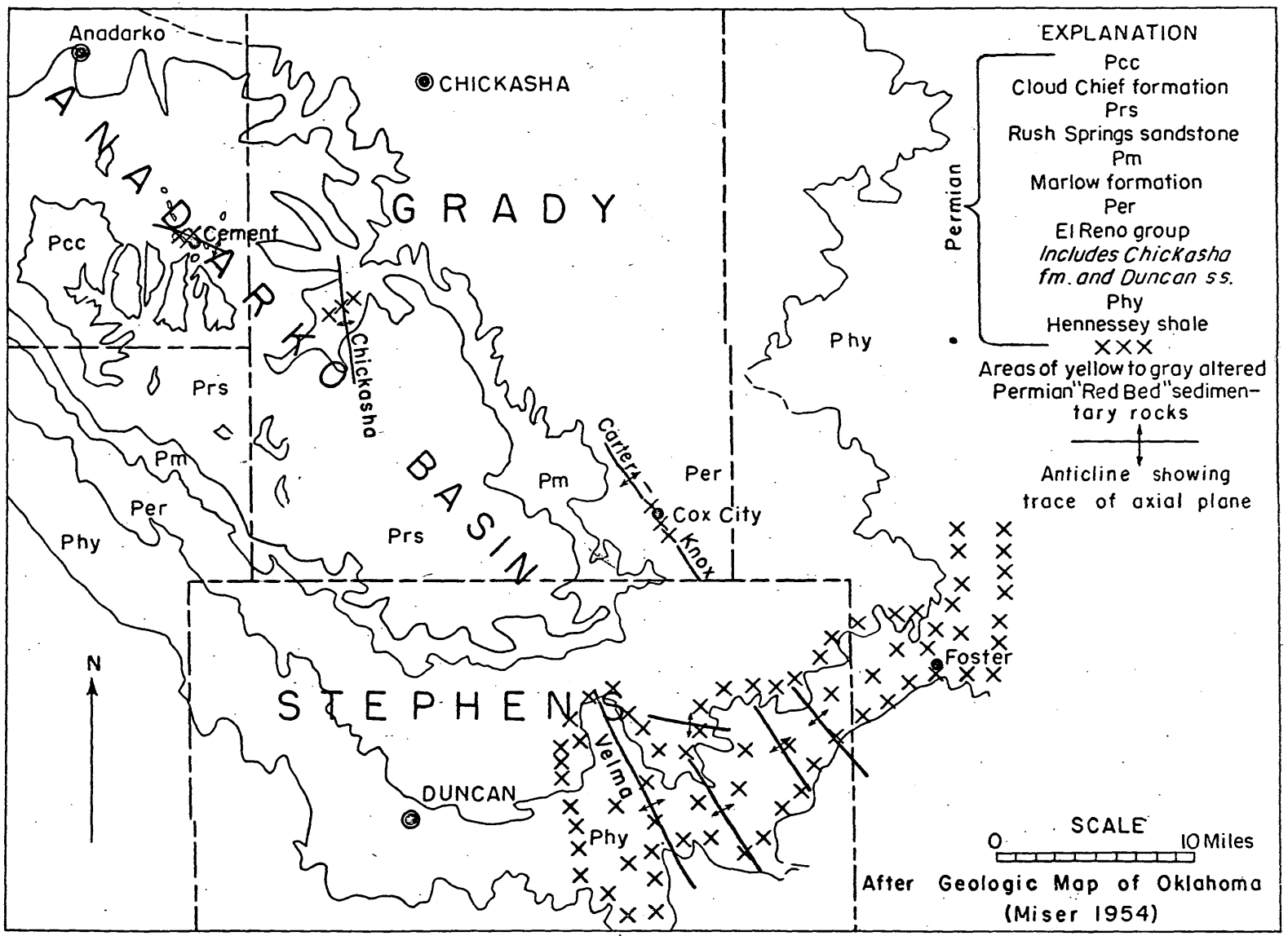

FIGURE 2—INDEX MAP SHOWING CEMENT DEPOSIT AND AREAS OF "RED BED" ALTERATION IN ANADARKO BASIN OF OKLAHOMA.

STRATIGRAPHY

Sedimentary rocks exposed in northern Texas and southern Oklahoma (table 1) are Permian and Late Pennsylvanian in age. In the Red River area and northward the rocks of Permian age are represented by a marginal marine "red bed" facies. To the south and west the "red bed" facies changes laterally to marine shale and limestone. Figure 3 illustrates this progressive change in lithology from the Red River area to north-central Texas.

Rocks of latest Pennsylvanian age are included in the Vanoss formation of Oklahoma and the Cisco group of Texas and are composed of yellow-brown coarse-grained cherty channel sandstones and conglomerates, drab claystones, and thin coal beds (Sellards, and others, 1932, p. 113-115). West of the map area, these rocks grade into limestone and shale. In the vicinity of the Red River and Wichita Mountains uplifts cherty sandstone grades laterally into arkosic sandstone (Sellards, and others, 1932, p. 165-175). Two rock units of Permian age, the Wichita and Whitehorse groups, contain uranium in places and are described in this report. These rocks have a common heavy mineral suite that was derived from a granitic and metamorphic terrane. The suite in nine thin sections is composed of leucoxene, staurolite, garnet, zircon, tourmaline, and rutile. Leucoxene is the dominant constituent.

Wichita group

Rocks composing the Wichita group of Texas and Wichita formation of Oklahoma are of Permian and Pennsylvanian age, (King, 1942). The Wichita is composed of sandstone and shale in the map area and is

Table 1.--General stratigraphic nomenclature and thickness of rocks in northern Texas and southern Oklahoma.

SYSTEM	SERIES	GROUP	TEXAS Formation	TEXAS Member	Thickness (feet)	OKLAHOMA GROUP	OKLAHOMA Formation
PERMIAN	GUADALUPE	Whitehorse	Cloud Chief		10-115		Cloud Chief
			Rush Springs ss.		40-250	Whitehorse	Rush Springs ss.
			Marlow		100		Marlow
	LEONARD	Clear Fork	Dog Creek sh.		1,500-3,100	El Reno	Dog Creek sh.
			Blaine gypsum				Blaine gypsum
			Flower Pot sh.				Flower Pot sh.
			San Angelo ss.				Duncan ss.
					1,200-1,500		Hennessey sh.
		Wichita	Lueders ls.		1,500-2,500		Wichita ("t" bed)
			Clyde				
			Belle Plains				
	WOLFCAMP		Admiral				
			Putnam	Coleman Junct. ls.			
			Moran				
			Pueblo				
PENNSYLVANIAN	UPPER PENNSYLVANIAN	Cisco	Thrifty		370		Vanoss
			Graham		570		
		Canyon	Caddo Creek		100-150		Ada

(Data from Moore (1949) and Miser (1954)

conveniently divided into upper and lower parts by a relatively persistent sandstone zone (the "t" bed of Miser, 1954) believed to be nearly equivalent to the Coleman Junction limestone member of the Putnam formation of Texas. The Coleman Junction is one of many distinctive limestone and shale units that compose the Wichita group south of the map area. (See fig. 3.) In northern Texas there is a lithologic transition from the base to the top of the Wichita group. This transition consists of a decrease in the amount of sandstone, chert, and gray shale and an increase in red shale and siltstone. Below the top of the Coleman Junction limestone equivalents, sandstone lenses are discontinuous and fill channels cut in relatively thin but extensive recognizable stratigraphic zones. In contrast, sandstone lenses above the Coleman Junction zone have a scattered stratigraphic distribution.

Lithology of "red bed" facies

Rocks of Wichita age have a maximum thickness of about 1,500 feet in the area of "red bed" facies (fig. 4). Sandstone and shale are generally red in color although locally these strata are banded, streaked, and mottled with colors varying from black and dark brown to white. Extreme textural variation in short horizontal distances is characteristic of rocks in the group. The rocks are mostly soft and friable and range in texture from pebble size conglomerate of quartz, feldspar, claystone, and limestone to very fine grains of the same material. Black and dark brown nodular, slabby or elongate, limy sandstone concretions several feet across, a foot or more thick, and up to fifty feet long are found in sandstone lenses throughout the unit. Sorting within the sandstones is

generally poor although well-sorted sandstone is present in places. Sandstone and mudstone commonly fill channels in claystone; the top of the sandstone grades laterally into limy mudstone conglomerate in many places. Carbonaceous fragments of fossil wood are found in channel-fill sandstone; barite concretions an inch to six inches in diameter are found in clayey siltstone.

Sandstone is present in simple lenticular bodies with complex internal bedding structure. In and above the Coleman Junction - "t" bed zone most of the sandstone lenses observed were less than five feet thick. Below this zone sandstone lenses are as much as fifty feet thick. Within sandstone lenses individual beds are in places thin-bedded, irregularly-bedded, separated by thin mudstone lenses, and massive with many cross-laminae. Slump features and scour-and-fill beds containing clay or mudstone pebble conglomerate and/or carbonaceous fragments are common within sandstone lenses. Sandstone that is mottled and streaked with residual oil was observed above the Coleman Junction - "t" bed zone, but greater amounts of oil-saturated sandstone appeared to be present in this zone and similar zones below it. Traces of copper (Fath, 1915) and uranium minerals are localized by carbonized wood, some of which retains pyrite-replaced cell structure.

The number and thickness of individual sandstone lenses present in stratigraphic intervals or in certain areas are only partly known because of poor exposures. In or near the Coleman Junction - "t" bed zone there is only one outcrop known (loc. 6, fig. 1) where sandstone lenses are numerous enough to be superimposed on one another. Here in a total section of 233 feet, six sandstone lenses comprising 98 feet of sandstone were measured

by Munn (1914). The thickest sandstone lens is 21 feet thick and contains uranium. Six hundred feet southeast of the measured section a total of less than 30 feet of sandstone is present. In the Honaker No. 78 well (fig. 4) there is 12 feet of sandstone in a 640-foot section above the Coleman Junction limestone zone. Between the Coleman Junction - "t" bed zone and the base of the Wichita group, there is 95 feet of sandstone in a 750-foot section and the thickest sandstone bed is no more than 33 feet thick.

Correlation of stratigraphic units

Stratigraphic correlation of sandstone zones in the "red bed" facies, while not definitive, is based on tracing of marker beds and interpretation of regional conditions of sandstone deposition in the map area. A sandstone zone slightly above the Coleman Junction limestone has been mapped to the Red River from southwest Archer County, Tex., by Nickel and Timms (Sellards, and others, 1932, p. 141-142). Field checking supports their work, and correlation with the youngest channel-fill sandstone or "t" bed zone in Oklahoma can be inferred with some confidence.

The youngest persistent channel-fill sandstone zone in southern Oklahoma has been mapped by several workers (Munn, 1914, and Bunn, 1930) and named the Asphaltum or Ryan sandstone. These and other sandstone zones thought to be equivalent have been named the "t" bed by Miser (1954). Mapping by Bunn shows that this zone outlines buried shallow positive features and deeper negative features on the Wichita Mountains uplift. Sandstone of this zone is exposed near the town of Ryan, Okla., which is north of and across the Red River from exposures of the sandstone zone

slightly above the Coleman Junction limestone in Texas. The distance between the two outcrops is about five miles. On the basis of southwest dip of sandstone beds at Ryan, Bunn assumed that the Ryan sandstone dipped below the Red River and was not correlative with the sandstone zone nearly equivalent to the Coleman Junction limestone. It is the writer's view that a reversal of dip is possible in the space of five miles, and that the youngest channel-fill sandstone zone on each side of the Red River near Ryan is probably stratigraphically equivalent with the other.

Correlation of the base of the Wichita group and the Coleman Junction limestone zone through the lines of section A-A' and B-B' (fig. 1) is generalized and questioned because correlation of persistent zones of discontinuous sandstone lenses is uncertain. Correlation of the Coleman Junction zone is possible, according to R. T. Drake of North Texas Sample Log Service Co. (personal communication), if gamma-ray logs of wells about a quarter of a mile apart are used.

The upper boundary of the Wichita group was mapped on the Lueders limestone westward to east-central Wilbarger County, Tex., where the limestones in the Lueders thin, pinch out, are found again in discontinuous outcrops, and then disappear. Unfortunately, persistent traceable units equivalent to the Lueders limestone are not present in most of the report area (fig. 1) and the contact of the Wichita group with the Clear Fork group - Hennessey shale is transitional from brick red sandstones and shales in the Wichita to chocolate colored shales in the Clear Fork and Hennessey.

Whitehorse group

Rush Springs sandstone

The Rush Springs sandstone is the upper formation of the Whitehorse group of late Permian age. It is overlain by the Cloud Chief formation and underlain by sandstones and shales of the Marlow formation of the Whitehorse group. The Rush Springs is exposed in the Anadarko basin, part of which is shown in the northeast corner of the map area (figs. 1 and 2). The festoon-bedded Rush Springs sandstone and the overlying Cloud Chief formation are notable for their persistence throughout the Anadarko basin. Below the Whitehorse group, a regional persistence of rock types and local variability in lithology is characteristic of alternating shales, sandstones, limestones, gypsum, and anhydrite that compose an estimated total of 3,100 feet of strata of Permian age.

The Rush Springs sandstone is 40 to 250 feet thick and is composed of fine-grained well sorted festoon- and ripple-bedded feldspathic quartz sandstone. The overlying Cloud Chief is 10-115 feet thick and is composed mostly of white finely crystalline massive gypsum. Pre-Cloud Chief erosion accounts for variable thicknesses of the Rush Springs sandstone on anticlinal structures in the Anadarko basin.

REGIONAL STRUCTURE

The area shown on figure 1 is underlain by two major positive structures, the buried east-west trending Red River uplift and the partly buried west-north-west trending Wichita Mountains uplift. The Wichita Mountains uplift is about 30 miles wide and the Red River uplift is about

7 miles wide. Both of these structures were folded and uplifted contemporaneously in Late Mississippian time (Cheney, 1940). The Wichita Mountains uplift is steeper on the northeast side adjacent to the Anadarko basin and is separated from the Red River uplift by the Hollis basin. South of the Red River uplift is the northward-plunging Bend arch which separates the Baylor basin, on the west, from the Fort Worth basin, on the east.

Structures parallel to the Wichita Mountains in the Anadarko basin are the Cement anticline, the Chickasha anticline, the Carter-Knox anticline, and the Velma anticline (fig. 2); structures on the Red River uplift are the Electra anticline and Petrolia anticline (fig. 1). These features have been subdivided into local parallel structures. Some of these positive structures are reflected in surface beds, and all have been proved by intensive oil well drilling. These buried positive features are composed of rocks ranging from Precambrian to Pennsylvanian in age. They are present at variable depths and consequently are overlain by rocks of variable thickness of Pennsylvanian and Permian age. Sediments onlapping the flanks of the Wichita Mountains and Red River uplifts have high initial dips, some of which are reported to be more than 13 degrees. Regional dip of surface beds is about a half a degree to the north-west (Kendrick and Laughlin, 1929, Fuqua and Thompson, 1929).

RADIOACTIVITY ANOMALIES

Regional geologic setting

Of the 19 radioactive localities studied (fig. 1 and table 2) three have visible uranium minerals and one contained ore. All the

Table 2.--List of radioactive localities in northern Texas and southern Oklahoma. 1/

Locality (See fig. 1.) No.	Description	Type of sample*	Laboratory no.	Analyses** eU (percent)	U (percent)
1	3.6 miles south of Petrolia	Carbonaceous sandstone with copper minerals	Grab	F-39259	0.021	-
				F-39260	.007	-
				F-39261	.087	0.062
2	S 1/2 sec. 35, T5S, R6W. (Oklahoma)	Arkosic conglomerate with copper minerals	do.	F-39266	.022	-
				F-39267	.008	-
3	3 1/4 miles northwest of Randlett	Carbonaceous clay with copper nodules	do.	F-39257	.075	.062
				F-39258	.028	-
4	6 miles south, 2 miles west of Electra	Carbonaceous sandstone	do.	F-39251	.004	-
				F-39252	.015	-
				F-39253	.011	-
5	S 1/2 sec. 1, T1S, R15W. (Oklahoma)	Arkosic conglomerate	Grab max,	217159	.14	.13
			Aver. of 8 grab	217159-62 and 66-69	.069	.070
6	SW 1/4 sec. 30, T9S, R12W. (Oklahoma)	Carbonaceous sandstone with copper minerals	Channel, 2 ft.	F-19008	.029	-
		Gray shale in sandstone	Grab	221506	.64	.82
		Carbonaceous sandstone and gray shale	Channel, 5 ft.	F-19006	.032	-
7	SW 1/4 sec. 30, T5S, R8W. (Oklahoma)	Ferruginous sandstone	Float	F-39376	.052	.070
8	SW 1/4 sec. 13, T7S, R6W. (Oklahoma	Carbonaceous sandstone	Channel, 1 ft.	F-39262	.004	-
		do.	Grab	F-39263	.029	-
9	2 miles north of Scotland	do.	Grab	F-36939	.054	.021
10	7 miles north of Bellevue	Ferruginous sandstone	Grab	F-39240	.021***	-
11	0.8 mile north of Henrietta	Very fine-grained sandstone	Channel, 1 ft.	F-39264	.001	-
		do.	Grab	F-39265	.039	-
12	4 miles southwest of Wichita Falls	Ferruginous sandstone	Grab	F-39268	.010	-
13	10 miles north of Archer City	Iron and manganese stained sandstone with visible uranium minerals	Grab	F-36905	.28	.36
				F-36906	.081	.025
14	5 miles north of Ringgold	Ironstone concretions in sandstone	do.	F-39379	.019***	-
15	1 mile northeast of Ringgold	Ferruginous and carbonaceous sandstone	Float	F-39238	.39	.308
16	Approx. 98°50'30", 33°55'30"	Ferruginous sandstone	Grab	F-36936	.039	.045
17	0.5 mile north of northwest corner of Archer City	Sandstone	do.	F-32407	.054	.057
18	0.5 mile south of Archer City	Sandstone	do.	F-32408	.038	
19	Cement, Okla.	Joint-fill in sandstone	Mill pulp for 12.94 tons of ore	252352	1.5	2.2

* Collected by personnel of the Atomic Energy Commission or submitted by taxpayers.

** Analyses by Denver Laboratory of the Geochemistry and Petrology Branch of U. S. Geological Survey.

*** Radioactivity measured by Scaler in Austin, Texas office of Atomic Energy Commission.

1/ Localities 1-18 are in Red River area; locality 19 is in Anadarko basin.

anomalies are in sandstone or adjacent shale. The radioactive occurrences are divided into two types: widely scattered uraniferous or radioactive occurrences in the Red River Valley that are associated in some places with copper minerals but everywhere with carbonized plant remains, and a uranium deposit in fracture zones in sandstone on the Cement oil field structure in the Anadarko basin.

The radioactive localities in the Red River Valley region have a scattered geographic distribution but are restricted almost entirely to a stratigraphic interval of about 700 feet in the upper half of the Wichita. The radioactive materials have an apparent stratigraphic selectivity which is demonstrated by the lack of radioactivity anomalies both in the area of marine limestone and shale south of the "red bed" facies (fig. 3) and in the area of channel-fill sandstone, drab shale, and limestone east of the Coleman Junction zone of outcrop. The transition from these unfavorable areas to the favorable area of "red bed" lithology is reflected in the description of the core from the Honaker well (fig. 4 and Appendix). The well bottomed in limestone of the Canyon group. Gray shaly sandstone and limestone are dominant in the overlying Cisco group; and the uppermost unit in the well, the Wichita group, grades from alternating greenish-gray and red shale and sandstone in the lower half to dominantly red shale and sandstone in the upper half. The gamma-ray log of the well (fig. 4) shows radioactivity measurements of shales to be relatively the same regardless of color. Mobilization and concentration of uranium appear to have been operative in a geochemical environment of relatively high oxidation-reduction potential and to have been inhibited in one of relatively low oxidation-reduction potential. The radioactive

localities as a group have no apparent relation to regional structure in the Red River Valley area.

The regional geologic setting of the deposit on the Cement anticline in the Anadarko basin merits a detailed description because additional ore deposits are considered most likely to be found in similar structural settings in other parts of the basin. The Cement uranium deposit, a vein-type deposit, is localized by fractures on the crest of the Cement anticline. The Cement anticline is near the deeper southwest part of the Anadarko basin adjacent to the Wichita Mountains. Paleozoic rocks in the basin were folded and faulted during Early and Late Pennsylvanian time and folds in the overlying rocks of Permian age were localized by buried Paleozoic structures during and after Permian time. These folds have a general northwesterly trend and form traps for oil and gas. The surface expression of anticlinal structures in the basin is outlined by a yellow or gray zone of altered "red beds" (fig. 5). In the Cement area oil is produced from beds of Permian age within the limits of this alteration. Production in lower Paleozoic rocks is found beyond the limits of the altered zone.

A relatively more rugged topography within the area of the basin, as compared to the topography surrounding the basin, is attributed by Paschal (1941) to the presence of resistant carbonate-cemented rocks. He attributes alteration and addition of carbonate in rocks on anticlinal folds to changes in hydrodynamic conditions during folding. Apparently uranium deposition is a phase of this larger geologic process that altered large volumes of rock in the Anadarko basin.

The Cement anticlinal structure (fig. 5), as contoured on the base of the Cloud Chief formation and independent of the two domes on the axis,

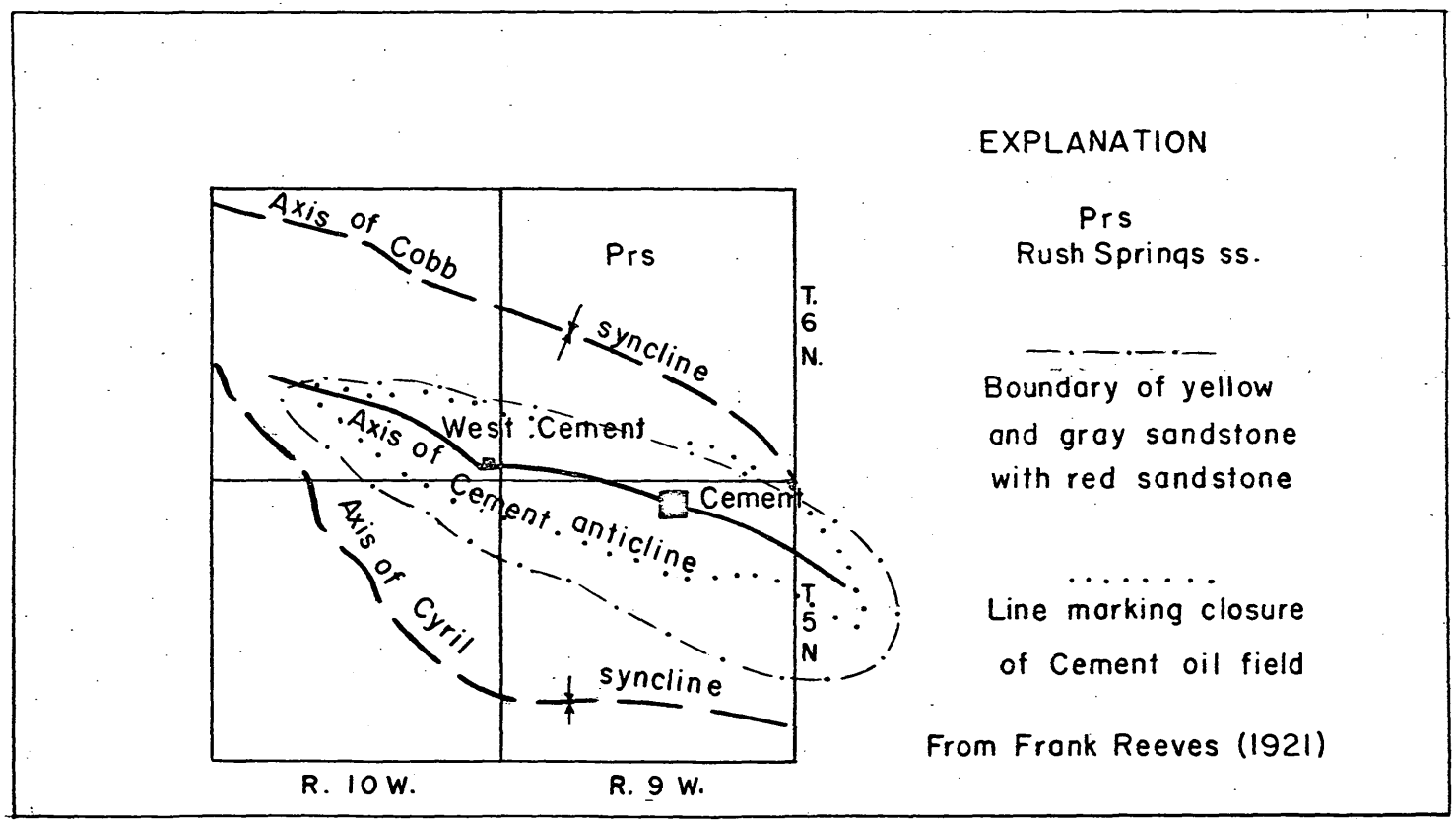

FIGURE 5 – MAP SHOWING RELATION OF COLOR ALTERATION TO THE CEMENT ANTICLINE.

is about 11 miles long and 2 miles wide. The west Cement dome has a closure of 140 feet and is about 1.5 miles long and three-quarters of a mile wide; the Cement dome has a closure of 60 feet and is about 3 miles long and 1.5 miles wide. Dips, ranging from 1 to 5 degrees, are slightly steeper on the northeast side of the axis, and the anticline is slightly asymmetric in that direction. The Cobb syncline to the north is about 100 feet higher structurally than the Cyril syncline to the south, and the West Cement dome is about 80 feet higher structurally than the Cement dome.

The altered yellow and gray sandstone zone, which seems to be a secondary alteration feature resulting from weathering of pyritized rock, includes the area of closure on the Cement anticline. This yellow and gray sandstone zone coincides with the line of closure on the northeast side and extends a mile or more beyond the line of closure on the southwest side of the anticlinal axis. Intensity of alteration of pyrite is indicated by pale yellow sandstone near the color boundary with red sandstone on the flank of the structure and by yellow to dark brown sandstone near the axis and crest of the structure. Also, diffusion bands of darker limonitic staining in white or gray sandstone, yellow brown sandstone mottled white, and non-radioactive pyrite nodules up to 6 inches across veined with anhydrite in soft yellow brown sandstone, occur on the axis. Well defined zones of resistant gray very limy pyritic sandstone are present on the West Cement and Cement domes. It should be noted that similar zones of carbonate-cemented sandstone make well-defined contacts with porous oil-bearing sandstone zones to a depth of 7,000 feet (Eisner, 1955).

Two poorly defined areas contain red sandstone on the axis of the Cement anticline. In a road cut northeast of the Cement school gymnasium building (fig. 6) the red sandstone is soft and earthy near a color

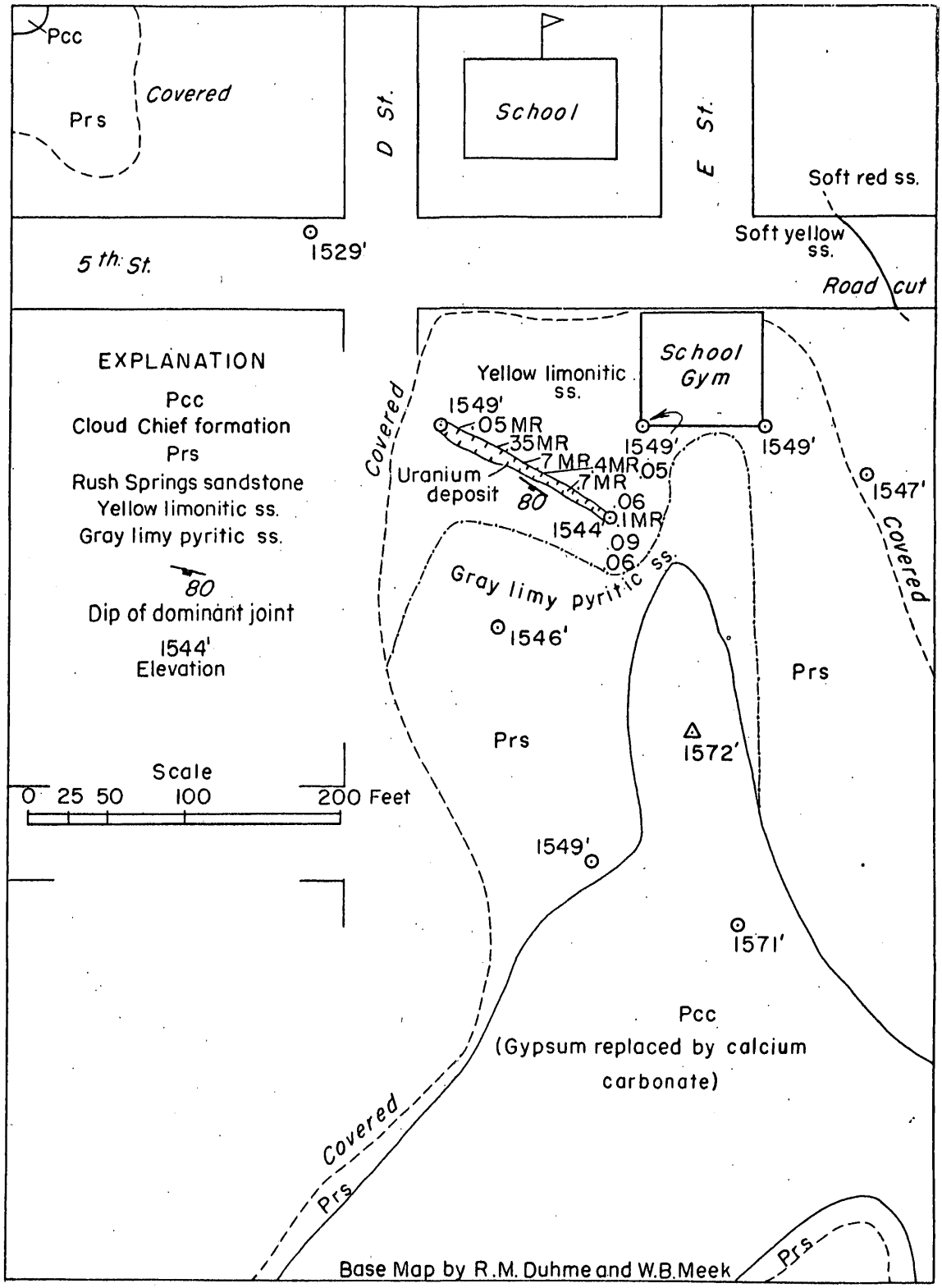

FIGURE 6.-MAP SHOWING RELATION OF ORE DEPOSIT TO ADJACENT ALTERED ROCKS ON CEMENT ANTICLINE.

boundary with soft yellow sandstone. In the middle of the western half of sec. 6, T. 6 N., R. 10 W., both red sandstone and gray sandstone are tightly cemented across the color boundary by calcium carbonate.

Calcium carbonate has replaced gypsum of the Cloud Chief to form a resistant cap rock on parts of the Cement and West Cement domes. Exposures of the cap rock generally have a massive appearance, although some have the appearance of rumpled and contorted bedding. Near and at the base of the carbonate-replaced gypsum, roughly lenticular bodies of yellow-brown, powdery to crusty gossan up to 3 feet thick and 30 feet long are present. The carbonate rock is gray and vuggy with a textural range from finely crystalline to half-inch crystals of calcite. Finely crystalline calcite contains fine-grained opaque minerals that oxidize to limonite.

The relation of uranium deposition to pyritic alteration, to formation of calcium carbonate, and to oil accumulation is only vaguely understood. It is apparent, however, that all of these processes are phases of hydrodynamic change resulting from deformation of the Anadarko basin.

Mineralogy and uranium in radioactive localities

Greater-than-average amounts of radioactivity in sediments are due mainly to the presence of primary and secondary uranium minerals and to daughter elements of uranium, potassium, and thorium. Some uraninite has been reported from locality No. 6, but most of the uranium is in secondary minerals such as carnotite, tyuyamunite, uranophane, autunite, and torbernite. Equivalent uranium analysis (eU percent) as given in table 2 is the uranium content of the sample assuming the uranium to be in equilibrium with its daughter products.

Description of representative uranium localities

The two types of uranium deposits representative of this area are characterized by localities 6 and 19 which are thought to be typical and the best of their class.

Byers prospect uranium deposit

Locality No. 6, Byers prospect, is stratigraphically near the middle of the Wichita formation and is an example of deposition in a "red bed" environment. It is located in SW 1/4 sec. 30, T. 5 S., R. 12 W., Cotton County, Okla., and is 100 feet below the top of a bluff on the north side of the Red River. The uranium-bearing sandstone has a maximum thickness of 21 feet and is exposed for 160 feet along the outcrop. The eastern 100 feet of outcrop strikes east-west and the western 60 feet strikes north-west. In the latter interval the base of the sandstone rises 5 feet toward the northwest. A bulldozed cut has exposed fresh uranium-bearing sandstone near the east side of the outcrop in a working 50 feet long and about 15 feet behind the outcrop (fig. 7a). Waste rock has been pushed to the east and covers the eastern limit of the sandstone. Lateral east-west thinning of the sandstone lens into red mudstone suggests that the long dimension of the thicker part of the sandstone trends north-south. The sandstone is separated into upper and lower halves by a persistent 2- to 3-foot lavender to purplish-red very limy sandstone zone.

Above the limy sandstone zone the sandstone is red and yellow-brown; below, it is dominantly gray to white with some red; the bedding is mostly festoon type. The sandstone is generally soft and friable, fine-to medium-grained, and fairly well sorted with variable amounts of interstitial clay. Below the limy sandstone zone thin red and grayish-green

Figure 7a

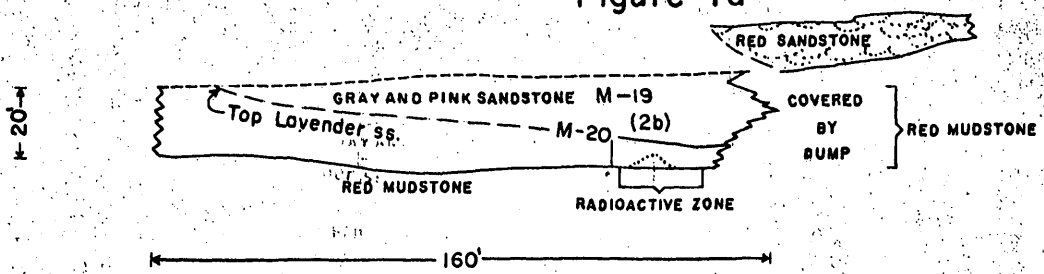

Figure 7b

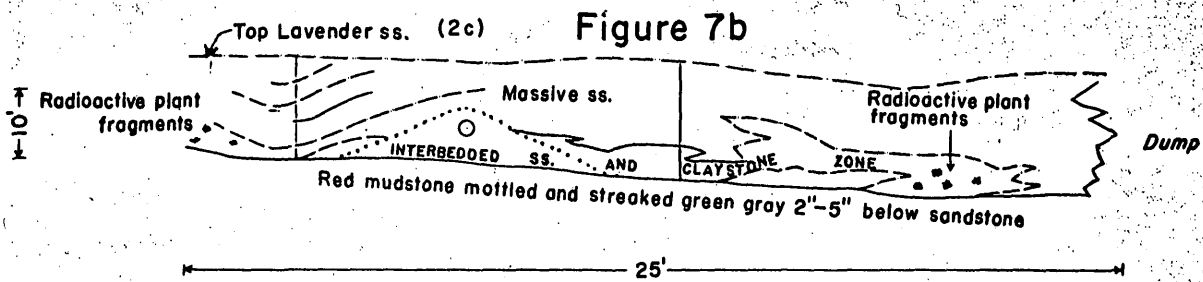

Figure 7c

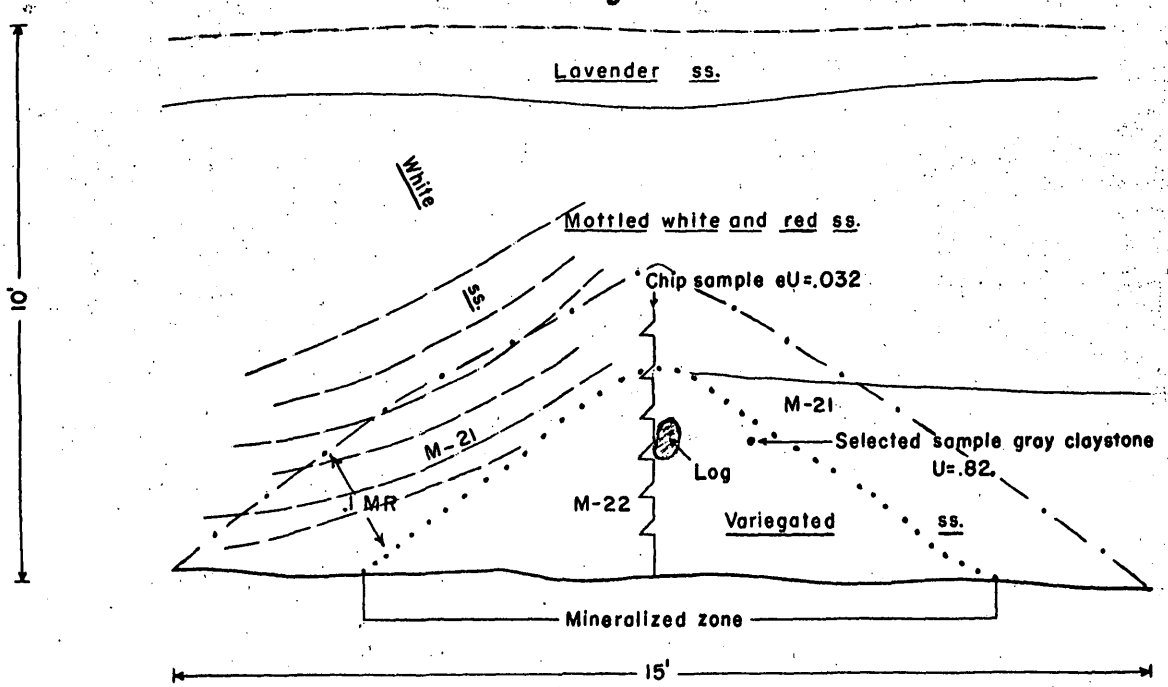

FIGURE 7-a,b,c-SKETCHES SHOWING LITHOLOGIC RELATIONS IN URANIUM-BEARING SANDSTONE AT BYERS PROSPECT, COTTON COUNTY, OKLAHOMA

claystone and mudstone lenses separate sandstone beds and make the festoon bedding prominent. Where these thin mudstone splits are absent, the sandstone appears massive; but close inspection shows festoon scour-and-fill bedding to be present. Mudstone altered from red to grayish green is two to five inches thick at the base of the sandstone. Analyses of samples collected from the different lithologic zones are given in table 3.

Table 3.--Analyses of chip samples shown on Figures 7a, c from Byers prospect, Cotton County, Oklahoma

Sample No.	eU percent	U percent	$CaCO_3$	Total Fe as Fe_2O_3%	MnO percent
M-19	0.001	0.001	25.0	2.15	1.08
M-20	0.001	0.001	0.1	0.92	0.01
M-21	0.002	0.002	1.5	1.50	0.16
M-22	0.012	0.008	0.4	2.68	0.02

The mineralized sandstone zone is near the base of the thickest part of the sandstone outcrop in contorted sandstone beds containing many carbonized wood fragments. A carbonized log about 8 inches in diameter extends into the sandstone and appears to be the locus of a mineralized zone 15 feet wide and 5 feet high that ranges from 0.2 MR to 0.5 MR per hour (figs. 7b, c). A radioactive halo about 0.1 MR per hour about two feet thick surrounds the mineralized zone. The lowest foot of the mineralized sandstone has the most consistently high radioactivity reading in the zone. Sandstone in the zone is red, lavender, yellow, and white. Efflorescent yellow uranium minerals stain weathered sandstone and claystone in places, and blue and green copper minerals occur as a coating on and as

discrete grains in the sandstone. Nodules of chalcocite about half an inch across are present in fresh rock. Carbonaceous plant fragments contain calcite crystals, malachite, and pyrite in micro-fractures, but no visible uranium minerals. A channel sample of the mineralized zone assayed 0.032 percent uranium, and a selected sample of gray claystone assayed 0.82 percent uranium. Scattered radioactive carbonized wood fragments a few inches across are found lateral to the base of the mineralized zone.

Cement uranium deposit

The Cement uranium deposit (fig. 2, table 2, loc. 19) is located on the axis of the Cement anticline in the middle of sec. 3, T. 5 N., R. 9 W., Caddo County, Okla. It is classified as a vein deposit controlled by a joint system trending north 70 degrees west. The deposit is about 150 feet long, 3 to 5 feet wide, and has been mined to a depth of 3 to 6 feet.

Ore minerals, tyuyamunite and carnotite, are disseminated in sandstone parallel to joints which dip about 80 degrees to the southwest. Uranium to vanadium ratio is 2 to 1 in ore which averages 9 percent calcium carbonate. Concentrations of ore minerals appear to be in poorly defined pockets along the strike of the joints. Radioactivity measurements range from 0.05 to 0.8 milliroentgens / per hour along the mined trench. The sandstone in the ore zone is bleached white and stained dark brown and red. White sandstone is prominent parallel to joints and also occurs as sharply defined patches in yellow-brown sandstone. Yellow sandstone is stained dark brown in diffusion bands adjacent to and away from joints. Patches of red sandstone are present parallel to dark brown diffusion bands.

Clusters of sand grains up to one-sixteenth of an inch in diameter are cemented by hematite and occur in yellow-brown and red sandstone. The bleached white sandstone is softer than the iron-stained sandstone but in places contains elliptical, very hard calcite-cemented concretions up to about 3 inches in largest dimension. Combustion tests of black specks one to two millimeters in diameter in bleached and yellow-brown sandstone were negative; the specks are probably manganese.

CONCLUSIONS

Uranium and radioactive occurrences are widely distributed in northern Texas and southern Oklahoma, but with the exception of the Cement deposit the known uranium occurrences are small and uneconomic. Results of exploration and reconnaissance do not favor the possibility of finding large reserves of uranium ore in the Red River Valley region. The sandstone lenses observed are probably too small and too discontinuous either to allow the transport of large volumes of ore-bearing solutions or to contain large ore bodies. On the other hand, the association of uranium mineralization with fractures on the Cement anticline, the presence of thick sandstone as potential host rocks for large volumes of ore, and the presence of similar faults and fractures on other folds in the Anadarko basin should encourage further exploration.

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9

LITHOLOGY AND RADIOACTIVITY OF THE MAGNOLIA PETROLEUM COMPANY NO. 78 HONAKER WELL IN THE ELECTRA FIELD WICHITA COUNTY, TEXAS

By

D. H. Eargle

INTRODUCTION

The core from the Magnolia Petroleum Company No. 78 Honaker well in the Electra oil field in the western part of Wichita County, Tex., (fig. 4) provides one of the most complete stratigraphic sections available for study of the lithology of the Wichita group and older rocks. A lithologic description of the core was made in January and February 1956. A Wentworth scale grain-size chart was used in describing texture, and a National Research Council color chart was used to describe rock color.

The cooperation of personnel of the Magnolia Petroleum Company in making the core available for study and in furnishing electric logs and other data of the well is gratefully acknowledged. D. A. Myers of the U. S. Geological Survey identified fusulinids of Pennsylvanian age and determined their stratigraphic position.

Inasmuch as most of the known surface occurrences of uranium and radioactivity anomalies are in the upper half of the Wichita group the stratigraphic relation of anomalous radioactivity on the surface to the lithology and radioactivity shown in the core log is significant. Surface radioactivity in the upper 700 feet of rocks assigned to the Wichita group is related to the last phase of color change that progresses upward from gray in rocks of Pennsylvanian age to dominantly greenish-gray in those of the lower half of the Wichita group, to "red beds" in the upper half of the Wichita group. The association of radioactivity with the dominantly red sedimentary rocks is in striking contrast to the lack of anomalous radioactivity in thick sandstone units in outcrops or in the subsurface within greenish-gray or gray sediments. Radioactivity measurements of shale are relatively uniform regardless of color.

STRATIGRAPHY

Permian system

Wichita group

The Wichita group is about 1,460 feet thick, assuming that the surface rocks at the Honaker well site are about 100 feet stratigraphically below the top of the group. A total of about 300 feet of the Wichita group is not represented in this described section; but it is assumed, from scattered outcrops, that the missing interval is much like the upper 550 feet of core, which is composed chiefly of red massive claystones and mudstones and lesser amount of greenish-gray colored claystones and mudstones. No fossils were noted above a depth of 380 feet in the well, but between depths of 380 and 550 feet plants, invertebrates and fish plates were noted. From the 550 to 603 foot interval the claystone is mainly greenish gray. Dolomite beds up to 5 feet thick are present. With increase in amount of greenish-gray claystone and the presence of dolomite there is an increase in amount of fish bones and teeth, pelecypods, pyrite, and chalcopyrite.

A sandstone unit that is probably the equivalent of the Coleman Junction limestone member of the Putnam formation lies between depths of 603 and 623 feet. This sandstone is light greenish gray to pale yellow brown and fine to very fine grained. Below this unit to a depth of 900 feet are greenish-gray shales that are mottled red, siltstone, and a few beds of fine-grained sandstone. In the interval between 900 feet and the probable base of the Wichita group sandstones are more abundant, coarser grained, and more arkosic than the sandstones above. Thin coals and lignitic shales are present, some of which have anomalous radioactivity. Claystones are mottled red and greenish gray. The basal unit in the Wichita

group is here a greenish-gray cross-bedded medium-grained arkosic sandstone.

Pennsylvanian system

Cisco group

Thrifty formation.--The Thrifty formation consists chiefly of greenish-gray shales and siltstones that are mottled red in the upper half, and gray and greenish-gray shales and siltstones in the lower half. The formation has a total thickness of 369 feet. Some thin coal beds and carbonaceous shales, fine-grained sandstone beds, and thin limestone beds are also present in the lower half of the formation. A one-half-foot thick limestone bed at a depth of 1,664 feet is probably the Breckenridge limestone member, and a one-foot-thick limestone bed at the base of the formation is probably the Speck Mountain limestone member.

Graham formation.--The Graham formation consists of 567 feet of alternating gray fine-grained sandstone, siltstone, and claystone. Limestone beds are thicker than those in the overlying Thrifty formation, and claystones and siltstones contain more marine fossils. With increase in number and thickness of limestone beds there is a conspicuous increase in gray and decrease in greenish-gray claystones and siltstones. Only traces of red rocks are present.

Canyon group

Caddo Creek formation.--The upper 35 feet of the Home Creek limestone member of the Caddo Creek formation is a gray fine-grained limestone bed and is the lowest unit penetrated in the Honaker well.

APPENDIX

DESCRIPTION OF CORE FROM MAGNOLIA PETROLEUM COMPANY NO. 78 HONAKER WELL, ELECTRA FIELD, WICHITA COUNTY, TEXAS

WELL DATA:

Location: 330 feet from the north line, and 375 feet from the west of the S P R R Survey No. A 665.

Elevation: 1,153 feet (top of 5½ in. casing collar.)

Total depth: 2,330 feet (steel-line measurement). Cored from surface to 2,330 feet (total depth); core preserved from 200 to 2,330 feet (total depth).

GAMMA RAY - NEUTRON LOG DATA:

Recorded by: Lane-Wells Company

Log measured from 7 feet above 5½ in. casing collar, elevation: 1,160 feet above sea level.

Drilling measured from kelly bushing.

Permanent datum: top 5½ in. casing collar.

Type of log: Gamma ray - neutron.

Date: 11-22-52

Top of logged interval: 10 feet

Bottom of logged interval: 2,304 feet.

Type of fluid in hole: water and oil.

Fluid level: 1,280.5 feet.

Neutron source strength and type: 600N.

Source spacing: 8.25 inches.

Length of measuring device: 36 inches gamma ray, 9 inches neutron.

O. D. of instrument: 3 5/8 inches.

Time constant: 6.5 seconds gamma ray, 4 seconds neutron.

Logging speed: 32 feet/minute.

Sensitivity reference: 274 gamma ray, 275 neutron.

Description

PERMIAN SYSTEM

WICHITA GROUP UNDIFFERENTIATED

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)		Thickness (feet)
200-200.5	Clay, silty, light-gray (N7), irregularly bedded, slightly dolomitic, very finely micaceous	0.5
200.5-202	Clay, medium light-gray (N6), irregularly bedded, very finely micaceous	1.5
202-205.5	Clay, silty, greenish-gray (5GY6/1), irregularly bedded	3.5
205.5-214	Clay, slightly silty, grayish-red (10R4/2), nonbedded to slightly bedded, very finely micaceous, compaction slickensides (hematite-coated), trace gypsum crystals	8.5
214-234	Clay, slightly silty, grayish-red (10R4/2), slightly mottled with greenish-gray (5Y6/1), very finely micaceous, "veinlets" of silt and very fine sand (mud cracks?), compaction	

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	slickensides (hematite-coated). 218-220 feet, circular spots of greenish-gray; 215-230 feet, more clayey	20.0
234-236	Clay, slightly silty, moderate-brown (10R4/4), mottled light to dark, very finely micaceous, slickensided.	2.0
236-259.5	Clay, slightly silty, grayish-red, slightly mottled w ith greenish-gray, very finely micaceous, slickensided, mud cracks (silty veinlets)	23.5
259.5-260.5	Siltstone, light greenish-gray (5GY8/1), nonbedded, dolomite veinlets 0.1 inches wide	1.0
260.5-266	Clay, slightly silty, same as 236-259.5. . . .	5.5
266-267	Silt and limestone conglomerate; silt is light greenish gray (5GY8/1), bedded, mud cracked, noncalcareous; limestone pebbles gray to brown 0.1 to 0.3 inches in diameter, rounded; claystone matrix.	1.0
267-286	Clay, slightly silty, same as 236-259.5. . . .	19.0
286-290	Clay, silty, greenish-gray mottled with grayish-red with 1.0-foot grayish-red zone 288-289, slightly silty	4.0
290-348	Clay, slightly silty, grayish-red, irregularly bedded, very slightly mottled with greenish-gray in top 4.0 feet.	58.0
348-367	Clay, silty, moderate yellowish-brown (10YR5/4) mottled with greenish-gray (5GY6/1), slickensides	19.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
367-369	Clay, very silty, greenish-gray (5GY6/1), nonbedded, conchoidal fracture, very finely micaceous	2.0
369-378	Clay, moderate brown (5YR4/4), waxy, polished slickensides	9.0
378-382	Shale, medium-gray (N6), laminated (darker gray with lighter gray), fossil pelecypods (Limestone, medium-gray (N6), massive, many ovate structures, some fish plates and chalcopyrite, 381-381.5).	4.0
382-401.5	Shale, slightly silty, moderate yellowish-brown to grayish-red to medium dark-gray. Dark-gray bands are 4-5 inches thick and subordinate	19.5
401.5-402	Siltstone, light greenish-gray, slightly and very finely micaceous, nonbedded, calcareous	0.5
402-425	Clay, slightly silty, moderate yellowish-brown, mottled with greenish-gray; grades downward into greenish-gray (5GY6/1), containing carbonaceous material	23.0
	(417-421, no core. Probably same as above.)	
425-439.5	Clay, silty, greenish-gray (5GY6/1), nonbedded plant remains as wide as 1.0 inch, pyritized, polished slickensides. Brownish-red zone 435-436.	14.5

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)	Description	Thickness (feet)
439.5-440.5	Clay, shaly, dark-gray (N3), very fossiliferous (pelecypods), prints	1.0
440.5-444.5	Clay, slightly silty, greenish-gray, nonbedded, carbonaceous flecks. Vertebrate fossil bones and large carbonaceous plant remains at 443	4.0
444.5-446.5	Siltstone, dolomitic, light greenish-gray (5G8/1), massive, carbonaceous material and fossil (?) fragments	2.0
446.5-449	Shale, slightly silty, greenish-gray; laminated siltstone with thin carbonaceous laminae at 446.5-446.7; medium dark-gray laminated clay (N4) at 448.5-448.7	2.5
449-450	Clay, slightly silty, grayish-red mottled with greenish-gray	1.0
450-451	Core removed for laboratory sample (probably sandstone)	1.0
451-464	Clay, slightly silty, grayish-red to greenish-gray, nonbedded to irregularly bedded, polished slickensides, slight yellowish-brown mottling near top	13.0
464-465	Clay, slightly silty, medium dark-gray (N4), crumbly.	1.0

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)	Description	Thickness (feet)
465-466	Dolomite, clayey, impure, light greenish-gray (5GY8/1)	1.0
466-470.5	Clay, slightly silty, medium-gray (N5), crumbly.	4.5
470.5-472	Clay, slightly silty, grayish-red (10R4/2). . .	1.5
472-476	Clay, slightly silty, medium-gray (N5), laminated; fossil pelecypods	4.0
476-484	Clay, slightly silty, grayish-red becoming dark yellowish-brown (10YR4/2) mottled with greenish gray (5GY5/1) toward bottom, nonbedded, very finely micaceous.	8.0
484-487	Clay, slightly silty, light greenish-gray (5GY6/1) mottled with dark greenish-gray (5GY4/1), non-bedded, very finely micaceous	3.0
487-489	Clay, light greenish-gray (5GY6/1).	2.0
489-495	Sandstone, clayey and silty, greenish-gray (5G6/1), very fine-grained, contains abundant carbonaceous matter and some well-preserved plant fossils (club mosses?), (especially at 488.5-489.5), very finely micaceous, well-bedded, some black layers, coaly; some pyrite nodules one inch by one-half inch, some coaly stems 2 inches wide. Grades down into fine sand, light gray, nonbedded; at 490.5, clayey. (491-494, core missing)	6.0

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)	Description	Thickness (feet)
495-500	Clay, greenish-gray (5GY6/1 to 5G6/1), slightly silty, slightly dolomitic toward top, smooth, nonsilty below 496, nonbedded. Grades down into dark yellowish-brown (10YR4/2) at 498	5.0
500-504	Clay, yellowish-brown (5YR4/4) to reddish-brown (10YR4/2) to greenish-gray (5YR4/1), nonbedded, slickensided	4.0
504-506	Clay, slightly silty, light olive-gray (5Y6/1) to pale-brown (5YR4/2), mottled especially along traces of plant fragments	2.0
506-509	Clay, dark bluish-gray (5B4/1) to dark greenish-gray (5GY4/1), moderately well-layered . .	3.0
509-515	Clay, slightly silty, pale-brown (5YR5/2) mottled with light olive-gray (5Y6/1), nonbedded, slickensided, more silty toward base. Iron-stone concretions at 511'	6.0
515-529	Clay, silty, greenish-gray (5GY6/1) mottled with dusky-yellow (5Y6/4). 521.5-523 is olive-gray (5Y4/1) and is moderately well bedded. Generally nonbedded	14.0
529-534	Sand, silty, greenish-gray (5GY6/1), very fine-grained, nonbedded, slightly dolomitic	5.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
534-551	Clay, slightly silty, dark reddish-brown (10R3/4), mottled with dark greenish-gray (5GY4/1), nonbedded	17.0
551-552	Dolomite, medium light-gray (N6), fine grained, laminated and interbedded with dark-gray clay. Fossil pelecypods	1.0
552-554	Clay, slightly silty, greenish-gray (5GY6/1), nonbedded, crumbly	2.0
554-557	Clay, grayish-red (10R4/2), slightly silty, slightly mottled with greenish-gray (5GY6/1)	3.0
557-558	Dolomite, light greenish-gray (5GY8/1), fine-grained, black phosphatic material (fish teeth)	1.0
558-564	Clay, slightly silty, greenish-gray (5GY6/1), nonbedded, slickensided	6.0
564-569	Dolomite, light greenish-gray to greenish-gray (5GY6/1), impure (clay), many small fish bones and plates at 558.5, hard, massive to brecciated and vertically fractured .	5.0
569-570	Clay, reddish-brown and gray mottled	1.0
570-582.5	Clay, greenish-gray (5G6/1) to dark greenish-gray (5G4/1), slickensided, very finely micaceous, abundant fossil fish bone fragments; abundant ostracodes 573-574;	

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	silty shale, pelecypods and plant fossils 575-575.5; coal at 575.5-576.0; light-brown staining 576-578; Pectens at 580.5-581.5; plant roots (?) replaced by copper at 580.0-582.5	12.5
582.5-584	Sand, clayey, light greenish-gray (5G8/1) slight brown oil stain, slightly dolomitic, very fine-grained	1.5
584-591	Clay, silty, greenish-gray (5G6/1), upper foot yellowish-brown staining (10YR5/4), very finely micaceous, moderately well-bedded, linguloid brachiopods at 585.5, pelecypods at 588.5. Dark greenish-gray (5G4/1) toward bottom, abundant fossils at 590.5 .	7.0
591-593	Dolomite, medium light-gray (N6), medium coarse crystals, abundant fossils, ostracodes	2.0
593-595	Clay, silty, dark greenish-gray (5G4/1), abundant fossils, ostracodes, pelecypods, well-bedded	2.0
595-603	Clay, greenisn-gray (5G6/1), slightly silty, very finely micaceous, nonbedded, yellowish-brown mottling at 599, and grayish-red mottling at 600.	8.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	Rocks equivalent to Coleman Junction limestone member of the Putnam formation	
603-606	Siltstone, greenish-gray (5G6/1)	3.0
606-615	Sand, dolomitic in upper foot, oil-stained, light greenish-gray (5G8/1), very fine-grained, slightly micaceous, nonbedded, slightly clayey	9.0
615-621	Clay, silty, greenish-gray (5G5/1), slightly mottled reddish-brown, carbon flakes, bottom 2 feet not mottled	6.0
621-624	Sand, clayey, pale yellowish-brown (10YR6/2), fine-grained, crossbedded, arkosic (?), micaceous, fine carbonaceous matter . . .	3.0
624-634.5	Clay, silty, medium bluish-gray (5B5/1), mottled with pale reddish-brown to yellowish-brown, much carbonaceous material and gray laminated clay at 625, abundant ostracodes and pelecypods at 633.5.	10.5
634.5-635	Limestone, greenish-gray (5GY6/1), abundantly fossiliferous, gastropods. (base of Coleman Junction limestone equivalent)	0.5
635-649.5	Clay, greenish-gray, nonbedded to well-bedded, carbonaceous and abundant fossils at 636-637 (ostracodes and pelecypods); plant fossils	

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	and carbon flakes to bottom. Pelecypods at 649-649.5 (Pectens common)	14.5
649.5-654	Clay, slightly silty, grayish-red (10R4/2), mottled with greenish-gray, especially near top	4.5
654-655	Siltstone, greenish-gray, very finely sandy, mottled with reddish-brown, dolomitic . . .	1.0
655-660	Clay, grayish-red (10R4/2)	5.0
660-666.5	Silt, clayey, greenish-gray mottled with grayish red, abundant ferruginous nodules	6.5
666.5-679	Sand, light greenish-gray (5G7/1), silty, very fine-grained, one foot grayish-red clay 668.5-669.5, slightly very finely micaceous, thin carbonaceous clay streaks. 672-678 removed for analysis. Probably sand	12.5
679-692.5	Silt, light greenish-gray, well-bedded, abundant plant fragments, pelecypods, more clayey toward bottom	13.5
692.5-693.5	Limestone, dolomitic, yellowish-gray (5Y8/1), very fossiliferous, large brachiopods (linguloid)	1.0
693.5-694.5	Clay, light greenish-gray (5G8/1) ostracodes .	1.0
694.5-695	Limestone, same as 692.5-693.5	0.5
695-703	Clay, greenish-gray (5G6/1), poorly bedded, calcareous nodules at 696.5 to 697, grayish-red	

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	mottling from 697-698	8.0
703-704	Silt, light greenish-gray, poorly bedded . .	1.0
704-705.5	Sand, light greenish-gray, poorly bedded . .	1.5
705.5-710	Silt, light greenish-gray, hard, few carbon flecks increasing toward base	4.5
710-715.5	Clay, dark greenish-gray, very fossiliferous, many pelecypods, very carbonaceous, interbedded with carbonaceous siltstone . . .	5.5
715.5-718	Clay, greenish-gray, not bedded, slickensided	2.5
718-721	Silt, light greenish-gray, moderately well-bedded, carbon flecks	3.0
721-734	Clay, greenish-gray, slickensided, carbonaceous silty layers, occasional red mottling . .	13.0
734-743.5	Silt, greenish-gray, fairly well-bedded, abundant plant fossils	9.5
743.5-754	Clay, grayish-red with greenish-gray mottling.	10.5
754-757	Silt, greenish-gray, poorly bedded, occasional red mottling	3.0
757-769.5	Sand, fine- to very fine-grained, crossbedded, fairly soft	12.5
769.5-773	Silt, light greenish-gray, hard, nonbedded, slightly clayey and slickensided	3.5
773-777	Clay, grayish-red (10R4/2), mottled with greenish-gray, nonbedded, slickensided, slightly silty	4.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
777-789	Clay, yellowish-brown (10YR5/3) mottled with grayish-red, calcareous concretions (small), nonbedded, less red mottling with depth	12.0
789-802	Clay, greenish-gray, moderately well-bedded, abundant plant impressions stained brown to black, scattered calcareous concretions, especially below 795, some are sideritic	13.0
802-805	Clay, greenish-gray mottled grayish-red, slickensided.	3.0
805-826	Clay, reddish-gray, slightly mottled with greenish gray, polished black slickensides	21.0
826-829	Clay, greenish-gray, fossiliferous, crinoid stems, pelecypods, joints, slickensides .	3.0
829-832	Clay, grayish-green, mottled with red, fossiliferous, abundant pelecypods at 831, slickensides	3.0
832-841	Clay, grayish-red mottled with greenish-gray, slickensided	9.0
841-843	Removed for core analysis	2.0
843-902	Clay, grayish-red mottled with greenish-gray, greenish-gray silt at 845.5-847, 858.5-869.5, 875.5-876.5, 877.5-878.5, calcareous concretions at 891-892	59.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
902-903.5	Sand, light greenish-gray, calcareous, slightly clayey, fine-grained, poorly or slightly bedded	1.5
903.5-905	Removed for analysis	1.5
905-916	Sand, light olive-gray (5Y6/1), fine-grained, arkose, scattered biotite, friable, faintly crossbedded (partially removed for analysis), oil-stained to 908.5	11.0
916-941	Clay, grayish-red to dark reddish-brown, slightly mottled with greenish-gray, streaks of greenish-gray clay with abundant pyrite at 917, slickensides obscure bedding	25.0
941-945.5	Clay, medium dark-gray (N4), streaks of reddish-brown, slickensides, bedding obscure	4.5
945.5-949.5	Clay, silty greenish-gray (5GY6/1), moderately well-bedded, irregular calcareous concretions, trace of plant fragments at 948 . .	4.0
949.5-951	Shale, laminated, very carbonaceous, dark-gray (N3) to black (N1), many plant stems . . .	1.5
951-963	Clay, silty, medium dark-gray (N4), becomes light gray from 957 downward, abundant fossils, pelecypods and brachiopods, clay becomes calcareous in basal foot	12.0
963-965	Limestone, medium dark-gray, very fossiliferous with mostly pelecypods; clayey	2.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
965-975	Clay, laminated, slightly calcareous, fossil pelecypods, medium dark-gray (N4), at 969 are plant stems, slickensides, at 972 becomes light greenish-gray with pelecypods, nonbedded, calcareous concretions	10.0
975-980.5	Clay, silty, medium dark-gray (N4), well-bedded, abundant plant fossils.	5.5
980.5-983	Siltstone, greenish-gray, very fine, finely carbonaceous, moderately well-bedded . . .	2.5
983-987	Clay, greenish-gray, obscurely bedded, slickensides	4.0
987-990.5	Sandstone, greenish-gray, very fine-grained, massive bedding	3.5
990.5-995	Clay, greenish-gray, obscure bedding	4.5
995-1027.5	Clay, silty, grayish-red mottled with greenish-gray, slickensides, poorly bedded. Some moderate yellowish-brown mottling below 1020. Calcareous concretions at 1022 . . .	32.5
1027.5-1035	Siltstone, light greenish-gray, calcareous, hard, clayey, moderately well-bedded, petroleum odor; grades down into very fine clayey sandstone at 1029.5. Soft zones. .	7.5
1035-1043	Removed for core analysis	8.0
1043-1050	Clay, grayish-red to grayish-red-purple with some greenish-gray spots. Moderately well-bedded and some mud cracks, smooth	7.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1050-1050.5	Clay, silty, medium dark-gray (N4), carbon flakes, brecciated	0.5
1050.5-1066	Sand, light greenish-gray, fine, petroleum odor, crossbedded, mica flakes	15.5
1066-1069	Clay, greenish-gray, sandy (mud cracks filled with sandy clay)	3.0
1069-1078.5	Siltstone, clayey, greenish-gray, moderately well-bedded.	9.5
1078.5-1091	Sand, greenish-gray, medium to coarse, coarse arkose, friable, mica; white feldspar, some pink; mostly weathered and soft, cross-bedded, few dark-gray clay pebbles	12.5
1091-1094	Clay, greenish-gray, nonbedded	3.0
1094-1100	Clay, grayish-red mottled with greenish-gray and vice versa, nonbedded to moderately well-bedded, calcareous concretions at 1094-1094.5, polished brown slickensides and mostly grayish-red-purple below 1096.	6.0
1100-1104	Clay, slightly silty, grayish-red-purple (5RP4/2), mottled with moderate yellowish-brown (10YR5/4), nonbedded, slickensided	4.0
1104-1109	Clay, slightly silty, grayish-red (10R4/2) mottled with greenish-gray (5GY6/1), slightly calcareous at 1108-1109, nonbedded	5.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1109-1121	Clay, slightly silty, grayish-red-purple intricately mottled with greenish-gray, non-bedded, slickensided	12.0
1121-1125	Siltstone, slightly calcareous, greenish-gray, hard, poorly bedded with a one-foot parting, at 1124-1125 which is clay as above, slickensided	4.0
1125-1128	Clay, grayish-red-purple mottled with greenish-gray, poorly bedded, slickensided.	3.0
1128-1131	Clay, silty, dull grayish-green slightly mottled with reddish-brown, small ferruginous and calcareous nodules, slickensided	3.0
1131-1139	Clay, slightly silty, grayish-red, slightly mottled with greenish-gray, moderately well-bedded.	8.0
1139-1143	Siltstone, clayey, greenish-gray, moderately well-bedded, becomes pink arkosic, medium sandy at 1141; becomes coarse arkosic sandy at 1142.	4.0
1143-1150	Clay, grayish-red-purple, slightly spotted with greenish-gray. Contains calcareous concretions as much as half an inch in diameter. Polished dark-brown slickensides	7.0
1150-1155	Core missing.	5.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1155-1175.5	Clay, grayish-green mottled more or less with grayish-red, nonbedded, slickensided. Grades into grayish-red toward base. Contains ferruginous concretions	20.5
1175.5-1180	Clay, greenish-gray, many calcareous concretions, calcareous clay, moderately well-bedded. Grayish-red streak 1178-1180. Slickensided	4.5
1180-1188.5	Siltstone, dolomitic, clayey, greenish-gray mottled with grayish-red, hard, poorly to moderately well-bedded	8.5
1188.5-1189.5	Clay, greenish-gray mottled with grayish-red, hard, moderately well-bedded	1.0
1189.5-1193	Clay, grayish-red, nonbedded, some gray streaks	3.5
1193-1197.5	Clay, calcareous, greenish-gray, hard, some grayish-red streaks.	4.5
1197.5-1200.5	Clay, grayish-red, some greenish-gray, nonbedded	3.0
1200.5-1205	Siltstone, light greenish-gray, hard, bedded, some clay, grades down into silty, very fine sand at 1205, slightly crossbedded, firm and hard	4.5
1205-1235	Sandstone, friable, pale-olive to grayish-olive (10Y6/2 to 10Y4/2), highly arkosic, medium- to coarse-grained, much is stained with oil,	

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	clayey streaks and finely crossbedded. . .	30.0
1235-1238	Sandstone, as above, except greenish-gray, coarse, very common pink feldspar, plant fragments, a little mica, and many dark greenish-gray clay fragments, some siderite nodules ½ to 1½ inches long and ½ inch thick	3.0
1238-1240	Lost core	2.0
1240-1243.25	Claystone, dark greenish-gray, laminated somewhat irregularly; very fine plant fragments, pyritized; pelecypods at 1241.75-1242.0	3.25
1243.25-1243.5	Coal, black, impure.	0.25
1243.5-1248.5	Claystone, greenish-gray (5GY6/1), less laminated than 1240-1243.25, slickensides, becomes pale yellowish-brown mottled below 1245.5, plant fragments and pelecypods common	5.0
1248.5-1253	Claystone, greenish-gray mottled with grayish-red-purple (5RP4/2), nonlaminated to 1249.5, laminated below	4.5
1253-1259	Siltstone, greenish-gray, hard, clayey, massive	6.0
1259-1270	Claystone, greenish-gray mottled with grayish-red purple, nonlaminated, slickensided. .	11.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1270-1275	Claystone, calcareous, grayish-red-purple, non-laminated, calcareous nodules with maximum diameter 0.25 inches, greenish-gray; glossy slickensides (MnO_2?), becomes noncalcareous toward bottom	5.0
1275-1281.5	Claystone, grayish-purple mottled with dark yellowish-orange (10YR6/6) to moderate yellowish brown (10YR5/4), nonlaminated, bottom two feet laminated and contains plant fragments and mottled with greenish-gray. .	6.5
1281.5-1286	Sandstone, silty, light greenish-gray, medium-grained	4.5
1286-1291	Lost core (silty sand)	5.0
1291-1293	Claystone, greenish-gray (5GY6/1), laminated, varved.	2.0
1293-1298.5	Claystone, grayish-black (N2), laminated, grades down into greenish-gray, some streaks mottled with grayish-red. Well-preserved pelecypods common. Plant fragments	5.5
1298.5-1307.5	Claystone, greenish-gray, poorly laminated, abundant plant fragments and impressions, becomes mottled with grayish-red-purple at 1303, more intense red-purple below 1304. .	9.0
1307.5-1314	Sandstone, silty, slightly calcareous, greenish gray, hard, laminated (massive), very	

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	fine-grained	6.5
1314-1317	Claystone, greenish-gray, nonlaminated. . .	3.0
1317-1326	Claystone, brownish-red-purple and greenish-gray mottled, slickensided	9.0
1326-1340	Claystone, dark-gray (N3), laminated, plant fragments and stems	14.0
1340-1342	Sandstone, medium-gray, arkosic, medium-grained, cross-bedded, much lignitic material, brachiopod prints.	2.0
1342-1346	Claystone, dark greenish-gray (5G4/1), much lignite and plant stems, laminated . . .	4.0
1346-1349	Claystone, greenish-gray (5G6/1), waxy, slickensided, nonlaminated	3.0
1349-1359	Sandstone, greenish-gray, medium-grained, slightly arkosic, steeply crossbedded, friable, oil-stained. Lost core 1354-1356	10.0

Description

PENNSYLVANIAN SYSTEM

Cisco Group

Thrifty Formation

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)		Thickness (feet)
1359-1362	Claystone, greenish-gray, waxy, slickensided poorly laminated	3.0
1362-1381.5	Claystone, medium-gray, poorly laminated, mottled with grayish-red-purple and dark yellowish-orange below 1365. Calcareous at 1379-1380. Black glossy slickensides at 1370.	19.5
1381.5-1393	Claystone, light olive-gray (5Y5/2), poorly to moderately well-laminated; brachiopods, pelecypods, and crinoid stems. Grades down at 1387 into olive-gray, very brittle, laminated, waxy clay with few fossils. Plant fossils 1392-1395.	11.5
1393-1407	Claystone, medium-gray, poorly laminated, dull luster, mottled with grayish-red-purple below 1398	14.0
1407-1416	Claystone, greenish-gray, waxy, mottled with grayish-red, slickensided.	9.0
1416-1420	Siltstone, light greenish-gray, laminated, hard, slightly calcareous	4.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1420-1435.5	Claystone, greenish-gray mottled with grayish-red-purple, slickensided	15.5
1435.5-1443.5	Claystone, greenish-gray, waxy, mottled with grayish-red and slickensided below 1438, poorly laminated	8.0
1443.5-1446	Siltstone, light greenish-gray, hard, slightly calcareous	2.5
1446-1454	Claystone, greenish-gray, slightly mottled with grayish-red-purple below 1451, poorly laminated	8.0
1454-1458	Siltstone, clayey, light greenish-gray, hard, slightly calcareous, banded, laminated . .	4.0
1458-1465	Claystone, greenish-gray, moderately well-laminated, slickensided, silty below 1461. . .	7.0
1465-1476	Claystone, grayish-brown (5YR3/2), somewhat mottled with olive-gray; calcareous concretions with maximum diameter $\frac{1}{2}$ inch. . .	11.0
1476-1483	Siltstone, clayey and calcareous in spots, light greenish-gray, laminated and very finely micaceous, grades into clayey and silty very fine sandstone at 1477 (clay is thinly interbedded), some fine plant fragments.	7.0
1483-1484	Lost core	1.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1484-1490	Claystone, silty, medium-gray, moderately laminated, grades down into greenish-gray at 1486	6.0
1490-1495	Siltstone, clayey, greenish-gray, moderately laminated, slightly calcareous, very fine micaceous, grades down into claystone at 1492	5.0
1495-1496.5	Siltstone, greenish-gray, clayey.	1.5
1496.5-1510	Claystone, greenish-gray, waxy, slickensided, moderately well-laminated.	13.5
1510-1516	Claystone, grayish-red mottled with greenish-gray, some calcareous concretions with $\frac{1}{4}$ inch maximum diameter	6.0
1516-1518	Claystone, silty, greenish-gray, moderately well-laminated, some plant fragments, non-silty and poorly laminated at 1516-1518. .	2.0
1518-1531.5	Claystone, silty, greenish-gray, moderately well-laminated, some plant fragments . . .	13.5
1531.5-1537	Sandstone, silty, greenish-gray, slightly laminated	5.5
1537-1539	Siltstone, clayey, greenish-gray, poorly laminated, accumulation of crinoid stems at 1538.5-1539	2.0
1539-1540	Claystone, greenish-gray, waxy, moderately laminated	1.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1540-1545	Siltstone, clayey, greenish-gray, laminated, plant fragments at 1543.	5.0
1545-1546	Clay, black, coaly, fissile	1.0
1546-1547	Clay, dark greenish-gray, nonlaminated. . . .	1.0
1547-1548	Coal, black, very friable, very fissile . . .	1.0
1548-1551	Claystone, silty, greenish-gray, nonlaminated	3.0
1551-1558	Claystone, olive-gray, nonlaminated, waxy, slickensided	7.0
1558-1564	Sandstone, silty, greenish-gray, very fine-grained, laminated and steeply crossbedded, abundant very fine plant fragments	6.0
1564-1565.5	Claystone, greenish-gray, nonlaminated, brown calcareous concretions	1.5
1565.5-1566.5	Siltstone, clayey, dark greenish-gray	1.0
1566.5-1567	Claystone, black, coaly	0.5
1567-1574	Claystone, slightly silty, dark greenish-gray, moderately laminated	7.0
1574-1576	Claystone, calcareous, greenish-gray, brown calcareous segregations.	2.0
1576-1581	Siltstone, clayey, greenish-gray, crossbedded and well-laminated	5.0
1581-1600	Sandstone, silty, light greenish-gray, very fine grained, laminated, some siderite concretions (small), steeply crossbedded from 1596 down.	19.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1600-1601	Siltstone, light-gray to medium light-gray, laminated crossbedded, brown siderite concretions at base	1.0
1601-1618	Claystone, medium dark-gray (N4), laminated; at 1615.5-1616.25 is coal, black, fissile. . .	17.0
1618-1618.5	Shale, coaly black at 1618.5, very fissile . .	0.5
1618.5-1623	Lost core	4.5
1623-1629	Claystone, silty, medium-gray (N5), some plant fragments, a few slickensides, laminated to 1627, very crumbly and nonlaminated at 1627-1629.	6.0
1629-1633	Claystone, greenish-gray, poorly laminated and slickensided, siderite at 1631.5	4.0
1633-1635	Claystone, silty, greenish-gray, laminated and crossbedded, not silty below 1633	2.0
1635-1654.5	Siltstone, clayey, medium-gray (N5), fairly well-bedded, siderite veinlets at 1636.5. Plant stems at 1641. Slickensides, black, glossy coated, at 1647.5. Lignitic plant stems at 1647.5 and 1648.5. Half a foot of clay, medium dark-gray (N4), at 1649.5-1650, slicken-sided, waxy. Plant stems at 1652-1653 . .	19.5
1654.5-1655.5	Claystone, medium dark-gray	1.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1655.5-1657	Claystone, calcareous, medium-gray, abundant crinoid stems (small), sandy at top, a few pelecypods	1.5
1657-1662	Claystone, dark-gray (N3), some lignitic plant stems and fragments, waxy, glossy slickensides, grades down into medium-gray (N5) at 1659.5	5.0
1662-1664	Siltstone, greenish-gray, hard, nonlaminated, a few inches of waxy clay on bottom.	2.0
	Breckenridge limestone member	
1664-1664.5	Limestone, pale yellowish-brown, sharp upper contact, cemented coquina of small crinoid stems and fusulines. (base of Breckenridge limestone)	0.5
1664.5-1669	Claystone, dark-gray, waxy to greenish-gray with spots of dusky red and pale yellowish-brown, grades down to grayish-brown (5YR3/2) at 1667	4.5
1669-1678	Siltstone, highly calcareous, greenish-gray (5G6/1), with abundant light-brown (5YR6/4) calcite nodules, very fine-grained. No fossils noted. White veinlets. Very salty to taste	9.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1678-1682	Claystone, slightly silty, greenish-gray (5GY6/1), with a few spots of grayish-red (5R4/2) at 1678-1680. $CaCO_3$ nodules and calcareous clay at 1678.5. Medium dark-gray (N4), at 1680. Greenish-gray at 1681. . .	4.0
1682-1683	Siltstone, calcareous, light greenish-gray, poorly bedded.	1.0
1683-1684	Claystone, medium-gray (N4), not bedded, slickensided	1.0
1684-1701	Claystone, slightly silty, greenish-gray, bedded, few streaks of grayish-red below 1688. Pelecypods at 1691. Slightly calcareous and trace of plant fragments from 1691 down. Pyrite at 1697.	17.0
1701-1722	Claystone, slightly calcareous, slightly silty, dark-gray (N3), trace plant stems, brachiopod print at 1702.5. Medium dark-gray at 1707-1709. Pelecypod print at 1709.5. Few slickensides. Pelecypods and brachiopods at 1716.5. Abundant fossil fragments at 1715.5. Large pelecypod and brachiopod fragments	21.0

Description

Speck Mountain limestone member

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)		Thickness (feet)
1722-1726	Limestone, very clayey, medium-gray, abundant fossil fragments at 1722-1723; medium light-gray at 1723-1724; medium light-gray, calcareous clay at 1724-1725; medium light-gray, abundant crinoid stems and fusulines at 1725-1726	4.0

Graham formation

1726-1728	Clay, very calcareous, medium-gray, very abundant brachiopods, crinoids, bryozoans	2.0
1728-1730	Claystone, medium-gray, spotted with grayish-red, slickensided.	2.0
1730-1733	Sandstone, silty, light-gray, very fine-grained, laminated	3.0
1733-1737	Clay, silty to nonsilty, and waxy, medium gray	4.0
1737-1740	Siltstone, medium light-gray, not laminated .	3.0
1740-1742	Clay, medium light-gray, poorly bedded . . .	2.0
1742-1745	Siltstone, light-gray, laminated, clayey, 1743-1743.5.	3.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1745-1748	Sandstone, very light-gray, very fine-grained, poorly bedded	3.0
1748-1749	Claystone, medium-gray, highly slickensided, waxy	1.0
1749-1750	Sandstone, very fine-grained (like 1745-1748). (Core misplaced?)	1.0
1750-1751	Claystone, medium-gray spotted with grayish-red, slickensided.	1.0
1751-1752	Claystone, greenish-gray, calcareous nodules, waxy, slickensided	1.0
1752-1764	Sandstone, silty, very light-gray, very fine-grained, laminated, clayey from 1754-1755, grades down into bed below, very fine plant fragments toward base	12.0
1764-1767.5	Siltstone, clayey, light-gray, some plant fragments (very fine), hard	3.5
1767.5-1768.5	Claystone, medium-gray, laminated	1.0
1768.5-1769.5	Claystone, calcareous, medium light-gray, many crinoid stems and brachiopods	1.0
1769.5-1774	Claystone, medium-gray, laminated	4.5
1774-1781.5	Claystone, very calcareous, medium-gray, many brachiopods, bryozoa, and crinoids. Fewer fossils and less calcareous below 1779.5	7.5

Description

("Megargel limestone" of geologists)

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)		Thickness (feet)
1781.5-1787	Limestone, medium light-gray, algal, fusulines at 1784, light-gray clay interbedded with knotty limestone from 1784 down.	5.5
1787-1790	Lost core	3.0
1790-1795	Limestone, light-gray, algal, clayey from 1791.5 down	5.0
1795-1796	Claystone, calcareous, medium dark-gray . . .	1.0
1796-1797	Limestone, medium dark-gray	1.0
	Wayland shale member	
1797-1800	Claystone, calcareous, dark-gray, laminated, not calcareous below 1798	3.0
1800-1806.5	Claystone, medium dark-gray, many fossil fragments, crinoid stems and brachiopods (?). Calcareous in upper two feet; noncalcareous below 1802.5. Vertical fractures with calcite and galena (?) flakes; thinly laminated. .	6.5
1806.5-1820	Siltstone with fine claystone thinly interlaminated, medium-gray, fine plant fragments	13.5
1820-1823	Sandstone thinly interbedded with siltstone, medium light-gray, crossbedded, plant fragments	3.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
1823-1825.5	Siltstone, medium-gray, thin-bedded, thin siderite lenses	2.5
1825.5-1829	Claystone, silty, medium-gray (N5), laminated; some slickensides, more silt at 1828.5-1829	3.5
1829-1839.5	Claystone, medium-gray, laminated	10.5
1839.5-1840.5	Claystone, silty, medium-gray, laminated . .	1.0
1840.5-1855	Claystone, medium dark-gray (N4), laminated, grades down into dark-gray (N3)	14.5
1855-1857.5	Claystone, silty, medium dark-gray, laminated	2.5
1857.5-1871.5	Claystone, medium dark-gray (N4), laminated, grades down into dark-gray (N3) at 1860. Fossils at 1870-1871.5. Gastropod of Wayland shale type	14.0
1871.5-1873	Limestone, medium-dark-gray (N4), medium-grained, contains fusulines, gastropods (tall spiral, smooth rounded spirae), Wayland shale types.	1.5
1873-1875.5	Claystone, medium-gray (N5), contains abundant small calcareous nodules . . .	2.5
1875.5-1881	Claystone, medium dark-gray, nonlaminated, waxy slickensides	5.5
1881-1882.5	Siltstone, greenish-gray (5G6/1), laminated	1.5
1882.5-1883	Claystone, medium dark-gray, waxy	0.5
1883-1894	Sandstone, light-gray, very fine-grained, very finely crossbedded. Some is soft and	

Depth in feet (below kelly bushing)	Description	Thickness (feet)
	friable, oil-stained	11.0
1894-1897	Claystone, silty, medium dark-gray, slightly mottled with grayish-red	3.0
1897-1900	Claystone, medium dark-gray, laminated. . .	3.0
1900-1901	Siltstone, medium light-gray, laminated . .	1.0
1901-1902	Claystone, medium-gray, waxy, slickensided	1.0
1902-1909	Siltstone, medium-gray, interbedded with claystone; contains some plant fragments	7.0
1909-1931.5	Sandstone, light-gray (N7), fine- to medium-grained, friable, oil-stained, faintly cross-bedded, well-sorted.	22.5
1931.5-1933	Claystone, dark-gray, waxy, slickensided, plant stems	1.5
1933-1935.5	Claystone, lignitic, black, many well-preserved plant stems and leaf impressions, highly laminated	2.5
1935.5-1942.5	Claystone, silty, medium dark-gray, sandy at base contains few slickensides and some plant fossils	7.0
1942.5-1971	Claystone, medium dark-gray, laminated, smooth	28.5

Description

Gunsight limestone member

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)		Thickness (feet)
1971-1991.5	Limestone, light olive-gray (5Y6/1), nodular rudite in upper part, very hard; algal structures; about one foot below top, sugary brown, oil-stained, stylolitic (black-coated), no fossils. Solid limestone, little porosity, 1990-1990.5, fusulinids rare in bottom foot. 1990.5-1991.5 argillaceous limestone with abundant fusulines. Grades down into very argillaceous limestone	20.5
1991.5-2019	Claystone, medium-gray (N5), laminated. Grades down at about 2002 into medium dark-gray (N4). Some waxy slickensides. Few pelecypods at 2012-2013. Pelecypods and brachiopods at 2018-2019, calcareous shale	27.5
2019-2029	Limestone, medium dark-gray, fine-grained, argillaceous streaks $\frac{1}{4}$ inch wide. Few crinoid stems and fusulines in upper $\frac{1}{2}$ foot. Becomes medium-gray one foot below top .	10.0

Description

Bluff Creek shale member

Magnolia No. 78 Honaker

Depth in feet (below kelly bushing)		Thickness (feet)
2029-2030.5	Claystone, silty, medium light-gray to medium dark-gray, plant matter and much pyrite at top, laminated	1.5
2030.5-2035	Siltstone, clayey streaks, medium dark-gray, finely micaceous, many plant fragments, laminated, dark-gray claystone at 2033-2034	4.5
2035-2038.5	Claystone, dark-gray, laminated	3.5
2038.5-2042.5	Claystone, dark greenish-gray (5G4/1), waxy slickensides	4.0
2042.5-2044	Siltstone, light-gray, with thin interlaminae, dark-gray	1.5
2044-2047	Claystone, dark greenish-gray, some waxy slickensides	3.0
2047-2049.5	Siltstone, light-gray, many plant fragments, laminated	2.5
2049.5-2052	Claystone, dark greenish-gray, waxy slickensides	2.5
2052-2053.5	Siltstone, greenish-gray.	1.5
2053.5-2057.5	Claystone, silty, dark greenish-gray	4.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
2057.5-2062.5	Siltstone, light-gray, laminated, lower one foot clayey	5.0
2062.5-2069.5	Claystone, medium dark-gray, varved with lighter gray, very highly laminated and lignitic from 2065 down to 2069.5	7.0
2069.5-2074	Claystone, medium dark-gray, laminated . . .	4.5
2074-2074.5	Limestone, medium light-gray, crinoid stems, argillaceous streaks.	0.5
2074.5-2080	Claystone, medium-gray, not laminated, smooth	5.5
2080-2083	Limestone, medium light-gray, crinoid stems, few fusulines, argillaceous streaks . . .	3.0
2083-2087	Siltstone, light-gray, somewhat laminated. .	4.0
2087-2089.5	Claystone, greenish-gray, laminated.	2.5
2089.5-2096	Siltstone, greenish-gray, clayey in streaks.	6.5
2096-2098	Claystone, dark greenish-gray, laminated . .	2.0
2098-2100.5	Sandstone, light-gray, dark streaks, cross-bedded, very fine-grained	2.5
2100.5-2102	Claystone, dark greenish-gray, laminated . .	1.5
2102-2104	Sand, light-gray with dark streaks of plant matter, medium-grained, crossbedded . . .	2.0
2104-2113	No core.	9.0
2113-2120	Siltstone, medium dark-gray, laminated, much plant matter	7.0
2120-2122	Claystone, medium dark-gray, laminated . . .	2.0
2122-2125	Siltstone, medium dark-gray, laminated . . .	3.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
2125-2127	Claystone, medium dark-gray, laminated, smooth	2.0
2127-2133.5	Siltstone, light-gray to medium-gray, claystone 2129-2129.5	6.5
2133.5-2136	Siltstone, clayey, greenish-gray, laminated. .	2.5
2136-2143	Claystone, dark greenish-gray, not laminated, smooth.	7.0
2143-2158	Sandstone, light-gray, darker streaks of many dark grains, crossbedded, fairly friable, oil-stained	15.0
2158-2158.5	Claystone, dark greenish-gray, waxy, slickensided	0.5
2158.5-2159	Sandstone	0.5
2159-2163	Siltstone, light-gray, laminated	4.0
2163-2166	Claystone, dark greenish-gray, waxy, slickensided, poorly laminated	3.0
2166-2170	Sandstone, calcareous, very fine-grained, light-gray inter-laminated with darker gray clay.	4.0
2170-2199.5	Claystone, dark-gray (N3), laminated	29.5
2199.5-2200	Sandstone, light-gray, very fine-grained, plant fragments	0.5
2200-2203	Claystone, medium dark-gray, smooth, laminated	3.0
2203-2205	Sandstone, silty, light-gray with dark streaks containing plant matter, very fine-grained	2.0

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Depth in feet (below kelly bushing)	Description	Thickness (feet)
2205-2206.5	Claystone, like 2200-2203	1.5
2206.5-2210	Sandstone, silty, very fine-grained, finely laminated	3.5
2210-2211	Sandstone, silty, light-gray, very fine grained	1.0
2211-2212	Claystone, silty, medium dark-gray laminations.	1.0
2212-2214	Sandstone, silty, light-gray, very fine-grained, irregularly bedded	2.0
2214-2216.5	Claystone, medium dark-gray, laminated, silty streaks	2.5
2216.5-2217.5	Siltstone, clayey, medium light-gray to medium dark-gray, interbedded with some clay streaks.	1.0
2217.5-2225	Claystone, medium dark-gray, sideritic streaks, laminated, silty zones 2220-2221, 2223-2224	7.5
2225-2233	Sandstone, silty, light-gray with abundant darker streaks, at 2228 shows flowage, finely cross-bedded	8.0
2233-2237	Claystone, medium dark-gray, laminated. . . .	4.0
2237-2242	Siltstone, medium light-gray, fine plant fragments, thinly laminated, interbedded with claystone below 2239	5.0

Depth in feet (below kelly bushing)	Description	Thickness (feet)
2242-2248	Sandstone, medium light-gray, silty, very fine-grained, abundant fine plant fragments, finely crossbedded	6.0
2248-2249	Claystone, dark-gray, sideritic	1.0
2249-2250	Sandstone, like 2242-2248.	1.0
2250-2272	Claystone, dark-gray, smooth, laminated . . .	22.0
2272-2275	Claystone, silty, medium-gray, laminated, plant fragments	3.0
2275-2282	Claystone, dark-gray, smooth, laminated. . . .	7.0
2282-2289	Claystone, and siltstone interbedded, medium light-gray	7.0
2289-2293.5	Claystone, dark-gray, very hackly, platy, crumbly, smooth	4.5
2293.5-2295	Claystone, calcareous, dark-gray, many brachiopods	1.5
	Canyon Group	
	Caddo Creek formation	
	Home Creek limestone member	
2295-2330	Limestone, medium light-gray, fine-grained, knotty; clayey streak at 2299.5-2300.5, medium-gray, smooth, fusulinids at 2299.5, stylolites. Bottom two feet milky-white, fusulinids	35.0