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THE BLAINE AND RELATED FORMATIONS OF NORTHWESTERN OKLAHOMA AND SOUTHERN KANSAS

by

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The Blaine and Related Formations of Northwestern Oklahoma and Southern Kansas

Robert O. Fay

ABSTRACT

The Flowerpot Shale (180-450 feet thick), Blaine Formation (40-100 feet thick), and overlying Dog Creek Shale (30-240 feet thick) of the El Reno Group (Guadalupean Series, Permian System) of northwestern Oklahoma and Kansas is part of a redbed sequence, predominantly shale, approximately 250-750 feet thick. The El Reno Group may be subdivided geographically into (1) a southern delta facies (Duncan Sandstone and overlying Chickasha Formation), 750 feet thick; (2) a central basin facies of shale, siltstone, sandstone, dolomite, and gypsum, 750 feet thick; and (3) a northern platform facies of rocks similar to those of the central basin, but thinner.

Many of the clastic rocks of the northern platform facies are discontinuous with those of the southern delta facies, showing that there must have been a dual origin for the sediments of the El Reno Group. Thin evaporites may be correlated over a wide area of the basin and platform, indicating that relative stability prevailed at many times. The upward repetition in the Blaine Formation from greenish-gray shale, to dolomite, to gypsum, to reddish-brown shale, back to greenish-gray shale is evidence of cyclic invasions of sea water in a semiarid environment during Blaine time. The mineralogic composition of the El Reno rocks is essentially uniform, with minor lithologic, stratigraphic, and geographic variations. The Ozark area to the northeast and the Ouachita and Arbuckle Mountains areas to the southeast are probably the source areas for the sediments of the El Reno Group in the region studied.

INTRODUCTION

Purpose and Scope

A study of the attributes of the Blaine Formation, Upper Permian, in relation to beds above and below, was made in order to understand the environment of deposition of the Blaine Formation

in northwestern Oklahoma and two adjacent counties in Kansas. The area of investigation includes Barber and Comanche Counties, Kansas; Woods, Harper, Woodward, Major, Blaine, Canadian, and Grady Counties, Oklahoma (fig. 1).

The formations which were studied for this report are part of the Upper Permian (Guadalupean) redbed sequence, consisting of the Marlow Formation of the Whitehorse Group, underlain by the Dog Creek Shale, Blaine Formation, and Flowerpot Shale (descending) of the El Reno Group. In Grady County, Oklahoma, the El Reno Group consists of the Chickasha Formation and the underlying Duncan Sandstone. The Marlow Formation rests upon the Chickasha Formation in that area.

The report includes a study of the stratigraphy and sedimentology of the formations mentioned in the areas outlined above.

Procedures

The present study was initiated in July 1956 when the author began to map the geology of Blaine County, Oklahoma, the type region for the Blaine Formation. Aerial photographs were used as a base, and the work was completed in the summer of 1958. The field work for the present study was started in the fall of 1958 and completed in the spring of 1960.

The measured sections are spaced three to ten miles apart, and each was measured with a ruler and hand level along cliff faces. Only one-third of the 1,000 samples collected for laboratory studies was needed for study. The laboratory work was begun in August 1959 and completed in May 1960.

The samples were collected from uniform lithologic units and placed in 500-gram bags. In the laboratory, each sample was crushed in a mortar and poured through a 100-mesh sieve until 100 grams passed the sieve. The 100-gram sample was then split, and the resulting 50-gram portion was used as the raw sample for sedimentation studies. Several large chips were collected with each sample for later preparation of thin sections. Data derived from these studies are on open file at the Oklahoma Geological Survey.

The pertinent literature was examined and any important information was recorded on cards. Much of this information served as background for the present report.

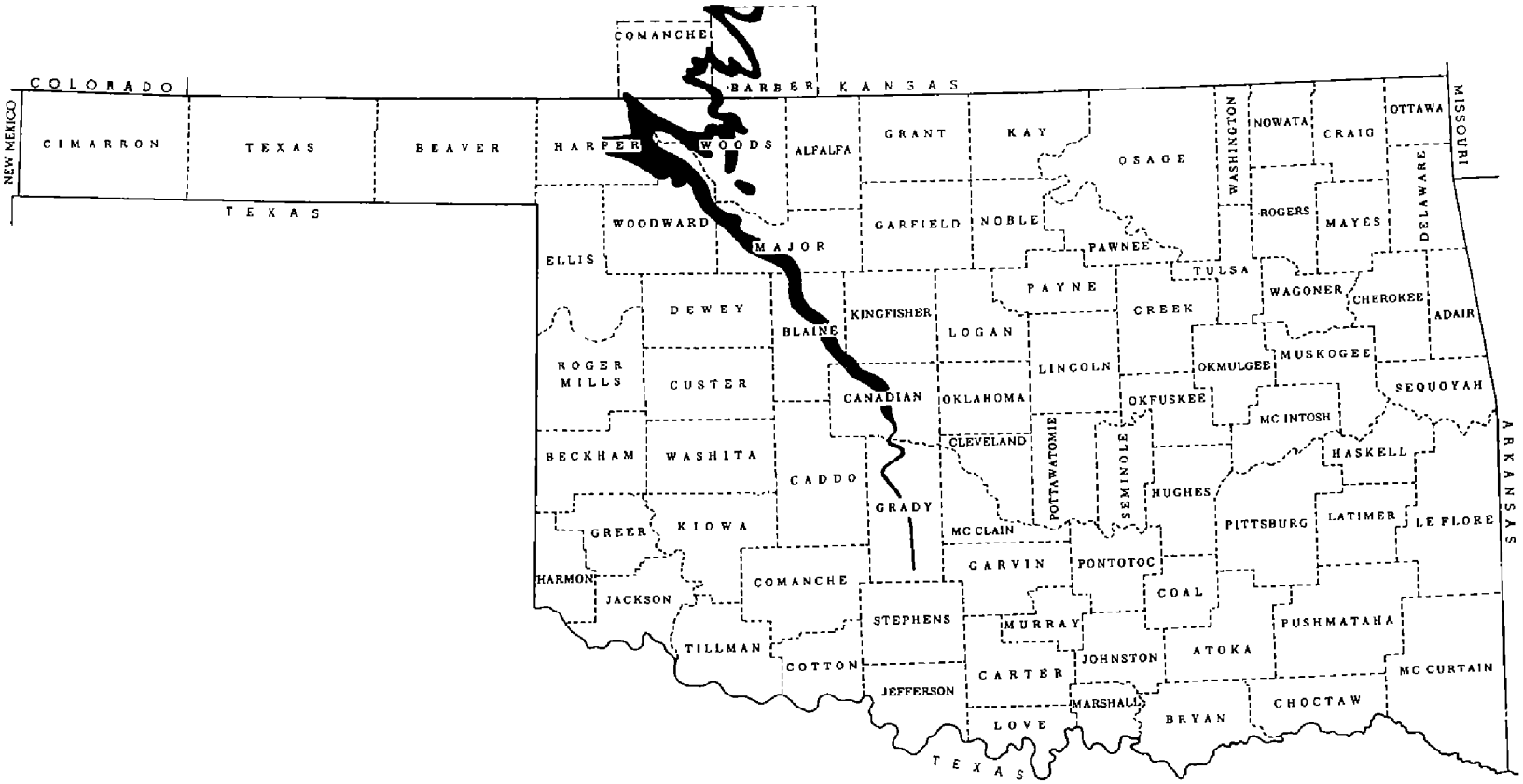

Figure 1. Outline map of Oklahoma showing distribution of Blaine outcrops in northwestern Oklahoma and adjacent Kansas.

Acknowledgments

Dr. Raymond C. Moore aided in field investigations and advised during the preparation of the manuscript, and Dr. H. A. Ireland, of the geology department, University of Kansas, advised on procedures in sedimentology.

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REGIONAL GEOLOGY

The Permian redbeds of the Midcontinent region extend from southern Nebraska through central Kansas and western Oklahoma into north-central Texas (fig. 2). These beds are several thousand feet thick and dip gently westward off the flanks of the Ozark dome, Ouachita and Arbuckle Mountains, and Bend arch into the Permian basin.

Several east-westward-trending structures interrupt this westerly dip. The Wichita Mountains, Amarillo mountains, and Electra arch are areas of uplift in southwestern Oklahoma and adjacent areas in Texas which divide the Permian basin into two units: the Anadarko basin to the north and the Midland basin to the south. The steep dip of the Permian beds on the flanks of these structures is evidence that much movement took place there in post-Permian time. The Cretaceous rocks of the Anadarko basin rest upon truncated edges of the Permian rocks; thus the folding of the Permian rocks must have ceased before Cretaceous time.

The time of uplift of the Ozark-Ouachita-Bend structures has been debated many times. The evidence resulting from this study indicates that these areas were uplifted extensively during the Guadalupean Epoch.

This report is written primarily about the Guadalupean redbeds that occur on the northeast flank of the Anadarko basin.

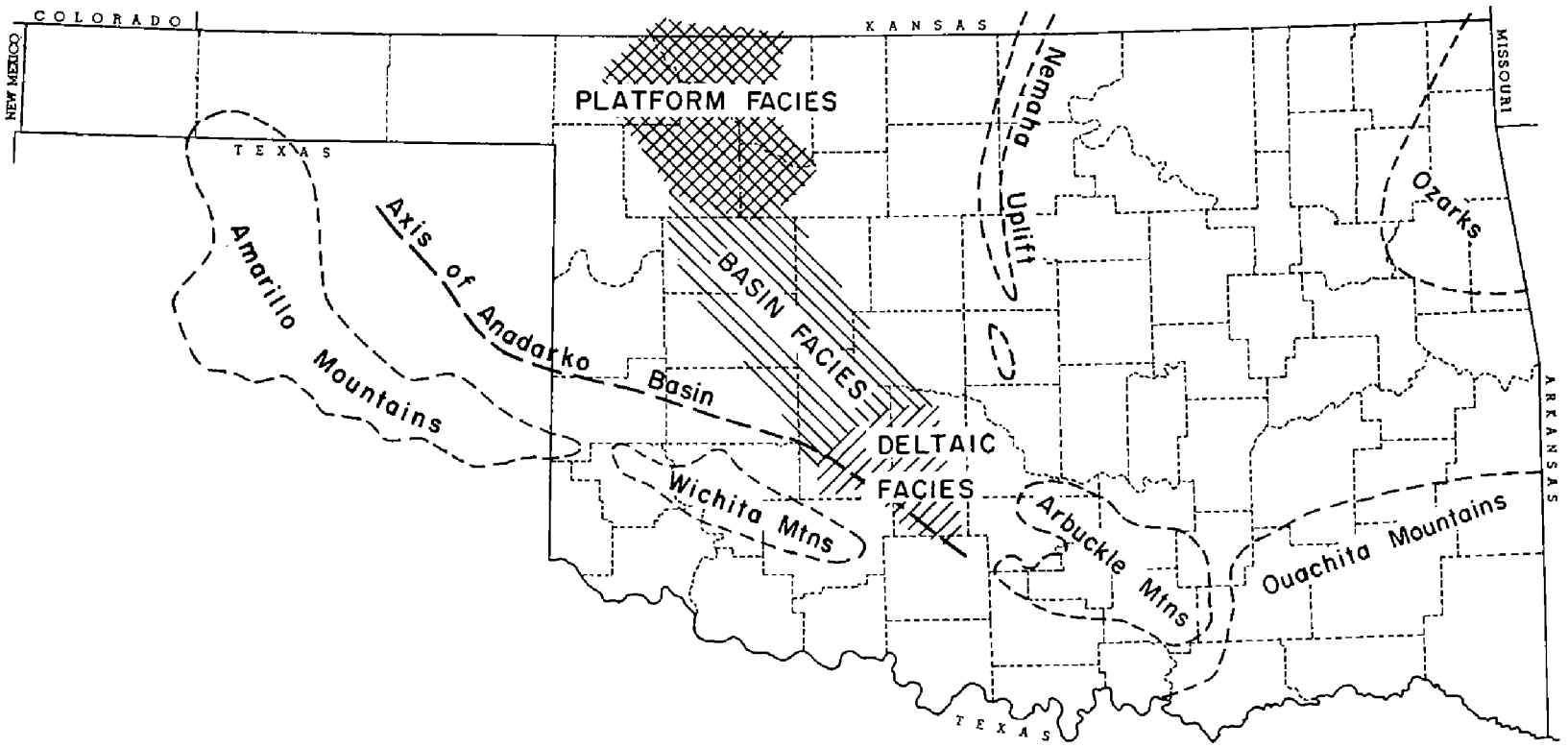


Figure 2. Schematic diagram showing some regional features in and adjacent to the Anadarko basin.

STRATIGRAPHY

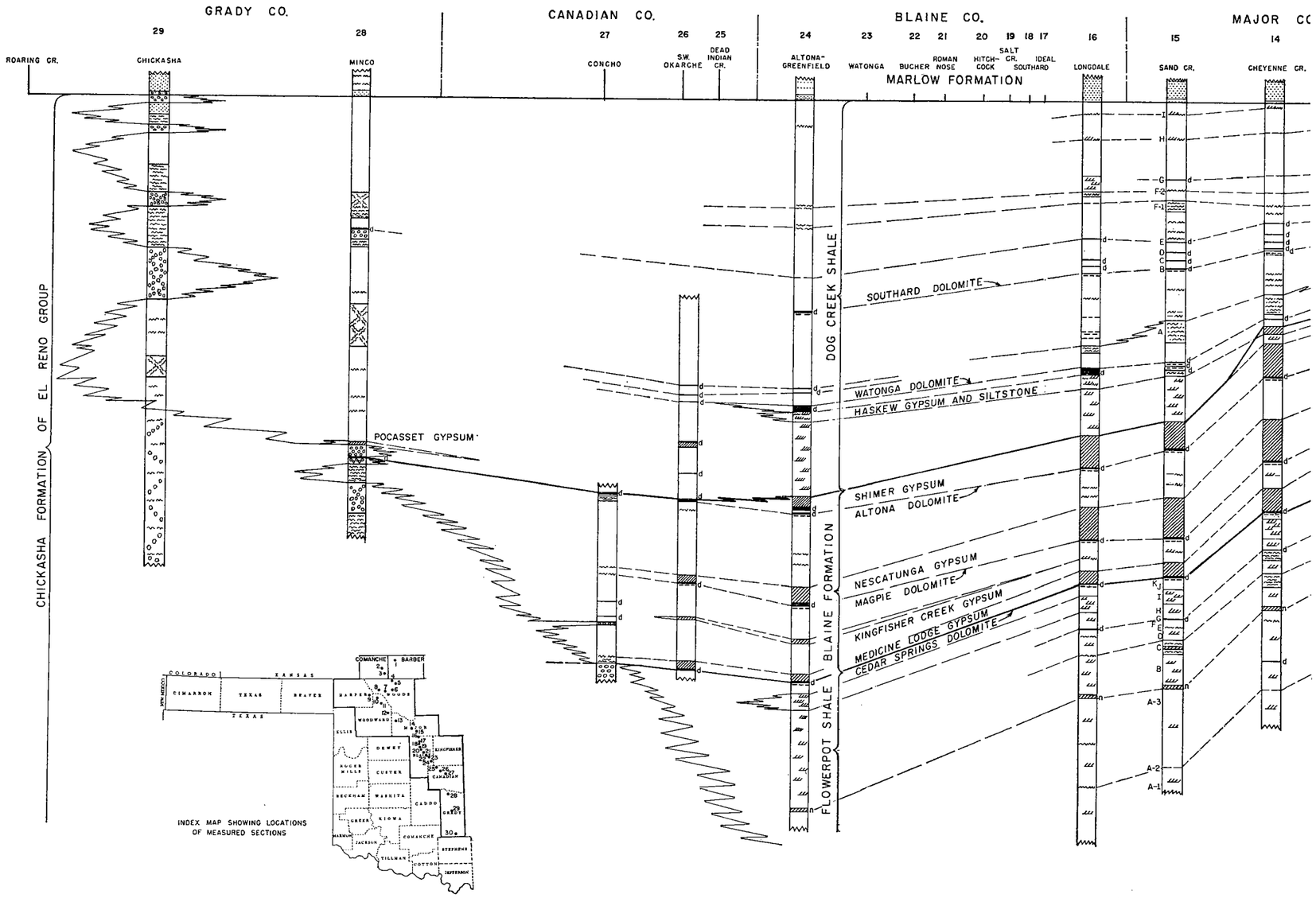
Introduction

The geologic section treated in this study comprises several hundred feet of redbeds of the El Reno and Whitehorse Groups of the Guadalupean Series, Permian System. The El Reno Group in upward succession from the base consists of the Flowerpot Shale (180 to 450 feet thick), Blaine Formation (40 to 100 feet thick), and Dog Creek Shale (30 to 240 feet thick). These formations are primarily reddish-brown shale, with some thick gypsums and thin dolomites in the Blaine Formation and some thin dolomites, siltstones, and sandstones in the Flowerpot and Dog Creek Shales. The thicker portions in Blaine and Canadian Counties belong to the central basin facies and the thinner portions from Major County northward belong to the northern platform facies. Southward, in Grady County, Oklahoma, the El Reno Group is represented by the Duncan Sandstone and the overlying Chickasha Formation, consisting of 750 feet of mudstone conglomerates, sandstones, siltstones, and interbedded reddish-brown shale. This portion is termed the southern delta facies and was called the Tussey delta by Green (1937, p. 1524).

Overlying the El Reno Group with apparent conformity is the Whitehorse Group, consisting of the Marlow Formation (100 to 130 feet thick) and the overlying Rush Springs Sandstone (100 to 300 feet thick), with maximum thickness at the southeastern end of the Anadarko basin. The entire Whitehorse Group was studied in detail in Blaine County, Oklahoma, but elsewhere only the basal portion was studied closely.

El Reno Group

The name El Reno Group is derived from the city of El Reno, Canadian County, Oklahoma. It was first known as the El Reno Formation, which was defined by Becker (1930, p. 55) to include strata between the Hennessey Shale below and the Whitehorse Group above. The name was changed to El Reno Group by Schweer (1937, p. 1553), a usage followed by subsequent workers (pl. 1).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CANADIAN CO.
BLAINE CO.
MAJOR CO
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ROARING CR.
CHICKASHA
MINCO
CONCHO
SW. OKARCHE
DEAD INDIAN CR.
ALTONA-GREENFIELD
WATONGA
BUCHER
ROMAN NOSE
HITCH-COCK
SALT CR.
IDEAL SOUTHARD
LONGDALE
SAND CR.
CHEYENNE CR.
MARLOW FORMATION
CHICKASHA FORMATION OF EL RENO GROUP
POCASSET GYPSUM
SOUTHARD DOLOMITE
DOG CREEK SHALE
WATONGA DOLOMITE
HASKEW GYPSUM AND SILTSTONE
SHIMER GYPSUM
ALTONA DOLOMITE
NESCATUNGA GYPSUM
MAGPIE DOLOMITE
KINGFISHER CREEK GYPSUM
MEDICINE LODGE GYPSUM
CEDAR SPRINGS DOLOMITE
BLAINE FORMATION
FLOWERPOT SHALE
I
H
G
F-2
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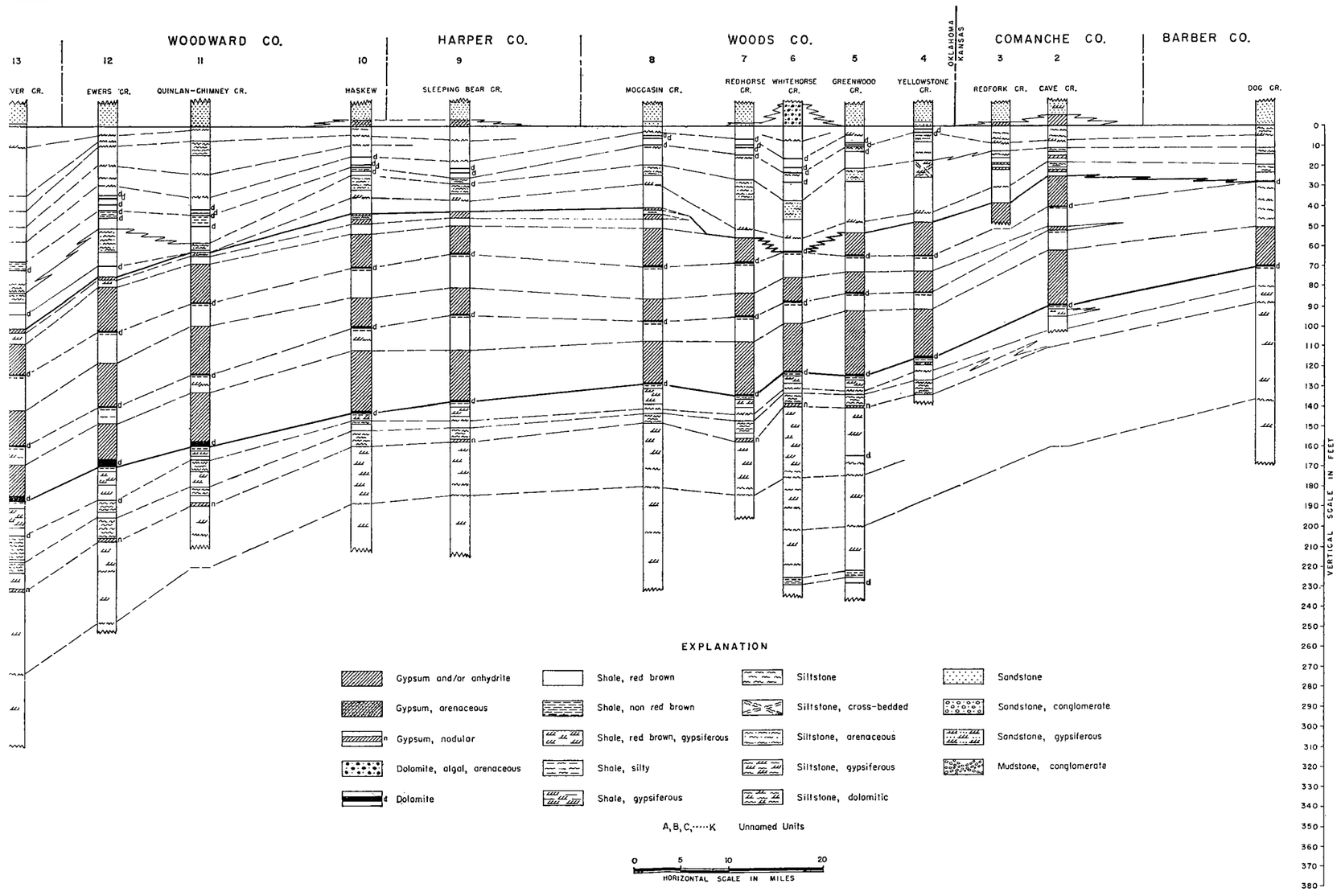
Kj
COMANCHE
BARBER
COLORADO
KANSAS
NEW MEXICO
TEXAS
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
ELLIS
WOODWARD
DEWEY
KINGFISHER
ROGER MILLS
CUSTER
CANADIAN
BECKHAM
WASHITA
CADDO
GRADY
GREER
KIOWA
HARMON
JACKSON
COMANCHE
TILLMAN
COTTON
STEPHENS
JEFFERSON
INDEX MAP SHOWING LOCATIONS OF MEASURED SECTIONS



REGIONAL STRATIGRAPHIC SECTION OF UPPER PART OF EL RENO GROUP FROM BARBER COUNTY, KANSAS, TO GRADY COUNTY, OKLAHOMA

Robert O. Fay

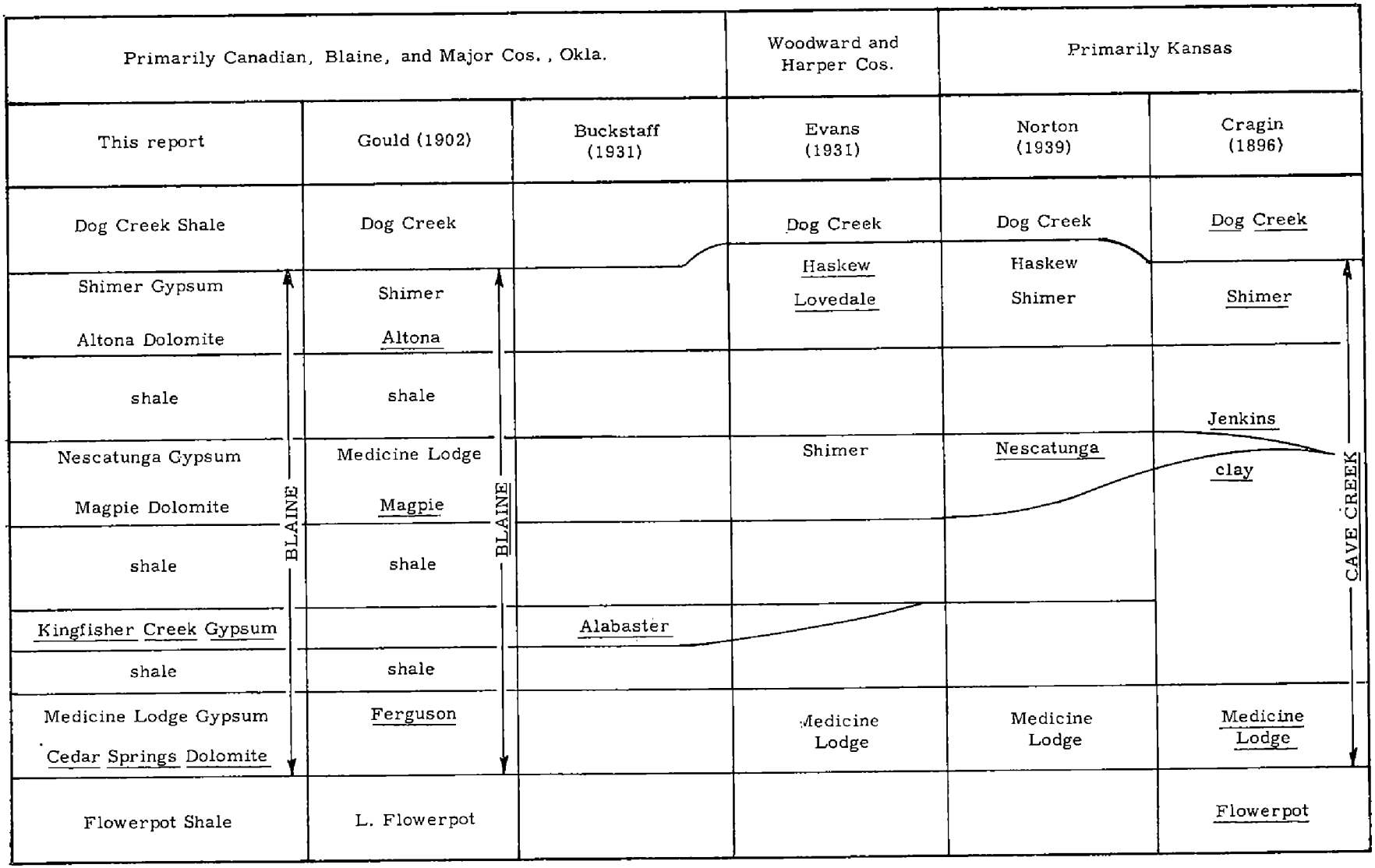


Figure 3. Nomenclatorial diagram showing interrelationships of the named members of the Blaine Formation as used by various authors in Kansas and northwestern Oklahoma. New names introduced by an author are underscored.

In Blaine County, Oklahoma, the El Reno Group consists mainly of 750 feet of reddish-brown shale and evaporite beds of gypsum, anhydrite, and dolomite, divided (in ascending order) into the Flowerpot Shale (with the Chickasha Tongue in the middle), Blaine Formation, and Dog Creek Shale. The upper and lower contacts are here considered to be conformable.

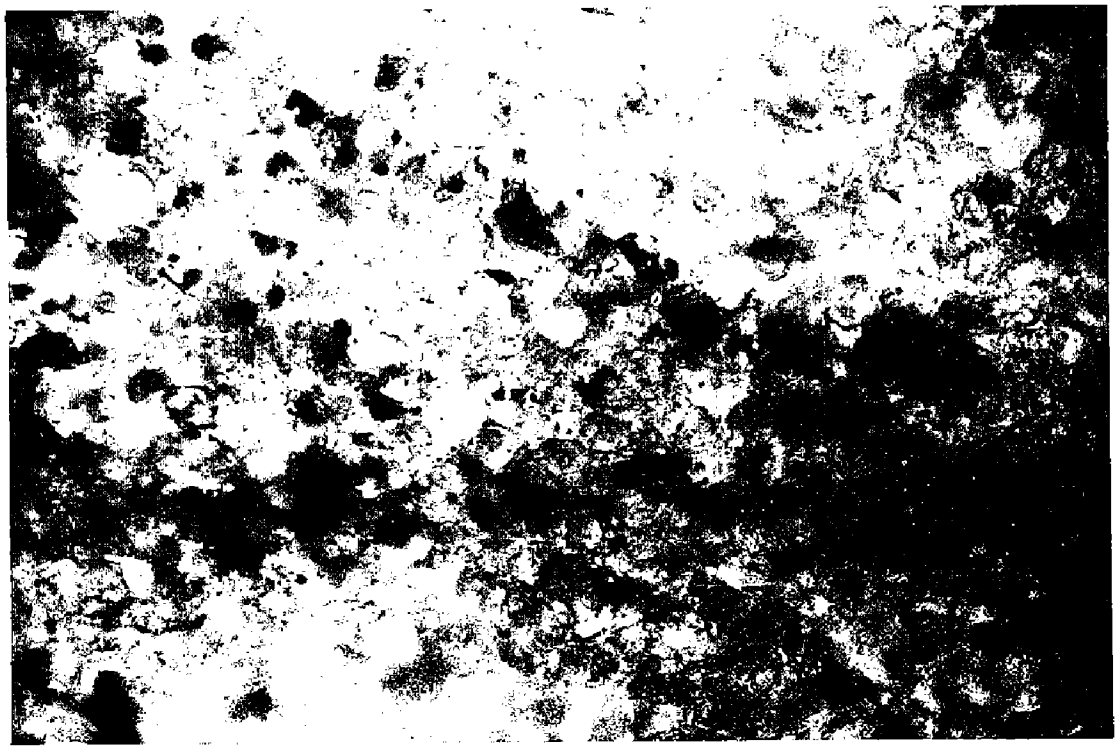
All units within the El Reno Group thin northward into Kansas, so that the total thickness in Kansas is approximately 250 feet. The clastic elements in Kansas and adjacent parts of Oklahoma appear to have a separate origin from those in southern Blaine County and extending to Grady County. The northern platform contains sandstones and siltstones that grade southward into shale in the central basin facies, the general region of change occurring in northern Blaine County, Oklahoma.

Southward from central Blaine County, the shales and evaporites grade into mudstone conglomerate, sandstone, and siltstone of the Duncan Sandstone and overlying Chickasha Formation comprising the Tussey delta. The northernmost extension of this southern delta facies occurs as a wedge, approximately 115 feet thick, in the middle of the Flowerpot Shale in Blaine County. Southward in Canadian County, the Chickasha Tongue gradually interfingers with the entire Flowerpot Shale and Blaine Formation. In central Canadian County the lower 30 feet is represented by the Duncan Sandstone, which forms a wedge in the lower 30 feet of the Flowerpot Shale where traced northward. In northern Grady County (pl. 2) the Dog Creek Shale is interbedded with many Chickasha tongues and a few miles to the south the entire Dog Creek Shale has graded into the Chickasha Formation (pl. 3). The rocks of the El Reno Group show similar facies changes westward from Grady County, Oklahoma.

FLOWERPOT SHALE

Name.—Cragin (1896, p. 24) first used the name "Flower-pot shales" for layers of reddish-brown gypsiferous shale between the Medicine Lodge Gypsum above and the Cedar Hills Sandstone below, at Flower-pot Mound, Barber County, Kansas. Norton (1939, p. 1792) reported a range in thickness from 173 to 190 feet in the type region, using the term "Flower-pot shales" for the rocks between the dolomite at the base of the Medicine Lodge Gypsum

A. Chickasha siltstone in Dog Creek Shale, 50 feet below top.



B. Photomicrograph of cross-bedded Dog Creek siltstone of Chcikasha Tongue, x125, 76 feet below top. Dark minerals are aligned along bedding planes showing torrential-type bedding.

PLATE 2

Chickasha siltstones, measured section 28, *Grady County, Oklahoma*

and the white sandstone at the top of the Cedar Hills Sandstone as redefined by him. This usage has been followed by subsequent writers. The form of the name has been changed to Flowerpot Shale (Swineford, 1955, p. 64; Moore and others, 1951, p. 39).

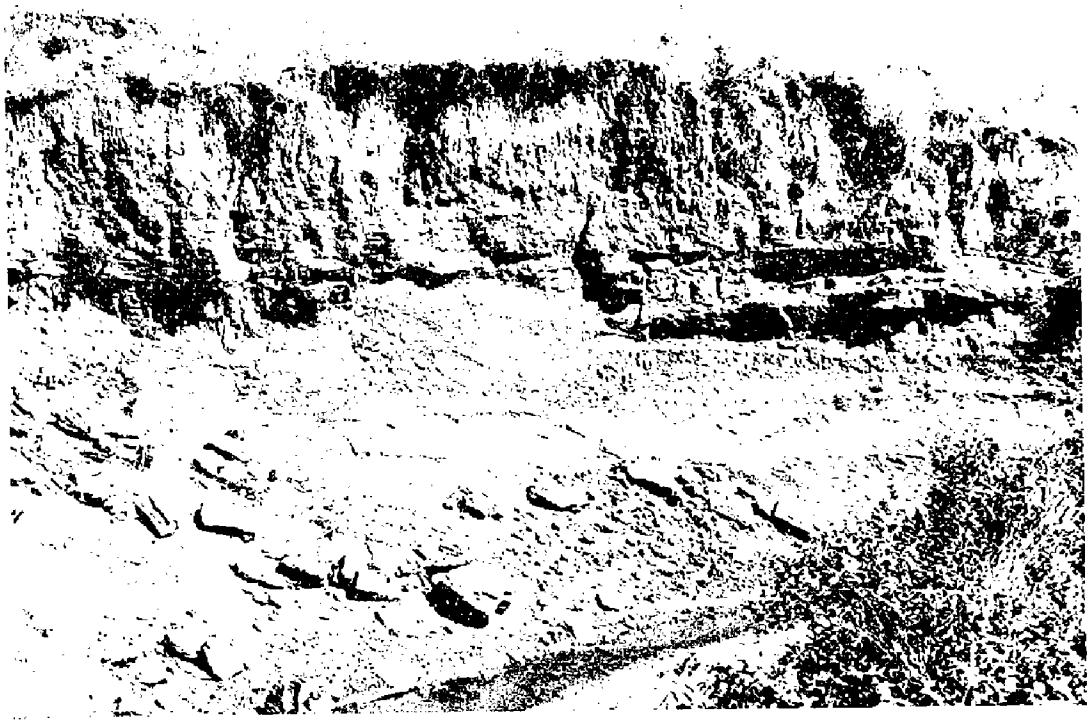
Type locality.—The type locality of the Flowerpot Shale is Flower-pot Mound, at the divide between East Cedar Creek and West Cedar Creek, near C SW¼ sec. 26, T. 32 S., R. 13 W., eight miles southwest of Medicine Lodge, Barber County, Kansas.

Description and stratigraphic relations.—In Blaine County, Oklahoma, the Flowerpot Shale is 437 to 465 feet thick and may be subdivided into several distinct lithologic units. The upper 50 feet contains beds of gypsum, dolomite, and siltstone, some of which can be correlated over a distance of 200 miles. The next lower 40 feet is the typical Flowerpot type of reddish-brown silty clay shale with little or no gypsum, dolomite, or siltstone. The next lower 160 feet consists of alternating reddish-brown gypsiferous shales and light greenish-gray siltstones, the lower 115 feet of which grades southward in southern Blaine County into the Chickasha Formation and is termed the Chickasha Tongue, consisting of mudstone conglomerate, quartzose sandstone, siltstone, and interbedded silty clay shale (pl. 4A). The remainder of the section below the Chickasha Tongue consists of 180 feet of reddish-brown silty clay shale with a few light greenish-gray siltstone beds (pl. 4B). Detailed information is given in plate 1 and in the measured sections.

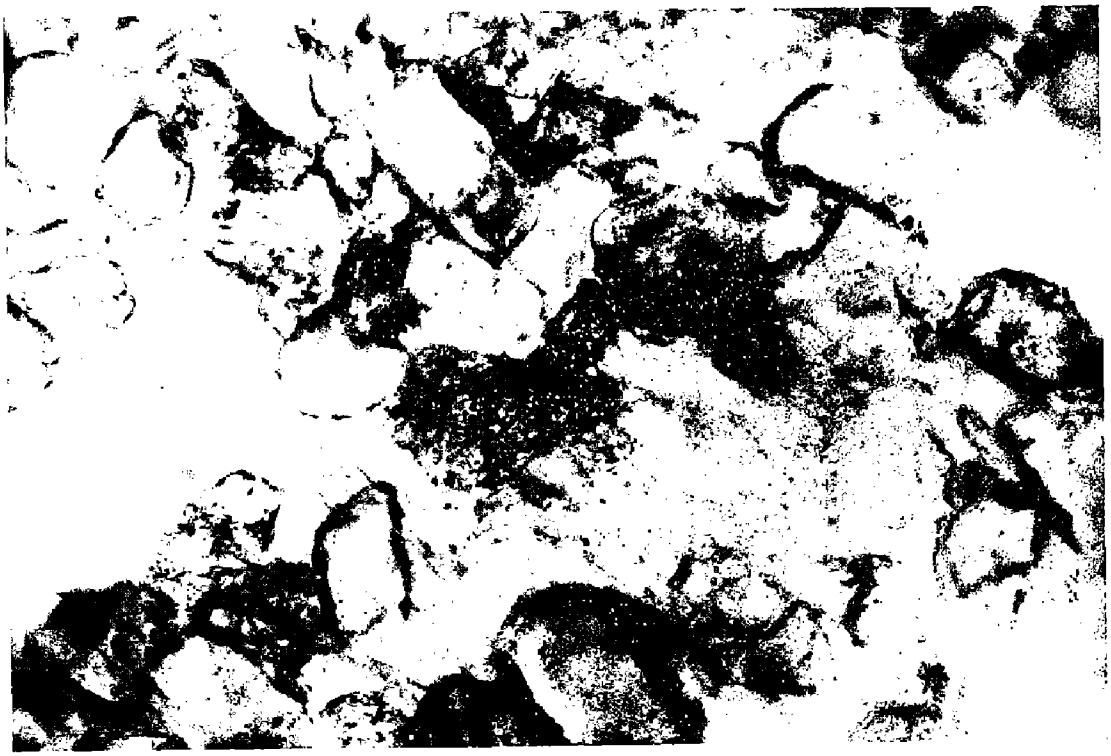
The Flowerpot Shale is conformably overlain by the Cedar Springs Dolomite Bed of the Blaine Formation, and it conformably overlies a 1- or 2-foot light greenish-gray gypsiferous siltstone of the Cedar Hills Sandstone Member of the Hennessey Shale (pl. 4B).

Southward in central Canadian County, Oklahoma, near El Reno, the Flowerpot Shale is represented by the Chickasha Formation and underlying 30 feet of the Duncan Sandstone. Northward in Kansas the Flowerpot Shale thins to 180 feet and contains thin sandstone units of local origin, apparently not continuous with units of the Chickasha Tongue. The upper 50 to 100 feet is described in detail in this report, with extreme detail given in the measured sections. The area of northern Blaine and southern Major Counties, Oklahoma, is here selected as a standard section for the description of the upper portion of the Flowerpot Shale (see pls. 1, 5-9; measured sections 15, 16).

The formation is divisible into stratigraphically recognizable



A. Chickasha siltstones and mudstone conglomerates, 40 feet below Altona Dolomite, view toward east in SW¼ NW¼ sec. 35, T. 9 N., R. 7 W.



B. Photomicrograph of Chickasha sandstone in Dog Creek Shale, x125, 100 feet below top of Dog Creek Shale.

PLATE 3

Chickasha siltstone and sandstone, measured section 28, *Grady County, Oklahoma*

parts, which here are designed as lettered units, the topmost as Unit K and the lowermost as Unit A.

Unit A

The beds that occur 50 to 100 feet or more below the base of the Blaine Formation consist mainly of reddish-brown clay shale, with some selenite and satin spar veins and thin greenish-gray siltstone beds, some of which may be locally correlated over a distance of several miles. One siltstone, termed A_2, is traced tentatively from Woods County to Blaine County, Oklahoma. These and lower units were not studied in detail, except for those in Blaine County.

Unit B

The overlying 15 to 20 feet of reddish-brown gypsiferous clay shale contains many small white to reddish-brown gypsum nodules in the basal few feet. This zone marks the base of the highly gypsiferous upper portion of the Flowerpot Shale and is several feet thick in Woodward County, Oklahoma, northward into Woods County. The gypsum nodules are 50 to 60 feet, 25 to 30 feet, and 15 to 20 feet below the base of the Blaine Formation in Blaine, Woodward, and Woods Counties, respectively.

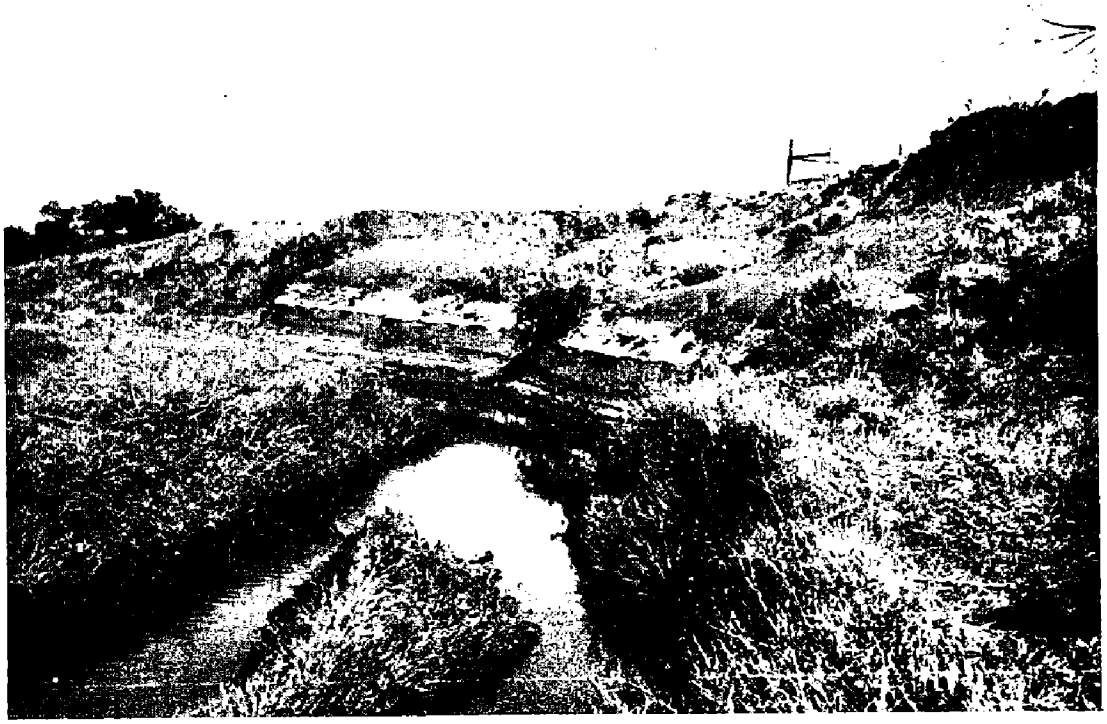
Unit C

In southern Major County, Oklahoma, Unit C is a light-brown variegated gypsiferous siltstone, about 6 feet thick and 30 feet below the base of the Blaine Formation, with a well-indurated gypsum lens several feet thick in the middle portions (pls. 6, 7). This gypsum lens is local, occurring only in this area, and has important bearing on nomenclature of the Blaine Formation.

In northern Blaine County, Unit C is 1 foot thick and is absent in central Blaine County, where it merges into reddish-brown gypsiferous clay shale. Northward in eastern Woodward County, this unit attains a maximum thickness of 9 feet, decreasing to 4 feet in Harper and Woods Counties, and to 2 feet in western Barber County, Kansas, where it is about 16 feet below the base of the Blaine Formation. The main clay minerals are illite and chlorite.

Gould (1902, p. 42; 1905, p. 44, 46) stated that in southern Major County, Oklahoma, southwest of Fairview and south of the Glass

A. Basal Chickasha Tongue overlying lower part of Flowerpot Shale, about 220 feet below top of Flowerpot Shale, east side of State Highway 8 near C of E line NE¼ sec. 36, T. 18 N., R. 11 W.



B. Upper greenish-gray siltstone of Cedar Hills Member at base of Flowerpot Shale, view toward southeast in SW¼ NW¼ SW¼ sec. 9, T. 18 N., R. 10 W.

PLATE 4

Lower part of Flowerpot Shale showing middle Chickasha Tongue and basal contact with Cedar Hills Member, Blaine County, Oklahoma

Mountains, the Ferguson Gypsum (now Medicine Lodge) "disappears" northward from the type locality in Blaine County. He concluded that the Cave Creek Gypsum of Kansas was entirely represented in this area and that an additional lower 30 feet of beds with a basal gypsum was present in this area but absent northward into Kansas. As a result, Gould (1902, p. 47) proposed the name Blaine Formation to include all equivalents of the Cave Creek Formation of Cragin (1896, p. 27), plus a new unit, the Ferguson Gypsum Member, and overlying 30 feet of beds. The type locality for the Ferguson Gypsum Member is central Blaine County, where it is several feet thick. Gould did not have the aid of aerial photographs, and in attempting to trace the Ferguson Gypsum northward into southern Major County, he apparently miscorrelated it with a gypsum 30 feet lower in the section and concluded that what is termed Unit C in this report was the northward-disappearing wedge of the Ferguson Gypsum. This correlation is erroneous. The Ferguson Gypsum is the same as the Medicine Lodge Gypsum, as pointed out by Evans (1931, p. 409), and in this area of southern Major County the Ferguson is present and is about 30 feet above Unit C, which was mistaken for the Ferguson by Gould. The name Blaine Formation would not have been proposed if Gould had not seen this local gypsum in the Flowerpot Shale. Many subsequent workers, following Gould's usage, have used the name Blaine in many different stratigraphic senses until, as used in Texas, so-called Blaine beds are not at all the same as in Oklahoma. The name "Cave Creek," as applied to these Permian rocks, has priority over Blaine, and is identical to it in stratigraphic span; however, Blaine has received wide usage and the name "Cave Creek" has fallen into disuse.

Unit D

The overlying unit is a reddish-brown gypsiferous clay shale, 6 to 8 feet thick in northern Blaine County, ranging from a few inches to several feet in thickness from northern Major County, Oklahoma, into Kansas.

Units E and F

A reddish-brown gypsiferous shale about 2 feet thick (Unit F) occurs immediately below Unit G, grading downward into a 1- or

A. Salt Creek Canyon, view toward south in SE¼ NE¼ sec. 22, T. 18 N., R. 12 W., measured section 19. (F-Flowerpot, M-Medicine Lodge, N-Nescatunga, S-Shimer).

B. Flowerpot escarpment capped by Medicine Lodge Gypsum, Glass Mountains, view toward east in NE¼ NE¼ SE¼ sec. 13, T. 21 N., R. 14 W., measured section 14.

PLATE 5

Blaine and Flowerpot escarpment, Blaine and Major Counties, Oklahoma

2-foot-thick greenish-gray siltstone or shale (Unit E). Southward in central Blaine County, these beds merge with reddish-brown gypsiferous clay shale, and northward they grade into a greenish-gray siltstone about 5 to 8 feet thick. In northern Woodward County, Oklahoma, this siltstone thins to 1 foot or less and is about 5 feet below the top of the Flowerpot Formation, maintaining this thickness, but with varying intervals up to 10 feet below the base of the Blaine Formation, through Harper and Woods Counties, Oklahoma, into Kansas.

Unit G

A thin persistent gray compact finely laminated dolomite with salt casts, about 6 inches thick, occurs next above Unit F (pl. 9B). It is first noticeable in northern Blaine County and may be traced to northern Woodward County, where it grades into the underlying siltstone and is 5 or 6 feet below the base of the Blaine Formation.

Unit H

The overlying 8 feet of beds is reddish-brown weakly indurated gypsiferous clay shale. The unit thins to several feet or less northward into Kansas and merges with underlying shale in central Blaine County and the region southward in Oklahoma.

Unit I

The overlying 7 or 8 feet of beds consists of many thin wavy layers of satin spar and reddish-brown silty clay shale, with local greenish-gray siltstones and dolomites, forming a resistant ledge (pl. 5). In some places in Blaine County this unit contains some light-gray and greenish-gray dolomites with malachite stains (measured sections 20, 22, 23).

A thin hematite band occurs at the top of this ledge in the Salt Creek and Southard areas of Blaine County (measured sections 18, 19). In central Major County (SW¼ sec. 5, T. 21 N., R. 13 W.) the upper 3 feet is massive well-indurated gypsum, about 1.5 feet below the base of the Blaine Formation, the intervening Units J and K being almost dolomite in this area.

This ledge-forming unit persists from northwestern Canadian

A. Flowerpot Shale bluff. Magpie Dolomite caps high flat area, Medicine Lodge Gypsum forms next lower escarpment, dolomite Unit G is at top of bluff face, and gypsum Unit C forms light streak in the bluff face.

B. Close-up view toward south of gypsum Unit C, thought to be Ferguson Gypsum by Gould (1905). Same area as above.

PLATE 6

Flowerpot Shale along Sand Creek, measured section 15, Major County, Oklahoma

County, Oklahoma, into Kansas, where it is about 4 feet thick and occurs about 1 foot below the base of the Blaine Formation.

Unit J

The unit consists of 5 or 6 feet of reddish-brown silty clay shale that is typical of the entire Flowerpot Shale. It thins northward to several inches and is mainly dolomitic in central and northwestern Major County, Oklahoma. In northwestern Canadian County, Oklahoma, this shale consists mainly of illite and chlorite, with a mean grain size of 8.90 phi, deviation 2.83, skewness —0.51, and kurtosis 0.86 (measured section 26, SW Okarche).

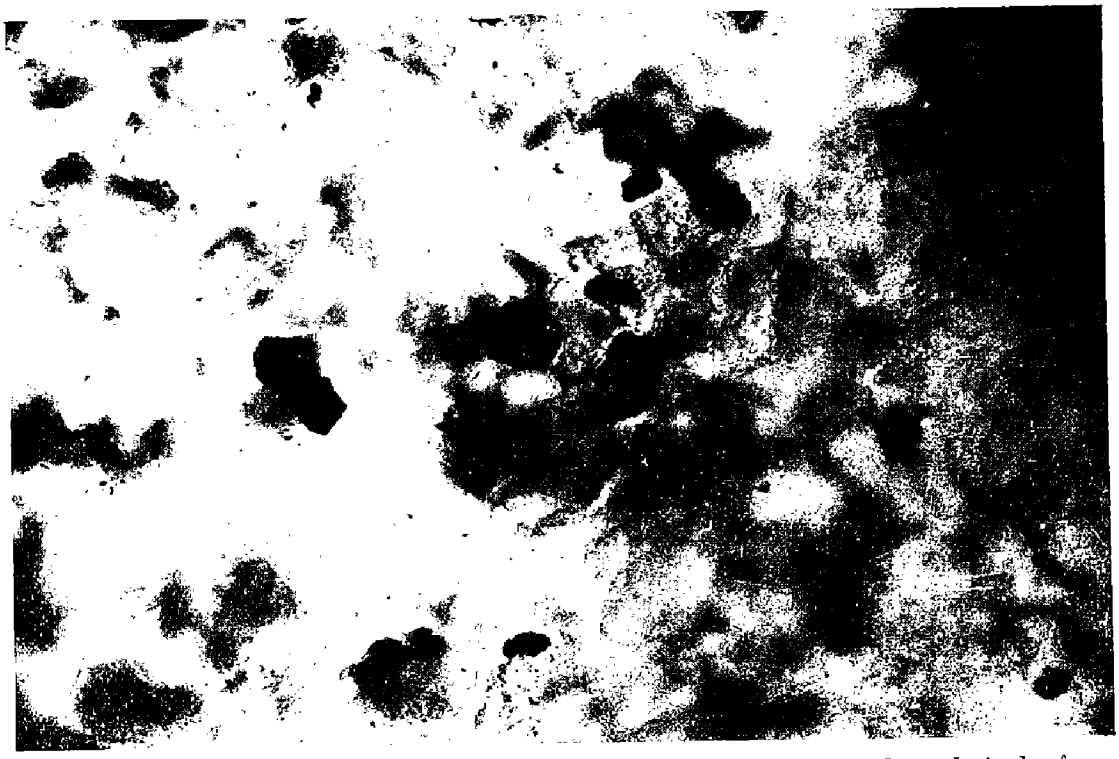
Unit K

The uppermost few inches of the Flowerpot Shale is a light greenish-gray clay shale that grades upward into a fine-grained compact greenish-gray dolomite, which is the basal bed of the Cedar Springs Dolomite Bed of the Blaine Formation. This unit is persistent from Kansas to Canadian County, Oklahoma, attaining a maximum thickness of 3 feet in central and northwestern Major County, Oklahoma, where the shale is dolomitic.

Distribution.—The Flowerpot Shale occurs in Barber and Comanche Counties, Kansas, extending southeastward to southern Canadian County, Oklahoma, where it grades into the Chickasha Formation and underlying Duncan Sandstone.

Thickness.—The Flowerpot Shale is approximately 180 feet thick in Kansas and 450 feet thick in Blaine County. This southward thickening takes place within all parts of the Flowerpot Shale, a marked difference being noticed from northern Major County to southern Woods County, Oklahoma (pl. 1). In Canadian, Grady, and Stephens Counties, Oklahoma, at the southeastern end of the Anadarko basin, the Flowerpot is absent and is represented by 140 feet of Duncan Sandstone at the base, overlain by 300 feet of the lower part of the Chickasha Formation. These deposits are here regarded as having been deposited simultaneously with all those of the Flowerpot Shale.

Topography.—The Flowerpot Shale erodes into valleys of badlands type, forming steep cliffs beneath the overlying Blaine Formation (pls. 5A, 6A). The Glass Mountains of Major County received



A. Gypsum Unit C, measured section 15, Major County. Note the relatively few siltstone grains present in the gypsum.

B. Siltstone Unit C, measured section 4, Yellowstone Creek, Woods County. Note dark hematite stains around grains.

PLATE 7

Photomicrographs of Unit C of Flowerpot Shale, x125, Major and Woods Counties, Oklahoma

that name because of the abundant glassy-appearing selenite gypsum present in the Flowerpot Shale in the numerous buttes capped by the Blaine Formation (pl. 5B). Flower-pot Mound received its name because, when viewed from a distance, it appeared like an inverted flowerpot, with the trees on top resembling flowers. In southern Blaine County and adjacent Canadian County, Oklahoma, the Chickasha-Duncan Tongue is a low set of ridges or hills.

Structure.—In the Blaine County area and adjacent counties, the beds dip southwestward at an average inclination of 14 feet per mile. The dip ranges from 7 to 20 feet per mile or more locally, and the strike also varies.

Paleontology.—Spores occur in the Flowerpot Shale in southwestern Oklahoma. The only other type of fossil found is a large unidentified reptile, discovered by the writer in the Chickasha Tongue, about 52 feet above the base, in NW¼ NW¼ NW¼ NW¼ sec. 19, T. 17 N., R. 9 W., Kingfisher County, Oklahoma. This places the find about 230 feet above the base of the Flowerpot Shale and is the first notice of the occurrence of vertebrates in the Flowerpot Shale. Other remains, including three additional genera, were found by E. C. Olson in the summer of 1961 (Olson and Barghusen, 1962).

Age and correlation.—The lower part of the Flowerpot Shale grades into the Duncan Sandstone. The Duncan of Oklahoma is considered to be the same as the San Angelo Sandstone of central Texas, according to Gould (1926, p. 152). The San Angelo Sandstone of the eastern shelf area of central Texas is correlated across the Midland basin with the Glorieta Sandstone that occurs in the northwestern shelf area north of the Midland basin and in the Central Basin platform west of the Midland basin (King, 1942, p. 695, pl. 2).

The Glorieta Sandstone is overlain by limestone containing *Parafusulina* in the Midland basin and on the Central Basin platform the species *P. rothi, P. sellardsi, P. lineata,* and *P. maleyi referta* being "found only in the Guadalupe series" in outcrops to the west (King, 1942, p. 701-702). Accordingly, the Flowerpot Shale is here considered to be the equivalent of rocks at the base of the Guadalupean Series.

Origin and environment of deposition.—The major type of sediment of the Flowerpot Shale is reddish-brown clay shale, composed mainly of illite and chlorite, and a large quantity of silt-size quartz.

This clay was deposited in three tectonic provinces on the eastern flank of the Anadarko basin, and accordingly slightly different sediments are in each province. These regions are termed the northern platform, central basin, and southern delta, or Tussey delta of Green (1937, p. 1524).

The northern platform extends from northern Major County northward into Kansas, the area of change into the central basin facies extending to northern Blaine County. In this area, in the upper part of the Flowerpot Shale, are siltstones and dolomites, such as Units C, E, and G, which attain maximum development in Major and Woodward Counties, Oklahoma. It is readily seen from a consideration of siltstones C and E, shown in plate 1, that these sediments thin northward and southward and evidently grade westward into shales in the Permian basin, having originated in the east or northeast in areas such as the Ozark dome. The minerals comprising these sediments are predominantly quartz and chert (63 percent and 10 percent, respectively), with about 6 percent feldspars, 14 percent carbonate, gypsum, and iron minerals, 7 percent clay, and 0.06 percent heavy minerals. The sand-size grains are subrounded to well rounded and evidently were derived from reworked sedimentary and igneous rocks. All grains are coated with iron stains (probably hematite), which could have been derived from weathered soils and deposited in a salt-water environment.

The environment of deposition of the above-mentioned rocks is interpreted as follows. The water was probably highly saline, ranging from 2 to 10 times normal salinity, into which fresh-water streams flowed from an eastern source area, such as the Ozarks. The competence of these fresh-water streams presumably was low, and the Ozarks may have been relatively close to sea level. These streams must have carried materials in suspension and solution most of the time, but occasionally they must have been able to transport some sand, such as that seen in Unit C. The evaporites and clastic rocks were probably formed in a marginal marine environment of a semiarid region with an eastern source area, such as the Ozark dome. The basal part of Unit B consists of gypsum nodules that are here interpreted to have been deposited as gypsum, dehydrated to anhydrite, and later hydrated to form gypsum. This same interpretation is here applied to most of the deposits of gypsum nodules in the Flowerpot Shale, because in the subsurface well cores (measured section 31) it is common to find anhydrite nodules throughout the

upper 100 feet or more of the Flowerpot strata. The selenite and satin spar gypsum are evidently secondary. The gypsum nodules at the base of Unit B were probably deposited when the sea water evaporated approximately to 20 percent of its original volume (Usiglio, 1849). According to Pettijohn (1949, p. 358-362), it is unlikely that anhydrite is precipitated directly in sea water at normal temperatures (approximately 30°C), but it is probable that gypsum is the first-formed product. If this is true, anhydrite probably formed from the original gypsum, and the gypsum that is now seen at the surface is a hydrated product of the anhydrite. The hematite coating on the clastics was probably formed in the regolith and transported to the site of deposition.

As Unit C was being deposited, there must have been a slight increase in the competence of the streams, perhaps due to uplift in the Ozark region. This could have brought in fine-grained sand and much silt that was deposited along with the normal gypsum. Unit D was then deposited, followed by Unit E, which is the first major greenish-gray shale and siltstone in this sequence. The color of Units C and E is due to several factors: (1) the abundant quartz grains tend to whiten the beds, giving them a light-brown color, (2) the presence of spores or any organic material (spores in the case of Unit E) reduces the ferric iron to a ferrous condition, resulting in a green color, and (3) the presence of gypsum. The light-brown, orange, and greenish-colored beds are siltstones or organic shales, with some carbonate, and it is here suspected that the many small greenish-gray specks throughout the redbeds are due to reduction by bacterial action of organic material. The presence of carbonate also imparts a light color to the rocks. Local conditions of quiescence probably prevailed when Unit G was being deposited, allowing the fine-grained light-gray calcite to accumulate over a wide area. The original calcium carbonate may have been altered by the magnesium in the sea water to form dolomite. The presence of salt hoppers in the dolomite indicates that the sea water must have been sufficiently high in concentration for salt brine to be trapped in the carbonate rock, but this condition does not mean that 90 percent evaporation had taken place. With continuing deposition of clays of Unit H, gypsum and calcium carbonate were deposited in some places with increasing salinity, forming Unit I. As Unit J was being deposited the salinity probably decreased until only clay could be deposited.

A period of extreme quiescence probably followed, with deposition of organic and carbonate material to form Unit K. The sea water must have evaporated to 20 to 40 percent of its original volume, allowing the basal dolomite of the Blaine Formation to be formed. Little or no influx of clay, quartz, or iron minerals occurred, and the bottom of the sea must have been ideal for the formation of oöliths, which are the predominant textural features of the dolomite at the base of the Blaine Formation.

The central basin area extends from northern Blaine County to northern Grady County, Oklahoma, the area of change into the deltaic facies being in central Blaine County for the middle part of the Flowerpot Shale, in southern Blaine and northern Canadian Counties for the upper portions of this formation, and in central Canadian County for the uppermost part. Dolomite Unit G and the siltstone Units C and E of the northern platform are absent in the central basin facies where they grade into reddish-brown gypsiferous clay shale. The only recognizable beds in the basin facies are Units K, J, I, and basal B. All units are thicker in the basin than on the northern platform, and therefore it is probable that the bottom of the sea was subsiding in the basin and that more sediment was being received in this area. As will be discussed later, the same is true of the southern delta facies farther south. This entire facies, several hundred feet thicker in northern Grady County than in southern Grady County and adjacent Stephens County, Oklahoma, indicates that a marginal shelf was present not far away and that the source area was nearby, probably in the Ouachita and Arbuckle Mountains region.

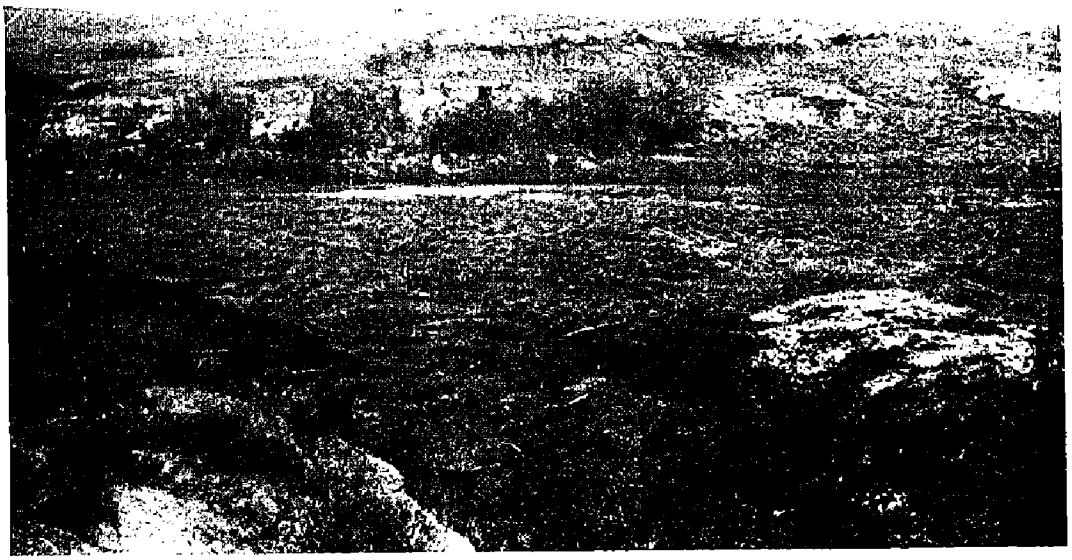
The southern delta area received deposits of fine silt and mud that were locally hardened and covered by water again after exposure to the air. A general increase in the amount of sand southward and southeastward indicates that this entire complex of sediments probably was derived by erosion of the Arbuckle Mountains area. That the siltstones in the upper part of the Flowerpot Shale on the northern platform are unrelated to those of the southern delta area clearly indicates at least two separate source areas for these sediments. Most of the clay and iron minerals may have been derived from the Ouachita Mountains, but some, no doubt, came from the Ozark dome. The evaporites and units of the central basin facies are absent in the deltaic facies, where influx of fresh water would have lowered the salinity.

In summary, it is evident that in order adequately to explain attributes of the rocks of the Flowerpot Shale and Chickasha-Duncan facies, three separate processes have to be considered: (1) the process of evaporation of sea water versus inflow of sea and fresh water, causing changes in salinity, pH, and Eh, thereby having a marked influence on the deposition of gypsum, calcium carbonate, iron minerals, and evaporites such as halite; (2) the process of regional downwarp of the Anadarko basin, with marked thickening basinward of the southern delta facies and the northern platform facies; and (3) the process of uplift of the Ozark dome and the Ouachita and Arbuckle Mountains, with concurrent weathering and transportation of clays, silt, sand, and dissolved solids. During Flowerpot time, evaporation must have exceeded inflow, the center of the Anadarko basin must have sunk two and one-half times more than did the margins, and the surfaces of the Ozark dome and Ouachita Mountains must have been close to sea level, with the rate of chemical weathering being greater than that of mechanical weathering.

BLAINE FORMATION

Name.—The name "Blaine division," derived from Blaine County, Oklahoma, was first used by Gould (1902, p. 47) for a sequence of gypsums and interbedded shales below the Dog Creek Shale and above the middle part of the Flowerpot Shale, thought to be interbedded northward in Kansas with the upper 40 feet of the Flowerpot Shale. Gould (1905, p. 44) changed the name to Blaine Formation. As pointed out under discussion of the upper part of the Flowerpot Shale, Gould miscorrelated the lowermost gypsum (Ferguson) unit northward into southern Major County and mistook what is Unit C of the Flowerpot Shale for the Ferguson, thus causing confusion in nomenclature and correlation of members of the Blaine. Much of this confusion can be removed by a simple correction, abandonment of the name "Ferguson gypsum" of Gould (1902) in favor of its equivalent, the earlier "Medicine Lodge gypsum" of Cragin (1896). The upper 40 feet of the Flowerpot Shale in Kansas is not equivalent to any portion of the Blaine Formation in northwestern Oklahoma.

The name "Cave Creek formation" was first used by Cragin (1896, p. 27) for rocks in Comanche and Barber Counties, Kansas, between the Flowerpot Shale, below, and the Dog Creek Shale, above



A. Blaine Formation on Cave Creek, NE¼ NE¼ sec. 2, T. 34 S. R. 17 W., measured section 2, Comanche County, with Shimer Gypsum at top, Medicine Lodge Gypsum at base, and thin Nescatunga Gypsum between. View from Comanche Cave.

B. Blaine escarpment in foreground, Doe Creek Sandstone knobs along horizon, view toward northwest in southeastern part of T. 25 N., R. 18 W., Chimney Creek, Woodward County.

PLATE 8

Blaine escarpment, Comanche County, Kansas, and Woodward County, Oklahoma

(pl. 8A). Although the name "Cave Creek" had definite priority over that of Blaine Formation, the name fell into disuse as a stratigraphic term because most workers thought that the Blaine Formation included rocks equivalent to all of the Cave Creek plus 40 feet of the Flowerpot Shale.

It was not until 1931, when Evans demonstrated the equivalence of the Medicine Lodge and Ferguson Gypsums and 1939, when Norton restudied type sections in Kansas, finding a gypsum missed by Cragin in his original description of the Cave Creek Formation, that the exact equivalence of the Blaine and Cave Creek Formations became established. All authors subsequent to Norton (1939) have followed his usage for named members and beds of the Blaine in Kansas and northern Oklahoma (pl. 8). Figure 3 shows interrelationships between named units of the Blaine Formation, extending from Kansas to Canadian County, Oklahoma. No implication of thickness is intended by the spacing between units except that the Nescatunga Gypsum thins northward into Kansas, having been missed entirely by Cragin (1896). The name Blaine Formation is accepted in this report because it has been extensively used in the literature. The Haskew Bed is locally considered as the upper part of the Blaine Formation in Harper and Woodward Counties, Oklahoma, as shown on plate 1. In this report it is considered under discussion of the Dog Creek Shale because of paleogeographic, regional, and sedimentologic considerations.

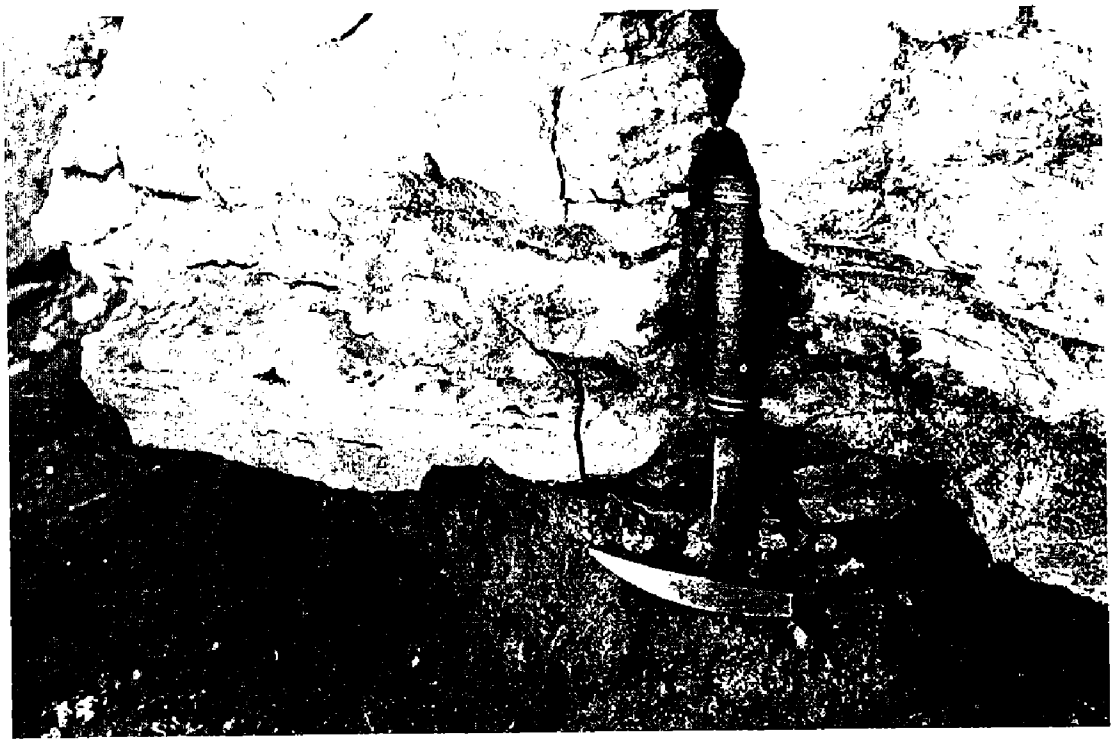
Type locality.—The type locality for the Blaine Formation is the area of Roman Nose and Salt Creek Canyons, in central to north-central Blaine County (pl. 5A). The type section is along State Highway 33, about seven miles east of Watonga, Blaine County, in the southern part of sec. 19 and northern part of sec. 30, and SW¼ sec. 20, T. 16 N., R. 10 W., where the entire formation is exposed.

The type locality for the "Cave Creek formation" is the area at Comanche Cave, on Cave Creek (now Sand Creek) of old Shimer Township, Tps. 33, 34, 35 S., R. 17 W., Comanche County, Kansas.

Description and stratigraphic relations.—Beginning with the Cedar Springs Dolomite Bed at the base and proceeding upward, the Blaine Formation may be described as follows.

Cedar Springs Dolomite Bed

The Cedar Springs Dolomite Bed of the Blaine Formation is the



A. Cedar Springs Dolomite (type section) at base of Medicine Lodge Gypsum Member of Blaine Formation, Sand Creek.

B. Dolomite Unit G of Flowerpot Shale, view toward south along Sand Creek.

PLATE 9

Cedar Springs Dolomite at type locality and dolomite Unit G, measured section 15, Major County, Oklahoma

name given to the dolomite at the base of the Blaine, conformably overlying the Flowerpot Shale and grading upward into the Medicine Lodge Gypsum (Fay, 1962). The name was derived from the town of Cedar Springs, in the north-central part of T. 20 N., R. 13 W., southern Major County, Oklahoma (pls. 6A, 9A).

The type locality is southern Major County, Oklahoma, in T. 20 N., R. 12 W., especially along Sand Creek.

The section exposed in the high bluff along the east bank of Sand Creek in NW¼ sec. 20, T. 20 N., R. 12 W., southern Major County, Oklahoma, is the type section (pls. 6A, 9A).

The Cedar Springs Dolomite Bed is a light-gray fine-grained oölitic massive dolomite about 9 inches thick with locally occurring argillaceous compact nonoölitic portions (pls. 9A, 10B).

In Blaine County, Oklahoma, the Cedar Springs is the same as in the type area except that it is 1 or 2 inches thick, or missing in places, and at several localities it contains stains of a green copper mineral, probably malachite (pl. 10B). Southward in Canadian County, the Cedar Springs grades laterally into a calcareous siltstone of the Chickasha Formation. Northward in central Major County (SW¼ sec. 5, T. 21 N., R. 13 W.) the unit thickens to almost 3 feet, the lower 1.5 feet being argillaceous, a 3-foot impure massive gypsum beneath it being included in the Flowerpot Shale (Unit I). In Kansas, Norton (1939, p. 1795) reported this dolomite to be 0.5 to 1 foot thick and ripple marked.

Medicine Lodge Gypsum Member

The name "Medicine Lodge gypsum" was first used by Cragin (1896, p. 28) for the thick massive gypsum above the Flowerpot Shale. This gypsum was named for the river and town of Medicine Lodge, Barber County, Kansas. The term "Medicine Lodge gypsum," as used by Gould (1902) in reports on the Blaine Formation in Oklahoma, refers to the next gypsum ledge (Nescatunga of Norton, 1939) above the Medicine Lodge Gypsum of Cragin. Both Cragin and Gould included the basal dolomite with the Medicine Lodge and Ferguson Gypsums in their nomenclature, but as used here, the basal dolomite is termed the Cedar Springs Dolomite Bed, and the overlying gypsum is termed the Medicine Lodge Gypsum Member (fig. 3). The "Ferguson gypsum member" of Gould is the equivalent of the "Medicine Lodge gypsum" of Cragin.

A. Shale above Medicine Lodge Gypsum with crinkly bedded Kingfisher Creek Gypsum in middle. Lopp quarry, SW¼ SW¼ NW¼ sec. 21, T. 20 N., R. 12 W., measured section 15, Major County.

B. Photomicrograph of copper-stained Cedar Springs Dolomite, x125, measured section 18. Dolomite is light, malachite is medium gray, and hematite is dark.

PLATE 10

Kingfisher Creek Gypsum, Major County, Oklahoma, and Cedar Springs Dolomite, Blaine County, Oklahoma

The type locality for the Medicine Lodge Gypsum Member is northern Barber County, Kansas, along Medicine Lodge River valley and southwest of Medicine Lodge.

The type section is here designated as that at Comanche Cave, in NE¼ NE¼ sec. 2, T. 34 S., R. 17 W., on Cave Creek (Sand Creek), Comanche County, Kansas.

In the type area of Kansas the best published description of the structure and microscopic character is that by Kulstad, Fairchild, and McGregor (1956, p. 41-45), who stated that the Medicine Lodge Gypsum Member in Barber and Comanche Counties, Kansas, ranges in thickness from 10 to 30 feet, the maximum thickness being exposed in the Pioneer mine, Sun City. Anhydrite is exposed at a few places in Barber County. In the mine, lenses of anhydrite are present within the gypsum about 10 feet above the base of the gypsum. The regional dip is about 11 feet per mile to the southwest. Where anhydrite is absent in the middle portion of the gypsum in the mine, breccia-filled solution channels of gypsum and red clay generally are present.

Petrographic studies show (1) local gradation of anhydrite to gypsum; (2) filling of fractures in the anhydrite with gypsum; (3) cutting of anhydrite crystals by gypsum without disturbing the optical continuity of the anhydrite; (4) radial aggregates of the anhydrite; (5) gradation of the basal dolomite into the gypsum; (6) localization of dolomite in the lower parts of the gypsum; (7) absence of anhydrite in the lower and upper parts of the gypsum; and (8) presence of iron oxide throughout the gypsum.

In Blaine County, Oklahoma, the Medicine Lodge ranges in thickness from about 4 feet at the south to 7 feet at the north. It contains no visible anhydrite, but insoluble-residue studies on the basal dolomite indicate presence of a high percentage of anhydrite in that portion. The Medicine Lodge has many reddish-brown clay shale seams, especially in its upper part, giving the appearance of a reddish-brown mottled gypsum ledge on the outcrop. Northward in central Major County, Oklahoma (NE¼ sec. 7, T. 22 N., R. 14 W.), this unit thickens to 15 feet and has a 6-inch-thick bed of anhydrite in the middle. In the Salt Creek canyon area of Blaine County, Muir (1934, p. 1304) reported small irregular aggregates of anhydrite in the middle part of the Medicine Lodge Gypsum and minor amounts of anhydite in the upper part. The Medicine Lodge

is white, compact to porous, fine- to coarse-crystalline, banded gypsum, mottled moderate reddish brown to pale pink and erodes into a pinkish-gray ledge, forming a mappable escarpment. It grades into the underlying Cedar Springs Dolomite and is conformably overlain by reddish-brown silty clay shale with greenish-gray streaks.

In the subsurface of Blaine County, about 20 miles west of the outcrop and 500 feet deep (measured section 31), a continuous set of 4-inch cores through the Medicine Lodge reveals that it is anhydrite in the subsurface.

In southern Blaine County, Oklahoma, the overlying reddish-brown clay shale is 15 feet thick and extends upward to the Kingfisher Creek Gypsum. In northern Blaine County, the shale is 7 feet thick and contains many layers of greenish-gray shale and gypsum. The Kingfisher Creek is there represented by an impure thin greenish-gray argillaceous gypsum that appears like the thin beds below but is more indurated. These beds contain increasing amounts of gypsum to the north and appear to grade into pure gypsum of the upper part of the underlying Medicine Lodge Gypsum in central Major County, Oklahoma, thus accounting in part for the increase in thickness of the Medicine Lodge Gypsum from southern to central Major County.

Kingfisher Creek Gypsum Bed

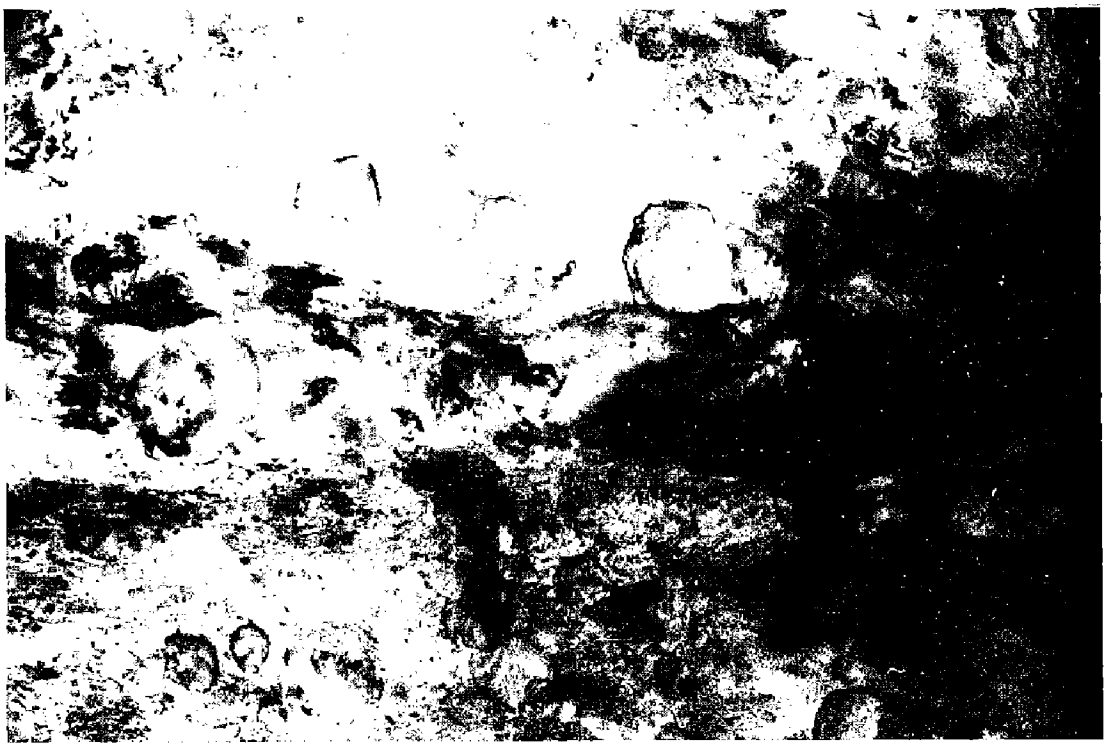
The name "Alabaster gypsum" was used by Buckstaff (1931, p. 435) for a thin gypsum in the shale unit between the Medicine Lodge Gypsum and Nescatunga Gypsum of the Blaine County area. No type locality was designated, the name being that of a rock type. This gypsum is named the Kingfisher Creek Gypsum Bed (Fay, 1962) from Kingfisher Creek, in eastern Blaine County, Oklahoma (pl. 11).

The type locality is southeastern Blaine County, especially Tps. 15, 16 N., R. 10 W.

The type section is the outcrop along State Highway 33, just north and south of the road, especially in SE¼ SE¼ sec. 19, T. 16 N., R. 10 W., Blaine County. This outcrop is included in the type section of the Blaine Formation.

At the type section the Kingfisher Creek Gypsum is approxi-

A. Kingfisher Creek Gypsum, north of road, east of Watonga.



B. Photomicrograph of Kingfisher Creek Gypsum showing silt grains in gypsum, with dark shale laminae, x125.

PLATE 11

Kingfisher Creek Gypsum Bed, at type locality, measured section 23, *Blaine County, Oklahoma*

mately 2.5 feet thick, ranging from 1 to 3 feet from central Blaine County to northwestern Canadian County, Oklahoma. It reaches its maximum thickness near the Blaine County-Canadian County line and southward grades into greenish-gray and reddish-brown silty clay shale. North of T. 17 N., the Kingfisher Creek grades into several thinner greenish-gray clay shale and gypsum units, one of which is more indurated than the others. These beds, in addition to the 7 feet of shale beds below, gradually become more gypsiferous northward in southern Major County, north of which they are impossible to distinguish from each other (pl. 14A).

In Blaine County, the Kingfisher Creek is a white fine-crystalline well-indurated gypsum, mottled greenish gray and pale pink to pale red, with many thin clay shale and selenite seams, forming a white to greenish-gray ledge. In the subsurface, about 20 miles west of the outcrop (measured section 31), this member is a fine-grained light-gray to moderate reddish-brown anhydrite, mottled greenish gray.

In Canadian County, where the Kingfisher Creek Gypsum is missing, the unit of reddish-brown silty clay shale between the top of the Medicine Lodge and the base of the Magpie Dolomite is approximately 30 to 35 feet thick. In southern Blaine County, the Kingfisher Creek Gypsum is 15 feet above the top of the Medicine Lodge Gypsum and 16 feet below the base of the Magpie Dolomite. In northern Blaine County, the same intervals are 7 and 9 feet, respectively. In central Major County and areas northward, where the Kingfisher Creek and underlying shales become thin, the interval between the top of the Medicine Lodge and the base of the Magpie is only 7 to 11 feet (pl. 10A). The shale is principally illite and chlorite.

The Kingfisher Creek Gypsum Bed is everywhere conformable with beds above and below.

Magpie Dolomite Bed

The Magpie Dolomite was named by Gould (1902, p. 48) to designate the thin dolomite at the base of the Nescatunga Gypsum (Medicine Lodge of Gould). The name is that of the permanent camp of the Arapahoe Chief Magpie on Bitter Creek, just below the Nescatunga Gypsum ledge in Roman Nose State Park area, Blaine County. The present Magpie residence is south of the park area

just south of C SW¼ SE¼ sec. 30, T. 17 N., R. 11 W., west of State Highway 8A.

The type locality is Roman Nose State Park, sec. 24, T. 17 N., R. 12 W., Blaine County.

The type section is on State Highway 33, about seven miles east of Watonga, in the southern part of sec. 19 and northern part of sec. 30, T. 16 N., R. 10 W., Blaine County. This is part of the type section for the Blaine Formation (pl. 12A).

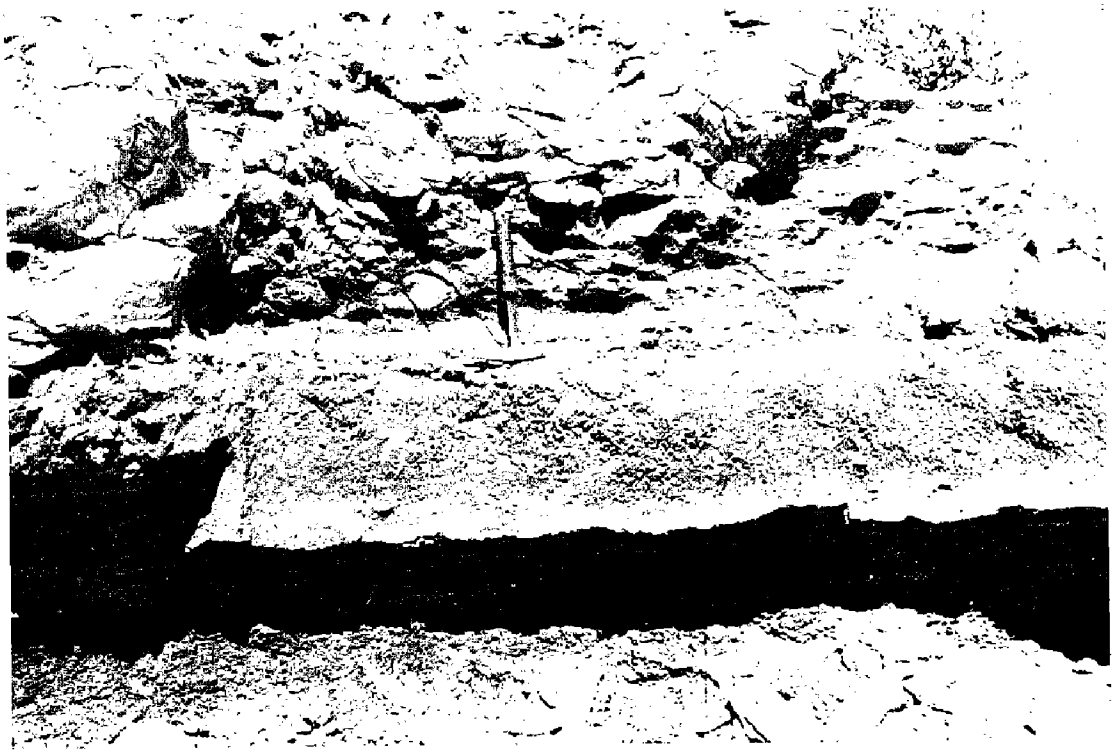
In the type region, the Magpie Dolomite Bed ranges in thickness from 0.5 to 1.5 feet. It is a light-gray to yellowish-gray fine-crystalline oölitic fossiliferous dolomite with a compact fine-crystalline argillaceous nonoölitic portion at the base and interlayered with the öolitic portions higher up (pl. 12). The common fossil is the marine clam *Permophorus,* which occurs as molds.

The Magpie is conformably underlain by a thin light greenish-gray silty clay shale and grades upward into the overlying Nescatunga Gypsum. Muir (1934, p. 1305-1307) reported small dolomite crystals completely surrounded by gypsum in the lower part of the Nescatunga and in the anhydrite in the middle part of the Nescatunga in the Salt Creek canyon area of central Blaine County.

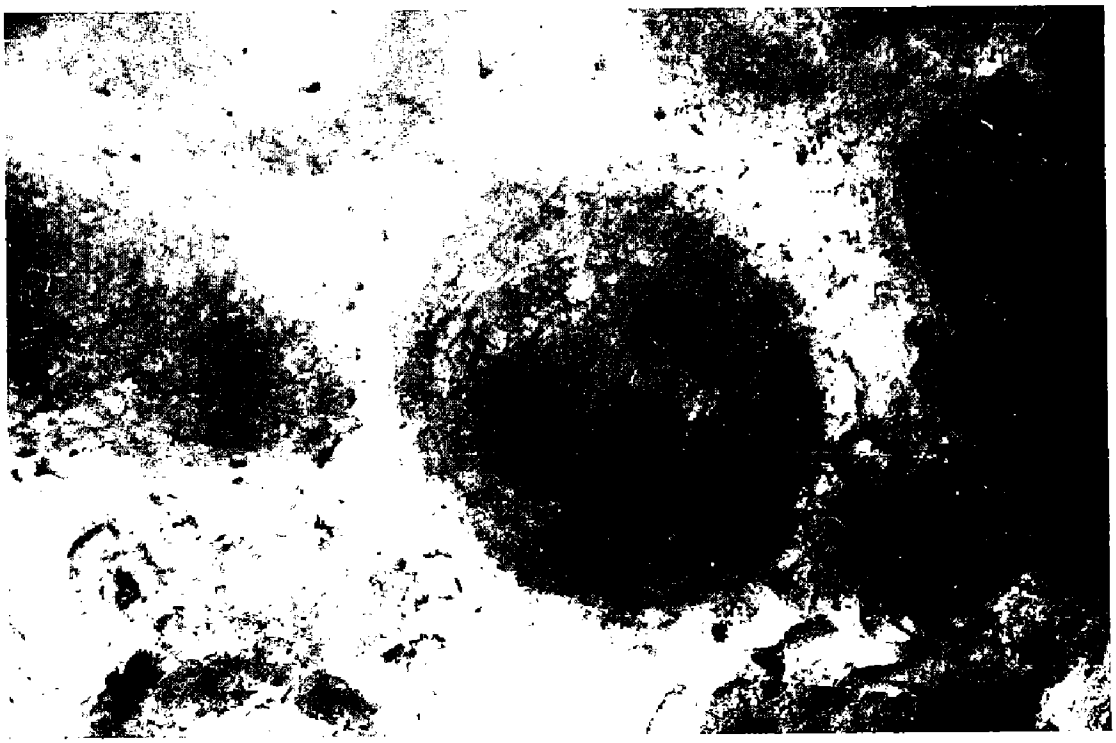
Southward into central Canadian County, Oklahoma, the Magpie grades into a light greenish-gray calcareous siltstone. Northward into Kansas, the Magpie grades into a greenish-gray shale at the base of the Nescatunga and loses its identity.

Nescatunga Gypsum Member

Nescatunga was the Comanche Indian name for Salt Fork River, Comanche County, Kansas. Norton (1939, p. 1794-1795) used the name for the 3- to 9-foot-thick bed of gypsum that is present 7 to 10 feet above the Medicine Lodge Gypsum and about the same interval below the Shimer Gypsum along the lower reaches of Nescatunga Creek and adjacent areas, Comanche County, Kansas (pl. 8A). Because of miscorrelations by Gould (1902) and Evans (1931), this bed had been correlated as the Medicine Lodge and Shimer, respectively, by them. Norton included the dolomite at the base with this member, but it is here separated and the name Nescatunga Gypsum Member applies only to the gypsum and anhydrite portions above the Magpie Dolomite Bed.



A. Magpie Dolomite, type locality, measured section 23, Blaine County. Nescatunga Gypsum at top, greenish-gray shale at base.



B. Photomicrograph of Magpie Dolomite, x125, showing oöliths in anhydrite matrix, from sample 472 feet down in well, measured section 31.

PLATE 12

Magpie Dolomite Bed, Blaine County, Oklahoma

The type locality is the lower reaches of Nescatunga Creek, T. 34 S., R. 17 W., southeastern Comanche County, Kansas.

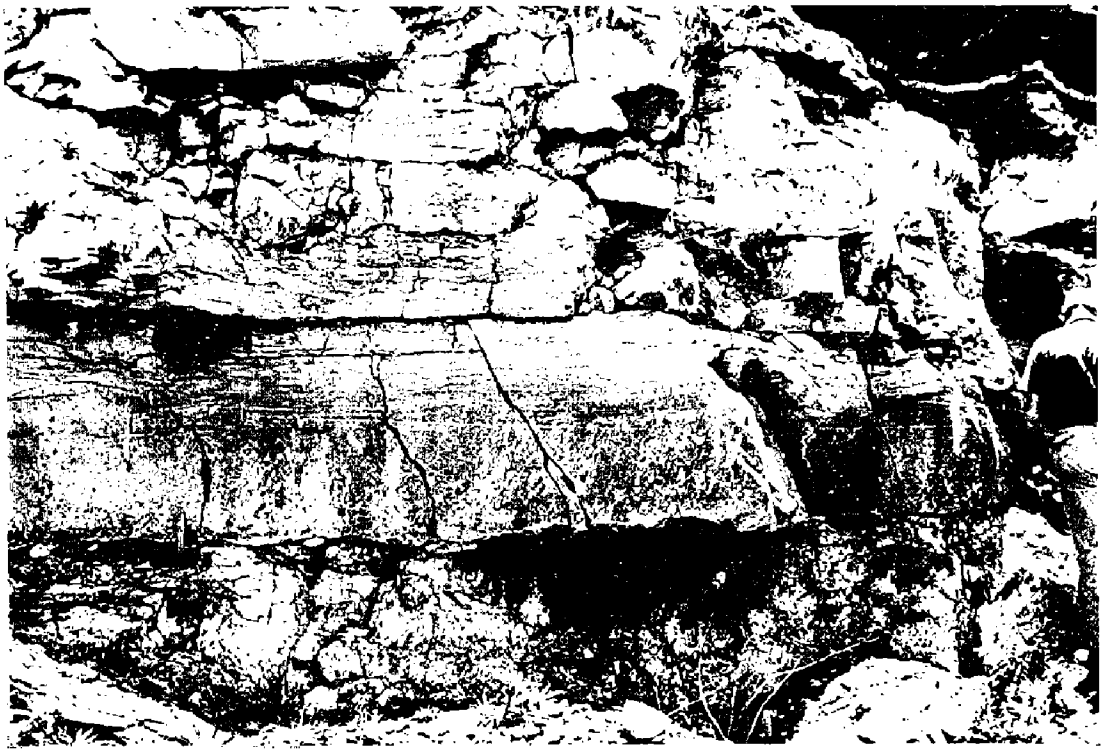
The type section is at Comanche Cave, in NE¼ NE¼ sec. 2, T. 34 S., R. 17 W., on Cave Creek (Sand Creek), Comanche County, Kansas.

Of the type area in Kansas, Norton (1939, p. 1797) stated that "The Nescatunga gypsum bed is well exposed along the lower reaches of Nescatunga Creek, where it is 8 feet thick and separated from the overlying and underlying gypsums by red shale beds of nearly the same thickness. Two miles west, near Liberty School, the member has thinned to 2 feet although protected by several feet of cover. In this area no dolomite occurs at the base although it is reported present in Oklahoma."

In Blaine County, the Nescatunga is divisible into three units: an upper gypsum portion and a lower gypsum portion separated by a middle bed of anhydrite (pl. 13). It is 12 to 15 feet thick in northern Blaine County and thins to 7 feet in the southern part of the county. The anhydrite portion is locally 9 feet thick in the Salt Creek canyon area of central Blaine County and is 4 feet thick in northern Blaine County. Elsewhere the middle anhydrite is absent except in artificial outcrops. In the subsurface of Blaine County (measured section 31), the entire Nescatunga Member is anhydrite, and the middle 4 feet contains large halite crystals about 1 inch in diameter. This is the first reported occurrence of salt in the Nescatunga.

Southward in central Canadian County, Oklahoma, the Nescatunga thins rapidly and grades into reddish-brown and greenish-gray silty clay shales. Northward in central Major County, the Nescatunga is 21 to 22 feet thick, with a little anhydrite developed in the middle. The Nescatunga thins to 2 feet northward into Kansas, where no anhydrite is reported. Where weathered, all parts of the Nescatunga have coarse-crystalline selenite on the surface. The Nescatunga forms an escarpment throughout Blaine County and adjacent areas and is identfied by its white ribbonlike pattern produced especially by weathering of the middle anhydrite (pl. 5A). This anhydrite is so evident in the Salt Creek canyon area of Blaine County that it has been called the Salt Creek marble locally by Suffel (1930, p. 69).

The lower gypsum unit is a white, fine- to coarse-granular



A. Nescatunga Member showing anhydrite (dark in middle) in gypsum (light). Universal Atlas quarry face, SE¼ NE¼ SW¼ sec. 27, T. 17 N., R. 11 W.

B. Close-up of above showing alternating laminations of anhydrite (dark) and gypsum (light).

PLATE 13

Nescatunga Gypsum (with anhydrite), measured section 22, Blaine County, Oklahoma

gypsum, with coarse crystals of satin spar and selenite. According to Muir (1934, p. 1305), small grains of anhydrite and fine-grained dolomite are surrounded by gypsum in the Salt Creek canyon area of Blaine County. At no place, except in the subsurface, is anhydrite in contact with the dolomite (pl. 16B). At some places the lower gypsum unit is deeply leached and dissolved, allowing the middle anhydrite to be lowered onto the Magpie Dolomite, but even here a thin brecciated clay shale is between the two, showing that leaching and solution of the lower gypsum have taken place.

The middle anhydrite is principally a light-gray compact fibrous anhydrite that weathers bright white, forming a bright-white ledge throughout the region. The anhydrite is associated with white compact fine-granular gypsum, some of which clearly cuts through anhydrite crystals that maintain optical continuity (Muir, 1934, p. 1306). The anhydrite occurs as radial aggregates with some gypsum and microscopic amounts of dolomite, with gypsum replacing some of the anhydrite. The lower contact is gradational with the underlying gypsum through an interval of 5 mm. In some places this unit is roughly banded. The borate minerals ulexite and probertite have been found associated with the margins of the anhydrite ledge in Blaine County, Oklahoma (Ham and others, 1961). Some ulexite and probertite occur in the gypsum immediately above the anhydrite in the quarries of the U. S. Gypsum Company at Southard, in northern Blaine County. In central Blaine County, at the Universal Atlas quarry, probertite is present immediately below the anhydrite, in the lower gypsum ledge. Where anhydrite is absent, the borates are absent; where anhydrite occurs, the borates are present only along the immediate margins. Apparently the borates are derived by hydration of the anhydrite into gypsum, with temporary concentration of the borate minerals. As hydration continues and becomes complete, the borates are probably carried away in solution. Preliminary spectrographic studies of the Nescatunga and other Blaine anhydrites from subsurface cores (measured section 31) show the presence of boron in sufficient quantity to account for the formation of these minerals by the process described (Ham and others, 1961).

The upper gypsum unit is a white fine-crystalline compact massive alabasterlike gypsum that is roughly banded with slightly darker bands in places. It contains microscopic amounts of anhydrite (Muir, 1934, p. 1307). It is overlain conformably by a thin greenish-gray layer of clay shale and gypsum in most places.

The overlying reddish-brown clay shale unit up to the base of the Altona Dolomite Bed (pl. 14A) is approximately 40 feet thick in central Canadian County, Oklahoma, where the Nescatunga is absent. In southern Blaine County this shale unit is 36 feet thick, gradually thinning northward to 8 feet thick in Kansas. This unit consists of moderate to dark reddish-brown blocky ferruginous clay shale, with many small greenish-gray round specks. The clay minerals are principally illite and chlorite. Present are several thin greenish-gray clay shale layers, two of which appear to be persistent, and many small selenite and satin spar crystals. The above-mentioned two shale layers are each about 1 foot thick, separated by 5 feet of reddish-brown shale, the bottom one occurring about 16 feet above the base of the unit in southern Blaine County and 8 feet above the base in northern Blaine County.

A thin persistent greenish-gray shale zone occurs at the top and base of this shale unit, at the base of the overlying Altona Dolomite Bed, and at the top of the underlying Nescatunga Gypsum Member.

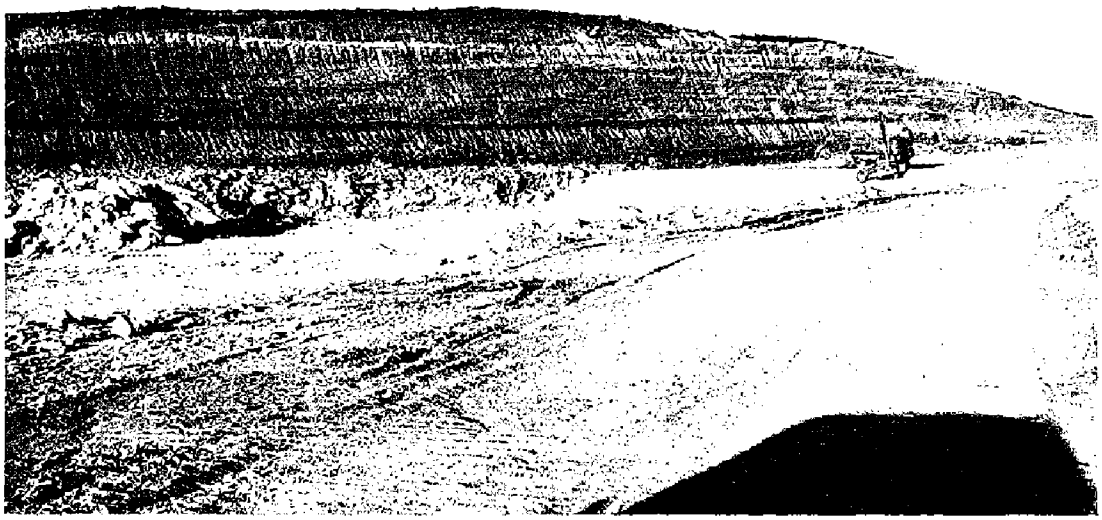
Altona Dolomite Bed

The Altona Dolomite, referring to dolomite at the base of the Shimer Gypsum, was named by Gould (1902, p. 48) for the town of Altona in southwestern Kingfisher County, Oklahoma. As used by Cragin (1896), Norton (1939), and other writers, the Shimer included the dolomite at the base. In this report the Altona Dolomite Bed is separated from the immediately overlying gypsum, termed the Shimer Gypsum Member.

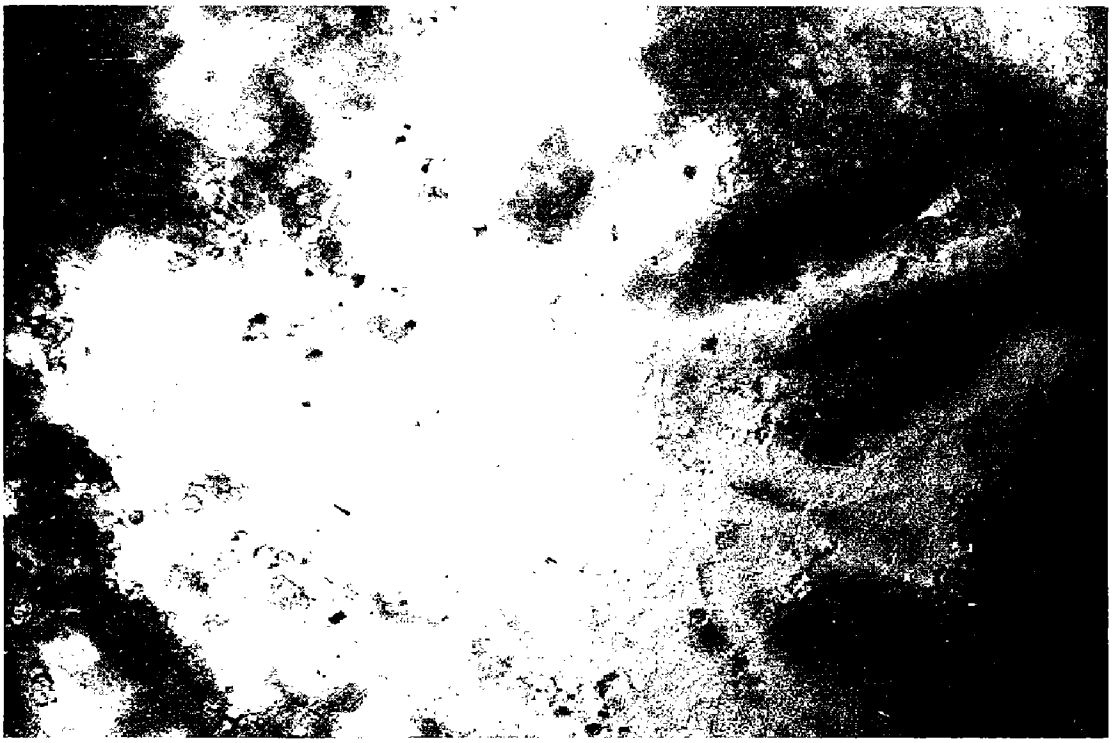
The type locality of the Altona Dolomite is southwestern Kingfisher County and southeastern Blaine County, especially southwest of Altona in the Gypsum Hills escarpment.

The section on State Highway 33, seven miles east of Watonga, Oklahoma, southern part of sec. 19 and northern part of sec. 30, T. 16 N., R. 10 W., Blaine County, is the type section for the Altona Dolomite Bed. This is also the area of the type section for the Blaine Formation.

In Blaine County the Altona Dolomite Bed is approximately one foot thick and is similar to the Magpie Dolomite (pl. 14A). It is a light-gray to yellowish-gray fine-crystalline oölitic dolomite with many molds of *Permophorus*. In the lower part and in thin layers throughout occurs a compact fine-crystalline argillaceous portion



A. Nescatunga Gypsum in U. S. Gypsum quarry, measured section 18, Southard. Notice thin Altona Dolomite near top.



B. Photomicrograph of anhydrite in Altona Dolomite, x125, from sample 415 feet down in well, measured section 31.

PLATE 14

Nescatunga Gypsum at Southard, and Altona Dolomite, Blaine County, Oklahoma

that is nonoölitic (pl. 14B). The Altona is conformable with the thin greenish-gray clay shale below and grades upward into the overlying Shimer Gypsum. In northern Grady County, Oklahoma, the Altona grades into a calcareous light greenish-gray siltstone, and the underlying shale grades into a massive sandstone and cross-bedded lenticular mudstone conglomerate of the Chickasha Formation. Northward in Kansas the Altona is 0.5 to 1.5 feet thick.

The Altona weathers commonly into boxworks. The dolomite is jointed, and secondary calcite fills these seams giving a boxwork appearance. The Magpie Dolomite has this characteristic to some degree. The Altona and the Magpie form similar-appearing escarpments. In Kansas, where the overlying Shimer Gypsum Member is absent, such as in the Dog Creek area, the Altona is a limestone, with large rhombs of dolomite sparsely present in a calcite matrix and with abundant boxworks.

In southeastern Blaine County, the Altona has a light greenish-gray dolomitic shale in the upper part just below the gypsum, and the total thickness of the dolomite and shale is almost 3 feet. In this same area and in adjacent Kingfisher County, the fossil clam *Permophorus* is so abundant that one might describe certain portions of the dolomite as a coquinite. This fossiliferous character persists in the Altona southward to the area just west of El Reno, central Canadian County, Oklahoma, and is useful for correlation in this region. About four miles south of El Reno the fossils have not been found. Northward in Blaine County, the abundance of fossils diminishes rapidly in T. 15 N., R. 10 W., so that the remaining portion of the Altona Dolomite in Blaine County and areas northward resembles the Magpie Dolomite in this respect.

Shimer Gypsum Member

Cragin (1896, p. 27) gave the name Shimer Gypsum to the uppermost gypsum and underlying dolomite of the Cave Creek Formation. It was named for Shimer Township, Comanche County, Kansas. Gould (1902, p. 48) applied the name "Shimer" to the gypsum portion only and named the underlying dolomite the Altona Dolomite, stating that the Shimer Gypsum marks the top of the Blaine division. In the present paper, the name Shimer Gypsum Member is used to designate the gypsum above the Altona Dolo-

mite Bed, forming the topmost unit of the Blaine Formation, conformably overlain by the Dog Creek Shale. Evans (1931, p. 410-411) proposed the name "Lovedale gypsum" for what he considered a higher unit in the Blaine Formation of Harper County, Oklahoma, but later work by Norton (1939, p. 1794-1795) and by Myers (1959, p. 30-32) has shown that the Lovedale is the Shimer.

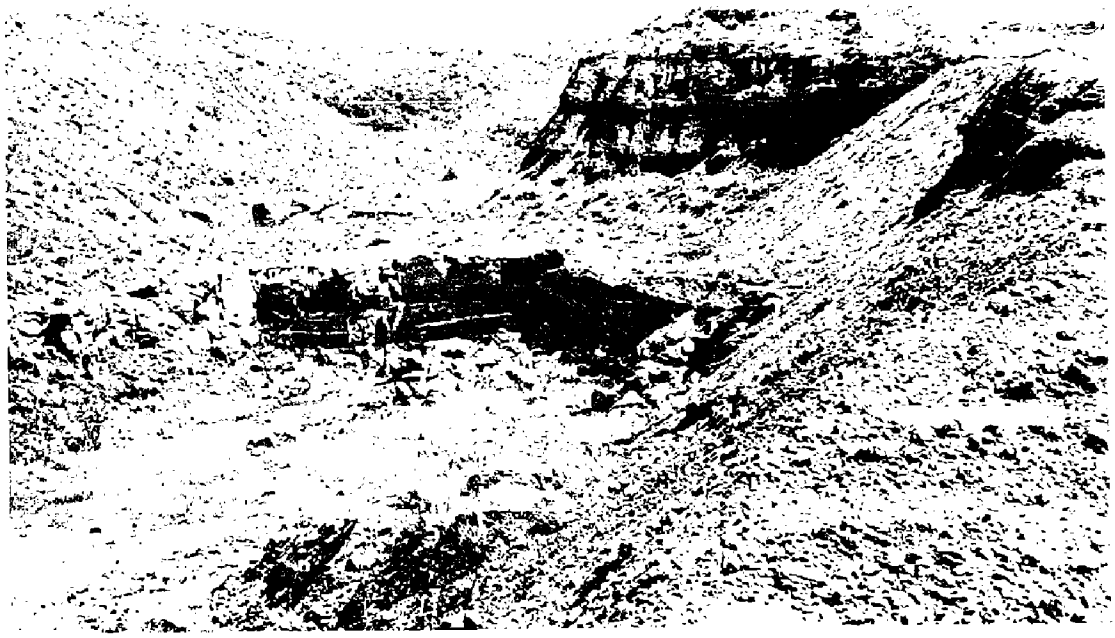
The type locality for the Shimer Gypsum Member is the old Shimer Township through which Cave Creek (now Sand Creek) flows, including Tps. 33, 34, 35 S., R. 17 W., Comanche County, Kansas.

The type section is on Cave Creek at Comanche Cave, in NE¼ NE¼ sec. 2, T. 34 S., R. 17 W., Comanche County, Kansas.

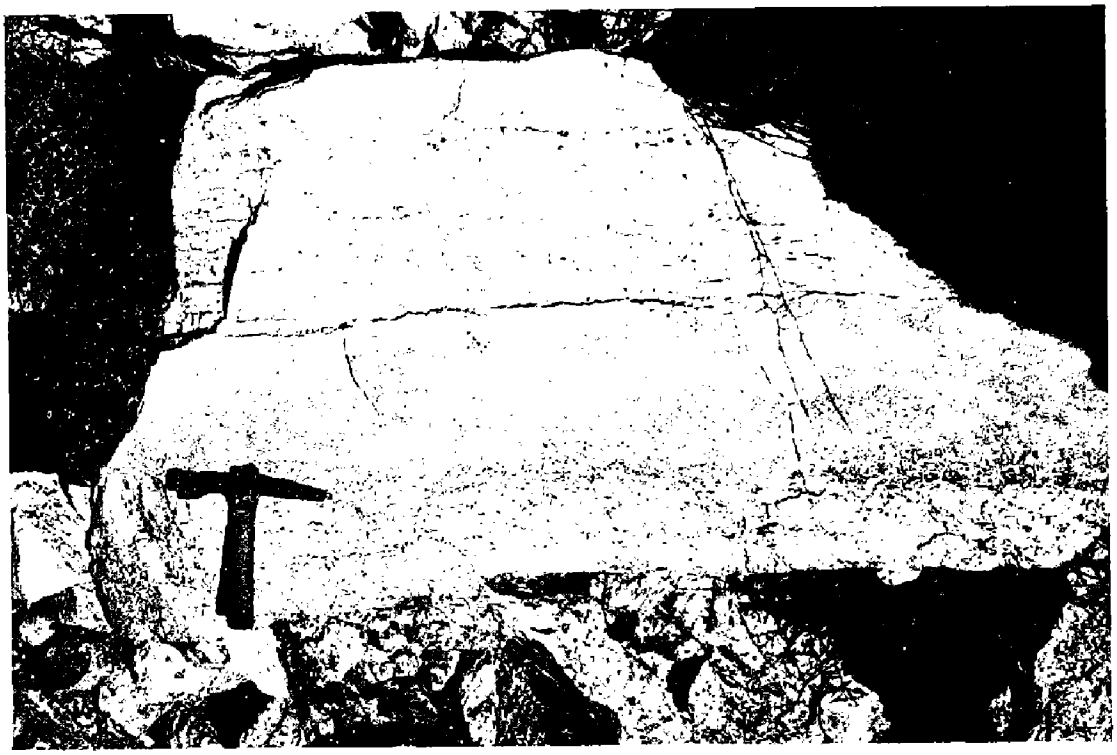
In Kansas the Shimer Gypsum is 14 feet thick on Cave Creek and is commonly much thinner, owing to excessive solution and erosion (pl. 8A). It is conformably overlain by the Dog Creek Shale and underlain by the Altona Dolomite. Northeastward in Barber County, Kansas, the Shimer grades into the Dog Creek Shale on Dog Creek, where only the Altona Dolomite Bed is present above the Medicine Lodge Gypsum and underlying Cedar Springs Dolomite. This is worthy of note because more than half of the beds in the type Dog Creek Shale on Dog Creek are equivalent to the type Blaine in Blaine County. The reason for this is that the Altona Dolomite had not been correlated by Cragin into the Dog Creek area, and as a result, the Dog Creek Shale was defined by Cragin as extending from the top of the Medicine Lodge Gypsum to the base of the Whitehorse Group (Marlow Formation). In the present work, the type Dog Creek Shale on Dog Creek (measured section 1) is emended to include only the beds above the Altona Dolomite Bed and below the Marlow Formation; the remaining portion below the Altona Dolomite Bed is included in the Blaine Formation.

In Blaine County the Shimer Gypsum is approximately 6 feet thick to the south and 16 to 21 feet thick to the north. Southward in Canadian County, the Shimer is about 4 feet thick and in central Canadian County it grades into reddish-brown silty clay shale. Northward toward Kansas, the Shimer maintains its thickness and finally grades into the type Dog Creek Shale of Barber County, Kansas.

The Shimer is a white, fine- to coarse-crystalline, compact to porous, massive gypsum that erodes into a massive white ledge



A. Shimer Gypsum in quarry showing thin anhydrite (light) lenses in middle. Lower portion of Dog Creek Shale exposed on right, capped by Haskew Bed, NW¼ SW¼ SW¼ sec. 10, T. 18 N., R. 12 W.



B. Anhydrite (gray) in Shimer Gypsum, measured section 18, SE¼ SW¼ SW¼ sec. 14, T. 18 N., R. 12 W.

PLATE 15

Shimer Gypsum, U. S. Gypsum quarry, Southard, Blaine County, Oklahoma

covered with coarse-crystalline selenite. It grades into the underlying Altona Dolomite (pl. 14B). The upper surface of the Shimer is wavy bedded with about 1 foot of relief and is everywhere conformable with the overlying Dog Creek Shale. The lower 20 to 35 feet of the Dog Creek contains a considerable amount of thick wavy-bedded satin spar layers, suggesting that sporadic deposition of gypsum continued for some time after the Shimer was deposited (pl. 15A).

Locally, in T. 17 N., Rs. 11, 12 W., in the Hitchcock-Roman Nose area, a 9-inch-thick bed of anhydrite is near the middle of the Shimer Gypsum. In the quarries at Southard, T. 18 N., R. 12 W., Blaine County, anhydrite is in the middle of the Shimer wherever 30 to 33 feet or more of natural overburden is present (pl. 15B). Otherwise, anhydrite is absent in the quarries and in the outcrops in that area. Muir (1934, p. 1308) reported a few irregular crystal fragments of anhydrite in the Shimer Gypsum of the Salt Creek canyon area.

It is not strange that thin massive lenticular gypsum beds are reported in the Dog Creek Shale. In northern Canadian County, Oklahoma, a 2-foot-thick unnamed gypsum occurs about 25 feet above the Altona Dolomite (SW¼ SW¼ sec. 20, T. 14 N., R. 8 W.), and in Harper and Woodward Counties, Oklahoma, a 4-foot-thick gypsum, named the Haskew Gypsum by Evans (1931, p. 411), is present about 4 feet above the top of the Shimer and has been included in the Blaine Formation in that area, but it is here included in the Dog Creek Shale (pl. 16).

In the subsurface of Blaine County (measured section 31) the Shimer comprises two thick anhydrite bodies with reddish-brown clay shale in the middle, showing southward gradation into shale and northward gradation into one anhydrite bed.

Distribution.—The Blaine Formation is present on the northeast flank of the Anadarko basin in central Canadian County, Kingfisher, Blaine, Major, Woodward, Harper, and Woods Counties, Oklahoma, ending in Comanche and Barber Counties, Kansas. Southward in Grady County, Oklahoma, the entire Blaine grades into the Chickasha Formation and only the Altona equivalent can be identified in northern Grady County.

Thickness.—In central Canadian County, Oklahoma, the Blaine Formation is approixmately 85 feet thick and is almost all reddish-

brown silty clay shale between the Altona Dolomite above and the Cedar Springs Dolomite at the base. In southern Blaine County, the Blaine is 90 feet thick; in central Blaine County, 100 feet thick; and in northern Blaine County, 75 feet thick (pl. 5A). In Kansas the Blaine is 60 feet thick on Cave Creek in Comanche County (pl. 8A) and 40 feet thick on Dog Creek, in Barber County.

The gypsum units are absent in central Canadian County and thicken to several feet in southern Blaine County. The Kingfisher Creek Bed then thins northward, whereas the other members thicken northward, reaching maximum development in Woodward County, where the Kingfisher Creek becomes insignificant. The Medicine Lodge Gypsum is well developed in Kansas, but the Nescatunga and Shimer thin northward and are absent in most of Barber County, Kansas. The intervening shale units are thin in Kansas and in Woods, Harper, Woodward, and Major Counties, Oklahoma, but they thicken markedly in Blaine County. Southward in central Canadian County, Oklahoma, where the gypsum units are thin or absent, the Blaine Formation is represented by reddish-brown clay shale for the greater part of the section.

Topography.—The gypsum units of the Blaine Formation form distinctive ledges that are resistant to erosion. These ledges extend the length of the outcrop of the Blaine Formation and form the Gypsum Hills of northwestern Oklahoma (pls. 5B, 6A, 8). The weakly resistant underlying Flowerpot Shale is eroded faster than the gypsum, thus leaving an escarpment that is several hundred feet high in places such as Salt Creek canyon (pl. 5A). In Blaine County, the top of this escarpment is almost 300 feet higher than the Cimarron River to the east, and if the overlying Dog Creek Shale is included, the escarpment is 400 feet higher than the Cimarron. Many salt and gypsum springs flow from this escarpment, the water probably coming from the sand and gravel of the overlying Pleistocene deposits and the gypsum and salt being supplied by the Dog Creek, Blaine, and Flowerpot Formations.

Many names have been applied to isolated buttes capped by the gypsums of the Blaine Formation, such as Henquenet's Butte in Salt Creek canyon and the Glass Mountains of central Major County. In Kansas and in Woods, Harper, and Woodward Counties, and in part of Major County, many gypsum units are thin or missing owing to excessive solution, leaving only the underlying dolomites to form

mappable escarpments. In Blaine County, slumping and solution are not so common. A rule-of-thumb used in the Southard area of Blaine County for judgment as to presence of gypsum is that if five feet or more of original overburden occurs above a gypsum, the gypsum is probably present in its entire thickness, but otherwise the gypsum may be cavernous and unworkable.

Structure.—Structure contours based upon elevations at the base of the Altona Dolomite Bed indicate that the Blaine Formation dips about 14 feet per mile to the southwest in Blaine County. Minor irregularities indicate the presence of broadly plunging noses with axes at right angles to the axis of the Anadarko basin. The structural information contained in this report is taken from Fay (1962).

Paleontology.—Fossils have been reported from the Magpie and Altona Dolomite Beds. *Permophorus albequus* (Beede) is the common clam in both dolomites. A specimen of an orthoceratite cephalopod was collected from the Altona Dolomite just west of the road in SE¼ sec. 16, T. 19 N., R. 12 W., northern Blaine County.

Clifton (1942, p. 688) listed names of some fossils which he collected from the Blaine Formation in Kingfisher and Blaine Counties, stating that they were collected from his "Acme member," which in Blaine County would probably be the Nescatunga Member and underlying Magpie Bed. Clifton had two collecting localities in this area: (1) SE¼ sec. 33, T. 15 N., R. 9 W., Kingfisher County, and (2) the common line between secs. 19 and 30, T. 16 N., R. 10 W., Blaine County. Clifton's description of the "Acme" as "fossiliferous enough that the trace of its surface expression is an attenuated series of fossil-bearing limestone outcrops" does not fit that of the Magpie for locality (1) but instead agrees with that of the Altona Dolomite. Both the Altona and Magpie crop out at Clifton's locality (2) where it is possible that he collected his fossils from the Magpie. He also stated that fossils occur in the gypsum but did not specify in which of his 14 collecting localities in Texas and Oklahoma he found them. The fossils listed by Clifton, with collecting localities for each, are as follows:

Wilkingia rothi (Newell) (1, 2)
Schizodus oklahomensis Beede? (1, 2)
Permophorus albequus (Beede) (1, 2)
Permophorus mexicanus (Girty) (2)
Perrinites hilli (Smith) (1, 2)

The oöliths present in the Cedar Springs, Magpie, and Altona Dolomite Beds may be algal in origin (pl. 12B). The center of each oölith is a fine-grained matrix of clay, silt, calcite, and dolomite, the latter predominating. The rim is a coarse-grained or coarser grained dolomite, circular to elliptical or elongate-elliptical, and commonly the rim of one oölith does not touch that of another adjacent to it. The matrix between oöliths is a mixture of fine-grained material and some coarse-grained dolomite. The form of these structures, without nuclei and radial structures, indicates that the oöliths were formed by secretions of blue-green algae. The algae probably secreted calcium carbonate which later was changed to dolomite.

Age and correlation.—Perrinites hilli (Smith), previously used as a marker for Leonardian strata, has been collected from the Word Formation, Glass Mountains, western Texas (Miller and Furnish, 1957, p. 1052). Equivalent members of the Blaine Formation in central Texas appear to grade into a limestone and dolomite sequence in the Midland basin to the west, and these carbonates contain fusulinids restricted to Guadalupean rocks. Therefore, the Blaine Formation is here considered to belong to the Guadalupean Series.

In Grady County a local 1-foot-thick gypsum bed, termed "Pocasset" by Davis (1955, p. 57), is here considered an equivalent of the Shimer Gypsum Member.

Origin and environment of deposition.—The interpretation of conditions under which the Blaine Formation was deposited is little different from that for the Flowerpot Shale. The same northern platform, central basin, and southern delta were present, receiving sediment from the Ozark dome and from the Ouachita and Arbuckle Mountains systems. The southern delta was probably receding from central Canadian County, Oklahoma, during Cedar Springs time to northern Grady County during Altona and Shimer time. The central basin probably continued to sink at a rate about twice that of the margins. The northern platform contained the same sediments and evaporites as the central basin, except that in Kansas, after the time of deposition of the Medicine Lodge Gypsum, the conditions evidently were favorable for deposition of clays and silts, but not of evaporites.

Regular repetition of deposits of the Blaine Formation takes place from greenish-gray clay shale to oölitic dolomite to gypsum to reddish-brown shale (ascending) from the basal Cedar Springs Bed

to greenish-gray shale just below the Magpie Dolomite Bed. This sequence is repeated up to the greenish-gray shale at the base of the Altona Dolomite, and again up through the reddish-brown shale above the Shimer Gypsum, included in the Dog Creek Shale. The following explanation is offered for this sequence.

The sea water must have been highly saline, with 80 to 90 percent evaporation taking place in the Anadarko basin. The marginal areas, such as the Ozark dome and Ouachita Mountains, probably supplied clay, fine silt, and iron minerals, but in small quantity, because the delta was evidently back-filling southward, and little sand is present in the Blaine Formation. The western part of the Wichita Mountains and the Amarillo mountains are overlapped by Hennessey and higher redbeds and therefore were below sea level during El Reno time. The sea water must have had gentle currents, as evidenced by ripple marks in the dolomites, and the water must have been relatively shallow over the entire Anadarko basin, as evidenced by widespread, thin oölitic dolomites. At the time marine animals lived in the inland sea, the sea water must have been of normal salinity; thus the dolomites of the Blaine with their contained fossils must have been formed under normal saline conditions. Conditions could have become favorable for blue-green algae to live, and these plants may have secreted oölithic structures, composed of concentric bands of calcium carbonate. The magnesium in the sea water later could have replaced some calcium ions to form dolomite (Pettijohn, 1949, p. 75-76, 308-309). With increasing salinity, more calcium carbonate was probably precipitated from solution, in addition to that secreted by the algae, until almost 80 percent evaporation took place. The algae died and calcium sulphate was deposited. A period of extreme quiescence must have prevailed, during which the sea brought in vast quantities of calcium sulphate and the sea water was five times normal salinity, allowing the gypsum to build up to a thickness of 30 feet in places. The center of the Permian basin was probably in the region of the Midland basin (Hills, 1942, fig. 5), with outlet to the south in Mexico. With continued inflow of sea water, the dense saline portion probably sank toward the bottom and the lighter less saline portion plus fresh water derived from land probably flowed southward with surface currents. A rise in sea level, therefore, could have occurred when gypsum was being deposited, as postulated by Ham (1960), furnishing a contin-

ual supply of ions of calcium carbonate and calcium sulphate, in addition to chlorides and bitterns. At the time that gypsum was being deposited, the clastic material from the Ozark, Ouachita, and Arbuckle Mountains must have been maintained at a minimum. Therefore these landmasses must have been low; rainfall, extremely low; and evaporation, high.

Then conditions must have been reversed; outflow of the sea water must have exceeded inflow, and rainfall must have begun to increase and evaporation to decrease, thus lowering the salinity of the sea water and increasing the competence of the eastern streams so that they could carry more clay and silt, allowing the reddish-brown clay shale to be deposited above the gypsum. With inflow of new sea water and decreasing rainfall on the eastern landmasses, the greenish-gray shale of the next cycle probably began to be deposited, succeeded by deposition of the Magpie and the overlying Nescatunga Member, and ended with deposition of a reddish-brown clay shale. This cycle would be repeated for the same reasons during Altona and Shimer time.

Thus the conditions of deposition of the Blaine Formation seem to be alternating rise and fall of sea level, perhaps accompanied by dry periods alternating with wet periods. Evaporites were probably deposited when the sea came in and the climate was arid, and clastics were probably deposited when the sea regressed and the climate was humid. Concurrently the central basin was sinking at a rate about twice that of the margins.

DOG CREEK SHALE

Name.—The name "Dog Creek shales" was used by Cragin (1896, p. 39-40) for a series of shales and thin dolomites and siltstones between the Cave Creek (now Blaine) formation, below, and the Red Bluff beds (now Whitehorse Group), above. It is named from Dog Creek, northwestern Barber County, Kansas. As used in this report, the type Dog Creek section (measured section 1) has to be emended, because Cragin actually defined the Dog Creek as extending from the top of the Medicine Lodge Gypsum Member of the Blaine Formation to the base of the Red Bluff (now Marlow) beds. The Altona Dolomite Bed at the top of the Blaine Formation actually separates the type Dog Creek section into two almost equal parts, and therefore at least the lower half of the type Dog Creek beds on

Dog Creek is a Blaine equivalent. The Dog Creek, as used here, is emended to include only those beds between the Altona Dolomite at the base and the Marlow Formation at the top, which have a total thickness of approximately 30 feet.

The Dog Creek Shale conformably overlies the Shimer Gypsum (or Altona Dolomite where the Shimer is absent) of the Blaine Formation and is conformably overlain by the Marlow Formation.

Type locality.—The type locality for the Dog Creek Shale is south of Lake City, in secs. 4, 9, T. 32 S., R. 14 W., Barber County, Kansas.

Type section.—The type section, here designated, is in N½ N½ sec. 9, T. 32 S., R. 14 W., along U. S. Highway 160, described in this report (measured section 1).

Description and stratigraphic relations.—In Blaine County, the reddish-brown blocky clay shale of the Dog Creek is divisible into several distinct mappable units. Each portion is thicker to the south, where the total thickness is about 190 feet (240 feet in the subsurface about 20 miles westward) and thinner northward in Kansas, where the Dog Creek is 30 feet thick. Two thin dolomites occur in the lower 80 feet of the Dog Creek in Blaine County and are named the Watonga Dolomite Bed (30-35 feet above the base) and the Southard Dolomite Bed (80 feet above the base). The Haskew Gypsum Bed is just below the Watonga Dolomite Bed. Several other thin persistent beds of dolomite, siltstone, and greenish-gray shale can be correlated in the Dog Creek Shale, and these are designated as Units A, B, C, D, E, F, and G (ascending). Some of these units and beds (Watonga, Southard, Units A, B, C, D) can be correlated into the type section in Kansas.

The lower part of the Dog Creek Shale below the base of the Watonga Dolomite is divisible into two contrasting units, a lower reddish-brown gypsiferous shale and a thin upper light-brown indurated gypsiferous siltstone named the Haskew Gypsum Bed (pls. 15A, 16). The lower shale unit is characterized by the presence of numerous thin to thick wavy-bedded satin spar layers throughout and a few greenish-gray thin beds of clay shale or calcareous siltstone. A locally developed 1-foot-thick bed of greenish-gray silty dolomitic gypsum and clay shale that is well indurated occurs as a resistant ledge several feet above the base. The lower shale unit is approximately 50 feet thick in Canadian County, where it extends

from the Altona Dolomite, below, to the Watonga Dolomite (pl. 17A), above. In this same area a 2-foot-thick gypsum bed occurs about 25 feet above the base with a thin dolomite at top, forming a local escarpment in SW¼ SW¼ sec. 20, T. 14 N., R. 8 W. (pl. 17B). In southern Blaine County, this shale unit is about 36 feet thick where the underlying Shimer Member and overlying Haskew Bed are first noticeable (pl. 18A). The lower shale unit is thinner northward until in Kansas it is only 5 or 6 feet thick. The clay minerals comprising this and other shales of the Dog Creek are mainly illite and chlorite.

Haskew Gypsum Bed

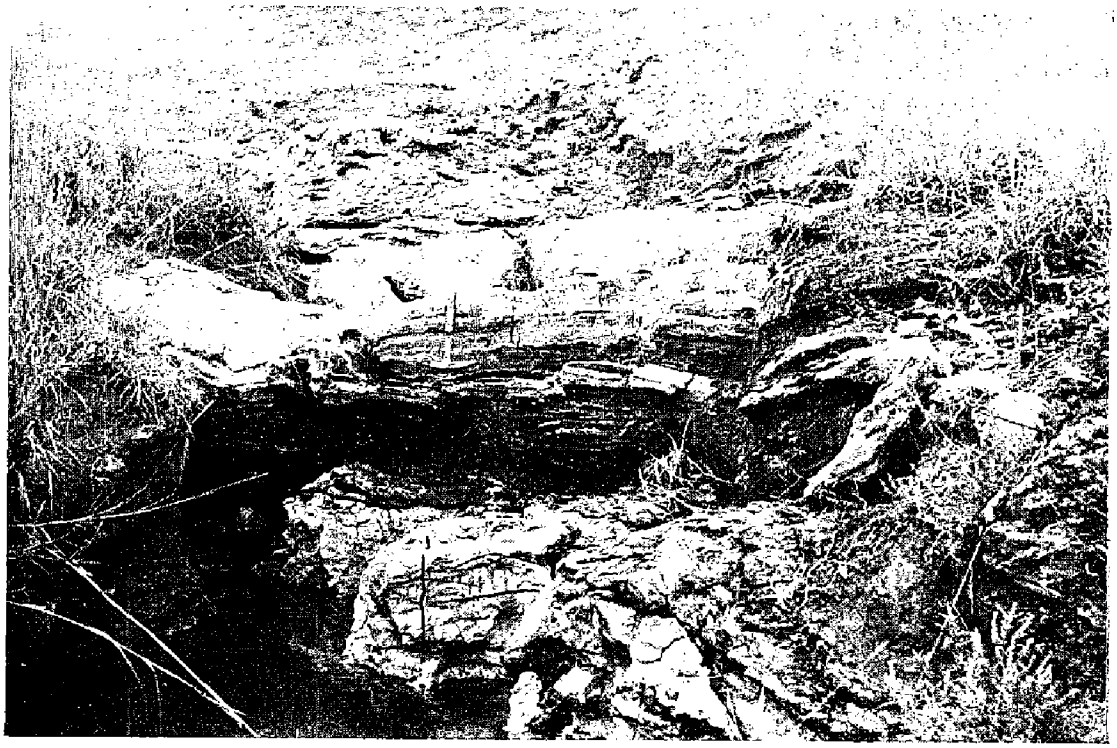
The Haskew Gypsum Bed was named Haskew gypsum member by Evans (1931, p. 411), for an abandoned store at NE cor. sec. 2, T. 25 N., R. 19 W., Woodward County, Oklahoma. Evans applied the name to a thin gypsum unit about 4 feet thick occurring some 4 feet above the Shimer Gypsum Member, well exposed in Woodward and Harper Counties, Oklahoma (pl. 16A). In this region it has been considered as the top member of the Blaine Formation.

The type locality for the Haskew is T. 25 N., R. 19 W., and surrounding area of Woodward and Harper Counties, Oklahoma.

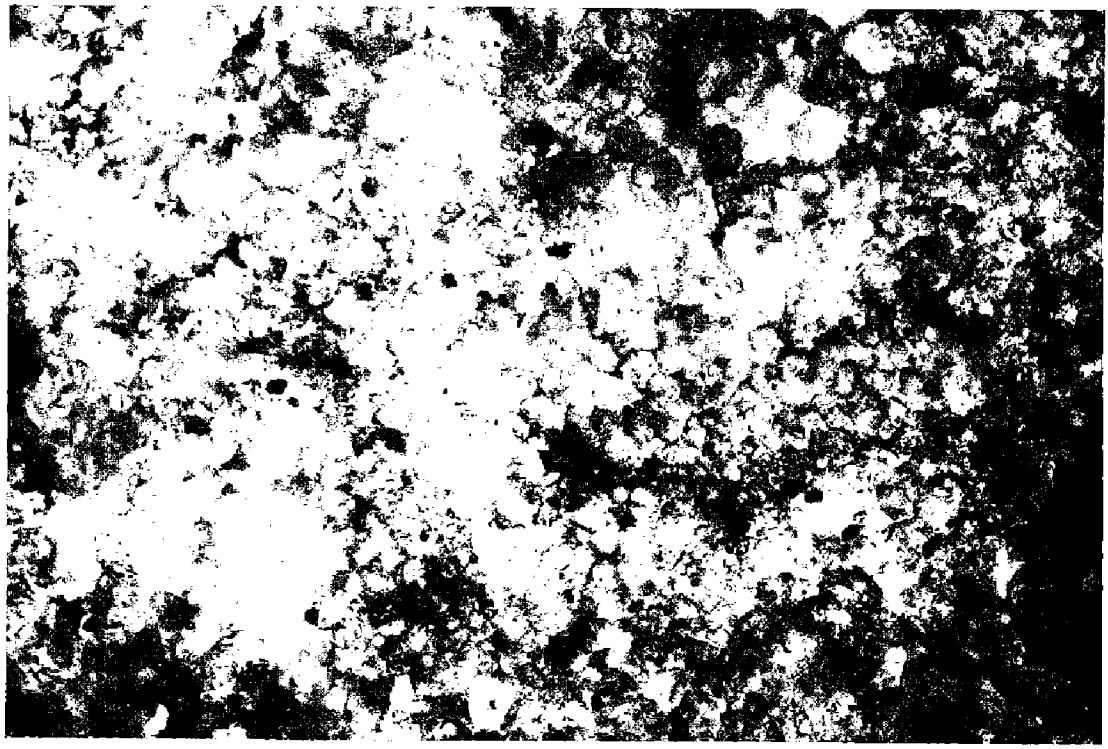
The type section is the exposure in SW¼ sec. 6, T. 25 N., R. 18 W., about 800 feet east and 200 feet north of the southwest corner of sec. 6 where about 53 feet of the Dog Creek Shale is exposed (pl. 16A; measured section 10).

The Haskew Gypsum Bed, at the type section, is divisible into four distinct units. The upper 0.5 foot is a massive wavy-bedded gypsum that weathers a reddish-orange color. Beneath this gypsum is a reddish-brown siltstone that is gypsiferous and thinly laminated, about 0.8 foot thick. A reddish-brown blocky shale is present below the siltstone and is 0.75 foot thick. The basal unit of the Haskew is a white fine-grained ledge that forms a mappable escarpment and is about 2.75 feet thick. Beneath the Haskew is a 4.5-foot-thick reddish-brown blocky clay shale resting upon the Shimer Gypsum. The top of the Haskew is about 42 feet below the base of the Marlow Formation.

In Blaine County the Haskew is considered to be a light-brown well-indurated gypsiferous siltstone, about 25 to 30 feet above the



A. Haskew Gypsum, type locality. Hammer rests upon middle gypsiferous siltstone and shale bed, SW¼ SW¼ SW¼ sec. 6, T. 25 N., R. 18 W., measured section 10, Woodward County.



B. Photomicrograph of Haskew Bed, x125, showing silt grains in gypsiferous matrix, measured section 15, Major County.

PLATE 16

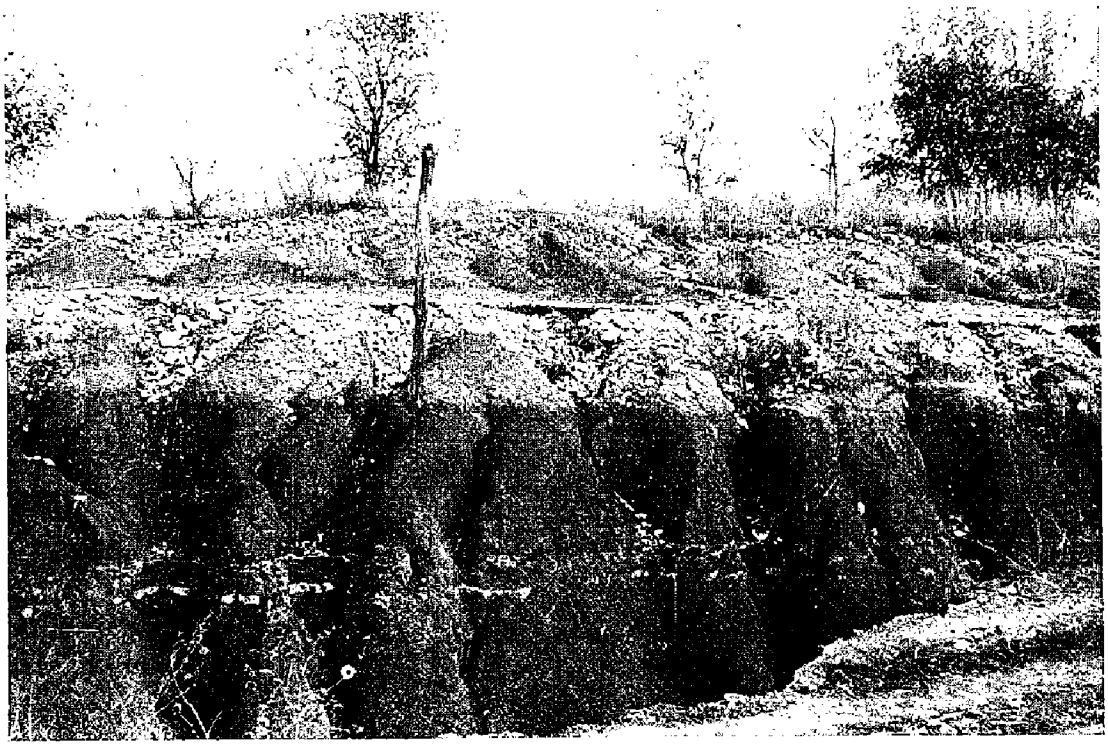
Haskew Gypsum, Woodward and Major Counties, Oklahoma

base of the Dog Creek, interbedded with some reddish-brown and greenish-gray clay shale layers (pls. 16B, 18A). It forms a resistant ledge and mappable escarpment, and is overlain by shale, siltstone, and dolomite of the Watonga Dolomite Bed. In southern Blaine County a thin greenish-gray to reddish-brown dolomitic and gypsiferous clay shale 2 or 3 feet thick is between the Haskew and Watonga Beds, but in northern Blaine County the Watonga rests directly upon the Haskew. In most places the overlying shale and interbedded dolomites at the top of the Haskew are included within the basal portion of the Watonga Dolomite. The Haskew Siltstone is 3 to 6 feet thick in Blaine County, becomes thinner and appears to be traceable into purer gypsum in Major County, and is about 4 feet thick and is almost pure gypsum in Woodward and Harper Counties. In Woods County it is developed along West Moccasin Creek but is absent northward into Kansas. From Major County northward, the overlying Watonga Dolomite grades into siltstone and sandstone, a thin dolomite being present in places, only a few inches thick or less. The intervening beds between the Watonga and Haskew range from 4 to 10 feet in thickness and consist principally of reddish-brown shale with some greenish-gray siltstone. The Haskew is absent at Dog Creek, Kansas, but the Watonga is present, overlying about 5 feet of reddish-brown clay shale. The Haskew Gypsum grades into this shale.

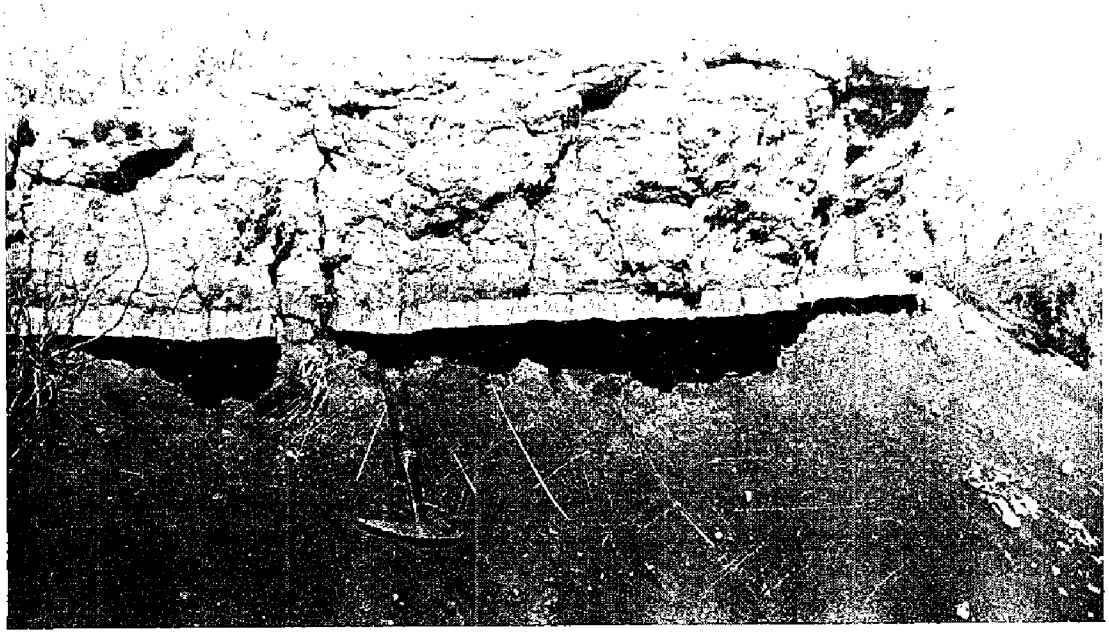
Watonga Dolomite Bed

The name Watonga Dolomite Bed was given to the 3- to 7-foot unit of thin-bedded dolomite and underlying interbedded dolomitic shales and siltstones in the lower portion of the Dog Creek Shale, about 25 to 40 feet above the top of the Shimer Gypsum (Fay, 1962). It is named for the town of Watonga, Blaine County, Oklahoma, east of which excellent exposures of the dolomite are present on State Highway 33 (pl. 18). Cragin (1897, p. 353-354, 358) used the name Amphitheatre dolomite for this same unit, with Chapman's Amphitheatre at the head of Salt Creek canyon in Blaine County as the type locality, but the name fell into disuse because neither illustrations nor measurements were given.

The area east and northeast of Watonga, Blaine County, in T. 16 N., Rs. 10, 11 W., is the type locality.



A. Watonga Dolomite, measured section 25.



B. Stray unnamed gypsum 21 to 23 feet below Watonga Dolomite, measured section 26.

PLATE 17

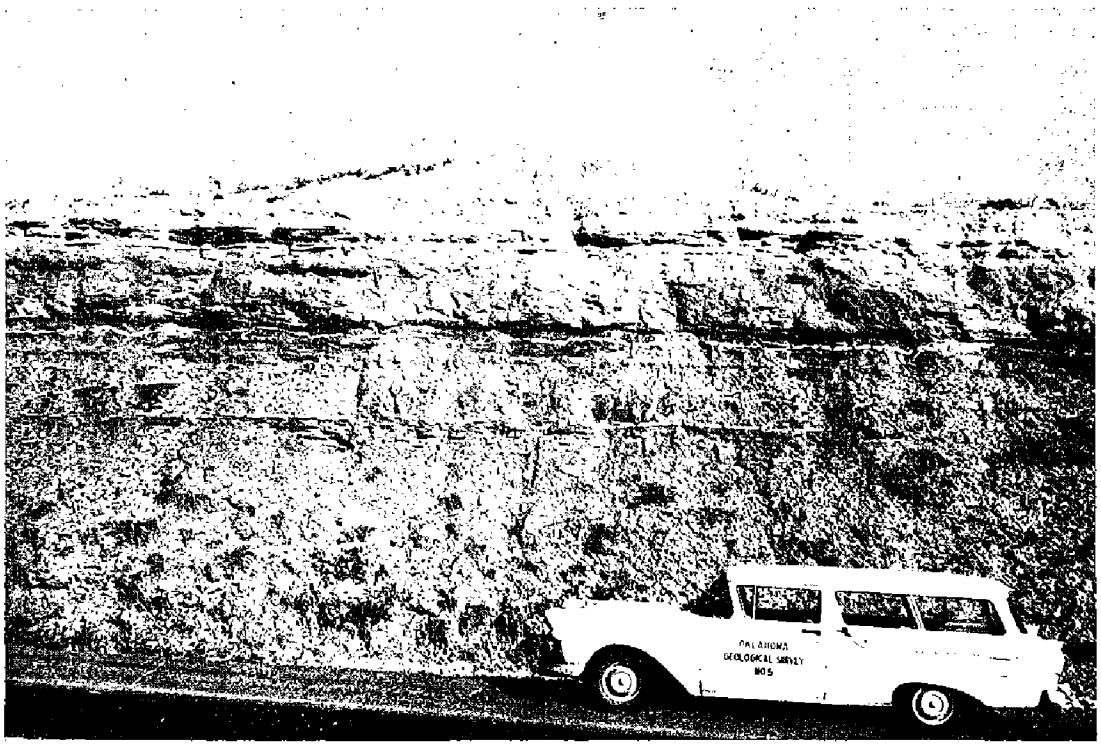
Watonga Dolomite and unnamed gypsum, Canadian County, Oklahoma

The section on State Highway 33, about seven miles east of Watonga, in SW¼ SW¼ sec. 19, T. 16 N., R. 10 W., and SE¼ SE¼ sec. 24, T. 16 N., R. 11 W., Blaine County, is the type section (pl. 1; measured section 23).

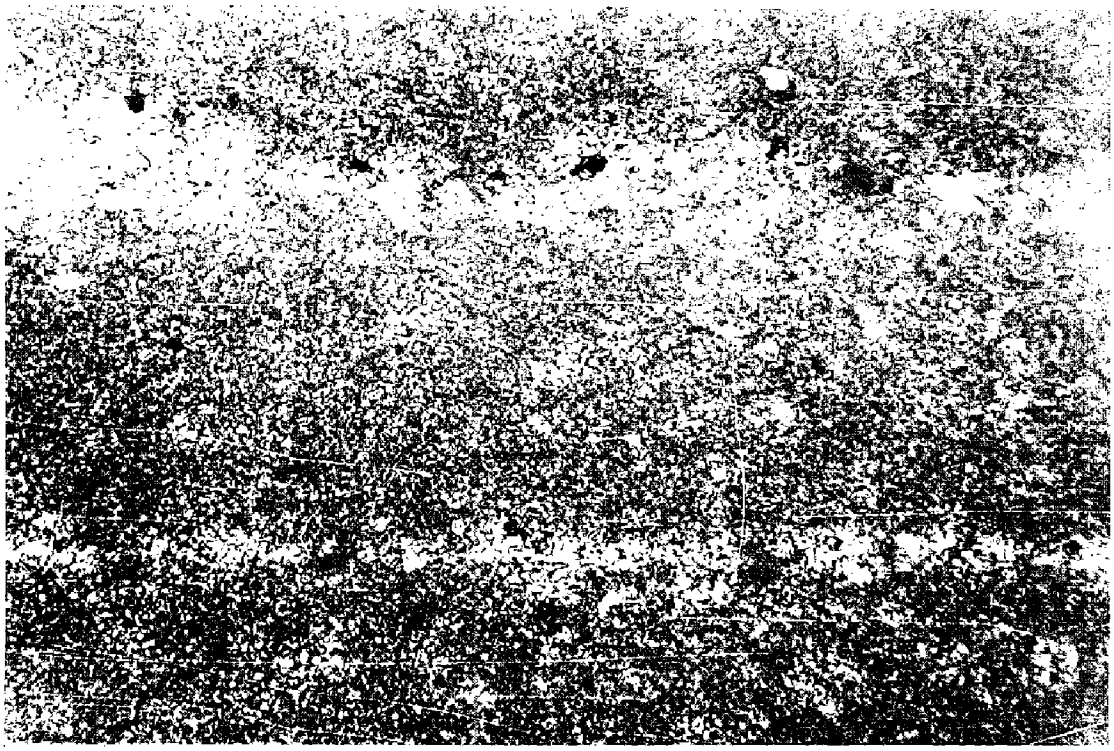
In Blaine County, the Watonga Dolomite consists of many thin beds of light bluish-gray fine-grained to compact dolomite with vuggy laminae interbedded with light bluish-gray to moderate reddish-brown blocky vuggy dolomitic shale and siltstone that are weakly indurated (pls. 17A; 18). It erodes into a light bluish-gray ledge together with the underlying Haskew Gypsum Bed. The lower 2 or 3 feet of the Watonga is interbedded with the shale and siltstone characteristic of the Haskew, the line of demarcation being drawn at the top of the massive portion of the underlying siltstone or where the first dolomitic shale or dolomite occurs at the base of the Watonga. The upper boundary of the Watonga is drawn at the contact with the overlying reddish-brown shale. Thin dolomites occur in the lower several feet of the overlying shale in central and southern Blaine County, but these are different in color (grayish white to orange brown) from the Watonga and are not included with the Watonga.

As defined above, the Watonga Dolomite is 3 to 7 feet thick in Blaine County, with more interbedded shale at its base to the south and less to the north. Southward in Canadian County, the Watonga is a thin greenish-gray and reddish-brown argillaceous dolomite, about 0.5 foot thick, overlain by reddish-brown shale and stray pinkish crinkly dolomites and underlain by reddish-brown shale. Northward toward Kansas the Watonga is a thin greenish-gray dolomite or dolomitic siltstone in Major, Woodward, Harper, and Woods Counties, grading into a ripple-marked sandstone in Kansas. In these areas it is several inches to 2 feet thick, in places it does not form a mappable escarpment, and it may be covered.

The overlying reddish-brown shale unit is about 45 feet thick and is divisible into several zones in northern Blaine County. These zones are absent in southern Blaine County, where the entire 45 feet is principally reddish-brown clay shale, with a few thin local dolomites in the basal portion. In northern Blaine County there is a light-brown to moderate reddish-brown siltstone, termed Unit A, about 4 feet thick and occurring about 6 feet above the Watonga Dolomite. The next overlying 35 feet of shale contains three thin



A. Watonga Dolomite, type locality along State Highway 33. Massive siltstone below is Haskew remnant. View toward north.



B. Photomicrograph of above dolomite, x125, showing two laminations of clear dolomite giving laminated appearance to rock.

PLATE 18

Watonga Dolomite, measured section 23, type locality, Blaine County, Oklahoma

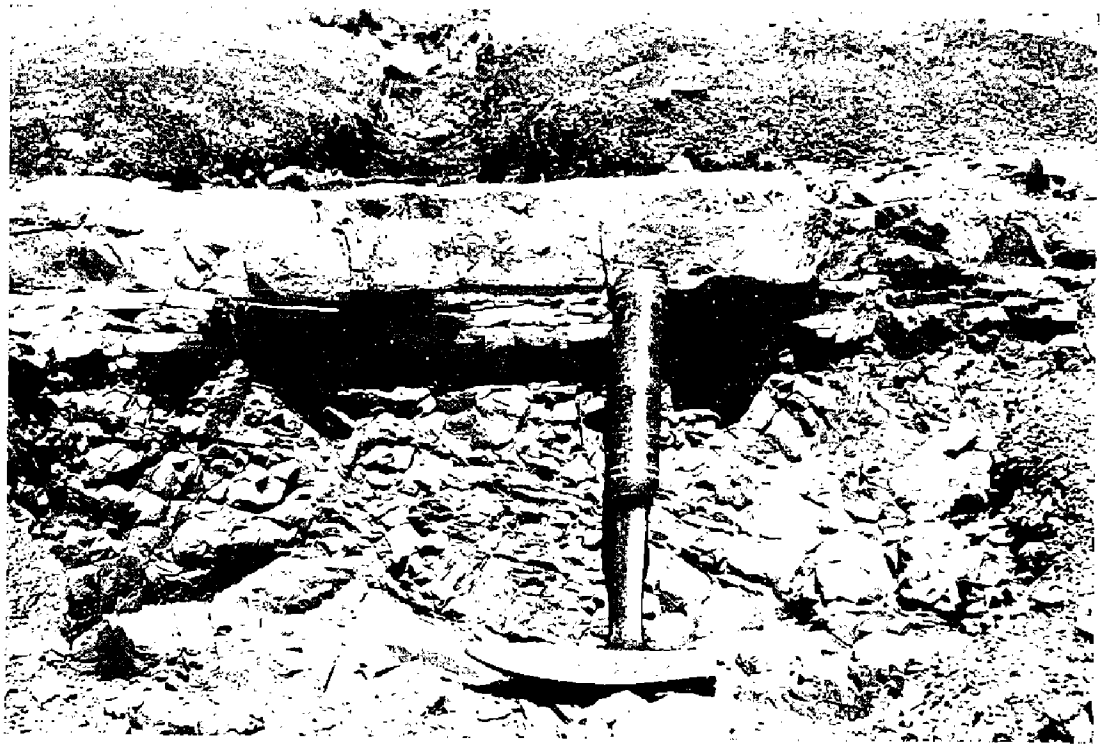
greenish-gray shale or siltstone beds, each about 1 foot thick, spaced 6 to 8 feet apart, the basal one occurring several feet above Unit A. These greenish-gray beds are local, extending into Major County. At the top is a greenish-gray shale or siltstone that locally contains stringers of dolomite and is here termed Unit B. This unit is present in southern Blaine County and persists to Kansas. Unit A forms a siltstone or sandstone escarpment in many places from Major County to Kansas and has been mistaken for the Marlow in some places where it is 10 feet thick, as in Woodward County, where it reaches its maximum thickness. It contains gypsum in northern Woods County and is only 2 feet thick in Kansas.

Unit B and the overlying Southard Dolomite Bed form one of the more persistent units of the Dog Creek Shale in Major, Woodward, Harper, and Woods Counties, Oklahoma, and can be found in almost all outcrops. In Major County these light bluish-gray units form an escarpment. In Kansas the Watonga Dolomite Bed and underlying siltstone (having graded into a sandstone) form a similar light bluish-gray escarpment that could easily be mistaken for the Southard escarpment, but no dolomite occurs in the Watonga in Kansas nor in northern Woods County, Oklahoma.

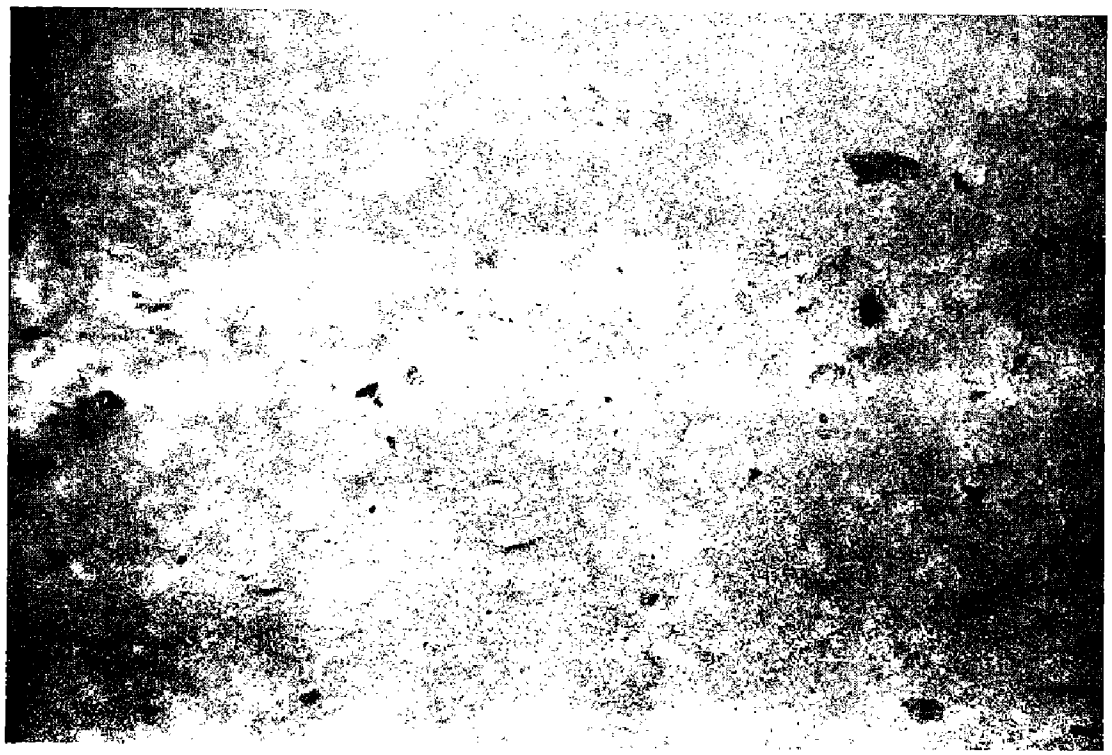
The interval between the Watonga and Southard Dolomites in Blaine County is 45 feet and in Kansas is about 10 to 14 feet, with marked thinning from northern Major County northward. Units A and B reach their maximum thickness and minimum average phi grain size in Woodward County and thin northward and southward from there. Therefore, the silt and sand in these units must have been derived from an eastern source, probably the Ozark dome.

Southard Dolomite Bed

The name Southard Dolomite Bed was given to a 3- to 4-inch light-gray dense fine-grained thinly laminated dolomite with salt casts that occurs about 80 feet above the base of the Dog Creek Shale, or 45 feet above the Watonga Dolomite, in northern and central Blaine County (Fay, 1962). It was named for the town of Southard in north-central Blaine County, south of which it crops out on State Highway 51A (pl. 19). Cragin (1897, p. 353-354, 358) applied the name "Chapman dolomite" to this same bed and a few higher dolomites in the same area, designating Chapman's Amphitheatre of the



A. Southard Dolomite, type locality south of Southard. View toward east.



B. Photomicrograph of above dolomite, x125, showing a clear dolomite lamination in fine-grained matrix of dolomite, silt, and clay.

PLATE 19

Southard Dolomite, measured section 18, type locality, Blaine County, Oklahoma

Salt Creek canyon area as the type locality. The name fell into disuse because Cragin failed to give measured sections or to map and describe the unit.

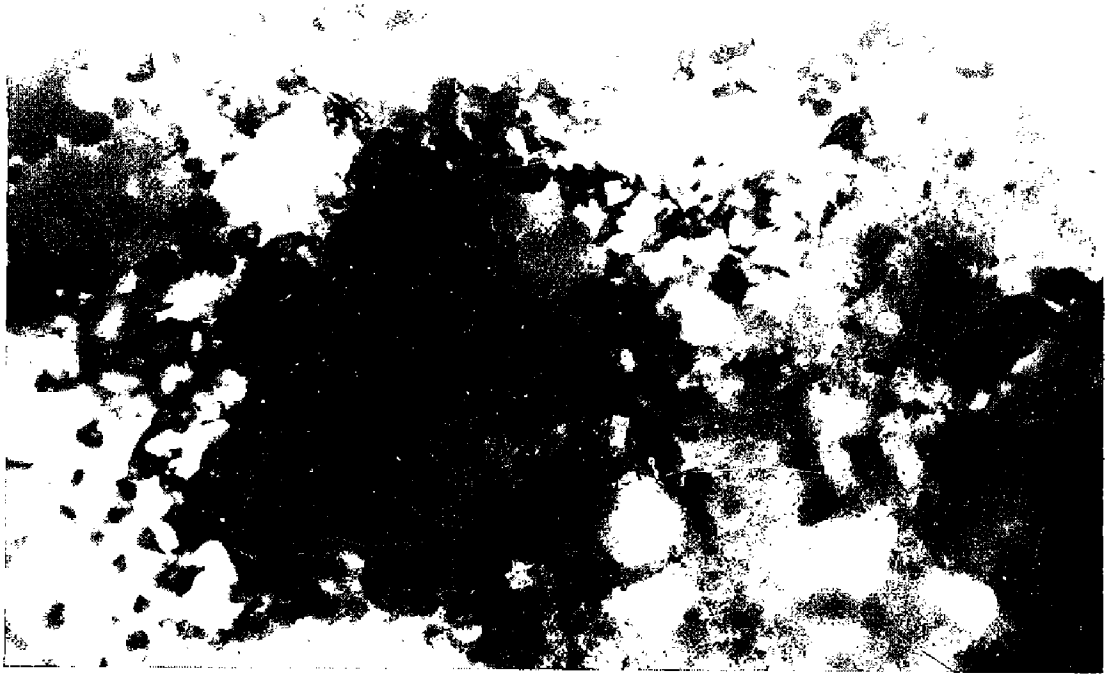
The type locality is the Southard area, Tps. 18, 19 N., R. 12 W., north-central Blaine County.

The type section for the Southard Dolomite Bed is on State Highway 51A in SW¼ SW¼ sec. 10, T. 18 N., R. 12 W., one mile south of Southard, northern Blaine County, and is described in measured section 18.

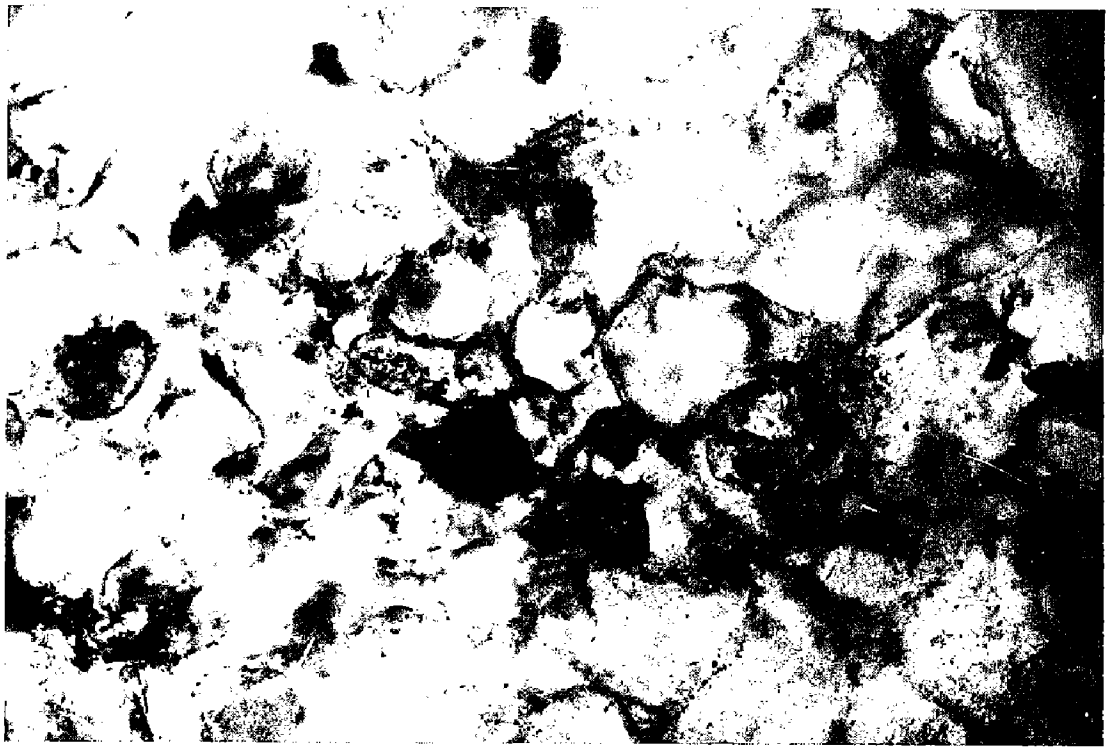
In Blaine County the Southard Dolomite is a yellowish-gray to light-gray fine-grained compact silty laminated dolomite with salt casts and scattered dark-black specks, eroding into a massive ledge forming a mappable escarpment. It is 4 inches thick at the type section and overlies Unit B, which is a greenish-gray clay shale and siltstone. In Major County this unit forms a mappable escarpment that divides the Dog Creek into almost equal halves and appears as a light bluish-gray ledge. The Southard and Unit B persist to northern Woods County where they are a few inches thick; in Kansas they are represented by greenish-gray and very dark-red dolomitic siltstone that occurs about 8 feet below the base of the Marlow Formation (sandstone) and 13 feet above the top of the Watonga Bed. In Blaine County the Southard is about 80 feet above the base of the Dog Creek, or 45 feet above the top of the Watonga Bed, and 80 to 100 feet below the base of the Marlow Sandstone. The southernmost exposure of the Southard Dolomite is that in and south of the town of Greenfield, sec. 4, T. 15 N., R. 11 W., southern Blaine County, south and west of State Highway 8. In this area the Southard is approximately 105 feet below the base of the Marlow Formation.

Upper Part of Dog Creek Shale

Several dolomites similar to the Southard occur 11 to 15 feet above the Southard in Blaine and southern Major Counties, and 5 to 8 feet above the Southard in Woodward, Harper, and Woods Counties, Oklahoma. These are lettered as Units C, D, and E in the measured sections. They do not have a thick greenish-gray siltstone at their bases and by this character can be distinguished from the Southard Dolomite. Many thin siltstones or fine-grained sandstones occur above these dolomites in the next 30 feet of section in



A. Dog Creek siltstone, 15 feet above Southard Dolomite, showing bimodal distribution of grains and poor sorting, measured section 15, Major County.



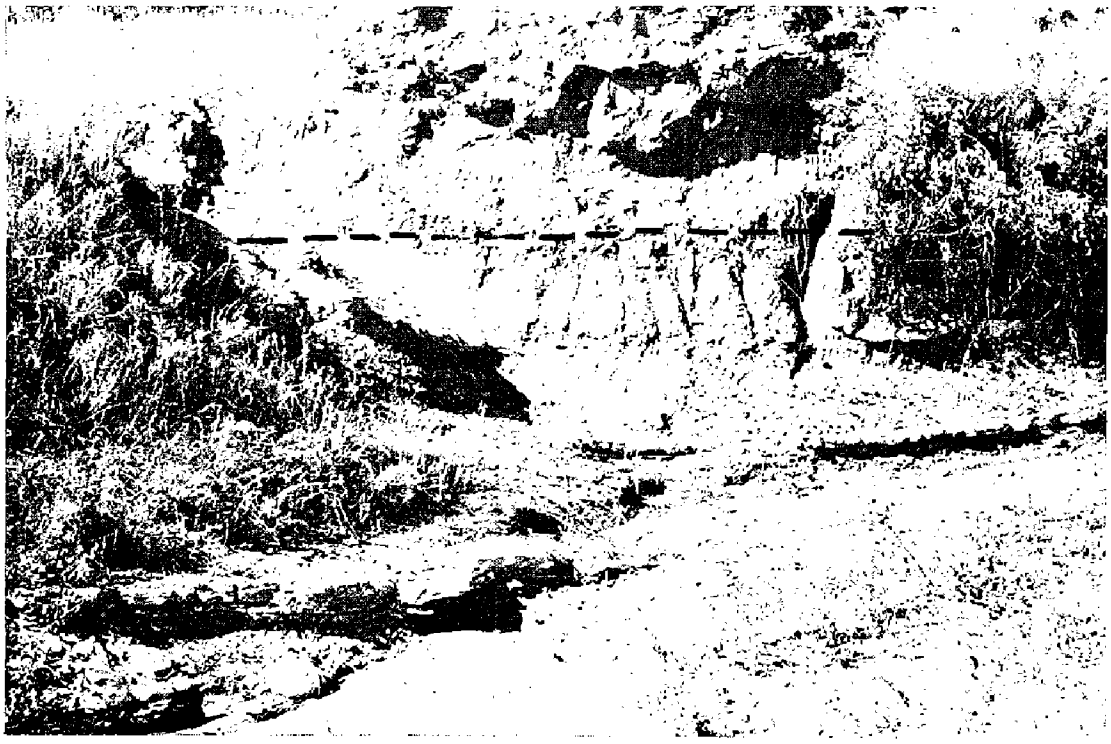
B. Dog Creek siltstone and sandstone Unit A showing large quartz grains in fine matrix of calcite, gypsum, silt, and clay, with hematite stains, measured section 12, Ewers Creek, Woodward County.

PLATE 20

Photomicrographs of Dog Creek siltstone, x125, Major and Woodward Counties, Oklahoma

southern Major County and apparently are confined to the northern platform (pl. 20A). Two of these beds are lettered as Units E and F. A few feet above this group of beds is a fine-grained greenish-gray and dark reddish-brown dolomite (Unit G) that forms a minor escarpment in southern Major County and may be traced northward into Woodward County, where it is probably a dark-red dolomitic shale. Many of these fine-grained dolomites have salt casts and form resistant light-colored ledges (pl. 21). In southern Major County the next overlying 35 feet of beds is primarily reddish-brown clay shale, but northward in Woods County, siltstones of the Marlow type are present. The siltstones and sandstones of the northern platform are lithologically and mineralogically similar to those of the Marlow Formation (pls. 20B, 21). The clay minerals in all these units are illite and chlorite.

The upper contact of the Dog Creek Shale is marked by a greenish-gray sandstone in the base of the Marlow Formation, which rests upon reddish-brown clay shale of the Dog Creek (pl. 21A) and forms a pronounced escarpment (pl. 22A). In Grady County (measured sections 28, 29) many small chert granules are present in this sandstone. In Blaine County, shale and siltstone are interbedded with the sandstone just above the greenish-gray sandstone (pl. 22B). In northwestern Woodward County and Harper County, Oklahoma, and in Comanche County, Kansas, the basal 2 to 27 feet of the Marlow is interbedded with gypsum and in many places is a pure-white to pinkish-white gypsum bed (pl. 23A). Large rounded frosted white quartz grains are abundant in the basal Marlow beds (pl. 23B). In Woods County, Oklahoma, at Whitehorse Springs, the type Whitehorse consists of several feet of reddish-brown algal dolomite and sandy limestone with approximately 40 percent large rounded quartz sand grains, averaging 1.5 phi (0.35 mm) in diameter, resting upon reddish-brown clay shale of the Dog Creek (pl. 24). The Marlow rests upon mudstone conglomerate, siltstone, and sandstone of the Chickasha Formation from central Grady County southward and upon reddish-brown clay shale from this area northward into Kansas. The Dog Creek Shale is here considered conformable with the overlying Marlow Formation. Evidence of lateral gradation or of an unconformity at the Marlow-Dog Creek boundary is lacking and in most places the contact between these two formations is sharp. The best evidence for an unconformity at the base of the Marlow Formation is that given by Davis (1955, p. 53, 67), who



A. Contact (dashed) between Marlow Formation and Dog Creek Shale, with Southard Dolomite in foreground, SE¼ NE¼ sec. 36, T. 28 N., R. 19 W.

B. Sandstone Unit A below Southard Dolomite (S), with stray dolomites above, SE¼ SW¼ NW¼ sec. 31, T. 28 N., R. 18 W.

PLATE 21

Dog Creek-Marlow contact and sandstone Unit A of Dog Creek below Southard Dolomite, measured section 8, Woods County, Oklahoma

stated that the Chickasha-Duncan complex is less than 200 feet thick in T. 2 N., R. 6 W., Stephens County, and 600 feet thick in sec. 31, T. 5 N., R. 8 W., Grady County, Oklahoma. This southeastward thinning is probably due to deposition over a southern marginal shelf. The deltaic deposits are thicker northward in the central basin where they interfinger with the Dog Creek Shale in central and northern Grady County.

Distribution.—The Dog Creek Shale extends from northern Grady County, Oklahoma, through Canadian, Blaine, Major, Woodward, Harper, and Woods Counties, Oklahoma, into Comanche and Barber Counties, Kansas.

Thickness.—At the type locality in Kansas the Dog Creek Shale is 30 feet thick, with the Watonga and Southard Dolomite Beds occurring about 6 and 22 feet above the base, respectively. At Whitehorse Springs in Woods County, the Dog Creek is 62 feet thick, and the Watonga and Southard Beds are present about 7 and 37 feet above the base, respectively. In southern Major County the Dog Creek is 157 feet thick, and the Watonga and Southard Beds occur 26 and 75 feet above the base, respectively. In southern Blaine County the Dog Creek is 195 feet thick, and the Watonga and Southard Beds occur 45 and 90 feet above the base, respectively. In the subsurface of Blaine County, about 20 miles west of the outcrop, the Dog Creek is about 240 feet thick, and the Watonga and Southard Beds occur about 65 and 145 feet above the base, respectively. In Grady County, the Chickasha-Duncan complex is approximately 710 feet thick, which is the same as the total thickness of the Flowerpot, Blaine, and Dog Creek Shale, and accordingly the upper 200 feet of the Chickasha Formation is here considered to be equivalent to the Dog Creek, into which it grades. In Stephens County, the Chickasha-Duncan complex is only 200 feet thick, and probably the Dog Creek equivalents are present in this thinner section.

Topography.—The Dog Creek Shale contains thin dolomites that form mappable escarpments. The Watonga Bed forms a prominent escarpment in Blaine County, Oklahoma, and in Barber County, Kansas (pl. 18A). The Southard Bed forms a similar escarpment in Blaine and Major Counties, Oklahoma. The thick siltstone or fine-grained sandstone Unit A in the lower part of the Dog Creek also forms a prominent bench from Major County northward into Kansas (pl. 21B). The reddish-brown shale of the Dog Creek is weakly resistant to erosion and is covered in many places, and where

the dolomites are silty and thin, the thick siltstone Unit A may be prominent. In these places it is possible to mistake the Marlow Sandstone for Unit A, and it would be easy for one to conclude that a major unconformity exists in such areas. The Dog Creek forms flat areas above the Blaine Formation, with steplike benches produced by the dolomites, and forms a cliff face, or slope, below the resistant Marlow Sandstone. Where a major river flows parallel to the strike of the beds, such as does the North Canadian River in Blaine County, the Dog Creek erodes into broad valleys (pl. 22A).

Structure.—The Dog Creek Shale conforms structurally with the dip of the underlying and overlying beds, averaging about 14 feet per mile dip to the southwest. The northward thinning of the Dog Creek to one-eighth that in the central basin and the southward thinning of the Chickasha to one-fourth that of the basinal deposits is due to thinning within the Dog Creek and Chickasha Formations and not due to erosion at the top of the Dog Creek, as shown by southward increase of the interval between the Watonga and Southard Dolomites.

Paleontology.—Some spores have been found in the greenish-gray shale just above Unit E in Major County (measured section 15), but otherwise no fossils have been found in this area.

Origin and environment of deposition.—The northern platform, central basin, and southern delta were in northwestern and central Oklahoma during Dog Creek time. The strand line of the southern delta was receding southward from northern Grady County during early Dog Creek time. The mudstone conglomerate, siltstone, and sandstone that were deposited in this delta obviously were derived from a local source, here considered to be the Ouachita and the Arbuckle Mountains. The rapid thinning from 700 feet to 200 feet southward reflects the position of the marginal shelf as present in the Stephens County area, and the landmass was not far beyond to the south or southeast. The deposits present in this southern delta facies are primarily fine-grained clastics, silt being the major constituent. This silt probably dried out temporarily and was transported by slow sluggish streams over the Tussey delta and deposited again as mudstone conglomerate. The proportion of sand to silt and clay is small, and therefore it is probable that the Arbuckle Mountains were the source area for the sand. The red color of the beds is due to iron minerals adhering to the clay and fine silt grains. The

iron was weathered chemically from the regolith and transported mechanically and chemically by the fresh-water streams. Although some of the iron was deposited chemically, most was deposited with the fine silt and clay fraction as a coating upon these particles. The coarser clastics are lighter colored because the iron-stained coatings were worn off during transportation.

Concurrent with deposition of the southern delta facies of the Chickasha Formation, the reddish-brown clay shale and thin dolomites of the central basin facies, and siltstones, dolomites, and shale of the northern platform facies were being deposited. There is no connection between the northern platform siltstones and sandstones with similar clastics of the Chickasha facies (pl. 1), and therefore there must have been a separate source area for these deposits. These northern clastics attain their maximum thickness and minimum phi size in Major, Woodward, and Woods Counties, Oklahoma, and thin both northward and southward from this region. The Permian basin was to the southwest, so these beds must contain sediments that were derived from an eastern source. This area is here considered to be the Ozark dome, and these beds may be due either to a minor series of uplifts of the dome or to temporary increases in rainfall and runoff which would have caused an increase in stream capacity.

The carbonate rocks are here interpreted as having been deposited under conditions of relatively calm seas and semiarid climate, when the sea water was evaporating to about 47 to 25 percent of original volume, and evaporation exceeded inflow of new water. After calcium carbonate was deposited, some of the calcium ions probably were replaced by the magnesium ions, and dolomite was formed. Salinity of the sea water was so high that animals and plants could not live; therefore fossils are not found in these dolomites, but salt casts are common.

The stray gypsums near the base, such as the Haskew, were deposited when the sea water evaporated to 20 percent or less of its original volume, with inflow of sea water from the southwest, in a semiarid environment. This was a temporary condition, and in general the Dog Creek sea must have been less saline or more brackish than that of the Blaine. Although the rate of chemical weathering probably exceeded that of mechanical weathering during Dog Creek time, mechanical weathering of the surrounding landmasses prob-

ably was more pronounced than in Blaine time because coarse clastic deposits were present during Dog Creek time.

In general the landmasses, such as the Ozark, Ouachita, and Arbuckle Mountains, are here considered to have been close to sea level during Dog Creek time. In early Dog Creek time the sea water was evaporating to the point that gypsum could be deposited, and evaporation must have exceeded inflow of water in a semiarid environment. With local fluctuations in sea level and in climate, thin carbonate rocks were deposited. Most of the clay was being deposited continually from the Ouachita and Arbuckle areas, being carried by streams flowing to the backfilling southern delta. In late Dog Creek time there was perhaps an increase in rainfall or uplift of the Ozark, Ouachita, and Arbuckle Mountains, allowing some sand and silt to be deposited. The strand line of the southern delta was receding southward or southeastward at the end of Dog Creek time, indicating that sea level was rising or perhaps stream competence was falling. Judging from relative thicknesses, the central basin must have sunk about eight, four, and ten times as much during early, medial, and late Dog Creek times than did the margins, if bottom depth is assumed to have been the same. From evidence of relative thicknesses and types of deposits, the last shale, siltstone, and mudstone conglomerate of the Dog Creek-Chickasha were formed in sea water of a brackish nature, and the bottom of the Anadarko basin was still sinking. The top of the Dog Creek Shale shows no evidence of erosion, and no assumption can be made that the sea receded from this area during late Dog Creek time. Instead, it is here assumed that the Ozark dome and Ouachita and Arbuckle Mountains system began to rise. Much of the clay and silt of these landmasses was carried away during El Reno time, thus accounting for the absence of these types of deposits as major constituents of the Whitehorse Group. The residual sand and coarse-grained silt of these landmasses remained behind, and when regional uplift of these areas probably occurred at the beginning of Marlow time, these coarser clastics were probably carried into the Marlow sea. The currents in this sea probably helped to distribute the sand and silt evenly over a wide area.

CHICKASHA AND DUNCAN FORMATIONS

Name and character.—The name Duncan Sandstone, published

by Gould (1924, p. 325-328), is derived from the town of Duncan, Stephens County, Oklahoma. Although Wegeman (1915, p. 44) first described this sandstone, he did not name it. The Duncan Sandstone, about 150 feet thick in the type region, rests upon the Hennessey Shale and is overlain by the Chickasha Formation. Westward, northwestward, and northward, the Duncan forms a wedge in the basal part of the Flowerpot Shale, into which it grades. In central Canadian County, Oklahoma, the Duncan is 30 feet thick and a few miles north it is absent. According to Wegeman (1915, p. 44), Gould (1924, p. 325-328), and Davis (1955, p. 48-51), the Duncan contains shale stringers and mudstone conglomerates, is white to light buff and coarse grained in the type area, and becomes progressively finer grained and more reddish brown northward and westward. Sawyer (1924, p. 313) noticed that the Duncan and the overlying Chickasha Formation are similar in lithology and character and used the name Duncan to apply to all of the strata between the Hennessey Shale below and the Marlow Sandstone above. Green (1936, p. 1454) followed Sawyer's usage, but Brown (1937, p. 1553) and Davis (1955, p. 48-54) reinstated the name Chickasha Formation as distinct from the name Duncan Sandstone, following Gould's original usage.

The name Chickasha Formation was first used by Gould (1924, p. 329) for the purple mudstone conglomerates and pink sandstones that occur above the Duncan Sandstone and below the Blaine Formation, the latter term being applied by Gould to the Marlow Formation in Grady and Stephens Counties. Gould (1924 p. 333) thought that the thin gypsum units in the basal 50 feet of the Marlow Formation were Blaine equivalents and that the Chickasha was the gradational equivalent of the Flowerpot Shale and underlying beds. It was Sawyer (1929, p. 10; 1930, p. 316) who recognized that the Marlow Formation rests upon the Chickasha Formation in the type region and that the Dog Creek and Blaine Formations are absent there. The name Chickasha is taken from the county seat of Grady County, Oklahoma, southeast of which is the type locality. The formation consists of sandstone, siltstone, shale, and mudstone conglomerate that is about 395 feet thick, purple to pink, and coarser grained at the type locality than in areas northward and westward (pls. 2, 3, 4A). In the latter areas the formation is reddish brown and attains a thickness of 580 feet (Davis, 1955, p. 53). It is evident that the character of the Duncan Sandstone is the same as that of the

Chickasha Formation outside the type region, and for this reason both formations are here considered together.

In Grady County the Duncan Sandstone and overlying Chickasha Formation attain a thickness of 670 feet or more. In northern Stephens County these formations are considered to be less than 200 feet thick at the southeastern tip of the Anadarko basin in T. 2 N., R. 6 W. (Russom, 1937, p. 1561; Davis, 1955, p. 67). In northern Grady County the Dog Creek Shale interfingers with the upper 200 feet of the Chickasha Formation and the name Dog Creek is here applied to these beds (pls. 2, 3B). Northward in central Canadian County, north of El Reno, the typical Blaine Formation can first be noticed, in addition to the upper part of the Flowerpot Shale. The last and northernmost remnant of the Chickasha Formation is in the middle of the Flowerpot Shale in the Salt Creek canyon area of Blaine County, where it occurs as siltstone stringers and a thin mudstone conglomerate (pl. 4A). The combined thickness of the Flowerpot, the Blaine, and the overlying Dog Creek Shale is about 750 feet and is approximately the same as that of the Duncan and Chickasha Formations, into which they grade (pl. 1).

Origin and environment of deposition.—The Chickasha and Duncan Formations are here considered to have been deposited at the mouth of a large river that flowed northwestward from the Ouachita Mountains system. The delta was termed the Tussey delta by Green (1937, p. 1524). Most of the material carried into this delta was silt which must have been exposed to the air temporarily at different places and the indurated granules carried seaward with the next flood, to be consolidated later into mudstone conglomerate. The sandstone and other clastic deposits are coarser grained southeastward (Davis, 1955, p. 50, 53) and the sand evidently came from that direction. The iron minerals (principally hematite and some limonite) that coat the clastic material were probably originally a coating on the grains in the regolith and later transported seaward. The coarser material had the hematite rubbed off and therefore is light colored, pink, buff, or white. The introduction of organic material probably reduced the red of some beds to greenish gray. The purple color may be due to a combination of ferrous and ferric iron, with possibly a hydrocarbon halo present over the large Cruce anticline that occurs in the type area. The purple color seems to be one of stratigraphic rather than geographic significance, and for

this reason the presence of hydrocarbons underground may have had little effect on the coloration of these beds.

The northward interfingering of the Chickasha and Duncan Formations with the Dog Creek, Blaine, and Flowerpot Formations, from Grady County to Blaine County, is shown in plate 1. This relationship is here interpreted to mean that the Chickasha portion of the delta was receding southward from central Blaine County during middle Flowerpot time to central Grady County at latest Dog Creek time.

The southward thinning of the Chickasha and Duncan Formations, from 670 feet in Grady County to less than 200 feet in northern Stephens County is interpreted in two ways. Some authors have stated that this southward thinning is evidence of an unconformity at the base of the Marlow Formation and that a period of uplift and erosion must have prevailed in this area after the Chickasha Formation was deposited. The base of the Duncan Sandstone apparently conforms with the structure of the Cruce anticline, but the Marlow apparently cuts across this structure. It is impossible to distinguish structures within the Duncan and Chickasha Formations because they are cross-bedded and interbedded, containing no reliable mappable members. Therefore, only the base of the Duncan Sandstone can be used to determine regional dip and strike. This evidence caused Russom (1937, p. 1561), Brown (1937), and Davis (1955, p. 67) to state that an unconformity exists at the base of the Marlow Formation. The southward thinning shows that the margin of the southern landmass was close to this area and that the change from the deltaic shelf to basin occurred within it. This interpretation implies that the thinning is depositional within all portions of the Duncan and Chickasha Formations and that a major unconformity does not exist at the base of the Marlow strata. The writer accepts the conclusion of Schweer (1937, p. 1555) that the Marlow sea merely receded southward over the southern delta area. In other words, this area was sinking instead of rising at the end of Chickasha time, and the marked change from purple mudstone conglomerate to even-bedded reddish-brown sandstone and siltstone is probably one from deltaic to shallow brackish-marine conditions. Actually, in many areas the siltstones and sandstones of the Chickasha and Duncan Formations are indistinguishable from those of the Marlow, and in the type region of the Marlow Sandstone are

purple beds reported to be similar to those of the Chickasha. Therefore, the Marlow in this area is gradational between deltaic and shallow brackish-marine sediments.

If the bulk of the Marlow, Rush Springs, and overlying Cloud Chief Formations is considered, it will become evident that large areas of uplift must have existed to account for this vast amount of sandstone. The sandstone resembles that of the Paleozoic sequence of the Ozarks or Arbuckle Mountains, with many well-rounded large frosted grains similar to those in the St. Peter or Simpson Sandstone. This sand must have been the coarser detrital material left behind when the El Reno rocks were being formed, and with concurrent uplift of the Ozark, Ouachita, and Bend areas, the streams were probably competent enough to carry sand seaward. Large amounts of shale were not deposited because the bulk of this type of material had already been eroded from the landmasses during El Reno time, and strong currents in the shallow sea probably carried most of the finer material seaward.

Thus the conditions that probably prevailed during late Dog Creek and Chickasha times are those of a receding southern delta, with continued sinking of the Anadarko basin, accompanied by the beginning of uplift of the Ozark dome, Ouachita and Arbuckle Mountains, and Bend arch areas.

Whitehorse Group

The name Whitehorse is derived from Whitehorse Springs in central Woods County, Oklahoma, where only the lower few feet of the Whitehorse Group is exposed, consisting of a calcareous reef with large rounded sand grains (pl. 24). This rock is atypical of the Whitehorse elsewhere. The Whitehorse consists of reddish-brown fine-grained sandstone and siltstone, with some thin dolomite and gypsum beds, ranging in thickness from 435 feet in Grady County to 225 feet in Kansas, subdivided into the Marlow Formation below (100 to 135 feet thick) and the Rush Springs Sandstone above. The upper and lower contacts of this group are here considered conformable with beds above and below.

Cragin (1896, p. 40) used the name "Red Bluff beds" for sandstone and shale between the Dog Creek Shale below and the Day Creek Dolomite above. The beds were named for the post office of Red Bluff, near Protection, western Comanche County, Kansas.

The name was preoccupied and a new name, "Whitehorse sandstone member," was proposed for this same sequence of beds by Gould (1905, p. 55), with type locality at Whitehorse Springs. Sawyer (1929, p. 11), Miser (1954), and Davis (1955, p. 62) used the name "Whitehorse group," subdivided into the Marlow Formation below, and Rush Springs Sandstone, above, to include all strata between the El Reno Group, below, and the base of the Cloud Chief Formation, above. The Weatherford Dolomite of Sawyer (1929, p. 11) marks the top of the Whitehorse Group south of the North Canadian River in Oklahoma, and the Day Creek Dolomite of Cragin (1896, p. 44) marks the top of the Whitehorse Group north of the North Canadian River into Kansas. These two dolomites may not be the same. Recent work indicates that the Weatherford is about 60 feet below the Day Creek Bed.

At Doe triangulation station, northwestern Woodward County, a 60-foot lenticular coarse-grained calcitic sandstone, and sandy limestone grading northeastward into algal dolomite and calcitic sandstone, 0 to 12 feet above the base of the Marlow, was named the Doe Creek Sandstone by Evans (1954, p. 196), but is herein changed to Doe Creek Lentil. At Whitehorse Springs, to the northeast, the Doe Creek is primarily a sandy algal dolomite and calcitic sandstone, 2 to 6 feet thick, resting directly upon Dog Creek Shale (measured section 6), and the remaining overlying Whitehorse has been eroded. The Doe Creek is less than 1 mile wide, strikes or trends southwestward for almost 40 miles from Woods County into Woodward County, and is contained entirely within the Marlow Formation below the Relay Creek Bed. The base and perhaps the top ascend in the section downdip into the basin, so that southwest of Whitehorse Springs the base of the Doe Creek is 10 to 15 feet above the base of the Marlow Formation (pl. 8B). Northeast and northwest of Whitehorse Springs, the base of the Doe Creek is 28 to 56 feet above basal Marlow.

The base of the Whitehorse is marked by a greenish-gray fine-grained sandstone that contains many large rounded frosted quartz grains at many places (pls. 23, 24B). This light-colored zone rests upon dark reddish-brown Dog Creek Shale in the northern platform and central basin or rests upon purple Chickasha mudstone conglomerate in the southern delta area, and is here considered conformable with the underlying beds (pls. 21, 22B). Various dolomites and

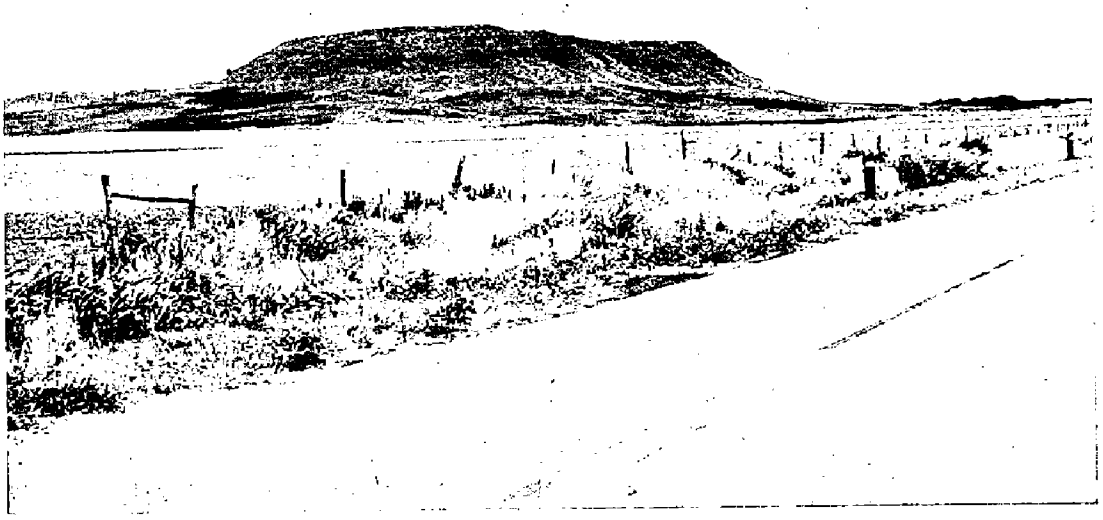
gypsums in the overlying Cloud Chief Formation mark the top of the Whitehorse in different areas and are considered conformable with the Whitehorse Group.

MARLOW FORMATION

The basal part of the Marlow was studied in detail throughout the area, but in Blaine County the entire section was examined from the base of the Marlow into the Cloud Chief Formation.

Name.—The name "Marlow Formation" was first used by Sawyer (1924, p. 313-315) for 120 feet of sandstone and shale above the "Duncan Sandstone" (of Sawyer) and beneath the "Whitehorse Sandstone" of Reeves (1921). It was named for the town of Marlow in northern Stephens County, Oklahoma. The Duncan described by Sawyer is the same as the El Reno Group, and Sawyer placed the Marlow above the Dog Creek Shale wherever the Duncan was missing. He did not know where to draw an upper contact and did not trace the Marlow northward to the type locality of the Whitehorse Group. Sawyer (1929, p. 11) separated the Whitehorse into two members, a lower unit called the Marlow Member and an upper one named the Rush Springs Member, the latter being the same as the Whitehorse Sandstone of Reeves (1921). Sawyer's only distinction between these two members was that the Marlow was even-bedded and the Rush Springs cross-bedded. Detailed investigations show that these characteristics are not reliable; in many places the Marlow is cross-bedded.

Evans (1931, p. 416) proposed the name "Relay Creek Dolomites" for three thin dolomites that occur at the top of the Marlow Formation in central Blaine County, to replace the preoccupied name Greenfield Limestone which had been applied to these beds by Stephenson (1925, p. 629-630). The upper two dolomite beds, 27 feet apart, were designated the Upper Relay Creek Dolomite (now Emanuel, Fay, 1962) and Lower Relay Creek Dolomite (now Relay Creek, Fay, 1962). The lowermost dolomite was unnamed because it thins rapidly and is absent outside the type area. Davis (1955, p. 64) placed the top of the Marlow at the top of the Emanuel Dolomite and this usage is followed in the present report. The name Relay Creek is that of the creek just northwest of Greenfield, Blaine County (pl. 22A).



A. Marlow escarpment capped by Relay Creek Dolomite. Dog Creek Shale forms slope. View toward northwest, northwest of Greenfield.

B. Close-up of basal greenish-gray sandstone of Marlow Formation in hill shown in A.

PLATE 22

Marlow Formation, measured section 24, northwest of Greenfield, Blaine County, Oklahoma

Cragin (1897, p. 360-363), while riding horseback from Greenfield, Blaine County, to Taloga in Dewey County, noticed the dolomite (Relay Creek) northwest of Greenfield and correlated this bed with the Day Creek Dolomite of Kansas, naming the Taloga Formation for beds above this (Relay Creek) dolomite. Thus, the Taloga Formation includes upper parts of the Marlow and all of the Rush Springs and Cloud Chief Formations; therefore, the name Taloga should be discarded.

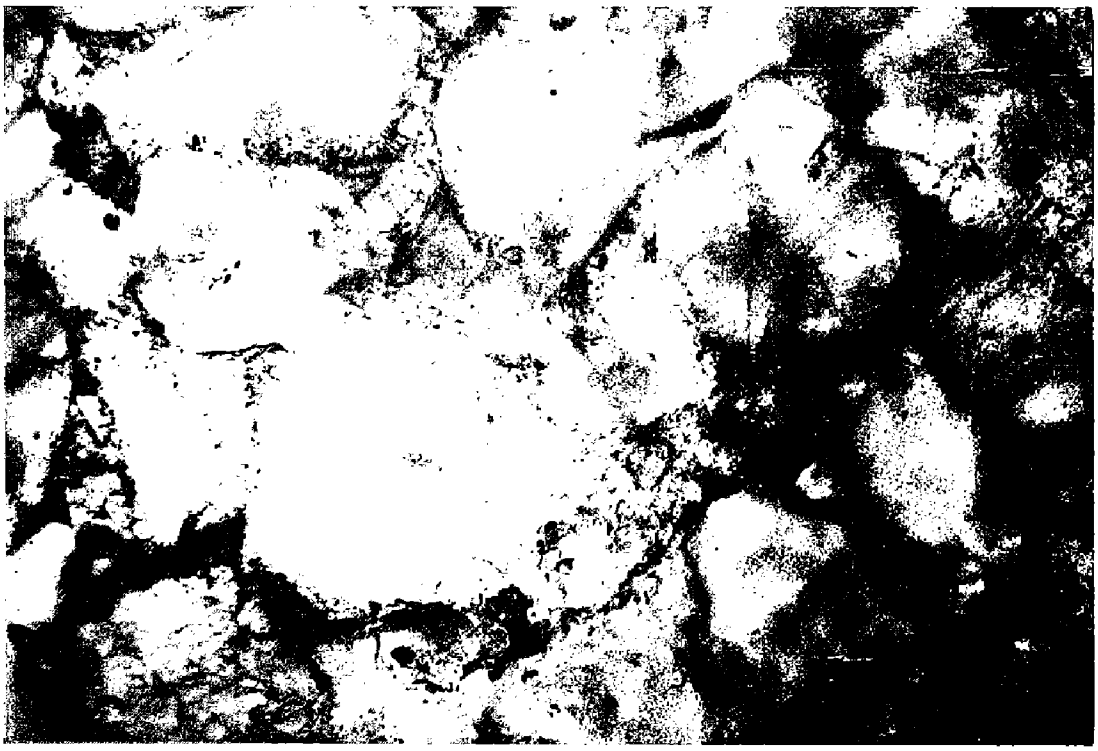
Type locality.—The type locality of the Marlow Formation is the vicinity of Marlow, Stephens County, Oklahoma.

Type section.—The type section for the Marlow Formation is in the Red Bluffs, NW¼ sec. 29, T. 15 N., R. 11 W., extending to NE¼ sec. 25, T. 15 N., R. 12 W., Blaine County.

Description and stratigraphic relations.—Davis (1955, p. 64) stated that in Grady County the Marlow is 105 to 135 feet thick and consists of even-bedded fine-grained silty sandstones and shales that are dominantly moderate-reddish brown. Several white gypsiferous layers are discernable. The Emanuel and Relay Creek Dolomite Beds at the top of the Marlow range from paper thin to 4 inches in thickness. They are separated by 15 to 20 feet of sandstone and shale, with a thin pink shale 1 foot below the Emanuel Bed and a local 2-foot-thick gypsum 2 feet above the Relay Creek Dolomite Bed. These beds were designated the "Gracemont Shale" by Brown (1937, p. 1543) and the "Agawam Gypsum" by Dott and others (1939, p. 15-16, 19, 24), with type localities near Gracemont, Caddo County, and Agawam, Grady County.

In Grady and Caddo Counties a coarse-grained calcareous sandstone occurs between a lower pink shale (60 feet above the base) and the Relay Creek Dolomite. This sandstone was termed the "Verden Sandstone" by Reed and Meland (1924, p. 151) and was known as the "Footprint sandstone." It is less than 1 mile wide, is about 50 miles long, trends in a north-northwesterly direction parallel to the outcrop, and contains fossils similar to the Blaine, together with many chert granules and large quartz grains cemented by calcium carbonate. It is contained entirely within the Marlow Formation, as previously mentioned. Although interpreted as an offshore bar or as a channel sand, it may be a sandy reef, with the calcium carbonate cement perhaps formed from fossils. The base of the Marlow Formation is marked by a light greenish-gray sandstone that contains chert granules locally.

A. Basal gypsum of Marlow Formation showing quartz grains, measured section 10, at Haskew, Woodward County.



B. Basal sandstone of Marlow Formation with quartz grains in calcite, silt, and clay matrix, measured section 24, Blaine County.

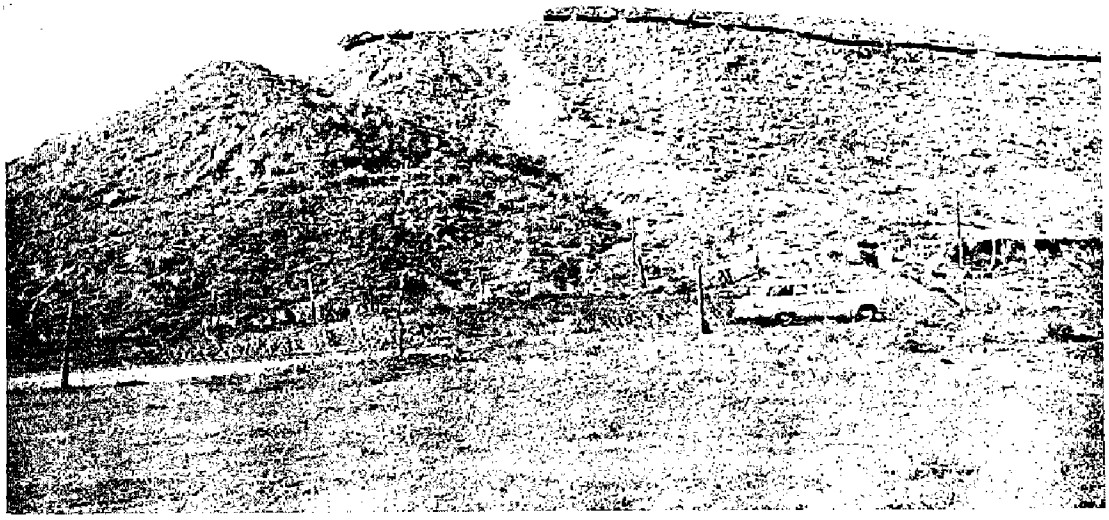
PLATE 23

Photomicrographs of basal part of Marlow Formation, x125, Woodward and Blaine Counties, Oklahoma

Westward and northwestward in Caddo County, Oklahoma, the Marlow is gypsiferous, especially at the base, and the pink shales are absent in northwestern Caddo County. In Blaine County, to the north, the pink shales, Agawam Gypsum, and Verden Sandstone are absent. The lower 80 feet of the Marlow is fine-grained sandstone; the Relay Creek Dolomite is 4 feet thick, separated by 27 feet of fine-grained cross-bedded sandstone from the Emanuel Dolomite, which is 9 inches thick. This latter condition prevails only at the type locality of the Emanuel and Relay Creek Dolomites in the Greenfield area of Blaine County (pl. 22). A local dolomite about 9 inches thick occurs about 5 feet below the Relay Creek Dolomite near Greenfield but is absent elsewhere in Blaine County.

The Marlow maintains its thickness of approximately 110 feet to Kansas, where an upper calcitic sandstone (Emanuel) and a lower dolomite (Relay Creek) are present at the top, separated by 22 feet of shale and sandstone. In Woods County, Oklahoma, and adjacent Woodward County, the Marlow is about 100 feet thick.

In Woods and Woodward Counties, the Doe Creek Lentil of Evans (1954, p. 196) occurs as a series of sheetlike bodies within the Marlow Formation, less than 1 mile wide in places and 40 miles long, extending in a southwesterly direction from Whitehorse Springs and vicinity, Woods County (pls. 8B, 24). In many places it is an algal dolomite and sandy limestone at the base and higher up, with large quartz sand grains that are well rounded, rather than a sandstone. The dolomite and limestone are at the base of the Whitehorse at Whitehorse Springs to the northwest and gradually appear higher in the section to the southwest, with 8 to 30 feet of normal fine-grained sandstone between the Doe Creek and the Dog Creek at the southwestern end of the reef, near Woodward. In this latter area, the Doe Creek is about 60 feet thick with the Relay Creek Dolomite above it and in places it is classed as a sandy limestone (Riley, 1961). In Major County to the east a 2-foot-thick gypsum occurs about 32 feet above the base of the Marlow and is considered an equivalent bed (measured section 13). To the west, in Harper County, the sequence is mostly fine-grained sandstone except at the base of the Marlow. The basal Marlow in northwestern Woodward County, all of Harper County, Oklahoma, and adjacent parts of Comanche County, Kansas, consists of a basal 4 to 27 feet of gypsum or gypsiferous sandstone, grading eastward into a fine-grained sandstone, except



A. Doe Creek escarpment, with 2 feet of algal dolomite, sandy limestone, and sandstone at top containing invertebrate fossils, underlain by Dog Creek Shale, measured section 6, Whitehorse Springs.

B. Photomicrograph of Doe Creek sandstone, x125, showing large quartz grains in calcite matrix, measured section 7, Redhorse Creek.

PLATE 24

Doe Creek Lentil, Woods County, Oklahoma

for the area of Whitehorse Springs, Woods County, where a coarse-grained 3- to 65-foot-thick section of sandstone, sandy limestone, and an algal dolomite constitutes the Doe Creek. The Emanuel and Relay Creek Dolomites, separated by 16 to 31 feet of sandstone and shale, are present in northwestern Oklahoma, and the Marlow is about 100 to 110 feet thick. In southwestern Harper County the Emanuel and Relay Creek Beds are gypsums, 1.5 to 3 feet thick. It is safe to say that the top parts of the Doe Creek Lentil are 0-15 feet lower than the Relay Creek Dolomite.

Distribution.—The Marlow Formation extends from Barber and Comanche Counties, Kansas, through Woods, Harper, Woodward, Major, Dewey, Blaine, Canadian, Caddo, Grady, and Stephens Counties, Oklahoma, along the northern and western flank of the Wichita Mountains of southwestern Oklahoma into Childress County, Texas, and south of there in north-central Texas.

Thickness.—In Grady and Stephens Counties, Oklahoma, the Marlow is about 135 feet thick; in Blaine, Major, Woodward, Woods, and Harper Counties, Oklahoma, and in Kansas it is 100 to 114 feet thick. In the subsurface in southwestern Blaine County the Marlow is approximately 150 feet thick (measured section 31).

Topography.—The Marlow forms a prominent escarpment of low rounded hills above the Dog Creek Shale. The Verden and Doe Creek Lentils form high isolated prominent buttes (pl. 8B). The Emanuel and Relay Creek Dolomite Beds form mappable escarpments with flat tops (pl. 22A). In Oklahoma these hills were called the second line of hills by settlers who came westward over the first line of Gypsum Hills of the Blaine escarpment, and currently these hills are termed the Western Sandstone Hills.

Structure.—Structure contours based upon points of elevations taken on the Relay Creek Dolomite, or extrapolated from the Emanuel Dolomite in Blaine County, show that the Marlow dips uniformly the same as the Blaine Formation below, taking into account regional northward thinning. Absence of evidence of erosional channels at the base of the Marlow wherever examined indicates that the Marlow is conformable with underlying beds.

Paleontology.—The fossils of the Marlow occur in the Doe Creek and Verden Lentils and are similar to those of the Blaine, the brackish-marine clam *Permophorus* being most abundant. The fossil

blue-green algae of the Doe Creek appear to have an oölithic shape near the base, gradually changing to an encrusting form higher in the section. The presence of these algal fossils in the Doe Creek suggests that they may also be present in the Verden. The author has not had opportunity to study the Verden in detail, and it is quite possible that this member is in part an algal reef. The fossils of the Verden and Doe Creek have been studied by Newell and others (1940) who listed the following forms from (1) Whitehorse Springs, (2) Doe Creek, 4 miles east of Woodward, and (3) Verden, in SE¼ SE¼ sec. 4, T. 6 N., R. 8 W., near Chickasha, Grady County. The forms listed are similar to species found in Capitan rocks of Texas and are indicative of brackish-marine conditions of deposition of the Marlow Formation.

	(1)	(2)	(3)
Dozierella gouldi (Beede)	x	x	x
Permophorus albequus (Beede)	x	x	x
Permophorus albequus longus (Beede)	x		
Lioclema dozierense Moore	x	x	
Conocardium oklahomense Beede	x		
Myalina sp.	x		
Gryphellina sellardsi (Beede)	x		
Schizodus oklahomensis Beede	x		
Aviculopecten vanvleeti Beede	x		
Spirorbis sp.	x		
Baylea capertoni (Beede)	x		
Cyclites depressus (Beede)	x		
Naticopsis transversa (Beede)	x		
Girtyspira? alvaensis (Beede)	x		
Cyclobathmus haworthi (Beede)	x		
Pakistania schucherti (Beede)	x		
Pseudodielasma perplexum Brill	x		
Composita mexicana (Hall)	x		
Composita subcircularis Brill	x		

Origin and environment of deposition.—The Marlow Formation is here considered to have been deposited in a shallow brackish-marine sea with outlets to the southwest in Texas, as shown by Hills (1942). The bottom of the Anadarko basin was sinking and shifting

farther southeastward than usual while the sand of the Marlow was being supplied by westward-flowing rivers from the newly uplifted Ozark dome, Ouachita and Arbuckle Mountains, and Bend arch. The sand that was being carried by these rivers was the residual material remaining as the regolith after the great bulk of clays and silts was removed during El Reno time.

In northwestern Oklahoma, in Harper County, northwestern Woodward County, and adjacent Comanche County, Kansas, gypsum was being deposited at the beginning of Marlow time, indicating that the salinity of the sea water was five times normal at that time. Farther east, in central Woods and Woodward Counties, a small spit or possibly high area of land was present on the bottom of the sea, allowing algae and animals to live, with currents flowing on either side and top, carrying away fine-grained material. This would have been the beginning of deposition of the Doe Creek algal reef, here considered to be a fringing reef because it projects at right angles to the shore line. Still farther east, fine-grained sand was being deposited by westward-flowing rivers from the Ozark dome. To the south in Caddo, Canadian, Grady, and Stephens Counties, the bottom of the Anadarko basin was sinking along the marginal shelf of the old Tussey delta, thus allowing even-bedded shallow brackish-marine deposits to rest upon cross-bedded deltaic deposits. The Ouachita and Arbuckle Mountains were being uplifted farther to the southeast, thus supplying the sand and silt from that direction.

In summary, in early Marlow time the gypsum in northwestern Oklahoma northwest of the Doe Creek algal reef shows that the waters there were highly saline. The water around the reef must have been brackish marine and favorable to plant and animal life The water south and southeast of the reef from Major County to Stephens County must have been highly saline because gypsum and calcium carbonate are common cements of the siltstones and sandstones.

With time, the Doe Creek fringing reef grew basinward to the southwest and a new reef and offshore bar, the Verden, began to develop close to the shore line on the northeastern side of the Anadarko basin, much like a barrier reef. Both reefs ceased to develop before the Relay Creek Bed was deposited. A period of extreme quiescence must have followed, in which the Emanuel and Relay

Creek Beds were formed over the Anadarko basin and north-central Texas area. The calcium carbonate and sulphate must have been a fine ooze that was temporarily disturbed in places by local currents and therefore deposited in patches and lenses in some places. Fossils have not been found in the Emanuel and Relay Creek Beds and it is here assumed that these are evaporite deposits. Thus, the close of Marlow time was probably quiescent with widespread evaporation taking place, allowing calcite, dolomite, and gypsum to be deposited. This may have been due to a slight rise in sea level, accompanied by decrease of rainfall or inflow of fresh water.

From the above interpretations it is evident that the Blaine Formation in northwestern Oklahoma was probably not uplifted and was not truncated by erosion of the advancing Marlow sea, but rather that the Blaine and its Chickasha equivalents were probably downwarped and covered by the Dog Creek and its Chickasha equivalents, and these covered by deposits of the Marlow sea, the bottom of which was also sinking. The thickness and type of deposits observed are probably due to processes of (1) evaporation versus inflow of water, (2) sinking of the Anadarko basin, and (3) uplift and erosion of eastern and southeastern landmasses. No evidence of uplift and erosion within the Anadarko basin during El Reno and Marlow times is apparent, but evidence of downwarping and inflow of fresh, brackish-marine, and saline-marine waters is indicated.

SEDIMENTOLOGY

Techniques

In the laboratory, the raw sample of 50 grams from each 500-gram sample was prepared by crushing the field sample in a mortar and sieving through a 100-mesh screen until 100 grams passed, then splitting the latter sample and using one-half of the 100-gram sample. If the sample contained carbonate, it was weighed to the fourth decimal place and placed in hydrochloric acid for insoluble-residue study, in which methods developed by Ireland (1950) were used. Otherwise the sample was placed in peptized distilled water in a 1,000-ml graduate, after being washed through a 230-mesh sieve, and analyzed by the pipette method. Each insoluble residue was washed through preweighed filter paper, dried, and weighed to the fourth decimal place, and the weight of the filter paper was subtracted from the total weight. The weight of the residue divided by the weight of the raw sample gives the percentage of insoluble residue. It is understood that the dissolved solids that are discarded include dolomite, calcite, apatite, and some gypsum, anhydrite, and iron, including other soluble salts, but this part is recorded as carbonate. The insoluble residue was then washed through a 230-mesh sieve and analyzed by the pipette method.

The peptizing agent used in pipette analyses is commercial Calgon and is satisfactory for dispersal of redbed sediments. In samples where the gypsum content is high, the amount of Calgon had to be increased many times over the 0.1N solution used (2.54 grams Calgon to 1,000 ml water). The preweighed sample was first placed in a mixer and stirred for several minutes with the peptizing agent and then placed in the 1,000-ml graduate, and the remaining volume was filled with distilled water until 1,000 ml was reached. The sand-size sample on the 230-mesh screen was weighed, giving the coarse fraction (S) and the first pipette sample, taken at a depth of 20 cm 20 seconds after the first stirring, was placed in a preweighed beaker and dried, and then weighed to give the total fraction finer than 4.0 phi (0.062 mm) or silt and clay sizes (F). The term phi means the negative reciprocal of the logarithm of the diameter to the base 2; thus 1.0 mm is 2^0 or 0 phi, 0.5 is 2^{-1} or 1

phi, 0.062 mm or 1/16 mm is 2^{-4} or 4 phi. The total of the coarse (S) and fine (F) fractions then gives the weight of the total sample. Pipette samples were taken for sizes of 4, 4.5, 5, 5.5, 6, 7, 8, 9, 10, 11, and 12 phi, or from 0.062 to 0.0002 mm, using 20-ml samples. Each was placed in a preweighed beaker and dried in an oven below 100°C. They were taken from the oven, allowed to cool, weighed to the fourth decimal place, and the weight of the beaker was then subtracted from the total weight. The weight of the Calgon was then subtracted from the resultant weight and this figure was multiplied by 50 because the 20 ml used is 1/50 of the total sample. The resulting figure gives the weight of the fine fraction coarser than the phi size of that particular sample. This number is divided by the total weight of the sample to give the individual cumulative percentage of sample that is coarser than that phi size analyzed. The samples were analyzed to 12 phi (0.0002 mm) size because this included 95 percent of most of the samples.

The resulting cumulative percentages were then plotted on logarithmic probability paper, with phi size plotted on the abscissa and cumulative percentage on the ordinate. From the resultant curves the graphic mean (M_z), inclusive graphic standard deviation (σ_I), inclusive graphic skewness (Sk_I), and graphic kurtosis (K_G) were calculated using the formulae given by Folk (1959, p. 44, 45, 46, 47).

The inclusive graphic standard deviation is a measure of sorting and the following verbal equivalents are used to express degree of sorting for sediments having σ_I values in the ranges indicated.

very well sorted	less than 0.35ϕ
well sorted	0.35 to 0.50ϕ
moderately well sorted	0.50 to 1.00ϕ
poorly sorted	1.00 to 2.00ϕ
very poorly sorted	2.00 to 4.00ϕ
extremely poorly sorted	4.00 to 10.00ϕ

Skewness or displacement of grain sizes from the median is expressed by the following verbal classification.

strongly fine-skewed	+1.00 to +0.30
fine-skewed	+0.30 to +0.10
near-symmetrical	+0.10 to −0.10
coarse-skewed	−0.10 to −0.30
strongly coarse-skewed	−0.30 to −1.00

Kurtosis is the ratio of sorting in the middle of the curve versus that at the ends of the curve and is described as:

very platykurtic	0.00 to 0.67
platykurtic or poor	0.67 to 0.90
mesokurtic or normal	0.90 to 1.11
leptokurtic	1.11 to 1.50
very leptokurtic	1.50 to 3.00
extremely leptokurtic	over 3.00

After completion of pipette analyses, a small sample of clay minerals was taken from the remaining liquid and placed upon a slide and allowed to dry. Two slides were prepared from the same sample, one being treated later with a glycerin and alcohol solution. Approximately 60 slides were prepared in this manner and placed in an X-ray diffraction unit, using both down-scanning and up-scanning methods. A CuK_a type of radiation was used, and a Geiger-Mueller tube with a nickel filter in front received the diffraction beam. The Geiger tube is connected to a potentiometer, the latter running at a rate of 1 degree of scanning per one-half inch of paper per minute. The range from 0 to 30 degrees was used. After scanning was completed, conversion tables were used to translate the angle of scanning into angstrom units, wherever major peaks occurred. In general, illite is the common mineral, with chlorite equally or slightly less common. Clay-mineral composition differs little with stratigraphic or geographic position.

The sand-size fraction retained on the 230-mesh screen, after being dried and weighed, was then examined for mineral content. The samples that contained approximately five grams or more of sample were placed in bromoform in separatory funnels and the heavy fractions separated. The heavy minerals were then weighed, and the weight of the total samples was divided into the weight of the heavies to get the percentage of the heavy mineral fraction. The heavy minerals were then placed in balsam on slides and approximately 300 grains were identified per slide and the relative percentage of each mineral was determined. The same was done with the light-mineral fraction.

Mineralogy

The minerals composing the rocks of the redbeds may be classed in two groups, detritals and chemical precipitates. The detrital group

may be subdivided into (a) clays and hematite, (b) principal light minerals, and (c) accessory heavy minerals. The chemical precipitates may be subdivided into (a) primary and (b) secondary, depending upon certain interpretations.

DETRITAL GROUP

The detrital minerals are those that are here considered to have been weathered into a regolith and transported to the site of deposition. Quartz is the major constituent of the siltstones and sandstones, and illite and chlorite are the primary clay minerals in the shales. The hematite is responsible for the red color and is here considered to have been transported as a coating or stain on the grains, the finer material retaining more than coarser material (pl. 7B).

Clays and Hematite

Most of the X-ray patterns obtained from specimens tested from the Marlow, Dog Creek, Blaine, Flowerpot, and Chickasha Formations are almost identical. A major peak occurs at 9.80A to 10.04A and another occurs at 7.00A to about 7.14A. Minor peaks occur at 3.31A to 3.33A, 3.51A to 3.55A, and 4.93A to 4.98A, with some from 13.40A to 14.40A. All other peaks are smaller than those listed above and many may be background peaks. The peaks above 10A may well be background, but those close to 14A are here interpreted to mean that iron chlorite is present. Illite is the major constituent with peaks at 9.80A, 4.93A, and 3.32A, and chlorite is next with peaks at 14.00A, 7.03A, and 3.52A. Some quartz (3.35A, 4.25A) and calcite (3.02A to 3.09A) are present.

The total clay content of a pure dolomite of the Blaine Formation averages about 1.68 percent, and that of a pure sandstone of the basal Marlow averages about 2.93 percent. The Doe Creek Lentil or calcitic sandstone averages about 1.79 percent clay minerals. The impure dolomites of the Dog Creek and Flowerpot and the siltstones, sandstones, and shales of the El Reno Group average 4.23 to 27.24 percent clay minerals, the former figure applying to silty shales, with dolomites between. The reddish-brown clay shales of the El Reno Group range from a graphic mean size of 8.07 to 9.07 phi, with a clay content (size) as high as 70 percent of the total

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rock. The clays are here interpreted to have been transported from eastern, southeastern, and southern regoliths.

The material surrounding the clay, silt, and sand particles, forming a coating or stain on the outside, is mostly hematite (Swineford, 1955, p. 97) and is 3 percent or less in siltstones and sandstones and 6 percent or less in reddish-brown shales. This is supported by chemical analyses of the reddish-brown shales of the Blaine Formation of southwestern Oklahoma, where 495 to 5.40 percent Fe_2O_3 is reported by Scott and Ham (1957, pl. 1). The hematite is here interpreted to have formed in surrounding regoliths and to have been transported to the site of deposition as a coating surrounding grains. The higher content in clay shales is explained by the fact that more iron would adhere to these small particles, less iron would remain on the silt, and the least on sand particles due to abrasion of these grains against each other. Some hematite must have been deposited chemically, as shown by a thin hematite band that occurs at the top of Unit I of the Flowerpot Shale in the Southard and Salt Creek areas of Blaine County. It was probably deposited as a marine evaporite and is rare.

Principal Light Minerals

Quartz, chert, orthoclase, plagioclase, and microcline are the important detrital minerals of low specific gravity in the redbeds. Quartz is the most abundant mineral, ranging from 4.91 percent in an average Blaine dolomite to 77.78 percent of the total rock in the basal Marlow Sandstone. If the soluble portion is removed, the quartz then comprises 67.43 to 83.76 percent of the insoluble portion, showing little variation in all types of deposits of the El Reno and Whitehorse Groups. The large grains are well rounded (pl. 24B) and the smaller grains are subangular to subrounded. The chert is stained reddish brown and comprises 0.43 percent of an average Blaine dolomite, ranging to 19.99 percent for an average of the Chickasha Tongue in the Dog Creek Shale. The feldspars, represented by orthoclase, plagioclase (close to oligoclase), and microcline, range from 0.84 percent for an average Blaine dolomite to 11.79 percent of the total rock for an average Dog Creek sandstone or siltstone. Orthoclase is the abundant type, ranging from 0.72 percent in an average Blaine dolomite to 9.51 percent in an average Dog Creek siltstone or sandstone. Individual beds may contain higher or lower

percentages, but the above ranges are extreme values for an average composition of the Flowerpot, Blaine, Dog Creek, Chickasha, and Marlow Formations.

If the carbonate and clay percentages are removed and the light minerals are recalculated to 100 percent, it is obvious that there is little change in this mineral suite either stratigraphically or geographically and that there is no difference between the Doe Creek Lentil and the Marlow Formation. The only possible exception to this similarity is the slightly higher percentage of chert in the Chickasha facies of the Dog Creek Shale, but much of this chert was probably derived locally in the Arbuckle Mountains or adjacent area and this higher percentage of chert may be expected. Otherwise the light-mineral fraction was probably evenly distributed over the Anadarko basin throughout El Reno and Whitehorse times, with temporary cessation where evaporites were deposited. Local variations are to be expected, considering the fact that several separate source areas probably supplied the basin with sediments.

It is here concluded that the above-described mineral suites were derived by erosion of multi-cycle sediments, and further that the St. Peter, Simpson, and later sandstones of the Ozark dome, Ouachita and possibly Arbuckle Mountains, and Bend arch probably supplied the bulk of the light minerals (quartz especially) that compose the El Reno and Whitehorse Groups. The clay was first removed to form the deposits of the El Reno Group and probably the deposition of the residual sand on top was due to uplift or an increase in rainfall, or both, to the east, southeast, and south, increasing the competence of the fresh-water streams, thus enabling them to transport the residual sand that is now the bulk of the Whitehorse Group.

Accessory Heavy Minerals

The minerals of high specific gravity include sphene, leucoxene, ilmenite, magnetite, pyrite (rare), zircon, garnet, red rutile, yellow rutile, brown to gray tourmaline, blue tourmaline, biotite, chlorite, muscovite, epidote, apatite, riebeckite (rare), anhydrite (not detrital), and an orange opaque mineral, the latter probably hematite-stained sphene and leucoxene. Some epidote may have been misidentified and may be staurolite. The average total amount of heavy minerals in the El Reno and Whitehorse Groups ranges from a trace

to 0.46 percent, and in individual beds may be higher. Where muscovite forms a high percentage of the heavies, it is also found in the light fraction and probably comprises several percent of the light fraction. The heavy minerals of individual siltstone beds of the Flowerpot and Dog Creek Shales contain from 25 to 82 percent muscovite.

In most samples sphene, leucoxene, ilmenite, and magnetite constitute the bulk of the minerals, with garnet, zircon, and brown to gray tourmaline next. The garnet is colorless and the tourmalines range from gray to dark gray to brown to greenish brown. A general stratigraphic trend was noticed in these minerals. Sphene, leucoxene, tourmaline (brown to gray), and micas decrease in abundance; and ilmenite, magnetite, garnet, zircon, and epidote increase in abundance from the Flowerpot Shale into the Marlow Formation. No difference exists between the heavy mineral suites of the Doe Creek Lentil and those of the Marlow Formation. The heavy minerals of the dolomites and the clastics of the Blaine Formation are alike.

Many samples of sandstones, siltstones, shales, and dolomites of the El Reno Group contain anhydrite in trace quantities. Gypsum that was deposited in minute quantities in the sediments was later dehydrated to form anhydrite. The anhydrite grains are euhedral and appear fresh.

Large grains of heavy minerals are well rounded and probably were derived from a previously eroded suite of sedimentary rocks. The type of minerals present indicates that an original source for the previous sediments must have been an eroded granitic landmass, perhaps now buried.

CHEMICAL PRECIPITATES

The chemical precipitates include those formed when the sea water was present in the area (primary) and those formed later (secondary). The primary precipitates include gypsum, dolomite, calcite, halite, and possibly chalcocite. The secondary precipitates include anhydrite, massive gypsum, selenite, satin spar, calcite, ulexite, probertite, and malachite.

In the subsurface of Blaine County (measured section 31) the Dog Creek, Blaine, and Flowerpot Shale contain massive anhydrite and many small anhydrite nodules throughout (pls. 12B, 14B).

These same beds and zones are represented by gypsum at the surface. In the quarries at Southard and Bucher, in Blaine County, the Shimer and Nescatunga Gypsum Members contain thick anhydrite lenses in the middle, the anhydrite becoming thicker with increasing overburden (pls. 13, 15). Minute quantities of anhydrite occur in the El Reno Group and especially in the gypsum beds at the surface (Muir, 1934, p. 1304; Kulstad and others, 1956, p. 41-45). The massive gypsum, selenite, and satin spar are here interpreted to be secondarily derived from solutions that have reworked the anhydrite. The anhydrite must have been formed from gypsum originally, as discussed in the part on the Flowerpot Shale of this report.

The presence of the borate minerals ulexite and probertite supports the theory for the secondary nature of massive gypsum. Boron is in the anhydrite in the subsurface of Blaine County, and borate minerals are in the Nescatunga Gypsum Member of the Blaine Formation, just above and below the middle anhydrite member, in the gypsum but not in the anhydrite. The minerals are present within several feet of the contact with the anhydrite and are absent farther away. These minerals are explained to be present in this manner by the same theory of hydration. The anhydrite, in hydrating to gypsum, is dissolved by ground water and the boron is also taken into solution. The boron is concentrated near the margins of the anhydrite and precipitated as borate minerals. With continued hydration the borate minerals are dissolved again, thus explaining the absence of these minerals on the outcrop and in weathered gypsum exposures in the quarries (Ham and others, 1961).

The dolomites may be subdivided into three types: (1) laminated, (2) oölitic, and (3) algal. The first type, consisting of fine-grained light-gray to light-tan thinly laminated blocky dolomite with as much as 45 percent silt, sand, and clay, containing no fossils, is characteristic of the Dog Creek and Flowerpot Shales (pls. 9B, 18, 19, 21). Salt casts are common in some of these beds. This type of dolomite appears to have been deposited by evaporation of relatively quiet sea water, allowing calcium carbonate to fall to the bottom, with magnesium ions in the sea water replacing the calcium ions to the extent that a dolomite was formed after accumulation on bottom. The oölitic type is restricted to the Blaine Formation, beneath the main gypsum ledges, and to part of the Doe Creek Lentil of the Marlow Formation. The Blaine dolomites are fine grained

with many round to elongate oöliths averaging about 0.25 mm in diameter (pls. 9A, 10B, 12). Each oölith has a light-tan to light-gray rim of fine-grained dolomite surrounding a much finer grained center of silt, clay, sand, calcite, and dolomite. Adjacent oöliths barely touch each other, and in many specimens the matrix between oöliths is the same as the material in the centers. The Blaine dolomites contain about 8 percent insoluble residue; the remainder is dolomite with a small amount of free calcite. Many fossils occur in this type of rock and these oöliths may be algal in origin. Some oöliths do not have rims and may be inorganic pellets.

The concentric type of oölith occurs in the basal part of the Doe Creek Lentil, where it can be demonstrated that a rim surrounding an öolith with no granular center is formed in the same manner as one around grains. Higher in the section the rims surround several oöliths or several sand grains, ending in an incrusting mass at top almost 1 foot or more in diameter. This incrusting mass is identified by L. R. Wilson (personal communication) as the material altered from deposits of blue-green algae and that the basal oölitic-type material is probably the same as the incrusting material. Therefore much of the Doe Creek is a true algal dolomite that must have formed in shallow water tolerant of animal life because fossils occur in this dolomite. The original material secreted by the algae was probably calcium carbonate, and the calcium was partly replaced by the magnesium ions in the sea water. It is quite possible that the oölitic dolomites of the Blaine Formation originated under similar conditions, combined with some evaporation, not allowing the incrusting stage to be reached. With continued evaporation and beginning of deposition of the superjacent gypsums, all life ceased to flourish. Salt casts occur in some of the Blaine dolomites, principally in the nonoölitic portions, suggesting that evaporation was probably responsible for the deposition of some of this type of rock. Anhydrite in trace quantities is also present in the dolomites.

Casts of halite are present in the dolomites of the El Reno Group and are indicative of highly saline water. In the subsurface of Blaine County (measured section 31) halite crystals almost 1 inch in diameter occur in the middle 4 feet of the Nescatunga Member (anhydrite) of the Blaine Formation, about 20 miles west of the outcrop. Some of the halite was probably formed from salt water trapped in the sediment and later crystallized, but massive rock

salt was probably deposited by 90 percent or more evaporation of the sea water. The presence of many salt springs in the Flowerpot Shale in Kansas and northwestern Oklahoma indicates that large quantities of salt must occur in the El Reno Group underground.

Malachite ($CuCO_3 \cdot Cu(OH)_2$) is present in a dolomite of Unit I of the Flowerpot Shale and in the Cedar Springs and Magpie Dolomite Beds of the Blaine Formation (pl. 10B). The malachite occurs as bright-green stains in veins that crosscut the dolomite and in incrusting layers. Merritt (1940) discussed the widespread occurrence of copper minerals in the redbeds and showed that chalcocite (Cu_2S) is formed first and that malachite is formed as a weathering product of chalcocite. The presence of copper over a wide area in a thin dolomite bed suggests that the copper ions were derived originally from sea water and were not introduced later by ground water.

Native copper in reddish-brown clay shale was reported by Gould (1910, p. 59), Haworth and Bennett (1901, p. 2-4), and Merritt (1940, p. 9), from the Wellington, Hennessey, and Flowerpot Shales. The writer examined one specimen from the Hennessey Shale of Garfield County, Oklahoma. The native copper occurs in thin sheets about 2 inches long, surrounded by a light greenish-gray halo. The copper is parallel to the bedding, but Haworth and Bennett reported that some copper crosscuts the bedding. The light greenish-gray silty shale surrounding the copper is calcareous and reacts with hydrochloric acid. The native copper thus must have formed under reducing conditions in a calcareous environment, after consolidation of the clay shale. For some unknown reason copper-bearing solutions must have existed in local areas and reacted with calcium carbonate in the presence of organic material, such as spores, to produce native copper. A plausible set of reactions, given by Haworth and Bennett is:

$$CuSO_4 + CaCO_3 \rightarrow CuO + CaSO_4 + CO_2$$

The CuO produced would then react with iron sulphate and some free sulphuric acid to produce native copper:

$$CuO + 2FeSO_4 + H_2SO_4 \rightarrow Cu\downarrow + Fe_2(SO_4)_3 + H_2O$$

Calcite veins commonly occur in the Altona Dolomite Bed of the Blaine Formation. They crosscut the bedding and fill boxwork fissures. They are present in other dolomites but are less common.

These are clearly secondary fillings and may be related to recent ground water. Some calcium carbonate occurs as a cement, widespread in redbeds, and may be of primary origin.

Petrography

The rocks of the redbeds contain granule-, sand-, silt-, and clay-size particles of minerals and rock fragments, carbonates, sulphates, hematite, halite, and minor minerals such as borates, malachite, and copper. The clastic or detrital portion consists mostly of sand, silt, clay, and hematite, which accounts for the bulk of the deposits and for their color. The chemical portion comprises the cement of carbonates and sulphates, and evaporites of anhydrite, gypsum, dolomite, and halite. Each type of rock is composed of the above combination of detrital and chemical constituents.

SHALE AND MUDSTONE CONGLOMERATE

The great bulk of rock present in the El Reno Group is reddish-brown shale. The sand portion of this type of rock is generally less than 5 percent, the silt ranges up to 50 percent or more, and generally the clay content (size) is greater than 50 percent. The clay minerals are mainly illite and chlorite. The silt is mostly quartz with some chert, feldspar, and muscovite. In samples with a high content of silt there is complete gradation to a fine-grained siltsone, and the color changes accordingly from a deep reddish brown to a moderate reddish brown or reddish orange. The term silty shale is applied if the rock appears like shale and has a phi size close to 8.00 (0.004 mm) but is distinctly gritty. The term shale or clay shale is applied if the phi size is 8.00 or higher and little grit or silt is present. The hematite content is higher in the shales than in any other redbed and decreases in amount with increase in silt or sand. Many small greenish-gray specks and larger spots are present in the reddish-brown shale. Some of these are calcitic, others gypsiferous, but most appear to differ in color only. The light color may be due to the reduction of iron, possibly caused by bacteria or other organic material (Tomlinson, 1916, p. 169-172). The native copper in the shale may have been deposited from altered copper minerals formed under local reducing conditions, the original copper ions probably coming from the sea water. The shale was probably

deposited in sea water of high salinity, with inflow exceeding evaporation and with currents of low velocity.

The mudstone conglomerates appear to be composed of shales, silty shales, and fine- to medium-grained siltstones that locally hardened, were rolled gently by water, and cemented in a similar matrix with some calcium carbonate. In many places it is difficult, if not impossible, to distinguish a mudstone conglomerate with weakly indurated matrix from a blocky silty shale, and for this reason is here included with shales. The detrital and chemical compositions of these conglomerates are similar to those of shales and siltstones, and the beds are here considered to be deltaic equivalents of the basin facies.

SILTSTONE

The siltstones have a phi size that ranges from 4.00 to 8.00 (0.062 to 0.004 mm). Most of the grains are quartz, with some chert, feldspar, and muscovite, but some may be gypsum. The common cements are calcite, dolomite, and gypsum. Where the cement content is high, such as in the Watonga Bed or Haskew Bed, the beds are well indurated and form a mappable escarpment. These types of beds grade to dolomite or gypsum. A common type of rock in the basal part of the Dog Creek Shale and in Unit I of the Flowerpot Shale is beds that appear to be a mixture of greenish-gray shale, siltstone, and selenite or satin spar gypsum, with some carbonate cement. The rock is well indurated and forms a ledge. The rock has been described as a siltstone because the silt content ranges from 61 to 80 percent, but in many places it appears like gypsiferous shale.

The siltstones are commonly light greenish gray to moderate reddish orange, the lighter color probably being caused by the presence of less hematite and more quartz, gypsum, and carbonates than in shales (pls. 2, 16B). The presence of organic material with a consequent reduction of the iron, may also be a factor that causes a lighter color. The siltstone tongues of the Chickasha Formation in the Flowerpot Shale are light greenish gray (pl. 4), but southward in the thick Chickasha sequence, this color has changed to moderate reddish orange. It is quite possible that more organic material accumulated in these basinward tongues than in the main Chickasha deposit and that therefore the iron in the tongues was reduced. It

is equally possible that more calcite and gypsum cements were precipitated in the tongues rather than in the main deltaic deposit.

The local siltstones of the Flowerpot Shale and the Dog Creek Shale in Major and Woodward Counties grade into sandstone and thin to the north and south (pls. 7B, 20). These beds are weakly indurated and appear to have been formed from loose sand and silt that were deposited from an eastern local source. They are a few feet thick and almost 100 miles long.

The Marlow Formation contains much siltstone, but it is coarse grained and moderate reddish orange, with little carbonate cement and much local gypsum cement. It is thick and extends from Kansas to Texas. In Kansas and adjacent northwestern Oklahoma the basal portion grades eastward into sandstone and westward into gypsum.

SANDSTONE

The sandstones of the El Reno and Whitehorse Groups are fine grained and are composed of 80 percent quartz, about 10 percent chert and feldspar, and 10 percent carbonates, sulphates, hematite, and clay minerals. In general, sandstone is rare in the El Reno Group, except in the Chickasha facies in which Freie (1930, p. 43) reported an increase in average size of the grains southeastward (pl. 3B). Unit C of the Flowerpot Shale, the siltstone with the Watonga Dolomite, and Unit A of the Dog Creek Shale in the northern platform facies grade into sandstone vertically and laterally, with a larger average size in Major and Woodward Counties, except for the Watonga which grades into sandstone in Kansas. The Watonga is light greenish gray and the others are moderate reddish brown to reddish orange. The Marlow is a fine-grained moderate reddish-orange sandstone in general, with many large well-rounded quartz grains (pl. 23). These well-rounded grains are found throughout the sandstones of the El Reno and Whitehorse Groups and appear to be concentrated in the Doe Creek Lentil (pl. 24B) and Verden Sandstone.

The Doe Creek is composed of 56 percent or more of dolomite and calcite, about 2 or 3 percent clay and silt, and the remainder of coarse sand grains of quartz and other minerals. These grains are well rounded and average about 1.5 phi (0.35 mm) in diameter. The chert and feldspar content is less than 10 percent and the feld-

spars are slightly fresher than the other material. The Doe Creek is highly cross-bedded in many places and is oölitic. The oöliths consist of concentric rims of dolomite about a center of quartz or fine-grained dolomite. Commonly a larger elongate oölith encloses several smaller oöliths, and stratigraphically higher in the formation, incrusting algal deposits surround these composite oöliths. Where algal structures have been destroyed or the dolomite dissolved, the rock that remains is a sandstone, sandy limestone, or dolomitic sandstone instead of a dolomite, grading into a fine-grained conglomerate.

The sandstones are weakly indurated as a rule and the cementing agents comprise three components: carbonate, gypsum, and hematite. Carbonate is present throughout and gypsum is local, with hematite coating each grain. Where well indurated, the sandstones form mappable escarpments, but where weakly indurated, they become a part of the colluvial wash on the lower slopes. The average phi size of the sandstones of the El Reno and Whitehorse Groups is between 3.00 and 4.00 phi (0.12 to 0.062 mm). The siltstones of the Whitehorse are close to 4.00 phi in diameter, whereas those of the El Reno Group average about 6.00 phi in diameter, showing the close relationship of the sandstones and siltstones of the Whitehorse Group. The various colored sandstones differ little chemically or mineralogically, except for the amount and type of cement and iron.

ANHYDRITE AND GYPSUM

Anhydrite ($CaSO_4$) and gypsum ($CaSO_4 \cdot 2H_2O$) are present as widespread monomineralic bedded sheetlike deposits 5 to 30 feet thick, and nodular deposits scattered throughout shales and siltstone of the El Reno Group, grading into rock where they form a cementing agent. The anhydrite is fine to coarse granular, light gray and fibrous; it erodes into a resistant bright-white ledge. It is common in the subsurface and rare at the surface. The gypsum is fine to coarse granular and white, erodes into a dull-white ledge, and is common at the surface and rare in the subsurface. As shown by Muir (1934) and Kulstad and others (1956), gypsum crystals commonly crosscut through anhydrite. In the U. S. Gypsum quarries at Southard, anhydrite is common in increased thickness with increase of overburden, the anhydrite grading into gypsum where overburden

is less. Anhydrite nodules are common in the Flowerpot Shales in the subsurface, whereas gypsum nodules are present at the surface. Some of these nodules are in zones that are traceable for 40 miles or more. These facts show that gypsum must have formed by hydration of anhydrite.

Selenite and satin spar gypsum are common throughout the redbeds and some are present in the subsurface. These are clearly secondary deposits formed from the primary deposits, commonly occurring as veins that crosscut the bedding planes.

Anhydrite is present in small quantity in the heavy mineral concentrates of the siltstones, sandstones, and dolomites of the El Reno Group. The anhydrite probably served as a partial cementing agent in diverse types of rocks.

DOLOMITE

Dolomite ($CaMg(CO_3)_2$) occurs in thin beds generally less than 1 foot thick in the El Reno and Whitehorse Groups. The beds form widespread blanket deposits and may be subdivided into three groups: (1) laminated, (2) oölitic, and (3) algal. These have already been described in the section on mineralogy. The material deposited was probably calcium carbonate that was replaced by magnesium ions (in part) from the sea water, and for this reason these dolomites are considered to be primary precipitates, as shown by Van Tuyl (1916, p. 274-285) and Cloud and Barnes (1948, p. 79-95). This type of alteration is termed penecontemporaneous.

Dolomite and calcite occur as cementing agents of the clastic rocks and also as irregular patches in these rocks. Weeks (1953) considered some of these calcite patches to have formed under reducing conditions caused by organic material creating ammonia that increased the pH of the solution.

MINOR FEATURES

The redbeds contain rocks that have mud cracks, ripple marks, cross-beds, salt casts, wavy beds, and lenticular beds. The mud cracks commonly occur in shales, the oscillatory ripple marks are common in siltstones and dolomites, and salt casts are common in the laminated dolomites. The siltstones and sandstones are cross-bedded and lenticular bedded, especially in the Chickasha facies and Mar-

low Formation. Wavy beds are common in the siltstones and gypsum Unit I of the Flowerpot Shale and in the lower portion of the Dog Creek Shale, which contains numerous satin spar layers. The Emanuel and Relay Creek Dolomites at the top of the Marlow Formation are commonly wavy bedded throughout Oklahoma. The above features indicate the shallow-water nature of the deposits and the close proximity to the shore line, but are not indicative of significant unconformities.

SUMMARY

The tectonic, paleogeographic, and sedimentologic frameworks of the El Reno deposits have to be considered separately in order to explain the origin and environment of deposition of these rocks.

The rocks of the El Reno Group in the Anadarko basin may be subdivided into three areal types: (1) northern platform, (2) central basin, and (3) southern delta. The platform and basin types are fine-grained clastics and evaporites, with a thicker shale sequence in the basin than on the platform. The platform type contains siltstones and sandstones that are absent in the basin and thin in Kansas, showing that these must have been derived from a local eastern source, here considered to be the Ozark dome. The southern delta types include cross-bedded mudstone conglomerates, sandstones, and fine-grained clastics that grade northward into the even-bedded basin deposits. These deltaic deposits are here interpreted to have been derived from a southeastern source, probably the Ouachita and Arbuckle Mountains area. Thus the Ozark, Ouachita, and Arbuckle areas probably had regoliths that were sources for most of the sediments of the El Reno Group. The bulk of the deposits of the El Reno Group are reddish-brown silty shales, the red coloration being due to hematite stains on clastic grains. Although the streams on the landmasses were able to transport sand, the bulk of the material carried by these streams must have been clay and silt. The hematite probably formed around clastic grains in the regoliths and was then transported to the site of deposition.

Each formation and member of the El Reno Group can be correlated over long distances from the basin to the platform. The changes in relative thickness between formations and members allow

one to demonstrate that the Anadarko basin sank at different rates at different times. In Flowerpot and Blaine times the center of the basin subsided from two to two-and-one-half times as much as did the margins. In Dog Creek time the center probably sank almost eight times as much as did the margins, with the rate evenly distributed from early to late Dog Creek time. During Marlow time the central basin was probably still subsiding, but the center was evidently shifted farther southward while the landmasses were probably rising, increasing the competence of their streams, allowing sand to be deposited in the basin.

The sea water must have fluctuated from brackish to highly saline. The evaporites must have been deposited under semiarid conditions where evaporation exceeded runoff and a continuous supply of additional sea water was maintained. The clastics must have been deposited where inflow or runoff exceeded evaporation and the new water diluted the sea water, retarding the effects of evaporation and preventing consequent deposition of evaporites. The Doe Creek algal reef is here interpreted to have formed as a fringing reef in early Marlow time, growing basinward through Marlow time, accompanied by currents that probably swept the reef clean of fine debris. No evidence that the inland sea of the Anadarko basin receded from the area during El Reno and Marlow times with consequent erosion of previously deposited beds is indicated. The bottom of the Anadarko basin probably was subsiding, receiving sediments from the Ozarks, Ouachitas, Arbuckles, and surrounding landmasses, which may have been rising during Whitehorse time, perhaps accompanied by an increase in rainfall.

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APPENDIX

Stratigraphic Sections

The detailed measured sections are here arranged in order north to south, beginning with those in Barber and Comanche Counties, Kansas, and ending with those in Grady County, Oklahoma, a linear distance of approximately 250 miles. Each section was measured with a ruler and hand level along cliff faces and road cuts. Almost 1,000 samples were collected for examination in the laboratory, consisting of hand specimens and 500-gram bags of spot and channel samples. Of the above samples, only one-third, consisting of 272 insoluble residues, 325 pipette analyses, 150 light- and heavy-mineral slides, 64 X-ray patterns, and 80 thin sections, was studied.

The recorded percentages of sand, silt, clay, and carbonate were determined by insoluble-residue pipette methods. Dolomite and calcite are placed together under the term "carbonate," and the term "calcareous" refers to the total carbonate content of the rock. The gypsum and hematite portions were not separated from the clay and carbonate portions taken into solution, and therefore the reported percentages of the clay and carbonate are probably high. Quantitative analysis was not attempted.

The heavy- and light-mineral fractions of the sand-size portion were separated by use of bromoform. These mineral grains were then placed upon slides, mounted in Canada balsam, and approximately 300 grains on each slide were identified in order to determine relative percentages. The "orange opaque" portion of the heavy-mineral fraction is probably a mineral such as sphene or leucoxene with hematite stains. Some of the grains identified as epidote may be staurolite. The microcline portion of the light minerals refers only to that type that shows the characteristic quadrille twinning. The chlorite-muscovite portion is included with the heavy fraction, and where this percentage is high, there is probably 5 to 10 percent that should be included with the light-mineral fraction.

Minor structures of the rocks were studied by means of thin sections cut at right angles to the bedding. The terms "thin-bedded," "medium-bedded," and "thick-bedded" indicate that the bedding planes are approximately ¼, 1, and 3 inches apart, respectively. The term "red-brown" or "reddish-brown" means moderate to dark reddish-brown color, probably due to hematite. Silt comprises a large percentage of the shales, and it is understood that the term "shale" means silty shale with as much as 40 percent or more silt-size particles in it, the silt being composed of quartz and clay aggregates plus at least 25 more minerals.

The clay-size particles, as determined by X-ray studies, consist mainly of minerals of the illite and chlorite group, with minor amounts of quartz and carbonates. The term "clay shale" means a rock with the above-mentioned clay minerals in it having a graphic mean

diameter of 8 phi or more. Unless complete pipette analyses are determined for each rock, it is impossible to distinguish a clay shale from a fine-grained siltstone in the field and therefore the term "shale" includes both types. For example, a shale with a graphic mean of 7.4 phi would be classed as a siltstone but would appear as shale, whereas a shale of graphic mean 8.25 would be a clay shale. Both types of rocks would be classed as shale or silty shale in the field and would not be distinguished from each other. The term "silty" is applied if appreciable amounts of fine-grained silt or grit can be seen or can be felt between the fingers or teeth.

In the following detailed measured sections, an asterisk (*) after a rock term indicates that mineralogic, lithologic, or X-ray analyses have been made and that the results are on open file at the Oklahoma Geological Survey.

SECTION 1. DOG CREEK SECTION
BARBER COUNTY, KANSAS

Beginning at the top in Marlow Formation along U. S. Highway 160, in N½ N½ sec. 9, T. 32 S., R. 14 W., ending in the Flowerpot Shale in SE¼ SW¼ sec. 5, T. 32 S., R. 14 W., Barber County, Kansas.

	Thickness (feet)
MARLOW FORMATION (top not exposed)	
Sandstone*, moderate reddish-brown to reddish-orange, fine grained, quartzose. Exposed thickness	10.0
DOG CREEK SHALE (type section, total thickness 30.9 feet)	
Shale*, red-brown, blocky; interbedded with reddish-orange, silty, thin-bedded, weakly indurated sandstone; as above	1.5
Unit F (Dog Creek):	
Sandstone*, reddish-orange, fine-grained, medium-bedded, well-indurated; forming ledge	2.2
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	0.5
Siltstone*, purple-brown, platy; with some greenish-gray streaks	0.2
Shale, purple-brown, blocky; with some satin spar layers	0.75
Shale, red-brown, silty, blocky	1.0
Unit C (Dog Creek):	
Siltstone*, red-brown, mottled greenish-gray, argillaceous, thin-bedded, well-indurated; forming ledge	0.9
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	1.0
Southard Dolomite Bed:	
Dolomite*, red-brown, mottled greenish-gray, silty, well-indurated	0.1
Unit B (Dog Creek):	
Shale, purple-brown, platy	0.75
Siltstone*, red-brown, calcareous, arenaceous, massive, well-	

	Thickness (feet)
indurated; forming ledge	1.65
Unnamed Unit (Dog Creek):	
Shale, dark red-brown, silty, blocky to platy, weakly indurated	4.0
Unit A (Dog Creek):	
Siltstone, moderate reddish-orange to reddish-brown, argillaceous, platy, thin-bedded, weakly indurated	1.0
Sandstone*, greenish-gray, mottled reddish-brown, quartzose, silty, massive, well-indurated; forming a ledge	1.0
Siltstone, greenish-gray, gypsiferous, massive, well-indurated; forming ledge	0.2
Shale, red-brown, blocky	0.2
Siltstone*, greenish-gray, arenaceous, calcareous, fine-grained, dense, well-indurated; forming light-colored ledge	0.2
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky, weakly indurated	5.25
Siltstone, greenish-gray, nodular, well-indurated	0.2
Watonga Dolomite Bed:	
Sandstone*, greenish-gray, mottled reddish-brown, silty, calcareous, medium-bedded, well-indurated; forming ledge	2.5
Shale, dark red-brown, silty, platy	0.1
Siltstone*, greenish-gray, arenaceous, calcareous, well-indurated, thinly laminated, platy, ripple-marked; forming ledge	0.9
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky, silty, mottled greenish-gray	0.8
Siltstone, greenish-gray, calcareous, well-indurated, nodular, massive	0.1
Siltstone, reddish-brown, mottled greenish-gray, well-indurated, massive	0.75
Siltstone, greenish-gray, mottled reddish-brown, well-indurated, massive	0.5
Siltstone, mottled reddish-brown and greenish-gray, argillaceous, well-indurated, massive	0.5
Shale, red-brown, blocky	2.2
BLAINE FORMATION (total thickness, 41.4 feet)	
Altona Dolomite Bed:	
Limestone*, light-gray to greenish-gray, gypsiferous, fine-grained, dense, well-cemented; grading into a finely laminated, crinkly bedded portion; weathering into box-works; forming prominent mappable escarpment	0.2
Limestone, greenish-gray, silty, massive; as above	0.2
Limestone, light-gray to greenish-gray, well-indurated, massive; as above; forming ledge	0.1
Unnamed Units (Blaine):	
Siltstone*, red-brown, argillaceous, blocky	1.9
Siltstone, greenish-gray, mottled reddish-brown, argillaceous, blocky, thin-bedded	0.5

	Thickness (feet)
Siltstone, mottled red-brown and greenish-gray, argillaceous, well-indurated, massive; forming ledge	0.7
Siltstone, red-brown, mottled greenish-gray, argillaceous, blocky, weakly indurated	1.5
Shale, red-brown, silty, blocky	1.75
Siltstone, red-brown, mottled greenish-gray, argillaceous, massive, blocky, weakly indurated	1.0
Siltstone, moderate reddish-orange, mottled greenish-gray, argillaceous, thin-bedded, well-indurated; forming ledge	0.25
Shale, red-brown, mottled greenish-gray, silty, blocky	4.5
Siltstone, greenish-gray, argillaceous, well-indurated	0.1
Shale, red-brown, silty, blocky, thin-bedded; with many thin greenish-gray siltstone beds	3.0
Gypsum, light-pink to white, massive, crinkly bedded, well-indurated; possibly representing the Nescatunga Member	0.4
Shale, green-gray, gypsiferous, blocky	0.1
Shale, red-brown, blocky	1.4
Siltstone, greenish-gray, gypsiferous, dolomitic, argillaceous, well-indurated, massive	0.1
Shale, red-brown, blocky; with much satin spar	2.5
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, mottled light-gray, massive, well-indurated; forming an escarpment	21.0
Cedar Springs Dolomite Bed:	
Dolomite*, dark-gray, fine-grained, oölitic, thin-bedded, well-indurated; grading into gypsum above	0.2
FLOWERPOT SHALE (exposed thickness, 92.9 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.25
Units H-J (Flowerpot):	
Shale, red-brown, blocky	0.6
Shale, greenish-gray, gypsiferous, blocky	0.2
Shale, red-brown, blocky; section extrapolated to SE¼ SW¼ sec. 5, T. 32 S., R. 14 W., in cliff along creek north of road	2.0
Shale, greenish-gray, gypsiferous, blocky	0.4
Shale, red-brown, silty, blocky; with some greenish-gray layers	5.0
Units E-G (Flowerpot):	
Gypsum, mottled reddish-brown and greenish-gray, argillaceous, massive, well-indurated; forming ledge	1.0
Unit D (Flowerpot):	
Shale, red-brown, blocky, gypsiferous; with some nodular gypsum; partly covered	6.25
Unit C (Flowerpot):	
Siltstone and gypsum*, red-brown, argillaceous, thin-bedded, crinkly bedded, well-indurated; forming ledge	1.25
Units A-B (Flowerpot):	

	Thickness *(feet)*
Shale, red-brown, gypsiferous, blocky	0.75
Shale, greenish-gray, gypsiferous, blocky	0.1
Shale, red-brown, gypsiferous, blocky	3.2
Shale, greenish-gray, gypsiferous, blocky	0.1
Shale, red-brown, gypsiferous, blocky; with some greenish-gray shale layers	2.75
Gypsum, red-brown, silty, well-indurated, massive	0.25
Shale, greenish-gray, blocky; with much satin spar	0.2
Shale, red-brown, gypsiferous, blocky; with many thin greenish-gray shale layers	38.0
Gypsum, greenish-gray, mottled red-brown, silty, well-indurated, platy, thin-bedded; forming ledge and base of extremely gypsiferous shale section	1.4
Siltstone, red-brown, weakly indurated, platy, thin-bedded; with some satin spar	1.0
Siltstone, red-brown, mottled greenish-gray, gypsiferous, well-indurated, massive	0.4
Shale, red-brown, blocky; with much satin spar and many thin greenish-gray layers	6.0
Shale, greenish-gray, blocky	0.3
Shale, red-brown, blocky; with much satin spar and many thin greenish-gray layers; exposed to creek	21.5

SECTION 2. CAVE CREEK
COMANCHE COUNTY, KANSAS

Measured along Cave Creek (Sand Creek), beginning at top in the Marlow Formation in NE¼ NW¼ sec. 35, T. 33 S., R. 17 W., ending in the Blaine and Flowerpot Formations at Comanche Cave and east of the cave east of the creek in NE¼ NE¼ sec. 2, T. 34 S., R. 17 W., which includes type Cave Creek Formation, type Shimer Gypsum, type Nescatunga Gypsum, and type Medicine Lodge Gypsum.

MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-orange to moderate reddish-brown, fine-grained, quartzose, massive; grading downward into gypsum	5.0
Gypsum, pink to reddish-brown, arenaceous, well-indurated, thin-bedded, crinkly bedded; becoming greenish gray in basal 2 inches; forming mappable escarpment	4.75
DOG CREEK SHALE (total thickness, 25.4 feet)	
Shale, red-brown, blocky	2.0
Unit F (Dog Creek):	
Sandstone*, moderate reddish-orange to moderate reddish-brown, gypsiferous, silty, well-indurated, platy; forming ledge	0.75
Unnamed Units (Dog Creek):	
Siltstone, greenish-gray, mottled red-brown, weakly indur-	

	Thickness (feet)
ated, massive	1.0
Shale, red-brown, blocky	0.9
Siltstone, red-brown, argillaceous, platy, weakly indurated; with nodular gypsum and satin spar	1.0
Unit C (Dog Creek):	
Siltstone, greenish-gray, weakly indurated, massive; with much satin spar	0.75
Unnamed Unit (Dog Creek):	
Shale, red-brown, platy	1.4
Southard Dolomite Bed:	
Dolomite, greenish-gray, silty, well-indurated, fine-grained, dense	0.1
Unit B (Dog Creek):	
Shale, red-brown, blocky	0.2
Siltstone, greenish-gray, mottled red-brown, weakly indurated	1.4
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky	2.4
Unit A (Dog Creek):	
Siltstone, red-brown and greenish-gray, argillaceous, weakly indurated	1.6
Siltstone, greenish-gray, argillaceous, well-indurated	0.2
Siltstone, red-brown and greenish-gray, argillaceous, weakly indurated	0.25
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty, blocky	0.2
Shale, red-brown, blocky	2.2
Gypsum, white, mottled red-brown, massive to thin-bedded; forming a prominent ledge	0.2
Shale, red-brown, blocky	1.0
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky	1.0
Watonga Dolomite Bed:	
Sandstone*, greenish-gray, dolomitic, well-indurated, fine-grained, massive; forming ledge	0.5
Siltstone, greenish-gray, mottled red-brown, weakly indurated; partly covered	2.2
Unnamed Units (Dog Creek):	
Shale and gypsum, greenish-gray, selenitic, silty, platy, thin-bedded, well-indurated; grading into siltstone	0.5
Shale, red-brown, blocky	1.0
Gypsum, red-brown and greenish-gray, argillaceous, platy, thin-bedded	0.3
Shale, greenish-gray and red-brown, blocky; with much satin spar	2.1
BLAINE FORMATION (total thickness, 63.2 feet)	
Shimer Gypsum Member (type section):	
Gypsum, white, fine-grained, massive, weathering coarsely	

	Thickness *(feet)*
selenitic; forming mappable escarpment	14.0
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, dense to oölitic, medium-bedded; weathering massive	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.2
Shale*, red-brown, blocky; with 1 foot of greenish-gray gypsiferous shale in middle	9.0
Nescatunga Gypsum Member (type section):	
Gypsum, white, fine-grained, well-indurated, massive; becoming dolomitic in basal 1 inch; forming a ledge	2.0
Unnamed Units (Blaine):	
Shale, greenish-gray, mottled red-brown, blocky	0.2
Shale*, red-brown, blocky; with some greenish-gray shale layers in middle	9.5
Medicine Lodge Gypsum Member (type section):	
Gypsum, white, fine-grained, thin-bedded, well-indurated; with anhydrite lenses in middle portion; weathering massive; forming escarpment and host rock for Comanche Cave	27.0
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-indurated, thin-bedded; grading upward into gypsum	0.25
FLOWERPOT SHALE (exposed thickness, 7.4 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.25
Unit J (Flowerpot):	
Shale, red-brown, blocky, selenitic	0.75
Unit I (Flowerpot):	
Shale, greenish-gray, mottled red-brown, selenitic, crinkly bedded	0.3
Shale, red-brown, blocky	0.25
Shale and gypsum, greenish-gray, mottled red-brown, well-indurated, crinkly bedded; forming ledge	0.75
Siltstone*, greenish-gray, argillaceous, weakly indurated; with some nodular gypsum	0.25
Shale, red-brown, blocky	0.75
Shale and gypsum, red-brown, selenitic, blocky	0.4
Shale, red-brown, blocky	0.6
Shale and gypsum, greenish-gray, selenitic, well-indurated, thin-bedded, crinkly bedded; with some red-brown shale beds	0.7
Unit H (Flowerpot):	
Shale, red-brown, blocky	1.0
Shale and gypsum, greenish-gray, well-indurated; as above; forming ledge	0.4
Shale, red-brown, blocky; exposed to creek	1.0

SECTION 3. REDROCK CREEK
COMANCHE COUNTY, KANSAS

Beginning at top in Marlow Formation, section measured along road in SE¼ SE¼ SE¼ sec. 30 and SW¼ SW¼ SW¼ sec. 29, T. 34 S., R. 16 W., southern Comanche County, Kansas.

	Thickness (feet)
MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-brown to moderate reddish-orange, fine-grained, weakly indurated; exposed to surface	10.0
Gypsum, red-brown, mottled white, fine-grained, well indurated, thinly laminated	0.75
Sandstone, red-brown, mottled greenish-gray, argillaceous, silty, weakly indurated, partly covered	1.0
Sandstone, greenish-gray, argillaceous, silty, fine-grained, weakly indurated, platy	0.1
DOG CREEK SHALE (total thickness, 36.1 feet)	
Shale, red-brown, blocky; conformable with beds above	1.2
Siltstone, greenish-gray, mottled red-brown, argillaceous, blocky	0.3
Shale, red-brown, blocky	1.0
Unit F (Dog Creek):	
Sandstone, greenish-gray, fine-grained, silty, friable to well-indurated; forming ledge	0.25
Unnamed Unit (Dog Creek):	
Siltstone, moderate reddish-brown to reddish-orange, mottled greenish-gray, arenaceous, well-indurated, thin-bedded	2.75
Unit C (Dog Creek):	
Siltstone, greenish-gray, thin-bedded, well-indurated	0.9
Unnamed Units (Dog Creek):	
Siltstone, moderate reddish-brown to moderate reddish-orange, argillaceous, weakly indurated	0.25
Shale, red-brown, blocky	0.75
Southard Bed:	
Siltstone, greenish-gray, dolomitic, platy, thin-bedded	0.1
Unit B (Dog Creek):	
Shale, red-brown, blocky	0.3
Siltstone, greenish-gray, mottled red-brown, dolomitic, well-indurated, thin-bedded	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky, partly covered	3.75
Gypsum, greenish-gray and red-brown, selenitic, argillaceous, well-indurated, thin-bedded, crinkly bedded	0.2
Shale, red-brown, blocky	0.5
Gypsum; as above	0.1
Shale, red-brown, blocky	0.4
Unit A (Dog Creek):	

	Thickness (feet)
Siltstone, greenish-gray, mottled red-brown, dolomitic, well-indurated, crinkly bedded	0.2
Siltstone, moderate reddish-brown to moderate reddish-orange, mottled greenish-gray, argillaceous, massive	0.6
Shale, red-brown, silty, blocky; with much selenite	1.5
Siltstone, greenish-gray, mottled red-brown to moderate reddish-orange, dolomitic, well-indurated, massive	0.6
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky; with much satin spar	1.75
Gypsum, white, mottled red-brown, well-indurated, crinkly bedded to massive	0.1
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky; with much satin spar	2.0
Gypsum, white, mottled red-brown and greenish-gray, well-indurated, massive, wavy bedded; forming prominent ledge	0.2
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky	2.0
Siltstone, greenish-gray, argillaceous, dolomitic, blocky; well-indurated in places	0.1
Shale, red-brown, blocky; with some greenish-gray siltstone bands	2.0
Siltstone, greenish-gray, well-indurated, massive	0.25
Shale, red-brown, silty, blocky	1.5
Watonga Dolomite Bed:	
Siltstone, greenish-gray, argillaceous, dolomitic, gypsiferous, well-indurated, thin-bedded; with many symmetrical ripple marks that strike west; selenitic and red brown in upper 6 inches; forming ledge	2.0
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky; with much satin spar	2.0
Siltstone, greenish-gray, mottled red-brown, well-indurated, massive	0.2
Shale, red-brown, blocky; with much satin spar	0.75
Siltstone, well-indurated; as above	1.7
Shale, red-brown, mottled greenish-gray, silty, blocky	2.0
BLAINE FORMATION (not examined)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, massive; with 2 feet of anhydritelike layer in middle; forming prominent mappable escarpment in region; underlain by normal Blaine sequence; exposed	10.0

SECTION 4. YELLOWSTONE CREEK
NORTHERN WOODS COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in SW¼ SE¼ SE¼ sec. 3, T. 28 N., R. 17 W., north of section-line road and

east of creek, down to lower part of Dog Creek Shale. Section then extrapolated to NE¼ NW¼ SE¼ sec. 15, T. 29 N., R. 17 W. for lower portion of Dog Creek Shale to Shimer Gypsum, and then NW¼ SW¼ sec. 26, T. 29 N., R. 17 W., in bluff east of road for Blaine and Flowerpot Formations, northern Woods County, Oklahoma.

	Thickness *(feet)*
MARLOW FORMATION (top not exposed)	
Sandstone*, moderate reddish-brown to moderate reddish-orange, fine-grained, weakly indurated, massive	5.0
Sandstone, greenish-gray, mottled moderate reddish-brown to moderate reddish-orange, fine-grained, weakly indurated, thinly laminated; as above	0.9
DOG CREEK SHALE (total thickness, 48.1 feet)	
Shale, red-brown, blocky	2.9
Unit C (Dog Creek):	
Dolomite,* greenish-gray, fine-grained, dense, well-indurated	0.25
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky; with well-indurated dolomitic shale in upper 1 inch	2.0
Southard Dolomite Bed:	
Dolomite*, light-gray, fine-grained, dense, well indurated	0.1
Unit B (Dog Creek):	
Shale*, purplish-brown, platy, thin-bedded; dolomitic in basal 1 inch	0.3
Shale, red-brown, blocky; with dolomitic shale in basal 1 inch	0.5
Shale, greenish-gray, mottled red-brown, weakly indurated, platy, thin-bedded	2.8
Siltstone*, greenish-gray, dolomitic, well-indurated, massive	0.5
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray siltstone layers	4.5
Sandstone*, greenish-gray and red-brown, silty, fine-grained, blocky	1.3
Shale, red-brown, blocky	3.0
Unit A (Dog Creek):	
Siltstone, light-brown, argillaceous, gypsiferous, well-indurated; forming a ledge	5.0
Siltstone*, red-brown, calcareous, gypsiferous, quartzose, thin-bedded, cross-bedded, well-indurated; forming ledge	4.0
Unnamed Units (Dog Creek):	
Siltstone, moderate reddish-brown to moderate reddish-orange, argillaceous, weakly indurated, blocky, massive	2.7
Siltstone, well-indurated, massive; as above	2.2
Shale, red-brown, mottled greenish-gray, silty, thin-bedded, weakly indurated; section extrapolated to sec. 15, T. 29 N., R. 17 W.	2.8
Sandstone*, greenish-gray, silty, weakly indurated	1.2

	Thickness (feet)
Shale, red-brown, blocky	2.0
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky	2.2
Siltstone, greenish-gray, mottled red-brown, weakly indurated	0.2
Shale, red-brown, silty, platy	2.0
Watonga Dolomite Bed:	
Siltstone*, greenish-gray, dolomitic, arenaceous, thin-bedded, platy; with two sets of symmetrical ripple marks, the top set striking northeast and the bottom set striking northwest	0.5
Unnamed Units (Dog Creek):	
Shale, greenish-gray, mottled red-brown, silty, weakly indurated	0.25
Shale, red-brown, silty, blocky	4.75
BLAINE FORMATION (total thickness, 63.9 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming mappable escarpment	15.75
Altona Dolomite Bed:	
Dolomite*, light-brown, fine-grained, oölitic, thin-bedded; forming ledge	0.3
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky; section extrapolated to sec. 26, T. 29 N., R. 17 W.	0.1
Shale, red-brown, blocky; with some greenish-gray shale layers	7.5
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming escarpment	10.5
Magpie Bed:	
Siltstone*, greenish-gray, arenaceous, dolomitic, weakly indurated	0.2
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky; with some greenish-gray layers	7.0
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, massive, weathering coarsely selenitic; forming a mappable escarpment	22.0
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray to light-brown, fine-grained, dense to oölitic, thin-bedded	0.3
FLOWERPOT SHALE (exposed thickness, 21.4 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.5
Units I-J (Flowerpot):	
Siltstone*, red-brown and greenish-gray, blocky, weakly indurated	2.4

	Thickness (feet)
Unit H (Flowerpot):	
Shale, red-brown, blocky; with some greenish-gray streaks	3.1
Units E-G (Flowerpot):	
Shale, greenish-gray, mottled red-brown, silty, weakly indurated, thin-bedded, blocky	1.0
Unit D (Flowerpot):	
Shale, red-brown, blocky	3.5
Unit C (Flowerpot):	
Siltstone*, red-brown, mottled greenish-gray, arenaceous, weakly-indurated, thin-bedded, blocky	2.75
Shale, greenish-gray, weakly indurated, blocky	0.1
Siltstone, red-brown and greenish-gray; as above	0.75
Shale, moderate-brown, mottled greenish-gray, silty, platy	0.25
Siltstone, red-brown and greenish-gray; as above	1.5
Shale, moderate-brown and greenish-gray, silty, platy	0.2
Siltstone, red-brown and greenish-gray; as above	1.2
Units A-B (Flowerpot):	
Shale, red-brown, blocky	3.0
Siltstone, greenish-gray, argillaceous, weakly indurated, blocky	0.1
Shale, red-brown, silty, blocky, exposed	1.0

SECTION 5. GREENWOOD CREEK
NORTHERN WOODS COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in NE¼ NW¼ NW¼ sec. 28, continued in Dog Creek Shale in NW¼ NE¼ sec. 28 and SE¼ SW¼ sec. 21 for lower part of Dog Creek Shale and entire Blaine Formation, ending in NE¼ SE¼ sec. 13, T. 28 N., R. 16 W., for Flowerpot Shale, northern Woods County, Oklahoma.

MARLOW FORMATION (top not exposed)	
Doe Creek Lentil:	
Sandstone*, moderate reddish-brown to moderate reddish-orange, calcareous, medium- to coarse-grained, quartzose, well-indurated, thin-bedded, cross-bedded; with box-work weathered surfaces; forming prominent mappable escarpment	8.25
Unnamed Unit (Marlow):	
Sandstone*, moderate reddish-brown to moderate reddish-orange, fine-grained, quartzose, weakly indurated, cross-bedded	56.0
DOG CREEK SHALE (total thickness, 51.6 feet)	
Shale, red-brown, mottled greenish-gray, blocky; conformable with beds above	4.2
Unit E (Dog Creek):	
Dolomite*, red-brown, argillaceous, fine-grained, well-indur-	

	Thickness (feet)
ated, wavy bedded, massive	0.1
Unnamed Units (Dog Creek):	
Siltstone, greenish-gray, mottled red-brown, argillaceous, platy, weakly indurated	0.4
Shale, red-brown, silty, blocky; with some greenish-gray beds	5.0
Unit C (Dog Creek):	
Dolomite*, light-brown to light-gray, fine-grained, dense, massive, blocky	0.2
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky	0.75
Southard Dolomite Bed:	
Dolomite*, mottled greenish-gray and pink, fine-grained, dense, well-indurated, massive	0.1
Unit B (Dog Creek):	
Shale, purplish-brown, platy	0.25
Shale, red-brown, blocky	1.0
Dolomite*, light-brown, fine-grained, dense, well-indurated, massive	0.1
Shale, red-brown, blocky	1.0
Dolomite*, mottled greenish-gray and light-pink, fine- grained, dense, well-indurated, massive	0.2
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky	8.25
Unit A (Dog Creek):	
Siltstone*, moderate reddish-brown to moderate reddish-orange, arenaceous, well-indurated, thin-bedded; forming prominent ledge	6.0
Siltstone, greenish-gray, mottled red-brown, well-indurated	0.5
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	3.0
Siltstone, red-brown, mottled greenish-gray, argillaceous, weakly indurated, thin-bedded	2.2
Siltstone, greenish-gray, mottled red-brown, moderately indurated, massive	0.5
Shale, red-brown, blocky; mottled greenish-gray at base	0.75
Siltstone, mottled red-brown and greenish-gray, moderately indurated, massive	0.8
Siltstone, greenish-gray, dolomitic, well-indurated, massive; forming a ledge	0.1
Siltstone, greenish-gray, mottled moderate reddish-orange, weakly indurated, massive	0.6
Shale, red-brown, blocky	0.8
Siltstone, mottled greenish-gray and red-brown, weakly indurated, thin-bedded	1.0
Shale, red-brown, blocky; silty at top	1.5
Siltstone, greenish-gray, argillaceous, platy; indurated in places	0.1
Shale, red-brown, blocky	2.3
Siltstone, greenish-gray, argillaceous, gypsiferous, weakly	

	Thickness (feet)
indurated	0.1
Shale, red-brown, blocky	0.8
Siltstone, greenish-gray, argillaceous, well-indurated, platy, thin-bedded	0.05
Shale, red-brown, blocky	2.8
Watonga Bed:	
Siltstone, greenish-gray, mottled red-brown, argillaceous, platy; dolomitic at top; forming small ledge	0.8
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray shale spots	5.25
BLAINE FORMATION (total thickness, 68.3 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming mappable escarpment	11.0
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-indurated, medium-bedded; weathering into box-works; forming escarpment	0.5
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.2
Shale and siltstone*, red-brown, blocky; with some greenish-gray layers	7.8
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming an escarpment	10.0
Magpie Bed:	
Siltstone*, light-brown to greenish-gray, gypsiferous, dolomitic, weakly indurated, massive	0.25
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.25
Shale*, red-brown, blocky; with some greenish-gray shale layers and crinkly bedded selenite	7.5
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming an escarpment	31.0
Cedar Springs Dolomite Bed:	
Dolomite*, light-brown to light-gray, fine-grained, oölitic, well-indurated, thin-bedded; grading into gypsum above	0.25
FLOWERPOT SHALE (exposed thickness, 148.7 feet; base not seen)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.1
Units I-J (Flowerpot):	
Shale, red-brown, selenitic, blocky; section extrapolated to sec. 13, T. 28 N., R. 16 W., in isolated butte	0.9
Shale, greenish-gray, selenitic, blocky	0.1
Shale, red-brown, selenitic, blocky	0.75

	Thickness (feet)
Shale, greenish-gray, silty, selenitic, blocky	0.1
Shale, red-brown, selenitic, blocky	2.6
Shale, mottled greenish-gray and red-brown, selenitic, well-indurated	0.1
Shale, red-brown, selenitic, blocky	1.5
Gypsum, white, mottled greenish-gray, nodular, well-indurated; forming a ledge	0.3
Unit H (Flowerpot):	
Shale, red-brown, selenitic, blocky	1.0
Units E-G (Flowerpot):	
Siltstone*, mottled greenish-gray and red-brown, arenaceous, thin-bedded, blocky	0.8
Unit D (Flowerpot):	
Shale, red-brown, silty, blocky; with some gypsum nodules	0.75
Unit C (Flowerpot):	
Siltstone*, red-brown, arenaceous, calcareous, weakly indurated, thin-bedded	3.0
Shale, mottled red-brown and greenish-gray, silty, thin-bedded	0.3
Siltstone, red-brown, argillaceous, weakly indurated, massive	2.0
Siltstone*, greenish-gray, arenaceous, weakly indurated, blocky	0.2
Unit B (Flowerpot):	
Shale, red-brown, blocky; with some gypsum nodules	2.6
Unit A_s (Flowerpot):	
Siltstone, greenish-gray, mottled red-brown, argillaceous, blocky; indurated in places	0.2
Shale, red-brown, selenitic, blocky	0.3
Siltstone, mottled greenish-gray and red-brown, argillaceous, weakly indurated, thin-bedded	0.6
Shale, red-brown, selenitic, blocky	0.6
Shale, red-brown, mottled greenish-gray, selenitic, well-indurated, crinkly bedded; forming a ledge	0.25
Shale, red-brown, selenitic, blocky	0.75
Shale, red-brown, selenitic, well-indurated, thin-bedded, crinkly bedded; forming a ledge	0.3
Shale, red-brown, blocky, selenitic; with some thin greenish-gray shale layers	2.5
Shale, greenish-gray, blocky	0.2
Shale, red-brown, selenitic, blocky	2.2
Shale, greenish-gray, mottled red-brown, selenitic, well-indurated, crinkly bedded	0.25
Shale, red-brown, selenitic, blocky	0.75
Shale, red-brown, mottled greenish-gray, selenitic, well-indurated, thin-bedded, crinkly bedded	0.25
Shale, red-brown, blocky	0.25
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky	1.0

	Thickness *(feet)*
Shale, greenish-gray, selenitic, silty, well-indurated, crinkly bedded	0.2
Shale, red-brown, selenitic, blocky	1.75
Shale, greenish-gray, mottled red-brown, selenitic, silty, well-indurated, thin-bedded, crinkly bedded	0.3
Shale, red-brown, selenitic, blocky	1.0
Shale, greenish-gray, selenitic, blocky	0.2
Shale, red-brown, selenitic, blocky	0.5
Shale, red-brown, selenitic, well-indurated, crinkly bedded	0.2
Shale, red-brown, selenitic, blocky	0.8
Shale, greenish-gray, selenitic, blocky	0.25
Shale, red-brown, selenitic, blocky; with some greenish-gray shale spots	5.2
Shale, greenish-gray, selenitic, well-indurated, thin-bedded, crinkly bedded; forming a ledge	0.25
Shale, red-brown, blocky	0.2
Dolomite*, greenish-gray, silty, fine-grained, dense, well-indurated, thin-bedded	0.2
Shale, red-brown, blocky; with some gypsum nodules	0.8
Shale, red-brown, gypsiferous, silty, well-indurated, thin-bedded, crinkly bedded	0.4
Shale, red-brown, blocky	1.0
Siltstone*, red-brown, mottled greenish-gray, calcareous, thin-bedded, weakly-indurated; with many small white gypsum nodules	1.6
Shale, red-brown, silty, blocky; with some gypsum nodules	2.3
Shale, greenish-gray, selenitic, blocky, well-indurated, crinkly bedded	0.2
Shale, red-brown, selenitic, blocky	0.8
Shale, greenish-gray, selenitic, well-indurated, crinkly bedded	0.1
Shale, red-brown, selenitic, blocky	1.0
Unit A_2 (Flowerpot):	
Siltstone*, greenish-gray, arenaceous, dolomitic, gypsiferous, well-indurated, massive; at base of extremely gypsiferous section; forming ledge	0.5
Siltstone, red-brown and greenish-gray, argillaceous, well-indurated, thin-bedded, platy	2.1
Siltstone, greenish-gray, argillaceous, blocky; well-indurated at top	0.2
Unit A_1 (Flowerpot):	
Shale, red-brown, blocky	1.75
Shale, greenish-gray, silty, blocky	0.2
Shale, red-brown, blocky; with some selenite	1.0
Shale, greenish-gray and red-brown, selenitic, blocky	0.6
Shale, red-brown, blocky	0.75
Shale, greenish-gray and red-brown, selenitic, blocky	0.75
Shale, red-brown, selenitic, blocky; with some gypsum nodules and thin greenish-gray shale layers	5.5

	Thickness *(feet)*
Shale, greenish-gray, selenitic, blocky	0.2
Shale, red-brown, blocky; with some selenite	2.6
Shale, greenish-gray, selenitic, blocky	0.3
Shale, red-brown, blocky	1.7
Shale, greenish-gray, selenitic, well-indurated, crinkly bedded	0.1
Shale, red-brown, blocky	0.9
Shale, greenish-gray, selenitic, well-indurated, crinkly bedded	0.1
Shale, red-brown, blocky	0.8
Shale, greenish-gray, selenitic, blocky	0.1
Shale, red-brown, blocky	1.0
Shale, greenish-gray, mottled red-brown, selenitic, blocky	0.2
Shale, red-brown, selenitic, blocky	1.8
Shale, greenish-gray, blocky	0.2
Siltstone*, mottled greenish-gray and red-brown, argillaceous, moderately indurated, thin-bedded	1.8
Shale, red-brown, silty, blocky	1.1
Siltstone, greenish-gray, argillaceous, blocky, massive	0.3
Shale, red-brown, blocky	0.8
Siltstone, greenish-gray, argillaceous, selenitic, well-indurated, crinkly bedded	0.1
Shale, red-brown, blocky; with some satin spar layers	1.4
Siltstone, greenish-gray, argillaceous, blocky	0.1
Shale, red-brown, blocky	1.25
Shale, greenish-gray, blocky	0.1
Shale, moderate- to dusky-brown, blocky	0.6
Shale, red-brown, blocky; with much satin spar	2.7
Shale, red-brown, blocky; with a 1-inch greenish-gray shale layer at top, one in middle, and one at base	1.0
Shale, red-brown, blocky	2.25
Shale, mottled greenish-gray and dusky-brown, blocky	0.25
Shale, red-brown, blocky; with some gypsum nodules	2.2
Shale, greenish-gray, selenitic, blocky	0.2
Shale, red-brown, selenitic, blocky	2.8
Shale, red-brown, selenitic, blocky; with many thin greenish-gray shale stringers	0.75
Shale, red-brown, selenitic, blocky	3.75
Shale, greenish-gray, selenitic, well-indurated, crinkly bedded	0.1
Shale, red-brown, blocky	0.25
Shale*, dusky-brown, mottled greenish-gray, blocky	3.0
Shale, red-brown, selenitic, blocky; with much satin spar and some greenish-gray layers	3.5
Dolomite*, greenish-gray, mottled red-brown, silty, blocky	0.1
Siltstone, greenish-gray, mottled red-brown, argillaceous, dolomitic, well-indurated, blocky	0.9
Shale, red-brown, silty, blocky	1.5
Siltstone, greenish-gray, argillaceous, selenitic, well-indur-	

	Thickness *(feet)*
ated, crinkly bedded	0.7
Shale, red-brown, blocky	1.0
Siltstone, greenish-gray, mottled red-brown, selenitic, argillaceous, thin-bedded, crinkly bedded	0.5
Shale, red-brown, blocky; with much satin spar	2.2
Siltstone, greenish-gray, mottled red-brown, thin-bedded, platy	0.25
Shale, red-brown, blocky; with thin satin spar veins	2.1
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky	4.2
Shale, red-brown, blocky; with much satin spar	3.0
Siltstone, greenish-gray, selenitic, well-indurated, crinkly bedded	0.1
Shale, red-brown, blocky	4.5
Siltstone, greenish-gray, argillaceous, selenitic, well-indurated	0.2
Shale, red-brown, blocky; with much satin spar	7.75
Siltstone, greenish-gray, argillaceous, selenitic, well-indurated	0.2
Shale, red-brown, blocky	1.0
Shale, mottled greenish-gray and red-brown, blocky	0.2
Shale, red-brown, blocky	1.0
Shale, mottled greenish-gray and red-brown, selenitic, well-indurated, blocky	0.5
Shale, red-brown, silty, blocky; with some satin spar	6.25
Siltstone, mottled greenish-gray and red-brown, moderately indurated, thin-bedded; forming a ledge	3.0
Shale, red-brown, blocky	1.8
Siltstone, greenish-gray, argillaceous, blocky	0.25
Shale, red-brown, blocky; with some satin spar	4.2
Siltstone, greenish-gray; with many gypsum nodules	0.2
Shale, red-brown, blocky	0.3
Siltstone, greenish-gray, argillaceous; with many gypsum nodules	0.2
Shale, red-brown, blocky	1.8
Siltstone, greenish-gray, argillaceous; weakly indurated at top	0.2
Shale, red-brown, blocky; exposed	3.0

SECTION 6. WHITEHORSE CREEK
CENTRAL WOODS COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, Doe Creek Lentil type area for the Whitehorse Group, in NE¼ NE¼ NW¼ sec. 29, T. 27 N., R. 16 W., north of highway, and in S½ SW¼ sec. 20 along Whitehorse Creek for the Blaine section, into the upper part of the Flowerpot Shale. The remainder of the Flowerpot was measured in SE¼ SE¼ NW¼ sec. 6, T. 26 N., R. 16 W., just west of Whitehorse Creek.

	Thickness (feet)
MARLOW FORMATION (only lower portion exposed)	
Doe Creek Lentil:	
Dolomite*, moderate reddish-brown to moderate reddish-orange, algal, arenaceous, quartzose, well-cemented; with medium- to coarse-subrounded to well-rounded grains; with fossil clams and snails abundant in middle 3 inches; clastic material abundant near base; and algal material abundant near top. The algae are of two forms, probably of the same species, being oölitic at base and lamellar-incrusting at top; section thicker toward north	1.75
DOG CREEK SHALE (total thickness, 62.3 feet)	
Shale, moderate reddish-brown to moderate reddish-orange, silty, blocky	1.25
Siltstone*, moderate reddish-brown to moderate reddish-orange, arenaceous, well-indurated, massive, blocky; with some 1-inch white calcite geodes; forming ledge	0.3
Shale, greenish-gray, blocky	0.1
Shale, red-brown, silty, blocky	4.5
Unit F_2 (Dog Creek):	
Siltstone*, moderate reddish-brown to moderate reddish-orange, arenaceous, well-indurated, massive; forming ledge	0.5
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky; with some greenish-gray layers at base	10.25
Unit E (Dog Creek):	
Dolomite*, very dusky red-purple, platy, silty, argillaceous, thin-bedded	0.2
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky	4.0
Unit C (Dog Creek):	
Dolomite*, light-brown, fine-grained, dense, well-indurated, massive; forming a ledge	0.1
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky	2.7
Southard Dolomite Bed:	
Dolomite*, greenish-gray, silty, argillaceous, well-indurated, platy	0.1
Unit B (Dog Creek):	
Dolomite and siltstone*, very dusky red-purple, well-indurated, massive, blocky	0.9
Shale, dark red-brown, blocky	3.75
Dolomite*, mottled greenish-gray and very dusky red-purple, silty, fine-grained, dense, well-indurated, massive	0.1
Unnamed Units (Dog Creek):	
Siltstone, red-brown, argillaceous, well-indurated, wavy bedded, massive	0.8
Shale, red-brown, blocky	1.2
Siltstone, greenish-gray, mottled red-brown, argillaceous,	

	Thickness (feet)
weakly indurated	0.25
Shale, red-brown, silty, blocky; with some greenish-gray spots and layers	6.0
Unit A (Dog Creek):	
Sandstone*, red-brown, mottled greenish-gray, silty, fine- to medium-grained, thin-bedded; forming ledge	9.0
Siltstone*, greenish-gray, dolomitic, well-indurated, thin-bedded	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky	0.75
Siltstone*, light-gray to greenish-gray, dolomitic, fine- grained, dense, well-indurated	0.1
Siltstone, red-brown, mottled greenish-gray, weakly indurated, thin-bedded	1.0
Shale, greenish-gray, mottled red-brown, weakly indurated, thin-bedded	0.2
Shale, red-brown, blocky; grading into siltstone at base	3.0
Siltstone, greenish-gray, argillaceous, weakly indurated, platy, crinkly bedded	0.3
Shale, red-brown, silty, platy	0.7
Siltstone, greenish-gray, mottled red-brown, platy	0.25
Shale, red-brown, blocky	2.75
Watonga Bed:	
Siltstone, greenish-gray, mottled red-brown, dolomitic, thin-bedded; well indurated in places	0.6
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky	2.5
Siltstone, greenish-gray, mottled red-brown, argillaceous, weakly indurated, massive	1.0
Shale, red-brown, blocky; with some greenish-gray siltstone beds	3.0
BLAINE FORMATION (total thickness, 56.1 feet)	
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic; weathering into box-works; forming ledge	1.0
Unnamed Unit (Blaine):	
Shale, red-brown, mottled greenish-gray, blocky; covered in part	11.0
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; silty at base; forming ledge	11.0
Magpie Bed:	
Siltstone*, light-gray, dolomitic, fine-grained, oölitic	0.75
Unnamed Unit (Blaine):	
Shale*, red-brown, blocky; mottled with greenish-gray shale spots	10.0
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled light-gray, fine-grained, massive;	

	Thickness *(feet)*
weathering coarsely selenitic; forming prominent mappable escarpment	22.0
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray to light-brown, fine-grained, oölitic, medium-bedded, massive	0.3
FLOWERPOT SHALE (exposed thickness, 112.9 feet; base not seen)	
Unit K (Flowerpot):	
Shale, greenish-gray, mottled red-brown, blocky	0.75
Unit J (Flowerpot):	
Shale, red-brown, selenitic, blocky	0.5
Unit I (Flowerpot):	
Shale, greenish-gray, selenitic, blocky	0.2
Shale, red-brown, selenitic, blocky	1.25
Shale, greenish-gray, blocky	0.25
Shale, red-brown, selenitic, blocky	0.9
Shale, greenish-gray, blocky	0.2
Shale, red-brown, selenitic, blocky	1.5
Siltstone, greenish-gray, gypsiferous, well-indurated, crinkly bedded	0.2
Unit H (Flowerpot):	
Siltstone, red-brown, mottled greenish-gray; with many 1- to 3-inch selenite patches	1.5
Units E-G (Flowerpot):	
Siltstone*, greenish-gray, dolomitic, argillaceous, weakly indurated, thin-bedded	1.75
Unit D (Flowerpot):	
Shale, red-brown, silty, blocky	1.9
Unit C (Flowerpot):	
Siltstone, greenish-gray, mottled red-brown, argillaceous, moderately indurated, crinkly bedded	0.5
Siltstone, red-brown, argillaceous, thin-bedded; with many small gypsum nodules	3.5
Siltstone, greenish-gray, selenitic, argillaceous, weakly indurated	0.1
Unit B (Flowerpot):	
Siltstone, red-brown, argillaceous; as above; with many moderate reddish-orange gypsum nodules	2.9
Unit A_3 (Flowerpot):	
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky, selenitic, partly covered; mottled with greenish-gray spots; section extrapolated to NW¼ sec. 6, T. 26 N., R. 16 W., in hill west of Whitehorse Creek	6.25
Siltstone*, greenish-gray, fine-grained; well indurated at top	0.2
Shale, red-brown, blocky; with much selenite	3.0
Siltstone, greenish-gray, argillaceous, weakly indurated, massive	0.2

	Thickness (feet)
Shale, red-brown, blocky; with much selenite	5.25
Shale, greenish-gray, weakly-indurated, blocky	0.2
Shale, red-brown, blocky	2.0
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky	0.2
Siltstone, greenish-gray, argillaceous, gypsiferous, well-indurated	0.1
Shale, red-brown, blocky	0.4
Siltstone, greenish-gray, mottled red-brown, weakly indurated, thin-bedded	0.25
Shale, red-brown, blocky	4.2
Shale, red-brown, blocky; with many greenish-gray shale layers and much nodular and selenitic gypsum; forming ledge and base of extremely gypsiferous section	2.5
Shale, greenish-gray, blocky	0.25
Shale, red-brown, blocky	0.6
Shale, greenish-gray, selenitic, blocky, thin-bedded	0.1
Shale, red-brown, blocky; with many satin spar veins	5.0
Siltstone*, greenish-gray, dolomitic, moderately indurated, crinkly bedded	0.3
Shale, red-brown, blocky; with some selenite crystals	2.0
Unit A_2 (Flowerpot):	
Siltstone*, greenish-gray, gypsiferous, dolomitic, arenaceous, well-indurated, crinkly bedded, thin-bedded; forming a ledge	0.8
Unit A_1 (Flowerpot):	
Shale, red-brown, blocky; with some thin selenite veins	3.3
Siltstone, mottled greenish-gray and red-brown, gypsiferous, weakly indurated, thin-bedded	0.75
Shale, red-brown, platy, thin-bedded	0.25
Shale*, greenish-gray, weakly indurated, blocky	0.3
Shale, red-brown, blocky; with some selenite	1.6
Shale, greenish-gray, mottled red-brown, gypsiferous, blocky; indurated in places	0.25
Shale, red-brown, blocky	2.0
Siltstone, greenish-gray, argillaceous, gypsiferous, well-indurated; forming a ledge	0.2
Shale, red-brown, blocky; with some gypsum nodules	2.0
Siltstone, greenish-gray, gypsiferous, argillaceous, well-indurated, crinkly bedded	0.1
Shale, red-brown, mottled greenish-gray, blocky	0.75
Siltstone*, greenish-gray, mottled reddish-brown, arenaceous, thin-bedded; light-brown at base; with alternating well-indurated and weakly indurated layers	1.5
Shale, red-brown, blocky	2.25
Shale, greenish-gray, weakly indurated, platy	1.2
Shale, red-brown, blocky; with some greenish-gray layers and gypsum nodules	7.0
Shale, greenish-gray, gypsiferous, weakly indurated, blocky	0.25

	Thickness (feet)
Shale, red-brown, blocky	0.3
Siltstone, greenish-gray, argillaceous, gypsiferous; well-indurated in places	0.1
Shale, red-brown, selenitic, blocky	2.0
Shale, greenish-gray, selenitic, blocky	0.7
Shale, red-brown, selenitic, blocky	3.5
Shale, greenish-gray, selenitic, blocky	0.1
Shale, red-brown, blocky	1.0
Shale, greenish-gray, gypsiferous, silty, blocky	0.2
Shale, red-brown, blocky; with some greenish-gray layers	2.0
Shale, greenish-gray, selenitic, silty, blocky	0.7
Shale, red-brown, blocky, selenitic	5.25
Siltstone*, greenish-gray, gypsiferous, dolomitic, weakly indurated, massive; forming prominent light-colored band	1.75
Shale, red-brown, blocky	2.6
Shale, greenish-gray, selenitic, blocky	0.1
Shale, red-brown, blocky; with greenish-gray layers at base	4.0
Shale, greenish-gray, blocky	0.1
Shale, dusky brown, mottled greenish-gray, weakly indurated, blocky	3.0
Shale, red-brown, blocky; exposed	10.0

SECTION 7. REDHORSE CREEK
CENTRAL WOODS COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in SW¼ NW¼ sec. 10, T. 27 N., R. 17 W. along creek, to Shimer Gypsum, continuing through the Blaine Formation in SW¼ SW¼ sec. 10, ending in the Flowerpot Shale and lower part of the Blaine Formation in SE¼ NW¼ NW¼ sec. 22, T. 27 N., R. 17 W., where Redhorse Creek crosses U. S. Highway 64, central Woods County, Oklahoma.

MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-brown to moderate reddish-orange, fine-grained, quartzose, weakly indurated	5.0
Doe Creek Lentil:	
Sandstone*, light-gray, coarse-grained, quartzose, moderately indurated, friable	0.25
DOG CREEK SHALE (total thickness, 54.2 feet)	
Shale, red-brown, silty	0.3
Siltstone*, light-gray to greenish-gray, calcareous, moderately indurated	0.2
Siltstone*, red-brown and greenish-gray, calcareous, moderately indurated, blocky	1.2
Shale, red-brown, blocky	2.25
Siltstone, greenish-gray, moderately indurated, crinkly bedded, thin-bedded	0 25

	Thickness (feet)
Shale, red-brown, mottled greenish-gray, weakly indurated, blocky	1.4
Siltstone*, greenish-gray, calcareous, platy; well-indurated at top	0.2
Shale, red-brown, weakly indurated, blocky	1.0
Unit E (Dog Creek):	
Siltstone*, greenish-gray, calcareous, well-indurated, platy	0.1
Dolomite*, light-gray, fine-grained, dense, well-cemented, massive; weathering light brown	0.1
Shale, red-brown, well-indurated, blocky	0.1
Dolomite*, light-gray to greenish-gray, silty, argillaceous, weakly indurated, platy	0.3
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky, thin-bedded	4.0
Unit D (Dog Creek):	
Dolomite*, light-brown, fine-grained, argillaceous, dense, blocky, massive; forming ledge	0.1
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky	0.8
Unit C (Dog Creek):	
Dolomite*, light-brown, silty, argillaceous, fine-grained, dense, massive, blocky	0.25
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky; silty at top	1.2
Shale, light-brown, mottled greenish-gray, weakly indurated, blocky	0.25
Shale, mottled greenish-gray and red-brown, weakly indurated, blocky	1.4
Southard Dolomite Bed:	
Dolomite*, greenish-gray, well-indurated, silty, crinkly bedded, thin-bedded; forming ledge	0.25
Unit B (Dog Creek):	
Siltstone*, greenish-gray, calcareous, argillaceous, weakly indurated; becoming dolomitic at base	0.8
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	2.75
Siltstone*, greenish-gray, calcareous, moderately indurated, massive; forming ledge	0.5
Shale, red-brown, blocky	2.0
Shale, mottled greenish-gray and red-brown, silty, blocky	0.8
Shale, red-brown, silty, blocky	4.0
Unit A (Dog Creek):	
Siltstone*, greenish-gray, arenaceous, quartzose, moderately indurated, friable; forming ledge	1.1
Siltstone*, moderate reddish-brown to moderate reddish-orange, calcareous, moderately indurated, thin-bedded; arenaceous at top; forming ledge	7.0
Siltstone, greenish-gray, argillaceous, thin-bedded, crinkly bedded	0.5

	Thickness (feet)
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, weakly indurated, blocky	0.75
Siltstone, mottled red-brown and greenish-gray, well-indurated, thin-bedded, crinkly bedded	0.5
Shale, red-brown, silty, blocky	5.5
Siltstone, mottled red-brown and greenish-gray, argillaceous, massive	0.7
Shale, red-brown, blocky	4.75
Siltstone*, greenish-gray, arenaceous, weakly indurated	1.5
Shale, red-brown, blocky	2.0
Watonga Bed:	
Siltstone*, greenish-gray, arenaceous, dolomitic, well-indurated, platy; with symmetrical ripple marks that strike northwest	0.1
Unnamed Unit (Dog Creek):	
Shale, red-brown, mottled greenish-gray, blocky	3.25
BLAINE FORMATION (total thickness, 56.4 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, crystalline, well-indurated, massive; wavy bedded at top; forming escarpment	12.0
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, medium-bedded, massive; weathering into box-works	0.75
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.2
Shale,* red-brown, mottled greenish-gray, weakly indurated, blocky	13.6
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming escarpment	11.5
Magpie Dolomite Bed:	
Dolomite*, light-gray, gypsiferous, fine-grained, massive; dense in part	0.25
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.1
Shale*, red-brown, silty; with 9-inch greenish-gray gypsiferous zone 4 feet above base	11.5
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, medium-bedded; weathering coarsely selenitic; forming escarpment; section extrapolated to SE¼ NW¼ NW¼ sec. 22, T. 27 N., R. 17 W., on U. S. Highway 64	26.0
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-indurated, massive	0.5
FLOWERPOT SHALE (exposed thickness, 62.7 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.25

	Thickness (feet)
Units I-J (Flowerpot):	
Shale, red-brown, blocky, selenitic; with many gypsum nodules and some thin greenish-gray shale layers	1.5
Shale, greenish-gray, silty, selenitic; with many gypsum nodules	0.25
Shale, red-brown, blocky; with some greenish-gray spots and layers	2.6
Siltstone*, greenish-gray, dolomitic, gypsiferous, well-indurated, crinkly bedded, massive; forming ledge	0.2
Unit H (Flowerpot):	
Shale, red-brown, blocky; with some greenish-gray spots and layers	2.7
Units E-G (Flowerpot):	
Siltstone, greenish-gray, mottled red-brown, gypsiferous, well-indurated, massive, crinkly bedded; forming ledge	0.2
Shale, red-brown, silty, blocky	0.8
Siltstone, greenish-gray, argillaceous, gypsiferous, well-indurated, crinkly bedded	0.1
Unit D (Flowerpot):	
Shale, red-brown, silty, blocky	1.0
Unit C (Flowerpot):	
Siltstone*, mottled red-brown and greenish-gray, thinly laminated, well-indurated; with many gypsum nodules; forming ledge	5.2
Unit B (Flowerpot):	
Shale, greenish-gray, mottled red-brown, silty, weakly indurated, blocky	0.5
Shale, red-brown, blocky; with some small gypsum nodules	4.0
Unit A_g (Flowerpot):	
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, blocky; with many gypsum nodules	1.8
Shale, mottled greenish-gray and red-brown, weakly indurated, blocky	0.75
Shale, red-brown, blocky	1.0
Siltstone*, greenish-gray, mottled red-brown, argillaceous, gypsiferous, moderately indurated, thin-bedded; with many small gypsum nodules; forming ledge	2.4
Shale, red-brown, blocky; with some greenish-gray spots and gypsum nodules	2.5
Siltstone*, greenish-gray, mottled light-brown, dolomitic, gypsiferous, argillaceous, selenitic, well-indurated, massive, crinkly bedded; forming ledge	0.2
Shale, red-brown, weakly indurated, platy	0.3
Shale, red-brown and greenish-gray, gypsiferous, thin-bedded, crinkly bedded; alternating weakly to well-indurated layers	0.6
Shale, red-brown, blocky; with some greenish-gray spots and thin seams of satin spar	5.25
Siltstone, greenish-gray, argillaceous, weakly indurated,	

	Thickness (feet)
platy	0.2
Shale, red-brown, blocky; with many thin greenish-gray shale layers and satin spar seams; forming base of extremely gypsiferous section	4.2
Shale, red-brown, weakly indurated, blocky	2.6
Shale, greenish-gray, silty, selenitic, weakly indurated, blocky	0.25
Shale, red-brown, blocky; with some greenish-gray spots and thin satin spar beds	1.8
Siltstone*, greenish-gray, dolomitic, selenitic, well-indurated, crinkly bedded; forming ledge	0.25
Shale, red-brown, blocky; with some greenish-gray spots and gypsum nodules	2.75
Unit A_2 (Flowerpot):	
Siltstone*, greenish-gray, mottled red-brown, dolomitic, gypsiferous, moderately indurated, thinly laminated	0.9
Unit A_1 (Flowerpot):	
Shale, red-brown, blocky; with some thin satin spar seams and gypsum nodules	1.3
Siltstone, red-brown, mottled greenish-gray, argillaceous, gypsiferous, well-indurated	0.3
Shale, red-brown, blocky	0.2
Shale, greenish-gray, blocky	0.3
Shale, red-brown, blocky; with some greenish-gray spots and thin satin spar layers	1.6
Siltstone, greenish-gray, mottled red-brown, gypsiferous, argillaceous, massive, well-indurated, crinkly bedded; forming ledge	0.6
Shale, red-brown, weakly indurated, blocky	1.2
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, blocky; with some thin satin spar veins	0.75
Shale, greenish-gray, blocky; with some satin spar layers	0.25
Shale, red-brown, silty, blocky, moderately indurated	0.9
Shale, red-brown, blocky	0.75
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky; exposed to base	6.0

SECTION 8. WEST MOCCASIN CREEK
WESTERN WOODS COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured along West Moccasin Creek in SE¼ NE¼ NE¼ sec. 36, T. 28 N., R. 19 W., proceeding downstream to base of Shimer Gypsum Member in SE¼ SW¼ NW¼ sec. 31, T. 28 N., R. 18 W. Section then extrapolated to road cut on U. S. Highway 64, south of highway and east of West Moccasin Creek for Blaine section, ending in the Flowerpot Shale in bluff on the Cimarron River in SW¼ SW¼ NW¼ sec. 28, T. 27 N., R. 18 W., western Woods County, Oklahoma.

	Thickness (feet)
MARLOW FORMATION (top not exposed)	
Sandstone, moderate red-brown to moderate reddish-orange, fine-grained, weakly indurated; exposed	5.0
Sandstone, light-brown, mottled greenish-gray, fine-grained, moderately indurated, thinly laminated, platy	0.6
Sandstone, moderate red-brown to moderate reddish-orange, fine-grained, weakly indurated	0.8
Sandstone*, greenish-gray, mottled red-brown to moderate reddish-orange, fine-grained, quartzose; with small irregular patches of red-brown shale	1.0
DOG CREEK SHALE (total thickness, 49.9 feet)	
Shale, red-brown, weakly indurated, blocky	0.75
Siltstone*, mottled greenish-gray and red brown to moderate reddish-orange, argillaceous, blocky	2.5
Unit E (Dog Creek):	
Siltstone*, greenish-gray, mottled red-brown to moderate reddish-orange, calcareous, argillaceous, well-indurated, massive; forming ledge	0.3
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky	0.75
Unit D (Dog Creek):	
Dolomite*, greenish-gray, silty, blocky; thin-bedded in middle; forming ledge	0.25
Shale, red-brown, blocky	0.4
Dolomite*, light-gray, mottled pink, silty, argillaceous, fine-grained, compact, well-indurated, nodular to massive; forming ledge	0.1
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky	1.25
Unit C (Dog Creek):	
Dolomite*, light-gray, silty, argillaceous, fine-grained, dense, nodular to massive; forming ledge	0.2
Unnamed Units (Dog Creek):	
Shale, greenish-gray, dolomitic, weakly indurated, blocky	0.25
Shale, red-brown, weakly indurated, blocky	3.3
Southard Dolomite Bed:	
Dolomite*, light-gray, silty, argillaceous, fine-grained, dense, well-indurated, platy; with many salt casts; forming an escarpment	0.4
Unit B (Dog Creek):	
Siltstone*, greenish-gray, calcareous, argillaceous, weakly indurated, thinly laminated to blocky; with some well-indurated dolomitic shale layers near base	2.0
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky; with some greenish-gray medium-bedded siltstone layers	7.4
Unit A (Dog Creek):	
Sandstone, light-brown, mottled red-brown to moderate red-	

	Thickness (feet)
dish-orange, fine-grained, quartzose, well-indurated, massive; forming ledge	1.0
Sandstone and siltstone, red-brown to moderate reddish-orange, fine-grained, quartzose, moderately indurated, thin- to medium-bedded; weathering massive; forming ledge	3.6
Siltstone*, greenish-gray, mottled red-brown to moderate reddish-orange, calcareous, thinly laminated; weakly indurated at top; well-indurated at base	1.0
Unnamed Units (Dog Creek):	
Shale, mottled red-brown and greenish-gray, silty, weakly indurated, thin-bedded, crinkly bedded	0.3
Siltstone, greenish-gray, argillaceous, well-indurated, thin-bedded, crinkly bedded; forming ledge	0.75
Shale, red-brown, silty, weakly indurated, blocky	1.5
Watonga Bed:	
Siltstone*, red-brown, mottled greenish-gray, dolomitic, fine-grained, thin-bedded, well-indurated; forming ledge	0.6
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	3.4
Shale, greenish-gray and red-brown, silty, weakly indurated, blocky; partly covered	6.25
Gypsum, greenish-gray, selenitic, silty, well-indurated, wavy bedded	0.2
Shale, red-brown, mottled greenish-gray, silty, gypsiferous, weakly indurated	0.6
Gypsum, greenish-gray, silty, well-indurated, wavy bedded, massive	0.4
Shale, red-brown, mottled greenish-gray, weakly indurated, blocky	0.7
Haskew Gypsum Bed:	
Gypsum and siltstone, interbedded, red-brown and greenish-gray, well-indurated, thinly laminated, crinkly bedded; forming ledge	1.3
Shale, red-brown, blocky, weakly indurated; with some thin satin spar layers	1.2
Gypsum, white, mottled red-brown and greenish-gray, fine-grained, well-indurated, crinkly bedded, massive; forming ledge	2.75
Unnamed Unit (Dog Creek):	
Shale, red-brown, mottled greenish-gray, blocky; with much satin spar	4.5
BLAINE FORMATION (total thickness, 83.5 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, well-indurated, massive; weathering coarsely selenitic	19.0
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-indurated;	

	Thickness (feet)
grading upward into gypsum	0.3
Unnamed Units (Blaine):	
Shale, greenish-gray, mottled red-brown, weakly indurated, blocky	0.5
Shale, red-brown, blocky; mottled with greenish-gray spots; with some selenite and satin spar beds in lower 5 feet	14.5
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive, weathering coarsely selenitic; being red-brown and greenish-gray in upper 2 feet; forming an escarpment	11.0
Magpie Bed:	
Siltstone*, light-gray, fine-grained, dense to oölitic, well-indurated, massive	0.2
Unnamed Unit (Blaine):	
Shale, red-brown, blocky; with some satin spar	9.0
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming escarpment	28.25
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, dense to oölitic, well-indurated	0.75
FLOWERPOT SHALE (exposed thickness, 100.6 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, weakly indurated, blocky; section extrapolated to SW¼ SW¼ NW¼ sec. 28, T. 27 N., R. 18 W., in bluff on Cimarron River	0.25
Unit J (Flowerpot):	
Shale, red-brown, selenitic, blocky	0.75
Unit I (Flowerpot):	
Siltstone*, greenish-gray, dolomitic, gypsiferous, thin-bedded, crinkly bedded; well-indurated in places	0.5
Shale, red-brown, selenitic, blocky	1.1
Shale, greenish-gray, selenitic, blocky	0.1
Shale, red-brown, selenitic, blocky; with many thin satin spar layers	4.5
Shale, greenish-gray, mottled red-brown, blocky; with much satin spar	0.8
Unit H (Flowerpot):	
Shale, red-brown, blocky; with some gypsum nodules	0.75
Shale, greenish-gray, mottled red-brown, selenitic, thin-bedded, crinkly bedded; alternating well- to weakly indurated layers	0.5
Shale, red-brown, selenitic, blocky	1.7
Units E-G (Flowerpot):	
Shale, greenish-gray, silty, weakly indurated, blocky	0.75
Unit D (Flowerpot):	
Shale, red-brown, silty, blocky; mottled with greenish-gray spots	1.6

	Thickness (feet)
Unit C (Flowerpot):	
Siltstone*, moderate red-brown, mottled greenish-gray, arenaceous, calcareous, well-indurated; with 1- to 3-inch gypsum nodules	1.25
Siltstone, light-brown to red-brown, mottled greenish-gray, argillaceous, massive, moderately indurated; with some gypsum nodules; forming ledge	3.1
Units A_3-B (Flowerpot):	
Shale, greenish-gray, mottled red-brown, silty, weakly indurated, thin-bedded, platy	0.2
Shale, red-brown, silty, weakly indurated, blocky; with some greenish-gray spots	7.1
Gypsum, white, mottled greenish-gray, well-indurated, fine-grained, crinkly bedded	0.2
Shale, greenish-gray to dark-gray, weakly indurated, blocky	0.2
Shale, red-brown, selenitic, blocky	1.1
Shale, greenish-gray to dark-gray, weakly indurated, blocky	0.25
Shale, red-brown, blocky	3.9
Shale, greenish-gray and red-brown, gypsiferous, well-indurated, thin-bedded, crinkly bedded; forming ledge	0.8
Shale, red-brown, blocky; with much satin spar	0.4
Shale, dark greenish-gray, weakly indurated, blocky; with satin spar	0 1
Shale, red-brown, blocky; with much satin spar	3.4
Shale, greenish-gray, blocky; with much satin spar	0.6
Shale, red-brown, blocky; with much satin spar	1.5
Shale, greenish-gray, blocky; with much satin spar; forming base of extremely gypsiferous section	0.7
Shale, red-brown, blocky	1.2
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky	3.8
Siltstone*, greenish-gray, dolomitic, argillaceous, well-indurated, crinkly bedded, massive; forming ledge	0.2
Shale, greenish-gray, mottled red-brown, weakly indurated, blocky	0.7
Shale, red-brown, blocky	1.3
Shale, greenish-gray, gypsiferous, well-indurated, crinkly bedded, platy	0.2
Shale, red-brown, blocky	0.3
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky	0.9
Shale, greenish-gray, mottled red-brown, gypsiferous, well-indurated, crinkly bedded; with much nodular gypsum and satin spar	0.4
Shale, red-brown, blocky; with some satin spar	2.5
Unit A_2 (Flowerpot):	
Siltstone, greenish-gray, mottled red-brown, argillaceous, gypsiferous, weakly indurated; with nodular gypsum	1.0
Unit A_1 (Flowerpot):	

	Thickness *(feet)*
Shale, red-brown, blocky	1.9
Shale, greenish-gray, blocky; with platy selenite	0.2
Shale, red-brown, blocky	0.8
Shale, greenish-gray, mottled red-brown, blocky; with nodular gypsum	0.8
Shale, red-brown, blocky	2.0
Shale, greenish-gray, blocky; with some satin spar	0.4
Shale, red-brown, blocky	1.1
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky	1.75
Shale, greenish-gray, mottled red-brown, blocky; with much satin spar	0.2
Shale, red-brown, blocky; with some satin spar	5.0
Shale, greenish-gray, selenitic, well-indurated, crinkly bedded	0.2
Shale, red-brown, blocky; with some satin spar	0.75
Shale, greenish-gray, blocky; with much satin spar	0.2
Shale, red-brown, blocky; with some paper-thin selenite and satin spar	0.8
Shale, greenish-gray, blocky; with some satin spar	0.3
Shale, red-brown, blocky	0.9
Siltstone*, greenish-gray, gypsiferous, well-indurated, massive, crinkly bedded	0.1
Shale, red-brown, blocky; with some paper-thin satin spar layers	7.2
Shale, greenish-gray, weakly indurated, blocky	0.4
Shale, red-brown, blocky; with some greenish-gray spots	4.0
Shale, greenish-gray, gypsiferous, well-indurated, crinkly bedded	0.1
Shale, red-brown, blocky	2.0
Shale, greenish-gray, mottled red-brown, gypsiferous, well-indurated, thin-bedded, crinkly bedded	0.3
Shale, red-brown, blocky	0.9
Shale, greenish-gray, mottled red-brown, blocky	0.6
Shale, red-brown, blocky; with many vertical paper-thin selenite veins	4.2
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, blocky	2.0
Shale, greenish-gray, blocky, weakly indurated; with some paper-thin satin spar	0.3
Shale, red-brown, moderately indurated, blocky	3.5
Shale, greenish-gray, mottled red-brown, weakly indurated, blocky	0.5
Shale, red-brown, weakly indurated, blocky; exposed	6.0

SECTION 9. SLEEPING BEAR CREEK
HARPER COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in SW¼

SE¼ sec. 10, T. 25 N., R. 20 W., supplemented by section along State Highway 34 between secs. 16 and 17, T. 25 N., R. 20 W., for section between Marlow Formation and Southard Dolomite, continuing to the Nescatunga Gypsum Member in NE¼ NW¼ sec. 15, T. 25 N., R. 20 W. and Magpie Dolomite Bed in NE¼ NE¼ SW¼ sec. 10, T. 25 N., R. 20 W. Section then extrapolated to NW¼ NW¼ sec 22, T. 26 N., R. 20 W., for remainder of Blaine Formation, ending in the Flowerpot Shale in the bluff on the Cimarron River in NE¼ SE¼ sec. 24, T. 27 N., R. 20 W., Harper County, Oklahoma.

	Thickness *(feet)*
MARLOW FORMATION (top not examined)	
Sandstone, moderate reddish-brown to moderate reddish-orange, fine-grained, gypsiferous, quartzose, weakly to well-indurated; forming gypsiferous ledge; grading into an impure arenaceous gypsum	2.0
Siltstone*, greenish-gray, arenaceous, gypsiferous, weakly indurated, thin-bedded, crinkly bedded	1.0
DOG CREEK SHALE (total thickness, 49.2 feet)	
Shale*, red-brown, silty, blocky	1.8
Shale, greenish-gray, mottled red-brown, silty, weakly indurated, blocky	0.1
Shale, red-brown, silty, blocky; with some greenish-gray spots	3.0
Shale, mottled greenish-gray and red-brown, silty, weakly indurated, blocky	0.5
Shale, red-brown, silty, blocky	2.0
Unit F_2 (Dog Creek):	
Siltstone*, mottled red-brown and greenish-gray, argillaceous, thin-bedded, weakly indurated, blocky; with basal 1 inch well indurated and greenish gray	2.7
Unnamed Units (Dog Creek):	
Shale, dark red-brown, blocky	1.1
Siltstone, greenish-gray, mottled red-brown, argillaceous, weakly indurated, blocky	0.2
Shale, dark red-brown, weakly indurated, blocky	2.5
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, dark red-brown, weakly indurated, blocky	2.25
Unit E (Dog Creek):	
Siltstone, greenish-gray, mottled red-brown, weakly indurated, thin-bedded, crinkly bedded	1.0
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky	1.4
Siltstone, greenish-gray, argillaceous, well-indurated, thin-bedded, crinkly bedded	0.2
Shale, red-brown, blocky	0.5
Unit D (Dog Creek):	
Siltstone, greenish-gray, argillaceous, well-indurated, thin-bedded	0.2
Unnamed Unit (Dog Creek):	

	Thickness (feet)
Shale, dark red-brown, blocky	2.75
Unit C (Dog Creek):	
Dolomite*, light-gray, fine-grained, dense, well-indurated, massive, blocky; section slumped	0.25
Unnamed Unit (Dog Creek):	
Shale, dark red-brown, blocky	2.0
Unit B and Southard Dolomite Bed:	
Shale, greenish-gray, blocky, dolomitic, partly covered	3.0
Dolomite*, light-gray, argillaceous, thin-bedded, fine-grained, dense, well-indurated; with salt casts; section slumped	0.1
Unit A (Dog Creek):	
Siltstone, red-brown, argillaceous, blocky, well-indurated; in places weakly indurated	5.0
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray spots	2.75
Shale, red-brown and greenish-gray, gypsiferous, crinkly bedded, thin-bedded; weakly to well-indurated alternating layers; slumped and partly covered; probably containing the Watonga Dolomite Bed	6.0
Haskew Gypsum Bed:	
Gypsum, white, mottled moderate reddish-orange and greenish-gray, coarsely selenitic, crinkly bedded	4.0
Unnamed Unit (Dog Creek):	
Shale, red-brown, mottled greenish-gray, gypsiferous, blocky	3.7
BLAINE FORMATION (total thickness, 84.8 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming escarpment	13.0
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, massive, well-cemented	1.5
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.2
Shale*, red-brown, blocky, with much paper-thin selenite	15.6
Nescatunga Gypsum Member:	
Gypsum, white, mottled light-gray, fine-grained, massive; weathering coarsely selenitic	13.0
Magpie Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-indurated, massive	0.75
Unnamed Unit (Blaine):	
Shale*, red-brown, mottled greenish-gray, blocky, weakly indurated	15.0
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic, forming ledge; section extrapolated to NW¼ sec. 22, T. 26 N., R. 20 W.	25.0

	Thickness (feet)
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, massive	0.75
FLOWERPOT SHALE (exposed thickness, 72.6 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.25
Unit J (Flowerpot):	
Shale, red-brown, blocky	0.8
Unit I (Flowerpot):	
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky; with gypsum nodules	2.0
Gypsum, white, mottled red-brown, nodular; section extrapolated to bluff on Cimarron River in SE¼ sec. 24, T. 27 N., R. 20 W.	0.75
Shale, red-brown, weakly indurated, blocky	1.6
Gypsum, white, mottled red-brown, well-indurated, nodular	0.4
Unit H (Flowerpot):	
Shale, red-brown, mottled greenish-gray, weakly indurated, blocky	0.6
Shale, greenish-gray, weakly indurated, blocky	0.25
Shale, red-brown, weakly indurated, blocky	0.75
Units E-G (Flowerpot):	
Shale, greenish-gray, weakly indurated, blocky	0.75
Unit D (Flowerpot):	
Shale, red-brown, blocky; with many gypsum nodules	1.3
Shale, greenish-gray, well-indurated, blocky; with many gypsum nodules	0.5
Shale, red-brown, blocky	0.6
Gypsum, white, mottled red-brown, nodular, well-indurated	0.6
Unit C (Flowerpot):	
Siltstone, mottled red-brown to moderate reddish-orange, weakly indurated, thin-bedded	1.7
Gypsum, white, nodular, well-indurated	0.2
Siltstone*, red-brown to moderate reddish-orange, mottled greenish-gray, weakly indurated, thin-bedded	0.8
Siltstone, greenish-gray, mottled red-brown, gypsiferous; well-indurated in places	1.0
Siltstone*, red-brown, mottled greenish-gray, argillaceous, weakly indurated, blocky	1.2
Unit B (Flowerpot):	
Gypsum, white, mottled red-brown and light-gray, nodular	0.2
Shale, red-brown, blocky; with some small gypsum nodules	2.5
Unit A_s (Flowerpot):	
Shale, greenish-gray, weakly indurated, blocky; with some satin spar	0.2
Shale, red-brown, blocky; with much satin spar	2.0
Shale, greenish-gray, platy	0.2
Shale, red-brown, platy	0.3
Gypsum and shale, interbedded, greenish-gray, mottled red-	

	Thickness (feet)
brown, well-indurated, crinkly bedded, thin-bedded; with much satin spar; forming ledge	1.0
Shale, red-brown, blocky; with many thin satin spar layers	1.0
Shale, greenish-gray, weakly indurated, blocky; with much satin spar	0.25
Shale, red-brown, blocky; with much satin spar and some greenish-gray shale beds	3.5
Shale, greenish-gray, blocky, well-indurated; with satin spar	0.2
Shale, red-brown, blocky, weakly indurated; with satin spar	0.25
Shale, greenish-gray, weakly indurated, blocky; with many crinkly satin spar layers	0.75
Shale, red-brown, blocky; with many thin satin spar beds	0.7
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, blocky; with many thin satin spar beds	1.75
Shale, mottled red-brown and greenish-gray, gypsiferous, well-indurated, crinkly bedded	1.0
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, blocky; with many thin satin spar beds	2.7
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky; with some satin spar beds	0.75
Shale, greenish-gray, gypsiferous, blocky; well indurated in upper 1 inch	0.7
Shale, red-brown, blocky; with much satin spar	0.8
Siltstone*, greenish-gray, mottled red-brown, gyspiferous, argillaceous, thin-bedded, crinkly bedded; well indurated in upper 1 inch	1.0
Shale, red-brown, blocky; with thin satin spar layers	1.0
Shale, greenish-gray, gypsiferous, well-indurated, platy	0.2
Shale, red-brown, blocky; with many thin satin spar layers	2.2
Siltstone, red-brown to moderate reddish-orange, mottled greenish-gray, argillaceous, weakly indurated, massive	0.75
Siltstone, greenish-gray, mottled moderate reddish-orange, gypsiferous, well-indurated, massive; forming ledge	0.6
Unit A_2 (Flowerpot):	
Siltstone*, mottled greenish-gray and red-brown, arenaceous, dolomitic; indurated in places	0.75
Unit A_1 (Flowerpot):	
Shale, red-brown, blocky; with some thin satin spar beds	1 75
Shale, greenish-gray, gypsiferous, blocky	0.1
Shale, red-brown, blocky; with many thin satin spar beds	1.0
Shale, mottled greenish-gray and red-brown, weakly indurated, blocky	0.6
Shale, greenish-gray, mottled red-brown, selenitic, well-indurated, crinkly bedded	0.4
Shale, red-brown, blocky; with some thin satin spar beds and greenish-gray spots	1.0
Shale, greenish-gray, mottled red-brown, selenitic	0.1
Shale, red-brown, blocky; with some greenish-gray spots and satin spar	1.0

	Thickness (feet)
Shale, greenish-gray, mottled red-brown, selenitic, well-indurated, crinkly bedded	0.4
Shale, red-brown, blocky; with some greenish-gray spots and thin selenite and satin spar beds	2.2
Shale, greenish-gray, selenitic, well-indurated, crinkly bedded	0.1
Shale, red-brown, blocky, with some greenish-gray layers and paper-thin selenite and satin spar layers; exposed	20.0

SECTION 10. HASKEW
NORTHWESTERN WOODWARD COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in SW¼ SW¼ SW¼ sec. 6, T. 25 N., R. 18 W., and NW¼ NW¼ NW¼ sec. 7, along creek and on State Highway 50, down to Altona Dolomite, including the type section for the Haskew Gypsum Bed of the Dog Creek Shale, ending in the Blaine Formation and Flowerpot Shale at Alabaster Caverns State Park, in SE¼ SE¼ SE¼ sec. 29, T. 26 N., R. 18 W., and NE¼ NE¼ SW¼ sec. 28, T. 26 N., R. 18 W., northwestern Woodward County, Oklahoma.

MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-brown to moderate reddish-orange, quartzose, silty, weakly indurated; exposed to top	5.0
Sandstone*, greenish-gray, mottled moderate reddish-orange, fine-grained, quartzose, weakly indurated	0.5
Gypsum, greenish-gray, mottled light-pink, arenaceous, well-cemented, finely laminated, crinkly bedded; weathering massive; forming ledge	1.7
Sandstone, red-brown to moderate reddish-orange, gypsiferous, well-indurated; forming massive ledge	1.0
DOG CREEK SHALE (total thickness, 51.8 feet)	
Siltstone, red-brown to moderate reddish-orange, mottled greenish-gray, gypsiferous, weakly indurated, massive	0.5
Shale, red-brown, blocky	0.2
Unit H (Dog Creek):	
Siltstone*, greenish-gray, gypsiferous, dolomitic, argillaceous, well-indurated, crinkly bedded, massive	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky	1.0
Siltstone, greenish-gray; as above	0.2
Shale, red-brown, blocky	0.2
Siltstone, greenish-gray; as above	0.25
Shale, red-brown, selenitic, blocky	1.0
Unit F_2 (Dog Creek):	
Siltstone, greenish-gray; as above	0.25
Shale, red-brown, selenitic, blocky	0.5
Siltstone, greenish-gray; as above	0.25

	Thickness (feet)
Shale, red-brown, blocky	0.3
Siltstone*, greenish-gray, gypsiferous, dolomitic, well-indurated, crinkly bedded	0.75
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky	1.0
Siltstone, greenish-gray, gypsiferous, argillaceous, well-indurated, crinkly bedded	0.2
Shale, red-brown, blocky; with paper-thin selenite	1.5
Unit F_7 (Dog Creek):	
Siltstone, greenish-gray, mottled red-brown; as above	1.0
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky; with interbedded greenish-gray gypsiferous siltstone beds 1 to 3 inches thick	6.0
Unit D (Dog Creek):	
Dolomite*, light-gray, fine-grained, dense, silty, thinly laminated	0.2
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky	3.5
Unit C (Dog Creek):	
Dolomite, pink to greenish-gray, fine-grained, dense; with many salt casts	0.1
Unnamed Unit (Dog Creek):	
Shale, grayish red-purple, blocky	1.0
Southard Dolomite Bed:	
Dolomite*, light-gray, fine-grained, dense, thinly laminated	0.2
Unit B (Dog Creek):	
Siltstone*, greenish-gray, dolomitic, argillaceous, mottled grayish red-purple; platy in upper 6 inches; with indurated 1-inch dolomitic siltstone at base	2.75
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray shale spots and moderate reddish-orange gypsum nodules	1.6
Unit A (Dog Creek):	
Siltstone, greenish-gray, gypsiferous, crinkly bedded; with interbedded red-brown shale; as above	1.0
Shale, red-brown, partly covered; as above	3.4
Gypsum, mottled greenish-gray and light-brown, silty, well-indurated, crinkly bedded; forming ledge	0.3
Siltstone*, red-brown to moderate reddish-orange, argillaceous, gypsiferous, weakly indurated	2.0
Siltstone, greenish-gray, mottled red-brown, gypsiferous, thin-bedded, crinkly bedded; with many paper-thin selenite layers	0.5
Unnamed Units (Dog Creek):	
Shale, red-brown, mottled greenish-gray, blocky, thin-bedded, crinkly bedded; with many paper-thin selenite layers; probably containing the equivalent of the Watonga Dolomite Bed; partly covered	4.75
Gypsum, white, mottled red-brown and greenish-gray to	

	Thickness (feet)
moderate reddish-orange, coarsely selenitic, wavy bedded, massive	0.4
Siltstone, moderate reddish-orange, mottled red-brown and greenish-gray, argillaceous, weakly indurated	1.6
Shale, red-brown, blocky	1.0
Gypsum, red-brown, argillaceous, thin-bedded, crinkly bedded	0.25
Shale, red-brown, blocky; mottled greenish-gray at top	1.5
Gypsum, white to red-brown, coarsely selenitic, well-indurated, crinkly bedded	0.2
Siltstone, greenish-gray, mottled red-brown, gypsiferous, well-indurated, thin bedded	1.0
Haskew Gypsum Bed (type section):	
Gypsum, mottled moderate reddish-orange and greenish-gray to white, wavy bedded, well-indurated, massive, fine-grained; weathering coarsely selenitic	0.5
Siltstone, red-brown and greenish-gray, gypsiferous, well-indurated, thinly laminated	0.8
Shale, red-brown, mottled greenish-gray, blocky	0.75
Gypsum, white, fine-grained, well-indurated, alabasterlike, massive; forming resistant ledge	2.75
Unnamed Unit (Dog Creek):	
Shale, red-brown, mottled greenish-gray, weakly indurated, blocky	4.5
BLAINE FORMATION (total thickness, 88.0 feet)	
Shimer Gypsum Member:	
Gypsum, white, mottled light-gray, fine-grained, massive, weathering coarsely selenitic; forming ledge	14.6
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, medium-bedded, weathering into massive box-works; section extrapolated to Alabaster Caverns State Park SE¼ sec. 29, T. 26 N., R. 18 W.	1.25
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, mottled greenish-gray, blocky; with some red-brown selenitic beds in middle	15.75
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, well-indurated, coarsely selenitic, massive; forming ledge	15.0
Magpie Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, weakly indurated	0.4
Unnamed Units (Blaine):	
Shale, greenish-gray, selenitic, blocky	0.1
Shale, red-brown, mottled greenish-gray, selenitic; with 3-inch red-brown gypsiferous shale about 4 feet below top	9.5
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled light-gray, fine-grained, massive;	

	Thickness *(feet)*
weathering coarsely selenitic; forming ledge	30.7
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-cemented, massive	0.5
FLOWERPOT SHALE (exposed thickness, 64.3 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.2
Unit J (Flowerpot):	
Shale, red-brown, weakly indurated, blocky; with some greenish-gray layers	1.25
Unit I (Flowerpot):	
Gypsum, white, mottled red-brown, fine-grained, nodular; forming ledge	0.75
Shale, greenish-gray, silty, blocky, weakly indurated	0.2
Shale, red-brown, blocky; with some greenish-gray spots	1.3
Gypsum, white, mottled red-brown, nodular; as above; forming ledge	1.0
Unit H (Flowerpot):	
Shale, red-brown, blocky, weakly indurated	0.25
Units E-G (Flowerpot):	
Siltstone*, greenish-gray, dolomitic, weakly indurated, blocky	0.5
Unit D (Flowerpot):	
Shale, red-brown, blocky; with some greenish-gray spots	0.6
Shale, greenish-gray, mottled red-brown, gypsiferous, well-indurated	0.1
Shale, red-brown, blocky; with some greenish-gray spots	1.5
Unit C (Flowerpot):	
Siltstone*, greenish-gray, mottled light-brown, arenaceous, dolomitic, weakly indurated, thin-bedded	0.5
Siltstone, light-brown, mottled red-brown, argillaceous, weakly indurated	0.75
Siltstone*, greenish-gray, mottled light-brown, gypsiferous, dolomitic, arenaceous; with many small to medium-size gypsum nodules; forming an escarpment	5.0
Siltstone, greenish-gray, gypsiferous, weakly indurated, massive	1.2
Units A_3-B (Flowerpot):	
Shale, red-brown, blocky; with some thin satin spar layers	5.3
Shale, greenish-gray, mottled red-brown, well-indurated, blocky, crinkly bedded; with many satin spar layers	1.0
Shale, red-brown, mottled greenish-gray, blocky	1.1
Gypsum, white, mottled greenish-gray, well-indurated, massive	0.5
Shale red-brown, mottled greenish-gray, blocky	0.9
Shale, greenish-gray and red-brown, gypsiferous, thin-bedded, crinkly bedded, platy; forming ledge	0.8
Shale, red-brown, weakly indurated, blocky	0.8
Siltstone*, greenish-gray, dolomitic, argillaceous, well-indur-	

	Thickness (feet)
ated, massive	0.25
Shale, red-brown, blocky; with some thin selenite beds	3.75
Gypsum, greenish-gray, mottled red-brown, argillaceous, well-indurated, nodular	0.2
Shale, red-brown; as above; with much selenite, satin spar, and nodular gypsum	4.5
Gypsum, greenish-gray, selenitic, well-indurated, platy, crinkly bedded; with interbedded red-brown shale; forming prominent ledge and base of extremely gypsiferous section	1.0
Shale, greenish-gray, blocky; with satin spar at top	0.75
Shale, red-brown, blocky; with some satin spar	0.75
Shale, greenish-gray, silty; with some satin spar	0.5
Shale, red-brown, blocky; with some greenish-gray spots and satin spar	3.1
Siltstone, greenish-gray, mottled red-brown; forming ledge	1.0
Shale, red-brown, silty, blocky	1.0
Unit A_2 (Flowerpot):	
Siltstone, greenish-gray, gypsiferous, argillaceous, moderately indurated, blocky	1.0
Siltstone*, red-brown, argillaceous, blocky	0.6
Unit A_1 (Flowerpot):	
Shale, greenish-gray, blocky; with some gypsum beds	0.3
Shale, red-brown, blocky	0.5
Shale, greenish-gray, blocky; as above	0.2
Shale, red-brown, blocky	0.9
Shale, greenish-gray, blocky; as above	0.7
Shale, red-brown; as above	2.5
Shale, greenish-gray, gypsiferous, blocky; as above	0.25
Shale, red-brown and greenish-gray; with much satin spar; exposed to base of measured section	15.0

SECTION 11. QUINLAN - CHIMNEY CREEK
CENTRAL WOODWARD COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in road cut between NW¼ sec. 17 and NE¼ sec. 18, T. 23 N., R. 17 W., down to Southard Dolomite Bed; then extrapolated to Copeland Ranch in SW¼ NW¼ NW¼ sec. 22, T. 24 N., R. 18 W., north side of branch of Chimney Creek to base of Dog Creek Shale. The Shimer was measured in SE¼ NE¼ NW¼ sec. 2, T. 23 N., R. 18 W., and the remainder of the Blaine to the Medicine Lodge was measured in SW¼ SE¼ NW¼ sec. 6, T. 24 N., R. 17 W. The Medicine Lodge and Flowerpot were measured in SE¼ SE¼ NE¼ sec. 1, T. 24 N., R. 18 W., central Woodward County, Oklahoma.

MARLOW FORMATION (top not exposed)
Sandstone*, red-brown to moderate reddish-orange, fine-

	Thickness (feet)
grained, quartzose, weakly indurated, friable, thin-bedded; exposed	20.0
DOG CREEK SHALE (total thickness, 67.5 feet)	
Siltstone*, dark red-brown to very dark-red, arenaceous, dolomitic, platy, thin-bedded, crinkly bedded	1.2
Unit H (Dog Creek):	
Siltstone*, moderate reddish-orange, mottled red-brown, dolomitic, arenaceous, well-indurated, blocky, massive; greenish-gray and dolomitic in basal 1 inch	0.7
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	3.0
Siltstone, moderate reddish-orange, argillaceous, well-indurated, massive	0.25
Shale, red-brown, blocky; mottled with some greenish-gray spots	2.4
Unit F_2 (Dog Creek):	
Siltstone, moderate reddish-orange, argillaceous, thin-bedded; grading into fine-grained quartzose sandstone	8.0
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, moderately indurated, blocky	4.0
Siltstone, red-brown, argillaceous, well-indurated, massive; forming ledge	0.2
Shale, red-brown, silty, blocky	3.75
Unit F_1 (Dog Creek):	
Siltstone*, greenish-gray, mottled red-brown, dolomitic, argillaceous, moderately indurated, thin-bedded; forming prominent light-colored band in region	0.5
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	3.6
Shale, mottled greenish-gray and red-brown, silty, blocky	0.75
Shale, red-brown, blocky	7.0
Unit E (Dog Creek):	
Siltstone*, greenish-gray, mottled moderate reddish-orange, thin-bedded, crinkly bedded	0.25
Unnamed Units (Dog Creek):	
Shale, red-brown, mottled greenish-gray, blocky	1.25
Siltstone, moderate reddish-orange, mottled greenish-gray, weakly indurated, massive	1.0
Shale, red-brown, blocky; mottled with some greenish-gray spots	3.0
Unit D (Dog Creek):	
Shale, greenish-gray, dolomitic, blocky	0.1
Unnamed Unit (Dog Creek):	
Shale, dark red-brown, blocky	1.0
Unit C (Dog Creek):	
Dolomite, greenish-gray, silty, argillaceous, fine-grained, well-indurated, massive	0.1
Unnamed Units (Dog Creek):	

	Thickness (feet)
Shale, red-brown, blocky	0.25
Shale, greenish-gray, dolomitic, well-indurated, blocky	0.1
Shale, red-brown, blocky	0.5
Southard Dolomite Bed:	
Dolomite, greenish-gray, argillaceous, silty, fine-grained, well-indurated, thin-bedded	0.1
Unit B (Dog Creek):	
Shale, greenish-gray, mottled red-brown, thinly laminated, platy; with some thin dolomite beds	5.0
Dolomite*, light-gray, fine-grained, dense, crinkly bedded, massive, blocky	0.3
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray spots	1.0
Shale, greenish-gray, silty, weakly indurated, blocky	0.2
Shale, red-brown, blocky; with some greenish-gray streaks; section extrapolated to Copeland Ranch	7.5
Unit A (Dog Creek):	
Siltstone, light-brown, gypsiferous, weakly indurated, massive	3.0
Unnamed Units (Dog Creek):	
Siltstone and gypsum, interbedded, red-brown, argillaceous, well-indurated, thin-bedded, crinkly bedded; probably containing Watonga and Haskew equivalents	4.5
Siltstone*, greenish-gray, mottled red-brown, gypsiferous, dolomitic, well-indurated, thin-bedded, crinkly bedded	3.0
BLAINE FORMATION (total thickness, 87.7 feet)	
Shimer Gypsum Member:	
Gypsum, white, coarsely selenitic; becoming wavy bedded and red brown at top; section measured in NW¼ sec. 2, T. 23 N., R. 18 W.	17.0
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-cemented; thin-bedded at base; massive at top; weathering into boxworks; section extrapolated to NW¼ sec. 6, T. 24 N., R. 17 W.	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated, blocky	0.25
Shale, red-brown, blocky; mottled greenish gray in spots	11.0
Nescatunga Gypsum Member:	
Gypsum, white to light-gray, fine-grained, well-cemented; weathering coarsely selenitic; with dolomite stringers in basal 2 feet; forming mappable escarpment	23.0
Magpie Dolomite Bed:	
Dolomite*, light-gray to greenish-gray, fine-grained, oölitic, well-cemented, medium-bedded	1.2
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated, blocky	0.25
Shale, red-brown, blocky; with some greenish-gray spots and	

	Thickness (feet)
layers; and with selenite nodules	4.2
Kingfisher Creek Gypsum Bed:	
Gypsum and shale, interbedded, red-brown, well-indurated, thin-bedded, crinkly bedded; forming minor ledge	0.25
Unnamed Unit (Blaine):	
Shale, red-brown, blocky; with many selenite nodules	3.0
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, well-cemented, massive; mottled red brown at top; forming ledge; section extrapolated to NE¼ sec. 1, T. 24 N., R. 18 W.	15.75
Anhydrite, light-gray, fine-grained, well-indurated, massive; weathering light white	3.5
Gypsum, white, fine-grained, well-indurated; forming ledge	5.25
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, weakly cemented, thin-bedded; weathering light gray	2.0
FLOWERPOT SHALE (exposed thickness, 46.6 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	1.0
Units I-J (Flowerpot):	
Shale, red-brown, mottled greenish-gray, crinkly bedded, blocky; with many satin spar stringers	1.8
Gypsum, greenish-gray, mottled red-brown, argillaceous, well-indurated, crinkly-bedded; forming ledge	0.5
Shale, greenish-gray, blocky	0.2
Unit H (Flowerpot):	
Shale, red-brown, blocky; with many greenish-gray spots and small gypsum nodules	2.2
Unit G (Flowerpot):	
Dolomite*, light-gray, well-indurated, thin-bedded; forming ledge	0.75
Units E-F (Flowerpot):	
Siltstone*, greenish-gray, blocky; with some light greenish-gray bands	5.3
Unit D (Flowerpot):	
Shale, red-brown, mottled greenish-gray, thin-bedded, crinkly bedded; with interbedded gypsum; forming ledge	0.3
Shale, red-brown, blocky; with some satin spar	2.75
Shale, greenish-gray, blocky; with much selenite	0.3
Siltstone, red-brown, weakly indurated, massive	0.2
Shale, red-brown, blocky; with much satin spar	2.0
Shale, greenish-gray, blocky; with much selenite	0.2
Shale, red-brown, blocky; with much satin spar	0.8
Shale, greenish-gray, gypsiferous, well-indurated, crinkly bedded	0.2
Unit C (Flowerpot):	
Siltstone*, light-brown to red-brown, gypsiferous, thin-bedded, crinkly bedded; forming ledge	3.2

	Thickness (feet)
Siltstone, greenish-gray, mottled red-brown, weakly indurated, massive	0.8
Unit B (Flowerpot):	
Shale, red-brown, blocky; with some greenish-gray spots	1.1
Gypsum, white, fine-grained, nodular	0.2
Shale, greenish-gray, silty, gypsiferous, blocky	0.75
Shale, red-brown, blocky; with some selenite veins	2.0
Shale, greenish-gray, mottled red-brown, blocky, thin-bedded, crinkly bedded, platy; with gypsum nodules at top and base	1.5
Unit A_3 (Flowerpot):	
Shale, red-brown, blocky; with some greenish-gray spots and satin spar layers	8.0
Shale, greenish-gray, gypsiferous, blocky, thin-bedded, crinkly bedded	0.5
Shale, red-brown, blocky; with many thin satin spar beds	1.0
Shale, greenish-gray; as above	0.5
Shale, red-brown; as above	1.5
Shale, greenish-gray, well-indurated; interbedded with gypsum	0.8
Shale, red-brown; as above	0.8
Shale and gypsum, greenish-gray; as above; forming base of extremely gypsiferous section	0.4
Shale, red-brown, blocky; with some greenish-gray streaks and spots, gypsum nodules, and vertical satin spar veins; exposed to base of measured section	5.0

SECTION 12. EWERS CREEK
EASTERN WOODWARD COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in SE¼ SW¼ SE¼ sec. 16, T. 22 N., R. 17 W., and NE¼ NW¼ NE¼ sec. 21, T. 22 N., R. 17 W., ending in Southard Dolomite. Section then continued from Southard Dolomite to Shimer Gypsum in SW¼ SE¼ SW¼ sec. 15, T. 22 N., R. 17 W., from Altona Dolomite to Nescatunga Gypsum in SW¼ SW¼ NW¼ sec. 11, T. 22 N., R. 17 W., from Nescatunga Gypsum to Medicine Lodge Gypsum in NE¼ SW¼ NE¼ sec. 10, T. 22 N., R. 17 W., Woodward County, and from Medicine Lodge Gypsum to 24 feet below Cedar Springs Dolomite in SE¼ SW¼ SW¼ sec. 33, T. 23 N., R. 16 W., ending in the Flowerpot Shale in SW¼ SW¼ NW¼ sec. 34, T. 23 N., R. 16 W., western Major County, Oklahoma.

MARLOW FORMATION (top not exposed)	
Siltstone*, moderate reddish-orange, coarse-grained quartzose, weakly indurated; with red-brown clay shale stringers in lower part; exposed	2.0

	Thickness (feet)
DOG CREEK SHALE (total thickness, 82.1 feet)	
Shale, red-brown, silty, well-indurated, blocky	0.2
Shale, red-brown, silty, moderately indurated, blocky	3.8
Siltstone, moderate reddish-orange, argillaceous, blocky, moderately indurated; forming minor ledge	0.5
Shale, red-brown, silty, blocky	3.5
Unit G (Dog Creek):	
Shale, dark red-brown to dark red, thinly laminated, platy	0.25
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky	1.25
Unit F_2 (Dog Creek):	
Siltstone, greenish-gray, mottled red-brown, well-indurated	0.4
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky; with many greenish-gray specks	9.2
Unit F_1 (Dog Creek):	
Siltstone*, light greenish-gray, arenaceous, well-indurated, vuggy, massive; forming ledge	0.25
Siltstone*, greenish-gray, arenaceous, dolomitic, weakly indurated; becoming red-brown in middle	0.75
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky; with some greenish-gray shale layers	3.75
Siltstone*, mottled red-brown and greenish-gray, arenaceous, dolomitic, weakly indurated	0.75
Siltstone*, mottled moderate reddish-orange and greenish-gray, arenaceous, dolomitic, well-indurated; forming ledge	0.2
Siltstone, mottled moderate reddish-orange and greenish-gray, gypsiferous, argillaceous, thinly laminated; forming ledge	1.75
Shale, red-brown, silty, platy; with many paper-thin selenite layers	1.5
Siltstone, moderate reddish-orange, mottled red-brown, argillaceous, moderately indurated, blocky; with some paper-thin selenite	1.2
Unit E (Dog Creek):	
Siltstone*, greenish-gray, argillaceous, weakly indurated	0.2
Unnamed Units (Dog Creek):	
Shale, red-brown, mottled greenish-gray, platy; with thin selenite in basal portion	1.6
Siltstone*, moderate reddish-orange, mottled greenish-gray, dolomitic, weakly indurated	0.4
Shale, red-brown, blocky; with some thin selenite layers	2.25
Siltstone*, greenish-gray, argillaceous, dolomitic, blocky; with many paper-thin selenite layers	0.2
Shale, red-brown, silty, blocky; mottled with some greenish-gray spots	1.0
Unit D (Dog Creek):	
Dolomite*, light-gray, fine-grained, dense, well-indurated,	

	Thickness (feet)
crinkly bedded, gypsiferous	0.1
Shale, dark-brown, weakly indurated, platy	0.8
Dolomite*, light-gray, mottled pink, fine-grained, dense, well-cemented; forming ledge	0.1
Unnamed Units (Dog Creek):	
Shale, dark-brown to dark red-brown, moderately indurated, blocky	2.6
Siltstone*, greenish-gray, argillaceous, dolomitic, platy to blocky; with a thin dolomite seam at top (*Unit C*) and one 11 inches below top	2.7
Southard Dolomite Bed:	
Dolomite*, light-gray, fine-grained, dense, well-cemented; forming a light-brown ledge	0.1
Unit B (Dog Creek):	
Shale, greenish-gray, dolomitic, blocky	1.75
Dolomite*, greenish-gray, silty, fine-grained, dense, well-indurated, thin-bedded, crinkly bedded, forming a ledge	0.2
Shale, red-brown, blocky	0.9
Dolomite*, light-gray to greenish-gray, silty, fine-grained, dense, thinly laminated, crinkly bedded	0.8
Shale, greenish-gray, moderately indurated, blocky	0.5
Unnamed Units (Dog Creek):	
Shale, dark red-brown, blocky; mottled with some greenish-gray spots	5.25
Siltstone*, light-brown, arenaceous, well-indurated; greenish-gray in upper 2 inches; forming ledge	1.2
Shale, red-brown, blocky, mottled with greenish-gray spots; section extrapolated to SW1/4 sec. 15, T. 22 N., R. 17 W.	0.6
Siltstone*, greenish-gray, mottled red-brown, arenaceous, weakly indurated	0.3
Shale and siltstone, red-brown to moderate reddish-orange, mottled greenish-gray, moderately indurated, blocky	3.3
Unit A (Dog Creek):	
Sandstone*, moderate reddish-orange, mottled greenish-gray, well-indurated, thinly laminated, gypsiferous, crinkly bedded; with many paper-thin satin spar beds; forming ledge	9.0
Unnamed Units (Dog Creek):	
Shale, red-brown, mottled greenish-gray, blocky	2.3
Shale, greenish-gray, mottled red-brown, thin-bedded, crinkly bedded	0.8
Shale, red-brown to dark-brown, blocky; as above	4.0
Watonga Dolomite Bed:	
Dolomite*, greenish-gray to light-gray, mottled red-brown, fine-grained, dense, thin-bedded, slabby, well-cemented	0.2
Unnamed Units (Dog Creek):	
Shale, red-brown, mottled greenish-gray, silty, platy	1.0
Siltstone*, greenish-gray, gypsiferous, crinkly bedded, thin-bedded; with many paper-thin selenite layers; well-indur-	

	Thickness (feet)
ated in basal 1 foot; forming ledge	1.5
Shale, dark-brown, silty, platy	1.0
Siltstone, red-brown, argillaceous, gypsiferous, well-indurated, thin-bedded, crinkly bedded; with much selenite; forming ledge	2.0
Haskew Gypsum Bed:	
Gypsum, white, mottled red-brown, fine-grained, wavy bedded, massive; forming ledge	0.5
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, well-indurated, crinkly bedded; with much gypsum	3.7
BLAINE FORMATION (total thickness, 86.5 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, well-cemented, laminated; with crinkly upper surface	21.0
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, medium-bedded; weathering massive, into box-works; section extrapolated to NW¼ sec. 11, T. 22 N., R. 17 W.	1.7
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated, blocky	0.3
Shale, red-brown, blocky; mottled with greenish-gray spots	12.5
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive, weathering coarsely selenitic; forming escarpment	22.0
Magpie Dolomite Bed:	
Dolomite*, light-gray, oölitic, well-cemented, massive; grading into gypsum at top; weathering into box-works	0.5
Unnamed Units (Blaine):	
Shale*, greenish-gray, dolomitic, blocky, weakly indurated; grading into argillaceous dolomite	2.0
Shale, red-brown, blocky	1.0
Kingfisher Creek Gypsum Bed:	
Gypsum, greenish-gray and red-brown, argillaceous, well-indurated, thin-bedded, crinkly bedded; forming ledge	1.2
Unnamed Unit (Blaine):	
Shale, red-brown, blocky; with much selenite	2.8
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled light-gray, fine-grained, massive; weathering coarsely selenitic; section extrapolated to SW¼ sec. 33, T. 23 N., R. 16 W., Major County	17.0
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray to light-brown, fine-grained, oölitic, thin-bedded; grading upward into gypsum	4.5
FLOWERPOT SHALE (exposed thickness, 97.0 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, weakly indurated, blocky; grading	

	Thickness (feet)
upward into dolomite	0.6
Units I-J (Flowerpot):	
Siltstone, greenish-gray to light-brown, dolomitic, gypsiferous, well-indurated, crinkly bedded	0.4
Siltstone*, moderate-yellow, dolomitic, gypsiferous, well-indurated, crinkly bedded	0.25
Shale, greenish-gray, mottled red-brown, weakly indurated, blocky; with some satin spar layers	1.25
Shale, red-brown, mottled greenish-gray; with many satin spar layers	5.25
Dolomite, greenish-gray, argillaceous, gypsiferous, well-indurated, crinkly bedded	0.1
Unit H (Flowerpot):	
Shale, red-brown, blocky; with some paper-thin selenite beds	2.0
Shale, greenish-gray, weakly indurated, blocky	1.5
Shale, red-brown, blocky; with some satin spar	3.75
Unit G (Flowerpot):	
Dolomite*, mottled red-brown and greenish-gray, silty, fine-grained, well-indurated, porous, thin-bedded, crinkly bedded	0.1
Units E-F (Flowerpot):	
Siltstone*, greenish-gray, blocky; with some red-brown shale streaks	5.5
Unit D (Flowerpot):	
Shale, red-brown, silty, blocky, weakly indurated; with some greenish-gray layers	3.25
Unit C (Flowerpot):	
Siltstone*, light-brown, mottled red-brown and greenish-gray, gypsiferous; with some satin spar layers; section extrapolated to NW¼ sec. 34, T. 23 N., R. 16 W., high bluff on east side of road, where Medicine Lodge thickness was measured	4.5
Siltstone, greenish-gray, argillaceous, weakly indurated	0.25
Units B-C (Flowerpot):	
Shale, red-brown, blocky; with some greenish-gray spots and satin spar	2.25
Siltstone, greenish-gray and red-brown, argillaceous, well-indurated, thin-bedded, crinkly bedded	1.7
Dolomite*, greenish-gray, silty, fine-grained, gypsiferous, well-indurated, massive; forming ledge	0.6
Unit A_3 (Flowerpot):	
Shale, red-brown, blocky; with many satin spar layers	3.25
Shale, greenish-gray, silty, well-indurated, thin-bedded, crinkly bedded, blocky; with much satin spar	0.5
Shale, red-brown, blocky; with much satin spar	2.8
Shale, greenish-gray, silty, blocky; with much satin spar	1.0
Shale, red-brown, blocky; with much satin spar	3.0
Shale, greenish-gray, well-indurated, crinkly bedded, blocky;	

	Thickness (feet)
with satin spar	0.3
Shale, red-brown, blocky; with much satin spar	0.8
Shale, mottled red-brown and greenish-gray, gypsiferous, well-indurated, thin-bedded, crinkly bedded, blocky; forming ledge and base of extremely gypsiferous section	1.5
Shale, greenish-gray, weakly indurated, blocky	0.25
Shale, red-brown, blocky; with some satin spar	2.9
Shale, red-brown and greenish-gray, thin-bedded, crinkly bedded, blocky, gypsiferous; forming ledge	0.75
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, blocky; with some satin spar	1.9
Shale, red-brown, blocky, thin-bedded, crinkly bedded, well-indurated; with satin spar; forming ledge	0.5
Shale, greenish-gray, weakly indurated, blocky	0.8
Shale, red-brown, blocky; with some greenish-gray beds and satin spar	4.75
Shale, greenish-gray and red-brown, gypsiferous, well-indurated, thin-bedded, crinkly bedded	1.25
Shale, greenish-gray, silty, blocky; with some red-brown shale layers	1.4
Shale, red-brown, silty, blocky; with some greenish-gray layers and selenite veins	8.25
Siltstone, greenish-gray, gypsiferous, argillaceous, well-indurated	0.5
Shale, red-brown, blocky	1.0
Unit A_2 (Flowerpot):	
Siltstone*, greenish-gray, argillaceous, blocky; mottled red-brown at top	0.8
Unit A_1 (Flowerpot):	
Shale, red-brown, blocky; with some paper-thin selenite	3.2
Shale, greenish-gray, gypsiferous, blocky, crinkly bedded; well-indurated in places	0.2
Shale, red-brown, blocky; with many satin spar veins and some greenish-gray layers	6.2
Siltstone, greenish-gray, mottled red-brown, gypsiferous, well-indurated; forming prominent ledge	1.0
Siltstone*, greenish-gray, mottled moderate reddish-orange, gypsiferous, dolomitic, arenaceous, weakly indurated	2.0
Shale, red-brown, blocky; with some greenish-gray spots	2.5
Shale, greenish-gray, gypsiferous, well-indurated, thin-bedded, crinkly bedded; with some red-brown shale layers; forming ledge	1.0
Shale, red-brown, blocky; with some greenish-gray spots	1.25
Shale, greenish-gray and red-brown, gypsiferous, thin-bedded, crinkly bedded, well-indurated; with much satin spar; forming ledge	0.75
Shale, red-brown, blocky; with some greenish-gray shale spots and layers; exposed to base of measured section	7.25

SECTION 13. GRIEVER CREEK
NORTHWESTERN MAJOR COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in SE¼ SE¼ SW¼ sec. 35, T. 22 N., R. 16 W., along ravine just west of house on Griever Creek, extending to the Altona Dolomite on Griever Creek. Section then continued through Blaine Formation in SW¼ SW¼ NE¼ sec. 29, T. 22 N., R. 15 W., ending in the Flowerpot Shale in NW¼ NW¼ SW¼ sec. 21, T. 22 N., R. 15 W., just east of road, Major County, Oklahoma.

	Thickness (feet)
MARLOW FORMATION (top not examined)	
Gypsum, pink and white, silty, fine-grained, thin-bedded, crinkly bedded; forming resistant ledge	2.0
Sandstone, moderate reddish-orange, gypsiferous, fine-grained, weakly indurated, friable	32.0
Sandstone*, greenish-gray and moderate reddish-orange, silty, fine-grained, weakly indurated, friable	1.0
DOG CREEK SHALE (total thickness, 106.9 feet)	
Shale, red-brown, silty, blocky; with some 1- to 2-inch greenish-gray spots	9.0
Unit H (Dog Creek):	
Dolomite*, moderate reddish-orange, silty, well-indurated, massive	0.1
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, platy, weakly indurated; with some small red-brown gypsum nodules; gradational into siltstone	58.75
Southard Dolomite Bed:	
Dolomite*, gray, silty, argillaceous, fine-grained, dense, massive; weathering light gray	0.2
Unit B (Dog Creek):	
Shale, greenish-gray, weakly indurated, blocky; with some gypsum nodules and dolomite stringers	5.1
Unnamed Units (Dog Creek):	
Siltstone, light-gray, gypsiferous, well-indurated, massive; mottled with yellow stains	0.5
Shale, red-brown, blocky; with some selenite	2.5
Siltstone, greenish-gray, mottled red-brown, dolomitic, gypsiferous, well-indurated, crinkly bedded	0.5
Shale, red-brown, blocky; mottled with greenish-gray spots	1.8
Siltstone, greenish-gray, mottled red-brown, dolomitic, gypsiferous; as above	0.3
Shale, red-brown, blocky; with some greenish-gray spots	3.0
Siltstone, light-brown, mottled greenish-gray, well-indurated, massive	0.3
Shale, red-brown, blocky	0.75
Unit A (Dog Creek):	
Siltstone*, greenish-gray, mottled red-brown, gypsiferous, well-indurated, crinkly bedded; dolomitic at top; form-	

	Thickness (feet)
ing ledge	4.25
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, thinly laminated; greenish gray at top	6.25
Watonga Dolomite Bed:	
Dolomite*, greenish-gray, fine-grained, dense, crinkly bedded	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	2.0
Siltstone, greenish-gray to light-brown, gypsiferous, well-indurated, crinkly bedded, massive	3.0
Shale, red-brown to dark-gray, blocky	1.25
Haskew Gypsum Bed:	
Gypsum, white, mottled moderate reddish-orange, crinkly bedded, well-indurated, massive; probably representing upper ledge of Haskew Bed	0.25
Unnamed Unit (Dog Creek):	
Shale, red-brown, crinkly bedded, with interbedded siltstone and gypsum	7.0
BLAINE FORMATION (total thickness, 74.3 feet)	
Shimer Gypsum Member:	
Gypsum, white to light-gray, fine-grained, alabasterlike, massive; weathering coarsely selenitic	14.0
Altona Dolomite Bed:	
Dolomite*, light-brown, fine-grained, oölitic, medium-bedded, massive; weathering light brown	2.2
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated, blocky	1.1
Shale, red-brown, blocky, mostly covered; with some thin greenish-gray shale streaks; section extrapolated to NE¼ sec. 29, T. 22 N., R. 15 W., east of road	13.0
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; forming escarpment	17.0
Magpie Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-cemented, thin-bedded	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	0.2
Shale, red-brown, selenitic, blocky	3.6
Kingfisher Creek Gypsum Bed:	
Gypsum, light red-brown, argillaceous, well-indurated, fine-grained, thinly laminated, crinkly bedded	0.4
Unnamed Unit (Blaine):	
Shale, red-brown, selenitic, blocky; becoming greenish gray in upper 2 inches	3.25
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, massive; coarsely selenitic; forming escarpment	16.0

	Thickness (feet)
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, thin-bedded to laminated; weathering massive at top; section continued in SW¼ sec. 21, T. 22 N., R. 15 W., east of road	2.5
FLOWERPOT SHALE (exposed thickness, 117.3 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, gypsiferous; well indurated at top	2.5
Units I-J (Flowerpot):	
Shale, red-brown, gypsiferous, blocky	4.25
Shale, greenish-gray and red-brown, mottled red-brown; with 5-inch white gypsum at top and 2-inch white gypsum at base	1.0
Shale, red-brown, blocky; with many small gypsum nodules	3.5
Shale, greenish-gray, blocky; with many gypsum nodules	1.0
Shale, red-brown, gypsiferous, blocky	0.75
Siltstone*, greenish-gray, arenaceous, dolomitic, well-indurated, laminated	0.1
Unit H (Flowerpot):	
Shale, red-brown, mottled greenish-gray, silty, gypsiferous, blocky	3.5
Unit G (Flowerpot):	
Dolomite*, light-gray, fine-grained, dense, laminated; with salt casts; weathering light brown, massive	0.2
Unit E-F (Flowerpot):	
Shale*, greenish-gray, silty, weakly indurated, blocky	8.5
Unit D (Flowerpot):	
Shale, red-brown, blocky	1.6
Unit C (Flowerpot):	
Siltstone, light-brown, gypsiferous, well-indurated; forming ledge	6.4
Unit B (Flowerpot):	
Shale, greenish-gray, weakly indurated, blocky	0.2
Shale, red-brown, blocky; with much selenite	2.0
Shale, greenish-gray, gypsiferous, blocky; with paper-thin satin spar	0.1
Shale, red-brown, blocky; with much selenite	1.9
Shale, greenish-gray, gypsiferous, blocky; with thin-bedded satin spar layers	0.25
Shale, red-brown, blocky; with much selenite	0.5
Shale, greenish-gray, silty, gypsiferous, weakly indurated, blocky	1.6
Siltstone*, greenish-gray at top; red-brown at base; gypsiferous, well-indurated, crinkly bedded; forming ledge and base of extremely gypsiferous section	1.0
Unit A_s (Flowerpot):	
Shale, red-brown, weakly indurated, blocky	0.5
Shale, greenish-gray, weakly indurated, blocky	0.6
Shale, red-brown, blocky; with some satin spar	3.25

	Thickness (feet)
Siltstone, greenish-gray, argillaceous, weakly indurated, blocky	1.0
Shale, red-brown, blocky; with some greenish-gray shale and thin satin spar layers	6.75
Shale, greenish-gray, blocky	1.2
Shale, red-brown, blocky	2.5
Shale, greenish-gray, gypsiferous, blocky	0.75
Shale, red-brown, blocky; with some satin spar	0.8
Shale, greenish-gray, gypsiferous, platy	0.1
Shale, red-brown, blocky; with many satin spar layers and some greenish-gray shale layers	5.25
Gypsum, greenish-gray, argillaceous, well-indurated	0.2
Shale, red-brown, blocky	1.25
Shale, greenish-gray, silty, gypsiferous, weakly indurated, blocky	0.8
Shale, red-brown, blocky; with some thin satin spar veins	3.75
Shale, greenish-gray, silty; red-brown at base; with many thin satin spar beds	1.75
Shale, red-brown, blocky	3.6
Shale, greenish-gray, mottled red-brown, gypsiferous, weakly indurated, blocky	0.8
Shale, red-brown, blocky	0.25
Shale, greenish-gray, weakly indurated, blocky	0.9
Shale, red-brown, blocky	2.0
Siltstone, greenish-gray, gypsiferous, argillaceous; with some satin spar	0.25
Shale, red-brown, blocky	1.7
Siltstone, greenish-gray, gypsiferous, argillaceous, weakly indurated	0.5
Shale, red-brown, blocky	0.25
Unit A_2 (Flowerpot):	
Siltstone, greenish-gray, argillaceous, weakly indurated	0.2
Sandstone*, greenish-gray, fine-grained, silty, dolomitic, gypsiferous; indurated at top	0.5
Unit A_1 (Flowerpot):	
Shale, red-brown, blocky	0.2
Siltstone*, greenish-gray, mottled red-brown, dolomitic, thinly laminated	0.2
Shale, red-brown, blocky	0.1
Siltstone, greenish-gray, argillaceous, well-indurated	0.1
Shale, red-brown, silty, weakly indurated, blocky	0.2
Siltstone, greenish-gray, argillaceous, weakly indurated	0.1
Shale, red-brown, blocky, weakly indurated	0.5
Shale, greenish-gray, silty, blocky	0.2
Shale, red-brown, blocky	1.3
Siltstone, greenish-gray, argillaceous, weakly indurated	0.3
Shale, red-brown, blocky	2.0
Shale*, greenish-gray, silty, weakly indurated	1.6
Shale*, red-brown, blocky	4.2

	Thickness (feet)
Siltstone*, greenish-gray, arenaceous, dolomitic, weakly indurated	1.5
Shale, red-brown, blocky; with some selenite veins	18.0
Siltstone*, greenish-gray, blocky; with some satin spar layers	1.5
Siltstone*, red-brown, blocky; with some selenite veins	3.0

SECTION 14. CHEYENNE CREEK
CENTRAL WESTERN MAJOR COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured south of road in NW¼ NE¼ NW¼ sec. 32, T. 21 N., R. 14 W., and along road between secs. 29 and 32 to siltstone below Southard Dolomite. Section then extrapolated to SE¼ SE¼ sec. 29, T. 21 N., R. 14 W., in hill west of road for section of Shimer Gypsum Member, continuing downstream along creek through the Blaine Formation in SW¼ SW¼ sec. 28, T. 21 N., R. 14 W. to the Nescatunga Gypsum. Section then extrapolated to SW¼ SE¼ sec. 28, T. 21 N., R. 14 W., stream cut south of road, for section to Medicine Lodge Gypsum. Section then extrapolated to NE¼ NE¼ SE¼ sec. 13, T. 21 N., R. 14 W., for remainder of section, ending in the Flowerpot Shale.

MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-orange, fine-grained, quartzose, silty, massive	5.0
Sandstone*, mottled greenish-gray and moderate reddish-orange, fine-grained, quartzose, friable	0.5
DOG CREEK SHALE (total thickness, 120.3 feet)	
Siltstone, moderate reddish-orange, argillaceous, blocky	1.0
Unit I (Dog Creek):	
Siltstone*, light-gray, dolomitic, finely laminated, moderately indurated; weathering light brown; forming small ledge	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky	5.75
Siltstone, moderate reddish-orange, well-indurated; mottled with small greenish-gray spots	0.1
Shale, red-brown, blocky; with some greenish-gray spots and gypsum nodules	15.75
Sandstone, mottled red-brown and greenish-gray, quartzose, fine-grained, gypsiferous, well-indurated	0.2
Shale, moderate reddish-orange, mottled greenish-gray, blocky; with some thin siltstone beds and gypsum nodules; covered in part	7.25
Unit G (Dog Creek):	
Dolomite*, mottled greenish-gray and pink, fine-grained, dense, argillaceous, well-cemented	0.2
Unnamed Units (Dog Creek):	

	Thickness *(feet)*
Siltstone*, red-brown, argillaceous, blocky	21.0
Siltstone, greenish-gray, argillaceous, gypsiferous, well-indurated	0.3
Siltstone, red-brown, argillaceous, gypsiferous, moderately indurated	2.0
Shale, greenish-gray, blocky	1.0
Shale, red-brown, silty, blocky	2.0
Shale, greenish-gray, silty, blocky	0.3
Siltstone*, red-brown, argillaceous, blocky	4.25
Unit E (Dog Creek):	
Siltstone*, red-brown, mottled greenish-gray, gypsiferous, well-indurated; forming ledge	0.1
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, platy; mottled with some greenish-gray laminae	4.0
Unit D (Dog Creek):	
Siltstone*, greenish-gray, mottled red-brown, argillaceous, dolomitic, weakly indurated, blocky; weathering light greenish gray	1.5
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray layers	1.9
Unit C (Dog Creek):	
Dolomite*, greenish-gray, gypsiferous, silty, well-indurated	0.2
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray streaks	3.0
Unit C, (Dog Creek):	
Dolomite, light-gray, fine-grained, dense, well-indurated, blocky	0.2
Shale, red-brown, blocky	0.3
Southard Dolomite Bed:	
Dolomite*, light-gray, fine-grained, dense, well-indurated, blocky	0.4
Unit B (Dog Creek):	
Shale, greenish-gray, blocky; partly covered	3.0
Unnamed Units (Dog Creek):	
Shale, dark red-brown, blocky; with some greenish-gray siltstone streaks	7.0
Siltstone*, greenish-gray, arenaceous, dolomitic, gypsiferous, well-indurated, massive	2.0
Shale, red-brown, blocky; with 1-inch greenish-gray streak in middle	1.0
Siltstone, mottled greenish-gray and red-brown, gypsiferous, well-indurated, massive	1.0
Shale, red-brown, silty, crinkly bedded, blocky; with many gypsiferous siltstone beds	3.0
Siltstone*, greenish-gray, mottled red-brown, gypsiferous, crinkly bedded, finely laminated	1.5
Shale, red-brown, silty, thinly laminated	1.5

	Thickness (feet)
Gypsum, red-brown, mottled greenish-gray, silty, well-indurated; becoming weakly indurated in top 1 foot	2.0
Unit A (Dog Creek):	
Siltstone, light-brown, mottled red-brown and greenish-gray, argillaceous, weakly indurated, laminated, friable	2.0
Siltstone, red-brown, mottled greenish-gray, argillaceous, gypsiferous, well-indurated, blocky	6.25
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky; partly covered; with many greenish-gray and red-brown gypsiferous and dolomitic layers; wavy bedded, one bed being Watonga equivalent; section extrapolated to SE¼ sec. 29, T. 21 N., R. 14 W., and SW¼ sec. 28 for Blaine section	6.75
Haskew Gypsum Bed:	
Gypsum, white, mottled red-brown and greenish-gray, selenitic, fine-grained, crinkly bedded; with many interbedded gypsum and shale layers; forming an escarpment	5.25
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky, wavy bedded; with many interbedded gypsiferous shale layers	5.25
BLAINE FORMATION (total thickness, 83.7 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained; mottled red-brown and greenish gray at top; weathering coarsely selenitic; forming a mappable escarpment	16.75
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-cemented, medium-bedded; weathering into box-works	1.25
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky, weakly indurated	0.2
Shale, red-brown, blocky; with some greenish-gray spots and streaks	5.75
Shale, greeenish-gray, gypsiferous, silty, moderately indurated	0.25
Shale, red-brown, blocky; as above	6.5
Shale, greenish-gray; as above	0.1
Shale, red-brown, blocky, crinkly bedded; with some greenish-gray streaks and many thin gypsiferous layers in basal 3 feet	6.4
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; wavy bedded at top; forming an escarpment; section extrapolated to SE¼ sec. 28, T. 21 N., R. 14 W.	21.0
Magpie Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, well-cemented, thin-bedded; with some nonoölitic portions	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated, blocky	0.2

	Thickness *(feet)*
Shale, red-brown, blocky; with some greenish-gray spots and layers and satin spar beds	5.0
Kingfisher Creek Gypsum Bed:	
Gypsum and shale, greenish-gray, mottled red-brown, well-indurated; with satin spar bands; forming ledge	1.0
Unnamed Units (Blaine):	
Shale, red-brown; as above	2.1
Shale, greenish-gray, gypsiferous, well-indurated, blocky; forming small ledge	0.2
Shale, red-brown, wavy bedded; as above; with much satin spar and many gypsum nodules	3.5
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled light-gray, fine-grained, alabaster-like, massive; forming an escarpment; section extrapolated to SE¼ sec. 13, T. 21 N., R. 14 W.	11.0
Cedar Springs Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, argillaceous, well-indurated, thin- to medium-bedded; weathering slabby to blocky, light brown	1.5
FLOWERPOT SHALE (exposed thickness, 105.4 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky; with some thin satin spar beds	1.8
Shale, greenish-gray, well-indurated, gypsiferous; with interbedded satin spar; forming ledge	1.25
Units I-J (Flowerpot):	
Shale, red-brown, blocky; with much selenite and satin spar and some greenish-gray spots and layers	9.25
Unit H (Flowerpot):	
Shale, greenish-gray, blocky; with some red-brown shale streaks	2.0
Dolomite*, light-gray, fine-grained, dense, massive, blocky; weathering greenish gray	0.3
Shale, greenish-gray, weakly indurated, blocky	0.25
Shale, red-brown, weakly indurated, blocky	0.25
Siltstone, red-brown, mottled greenish-gray, argillaceous, gypsiferous, moderately indurated; with some satin spar	0.7
Shale, red-brown, blocky with some satin spar layers	1.6
Unit G (Flowerpot):	
Dolomite*, light-gray, argillaceous, fine-grained, dense, laminated; gypsiferous at top	0.5
Units E-F (Flowerpot):	
Shale, greenish-gray, blocky; with some red-brown layers	5.4
Unit D (Flowerpot):	
Shale, red-brown, blocky; with some greenish-gray shale spots	1.75
Shale, red-brown, blocky; with much interbedded satin spar	2.0
Gypsum, pink to moderate reddish-orange, silty, well-indurated, massive; forming ledge	1.7
Unit C (Flowerpot):	

	Thickness (feet)
Siltstone, moderate reddish-orange, mottled red-brown and greenish-gray, argillaceous, thinly laminated, weakly indurated, friable	6.3
Unit B (Flowerpot):	
Shale, greenish-gray, silty, weakly indurated, blocky	1.0
Shale, red-brown, blocky; with much satin spar	4.0
Shale, greenish-gray, blocky; with some red-brown layers	1.75
Shale, red-brown, blocky; with much satin spar	3.0
Shale, greenish-gray, crinkly bedded, blocky; with much satin spar; forming ledge and base of extremely gypsiferous section	0.5
Unit A_2 (Flowerpot):	
Shale, red-brown, blocky; with many irregular spots and seams of greenish-gray shale and some satin spar	5.25
Siltstone*, greenish-gray, argillaceous, arenaceous, dolomitic, gypsiferous, massive; with well-indurated dolomitic layer 0.5 feet below top	2.5
Shale, red-brown, blocky; with some thin satin spar layers in middle	8.0
Shale, red-brown, gypsiferous; with much interbedded satin spar, and white to greenish-white gypsum nodules in basal 3 inches	1.5
Shale, red-brown, blocky; with some satin spar	8.25
Dolomite*, red-brown, mottled greenish-gray, argillaceous, fine-grained, well-indurated, blocky	0.2
Shale, red-brown, blocky; with many small round greenish-gray spots with dark centers	2.0
Gypsum, white to greenish-white, nodular; small nodules	0.5
Shale, red-brown; as above	5.6
Gypsum, greenish-white, nodular; as above	0.2
Shale, red-brown; as above, including *Unit A_2*	15.5
Unit A_1 (Flowerpot):	
Shale, greenish-gray, silty, blocky, selenitic, weakly indurated	0.6
Shale, red-brown, blocky; exposed to base of section	10.0

SECTION 15. SAND CREEK
SOUTH-CENTRAL MAJOR COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured along section-line road and north of road in ravine in S½ SE¼ sec. 11, NE¼ NE¼ sec. 14, and along road and west of road in SW¼ NW¼ sec. 13, T. 20 N., R. 13 W., to Watonga Dolomite Bed, continuing in SE¼ SE¼ SW¼ sec. 13, T. 20 N., R. 13 W., for Shimer and lower portion of Dog Creek Shale. Section then extrapolated to Santa Fe Railroad cut in NE¼ SE¼ sec. 29, T. 20 N., R. 12 W., for section to Magpie Dolomite, continued to base of Blaine Formation in Lopp quarry in SW¼ NW¼ sec. 21, T. 20 N., R. 12 W., ending in bluff east of Sand Creek in SE¼ NW¼ sec. 20, T. 20 N., R. 12 W., for the

type section of the Cedar Springs Dolomite and upper part of the Flowerpot Shale, Major County.

	Thickness *(feet)*
MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-orange to moderate reddish-brown, quartzose, fine-grained, weakly indurated, friable; exposed	10.0
Sandstone, greenish-gray, quartzose, fine-grained, weakly indurated, friable	0.5
DOG CREEK SHALE (total thickness, 157.2 feet)	
Shale, red-brown, silty, blocky	5.5
Unit I (Dog Creek):	
Siltstone, mottled greenish-gray and red-brown, dolomitic, well-indurated, speckled; forming light greenish-gray ledge	1.2
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky	10.2
Shale, red-brown and greenish-gray, silty, thin-bedded; forming light-colored greenish-gray band	0.25
Shale, red-brown, silty, blocky	2.0
Unit H (Dog Creek):	
Siltstone, greenish-gray, dolomitic, argillaceous, moderately indurated; forming light-colored greenish-gray band	0.2
Unnamed Unit (Dog Creek):	
Shale*, red-brown, silty, blocky; grading into siltstone	19.25
Unit G (Dog Creek):	
Dolomite*, light greenish-gray, mottled light-red, argillaceous, weakly to well-indurated, crinkly bedded, platy; forming prominent ledge	0.4
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, weakly indurated	4.0
Unit F_2 (Dog Creek):	
Siltstone, greenish-gray, argillaceous, gypsiferous, weakly indurated; with some well-indurated layers	0.75
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, well-indurated, platy	1.0
Shale, greenish-gray and red-brown, gypsiferous, silty, well-indurated; with much satin spar	4.0
Unit F_1 (Dog Creek):	
Shale, dusky-brown, well-indurated, blocky; becoming platy and greenish gray in upper 2 feet	5.75
Dolomite, light greenish-gray, rubbly; grading upward into shale	0.3
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, well-indurated; with some greenish-gray layers and much satin spar	4.0
Siltstone, greenish-gray, gypsiferous, argillaceous, well-indurated	1.2
Shale, greenish-gray and red-brown, silty, thin-bedded, crink-	

	Thickness (feet)
ly bedded	3.2
Siltstone, red-brown and greenish-gray, argillaceous, gypsiferous, well-indurated	0.75
Shale, red-brown, silty	1.25
Siltstone, greenish-gray, gypsiferous, weakly indurated	1.5
Shale, red-brown, silty, well-indurated	1.0
Siltstone, greenish-gray, mottled red-brown, argillaceous, weakly indurated	2.0
Unit E (Dog Creek):	
Dolomite*, light-gray, silty, fine-grained, crinkly bedded	0.5
Unnamed Units (Dog Creek):	
Shale, red-brown, silty; mottled moderate reddish brown in middle	1.8
Siltstone, greenish-gray, mottled red-brown, argillaceous	0.75
Shale, red-brown, silty, well-indurated	0.75
Unit D (Dog Creek):	
Dolomite, light-gray, fine-grained, dense, well-indurated, blocky, even-bedded	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, well-indurated, blocky	3.0
Shale, greenish-gray, silty, platy, weakly indurated	0.5
Shale, red-brown, silty, weakly indurated	0.8
Shale, greenish-gray, mottled red-brown, platy	0.5
Unit C (Dog Creek):	
Dolomite, light-gray to light-brown, fine-grained, dense, thin-bedded, well-indurated, blocky; with some reddish-brown streaks	0.4
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty, well-indurated; with red-brown shale in upper part	2.75
Shale, red-brown, silty	0.75
Southard Dolomite Bed:	
Dolomite*, light-gray to yellow-gray, fine-grained, dense, thinly laminated, well-indurated; forming prominent ledge	0.5
Unit B (Dog Creek):	
Shale, greenish-gray, silty	3.0
Unnamed Units (Dog Creek):	
Shale, reddish-brown, silty, blocky	5.25
Siltstone, greenish-gray, argillaceous	1.75
Shale, red-brown, silty, blocky	2.0
Siltstone, greenish-gray, argillaceous, weakly indurated	0.5
Shale, red-brown, silty, blocky	5.25
Siltstone, greenish-gray to red-brown; with interbedded shale	1.5
Shale, red-brown, silty, blocky	1.0
Siltstone, greenish-gray, argillaceous	0.3
Shale, red-brown, silty, blocky	1.1
Siltstone, light-brown, mottled greenish-gray, weakly indurated	2.7

	Thickness (feet)
Shale, dark red-brown, silty, blocky	1.5
Unit A (Dog Creek):	
Siltstone, light-brown, mottled greenish-gray, weakly indurated	10.5
Unnamed Units (Dog Creek):	
Shale, greenish-gray, blocky	0.75
Shale, red-brown, silty, blocky	3.1
Shale, greenish-gray, platy	1.25
Shale, red-brown, silty, blocky	4.25
Watonga Dolomite Bed:	
Dolomite, light bluish-gray, fine-grained, dense, well-indurated	0.5
Shale, red-brown, silty	0.2
Dolomite, light bluish-gray; as above	0.75
Siltstone*, light bluish-gray to greenish-gray, dolomitic, platy; including thin dolomite stringers	1.25
Haskew Bed:	
Siltstone, light-brown, gypsiferous, well-indurated, massive; forming ledge	3.0
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, gypsiferous; with some greenish-gray shale layers and much crinkly bedded satin spar	23.0
BLAINE FORMATION (total thickness, 75.6 feet)	
Shimer Gypsum Member:	
Gypsum, white, coarsely selenitic, deeply weathered; forming an escarpment; absent in many places	13.0
Altona Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic and nonoölitic, well-cemented, thin- to medium-bedded, fossiliferous; weathering light brown, vuggy in boxworks; section extrapolated to railroad cut in NE¼ SE¼ sec. 29, T. 20 N., R. 12 W.	1.5
Unnamed Units (Blaine):	
Shale, greenish-gray, silty, blocky	0.25
Shale, red-brown, mottled greenish-gray, blocky	4.0
Shale, red-brown, silty; with much selenite	6.75
Shale, greenish-gray, selenitic, moderately indurated, crinkly bedded; weathering greenish gray	0.7
Shale, red-brown, silty, blocky; with much selenite	3.5
Shale, mottled red-brown and greenish-gray, selenitic; with satin spar; forming reddish-brown ledge	0.75
Shale, red-brown, silty, blocky	1.2
Shale, greenish-gray, blocky; with much paper-thin selenite	0.8
Shale, red-brown, blocky; with some selenite	1.2
Shale, red-brown, selenitic, blocky, crinkly bedded; well indurated at top and base	1.5
Shale, red-brown, blocky; with much selenite near base	2.0
Nescatunga Gypsum Member:	

	Thickness *(feet)*
Gypsum, red-brown, well-indurated, thinly laminated; with many selenite, satin spar, and red-brown clay shale seams	0.8
Gypsum, greenish-gray, selenitic, thinly laminated; with much satin spar and many greenish-gray shale seams	0.9
Gypsum, white, fine-grained, alabasterlike; mottled with irregular red-brown streaks and seams; with 1.5 feet of anhydrite in middle portion	15.75
Magpie Dolomite Bed:	
Dolomite*, light-gray to greenish-gray, oölitic, fine-grained, medium-bedded, fossiliferous; eroding into light-brown medium blocks; forming a mappable escarpment; section measured in Lopp quarry, SW¼ NW¼ sec. 21, T. 20 N., R. 12 W.	0.7
Unnamed Units (Blaine):	
Shale, greenish-gray, mottled red-brown, blocky	0.4
Shale, red-brown, blocky	0.5
Shale, greenish-gray; as above	0.1
Shale, red-brown, blocky	2.75
Shale, greenish-gray; as above	0.25
Shale, red-brown, blocky; with some satin spar	2.0
Kingfisher Creek Gypsum Bed:	
Gypsum and shale, interbedded, mottled greenish-gray and red-brown, crinkly bedded; with much satin spar	1.5
Unnamed Units (Blaine):	
Shale, red-brown; with some greenish-gray streaks	2.75
Shale, greenish-gray and red-brown, crinkly bedded; with much satin spar	1.0
Shale, red-brown, blocky	0.75
Gypsum and shale, interbedded, red-brown, well-indurated, crinkly-bedded, blocky; with some satin spar	0.5
Shale, red-brown, blocky; with some satin spar	0.5
Gypsum and shale, interbedded, red-brown, well-indurated, crinkly bedded	0.5
Medicine Lodge Gypsum Member:	
Gypsum, light-gray and red-brown, well-indurated, fine-grained, crinkly bedded	1.0
Gypsum, light-gray to white, fine-grained, laminated; with some light-gray and red-brown streaks	5.25
Cedar Springs Dolomite Bed (type section):	
Dolomite*, light-gray, fine-grained, dense to oölitic, well-indurated, massive; grading upward into gypsum; forming ledge; section extrapolated to NW¼ sec. 20, T. 20 N., R. 12 W.	0.5
FLOWERPOT SHALE (exposed thickness, 104.3 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, blocky	0.2
Unit J (Flowerpot):	
Shale, dark-red to dark reddish-brown, blocky	1.0

	Thickness (feet)
Shale, red-brown, blocky	2.0
Shale, greenish-gray to gray, blocky	2.5
Unit I (Flowerpot):	
Gypsum, white, mottled red-brown and greenish-gray, limonitic, argillaceous, well-indurated, crinkly bedded; with much satin spar; forming prominent ledge	0.75
Shale, red-brown, blocky	1.0
Shale and gypsum, interbedded, red-brown, blocky; with some greenish-gray layers and much satin spar	5.25
Unit H (Flowerpot):	
Shale, red-brown, blocky; with many crinkly satin spar beds	7.5
Unit G (Flowerpot):	
Dolomite*, light-gray, fine-grained, laminated, wavy bedded, massive; weathering light-brown	0.5
Unit F (Flowerpot):	
Shale, red-brown, blocky; with many paper-thin selenite layers	2.75
Unit E (Flowerpot):	
Shale, greenish-gray, well-indurated, blocky; with some thin irregular satin spar seams	1.6
Unit D (Flowerpot):	
Shale, red-brown, blocky; with much satin spar and selenite near top	6.5
Unit C (Flowerpot):	
Siltstone*, greenish-gray, argillaceous, gypsiferous, weakly indurated	2.0
Gypsum, greenish-gray, argillaceous, well-indurated, massive; grading into beds above and below; forming prominent ledge. This is Gould's (1902, 1905) "northward disappearing wedge of Ferguson Gypsum" which is actually not the Ferguson but is about 30 feet below the Ferguson (now Medicine Lodge) Gypsum	1.2
Siltstone, greenish-gray, argillaceous, gypsiferous, weakly indurated; laminated with red-brown shale streaks; as above	2.5
Unit B (Flowerpot):	
Shale, red-brown, blocky	1.75
Shale, red-brown, blocky; with much satin spar and selenite	8.25
Shale, red-brown, blocky; speckled with greenish-gray spots; with some satin spar near top	5.75
Gypsum, white, mottled red-brown and greenish-gray, fine-grained, well-indurated; forming prominent band	0.2
Unit A_3 (Flowerpot):	
Shale, red-brown, silty, blocky	4.0
Gypsum, white, mottled greenish-gray, fine-grained, nodular	0.2
Shale, red-brown, silty, blocky	0.75
Shale, greenish-gray, gypsiferous; well indurated in places	0.1
Shale, red-brown, silty, blocky	2.6

	Thickness (feet)
Shale, mottled red-brown and greenish-gray, dolomitic, well-indurated, blocky	0.1
Shale, red-brown, silty, blocky; well indurated in middle	1.0
Gypsum, white, selenitic, nodular	0.2
Shale, red-brown, silty, blocky	1.5
Gypsum, greenish-gray, argillaceous, selenitic	0.1
Shale, red-brown, silty, blocky	4.0
Gypsum, white, mottled greenish-gray, well-indurated, nodular; forming base of extremely gypsiferous section	0.75
Shale, red-brown, silty, blocky; with many small greenish-gray spots and some vertical selenite veins	4.0
Shale, mottled red-brown and greenish-gray, dolomitic, well-indurated, blocky	0.25
Shale, red-brown, silty, blocky	1.75
Shale, greenish-gray; with some satin spar	0.1
Shale, red-brown, silty, blocky	2.1
Gypsum, white, mottled greenish-gray, selenitic, nodular	0.6
Shale, red-brown, silty, blocky	1.5
Shale and gypsum, greenish-gray, selenitic, nodular	0.2
Shale, red-brown, silty, blocky	9.0
Shale, greenish-gray, gypsiferous, crinkly bedded	0.3
Shale, red-brown, silty, blocky; including *Unit* A_2	11.5
Unit A_1 (Flowerpot):	
Shale, red-brown, silty, well-indurated, blocky; with some small greenish-gray spots with dark centers; forming a resistant ledge	3.0
Gypsum, white, fine-grained, nodular	0.5
Shale, red-brown, silty, well-indurated, blocky; exposed	1.0

SECTION 16. LONGDALE
NORTHERN BLAINE COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured just below Canton Dam, in NE¼ NE¼ SE¼ sec. 32 and SW¼ SW¼ NW¼ sec. 33, T. 19 N., R. 13 W., including upper 51 feet of the Dog Creek Shale. Middle part of section covered; section of lower 96 feet of Dog Creek measured in high hill in SE¼ sec. 21, T. 19 N., R. 12 W., continuing in the Blaine Formation in NW¼ sec. 27 and SE¼ sec. 16, ending in the Flowerpot Shale in center NE¼ SW¼ sec. 10, T. 19 N., R. 12 W., east of Longdale, Blaine County, Oklahoma.

MARLOW FORMATION (top not exposed)	
Sandstone*, moderate reddish-orange, fine-grained, quartzose; with subrounded grains; weakly indurated, massive; with many small greenish-gray spots	10.0
DOG CREEK SHALE (total thickness, approximately 163 feet)	
Siltstone, moderate reddish-orange, well-indurated, medium-	

	Thickness (feet)
bedded; speckled with greenish-gray spots; weathering red brown with many small quartz-lined vugs; forming ledge	0.5
Shale, red-brown, silty, well-indurated, blocky; forming ledge	0.25
Siltstone, moderate reddish-orange; as above	0.2
Siltstone, greenish-gray, mottled moderate reddish-orange; as above; forming ledge	0.2
Shale, red-brown, blocky	1.5
Siltstone, greenish-gray and moderate reddish-orange; as above	0.1
Shale, red-brown; as above	2.0
Siltstone, moderate reddish-orange, well-indurated; as above; weathering red-brown; forming ledge	0.2
Shale, red-brown, blocky	1.5
Unit I (Dog Creek):	
Dolomite*, moderate reddish-orange and greenish-gray, well-indurated, massive; with many greenish-gray spots; eroding in rounded masses; forming ledge	0.5
Unnamed Unit (Dog Creek):	
Shale, red-brown, blocky; with some greenish-gray spots	12.75
Unit H (Dog Creek):	
Siltstone, red-brown, argillaceous, thin-bedded, well-indurated; with thin calcite veins and small greenish-gray spots, forming ledge	0.25
Unnamed Units (Dog Creek):	
Shale, red-brown, blocky; as above	2.0
Shale, red-brown; as above; with a thin indurated siltstone at base forming small ledge	0.5
Shale, red-brown, blocky; with some greenish-gray spots; and with satin spar near base	14.75
Shale, red-brown, blocky; with many thin satin spar layers; and with several thin greenish-gray calcareous siltstones in basal part	8.0
Unit F_2 (Dog Creek):	
Siltstone, moderate reddish-orange and greenish-gray, arenaceous, well-indurated; with many thin satin spar veins and layers at top	2.0
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, blocky; exposed in bed of North Canadian River	2.0
Section covered by alluvium; section extrapolated to SE¼ sec. 21, T. 19 N., R. 12 W.	17.0
Unit E (Dog Creek):	
Dolomite, light-gray, fine-grained, dense, well-indurated, massive; forming an escarpment	0.7
Unnamed Units (Dog Creek):	
Shale, red-brown, silty	1.0
Shale, greenish-gray, silty, well-indurated	0.25

	Thickness (feet)
Shale, red-brown, silty	2.0
Siltstone, mottled greenish-gray and red-brown, massive	2.0
Siltstone, greenish-gray, argillaceous, weakly indurated	0.75
Shale, dark red-brown, silty, blocky; with some greenish-gray spots and seams	3.5
Unit D (Dog Creek):	
Dolomite, light-gray, fine-grained, dense, well-indurated, thin-bedded; weathering massive	0.2
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty; with 2-inch greenish-gray shale in middle	6.25
Southard Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, argillaceous, fine-grained, dense, vuggy, medium-bedded; forming a massive ledge	0.6
Unit B (Dog Creek):	
Shale; greenish-gray at top; red-brown at base, silty	6.75
Unnamed Units (Dog Creek):	
Shale, greenish-gray, mottled red-brown, silty	1.0
Shale, red-brown, silty	3.0
Siltstone, greenish-gray, mottled red-brown, gypsiferous, argillaceous, well-indurated, massive; with white gypsum nodules in upper part; forming a resistant ledge	0.75
Siltstone, greenish-gray, mottled moderate red-brown, argillaceous, weakly indurated	0.75
Shale, red-brown, silty; with many thin selenite layers and some greenish-gray shale seams	7.0
Shale, greenish-gray, silty; with some thin-bedded fine-grained dense dolomite beds and greenish-white gypsum nodules	1.0
Shale, moderate reddish-brown, argillaceous, silty, blocky; with some thin satin spar layers and a 1-inch greenish-gray shale seam near base	4.0
Shale, red-brown, silty, well-indurated; with a 1-inch greenish-gray shale seam in middle	3.0
Shale, greenish-gray, silty; with a 2-inch argillaceous dolomite ledge in middle	2.5
Shale, red-brown, silty; with much paper-thin selenite	0.5
Shale, greenish-gray, silty, gypsiferous, dolomitic; with some selenite	1.0
Shale, red-brown, silty; with some gypsum nodules and a 2-inch greenish-gray shale bed in middle	3.5
Shale, greenish-gray, silty, well-indurated; mottled very dark red in places	0.5
Unit A (Dog Creek):	
Siltstone, moderate reddish-brown, argillaceous; with many paper-thin selenite and satin spar layers	4.0
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty; with some paper-thin selenite layers	0.5

	Thickness (feet)
Shale, red-brown, silty, well-indurated	1.0
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty; mottled with greenish-gray patches	1.75
Shale, greenish-gray, mottled red-brown, silty, well-indurated	3.0
Watonga Dolomite Bed:	
Dolomite, light bluish-gray, fine-grained, dense, well-indurated, thin-bedded; forming a resistant ledge	0.25
Shale, red-brown, silty	0.25
Siltstone, light bluish-gray, argillaceous, blocky	0.5
Dolomite; as above; gypsiferous at top	0.75
Siltstone*, light bluish-gray, dolomitic, well-indurated, blocky; with some satin spar	1.5
Haskew Bed:	
Gypsum, dark greenish-gray, argillaceous, well-indurated, platy	0.3
Siltstone, light-brown, mottled greenish-gray, gypsiferous, argillaceous, well-indurated, platy; forming resistant ledge	1.25
Shale, greenish-gray, silty, selenitic, platy to blocky	2.75
Siltstone, light-brown; as above	2.0
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty, gypsiferous; with much satin spar	0.5
Shale, red-brown, silty; with many greenish-gray spots and paper-thin satin spar layers	4.0
Shale, greenish-gray, silty, gypsiferous; with much satin spar	0.3
Shale, red-brown, silty; as above	5.25
Shale, greenish-gray, silty, gypsiferous, selenitic, well-indurated; with gypsum nodules; forming ledge	1.0
Shale, red-brown, silty; as above; with satin spar, selenite, and gypsum nodules	3.0
Shale, mottled red-brown and greenish-gray, argillaceous, silty, dolomitic, well-indurated, crinkly bedded; forming ledge	2.0
Shale, red-brown, silty; with much satin spar and nodular gypsum	1.75
Shale, greenish-gray, argillaceous, gypsiferous, dolomitic, well-indurated; forming ledge	0.5
Shale, red-brown, silty; as above; with much selenite	1.5
Shale, greenish-gray, wavy bedded; as above	1.5
Shale, red-brown, silty, gypsiferous, wavy bedded, with many greenish-gray selenite and shale layers	2.0
BLAINE FORMATION (total thickness, 74.3 feet)	
Shimer Gypsum Member:	
Gypsum, white, coarsely selenitic, massive; eroding into a massive ledge; forming a mappable escarpment	16.0
Altona Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, fossiliferous; with *Permophorus;* grading upward	

	Thickness *(feet)*
into gypsum; forming a massive ledge	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty; with some selenite and some 1- to 2-inch gypsum nodules in upper 1 foot	5.25
Siltstone, greenish-gray, mottled moderate red-brown, argillaceous	0.75
Shale, red-brown, silty	1.5
Siltstone, greenish-gray; as above	0.75
Shale, red-brown, silty	1.5
Shale, greenish-gray, silty	0.2
Shale, red-brown, silty; with some selenite	2.0
Shale, greenish-gray, silty, gypsifereous, well-indurated, platy	0.5
Shale, red-brown, silty	1.0
Shale, greenish-gray, silty	1.0
Shale, dark red-brown to very dark-red, argillaceous, silty, blocky; with much selenite	1.0
Shale, greenish-gray, silty	0.3
Shale, red-brown, silty	1.75
Gypsum, red-brown, selenitic, well-indurated	0.2
Shale, red-brown, silty	0.3
Siltstone, mottled red-brown and greenish-gray	0.25
Shale, red-brown, silty	1.0
Shale, greenish-gray, silty, gypsiferous, well-indurated, crinkly bedded	0.75
Nescatunga Gypsum Member:	
Gypsum, white, fine-crystalline, dense, finely laminated, well-indurated, crinkly bedded; mottled red brown at top	6.0
Anhydrite, light-gray, fine-crystalline, fibrous, well-indurated; grading into gypsum; eroding as a resistant bright-white ledge with a sharp pitted surface	4.0
Gypsum, white, fine- to coarse-crystalline, porous; mottled red brown in places; forming ledge	3.0
Magpie Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, thin-bedded, well-indurated, fossiliferous; grading upward into gypsum; forming a massive ledge	0.75
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.3
Shale, red-brown, silty; mottled with greenish-gray patches	4.0
Shale, greenish-gray, silty	0.3
Shale, red-brown, silty; with satin spar	2.5
Shale, greenish-gray, silty	0.75
Shale, red-brown, silty; with thin satin spar seams	2.5
Kingfisher Creek Gypsum Bed:	
Gypsum and shale, greenish-gray, well-indurated; with much satin spar; forming ledge	0.25
Gypsum and shale, red-brown, argillaceous; with much satin	

	Thickness (feet)
spar	0.5
Gypsum and shale, greenish-gray; as above	0.5
Unnamed Units (Blaine):	
Shale, red-brown, silty; with nodular gypsum near base and with many greenish-gray shale layers	4.0
Shale, greenish-gray, silty, gypsiferous	0.5
Shale, red-brown, silty, gypsiferous	0.5
Medicine Lodge Gypsum Member:	
Gypsum, white, coarse-crystalline, selenitic, wavy bedded; mottled red brown to pinkish white in upper part and greenish gray in lower part; forming massive pinkish-white ledge	6.25
Cedar Springs Dolomite Bed:	
Dolomite, greenish-gray, gypsiferous; grading upward into gypsum; absent in many places	0.2
FLOWERPOT SHALE (exposed thickness, 124.2 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, silty, mottled red-brown	0.2
Unit J (Flowerpot):	
Shale, red-brown, silty	2.0
Shale, greenish-gray, silty	3.0
Unit I (Flowerpot):	
Gypsum and shale, mottled greenish-gray and red-brown, well-indurated; with much satin spar; forming resistant ledge	1.25
Shale, red-brown, silty, well-indurated; with much satin spar	4.5
Gypsum and shale; as above	0.25
Shale, red-brown, silty; as above; with much satin spar	2.0
Gypsum and shale; as above	0.5
Unit H (Flowerpot):	
Shale, red-brown, silty; with some greenish-gray shale seams and much satin spar	7.25
Shale, red-brown, silty	1.5
Unit G (Flowerpot):	
Dolomite*, light-brown to light-gray, fine-grained, well-indurated; grading into greenish-gray shale	0.25
Unit F (Flowerpot):	
Shale, red-brown, silty	2.75
Unit E (Flowerpot):	
Shale, greenish-gray, silty	1.0
Unit D (Flowerpot):	
Shale, red-brown, silty; with some selenite	3.5
Shale, greenish-gray, silty, gypsiferous, well-indurated; with many thin selenite veins	0.3
Shale, red-brown, silty; with some selenite	4.0
Unit C (Flowerpot):	
Siltstone, mottled greenish-gray and red-brown, argillaceous, gypsiferous, weakly indurated; forming prominent light-	

	Thickness *(feet)*
colored band	1.0
Unit B (Flowerpot):	
Shale, red-brown, silty, well-indurated; mottled with small greenish-gray spots; with some selenite	10.0
Gypsum, yellowish-white, nodular	0.3
Shale, red-brown, silty	3.75
Gypsum, yellowish-white, nodular	0.2
Shale, red-brown, silty	0.75
Gypsum, yellowish-white, nodular	0.2
Shale, red-brown, silty	2.0
Gypsum, yellowish-white, nodular	0.2
Shale, red-brown, silty	0.75
Gypsum, yellowish-white, selenitic	0.2
Shale, red-brown, silty	0.8
Gypsum, yellowish-white, nodular; in two bands separated by reddish-brown silty clay shale, marking base of extremely gypsiferous section	0.7
Unit A_3 (Flowerpot):	
Shale, red-brown, silty; with many thin veins and small spots of greenish-gray shale	25.0
Siltstone, mottled greenish-gray and red-brown, argillaceous	1.25
Shale, red-brown, silty; with some vertical selenite veins and gypsum nodules	15.0
Unit A_2 (Flowerpot):	
Siltstone, mottled greenish-gray and red-brown, cross-bedded; with 19 degree dip in N 35 degree W direction; probably northward remnant of Chickasha Tongue	1.75
Unit A_1 (Flowerpot):	
Shale, red-brown, silty	5.25
Gypsum, white, nodular	0.5
Shale, red-brown, silty	7.0
Shale, greenish-gray, mottled red-brown, silty; probably a northward remnant of a Chickasha tongue	1.5
Shale, red-brown, silty	2.0
Shale, mottled greenish-gray and red-brown, silty	0.8
Shale, red-brown, silty	7.0
Siltstone, greenish-gray, argillaceous; forming prominent light-colored band in region; probably a northward remnant of a Chickasha tongue	2.0
Shale, red-brown, silty, mostly covered; not measured	

SECTION 17. IDEAL
NORTHERN BLAINE COUNTY, OKLAHOMA

Beginning at top in Dog Creek Shale, section measured along State Highway 51 in NW¼ sec. 3, T. 18 N., R. 12 W., north and south of highway, continuing into NW¼ sec. 35, T. 19 N., R. 12 W., ending in NW¼ NW¼ sec. 25, T. 19 N., R. 12 W., at the abandoned Ideal Cement Company quarry area, Blaine County, Oklahoma.

	Thickness (feet)
DOG CREEK SHALE (top not exposed, estimated thickness, 168 feet; exposed thickness of lower portion, 99.5 feet)	
Shale, red-brown, silty; with 1- to 2-inch light-gray dolomite near top	10.0
Unit E (Dog Creek):	
Dolomite, light-gray, fine-grained, dense, thin-bedded; with 8 inches of interbedded greenish-gray shale	1.0
Unnamed Unit (Dog Creek):	
Shale, red-brown, mottled greenish-gray, silty; with three 3-inch greenish-gray shale bands spaced 2, 4, and 6 feet above the base	7.0
Unit C (Dog Creek):	
Siltstone, light-gray, dolomitic, argillaceous; grading into greenish-gray shale in lower 8 inches	1.0
Unnamed Units (Dog Creek):	
Shale, red-brown, silty	2.0
Shale, greenish-gray, silty, flaky	0.75
Shale, red-brown, silty	0.5
Southard Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, argillaceous, fine-grained, dense, well-indurated, thin-bedded; eroding into a massive ledge; forming a mappable escarpment	0.3
Unit B (Dog Creek):	
Shale, dark red-brown to very dark-red, argillaceous, silty, blocky	0.75
Shale, greenish-gray, mottled red-brown, silty	2.25
Unnamed Units (Dog Creek):	
Shale, red-brown, silty; mottled with 1- to 3-inch greenish-gray spots	3.75
Siltstone, greenish-gray, mottled moderate reddish-brown, porous, well-indurated, medium-bedded	1.5
Shale, red-brown, silty	2.6
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty	1.0
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty	6.1
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty	1.0
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty	2.6
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty	1.0
Shale, greenish-gray, silty	0.5
Shale, greenish-gray, silty, platy to blocky	1.0
Dolomite, light bluish-gray, argillaceous, fine-grained, dense, well-indurated, massive	0.1
Shale, greenish-gray, silty; dolomitic at base	1.25
Shale, dark red-brown to very dark-red, mottled greenish-gray, argillaceous, blocky	0.75

	Thickness (feet)
Shale, red-brown, silty; with thin dolomite seam at base	0.75
Siltstone, greenish-gray, mottled red-brown, argillaceous	0.7
Shale, red-brown, silty; mottled with 1- to 4-inch greenish-gray spots; with several thin selenite seams in middle	4.5
Shale, greenish-gray, silty; with many thin yellowish-white gypsum nodules	0.5
Unit A (Dog Creek):	
Siltstone, light-brown, weakly indurated; greenish-gray with mud cracks at top; satin spar in lower part	5.75
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty	1.75
Shale, greenish-gray, silty	0.75
Shale, red-brown, silty; with some thin selenite seams and 2- to 3-inch greenish-gray spots	2.2
Shale, greenish-gray, silty, dolomitic; indurated at base	0.75
Shale, dark red-brown to very dark-red, mottled greenish-gray, argillaceous, well-indurated, blocky	1.0
Shale, red-brown, silty	1.5
Watonga Dolomite Bed:	
Dolomite, light bluish-gray, fine-grained, dense, well-indurated, thin-bedded; forming a massive ledge	0.3
Shale, light bluish-gray, mottled red-brown, argillaceous, dolomitic, blocky; with many selenite and satin spar layers	0.7
Dolomite, vuggy; as above; with thin gypsum layers	0.3
Dolomite, mottled red-brown; as above; with interbedded greenish-gray shale and satin spar	0.75
Shale, red-brown, silty; with thin satin spar layers	0.6
Dolomite, silty; as above; with interbedded greenish-gray shale and satin spar; forming ledge	1.5
Haskew Bed:	
Siltstone, light-brown, gypsiferous, argillaceous, well-indurated; with many thin greenish-gray shale streaks and satin spar layers	1.5
Siltstone, light-brown, mottled greenish-gray, weakly indurated	1.75
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, crinkly bedded; with a few greenish-gray layers and much satin spar; with one 2-foot indurated greenish-gray gypsiferous shale eleven feet above base	21.0
BLAINE FORMATION (total thickness, 68.3 feet)	
Shimer Gypsum Member:	
Gypsum, white, coarse-crystalline, banded; mottled greenish-gray at top; forming a massive ledge with deep holes	12.0
Altona Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, fine-grained, dense, oölitic, fossiliferous; grading into gypsum above; forming a ledge	0.75

	Thickness (feet)
Unnamed Units (Blaine):	
Shale, greenish-gray, silty, well-indurated	0.5
Shale, moderate red-brown, mottled greenish-gray, silty, blocky; with a 2-inch greenish-gray shale seam at base	2.75
Shale, red-brown, silty	2.75
Siltstone, greenish-gray, mottled red-brown, argillaceous, blocky	2.0
Shale, red-brown, silty, well-indurated	3.0
Shale, greenish-gray, silty, gypsiferous, platy; with white gypsum nodules at top	0.75
Shale, red-brown, silty	2.5
Shale, greenish-gray, silty, gypsiferous; with 2-inch moderate red-brown gypsum band in middle	1.0
Shale, red-brown, silty	1.5
Shale, greenish-gray, silty, gypsiferous, well-indurated	1.5
Shale, red-brown, silty, thin-bedded, crinkly bedded, blocky; alternating with greenish-gray argillaceous gypsiferous laminae	1.5
Nescatunga Gypsum Member:	
Gypsum, white, fine-crystalline, thinly laminated, well-indurated; forming a ledge	6.5
Anhydrite, light-gray, fine-crystalline, fibrous, well-indurated, massive; with interbedded fine-grained gypsum; eroding into a bright-white pitted ledge	2.0
Gypsum, white, fine- to coarse-crystalline; becoming greenish-gray in lower 3 inches	3.0
Magpie Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, dense, thin-bedded, fossiliferous; oölitic near top; with much satin spar grading upward into gypsum	1.1
Unnamed Units (Blaine):	
Shale, greenish-gray, silty; with yellowish-white gypsum nodules at base	0.5
Shale, red-brown, silty; with some small greenish-gray spots and thin satin spar layers	3.0
Shale, greenish-gray, mottled moderate reddish-brown, silty	1.25
Shale, red-brown, silty	1.75
Kingfisher Creek Gypsum Bed:	
Gypsum and shale, greenish-gray, well-indurated, platy to blocky; forming ledge	0.5
Unnamed Units (Blaine):	
Shale, red-brown, silty; with some greenish-gray shale streaks and spots	9.0
Shale, greenish-gray, silty; with many thin red-brown shale seams	1.1
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled moderate red-brown to pale-pink, fine- to coarse-crystalline, banded; mottled greenish-gray	

	Thickness (feet)
in lower part; forming massive ledge	6.5
Cedar Springs Dolomite Bed:	
Dolomite, greenish-gray, argillaceous, fine-crystalline, thin-bedded, crinkly bedded; grading upward into gypsum; absent at many places	0.1
FLOWERPOT SHALE (exposed thickness, 68.5 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, mottled moderate red-brown, silty	0.25
Unit J (Flowerpot):	
Shale, red-brown, silty	2.25
Shale, greenish-gray, silty; with many thin satin spar seams near base	3.0
Unit I (Flowerpot):	
Hematite, very dark-red, argillaceous, well-indurated	0.025
Gypsum and shale, greenish-gray and red-brown, well-indurated, thin-bedded; with many satin spar layers; forming a ledge	1.0
Shale, red-brown, silty, gypsiferous, well-indurated; with some greenish-gray layers and much satin spar; forming a ledge	5.0
Gypsum and shale, greenish-gray; as above	1.0
Shale, red-brown, silty, gypsiferous; with much satin spar	2.0
Gypsum and shale, greenish-gray; as above; forming a ledge	0.5
Unit H (Flowerpot):	
Shale, red-brown, silty; with some satin spar	7.75
Gypsum, greenish-white, nodular	0.25
Shale, red-brown, silty; with some satin spar	1.5
Unit G (Flowerpot):	
Dolomite, mottled greenish-gray to light-brown, argillaceous, well-indurated, dense, massive; weathering light brown	0.2
Units D-F (Flowerpot):	
Shale, red-brown, silty; with some 2-inch greenish-gray gypsiferous shale layers	10.5
Unit C (Flowerpot):	
Shale, greenish-gray, mottled red-brown, silty; gypsiferous at base	1.25
Unit B (Flowerpot):	
Shale, red-brown, silty; with 2- to 3-inch white gypsum nodules at top and in basal 2 feet; marking base of extremely gypsiferous section	19.0
Unit A_2 (Flowerpot):	
Shale, red-brown, silty, with many 2- to 3-inch greenish-gray spots and veins; exposed	15.0

SECTION 18. SOUTHARD
NORTHERN BLAINE COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured along

road in NE¼ NW¼ sec. 27, T. 18 N., R. 13 W., including upper 10 feet of Dog Creek Shale. Section then covered by North Canadian River alluvium and Pleistocene deposits, cutting out about 80 feet of Dog Creek Shale. Section then extrapolated to road cut south of Southard in SW¼ sec. 10, T. 18 N., R. 12 W., for lower half of Dog Creek Shale, continuing into SE¼ sec. 3 and NE¼ sec. 10 for Blaine portion, ending in SW¼ sec. 2, T. 18 N., R. 12 W., for Flowerpot portion, along road and south of road east of Southard, Blaine County, Oklahoma.

	Thickness *(feet)*
MARLOW FORMATION (top not exposed)	
Sandstone, moderate red-brown to moderate reddish-orange, silty, fine-grained, quartzose, massive, weakly indurated; mottled with some small greenish-gray spots	21.75
Sandstone, greenish-gray, mottled moderate red-brown, fine-grained, quartzose, weakly indurated, massive	2.5
DOG CREEK SHALE (estimated thickness, 170 feet; upper 10 feet exposed; middle 78 feet covered; lower 82 feet exposed)	
Shale, red-brown, silty, blocky	10.0
Covered; probably mostly red-brown blocky shale; estimated	78.0
Shale, mottled red-brown and greenish-gray, silty, blocky, crinkly bedded, thin-bedded; with some satin spar and several indurated bands; section extrapolated to SW¼ sec. 10, T. 18 N., R. 12 W., south of Southard, along road	1.0
Shale, red-brown, silty	0.75
Unit E (Dog Creek):	
Dolomite, greenish-gray, argillaceous, silty, fine-grained, porous; with some gypsum	0.5
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty; mottled with some greenish-gray spots and streaks	2.5
Unit D (Dog Creek):	
Shale, greenish-gray, dolomitic, well-indurated, porous	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, silty	0.75
Shale, greenish-gray; as above	0.2
Shale, red-brown, silty	1.0
Shale, greenish-gray; as above	0.1
Shale, red-brown, silty; becoming greenish gray toward base	1.5
Unit C (Dog Creek):	
Dolomite, light-gray, fine-grained, dense, well-indurated	0.1
Shale, red-brown, silty	0.3
Dolomite, light-gray; as above	0.1
Unnamed Units (Dog Creek):	
Shale, red-brown, silty	0.2
Shale, greenish-gray, dolomitic, silty, well-indurated	0.25
Shale, red-brown, silty	2.0

	Thickness (feet)
Shale, greenish-gray, silty, well-indurated	1.0
Shale, red-brown, silty	0.7
Southard Dolomite Bed (type section):	
Dolomite*, light-gray to yellowish-gray, silty, fine-grained, well-indurated, thin-bedded, dense, vuggy; eroding as a light-brown massive ledge; forming an escarpment	0.3
Unit B (Dog Creek):	
Shale, greenish-gray, silty	1.0
Unnamed Units (Dog Creek):	
Shale, mottled red-brown and greenish-gray, silty, blocky	0.2
Shale, red-brown, silty	1.5
Siltstone, greenish-gray, argillaceous, weakly indurated	0.3
Shale, red-brown, mottled greenish-gray, argillaceous	4.5
Shale, greenish-gray, mottled red-brown, silty, dolomitic, well-indurated	1.5
Shale, red-brown, silty	2.6
Shale, mottled red-brown and greenish-gray; as above	1.5
Shale, red-brown, silty	3.0
Shale, greenish-gray, mottled red-brown, silty	1.25
Shale, red-brown, silty	5.0
Shale, greenish-gray; silty at base	0.5
Unit A (Dog Creek):	
Siltstone, light-brown, massive	3.0
Unnamed Units (Dog Creek):	
Shale, red-brown, silty; with many thin satin spar layers and four 2-inch greenish-gray shale beds, spaced at top and base and two evenly between	5.0
Shale, greenish-gray, silty; with much white to pink satin spar	1.0
Shale, dark red-brown to very dark-red, silty, blocky; with many yellowish-white gypsum nodules	1.75
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty; with some thin satin spar layers	2.5
Shale, greenish-gray, mottled red-brown, silty	1.0
Shale, dark red-brown to very dark-red, mottled greenish-gray, silty, blocky	2.0
Watonga Dolomite Bed:	
Dolomite*, light bluish-gray, fine-grained, dense, well-indurated; forming a mappable escarpment	0.1
Shale; red-brown at top; light bluish-gray at base; argillaceous, blocky; with thin satin spar layers	1.0
Dolomite, thin-bedded; as above	0.4
Shale, silty; as above	0.5
Siltstone, light-brown, crinkly bedded, platy; becoming dolomitic at base	1.75
Dolomite, crinkly bedded, porous; as above; with interbedded shale and satin spar layers	0.2
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty	0.3

	Thickness (feet)
Shale, red-brown, silty	0.25
Haskew Bed:	
Siltstone, greenish-gray, gypsiferous, well-indurated, thin-bedded	0.5
Siltstone, light-brown, gypsiferous, well-indurated, platy, crinkly bedded; forming resistant ledge	3.0
Unnamed Units (Dog Creek):	
Shale, greenish-gray, gypsiferous, well-indurated, vuggy; with many gypsum nodules and much satin spar	1.0
Shale, red-brown, silty, well-indurated; with many satin spar layers	1.0
Shale, greenish-gray, silty, gypsiferous	0.7
Shale, red-brown, silty; with much satin spar	3.0
Shale, greenish-gray, silty, gypsiferous	0.6
Shale, red-brown and greenish-gray, silty, crinkly bedded; with much satin spar and prominent greenish-gray indurated band about 4 feet below top	12.75
Siltstone, greenish-gray, argillaceous, gypsiferous, well-indurated; forming ledge	0.3
Shale, red-brown and greenish-gray, silty, blocky, crinkly bedded; with impure gypsiferous greenish-gray shale at base	1.75
BLAINE FORMATION (total thickness, 86.6 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine- to coarse-crystalline, banded; the middle portion grading into anhydrite in quarry faces where there is 33 feet or more of natural overburden; forming ledge	21.0
Altona Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, fossiliferous; thin bedded in upper part; grading upward into gypsum; forming a massive ledge	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	1.0
Shale, red-brown, mottled greenish-gray, silty	8.0
Shale, greenish-gray, gypsiferous, well-indurated; with red-brown satin spar; forming ledge	1.0
Shale, red-brown, silty; with some thin selenite seams	1.5
Shale, greenish-gray, silty; with some selenite layers	1.0
Shale, red-brown; as above	3.5
Gypsum and shale, greenish-gray, selenitic, well-indurated; forming ledge	1.0
Shale, red-brown, silty; with thin selenite veins; mottled greenish gray at top and base	1.5
Shale, greenish-gray, mottled dark red-brown, silty	3.5
Shale, red-brown, silty; with satin spar layers	0.75
Shale, greenish-gray, silty; with many thin satin spar seams	0.25
Shale, red-brown, silty	1.75

	Thickness (feet)
Shale, greenish-gray, mottled red-brown, gypsiferous; with satin spar	0.5
Shale, red-brown, silty; with much satin spar	0.8
Shale, greenish-gray; as above	0.2
Shale, red-brown; as above	0.3
Shale, greenish-gray, mottled very dark-red, silty	0.25
Shale, red-brown, mottled greenish-gray, silty	0.5
Shale, greenish-gray, silty, crinkly bedded; well-indurated at top; grading into impure gypsum	1.5
Nescatunga Gypsum Member:	
Gypsum, white, fine-crystalline, thinly laminated to banded; mottled red brown and greenish gray in upper 1 foot with ulexite and probertite in basal 1 foot; forming resistant ledge	5.0
Anhydrite, light-gray, fine-grained, fibrous, compact, well-indurated; grading into fine-grained gypsum; forming resistant white ledge	4.5
Gypsum, white, mottled greenish-gray, fine- to coarse-crystalline, porous, massive; leached locally, allowing the anhydrite to rest on a thin shale above the Magpie Dolomite, giving the appearance of anhydrite on dolomite	4.5
Magpie Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, well-indurated, porous, fossiliferous; thin bedded at top; massive at base; grading upward into gypsum; forming a massive ledge	0.7
Unnamed Units (Blaine):	
Shale, greenish-gray, mottled red-brown, silty	0.75
Shale, red-brown, silty; with many small yellowish-white gypsum nodules and selenite seams	0.75
Shale, red-brown, silty; with some greenish-gray layers	3.0
Shale, greenish-gray, silty, mottled red-brown	1.5
Shale, red-brown, silty, partly covered; probably including impure gypsum beds that are the equivalent of the Kingfisher Creek Gypsum	2.75
Shale, greenish-gray, silty	0.75
Shale, alternating red-brown and greenish-gray, silty, blocky	6.0
Medicine Lodge Gypsum Member:	
Gypsum, white, fine- to coarse-crystalline, banded; mottled red brown at top and greenish gray in middle and at base; wavy bedded at base; forming massive ledge	5.25
Cedar Springs Dolomite Bed:	
Dolomite*, greenish-gray, fine-crystalline, dense, porous, well-indurated; grading upward into gypsum; absent in many places	0.3
FLOWERPOT SHALE (exposed thickness, 65.8 feet)	
Unit K (Flowerpot):	
Shale, greenish-gray, mottled red-brown, silty	0.3

	Thickness (feet)
Unit J (Flowerpot):	
Shale, red-brown, silty; mottled greenish-gray in places	3.0
Shale, greenish-gray, well-indurated, silty	2.0
Shale, red-brown, well-indurated, silty	1.0
Shale, greenish-gray, mottled red-brown, silty	1.25
Unit I (Flowerpot):	
Hematite, very dark-red; altered to limonite in places	0.025
Gypsum and shale, greenish-gray, mottled red-brown, well-indurated; with much satin spar; forming a ledge	0.5
Shale, red-brown, silty; with many thin satin spar beds	2.5
Shale, red-brown, well-indurated; as above; forming ledge	0.5
Shale, red-brown, silty; as above	2.0
Gypsum and shale, greenish-gray; as above; forming a ledge	0.25
Shale, red-brown, silty; as above; with some thin greenish-gray shale seams at top	1.5
Gypsum and shale, greenish-gray; as above; forming a ledge	1.0
Units B-H (Flowerpot):	
Shale, red-brown, silty; with some greenish-gray beds and many satin spar layers; several nodular gypsum layers at base; marking base of extremely gypsiferous section	40.0
Unit A_3 (Flowerpot):	
Shale, red-brown, silty; with some greenish-gray shale layers and gypsum; exposed	10.0

SECTION 19. SALT CREEK
NORTH-CENTRAL BLAINE COUNTY, OKLAHOMA

Beginning at top in Dog Creek Shale in SW¼ sec. 27, T. 18 N., R. 12 W., proceeding downstream along south branch of Salt Creek into SE¼ sec. 27 to base of Blaine Formation, ending in SE¼ sec. 23, T. 18 N., R. 12 W., north side of Salt Creek canyon, for upper portion of Flowerpot Shale. Part of type area for Blaine Formation, Blaine County, Oklahoma.

DOG CREEK SHALE (top not exposed, exposed thickness, 113.4 feet)	
Shale, red-brown, well-indurated	2.0
Shale, greenish-gray, mottled red-brown, dolomitic, well-indurated	0.4
Shale, moderate red-brown, mottled greenish-gray; with a 2-inch very dark-red silty shale band 2 feet above base	4.5
Unit F_2 (Dog Creek):	
Shale, greenish-gray, mottled red-brown, dolomitic	0.5
Unnamed Units (Dog Creek):	
Shale, moderate red-brown, dolomitic	1.0
Shale, greenish-gray, dolomitic, dense, well-indurated, flaky	0.5
Unit F_1 (Dog Creek):	
Shale, brown to light-tan, mottled greenish-gray, well-indurated, blocky; with thin dolomite layers and concretions	9.0

	Thickness *(feet)*
Dolomite, light-gray to greenish-gray, argillaceous, fine-grained, dense, thin-bedded	0.5
Unnamed Units (Dog Creek):	
Shale, red-brown, well-indurated	0.75
Dolomite, greenish-gray, silty; brown at base; as above	0.5
Shale, red-brown, weakly indurated	2.0
Shale, greenish-gray, dolomitic	0.25
Shale, red-brown, mottled greenish-gray	2.5
Dolomite, greenish-gray, silty, gypsiferous, fine-grained, thin-bedded; with thin greenish-gray selenite layers and brownish gypsum nodules	1.0
Shale, red-brown; with much selenite	1.25
Unit E (Dog Creek):	
Dolomite; as above; with some red-brown shale laminae	1.0
Unnamed Units (Dog Creek):	
Shale, red-brown; with some selenite bands and a 2-inch greenish-gray shale band	3.0
Shale, greenish-gray, wavy bedded; with some selenite	0.5
Shale, brown, mottled greenish-gray, well-indurated, blocky	5.0
Unit C (Dog Creek):	
Dolomite, greenish-gray; with red-brown shale and selenite in middle and greenish-gray shale at base	1.0
Unnamed Unit (Dog Creek):	
Shale, brown, mottled greenish-gray, well-indurated, blocky; with red-brown and greenish-gray shale bands near base	3.0
Southard Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, silty, fine-grained, compact, medium-bedded to thinly laminated; with many small dark-black specks; eroding as a massive yellowish-gray ledge; forming a mappable escarpment	0.4
Unit B (Dog Creek):	
Shale, greenish-gray	0.25
Unnamed Units (Dog Creek):	
Shale, moderate red-brown, mottled greenish-gray, silty, dolomitic, selenitic; with 9-inch red-brown shale in middle	2.0
Shale, brown; with many thin satin spar layers and 4 or 5 greenish-gray shale seams 2 to 3 inches thick	21.0
Shale, greenish-gray	1.0
Shale, red-brown	4.0
Unit A (Dog Creek):	
Shale, greenish-gray, silty; with many thin greenish-gray and pink satin spar layers	1.0
Unnamed Units (Dog Creek):	
Shale, red-brown	5.0
Shale, greenish-gray, gypsiferous, silty; with some thin satin spar layers and a 6-inch red-brown shale seam about 3 inches above the base	3.0
Shale, red-brown; with many thin satin spar layers and veins	2.0
Shale, greenish-gray	0.25

	Thickness (feet)
Shale, dark red-brown to very dark-red, blocky	2.0
Watonga Dolomite Bed:	
Dolomite, light bluish-gray, fine-grained, dense, compact; with lenticular vuggy laminae; interbedded with light bluish-gray to moderate red-brown dolomitic shale; with thin satin spar layers at base; forming a prominent ledge	4.5
Dolomite; as above; overlain by a 1-foot light-brown siltstone bed	2.0
Haskew Bed:	
Siltstone, light-brown, gypsiferous, argillaceous, well-indurated, massive; with greenish-gray layers; with red-brown and greenish-gray shale spots and satin spar layers; eroding into a light-brown ledge	3.0
Unnamed Units (Dog Creek):	
Shale, red-brown, gypsiferous, silty, crinkly bedded; with many satin spar layers and two 3- to 6-inch greenish-gray shale beds	11.5
Shale and gypsum, greenish-gray, dolomitic, well-indurated, compact	0.75
Shale, red-brown, wavy bedded; with much satin spar and greenish-gray gypsiferous shale	9.5
BLAINE FORMATION (total thickness, 91.8 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine- to coarse-crystalline, massive, porous to dense; wavy bedded at top; weathering bright white; forming a mappable escarpment	15.0
Altona Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, fine-grained; oölitic at top; dense at base; with *Permophorus;* grading upward into gypsum; eroding into a gray to light-brown massive ledge	0.75
Unnamed Units (Blaine):	
Shale, greenish-gray	0.9
Shale, red-brown; with some thin satin spar layers	9.0
Shale, greenish-gray; with satin spar	1.0
Shale, red-brown, silty, blocky	5.0
Shale, greenish-gray, gypsiferous	1.0
Shale, red-brown; with greenish-gray shale streaks	10.5
Shale and gypsum, greenish-gray and red-brown, thin-bedded, crinkly bedded	1.0
Nescatunga Gypsum Member:	
Gypsum, white, fine-crystalline, dense, compact, massive to thin-bedded; mottled greenish-gray and pink at top; forming a prominent escarpment	4.5
Anhydrite, light-gray, compact, fine-crystalline, fibrous, massive; eroding into a prominent resistant bright-white ledge; locally termed Salt Creek Marble	9.5
Gypsum, white to gray, fine-crystalline, thin-banded	1.0

	Thickness (feet)
Magpie Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, fine-grained, well-indurated, massive, fossiliferous; oölitic at top; dense at base; grading into gypsum above; eroding into a gray to light-brown massive ledge	0.75
Unnamed Units (Blaine):	
Shale, red-brown; with 6-inch greenish-gray shale at top	5.0
Shale, alternating red-brown and greenish-gray; partly covered	7.0
Kingfisher Creek Gypsum Bed:	
Gypsum, greenish-gray, argillaceous, thick-bedded	1.5
Unnamed Unit (Blaine):	
Shale, alternating red-brown and greenish-gray; partly covered	13.0
Medicine Lodge Gypsum Member (type locality for Ferguson; same as Medicine Lodge Gypsum):	
Gypsum, white, fine- to coarse-crystalline, massive; mottled moderate red-brown to pale-pink at top and greenish-white at base; eroding as a pinkish-gray ledge; forming a mappable escarpment	5.25
Cedar Springs Dolomite Bed:	
Dolomite, light-gray, fine-grained, dense; absent in many places	0.1
FLOWERPOT SHALE (total thickness, 437 feet; upper portion only described)	
Units J-K (Flowerpot):	
Shale, greenish-gray, well-indurated	5.5
Unit I (Flowerpot):	
Hematite, very dark-red, well-indurated	0.01
Shale; red-brown at top; greenish-gray at base; gypsiferous, well-indurated; forming a prominent ledge	0.7
Shale, yellow-brown, limonitic, blocky; with many thin satin spar streaks	1.8
Gypsum, white, mottled pink, well-indurated; with hematite band at top and greenish-gray shale band at base; forming a resistant ledge	0.25
Shale, red-brown; with much satin spar	2.0
Shale, greenish-gray, gypsiferous, well-indurated, thin-bedded; with much satin spar; forming resistant ledge	1.0
Shale, red-brown, silty; speckled with small greenish-gray round spots; with some satin spar streaks	2.0
Shale, greenish-gray, gypsiferous, well-indurated, massive; with selenite streaks; forming ledge	0.25
Units B-H (Flowerpot):	
Shale, red-brown; as above	5.0
Shale, greenish-gray; as above; forming ledge	0.25
Shale, red-brown; as above	6.5
Shale, greenish-gray; as above; forming ledge	0.25

	Thickness (feet)
Shale, red-brown; as above	2.5
Shale, greenish-gray, gypsiferous; as above	0.75
Shale, red-brown, well-indurated; as above	4.0
Gypsum, yellowish-white, nodular, vuggy; interbedded with greenish-gray and red-brown shale	0.5
Shale, red-brown; as above	3.0
Gypsum, yellowish-white, nodular; as above	0.25
Shale, red-brown; as above	2.75
Gypsum, yellowish-white, nodular; as above	0.25
Shale, red-brown; as above	2.0
Gypsum, greenish-gray to white, nodular; interbedded with greenish-gray shale	0.4
Shale, red-brown; as above	1.75
Gypsum, greenish-gray to white, nodular; as above	0.25
Shale, red-brown; as above	2.5
Shale, greenish-gray, gypsiferous; as above; forming base of extremely gypsiferous section	0.25
Unit A_3 (Flowerpot):	
Shale, red-brown, silty; with many small greenish-gray spots and veins of greenish-gray shale; with some gypsums in upper 10 feet	39.0
Unit A_2 (Flowerpot):	
Siltstone, greenish-gray, mottled red-brown, dolomitic; weathering light brown; possibly a northward remnant of the Chickasha Tongue	1.5
Unit A_1 (Flowerpot):	
Shale, red-brown, mottled greenish-gray, silty; with dolomitic streaks	5.5
Shale, red-brown, mottled greenish-gray, dolomitic, well-indurated, blocky	0.7
Shale, red-brown, mottled greenish-gray, silty	3.0
Shale, red-brown, mottled greenish-gray, dolomitic, well-indurated	0.5
Shale, red-brown, silty	11.5
Siltstone, red-brown, mottled greenish-gray, dolomitic; with asymmetrical ripple marks that strike N 15 degrees E with steep side to southeast; cross-bedded with 15 degree dip in N55 degree W direction; being northward remnant of Chickasha Tongue	0.2
Shale, red-brown, silty; mottled with greenish-gray spots	3.0
Siltstone, greenish-gray, mottled red-brown, dolomitic; being northward remnant of Chickasha Tongue	3.0
Shale, red-brown; mottled greenish gray in places	11.0
Siltstone, greenish-gray, argillaceous, weakly indurated; being northward remnant of Chickasha Tongue	2.0
Shale, red-brown; mottled with some black and greenish-gray spots	7.0
Siltstone, greenish-gray, argillaceous, well-indurated, thin-bedded; being northward remnant of Chickasha Tongue	1.5

	Thickness (feet)
Shale, red-brown, silty, thin-bedded; with many small greenish-gray specks	11.0
Siltstone, greenish-gray, mottled moderate red-brown, dolomitic, argillaceous, thin-bedded; with symmetrical ripple marks that strike N 25 degrees E; being northward remnant of Chickasha Tongue	0.5
(Remainder of section measured in detail, but not here given)	

SECTION 20. HITCHCOCK
NORTH-CENTRAL BLAINE COUNTY, OKLAHOMA

Beginning at top in Dog Creek Shale, section measured in SE¼ sec. 11, T. 17 N., R. 12 W., south of road along creek and along section-line road, ending in Flowerpot Shale in bluff north of road in SE¼ sec. 6, T. 17 N., R. 11 W., west of Hitchcock, Blaine County, Oklahoma.

DOG CREEK SHALE (exposed thickness, 91.9 feet)	
Unit C (Dog Creek):	
Dolomite, light greenish-gray, silty, fine-grained, weakly indurated, thin-bedded	1.0
Unnamed Units (Dog Creek):	
Shale, red-brown, silty	2.0
Siltstone*, greenish-gray, dolomitic, argillaceous	1.5
Shale, red-brown, silty	0.25
Southard Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, well-indurated, thin-bedded; weathering light brown; forming massive ledge and mappable escarpment	0.3
Unit B (Dog Creek):	
Shale, greenish-gray, silty, flaky	0.2
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, thin-bedded, blocky; mottled with greenish-gray shale spots and streaks; with some satin spar	7.5
Shale, red-brown, silty; with some red-brown streaks	1.75
Shale, brown, blocky; with some greenish-gray streaks and many thin satin spar layers	9.5
Siltstone, greenish-gray; with many red-brown and greenish-gray satin spar layers and some dolomite nodules	1.75
Shale, red-brown, mottled greenish-gray, silty, flaky	1.75
Shale, greenish-gray, mottled light-brown, dolomitic, silty, blocky	1.0
Shale, red-brown, silty; with some greenish-gray spots and thin satin spar layers at top and bottom	4.25
Siltstone, greenish-gray, dolomitic, argillaceous; with some wavy bedded thin seams of satin spar and red-brown shale	1.0
Shale, red-brown, silty; with some thin satin spar layers	4.25
Unit A (Dog Creek):	

	Thickness (feet)
Siltstone, greenish-gray, argillaceous, dolomitic; with some satin spar and gypsum nodules	1.0
Unnamed Units (Dog Creek):	
Shale, red-brown, silty; with some greenish-gray shale and gypsum nodules	12.0
Shale, greenish-gray, dolomitic, blocky, well-indurated; with some satin spar	1.0
Shale, red-brown, silty; with some greenish-gray streaks	0.75
Watonga Dolomite Bed:	
Dolomite*, light bluish-gray, argillaceous, well-indurated, fine-grained, dense; forming resistant ledge	0.25
Shale, red-brown, silty	0.25
Siltstone, greenish-gray; with some thin satin spar layers	0.75
Shale, dark red-brown to very dark-red, silty; flaky at top; blocky at base	0.75
Siltstone*, light bluish-gray, argillaceous, dolomitic; with interbedded dolomite stringers that are fine grained, dense, vuggy, and thin bedded; forming an escarpment	1.5
Unnamed Units (Dog Creek):	
Shale, light-brown, silty; with some light bluish-gray shale streaks	1.5
Siltstone, greenish-gray, gypsiferous, argillaceous, well-indurated; with thin satin spar seams	1.0
Shale, red-brown, silty	1.0
Haskew Bed:	
Siltstone, light-brown, gypsiferous, argillaceous, well-indurated; with many thin satin spar layers; forming a resistant ledge	3.0
Unnamed Units (Dog Creek):	
Siltstone, greenish-gray, gypsiferous, argillaceous	0.5
Siltstone, red-brown, dolomitic; with much satin spar and some greenish-gray shale seams and spots	5.0
Siltstone, greenish-gray; as above	0.5
Shale, red-brown, silty, gypsiferous	2.0
Gypsum, pinkish-white, crinkly bedded; with satin spar	0.6
Shale, red-brown, silty; with much satin spar and many greenish-gray shale layers	2.25
Shale, greenish-gray, gypsiferous, silty, well-indurated; forming ledge	0.75
Shale, red-brown, silty, crinkly bedded; with some greenish-gray shale layers and much satin spar	17.5
BLAINE FORMATION (total thickness, 97.8 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine- to coarse-crystalline, banded; mottled greenish-gray at top; with a more indurated 6-inch anhydritelike layer near middle; forming resistant ledge	14.5
Altona Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, fossiliferous, vuggy; grading upward into gypsum;	

	Thickness (feet)
forming a massive ledge	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty, gypsiferous	2.0
Shale, greenish-gray, mottled red-brown, silty	0.25
Shale, red-brown, silty; with some greenish-gray shale streaks, selenite, gypsum nodules, and many thin satin spar layers	11.0
Shale, greenish-gray, silty; with some selenite	1.5
Shale, red-brown, silty; with some greenish-gray shale spots	2.5
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty; with some greenish-gray shale in middle	2.0
Shale, greenish-gray, silty	2.0
Shale red-brown, silty	2.0
Shale, greenish-gray, silty	5.0
Shale, red-brown, silty with many greenish-gray shale layers and much selenite and satin spar	4.0
Shale, greenish-gray, selenitic, silty, well-indurated; even bedded at base	2.0
Nescatunga Gypsum Member:	
Gypsum, white, fine-crystalline, thinly laminated, dense, compact; forming a massive white ledge with much coarse-crystalline selenite	5.0
Anhydrite, light-gray, fine-crystalline, fibrous, compact, well-indurated; with interbedded gypsum; eroding as a bright-white ledge	3.0
Gypsum, white, fine- to coarse-crystalline, porous, selenitic	4.5
Magpie Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, vuggy, fossiliferous; grading upward into gypsum; forming a resistant ledge	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty; with some greenish-gray shale streaks	6.0
Shale, greenish-gray, silty, gypsiferous	0.25
Shale, red-brown, silty	1.5
Shale, greenish-gray, gypsiferous	1.0
Shale, red-brown, silty	4.0
Kingfisher Creek Gypsum Bed:	
Gypsum, greenish-white, mottled pinkish-white, argillaceous, thin-bedded, crinkly bedded; forming small ledge	0.5
Shale, greenish-gray, mottled red-brown, gypsiferous	0.75
Gypsum, greenish-white; as above	0.75
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.75
Shale, red-brown, silty	2.0
Shale, greenish-gray, silty	0.5
Shale, greenish-gray, gypsiferous, crinkly bedded, well-indurated	0.25

	Thickness (feet)
Shale, red-brown, silty	5.0
Shale, greenish-gray, silty, gypsiferous	0.25
Shale, red-brown, silty	4.0
Shale, greenish-gray, silty, weakly indurated	0.25
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled moderate red-brown to pale-pink, fine- to coarse-crystalline, crinkly bedded, well-indurated, thin-bedded; greenish gray in middle; forming a massive ledge	5.5
Cedar Springs Dolomite Bed:	
Dolomite*, light-brown to greenish-gray, fine-crystalline; grading upward into gypsum; absent in many places	0.05
FLOWERPOT SHALE (exposed thickness, 54.3 feet)	
Units J-K (Flowerpot):	
Shale, dark red-brown; silty, selenitic, blocky; with some gypsum nodules; with greenish-gray shale at top and ¼-inch hematite band at base	5.25
Unit I (Flowerpot):	
Shale, greenish-gray, gypsiferous, well-indurated; with many thin satin spar beds; forming resistant ledge	1.0
Shale, red-brown, silty, gypsiferous; with many satin spar beds and some resistant greenish-gray shale layers	5.5
Dolomite*, light-gray to brown, fine-grained, vuggy, well-indurated; forming ledge	0.5
Units B-H (Flowerpot):	
Shale, red-brown, silty; with much satin spar	5.5
Shale, greenish-gray, silty, gypsiferous, well-indurated	0.5
Shale, red-brown, silty	8.0
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty; with some satin spar	5.0
Shale, red-brown, silty; with a band of greenish-gray gypsum nodules at top and bottom	0.75
Shale, red-brown, silty	5.0
Gypsum, greenish-gray, nodular; marking base of extremely gypsiferous section	0.5
Unit A_3 (Flowerpot):	
Shale, moderate red-brown, silty; mottled with 1- to 3-inch greenish-gray spots and veins of shale	6.5
Shale, greenish-gray, silty, selenitic; with some white gypsum nodules	0.5
Shale, red-brown, silty	4.0
Shale, greenish-gray, mottled red-brown, dolomitic; well-indurated at top; eroding into a light band	2.25
Shale, red-brown, silty, exposed	3.0

SECTION 21. ROMAN NOSE STATE PARK
CENTRAL BLAINE COUNTY, OKLAHOMA

Beginning at top in Dog Creek Shale, section measured along Cat

Creek canyon in north-central part of sec. 30, T. 17 N., R. 11 W., extending into SW¼ sec. 19, T. 17 N., R. 11 W., then Roman Nose Park in NE¼ sec. 24, T. 17 N., R. 12 W., for Blaine portion, ending in NW¼ sec. 19, NW¼ sec. 16, and SW¼ sec. 9, T. 17 N., R. 11 W., for remainder of Blaine Formation and upper portion of Flowerpot Shale, Blaine County, Oklahoma.

	Thickness *(feet)*
DOG CREEK SHALE (exposed thickness, 91.8 feet)	
Shale, red-brown, mottled greenish-gray, silty	1.0
Shale, dark red-brown, silty; with greenish-gray streaks at top and base	0.5
Shale, red-brown, silty	1.0
Unit C (Dog Creek):	
Dolomite, light-gray, fine-grained, well-indurated, dense, thin-bedded; forming a ledge	0.25
Unnamed Units (Dog Creek):	
Shale, greenish-gray, silty	1.0
Shale, moderate red-brown, silty, blocky	1.5
Shale, greenish-gray, silty	0.7
Shale, red-brown, silty	0.6
Southard Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, silty, fine-crystalline, compact; with small black specks; forming a massive ledge	0.25
Unit B (Dog Creek):	
Shale, greenish-gray, silty	0.25
Unnamed Units (Dog Creek):	
Shale, red-brown, silty; with greenish-gray spots	4.0
Shale, greenish-gray, silty	0.5
Shale, moderate red-brown, silty, blocky; with some greenish-gray shale spots	1.75
Shale, greenish-gray, silty	1.0
Shale, moderate red-brown, silty; becoming dark red-brown at base	1.0
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty; with 3-inch to 1-foot greenish-gray spots	10.5
Shale, greenish-gray, silty; with many thin satin spar layers and white gypsum nodules	2.0
Shale, red-brown, silty	7.25
Shale, greenish-gray, silty, platy; with some thin satin spar beds at top; becoming indurated and dolomitic at base	2.25
Shale, red-brown, silty; with many thin satin spar layers and selenite veins	3.5
Unit A (Dog Creek):	
Shale, greenish-gray, silty; with much satin spar and yellowish-white nodular gypsum	0.75
Unnamed Units (Dog Creek):	
Shale, moderate red-brown, silty; with satin spar and gyp-	

	Thickness (feet)
sum nodules in middle and selenite toward base	5.5
Shale, greenish-gray, silty	0.75
Shale, red-brown, silty; mottled with some greenish-gray spots; with yellowish-white gypsum nodules in middle	3.5
Shale, greenish-gray, silty	0.2
Shale, red-brown, silty	0.2
Gypsum, yellowish-white and greenish-gray, nodular	0.2
Shale, moderate red-brown, mottled greenish-gray, silty; with many gypsum nodules; as above	2.0
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty; with some 2- to 6-inch greenish-gray spots	3.0
Watonga Dolomite Bed:	
Dolomite, light bluish-gray, fine-grained, dense, well-indurated, blocky; with some shale; forming ledge	0.2
Shale, dark red-brown to very dark-red, blocky	0.7
Dolomite, light bluish-gray, thin-bedded, platy; as above	0.5
Shale, red-brown, silty	0.5
Shale, greenish-gray, silty	0.5
Shale, dark red-brown to very dark-red, blocky	1.0
Siltstone*, light bluish-gray, dolomitic, thin-bedded; with interbedded shale and thin dolomite layers; forming a ledge	1.5
Dolomite, light bluish-gray, massive; as above	0.25
Unnamed Units (Dog Creek):	
Siltstone, light-brown, mottled greenish-gray, argillaceous	0.3
Siltstone, light-brown, gypsiferous, argillaceous; with some thin dark greenish-gray gypsum layers	1.25
Shale, greenish-gray, gypsiferous, well-indurated; forming ledge	0.75
Siltstone, greenish-gray, argillaceous	0.2
Satin spar, greenish-gray	0.2
Shale, red-brown, silty	0.2
Haskew Bed:	
Siltstone, light-brown, gypsiferous, argillaceous, well-indurated	0.25
Siltstone, light-brown, gypsiferous, argillaceous, well-indurated; with much satin spar and many gypsum nodules; forming ledge	3.6
Unnamed Units (Dog Creek):	
Shale, red-brown, silty; with much satin spar	1.0
Siltstone, light-brown; as above	0.5
Shale, greenish-gray, silty, platy; with a 1-inch satin spar seam near base	0.5
Shale, red-brown, silty; with small greenish-gray shale spots and thin layers; with much satin spar	2.6
Shale, greenish-gray, silty, gypsiferous, crinkly bedded	0.5
Satin spar, pinkish-white	0.4
Shale, greenish-gray, gypsiferous; as above	0.3

	Thickness (feet)
Shale, red-brown, silty; with much selenite and many satin spar veins	1.25
Shale, greenish-gray; as above; with 2-inch satin spar bed at top	0.5
Shale, red-brown, silty; with a 3-inch satin spar seam at base	2.0
Shale, greenish-gray, silty; with some gypsum nodules	0.25
Shale, red-brown, silty; with some satin spar	1.0
Shale, greenish-gray, silty, gypsiferous, thin-bedded	0.2
Shale, red-brown, mottled greenish-gray, silty	1.7
Shale, greenish-gray, gypsiferous, silty, crinkly bedded	0.5
Shale, red-brown, silty; with a 1-inch greenish-gray band in middle	1.2
Shale, dark greenish-gray, gypsiferous, well-indurated, crinkly bedded	0.5
Shale, red-brown, silty; with many 2- to 3-inch satin spar beds	1.5
Shale, red-brown, silty, gypsiferous, crinkly bedded to wavy bedded; with much satin spar; becoming dark greenish gray at base	2.75
Shale, red-brown, silty; with much satin spar	2.0
Shale, greenish-gray, gypsiferous, silty, crinkly bedded to wavy bedded; with much satin spar and many gypsum nodules	1.0
BLAINE FORMATION (total thickness, 92.4 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine- to coarse-crystalline, porous, massive; with a 3- to 9-inch anhydrite about 6 feet below top; forming a prominent ledge	12.0
Altona Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, fossiliferous; with *Permophorus* molds and symmetrical ripple marks that strike N 75 deegrees W; forming a massive ledge	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty	2.0
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty	10.5
Shale, greenish-gray, silty	0.3
Shale, red-brown; with greenish-gray streaks and spots	4.5
Shale, greenish-gray, silty; with some selenite veins and beds	3.0
Shale, red-brown, silty	5.0
Shale, greenish-gray, silty	1.5
Shale, red-brown, silty; with much selenite and yellowish-white gypsum nodules in middle	2.25
Shale, greenish-gray, gypsiferous, well-indurated, platy	0.3
Shale, greenish-gray, silty; mottled with small brown spots	0.8
Shale, red-brown, silty	0.75

	Thickness (feet)
Shale, greenish-gray, gypsiferous, well-indurated	0.25
Shale, greenish-gray, silty	0.2
Shale, red-brown, selenitic: becoming even bedded and greenish gray at base	1.5
Nescatunga Gypsum Member:	
Gypsum, white, fine-crystalline, dense, compact, thinly laminated; mottled greenish gray and moderate red brown at top; forming ledge and mappable escarpment	6.0
Anhydrite, light-gray, fibrous, compact, fine-crystalline; eroding into a massive resistant bright-white pitted ledge	4.0
Gypsum, white, coarse-crystalline, selenitic, compact, massive	3.0
Magpie Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, well-indurated, porous, fossiliferous; forming a massive ledge	1.2
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.2
Shale, red-brown, silty; with some greenish-gray spots and vertical selenite veins	5.75
Shale, greenish-gray, mottled moderate red-brown, silty; selenitic at base	0.75
Shale, greenish-gray, silty; mottled with brown shale spots	0.5
Shale, red-brown, silty	2.0
Kingfisher Creek Gypsum Bed:	
Gypsum, greenish-white, argillaceous, laminated, well-indurated, fine-crystalline; forming a ledge	0.4
Gypsum, pinkish-white, argillaceous, banded; forming ledge	0.2
Shale, greenish-gray, silty	0.5
Gypsum, very dark-red, hematitic, argillaceous, well-indurated, platy	0.025
Shale, red-brown, silty	0.25
Gypsum, very dark-red; as above	0.025
Gypsum, greenish-white, mottled red-brown, well-indurated, fine-crystalline, selenitic; forming ledge	1.25
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.2
Shale, red-brown, silty; with some thin seams of satin spar and selenite	2.0
Shale, greenish-gray, silty; with some satin spar and reddish-brown shale	0.7
Shale, red-brown, silty; with some thin satin spar layers	2.0
Shale, greenish-gray, silty	0.3
Shale, red-brown, silty	4.0
Shale, greenish-gray, silty; with brown dolomitic shale at base	0.5
Shale, red-brown, silty	1.5
Shale, greenish-gray, silty	0.2
Shale, red-brown, silty	1.5
Shale, red-brown; with red-brown gypsum nodules	0.1

	Thickness (feet)
Shale, red-brown, silty; mottled with small greenish-gray spots	0.25
Medicine Lodge Gypsum Member:	
Gypsum, white to pinkish-white, fine- to coarse-crystalline, selenitic, massive; mottled greenish-white in lower 2 feet; forming pinkish ledge and mappable escarpment	6.0
Cedar Springs Dolomite Bed:	
Dolomite, mottled red-brown and greenish-gray, fine-crystalline, porous, well-indurated, thin-bedded; grading upward into gypsum; absent in many places	0.2
FLOWERPOT SHALE (exposed thickness, 138.2 feet)	
Units J-K (Flowerpot):	
Shale; greenish-gray at top; red-brown below; silty	3.5
Shale, dark red-brown to very dark-red, flaky	0.5
Unit I (Flowerpot):	
Shale, greenish-gray, gypsiferous, well-indurated, crinkly bedded; with much satin spar; forming ledge	0.75
Shale, red-brown, silty, well-indurated; with many thin satin spar veins and layers	2.5
Shale, greenish-gray, gypsiferous; with some 1-inch satin spar layers	0.5
Shale, red-brown, silty	4.0
Shale, greenish-gray, gypsiferous; forming a ledge	0.1
Dolomite, greenish-gray, fine-crystalline, dense, compact, vuggy; with greenish-colored mineral resembling malachite; forming a ledge	0.5
Units B-H (Flowerpot):	
Shale, red-brown, silty; with many small greenish-gray spots	4.0
Shale, greenish-gray, gypsiferous, well-indurated	0.25
Shale, red-brown, silty	1.25
Shale, greenish-gray, gypsiferous	0.25
Shale, red-brown, silty; with some 1-inch greenish-gray spots and many selenite veins and layers	11.75
Shale, greenish-gray, mottled red-brown, dolomitic	0.2
Shale, red-brown, silty	0.75
Gypsum, yellowish-green, nodular; with selenite, in red-brown shale	1.0
Shale, red-brown, silty	3.5
Shale, greenish-gray, gypsiferous, silty; with gypsum nodules	0.5
Shale, red-brown, silty	0.8
Siltstone, greenish-gray, argillaceous, weakly indurated	0.25
Shale, red-brown, silty	1.5
Gypsum, nodular; as above	0.5
Shale, red-brown, silty	6.25
Gypsum, pinkish-white, argillaceous, nodular; marking base of extremely gypsiferous section	1.0
Unit A_3 (Flowerpot):	
Shale, red-brown, silty	17.0

	Thickness (feet)
Shale, red-brown, dolomitic, well-indurated, blocky	0.25
Shale, moderate red-brown, silty	3.0
Shale, greenish-gray, mottled moderate red-brown, silty	0.8
Shale, moderate red-brown, silty	9.0
Shale, greenish-gray and red-brown, silty	1.0
Shale, moderate red-brown, silty	1.5
Shale, greenish-gray, dolomitic, well-indurated, crinkly bedded	0.025
Shale, moderate red-brown; with some mud cracks 1 foot above base	5.25
Unit A_2 (Flowerpot):	
Siltstone, greenish-gray, argillaceous, dolomitic, cross-bedded; with 18 degree dip in N 40 degree W direction on cross-beds; representing a northward remnant of the Chickasha Tongue	0.7
Unit A_1 (Flowerpot):	
Shale, red-brown, silty	10.75
Siltstone, greenish-gray, argillaceous, dolomitic, thin-bedded; mottled with moderate red-brown spots; cross-bedded with 20 degree dip in N 85 degree W direction on cross-bedding; representing a northward remnant of the Chickasha Tongue	2.0
Shale, red-brown, silty	3.0
Siltstone, greenish-gray, mottled moderate red-brown, dolomitic, thin-bedded, wavy bedded, flaky	0.5
Shale, red-brown, silty; mottled with many small greenish-gray spots	2.0
Siltstone, greenish-gray, flaky; as above; being a northward remnant of a Chickasha tongue	0.25
Shale, red-brown, silty	15.0
Siltstone, greenish-gray, weakly indurated; containing a vertical vein of cross-bedded dolomitic siltstone striking N 85 degrees W, with a dip of 22 degrees on the cross-beds in the same direction as the strike of the vein; being a northward remnant of a Chickasha tongue	1.5
Shale, red-brown, silty	5.25
Siltstone, mottled greenish-gray and red-brown, argillaceous, weakly indurated; being a northward remnant of a Chickasha tongue	2.0
Shale, moderate red-brown, silty, blocky; with greenish-gray shale streaks and spots	3.0
Siltstone, greenish-gray, mottled moderate red-brown, argillaceous, well-indurated, blocky; being a northward remnant of a Chickasha tongue	0.75
Shale, moderate red-brown, silty	4.0
Siltstone, greenish-gray, mottled moderate red-brown, argillaceous, well-indurated, blocky; being a northward remnant of a Chickasha tongue	0.6
Shale, red-brown, silty; exposed	3.0

Thickness
(feet)

The next 112 feet of section below comprises red-brown shale with interbedded cross-bedded siltstones and mudstone conglomerates of the Chickasha Tongue. Below this are even-bedded red-brown shales of the lower part of the Flowerpot Shale to the base. The total thickness of the Flowerpot Shale, including the middle Chickasha Tongue, is approximately 465 feet.

SECTION 22. BUCHER
CENTRAL BLAINE COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured west of Watonga in S½ NE¼ sec. 20, T. 16 N., R. 12 W., extending 54 feet into the Dog Creek Shale. Section covered for next 56 feet and then extrapolated to area along stream and State Highway 8 near Bucher Siding, beginning at top in Dog Creek Shale in NW¼ sec. 33, continuing into NE¼ sec. 33, NW¼ sec. 34, NE¼ sec. 34, ending in the Flowerpot Shale in NE¼ sec. 27, T. 17 N., R. 11 W. The section is then extrapolated to NW¼ sec. 26, T. 17 N., R. 10 W., including the upper part of the Chickasha Tongue, Blaine County, Oklahoma.

MARLOW FORMATION (top not exposed)

Sandstone, red-brown to moderate reddish-orange, fine-grained, quartzose, calcareous, weakly to well-indurated; with some medium-size well-rounded frosted grains; speckled with many small greenish-gray spots 5.0

Sandstone, dolomitic, crinkly bedded, slabby; as above 0.3

Sandstone; as above; speckled with many greenish-gray spots 1.2

Sandstone*, light greenish-gray, quartzose, fine-grained; mottled with moderate red-brown spots; well indurated in places; with many medium- to coarse-size well-rounded frosted white grains; crinkly bedded at base; weathering as a prominent light-colored band 2.5

DOG CREEK SHALE (total thickness, approximately 183 feet; exposed at top 54.4 feet; covered 56 feet; exposed at base 73 feet)

Shale, red-brown, well-indurated; with some lenticular greenish-gray beds and many 2- to 3-inch greenish-gray shale spots 28.0

Shale, red-brown; as above; with some thin- to medium-bedded greenish-gray dolomitic shale layers at top and greenish-gray shale layers at base 10.0

Siltstone, greenish-gray, argillaceous, vuggy; dolomitic at top; weathering as a light-colored band 0.75

Siltstone, speckled greenish-gray and red-brown, argillaceous, weakly indurated, platy 0.7

Shale, dark-brown, silty, weakly indurated, platy 0.25

	Thickness (feet)
Siltstone, platy; speckled as above; with ripple marks in middle	0.5
Shale, red-brown, silty	7.75
Siltstone, well-indurated; speckled as above	0.3
Shale, moderate red-brown and greenish-gray, silty, weakly indurated, massive	0.9
Siltstone, greenish-gray, argillaceous, weakly indurated, crinkly bedded, thin-bedded	0.25
Shale, red-brown, silty, well-indurated; exposed	5.0
Covered by North Canadian River alluvium and Pleistocene deposits, approximately	56.0
Shale, dark red-brown, silty; section extrapolated to NW¼ sec. 33, T. 17 N., R. 11 W.	6.25
Shale, moderate red-brown, silty; with some greenish-gray beds	2.0
Shale, greenish-gray, blocky	0.25
Shale, dark red-brown, silty, well-indurated; with a 6-inch greenish-gray layer 2 feet above base	7.0
Siltstone, greenish-gray, mottled moderate red-brown, argillaceous, weakly indurated, blocky	1.75
Shale, dark red-brown, silty	3.0
Dolomite, mottled red-brown and gray, argillaceous, blocky, well-indurated; weathering light gray	0.1
Shale, dark red-brown, silty	5.5
Siltstone, greenish-gray, argillaceous, blocky; with a thin red-brown shale streak near middle and several thin dolomite beds near base	2.0
Shale, dark red-brown, silty	3.5
Shale, greenish-gray, flaky	0.25
Shale, dark red-brown, silty	0.2
Shale, greenish-gray, argillaceous, blocky	0.25
Shale, red-brown, silty	5.25
Shale, greenish-gray, dolomitic, well-indurated	0.5
Shale, red-brown, silty; with a 1-inch greenish-gray dolomitic shale 1 foot above base	4.0
Shale, mottled greenish-gray and red-brown, dolomitic, well-indurated, blocky	1.25
Shale, red-brown, silty	2.0
Watonga Dolomite Bed:	
Dolomite, light bluish-gray, argillaceous, well-indurated, fine-grained, compact, blocky, thin- to medium-bedded; forming a prominent bluish-gray ledge	0.75
Shale, light bluish-gray, dolomitic, argillaceous, well-indurated, blocky	0.25
Shale, moderate red-brown, dolomitic, argillaceous, blocky	0.5
Shale, light bluish-gray; as above	0.25
Dolomite, light bluish-gray, thin- to medium-bedded; as above	0.6
Shale, light bluish-gray, mottled moderate red-brown, dolomitic	3.5

	Thickness *(feet)*
Dolomite*, light bluish-gray, silty, argillaceous; thin-bedded, well-indurated, dense; alternating with light bluish-gray shale layers	1.1
Haskew Bed:	
Siltstone, light-brown, mottled greenish-gray, gypsiferous, argillaceous; crinkly bedded at top	4.5
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, platy	1.5
Shale, red-brown, silty, crinkly bedded; with some greenish-gray layers and much satin spar	15.0
BLAINE FORMATION (total thickness, 102.3 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine- to coarse-crystalline, porous, massive, leached; eroding into a massive ledge of coarse selenite crystals; forming a mappable escarpment	14.0
Altona Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, thin-bedded; oölitic at top; with *Permophorus;* eroding into a massive ledge; forming a mappable escarpment	1.25
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated	0.25
Shale, red-brown, silty	2.0
Shale, greenish-gray, silty	0.25
Shale, red-brown, blocky	3.5
Shale, greenish-gray, blocky	0.6
Shale, red-brown; with some greenish-gray shale streaks and 1-inch satin spar layers	5.75
Shale, greenish-gray, blocky	0.5
Shale, red-brown, silty	6.0
Shale, greenish-gray, blocky	1.0
Shale, red-brown, blocky; with many thin satin spar veins and layers and a 1-foot greenish-gray shale, mottled red-brown, 2 feet above base	11.0
Shale, greenish-gray, gypsiferous, weakly indurated	0.5
Shale, red-brown, blocky	0.5
Shale, greenish-gray, gypsiferous; with some well-indurated satin spar	0.8
Shale, red-brown, well-indurated	0.75
Shale, greenish-gray, gypsiferous, blocky	0.3
Shale, red-brown, mottled greenish-gray, blocky	0.2
Satin spar, pinkish-white, crinkly bedded	0.2
Shale, red-brown; with some satin spar	1.5
Shale, greenish-gray, gypsiferous; with thin satin spar beds	0.3
Shale, red-brown and greenish-gray; with gypsum nodules	0.75
Nescatunga Gypsum Member:	
Gypsum, white, medium- to fine-grained, laminated to coarsely banded, compact; forming ledge and mappable escarpment	4.0

	Thickness (feet)
Anhydrite, light-gray, compact, fibrous; interbedded with well-indurated gypsum; weathering bright white; forming a resistant ledge	6.0
Gypsum, white; as above	5.0
Magpie Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, thin- to medium-bedded; dense with salt casts near base; oölitic with *Permophorus* at top; grading upward into gypsum; eroding into a massive resistant ledge	2.0
Unnamed Units (Blaine):	
Shale, greenish-gray; with red-brown shale seam near top	0.3
Shale, red-brown; with some 1- to 6-inch greenish-gray shale layers in basal 4 feet	11.5
Shale, greenish-gray, flaky	1.2
Shale, red-brown, silty	0.25
Shale, greenish-gray, silty	0.5
Kingfisher Creek Gypsum Bed:	
Gypsum, white to greenish-gray, fine-grained, laminated, well-indurated, wavy bedded	1.2
Unnamed Units (Blaine):	
Shale, greenish-gray, gypsiferous, well-indurated, wavy bedded	0.2
Shale, red-brown and greenish-gray, alternating layers, blocky, weakly indurated	3.0
Shale, red-brown, silty; with many small greenish-gray spots	5.0
Shale, greenish-gray, silty	1.0
Dolomite*, greenish-gray, silty, well-indurated, thin-bedded, crinkly bedded	0.25
Shale, red-brown; with many small gypsum nodules and paper-thin selenite layers; and with 3- to 4-inch layers and spots of greenish-gray shale	6.75
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled moderate red-brown to pale-pink, fine- to coarse-grained, porous, well-indurated; forming a ledge	2.0
Cedar Springs Dolomite Bed:	
Dolomite*, red-brown, ferruginous, well-indurated; with bright-green stains of a mineral, probably malachite	0.2
FLOWERPOT SHALE (total thickness, 465 feet, with middle 115 feet assigned to Chickasha Tongue; section given here only to top of Chickasha Tongue)	
Units J-K (Flowerpot):	
Shale, red-brown, silty; greenish-gray at top; with thin veins of greenish-gray gypsiferous shale	6.5
Shale, greenish-gray, mottled moderate red-brown, silty	0.25
Shale, dark red-brown to very dark-red, flaky	1.0
Unit I (Flowerpot):	
Shale, greenish-gray, gypsiferous, well-indurated, crinkly bedded; with thin satin spar layers; forming ledge	0.9

	Thickness (feet)
Shale, moderate red-brown, silty; with many thin satin spar layers	2.0
Dolomite*, greenish-gray, gypsiferous; with malachite stains	0.25
Shale, moderate red-brown, gypsiferous; as above	5.0
Units B-H (Flowerpot):	
Shale, greenish-gray; with some thin satin spar seams	1.0
Shale, red-brown, silty; with some thin satin spar seams	0.5
Shale, greenish-gray, gypsiferous, silty	0.2
Shale, red-brown; as above; with some greenish-gray spots	0.3
Shale, red-brown, silty; with some thin light-brown silty shale veins	4.0
Shale, greenish-gray; as above	0.2
Shale, moderate red-brown, silty	1.5
Shale, greenish-gray; as above	0.2
Shale, moderate red-brown, silty	9.0
Gypsum, yellowish-green, nodular	0.25
Shale, moderate red-brown, silty	5.0
Shale, light-brown, dolomitic, argillaceous, dense, well-indurated, blocky	0.3
Shale, red-brown, silty	1.0
Siltstone, light greenish-gray, argillaceous, quartzose, moderately to weakly indurated; mottled with small moderate red-brown spots; weathering as a prominent light-colored band	1.0
Shale, red-brown, silty	5.0
Shale, greenish-gray, mottled red-brown; with alternating interbedded thin siltstones	1.0
Shale, red-brown, silty	4.2
Gypsum, greenish-gray, nodular	0.2
Shale, red-brown, silty; with some dolomitic streaks	5.0
Shale, greenish-gray, gypsiferous; with some pink gypsum nodules and satin spar layers	0.5
Shale, red-brown, silty	0.5
Shale, greenish-gray, gypsiferous; as above; marking base of extremely gypsiferous section	0.5
Unit A_3 (Flowerpot):	
Shale, red-brown, silty; exposed	5.0
Shale, red-brown, silty; with many thin light greenish-gray siltstones and portions of Chickasha conglomerate in the lower 30 feet; covered in part; section extrapolated to NW¼ sec. 26, T. 17 N., R. 10 W.	97.0
Chickasha Tongue:	
Mudstone conglomerate, moderate red-brown, silty, well-indurated; with some light greenish-gray shale layers; cross-bedded at top; with interbedded shale, siltstone, and fine-grained sandstone; forming a mappable ledge	15.0

Section measured in detail but not here given.

SECTION 23. WATONGA
CENTRAL BLAINE COUNTY, OKLAHOMA

Beginning at top in Dog Creek Shale, section measured along State Highway 33 in SW¼ sec. 24, T. 16 N., R. 11 W., continuing east into SW¼ sec. 19, NE¼ sec. 30, SW¼ sec. 20, ending in Flowerpot Shale in NE¼ SE¼ sec. 20, T. 16 N., R. 10 W., including type section for Blaine Formation, Watonga Dolomite, Altona Dolomite, Magpie Dolomite, and Kingfisher Creek Gypsum Beds, about 7 miles east of Watonga, Blaine County, Oklahoma.

	Thickness *(feet)*
DOG CREEK SHALE (exposed thickness, 71.5 feet)	
Shale, red-brown, silty; with small greenish-gray spots	4.0
Shale, red-brown, silty, platy	0.5
Shale, red-brown, silty; with many small greenish-gray spots and thin veins of greenish-gray shale	5.5
Shale, greenish-gray, well-indurated; silty near top	0.6
Shale, red-brown; as above	5.25
Shale, greenish-gray, silty	0.25
Shale, red-brown; as above	3.25
Shale, greenish-gray, dolomitic, well-indurated	0.3
Shale, red-brown; as above	8.0
Shale, greenish-gray, dolomitic, well-indurated	0.75
Shale, red-brown, dolomitic, well-indurated	2.0
Dolomite, light-gray, argillaceous, fine-grained, well-indurated, dense, massive, blocky; eroding blocky	0.2
Shale, red-brown, silty	1.0
Dolomite, moderate red-brown, mottled greenish-gray, argillaceous, fine-grained, dense, well-indurated, thin-bedded; forming a ledge	0.6
Shale, greenish-gray and red-brown, silty	0.6
Shale, greenish-gray, dolomitic	0.25
Shale, dark red-brown, platy	0.3
Shale, greenish-gray, dolomitic	0.25
Shale, dark red-brown, mottled greenish-gray, silty	1.0
Shale, greenish-gray; with a few thin dolomite layers	1.0
Watonga Dolomite Bed (type section):	
Dolomite*, light bluish-gray, silty, argillaceous, well-indurated, fine-grained, dense, compact, thin-bedded, platy; eroding into a prominent ledge	0.3
Shale, light bluish-gray, dolomitic, blocky	1.0
Shale; as above; with moderate red-orange band at top; with many thin dolomite beds	1.25
Siltstone, light bluish-gray to greenish-gray, argillaceous, dolomitic	0.6
Shale, light bluish-gray, argillaceous, platy	0.25
Dolomite, light bluish-gray; as above; with small vugs	0.2

	Thickness *(feet)*
Shale, light bluish-gray, mottled dark red-brown, platy	0.75
Dolomite, light bluish-gray; as above	0.25
Shale, greenish-gray, mottled red-brown, dolomitic, silty, platy	0.6
Shale, greenish-gray, gypsiferous; with interbedded thin dolomite and some satin spar	0.9
Unnamed Unit (Dog Creek):	
Shale, greenish-gray, mottled red-brown, gypsiferous; silty near base; with many small gypsum nodules and some satin spar	1.2
Haskew Bed:	
Siltstone, light-brown, gypsiferous, massive, well-indurated; with many small gypsum nodules and satin spar layers; forming a prominent mappable escarpment	3.0
Unnamed Units (Dog Creek):	
Shale, red-brown, silty, well-indurated; with many thin satin spar seams	1.5
Siltstone, greenish-gray, gypsiferous, argillaceous, well-indurated	0.2
Siltstone, red-brown, gypsiferous, argillaceous, well-indurated	0.25
Siltstone, greenish-gray; as above	0.25
Shale, red-brown, silty; with some thin satin spar layers	2.25
Shale, alternating red-brown and greenish-gray; with many thin satin spar layers	3.0
Shale, red-brown, silty; with many small greenish-gray spots	1.5
Shale, greenish-gray, platy	0.5
Satin spar, pinkish-white, crinkly bedded	0.5
Shale, greenish-gray, silty	0.2
Shale, red-brown, silty	0.7
Shale, greenish-gray, gypsiferous, well-indurated, crinkly bedded, thin-bedded; with many thin satin spar beds	1.6
Shale, red-brown, silty; with small greenish-gray shale spots	1.5
Shale, greenish-gray, gypsiferous; as above	0.25
Satin spar; as above	0.2
Shale, red-brown; as above	0.75
Shale, greenish-gray, silty, blocky	0.2
Shale, red-brown; as above	0.6
Shale, greenish-gray; as above	0.2
Shale, red-brown; as above	0.75
Shale, greenish-gray, gypsiferous; with many thin satin spar layers	0.6
Shale, moderate red-brown, silty, blocky	0.9
Satin spar; as above	0.4
Shale, moderate red-brown, silty, gypsiferous	0.8
Shale, greenish-gray, mottled red-brown, gypsiferous, well- to weakly indurated, crinkly bedded; with many thin satin spar layers	6.0

	Thickness (feet)
BLAINE FORMATION (type section, total thickness, 93.8 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine- to coarse-grained, massive, porous; with a 1-foot bed of alabasterlike gypsum in middle; eroding into a prominent white coarsely selenitic ledge	12.0
Altona Dolomite Bed (type section):	
Dolomite*, light-gray to yellowish-gray, well-indurated, fine-grained, thin-bedded, porous, fossiliferous; dense at top and base; oölitic in middle; grading upward into gypsum	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	1.1
Shale, red-brown, silty; with some vertical veins and thin layers of satin spar and some greenish-gray shale streaks	13.0
Shale, greenish-gray, silty, well-indurated	1.75
Shale, red-brown, well-indurated; with some thin satin spar layers	4.0
Shale, greenish-gray, gypsiferous, silty, well-indurated	0.6
Shale, red-brown, silty; with some 2- to 3-inch greenish-gray spots and many thin satin spar veins	8.0
Shale, greenish-gray, mottled red-brown, silty	0.3
Shale, red-brown, silty	2.25
Shale, greenish-gray, silty, gypsiferous; with much satin spar	0.7
Shale, red-brown, silty	0.4
Shale, greenish-gray, gypsiferous; with interbedded red-brown shale beds	1.7
Shale, greenish-gray, silty; with thin satin spar layers	0.8
Shale, red-brown, silty	0.25
Shale, greenish-gray, gypsiferous, wavy bedded; well-indurated in places; with some satin spar	1.0
Shale, red-brown, gypsiferous; well-indurated at base; with some greenish-gray layers	0.3
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, laminated to banded, dense; mottled greenish gray at top; forming a ledge	2.0
Alabaster, light-gray, fibrous, compact, fine-grained; eroding into a bright-white resistant ledge	1.25
Gypsum, mottled gray; as above	3.0
Gypsum, mottled pinkish-white; as above	1.0
Gypsum, mottled gray; as above	2.5
Magpie Dolomite Bed (type section):	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, fossiliferous; dense at base with bright-green mineral, probably malachite; oölitic above; grading upward into gypsum; with ripple marks that strike N 55 degrees W; eroding into a resistant ledge	1.5
Unnamed Units (Blaine):	
Shale, greenish-gray, silty, platy	0.2

	Thickness (feet)
Shale, red-brown, silty; with many small greenish-gray spots	6.0
Shale, alternating red-brown and greenish-gray, silty	0.75
Shale, red-brown; as above; with some small gypsum nodules and many thin satin spar veins and layers	3.5
Shale, greenish-gray, silty; with alternating red-brown shale beds	0.5
Shale, red-brown, silty	1.0
Shale, greenish-gray, silty; alternating with red-brown shale beds	0.25
Shale, red-brown, silty	2.0
Shale, greenish-gray, silty; with much gypsum	0.3
Kingfisher Creek Gypsum Bed (type section):	
Gypsum, white to greenish-gray, argillaceous, well-indurated; eroding as a prominent resistant ledge	2.0
Unnamed Units (Blaine):	
Shale*, greenish-gray, gypsiferous, silty, well-indurated	0.3
Shale, red-brown, silty; with some selenite veins	6.0
Shale, greenish-gray, silty	0.3
Shale, red-brown, silty	0.25
Shale, greenish-gray, silty	0.25
Shale, red-brown, silty	0.25
Shale, greenish-gray, mottled red-brown, silty	0.2
Shale, red-brown, silty	3.0
Shale, greenish-gray, silty; with some small yellowish-green gypsum nodules	0.1
Shale, red-brown, silty	1.5
Shale, alternating red-brown and greenish-gray; with thin satin spar beds and small yellowish-green gypsum nodules	0.5
Shale, red-brown, silty	2.0
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled pale pink, fine- to coarse-grained, porous; eroding into resistant selenitic ledge	4.0
Cedar Springs Dolomite Bed:	
Dolomite*, olive to reddish-brown, porous, fine-grained, well-indurated; grading upward into gypsum; weathering red-brown	0.2
FLOWERPOT SHALE (exposed thickness, 107 feet)	
Units J-K (Flowerpot):	
Shale, red-brown; greenish-gray at top; with many thin veins and small spots of greenish-gray shale	4.25
Shale, dark red-brown, argillaceous, flaky; with several thin greenish-gray gypsiferous shale beds	1.5
Unit I (Flowerpot):	
Dolomite*, greenish-gray, gypsiferous, crinkly bedded; forming a resistant ledge	0.7
Shale, red-brown; with many thin satin spar beds	2.0
Gypsum and shale, greenish-gray, thin-bedded, well-indurated, crinkly bedded; forming a resistant ledge	0.25

	Thickness (feet)
Shale, red-brown; as above	5.0
Gypsum and shale, greenish-gray; as above; forming a ledge	0.9
Units B-H (Flowerpot):	
Shale, red-brown, silty; with much nodular gypsum	7.0
Shale, greenish-gray, gypsiferous, silty	0.6
Shale, red-brown, silty	4.0
Shale, mottled greenish-gray and red-brown, silty, dolomitic	0.3
Shale, red-brown, silty; with satin spar	2.0
Shale, greenish-gray, gypsiferous; with white gypsum nodules; forming a ledge	0.7
Shale, red-brown; as above	3.5
Shale, greenish-gray; as above	0.2
Shale, red-brown, dolomitic; as above	1.0
Shale, greenish-gray; as above; with bluish-gray gypsum nodules	0.2
Shale, red-brown; as above	5.0
Shale, greenish-gray; with 3-inch red-brown dolomitic shale with mud cracks in upper part and gypsum nodules in lower part	1.0
Shale, moderate red-brown, silty; with satin spar	4.5
Gypsum, white, nodular, well-indurated; forming ledge	0.4
Shale, greenish-gray, dolomitic, well-indurated, dense; forming a ledge	0.2
Shale, red-brown, dolomitic, well-indurated; forming a resistant ledge	3.5
Gypsum, greenish-gray, nodular, well-indurated; in gypsiferous shale; forming ledge; marking base of extremely gypsiferous section	1.0
Unit A_3 (Flowerpot):	
Shale, red-brown, silty	6.5
Siltstone, greenish-gray, mottled moderate red-brown, argillaceous, flaky	0.6
Shale, moderate red-brown, silty	3.5
Siltstone, moderate red-brown, mottled greenish-gray, thin-bedded, cross-bedded, with 23 degrees dip in N 30 degree E direction on cross-beds	1.0
Siltstone, greenish-gray, mottled moderate red-brown, cross-bedded; same as above	0.5
Shale, red-brown, silty	2.5
Shale, mottled greenish-gray and red-brown, silty, thin-bedded; with some nodular gypsum	0.7
Shale, red-brown, silty, partly covered	9.0
Shale, mottled greenish-gray and red-brown, silty; section extrapolated to SE¼ sec. 20, T. 16 N., R. 10 W.	2.0
Shale, mottled greenish-gray and red-brown, dolomitic, well-indurated, thin-bedded, lenticular, blocky; eroding into a resistant ledge	1.0
Shale, red-brown, silty	3.0

	Thickness (feet)
Shale, greenish-gray, silty; mottled with some moderate red-brown spots	0.5
Shale, red-brown, silty; with some small greenish-gray spots and a 2-inch well-indurated dolomitic shale, 2 feet above the base	7.0
Shale, greenish-gray, dolomitic, well-indurated, thin-bedded	0.25
Shale, red-brown, silty; with a 2-inch greenish-gray shale streak in middle	3.75
Shale, mottled greenish-gray and red-brown, silty, blocky	1.0
Shale, red-brown, silty	1.0
Unit A_2 (Flowerpot):	
Siltstone, greenish-gray, mottled moderate red-brown, cross-bedded; with 14 degree dip in N 75 degree W direction on cross-beds; being a northward remnant of the Chickasha Tongue	1.5
Unit A_1 (Flowerpot):	
Shale, red-brown, silty	0.8
Gypsum, white, mottled pinkish-white, nodular, flattened	0.2
Shale, red-brown, silty; mottled with some small greenish-gray spots	5.0
Siltstone, greenish-gray, argillaceous, weakly indurated	0.3
Shale, red-brown, silty, exposed	1.0

SECTION 24. GREENFIELD-ALTONA
SOUTHEASTERN BLAINE COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured in high hill northwest of Greenfield in NW¼ sec. 29, T. 15 N., R. 11 W., extending 76 feet down in the Dog Creek Shale. Section then extrapolated to NW¼ sec. 4, T. 14 N., R. 11 W., south of Greenfield, for next 35 feet including the Southard Dolomite, partly covered. The North Canadian River deposits cover approximately 10 feet of section of the Dog Creek Shale. The section is then extrapolated to NE¼ sec. 22, T. 15 N., R. 10 W., along creek and road between secs. 14 and 15 for lower 75 feet of Dog Creek Shale, continuing into NE¼ sec. 14 for Blaine Formation, ending in SE¼ sec. 11, T. 15 N., R. 10 W., for Flowerpot Shale section, a few miles west of Altona, southeastern Blaine County, Oklahoma.

MARLOW FORMATION (total thickness, 112 feet; only lower part described)	
Sandstone*, light greenish-gray, silty, calcareous, quartzose, fine-grained; with many medium- to coarse-size grains, well-rounded to subrounded, frosted, white, weakly cemented; well-indurated in middle 9 inches	4.25
DOG CREEK SHALE (total thickness, approximately 195 feet)	
Shale*, dark red-brown, well-indurated, blocky; mottled with some 1- to 2-inch greenish-gray spots	14.75

	Thickness (feet)
Shale, dark-brown, well-indurated, blocky; with a 1-inch greenish-gray layer at top, and one at base	0.75
Shale, red-brown; as above	37.75
Unit F_2 (Dog Creek):	
Siltstone, greenish-gray, arenaceous, weakly indurated, massive	2.5
Unnamed Units (Dog Creek):	
Shale, red-brown; as above	2.0
Shale, greenish-gray, weakly indurated	0.75
Shale, red-brown; as above	2.0
Shale, red-brown, dolomitic, nodular; as above	0.2
Shale, red-brown; as above	3.0
Unit F_1 (Dog Creek):	
Siltstone, light greenish-gray, argillaceous; with some fine-grained quartzose sandstone	2.5
Unnamed Units (Dog Creek):	
Shale, red-brown, well-indurated; exposed	10.0
Shale, red-brown, covered; as above; section extrapolated to NW¼ sec. 4, T. 14 N., R. 11 W.	24.0
Southard Dolomite Bed:	
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, well-indurated, medium-bedded; forming ledge	0.3
Unit B (Dog Creek):	
Shale, greenish-gray, silty	0.3
Unnamed Units (Dog Creek):	
Shale, red-brown, silty; exposed	10.0
Shale, red-brown, covered; as above; section extrapolated to NE¼ sec. 22, between secs. 14 and 15, NE¼ sec. 14, and SE¼ sec. 11, T. 15 N., R. 10 W.	10.0
Shale, red-brown, silty; with some 1- to 2-inch greenish-gray spots	2.0
Shale, red-brown, platy; as above; with some thin calcite beds	0.2
Shale, red-brown, silty	3.0
Shale, red-brown; as above; with thin calcite layers	0.8
Shale, red-brown, silty	0.8
Shale, greenish-gray, silty; with a 3-inch red-brown band in middle	0.8
Shale, red-brown, silty	1.2
Shale, red-brown, silty, well-indurated, platy	1.7
Shale, red-brown, silty	1.5
Shale, greenish-gray, silty	0.2
Shale, red-brown, silty; speckled with small greenish-gray spots	7.0
Dolomite, light-gray, fine-grained, dense, well-indurated, massive	0.3
Shale, red-brown, silty, dolomitic, well-indurated, blocky	0.8
Shale, red-brown, indurated; as above	0.25
Shale, red-brown, silty	0.2

	Thickness (feet)
Shale, greenish-gray, silty	0.1
Shale, red-brown, silty, dolomitic; mottled light-brown to greenish-gray in middle	1.0
Shale, greenish-gray, dolomitic; mottled with moderate red-brown spots	0.2
Shale, dark red-brown, mottled very dark-red, dolomitic, blocky	0.2
Shale, red-brown, silty	1.5
Shale, red-brown, silty; with 1- to 2-inch greenish-gray spots	0.5
Shale, red-brown, silty	0.5
Shale, greenish-gray and red-brown, silty	0.5
Shale, red-brown, silty	3.25
Shale, mottled greenish-gray and very dark-red, blocky	1.0
Shale, dark red-brown, mottled very dark-red, blocky; with a 1-inch greenish-gray shale layer at top, one in middle, and one at the base	1.0
Watonga Dolomite Bed:	
Dolomite*, light bluish-gray, fine-grained, dense, well-indurated, vuggy, wavy bedded, thin-bedded; with black dendrites and some shale streaks; eroding into a resistant ledge	0.3
Dolomite, argillaceous, nodular; as above	0.2
Shale, dark red-brown to very dark-red, weakly indurated	0.2
Dolomite, argillaceous, nodular; as above	0.2
Shale, dark red-brown; as above	0.1
Dolomite, light bluish-gray, mottled very dark-red, thin-bedded	0.25
Shale, light bluish-gray, dolomitic, silty	0.5
Shale, dark red-brown, mottled very dark-red, silty, dolomitic, well-indurated	1.7
Siltstone, moderate red-brown, argillaceous, vuggy, massive; with some small greenish-gray spots	1.5
Shale, light bluish-gray, dolomitic, thin-bedded, platy	0.3
Dolomite, light bluish-gray, argillaceous, fine-grained	0.25
Siltstone, light bluish-gray, dolomitic, well-indurated, thin-bedded	0.2
Dolomite, light bluish-gray, silty, wavy bedded, thin-bedded; with interbedded shale	0.2
Haskew Bed:	
Siltstone, light-brown; mottled with small greenish-gray shale streaks; massive at top; thin-bedded at base; eroding as a resistant ledge	2.5
Unnamed Units (Dog Creek):	
Shale, red-brown; with some thin satin spar layers	4.5
Siltstone, greenish-gray, argillaceous, dolomitic, well-indurated, blocky; grading into gypsiferous shale at base	0.25
Shale, red-brown, silty; with small greenish-gray spots	0.6
Shale, greenish-gray and red-brown, silty, blocky	0.3
Shale, red-brown, silty; with small greenish-gray spots and	

	Thickness (feet)
many thin satin spar veins and layers	4.6
Shale, greenish-gray, gypsiferous, silty, well-indurated; with much satin spar	0.3
Shale, red-brown, silty; mottled with many small greenish-gray spots; with many thin satin spar layers; partly covered	2.5
Gypsum, mottled pinkish-white and greenish-gray; with some interbedded shale; forming a resistant ledge	0.6
Shale, red-brown, silty; with some thin satin spar seams	0.9
Shale, dark red-brown, mottled very dark-red; with greenish-gray gypsiferous shale streaks	1.0
Shale, red-brown, silty; with many thin satin spar layers	3.0
Shale, greenish-gray and red-brown, gypsiferous, nodular	0.2
Shale, red-brown, silty; with thin satin spar layers	1.5
Shale, greenish-gray, gypsiferous, well-indurated	0.25
Shale, red-brown, silty	0.6
Shale, greenish-gray; as above	0.1
Shale, red-brown, silty; with much satin spar	0.5
Shale, greenish-gray, gypsiferous, well-indurated, wavy bedded, mottled red-brown; with many thin satin spar layers	1.2
Shale, red-brown, silty, wavy bedded; with much satin spar	3.0
Shale, greenish-gray, gypsiferous, well-indurated, wavy bedded; with much satin spar	2.0
Shale, red-brown, silty; with much satin spar	5.25
Shale, greenish-gray, gypsiferous, well-indurated	0.6
Shale, red-brown; as above	1.8
Shale, moderate red-brown, mottled greenish-gray, gypsiferous, silty, weakly indurated	0.5
Siltstone, moderate red-brown, mottled greenish-gray, argillaceous	0.5
BLAINE FORMATION (total thickness, 90.9 feet)	
Shimer Gypsum Member:	
Gypsum, white, coarse-grained, wavy bedded; interbedded at top with red-brown shale	2.0
Gypsum, white, mottled pinkish-white and greenish-white, coarse-grained, laminated, wavy bedded; forming a ledge	4.5
Siltstone, gray, mottled red-brown, argillaceous, well-indurated, wavy bedded; grading upward into gypsum	0.25
Altona Dolomite Bed:	
Shale, greenish-gray, dolomitic, finely laminated, even-bedded, well-indurated, platy; with some gypsum	1.0
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, thin-bedded; with many *Permophorus,* resembling a coquina, with symmetrical ripple marks that strike west; weathering into a massive ledge	0.75
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.75

	Thickness (feet)
Shale, red-brown, silty	1.2
Shale, greenish-gray, silty	0.2
Shale, greenish-gray, dolomitic, well-indurated, lenticular	0.2
Shale, red-brown, silty; with some 1- to 2-inch greenish-gray streaks and spots	11.3
Shale, greenish-gray, silty	0.5
Shale, red-brown, silty	5.5
Shale, greenish-gray, silty; with some lenticular red-brown shale	0.5
Shale, red-brown, silty	15.75
Nescatunga Gypsum Member:	
Gypsum, white, mottled red-brown, coarse-grained	1.0
Gypsum, white, fine-grained, mottled greenish-gray, wavy bedded; weathering bright white	2.0
Gypsum, white, mottled red-brown and greenish-gray, coarsely crystalline, wavy bedded	4.25
Magpie Dolomite Bed:	
Shale, greenish-gray, dolomitic, well-indurated, thin-bedded, platy	0.2
Dolomite*, light-gray to yellowish-gray, fine-grained, dense, oölitic, thin- to medium-bedded; with some *Permophorus* and green stains resembling malachite in lower portion; eroding as a massive ledge	1.75
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.75
Shale, red-brown, silty	4.0
Shale, greenish-gray, gypsiferous; with some thin satin spar layers	0.6
Shale, red-brown, silty	0.25
Shale, greenish-gray; as above	0.1
Shale, red-brown, silty	0.2
Shale, greenish-gray; as above; with many small red-brown spots	0.4
Shale, red-brown, silty; with some small greenish-gray spots	5.25
Shale, greenish-gray, gypsiferous, silty; with some satin spar	0.2
Shale, red-brown, silty, partly covered	4.0
Kingfisher Creek Gypsum Bed:	
Gypsum, white, mottled greenish-gray, fine-grained, well-indurated; eroding into a ledge; forming a mappable escarpment	0.75
Gypsum, greenish-white, fine-grained, well-indurated, crinkly bedded; mottled with moderate red-brown streaks; forming a ledge	0.8
Gypsum, greenish-gray, argillaceous, dolomitic, fine-grained, medium-bedded, wavy bedded; forming a ledge	0.4
Unnamed Units (Blaine):	
Shale, greenish-gray, silty	0.1
Shale, moderate red-brown, silty; with some thin satin spar layers and many small greenish-gray spots	2.5

	Thickness (feet)
Shale, mottled greenish-gray and red-brown, silty, blocky	3.75
Shale, greenish-gray, gypsiferous, well-indurated; forming a ledge	0.2
Shale, red-brown, silty	0.2
Shale, greenish-gray; as above; with many white gypsum nodules	0.25
Shale, red-brown, silty	2.8
Gypsum, white, nodular	0.2
Shale, red-brown, silty; becoming greenish-gray with gypsum nodules at base	5.0
Medicine Lodge Gypsum Member:	
Gypsum, pinkish-white, mottled greenish-white, coarse-grained, selenitic; eroding into a ledge	4.5
Cedar Springs Dolomite Bed:	
Dolomite*, pinkish-gray, fine-grained, dense, wavy bedded, nodular; with many bright-green stains of a mineral resembling malachite; grading upward into gypsum	0.1
FLOWERPOT SHALE (exposed thickness, 71.2 feet)	
Units J-K (Flowerpot):	
Shale, dark red-brown, blocky; greenish-gray at top; mottled very dark-red below	3.0
Gypsum, white, mottled greenish-gray, argillaceous, well-indurated, wavy bedded; forming a ledge	0.25
Shale, red-brown, silty; with some greenish-gray spots and streaks	1.5
Shale, greenish-gray, silty, gypsiferous; with some red-brown shale	0.25
Unit I (Flowerpot):	
Shale, greenish-gray, silty, gypsiferous, thin-bedded, wavy bedded, well-indurated; forming a ledge	0.3
Shale, greenish-gray, mottled red-brown, gypsiferous; forming a ledge	0.2
Shale, red-brown, silty; with many thin satin spar layers and veins	1.75
Shale, greenish-gray, gypsiferous; with some red-brown shale	4.75
Shale, greenish-gray, gypsiferous, well-indurated	0.3
Units B-H (Flowerpot):	
Shale, red-brown, silty; with some small greenish-gray spots and white gypsum nodules and many paper-thin satin spar beds	10.0
Shale, greenish-gray, gypsiferous, silty; well-indurated near base	1.0
Shale, red-brown, silty; dolomitic near top	4.5
Gypsum, white, nodular, wavy bedded; forming a ledge	0.25
Shale, red-brown, silty	1.5
Shale, greenish-gray, gypsiferous; well-indurated in upper part	0.4
Shale, red-brown, silty	4.0

	Thickness (feet)
Gypsum, pinkish-white, nodular	0.25
Shale, red-brown, silty	2.0
Gypsum, white to pinkish-white, nodular; in selenitic shale	0.5
Shale, red-brown, silty	1.25
Gypsum; as above	0.1
Shale, red-brown, silty	0.75
Siltstone, greenish-gray, argillaceous, weakly indurated	0.2
Shale, red-brown, silty	0.25
Gypsum, white to orange-white, nodular	0.2
Shale, red-brown, silty, dolomitic, well-indurated, blocky; with some small greenish-gray spots	3.0
Shale, mottled red-brown and greenish-gray, silty	0.75
Shale, red-brown, silty	2.75
Gypsum, white, mottled pink, nodular	0.1
Shale, red-brown, silty	0.75
Gypsum; as above	0.2
Shale, red-brown, silty; with thin gypsiferous band in middle	2.0
Gypsum, white, mottled greenish-gray and moderate red-brown	0.2
Shale, red-brown, silty	3.25
Gypsum, white, mottled red-brown, nodular	0.3
Shale, red-brown, silty	2.0
Shale, greenish-gray, silty; with small gypsum nodules	0.25
Shale, red-brown, silty	4.25
Gypsum, pinkish-white, nodular; marking base of extremely gypsiferous section	0.1
Unit A_3 (Flowerpot):	
Shale, red-brown, silty	0.75
Siltstone, greenish-gray, argillaceous, platy; with a few small white gypsum nodules and some selenite	0.6
Shale, red-brown, silty, well-indurated	3.0
Siltstone, mottled greenish-gray and red-brown, argillaceous, cross-bedded; being a northward remnant of the Chickasha Tongue	4.0
Shale, red-brown, silty, exposed	3.0

SECTION 25. DEAD INDIAN CREEK
NORTHWESTERN CANADIAN COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured south of U. S. Highway 66, in NW¼ sec. 5, T. 12 N., R. 10 W., extending into upper 30 feet of Dog Creek Shale. Section covered next 100 feet by North Canadian River deposits, then extrapolated to road cut between secs. 15 and 16, T. 14 N., R. 9 W., for lower 60 feet of Dog Creek Shale, ending in Flowerpot Shale in SW¼ SW¼ SE¼ sec. 2, T. 14 N., R. 9 W., in new quarry north of road.

	Thickness *(feet)*
MARLOW FORMATION (only base described)	
Sandstone*, greenish-gray, fine-grained, quartzose, weakly indurated; grading into a siltstone	0.4
DOG CREEK SHALE (total thickness, approximately 197 feet; top 30 feet exposed, middle 111 feet covered, lower 56 feet exposed)	
Shale, red-brown, silty, blocky	30.0
Shale, red-brown, covered; as above; section extrapolated to road cut between secs. 15 and 16, T. 14 N., R. 9 W.	111.0
Dolomite*, moderate red-brown to pink, fine-grained, dense, well-indurated; forming mappable ledge	0.1
Shale, red-brown, silty	3.0
Dolomite*, greenish-gray, fine-grained, dense, well-indurated; forming a mappable ledge	0.1
Shale, greenish-gray, blocky	0.5
Shale, red-brown, blocky; with a 6-inch greenish-gray shale layer in middle	5.0
Watonga Dolomite Bed:	
Dolomite*, light-brown, fine-grained, well-indurated; forming a mappable ledge	0.2
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky; mostly covered	47.0
BLAINE FORMATION (total thickness, 83 feet)	
Altona Dolomite Bed:	
Dolomite*, light-gray, fine-grained, oölitic, thin- to medium-bedded; extremely fossiliferous with many *Permophorus*; forming a mappable escarpment	0.75
Unnamed Unit (Blaine):	
Shale, red-brown, silty, blocky; covered	39.0
Magpie Dolomite Bed:	
Dolomite, light-brown, crinkly bedded, vuggy, deeply weathered	0.3
Dolomite*, greenish-gray to gray, dense, oölitic; thin-bedded at top; massive at base; with no fossils observed; forming a mappable escarpment	0.9
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated	0.2
Shale, red-brown, silty, weakly indurated	8.25
Siltstone, greenish-gray, mottled moderate reddish-orange, argillaceous, weakly indurated	1.0
Siltstone, greenish-gray, argillaceous, weakly indurated	0.2
Shale, red-brown; as above	6.75
Siltstone, greenish-gray; as above	0.25
Shale, red-brown; as above; with many small greenish-gray spots	3.0
Siltstone, greenish-gray, discontinuous; as above; probably representing a leached remnant of the Kingfisher Creek Gypsum Bed	0.1
Shale*, red-brown, silty, blocky; with greenish-gray spots	17.75

	Thickness (feet)
Medicine Lodge Gypsum Member:	
Gypsum, pinkish-white, fine- to coarse-grained, massive, nodular and selenitic; argillaceous at top; eroding as a mappable ledge	4.0
Cedar Springs Dolomite Bed:	
Dolomite*, greenish-gray, argillaceous, nodular, massive, fine-grained, porous	0.25
FLOWERPOT SHALE (exposed thickness, 4 feet)	
Units J-K (Flowerpot):	
Shale, red-brown, silty, blocky; exposed	4.0

SECTION 26. OKARCHE
NORTHWESTERN CANADIAN COUNTY, OKLAHOMA

Beginning at top in Dog Creek Shale, section measured along creek in NW¼ sec. 29, T. 14 N., R. 8 W., continuing in SW¼ sec. 20 and NW¼ sec. 20, T. 14 N., R. 8 W., for Blaine portion, ending in Flowerpot Shale in creek just east of road in SW¼ sec. 17, T. 14 N., R. 8 W., about 7 miles southwest of Okarche, Canadian County, Oklahoma.

DOG CREEK SHALE (exposed thickness, approximately 97 feet)	
Shale, red-brown, silty, blocky; mottled with greenish-gray spots	11.0
Siltstone, greenish-gray, mottled moderate reddish-orange, argillaceous, blocky	0.3
Shale, red-brown, silty, blocky	5.5
Siltstone, greenish-gray, argillaceous, weakly indurated, blocky	0.25
Shale, red-brown, silty, blocky	23.5
Dolomite*, pink to greenish-gray, argillaceous, fine-grained, blocky; forming a mappable ledge	0.2
Shale, red-brown, silty, platy	3.0
Siltstone*, moderate reddish-orange, dolomitic, well-indurated	0.1
Siltstone, moderate reddish-orange, argillaceous, weakly indurated	0.75
Siltstone, greenish-gray, dolomitic, indurated	0.1
Shale, red-brown, silty, blocky	0.2
Dolomite*, pink, fine-grained, crinkly bedded, vuggy, well-indurated; forming a mappable ledge	0.5
Shale, red-brown, blocky	3.0
Watonga Dolomite Bed:	
Dolomite*, mottled greenish-gray and red-brown, silty, fine-grained, well-indurated	0.5
Unnamed Units (Dog Creek):	

	Thickness (feet)
Shale*, red-brown, silty, blocky	21.0
Dolomite*, greenish-gray, fine-grained, well-indurated, blocky to nodular	0.1
Gypsum, white, mottled red-brown, argillaceous, silty; forming a massive ledge and a mappable escarpment	1.75
Shale, red-brown, silty, blocky	12.0
Dolomite*, greenish-gray, fine-grained, well-indurated	0.2
Shale, red-brown, silty, blocky	13.0
BLAINE FORMATION (total thickness, approximately 85 feet)	
Altona Dolomite Bed:	
Dolomite*, light-brown to light-gray, fine-grained, oölitic, thin- to medium-bedded, blocky; extremely fossiliferous with many *Permophorus;* eroding vuggy	0.6
Unnamed Units (Blaine):	
Shale, greenish-gray, weakly indurated, blocky	0.25
Shale, red-brown, silty, weakly indurated, blocky	4.0
Siltstone, greenish-gray, argillaceous, weakly indurated, massive	1.0
Shale, red-brown, silty, blocky; with some greenish-gray spots	8.5
Gypsum, greenish-white, nodular, crinkly bedded; with some thin satin spar layers; forming a discontinuous band	0.2
Shale, red-brown, silty, blocky	24.0
Nescatunga Gypsum Member:	
Gypsum, greenish-gray, argillaceous, selenitic	0.1
Gypsum, white, mottled red-brown, nodular; interbedded with red-brown shale and satin spar	3.0
Magpie Dolomite Bed:	
Siltstone*, greenish-gray, dolomitic, gypsiferous; with lenses of dolomite nodules	0.5
Unnamed Unit (Blaine):	
Shale, red-brown, silty, blocky	15.75
Kingfisher Creek Gypsum Bed:	
Gypsum, white, mottled pink, selenitic, argillaceous; with indurated greenish-gray band at top; forming a mappable escarpment	1.0
Unnamed Unit (Blaine):	
Shale, red-brown, silty, blocky	20.5
Medicine Lodge Gypsum Member:	
Gypsum, pinkish-white to red-brown, nodular; interbedded with red-brown shale; forming weakly defined escarpment; being southernmost area of outcrop of basal Blaine	4.0
FLOWERPOT SHALE (exposed thickness, 10 feet)	
Units I-K (Flowerpot):	
Shale*, red-brown, silty, blocky; exposed	10.0

SECTION 27. CONCHO
CENTRAL CANADIAN COUNTY, OKLAHOMA

Beginning at top in Blaine Formation in NW¼ NW¼ sec. 1, T. 13 N., R. 8 W., outcrop along road, section measured down to the shale above the Magpie Dolomite. Section then extrapolated to U. S. Highway 81, middle of section line between secs. 15 and 16, T. 13 N., R. 7 W., ending in Flowerpot Shale, east of Concho (Indian School), Canadian County, Oklahoma.

	Thickness (feet)
BLAINE FORMATION (total thickness, approximately 84 feet)	
Altona Dolomite Bed:	
Dolomite*, greenish-gray to light-brown, dense, oölitic; thin-bedded at top; massive at base; extremely fossiliferous with many *Permophorus;* forming a mappable escarpment	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, silty, weakly indurated	0.1
Shale, red-brown, silty, weakly indurated, blocky	2.0
Siltstone, greenish-gray, weakly indurated, massive; grading as stringers into shale northwestward	3.0
Shale, red-brown, well-indurated, blocky; with some medium-bedded greenish-gray shale layers near top	18.0
Siltstone, greenish-gray; as above	0.75
Shale, red-brown, as above; partly covered	17.0
Magpie Dolomite Bed:	
Siltstone, greenish-gray, mottled red-brown, argillaceous, dolomitic, gypsiferous, moderately indurated; weathering greenish gray; section extrapolated to U. S. Highway 81, between secs. 15 and 16, T. 13 N., R. 7 W.	0.6
Unnamed Units (Blaine):	
Shale, red-brown; as above	0.5
Siltstone, greenish-gray, weakly indurated, lenticular, massive; with some red-brown shale stringers	2.0
Shale, red-brown, silty, blocky	13.0
Dolomite*, light-gray, well-indurated, blocky; grading into paper-thin pink shale at base; forming a small ledge that occurs several feet above the Kingfisher Creek Gypsum Bed about 1 mile northwestward	0.1
Shale, very dark-red, well-indurated, blocky	0.9
Shale, greenish-gray, mottled moderate reddish-orange, weakly indurated, blocky; weathering greenish-gray	0.3
Shale, red-brown, silty, blocky	4.75
Siltstone, pink, dolomitic, well-indurated, blocky; mottled with many small greenish-gray spots	0.2
Shale, red-brown, silty, blocky	1.25
Dolomite*, greenish-gray, mottled moderate reddish-orange, argillaceous, well-indurated; forming a prominent ledge	0.25
Shale, greenish-gray, weakly indurated, blocky	0.25

	Thickness (feet)
Shale, red-brown, well-indurated, blocky	2.5
Siltstone*, greenish-gray, argillaceous, well-indurated, blocky; mottled red brown at top	0.5
Shale, red-brown, silty, blocky	13.0
Medicine Lodge Gypsum Member:	
Siltstone, greenish-gray, argillaceous, thin-bedded, cross-bedded, weakly indurated; grading downward into mudstone conglomerate of the Chickasha Tongue	3.0
CHICKASHA FORMATION (exposed thickness, 4 feet)	
Mudstone conglomerate, red-brown, mottled greenish-gray, silty, well-indurated, cross-bedded; forming a ledge in places; exposed	4.0

SECTION 28. MINCO
NORTHERN GRADY COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured along road in NW¼ NW¼ sec. 11 and stream near center of section line between secs. 11 and 14, T. 9 N., R. 7 W., ending in lower part of Dog Creek Shale in SW¼ SE¼ NE¼ sec. 22 and Blaine-Chickasha complex in NW¼ NE¼ SE¼ sec. 22, T. 9 N., R. 7 W., including the type section of the Pocasset Gypsum, south of Minco and north of Pocasset, Grady County, Oklahoma.

MARLOW FORMATION (top not exposed)	
Siltstone* moderate reddish-orange, argillaceous, weakly indurated, crinkly bedded; with some thin satin spar layers; becoming greenish-gray in basal portion; containing some fine-grained conglomerate composed of chert granules	2.0
DOG CREEK SHALE (total thickness, approximately 167 feet)	
Shale*, red-brown, blocky, weakly indurated; mottled with some greenish-gray round spots and layers; partly covered	26.3
Shale, greenish-gray, weakly indurated, blocky	0.5
Shale, red-brown; as above; with many greenish-gray shale beds; covered in part	14.0
Shale, greenish-gray, weakly indurated, blocky	0.05
Shale, red-brown, mottled very dark-red, weakly indurated, platy	0.75
Shale, greenish-gray; as above	0.05
Siltstone, moderate reddish-orange, argillaceous, weakly indurated, massive	1.0
Shale, greenish-gray; as above	0.05
Shale, very dark-red, weakly indurated, platy	1.0
Shale, greenish-gray, wavy bedded; with many gypsum	

	Thickness (feet)
nodules	0.2
Shale, very dark-red, weakly indurated, platy; with gypsum nodules at top, thin greenish-gray shale beds in middle, and well-indurated red-brown to olive-green dolomitic mudstone at base	3.0
Siltstone, moderate reddish-orange, arenaceous, quartzose, well-indurated, massive; with lenticular thin-bedded cross-bedded sandstone layers with dip in N 35 degree W direction; forming a massive escarpment	4.0
Siltstone, greenish-gray, weakly indurated, thin-bedded	0.4
Shale, red-brown, well-indurated, blocky; with many greenish-gray and moderate reddish-orange siltstone layers; together with above two units being a northward remnant of the Chickasha Tongue	8.25
Shale, greenish-gray, silty, weakly indurated, blocky	0.4
Shale, red-brown, blocky; with well-indurated moderate reddish-orange siltstone near top; mottled with greenish-gray specks	2.75
Gypsum, white, mottled red-brown, nodular	0.25
Shale, red-brown; as above	0.75
Shale, olive-green, silty, weakly indurated, platy	0.1
Shale, red-brown; as above	1.0
Siltstone*; red-brown at top; greenish-gray at base; argillaceous, dolomitic, thin-bedded, crinkly bedded	0.4
Siltstone, light-brown, argillaceous, weakly indurated, thin-bedded; together with next lower 10 feet being a northward tongue of the Chickasha Formation	0.6
Siltstone, red-brown, argillaceous, weakly indurated, thin-bedded, cross-bedded; with interbedded lenticular mudstone conglomerate	3.0
Siltstone, greenish-gray, argillaceous, weakly indurated, thin-bedded	0.4
Shale, red-brown, well-indurated, blocky; as above	1.0
Siltstone, greenish-gray; as above	0.7
Shale, red-brown, silty; as above	1.0
Siltstone, greenish-gray, lenticular; as above	0.6
Shale, red-brown; as above	0.8
Siltstone, greenish-gray, argillaceous; as above	0.2
Shale, very dark-red to red-brown, weakly indurated, blocky, mottled moderate reddish-orange; with some 2- to 3-inch white gypsum nodules	21.0
Sandstone, mottled red-brown and greenish-gray, even-bedded, thin-bedded, medium-grained, quartzose, well-indurated; with subrounded to subangular grains	0.75
Shale, red-brown, well-indurated, blocky; as above	1.2
Gypsum, white, mottled moderate reddish-orange, wavy bedded, nodular; with some satin spar	0.25
Shale, red-brown to very dark-red; as above	3.0
Shale, greenish-gray, weakly indurated, silty; as above	0.5

	Thickness (feet)
Shale*, red-brown; as above; with many thick lenticular massive cross-bedded lenses of moderate reddish-orange siltstone, thin olive-green shale beds and satin spar layers, and small gypsum nodules; being a northward remnant of the Chickasha Formation	21.0
Shale, greenish-gray; as above	0.7
Shale, red-brown, platy; as above	2.0
Shale, olive-green, silty, weakly indurated, blocky	0.5
Shale, red-brown, silty, platy; as above	0.75
Shale, greenish-gray; as above	0.1
Shale, red-brown, covered; as above	9.0
Siltstone, greenish-gray, mottled reddish-orange, weakly indurated, laminated; becoming dolomitic and well-indurated in places	0.25
Shale*, red-brown, silty, weakly indurated, platy; as above	10.3
Siltstone, greenish-gray, argillaceous, weakly indurated; with red-brown gypsum nodules at base	0.25
Shale, red-brown; with many thin arenaceous beds	1.25
Sandstone, dark greenish-gray, argillaceous, dolomitic, fine-grained, quartzose, weakly to well-indurated	0.1
Shale, red-brown, selenitic, blocky; with many small gypsum nodules	2.0
Siltstone, dark greenish-gray, argillaceous, weakly indurated; mottled moderate reddish-orange in places	0.1
Shale, red-brown, blocky; with some greenish-gray siltstone layers; covered in part	3.0
Siltstone, greenish-gray, weakly indurated; dolomitic in places	0.75
Shale, red-brown; as above; with some small gypsum nodules in basal portion	12.3
BLAINE FORMATION (total thickness, 7.4 feet; only upper part recognizable)	
Pocasset Gypsum Bed (type section):	
Gypsum; greenish-gray at top; very dark-red at base; amorphous, well-indurated, thin-bedded, even-bedded, vuggy; selenitic at top; with satin spar in middle; forming mappable ledge; probably a partial equivalent of the Shimer Gypsum Member	0.3
Mudstone conglomerate, very dark-red, finely granular, weakly indurated, platy; grading into shale	0.5
Gypsum, greenish-gray, mottled moderate reddish-orange, arenaceous, massive, amorphous, well-indurated; forming a ledge	0.2
Unnamed Units (Blaine):	
Sandstone, greenish-gray, fine-grained, weakly indurated, even-bedded	0.1
Mudstone conglomerate, very dark-red, silty; mottled moderate reddish-orange at top and base; becoming arenaceous	

	Thickness (feet)
at top and base; partly covered	6.0
Altona Dolomite Bed:	
Siltstone*, greenish-gray; well-indurated at top and base; arenaceous in places; pink, vuggy at base; weathering greenish gray; forming a resistant ledge, used by many authors as base of Blaine (instead it is near top)	0.3
CHICKASHA FORMATION (exposed thickness, approximately 40 feet)	
Sandstone, moderate reddish-orange, fine-grained, weakly indurated; argillaceous near top	0.75
Sandstone, moderate reddish-orange to very dark-red, gypsiferous, well-indurated, even-bedded	0.4
Sandstone, moderate reddish-orange, calcareous, fine-grained, weakly to well-indurated, massive	0.3
Sandstone, greenish-gray, calcareous, fine-grained, weakly indurated, even-bedded	0.05
Mudstone conglomerate, very dark-red, argillaceous, weakly indurated, platy; with some moderate reddish-orange sandstone streaks	1.75
Sandstone, moderate reddish-orange, fine-grained, weakly indurated; quartzose; with subrounded grains	0.5
Siltstone, greenish-gray and very dark-red, argillaceous, weakly indurated, platy; dolomitic in places	0.1
Mudstone conglomerate, very dark-red, fine-granular, weakly indurated; with many well-indurated siliceous concretions in basal part	1.25
Dolomite, greenish-gray, silty, well-indurated, wavy bedded; weathering greenish-gray	0.05
Sandstone, moderate reddish-orange, argillaceous, fine-grained, quartzose, weakly indurated, massive, blocky	5.5
Sandstone, moderate reddish-orange, gypsiferous, fine-grained, quartzose, moderately indurated; with subrounded grains; with many small rounded granules of selenite and some lenses of very dark-red mudstone conglomerate and sandstone, being lenticular, cross-bedded, crinkly bedded, laminated; with some well-indurated thin greenish-gray siltstone streaks	3.0
Mudstone conglomerate, red-brown, fine-granular, well-indurated, blocky, argillaceous to arenaceous; with some greenish-gray streaks and spots in upper part and lenses of moderate reddish-orange sandstone; covered at base	15.0
Siltstone, moderate reddish-orange; as above; wavy bedded at base; section extrapolated to SW¼ NW¼ sec. 35, T. 9 N., R. 7 W., east of road in creek	2.0
Shale, red-brown, silty, blocky	2.0
Shale, greenish-gray, silty, blocky	0.1
Siltstone, moderate reddish-orange; as above	3.0
Shale, greenish-gray, silty, blocky	0.1

	Thickness (feet)
Siltstone*, moderate reddish-orange; as above; exposed to creek	4.0

SECTION 29. CHICKASHA
CENTRAL GRADY COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured along road east of Norge and nearby creek in SW¼ sec. 17, T. 6 N., R. 7 W., continuing in SE¼ sec. 17 and along road south of sec. 16, ending in Chickasha Formation in NE¼ SW¼ sec. 15 and SE¼ SW¼ sec. 15, T. 6 N., R. 7 W., C and NW¼ sec. 13, T. 6 N., R. 7 W., SW¼ sec. 18 and NW¼ sec. 19, T. 6 N., R. 6 W., south of Chickasha, Grady Couty, Oklahoma. The Blaine Formation has graded into the Chickasha Formation and is not here recognized.

MARLOW FORMATION (top not exposed)	
Siltstone and fine-grained sandstone, moderate reddish-orange to moderate red-brown, argillaceous; alternating weakly and well-indurated beds; exposed	8.0
Siltstone, moderate reddish-orange, weakly indurated; as above; with many greenish-gray zones and spots	4.5
Siltstone, moderate reddish-orange; as above; with many thin wavy bedded calcareous platy layers	3.25
Siltstone, moderate reddish-orange; as above; with many small greenish-gray spots	5.25
Siltstone, greenish-gray, argillaceous, gypsiferous, weakly indurated	0.5
Siltstone, moderate reddish-orange, weakly indurated	0.8
Sandstone and conglomerate, white to moderate reddish-orange, fine-grained, quartzose, calcareous, gypsiferous, ferruginous; with subrounded to subangular grains; with many chert granules averaging 2 or 3 millimeters in diameter	0.25
DOG CREEK SHALE (total thickness, approximately 125 feet, the basal portion having graded into the Chickasha Formation)	
Mudstone conglomerate, red-brown to very dark-red, mottled greenish-gray, cross-bedded; being a northward remnant of the Chickasha Tongue. All similar beds, in addition to sandstones and siltstones lower in the section, are here considered to be Chickasha tongues	3.25
Sandstone, red-brown, fine-grained, quartzose, massive; with subrounded to subangular grains	5.25
Mudstone conglomerate, even-bedded; as above	0.25
Siltstone, moderate reddish-orange, argillaceous, weakly indurated; partly covered	5.0
Sandstone, moderate reddish-orange, medium-grained, quartzose, cross-bedded, well-indurated; with subrounded to	

	Thickness (feet)
subangular grains; with interbedded mudstone conglomerate	1.7
Mudstone conglomerate, red-brown to very dark-red; as above; mottled with many greenish-gray spots and layers	2.6
Siltstone, greenish-gray, argillaceous, weakly indurated, platy	0.25
Shale, red-brown, weakly indurated, platy; with some greenish-gray shale spots	5.25
Siltstone, greenish-gray, argillaceous, weakly indurated; weathering greenish gray	0.2
Shale, red-brown, weakly indurated, platy to blocky; partly covered	10.5
Siltstone, greenish-gray, argillaceous, weakly indurated, platy	0.2
Shale, red-brown, weakly indurated, platy to blocky	0.1
Siltstone, greenish-gray, argillaceous, weakly indurated, thinly laminated; grading into dolomitic siltstone	0.3
Shale, red-brown, weakly indurated, platy to blocky	0.7
Siltstone, greenish-gray, argillaceous, weakly indurated, platy; weathering greenish gray	0.1
Shale, red-brown, platy to blocky; with greenish-gray siltstone spots	0.6
Siltstone, greenish-gray, argillaceous, platy	0.2
Shale, red-brown, weakly indurated, platy to blocky	0.25
Siltstone, greenish-gray, argillaceous, calcareous, gypsiferous, weakly indurated; grading into a fine-grained sandstone; with a bright-yellow stained layer	0.2
Shale, dark red-brown to very dark-red, silty, well-indurated, platy to blocky	5.75
Siltstone, greenish-gray, argillaceous, weakly indurated; with a thin bright-yellow seam at top	0.25
Shale, red-brown to very dark-red, silty; with lenticular sandstone beds and greenish-gray shale seams	1.5
Shale, red-brown; with many thin greenish-gray and very dark-red silty shale seams	3.5
Mudstone conglomerate, red-brown to very dark-red, well-indurated; with interbedded, cross-bedded fine-grained sandstone and siltstone; with small gypsum nodules at top	2.0
Sandstone, moderate reddish-orange, fine-grained, well-indurated, cross-bedded; interbedded with mudstone conglomerate and siltstone	5.5
Shale, red-brown, silty, platy; with many thin greenish-gray layers	16.0
Shale, red-brown, silty, blocky; with some siltstones and mudstone conglomerates; mostly covered	30.6
Shale, red-brown, weakly indurated, blocky; with calichelike layer at top; section extrapolated to SW¼ sec. 15, T. 6 N., R. 7 W.	2.5

	Thickness (feet)
Siltstone, greenish-gray, argillaceous, weakly indurated, blocky	0.4
Shale, red-brown, silty, blocky; with some thin greenish-gray shale stringers	1.0
Sandstone, red-brown, fine-grained, quartzose, weakly indurated, lenticular, platy; with some indurated beds	1.75
Shale, greenish-gray, silty, weakly indurated	0.1
Shale, red-brown; as above	2.0
Siltstone, greenish-gray; as above	0.2
Shale, red-brown; as above; with some small greenish-gray spots	1.0
Siltstone, red-brown, lenticular; grading into red-brown shale	1.75
Shale, greenish-gray, silty; as above	0.25
Shale, red-brown; as above; covered	6.0
Shale, greenish-gray, silty, wavy bedded; as above	0.1
Shale, dark red-brown to very dark-red, weakly indurated, blocky	5.25
Shale, greenish-gray, mottled moderate reddish-orange, silty, weakly indurated	0.1
Shale, red-brown, silty; as above; with a thin very dark-red shale layer in middle	0.5
CHICKASHA FORMATION (exposed thickness, 115 feet)	
Siltstone, greenish-gray, calcareous, argillaceous, weakly indurated, cross-bedded; forming a prominent light-colored band in region	0.5
Siltstone, red-brown, quartzose, cross-bedded, lenticular, massive; with some indurated layers	3.5
Sandstone, greenish-gray and moderate reddish-orange, fine-grained, quartzose, calcareous, well-indurated, cross-bedded; with subrounded grains	0.25
Shale, greenish-gray, calcareous, silty	0.75
Shale, red-brown, silty	9.0
Shale, greenish-gray; as above	0.2
Shale, red-brown, silty	2.0
Sandstone, moderate reddish-orange, cross-bedded, weakly to well-indurated; with interbedded mudstone conglomerate; section extrapolated to C sec. 13 and SE¼ SE¼ NW¼ sec. 13, T. 6 N., R. 7 W., and SW¼ SW¼ sec. 18, and NW¼ sec. 19, T. 6 N., R. 6 W., along State Highway 19	30.0
Mudstone conglomerate, red-brown, mottled greenish-gray, arenaceous, silty, cross-bedded, well-indurated	7.25
Shale, red-brown, mottled greenish-gray, weakly indurated, platy; with mudstone conglomerate in upper and lower parts	5.0
Shale, red-brown, mottled greenish-gray, silty, platy, weakly indurated; with a thin greenish-gray layer in middle	3.5

	Thickness (feet)
Siltstone, moderate reddish-orange, arenaceous, cross-bedded, weakly indurated	2.5
Shale, red-brown, weakly indurated, platy; with a greenish-gray layer at base	0.3
Mudstone conglomerate, red-brown, mottled greenish-gray, lenticular; as above	2.2
Sandstone, red-brown and greenish-gray, calcareous, medium-grained, cross-bedded	0.3
Mudstone conglomerate, red-brown, mottled greenish-gray, silty, blocky; with flat calcareous concretions in middle part	1.5
Shale, red-brown and greenish-gray, thin-bedded, weakly indurated, platy	0.4
Sandstone, red-brown, silty, fine-grained, quartzose, cross-bedded; well-indurated at top; weakly indurated at base	4.5
Mudstone conglomerate, red-brown and greenish-gray, silty, arenaceous, cross-bedded, well-indurated	0.25
Shale, red-brown, weakly indurated, blocky; greenish-gray at base	2.0
Siltstone, red-brown, arenaceous, weakly indurated, cross-bedded	1.0
Mudstone conglomerate, red-brown, mottled greenish-gray, silty, well-indurated, cross-bedded	2.0
Sandstone, red-brown, silty, fine-grained, quartzose, cross-bedded, well-indurated	5.25
Mudstone conglomerate, red-brown, silty, cross-bedded; with some greenish-gray spots	1.0
Sandstone, red-brown, silty, fine-grained, quartzose, cross-bedded; with subrounded to subangular grains; with some interbedded mudstone conglomerate	10.5
Mudstone conglomerate, red-brown, silty, well-indurated, cross-bedded	10.5
Sandstone, red-brown, mottled greenish-gray, silty, fine-grained, quartzose, cross-bedded, well-indurated; with mudstone conglomerate in lower 3 feet	8.0
Siltstone, red-brown, mottled greenish-gray, argillaceous, weakly indurated, blocky; with some well-indurated sandstone beds	8.0
Sandstone, moderate reddish-orange, silty, fine-grained, cross-bedded, well-indurated; exposed	10.5

SECTION 30. RUSH CREEK
SOUTHERN GRADY COUNTY, OKLAHOMA

Beginning at top in Marlow Formation, section measured along road in NE¼ NE¼ sec. 14, T. 3 N., R. 6 W., extending 20 feet into the Chickasha Formation. Section then extrapolated to C line between secs. 13 and 24, T. 3 N., R. 6 W., along road, north of Rush Creek, west of Cox City, southern Grady County, Oklahoma.

	Thickness (feet)
MARLOW FORMATION (top not exposed)	
Siltstone, moderate reddish-orange, weakly indurated	20.0
Siltstone, moderate reddish-orange, mottled greenish-gray, arenaceous; grading into a fine-grained sandstone; with thin dolomite lenses	1.75
Siltstone, red-brown, argillaceous, weakly indurated	5.25
Sandstone, greenish-gray, argillaceous, fine-grained, weakly indurated	0.25
Siltstone, moderate reddish-orange, argillaceous, weakly indurated	0.5
Sandstone, greenish-gray, fine-grained, quartzose; with subrounded to subangular grains and many small chert and quartz granules; becoming calcareous at base	1.0
Siltstone, red-brown, argillaceous, weakly indurated; mottled with some greenish-gray spots; with a thin greenish-gray dolomitic siltstone in middle	4.0
Sandstone, greenish-gray, mottled red-brown, fine-grained, weakly indurated; with well-indurated dolomitic layer at base	0.5
Siltstone, red-brown, mottled greenish-gray, argillaceous, weakly indurated	1.0
CHICKASHA FORMATION (exposed thickness, approximately 63 feet)	
Mudstone conglomerate, purple, silty, weakly indurated	0.2
Siltstone, greenish-gray, argillaceous, weakly indurated	0.25
Mudstone conglomerate, purple, mottled greenish-gray, silty, weakly indurated, platy	0.25
Sandstone, greenish-gray, silty, fine-grained, weakly indurated	0.75
Siltstone, purple, mottled greenish-gray, arenaceous, weakly indurated; with some mudstone conglomerate lenses	4.0
Shale, greenish-gray, mottled purple, silty, weakly indurated, platy	2.5
Siltstone, greenish-gray, argillaceous, weakly indurated; grading into fine-grained sandstone	0.5
Mudstone conglomerate, purple, mottled greenish-gray and light-brown, silty, weakly indurated	0.5
Sandstone, greenish-gray, mottled purple, weakly indurated, massive	1.5
Shale, purple and red-brown, silty, weakly indurated, blocky	0.25
Sandstone, light-purple and olive-green to gray, fine-grained, weakly indurated; grading laterally into a well-indurated cross-bedded mudstone conglomerate	4.25
Siltstone, greenish-gray and purple, mottled light-brown to pink, arenaceous, weakly indurated, cross-bedded; grading into sandstone at top and shale at base; with some small purple concretions; basal part extrapolated to C of line beween secs. 13 and 24, T. 3 N., R. 6 W., along road	26.5

	Thickness (feet)
Sandstone, greenish-gray, mottled light-purple, silty, fine-grained, well-indurated, cross-bedded	4.25
Mudstone conglomerate, purple, mottled greenish-gray, silty, well-indurated, cross-bedded; with 1- to 3-inch arenaceous dolomite lenses at base	1.5
Sandstone, mottled greenish-gray and purple, fine-grained, weakly indurated, cross-bedded; grading into mudstone conglomerate at top	5.0
Mudstone conglomerate, purple and greenish-gray, silty, well-indurated, cross-bedded	1.0
Shale, purple, mottled greenish-gray, silty, weakly indurated, platy	2.25
Siltstone, light-brown, mottled greenish-gray and purple, arenaceous, thin-bedded, weakly indurated	3.5
Mudstone conglomerate, purple and greenish-gray, silty, well-indurated, cross-bedded	2.0
Shale, red-brown, weakly indurated, blocky	0.3
Siltstone, greenish-gray, mottled red-brown, argillaceous, weakly indurated, platy; exposed	1.0

SECTION 31. SUNRAY MID-CONTINENT BAKER NO. 1 RELIEF CORE HOLE SOUTHWESTERN BLAINE COUNTY, OKLAHOMA

Beginning at top in basal part of Rush Springs Sandstone, at ground elevation 1,566 feet, in NW¼ SE¼ SW¼ sec. 36, T. 14 N., R. 13 W., the first 397 feet to Blaine top was drilled, the next 373 feet into the Flowerpot Shale was cored (3-inch cores), and the last 230 feet was drilled, to a total depth of 1,000 feet. The Relay Creek, Southard, and Watonga Dolomite Beds are extrapolated from surface information, supplemented by examination of cuttings.

RUSH SPRINGS SANDTONE (base locally exposed)	
Sandstone, red-brown, fine-grained, quartzose	1.0
MARLOW FORMATION (total thickness, 153 feet)	
Emanuel Dolomite Bed:	
Dolomite and shale, red-brown, mottled very dark-red, arenaceous, platy, crinkly bedded, well-indurated; forming a ledge	0.1
Unnamed Unit (Marlow):	
Sandstone, red-brown to moderate reddish-orange, fine-grained, quartzose	19.8
Relay Creek Dolomite Bed:	
Dolomite and shale, red-brown; as above	0.1
Unnamed Unit (Marlow):	
Sandstone, red-brown; as above	133.0

	Thickness (feet)
DOG CREEK SHALE (total thickness, 243 feet)	
Shale, red-brown, silty, blocky	98.0
Southard Dolomite Bed:	
Dolomite, light-brown to light-gray, well-indurated, fine-grained; appearing as light-brown specks in cuttings	0.5
Unnnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky; with some anhydrite	71.5
Watonga Dolomite Bed:	
Siltstone, greenish-gray, dolomitic, well-indurated; with some anhydrite; including Haskew Bed at base	8.0
Unnamed Unit (Dog Creek):	
Shale, red-brown, silty, blocky; with much satin spar and three prominent thick beds of anhydrite; with anhydrite stringers throughout	65.0
BLAINE FORMATION (total thickness, 108.5 feet)	
Shimer Gypsum Member:	
Anhydrite, red-brown, argillaceous	1.7
Anhydrite, gray, massive	6.0
Shale, greenish-gray	2.0
Shale, red-brown; with anhydrite bands	3.0
Anhydrite, gray, massive	4.5
Altona Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, fine-grained, oölitic; extremely fossiliferous with many *Permophorus*	1.0
Unnamed Units (Blaine):	
Shale, greenish-gray, blocky	1.5
Shale, red-brown; with some greenish-gray layers	30.3
Shale, red-brown, blocky	15.0
Nescatunga Gypsum Member:	
Anhydrite, gray, massive	2.0
Anhydrite, gray, massive; with clear halite filling drusy holes about 1-inch in diameter	4.0
Anhydrite, gray, massive	3.0
Magpie Dolomite Bed:	
Dolomite, light-gray to yellowish-gray, fine-grained, dense to oölitic	1.0
Unnamed Unit (Blaine):	
Shale, red-brown, silty, blocky	15.5
Kingfisher Creek Gypsum Bed:	
Anhydrite, gray, mottled red-brown, massive	2.0
Unnamed Unit (Blaine):	
Shale, red-brown, blocky; with greenish-gray streaks	12.5
Medicine Lodge Gypsum Member:	
Anhydrite, gray, massive, mottled reddish-brown	3.25
Cedar Springs Dolomite Bed:	
Dolomite, light-gray to red-brown, fine-grained, dense, thin-bedded, wavy bedded	0.25

	Thickness *(feet)*
FLOWERPOT SHALE (base not determinable)	
Units J-K (Flowerpot):	
Shale, red-brown, blocky	3.0
Unit I (Flowerpot):	
Anhydrite, gray, massive	0.5
Units A-I (Flowerpot):	
Shale, red-brown, silty, blocky; with some thin greenish-gray siltstone and shale beds, and with some anhydrite nodules	23.0
Shale, red-brown, blocky; as above	88.0
Shale, red-brown, blocky; with anhydrite nodules	8.0
Shale, red-brown, mottled greenish-gray, salty	10.0
Shale, red-brown; with some greenish-gray shale layers	13.0
Chickasha Tongue:	
Siltstone, greenish-gray, well-indurated, salty	5.0
Siltstone, moderate reddish-orange; with interbedded red-brown shale	20.0
Shale, red-brown; with some greenish-gray spots	11.0
Shale, red-brown, blocky; with anhydrite nodules	3.0
Siltstone, greenish-gray, mottled moderate reddish-orange, cross-bedded, salty; with some red-brown shale stringers	30.0
Siltstone, greenish-gray; interbedded with red-brown blocky shale	10.0
Mudstone conglomerate, red-brown, mottled greenish-gray	1.0
Shale, red-brown; with small anhydrite nodules	4.0
Siltstone, greenish-gray; with some red-brown shale layers	2.0
Siltstone, red-brown, argillaceous, salty, blocky; with some greenish-gray spots	7.0
Mudstone conglomerate, red-brown, mottled greenish-gray silty	2.0
Siltstone, red-brown, argillaceous, blocky; with some greenish-gray shale patches	9.0
Siltstone, greenish-gray, argillaceous, salty	15.0
Siltstone and shale; as above; drilled. The projected base of the Chickasha Tongue from the outcrop would be somewhere in this part of the section, and the base of the Flowerpot Shale would be another 180 feet farther down.	230.0
Total Depth	1,000.0

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(*Italic numbers* indicate main references)