Geology of Woods County, Oklahoma

A sand dune in Little Sahara State Recreation Area, just west of U. S. Highway 281, south of Waynoka, Woods County, Oklahoma. Ancient sands of the Pleistocene Epoch were deposited in this area and prevailing southwesterly winds have stripped away vegetation, blowing the loose sand into dunes.
(Photograph by Bob Taylor, Cordell, Oklahoma)

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GEOLOGY AND MINERAL RESOURCES OF WOODS COUNTY, OKLAHOMA

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Geology and Mineral Resources of Woods County, Oklahoma

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ABSTRACT

Woods County, comprising 1,271 square miles in northwestern Oklahoma adjacent to Kansas, is in the Great Plains, ranging in elevation from 2,110 feet in the northwest to 1,250 feet in the east and southeast. The major drainage ways are the Cimarron River along the southern edge of the county and Salt Fork in the northeastern part. The southern part of the area and the areas northeast of the main rivers are covered with Pleistocene deposits.

The geologic column of Woods County consists of approximately 850 feet of Permian redbeds of the Cimarronian and Custerian Series, overlain by 0-140 feet of Lower Cretaceous beds in the northwestern part of the county, and these in turn overlain by 0-100 feet of Pliocene (Ogallala) beds. The Pleistocene deposits, occurring in several terrace levels on either side of the main rivers, form a thin veneer of clay and silt on the southwestern sides of the rivers and sand and gravel deposits, 10 to 100 feet thick, on the northeastern sides of the rivers. The higher Pleistocene levels are below the base of the Ogallala Formation, and locally the Pearlette ash occurs in one level near the Salt Fork.

In ascending order, the Permian rocks consist of the upper part of the Bison Member of the Hennessey Shale Formation (10 feet), overlain by the Cedar Hills Sandstone Member of the Hennessey Shale (180 feet); the Flowerpot Shale (220-380 feet), Blaine Formation (50-85 feet), and Dog Creek Shale (45-70 feet) of the El Reno Group; the Marlow Formation (100 feet) and Rush Springs Sandstone (90 feet) of the Whitehorse Group; and the Cloud Chief Formation (50 feet, top eroded). The Cimarronian Series comprises all of the redbeds up to the base of the Whitehorse Group, and the Custerian Series extends from the base of the Whitehorse Group through the Elk City Sandstone.

The Bison Member is a reddish-brown, micaceous clay shale with many thin, greenish-gray siltstone and sandstone bands. The Cedar Hills Member occurs in the northeastern part of the county along Driftwood Creek and the Salt Fork, and the upper part occurs along

Eagle Chief Creek in the eastern part of the county. The Cedar Hills is an orange-brown, fine-grained sandstone with some interbedded shale and much siltstone to the north, gradational into red-brown shale and siltstone with some sandstone to the south in Major County. The Cedar Hills is subdivided into six mappable units, each being a prominent sandstone ledge with greenish-gray beds. The upper unit contains gypsum nodules locally. A middle unit, about 100 feet down, is named the Peace Treaty Bed and is about 10 feet thick.

The Flowerpot Shale is a red-brown, gypsiferous, silty shale, 220 feet thick in the northern part of the county and 380 feet thick in the southern part. It is subdivided into seven mappable units, each consisting of 1 to 5 feet of orange-brown and greenish-gray siltstone and sandstone, the bottom two of which contain much gypsum. The thickness of the sandstones decreases southward, where the sandstones are gradational into shale.

The Blaine Formation is an alternating series of three gypsum units, each with dolomite at the base of the gypsum and separated from each other by 7 to 10 or more feet of red-brown shale. The named units (ascending) are Cedar Springs Dolomite (1-2 feet thick), Medicine Lodge Gypsum (25 feet), shale (10 feet), Magpie Dolomite (1 foot), Nescatunga Gypsum (10 feet), shale (10 feet), Altona Dolomite (1-3 feet), and Shimer Gypsum (10-15 feet). About 10 miles north of Woods County, the Nescatunga thins rapidly to 2 feet and is missing farther northward. The Blaine is eroded into high escarpments in the northwestern part of the county.

The Dog Creek Shale is a red-brown, silty shale with three named units, increasing in thickness southward. The Haskew Gypsum Bed is about 5 feet thick in the western part of the county, occurring about 5 feet above the base. Elsewhere in the county it is absent. The Watonga Bed is a greenish-gray, dolomitic or calcitic siltstone, about 3 inches thick, a few feet above the Haskew Bed or 6 to 10 feet above the base. A prominent orange-brown sandstone and siltstone, 5 to 10 feet thick, occurs in the middle of the Dog Creek. The Southard Dolomite Bed is about 4 inches thick, being a fine-grained, light-gray dolomite, occurring about 5 feet below the top to the north and almost 30 feet or more below the top to the south. It is eroded into a prominent light-colored zone and resistant ledge.

The Marlow Formation, a fine-grained, orange-brown sandstone, is eroded into an escarpment above the Dog Creek Shale. The Doe Creek Lentil is a series of disconnected hills of coarse-grained sandstone and sandy limestone with some reworked conglomerate, occurring within the Marlow at various levels from 0 to 78 feet above the base. The outcrop of the Doe Creek is less than a mile wide and about 15 miles long, extending in a southwesterly direction from about the center of the county. The Relay Creek Dolomite Bed is about 3 inches thick, occurring about 15 feet below the top of the Marlow, with red-brown shale above. Locally the Relay Creek is gypsum. The top of the Marlow is marked at the Emanuel Bed, which is a fine-grained, greenish-gray, calcitic sandstone. The top of the Doe Creek is below the Relay Creek Bed.

The Rush Springs Formation is a series of orange-brown sandstones and reddish-brown shales, restricted to the northwestern part of the county. A massive sandstone, about 30 feet thick, occurs at the top.

The Cloud Chief Formation is a red-brown shale, with a 5-foot, greenish-gray, calcitic sandstone and dolomite or double dolomite at the base, named Moccasin Creek Bed. The Day Creek Dolomite Bed is about 2 feet thick, occurring about 25 feet above the Moccasin Creek Bed and is eroded into a prominent escarpment similar to that of the Moccasin Creek. The beds below the Day Creek, excluding the Moccasin Creek, belong to the Kiger Member. The Big Basin Member includes the beds above the Day Creek, which are mainly red-brown shale. The exposed thickness of the Cloud Chief is 50 feet.

The Kiowa Shale (Lower Cretaceous, Comanchean) is a dark-gray to yellow-brown shale with some interbedded sandstone at the base and yellow-brown limestone beds in the middle and top. It is subdivided into several units in Woods County. The lower unit is a 0.5- to 5-foot coarse-grained sandstone, about 10 to 15 feet above the base, and the upper unit is a *Cyprimeria* limestone, about 40 feet above the base. Higher units occur a few miles north of the county, in Avilla Hill.

The Ogallala Formation (Pliocene) is a variegated sandstone and siltstone unit, with some volcanic ash and mortar beds, containing fossil vertebrates. Some gray clay and caliche are present. The Ogallala and Kiowa are unconformable upon the redbeds below and form low hills on a high ridge in the northwestern part of the county.

The Permian formations are conformable upon each other, and structurally they dip about 4 to 10 feet per mile to the southwest. In the Whitehorse Springs area is an anticlinal feature and in the Freedom area is a structural sag, probably due to solution of salt in the Flowerpot Shale and lower units. In the Edith area and northwest along the Cimarron River, a 57-foot bed of rock salt occurs in the Flowerpot Shale about 150 feet below the top of the formation, just below the river bed and is probably the source of salt for the Big Salt Plain and Little Salt Plain.

INTRODUCTION

Woods County is in northwestern Oklahoma adjacent to Kansas and is approximately 1,271 square miles in area (fig. 1). The county seat, Alva, in the east-central part, has a population of 6,258. Smaller towns are Avard (56), Capron (102), Dacoma (219), Freedom (268), and Waynoka (1,794). Unincorporated or smaller communities are Brace, Brink, Camp Houston, Cora, Edith, Fairvalley, Farry, Galena, Heman, Hopeton, Lookout, McKinley, Noel, O'Connor, Plainview, Tegarden, and Whitehorse. Some old ghost towns or tent post offices are in the northwestern part of the county, such as Abbie (NE¼ sec. 32, T. 29 N., R. 17 W.), Coy (SW¼ sec. 25, T. 29 N., R. 20 W.), old Farry (near center west line sec. 28, T. 28 N., R. 17 W.), Faulkner (SW¼ sec. 4, T. 28 N., R. 16 W.), old Freedom (near center north line sec. 11, T. 27 N., R. 18 W.), Irene (NW¼ SE¼ sec. 35, T. 29 N., R. 18 W.), Kingman (NE¼ sec. 15, T. 29 N., R. 17 W.), Saratoga (NW¼ sec. 25, T. 28 N., R. 20 W.), old Whitehorse (SW¼ sec. 5, T. 27 N., R. 16 W.), and Winchester (SW¼ sec. 26, T. 29 N., R. 15 W.). In the eastern part of the county are Clymer (SW¼ sec. 17, T. 24 N., R. 13 W.), Lake (NE¼ sec. 33, T. 24 N., R. 13 W.), Wisby (NE¼ sec. 29, T. 23 N., R. 13 W.), and Zula (NW¼ sec. 32, T. 26 N., R. 13 W.). Dacoma was previously known as Kintz and Capron was Virgel. In older geological survey reports, some geological features are discussed with

Figure 1. Index map of Oklahoma showing location of Woods County.

respect to some of these old towns, thus making it important to record these places. U. S. Highway 64 and State Highways 45 and 11 extend east-west through the county, and U. S. Highway 281 and State Highways 50 and 14 extend north-south. The Atchison, Topeka and Santa Fe Railway operates through Alva, Waynoka, and Freedom, and the St. Louis-San Francisco Railway extends to Avard from the east. The Chicago Rock Island and Pacific Railroad connects eastward from Alva.

Areas of interest in the county are the sand dunes south of Waynoka in Little Sahara State Park; Kelsey Field, northeast of Waynoka, where first transcontinental flights landed; the Little and Big Salt Plains of the Cimarron River near Edith, reportedly visited by Coronado in 1541; Whitehorse Mounds and Wildcat Buttes near the center of the county; and the Cleveland Hills northwest of Whitehorse Mounds.

Economically the county is known for its wheat, cattle, gas, and oil. Salt has long been used by Indians and settlers from the salt plains and is still in limited production by Ezra Blackmon. In the 1930's the Day Creek Dolomite was used in construction of Fort Supply dam. Sand and gravel are used locally for road metal and concrete, and caliche is used locally for road metal. Ground water is produced from the southern sand-dune area for Waynoka and Alva, and many springs, such as Fairvalley Springs, flow from the Pleistocene deposits. The Doe Creek Sandstone is also a source of spring water, such as Whitehorse Springs, and the Doe Creek could be used as a source of rock wool. A gypsum plant was located in Alva in 1913, but the quarry was in the Medicine Lodge Gypsum in Woodward County (sec. 10, T. 23 N., R. 17 W.); otherwise gypsum was used locally for homemade cement. Gypsum could be quarried and used in the northwestern part of the county. A volcanic-ash deposit occurs in SE¼ sec. 32, T. 29 N., R. 15 W., and could be used locally as an abrasive. In 1913, Z. W. Cox operated a brick plant in Alva, producing about 10,000 bricks a day from a local pit in the lower part of the Flowerpot Shale.

Two rivers flow southeastward through Woods County: the Cimarron River along the southwest border and the Salt Fork in the northeastern part of the county. The average gradient of the Cimarron is 6 feet per mile and that of the Salt Fork is 8 feet per mile, both streams leaving the county at an elevation of approximately

1,250 feet. The highest part of the county is Avilla Hill in the northwestern section, rising to 2,110 feet above sea level just north of the state line on the Kansas side. This hill is a part of a high southeastward-trending ridge in the northwestern part of the county, underlain predominantly by Permian redbeds above the Blaine Formation. Small streams, such as Keno, Day, Sand, Moccasin, Anderson, Houston, Wildcat, Redhorse, Whitehorse, Dog, and Eagle Chief Creeks, flow southward from this ridge into the Cimarron River. Yellowstone, Greenwood, Turkey, and Driftwood Creeks flow eastward from this ridge into the Salt Fork. Most of the streams are perennial. The Gypsum Hills terminate the above-mentioned ridge in a series of eastward-facing escarpments on the northeast side and southward-facing escarpments on the southwest side. The Medicine Lodge Gypsum, the lowest member of the Blaine Formation, is the primary ledge-forming unit. The Cedar Hills Sandstone underlies a low ridge along the Salt Fork of the Arkansas.

The Pleistocene sand and gravel deposits may be divided into three areas, termed Cimarron River, Salt Fork, and Arkansas River. These deposits are less than 100 feet thick and occur in terrace levels, the highest level the oldest. The Cimarron River area has thick sand and gravel on the northeastern side and a veneer of silt and clay on bedrock on the southwestern side. An extension from the Gypsum Hills southeastward to Alfalfa County, parallel to the Cimarron, separates the Cimarron area from the Salt Fork area. The Salt Fork area may be subdivided into two regions: the old Salt Fork system from Alva southward and the present Salt Fork system along both sides of the Salt Fork. The old system, consisting of a thick deposit to the east and south, thins westward against the base of the Gypsum Hills. The present system, consisting of thick deposits northeast of the Salt Fork and a veneer west of the river, contains the Pearlette ash in SE¼ sec. 32, T. 29 N., R. 15 W. At Alva the Salt Fork bends abruptly eastward and appears to crosscut the Cedar Hills ridge with the Pleistocene beds on top of the ridge. Thus it is suspected that the old and present systems once were connected in this region. This would mean that an ancient Salt Fork once flowed southward and, in the area of Aline, Alfalfa County, probably connected with the older Cimarron River where the ridge extending from the Gypsum Hills terminates. The valley of Eagle Chief Creek probably follows this ancient river, and this creek is probably an underfit

stream. The present Salt Fork was probably a small stream working headward (westward) from the Arkansas River and pirated the old river in the Alva region, perhaps during late Kansan time. The Arkansas River area, the low, wide, flat region northeast of the Cedar Hills escarpment, extends through Alfalfa County and includes the Great Salt Plain. Most of these deposits are a veneer of silt and clay with some sand and gravel on bedrock. These are termed Arkansas River Pleistocene beds because they probably were once part of this river system, extending southeastward from Dodge City, Kansas, along the Medicine Lodge River to the Salt Fork, thence eastward to the present Arkansas River, near Ponca City, Oklahoma.

ACKNOWLEDGMENTS

Carl C. Branson field-checked the final map and gave helpful suggestions on nomenclature and drafting of plates. William E. Ham aided in drafting of the geologic map, and Roy D. Davis supervised the drafting of figures and plates. Mrs. Alice Timmons, of the Phillips Collection, and Mr. Jack D. Haley, of the Division of Manuscripts, The University of Oklahoma, kindly supplied data on Sentinel Mound.

STRATIGRAPHY

INTRODUCTION

The geologic section of Woods County consists of 850 feet of Permian redbeds of the Cimarronian and Custerian Series, overlain by Kiowa Shale (Lower Cretaceous) up to 140 feet thick in the northwestern part of the county, and these in turn are overlain by Ogallala beds (Pliocene) up to 100 feet thick. The Pleistocene deposits occur at various levels below the base of the Ogallala and have been discussed previously, the separate areas being shown on the geologic map (pl. I) by different patterns. The redbeds dip from 4 to 10 feet per mile southwestward, with an anticline in the Whitehorse Springs area and a structural sag in the Freedom area, probably owing to solution of underlying salt and gypsum (pl. II).

The Cimarronian Series includes the redbeds up to the base of the Whitehorse Group, and the Custerian Series extends from the base of the Whitehorse to the top of the Permian redbed sequence. This usage is a new combination based upon studies by O'Connor (1963, p. 1875) and Roth (1932, p. 689), and modified herein. The type Cimarronian area is the region along the Cimarron River and its tributaries in Oklahoma, and the type area of the Custerian is Custer County, Oklahoma, and adjacent areas. The Whitehorse Group is redefined with respect to the upper boundary, and a map has been prepared with cross sections to show the structural attitude of the base of the Whitehorse and the stratigraphic relationships of the Whitehorse Group and the Cloud Chief and Doxey Formations in northwestern Oklahoma, Texas Panhandle, and adjacent parts of Kansas (pl. III). The lower contact of the Cloud Chief Formation is different from that shown on the geologic map of Oklahoma, and in west-central Oklahoma the mapped areal extent of the Cloud Chief is greatly reduced.

The lowest and oldest formation exposed in Woods County is the Bison Member of the Hennessey Shale Formation (upper 10 feet present), overlain by the Cedar Hills Sandstone Member of the Hennessey Shale (180 feet thick), occurring in the northeastern part of the county. Next above the Cedar Hills is the El Reno

Group, consisting of the Flowerpot Shale (220-380 feet thick), Blaine Formation (50-85 feet), and Dog Creek Shale (45-70 feet). The Hennessey Formation and El Reno Group belong to the Cimarronian Series, the Hennessey and Flowerpot underlying part of the Redbed Plains, and the Blaine eroded into the Gypsum Hills in northwestern Woods County. The El Reno Group is thicker southward, with less sandstone in the sequence in Major County (pl. IV). The Whitehorse Group is above the El Reno Group, comprising the Marlow Formation at the base (100 feet) and the Rush Springs Formation above (90 feet). The Marlow is primarily sandstone and the Rush Springs is sandstone and shale, classed as forming part of the Western Sandstone Hills by Curtis and Ham (1957). The Cloud Chief Formation, mostly shale with several dolomite beds, overlies the Whitehorse Group at an elevation of about 1,950 feet in northwestern Woods County. The top is eroded and only the lower 50 feet is exposed. The Whitehorse and Cloud Chief belong to the Custerian Series. The redbeds are conformable upon each other.

The Kiowa Shale (Lower Cretaceous, Comanchean) is a dark-gray to yellow-brown shale with some interbedded sandstone near the base and yellow-brown limestone beds in the middle and near the top. It is subdivided into several units in Woods County, where the lower 45 feet is gray shale. Unit 1 is a 0.5- to 5-foot coarse-grained sandstone, about 10 to 15 feet above the base, and Unit 2 is the *Cyprimeria* limestone, less than 1 foot thick, about 40 feet above the base. Higher units occur a few miles north of the county, in Avilla Hill, where the formation is 140 feet thick. Here other zones are present such as that of *Gryphaea corrugata* 47 feet above the base, *Oxytropidoceras* 92 feet above the base, and *Gryphaea* zones higher in the section.

The Ogallala Formation (Pliocene) is a variegated sandstone and siltstone unit, with some volcanic-ash and mortar beds, containing fossil vertebrates. Some gray clay and caliche are present. The Ogallala and Kiowa are unconformable with the redbeds below and form the highest area of the northwestern part of the county.

PERMIAN SYSTEM

CIMARRONIAN SERIES

The terms Leonardian and Guadalupean Series are not used in this region because of offset correlations of these series with the redbed sequence. For instance, the Leonardian-Guadalupean boundary is approximately in the middle of the Flowerpot Shale, and the Guadalupean-Ochoan boundary has nowhere been satisfactorily established in Oklahoma. Thus it is advisable to establish a nomenclature that applies to Kansas, Oklahoma, and Texas as distinct from the Southwest Texas-New Mexico region. The area of redbed exposures along the Cimarron River and tributaries in Oklahoma is selected as the type area for the Cimarronian Series (Cragin, 1896, p. 3), but the upper boundary of this series is here redefined from that on the state geologic map of Kansas (Jewett and others, 1964). The top of the Dog Creek Shale of the El Reno Group marks the top of the Cimarronian Series according to O'Connor (1963, p. 1875), or the base of the Marlow Formation and top of the Chickasha Formation of south-central Oklahoma marks the same boundary. Plate III is a structure map at this horizon.

The Cimarronian Series includes the Wellington, Garber, and Hennessey Formations and the El Reno Group. The Hennessey and El Reno are exposed in Woods County, in part of the Redbed Plains of the Great Plains in the eastern part of the county. The Blaine Formation of the El Reno Group is eroded into the Gypsum Hills, above the Redbed Plains.

Hennessey Shale Formation

The type region for the Hennessey Shale is the area just west of Hennessey, in north-central Kingfisher County, Oklahoma (measured section 16). The Hennessey was first named by Aurin and others (1926, p. 790). Schweer (1939, p. 41) gave a total thickness of 865 feet for the Hennessey in the Guthrie-Kingfisher area of Kingfisher and Logan Counties. This formation is primarily a red-brown shale, with interbedded greenish-gray siltstone and orange-brown sandstone and siltstone beds, the proportion of sandstone increasing northward in the top 180 feet of the formation. The Hennessey is subdivided into three members, termed Fairmont

Shale Member, Bison Member, and Cedar Hills Sandstone Member (ascending).

The Fairmont Shale Member, named by Aurin and others (1926, p. 796) for the town of Fairmont in central Garfield County, is about 250 feet thick and is composed of red-brown clay shale with some thin, greenish-gray siltstone or shale streaks, few more than a few inches thick. It rests upon an upper sandstone member of the Garber Sandstone.

The Bison Member was first named Bison Banded Member by Aurin and others (1926, p. 796) for the town of Bison in southwestern Garfield County. This unit is about 150 feet thick and is primarily a red-brown shale with many greenish-gray siltstone and sandstone beds up to four feet thick (measured section 16).

The Cedar Hills Sandstone Member was first named by Cragin (1896, p. 24) for sandstone beds below the Flowerpot Shale and above the Salt Plains Siltstone, in the area of Cedar Hills, east-central Barber County, Kansas. Cragin used the term Cedar Hills Sandstone as a formation name and referred to the beds below as the Salt Plain Measures. The term Salt Plains Siltstone was introduced by Jewett (1959), and probably the upper 150 feet is the equivalent of the Bison Member. The Cedar Hills is an orange-brown, fine-grained sandstone with some interbedded siltstone and shale, gradational southward into red-brown shale in Kingfisher County. It is 180 to 200 feet thick.

The base of the Hennessey in Kansas is close to the base of the Stone Corral Dolomite, which corresponds with the top of the Garber Sandstone in Oklahoma. If the Runnymede Siltstone of Kansas is the equivalent of the Hayward Sandstone Member of the Garber Sandstone Formation in Oklahoma, then the Stone Corral would be the basal member of the Hennessey Shale. The interval from the Stone Corral to the top of the Cedar Hills is about 600 feet in Kansas (Jewett, 1959). In Oklahoma, the interval from the top of the Garber to the top of the Cedar Hills is about 600 feet in Garfield County (Aurin and others, 1926, p. 796) and 865 feet in Logan and Kingfisher Counties (Schweer, 1939, p. 41). The Cedar Hills is 180 to 200 feet thick from Canadian County, Oklahoma, to Cedar Hills, Kansas, so the southward thickening of the Hennessey must be within the Bison and Fairmont Members.

BISON MEMBER

In Woods County the upper ten feet of the Bison Member is present in the valley sides of Driftwood Creek and south side of Salt Fork, near the Alfalfa County line (measured section 14). It is covered in Woods County but is exposed a few yards east of the county line in the south bank of Driftwood Creek in NW¼ NW¼ sec. 18, T. 28 N., R. 12 W. Here the basal greenish-gray sandstone of the Cedar Hills rests upon red-brown clay shale of the Bison Member, eroding into a low rounded escarpment.

In Garfield County, about 4 miles west of Bison, east of Turkey Creek along the road in NE¼ sec. 20, T. 20 N., R. 7 W., the type Bison consists of 50 feet or more of red-brown shale with many greenish-gray siltstone beds up to 3 feet thick and some orange-brown sandstone beds up to 6 feet thick. The top of the exposed section is about 20 feet below the base of the Cedar Hills. In this general region the basal Cedar Hills is a 3-foot, greenish-gray sandstone. The 13-foot, orange-brown sandstone beneath the town of Bison is Unit 2 of the Cedar Hills, and the underlying 40 feet of beds is Cedar Hills.

In Kingfisher County, just west of Hennessey in SE¼ sec. 23, T. 19 N., R. 7 W., the type Hennessey consists of the basal greenish-

Figure 2. Cliff of basal Cedar Hills Sandstone, Unit 1; view toward the southeast in SW¼ NE¼ sec. 13, T. 27 N., R. 13 W., south of Salt Fork.

gray sandstone of the Cedar Hills and about 65 feet of the Bison Member. The Bison here is a red-brown shale with many greenish-gray siltstone beds 1 to 2 or more feet thick (measured section 16).

In northeastern Barber County, Kansas, 2 miles north of Sharon in NW¼ sec. 9, T. 32 S., R. 10 W., the Bison is a red-brown shale and orange-brown siltstone with some greenish-gray siltstone beds. The upper 55 feet is exposed below the basal 2-foot, greenish-gray sandstone of the Cedar Hills (measured section 6).

CEDAR HILLS SANDSTONE MEMBER

In Woods County, the Cedar Hills is an alternating series of fine-grained, orange-brown sandstones and red-brown shales, with some greenish-gray beds in the sandstones. It is about 180 feet thick, with six mappable units of sandstone designated from bottom to top as Units 1 and 2, Peace Treaty Bed, and Units 3, 4, and 5 (pl. IV) (measured sections 9, 10, 14, 15). Unit 1 is the basal greenish-gray sandstone gradational into orange-brown sandstone, eroding into an escarpment (fig. 2). Unit 2 is a resistant, orange-brown sandstone, locally with a thin, greenish-gray band in the middle, ranging in thickness from 10 to 20 feet, eroding into a prominent escarpment (fig. 3). The Peace Treaty Bed is a 10- to 15-foot

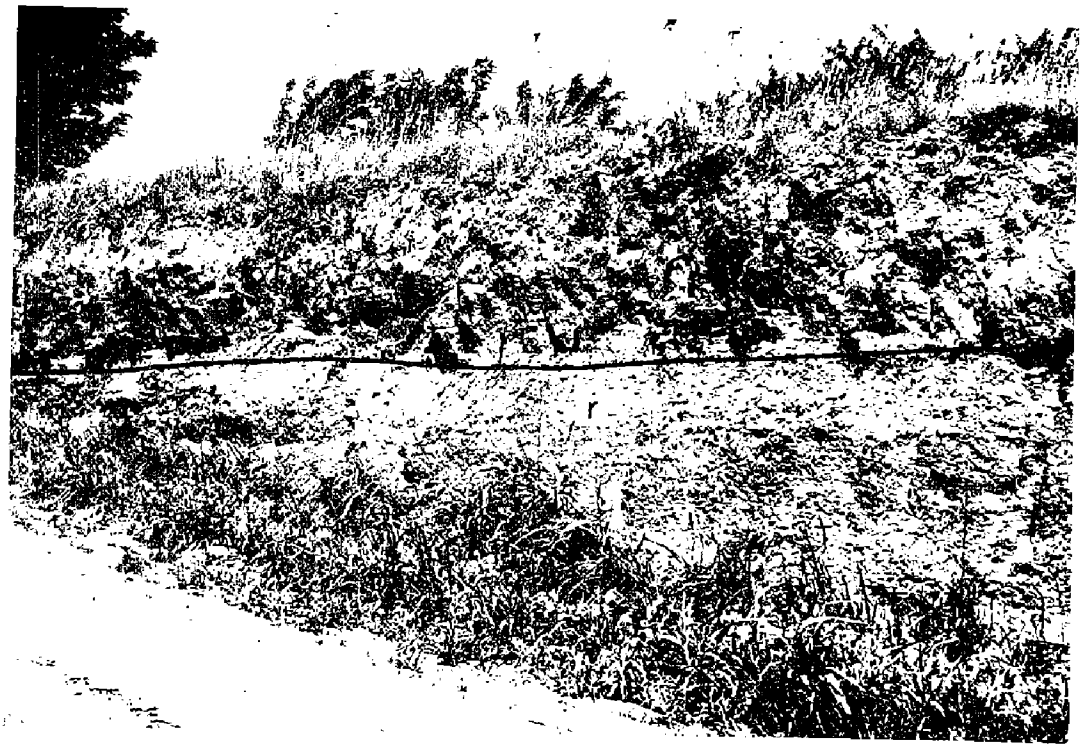

Figure 3. Basal half of Unit 2 of Cedar Hills Sandstone, resting upon shale; view toward the northwest on north side of road in NW¼ sec. 23, T. 27 N., R. 13 W. Note greenish-gray sandstone at base, above the reddish-brown shale (r).

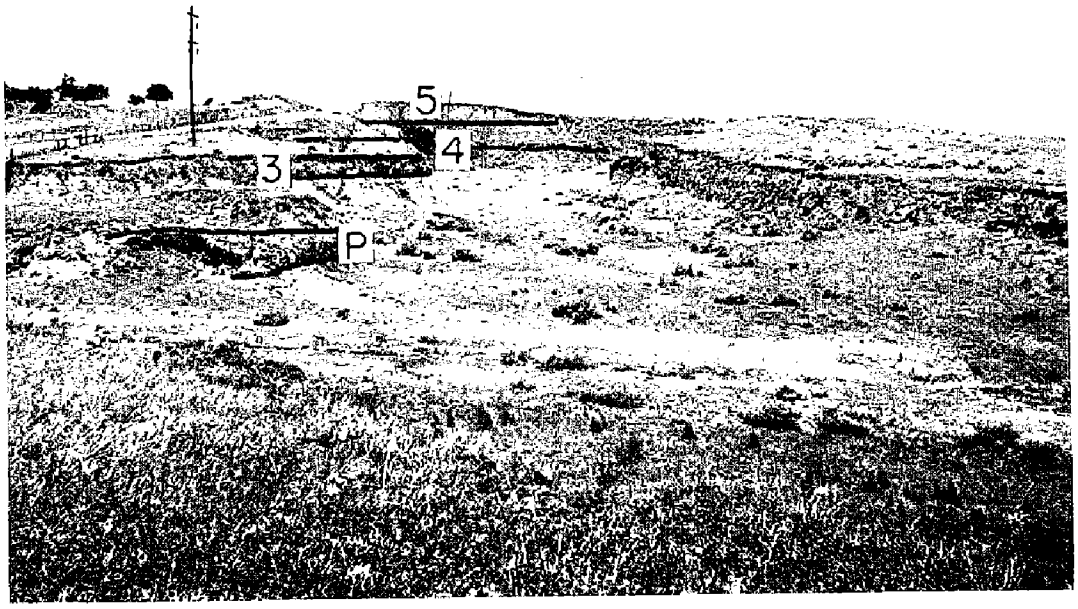

Figure 4. Cedar Hills Member in badlands, with Peace Treaty Sandstone (P), and sandstone Units 3, 4, and 5 eroded into escarpments, with reddish-brown shale beneath each; view toward the north in SW¼ NW¼ sec. 8, T. 27 N., R. 13 W.

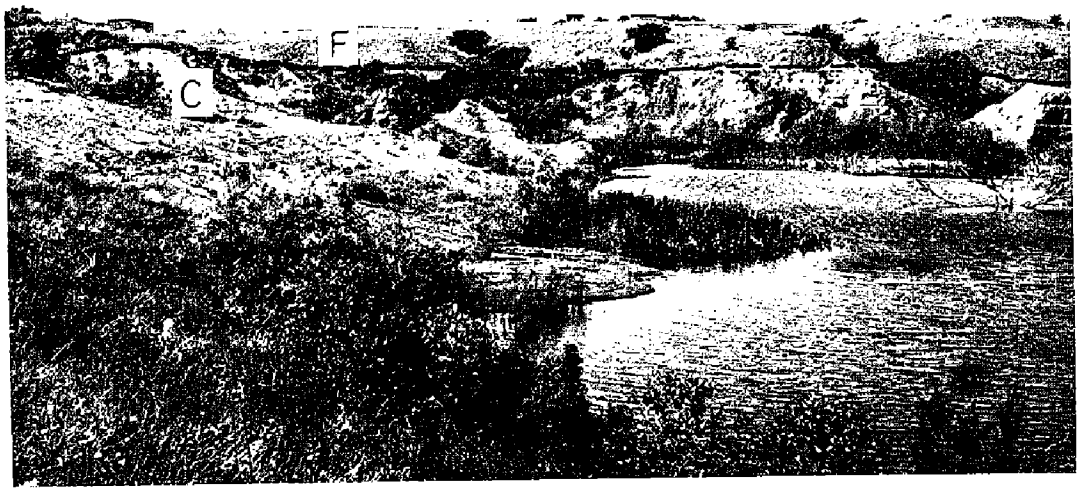

Figure 5. Flowerpot Shale (F) on Cedar Hills Sandstone (C), with about 10 feet of Pleistocene beds at top, west of Alva football field; view toward the southwest in SE¼ NE¼ SE¼ sec. 22, T. 27 N., R. 14 W.

resistant sandstone similar to Unit 2, with a greenish-gray band in the middle, occurring about 105 feet below the top. The Peace Treaty was first mentioned by Norton (1939, p. 1789), and the type area is the state park 2 miles east of Medicine Lodge, Kansas, where this bed forms a natural amphitheater in which a peace treaty was signed with the Indians in 1867. Units 3 and 4 are greenish-gray sandstone beds, and Unit 5 is a greenish-gray sandstone at the top of the Cedar Hills (fig. 4). Unit 5 locally contains gypsum nodules, eroding into a prominent escarpment below the red-brown shale of the Flowerpot (fig. 5), and extends up Eagle Chief Creek to a point a few miles west of Hopeton (pl. I).

In Blaine County, the upper 105 feet of the Cedar Hills is exposed, and five mappable units were designated on the Blaine County map (Fay, 1962, p. 18), all of which are above the Peace Treaty Bed. These units seem to be offset with the higher units in Woods County, except for bed 5. In Blaine County the Cedar Hills is mostly a red-brown shale with a few feet of greenish-gray or orange-brown siltstones. North of the Cimarron in Major County are thicker sandstone units, and south of the river are more shales in the same interval, the change in facies taking place on either side of the river.

In Canadian County the Cedar Hills is about 190 feet thick and is red-brown shale with some thin, greenish-gray siltstone beds and a 5- to 8-foot orange-brown and greenish-gray sandstone at the top and another at the base. The basal sandstone was named the Reeding Sandstone by Schweer (1939, p. 40) for exposures west of Reeding, Kingfisher County, and the upper unit was named Piedmont Sandstone by Schweer (1937, p. 1553) for beds west of Piedmont, Canadian County. The name Piedmont is preoccupied and is discarded, but the name Reeding is valid and may be used. The Duncan Sandstone occurs about 30 feet above the top of the Cedar Hills in Canadian County, showing that the Cedar Hills is not the same as the Duncan. The Duncan is a southern tongue of the Flowerpot Shale (Fay, 1962, p. 19).

No type section has been given for the Cedar Hills in Kansas, so the strata of the following region are here designated as the type: SE¼ sec. 21, NE¼ sec. 28, and SW¼ sec. 24, T. 33 S., R. 12 W., several miles west of Gerlane, Barber County, Kansas. A detailed measured section is given in the appendix as measured section 7.

The total thickness is 179 feet and all named members are present (pl. IV). This section is primarily sandstone and siltstone, with some shale, and is mostly orange brown with some greenish-gray bands. The Cedar Hills area has good exposures of the middle part of the member, but the upper contact is lacking and the lower contact is covered. In the region southwest of Medicine Lodge, Kansas, the upper half of the Cedar Hills is well exposed, but the lower part is not exposed (measured section 6). In the Little Mule Creek area of southern Barber County, Kansas, is a slight increase in the amount of shale (measured section 9), and the Cedar Hills is 183 feet thick.

EL RENO GROUP

The El Reno Group comprises the Flowerpot Shale, Blaine Formation, and Dog Creek Shale (ascending). In Barber and Comanche Counties, Kansas, this group is 250 to 275 feet thick (measured sections 3-6), increasing in thickness southward to 340 feet in the Yellowstone Creek area of northern Woods County (pl. IV) (measured section 9). In the Alva area of central Woods County, the El Reno is about 390 feet thick (measured sections 13, 14), increasing to 470 feet in the Avard-Hopeton area of southern Woods County (measured section 15) and 560 feet in central Major County (measured section 16).

In Blaine County the group is 650 to 750 feet thick, and farther south the El Reno is gradational into the Duncan Sandstone below (lower 100 feet) and the Chickasha Formation above. In northern Stephens County the El Reno is only 200 feet thick but is interpreted to represent the full thickness to the north, owing to thinning along a southern ancient marginal landmass (Fay, 1964, p. 73). The thinner portion of the El Reno in Kansas is termed the northern platform facies, and the thick portion in Blaine County is termed the central basin facies; thus Woods County is in the southern part of the northern platform facies (Fay, 1964, p. 10).

The name El Reno formation, for the town of El Reno, Canadian County, Oklahoma, was first used by Becker (1930, p. 55) for strata between the Hennessey Shale below and the Whitehorse Group above. Schweer (1937, p. 1553) changed the name to El Reno Group, a usage followed by subsequent workers.

Flowerpot Shale Formation

Name.—Cragin (1896, p. 24) used the name "Flower-pot shales" for the 180 feet of shale between the Medicine Lodge Gypsum above and the Cedar Hills Sandstone below, in Flower-pot Mound, Barber County, Kansas. Norton (1939, p. 1792) reported the Flowerpot to be 173 to 190 feet thick in the type area and used the term "Flowerpot shales" for the beds between the dolomite at the base of the Medicine Lodge Gypsum (Cedar Springs Dolomite) and the greenish-gray sandstone at the top of the Cedar Hills Sandstone. The form of the name was changed to Flowerpot Shale by Swineford (1955, p. 64) and Moore and others (1951, p. 39).

Type locality.—The type locality for the Flowerpot Shale is Flower-pot Mound near C SW¼ sec. 26, T. 32 S., R. 13 W., about 8 miles southwest of Medicine Lodge, Barber County, Kansas.

Type section.—The type section for the Flowerpot Shale is here designated as that along the road and the area adjacent from NW¼ NW¼ sec. 29, T. 32 S., R. 12 W., in northeast face of hill, to NW¼ sec. 20, T. 32 S., R. 12 W., about 5 miles southwest of Medicine Lodge, Kansas. There the Flowerpot is 190 feet thick and contains many sandstone units 0.5 to 7 feet thick, some of which

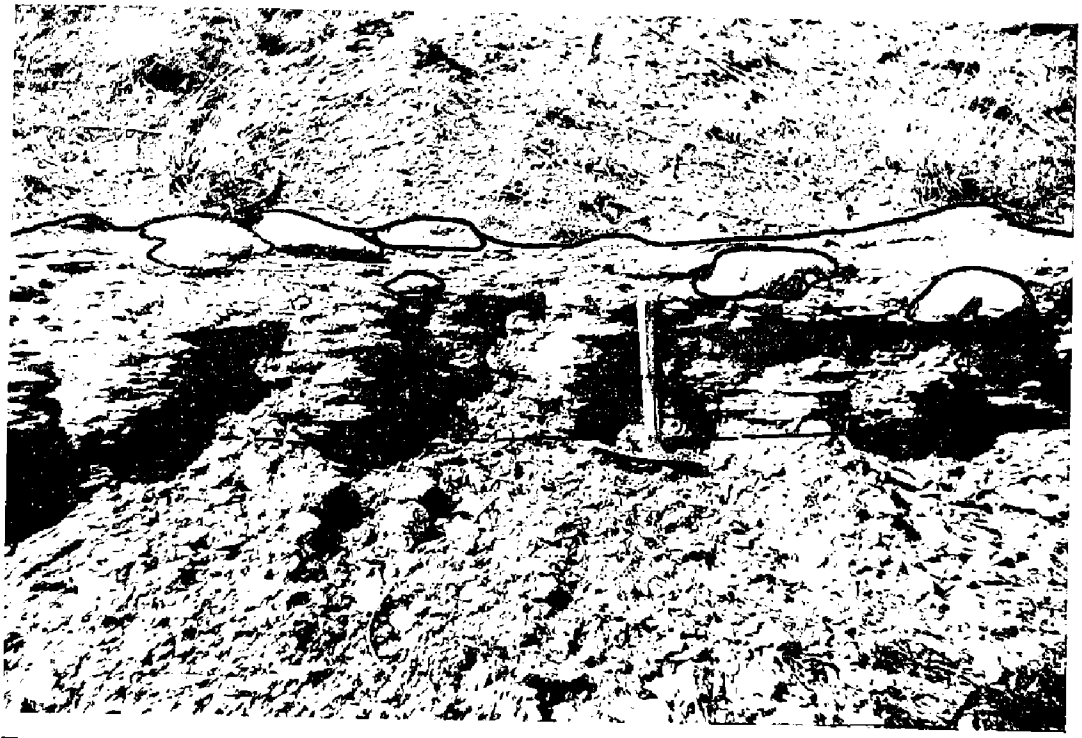

Figure 6. Gypsiferous siltstone Unit 1 of Flowerpot Shale, with large gypsum nodules at top; view toward the north on north side of road, south of Greenwood Creek, in SW¼ SW¼ sec. 9, T. 28 N., R. 15 W.

are numbered Units 1, 2, 3, 3-4, 4, 5, and 6 (measured section 6). The Flowerpot is primarily a red-brown shale with many orange-brown and greenish-gray, fine-grained sandstone and coarse-grained siltstone units in Kansas. The above numbered units may be traced southward into Oklahoma, where they form mappable ledges. Some ledges contain gypsum cement or gypsum nodules.

Description in Woods County.—In Woods County the Flowerpot Shale is 220 to 380 feet thick, with less sandstone in the section southward, but with mappable Units 1, 2, 3, 3-4, 4, 5, and 6 traceable over the entire county (pls. I, IV). Northward in the Yellowstone and Greenwood Creek areas, the Flowerpot is 222 to 228 feet thick, and Units 1-6 are 50, 68, 90, 125, 154, 174, and 211 feet above the base, respectively, in the Yellowstone Creek section (measured section 9). The numbered units are primarily greenish-gray and orange-brown siltstone beds, less than 3 feet thick, the lower two of which contain much gypsum. Unit 1 is characterized by having gypsum nodules up to one foot in diameter (fig. 6). Unit 2 is eroded into a prominent escarpment of light-colored rocks, forming one of the more prominent mappable units in the county (fig. 7), containing much gypsum cement. Unit 3 is also a gypsiferous silt-

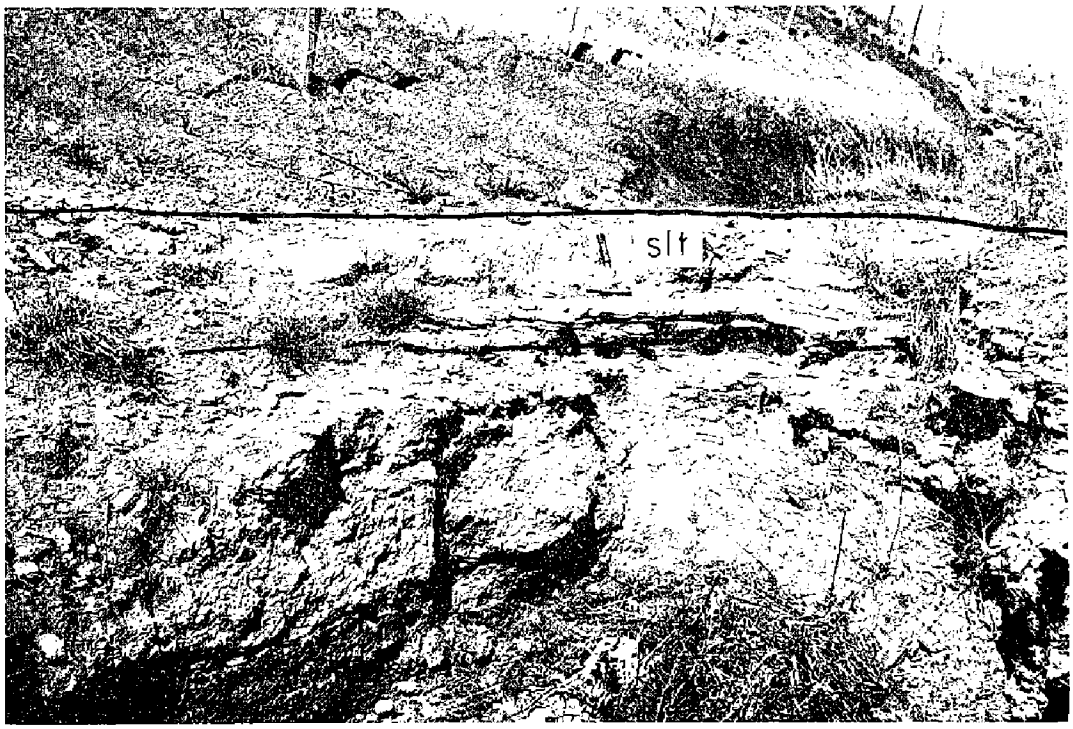

Figure 7. Gypsiferous siltstone Unit 2 of Flowerpot Shale (slt); view toward the east on north side of road, in SE¼ SW¼ sec. 10, T. 28 N., R. 15 W.

Figure 8. Gypsiferous siltstone Unit 3 of Flowerpot Shale, on reddish-brown shale; view toward the east in SW¼ SW¼ SW¼ sec. 30, T. 29 N., R. 15 W.

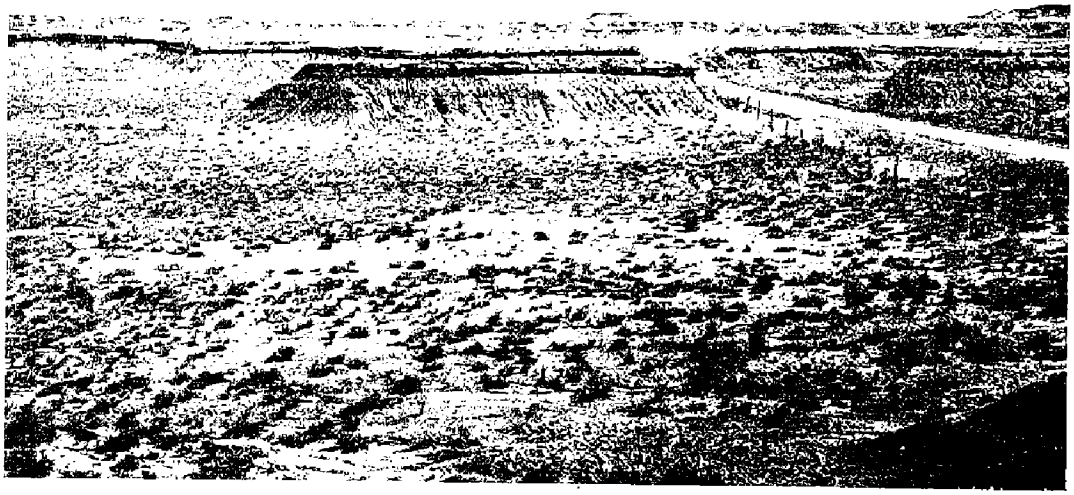

Figure 9. Escarpment of Unit 3 of Flowerpot Shale in badlands country; view toward the south in SE¼ SE¼ SE¼ sec. 25, T. 29 N., R. 16 W.

stone, eroded into a prominent escarpment in badlands country (figs. 8, 9), locally with a thin dolomite at the top. Units 3-4, 4, 5, and 6 contain relatively small amounts of gysum but are eroded into prominent bands in the red-brown shale of the Flowerpot (fig. 10). In southern Woods County near Avard and eastward along Eagle Chief Creek, Units 1-6 are 57, 89, 133, 207, 250, 288, and 340 feet above the base, respectively, and the total thickness of the Flowerpot is 356 feet (measured section 15). The units are lithologically about the same as the section to the north, but Unit 6 is slightly thicker, and the intervals between units are thicker, showing increased thickness southward within all parts of the Flowerpot Shale. A greenish-gray shale occurs above Unit 6, and a thin, gray dolomite occurs above the shale (fig. 10), traceable southward into the Glass Mountains of Major County. In southern Major County the dolomite contains salt casts and occurs about 20 feet below the top of the Flowerpot, thinning out into shale in northern Blaine County (pl. IV) (measured section 16).

In the Edith area along the Cimarron River, a 57-foot bed of rock salt occurs beneath the river bed, according to Ward (1961b,

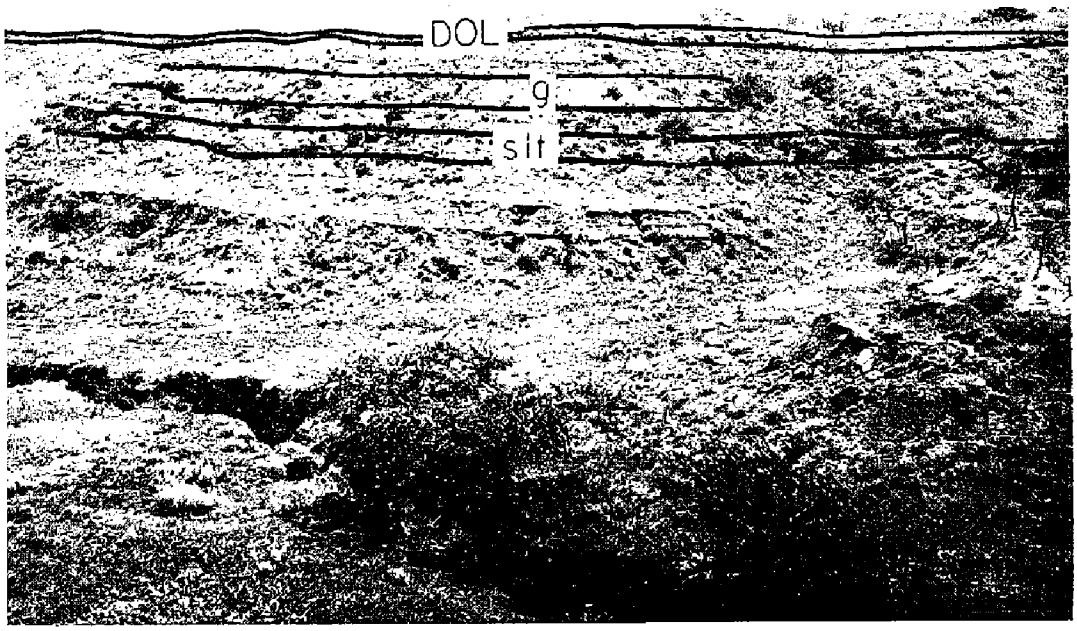

Figure 10. Cedar Springs Dolomite (DOL) above upper part of Flowerpot Shale, with 6-foot, tan siltstone Unit 6 (slt) about 20 feet below top and 6-foot, greenish-gray shale (g) about 10 feet below top of Flowerpot Shale; view toward the east, east of road, in SW¼ NW¼ sec. 23, T. 25 N., R. 15 W.

p. 275). The exposed portion of the Flowerpot Shale in SE¼ sec. 24, T. 27 N., R. 20 W., in Harper County along the Cimarron River is 72 feet (Fay, 1964, p. 140). The upper 100 feet of Flowerpot is exposed between Edith and Freedom in NW¼ sec. 28, T. 27 N., R. 18 W., along the river (measured section 11). Edith is about halfway between these areas, and so the top of the river bed would be about 85 feet below the top of the Flowerpot and the top of the salt would occur 30 to 138 feet below the surface of the alluvium, or 115 to 221 feet below the top of the Flowerpot. The alluvium is about 15 feet thick and the channel is about 55 feet deep, so that part of the salt deposit north of the river is actually above the base of the channel by about 30 feet. The deep channel is about half a mile north of the present river, and the shallowest part of the salt is about half a mile north of the center of this old channel. The total thickness of salt or salty shale in the Flowerpot in this area is less than 200 feet, according to Jordan and Vosburg (1963, p. 62), and the total thickness of the Flowerpot is about 300 feet, so that the salt sequence is in the lower two-thirds of the Flowerpot. The 57-foot bed is about 20 percent shale and 80 percent halite, and the top is about 150 feet below the top of the Flowerpot, which would be between Units 2 and 3-4 of the measured sections. A 1-inch, greenish-gray zone with salt casts occurs between Units 1 and 2 in NW¼ SW¼ NW¼ sec. 4, T. 25 N., R. 14 W., about 3 miles west of Hopeton, showing that salt was present in this part of the Flowerpot in eastern Woods County (measured section 15).

Blaine Formation

Name.—The name "Blaine division" was first used by Gould (1902, p. 47) for gypsums and shales beneath the Dog Creek Shale and above the Flowerpot Shale. The name was changed to Blaine Formation by Gould (1905, p. 44). The name Cave Creek Formation was used by Cragin (1896, p. 27) for the same sequence, but a series of miscorrelations led Gould to believe that the Blaine of Oklahoma included some of the Flowerpot of Kansas, and he used the name Blaine. The details of the miscorrelations are discussed by Fay (1962, p. 31, 35; 1964, p. 28, 30, 32). The name Blaine For-

mation has been extensively used and the term Cave Creek has fallen into disuse.

Type locality.—The type locality for the Blaine Formation is the region around Roman Nose Canyon and Salt Creek Canyon of Blaine County. The type locality for the Cave Creek Formation is Cave Creek, at Comanche Cave, NE¼ sec. 2, T. 34 S., R. 17 W., Comanche County, Kansas.

Type section.—The type section for the Blaine Formation is the exposure along State Highway 33 about 7 miles east of Watonga in secs. 19, 30, and SW¼ sec. 20, T. 16 N., R. 10 W., Blaine County (Fay, 1962, p. 33). The type section for the Cave Creek is that at Comanche Cave in NE¼ sec. 2, T. 34 S., R. 17 W., Comanche County, Kansas (Fay, 1964, p. 46, 110) (measured section 4).

Description in Woods County.—In Woods County, the Blaine is approximately 50 to 75 feet thick and consists of three gypsum members with dolomites at the base of each, separated by two shales about 7 to 10 feet or more thick (measured sections 9-15). The dolomites and gypsums erode into prominent escarpments in the northwestern part of the county, extending into a ridge southeastward

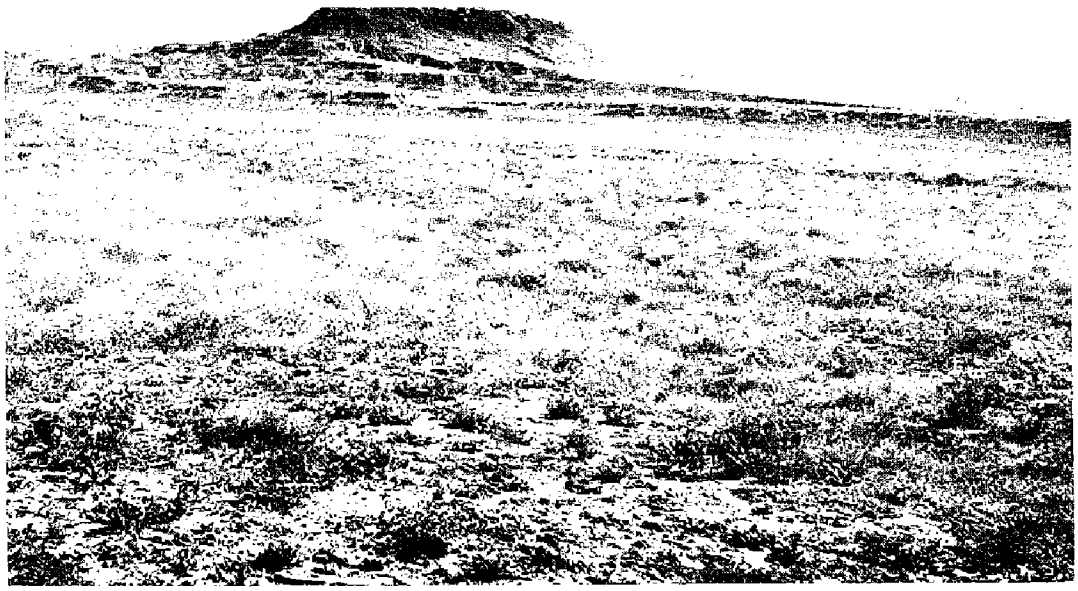

Figure 11. Butte of Flowerpot Shale capped by Medicine Lodge Gypsum; view toward the south, south of Greenwood Creek, in NE¼ SE¼ sec. 13, T. 28 N., R. 16 W. The hill is about 180 feet high.

from Avard. The early settlers termed this region the Gypsum Hills (fig. 11).

The named units of the Blaine are (ascending) Cedar Springs Dolomite Bed, Medicine Lodge Gypsum Member, Magpie Dolomite Bed, Nescatunga Gypsum Member, Altona Dolomite Bed, and Shimer Gypsum Member; shale beds between the Medicine Lodge and Magpie and between the Nescatunga and Altona are unnamed.

CEDAR SPRINGS DOLOMITE BED

Name.—The name Cedar Springs Dolomite Bed, for the town of Cedar Springs, southern Major County, was first used by Fay (1962, p. 34) for the dolomite at the base of the Blaine Formation.

Type section.—The section exposed in the bluff of Sand Creek in NW¼ sec. 20, T. 20 N., R. 12 W., southern Major County, was designated the type section.

Description in Woods County.—In Woods County the Cedar Springs is a light-gray to light-brown, fine-grained, dense to oölitic dolomite 0.25 to 2.5 feet thick (measured sections 9-15). The thicker portion is in the Avard area (measured section 15), where the basal 1.5 feet is a greenish-gray, dolomitic shale. The Cedar Springs forms a prominent escarpment in the region east of Waynoka and accounts for the high ridge separating the Salt Fork Pleistocene deposits from the Cimarron River deposits. The average elevation along this ridge is about 1,700 feet, whereas the rivers are 1,250 to 1,300 feet above sea level.

MEDICINE LODGE GYPSUM MEMBER

Name.—The name Medicine Lodge Gypsum, for the town and river of Medicine Lodge, Barber County, Kansas, was first used by Cragin (1896, p. 28) for the basal gypsum of the Blaine Formation. The basal dolomite was included with this unit.

Type section.—The type section for the Medicine Lodge Gypsum Member is that at Comanche Cave on Cave Creek in NE¼ sec. 2, T. 34 S., R. 17 W., Comanche County, Kansas (Fay, 1964, p. 34, 110). The Medicine Lodge is 27 feet thick there and contains some anhydrite lenses in the middle (measured section 4).

Description in Woods County.—The Medicine Lodge is about 15 feet thick east of Waynoka in southern Woods County and is 22 to 31 feet thick in northwestern Woods County (measured sections 9-15). It is a fine- to medium-grained, white to gray gypsum, with

Figure 12. Blaine Formation; view toward the northeast, north of iron bridge, in SW¼ sec. 5, T. 28 N., R. 16 W. The three gypsum members are present in this region, with the Medicine Lodge (M) at base, the Nescatunga (N) in middle, and Shimer (S) at top, with reddish-brown shale between, totaling 64 feet in thickness.

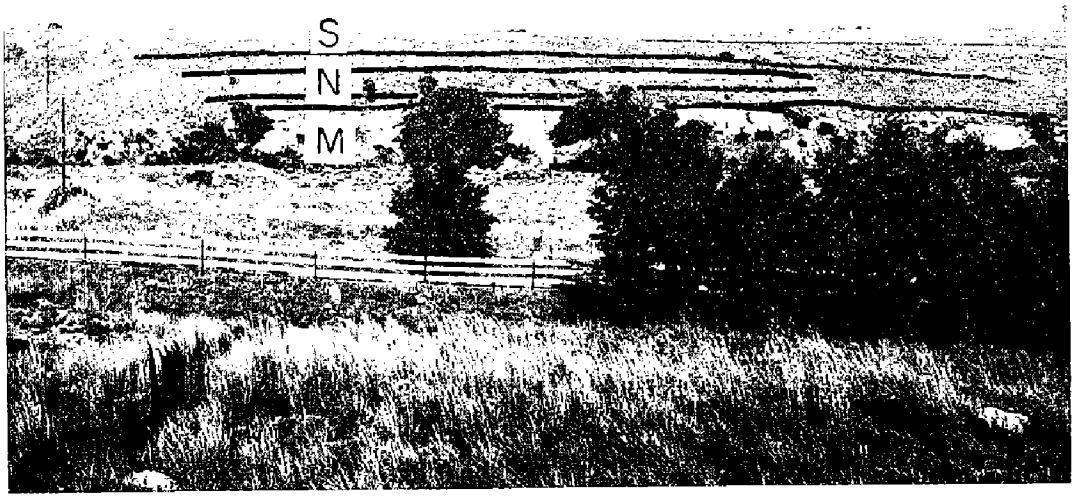

Figure 13. Blaine Formation on West Moccasin Creek; view toward the east, in NE¼ NW¼ sec. 7, T. 27 N., R. 18 W. The three gypsum members, Medicine Lodge (M), Nescatunga (N), and Shimer (S), are present in this area.

many coarse selenite crystals, and forms the cap rock for most of the Gypsum Hills (fig. 11). It is well developed in the Yellowstone Creek and Mocassin Creek areas (figs. 12, 13).

The overlying shale is a red-brown, gypsiferous clay shale with some greenish-gray streaks, 7 to 12 feet thick, the thicker section being southward.

MAGPIE DOLOMITE BED

Name.—Gould (1902, p. 48) first applied the name Magpie Dolomite to the 1-foot dolomite at the base of the Nescatunga Gypsum, named after the camp of the Arapahoe chief, Magpie, on Bitter Creek in Roman Nose State Park, Blaine County. Because of miscorrelations Gould called the overlying gypsum the Medicine Lodge in this area.

Type section.—The type section for the Magpie is that on State Highway 33, in secs. 19, 30, T. 16 N., R. 10 W., Blaine County (Fay, 1962, p. 39).

Description in Woods County.—The Magpie Bed is a 0.2- to 0.75-foot, tan to greenish-gray siltstone in the northwestern part of Woods County and is a 1-foot, tan to light-gray dolomite in southern Woods County, east of Waynoka (measured sections 9-15). It does not form a prominent escarpment and is found at few places.

NESCATUNGA GYPSUM MEMBER

Name.—Norton (1939, p. 1794-1795) first used the term Nescatunga Gypsum for the 3- to 9-foot gypsum bed between the Medicine Lodge and Shimer Gypsum beds along Nescatunga River (Salt Fork), Comanche County, Kansas. The basal Magpie dolomite was included with this unit, but this has now been separated (Fay, 1962, p. 41).

Type section.—The type section for the Nescatunga Gypsum is that at Comanche Cave on Cave Creek, in NE¼ sec. 2, T. 34 S., R. 17 W., Comanche County, Kansas, where the gypsum is 2 feet thick (Fay, 1964, p. 40, 110, 112). The basal Magpie Bed is missing (measured section 4).

Description in Woods County.—In northwestern Woods County, the Nescatunga is 10 to 11 feet thick and is a white, fine-grained gypsum. It is absent in most places but is present where the overlying Shimer is thick and in the V-shaped valleys at the heads of streams (figs. 12, 13). It is absent in southern Woods County

owing to erosion and solution, but the underlying dolomite is present (measured sections 9-15). Northward in Kansas the bed is only 2 feet thick, and north of Cave Creek it is absent or unrecognizable (measured sections 3-5).

The overlying shale is a red-brown clay shale with some gypsum crystals, ranging in thickness from 7.5 to 17 feet, the thicker portion to the south. A greenish-gray shale occurs at the top, just below the Altona Dolomite.

ALTONA DOLOMITE BED

Name.—Gould (1902, p. 48) used the name Altona Dolomite, for Altona, southwestern Kingfisher County, for the bed at the base of the Shimer Gypsum.

Type section.—The type section for the Altona Dolomite Bed is that on State Highway 33, in secs. 19, 30, T. 16 N., R. 10 W., 7 miles east of Watonga, Blaine County. Here the dolomite is light gray to yellow gray, oölitic to fine grained, with fossils, and about 1 foot thick (Fay, 1962, p. 44).

Description in Woods County.—In Woods County, the Altona is 0.3 to 1 foot thick and is a light-gray to tan, fine-grained to

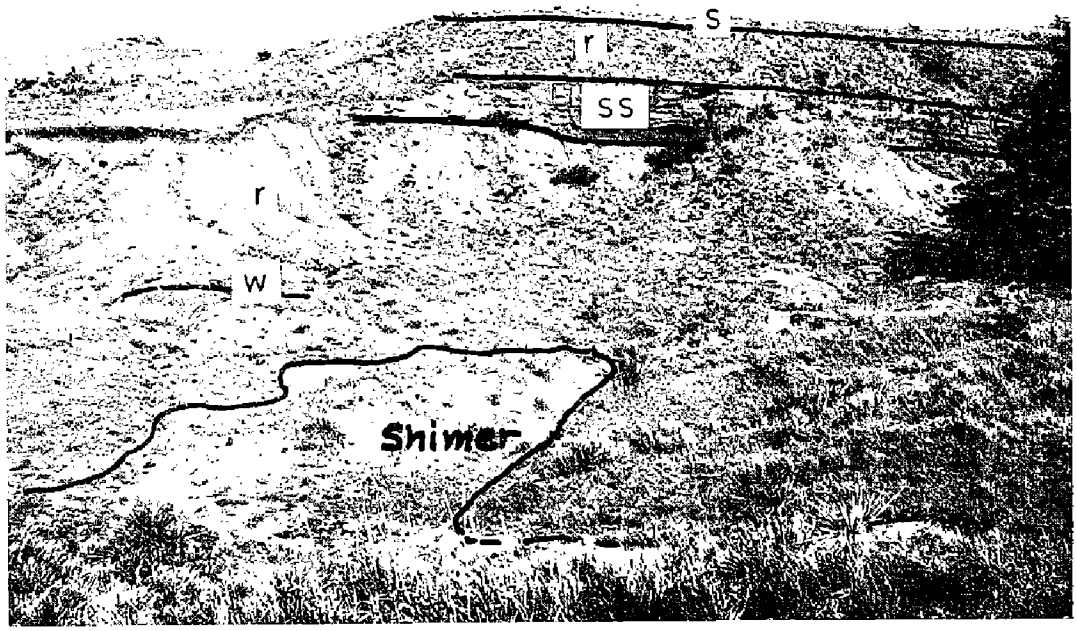

Figure 14. Dog Creek Shale above Shimer Gypsum; view toward the southeast, in SE¼ SW¼ sec. 21, T. 28 N., R. 16 W. The Southard Dolomite (s) caps the ridge, with about 12 feet of reddish-brown shale (r) below. The middle orange-brown sandstone (ss) is about 6 feet thick, and the Watonga Bed of calcitic siltstone (w) is about 5 feet above the top of the Shimer.

oölitic dolomite, weathering into boxworks. It is thicker to the south and is eroded into a prominent escarpment, commonly marking the top of the Blaine Formation. In places fossils occur in the Altona but they are not common (measured sections 9-15).

SHIMER GYPSUM MEMBER

Name.—The name Shimer Gypsum, for Shimer Township, Comanche County, Kansas, was first used by Cragin (1896, p. 27) for the uppermost gypsum member of the Blaine Formation. Evans (1931, p. 410-411) used the name Lovedale gypsum for what he considered a higher unit in the Blaine in Harper County, but work by Myers (1959, p. 30-32) showed that the Lovedale is the same as the Shimer.

Type section.—The type section for the Shimer Gypsum is that at Comanche Cave on Cave Creek, in NE¼ sec. 2, T. 34 S., R. 17 W., Comanche County, Kansas, where it is a white, fine-grained gypsum, 14 feet thick (Fay, 1964, p. 46, 111) (measured section 4).

Description in Woods County.—The Shimer is an 11- to 19-foot, white, fine-grained gypsum, eroding into a prominent escarpment in northwestern Woods County. Although absent in most places, it occurs at many places where the Dog Creek is thick, such as the headwaters of Yellowstone and Greenwood Creeks or along Mocassin Creek (figs. 12-14). The Shimer marks the top of the Blaine Formation in Woods County and is conformable with beds above and below (measured sections 9-15).

Dog Creek Shale Formation

Name.—Cragin (1896, p. 39-40) first used the term Dog Creek shales, for Dog Creek, northwestern Barber County, Kansas, for the beds between the Cave Creek (Blaine) Formation below and the Red Bluff beds (now Whitehorse) above. The lower boundary was raised from the Medicine Lodge Gypsum to the Altona Dolomite in this area by Fay (1964, p. 53), and the revised total thickness is 30 feet (measured section 5).

Type section.—The type section (measured section 5) for the Dog Creek Shale is that on State Highway 160, in N½ sec. 9, T. 32 S., R. 14 W., Barber County, Kansas (Fay, 1962, p. 51).

Description in Woods County.—In Woods County, the Dog Creek is primarily a red-brown, silty shale 48 to 62 feet thick, with

a gypsum and a siltstone unit in the lower 10 feet, termed Haskew Gypsum Bed and Watonga Bed, with an orange-brown sandstone about 10 feet above, and an upper dolomite termed Southard Dolomite Bed about 5 to 20 feet or more below the top (measured sections 9-13). Several thin dolomites occur above the Southard but are unnamed (figs. 14-19). The named units and dolomites form local escarpments, the most prominent being the Southard Bed with its underlying greenish-gray shale that is commonly found slumped over much of the outcrop area of northwestern Woods County.

HASKEW GYPSUM BED

Name.—The name Haskew Gypsum was applied by Evans (1931, p. 411) to a 4-foot gypsum unit about 4 feet above the top of the Shimer Gypsum. It was named for Haskew township and Haskew store in northwestern Woodward County. In Harper and Woodward Counties it is used as the upper boundary of the Blaine Formation, but in Major and Woods Counties it is included in the Dog Creek Shale because it occurs only in the western parts of those counties (measured sections 11, 16).

Type section.—The type section for the Haskew is in SW¼ SW¼ sec. 6, T. 25 N., R. 18 W., east of State Highway 50 in a creek

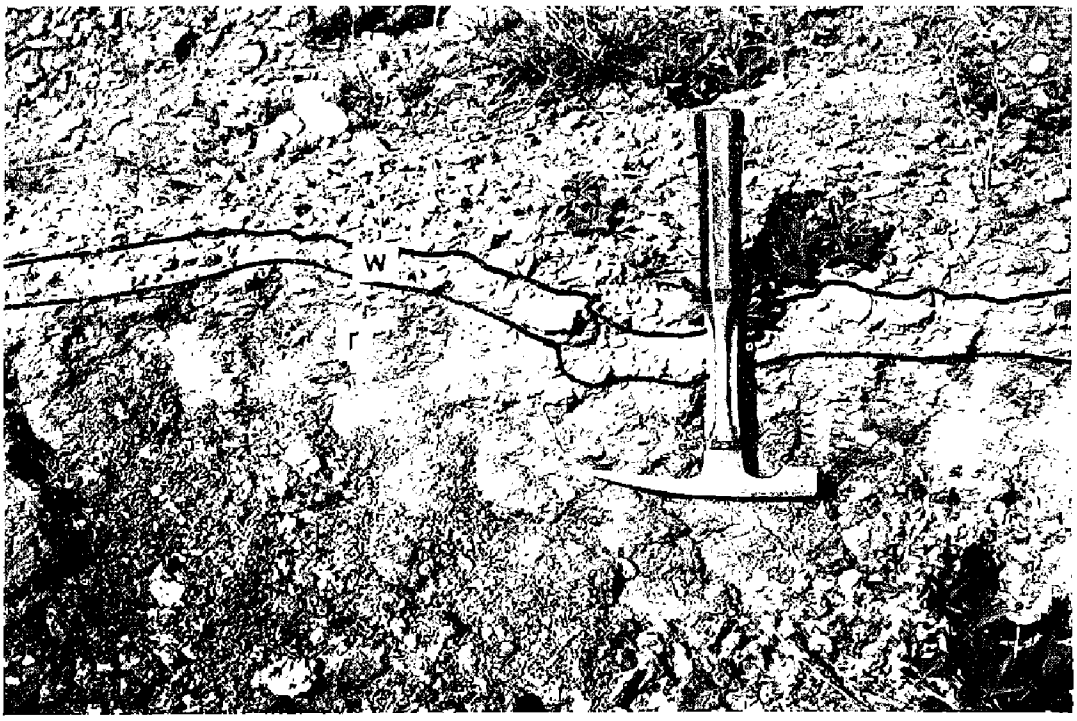

Figure 15. Watonga Bed; closeup view in SE¼ SW¼ sec. 21, T. 28 N., R. 16 W. The Watonga (w) is a greenish-gray, ripple-marked, calcitic siltstone, about 2 inches thick, resting upon reddish-brown shale (r), and is exposed in few places.

bank, northwestern Woodward County (Fay, 1962, p. 54; 1964, p. 55-57).

Description in Woods County.—The Haskew occurs in northwestern Woods County from West Moccasin Creek westward and is divisible into three units. The lower 2.75 feet is a white, fine-grained, massive gypsum, occurring 4.5 feet above the top of the Shimer. This basal gypsum is overlain by 1.2 feet of red-brown gypsiferous shale, and this in turn is overlain by 1.3 feet of red-brown and greenish-gray gypsum and siltstone. The Watonga Bed occurs about 11 feet above the Haskew, the intervening section being red-brown shale with some greenish-gray gypsum and shale (measured section 11). The Haskew has not been identified in Kansas and should not be included in generalized sections for that state.

WATONGA BED

Name.—The name Watonga Dolomite Bed, for the town of Watonga, was first applied by Fay (1962, p. 56) to a 3- to 7-foot

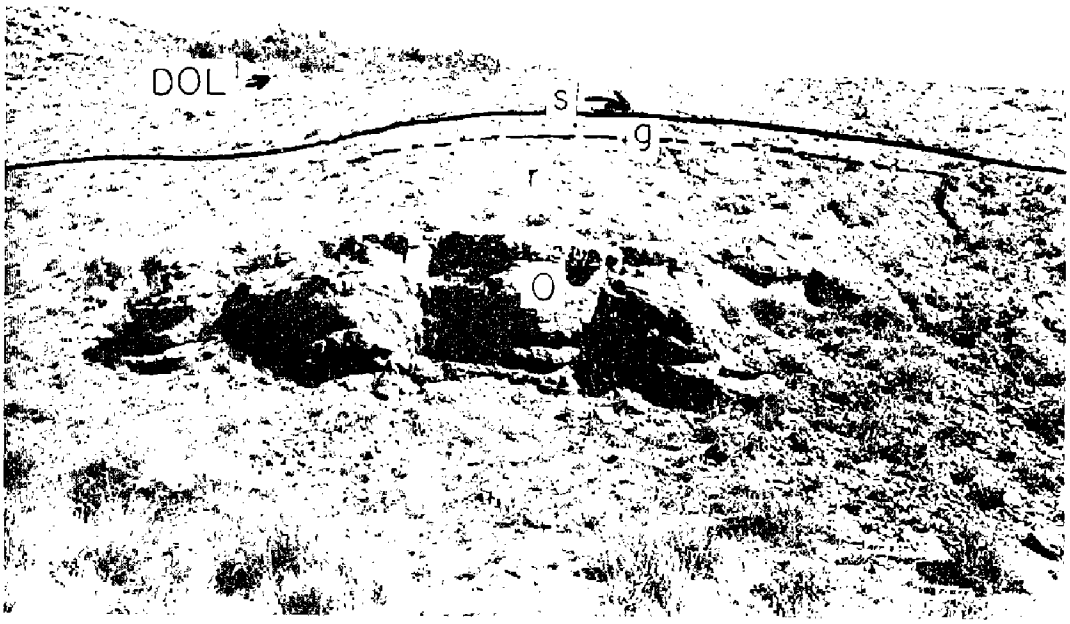

Figure 16. Middle part of Dog Creek Formation; view toward the north along a west branch of West Moccasin Creek, in SE¼ SW¼ NW¼ sec. 31, T. 28 N., R. 18 W. At the base is the even-bedded, orange-brown sandstone and siltstone (O), about 6 feet thick, overlain by about 8 feet of reddish-brown shale (r), and 2 feet of greenish-gray siltstone (g). The Southard Dolomite (s) and a stray dolomite (DOL) cap the hill. The hill on the left is probably slumped Marlow Sandstone.

dolomite and siltstone occurring about 25 to 40 feet above the top of the Shimer Gypsum in Blaine County.

Type section.—The type section for the Watonga Bed is that on State Highway 33, about 7 miles east of Watonga, Blaine County, in SW ¼ sec. 19, T. 16 N., R. 10 W., and SE¼ sec. 24, T. 16 N., R. 11 W. (Fay, 1962, p. 56).

Description in Woods County.—The Watonga is a greenish-gray, calcitic, ripple-marked siltstone, 0.1 to 0.8 foot thick, occurring from 3 to 6 feet above the Shimer, or about 21 feet above the Shimer where the Haskew is present (figs. 14, 15). It is overlain by red-brown, silty shale with some greenish-gray siltstones and sandstones, 3 to 17 feet thick, above which is a 5- to 9-foot, orange-brown and greenish-gray sandstone and siltstone bed (fig. 16). In a region where the overlying Marlow Formation is slumped, the lithology of this sandstone bed is almost identical with that of the Marlow, and one might conclude that the Marlow is almost resting upon the

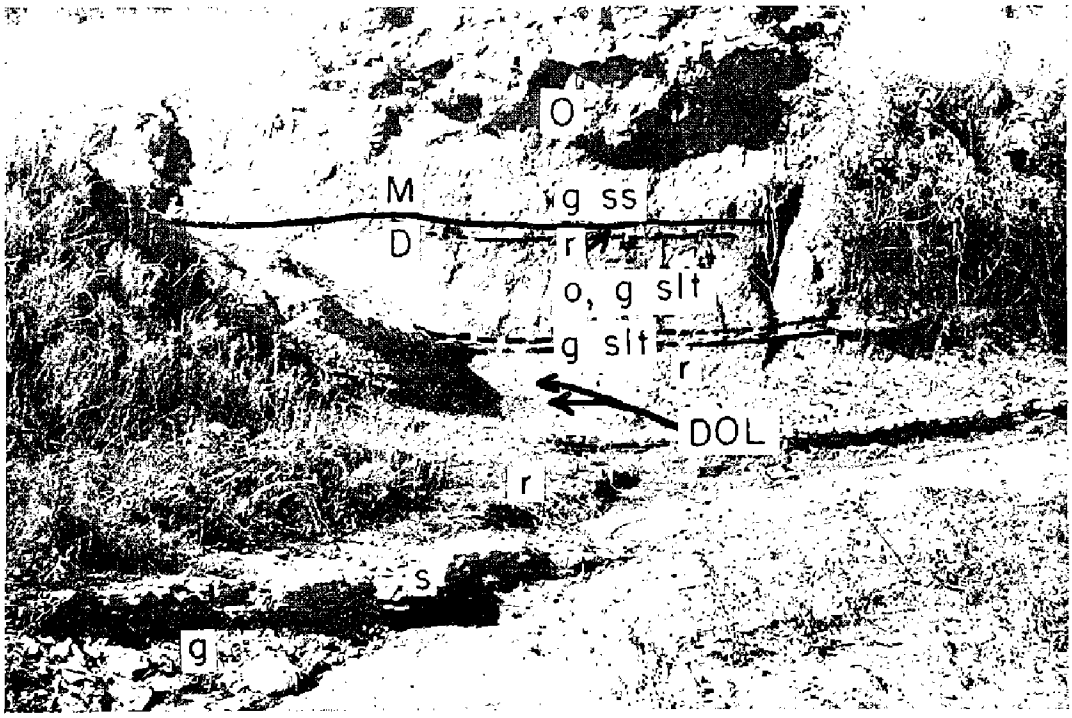

Figure 17. Marlow Formation (M) on Dog Creek Shale (D); view toward the southwest, on a west branch of West Moccasin Creek, in SE¼ NE¼ NE¼ sec. 36, T. 28 N., R. 19 W. The Marlow is an orange-brown, fine-grained sandstone (O), with a basal 1-foot, greenish-gray sandstone (g ss), probably conformable upon the reddish-brown shale (r) of the Dog Creek. The Southard Dolomite (s) is about 5 inches thick, above a 2-foot, greenish-gray shale and siltstone (g) in creek bottom. The unit between the Southard Bed and Marlow base is reddish-brown shale (r) with interbedded, fine-grained dolomite (DOL), greenish-gray siltstone (g slt), and orange-brown to greenish-gray siltstone (o, g slt).

Shimer in places, thus postulating a major unconformity in the region.

The middle sandstone ledge is overlain by 9 to 12 feet of red-brown shale with some greenish-gray beds, the upper 1 to 3 feet a greenish-gray siltstone and shale immediately beneath the Southard Dolomite Bed. Locally a few thin dolomites occur in this upper shale, forming a light-colored zone and prominent marker bed near the middle and top of the Dog Creek (measured sections 9-13).

SOUTHARD DOLOMITE BED

Name.—The name Southard Dolomite Bed was first used by Fay (1962, p. 58) for a 3- to 4-inch light-gray, dense dolomite that occurs about 80 feet above the base of the Dog Creek Shale in Blaine County, about 1 mile south of Southard.

Type section.—The type section for the Southard is that along State Highway 51A in SW¼ sec. 10, T. 18 N., R. 12 W., 1 mile south of Southard, Blaine County (Fay, 1962, p. 59).

Description in Woods County.—In Woods County, the Southard is a light-gray, dense, fine-grained dolomite, ranging in thick-

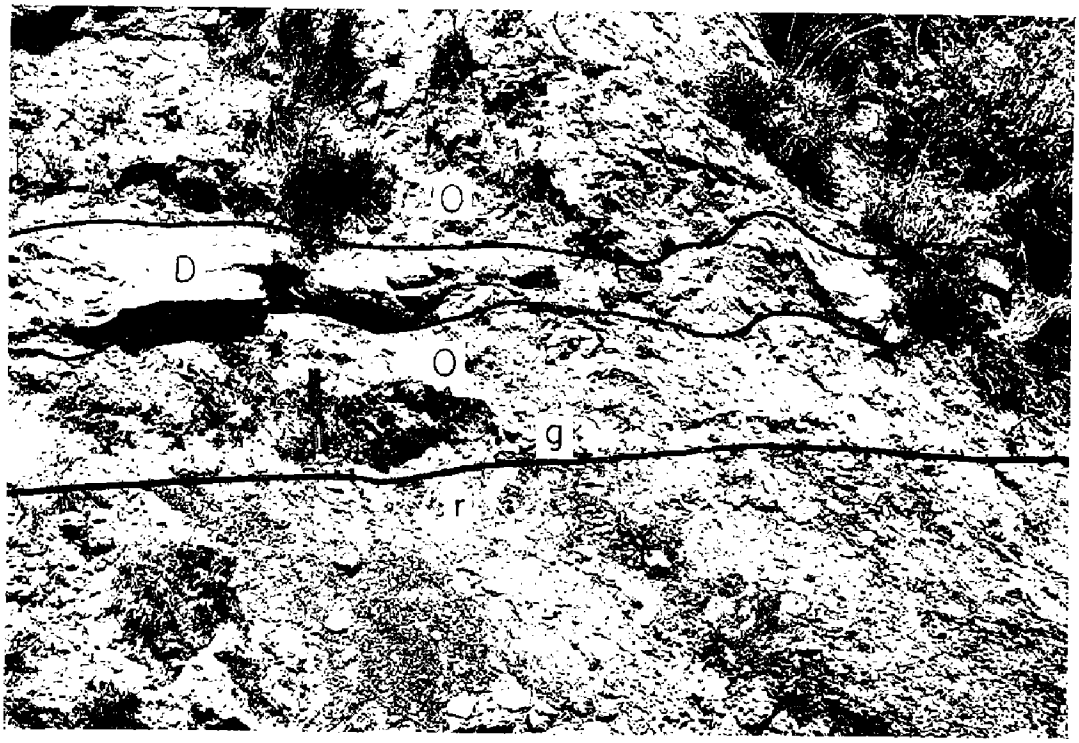

Figure 18. Marlow-Dog Creek contact (at hammer head) in east side of hill; view toward the west, in NW¼ NW¼ SW¼ sec. 11, T. 27 N., R. 16 W. A 1.5-foot lentil of orange-brown, coarse-grained Doe Creek Sandstone (D) is interbedded with fine-grained, orange-brown Marlow Sandstone (O). The basal Marlow is a 0.5-1.5-foot, greenish-gray sandstone (g), resting upon the reddish-brown shale (r) of the Dog Creek.

ness from 0.1 to 0.4 feet, eroding into a prominent ledge (figs. 16, 17, 19). Locally it contains salt casts, thus showing that salt was present in this part of the Dog Creek Shale in Woods County.

The overlying section is principally red-brown shale with several thin dolomites, ranging in thickness from 5 to 24 feet, the thicker section southward (figs. 17-19). The Dog Creek appears to be conformable with the overlying Marlow Formation, taking into account the regional thinning northward of the Dog Creek Shale and the peculiar occurrence of the Doe Creek Sandstone Lentil of the Marlow, which locally rests upon the Dog Creek in the Whitehorse Springs area (measured sections 9-13). A structure contour map based upon points taken at the top of the Dog Creek Shale or base of the Marlow Formation shows no major unconformity at the base of the Marlow in Oklahoma, Texas Panhandle, or Kansas in the subsurface (pl. III). Instead a facies change, occurring westward at the base of the Marlow from fine-grained sandstone to the east

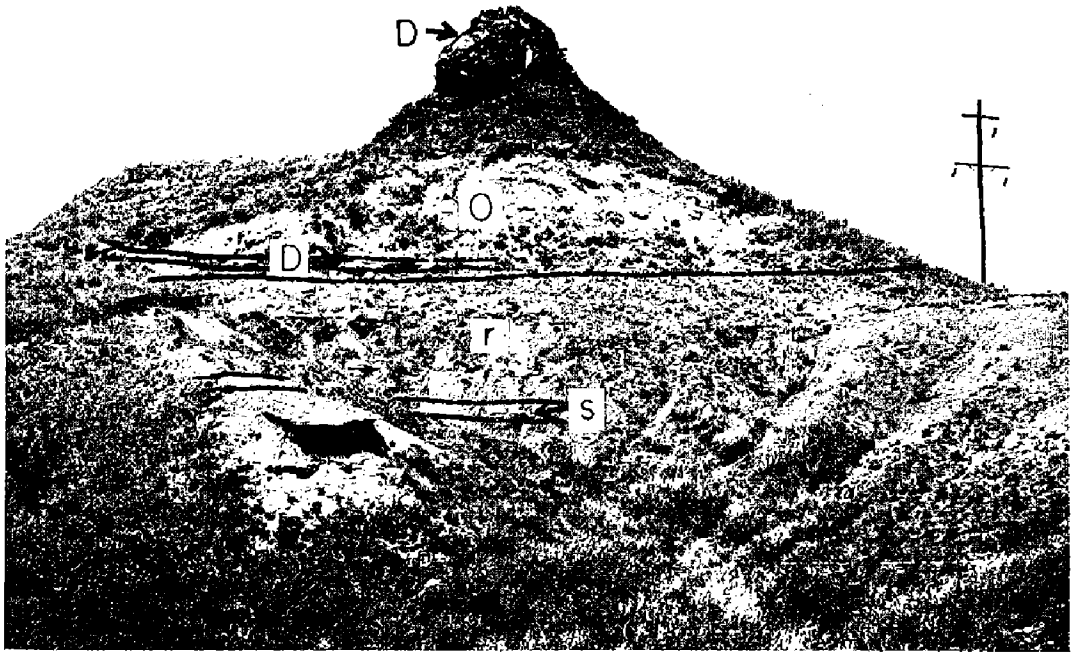

Figure 19. Doe Creek Lentil and Marlow Formation on Dog Creek Shale; view toward the west, on east side of hill, in NW¼ NW¼ SW¼ sec. 11, T. 27 N., R. 16 W. The Doe Creek (D) is a resistant, orange-brown, calcitic sandstone and conglomerate with much sparry calcite, eroded into a 19-foot cap above 28 feet of orange-brown, fine-grained Marlow Sandstone (O), with a 1.5-foot lentil near the base of the Marlow. The Dog Creek is a reddish-brown shale (r) with orange-brown and greenish-gray siltstones and fine-grained dolomites in the middle. The Southard Dolomite (s) is about 25 feet below the top.

to gypsum and dolomite to the west, shows that the Dog Creek and Marlow were once marginal marine sediments in a sinking basin. The Dog Creek and Blaine Formations are almost inseparable in the subsurface because the Dog Creek contains more gypsum units similar to the Blaine units, but the Dog Creek-Blaine interval remains constant below the Marlow, taking into account regional thickening southward into the Anadarko basin and solution work on salt and gypsum.

Custerian Series

The Custerian Series was named by Roth (1932, p. 689) for the redbeds above the El Reno Group to the top of the redbed sequence. Roth thought that this part of the column was Triassic, but fossils in the Whitehorse Group at the base are Permian in age. The type region for the Custerian Series is Custer County and adjacent areas. The series includes the Whitehorse Group, overlain by the Cloud Chief Formation, Doxey Shale, and Elk City Sandstone. The term Quartermaster Formation or Group is here discarded because of a lack of grouping of the Doxey and Elk City into a natural unit, based upon work in Custer County. In Oklahoma the Custerian Series is approximately 1,155 feet thick in eastern Beckham County near the axis of the Anadarko basin, the Whitehorse 385 feet thick, the Cloud Chief 430 feet, Doxey 165 feet, and exposed Elk City 185 feet (Ham and Jordan, 1961, p. 6-7). Farther north in Custer County, the Whitehorse is 360 to 410 feet thick, the Cloud Chief 175 feet, the Doxey 190 feet, and the exposed lower part of the Elk City 30 feet, or a total of 805 feet. In western Dewey County, the Whitehorse is 310 feet thick, the Cloud Chief 175 feet, and the exposed lower part of the Doxey about 80 feet, or a total of 565 feet. In Woods County, the Whitehorse is about 200 feet thick, and the exposed lower part of the Cloud Chief 50 feet, or a total of 250 feet (measured sections 8, 10, 11). In Ellis County the Whitehorse is 310 feet thick, the Cloud Chief 125 feet, and the exposed lower Doxey 25 feet, or a total of 460 feet. In the Texas Panhandle near Borger, the Whitehorse is about 165 feet thick, the Cloud Chief 105 feet, and the exposed lower part of the Doxey about 45 feet, or a total of 315 feet. In southwestern Beaver County, the Whitehorse is about 240 feet thick, the Cloud Chief 150 feet, and the exposed lower part of

the Doxey about 40 feet, or a total of 430 feet (pl. III). It is obvious that the Whitehorse and Cloud Chief are thinner northward and westward from the Custer County area, thinning by as much as 50 to 75 percent.

WHITEHORSE GROUP

The name Whitehorse sandstone member for Whitehorse Springs, Woods County, was first proposed by Gould (1905, p. 55) for beds between the Dog Creek Shale below and the Day Creek Dolomite above (measured section 13). Sawyer (1929, p. 11) changed the wording to Whitehorse Group, subdividing it into the Marlow Formation below and the Rush Springs Sandstone above, and this usage is followed at present. Cragin (1896, p. 40) previously used the term "Red Bluff beds" for the same sequence as the Whitehorse, named after Red Bluff post office near Protection, Comanche County, Kansas (measured section 1). The name was preoccupied, so Gould proposed a new name, Whitehorse, for this sequence.

The base of the Whitehorse is easily recognizable in Kansas, Texas, and Oklahoma and can be easily picked in the subsurface. The upper boundary is different in different areas, and with continued study in Woods and Custer Counties and areas westward in Texas, it was deemed necessary to revise the basic definition of the upper boundary and to propose a new boundary that would be consistent over the three states. As a result, a major study of the Whitehorse and Cloud Chief was undertaken during the past few years, and some of the results are shown in plate III.

The type section for the Whitehorse Group is here proposed to be that along the headwaters of West Moccasin Creek in SE¼ sec. 8 and NE¼ sec. 19, T. 28 N., R. 18 W., western Woods County (measured section 11). Here the Whitehorse, 194 feet thick, is subdivided into the Marlow Formation below (117 feet) and the Rush Springs Formation above (77 feet). The lower boundary is the top of the Dog Creek Shale, and the upper boundary is the base of the Moccasin Creek Bed of the Cloud Chief Formation. The Day Creek Dolomite is 36 feet above the base of the Cloud Chief. The Moccasin Creek is a pink to white dolomite and greenish-gray to orange-brown, calcitic sandstone and siltstone, about 3 feet thick. Elsewhere the basal zone is a dolomite so that the Moccasin Creek may

be described as a double dolomite. In Dewey County and westward to Texas and in Beaver County, the Moccasin Creek is a double, triple, or quadruple gypsum sequence, from 9 to 24 feet thick. In Custer and Washita Counties, the Moccasin Creek is gradational into a gypsum up to 120 feet thick, and is about 60 feet thick farther west in the subsurface. In these areas it may not be advisable to use the term Moccasin Creek but instead to use the name Cloud Chief Gypsum.

In Dewey County and the area southward, the Weatherford Dolomite or its equivalent gypsum (One Horse Gypsum) has been used as an upper boundary of the Whitehorse Group (Miser, 1954). In this region, the Moccasin Creek is a thin gypsum, or greenish-gray zone where the gypsum is leached, with shale above and sandstone below. The Weatherford is 25 feet below the Moccasin Creek, within the Rush Springs Sandstone, as seen in the bluff a mile northeast of Camargo, Dewey County. There the Moccasin Creek is a double gypsum 9 feet thick with a 1-foot, red-brown siltstone in the middle, and the Weatherford is a gypsum 2.5 feet thick occurring about 25 feet below the base of the Moccasin Creek. In the Seiling area, in the high hill a few miles south of town, the Day Creek Dolomite caps the hill and the Moccasin Creek double dolomite occurs about 31 feet below, resting upon Rush Springs Sandstone, with a red-brown shale above to the Day Creek (measured section 16). Thus in the Seiling-Camargo area of northern Dewey County, the Weatherford is about 56 feet below the Day Creek and the Moccasin Creek is recognized in both areas. The Moccasin Creek should be used for mapping purposes to mark the Whitehorse-Cloud Chief boundary in Oklahoma because the previously used marker beds (Day Creek and Weatherford) are not the same and occur only locally. The Day Creek is found at few places south of the Canadian River, and the Weatherford is barely present north of the river, but the Moccasin Creek occurs from Kansas to Texas throughout Oklahoma and can be found in the subsurface where a change occurs from sandstone below to shale above.

Marlow Formation

Name.—The name Marlow Formation was first used by Sawyer (1924, p. 313-315) for 120 feet of sandstone and shale overlying

the Duncan Sandstone (now Chickasha) and underlying the Whitehorse Sandstone of Reeves (1921) (now Rush Springs). It was named for the town of Marlow, northern Stephens County.

Type section.—The type section for the Marlow is that in the Red Bluffs, in NW¼ sec. 29, T. 15 N., R. 11 W., and NE¼ sec. 25, T. 15 N., R. 12 W., central Blaine County (Fay, 1962, p. 67). There the Marlow is 114 feet thick, consisting mainly of fine-grained orange-brown sandstone, with a 9-inch dolomite at the top termed Emanuel Bed and a 4-foot dolomite 28 feet below termed Relay Creek Bed. A stray dolomite up to 1.3 feet thick is locally present about 5 feet below the Relay Creek. The base of the Marlow is marked by a greenish-gray sandstone, overlain by 20 feet of reddish-brown shale, siltstone, and sandstone. The Dog Creek Shale is well exposed in the bluff face below the Marlow.

Description in Woods County.—In Woods County, the Marlow is a fine-grained, orange-brown sandstone, from 99 to 117 feet thick, with 12 to 20 feet of red-brown shale in the upper part separating the Emanuel Bed from the Relay Creek Bed (measured sections 8, 10, 11). The Emanuel is a greenish-gray, calcitic sandstone at the top of the Marlow, and the Relay Creek is a 1- to 3-inch, tan to maroon dolomite. The Doe Creek Sandstone Lentil is a coarse-grained sandstone and conglomerate with algae and other fossils, occurring in separate areas at various intervals from the base of the Marlow to 15 feet or less below the Relay Creek Bed. The base of the Marlow is a greenish-gray sandstone, resting conformably upon the red-brown shale of the Dog Creek (figs. 17-19). A 1-foot, stray gypsum occurs about 15 feet below the Relay Creek Bed in SE¼ SW¼ sec. 20, T. 28 N., R. 18 W., and is within a mile or so of that spot. Evans (1931, p. 420) thought that this gypsum was part of the Cloud Chief Formation. In the area just east of old Coy, in SE¼ SE¼ sec. 25, T. 29 N., R. 20 W., salt casts were found in a 3-inch, pink shale 12 feet below the top of the Marlow, this being the first reported occurrence of salt in the Marlow at the surface in Oklahoma (measured section 8). The Relay Creek is a gypsum bed along the road in SW¼ NW¼ sec. 10, T. 28 N., R. 17 W., but is dolomite just a few yards west and south along the road.

Description in Kansas.—In Kansas, the basal 5 feet of the Marlow is gypsum (Cave Creek, measured section 4), gradational eastward into fine-grained, orange-brown sandstone. The upper half

of the Marlow is interbedded red-brown shale and orange-brown sandstone with many greenish-gray sandstone beds (measured section 1). The Emanuel is a 3-foot greenish-gray sandstone, and the Relay Creek is a 1.5-foot greenish-gray sandstone with a calcitic zone at top gradational southward into a 1-inch, pink dolomite near the Oklahoma border. The Emanuel is about 12 feet above the Relay Creek Bed (measured section 1, type Red Bluff). The lower half of the Marlow is a fine-grained orange-brown massive sandstone, and the total thickness of the Marlow is 99 feet (pl. IV).

Description in Harper County.—In Harper County, the Marlow is 103 to 107 feet thick and contains more gypsum southwestward. In the Sleeping Bear Creek area, in NE¼ sec. 18, T. 25 N., R. 20 W., and along State Highway 34 in E½ sec. 17 and NE¼ sec. 20, T. 25 N., R. 20 W., the basal 36 feet of the Marlow contains much impure gypsum and a few ledges of white to orange-brown gypsum lenses up to 2 feet thick or more. The overlying 40 feet is a fine-grained silty orange-brown sandstone, overlain by a 2-inch bed of pink and white Relay Creek Dolomite. The Relay Creek forms a ledge and marker bed in the region and is overlain by 26 feet of red-brown shale and orange-brown sandstone. The Emanuel Bed is a ½-inch, light-pink dolomite, immediately above a 2-foot orange-brown, fine- to medium-grained sandstone, marking the top of the Marlow.

South of Buffalo, in NE¼ sec. 13 and SE¼ sec. 12, T. 26 N., R. 23 W., NE¼ sec. 25, T. 27 N., R. 23 W., and NW¼ sec. 5, T. 26 N., R. 22 W., the basal 1 foot of the Marlow is a greenish-gray sandstone, surmounted by 28 feet of gypsum and interbedded sandstone, the upper 9 feet pure gypsum. This unit is overlain by 50 feet of orange-brown, fine-grained sandstone, with a 1-inch, pink and white Relay Creek Dolomite on top, and 24 feet of red-brown shale and orange-brown siltstone above the Relay Creek. A 2-foot gypsiferous cross-bedded sandstone overlies the shale and siltstone, with the Emanuel Bed on top, consisting of white and pink gypsum, 1 foot thick. About 6 miles westward, the Relay Creek is a double gypsum about 3 or more feet thick, surmounted by 18 feet of red-brown shale, and the Emanuel Bed is a 1.5-foot bed of gypsum, each eroding into prominent mappable ledges in NE¼ sec. 13, T. 26 N., R. 24 W. Evans (1931, p. 421) published a photograph of this section and classed these beds as part of the Cloud Chief Formation, correlating the double Relay Creek Gypsum Bed with the double

Moccasin Creek Gypsum Bed, at Camargo in Dewey County. This valley should be mapped as Marlow, with the Rush Springs Sandstone above the Emanuel Bed.

In the area west and northwest of Buffalo, in E½ sec. 26 and NE¼ sec. 35, T. 28 N., R. 24 W., and NE¼ sec. 16, T. 27 N., R. 23 W., the basal Marlow is a 13-foot gypsum, surmounted by 68 feet of orange-brown, fine-grained sandstone and 1 foot of red-brown shale, overlain by a 1-inch bed of pink Relay Creek Dolomite. Above the Relay Creek is 20 feet of red-brown shale and orange-brown siltstone, surmounted by 5 feet of fine-grained orange-brown sandstone, with a 2-inch maroon to pink Emanuel Dolomite at top.

Description in Woodward County.—In Woodward County, the Marlow is 104 to 110 feet thick from Chimney Creek in northeastern Woodward County to Quinlan in the southeastern part. In the Chimney Creek area, the Doe Creek Sandstone is 15 to 60 feet thick, occurring 12 feet above the top of the Dog Creek Shale and immediately beneath the Relay Creek Dolomite in sec. 17, T. 24 N., R. 18 W., along the road 1 mile north, and NW¼ sec. 35, T. 25 N., R. 18 W. (measured section 15). The Doe Creek is a cross-bedded coarse-grained sandstone and conglomerate, with calcite cement, occurring 4 miles east of Woodward and striking northeastward through Doe triangulation station to Whitehorse Springs in Woods County. It contains Permian fossils, is not wider than 1,000 yards, and may be a submarine channel or a series of unrelated channels. Riley (1961) studied the problem of the Doe Creek in Woodward and Woods Counties, concluding that it was a channel sand with current directions northeastward.

The basal 1 foot of the Marlow is a greenish-gray sandstone, surmounted by 68 feet of orange-brown fine-grained sandstone outside the Doe Creek area. In the Haskew region, the basal 5 feet is gypsum. The Relay Creek rests upon this 68-foot sandstone and is a 1-inch maroon to pink dolomite, eroding into a ledge. Above the Relay Creek is 36 feet of red-brown shale and orange-brown siltstone and sandstone, with a 1-inch maroon to light-pink Emanuel Dolomite Bed at top.

In the Quinlan area, the lower 75 feet of the Marlow is an orange-brown, fine-grained sandstone, with a 2-inch light-pink to maroon Relay Creek Dolomite on top. On top of the Relay Creek is 34 feet of orange-brown sandstone and siltstone, with a 1-inch

white to pink and maroon Emaunel Dolomite at top. It is obvious that southward a facies change from shale to sandstone has occurred in the Relay Creek-Emanuel interval.

Description in Major County.—In western Major County, north of Chester in NE¼ sec. 8, NW¼ sec. 9, NW¼ sec. 10, T. 21 N., R. 16 W., along Griever Creek, the Marlow is 109 feet thick (measured section 16). The basal 6 inches is a greenish-gray sandstone, with 80 feet of overlying orange-brown fine-grained sandstone. This sandstone has a 2.5-foot gypsum bed 35 feet above the base and a 5-foot gypsum and gypsiferous sandstone bed 66 feet above the base, with impure gypsiferous sandstones between to within 20 feet of the base. The Relay Creek rests upon this 80-foot bed and is a 1-foot, white gypsum, with 27 feet of gypsiferous sandstone above. The Emanuel is poorly developed here, being a 1-foot light-brown sandstone, eroding into an even-bedded ledge.

Description in Dewey County.—In Dewey County, only the upper part of the Marlow is exposed, along the Canadian River in the eastern part of the county. Here the Relay Creek is a gypsum up to 8 feet thick, and the Emanuel Bed is a 1-inch maroon to pink dolomite, with the interval between being 27 feet of orange-brown fine-grained sandstone. Good exposures occur in NW¼ sec. 25 and SW¼ sec. 24, NE¼ sec. 5, T. 16 N., R. 15 W., N½ sec. 18 and NW¼ sec. 6, T. 17 N., R. 15 W., and SE¼ sec. 36, T. 18 N., R. 16 W. The exposures of Marlow outlined on the geologic map of Oklahoma (Miser, 1954) in the Lenora and Camargo areas of northwestern Dewey County are not Marlow but belong higher in the section in the Rush Springs. The 1-foot gypsum bed in this area, upon which the Marlow interpretation is based, is the Old Crow Gypsum bed of the Rush Springs Sandstone and occurs about 108 feet above the Emanuel Bed.

Description in the Taxas Panhandle.—The Marlow is primarily a 75- to 110-foot, orange-brown, fine-grained sandstone, with interbedded gypsums, in the subsurface of the Texas Panhandle. In the Borger-Amarillo area of Hutchinson and Carson Counties, the formation is gypsum and dolomite, with some sandstone, and farther westward salt appears in the section. The structure map of the base of the Marlow (pl. III) shows the axis of the Anadarko basin to leave Oklahoma just south of the Beckham-Roger Mills county line, curving in a gentle arc northwestward through central

Roberts and eastern Hansford Counties, Texas, to south-central Texas County, Oklahoma. The axis of the buried Amarillo mountains parallels this basin but is about 25 miles farther southwest or west. The change from sand to the east and north, to gypsum and dolomite southwestward, takes place southwest of the Amarillo axis.

DOE CREEK SANDSTONE LENTIL

Name.—The Doe Creek Sandstone was named by Evans (1954, p. 196) for a 0- to 78-foot, lenticular, coarse-grained, cross-bedded sandstone in the Marlow Formation, occurring in the region east of Woodward, Woodward County, and extending in a linear northeastern direction to the region of Whitehorse Springs, Woods County (measured sections 10, 13, 15). It is no wider than 1,000 yards, is fossiliferous with marine algal fossils, and contains a high percentage of calcite cement, being described as a sandy limestone by Riley (1961). The nomenclature was changed to Doe Creek Lentil by Fay (1964, p. 75) because the lithology differs from one area to another, and the isolated outcrops occur at different intervals above the base, but sandstone is the main constituent and so the term Doe Creek Sandstone Lentil is used herein. The type area for the Doe Creek is the creek of the same name just north of Doe triangulation station in northeastern Woodward County. In this area the upper part of the section is eroded so that it is impossible to determine the exact stratigraphic relationships above the Doe Creek. The Relay Creek occurs above the Doe Creek southwest of there, but, because the base of the Doe Creek is not well exposed with relation to the Dog Creek Shale, a composite section from the area of Doe triangulation station to sec. 17, T. 24 N., R. 18 W., is herein selected as the type section.

Type section.—The type section for the lower part of the Doe Creek Sandstone Lentil is that east of the road in NW¼ sec. 35, T. 25 N., R. 18 W.

There the Doe Creek is about 60 feet thick and the base occurs about 12 feet above the top of the Dog Creek Shale, with normal fine-grained, orange-brown sandstone and a basal one-foot, greenish-gray sandstone of the Marlow Formation below the Doe Creek. The upper contact is best seen in NW¼ sec. 8, T. 24 N., R. 18 W., where 15 feet or more of Doe Creek occurs beneath the maroon Relay Creek Dolomite. A complete section just on the margin of the above

sections, showing a mixture of normal Marlow sandstone with Doe Creek sandstone, is that in center sec. 17, T. 24 N., R. 18 W., northeastern Woodward County (measured section 15). The total thickness of the Marlow is 104 feet and the section exposed below the Relay Creek is 68 feet thick, so the total thickness of the Doe Creek is probably not more than 60 feet.

Description in Woods County.—In Woods County are three separate areas of isolated exposures of Doe Creek Sandstone, termed Wildcat Buttes, Whitehorse Springs (measured section 13), and Cleveland Hills (measured section 10). Within those areas are small mounds or hills, each isolated from the other, with the upper part of the Marlow removed so that the upper boundary is indeterminable except in the Cleveland Hills area. The Wildcat and Whitehorse areas are aligned in a northeasterly direction, being less than 1,000 yards wide, with the base of the Doe Creek 0 to 16 feet above the Dog Creek Shale (figs. 18-20). In the Cleveland Hills area the basal Doe Creek is 42 to 56 feet above the base of the Marlow, with no preferred direction, the outcrops being tabular in nature.

The Wildcat Buttes are five isolated mounds (fig. 20) in sec. 14, T. 26 N., R. 17 W. The three gypsum units of the Blaine

Figure 20. Wildcat Buttes; view toward the southeast, showing typical escarpment of the Doe Creek Lentil, in sec. 14, T. 26 N., R. 17 W., taken from NW¼ sec. 33, T. 25 N., R. 17 W.

Formation and about 50 feet of Dog Creek Shale are below the mounds, with a good contact of basal Marlow on the south side of the northernmost mound. The Watonga and Southard Beds are also well exposed within the Dog Creek, so that the entire Dog Creek is represented. The base of the Marlow is a greenish-gray sandstone, occurring at an elevation of 1,784 feet, with about 10 feet of fine-grained, orange-brown Marlow sandstone above. This unit is overlain by about 35 feet of cross-bedded, coarse-grained Doe Creek Sandstone, with fossils. The cross-bedding dips northward to northeastward. In places fossil algae are present, but most fossils are clams and snails, with some bryozoans.

The Whitehorse Springs area contains 13 isolated exposures in the center of T. 27 N., R. 16 W., in parts of secs. 3, 9, 10, 11, 15, 16, 20, 21, and 29, the two main bodies being in secs. 10 and 21. Whitehorse Springs is near the center of NW¼ sec. 21, and the type Whitehorse was named for the Doe Creek exposures in this area and its extension into section 20 to the southwest. In the north-central part of sec. 29 the Blaine Formation is present up through the Altona Dolomite, but the Shimer Gypsum is missing, probably

Figure 21. Photomicrograph of basal Marlow Sandstone (Doe Creek Lentil), x125, in SW¼ NW¼ sec. 10, T. 27 N., R. 17 W. Note the large rounded quartz grains and the sparry calcite matrix.

owing to solution by ground water. The Dog Creek Shale is 62 feet thick, with the Watonga and Southard Beds present, so the Dog Creek is not eroded (measured section 13). The Doe Creek rests upon the Dog Creek at an elevation of 1,832 feet, so the base of the Doe Creek is about 38 feet higher than the base at Wildcat Buttes. The Doe Creek is 2 to 3 feet thick in sec. 29, increasing to 40 feet or more just north of Whitehorse Springs. In places the basal Marlow is a coarse-grained sandstone outside the Whitehorse area, and it is possible to use the term Doe Creek for this bed (fig. 21). In the west-central part of sec. 11 are excellent exposures of the Dog Creek, Marlow, and Doe Creek in the east face of a small butte (figs. 18, 19). There the Doe Creek is a 19-foot bed of sandstone conglomerate, with many calcite veins, resting upon 28 feet of orange-brown, fine-grained Marlow sandstone, but with a 1.5-foot bed of Doe Creek Sandstone forming a lentil in the Marlow near the base. The basal Marlow is a 1-foot bed of greenish-gray sandstone, resting upon red-brown Dog Creek Shale, with the Southard Dolomite and a normal Dog Creek section below. The Doe Creek is a coarse-grained sandstone, but the large blocks are recemented by calcite and at all angles of repose, giving the appearance of being moved and recemented much later, after the sandstone was consolidated and eroded. In SW¼ sec. 10 and NW¼ sec. 15, the Doe Creek is 63 feet thick, with 16 feet of Marlow below, resting upon Dog Creek Shale (fig. 22). In NW¼ sec. 16, the Doe Creek is about 2 to 10 feet thick, but the base is about 42 feet above the base of the Marlow. Fossils are found in most of these exposures, with a large concentration of cabbage-head algae in the southwestern-most outcrop. The algal blocks are as large as 1 foot in diameter and weigh 50 pounds or more, being a new species of Permian blue-green algae, according to L. R. Wilson (personal communication). A section through the basal part of one of these specimens shows the initial growth stages as isolated oölites, later enclosed by larger oölitic growths, ending in incrusting layers. The direction of dip of the cross-bedding is toward the north and northeast.

The Cleveland Hills area is composed of 18 isolated exposures, grouped into three areas within T. 28 N., R. 16 W. The first area contains four hills in SW¼ sec. 26 and along the south line sec. 27, where the Doe Creek is about 5 to 10 feet thick, cross-bedded to the north-northwest, with the base 42 to 50 feet above the base of the

Marlow. The base of the Marlow is about 1,810 feet above sea level, so the base of the Doe Creek is 1,852 to 1,860 feet in elevation, or about 20 to 28 feet higher than the base in the southern part of the Whitehorse Springs area. The hills are aligned east-west and are composed of many recemented sandstone blocks, with many calcite veins. Apparently no direct relationship exists with the Doe Creek of the Whitehorse area. The main area of Doe Creek, just east of the Cleveland Hills proper (SW¼ sec. 30), in secs. 28-33, is composed of nine isolated exposures, one of which covers about 1 square mile. A measured section taken in NW¼ sec. 28 and SE¼ sec. 30 (measured section 10) reveals 56 feet of Marlow sandstone above the Dog Creek Shale, surmounted by about 20 feet of Doe Creek, with 15 feet of Marlow sandstone above the Doe Creek up to the Relay Creek Dolomite (fig. 23). The Relay Creek is a 2-inch, maroon, crinkly bedded dolomite, with a 1-inch, light greenish-gray dolomite about 3 feet above, surmounted by 17 feet of red-brown shale and orange-brown siltstone and sandstone. The Emanuel Bed is a 1-inch, light-greenish-gray, calcitic sandstone, above a 1.2-foot, orange-brown, medium-grained sandstone. The upper part of the section was

Figure 22. Doe Creek Lentil on south side of road; view toward the southeast, in NW¼ NE¼ NW¼ sec. 15, T. 27 N., R. 16 W. Note cross-bedded, lenticular nature of this conglomerate, sandstone, and sandy limestone.

measured in NE¼ sec. 25, T. 28 N., R. 17 W. (fig. 24), and the total thickness of the Marlow is 111 feet. In NW¼ sec. 28, the base of the Marlow occurs at an elevation of 1,820 feet, so the base of the Doe Creek is 1,876 feet, or 16 to 24 feet higher than the base in the hills to the east, 44 feet higher than in the Whitehorse area, and 82 feet higher than basal Doe Creek in Wildcat Buttes. The Doe Creek is fossiliferous in the Cleveland Hills exposures, and the

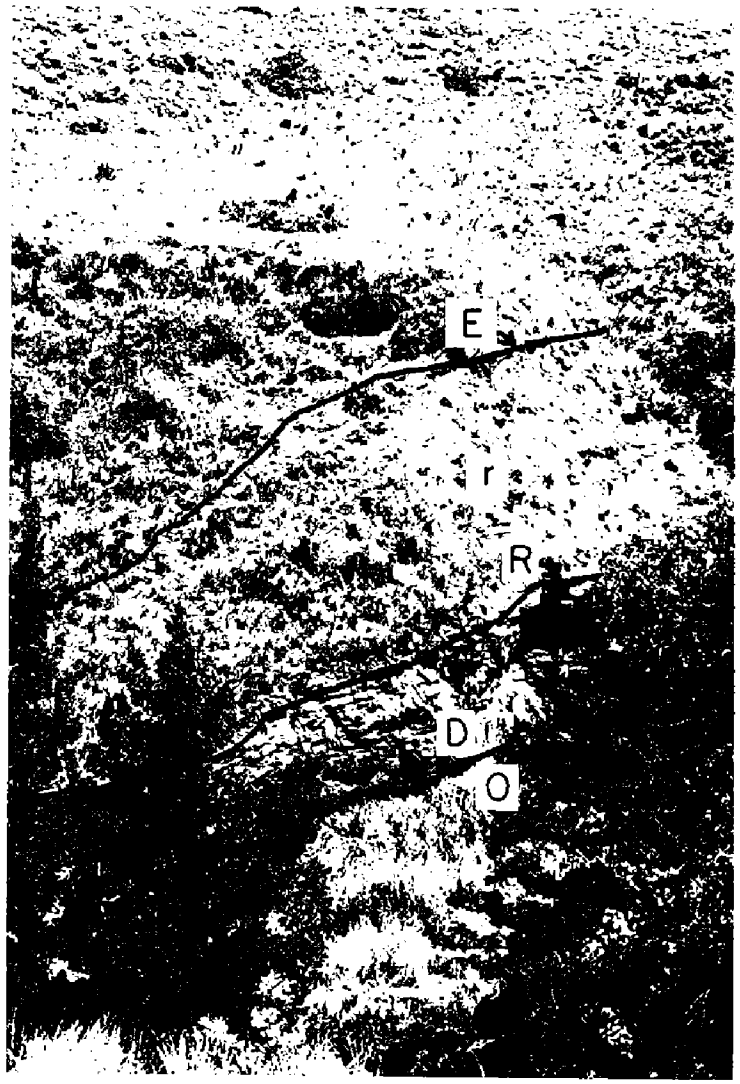

Figure 23. Upper part of Marlow Formation, including Doe Creek Lentil; view toward the southeast, on east side of Cleveland Hills, near C SE¼ SE¼ sec. 30, T. 28 N., R. 16 W. The Emanuel Bed (E) is a resistant, greenish-gray, calcitic sandstone about 1 inch thick, at the top of the Marlow, with about 22 feet of reddish-brown shale (r) below. The Relay Creek Bed (R) is a maroon, calcitic dolomite about 2 inches thick, above the orange-brown, coarse-grained, cross-bedded, calcitic sandstone of the Doe Creek (D). The Doe Creek is about 15 feet thick, resting upon orange-brown, fine-grained sandstone (O) of the Marlow Formation.

relationships with the Relay Creek Bed can be observed in NE¼ SW¼ sec. 32 and SE¼ sec. 30, where the total thickness of the Doe Creek is well exposed. The cross-bedding is toward the north and northwest. The third area of Doe Creek Sandstone is that in NW¼ sec. 8 and SE¼ sec. 6, where five isolated exposures, each about 5 feet thick, occur about 50 feet above the base of the Marlow. The base of the Marlow is about 1,815 feet in elevation, so the base of the Doe Creek is at about 1,865 feet, or almost the same as that of the exposures 3 miles to the south. The Doe Creek does not extend north of these exposures and is absent on the west side of the Cleveland Hills. Eastward, a small block in NW¼ sec. 36, T. 28 N., R. 16 W., almost rests upon Altona Dolomite, so evidently the Doe Creek is confined to T. 28 N., R. 16 W., and the region southward to Wildcat Buttes, in Woods County.

The interpretation of the depositional environment of the Doe Creek depends somewhat on how one connects these 37 isolated exposures in Woods County and the dozen or more in Woodward

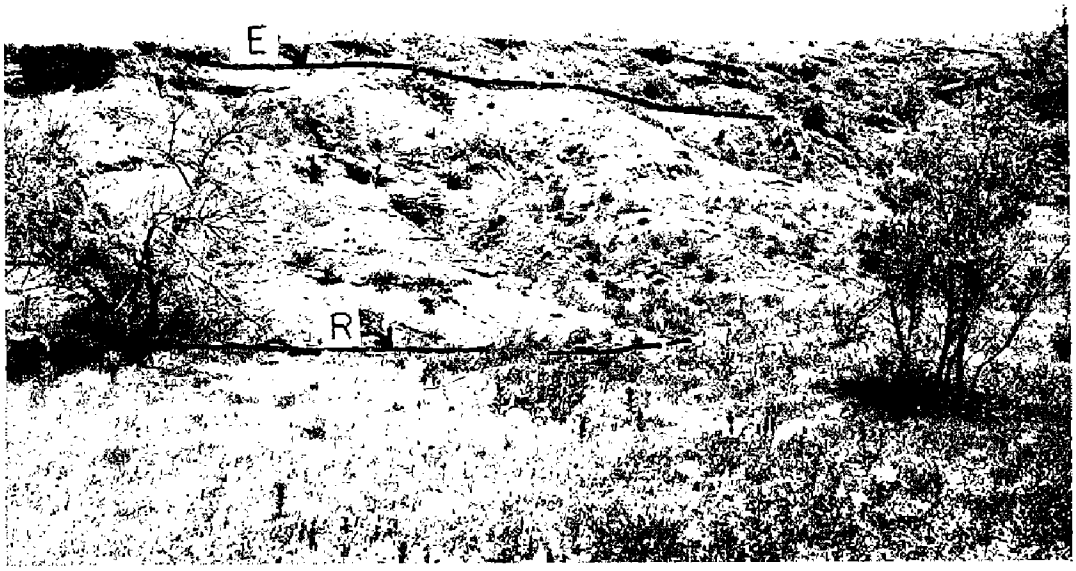

Figure 24. Upper part of Marlow Formation from Relay Creek Bed (R) to Emanuel Bed (E); view toward the northeast, in SE¼ SE¼ NE¼ sec. 25, T. 28 N., R. 17 W., on western side of the Cleveland Hills. The interval between the Emanuel and Relay Creek Beds is mainly reddish-brown shale, about 20 feet thick, with a 1-foot, orange-brown sandstone immediately below the Emanuel, and a 4.5-foot, orange-brown sandstone in the middle. The Rush Springs is reddish-brown shale and sandstone, above the Emanuel Bed.

County. It is possible that there never was a connection and that each exposure represents an isolated submarine channel. If a cross section is drawn from the Woodward area to the Cleveland Hills, it is obvious that the Doe Creek occurs entirely within the Marlow Sandstone, below the Relay Creek Bed, and the lowest stratigraphic position of the Doe Creek base is in the Whitehorse area, the base being higher from there both northward and southward. The greatest concentration of algal fossils is near the base, and this area was interpreted as a possible fringing reef by Fay (1964, p. 80-84), but it now seems more likely that the Doe Creek represents submarine channels which had strong northeastward and northward currents. The fine debris was removed, leaving the larger sand grains in these channels and allowing animals and plants to flourish. The algae could have lived on the bottom and did not have to live at or near wave base. The Doe Creek strikes into the basin for almost 40 miles, so the interpretation of this lentil as an offshore bar is not reasonable.

EMANUEL BED AND RELAY CREEK DOLOMITE BED

Names.—The name Greenfield limestone was used by Stephenson (1925, p. 629) for the dolomites capping the hill northwest of

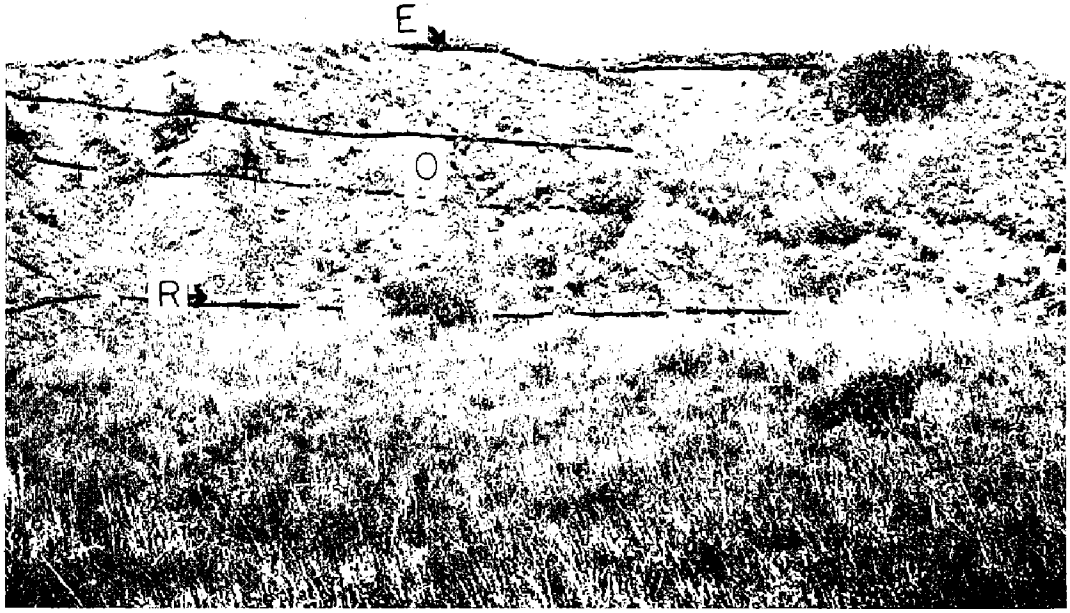

Figure 25. Upper part of Marlow Formation from Relay Creek Bed (R) to Emanuel Bed (E), with about 20 feet of reddish-brown shale between, and a 4-foot orange-brown sandstone (O) in middle; view toward the northeast, in NE¼ SW¼ NE¼ sec. 9, T. 28 N., R. 17 W. Note the 3-foot, greenish-gray sandstone immediately below the Emanuel Bed, into which it is gradational as a calcitic sandstone, appearing as a white marker bed in the region. The Relay Creek is a 2-inch, fine-grained, calcitic dolomite, gradational into a pink and white gypsum on the opposite side of the hill.

Greenfield, Blaine County. The name was preoccupied, so Evans (1931, p. 416) applied the name Relay Creek dolomites to these beds using the terms Upper Relay Creek dolomite and Lower Relay Creek dolomite for the two prominent beds 28 feet apart, recognizing a stray dolomite about 1 foot thick, about 5 to 7 feet below the Lower Relay Creek dolomite. The Upper Relay was changed to Emanuel Bed and the Lower Relay to Relay Creek Bed by Fay (1962, p. 66, 69). Cragin (1897, p. 360-363) termed the dolomite capping the hill in that area as Day Creek, naming the Taloga formation as that above this dolomite, so the name Taloga must be discarded. The Emanuel Bed marks the top of the Marlow, and the type section for the Marlow is that in the same hill as the type section for the Relay Creek and Emanuel Beds. The Marlow is 114 feet thick there.

Type section.—The type section for the Emanuel and Relay Creek Beds is NE¼ NE¼ sec. 25 and SE¼ SE¼ sec. 24, T. 15 N., R. 12 W., south of Relay Creek and about 5 miles east of Emanuel, Blaine County (Fay, 1962, p. 70).

Description in Woods County.—In Woods County, the Relay

Figure 26. Relay Creek Bed (R); view toward the south in road ditch in SW¼ SW¼ NW¼ sec. 10, T. 28 N., R. 17 W. The pink and white gypsum is about 4 inches thick and is gradational into dolomite on the opposite side of the road.

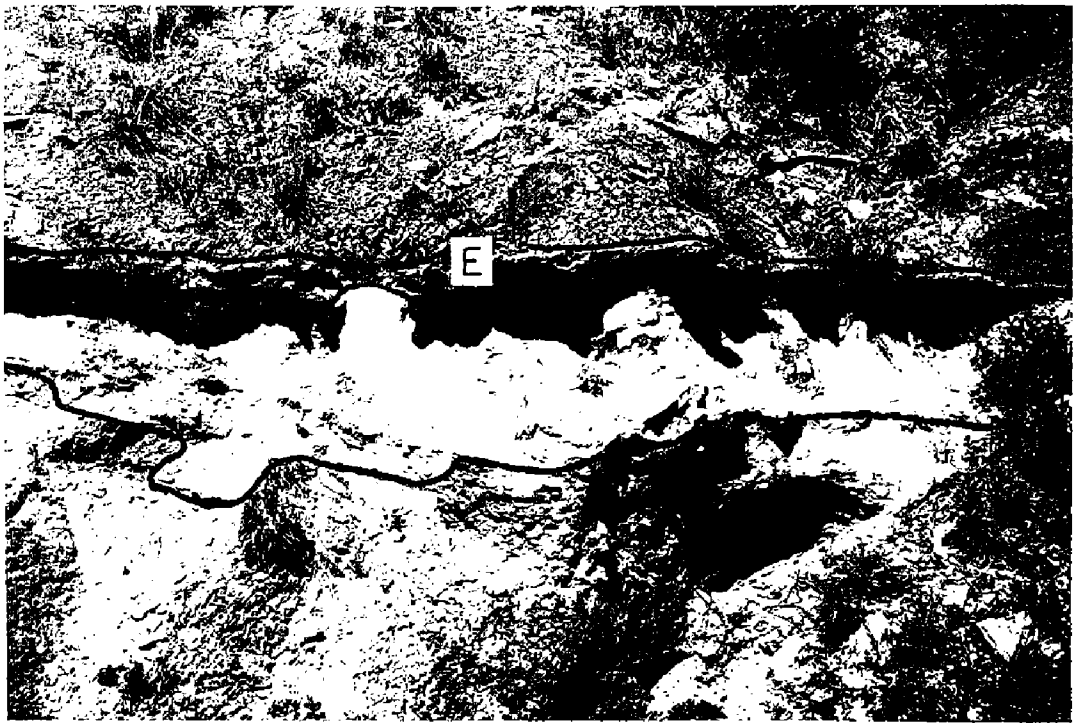

Figure 27. Emanuel Bed (E) of well-indurated, calcitic sandstone, resting upon 3 feet of greenish-gray, cross-bedded sandstone, which in turn rests upon reddish-brown shale; view toward the east in NE¼ SW¼ NE¼ sec. 9, T. 28 N., R. 17 W. Note reddish-brown shale of Rush Springs Formation resting upon the Emanuel Bed.

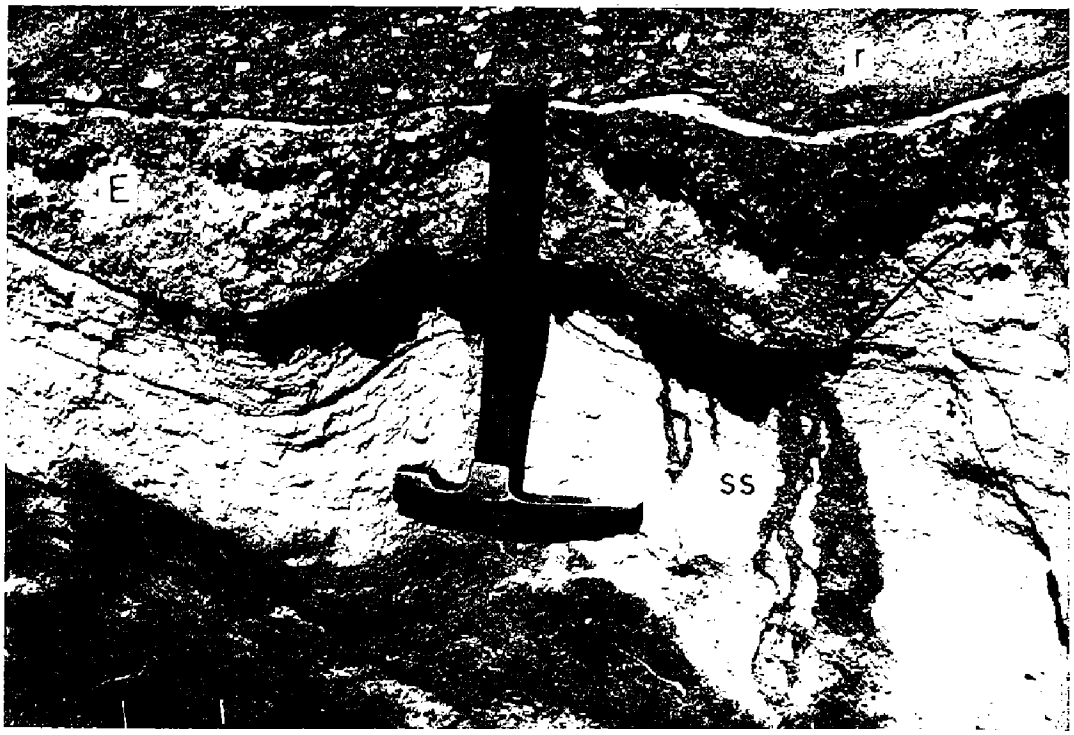

Figure 28. Emanuel Bed (E) with reddish-brown shale (r) above and greenish-gray, cross-bedded sandstone (ss) below; closeup view toward the northeast, in NE¼ SW¼ NE¼ sec. 9, T. 28 N., R. 17 W. The Emanuel is a well-indurated, calcitic sandstone about 4 inches thick.

Creek is a 1- to 3-inch, tan to light-gray to maroon dolomite, fine-grained and dense, eroding into a ledge (measured sections 8, 10, 11). It overlies 80 to 90 feet of fine-grained, orange-brown Marlow sandstone and is overlain by 12 to 20 feet of red-brown shale with some interbedded orange-brown sandstone and siltstone (figs. 23-25). In NW¼ sec. 10, T. 28 N., R. 17 W., east of the road, the Relay Creek is a gypsum about 4 inches thick.

The Emanuel Bed is a 1- to 6-inch greenish-gray calcitic sandstone, resting upon a 1- to 3-foot, greenish-gray and orange-brown, medium-grained sandstone, eroding into a ledge (figs. 23-25, 27-28) (measured sections 8, 10, 11). The surface weathers into sand balls about 0.25 inch in diameter, and the underlying sandstone is commonly cross-bedded and friable, forming a white ribbonlike pattern on the ground, easily seen on aerial photographs. The Emanuel and Relay Creek Beds maintain their identity and interval in southern Comanche County, Kansas (S½ sec. 9, T. 35 S., R. 16 W.; NW¼ sec. 3, T. 35 S., R. 19 W.), but farther northward they are greenish-gray sandstones (measured section 1). The Emanuel marks the top of the Marlow Formation in Oklahoma and Kansas.

Rush Springs Formation

Name.—Sawyer (1929, p. 11) used the name Rush Springs member for the sandstone between the Marlow member below and a gypsum above, named for Rush Springs, Grady County. Sawyer named the Weatherford Dolomite, a 1-foot dolomite occurring about 40 feet below the gypsum, for the town of Weatherford, Custer County. Evans (1931, p. 416) placed the lower contact of the Rush Springs at the top of the Upper Relay Creek dolomite (now Emanuel Bed), a usage now followed. Miser (1954) changed the rank to Rush Springs Sandstone (Formation) of the Whitehorse Group, but the term Rush Springs Formation is used herein because shale, gypsum, and dolomite are present in the Rush Springs.

The upper boundary of the Rush Springs was not the same horizon in different parts of Oklahoma, and different authors have used separate terms for beds in order to define this boundary. For instance, Gould (1905, p. 55) defined the top at the base of the Day Creek Dolomite of Woods County, when he defined the top of the Whitehorse. Sawyer (1929, p. 11) used a gypsum 40 feet above the Weatherford Dolomite as a marker bed at the top of the Rush

Springs in his original definition. Miser (1954) used the Day Creek Dolomite north of the Canadian River and mostly the Weatherford Dolomite and Cloud Chief Gypsum south of the river as the upper boundary. Clapp (1920, p. 34-35) defined a 2- to 80-foot gypsum bed in the Cyril-Cement area of Caddo County as the Cyril Gypsum, and this has been used as a marker for the top of the Rush Springs. Reeves (1921, p. 48-50) stated that the Cyril is two beds: an upper gypsum 0 to 85 feet thick and a lower gypsum 1 to 40 feet thick, with 15 to 20 feet of sandy shale between. The lower gypsum has a 1-foot dolomite bed at the base, a bed correlated with the Weatherford Dolomite. Where the lower gypsum was missing, the upper gypsum was used as the boundary. Gould (1924, p. 337) defined the Cloud Chief Formation, with the dolomite at Weatherford at the base.

In the area of Rush Springs, Grady County, the top of the Rush Springs is eroded, so a type locality was selected by Davis (1955, p. 68) as that in sec. 36, T. 7 N., R. 10 W., Caddo County. There the Emanuel and Relay Creek Beds are gypsums near the base of the cliffs, surmounted by 280 feet of Rush Springs Sandstone, with a few inches of Weatherford Dolomite and gypsum on top (O'Brien, 1963, p. 27, 29). With redefinition of the top of the type Whitehorse at the base of the Moccasin Creek Bed in Woods County, it seems best to select a type section for the Rush Springs in the same region as the type Whitehorse and type Moccasin Creek. The area of Cloud Chief, Washita County, is undesirable for a type section because of lack of a good base, and the Weatherford region is poor because the Emanuel Bed is about 10 miles away from the Weatherford outcrops.

Type section.—The type section for the Rush Springs Formation is herein selected as that in SE¼ sec. 8, T. 28 N., R. 18 W., at the headwaters of West Moccasin Creek, which includes the type section for the Whitehorse Group and the Moccasin Creek Bed, Woods County. Here the Rush Springs is 77 feet thick, with the greenish-gray Emanuel Bed (sandstone) below and the 3-foot dolomite and greenish-gray to orange-brown siltstone and sandstone of the Moccasin Creek Bed above. The Rush Springs is an orange-brown, fine-grained sandstone with interbedded red-brown shale, with a massive sandstone near the top. The Day Creek Dolomite is about 2 feet thick, with 31 feet of red-brown shale between it and

the Moccasin Creek Bed, termed the Kiger Member of the Cloud Chief Formation. The Moccasin Creek is the lowest bed of the Cloud Chief Formation, the base of which rests upon the Rush Springs (measured section 11).

Description in Woods County.—In northwestern Woods County, the Rush Springs is primarily an orange-brown, fine-grained sandstone and siltstone, with some interbedded, red-brown shale. It is 77 feet thick in the type region along West Moccasin Creek, 89 feet near Coy, and 96 feet in the Cleveland Hills (fig. 29) (measured sections 8, 10, 11). The Cleveland Hills, primarily confined to the SW¼ sec. 30, T. 28 N., R. 16 W., is composed mainly of Rush Springs Sandstone with the Moccasin Creek Bed and Kiger Member of the Cloud Chief Formation above, and one small area of slumped Day Creek Dolomite on top. A veneer of Ogallala gravel with fossil oyster shells covers the top, and contains some slumped blocks of Day Creek at an elevation of about 2,010 feet. Steep-sided canyons cut into the Rush Springs, exposing nearly vertical sections of the upper 30-foot sandstone at places. The overlying Moccasin Creek is eroded into a mappable ledge, with a

Figure 29. Rush Springs Formation, southeast part of Cleveland Hills; view toward the south, near C SW¼ SE¼ sec. 30, T. 28 N., R. 16 W. The cliffs are orange-brown, resistant sandstones, and the slopes are reddish-brown shales with interbedded, nonresistant, orange-brown siltstones and sandstones, totaling about 90 feet in thickness.

gentle shale slope above (figs. 30, 31). The base of the Rush Springs is a red-brown shale, gradational southward into orange-brown siltstone.

Description in Kansas.—Norton (1939, p. 1805) used the term "even-bedded member" of the Whitehorse for the Rush Springs. It is 98 feet thick in the type Red Bluff region of eastern Clark County, where more shale and more greenish-gray sandstone beds occur than in Woods County (measured section 1). Norton mentioned that it was possible to correlate several beds within this sequence from Clark County to Comanche County. About six orange-brown to greenish-gray, fine-grained sandstone beds, separated by red-brown shale, are in the Rush Springs, with an 8-foot, orange-brown sandstone at top, overlain by a 2.5-foot bed of greenish-gray calcitic sandstone of the Moccasin Creek.

Description in Beaver County.—In northwestern Beaver County along the Cimarron River, in NW¼ sec. 33, T. 6 N., R. 28 ECM.,

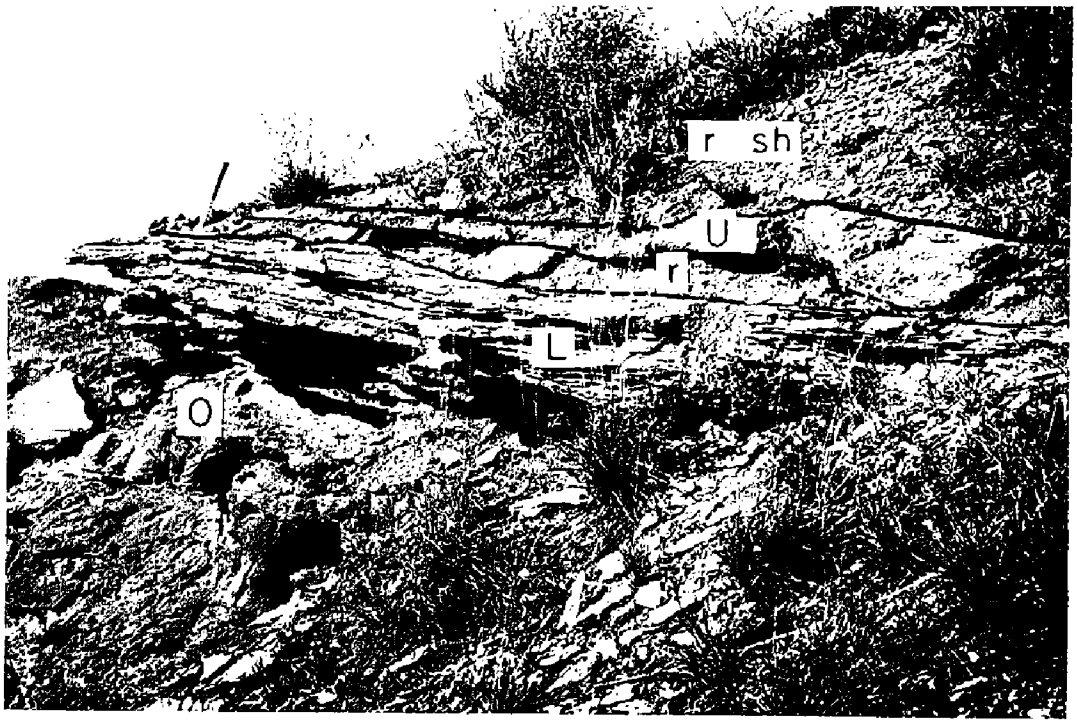

Figure 30. Moccasin Creek Bed, type section; view toward the northeast, near C SE¼ SE¼ sec. 8, T. 28 N., R. 18 W. The Moccasin Creek is composed of three parts: an upper greenish-gray, quartzose limestone (U) about 4 inches thick, a middle reddish-brown, argillaceous siltstone (r) about 1 foot thick, and a lower greenish-gray to orange-brown, thinly laminated calcitic sandstone (L) with much illite and some chlorite, gypsum, and montmorillonite, about 1.5 feet thick. Beneath the Moccasin Creek is a 5-foot, fine-grained, orange-brown, dolomitic and illitic sandstone (O), with some chlorite and montmorillonite, comprising the uppermost part of the Rush Springs Formation.

a 2-foot, white gypsum occurs at water level with eastward dip. Westward a few yards, a 0.5-foot gypsum occurs about 8 feet below, and about 15 feet of shale occurs below the latter bed, with 2 feet of orange-brown sandstone exposed at the base. The upper gypsum is tentatively identified as the Emanuel Bed, at the base of the Rush Springs Formation, with 94 feet of red-brown shale and orange-brown sandstone above, capped by a caliche bed. A 10-foot sandstone immediately overlies the 2-foot gypsum, with 12.5 feet of red-brown shale above, and an 8.5-foot sandstone bed above the shale. A 14-foot, red-brown shale overlying the 8.5-foot bed has been correlated a few miles to the southeast in Harper County in SE¼ sec. 1, T. 28 N., R. 26 W., at the base of the northwest side of a high hill. In this area, the Moccasin Creek and Day Creek are exposed, with 60 feet of beds

Figure 31. Day Creek Dolomite escarpment and Cloud Chief-Rush Springs contact; view toward the east, at head of Moccasin Creek, in NW¼ SE¼ SE¼ sec. 8, T. 28 N., R. 18 W. The Cloud Chief comprises an upper 15-foot, reddish-brown shale and siltstone (r) with much dolomite, calcite, aragonite, quartz, montmorillonite, and minor amounts of illite; the 2-foot, white, compact Day Creek Dolomite (D) (type section) eroded into a prominent escarpment; a 31-foot section of reddish-brown shale with interbedded, greenish-gray and orange-brown siltstones and sandstones (r), similar in composition as beds above (type Kiger); and the 3-foot Moccasin Creek Bed (M) (type section) at the base, composed of greenish-gray to orange-brown, illitic and calcitic siltstone and sandstone with some montmorillonite; resting upon orange-brown (O) and greenish-gray (g), fine-grained sandstones with some interbedded, reddish-brown shale of the Rush Springs Formation. This is also the type section for the Rush Springs Formation and Whitehorse Group.

above the 14-foot shale to the base of the Moccasin Creek. There the Moccasin Creek is a double dolomite, each about 8 inches thick, with 10 inches of red-brown, silty shale between. The Kiger is 31 feet of red-brown shale and orange-brown sandstone, overlain by 9 inches of maroon and greenish-gray dolomite and sandstone of the Day Creek, with about 45 feet of shale and orange-brown sandstone to the top. Thus the total thickness of the Rush Springs in this area is about 105 feet, and the top of the section in Beaver County is about 11 feet below the top of the Rush Springs.

In central Beaver County along Clear Creek, in sec. 11, T. 3 N., R. 24 ECM., about 25 feet of orange-brown, fine-grained sandstone is exposed in a cliff face on the east side of the creek, with four massive gypsum ledges separated by red-brown shale above, totaling 25 feet in thickness. These ledges are here correlated as the Moccasin Creek bed, and were classed by Gould and Lonsdale (1926, p. 19) as part of the Cloud Chief Formation. The underlying sandstone is classed as Rush Springs. Above the gypsums is 14 feet of orange-brown sandstone, surmounted by 4 feet of red-brown shale, 0.5 foot of gypsum, 6.5 feet of sandstone, 5 feet of shale, and 1 foot of white gypsum. This latter gypsum is tentatively correlated with the Day Creek Bed, but no true Day Creek Dolomite is present. Overlying the gypsum is 22 feet of red-brown shale, 5 feet of orange-brown siltstone, 27 feet of red-brown shale, a 3-inch, pink dolomite gradational into gypsum, 9 feet of red-brown shale, and 10 feet of orange-brown sandstone. Locally in the East Mocane core hole, in NW¼ NW¼ SW¼ sec. 13, T. 5 N., R. 25 ECM., at elevation 2,560 feet, the base of the Whitehorse occurs 690 feet down, with the top of the Relay Creek Gypsum (5 feet) at 615 feet, the top of the Emanuel Gypsum (10 feet) at 590 feet, and the top of the Rush Springs at 500 feet, or a total of 190 feet for the Whitehorse and 90 feet for the Rush Springs. The top of a 10-foot gypsum occurs at 440 feet and the bed may be the Day Creek equivalent. This is overlain by 55 feet of shale and siltstone, with a 10-foot, orange-brown sandstone at the top. The top of the Cloud Chief is tentatively placed at the top of this 10-foot bed, which is correlated with the sandstone at the top of the measured section along Clear Creek. In the Mocane core this bed is overlain by 20 feet of red-brown shale, 8 feet of orange-brown sandstone, 37 feet of red-brown siltstone and shale, and 45 feet of red-brown shale of the Doxey Formation. Thus the Cloud

Chief is about 125 feet thick, and the lower portion of the Doxey is 110 feet thick.

Description in Harper County.—In north-central Harper County, in E½ sec. 26, T. 28 N., R. 24 W., the Rush Springs is 91 feet thick, with a 19-foot, orange-brown sandstone at top, overlain by a 0.6-foot, greenish-gray sandstone, 1.9-foot, red-brown shale, and a 1-inch, pink and white dolomite of the Moccasin Creek Bed. This is overlain by 30 feet of red-brown shale, with some orange-brown and greenish-gray sandstone, up to the Day Creek Dolomite. The Day Creek is in two ledges: a basal pink and white dolomite 1.6 feet thick and an upper 9-inch, pink and greenish-gray dolomite, with 2.5 feet of red-brown and greenish-gray sandstone between. Above the Day Creek is 31 feet of red-brown shale, with orange-brown and greenish-gray siltstone and sandstone beds. The Rush Springs is a series of alternating red-brown shales and orange-brown sandstones and siltstones, with 12 feet of shale at the base resting upon the 2-inch, maroon to pink dolomite and gypsum of the Emanuel Bed.

In southwestern Harper County, in NE¼ sec. 13, T. 26 N., R. 24 W., the Rush Springs is 95 feet thick, with 58 feet of red-brown shale and orange-brown, fine-grained sandstone at the base above the 1.5-foot gypsum of the Emanuel Bed, surmounted by 37 feet of orange-brown sandstone at top. The Moccasin Creek is a 3-inch, greenish-gray dolomite and sandstone, with 37 feet of red-brown shale and orange-brown sandstone above, capped by 0.5 to 1 foot of Day Creek Dolomite.

In central Harper County, in NE¼ sec. 13, T. 26 N., R. 23 W., the Rush Springs is 95 feet thick, with 31 feet of orange-brown sandstone at top and 16 feet of red-brown shale at the base, resting upon the Emanuel Gypsum (1 foot thick). The middle portion is an alternating series of red-brown shales and fine-grained, orange-brown sandstones and siltstones. The Moccasin Creek is 4.2 feet thick, consisting of a basal 2-inch, greenish-gray sandstone and dolomite, surmounted by 3.7 feet of orange-brown siltstone and sandstone, with a 2-inch, pink and greenish-gray dolomite at top. The Kiger is 32 feet of red-brown shale and some orange-brown sandstone, with 2 feet of Day Creek Dolomite capping the hill.

In southeastern Harper County, in N½ sec. 18, T. 25 N., R. 20

W., the Rush Springs is 116 feet thick, with a 27-foot, orange-brown sandstone eroded into steep-sided canyons about 27 feet below the top, and a 5-foot, red-brown shale at the base resting upon a ½-inch, pink dolomite classed as the Emanuel Bed. The sequence is mostly red-brown shale and orange-brown sandstone, with the overlying Moccasin Creek a double dolomite 3.25 feet thick. The basal dolomite is 0.5 feet thick and is pink with a 1-inch, maroon shale at the base, surmounted by 1.75 feet of red-brown shale, and the upper dolomite is white to light pink, and 1 inch thick. The Kiger is 35 feet of red-brown shale and orange-brown sandstone, capped by 1.75 feet of Day Creek Dolomite.

Description in Woodward County.—In northern Woodward County, in C sec. 17, T. 24 N., R. 18 W., the Rush Springs is 93 feet thick, with a 40-foot, orange-brown sandstone and siltstone at top and 53 feet of red-brown shale and orange-brown sandstone below, resting upon a 1-inch, maroon to light-pink dolomite, classed as the Emanuel Bed. The Moccasin Creek is 4.6 feet thick, with a 3.5-foot greenish-gray, calcitic sandstone at the base, surmounted by 1 foot of orange-brown siltstone, and a 1-inch, pink to white dolomite at top. The overlying Kiger is 24 feet of red-brown shale and orange-brown siltstone with some greenish-gray sandstone beds, and the Day Creek is a 1.7-foot, white to pink dolomite. The Big Basin Member of the Cloud Chief, about 50 feet thick, is composed of red-brown shale and light greenish-gray sandstones, with several thin dolomites in the upper 8 feet (measured section 15).

In central Woodward County, in E½ sec. 6, T. 22 N., R. 19 W., the Rush Springs is 125 feet thick, with about 28 feet of sandstone at top above an alternating sequence of red-brown shales and orange-brown sandstones, the underlying Emaunel Bed being a 1/8-inch, maroon, calcitic zone at the top of a 1-foot light-brown medium-grained cross-bedded sandstone. The Moccasin Creek, 1.5 feet thick, is composed of two 3-inch, white to maroon dolomites, with red-brown shale between. The Kiger is 22 feet of orange-brown siltstone and red-brown shale, and the Day Creek is 1.75 feet of white to light-gray dolomite.

In southeastern Woodward County near Quinlan, in SW¼ sec. 19, T. 23 N., R. 17 W., some loose blocks of Day Creek Dolomite are slumped down on about 10 feet of the Kiger Shale at the top of the

section. The Rush Springs is 86 feet thick, with a 43-foot, orange-brown sandstone at top, and an alternating sequence of orange-brown sandstones, siltstones, and shales below, resting upon the Emanuel Bed, which is a 1-inch, pink and white to maroon dolomite. The Moccasin Creek is a purple platy sequence of cross-bedded, calcitic sandstones, 18.5 feet thick, with a 6-foot, pink to purple dolomite and dolomitic sandstone at top, and a 1.5-foot, pink and white dolomite and dolomitic sandstone at the base, resting upon the Rush Springs.

In southern Woodward County, in the area northeast of Sharon in SW¼ sec. 14, T. 21 N., R. 20 W., the upper 20 to 30 feet of the Rush Springs is an orange-brown, fine-grained sandstone, overlain by 35 feet of shale with the double Moccasin Creek Dolomite in the basal few feet, and the Day Creek Dolomite at top.

Description in Dewey County.—In north-central Dewey County, in SE¼ sec. 23 to NW¼ sec. 11, T. 19 N., R. 16 W., southeast of Seiling, the Rush Springs is about 186 feet thick and is almost all fine-grained, orange-brown sandstone. The Moccasin Creek is a double dolomite zone, 2.4 feet thick, with a 2-inch, pink to white dolomite at the base, surmounted by 2 feet of red-brown shale, and a 2-inch, pink to maroon dolomite at the top. The Kiger is 28 feet of red-brown to orange-brown siltstone and shale, with some orange-brown sandstone, overlain by the Day Creek Dolomite, which is about 1 foot thick at elevation 1,991 feet (measured section 16).

In northwestern Dewey County, in the Vici-Camargo area, the upper 60 feet of Cloud Chief shales and orange-brown to greenish-gray sandstones is exposed in NE¼ sec. 20, T. 18 N., R. 19 W., resting upon a double gypsum ledge 9 feet thick. This gypsum is the Moccasin Creek, with a 1-foot, red-brown siltstone in the middle 5 feet above the base, eroded into a prominent ledge in SW¼ sec. 18, T. 18 N., R. 19 W., at elevation 2,132 feet. At this locality, a 2.5-foot gypsum, occurring 25 feet below, was correlated as the Weatherford Bed by Evans (1931, p. 439), which seems correct. A 2-inch gypsum occurs 45 feet lower in the section, and 29 feet still lower is a 1-foot gypsum, resting upon 10 feet of orange-brown sandstone. This lower 1-foot bed is the Old Crow Gypsum of Cragin (1897, p. 363) and is about 115 feet above the Emanuel Bed,

so what has incorrectly been mapped as Marlow in this region should be mapped as Rush Springs. The Old Crow is eroded into a ledge in the valley sides within about 20 or more feet above the Canadian River. The Day Creek was not found in this region.

In southwestern Dewey County in the U. S. Army Corps of Engineers West Leedy core in NW¼ SE¼ SW¼ SE¼ sec. 7, T. 16 N., R. 20 W., is 226 feet of beds referred to the Cloud Chief Formation (upper 134 feet) and the Rush Springs Formation (lower 92 feet).* The Cloud Chief portion is red-brown shale and orange-brown siltstones and sandstones with some greenish-gray sandstone beds. Exposed at the surface just northwest of the well site is about 37 feet of the upper part of the Cloud Chief Formation, consisting of orange-brown shales and siltstones, up to the base of the Doxey Shale. In SE¼ SW¼ sec. 6, T. 16 N., R. 20 W., is approximately 75 feet of red-brown Doxey Shale with interbedded, tan, dolomitic siltstones in the basal 40 feet. In the core, a 3-foot white gypsum occurs 42 to 45 feet above the base of the Cloud Chief, and is tentatively correlated with the Day Creek Bed. The basal 13 feet of the Cloud Chief, classed as the Moccasin Creek Bed, consists of a basal 2-foot gypsum, surmounted by 3 feet of orange-brown to red-brown siltstone, an 8-inch gypsum, 4.5 feet of red-brown shale, and 3 feet of gypsum at top. A 1-foot gypsum, identified as the Weatherford, occurs about 25 feet below the base of the Moccasin Creek, with orange-brown siltstone and sandstone of the Rush Springs up to the Moccasin Creek. About 65 feet of siltstone and sandstone occurs below the Weatherford to the bottom of the core. Local wells in the region show the Rush Springs to be 180 to 225 feet thick, with the Old Crow about 95 feet below the top, and several gypsums 40 to 65 feet below the Old Crow, the main lithology being orange-brown sandstone and siltstone.

In central Dewey County, along the south side of the Canadian River bluffs in NE¼ sec. 34 and NE¼ sec. 33, T. 18 N., R. 17 W., the Rush Springs is exposed for 188 feet to river level, with about 39 feet of beds above. The Moccasin Creek is about 2.2 feet thick, with a 2-inch, pink to maroon dolomite at the base, overlain by 2 feet of red-brown shale, with a ½-inch, greenish-gray calcitic shale

* The core is on deposit at The University of Oklahoma, School of Geology, Core Library.

at top. The remainder of he Cloud Chief is red-brown shale with some orange-brown and greenish-gray sandstones, with a ½-inch, greenish-gray dolomite and shale about 5 feet below the top. This latter bed may be the Day Creek at elevation 1,904 feet. The upper 116 feet of the Rush Springs is an orange-brown sandstone, with a 5-inch, greenish-gray to pink dolomite 16 feet below the top. The next lower 40 feet is an alternating series of six gypsum ledges with orange-brown sandstone, in beds 1 to 4.5 feet thick, and the lowest 32 feet is gypsiferous sandstone to river level. The Old Crow is tentatively identified as a 3-foot, orange to white gypsum, 65 feet above river level, or about 123 feet below the top of the Rush Springs, and the Rush Springs is about 200 feet thick in this region.

In eastern Dewey County, northwest of Eagle City, Blaine County, in SE¼ sec. 1, T. 17 N., R. 14 W., four dolomites occur in a sandstone sequence, the top dolomite being 4 feet thick (elevation 1,930 feet) and occurring 280 feet above the Emanuel Bed, with a 3-foot dolomite 26 feet below the top bed, and a 9-inch dolomite 67 feet below the latter, with a stray 9-inch dolomite 35 feet below the 9-inch bed. The second bed above the bottom was tentatively identified as the Weatherford? by Fay (1962, p. 77), but further work indicates that this bed may be about 30 feet below the Weatherford. The Rush Springs-Cloud Chief boundary was placed at this horizon. The Eagle City outcrops may be correlated with those south of Seiling, and the upper dolomite is correlated with the Day Creek, the next one down with Moccasin Creek, and the bottom two considered as strays. With this interpretation, the Rush Springs would be 247 feet thick, with two stray dolomites in the middle, the basal one of which may be the equivalent of the Old Crow, or slightly above the Old Crow horizon.

In southeastern Dewey County, in the type One Horse and Old Crow region, in NW¼ sec. 27, SE¼ and NE¼ sec. 22, to SE¼ sec. 15 and NW¼ sec. 25, T. 16 N., R. 15 W., the Rush Spring is 270 feet thick, being orange-brown, fine-grained sandstone with several gypsums. The upper gypsum is 4 feet thick, occurring about 32 feet below the 0.5-foot Moccasin Creek Dolomite (elevation 1,820 feet) in NW¼ sec. 27, and is the type One Horse Gypsum of Cragin (1897, p. 363). This bed can be traced to the Weatherford area and is the equivalent of the Weatherford Dolomite. Although the name One Horse has priority, the name Weatherford has been used

extensively, so it is here suggested that the name One Horse be suppressed. About 90 feet below the type One Horse is the top of the type Old Crow Gypsum, which is about 3 feet thick, with 17 feet of gypsum and sandstone below included in the bed. The base of the Old Crow is about 94 feet above the Emanuel Bed, which is a 1-inch, pink to maroon dolomite in NW¼ sec. 25. About 27 feet of orange-brown sandstone occurs below the Emanuel, resting on a 1-foot, white to pink gypsum, correlated as the Relay Creek Bed, just above the Canadian River. The One Horse and Old Crow Gypsums erode into prominent buttes and escarpments, and have been mapped throughout parts of Dewey and Custer Counties.

Description in Custer County.—In southeastern Custer County, in the Weatherford district, in SE¼ sec. 18, the type Weatherford Dolomite is about 1 foot thick, occurring about 37 feet below an 8-foot, massive, white gypsum (Moccasin Creek), with orange-brown siltstone and sandstone between the two beds. About 270 feet of orange-brown, fine-grained, cross-bedded sandstone occurs below the Weatherford Bed, as measured in a core taken by the U. S. Army Corps of Engineers at the Weatherford site (NW¼ sec. 2, T. 12 N., R. 14 W.), where the Emanuel Bed was penetrated and extrapolated to the outcrop.* Thus the Rush Springs is about 310 feet thick, and the Weatherford Dolomite is a bed in the Rush Springs about 40 feet below the top. The Moccasin Creek may be as much as 120 feet thick in northern Washita County and 70 feet thick in the Weatherford area. Where the gypsum is this thick, it may be advisable to use the term Cloud Chief Gypsum for this unit.

About 5 miles or more west and northwest of Weatherford, the Moccasin Creek is less than 10 feet thick, and in a core taken by the U. S. Army Corps of Engineers at the East Clinton site (C sec. 9, T. 12 N., R. 16 W.), the Moccasin Creek is a double dolomite 9.5 feet thick, with 4 feet of orange-brown shale and siltstone in the middle, the base occurring at an elevation of 1,547 feet.* The dolomite is pink and white, the basal one 2.5 feet thick and the upper one 2 feet thick. About 32 feet of sandstone occurs below the Moccasin Creek, with 6 feet of Weatherford Dolomite below, and 31 feet of sandstone below the Weatherford to the bottom of the core. About 50 feet of orange-brown shale, sandstone, and siltstone occurs

* The core is on deposit at The University of Oklahoma, School of Geology, Core Library.

above the Moccasin Creek, with several thin dolomites in the upper 6 feet, surmounted by 3.7 feet of pink and white dolomite, here correlated with the Day Creek Bed. About 96 feet of shale and siltstone is present above the Day Creek to the top.

In northeastern Custer County, a high hill, termed Sugar Loaf, is present south of Thomas, in NE¼ sec. 7, T. 14 N., R. 14 W. Several thin dolomites cap the hill, and are here correlated with the Day Creek, at an elevation of 1,880 feet. A white to pink dolomite about 2 feet thick occurs about 40 feet below the upper dolomites and is here correlated with the Moccasin Creek Bed. A lower dolomite about 1.5 feet thick occurs another 24 feet down and is here correlated with the Weatherford Bed. The beds between and below are mostly orange-brown, fine-grained sandstone with some siltstone toward the top, and the Rush Springs is about 260 feet thick from the Emanuel Bed to the base of the Moccasin Creek.

North of Thomas are three dolomite-capped hills, the southernmost mound termed Dead Woman Mound and capped by one dolomite (Weatherford), and the other two capped by two dolomites, about 42 feet apart. The upper dolomite is about 1 foot thick and is correlated with the Moccasin Creek Bed, and the lower one is correlated with the Weatherford Bed. Shale and siltstone with some orange-brown sandstone occurs between, and orange-brown, fine-grained sandstone occurs below to the Emanuel Bed in NW¼ sec. 22, T. 15 N., R. 14 W. The Rush Springs is 247 feet thick, with two 1-inch, pink and white dolomites 105 and 137 feet below the top in NW¼ sec. 19, T. 15 N., R. 14 W.

Description in Caddo and eastern Washita Counties.—In eastern Washita County, a core taken by the U. S. Army Corps of Engineers at the West Eakly site (NE¼ NW¼ sec. 3, T. 9 N., R. 14 W.; elevation 1,605 feet), contains 70 feet of gypsum and anhydrite at the top, with a 2-inch dolomite below.* Below the dolomite is 44 feet of orange-brown, fine-grained sandstone, resting upon a 1-foot bed of greenish-gray, pink, and maroon dolomite, here correlated with the Weatherford Bed. The remaining 110 feet below the Weatherford is also sandstone. The Rush Springs is about 300 feet thick in this area, up to the base of the thick gypsum.

In the Cement-Cyril area, Reeves (1921, p. 48-50) stated that

* The core is on deposit at The University of Oklahoma, School of Geology, Core Library.

there are two gypsums, an upper one from 0 to 85 feet thick, resting upon 15 to 20 feet of sandy shale, and a lower one 1 to 40 feet thick, with a 1-foot dolomite at the base, resting upon sandstone These were named Cyril gypsum by Clapp (1920, p. 34-35), but it is here recommended that the lower unit be called Weatherford and the upper unit Moccasin Creek or simply Cloud Chief Gypsum where 50 feet or more thick. The sandstone below the Weatherford is 280 feet thick down to the Emanuel Bed in sec. 36, T. 7 N., R. 10 W., so the total thickness of the Rush Springs would be 300 feet or more, depending upon the thickness of the Weatherford Bed.

Description in Texas Panhandle.—In Hemphill County, Texas, along the Canadian River and extending into Roger Mills County, a series of gypsums or dolomites occur about 25 feet above orange-brown, fine-grained sandstone of the Rush Springs. These are collectively designated as the Moccasin Creek Bed, with interbedded shale between ledges, and overlain by shale and orange-brown siltstone of the Cloud Chief Formation. The Day Creek is absent. One of the best exposures is that north of the Oscar Forgey ranchhouse, in sec. 128, H. & T. C. R. R. Co. Survey, Blk. 41, where three gypsum units occur above 10 feet of Rush Springs Sandstone. The basal gypsum is 3.5 feet thick, surmounted by 1.5 feet of red-brown shale, then 3.5 feet of gypsum, 5 feet of shale, and 1 foot of gypsum at top, or 14.5 feet for the total thickness of the Moccasin Creek Bed at the base of the Cloud Chief Formation. About 25 feet of orange-brown shale is above the gypsums, with 10 feet of sandstone and siltstone at top. Laterally the gypsums are gradational into dolomites or greenish-gray beds. A stratigraphic test taken about 1 mile southeast of the gypsum outcrop (3,800 feet N, 2,520 feet W of SE cor. sec. 111, Blk. 41, elevation 2,267 feet), shows that the base of the Moccasin Creek is at 2,072 feet, and the Whitehorse is 236 feet thick, with the Rush Springs portion being 125 feet thick, but fully represented.

In central Hutchinson County, in the Borger-Sanford area, is about 61 feet of orange-brown sandstone and red-brown shale of the Rush Springs below a 21.5-foot bed of Moccasin Creek gypsum and shale. The Moccasin Creek is composed of three gypsums, separated by red-brown shale, the sequence from bottom to top being 5 feet gypsum, 4 feet shale, 5.5 feet gypsum, 2 feet shale, and 5 feet gypsum. The Moccasin Creek is overlain by 70 feet of shale, 8 feet of

orange-brown sandstone, and 4.5 feet of red-brown shale, or a total thickness of 104 feet for the Cloud Chief. The Alibates Dolomite occurs above the Cloud Chief and is 14 to 19 feet thick, being composed of two dolomite beds separated by 5 feet of orange-brown shale and siltstone. The basal dolomite is 7 to 9 feet thick, and the upper one is 2 to 5 feet thick. The Alibates is here considered to be part of the basal Doxey Shale and is overlain by 35 feet or more of red-brown shales and orange-brown siltstones. Good exposures of these units occur about 2 miles east of Borger, along State Highway 152 and local highway 2171, and about 1 mile east of Sanford, south of local highway 2196. In the Phillips 73 Whittenburg well, about 3 miles north-northeast of Borger, the Rush Springs is about 100 feet thick, consisting of sandstone and shale, with a 25-foot gypsum bed in the middle, here correlated with the Old Crow Bed. The total thickness of the Whitehorse is 165 feet, and the Cloud Chief thickness is the same as that measured at the surface; thus the Cloud Chief and Rush Springs normally thin westward from Custer County, Oklahoma, to Hutchinson County, Texas. Westward to New Mexico, the Whitehorse averages about 200 feet in thickness, with the lithology remaining about the same.

POST-WHITEHORSE ROCKS

Cloud Chief Formation

Name.—The name Cloud Chief was first used by Gould (1924, p. 337) for beds above the dolomite now termed Weatherford or, where this bed is missing, for beds above the Whitehorse sandstone, to the base of the Quartermaster Formation. The name Taloga formation of Cragin (1897, p. 362) was abandoned by O'Conner (1963, p. 1875-1877). Cragin thought the Relay Creek dolomite near Greenfield, Blaine County, was the Day Creek and named the Taloga for the beds above this (Relay Creek) dolomite.

Type section.—In the Cloud Chief region, the base of the Cloud Chief is exposed south of town, but the top is eroded, so rocks of this area are inappropriate for a type section. The rocks of the area on the south flank of the Anadarko basin are poorly exposed, so the section should be on the north flank of the basin. The closest section that is nearly complete is that northwest of Clinton, in the

Red Hills, Custer County, but there a part of the middle is covered for a short distance, and slumped areas are common. A composite thickness is 175 feet in this region. In the north Cheyenne area of Roger Mills County, the Cloud Chief is about 190 feet thick, with a good base and top exposed, but the middle portion is slumped in many places. In the Strong City-Hammon area is much slump, and in the area south of Harmon, Ellis County, where 125 feet was measured below the Doxey, the lower part is not well exposed. After consideration of the many areas available, the best information obtainable is that in the U. S. Army Corps of Engineers West Leedey core*, which was spudded in 37 feet below the base of the Doxey and penetrated the Day Creek, Moccasin Creek, and Weatherford Beds, with about 65 feet of sandstone below the Weatherford. The Cloud Chief is about 170 feet thick from the Doxey base to the base of the Moccasin Creek Bed, and the upper part is well exposed to the west and northwest of the core site (SW¼ SE¼ sec. 7, T. 16 N., R. 20 W.; elevation 2,090 feet; elevation on base Moccasin Creek 1,955 feet). The Weatherford is a 1-foot, white gypsum, about 25 feet below the base of the Moccasin Creek, with orange-brown sandstone and siltstone above and below. The Moccasin Creek is a triple gypsum sequence about 14 feet thick, with red-brown shale and siltstone between: basal gypsum 2 feet thick, with 8-inch, dolomitic gypsum at base, siltstone 3 feet, gypsum 1 foot, shale 5 feet, gypsum 3 feet. The Kiger Member of the Cloud Chief is 29 feet of red-brown shale and orange-brown siltstone, with a 7-inch gypsum 18 feet above the top of the Moccasin Creek. The Day Creek is a 3-foot, white to light-orange, massive gypsum. The Big Basin Member is 125 feet of red-brown shale, orange-brown siltstone, and greenish-gray sandstone and siltstone, predominantly shale in the basal 45 feet and orange-brown siltstone and sandstone in the upper part. Tentatively the West Leedey site will be considered the type section until better information is available. The upper contact and 75 feet of the lower Doxey are exposed just northwest, especially in SE¼ SW¼ sec. 6, T. 16 N., R. 20 W., where the lower 32 feet of Doxey contains tan, dolomitic siltstones in red-brown shale, resting upon orange-brown sandstone and shale of the Cloud Chief.

* NW¼ SE¼ SW¼ SE¼ sec. 7, T. 16 N., R. 20 W., southwestern Dewey County. Core is deposited at The University of Oklahoma, School of Geology, Core Library.

Subdivisions of the Cloud Chief Formation.—The Cloud Chief Formation has never been subdivided, but in Kansas terms such as Day Creek, Kiger, and Big Basin have been used by O'Connor (1963, p. 1877), and in Oklahoma the terms Weatherford, Cyril, Day Creek, One Horse, and now Moccasin Creek have been used as names for markers of certain boundaries. It is here proposed that the Cloud Chief Formation be recognized in Kansas, Texas, and Oklahoma, with two beds and two members, where it is possible to recognize marker beds. The base is placed at the base of the Moccasin Creek Bed. The Moccasin Creek is surmounted by red-brown shale of the Kiger Member, then Day Creek Bed, with the Big Basin Member at top, and base of the Doxey Shale marking the top of the Cloud Chief. All four units are present in Woods County although the upper part of the Big Basin has been eroded away so that only the lower 10 feet of this unit remains. The Moccasin Creek is 3 to 5 feet thick, being mostly a double dolomite

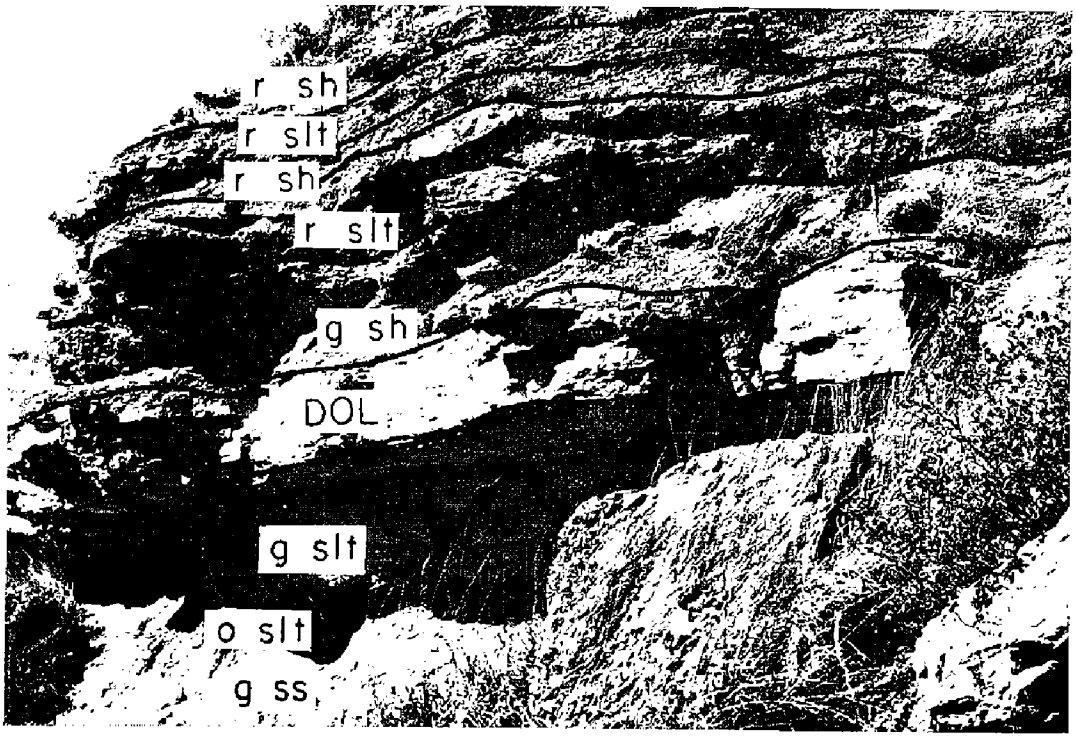

Figure 32. Day Creek Dolomite (DOL) (type section) and associate beds of the Cloud Chief Formation; closeup view toward the northeast, in NW¼ SE¼ SE¼ sec. 8, T. 28 N., R. 18 W. The Day Creek is about 2 feet thick and is overlain by a 2-foot, greenish-gray shale (g sh) containing much quartz, calcite, and montmorillonite. Above the shale are reddish-brown siltstones (r slt) and shales (r sh) of similar composition, with some dolomite and illite. The section below the Day Creek is greenish-gray siltstone (g slt) about 2 feet thick, underlain by a 1-foot, orange-brown siltstone (o slt), and a 2-foot, greenish-gray sandstone (g ss).

and greenish-gray sandstone, with red-brown shale between the 1- to 2-inch dolomites (fig. 30). The Kiger is about 25 feet or more of red-brown shale (fig. 31). The Day Creek is a dolomite about 2 feet thick, with a greenish-gray siltstone or shale at the base and immediately above (fig. 32). The Big Basin is a red-brown shale and siltstone, with a greenish-gray shale at the base (measured sections 1, 8, 10, 11, 15, 16).

MOCCASIN CREEK BED

Name.—The name Moccasin Creek Bed is here proposed for the bed at the base of the Cloud Chief Formation, named for West Moccasin Creek, Woods County, where it is well exposed. This is the same as the "purple-platy" beds of Evans (1931, p. 424) and the lower part of the "upper shale member" of Norton (1939, p. 1806). It correlates with the upper part of the Cyril Gypsum of Reeves (1921, p. 48-50) and the base of the thick Cloud Chief Gypsum of the Weatherford-Clinton-Cloud Chief area, and is the same as the double gypsum near Camargo, Dewey County, mentioned by Evans (1931, p. 420). Griley (1931, p. 433-434) recognized this zone in Roger Mills and Dewey Counties, with sandstone below and shale above, and mentioned the persistence of this horizon over a much wider area. In the original definition of the top of the Rush Springs Sandstone, Sawyer (1929, p. 11) used this gypsum for his upper boundary of the Whitehorse Group. Gould (1924, p. 337) used the Weatherford Dolomite to mark the lower boundary of the Cloud Chief when he named the Cloud Chief Formation, but this bed is now relegated to the upper part of the Rush Springs Formation, about 40 feet below the top. The Weatherford was named by Sawyer (1929, p. 11) and is the same as the One Horse Gypsum of Cragin (1897, p. 363) in Dewey County.

Type section.—The type section for the Moccasin Creek Bed is that in SE¼ SE¼ sec. 8, T. 28 N., R. 18 W., Woods County, along the headwaters of West Moccasin Creek (fig. 30) (measured section 11). There the Moccasin Creek is divided into three parts: (1) an upper 4-inch, greenish-gray, quartzose limestone or dolomite, (2) a middle 1-foot, red-brown siltstone and shale, and (3) a lower 1.5-foot, greenish-gray, calcitic sandstone. The lower unit rests upon fine-grained, orange-brown sandstone of the Rush Springs Formation, and the upper unit is overlain by red-brown shale of the Kiger Member.

Description in Woods County.—In the Cleveland Hills, in NW¼ SW¼ sec. 30, T. 28 N., R. 16 W., the Moccasin Creek is a 4-foot, orange-brown, calcitic sandstone, eroded into a prominent ledge, with shale and some sandstone above and massive, orange-brown sandstone below (measured section 10). In the Coy area, in SE¼ sec. 6, T. 28 N., R. 19 W., the Moccasin Creek is 4 feet thick and consists of a 0.5-foot, pink and white dolomite at top, with a 2.5-foot, red-brown shale below and a 1-foot, pink and white dolomite at the base, resting upon red-brown siltstone of the Rush Springs. The upper dolomite is overlain by red-brown shale of the Kiger Member (measured section 8).

The description of the Moccasin Creek in Kansas, Oklahoma, and the Texas Panhandle is given under discussion of the Rush Springs Formation. Essentially it is a greenish-gray, calcitic sandstone in Kansas; a single or double dolomite zone with associated greenish-gray sandstone in Woods, Harper, Woodward, and parts of Dewey Counties; a single or double gypsum in Caddo, Washita, Custer, Dewey, Beckham, Roger Mills, and Ellis Counties, where dolomites are gradational into the gypsums; a triple gypsum sequence 14 to 21 feet thick in the Texas Panhandle; and a quadruple gypsum sequence in Beaver County, where it is almost 24 feet thick. It is recognized in subsurface cores and samples by the change from shale above to sandstone below, with associated gypsum and/or dolomite at the boundary.

KIGER MEMBER

Name.—The name Kiger division, for Kiger Creek, Clark County, Kansas, was first used by Cragin (1896, p. 39) for the beds above the Blaine Formation (Cave Creek). It is here restricted to the shale member between the top of the Moccasin Creek Bed and the base of the Day Creek Dolomite, as redefined by O'Connor (1963, p. 1877), but here placed in the Cloud Chief Formation.

Type section.—A type section for the Kiger Member has not been proposed, so the section at the headwaters of Moccasin Creek, in SE¼ SE¼ sec. 8, T. 28 N., R. 18 W., Woods County, is here selected as the type section. There the Kiger is 31 feet thick and consists of red-brown shale, with interbedded, greenish-gray siltstones and sandstones in the upper half, overlain by the Day Creek Dolomite (fig. 31) (measured section 11).

Description in Woods County.—In the Cleveland Hills, in NW¼ SW¼ sec. 30, T. 28 N., R. 16 W., the Kiger is 32 feet thick and is red-brown shale, with a 10-foot, orange-brown sandstone at the top, beneath a slumped, 1-foot bed of Day Creek Dolomite (measured section 10). In the Coy area, in SE¼ sec. 6, T. 28 N., R. 19 W., the Kiger is 26 feet thick and is red-brown shale, with some greenish-gray sandstones and siltstones in the upper part (measured section 8).

Description in Clark County, Kansas.—The Kiger is well exposed in NW¼ sec. 2, T. 32 S., R. 22 W., in the Mt. Jesus area, where it is 24 feet thick and consists of red-brown shale, with a 3-foot, greenish-gray siltstone at the top and a 4-foot, orange-brown sandstone about 7 feet below the top. Kiger Creek is in western Clark County, and the section from the Day Creek Dolomite into the upper 50 feet of the Rush Springs is exposed in SW¼ sec. 3, T. 33 S., R. 24 W. Swineford (1955, p. 82-83) gave a detailed measured section in NE¼ sec. 27, T. 31 S., R. 22 W., where the Kiger is about 35 feet thick, consisting of red-brown clay shale and some interbedded, red-brown siltstones, with a 3-foot, white sandstone at top. The Moccasin Creek is a 1.2-foot, greenish-gray siltstone (bed 7).

Description in Oklahoma.—In Woods, Harper, Woodward, and northern Dewey Counties, the Kiger is 25 to 35 feet thick and consists of red-brown shale, with some greenish-gray siltstones and sandstones near the top and some orange-brown siltstones near the middle and top (measured sections 8, 10, 11, 15, 16). From northern Dewey County to Custer County, in the eastern parts, there is gradation from shale to orange-brown, fine-grained sandstone, and in the Weatherford district, the Day Creek is equivalent to the middle or upper parts of the thick gypsum at the base of the Cloud Chief, so the Kiger equivalent would be gypsum. Farther west in the Clinton district, the gypsum is absent, and the Kiger is about 50 feet thick and consists of orange-brown siltstone and sandstone, with some shale, with 3 feet of Day Creek Dolomite above and a double dolomite and shale 9 feet thick below (Moccasin Creek). Farther west in Custer County, and in Roger Mills, Beckham, and Ellis Counties, the Day Creek is apparently absent, being represented in places by a greenish-gray shale and siltstone zone about 40 to 60 feet above the Moccasin Creek Bed. In these areas, the

Kiger is red-brown shale and orange-brown siltstone, with some sandstone, and many greenish-gray siltstone layers near the top. In southwestern Dewey County, at the West Leedey core site, the Kiger is about 28 feet of orange-brown siltstone and red-brown shale, beneath a 3-foot bed of gypsum (Day Creek) and above a 14-foot, triple gypsum and shale sequence (Moccasin Creek). This is about as far southwest in Oklahoma that a bed can be identified as Day Creek.

In central Beaver County, a 1-foot gypsum, here tentatively identified as Day Creek, occurs about 30 feet above the top of the quadruple gypsums of the Moccasin Creek, with the Kiger being represented by red-brown shale and orange-brown sandstone. It is possible that this 1-foot gypsum is too high and that the Day Creek is absent. In the subsurface farther west in Texas and Cimarron Counties, a gypsum or two can be found at this general stratigraphic level or 30 feet higher, where more gypsums and dolomites occur, and these have been identified on logs as Day Creek. Where the gypsum or dolomite is 70 to 90 feet thick or more and the top is another 30 to 60 feet higher, the term Alibates Dolomite, or Bed, has been applied. In the Clear Creek area another gypsum and dolomite bed about 3 inches thick occurs another 54 feet above the Day Creek, and this is correlated with the prominent 3-foot gypsum in the Sand Creek area of southwestern Beaver County, which is about 21 feet below the base of the Doxey Shale in NE¼ sec. 6, T. 1 N., R. 20 ECM. The Alibates Dolomite of the central Panhandle of Texas is in the basal Doxey, and so, by correlation, this stray gypsum in southwestern Beaver County would be 21 feet below the Alibates horizon and at least 54 feet or more above the Day Creek horizon. Thus positive identification of Day Creek in Beaver, Texas, and Cimarron Counties is questionable, and use of the term Kiger is also questionable. Further details are given under discussion of the Rush Springs Formation.

DAY CREEK BED

Name.—The name Day Creek Dolomite was first used by Cragin (1896, p. 3) for the prominent 2-foot dolomite capping buttes and hills north of Sitka and Ashland, Kansas. The dolomite was named for Day Creek, Clark County, Kansas. It overlies the Red Bluff (Whitehorse) beds of Cragin and Gould, but is here included

in the Cloud Chief Formation, occurring 25 feet or more above the top of the Rush Springs Formation. Evans (1931, p. 425) recognized a 3-inch, dolomitic zone about 3 feet above the massive Day Creek in parts of Harper, Woods, and Woodward Counties, and subdivided the Day Creek into an upper and a lower Day Creek. A description of this zone is included in the discussion under the Rush Springs Formation, north-central Harper County, where it is simply included with the Day Creek Bed as an upper unit. The southernmost exposure of Day Creek, as a dolomite, in conjunction with Moccasin Creek and Kiger, similar to the type area, is that in the high hill south of Seiling, northern Dewey County. From this region eastward, southward, and westward, the Day Creek is identified by correlation of beds in individual buttes or cores and may be represented by greenish-gray shale and siltstone or gypsum. Cragin (1896, p. 45) correlated the Day Creek with a dolomite capping Centennial Mound (formerly Sentinel Mound) in old Woodward County, naming the bed Centennial Mound dolomite. The mound is possibly the one in SE¼ sec. 6, T. 28 N., R. 19 W., Woods County.

Type section.—No type section for the Day Creek Bed exists, so the area at the headwaters of Moccasin Creek, in SE¼ SE¼ sec. 8, T. 28 N., R. 18 W., Woods County, is here selected as the type section, which is also the type for Kiger, Moccasin Creek, Rush Springs, and Whitehorse. There the Day Creek is about 2 feet thick, overlain by a 2-foot bed of greenish-gray shale and underlain by 2 feet of greenish-gray siltstone, occurring as a single bed (fig. 32). The Kiger is 31 feet thick, and the Moccasin Creek is 3 feet thick, so the Day Creek occurs 34 feet above the base of the Cloud Chief, with 15 feet of red-brown shale and siltstone of the Big Basin Member above the Day Creek (measured section 11).

Description in Woods County.—In the type section, the Day Creek is a 2-foot, white to light-gray, compact, thin-bedded, well-indurated, crinkly bedded dolomite with many black to orange-brown, limonite concretions and with layers and filled vugs of chalcedony and opaline quartz, eroding into a prominent escarpment. In the Cleveland Hills it is about 1 foot thick and is slumped (measured section 11). In the Coy area it is about 2 feet thick, capping the hills (measured section 8). From Coy to the Cleveland Hills, the Day Creek is eroded into a prominent, south-facing

escarpment, occurring at an elevation of 1,980 feet or higher. In northern Woods County and adjacent parts of Comanche County, Kansas, in secs. 14-16, T. 29 N., R. 19 W., and secs. 13-15, T. 35 S., R. 18 W., small outliers of Day Creek occur.

Description in Clark County, Kansas.—In NW¼ sec. 2, T. 32 S., R. 22 W., the Day Creek is a 2-foot, light-pink to white, fine-grained, compact dolomite, well-indurated and crinkly bedded, eroding into a prominent escarpment, above 24 feet of Kiger shale. The Day Creek immediately overlies a 3-foot bed of light greenish-gray siltstone and is overlain by a 1-foot bed of red-brown shale, as measured in SW¼ sec. 14, T. 32 S., R. 23 W., north of Ashland (measured section 1). A detailed description was given by Swineford (1955, p. 83-85), who stated that the bed is 2 to 3 feet thick in Kansas, and that the chert may be original or derived from post-Permian rocks owing to solution work.

Description in Oklahoma.—The detailed description of the Day Creek is given under discussion of the Rush Springs Formation and Kiger Member, with respect to stratigraphic position of the bed. In general, the Day Creek is a dolomite from Seiling, Dewey County, northward into Clark County, Kansas, and is 1 to 3 feet thick (measured sections 1, 8, 10, 11, 15, 16). At places in Harper County it is a double dolomite. In northwestern Blaine County, in isolated buttes in southeastern Dewey County, and in northeastern Custer County, it is a dolomite occurring about 25 to 40 feet above the Rush Springs Formation. In the Weatherford district, it is equivalent to the middle or upper part of the 50- to 70-foot gypsum at the base of the Cloud Chief. In the Clinton area, it is a 2- to 3-foot bed of dolomite and occurs about 50 to 60 feet above the Rush Springs but is represented by a greenish-gray shale and siltstone farther west. In the Leedey area of southwestern Dewey County, the Day Creek is a 3-foot gypsum, occurring about 42 feet above the top of the Rush Springs. In Beckham, Roger Mills, and Ellis Counties, it has not been identified. In Beaver County, it has not been identified but is here correlated with a 1-foot gypsum occurring about 54 feet above the top of the Rush Springs in the Clear Creek area, where the Moccasin Creek is a 24-foot bed of quadruple gypsums and shales. Actually the Day Creek should occur lower than this 1-foot bed. In Texas and Cimarron Counties, in the subsurface, several gypsums and dolomites occur from 60 to 120 feet or more above the

top of the Rush Springs, and the lower units may correlate with the Day Creek, whereas the upper units correlate with the Alibates Dolomite.

The Alibates Bed is dolomite and gypsum in the subsurface of central Texas County and all of Cimarron County and is 15 to 35 feet thick to the east and 100 feet thick or more to the west, occurring 150 to 200 feet above the top of the Rush Springs in the east and 50 to 100 feet above the Rush Springs to the west. It is apparent that lower parts to the west may correlate with the Day Creek, but in the absence of direct correlation across Beaver County, it is deemed advisable to use the term Alibates for these subsurface units. In the type Alibates region of northwestern Potter County, Texas, at the headwaters of Alibates Creek, the Alibates is a double dolomite, with 5 feet of orange-brown shale between, totaling about 19 feet in thickness and occurring about 105 feet or more above the top of the Rush Springs, in the basal part of the Doxey Shale. The bed is eroded into a prominent escarpment in Potter, Moore, and Hutchinson Counties, Texas, and is easily identified in cores westward and northward to Oklahoma. For this reason, it is here suggested that the term Alibates be applied to the 15- to 100-foot dolomite or gypsum in the subsurface of Texas and Cimarron Counties and be used to mark the base of the Doxey Shale. The Alibates has not been identified east of the southwest corner of Roberts County, Texas, and east of central Texas County, Oklahoma, as shown on plate III. Thus little opportunity exists for overlap of the Day Creek and Weatherford Beds with the Alibates, but the Moccasin Creek Bed occurs in all these areas.

BIG BASIN MEMBER

Name.—The name Big Basin Sandstone was first used by Cragin (1896, p. 46) for the 2- to 12-foot, greenish-gray sandstone and mudstone conglomerate about 40 feet above the Day Creek Dolomite. The sandstone was named for the depression of the same name in Clark County, Kansas. The shales below were termed Hackberry, but this name is preoccupied, so the name for all of the beds above the Day Creek were termed Big Basin formation by Norton (1939, p. 1813), O'Connor (1963, p. 1877), and Jewett (1964). The name is here changed to Big Basin Member of the Cloud Chief Formation, with the lower limit placed at the top of

the Day Creek Dolomite and the upper limit placed at the base of the Doxey Shale or base of the Alibates Dolomite.

Type section.—No type section has been proposed for the Big Basin Member, but the West Leedey core site* (SE¼ sec. 7, T. 16 N., R. 20 W., southwestern Dewey County) is the most suitable, because the top and base are present there as well as in the area to west and northwest. This is the tentative type section for the Cloud Chief Formation, and the details are given under discussion of that section. The Big Basin is 125 feet thick, with red-brown shale in the basal 45 feet and orange-brown siltstone and greenish-gray sandstones and siltstones, with some orange-brown sandstone, in the upper 80 feet. The Doxey is a red-brown shale, with tan, dolomitic siltstones in the lower 40 feet and is easily identified by the color change from the orange-brown sandstones of the upper Cloud Chief.

Description in Woods County.—In Woods County, along the headwaters of West Moccasin Creek in SE¼ sec. 8, T. 28 N., R. 18 W., and adjacent region, the maximum observed thickness of the Big Basin is 15 feet, being mostly red-brown shale and siltstone, with much aragonite, with the upper part eroded below the Ogallala gravels (fig. 32) (measured section 11).

Description in Clark County, Kansas.—In SW¼ sec. 14, T. 32 S., R. 23 W., north of Ashland, the Big Basin is exposed for 52 feet, with a 1-foot, red-brown shale at the base, surmounted by 3 feet of greenish-gray shale, 36 feet of red-brown shale, and 2 feet of greenish-gray to red-brown sandstone and calcitic siltstone and mudstone conglomerate (original true Big Basin), overlain by 10 feet of red-brown shale, truncated by Cretaceous beds (measured section 1).

Description in Woodward County.—In C sec. 17, T. 24 N., R. 18 W., the Big Basin is exposed for 50 feet. The basal 1.75 feet is a greenish-gray shale, surmounted by 3.5 feet of red-brown shale, with a 3-inch, maroon to greenish-gray dolomite on the shale, not included in the Day Creek. This is overlain by 34 feet of red-brown shale, with three greenish-gray sandstones 1 to 4 feet thick in the upper part. A 3-inch, light greenish-gray dolomite overlies the 34-foot unit, with 5 feet of red-brown shale above, then 1.5 feet of

* U. S. Army Corps of Engineers core on deposit at the University of Oklahoma, School of Geology, Core Library.

orange-brown sandstone, capped by 1.5 feet of light greenish-gray to light-gray dolomite (measured section 15).

Description in Beaver County.—The Big Basin is about 80 feet thick in the Clear Creek region of central Beaver County, if correlation of the Day Creek equivalent is correct. It is mostly red-brown shale, with some interbedded, orange-brown sandstones near the middle and at the top and a prominent gypsum about 25 feet below the top. This upper gypsum is about 3 feet thick in southwestern Beaver County, in the Sand Creek area, and is about 21 feet below the Doxey Shale. The beds above the gypsum are mostly orange-brown shale, siltstone, and sandstone, and the 44 feet of beds below are red-brown shale and some orange-brown siltstone, with a 3-inch, pink to greenish-gray dolomite near the base (SW¼ sec. 19, T. 2 N., R. 20 ECM.). This lower dolomite may be the Day Creek, but a core taken nearby indicates that this zone is at least 90 feet above the top of the Rush Springs or 60 feet above the top of the Moccasin Creek gypsums, and the Day Creek should occur only about 30 feet above the top of the Moccasin Creek. The Doxey is about 44 feet of red-brown shale and tan siltstone, overlain by 10 feet or more of pink conglomerate and sandstone of the Triassic Santa Rosa Conglomerate (Dockum Group).

Description in Custer County.—In the Clinton area, northwest of the town in the Red Hills region, the Cloud Chief is 175 feet thick, the lower 52 feet mostly red-brown shale and siltstone, and the Day Creek a 2-foot, greenish-gray and orange-brown sandstone. The upper 121 feet, classed as Big Basin, consists of orange-brown, fine-grained shales, sandstones, and siltstones, with a 25-foot ledge of sandstone near the base, a 7-foot ledge about 10 feet above, and a 5-foot, greenish-gray siltstone ledge about 10 feet below the top, with satin spar below. The base of the Doxey is a 2-foot, greenish-gray, calcitic, ripple-marked siltstone, overlain by 23 feet of red-brown shale and capped by 11 feet of red-brown siltstone, eroding into badlands country. In the East Clinton core (C sec. 9, T. 12 N., R. 16 W.), a prominent 13-foot sandstone occurs about 70 feet above the Day Creek, capping the hills, and this bed was mapped as Doxey on the geologic map of Oklahoma (Miser, 1954) but belongs in the middle of the Big Basin Member of the Cloud Chief Formation. The greenish-gray, calcitic siltstone in the base of the Doxey correlates with the Alibates Dolomite of Texas, so the Day Creek

would be about 121 feet below the Alibates horizon in this area.

For detailed description in other areas, please refer to the section on the Rush Springs Formation.

CRETACEOUS SYSTEM

COMANCHEAN SERIES

Kiowa Shale Formation

Name.—The name Kiowa Shale was first proposed by Cragin (1894, p. 49) for a fossiliferous shale sequence above the Cheyenne Sandstone, with the top eroded, in Kiowa County, Kansas. In 1895 (p. 361, 368) he gave the name Champion shell bed to a gypsiferous 1.5-foot bed at the base. South of Kiowa County, the Cheyenne pinches out, and the Champion Bed is missing, so the Kiowa rests directly upon redbeds, mostly above the Day Creek Dolomite.

Type section.—No type section has been proposed, but one of the more complete sections is that in the northwest side of Avilla Hill, in southern Comanche County, Kansas (measured section 2). There the Kiowa is 140 feet thick, resting upon the Rush Springs Formation, with Ogallala gravels above. Avilla Hill is a high area extending across the Oklahoma-Kansas border in secs. 18, 19, T. 29 N., R. 19 W., and secs. 13, 24, T. 29 N., R. 20 W., north of the Coy schoolhouse.

Description in Comanche County, Kansas.—In SW¼ sec. 36, T. 34 S., R. 19 W., on the northwest side of Avilla Hill, the Kiowa is subdivided into six zones or units, used as marker beds (measured section 2). The basal 5 feet is a greenish-gray to yellow-brown siltstone and shale, with some interbedded white sandstone at top, surmounted by 6 feet of dark-gray, fossiliferous shale with white, selenite crystals. This is surmounted by 0.6 foot of white sandstone, which at other places is 5 or more feet thick and contains fossils. This is mapped as Unit Kk_1 on the Woods County map. This is overlain by 29 feet of dark-gray shale with selenite crystals, capped by a 0.8-foot tan limestone, containing *Cyprimeria, Gryphaea,* and *Turritella,* termed the *Cyprimeria* zone, and mapped as Unit Kk_2 in Woods County. The *Cyprimeria* zone is overlain by a 7.8-foot, dark-gray shale, with a 0.8-foot, tan limestone and sandstone above,

containing purple-tinted *Gryphaea corrugata,* the basis for the name *Gryphaea corrugata* zone. This unit is overlain by 21 feet of dark-gray shale, with a 1-foot, gray sandstone 8 feet above the base, gradational at top into yellow-brown shale and sandstone. The next 23 feet is yellow-brown shale, with a 0.2-foot, tan limestone at top containing many ammonites and named the *Oxytropidoceras* zone. Above this zone is 3 feet of yellow-brown shale, with a 0.2-foot, yellow-brown, coquinoid limestone, termed *Gryphaea* zone (lower), overlain by 37 feet of yellow-brown and some dark-gray shale, with some yellow-brown limestones and sandstones. Above this is a 0.5-foot, yellow-brown limestone, named *Gryphaea* zone (upper), surmounted by 3 feet of yellow-brown shale at the top, covered by Ogallala gravels.

In NE¼ SE¼ sec. 14, T. 35 S., R. 18 W., the lower 45 feet of the Kiowa is exposed, the top of the section being above the Kk_2 and *Gryphaea corrugata* zone, and the base resting upon beds just above the Day Creek Dolomite (fig. 33). This is typical of the

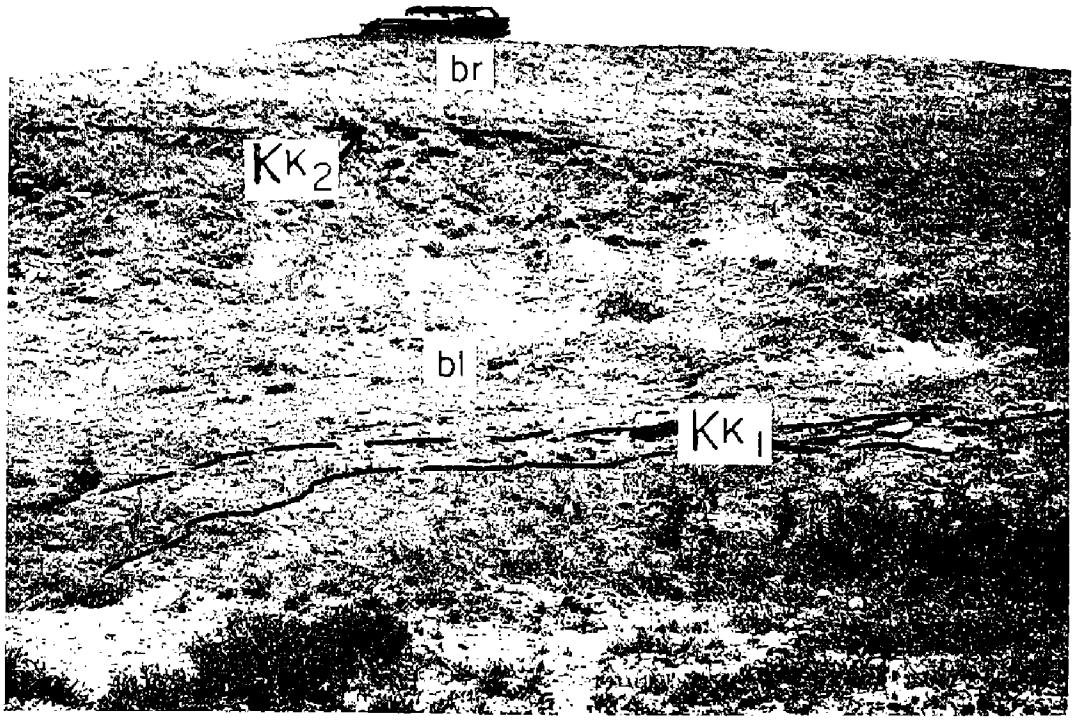

Figure 33. Kiowa Shale; view toward the east, in NE¼ SE¼ sec. 14, T. 35 S., R. 18 W., Comanche County, Kansas, about ¼ mile north of NW¼ NE¼ NW¼ sec. 15, T. 20 N., R. 19 W., Woods County, Oklahoma. A 1-foot, tan sandstone (Kk_1) about 5 feet above the base is shown in the foreground, with about 30 feet of dark-gray to black shale (bl) above. At the top of the black shale is the 1-foot zone of thinly laminated, tan limestone, containing *Cyprimeria* (Kk_2). The upper part of the section is interbedded gray and yellow-brown shales (br) with *Gryphaea* and other Cretaceous fossils.

section in Woods County, where the lower 45 feet is preserved, and is typical of the outliers in Harper, Woodward, Dewey, Roger Mills, Custer, and Washita Counties, where dark-gray shale and limestone containing *Gryphaea corrugata* are common. The Kk_1 sandstone is not the Cheyenne Sandstone because the Cheyenne pinches out before reaching Oklahoma and the Cheyenne contains plant fossils, whereas the Kk_1 sandstone contains marine fossils.

Description in Woods County.—The Kk_1 sandstone is exposed on the east and west sides of Avilla Hill, is 5 feet or more thick, and contains marine fossils in SE¼ sec. 18, T. 35 S., R. 18 W., just a few yards north of the county in Kansas. The Kk_2 and *Gryphaea corrugata* zones are exposed on the west side of Avilla Hill, extending around the southern end, but were truncated by erosion before the Ogallala gravels were deposited on the eastern side. Approximately 15 feet or more of dark-gray shale is exposed above the Kk_2 zone on the west side, up to the base of the Ogallala. The Kiowa rests upon upper Rush Springs, Moccasin Creek, or Day Creek in the vicinity of Avilla Hill.

TERTIARY SYSTEM

Pliocene Series

Ogallala Formation

Name.—The name Ogallala Formation was proposed by Darton (1899, p. 734) for 150 to 300 feet of gravels, sands, clays, and limestones of late Tertiary age, east of the Rocky Mountains, extending from Wyoming to Texas and from central Nebraska to western Oklahoma. The formation was named for Ogallala station, western Nebraska. Lugn (1939, p. 1260-1263) subdivided the Ogallala Group into four formations (ascending): Valentine, Ash Hollow, Sidney, and Kimball. The Sidney is regarded as a basal gravel lentil of the Kimball in Kansas, according to Moore and others (1951, p. 20), and the Ogallala is recognized as of formational rank.

Type section.—The type section for the Ogallala is that exposure about 2 miles east of Ogallala, Nebraska, at the Feldt ranch in SE¼ sec. 33, T. 14 N., R. 38 W., as proposed by Elias (1931) and Hesse (1935).

Figure 34. Ogallala Formation; view toward the north, in SE¼ NW¼ sec. 16, T. 28 N., R. 17 W. The section is composed of about 30 feet of tan sand and gravel, with 5 or more feet of mortar beds near the base, resting upon the reddish-brown sandstone of the Rush Springs Formation (r).

Figure 35. Volcanic ash and caliche of the Ogallala Formation; view toward the east, in NE¼ SW¼ sec. 28, T. 29 N., R. 18 W. The ash is interbedded with gray clay above and tan sand below.

Description in Woods County.—The Ogallala caps the high ridge in northwestern Woods County, extending from Avilla Hill in the northwest to the Cleveland Hills to the east, the base of which is generally above the Day Creek Dolomite at an elevation of 1,980 to 2,000 feet or higher, and the eroded top is about 2,116 feet high at the top of Avilla Hill. There the top of the Cretaceous is at an elevation of about 2,030 feet, so the maximum thickness would be 86 feet for the Ogallala, but close by the base is at 1,980 feet above sea level, and a thickness of 150 feet is indicated. The average thickness in this area is therefore probably close to 100 feet. The basal 10 or more feet is composed of black pebbles, fossil oyster shells (reworked), and pebbles and larger pieces of quartzite from the Rocky Mountains, in many places cemented into mortar beds (fig. 34). This basal part is surmounted by tan to gray shales, sands, and silts, with some interbedded gravel, and tan to white caliche beds that appear to be formed from altered volcanic ash (fig. 35). Fossil bones and teeth are common in places in the gravels, and some fossil plants were found in NE¼ NE¼ sec. 18, T. 29 N., R. 18 W., in a basal limestone. The above description fits that of the Ash Hollow Member and tentatively these beds will be considered as Ash Hollow. The exposures in the Cleveland Hills are the easternmost recognized beds of the Ogallala Formation in Oklahoma, none having been recognized east of sec. 32, T. 28 N., R. 16 W.

QUATERNARY SYSTEM

Pleistocene Series

Three separate areas of Pleistocene deposits exist in Woods County, each having a separate origin from the others, and each occurring in a separate geomorphologic province, all below the base of the Ogallala Formation. These areas are termed the Cimarron, Salt Fork, and Arkansas River areas, each mapped separately on the geologic map (pl. I). The high ridge extending from Avilla Hill (elevation 2,116 feet) southeastward to the Cleveland Hills (elevation 2,010 feet), to Whitehorse Mounds (elevation 1,870 feet), to the area east of Waynoka capped by the Blaine Formation (elevation 1,730 feet) forms a barrier between the Cimarron River deposits to the southwest and south and the ancient Salt Fork

deposits to the northeast and north. In the Alva area, the upper sandstones of the Cedar Hills are resistant and form a ridge eastward and northwestward from Alva, capped by the ancient Salt Fork Pleistocene deposits. East and north of this ridge is a veneer of clays and silts, about 100 feet lower, that belong to another ancient river system, here interpreted to be the ancient Arkansas River which flowed from the Dodge City, Kansas, area to the Great Salt Plains of Alfalfa County. The Medicine Lodge River now follows this old valley, and the clays and silts in Woods County are considered to be part of the old flood-plain deposits of this river. The present Salt Fork is late Pleistocene in origin, and the deposits in the valley that breaches the Alva ridge are Illinoian and younger. Extensive stream piracy must have taken place in late Kansan time to account for the distribution of these deposits and to account for the bends in the Salt Fork and the Arkansas River in the Alva and Dodge City areas. The Great Salt Plains may be an underfit lake, formed on the flood plain of an underfit stream, cut off by stream piracy. Various Pleistocene and Recent deposits are shown in figures 36-40.

Cimarron River Deposits

The Cimarron River deposits consist of 100 feet or more of gravels, sands, silts, and clays in three or more terrace levels on the northeast side of the river, and a veneer of clay and silt on the southwest side. These have been discussed in the Blaine County area by Fay (1962, p. 96-99), where it may be shown that all parts of the Pleistocene are represented and that the Pearlette ash occurs in the higher gravel deposits but not in the highest.

The oldest deposits are those at the higher elevations to the northeast, with successively younger deposits to the southwest. The gravels in these areas represent former positions of the stream channel, and, with the absence of gravels on the southwest side of the river, they indicate a progressive lateral shift of the stream channel toward the southwest down the dip of the bedrock throughout the Pleistocene. The flood-plain deposits are on the southwest side of the river, in corresponding terraces of the successive Pleistocene epochs. The sand is much thicker on the northeast side owing to southwesterly winds blowing dust and sand from the river flood

plain, and in places active dunes are formed (fig. 39). The present flood plain is about a mile wide, with a gradient of about 6 feet per mile, entering at an elevation of about 1,700 feet and leaving Woods County about 1,250 feet above sea level. The sand and gravel deposits, 30 to 50 feet thick, below the plain show that the present-day river has been building up its flood plain since early Wisconsinan time. In the Edith area, the river has cut through a 57-foot bed of rock salt in the Flowerpot Shale. Solution of this salt and its subsequent precipitation through evaporation of the water have created the Big Salt Plain (fig. 40). Farther north the Little Salt Plain is formed in a similar manner, probably from salt a little higher in the section.

Salt Fork Deposits

In eastern Woods County, east and north of the Blaine escarpment, a veneer of gravel, sand, silt, and clay occurs south and west of the Salt Fork, and a thick deposit of gravel and sand occurs north and east of the river, 50 to 100 feet or higher above the river (fig. 36). The deposit does not follow the present Salt Fork but

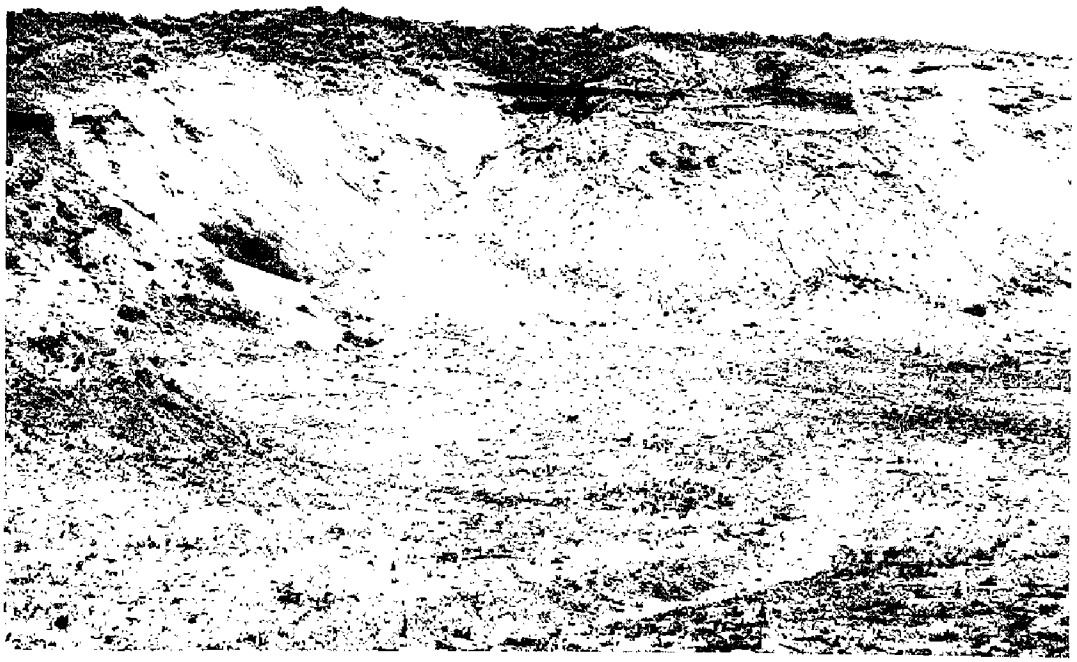

Figure 36. Pleistocene sand and gravel of Salt Fork system, view toward the east in gravel pit, in SW¼ SE¼ sec. 35, T. 28 N., R. 14 W. The deposits are tan to gray and contain some fossil bones and black pebbles.

extends southward from Alva and then gradually southeastward toward Aline, southwestern Alfalfa County, following in a direction parallel to Eagle Chief Creek. This is termed the ancient Salt Fork region. In NE¼ SW¼ sec. 32, T. 29 N., R. 15 W., is 11 feet of Pearlette ash on the Flowerpot Shale, interbedded with yellow-brown silt and gravel (figs. 37-38). This may be used as a marker to date the deposits as at least late Kansan in age; thus higher gravels would probably be Nebraskan. The thicker deposits are farther east, east of the present-day river, probably because the ancient channel was in this position and the sand was blown in that direction.

In the Aline-Cleo Springs area of southwestern Alfalfa and northern Major Counties, where Eagle Chief Creek empties into the Cimarron River, the Blaine-Flowerpot escarpment gradually is lower in elevation, and the ancient Salt Fork deposits connect with the higher Cimarron River deposits. Here the valley of Eagle Chief Creek is several miles wide, with gravel and sand as much as 50 feet thick or more extending for 5 miles or more on either side. Obviously, the Nebraskan-late Kansan Salt Fork was a tributary to the Cimarron River, flowing southward into the Cimarron

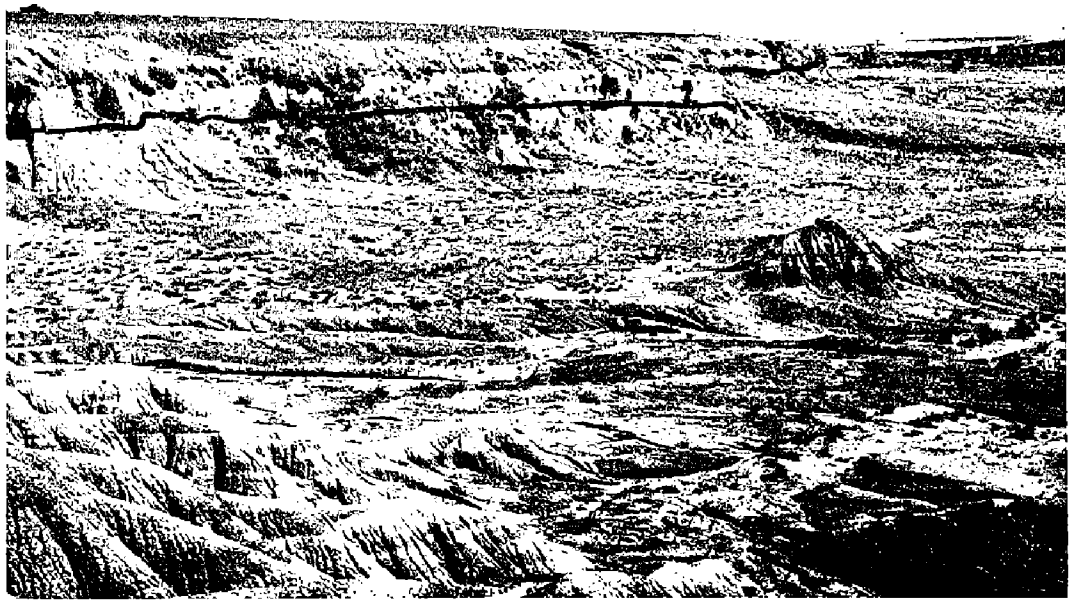

Figure 37. Pearlette ash on Flowerpot Shale; view toward the southeast, in NE¼ SW¼ sec. 32, T. 29 N., R. 15 W. The bed is about 11 feet thick, interbedded with yellow-brown silt and gravel, with 2 feet of gray clay above.

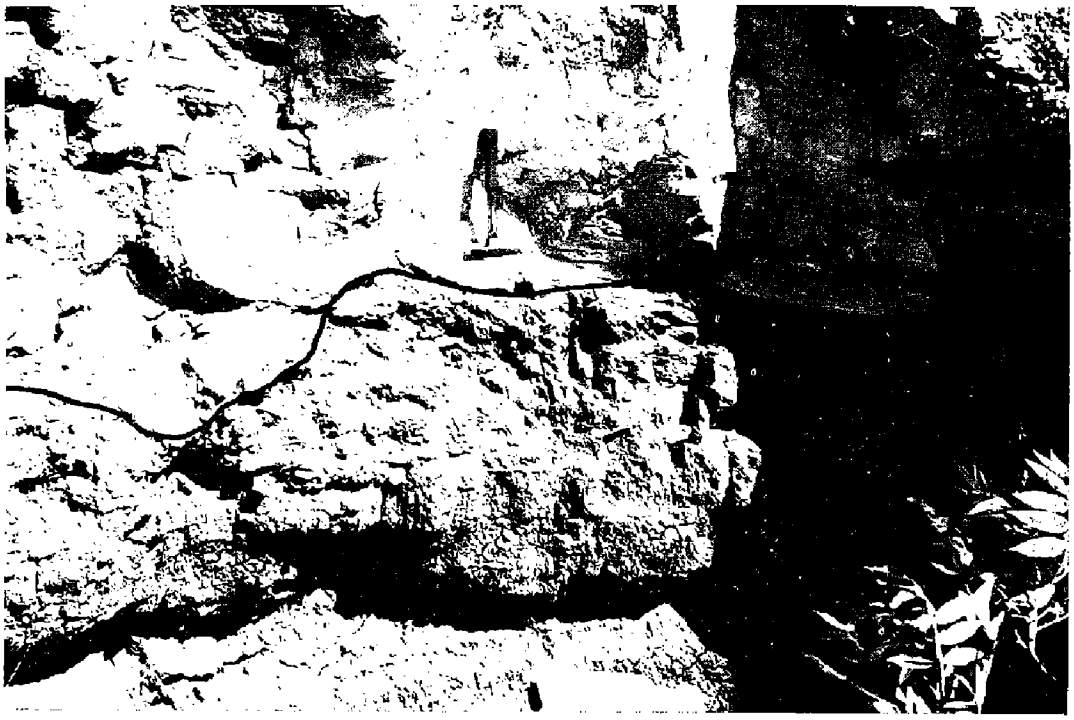

Figure 38. Pearlette ash on Flowerpot Shale; closeup view in NE¼ SW¼ sec. 32, T. 29 N., R. 15 W. In previous publications this is the "Alva" locality erroneously reported to be southeast of Alva in one publication.

Figure 39. Sand dunes in Little Sahara State Recreation Area, about 3 miles south of Waynoka on west side of U. S. Highway 281, in SW¼ SE¼ sec. 23, T. 24 N., R. 16 W. The original sand is probably older Pleistocene river sand of the Cimarron River system, whereas the dunes were probably formed much later by the prevailing southwesterly winds.
(Photograph courtesy of Oklahoma Planning and Resources Board)

Figure 40. Big Salt Plain of Cimarron River; view toward the south, in S½ sec. 21 and in sec. 28, T. 27 N., R. 19 W. The prominent escarpment is formed by Medicine Lodge Gypsum above 85 feet of Flowerpot Shale. A 57-foot bed of rock salt is reported to be present just below the river bottom, in the Flowerpot Shale.

near Aline. Then, probably in late Kansan time, after the Pearlette ash was deposited, a small westward-heading stream in the Alva region pirated the ancient Salt Fork, becoming the present-day stream. The Salt Fork then shifted its course eastward, leaving the ancient channel high and almost dry, to become the present Eagle Chief Creek, which is an underfit stream.

The immediate sharp terrace levels along the Salt Fork would then be post-Kansan in age, or Illinoian-Wisconsinan, and the breach in the Cedar Hills ridge east of Alva would be explained by piracy from an eastern stream working headward to capture the ancient Salt Fork. The present river has a gradient of about 8 feet per mile, entering Woods County at an elevation of about 1,500 feet and leaving at about 1,250 feet.

Arkansas River Deposits

In northeastern Woods County, along Driftwood Creek and its tributaries, is a veneer of silt, sand, and clay, the top of which is

50 to 100 feet or more below the base of the Salt Fork deposits to the west and south. This area is the western part of a large plain that extends eastward for 40 miles or more and is a remnant of deposits of an old river system. In Noble County, north of Perry, are high-level quartzite gravels termed Black Bear gravels locally and probably derived from the Rocky Mountains. These seem to connect with the deposits farther northwest in the Great Salt Plains area of Alfalfa County and extend northward into Kansas, following the Medicine Lodge River, striking toward Dodge City, Kansas. The entire system of gravels, sands, silts, and clays at various levels, extending from the Ponca City-Black Bear Creek area, Oklahoma, to the Dodge City region, Kansas, is here termed the ancient Arkansas River system. The Salt Fork east of Alva and the Medicine Lodge River follow this ancient stream, and are here considered underfit streams, filling in the valley of the old Arkansas River.

The point of convergence of the Medicine Lodge River with the Salt Fork is in central Alfalfa County, where the Great Salt Plains were formed. It seems that this lake became a dried-up remnant or underfit lake when stream piracy near Dodge City, Kansas, took place and the Arkansas River shifted its channel northeastward, giving rise to the great bend of the Arkansas. Norton (1939, p. 1798), Latta (1948, p. 105), and Frye and Leonard (1952, p. 192, 194, 199) gave evidence for an ancestral Arkansas River and farther west an ancestral Salt Fork connecting with those previously postulated for Oklahoma.

Probably a small tributary to the ancestral Arkansas worked its way westward from the Great Salt Plains area toward the Alva region and pirated the ancestral Salt Fork in late Kansan time. Then shortly afterwards, the ancestral Arkansas was probably pirated near Dodge City, Kansas, by a southwestward-flowing stream, giving rise to the great bend in the Arkansas. Thus the Great Salt Plains region was an area of convergence of two large river systems in late Kansan time, and the alluvial outwash from both rivers probably formed a natural dam in this area. The salt was probably dissolved from the Flowerpot Shale and Cedar Hills Sandstone and carried by streams to the region of the Great Salt Plains. Here the salt was precipitated owing to evaporation of the stagnant water trapped in the underfit lake after stream piracy of the headwaters.

MINERAL (NONFUELS) RESOURCES

The natural resources of Woods County are little used at present, and only a short summary of the economic geology is presented. Gypsum, salt, dolomite, shale, sandstone, sand and gravel, volcanic ash, and ground water are the basic items of importance that occur in the county.

The gypsum deposits are restricted to the Blaine Formation in the northwestern part of the county, where mainly the lower 25- to 30-foot member is present (Medicine Lodge Gypsum). In a few areas, such as the headwaters of Yellowstone, Greenwood, and West Moccasin Creeks, the Nescatunga and Shimer Gypsums are present, each about 10 to 15 feet thick, separated by about 7 to 10 feet of shale. The upper units are leached or eroded in most other places, and in isolated areas, such as those east of Waynoka, only dolomites can be found in the Blaine. The extent of anhydrite beneath the surface with respect to amount of overburden is unknown, so the estimated reserves of gypsum may include some anhydrite. The estimates are based upon outcrop information where the natural overburden is less than 30 feet, and gypsum is 140 pounds per cubic foot or 3,000 tons per acre-foot. The total amount of estimated reserves is about 2.3 billion tons, with the best areas for surface mining in T. 27 N., Rs. 17, 18 W.; T. 28 N., Rs. 16, 17 W.; and T. 29 N., R. 17 W. The gypsum is of high purity, comparable to that mined by the U. S. Gypsum Company at Southard, Blaine County.

Salt deposits occur along the flood plain of the Cimarron River from Edith to the Kansas border, in two areas, designated as the Little Salt Plain (E½ of T. 29 N., R. 21 W., and T. 28 N., R. 21 W., sec. 1) and Big Salt Plain (S½ of T. 27 N., R. 19 W.). The Little Salt Plain covers about 2,000 acres and the Big Salt Plain covers about 4,100 acres, including 4 miles of Buffalo Creek. Ezra Blackmon has a small operation in sec. 20 and part of sec. 29, about 3 miles west of Edith. The salt is produced by evaporation of the brine water, and some of the salt contains sand. The source of the salt appears to be a 57-foot bed of rock salt (halite, NaCl) that occurs 65 to 122 feet beneath the flood plain, and other stray salt layers in shale that occur 30 to 138 feet below the surface of the flood plain,

TABLE 1.—ESTIMATED RESERVES OF GYPSUM IN BLAINE FORMATION OF WOODS COUNTY

Member	T. R.	Workable Thickness (feet)	Overburden (feet)	Workable Area (acres)	Reserves (1,000 short tons)	Total Gypsum (1,000 tons)
Shimer Gypsum						
	26N-17W	8	20	50	1,200	
	27N-16W	8	20	650	15,600	
	27N-17W	10	20	780	23,400	
	27N-18W	10	30	420	12,600	
	27N-19W	10	30	70	2,100	
	28N-16W	10	20	680	20,400	
	28N-17W	10	20	800	24,000	
	28N-18W	10	30	400	12,000	
	28N-19W	10	30	600	18,000	
	28N-20W	10	30	460	13,800	
	29N-17W	10	30	730	21,900	
	29N-20W	10	20	120	3,600	
						168,600
Nescatunga Gypsum						
	26N-15W	10	15	60	1,800	
	26N-16W	10	15	260	7,800	
	26N-17W	10	20	140	4,200	
	27N-16W	10	15	1,600	48,000	
	27N-17W	10	20	1,840	55,200	
	27N-18W	10	20	1,580	47,400	
	27N-19W	10	30	150	4,500	
	28N-15W	10	10	10	300	
	28N-16W	10	30	1,950	58,500	
	28N-17W	10	25	1,090	32,700	
	28N-18W	10	25	200	6,000	
	28N-19W	10	30	1,000	30,000	

according to Ward (1961b, p. 275). The old river channel is about half a mile north of the present channel, and the shallowest portion of the salt occurs on the north edge of this old channel. Small springs seep upward from ground water flowing into the river at depth, and the shallow salt is dissolved, giving rise to salt springs. The top of the 57-foot bed occurs about 150 feet below the base of the Blaine Formation, in the Flowerpot Shale, and the highest salt occurs about 115 feet below the base of the Blaine. The 57-foot bed is 20 percent shale and 80 percent halite, or about the equivalent of a 45-foot bed of pure rock salt. According to Ward (1961a, p. 84) the approximate flow of water in the Little Salt Plain is 0.2 cubic

Member	T. R.	Workable Thickness (feet)	Overburden (feet)	Workable Area (acres)	Reserves (1,000 short tons)	Total Gypsum (1,000 tons)
	28N-20W	10	25	960	28,800	
	29N-16W	10	20	580	17,400	
	29N-17W	10	30	1,630	48,900	
	29N-20W	10	25	180	5,400	
						396,900
Medicine Lodge Gypsum						
	25N-15W (sec. 25)	10	20	10	300	
	25N-16W	10	20	150	4,500	
	26N-15W	10	20	150	4,500	
	26N-16W	10	20	1,360	40,800	
	26N-17W	20	20	710	42,600	
	27N-15W	20	20	180	10,800	
	27N-16W	20	30	4,000	240,000	
	27N-17W	25	30	3,800	285,000	
	27N-18W	25	30	2,100	157,500	
	27N-19W	25	30	760	57,000	
	27N-20W	25	15	10	750	
	28N-15W	25	15	130	9,750	
	28N-16W	25	40	4,200	315,000	
	28N-17W	25	40	1,350	101,250	
	28N-19W	25	40	1,200	90,000	
	28N-20W	25	40	1,900	142,500	
	29N-16W	25	35	1,300	32,500	
	29N-17W	25	40	2,340	175,500	
	29N-20W	25	30	280	21,000	
						1,731,250
					Grand Total	2,296,750

feet per second, and 150 tons of salt per day is added in this area. The Big Salt Plain receives water at the rate of 3.4 cubic feet per second, and about 2,500 tons of salt per day is deposited or dissolved and carried away. The alluvium is about 10 feet thick beneath the Big Salt Plain and Buffalo Creek but is 50 to 60 feet thick in the channel to the north, and the top of the highest salt is about 30 feet above the base of the channel. Based upon a value of 135 pounds per cubic foot for rock salt, or 1.88 million short tons per square mile-foot, a 50-foot bed over a 12-square-mile area of the Big Salt Plain could supply at least 1,128,000,000 tons of salt. Jordan and Vosburg (1963, pl. III) gave an average thickness of 200 feet of

rock salt in this area in the Flowerpot Shale, so assuming a 20-percent shale content, the total supply in the 12-square-mile area would be about 4 billion tons. The Pleistocene terraces above the Blaine escarpment are an excellent source of water, which would flow toward the Cimarron River underground, dissolving the salt in the Flowerpot, and then return to the surface under pressure, appearing as a salt brine. The total reserves of salt in the Flowerpot in Woods County from T. 27 N. to T. 29 N., and R. 19 W. to R. 21 W., based upon a thickness of 200 feet, would be about 88 billion tons over a 235-square-mile area. Appreciable amounts of Flowerpot salt are not reported much farther east or south in Woods County, but it is possible that much of the salt was dissolved in the past from the outcrop. At the rate of 1 million tons of salt per year, the time at which the supply will be dissolved away from the Cimarron River area will be at least 4,000 years if just the 12-square-mile area around the Big Salt Plain is considered as the only supply. If the thicker sections farther west are considered, it will probably be several hundred thousand years before the supply will be dissolved by the Cimarron and its tributaries.

The Day Creek Dolomite was extensively quarried in secs. 2, 3, 4, T. 28 N., R. 19 W., and secs. 34, 35, T. 29 N., R. 19 W., in the 1930's and used in construction of the Fort Supply dam in Woodward County. The dolomite is about 2 feet thick and has less than 5 feet of overburden, being used locally for foundations or retaining walls. The Altona Dolomite of the Blaine Formation is about 1 foot thick and has been used locally for foundations. The cement used to hold the blocks together in places is the old gypsum cement, prepared by breaking pieces of gypsum into a powder and throwing the powder into a trench of burning logs, and then mixing the slaked gypsum with water after cooling. One such foundation still stands just west of Tegarden, on the north side of U. S. Highway 64, and another is on the west side of the Cleveland Hills.

Snider (1911, p. 264) reported that 10,000 bricks per day were made in Alva by Z. W. Cox, but this industry was discontinued shortly thereafter. The lower part of the Flowerpot Shale was quarried. A gypsum plant was also located in Alva in 1913, and the quarry was in the Medicine Lodge Gypsum of Woodward County, in sec. 10, T. 23 N., R. 17 W. An 11-foot bed of volcanic ash (Pearlette) occurs over about 20 acres in SE¼ sec. 32, T. 29 N., R.

15 W., locally termed the "Alva" deposits. The ash can be used as a fine abrasive but has not been exploited. The Doe Creek Sandstone of the Whitehorse Springs-Cleveland Hills area could be used for rock wool, but the deposits are small. Sand and gravel have been and are being used locally for road metal and concrete. One large active pit is northeast of Alva in SE¼ sec. 1, T. 27 N., R. 14 W., and another is in SE¼ sec. 35, T. 28 N., R. 14 W. Abandoned pits may be found in the Ogallala and Pleistocene areas, and smaller active and abandoned pits may be scattered at random.

Ground-water studies have not been made in this area, but the Cimarron Pleistocene gravels and sands are about 100 feet thick and furnish an ample supply of good-quality water for Waynoka and Alva. Fairvalley Springs originate in the Cimarron terrace gravels, and Whitehorse Springs originate in the Doe Creek Sandstone. Most of the larger streams have water flowing all year, the source being ground water from the Ogallala and Pleistocene deposits. The water is good quality and has been used locally for drinking, for irrigation, and for cattle.

Of local interest are the sand dunes south of Waynoka, where Little Sahara State Recreation Area is located. Here the Pleistocene sand is blown by the wind from the southwest, and where blowouts occur, the vegetation is stripped away. The loose sand then drifts into dunes 30 to 50 feet high, creating a desert effect (frontispiece, fig. 39). Dromedary camels and other animals are presently kept in the park area and some recreational facilities are available.

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APPENDIX

Measured Sections

The following sixteen measured sections are in part represented on plate IV, as composite sections numbered I through VI. Many of the mineralogic details that were omitted in Bulletin 98 (Fay, 1964) are here included in the Marlow, Dog Creek, Blaine, and upper Flowerpot portions. The extreme details were needed in this study because it was possible to subdivide the Cedar Hills Member and Flowerpot Shale into about six mappable zones each, and these are expressed on the geologic map (pl. I) and clarified in the measured sections. Also, the type sections for the Hennessey, Bison, Cedar Hills, Flowerpot, members of the Blaine, Dog Creek, Doe Creek, Whitehorse, Rush Springs, Moccasin Creek, Kiger Member, and Day Creek units are included in these measured sections, making it necessary to have basic data in extreme detail.

Section 1.
Ashland-Protection, Clark and Comanche Counties, Kansas

Beginning at top in Big Basin Member of Cloud Chief Formation to Day Creek Dolomite, section measured in SW¼ and near C sec. 14, T. 32 S., R. 23 W., about 4.3 miles north and 0.5 mile west of the west edge of Ashland, Clark County, Kansas. Section then extrapolated to Mt. Jesus area, in NW¼ sec. 2, T. 32 S., R. 22 W., east of road, for Day Creek Dolomite and underlying Kiger Member of Cloud Chief Formation. The underlying Rush Springs Formation to upper Marlow was measured in the high bluffs in SE¼ sec. 17, T. 32 S., R. 21 W., to NW¼ sec. 23, T. 32 S., R. 21 W., along a branch of Bluff Creek, and is the type area for the Red Bluff Beds. The Marlow Formation, from the Emanuel and Relay Creek Beds to the Dog Creek Shale, was measured in SW¼ sec. 34, T. 34 S., R. 19 W., and near C sec. 3, T. 35 S., R. 19 W., Comanche County, Kansas.

	Thickness (feet)
CUSTERIAN SERIES	
CLOUD CHIEF FORMATION (top not exposed; thickness 81 feet)	
Big Basin Member: (top not exposed; thickness 52 feet)	
Shale, red-brown, silty, blocky, weakly indurated, with some 2- to 3-inch indurated siltstone beds and 1-inch calcite veins	10.0+
Mudstone conglomerate and sandstone, greenish-gray, mottled red-brown, thin-bedded, well-indurated, brecciated, calcareous; gradational into siltstone and dolomite; eroding into an escarpment	2.0
Shale, red-brown, silty, blocky, weakly indurated; mottled with 0.5- to 1-inch greenish-gray spots	36.0
Shale, greenish-gray, silty, blocky, weakly indurated	3.0
Shale, red-brown, silty, blocky, weakly indurated	1.0
Day Creek Dolomite Bed:	
Dolomite, white to light-pink, very fine-grained, compact, well-in-	

	Thickness (feet)
durated, thinly laminated, crinkly bedded; eroding into a prominent ledge	2.0
Kiger Member: (total thickness, 24.5 feet)	
Siltstone, light greenish-gray, arenaceous, quartzose, weakly indurated	3.0
Shale, red-brown, silty, blocky, weakly indurated	3.75
Sandstone, orange-brown, very fine-grained, quartzose, weakly indurated; with a 3-inch greenish-gray zone at base	4.5
Shale, red-brown; as above; with some 2- to 4-inch orange-brown siltstone beds	13.25
Moccasin Creek Bed:	
Sandstone, greenish-gray and red-brown, very fine-grained, silty, calcitic, thinly laminated; well indurated in top 1 foot; weakly indurated below; eroding into a ledge at top	2.5
WHITEHORSE GROUP (total thickness, 197.6 feet)	
RUSH SPRINGS FORMATION (total thickness, 98.5 feet)	
Sandstone, orange-brown, very fine-grained, quartzose, weakly indurated; with a 1-inch greenish-gray siltstone at base	7.75
(*Section extrapolated to SE¼ sec. 17, T. 32 S., R. 21 W.*)	
Shale, red-brown, silty, blocky, weakly indurated	0.8
Siltstone, red-brown, argillacous, blocky, thin-bedded, moderately indurated	0.8
Shale, red-brown; as above	0.5
Siltstone, red-brown, mottled greenish-gray, calcitic, well-indurated; as above	0.25
Shale, red-brown; as above	1.5
Siltstone, red-brown, mottled greenish-gray, well-indurated; as above; eroding into a ledge	2.0
Shale, red-brown; as above	0.8
Siltstone, red-brown, well-indurated; mottled greenish-gray in middle 2 inches; as above; eroding into a ledge	2.75
Shale, red-brown; as above	1.0
Shale, greenish-gray, blocky, weakly indurated; with some 0.5-inch calcite veins	0.25
Sandstone, orange-brown, very fine-grained, quartzose, silty, thinly laminated, weakly indurated	2.0
Sandstone, red-brown, very fine-grained, quartzose, silty, well-indurated; with 1-inch greenish-gray zone at base; eroding into a ledge	2.75
Shale, red-brown; as above	0.2
Sandstone, red-brown; as above; eroding into a ledge	1.8
Shale, red-brown; as above; with a 3-inch greenish-gray zone at top and base	2.5
Sandstone and siltstone, orange-brown to red-brown, very fine-grained, quartzose, well-indurated; eroding into a ledge	5.5
Shale, red-brown; as above; with some 1- to 2-inch greenish-gray layers	2.5
Sandstone, orange-brown, fine-grained, quartzose, massive, moderately to well-indurated; mottled with greenish-gray spots; eroding into a ledge	7.0
Shale and siltstone, red-brown, platy, thin-bedded, moderately to weakly indurated; with a 2- to 3-inch greenish-gray zone at top and base	6.75
Sandstone, orange-brown, moderately indurated; as above; eroding into a ledge	5.25
Sandstone, orange-brown, weakly indurated; as above	2.75
Siltstone, greenish-gray, mottled red-brown, micaceous, thinly laminated, well-indurated; eroding into a ledge	1.8
Shale, red-brown; as above	5.25

	Thickness (feet)
Siltstone, red-brown, micaceous, blocky, well-indurated; eroding into a ledge	3.0
Shale, red-brown; as above	1.0
Sandstone, light greenish-gray, very fine-grained, silty, quartzose, calcitic, thinly laminated, moderately indurated; with some interbedded red-brown shale; mottled orange brown and well indurated in middle 5 feet; eroding into several ledges	10.5
Shale, red-brown; as above	7.75
Sandstone, light greenish-gray, very fine-grained, thin-bedded, moderately indurated	1.0
Shale, red-brown; as above	1.0
Sandstone, very fine-grained, quartzose, well-indurated; orange brown above; greenish gray in basal 1 foot; eroding into a ledge	2.8
Shale, red-brown; as above; with a 6-inch greenish-gray to red-brown dolomitic siltstone and sandstone 1.5 feet below top; well indurated in places; eroding into a ledge	7.0
MARLOW FORMATION (total thickness, 100.5 feet)	
Emanuel Bed:	
Sandstone, very fine-grained, quartzose, moderately indurated; greenish gray in top 1 foot; orange brown and greenish gray in basal 6 inches; eroding into a ledge	3.0
Unnamed Units:	
Shale, red-brown, silty, blocky, weakly indurated	1.25
Siltstone, greenish-gray and red-brown, blocky, weakly indurated	1.5
Shale, red-brown; as above	0.5
Siltstone, orange-brown, blocky, weakly indurated	3.0
(Section extrapolated to NW¼ sec. 23, T. 32 S., R. 21 W., east of road)	
Shale, red-brown; as above	5.75
Relay Creek Bed:	
Sandstone, light greenish-gray, fine-grained, quartzose, weakly indurated; with 0.25-inch indurated calcitic zone at top	1.5
Unnamed Units:	
Sandstone, orange-brown, very fine-grained, quartzose, silty, weakly to moderately indurated	7.75
Shale, red-brown, weakly indurated; as above; with some 0.5-inch greenish-gray calcitic siltstone beds	1.0
Sandstone, orange-brown; as above; weakly indurated above; mottled greenish gray in middle 3 feet; well indurated in basal 3 feet	6.0
Shale and siltstone, red-brown; as above; with some 0.5-inch greenish-gray beds at top and a 2.5-foot well-indurated orange-brown sandstone 1.5 feet below the top	13.0+
(Section up to Relay Creek Bed extrapolated to creek in SW¼ sec. 34, T. 34 S., R. 19 W., and adjacent part of sec. 3, T. 35 S., R. 19 W., Comanche County, Kansas)	
Relay Creek Bed:	
Dolomite and sandstone, pink to orange-brown, fine-grained, crinkly bedded, well-indurated; eroding into a ledge; this is a transition zone from a carbonate bed in Oklahoma to a greenish-gray calcitic sandstone in southern Kansas	0.1
Unnamed Units:	
Sandstone, orange-brown, very fine-grained, silty, quartzose, weakly indurated, even-bedded; with some interbedded orange-brown siltstone	83.0
Sandstone, light greenish-gray, fine-grained, quartzose, weakly indurated	1.0

	Thickness (feet)
CIMARRONIAN SERIES	
EL RENO GROUP	
DOG CREEK SHALE (base not exposed; measured thickness 18.2 feet)	
Shale, red-brown, silty, blocky, weakly indurated	2.0
Southard Dolomite Bed:	
Dolomite, light greenish-gray, very fine-grained, silty, compact, platy, well-indurated	0.2
Unnamed Units:	
Shale, red-brown, silty, blocky	8.5
Sandstone, very fine-grained, quartzose, weakly indurated; greenish gray at top; orange brown below	3.0
Siltstone and sandstone, greenish-gray, silty, blocky, thinly laminated, weakly indurated, mottled orange-brown	2.5
Shale, red-brown, silty, blocky, weakly indurated	2.0+

SECTION 2.
AVILLA HILL, COMANCHE COUNTY, KANSAS

Beginning at top in Cretaceous Kiowa Shale, section measured in SW¼ sec. 36, T. 34 S., R. 19 W., on northwest side of Avilla Hill, Comanche County, Kansas.

	Thickness (feet)
TERTIARY SYSTEM?	
OGALLALA FORMATION?	
Mortar beds, with gravel, moderately to well-indurated; capping hill	4.0+
CRETACEOUS SYSTEM	
COMANCHEAN SERIES	
KIOWA SHALE (measured thickness, 139.55 feet)	
Shale, yellow-brown and greenish-gray, blocky, weakly indurated; top eroded; unconformable with beds above	3.0
Gryphaea Zone (upper) :	
Limestone, yellow-brown, weakly indurated; like a coquina; with many white **Gryphaea** shells 1- to 2 inches in diameter	0.5
Unnamed Zones:	
Shale, light yellow-brown, blocky, weakly indurated; with some 1- to 2-inch yellow-brown sandstone ledges	13.0
Limestone, yellow-brown, fine-grained, well-indurated, thinly laminated; like a coquina; eroding into a ledge	0.2
Shale, dark-gray and yellow-brown, platy, weakly indurated; with a 1-inch yellow-brown coquinoid limestone 4 feet above the base	9.5
Sandstone, tan, very fine-grained, calcitic, well-indurated, thinly laminated; fossiliferous at base; gradational into sandy limestone; eroding into a ledge	0.2
Shale, dark-gray and yellow-brown, platy, weakly indurated	15.0
Gryphaea Zone (lower) :	
Limestone, yellow-brown, coquinoid, fine-grained, thinly laminated, well-indurated; with many **Gryphaea** fragments; eroding into a ledge	0.2
Unnamed Zone:	
Shale, yellow-brown, mottled dark-gray, platy, weakly indurated	3.0
Oxytropidoceras Zone:	
Limestone, light-tan, fine-grained, arenaceous, thinly laminated, fossiliferous; with many clam shells and **Oxytropidoceras**; gradational into sandstone; eroding into a ledge	0.2

	Thickness (feet)
Unnamed Zones:	
Shale, yellow-brown, platy, weakly indurated; with some interbedded dark-gray shale	23.0
Shale, dark-gray to black, mottled yellow-brown, platy, weakly indurated; with some 1- to 2-inch tan fossiliferous sandstone lenses	12.5
Sandstone, gray to tan, fine-grained, micaceous, platy, well-indurated, fossiliferous; with interbedded dark-gray to yellow-brown shale; eroding into a ledge	1.0
Shale, dark-gray to black, fissile, platy, fossiliferous, weakly indurated; mottled with many limonitic streaks	8.0
Gryphaea corrugata Zone:	
Limestone and sandstone, gray to tan, fine-grained, thinly laminated, weakly indurated; interbedded with dark-gray shale; with many 0.5-inch aragonite beds and large purple-tinted **Gryphaea;** eroding into a ledge	0.8
Unnamed Zone:	
Shale, dark-gray to black, fissile, platy, weakly indurated, fossiliferous	7.8
Cyprimeria Zone: (Kk_2 on map)	
Limestone, tan to gray, fine-grained, arenaceous, well-indurated, thinly laminated, platy; with many 0.5-inch aragonite layers and **Cyprimeria, Gryphaea,** and **Turritella;** eroding into a ledge	0.8
Unnamed Zone:	
Shale, dark-gray to black, thinly laminated, platy, weakly indurated, fossiliferous; with many white selenite crystals and some 1-inch gray sandstone layers	29.0
Unit Kk_1 on map:	
Sandstone, white, mottled rusty-brown, coarse-grained, quartzose, conglomeratic, moderately to well-indurated; with iron stains; eroding into a prominent ledge; fossiliferous at other places	0.6
Unnamed Units:	
Shale, dark-gray to black, thinly laminated, platy, weakly indurated, fossiliferous; mottled with thin limonite streaks, with white selenite crystals, and with a 2-inch platy fine-grained gray sandstone in middle	6.0
Shale, greenish-gray and yellow-brown, silty, blocky, thinly laminated, weakly indurated; with small selenite flakes, and with some 1- to 2-inch white indurated sandstone lenses in top foot	4.25
Siltstone, yellow-brown and greenish-gray, arenaceous, quartzose, thinly laminated, weakly indurated	1.0
PERMIAN SYSTEM	
CUSTERIAN SERIES	
WHITEHORSE GROUP	
RUSH SPRINGS FORMATION	
Shale, red-brown, silty, blocky, weakly indurated; unconformable with beds above	5.0+

SECTION 3.

REDFORK 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, proceeding through the Dog Creek Shale to the Shimer Gypsum.

	Thickness (feet)
PERMIAN SYSTEM	
CUSTERIAN SERIES	
WHITEHORSE GROUP	
MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-brown to moderate reddish-orange, fine-grained, weakly indurated; exposed to top	10.0+
Gypsum, red-brown and 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
CIMARRONIAN SERIES	
EL RENO GROUP	
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
Sandstone, greenish-gray, fine-grained, silty, friable to well-indurated; eroding into a ledge	0.25
Siltstone, moderate reddish-brown to moderate reddish-orange, mottled greenish-gray, arenaceous, well-indurated, thin-bedded; eroding into a ledge	2.75
Siltstone, greenish-gray, thin-bedded, well-indurated	0.9
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
Unnamed Beds:	
Shale, red-brown, blocky	0.3
Siltstone, greenish-gray, mottled reddish-brown, dolomitic, well-indurated, thin-bedded	0.1
Shale, red-brown, silty, blocky; partly covered	3.75
Gypsum, greenish-gray to 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
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
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; eroding into a 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

	Thickness (feet)
Shale, red-brown, silty, blocky	0.5
Siltstone, greenish-gray, mottled red-brown, gypsiferous, well-indurated, massive	1.0
Shale, red-brown, silty, blocky	1.5
Watonga Bed:	
Siltstone, greenish-gray, argillaceous, dolomitic, gypsiferous, well-indurated, thin-bedded; selenitic and red brown in upper 6 inches; with many symmetrical ripple marks that strike west; eroding into a ledge	2.0
Unnamed Beds:	
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 anhydritelike layer in middle; eroding into a mappable escarpment; exposed	10.0+

SECTION 4.
CAVE CREEK, COMANCHE COUNTY, KANSAS

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

	Thickness (feet)
PERMIAN SYSTEM	
CUSTERIAN SERIES	
WHITEHORSE GROUP	
MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-orange to moderate reddish-brown, fine-grained, quartzose, massive; gradational into gypsum	5.0
Gypsum, pink to reddish-brown, arenaceous, well-indurated, thin-bedded, crinkly bedded; greenish-gray in basal 2 inches; eroding into a mappable escarpment	4.75
CIMARRONIAN SERIES	
EL RENO GROUP	
DOG CREEK SHALE (total thickness, 25.4 feet)	
Shale, red-brown, blocky	2.0
Sandstone, moderate reddish-orange to moderate reddish-brown, silty, gypsiferous, well-indurated, platy; eroding into a ledge; consisting of 56.6 percent sand, 27.0 percent silt, 2.6 percent clay, and 13.8 percent gypsum and carbonate. The heavy-mineral fraction, comprising 0.27 percent of the sand-size fraction of the insoluble residue, consists of (in percent) 37.71 ilmenite-magnetite, 13.13 sphene-leucoxene, 3.03 orange opaque, 25.25 garnet, 10.77 zircon, 4.04 brown to gray tourmaline, 2.02 biotite, 1.35 chlorite-muscovite, 1.01 epidote, 0.34 yellow rutile, and 1.35 anhydrite. The light-mineral fraction consists of 75.24 quartz, 7.52 chert, 15.05 orthoclase, 0.63 plagioclase, and 1.57 microcline	0.75

	Thickness (feet)
Siltstone, greenish-gray, mottled red-brown, weakly indurated, massive	1.0
Shale, red-brown, blocky	0.9
Siltstone, red-brown, argillaceous, platy, weakly indurated; with satin spar and nodular gypsum	1.0
Siltstone, greenish-gray, weakly indurated, massive; with much satin spar	0.75
Shale, red-brown, platy	1.4
Southard Bed:	
Dolomite, greenish-gray, silty, well-indurated, fine-grained, dense	0.1
Unnamed Beds:	
Shale, red-brown, blocky	0.2
Siltstone, greenish-gray, mottled red-brown, weakly indurated	1.4
Shale, red-brown, silty, blocky	2.4
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
Shale, greenish-gray, silty, blocky	0.2
Shale, red-brown, blocky	2.2
Gypsum, white, mottled red-brown, massive to thin-bedded; eroding into a prominent ledge	0.2
Shale, red-brown, blocky	1.0
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky	1.0
Watonga Bed:	
Sandstone, greenish-gray, dolomitic, fine-grained, well-indurated, massive; eroding into a ledge; with mean of 4.00 phi, deviation 1.88, skewness 0.71, and kurtosis 3.93	0.5
Siltstone, greenish-gray, mottled red-brown, weakly indurated; partly covered	2.2
Unnamed Beds:	
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, 59.2 feet)	
Shimer Gypsum Member: (type section)	
Gypsum, white, fine-grained, massive, weathering coarsely selenitic, eroding into an escarpment	14.0
Altona Dolomite Bed:	
Dolomite, light-gray, fine-grained, dense to oölitic, medium-bedded; consisting of (in percent) 3.6 sand, 3.9 silt, 3.6 clay, and 89.9 carbonate	1.0
Unnamed Beds:	
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky; with one foot of greenish-gray gypsiferous shale in middle; with mean of 7.63 phi, deviation 3.22, skewness 1.03, and kurtosis 0.77. The heavy-mineral fraction, comprising 0.01 percent of the sand-sized fraction of the washed residue, consists of (in percent) 23.47 ilmenite-magnetite, 17.01 sphene-leucoxene, 2.38 orange opaque, 0.68 pyrite, 23.47 garnet, 4.42 zircon, 8.16 brown to gray tourmaline, 0.34 blue tourmaline, 4.08 biotite, 7.14 chlorite-muscovite, 5.44 apatite, 0.34 yellow rutile, 0.34 riebeckite, and 2.72 anhydrite. The light-mineral fraction consists of 70.74 quartz, 10.61 chert, 8.04 orthoclase, 0.96 plagioclase, 0.32 microcline, and 9.32 car-	

	Thickness (feet)
bonate. The clay minerals, including dissolved gypsum and hematite, are 41.85 percent of the total sample, comprising illite and chlorite	9.0
Nescatunga Gypsum Member (type section) :	
Gypsum, white, fine-grained, well-indurated, massive; eroding into a ledge; calcareous in basal 1 inch	2.0
Unnamed Beds:	
Shale, greenish-gray, mottled red-brown, blocky	0.2
Shale, red-brown, blocky; with some greenish-gray shale layers in middle; with mean of 7.67 phi, deviation 3.25, skewness 0.55, and kurtosis 0.96. The clay minerals are illite and chlorite	5.5
Medicine Lodge Gypsum Member (type section) :	
Gypsum, white, fine-grained, thin-bedded, well-indurated; with anhydrite lenses in middle portion; eroding massive; and host rock for Comanche Cave	27.0
Cedar Springs Bed:	
Dolomite, light-gray, fine-grained, oölitic, well-indurated, thin-bedded; gradational upward into gypsum; composed of 0.9 percent sand, 8.2 percent silt, 7.8 percent clay, and 83.1 percent carbonate	0.25
FLOWERPOT SHALE (exposed thickness, 7.4 feet)	
Shale, greenish-gray, blocky	0.25
Shale, red-brown, blocky, selenitic	0.75
Shale, greenish-gray, mottled red-brown, selenitic, crinkly bedded	0.3
Shale, red-brown, blocky	0.25
Shale, greenish-gray, mottled red-brown, gypsiferous, well-indurated, crinkly bedded; eroding into a ledge	0.75
Siltstone, greenish-gray, argillaceous, weakly indurated; with some nodular gypsum; consisting of (in percent) 3.7 sand, 76.4 silt, 6.7 clay, and 13.2 carbonate and gypsum. The heavy-mineral fraction, comprising 0.05 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 5.26 ilmenite-magnetite, 27.19 sphene-leucoxene, 2.19 orange opaque, 17.98 garnet, 0.88 zircon, 26.75 brown to gray tourmaline, 0.88 blue tourmaline, 12.28 biotite, 4.39 chlorite-muscovite, 1.32 epidote, 0.44 yellow rutile, and 0.44 apatite. The light-mineral fraction consists of (in percent) 66.23 quartz, 28.20 chert, 3.28 orthoclase, 0.66 plagioclase, and 1.64 microcline	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 layers	0.7
Shale, red-brown, blocky	1.0
Shale and gypsum, greenish-gray, well-indurated; as above; eroding into a ledge	0.4
Shale, red-brown, blocky; exposed to creek	1.0

SECTION 5.
DOG CREEK, BARBER COUNTY, KANSAS

Beginning at top in Marlow Formation along State 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.

PERMIAN SYSTEM
CUSTERIAN SERIES

	Thickness (feet)
WHITEHORSE GROUP	
MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-brown to reddish-orange, fine-grained, quartzose, moderately indurated; with red-brown shale streaks near base; consisting of (in percent) 80.4 sand, 13.2 silt, 2.2 clay, and 4.2 carbonate and gypsum. The heavy minerals, comprising 0.19 percent of the sand-sized fraction, consist of (in percent) 50.3 ilmenite-magnetite, 12.5 leucoxene, 3.04 orange opaque, 16.46 garnet, 8.53 zircon, 0.91 brown and gray tourmaline, 0.30 blue tourmaline, 1.82 biotite, 0.60 epidote, and 0.30 yellow rutile. The light minerals of the sand-sized fraction consist of 87.66 quartz, 2.54 chert, 8.23 orthoclase, 0.63 plagioclase, and 0.94 microcline. The red color is due to stains of hematite coating grains. Exposed thickness	10.0
CIMARRONIAN SERIES	
EL RENO GROUP	
DOG CREEK SHALE (type section, total thickness 29.0 feet)	
Shale, red-brown, blocky; interbedded with reddish-orange, silty, thin-bedded, weakly indurated sandstone; conformable with beds above; consisting of (in percent) 60.8 sand, 32.3 silt, 3.7 clay, and 3.2 carbonate and gypsum. The heavy minerals, comprising 0.12 percent of the sand-sized fraction, consist of (in percent) 57.86 ilmenite-magnetite, 12.89 sphene-leucoxene, 1.89 orange opaque, 16.04 garnet, 2.52 zircon, 4.40 tourmaline, 2.20 biotite, 0.31 chlorite, 0.63 epidote, 0.31 yellow rutile, and 0.94 anhydrite. The light minerals of the sand-sized fraction consist of 72.46 quartz, 15.41 chert, 9.84 orthoclase, 1.31 plagioclase, and 0.98 microcline	1.5
Sandstone, reddish-orange, fine-grained, medium-bedded, well-indurated; eroding into a ledge; consisting of (in percent) 52.4 sand, 31.1 silt, 1.9 clay, and 14.6 carbonate and gypsum	2.2
Shale, red-brown, silty, blocky	0.5
Siltstone, purple-brown, platy; with some greenish-gray streaks; consisting of (in percent) 0.24 sand, 75.0 silt, 18.1 clay, and 6.6 carbonate and gypsum, with mean of 6.47 phi, deviation 1.92 phi, skewness 0.47, and kurtosis 1.21	0.2
Shale, purple-brown, blocky; with some satin spar layers	0.75
Shale, red-brown, silty, blocky	1.0
Southard Bed:	
Dolomite, red-brown, mottled greenish-gray, silty, well-indurated; consisting of (in percent) 0.3 sand, 45.6 silt, 7.9 clay, and 46.2 carbonate	0.1
Unnamed Beds:	
Shale, purple-brown, platy	0.75
Siltstone, red-brown, calcareous, arenaceous, massive, well-indurated; eroding into a ledge; consisting of (in percent) 10.9 sand, 72.1 silt, 3.6 clay, and 13.4 carbonate and gypsum. The heavy minerals of the sand-sized fraction of the insoluble residue, in trace quantity, consist of (in percent) 27.8 ilmenite-magnetite, 26.2 sphene-leucoxene, 2.6 orange opaque, 19.1 garnet, 2.6 zircon, 0.97 gray to brown tourmaline, 0.32 biotite, 15.5 chlorite-muscovite, 2.6 epidote, 0.65 yellow rutile, 0.32 red rutile, and 1.3 anhydrite. The light-mineral fraction of the insoluble residue consists of 75.2 quartz, 13.9 chert, 7.3 orthoclase, 1.8 plagioclase, and 1.8 microcline	1.6
Shale, dark red-brown, silty, blocky to platy, weakly indurated	4.0
Siltstone, moderate reddish-orange to moderate reddish-brown, argillaceous, platy, thin-bedded, weakly indurated	1.0
Sandstone, greenish-gray, mottled reddish-brown, quartzose, silty, massive, well-indurated; eroding into a ledge; consisting of	

	Thickness (feet)
(in percent) 62.9 sand, 24.7 silt, 2.5 clay, and 9.9 carbonate and gypsum. The heavy-mineral fraction of the insoluble residue, comprising 0.08 percent of the sand-sized fraction, consists of (in percent) 34.3 ilmenite-magnetite, 15.6 sphene-leucoxene, 0.61 orange opaque, 34.6 garnet, 6.4 zircon, 2.5 gray to brown tourmaline, 0.61 blue tourmaline, 1.8 biotite, 0.9 chlorite-muscovite, 1.5 epidote, 0.61 yellow rutile, and 0.61 anhydrite. The light-mineral fraction consists of 84.7 quartz, 5.4 chert, 6.7 orthoclase, 1.5 plagioclase, and 1.5 microcline	1.0
Siltstone, greenish-gray, gypsiferous, massive, well-indurated; eroding into a ledge	0.2
Shale, red-brown, blocky	0.2
Siltstone, greenish-gray, arenaceous, calcareous, fine-grained, dense, well-indurated; eroding into a light-colored ledge; consisting of (in percent) 11.4 sand, 71.8 silt, 3.7 clay, and 13.1 carbonate and gypsum	0.2
Shale, red-brown, blocky, weakly indurated	5.25
Siltstone, greenish-gray, nodular, well-indurated	0.2
Watonga Bed:	
Sandstone, greenish-gray, mottled reddish-brown, silty, calcareous, medium-bedded, well-indurated; eroding into a ledge; consisting of (in percent) 64.8 sand, 25.4 silt, 1.4 clay, and 8.4 carbonate and gypsum. The heavy-mineral fraction, comprising 0.05 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 15.5 ilmenite-magnetite, 26.9 sphene-leucoxene, 0.55 orange opaque, 32.1 garnet, 3.9 zircon, 7.8 gray to brown tourmaline, 0.28 blue tourmaline, 13.3 biotite, 3.6 chlorite-muscovite, 3.6 epidote, 0.55 yellow rutile, 0.28 red rutile, and 1.7 anhydrite. The light-mineral fraction consists of 83.2 quartz, 5.9 chert, 7.9 orthoclase, 1.7 plagioclase, and 1.4 microcline	2.5
Shale, dark red-brown, silty, platy	0.1
Siltstone, greenish-gray, arenaceous, calcareous, well-indurated, platy, thinly laminated, ripple-marked; eroding into a ledge; consisting of (in percent) 11.2 sand, 70.2 silt, 2.9 clay, and 15.7 carbonate and gypsum	0.9
Unnamed Beds:	
Shale, red-brown, blocky; mottled with greenish-gray silty patches	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 Bed:	
Limestone, light-gray to greenish-gray, gypsiferous, fine-grained, dense, well-cemented, thinly laminated, crinkly bedded; with euhedral rhombs 0.5 to 0.8 mm in diameter surrounded by calcite crystals averaging 0.1 mm in diameter; gradational into a fine-grained portion; composed of (in percent) 2.25 sand, 2.21 silt, 0.49 clay, and 95.15 carbonate and gypsum. The heavy-mineral portion, comprising 0.16 percent of the sand-sized fraction, consists of (in percent) 14.47 ilmenite-magnetite, 36.48 sphene-leucoxene, 7.23 orange opaque, 0.31 pyrite, 19.81 garnet, 1.26 zircon, 5.35 gray to brown tourmaline, 2.52 biotite, 6.60 chlorite-muscovite, 0.63 rutile, 1.26 apatite, and 4.09 anhydrite. The light-mineral fraction consists of 75.25 quartz, 12.87	

	Thickness (feet)
chert, 9.90 orthoclase, 0.99 plagioclase, and 0.99 microcline; erodes into boxworks and 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; eroding into a ledge	0.1
Unnamed Beds:	
Siltstone, red-brown, argillaceous, blocky, composed of (in percent) 0.7 sand, 83.4 silt, 10.9 clay, and 5.0 carbonate and gypsum	1.9
Siltstone, greenish-gray, mottled reddish-brown, argillaceous, blocky, thin-bedded	0.5
Siltstone, mottled red-brown and greenish-gray, argillaceous, well-indurated, massive; eroding into a 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; eroding into a 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 being the Nescatunga Member	0.4
Shale, greenish-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; eroding into an escarpment	21.0
Cedar Springs Bed:	
Dolomite, dark-gray, fine-grained, oölitic, thin-bedded, well-indurated; gradational into gypsum above; eroding into a ledge; composed of (in percent) 4.7 sand, 21.8 silt, 3.5 clay, 70.0 carbonate	0.2
FLOWERPOT SHALE (exposed thickness, 92.9 feet)	
Shale, greenish-gray, blocky	0.25
Shale, red-brown, blocky	0.6
Shale, greenish-gray, gypsiferous, blocky	0.2
(*Section extrapolated to SE¼ SW¼ sec. 5, T. 32 S., R. 14 W., in cliff along creek north of road*)	
Shale, red-brown, blocky	2.0
Shale, greenish-gray, gypsiferous, blocky	0.4
Shale, red-brown, silty, blocky; with some greenish-gray layers	5.0
Gypsum, mottled red-brown and greenish-gray, argillaceous, massive, well-indurated; eroding into a ledge	1.0
Shale, red-brown, gypsiferous, blocky; with some nodular gypsum; partly covered	6.25
Siltstone and gypsum, red-brown, argillaceous, thin-bedded, crinkly bedded, well-indurated; eroding into a ledge; consisting of (in percent) 3.7 sand, 65.5 silt, 10.8 clay, and 20.0 carbonate and gypsum. The heavy-mineral fraction, comprising 0.17 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 4.72 ilmenite-magnetite, 6.78 sphene-leucoxene, 1.47 orange opaque, 2.06 garnet, 1.18 gray to brown tourmaline, 0.29 blue tourmaline, 0.88 biotite, and 82.60 chlorite-	

	Thickness (feet)
muscovite. The light-mineral fraction consists of 85.04 quartz, 12.61 chert, 1.17 orthoclase, 0.29 plagioclase, and 0.88 microcline	1.25
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 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 layers	38.0
Gypsum, greenish-gray, mottled red-brown, silty, well-indurated, platy, thin-bedded; at base of extremely gypsiferous shale section; eroding into a ledge	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 6.
MEDICINE LODGE-SHARON, BARBER COUNTY, KANSAS

Beginning at top in Medicine Lodge Gypsum and proceeding downward, type Flowerpot section measured in hill with Schlumberger antenna tower at top in NW¼ NW¼ sec. 29, T. 32 S., R. 12 W., in northeast face; then extrapolated to NW¼ sec. 20, T. 32 S., R. 12 W., to top of Cedar Hills Sandstone, a few miles southwest of Medicine Lodge, Barber County, Kansas. Section then was extrapolated to SE¼ sec. 16, SW¼ sec. 15, E½ sec. 21, and W½ sec. 22, T. 32 S., R. 12 W., for major part of Cedar Hills Sandstone, ending in the NW¼ sec. 9, T. 32 S., R. 10 W., in high hill east of road, 2 miles north of Sharon, for basal portion of the Cedar Hills.

	Thickness (feet)
BLAINE FORMATION (basal part measured only)	
Medicine Lodge Gypsum Member:	
Gypsum, white, finely granular, massive; with a 1.5-foot alabaster-like bed 10.5 feet above base; eroding into a prominent ledge; exposed	19.0+
Cedar Springs Bed:	
Dolomite, greenish-gray, argillaceous, gypsiferous	0.3
FLOWERPOT SHALE (total thickness, 190.15 feet, type section)	
Shale, greenish-gray, gypsiferous; with some satin spar	0.2
Shale, red-brown, gypsiferous, blocky; with some greenish-gray streaks	1.0
Siltstone, orange-brown, mottled greenish-gray, gypsiferous, moderately indurated	0.2
Shale, greenish-gray, silty, gypsiferous, blocky	0.4
Shale, red-brown, blocky	0.6

	Thickness (feet)
Shale, greenish-gray, silty, blocky	0.15
Shale, red-brown, blocky	0.3
Siltstone, greenish-gray, argillaceous, well-indurated, platy; appearing dolomitic	0.1
Gypsum, white, mottled light-pink, medium-granular, nodular	0.15
Sandstone, light greenish-gray to white, very fine-grained, friable, weakly indurated	0.1
Shale, red-brown, blocky; with some satin spar	1.3
Sandstone, white, very fine-grained, gypsiferous, friable, weakly indurated	1.5
Shale, red-brown, blocky; with a 1-inch satin spar bed	0.5
Siltstone, greenish-gray, argillaceous, gypsiferous	0.15
Shale, red-brown, blocky; with much satin spar	1.4
Sandstone, orange-brown and greenish-gray, silty, argillaceous; with much satin spar	1.25
Shale, red-brown, blocky; with some satin spar	1.0
Satin spar, white, mottled red-brown, wavy bedded	0.1
Shale, greenish-gray, gypsiferous, blocky	0.15
Unit 6:	
Sandstone, tan to light-tan, mottled greenish-gray, friable, weakly indurated; moderately indurated near base	1.4
Sandstone, tan to light-tan, gypsiferous, argillaceous, thin-bedded, wavy bedded, well-indurated	4.5
Gypsum and sandstone, greenish-gray, argillaceous, platy; as above	0.3
Sandstone and gypsum, tan to light-tan, mottled greenish-gray, well-induraed; as above; with beds above forms a prominent escarpment	1.4
Unnumbered Units:	
Shale, red-brown, gypsiferous, silty; with some thin greenish-gray streaks	5.0
Siltstone, greenish-gray, mottled orange-brown, coarse-grained, calcareous; with symmetrical ripple marks that strike N. 50° W.	0.15
Shale, red-brown, gypsiferous, blocky; with some greenish-gray shale streaks	2.75
Sandstone, greenish-gray, very fine-grained, silty, gypsiferous, moderately indurated	0.3
Shale, red-brown, blocky; with some satin spar and greenish-gray shale beds	17.0
Siltstone, greenish-gray, gypsiferous, argillaceous, moderately indurated; with symmetrical ripple marks that strike west	0.1
Shale, red-brown, blocky; with greenish-gray indurated gypsiferous layers	2.75
Unit 5:	
Sandstone, greenish-gray, fine-grained, gypsiferous, argillaceous, well-indurated, wavy bedded; eroding into a prominent ledge	1.0
Shale and siltstone, red-brown, blocky, moderately indurated	0.6
Sandstone, greenish-gray, mottled red-brown, fine-grained, thin-bedded, as above; eroding into a ledge	0.6
Unnumbered Units:	
Shale, red-brown and greenish-gray, blocky	0.8
Shale, red-brown, blocky; with some greenish-gray beds and satin spar	3.5
Shale, greenish-gray, gypsiferous, blocky	0.3
Shale, red-brown, blocky; with some greenish-gray beds and satin spar	8.5
Unit 4:	
Sandstone, tan and greenish-gray, fine-grained, argillaceous, gypsiferous, thin-bedded, crinkly bedded, well-indurated; mottled red brown and argillaceous in middle; greenish gray in basal six inches; eroding into a prominent ledge	6.0

	Thickness (feet)
Unnumbered Units:	
Shale, red-brown, gypsiferous, blocky; with some thin greenish-gray shale streaks	11.25
Shale, greenish-gray, silty, gypsiferous, blocky, moderately indurated; eroding into a ledge	0.9
Shale, red-brown, blocky; with much satin spar	6.3
Shale, greenish-gray, gypsiferous, silty, blocky	0.3
Shale, red-brown, blocky; with much satin spar and many thin greenish-gray beds	26.35
Unit 3:	
Siltstone, greenish-gray, gypsiferous, argillaceous, moderately to well-indurated; with much satin spar; eroding into a prominent ledge	0.9
Unnumbered Unit:	
Shale, red-brown, blocky; with much paper-thin satin spar, some greenish-gray shale beds, and with many greenish-gray gypsiferous shale beds in basal 3 feet	19.5
Unit 2:	
Siltstone, orange-brown to red-brown, argillaceous, gypsiferous; mottled with greenish-gray streaks; with much satin spar; well indurated in top 6 inches; eroding into prominent ledge	3.0
Unnumbered Units:	
Shale, red-brown, blocky; with many greenish-gray beds and much satin spar	21.0
Siltstone, orange-brown, gypsiferous; well-indurated at top, greenish-gray in middle, and weakly indurated below	3.5
Shale, red-brown, silty, blocky	3.0
Unit 1:	
Siltstone, greenish-gray and red-brown, mottled orange-brown, arenaceous, gypsiferous, well-indurated, platy; eroding into a ledge	4.5
(*Section extrapolated to NW¼ sec. 20, T. 32 S., R. 12 W.*)	
Unnumbered Unit:	
Shale, red-brown, blocky; with much satin spar and some thin greenish-gray shale beds	21.75
(*Section extrapolated to SW¼ sec. 15, SE¼ sec. 16, E½ sec. 21, and W½ sec. 22, T. 32 S., R. 12 W.*)	
HENNESSEY FORMATION (base not measured)	
Cedar Hills Sandstone Member: (total thickness, 188.95 feet)	
Unit 5:	
Sandstone, greenish-gray, very fine-grained, calcareous; with many large gypsum nodules 0.7-foot or more in diameter at top, and a prominent greenish-gray gypsiferous shale 6.2 feet above in the Flowerpot; eroding into a prominent light-colored ledge in region	1.0
Unnumbered Unit:	
Sandstone, orange-brown, fine-grained, silty, moderately indurated, medium- to thin-bedded, friable	20.0
Unit 4:	
Sandstone, orange-brown, gypsiferous, well-indurated, thin-bedded; with much satin spar; mottled with many greenish-gray spots; eroding into a prominent ledge	1.25
Unnumbered Units:	
Sandstone, orange-brown, silty, moderately indurated	2.5
Siltstone and shale, orange-brown to red-brown, arenaceous, weakly indurated, platy to blocky	6.25
Sandstone, orange-brown, fine-grained, gypsiferous, platy, well-indurated; as above; speckled with many greenish-gray spots	0.3
Siltstone and shale, red-brown, blocky, moderately indurated; with	

	Thickness (feet)
some satin spar and greenish-gray layers	6.75
Shale, red-brown, silty, blocky	4.75
Sandstone, greenish-gray to light-brown and tan, very fine-grained, calcareous, gypsiferous, silty, friable, weakly indurated; weathering into a light-colored band in the region	0.9
Shale, red-brown, blocky	2.5
Siltstone, orange-brown, arenaceous; mottled with some greenish-gray spots and red-brown shale seams	1.0
Shale, red-brown, silty, blocky; with some thin greenish-gray shale seams and many thin satin spar layers	5.25
Sandstone, orange-brown and greenish-gray, very fine-grained, silty, friable, weakly indurated	2.0
Shale, red-brown, blocky, silty, weakly indurated; with some satin spar, greenish-gray shale seams, and orange-brown platy siltstone	8.25
Unit 3:	
Sandstone, orange-brown, very fine-grained, well-indurated; mottled with greenish-gray spots; eroding into a small ledge	0.2
Sandstone, orange-brown, silty, weakly indurated, friable	2.0
Sandstone, orange-brown, very fine-grained, well-indurated;mottled with greenish-gray spots; with gyp nodules; eroding into a ledge	0.1
Siltstone, orange-brown, argillaceous, platy, friable, weakly indurated	0.75
Siltstone, orange-brown, gypsiferous, well-indurated; mottled with greenish-gray specks; eroding into a ledge	0.2
Unnumbered Units:	
Shale, red-brown, silty, platy, weakly indurated; with some interbedded orange-brown siltstone	0.5
Sandstone, orange-brown, silty, weakly indurated	7.5
Siltstone, orange-brown, mottled red-brown, argillaceous, blocky, moderately indurated; mottled with some greenish-gray spots	7.0
Siltstone, orange-brown to red-brown, argillaceous, well-indurated, blocky; eroding into a ledge; being the third prominent marker bed below the top of the Cedar Hills	0.4
Siltstone and shale, red-brown, platy	1.0
Sandstone, orange-brown, very fine-grained, silty, weakly indurated; mottled with some greenish-gray spots	1.5
Siltstone and shale, red-brown, platy; with some interbedded orange-brown sandstone	3.0
Sandstone, orange-brown, fine-grained, friable, weakly indurated	1.6
Peace Treaty Bed:	
Sandstone, light greenish-gray, fine-grained, friable, weakly indurated	0.75
Sandstone, orange-brown, fine-grained, friable, weakly indurated; mottled with greenish-gray specks; with several thin greenish-gray zones, especially one 0.2-foot thick about 7 feet below top; eroding into a prominent ledge	13.0
Unnamed Beds:	
Siltstone, red-brown, argillaceous, blocky, weakly indurated	0.3
Siltstone, red-brown, argillaceous, massive, well-indurated; with many greenish-gray spots; eroding into a prominent ledge	0.4
Shale and siltstone, red-brown, platy	1.5
Siltstone, red-brown, argillaceous, well-indurated; eroding into a ledge	0.3
Siltstone and shale, red-brown, mottled orange-brown, platy, weakly indurated; mottled with many greenish-gray specks	3.0
Siltstone and sandstone, orange-brown, arenaceous, moderately indurated; mottled with greenish-gray specks; eroding into a ledge	0.5
Sandstone and siltstone, orange-brown, weakly indurated; as above	1.75

	Thickness (feet)
Shale, red-brown, silty, platy, with greenish-gray spots; mottled greenish gray at top	2.25
Siltstone, red-brown, argillaceous, platy, moderately indurated; mottled greenish gray at top; eroding into a ledge	0.6
Siltstone and shale, orange-brown to red-brown, platy, weakly indurated; mottled with greenish-gray spots	2.2
Sandstone, orange-brown, very fine-grained, moderately indurated; mottled with greenish-gray spots; eroding into a ledge	4.75
Siltstone, red-brown to orange-brown, moderately indurated, speckled greenish-gray; eroding in a recession	2.0
Siltstone, red-brown to orange-brown, weakly indurated; as above; partly covered	5.3
Unit 2:	
Sandstone, orange-brown, moderately indurated; mottled with greenish-gray spots	10.5
Siltstone, orange-brown, weakly indurated; mottled with greenish-gray specks	1.5
Shale, red-bown, silty, platy, weakly indurated; mottled with greenish-gray spots; with interbedded orange-brown siltstone	7.0
Siltstone, orange-brown, moderately indurated, speckled greenish-gray; eroding into a ledge	0.3
Sandstone, orange-brown, very fine-grained, silty, thin-bedded, weakly indurated; mottled with greenish-gray spots	1.3
Sandstone, white to light greenish-gray, fine-grained, weakly indurated, mottled orange-brown; weathering into a prominent light-colored band in region	0.4
Unnumbered Units:	
Siltstone, orange-brown, very fine-grained, silty, calcareous, weakly indurated; mottled with greenish-gray spots	1.2
Sandstone, orange-brown, silty, moderately indurated, medium-bedded; mottled with greenish-gray spots; eroding into a ledge	4.5
Shale, red-brown, silty, calcareous, platy	0.8
Siltstone, red-brown, argillaceous, calcareous, wavy bedded, moderately indurated; eroding into a ledge	0.2
Siltstone, orange-brown, arenaceous, coarse-grained, moderately indurated; mottled with greenish-gray spots; eroding into a ledge	0.75
Shale, red-brown, silty, calcareous, platy, weakly indurated	1.25
Siltstone, greenish-gray, calcareous, well-indurated, platy	0.05
Shale, weakly indurated; as above	1.5
Siltstone, greenish-gray, well-indurated, platy; as above	0.05
Shale, red-brown, weakly indurated; as above	2.5
Siltstone, greenish-gray, calcareous, platy, well-indurated, mottled orange-brown; eroding into a ledge	0.1
Siltstone, orange-brown, calcareous, moderately indurated; mottled with greenish-gray spots; eroding into a ledge with bed above	0.9
Sandstone, orange-brown, very fine-grained, silty, calcareous, weakly indurated; mottled with greenish-gray spots	1.0
Siltstone, orange-brown, arenaceous, calcareous, moderately indurated, medium bedded; mottled with greenish-gray spots; eroding into a ledge	4.75
Shale, red-brown, silty, calcareous, platy, weakly indurated	1.75
Siltstone, orange-brown, arenaceous, calcareous, weakly indurated; mottled with greenish-gray spots	1.6
Sandstone, orange-brown, very fine-grained, silty, calcareous, moderately indurated; mottled with greenish-gray spots; greenish gray in lower six inches; eroding into a ledge	5.75
Shale, red-brown, silty, platy, calcareous, weakly indurated	1.5
Sandstone, orange-brown, silty, calcareous, moderately indurated; mottled with greenish-gray spots; greenish gray in lower six inches; eroding into a prominent ledge	7.0

	Thickness (feet)
Shale, red-brown, calcareous, silty, platy, weakly indurated	1.25
Sandstone, orange-brown, very fine-grained, silty, weakly indurated, finely laminated; mottled with greenish-gray specks	1.3
Unit 1:	
Sandstone, greenish-gray, fine-grained, calcareous, weakly indurated, friable; mottled with some orange-brown spots; thinly laminated at top; conformable with beds below; weathering into a prominent light-colored band in region	1.9
Bison Member (exposed thickness 55.35 feet):	
Siltstone, red-brown, argillaceous, calcareous, moderately indurated; mottled with greenish-gray spots	0.25
Shale, red-brown, silty, calcareous, platy	1.5
Siltstone, red-brown, moderately indurated; mottled with greenish-gray spots; eroding into a ledge	0.75
Shale, red-brown, weakly indurated, platy; with greenish-gray spots at base	2.0
Siltstone, orange-brown and greenish-gray, argillaceous, calcareous, moderately indurated; eroding into a ledge	0.3
Shale, red-brown, silty, platy, weakly indurated; mottled with some greenish-gray spots	1.0
Shale, greenish-gray and red-brown, platy	0.2
Shale, red-brown, silty, platy	2.25
Siltstone, moderate red-brown to orange-brown, argillaceous, moderately indurated; mottled with greenish-gray spots; with interbedded red-brown shale	5.25
Siltstone, greenish-gray, mottled red-brown, argillaceous, calcareous, weakly indurated; weathering into first prominent light band below top	0.7
Siltstone, orange-brown, mottled greenish-gray, argillaceous, platy, moderately indurated; eroding into a ledge	0.5
Shale, red-brown, silty, platy, weakly indurated	1.0
Siltstone, orange-brown, argillaceous, moderately indurated; mottled with greenish-gray spots; with interbedded red-brown shale; partly covered	6.25
Siltstone, greenish-gray, mottled red-brown, argillaceous, calcareous, weakly indurated; weathering light greenish gray; eroding into the second light band below top	1.0
Shale, red-brown, silty, platy; partly covered	3.0
Siltstone, red-brown, argillaceous, platy, thin-bedded, micaceous, well-indurated; eroding into a prominent escarpment	0.5
Siltstone, greenish-gray, mottled orange-brown, weakly indurated, thinly laminated; eroding into third light band below top	0.6
Siltstone, orange-brown, mottled greenish-gray, argillaceous, platy, thinly laminated	0.6
Shale, red-brown, silty, platy, weakly indurated; with some interbedded orange-brown and greenish-gray siltstone	4.25
Siltstone, red-brown, argillaceous, moderately indurated; mottled with greenish-gray spots	0.3
Shale, red-brown, silty, platy, weakly indurated; mottled with greenish-gray spots	6.7
Sandstone, greenish-gray and orange-brown, very fine-grained, calcareous, well-indurated, crinkly bedded; eroding into a ledge	0.05
Shale, red-brown, silty, platy; mottled with greenish-gray spots	0.6
Sandstone, greenish-gray and orange-brown, very fine-grained; as above	0.05
Shale, red-brown, silty, platy; mottled with greenish-gray spots; partly covered	3.25
Siltstone, orange-brown, arenaceous, thin-bedded, argillaceous, moderately indurated; mottled with greenish-gray spots	10.5
Siltstone, red-brown, argillaceous, weakly indurated	2.0+

SECTION 7.
GERLANE, BARBER COUNTY, KANSAS

Beginning at top in Cedar Springs Dolomite at base of Blaine Formation and proceeding down section through Flowerpot Shale, section measured along road in NW¼ sec. 29 and along creek in SE¼ sec. 20 and SW¼ sec. 21, T. 33 S., R. 13 W. The section was then extrapolated to SE¼ sec. 15, T. 33 S., R. 13 W., and SW¼ sec. 12, T. 34 S., R. 12 W., for basal part of Flowerpot Shale from Unit 1 to base. The Cedar Hills Sandstone (type section) was measured in a series of continuous exposures in SE¼ sec. 21, NE¼ sec. 28, and SW¼ sec. 24, T. 33 S., R. 12 W., several miles west of Gerlane, Barber County, Kansas.

	Thickness (feet)
BLAINE FORMATION	
Cedar Springs Bed:	
Dolomite, greenish-gray, fine- to medium-granular, silty, gypsiferous, well-indurated, medium-bedded to massive, crinkly bedded; eroding into a prominent escarpment	0.4
FLOWERPOT SHALE (total thickness, 196.7 feet)	
Shale, greenish-gray, silty, calcareous, thin-bedded, blocky, weakly indurated	1.0
Shale, red-brown, calcareous, blocky, weakly indurated	1.25
Shale, greenish-gray, calcareous, blocky, weakly indurated	0.3
Shale, red-brown, silty, blocky, weakly indurated; mottled with greenish-gray spots	0.25
Shale, greenish-gray, silty, blocky, weakly indurated	0.1
Shale, red-brown, mottled orange-brown, silty, blocky, weakly indurated; with greenish-gray spots	2.6
Siltstone, greenish-gray, calcareous, moderately indurated	0.2
Shale, red-brown, silty, blocky, weakly indurated; mottled with greenish-gray spots	1.0
Sandstone, greenish-gray, mottled orange-brown, fine-grained, calcitic, moderately indurated; eroding into a ledge	0.3
Sandstone, orange-brown, fine-grained, calcitic, argillaceous, weakly indurated; mottled with greenish-gray spots	1.4
Shale, red-brown, blocky, weakly indurated; mottled with greenish-gray spots	0.75
Sandstone, greenish-gray, very fine-grained, calcitic, vuggy, moderately indurated; eroding into a small ledge	0.2
Siltstone, mottled orange-brown to red-brown, calcitic, finely laminated; with greenish-gray spots	1.2
Siltstone, orange-brown, arenaceous, weakly indurated	1.3
Unit 6:	
Sandstone, light-brown to tan, very fine-grained, silty, thinly laminated, weakly to moderately indurated; with red-brown and greenish-gray shale streaks; eroding into a ledge	7.5
Unnumbered Units:	
Shale, red-brown to orange-brown, silty, blocky, weakly indurated; mottled with greenish-gray spots; with many thin greenish-gray siltstone beds	2.5
Siltstone, greenish-gray and orange-brown, argillaceous, weakly indurated	0.2
Shale, red-brown, silty, thin-bedded, blocky, weakly indurated	1.5
Siltstone, greenish-gray, mottled orange-brown, calcitic, crinkly bedded, moderately indurated; eroding into a small ledge	0.75
Shale, red-brown, silty, blocky, weakly indurated	1.2
Shale, greenish-gray, mottled red-brown, blocky, weakly indurated	0.1

	Thickness (feet)
Siltstone, orange-brown, argillaceous, blocky, weakly indurated	0.75
Shale, greenish-gray, blocky, weakly indurated	0.2
Shale, red-brown, blocky, weakly indurated	1.6
Shale, greenish-gray, blocky, weakly indurated	0.15
Shale, red-brown, silty, blocky	0.75
Siltstone, greenish-gray, mottled red-brown, calcitic, argillaceous, thin-bedded, blocky, moderately indurated; eroding into a ledge	0.5
Shale, red-brown, blocky, weakly indurated, silty; orange brown in middle 2 feet; with greenish-gray spots and 1-inch greenish-gray beds in basal 10 inches	4.0
Shale, greenish-gray, blocky, weakly indurated	0.2
Shale, red-brown, blocky, weakly indurated	2.4
Shale, greenish-gray, blocky, weakly indurated	0.1
Shale, red-brown, blocky, weakly indurated	1.5
Siltstone, greenish-gray, argillaceous, calcareous, blocky, moderately indurated; eroding into a ledge	0.3
Siltstone, orange-brown, argillaceous, weakly indurated; with some interbedded red-brown shale and greenish-gray siltstone	5.5
Shale, red-brown, blocky, weakly indurated	0.7
Shale, greenish-gray, silty, calcareous, blocky; moderately indurated in places	0.3
Siltstone, orange-brown, argillaceous, weakly indurated	1.0
Shale, red-brown, silty, platy, weakly indurated	0.75
Siltstone, red-brown, platy; as above; with interbedded red-brown shale	2.0
Unit 5:	
Siltstone, greenish-gray and orange-brown, calcitic, moderately indurated; with some interbedded red-brown shale; eroding into a ledge	0.2
Unnumbered Units:	
Shale, red-brown, blocky, weakly indurated; with greenish-gray spots	2.2
Shale and siltstone, greenish-gray, calcitic, platy, moderately indurated; with some interbedded red-brown shale; eroding into a ledge	1.3
Shale, red-brown, blocky, weakly indurated	1.2
Shale, greenish-gray, mottled red-brown, selenitic, blocky; eroding into the first light gypsiferous band below top	1.0
Shale, red-brown, mottled greenish-gray, weakly indurated; with much selenite and paper-thin satin spar	6.0
Shale, greenish-gray, mottled red-brown, highly gypsiferous, selenitic, well-indurated; with interbedded weakly indurated red-brown shale; eroding into a ledge	2.0
Shale, red-brown and greenish-gray, gypsiferous, blocky, crinkly bedded; with much selenite and many snowball gypsum nodules	6.5
Unit 4:	
Siltstone, greenish-gray, highly gypsiferous, thin-bedded, crinkly bedded; with interbedded red-brown shale; well indurated in middle; orange brown at base; eroding into a prominent escarpment	2.5
Unnumbered Units:	
Shale, red-brown, mottled orange-brown, gypsiferous, silty, weakly indurated	3.75
Shale, greenish-gray, gypsiferous, crinkly bedded, well-indurated; eroding into a ledge	0.1
Shale, red-brown, silty, gypsiferous, platy, weakly indurated; with many greenish-gray beds	4.75
Shale, greenish-gray, gypsiferous, platy, crinkly bedded, moderately indurated; eroding into a ledge	0.75
Shale, red-brown, gypsiferous, blocky; with much paper-thin selenite	2.75

	Thickness (feet)
Shale, greenish-gray, gypsiferous, blocky, mottled red-brown; eroding into a ledge	0.5
Shale, red-brown, gypsiferous, blocky, mottled greenish-gray	1.0
Shale, greenish-gray, gypsiferous, moderately indurated; as above; eroding into a ledge	0.1
Shale, red-brown, gypsiferous, blocky, weakly indurated	0.75
Shale, greenish-gray, gypsiferous, moderately indurated; as above; eroding into a ledge	0.1
Shale, red-brown, blocky	0.25
Shale, dark-brown to chocolate-brown, blocky, weakly indurated	2.0
Shale, greenish-gray, mottled red-brown, blocky, weakly indurated	0.2
Shale, red-brown, gypsiferous, blocky, weakly indurated	8.25
Shale, greenish-gray, gypsiferous, blocky, weakly indurated; with interbedded red-brown shale	1.0
Unit 3-4:	
Shale, greenish-gray, silty, gypsiferous, blocky, weakly to well-indurated, crinkly bedded; with some red-brown shale, eroding into a ledge	0.75
Unnumbered Units:	
Shale, red-brown, gypsiferous, blocky, weakly indurated, mottled greenish-gray; partly covered	15.1
Shale, greenish-gray and red-brown, gypsiferous, moderately indurated, crinkly bedded; eroding into a ledge	0.5
Shale, red-brown, gypsiferous, blocky	0.9
Shale, greenish-gray; as above	0.5
Shale, red-brown; as above	0.75
Shale, greenish-gray; as above	0.5
Shale, chocolate-brown, gypsiferous, weakly indurated, mottled greenish-gray	2.8
Unit 3:	
Shale, greenish-gray, gypsiferous, well-indurated, blocky, crinkly bedded; eroding into a ledge	0.5
Siltstone, red-brown, argillaceous, gypsiferous, blocky; with some interbedded greenish-gray shale beds	1.4
Unnumbered Units:	
Shale, chocolate-brown, mottled red-brown, silty, blocky, moderately indurated; with much selenite	4.0
Shale and siltstone, greenish-gray, gypsiferous, blocky to platy, moderately indurated, wavy bedded	0.4
Shale, dark red-brown, blocky, moderately indurated; with much selenite	2.2
Shale, greenish-gray, blocky, wavy bedded	0.1
Shale, red-brown, silty, blocky	0.75
Siltstone, greenish-gray, argillaceous, moderately indurated, blocky	0.2
Shale, red-brown, selenitic, blocky	0.5
Shale, greenish-gray, silty, blocky, mottled red-brown	0.2
Shale, red-brown, selenitic, blocky	0.5
Shale, greenish-gray, silty, gypsiferous, blocky to platy; with interbedded red-brown shale; eroding into a ledge	0.75
Shale, red-brown, blocky	0.3
Shale, chocolate-brown, selenitic, blocky	0.8
Siltstone and shale, red-brown, selenitic, blocky; with many satin spar veins	0.25
Shale, greenish-gray, extremely gypsiferous, selenitic, wavy bedded, moderately indurated, blocky to platy, mottled red-brown	3.6
Siltstone, mottled greenish-gray and orange-brown, argillaceous, gypsiferous, moderately indurated; eroding into a ledge	1.0
Siltstone, orange-brown, gypsiferous, argillaceous, selenitic, blocky, weakly indurated	2.0
Siltstone, greenish-gray, argillaceous, gypsiferous, moderately indurated; with small yellow-green gypsum nodules; eroding	

	Thickness (feet)
into a ledge	0.25
Unit 2:	
Siltstone and shale, orange-brown and greenish-gray, argillaceous, arenaceous, moderately indurated, thinly laminated; weakly indurated at top; with some intrebedded orange-brown sandstone	4.0
Unnumbered Units:	
Shale, red-brown, silty, well-indurated; mottled with some greenish-gray spots	0.75
Siltstone and shale, greenish-gray, gypsiferous, selenitic, platy, crinkly bedded, well-indurated; with interbedded red-brown shale; eroding into several ledges	2.75
Shale, red-brown, gypsiferous, blocky, weakly indurated	1.2
Shale and gypsum, red-brown, blocky, crinkly bedded, selenitic; with greenish-gray bed in middle, eroding into a ledge	2.0
Shale, greenish-gray and red-brown, gypsiferous, moderately indurated, blocky	0.8
Shale and siltstone, red-brown, mottled greenish-gray, gypsiferous	2.75
Sandstone, greenish-gray, mottled orange-brown, silty, massive, well-indurated	0.75
Shale and siltstone, red-brown, mottled greenish-gray, weakly indurated; selenitic in middle 2 feet	4.5
Unit 1:	
Sandstone, greenish-gray, mottled orange-brown, very fine-grained, silty, gypsiferous, moderately indurated, massive; with yellow-green gypsum nodules	3.0
Unnumbered Units:	
Siltstone, orange-brown, argillaceous, massive, weakly indurated; arenaceous at top	1.0
Shale and siltstone, red-brown, blocky	1.25
Sandstone, orange-brown, fine-grained, weakly indurated; mottled with greenish-gray spots	9.0
(*Section extrapolated to SW¼ sec. 12, T. 34 S., R. 12 W.*)	
Shale, and siltstone, orange-brown to red-brown; with some greenish-gray beds	15.75
Shale, greenish-gray, crinkly bedded, well-indurated, gypsiferous; yellow-green at top	2.0
Shale, red-brown, selenitic, blocky	6.25
HENNESSEY FORMATION	
Cedar Hills Sandstone Member: (type section, total thickness 180 feet)	
Unit 5:	
Sandstone and siltstone, greenish-gray, mottled orange-brown, very fine-grained, massive, gypsiferous; with small gypsum nodules in places	2.0
Unnumbered Units:	
Sandstone and siltstone, orange-brown, very fine-grained, massive; mottled with greenish-gray spots and greenish-gray layers; with yellow-brown gypsum nodules 4 feet below top	25.0
Siltstone, red-brown to orange-brown, argillaceous, thin-bedded, moderately to weakly indurated; mottled with greenish-gray spots; arenaceous at top	7.5
Unit 4:	
Sandstone, light greenish-gray to white, fine-grained, gypsiferous, well-indurated, thin-bedded, platy; eroding into a ledge	1.0
Unnumbered Units:	
Siltstone and shale, orange-brown to red-brown, platy to blocky, weakly indurated; mottled with greenish-gray spots; with some paper-thin satin spar	15.75
Siltstone, greenish-gray and orange-brown, arenaceous, gypsiferous, moderately indurated; eroding into a ledge	1.5
Shale, red-brown, blocky, selenitic, weakly indurated; with some	

	Thickness (feet)
satin spar and interbedded orange-brown siltstone	7.0
Unit 3:	
Sandstone and shale, greenish-gray, mottled orange-brown, fine-grained, silty, gypsiferous; moderately indurated at base; eroding into a ledge and second prominent light-colored ledge below top	1.3
Unnumbered Units:	
Siltstone, orange-brown, arenaceous, argillaceous, weakly indurated, blocky; with interbedded red-brown shale and satin spar; with light greenish-gray shale at top	5.25
Gypsum, white, mottled yellow-green, nodular, well-indurated; eroding into a ledge	0.1
Siltstone, orange-brown, argillaceous, moderately indurated; speckled with many greenish-gray spots; eroding into a ledge	0.25
Siltstone, orange-brown, argillaceous, arenaceous, thinly laminated to massive, moderately to weakly indurated; mottled with greenish-gray spots; with some satin spar veins	14.75
Shale, red-brown, silty, blocky, weakly indurated; with some 1- to 2-inch greenish-gray zones alternating with some orange-brown siltstones	8.25
Sandstone, orange-brown, very fine-grained, silty, weakly indurated, thinly laminated; mottled with greenish-gray spots; even bedded at top; with many snowball gypsum nodules	4.25
Shale, red-brown, silty, platy, weakly indurated	1.4
Peace Treaty Bed:	
Sandstone, orange-brown, very fine-grained, silty, moderately indurated, massive; speckled with many greenish-gray spots; with many 0.5- to 1-inch snowball gypsum nodules; eroding into a prominent escarpment; with a prominent 1-inch white sandstone 5 feet below top; a 2-inch weakly indurated siltstone 6.6 feet below the top, eroding in a recession; and the basal 3 feet gradational into shale and siltstone	11.0
Unnamed Beds:	
Siltstone and shale, red-brown, weakly indurated, blocky; speckled with greenish-gray spots; with some orange-brown siltstone and paper-thin satin spar	4.25
Sandstone, orange-brown, very fine-grained, silty, gypsiferous, moderately indurated; mottled with greenish-gray spots; eroding into a ledge	1.0
Shale, red-brown, silty, blocky, weakly indurated; mottled with greenish-gray spots and orange-brown streaks; with much satin spar	5.25
Sandstone, orange-brown, mottled greenish-gray, fine-grained, silty; moderately indurated at top; weakly indurated below; with many 0.5- to 1-inch snowball gypsum nodules	3.0
Shale, red-brown, silty, platy, weakly indurated; mottled with greenish-gray spots; with some paper-thin satin spar	1.4
Siltstone and shale, orange-brown to red-brown, platy, weakly indurated; mottled with many greenish-gray spots	1.75
Sandstone, orange-brown, mottled greenish-gray, very fine-grained, silty, massive, moderately indurated; eroding into a ledge	3.0
Siltstone and sandstone, orange-brown, very fine-grained, argillaceous, moderately indurated, thin-bedded; mottled with greenish-gray spots; eroding into a recession	6.75
Unit 2:	
Sandstone, orange-brown, very fine-grained, silty, well-indurated; mottled with greenish-gray spots; eroding into a prominent ledge; weakly indurated in lower 3 feet; with a prominent 2-inch light greenish-gray sandstone 12.5 feet below the top	16.5
Unnumbered Units:	
Siltstone, greenish-gray and orange-brown, argillaceous, platy, weakly indurated	0.5

	Thickness (feet)
Sandstone, orange-brown, very fine-grained, silty, moderately indurated; mottled with greenish-gray spots	1.8
Siltstone, orange-brown, mottled red-brown, blocky, weakly indurated; with some interbedded greenish-gray layers and red-brown shale	5.5
Siltstone, orange-brown, arenaceous, medium-bedded, well-indurated; mottled with greenish-gray spots; with sharp upper and lower boundaries	0.75
Sandstone and siltstone, orange-brown, mottled greenish-gray, very fine-grained, thin-bedded, moderately to weakly indurated; massive at top	4.5
Shale, red-brown, silty, platy, weakly indurated; gradational into orange-brown siltstone	1.75
Sandstone, orange-brown, very fine-grained, silty, moderately indurated, thin-bedded, platy; speckled with greenish-gray spots	0.75
Sandstone, light greenish-gray, mottled orange-brown, very fine-grained, silty, thin-bedded, moderately indurated	0.2
Sandstone, orange-brown, very fine-grained, silty, well-indurated, thin bedded; mottled with greenish-gray specks; weakly indurated at base; eroding into a ledge	10.5
Shale and siltstone, orange-brown to red-brown, platy, weakly indurated	1.75
Sandstone, orange-brown, very fine-grained, silty, moderately indurated; mottled with many greenish-gray spots; eroding into a ledge	1.2
Unit 1:	
Sandstone, greenish-gray, mottled orange-brown, fine-grained, thin-bedded, weakly indurated	1.6
Bison Member:	
Siltstone, orange-brown, argillaceous, thin-bedded, weakly indurated; mottled with some greenish-gray spots	2.0
Shale, red-brown, silty, blocky, weakly indurated	2.0
Shale, greenish-gray, silty, blocky, weakly indurated	0.2
Shale, red-brown, silty, platy, weakly indurated	2.0+

SECTION 8.
COY, WOODS COUNTY, OKLAHOMA

Beginning at top with Day Creek Dolomite and proceeding downward, section measured in SE¼ sec. 6, T. 28 N., R. 19 W., to Moccasin Creek Bed. Section then extrapolated to SE¼ SE¼ sec. 25, T. 29 N., R. 20 W., for portion below Moccasin Creek, ending in the Dog Creek Shale in SW¼ SW¼ NW¼ sec. 2, T. 28 N., R. 20 W., Woods County.

	Thickness (feet)
CLOUD CHIEF FORMATION (exposed thickness, 32 feet)	
Day Creek Bed:	
Dolomite, white to light-gray, fine-grained, well-indurated; capping butte and eroding into a prominent escarpment	2.0
Kiger Shale Member:	
Shale and sandstone, greenish-gray, fine-grained, weakly indurated	5.0
Shale and siltstone, red-brown, blocky, weakly indurated	2.5
Sandstone, greenish-gray, fine-grained, weakly indurated	2.5
Shale and siltstone, red-brown, weakly indurated	16.0
Moccasin Creek Bed:	
Dolomite, pink and white, finely crystalline, well-indurated, crinkly bedded; eroding into a ledge	0.5
Shale, red-brown, silty, blocky, weakly indurated	2.5

	Thickness (feet)
Dolomite, pink and white; as above	1.0
(Section extrapolated to SE¼ SE¼ sec. 25, T. 29 N., R. 20 W.)	
WHITEHORSE GROUP (total thickness, 195 feet)	
RUSH SPRINGS FORMATION (total thickness, 89.85 feet)	
Siltstone, red-brown, argillaceous, weakly indurated, thinly laminated; with some greenish-gray streaks	2.5
Sandstone, light greenish-gray, micaceous, quartzose, very fine-grained, massive, moderately to weakly indurated; weathering into a light-colored band	4.0
Siltstone, orange-brown, micaceous, thinly laminated, weakly indurated	1.0
Sandstone, orange-brown, very fine-grained, quartzose, micaceous, medium-bedded, moderately indurated	3.0
Siltstone, orange-brown, thinly laminated, weakly indurated; mottled with some 1- to 2-inch greenish-gray streaks	3.75
Sandstone, orange-brown, quartzose, micaceous, very fine-grained, moderately indurated, thin-bedded; eroding into a ledge	4.5
Shale, red-brown, silty, thinly laminated; with interbedded moderately indurated siltstone beds; eroding into a slope	5.25
Sandstone, light greenish-gray, mottled orange-brown, very fine-grained, quartzose, calcitic, thinly laminated to massive, well-indurated; eroding into a prominent escarpment; with many ¼-inch sand balls at top	9.0
Siltstone, red-brown, argillaceous, micaceous, platy, weakly indurated	2.0
Siltstone, red-brown, argillaceous, massive, moderately indurated	1.2
Siltstone, red-brown, argillaceous, weakly indurated	1.0
Siltstone, red-brown, argillaeous, medium-bedded to massive, well-indurated; with 0.5-foot weakly indurated siltstone 2 feet above base; eroding into a ledge	7.25
Shale, red-brown, silty, blocky, weakly indurated, with 1- to 2-inch greenish-gray beds at top and base	3.2
Sandstone, orange-brown, very fine-grained, quartzose, micaceous, silty, thin-bedded, weakly indurated; with irregular 1-foot wide greenish-gray patches, and with interbedded red-brown shale in upper two feet	12.75
Shale, red-brown, silty, blocky, weakly indurated; with many greenish-gray spots and 1- to 3-inch greenish-gray beds	12.5
Sandstone, orange-brown, very fine-grained, quartzose, micaceous, weakly indurated, friable	3.0
Shale, red-brown, silty, thinly laminated, weakly indurated; with some 1-inch greenish-gray beds	6.25
Sandstone, light greenish-gray to white, mottled orange-brown, very fine-grained, quartzose, weakly indurated	1.2
Shale, red-brown; as above	2.0
Sandstone, light greenish-gray; as above	0.75
Shale, red-brown; as above	3.75
MARLOW FORMATION (total thickness, 105 feet)	
Emanuel Bed:	
Sandstone, light greenish-gray to white, fine-grained, well-indurated; calcareous in places; weathering as a prominent light band	0.5
Unnamed Beds:	
Shale, red-brown, silty, blocky, weakly indurated	11.25
Shale, light-pink, platy, weakly indurated; with salt casts, and with interbedded maroon and greenish-gray shale	0.25
Shale, red-brown, silty, blocky, weakly indurated	3.0
Relay Creek Bed:	
Sandstone, light greenish-gray to orange-brown, very fine-grained,	

	Thickness (feet)
weakly indurated, thinly laminated; with ¼-inch pink dolomite at top; weathering into a prominent light-colored band in region	1.0
(Section extrapolated to sec. 2, T. 28 N., R. 20 W.)	
Sandstone, orange-brown, silty, platy, weakly indurated; thin-bedded to massive	89.0
EL RENO GROUP	
DOG CREEK SHALE	
Shale, red-brown, blocky, weakly indurated	5.0+

SECTION 9.
YELLOWSTONE CREEK, WOODS COUNTY, OKLAHOMA
LITTLE MULE CREEK, BARBER COUNTY, KANSAS

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 to lower part of Dog Creek Shale. Section extrapolated to NE¼ NW¼ SE¼ sec. 15, T. 29 N., R. 17 W., for lower Dog Creek to Shimer Gypsum, and then NW¼ SW¼ sec. 26, T. 29 N., R. 17 W., for section to Flowerpot Shale Unit 6. Section then extrapolated to SW¼ SW¼ SE¼ sec. 22, T. 29 N., R. 16 W., along creek to Yellowstone Creek, Woods County, Oklahoma. The basal 15 feet of Flowerpot was measured in NW¼ sec. 8, T. 35 S., R. 14 W., Barber County, Kansas. The Cedar Hills Sandstone was measured along a branch of Little Mule Creek, in SE¼ and NW¼ sec. 7, T. 34 S., R. 12 W., down to Unit 2. Then a series of sections downstream were measured below Unit 2 in NE¼ sec. 8, SE¼ sec. 5, NW¼ sec. 9, T. 34 S., R. 12 W., continuing in NW¼ sec. 6, SE¼ sec. 32, along road in sec. 29, and ending in SW¼ sec. 21, T. 34 S., R. 11 W., Barber County, Kansas.

	Thickness (feet)
CUSTERIAN SERIES	
WHITEHORSE GROUP	
MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-brown to moderate reddish-orange, fine-grained, weakly indurated, massive; composed of (in percent) 76.2 sand, 15.9 silt, 2.1 clay, and 5.8 carbonate and gypsum. The heavy-mineral fraction, comprising 0.26 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 18.2 ilmenite-magnetite, 12.5 sphene-leucoxene, 1.49 orange opaque, 32.23 garnet, 7.16 zircon, 5.67 brown to gray tourmaline, 1.49 blue tourmaline, 1.79 biotite, 0.29 chlorite and muscovite, 0.59 epidote, 0.59 red rutile, and 0.29 yellow rutile. The light-mineral fraction consists of 64.49 quartz, 13.35 chert, 19.54 orthoclase, 1.30 plagioclase, and 1.30 microcline	5.0
Sandstone, greenish-gray, mottled moderate red-brown to moderate red-orange, fine-grained, weakly indurated, thinly laminated; as above	0.9
CIMARRONIAN SERIES	
EL RENO GROUP (total thickness, 333.5 feet)	
DOG CREEK SHALE (total thickness, 48.1 feet)	

	Thickness (feet)
Shale, red-brown, blocky	2.9
Dolomite, greenish-gray, fine-grained, dense, well-indurated; composed of (in percent) 0.9 sand, 14.2 silt, 6.1 clay, and 78.8 carbonate	0.25
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; composed of (in percent) 0.06 sand, 24.36 silt, 9.49 clay, and 64.09 carbonate	0.1
Unnamed Beds:	
Shale, purplish-brown, platy, thin-bedded; becoming dolomitic in basal 1 inch; composed of (in percent) 0.4 sand, 37.3 silt, 39.2 clay, and 23.1 carbonate	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; composed of (in percent) 3.4 sand, 54.2 silt, 4.7 clay, and 37.7 carbonate	0.5
Shale, red-brown, blocky; with some greenish-gray siltstone beds	4.5
Sandstone, greenish-gray and red-brown, silty, fine-grained, blocky; composed of (in percent) 57.6 sand, 22.5 silt, 3.3 clay, and 16.6 carbonate. The heavy-mineral fraction, comprising 0.34 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 27.2 ilmenite-magnetite, 22.1 sphene-leucoxene, 1.98 orange opaque, 27.48 garnet, 5.1 zircon, 9.63 brown to gray tourmaline, 1.13 biotite, 2.55 chlorite and muscovite, 1.98 epidote, 0.28 yellow rutile, and 0.57 anhydrite. The light-mineral fraction consists of 72.70 quartz, 12.38 chert, 13.33 orthoclase, 0.63 plagioclase, and 0.95 microcline	1.3
Shale, red-brown, blocky	3.0
Siltstone, light-brown, argillaceous, gypsiferous, well-indurated; eroding into a ledge	5.0
Siltstone, red-brown, calcareous, gypsiferous, quartzose, thin-bedded, cross-bedded, well-indurated; eroding into a ledge; composed of (in percent) 0.2 sand, 76.4 silt, 5.4 clay, and 18.0 carbonate and gypsum	4.0
Siltstone, moderate red-brown to red-orange, argillaceous, weakly indurated, blocky, massive	2.7
Siltstone, well-indurated; as above	2.2
(*Section extrapolated to sec. 15, T. 29 N., R. 17 W.*)	
Shale, red-brown, mottled greenish-gray, silty, thin-bedded, weakly indurated	2.8
Sandstone, greenish-gray, silty, weakly indurated; composed of (in percent) 59.5 sand, 28.0 silt, 4.1 clay, and 8.4 carbonate	1.2
Shale, red-brown, blocky	2.0
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky	2.2
Siltstone, greenish-gray, motttled red-brown, weakly indurated	0.2
Shale, red-brown, silty, platy	2.0
Watonga 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; composed of (in percent) 18.5 sand, 75.7 silt, 1.9 clay, and 3.9 carbonate	0.5
Unnamed Beds:	
Shale, greenish-gray, mottled red-brown, silty, weakly indurated	0.25
Shale, red-brown, silty, blocky	4.75

	Thickness (feet)
BLAINE FORMATION (total thickness, 63.9 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; eroding into a mappable escarpment	15.75
Altona Dolomite Bed:	
Dolomite, light-brown, fine-grained, oölitic, thin-bedded; eroding into a ledge; composed of (in percent) 5.4 sand, 11.4 silt, 4.4 clay, and 78.8 carbonate	0.3
(*Section extrapolated to sec. 26, T. 29 N., R. 17 W.*)	
Unnamed Beds:	
Shale, greenish-gray, blocky	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; eroding into an escarpment	10.5
Magpie Bed:	
Siltstone, greenish-gray, argillaceous, gypsiferous, weakly indurated; composed of (in percent) 8.1 sand, 69.9 silt, 3.4 clay, and 18.6 carbonate and gypsum	0.2
Unnamed Beds:	
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 selenitic; eroding into a mappable escarpment	22.0
Cedar Springs Bed:	
Dolomite, light-gray to light-brown, fine-grained, dense to oölitic, thin-bedded; composed of (in percent) 5.8 sand, 6.5 silt, 6.9 clay, and 80.8 carbonate	0.3
FLOWERPOT SHALE (total thickness, 221.5 feet)	
Shale, greenish-gray, blocky	0.5
Siltstone, red-brown and greenish-gray, blocky, weakly indurated; composed of (in percent) 4.5 sand, 61.9 silt, 10.4 clay, and 23.2 carbonate	2.4
Shale, red-brown, blocky; with some greenish-gray streaks	3.1
Shale, greenish-gray, mottled red-brown, silty, blocky, weakly indurated, thin-bedded	1.0
Shale, red-brown, blocky	3.5
Unit 6:	
Siltstone, red-brown to orange-brown, mottled greenish-gray, arenaceous, blocky, thin-bedded, weakly indurated; composed of (in percent) 25.1 sand, 63.0 silt, 4.0 clay, and 7.9 carbonate. The heavy-mineral fraction, comprising 0.07 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 15.26 ilmenite-magnetite, 27.95 sphene-leucoxene, 7.79 orange opaque, 29.87 garnet, 1.30 zircon, 8.44 brown to gray tourmaline, 0.32 blue tourmaline, 5.52 biotite, 0.65 chlorite and muscovite, and 2.9 epidote. The light-mineral fraction comprises 78.80 quartz, 13.92 chert, 4.75 orthoclase, 0.63 plagioclase, and 1.90 microcline	2.75
(*Section extrapolated to sec. 22, T. 29 N., R. 16 W.*)	
Unnumbered Beds:	
Shale, red-brown and greenish-gray, silty, platy, weakly indurated	1.0
Siltstone, red-brown to orange-brown, weakly indurated; as above	1.9
Shale, greenish-gray, blocky, weakly indurated	0.25
Shale, red-brown, selenitic, blocky, weakly indurated	0.8
Shale, greenish-gray, gypsiferous, blocky, weakly indurated	0.1
Shale, red-brown, silty, gypsiferous, blocky, weakly indurated; mottled with many greenish-gray spots	3.8
Shale and gypsum, greenish-gray to red-brown, crinkly bedded,	

	Thickness (feet)
moderately indurated; eroding into a ledge	0.25
Shale, red-brown, gypsiferous, selenitic, blocky, weakly indurated	1.25
Shale, greenish-gray, gypsiferous, blocky, weakly indurated	0.25
Shale, red-brown, selenitic, blocky, weakly indurated	0.25
Shale, greenish-gray, gypsiferous, blocky, weakly indurated	0.3
Shale, red-brown, selenitic, blocky	1.2
Shale, greenish-gray, mottled orange-brown, silty, weakly indurated	0.1
Shale, red-brown, selenitic, blocky, weakly indurated	1.5
Shale, greenish-gray, selenitic, blocky, weakly indurated	0.2
Shale, red-brown, selenitic, blocky, weakly indurated	1.8
Shale, greenish-gray, selenitic, blocky; with red-brown shale in middle	0.4
Shale, red-brown, selenitic, blocky, weakly indurated	0.75
Shale, greenish-gray, selenitic, blocky, moderately indurated	0.4
Shale, red-brown, selenitic, blocky	1.1
Shale, greenish-gray, silty, weakly indurated; as above	0.3
Shale, red-brown, weakly indurated; as above	1.2
Shale, greenish-gray, moderately indurated; as above	0.1
Shale, red-brown; as above	0.7
Shale, greenish-gray and red-brown, selenitic, blocky	0.4
Shale, greenish-gray, gypsiferous, moderate to weakly indurated; eroding into a prominent ledge	3.0
Shale, red-brown, selenitic, blocky, weakly indurated	3.5
Shale, greenish-gray, mottled red-brown, gypsiferous, silty, weakly indurated	0.8
Shale, red-brown, silty, gypsiferous, blocky, weakly indurated	0.3
Siltstone, orange-brown, mottled greenish-gray, gypsiferous, argillaceous, crinkly bedded, well-indurated; eroding into a ledge	0.7
Siltstone and shale, greenish-gray, mottled red-brown, thin-bedded platy; moderately indurated at top	0.5
Shale, red-brown, silty, gypsiferous, blocky, weakly indurated	0.4
Siltstone, orange-brown, mottled greenish-gray, gypsiferous, agillaceous, massive, moderately indurated	0.5
Shale, red-brown, selenitic, blocky, weakly indurated; mottled with greenish-gray spots	1.5
Siltstone, greenish-gray, gypsiferous, argillaceous, crinkly bedded, well-indurated; eroding into a ledge	0.6
Shale, red-brown, selenitic, blocky, weakly indurated	1.2
Shale, greenish-gray, selenitic, blocky; weakly indurated at top, moderately indurated at base; eroding into a ledge	0.75
Unit 5:	
Sandstone and siltstone, orange-brown, very fine-grained, gypsiferous, thinly laminated, moderately to weakly indurated; eroding into a prominent ledge	1.2
Unnumbered Units:	
Shale, red-brown, blocky, weakly indurated	1.0
Shale, greenish-gray, silty, gypsiferous, blocky, mottled orange-brown	0.6
Shale, red-brown, gypsiferous, blocky, weakly indurated	1.2
Shale, greenish-gray, gypsiferous, silty, blocky, moderately indurated; eroding into a ledge	0.3
Shale, red-brown, selenitic, blocky, weakly indurated	2.4
Shale, greenish-gray, gypsiferous, blocky, weakly indurated; with interbedded red-brown shale and a 2-inch chocolate-brown shale at top	0.9
Shale, red-brown, selenitic, blocky, weakly indurated	0.5
Shale, greenish-gray, gypsiferous, weakly indurated; as above	0.2
Shale, red-brown, selenitic, blocky, weakly indurated	4.25
Siltstone, greenish-gray, argillaceous, gypsiferous, well-indurated; eroding into a ledge	0.2
Shale, red-brown, selenitic, blocky, weakly indurated	1.1

	Thickness (feet)
Shale, greenish-gray, gypsiferous, platy, weakly indurated	0.2
Shale, red-brown, selenitic, blocky, mottled greenish-gray	2.2
Shale, greenish-gray, selenitic, blocky, weakly indurated	0.3
Shale, red-brown, blocky; with some 1-inch greenish-gray shale beds	3.0
Unit 4:	
Siltstone, greenish-gray, mottled red-brown, gypsiferous, argillaceous, weakly indurated	2.0
Unnumbered Units:	
Shale, red-brown, selenitic, silty, blocky, weakly indurated; mottled with greenish-gray spots	3.0
Shale, greenish-gray, mottled red-brown, selenitic, blocky, moderately to weakly indurated	0.3
Shale, red-brown, selenitic, blocky; with many 0.5-inch greenish-gray zones	6.2
Shale, greenish-gray, gypsiferous, blocky, weakly indurated; with some interbedded red-brown shale	1.25
Shale, red-brown, selenitic, blocky, weakly indurated	2.1
Shale, greenish-gray, gypsiferous, silty, weakly indurated; with interbedded red-brown shale	0.25
Shale, red-brown, blocky, weakly indurated	0.4
Shale, greenish-gray, blocky, weakly indurated	0.4
Shale, red-brown, blocky; with some satin spar	1.0
Shale, greenish-gray, selenitic, blocky	0.4
Shale, red-brown, selenitic, blocky, weakly indurated; chocolate brown in lower 1 inch; with some 0.5- to 1-inch greenish-gray shale beds	6.0
Shale, greenish-gray, blocky, weakly indurated; being the first thick greenish-gray zone below the top	1.5
Shale, red-brown, gypsiferous, blocky	1.0
Shale, greenish-gray, gypsiferous, crinkly bedded, weakly indurated	0.2
Shale, red-brown, platy	1.0
Shale, greenish-gray and red-brown, gypsiferous, silty, platy, weakly indurated	1.8
Unit 3-4:	
Siltstone, orange-brown, mottled greenish-gray, argillaceous, gypsiferous, weakly indurated	1.4
Unnumbered Units:	
Shale, greenish-gray, silty, moderately to weakly indurated	0.5
Shale, red-brown, gypsiferous, blocky	1.0
Shale, greenish-gray, gypsiferous, moderately indurated; with some interbedded red-brown shale	1.0
Shale, red-brown, selenitic, blocky	0.75
Shale, greenish-gray, moderately indurated; with interbedded red-brown shale	0.5
Shale, red-brown, gypsiferous, blocky, weakly indurated	1.0
Shale, greenish-gray, gypsiferous, platy, moderately indurated	0.1
Shale, red-brown, selenitic, blocky	1.9
Shale, greenish-gray, mottled red-brown, selenitic, weakly indurated	0.3
Shale, red-brown, gypsiferous, blocky, weakly indurated	1.8
Shale, greenish-gray, blocky, weakly indurated	0.2
Shale, red-brown, blocky, weakly indurated; with some paper-thin selenite	1.5
Shale, greenish-gray and red-brown, blocky, weakly indurated	0.4
Shale, red-brown; as above	0.6
Shale, greenish-gray, gypsiferous, blocky, weakly indurated	0.2
Shale, red-brown; as above	0.5
Shale, greenish-gray; as above	0.2
Shale, chocolate-brown, selenitic, blocky, weakly indurated	1.8
Shale, red-brown; as above	1.6
Shale, greenish-gray and red-brown, selenitic, blocky, moderately	

	Thickness (feet)
indurated	3.5
Shale, red-brown; as above	1.2
Shale, greenish-gray and red-brown; as above	0.5
Shale, red-brown; as above	2.7
Shale, greenish-gray and red-brown; as above; with a 2- to 3-inch greenish-gray bed at top, in middle, and at base	3.2
Shale, red-brown, moderately indurated; as above	3.2
Shale, greenish-gray, gypsiferous, calcareous in middle, platy	0.4
Shale, red-brown; as above	1.6
Siltstone, greenish-gray, mottled orange-brown, argillaceous, moderately indurated	0.4
Shale, red-brown; as above	0.9
Siltstone and gypsum, greenish-gray and red-brown, argillaceous, moderately indurated	0.25
Shale, red-brown; as above	0.25
Unit 3:	
Siltstone, greenish-gray, mottled orange-brown, argillaceous, gypsiferous, thinly laminated, moderately to weakly indurated; eroding into the third prominent light-colored ledge below the top	1.75
Unnumbered Units:	
Shale, red-brown, gypsiferous; as above; with some 1-inch greenish-gray shale beds	20.75
Unit 2:	
Siltstone, greenish-gray, mottled orange-brown, gypsiferous, platy, thin-bedded, crinkly bedded; eroding into one of the most prominent light-colored escarpments in the region	2.0
Unnumbered Units:	
Siltstone, orange-brown, argillaceous, weakly indurated	1.5
Shale, red-brown, blocky, weakly indurated	0.75
Shale, greenish-gray, gypsiferous, well-indurated, wavy bedded	0.75
Shale, dark red-brown, blocky, weakly indurated	0.7
Shale, greenish-gray, gypsiferous; as above	0.5
Shale, red-brown, silty, blocky	1.0
Shale, greenish-gray, gypsiferous; as above	0.25
Siltstone and sandstone, orange-brown, very fine-grained, massive, weakly indurated; mottled with some greenish-gray spots	1.0
Shale, red-brown, selenitic, platy, wavy bedded, well-indurated, mottled greenish-gray; eroding into a ledge	0.8
Shale, red-brown, selenitic, blocky, weakly indurated	1.0
Siltstone, greenish-gray, mottled orange-brown, gypsiferous, calcitic, wavy bedded, well-indurated; with some interbedded red-brown shale; eroding into a ledge	1.5
Shale, red-brown, selenitic, silty, blocky, weakly indurated	1.25
Shale, greenish-gray, gypsiferous, blocky, moderately indurated	0.3
Siltstone, orange-brown, mottled greenish-gray, gypsiferous, massive, moderately to well-indurated, wavy bedded	1.2
Siltstone and shale, red-brown, gypsiferous, blocky, weakly indurated; mottled greenish gray in basal 2 inches	1.9
Shale, red-brown, blocky, weakly indurated; with some satin spar	1.25
Unit 1:	
Sandstone, light greenish-gray, mottled orange-brown, very fine-grained, silty, thin-bedded, well-indurated; with many snowball gypsum nodules 1 to 4 inches wide or more; eroding into a prominent ledge	2.0
Unnumbered Units:	
Shale, red-brown, silty, gypsiferous, blocky, weakly indurated; mottled with greenish-gray spots	1.75
Siltstone, orange-brown, mottled greenish-gray, arenaceous, gypsiferous, massive, moderately indurated	2.25
Shale, red-brown, mottled orange-brown, silty, blocky, weakly	

	Thickness (feet)
indurated	0.75
Siltstone, orange-brown, mottled greenish-gray; as above	6.0
Siltstone, greenish-gray and orange-brown, gypsiferous, moderately indurated; eroding into ledge	0.5
Siltstone and sandstone, orange-brown, very fine-grained, gypsiferous, moderately indurated; mottled with greenish-gray spots	4.0
Shale, red-brown, silty, blocky, weakly indurated	1.0
Shale, greenish-gray, gypsiferous, blocky, moderately indurated; with some interbedded chocolate-brown shale	0.2
Siltstone, orange-brown, mottled greenish-gray, moderately indurated	0.5
Sandstone, orange-brown, very fine-grained, silty, gypsiferous, well-indurated; mottled with greenish-gray spots; vuggy at top; eroding into a ledge	3.25
Shale, red-brown, silty, gypsiferous, wavy bedded, blocky, weakly to moderately indurated; with interbedded orange-brown siltstone	6.5
Siltstone and sandstone, orange-brown, mottled greenish-gray, very fine-grained, argillaceous, gypsiferous, platy, well-indurated, wavy bedded; eroding into a ledge at base	3.1
Shale, red-brown, gypsiferous, blocky, weakly indurated; mottled greenish gray at base	1.75
Siltstone, greenish-gray and orange-brown, gypsiferous, well-indurated, wavy bedded; with greenish-gray to chocolate-brown shale at top, orange-brown beds in middle, and greenish gray at base; eroding into a ledge	2.1
(Section extrapolated to NW¼ sec. 8, T. 35 S., R. 14 W., on Salt Fork, Barber County, Kansas)	
Shale, red-brown, silty, gypsiferous, blocky	14.75
(Section extrapolated to sec. 7, T. 34 S., R. 12 W.)	
CIMARRONIAN SERIES	
HENNESSEY FORMATION	
Cedar Hills Sandstone Member: (total thickness, 185.5 feet)	
Unit 5:	
Sandstone, light greenish-gray to white, very fine-grained, silty, thinly laminated, moderately indurated; with many snowball gypsum nodules	2.0
Unnumbered Unit:	
Sandstone, orange-brown, very fine-grained, silty, moderately indurated, thinly laminated; mottled with many greenish-gray spots	27.0
Unit 4:	
Sandstone, light greenish-gray, very fine-grained, silty, weakly indurated; eroding into a ledge	1.8
Unnumbered Units:	
Shale, red-brown, silty, platy, weakly indurated; with some interbedded orange-brown siltstone and 1-inch greenish-gray beds	17.25
Siltstone, greenish-gray, arenaceous, weakly indurated; mottled orange brown in middle; weathering into a prominent light-colored band	1.75
Shale and siltstone, red-brown, mottled orange-brown, platy, weakly indurated; with some light greenish-gray spots	5.25
Gypsum nodules, white, snowball shaped to flattened, well-indurated; 2 to 3 inches wide	0.2
Unit 3:	
Siltstone, orange-brown and greenish-gray, argillaceous, moderately indurated; with gypsum nodules; eroding into a ledge	1.75
Unnumbered Units:	
Siltstone, orange-brown and greenish-gray, weakly indurated; as above; with interbedded red-brown shale	5.0
Sandstone, orange-brown, very fine-grained, silty, weakly indu-	

	Thickness (feet)
rated, massive; mottled with greenish-gray spots	7.75
Shale, red-brown, silty, platy, weakly indurated; with some 0.5-inch greenish-gray beds	2.5
Shale, greenish-gray, silty, weakly indurated; mottled with orange-brown patches; weathering light-greenish gray	0.9
Shale, red-brown, silty, weakly indurated; mottled with greenish-gray patches	4.0
Siltstone and sandstone, orange-brown and greenish-gray, argillaceous, gypsiferous, weakly indurated, thin-bedded; with much selenite at top and snowball gypsum nodules at base	6.75
Sandstone, orange-brown, very fine-grained, silty, weakly indurated	4.25
Peace Treaty Bed:	
Sandstone, orange-brown, very fine-grained, silty, thinly laminated, moderately indurated; mottled greenish gray at top; with many greenish-gray spots; eroding into a massive resistant ledge	10.75
Unnamed Units:	
Siltstone, orange-brown to red-brown, argillaceous, moderately indurated	2.0
Siltstone, greenish-gray, mottled orange-brown, argillaceous, moderately indurated	0.5
Siltstone and shale, orange-brown, mottled red-brown, massive, weakly indurated; with greenish-gray spots	5.25
Shale, greenish-gray and red-brown, silty, platy, weakly indurated	0.75
Shale, red-brown, silty, blocky, weakly indurated	4.25
Sandstone, orange-brown, mottled greenish-gray, very fine-grained, silty, friable, weakly indurated; with even-bedded top; eroding into a ledge above lake near dam near east fence line of sec. 7	3.0
Siltstone, orange-brown, argillaceous, platy, weakly indurated; mottled with greenish-gray spots	2.75
Sandstone, orange-brown and greenish-gray, silty, platy, weakly indurated	3.0
Shale and siltstone, orange-brown to red-brown, blocky, weakly indurated; mottled with greenish-gray spots; with prominent 2- to 6-inch greenish-gray zone 4 feet above base; gradational into a 2-foot sandstone eastward	9.75
Unit 2:	
Sandstone, orange-brown, very fine-grained, silty, friable, massive, moderately indurated; mottled with many greenish-gray spots; platy at top; with a prominent 1- to 3-inch greenish-gray sandstone 11 feet below top; eroding into the second thick sandstone below top	15.0
(Section extrapolated to secs. 8, 5, 9, T. 34 S., R. 12 W.)	
Unnumbered Units:	
Shale and siltstone, light greenish-gray and orange-brown, thinly laminated, platy, weakly indurated	0.5
(Section extrapolated to sec. 6, T. 35 S., R. 11 W).	
Siltstone, orange-brown to red-brown, argillaceous, weakly indurated; mottled with many greenish-gray spots	1.5
Sandstone, orange-brown, very fine-grained, silty, micaeous, platy, well-indurated; eroding into a ledge	2.0
Sandstone, orange-brown, very fine-grained, silty, massive, weakly indurated	1.8
Siltstone, orange-brown, arenaceous, thin-bedded, platy, well-indurated; eroding into second prominent ledge below Unit 2	3.2
(Section extrapolated to sec. 32, T. 35 S., R. 11 W.)	
Siltstone, orange-brown, argillaeous, micaceous, blocky, weakly indurated; with interbedded red-brown shale	3.0
Siltstone, orange-brown, mottled greenish-gray, micaceous, platy, well-indurated; eroding into the third ledge below Unit 2	0.75

	Thickness (feet)
Siltstone, orange-brown, weakly indurated, mottled with greenish-gray spots	2.6
Sandstone, light greenish-gray, very fine-grained, silty, platy, weakly indurated	0.1
(Section extrapolated to sec. 29 along road, in T. 34 S., R. 11 W.)	
Shale and siltstone, orange-brown to red-brown, mottled greenish-gray, arenaceous, weakly indurated; covered in part	11.5
(Section extrapolated to SW¼ sec. 21, T. 34 S., R. 11 W., in road)	
Sandstone, orange-brown, mottled greenish-gray, thinly laminated, weakly indurated	1.5
Siltstone, orange-brown, argillaceous, thinly laminated, weakly indurated	1.0
Siltstone, greenish-gray and orange-brown, argillaceous, weakly indurated	0.4
Shale, orange-brown, silty, platy, thinly laminated, weakly indurated	2.25
Unit 1:	
Sandstone and siltstone, greenish-gray and orange-brown, very fine-grained, silty, thinly laminated, well-indurated; eroding into a prominent light-colored ledge	1.3
Bison Member:	
Shale, red-brown, platy, well- to weakly indurated; with interbedded orange-brown siltstone	0.5
Siltstone, orange-brown, platy, well-indurated; mottled with some greenish-gray spots; eroding into a ledge	0.5
Siltstone and shale, orange-brown, argillaceous, platy, thin-bedded, weakly indurated	3.75
Sandstone and siltstone, orange-brown, mottled greenish-gray, thinly laminated, moderately indurated; eroding into a ledge	1.25
Shale, red-brown, silty, platy, weakly indurated; mottled with greenish-gray spots; exposed to base	1.0+

SECTION 10.

CLEVELAND HILLS AND GREENWOOD CREEK, WOODS COUNTY, OKLAHOMA

Beginning at top in slumped Day Creek Dolomite in E½ NW¼ SW¼ sec. 30, T. 28 N., R. 16 W., section measured to Relay Creek in SE¼ SE¼ SE¼ NE¼ sec. 25, T. 28 N., R. 17 W., then Marlow in SW¼ SE¼ SE¼ sec. 30 to Doe Creek, and Doe Creek in W½ sec. 28, T. 28 N., R. 16 W., and lower part of Marlow in NW¼ NW¼ sec. 28, T. 28 N., R. 16 W., in the Cleveland Hills. Section then measured in Dog Creek Shale in NW¼ NE¼ sec. 28 and SE¼ SW¼ sec. 21 through the Blaine Formation, ending in the NE¼ SE¼ sec. 13, T. 28 N., R. 16 W., for Flowerpot Shale down to Unit 3. Section then measured in NE¼ NE¼ NE¼ sec. 20 and SE¼ SE¼ SE¼ sec. 17, T. 28 N., R. 15 W., to Unit 1, and then SW¼ SW¼ SE¼ sec. 7, T. 28 N., R. 15 W., for beds around Unit 1, and W½ SE¼ SW¼ sec. 10, T. 28 N., R. 15 W., for beds below Unit 1 to top of Cedar Hills Sandstone. Then section extrapolated to NW¼ NE¼ SE¼ sec. 10, T. 28 N., R. 15 W., ending in the SE¼ SE¼ NE¼ sec. 10, T. 28 N., R. 15 W., along Greenwood Creek, northern Woods County, Oklahoma.

	Thickness (feet)
TERTIARY SYSTEM	
PLIOCENE SERIES	
OGALLALA FORMATION	
Gravel, tan, weakly indurated; composed of oyster shells, black ironstone pebbles, quartzite cobbles and pebbles, Cretaceous limestone, and quartz; capping the Cleveland Hills	5.0+
PERMIAN SYSTEM	
CUSTERIAN SERIES	
CLOUD CHIEF FORMATION (exposed thickness, 37 feet)	
Day Creek Dolomite Bed:	
Dolomite, light-gray to white, fine-grained, compact, thin-bedded, well-indurated; slumped at one spot about 10 square feet wide	1.0+
Kiger Member:	
Sandstone, orange-brown, fine-grained, calcitic, mottled greenish-gray	10.0
Shale, red-brown; with some sandstone lenses	16.0
Sandstone, tan to orange-brown, fine-grained, calcitic; eroding into a ledge	1.0
Shale and sandstone, orange-brown, platy, weakly indurated	5.0
Moccasin Creek Bed:	
Sandstone, orange-brown, fine-grained, calcitic, well-indurated; eroding into a prominent ledge	4.0
WHITEHORSE GROUP (total thickness, 207.3 feet)	
RUSH SPRINGS FORMATION (total thickness, 96 feet)	
Sandstone, light orange-brown, fine-grained, massive, moderately indurated	17.0
Sandstone, light orange-brown and greenish-gray, calcitic, massive; eroding into a ledge	1.0
Sandstone, orange-brown, fine-grained, massive, weakly indurated	20.0
Shale, orange-brown; with interbedded fine-grained sandstone	10.0
Sandstone, tan, medium-grained, quartzose, friable	1.0
Shale and sandstone, red-brown, interbedded; as above	10.0
Sandstone, orange-brown; as above	27.0
Shale and sandstone, red-brown, interbedded; as above	10.0
(*Section extrapolated to NE¼ sec. 25*)	
MARLOW FORMATION (total thickness, 111.3 feet)	
Emanuel Bed:	
Sandstone, light greenish-gray, calcitic, well-indurated; gradational into arenaceous dolomite; eroding into a ledge	0.1
Unnamed Beds:	
Sandstone, orange-brown, medium-grained, massive, weakly indurated	1.2
Siltstone, orange-brown, argillaceous, platy	3.0
Shale, red-brown, silty, platy, weakly indurated	3.2
Sandstone, orange-brown, very fine-grained, silty, massive, weakly indurated	4.5
Sandstone, light greenish-gray, calcitic, platy	0.75
Shale, red-brown, silty, platy, weakly indurated	4.5
Dolomite, light greenish-gray, fine-grained, crinkly bedded, well-indurated; with much satin spar	0.1
Shale, red-brown, silty, platy, weakly indurated; with interbedded orange-brown siltstone	2.75
Relay Creek Bed:	
Dolomite, maroon and greenish-gray, argillaceous, crinkly bedded, well-indurated; eroding into a ledge	0.2
Unnamed Beds:	
Sandstone, orange-brown, quartzose, fine-grained, thin-bedded, weakly indurated; gradational into Doe Creek type of sand-	

	Thickness (feet)
stone eastward	15.0
(*Section extrapolated to W½ sec. 28*)	
Doe Creek Lentil:	
Sandstone, moderate reddish-brown to reddish-orange, medium- to coarse-grained, quartzose, calcitic, well-indurated, thin-bedded; cross-bedded toward north, northwest, and northeast; wavy bedded, with interbedded fine-grained sandstone and fossiliferous sandy limestone; eroding into prominent buttes at different levels; composed of (in percent) 48.8 sand, 11.6 silt, 1.6 clay, and 38.0 carbonate	20.0
Unnamed Beds:	
Sandstone, moderate red-brown to red-orange, fine-grained, quartzose, cross-bedded, weakly indurated; composed of (in percent) 49.4 sand, 38.7 silt, 2.7 clay, and 9.2 carbonate	56.0
CIMARRONIAN SERIES	
EL RENO GROUP (total thickness, 354 feet)	
DOG CREEK SHALE (total thickness, 52.5 feet)	
Shale, red-brown, mottled greenish-gray, blocky; conformable with above beds	4.2
Dolomite, red-brown, argillaceous, fine-grained, well-indurated massive, wavy bedded; composed of (in percent) 0.03 sand, 6.41 silt, 5.26 clay, and 88.3 carbonate	0.1
Siltstone, greenish-gray, mottled red-brown, argillaceous, platy, weakly indurated	0.4
Shale, red-brown, silty, blocky; with some greenish-gray layers	5.0
Dolomite, light-brown to light-gray, fine-grained, dense, massive, blocky; composed of (in percent) 0.01 sand, 11.10 silt, 6.62 clay, and 82.3 carbonate	0.2
Shale, red-brown, blocky	0.75
Southard Bed:	
Dolomite, pink and greenish-gray, fine-grained, dense, well-indurated, massive; composed of (in percent) 0.02 sand, 7.10 silt, 7.88 clay, and 85.0 carbonate	0.1
Unnamed Beds:	
Shale, purplish-brown, platy	1.25
Shale, red-brown, blocky	1.0
Dolomite, light-brown, fine-grained, dense, well-indurated, massive; composed of (in percent) 0.03 sand, 6.43 silt, 9.50 clay, and 84.0 carbonate	0.1
Shale, red-brown, blocky	1.0
Dolomite, light-pink to greenish-gray, fine-grained, dense, well-indurated, massive; composed of (in percent) 0.05 sand, 4.49 silt, 8.72 clay, and 86.7 carbonate	0.2
Shale, red-brown, silty, blocky	8.25
Siltstone, moderate red-brown to red-orange, arenaceous, well-indurated, thin-bedded; eroding into a prominent ledge; composed of (in percent) 39.8 sand, 46.3 silt, 1.5 clay, and 12.4 carbonate. The heavy-mineral fraction, comprising 0.04 percent of the sand-sized fraction of the insoluble residue, consists of (in percent) 30.86 ilmenite-magnetite, 29.01 sphene-leucoxene, 4.63 orange opaque, 14.51 garnet, 3.09 zircon, 9.26 brown to gray tourmaline, 0.31 blue tourmaline, 3.40 biotite, 1.85 chlorite-muscovite, 0.31 epidote, 1.54 yellow rutile, 0.31 riebeckite, and 0.93 anhydrite. The light-mineral fraction consists of 84.26 quartz, 7.87 chert, 5.25 orthoclase, 1.64 plagioclase, and 0.98 microcline	6.0
Siltstone, greenish-gray and red-brown, well-indurated	0.5
Shale, red-brown, silty, blocky	3.0
Siltstone, red-brown and greenish-gray, argillaceous, weakly indurated, thin-bedded	2.2

	Thickness (feet)
Siltstone, greenish-gray and 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; eroding into a ledge	0.1
Siltstone, greenish-gray and red-orange, weakly indurated, massive	0.6
Shale, red-brown, blocky	0.8
Siltstone, greenish-gray and red-brown, thin-bedded, weakly indurated	1.0
Shale, red-brown, blocky; silty at top	1.5
Siltstone, greenish-gray, argillaceous, platy	0.1
Shale, red-brown, blocky	2.3
Siltstone, greenish-gray, argillaceous, gypsiferous, weakly 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, dolomitic, platy, ripple-marked; eroding into a ledge	0.8
Unnamed Beds:	
Shale, red-brown, blocky; with some greenish-gray shale spots	5.25
BLAINE FORMATION (total thickness, 68.7 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, massive; coarsely selenitic on weathered surface; eroding into a mappable escarpment	11.0
Altona Bed:	
Dolomite, light-gray, fine-grained, oölitic, well-indurated, medium-bedded; weathering into boxworks; eroding into an escarpment; composed of (in percent) 0.3 sand, 2.9 silt, 1.8 clay, and 95.0 carbonate. The heavy-mineral fraction, comprising 3.08 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 18.06 ilmenite-magnetite, 13.87 sphene-leucoxene, 37.17 orange opaque, 14.14 garnet, 10.73 zircon, 0.52 brown to gray tourmaline, 0.26 biotite, 0.26 chlorite-muscovite, 0.26 epidote, and 4.71 anhydrite. The light-mineral fraction consists of 72.39 quartz, 9.92 chert, 15.28 orthoclase, 0.80 plagioclase, and 1.61 microcline	0.5
Unnamed Beds:	
Shale, greenish-gray, blocky	0.2
Shale and siltstone, red-brown, blocky; with some greenish-gray layers; composed of (in percent) 6.9 sand, 71.0 silt, 8.3 clay, and 13.8 carbonate. The heavy-mineral fraction, comprising 0.07 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 14.79 ilmenite-magnetite, 26.05 sphene-leucoxene, 12.54 orange opaque, 8.68 garnet, 7.72 zircon, 11.90 brown to gray tourmaline, 1.61 biotite, 12.86 chlorite-muscovite, 0.32 epidote, and 3.54 anhydrite. The light-mineral fraction consists of (in percent) 81.67 quartz, 9.32 chert, 7.72 orthoclase, 0.64 plagioclase, and 0.64 microcline	7.8
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; eroding into an escarpment	10.0
Magpie Bed:	
Siltstone, light-brown to greenish-gray, gypsiferous, dolomitic, weakly indurated, massive; consisting of (in percent) 5.5 sand,	

	Thickness (feet)
67.5 silt, 1.4 clay, and 25.6 carbonate and gypsum	0.25
Unnamed Beds:	
Shale, greenish-gray, blocky	0.25
Shale, red-brown, blocky; with some greenish-gray shale beds and crinkly bedded selenite; composed of (in percent) 2.4 sand, 75.8 silt, 5.3 clay, and 16.5 carbonate and gypsum	7.5
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; eroding into an escarpment	31.0
Cedar Springs Bed:	
Dolomite, light-brown to light-gray, fine-grained, oölitic, thin-bedded, well-indurated; composed of (in percent) 0.03 sand, 1.33 silt, 2.22 clay, and 96.4 carbonate	0.25
FLOWERPOT SHALE (total thickness, 233 feet)	
Shale, greenish-gray, blocky	0.1
(*Section extrapolated to isolated butte in sec. 13, T. 28 N., R. 16 W.*)	
Shale, red-brown, selenitic, blocky	0.9
Shale, greenish-gray, selenitic, blocky	0.1
Shale, red-brown, selenitic, blocky	0.75
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; eroding into a ledge	0.3
Shale, red-brown, selenitic, blocky	1.0
Siltstone, mottled greenish-gray and red-brown, arenaceous, thin-bedded, blocky; composed of (in percent) 29.5 sand, 64.1 silt, 3.8 clay, and 2.6 carbonate. The heavy-mineral fraction, comprising 0.17 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 17.28 ilmenite-magnetite, 20.27 sphene-leucoxene, 9.97 orange opaque, 34.88 garnet, 2.33 zircon, 8.97 brown to gray tourmaline, 0.33 blue tourmaline, 2.33 biotite, 0.33 chlorite-muscovite, 2.66 epidote, and 0.33 yellow rutile. The light-mineral fraction consists of (in percent) 81.07 quartz, 13.33 chert, 2.13 orthoclase, 1.07 plagioclase, and 2.40 microcline	0.8
Shale, red-brown, silty, blocky; with some gypsum nodules	0.75
Unit 6:	
Siltstone, red-brown, arenaceous, calcareous, weakly indurated, thin-bedded; composed of (in percent) 14.6 sand, 72.2 silt, 3.7 clay, and 9.5 carbonate	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; composed of (in percent) 12.5 sand, 78.1 silt, 3.1 clay, and 6.3 carbonate	0.2
Unnamed Beds:	
Shale, red-brown, blocky; with some gypsum nodules	2.6
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; eroding into a ledge	0.25
Shale, red-brown, selenitic, blocky	0.75
Shale, red-brown, selenitic, well-indurated, thin-bedded, crinkly bedded; eroding into a ledge	0.3

	Thickness (feet)
Shale, red-brown, blocky, selenitic; with some thin greenish-gray shale layers	2.5
Shale, greenish-gray, blocky	0.2
Shale, red-brown, blocky, selenitic	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
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; eroding into a ledge	0.25
Shale, red-brown, blocky	0.2
Dolomite, greenish-gray, silty, fine-grained, dense, well-indurated, thin-bedded; composed of (in percent) 0.4 sand, 41.6 silt, 12.4 clay, and 45.6 carbonate	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; composed of (in percent) 2.1 sand, 84.1 silt, 4.8 clay, and 9.0 carbonate	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 5:	
Siltstone, greenish-gray, arenaceous, dolomitic, gypsiferous, well-indurated, massive; at base of extremely gypsiferous section; eroding into a prominent escarpment; composed of (in percent) 19.8 sand, 58.2 silt, 1.7 clay, and 20.3 carbonate. The heavy-mineral fraction, comprising 0.04 percent of the sand-sized fraction of the insoluble residue, consists of (in percent) 2.30 ilmenite-magnetite, 28.20 sphene-leucoxene, 34.43 orange opaque, 8.52 garnet, 18.69 brown to gray tourmaline, 0.33 blue tourmaline, 4.59 biotite, 0.98 chlorite-muscovite, 1.31 epidote, 0.33 yellow rutile, and 0.33 anhydrite. The light-mineral fraction consists of (in percent) 79.93 quartz, 11.04 chert, 6.69 orthoclase, 1.08 plagioclase, and 1.34 microcline	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
Unnamed Beds:	
Shale, red-brown, blocky	1.75

	Thickness (feet)
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
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
Unit 4:	
Siltstone, mottled greenish-gray and red-brown, argillaceous, moderately indurated, thin-bedded; composed of (in percent) 7.9 sand, 70.9 silt, 14.9 clay, and 6.3 carbonate. The heavy-mineral fraction, comprising 0.08 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 3.54 ilmenite-magnetite, 17.98 sphene-leucoxene, 24.25 orange opaque, 8.17 garnet, 0.82 zircon, 3.81 brown to gray tourmaline, 0.27 blue tourmaline, 1.36 biotite, 16.89 chlorite-muscovite, 1.36 apatite, and 21.53 anhydrite. The light-mineral fraction consists of (in percent) 75.59 quartz, 18.53 chert, 3.53 orthoclase, 0.88 plagioclase, and 1.47 microcline	1.8
Unnamed Beds:	
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; with a mean of 8.23 phi, deviation 3.07, skewness 0.18, and kurtosis 0.82. The clay minerals are illite (peaks at 3.34, 4.98, 10.04a) and chlorite (peak at 7.20a)	3.0

	Thickness (feet)
Shale, red-brown, selenitic, blocky; with much satin spar and some greenish-gray layers	3.5
Unit 3-4:	
Dolomite, greenish-gray, mottled red-brown, silty, blocky; composed of (in percent) 0.3 sand, 24.9 silt, 11.6 clay, and 63.2 carbonate	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-indurated, crinkly bedded	0.7
Shale, red-brown, blocky	1.0
Siltstone, greenish-gray, mottled red-brown, selenitic, argillaceous, thin-bedded, crinkly bedded	0.5
Unnamed Beds:	
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
Unit 3:	
Siltstone, mottled greenish-gray and red-brown, moderately indurated, thin-bedded; eroding into an escarpment	1.75
(*Section extrapolated to NE¼ sec. 20 and SE¼ sec. 17, T. 28 N., R. 15 W.*)	
Unnamed Beds:	
Shale, red-brown, blocky, gypsiferous, selenitic, weakly indurated	7.0
Siltstone, greenish-gray, gypsiferous, argillaceous, well-indurated, wavy bedded; eroding into a ledge	0.2
Shale, red-brown, selenitic, blocky, weakly indurated	3.0
Siltstone, greenish-gray, argillaceous, platy, weakly indurated	0.2
Shale, red-brown, gypsiferous, blocky, weakly indurated	2.0
Siltstone, greenish-gray, argillaceous, dolomitic, well-indurated, blocky; eroding into a ledge	0.3
Shale, red-brown, gypsiferous, blocky, selenitic, weakly indurated; with some gypsum nodules near top	7.0
Siltstone, greenish-gray, mottled orange brown, gypsiferous, platy, crinkly bedded, well-indurated; with interbedded red-brown shale: eroding into a ledge	1.5
Shale, red-brown, selenitic, silty, blocky, crinkly bedded; with some satin spar beds and 1-inch greenish-gray beds	5.25
Unit 2:	
Siltstone, light greenish-gray, gypsiferous, argillaceous well-indurated, thin-bedded, crinkly bedded; eroding into a prominent escarpment	3.0
Unnamed Beds:	
Siltstone, orange-brown, argillaceous; mottled with greenish-gray spots	1.2
Shale, red-brown, blocky, weakly indurated; with many alternating 1- to 6-inch greenish-gray, gypsiferous shale beds with gypsum nodules; eroding into small ledges	6.5
Siltstone and shale, greenish-gray and red-brown, gypsiferous, thin-	

	Thickness (feet)
bedded, crinkly bedded, well-indurated; in several ledges	2.0
(Section extrapolated to SW¼ SW¼ SE¼ sec. 7, T. 28 N., R. 15 W., north of road)	
Shale, red-brown, silty, gypsiferous, blocky, weakly indurated; mottled with greenish-gray laminae	4.0
Siltstone, greenish-gray, argillaceous, gypsiferous, platy	0.2
Shale, red-brown, weakly indurated; as above	1.0
Shale, greenish-gray, gypsiferous, silty, blocky	1.0
Shale, red-brown, weakly indurated; as above	3.0
Unit 1:	
Sandstone, greenish-gray, mottled orange-brown, thinly laminated, moderately indurated; with many large white gypsum nodules 0.75 to 1 foot in diameter; eroding into a ledge	2.0
Unnamed Beds:	
Shale, red-brown, silty, gypsiferous, blocky, weakly indurated	3.0
Siltstone, mottled greenish-gray and orange-brown, gypsiferous, argillaceous, moderately to weakly indurated, crinkly bedded; gradational into fine-grained sandstone; eroding into a ledge	1.2
(Section extrapolated along north side of road in W½ SE¼ SW¼ sec. 10, T. 28 N., R. 15 W.)	
Siltstone, orange-brown, arenaceous, platy, crinkly bedded; with many greenish-gray gypsiferous shale beds; eroding into a ledge	0.5
Shale, red-brown, silty, blocky, gypsiferous, thinly laminated, weakly indurated; with some interbedded sandstone	0.5
Siltstone, orange-brown, arenaceous, weakly indurated; mottled with greenish-gray spots	1.3
Siltstone, well-indurated, crinkly bedded; as above; with many greenish-gray gypsum nodules; eroding into a ledge	0.6
Siltstone, orange-brown, massive, weakly indurated	1.5
Siltstone, orange-brown and greenish-gray, thinly laminated, crinkly bedded, moderately indurated; with many 1-inch greenish-gray gypsum nodules; eroding into a ledge and forming a marker bed	0.9
Siltstone, orange-brown, argillaceous, massive, weakly indurated; with some paper-thin selenite	5.5
Siltstone, greenish-gray and orange-brown, platy, crinkly bedded, moderately indurated; gypsiferous at top	1.2
Shale, red-brown, blocky, weakly indurated; with some greenish-gray streaks	1.1
Siltstone, greenish-gray, mottled orange-brown, gypsiferous, well-indurated; with 1-inch yellow-green gypsum nodules; eroding into a ledge	0.3
Shale, red-brown, blocky; mottled with greenish-gray spots	0.25
Siltstone, orange-brown, argillaceous, moderately indurated, massive; mottled with greenish-gray spots; with some paper-thin selenite	1.75
Siltstone, greenish-gray, mottled orange-brown, argillaceous, crinkly bedded, well-indurated; with much paper-thin selenite	0.6
Siltstone, orange-brown; as above; with much paper-thin selenite; gradational into blocky shale	1.1
Siltstone, greenish-gray; as above; eroding into a small ledge	0.4
Siltstone, orange-brown; as above	0.7
Siltstone, greenish-gray; as above	0.25
Siltstone, orange-brown; as above	0.6
Shale and siltstone, greenish-gray, mottled orange-brown, gypsiferous, blocky, well-indurated; eroding into a ledge	0.75
Shale and siltstone, red-brown, gypsiferous, weakly indurated; mottled with greenish-gray streaks	2.2
Shale and siltstone, well-indurated, crinkly bedded; as above; eroding into a ledge	0.8

	Thickness (feet)
Shale and siltstone, red-brown, blocky, weakly indurated; with gypsum nodules and selenite and some greenish-gray patches	5.2
Siltstone, mottled greenish-gray and orange-brown, argillaceous, gypsiferous, platy, crinkly bedded; well-indurated at top; eroding into a prominent greenish-gray ledge	1.5
Shale, red-brown, blocky; with much satin spar; mottled with many greenish-gray spots	2.5
Siltstone, orange-brown, gypsiferous, moderately indurated, massive; mottled with greenish-gray spots	1.0
Siltstone, well-indurated; as above; eroding into a ledge	0.75
Siltstone, argillaceous, blocky, weakly indurated, massive; as above; with much satin spar	4.25
(Section extrapolated to creek bluff in NW¼ NE¼ SE¼ sec. 10, T. 28 N., R. 15 W.)	
CIMARRONIAN SERIES	
HENNESSEY FORMATION (base not exposed)	
Cedar Hills Sandstone Member: (base not exposed; exposed thickness 51.6 feet)	
Unit 5:	
Siltstone and gypsum, greenish-gray and orange-brown, crinkly bedded, selenitic; with many flat 3- to 6-inch gypsum nodules; eroding into a prominent zone	0.3
Unnamed Bed:	
Siltstone and sandstone, mottled greenish-gray and orange-brown, very fine-grained, friable, thinly laminated, weakly indurated; with some satin spar veins; argillaceous in lower half; with a 2-foot greenish-gray and orange-brown sandstone 10 feet above base and a 1-foot greenish-gray sandstone 4 feet above base, forming conspicuous light-colored zones	22.1
Unit 4:	
Sandstone, greenish-gray, gypsiferous; with many gypsum nodules	0.4
(Section extrapolated to SE¼ SE¼ NE¼ sec. 10, T. 28 N., R. 15 W.)	
Unnamed Beds:	
Shale and siltstone, orange-brown, blocky, weakly indurated; with some greenish-gray streaks and a conspicuous 6-inch greenish-gray layer 5 feet below top	14.25
Siltstone, mottled orange-brown and greenish-gray, gypsiferous, platy, crinkly bedded, weakly indurated	2.0
Siltstone, red-brown, mottled greenish-gray, gypsiferous, well-indurated, crinkly bedded; eroding into a ledge	1.0
Siltstone and shale, red-brown, gypsiferous, blocky, weakly indurated	2.5
Siltstone, greenish-gray, mottled orange-brown, gypsiferous, well-indurated; eroding into a ledge	1.5
Siltstone, mottled orange-brown and greenish-gray, gypsiferous, massive, weakly indurated; with some 2- to 6-inch greenish-gray beds	5.25
Siltstone, greenish-gray, gypsiferous, platy, crinkly bedded: with many gypsum nodules; eroding into a conspicuous ledge on edge of Greenwood Creek	0.3
Siltstone, mottled orange-brown and greenish-gray, massive weakly indurated; exposed	2.0

SECTION 11.
WEST MOCCASIN CREEK, WOODS COUNTY, OKLAHOMA

Beginning at top in Ogallala Formation in C SE¼ sec. 8, T. 28 N., R. 18 W., and proceeding down section in Cloud Chief Formation

to type Day Creek Bed, type Kiger Member, and type Moccasin Creek Bed, then type Whitehorse section and type Rush Springs Formation to Emanuel Bed, then Marlow Formation to Relay Creek Bed at head of West Moccasin Creek. Section then extrapolated to S½ S½ NE¼ sec. 19, T. 28 N., R. 18 W., for remainder of Marlow to Dog Creek Shale. Section then extrapolated to SE¼ NE¼ NE¼ sec. 36, T. 28 N., R. 19 W., to base of Shimer Gypsum in SE¼ SW¼ NW¼ sec. 31, T. 28 N., R. 18 W. The Blaine portion was measured on the east side of West Moccasin Creek along U. S. Highway 64, in NE¼ NE¼ NW¼ sec. 7, T. 27 N., R. 18 W., ending in the Flowerpot Shale on the Cimarron River in SW¼ SW¼ NW¼ sec. 28, T. 27 N., R. 18 W., western Woods County. A local gypsum 1 foot thick occurs in the Marlow Formation, 39 feet below the top in SE¼ NE¼ SE¼ SW¼ sec. 20, T. 28 N., R. 18 W., and is found locally in this region below the Relay Creek Bed.

	Thickness (feet)
TERTIARY SYSTEM	
PLIOCENE SERIES	
OGALLALA FORMATION	
Gravel, tan, weakly indurated; composed of oyster shells and black ironstones, quartzite pebbles and cobbles, unconformable on beds below	5.0
PERMIAN SYSTEM	
CUSTERIAN SERIES	
CLOUD CHIEF FORMATION (top not exposed; exposed thickness 51.85 feet)	
Big Basin Member (top not exposed; exposed thickness 15.85 feet) :	
Shale, red-brown, silty, thin-bedded	1.0
Siltstone and shale, yellow-brown, gypsiferous, calcitic, thin-bedded, weakly to well-indurated	2.0
Shale, red-brown, silty, thin-bedded, weakly indurated; with interbedded red-brown siltstone	6.5
Siltstone, greenish-gray and red-brown, calcitic, massive, brecciated, well-indurated; eroding into a ledge	0.5
Shale, red-brown, silty, thin-bedded, weakly indurated	1.4
Siltstone, red-brown, mottled greenish-gray, arenaceous, calcitic, brecciated, well-indurated	0.75
Shale, red-brown, silty, thin-bedded, blocky, weakly indurated	0.2
Siltstone, red-brown, argillaceous, calcitic, well-indurated	1.5
Shale, light greenish-gray, dolomitic; weakly indurated at top; well-indurated at base	2.0
Day Creek Dolomite Bed (type section, total thickness 2 feet) :	
Dolomite, light-gray to white, compact, very fine-grained, thin-bedded, well-indurated, crinkly bedded; with many black to orange-brown limonite concretions, and layers and vugs of chalcedony and opaline quartz; eroding into the most prominent escarpment in the region	2.0
Kiger Member (total section, total thickness, 30.8 feet) :	
Siltstone, greenish-gray, arenaceous, argillaceous, thin-bedded, weakly indurated; gradational into fine-grained sandstone	2.2
Siltstone, orange-brown, arenaceous, weakly indurated	1.0
Sandstone, greenish-gray, silty, weakly indurated; gradational into dark-gray shale in lower 6 inches	1.9
Shale, red-brown, silty, blocky, weakly indurated	3.5
Sandstone, greenish-gray, fine-grained, quartzose, weakly indurated; mottled orange brown in middle	2.0

	Thickness (feet)
Shale, red-brown, platy, weakly indurated	3.7
Siltstone, greenish-gray and red-brown, argillaceous, thin-bedded, moderately indurated	0.5
Shale, red-brown, platy, weakly indurated; with some 0.5- to 2-foot indurated calcitic siltstones in middle	16.0
Moccasin Creek Bed (type section, 3.2 feet thick):	
Dolomite, pink and white, very fine-grained, silty, well-indurated	0.3
Siltstone and sandstone, greenish-gray, very fine-grained, weakly indurated, friable; gradational into red-brown siltstone	1.2
Sandstone, orange-brown, very fine-grained, quartzose, micaceous, weakly indurated	1.2
Sandstone, greenish-gray, very fine-grained, weakly indurated; very calcitic in upper 2 inches	0.5
WHITEHORSE GROUP (type section, total thickness, 194.35 feet)	
RUSH SPRINGS FORMATION (type section, total thickness, 77.25 feet)	
Sandstone, orange-brown, very fine-grained, quartzose, weakly indurated, mottled greenish-gray	5.0
Siltstone, red-brown, argillaceous, well-indurated, massive; eroding into a ledge	2.5
Shale, red-brown, silty, weakly indurated	3.0
Sandstone, orange-brown, very fine-grained, silty, micaceous, quartzose, moderately to weakly indurated, thin-bedded to massive; eroding into a prominent ledge	23.0
Sandstone, greenish-gray, calcitic; well-indurated at base; gradational into red-brown siltstone	0.5
Shale, red-brown, silty, platy	4.0
Sandstone, orange-brown, weakly indurated; as above; eroding into a small ledge	3.0
Shale, red-brown; as above	2.0
Sandstone, orange-brown; as above	2.5
Shale, red-brown; as above; with some thin greenish-gray beds	7.0
Sandstone, orange-brown; as above; with some thin shale seams	5.0
Shale, red-brown; as above	3.0
Sandstone, orange-brown; as above	1.5
Shale, red-brown; as above; with some interbedded orange-brown sandstone	6.0
Sandstone, orange-brown; as above; eroding into a sharp angular escarpment	3.0
Shale, red-brown; as above	2.0
Sandstone, orange-brown; as above	1.0
Shale, greenish-gray, arenaceous, platy, weakly indurated	0.5
Shale, red-brown; as above	2.75
MARLOW FORMATION (total thickness, 117.1 feet)	
Emanuel Bed:	
Sandstone, greenish-gray, calcitic, fine to medium-grained; moderately indurated at top	0.25
Unnamed Beds:	
Sandstone, light orange-brown, fine- to medium-grained, cross-bedded, weakly indurated	2.0
Sandstone, orange brown, fine- to medium-grained, massive, weakly indurated; greenish gray in basal 6 inches	5.5
Shale, red-brown; as above; with some 1- to 2-inch greenish-gray shale layers	16.75
Relay Creek Bed:	
Dolomite, pink to maroon, fine-grained, crinkly bedded, platy, well-indurated; eroding into a prominent ledge	0.05

(*Section extrapolated to S½ S½ NE¼ sec. 19, T. 28 N., R. 18 W.*)

	Thickness (feet)
Unnamed Beds:	
Sandstone, orange-brown, fine-grained, moderately indurated	8.3
Shale and siltstone, red-brown, mottled orange-brown, thin-bedded, moderately to weakly indurated	4.25
Sandstone, orange-brown, very fine-grained, silty, weakly indurated	3.0
Gypsum, pink and white, fine-grained, massive, well-indurated; this bed occurs in SE¼ NE¼ SE¼ SW¼ sec. 20, T. 28 N., R. 18 W.	1.0
Sandstone, moderate red-brown to moderate reddish-orange, fine-grained, silty, weakly indurated	73.6
Sandstone, light-brown, mottled greenish-gray, fine-grained, moderately indurated, thinly laminated, platy	0.6
(*Section extrapolated to SE¼ NE¼ NE¼ sec. 36, T. 28 N., R. 19 W.*)	
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 0.5- to 1-inch irregular patches of red-brown shale; with mean of 3.43 phi, deviation 0.51, skewness 0.19, and kurtosis 1.56. The heavy-mineral fraction, comprising 1.41 percent of the sand-sized fraction of the insoluble residue, consists of (in percent) 48.54 ilmenite-magnetite, 12.29 sphene-leucoxene, 0.32 orange opaque, 22.33 garnet, 11.00 zircon, 0.64 brown to gray tourmaline, 0.32 blue tourmaline, 1.61 biotite, 0.32 epidote, 0.97 red rutile, 0.97 yellow rutile, and 0.64 apatite. The light-mineral fraction consists of (in percent) 74.38 quartz, 15.08 chert, 7.36 orthoclase, 2.10 plagioclase, and 1.05 microcline	1.0
CIMARRONIAN SERIES	
EL RENO GROUP	
DOG CREEK SHALE (total thickness, 49.9 feet)	
Shale, red-brown, weakly indurated, blocky	0.75
Siltstone, mottled greenish-gray to red-brown to moderate reddish-orange, argillaceous, blocky; composed of (in percent) 1.6 sand, 81.8 silt, 10.5 clay, and 6.1 carbonate	2.5
Siltstone, greenish-gray, mottled red-brown to moderate reddish-orange, calcareous, argillaceous, well-indurated, massive; composed of (in percent) 1.2 sand, 81.3 silt, 7.4 clay, and 10.1 carbonate; eroding into a ledge	0.3
Shale, red-brown, blocky	0.75
Dolomite, greenish-gray, silty, blocky; thin-bedded in middle; composed of (in percent) 0.6 sand, 39.1 silt, 16.6 clay, and 43.7 carbonate; eroding into a ledge	0.25
Shale, red-brown, blocky	0.4
Dolomite, light-gray, mottled pink, silty, argillaceous, fine-grained, dense, well-indurated, nodular to massive; composed of (in percent) 0.2 sand, 25.1 silt, 9.1 clay, and 65.6 carbonate; eroding into a ledge	0.1
Shale, red-brown, blocky	1.25
Dolomite, light-gray, silty, argillaceous, fine-grained, dense, nodular to massive; composed of (in percent) 0.1 sand, 24.9 silt, 9.2 clay, and 65.8 carbonate; eroding into a ledge	0.2
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, platy, well-indurated; with many salt casts; composed of (in percent) 0.03 sand, 13.90 silt, 10.25 clay, and 75.82 carbonate; eroding into a prominent escarpment	0.4

	Thickness (feet)
Unnamed Beds:	
Siltstone, greenish-gray, calcareous, argillaceous, weakly indurated, thinly laminated to blocky; with some well-indurated dolomitic shale layers near base; composed of (in percent) 0.4 sand, 66.0 silt, 15.6 clay, and 18.0 carbonate	2.0
Shale, red-brown, silty, blocky; with some greenish-gray medium-bedded siltstone layers	7.4
Sandstone, light-brown, mottled red-brown to moderate reddish-orange, fine-grained, quartzose, well-indurated, massive; eroding into a ledge	1.0
Sandstone and siltstone, red-brown to moderate reddish-orange, fine-grained, quartzose, moderately indurated, thin- to medium-bedded; weathering massive; eroding into a ledge	3.6
Siltstone, greenish-gray, mottled red-brown to moderate reddish-orange, calcareous, thinly laminated; weakly indurated at top; well indurated at base; composed of (in percent) 3.0 sand, 87.2 silt, 2.5 clay, and 7.3 carbonate	1.0
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; eroding into a 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; composed of (in percent) 0.05 sand, 62.65 silt, 6.53 clay, and 30.77 carbonate	0.6
Unnamed Beds:	
Shale, red-brown, silty, blocky	3.4
Shale, greenish-gray and red-brown, silty, blocky, weakly indurated; 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 Member:	
Gypsum and siltstone, interbedded, red-brown and greenish-gray, well-indurated, thinly laminated, crinkly bedded; eroding into a 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 to massive; eroding into a ledge	2.75
Unnamed Bed:	
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 into coarsely selenitic gypsum	19.0
Altona Dolomite Bed:	
Dolomite, light-gray, fine-grained, oölitic, well-indurated: gradational upward into gypsum; composed of (in percent) 3.1 sand, 19.3 silt, 5.4 clay, and 72.2 carbonate	0.3
Unnamed Beds:	
Shale, greenish-gray, mottled red-brown, weakly indurated, blocky	0.5
Shale, red-brown, blocky; mottled with greenish-gray spots; with some medium-bedded selenite and satin spar beds in lower 5	

	Thickness (feet)
feet	14.5
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; red-brown and greenish-gray in upper 2 feet; weathering coarsely selenitic; eroding into an escarpment	11.0
Magpie Dolomite Bed:	
Siltstone, light-gray, fine-grained, dense to oölitic, well-indurated, massive; composed of (in percent) 18.9 sand, 65.1 silt, 5.5 clay, and 10.5 carbonate	0.2
Unnamed Bed:	
Shale, red-brown, blocky; with some satin spar	9.0
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; eroding into an escarpment	28.25
Cedar Springs Dolomite Bed:	
Dolomite, light-gray, fine-grained, dense to oölitic, well-indurated; composed of (in percent) 0.4 sand, 1.7 silt, 0.8 clay, and 97.1 carbonate	0.75
(*Section extrapolated to SW¼ SW¼ NW¼ sec. 28, T. 27 N., R. 18 W., on Cimarron River*)	
FLOWERPOT SHALE (base not exposed; exposed thickness 100.6 feet)	
Shale, greenish-gray, weakly indurated, blocky	0.25
Shale, red-brown, selentic, blocky	0.75
Siltstone, greenish-gray, dolomitic, gypsiferous, thin-bedded, crinkly bedded; well-indurated in places; composed of (in percent) 3.9 sand, 72.1 silt, 5.0 clay, and 19.0 carbonate and gypsum	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 beds	4.5
Shale, greenish-gray, mottled red-brown, selenitic, blocky; with much satin spar	0.8
Shale, red-brown, blocky; with some gypsum nodules	0.75
Shale, greenish-gray, mottled red-brown, selenitic, thin-bedded, crinkly bedded; alternating weakly to well-indurated layers	0.5
Shale, red-brown, selenitic, blocky	1.7
Shale, greenish-gray, silty, weakly indurated, blocky	0.75
Shale, red-brown, silty, blocky; mottled with greenish-gray spots	1.6
Unit 6:	
Siltstone, moderate red-brown, mottled greenish-gray, arenaceous, calcareous, well-indurated; with many 1- to 3-inch gypsum nodules; composed of (in percent) 18.8 sand, 65.9 silt, 5.2 clay, and 10.1 carbonate and gypsum. The heavy-mineral fraction, comprising 0.07 percent of the sand-sized fraction of the insoluble residue, consists of (in percent) 15.63 ilmenite-magnetite, 28.75 sphene-leucoxene, 8.75 orange opaque, 25.94 garnet, 1.88 zircon, 9.38 brown to gray tourmaline, 4.69 biotite, 1.88 chlorite-muscovite, 1.88 epidote, and 1.25 anhydrite. The light-mineral fraction consists of (in percent) 79.13 quartz, 13.01 chert, 5.96 orthoclase, 0.81 plagioclase, and 1.08 microcline	1.25
Siltstone, light-brown to red-brown, mottled greenish-gray, argillaceous, massive, moderately indurated; with some gypsum nodules; eroding into a ledge	3.1
Unnamed Beds:	
Shale, greenish-gray, mottled red-brown, silty, weakly indurated, platy, thin-bedded	0.2
Shale, red-brown, silty, weakly indurated, blocky; with some greenish-gray spots	7.1
Gypsum, white, mottled greenish-gray, fine-grained, well-indu-	

	Thickness (feet)
rated, 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; eroding into a 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; marking 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; eroding into a ledge; composed of (in percent) 3.3 sand, 63.5 silt, 11.2 clay, and 22.0 carbonate	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 5:	
Siltstone, greenish-gray, mottled red-brown, argillaceous, gypsiferous, weakly indurated; with gypsum nodules	1.0
Unnamed Beds:	
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 gypsum nodules	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
Unit 4:	
Siltstone, greenish-gray, gypsiferous, well-indurated, massive, crinkly bedded; with mean of 4.85 phi, deviation 2.36, skewness 0.76, and kurtosis 2.08	0.1
Unnamed Beds:	

	Thickness (feet)
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 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 to base of section	6.0

SECTION 12.

REDHORSE CREEK, WOODS COUNTY, OKLAHOMA

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

	Thickness (feet)
PERMIAN SYSTEM	
CUSTERIAN SERIES	
WHITEHORSE GROUP	
MARLOW FORMATION (top not exposed)	
Sandstone, moderate reddish-orange to moderate reddish-brown, fine-grained, quartzose, weakly indurated	5.0
Doe Creek Sandstone Lentil:	
Sandstone, light-gray, coarse-grained, quartzose, moderately indurated, friable; with well-rounded frosted grains of heavy and light minerals; cemented with sparry calcite; composed of (in percent) 68.6 sand and 31.4 carbonate, with mean of 1.53 phi, deviation 0.21, skewness 0.54, and kurtosis 1.43. The heavy-mineral fraction, comprising 0.16 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 7.81 ilmenite-magnetite, 13.43 sphene-leucoxene, 1.25 orange opaque, 53.75 garnet, 2.81 zircon, 2.18 brown to gray tourmaline, 0.31 blue tourmaline, 0.93 biotite, 0.31 chlorite-muscovite, 5.93 pyrite, 10.93 epidote, and 0.31 yellow rutile. The light-mineral fraction consists of (in percent) 82.24 quartz, 7.47 chert, 6.85 orthoclase, 1.24 plagioclase, and 2.18 microcline	0.25
CIMARRONIAN SERIES	
EL RENO GROUP	
DOG CREEK SHALE (total thickness, 54.2 feet)	
Shale, red-brown, silty	0.3
Siltstone, light-gray to greenish-gray, calcareous, moderately indurated; composed of (in percent) 2.2 sand, 75.8 silt, 3.9 clay,	

	Thickness (feet)
and 18.1 carbonate. The heavy-mineral fraction, comprising a trace of the sand-sized fraction of the insoluble residue, consists of (in percent) 24.32 ilmenite-magnetite, 19.22 sphene-leucoxene, 0.90 orange opaque, 12.91 garnet, 5.41 zircon, 1.50 brown to gray tourmaline, 3.30 biotite, 29.73 chlorite-muscovite, 2.40 epidote, 0.90 riebeckite, and 0.30 yellow rutile. The light-mineral fraction consists of (in percent) 65.62 quartz, 10.73 chert, 20.50 orthoclase, 1.26 plagioclase, and 1.89 microcline	0.2
Siltstone, red-brown and greenish-gray, calcareous, moderately indurated, blocky; composed of (in percent) 4.7 sand, 77.1 silt, 3.9 clay, and 14.3 carbonate	1.2
Shale, red-brown, blocky	2.25
Siltstone, greenish-gray, moderately indurated, crinkly bedded, thin-bedded	0.25
Shale, red-brown, mottled greenish-gray, weakly indurated, blocky	1.4
Siltstone, greenish-gray, calcareous, platy; well-indurated at top; composed of (in percent) 8.3 sand, 72.7 silt, 3.4 clay, and 15.6 carbonate	0.2
Shale, red-brown, weakly indurated, blocky	1.0
Siltstone, greenish-gray, calcareous, well-indurated, platy; composed of (in percent) 9.3 sand, 74.3 silt, 2.2 clay, and 14.2 carbonate	0.1
Dolomite, light-gray, fine-grained, dense, well-cemented, massive; weathering light brown; composed of (in percent) 0.06 sand, 4.7 silt, 6.7 clay, and 88.54 carbonate	0.1
Shale, red-brown, well-indurated, blocky	0.1
Dolomite, light-gray to greenish-gray, silty, argillaceous, platy, weakly indurated; composed of (in percent) 0.3 sand, 34.1 silt, 21.5 clay, and 44.1 carbonate	0.3
Shale, red-brown, silty, blocky, thin-bedded	4.0
Dolomite, light-brown, fine-grained, argillaceous, dense, blocky, massive; eroding into a ledge; composed of (in percent) 0.01 sand, 7.28 silt, 12.49 clay, and 80.22 carbonate	0.1
Shale, red-brown, blocky	0.8
Dolomite, light-brown, silty, argillaceous, fine-grained, dense, massive, blocky; composed of (in percent) 0.02 sand, 17.09 silt, 11.43 clay, and 71.46 carbonate	0.25
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; eroding into a ledge; composed of (in percent) 0.03 sand, 35.97 silt, 12.95 clay, and 51.05 carbonate	0.25
Unnamed Beds:	
Siltstone, greenish-gray, calcareous, argillaceous, weakly indurated; dolomitic at base; composed of (in percent) 0.1 sand, 44.1 silt, 22.8 clay, and 33.0 carbonate. The basal portion is (in percent) 0.3 sand, 20.6 silt, 11.7 clay, and 67.4 carbonate	0.8
Shale, red-brown, silty, blocky	2.75
Siltstone, greenish-gray, calcareous, moderately indurated, massive; eroding into a ledge; composed of (in percent) 4.8 sand, 79.9 silt, 2.4 clay, and 12.9 carbonate	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
Siltstone, greenish-gray, arenaceous, quartzose, moderately indurated, friable; eroding into a ledge; composed of (in percent) 30.9 sand, 55.5 silt, 0.7 clay, and 12.9 carbonate. The heavy-mineral fraction, comprising 0.04 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 31.71	

	Thickness (feet)
ilmenite-magnetite, 26.52 sphene-leucoxene, 1.83 orange opaque, 23.17 garnet, 5.79 zircon, 3.66 brown to gray tourmaline, 0.30 blue tourmaline, 1.52 biotite, 1.52 chlorite-muscovite, 2.74 epidote, 0.30 riebeckite, 0.30 red rutile, 0.61 yellow rutile, and 0.30 anhydrite. The light-mineral fraction consists of (in percent) 70.57 quartz, 9.81 chert, 18.35 orthoclase, 0.63 plagioclase, and 0.63 microcline	1.1
Siltstone, moderate reddish-brown to moderate reddish-orange, calcareous, moderately indurated, thin-bedded; arenaceous at top; eroding into a ledge; the basal part composed of (in percent) 2.2 sand, 77.5 silt, 1.8 clay, and 18.5 carbonate	7.0
Siltstone, greenish-gray, argillaceous, thin-bedded, crinkly bedded	0.5
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; composed of (in percent) 21.6 sand, 69.7 silt, 1.9 clay, and 6.7 carbonate. The heavy-mineral fraction, comprising 0.21 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 7.76 ilmenite-magnetite, 37.64 sphene-leucoxene, 2.87 orange opaque, 12.64 garnet, 1.72 zircon, 4.60 brown to gray tourmaline, 2.30 biotite, 27.30 chlorite-muscovite, and 3.16 epidote. The light-mineral fraction consists of (in percent) 74.85 quartz, 6.51 chert, 15.09 orthoclase, 1.48 plagoclase, and 0.59 microcline	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; composed of (in percent) 9.1 sand, 83.9 silt, 2.9 clay, and 4.1 carbonate	0.1
Unnamed Bed:	
Shale, red-brown, mottled greenish-gray, blocky	3.25
BLAINE FORMATION (total thickness, 76.4 feet)	
Shimer Gypsum Member:	
Gypsum, white, fine-grained, crystalline, well-indurated, massive; wavy bedded at top; eroding into an escarpment	12.0
Altona Dolomite Bed:	
Dolomite, light-gray, fine-grained, oölitic, medium-bedded, massive; weathering into boxworks; composed of (in percent) 3.8 sand, 8.5 silt, 2.8 clay, and 84.9 carbonate. The heavy-mineral fraction, comprising 0.05 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 6.81 ilmenite-magnetite, 40.31 sphene-leucoxene, 0.52 orange opaque, 16.23 garnet, 1.57 zircon, 17.80 brown to gray tourmaline, 0.52 blue tourmaline, 8.90 biotite, 1.57 chlorite-muscovite, 3.14 epidote, 0.52 apatite, 0.52 yellow rutile, and 1.57 riebeckite. The light-mineral fraction consists of (in percent) 80.17 quartz, 5.31 chert, 12.57 orthoclase, 0.56 plagioclase, and 1.40 microcline	0.75
Unnamed Beds:	
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; eroding into an escarpment	11.5
Magpie Dolomite Bed:	
Dolomite, light-gray, gypsiferous, fine-grained, massive; dense in	

	Thickness (feet)
places; composed of (in percent) 5.2 sand, 24.3 silt, 31.1 clay, and 39.4 carbonate	0.25
Unnamed Beds:	
Shale, greenish-gray, blocky	0.1
Shale, red-brown, blocky; with prominent 9-inch greenish-gray gypsiferous zone about 4 feet above the base; composed of (in percent) 1.2 sand, 77.2 silt, 7.9 clay, and 13.7 carbonate and gypsum	11.5
(*Section extrapolated to SE¼ NW¼ NW¼ sec. 22, T. 27 N., R. 17 W., on U. S. Highway 64*)	
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-grained, medium-bedded; weathering coarsely selenitic; eroding into an escarpment	26.0
Cedar Springs Dolomite Bed:	
Dolomite, light-gray, fine-grained, oölitic, well-indurated, massive; composed of (in percent) 0.3 sand, 2.07 silt, 2.40 clay, and 95.23 carbonate	0.5
FLOWERPOT SHALE (base not exposed; exposed thickness, 61.7 feet)	
Shale, greenish-gray, blocky	0.25
Shale, red-brown, selenitic, blocky; 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; eroding into a ledge; composed of (in percent) 2.9 sand, 65.7 silt, 8.3 clay, and 23.1 carbonate and gypsum	0.2
Shale, red-brown, blocky; with some greenish-gray spots and layers	2.7
Siltstone, greenish-gray, mottled red-brown, gypsiferous, massive, well-indurated, crinkly bedded; eroding into a ledge	0.2
Shale, red-brown, silty, blocky	0.8
Siltstone, greenish-gray, argillaceous, gypsiferous, well-indurated, crinkly bedded	0.1
Shale, red-brown, silty, blocky	1.0
Unit 6:	
Siltstone, mottled red-brown and greenish-gray, thinly laminated, well-indurated; with many gypsum nodules; eroding into a ledge; composed of (in percent) 6.6 sand, 76.3 silt, 6.9 clay, and 10.2 carbonate and gypsum. The heavy-mineral fraction, comprising 0.05 percent of the sand-sized fraction of the insoluble residue, consists of (in percent) 12.55 ilmenite-magnetite, 28.63 sphene-leucoxene, 7.84 orange opaque, 12.16 garnet, 1.96 zircon, 15.69 brown to gray tourmaline, 3.92 biotite, 12.55 chlorite-muscovite, 3.14 epidote, 1.18 apatite, and 0.39 anhydrite. The light-mineral fraction consists of (in percent) 78.20 quartz, 11.42 chert, 6.92 orthoclase, 1.38 plagioclase, and 2.08 microcline	5.2
Unnamed Beds:	
Shale, greenish-gray, mottled red-brown, silty, weakly indurated, blocky	0.5
Shale, red-brown, blocky; with some 0.25-inch gypsum nodules	4.0
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 0.25- to 1-inch gypsum nodules; eroding into a ledge; with mean of 6.59 phi, deviation 3.01, skewness 0.74, and kurtosis 0.71	2.4

	Thickness (feet)
Shale, red-brown, blocky; with some greenish-gray spots and gypsum nodules	2.5
Siltstone, greenish-gray, mottled light-brown, dolomitic, gypsiferous, argillaceous, well-indurated, massive, selenitic, crinkly bedded; eroding into a ledge; composed of (in percent) 10.9 sand, 48.6 silt, 12.4 clay, 28.1 carbonate and gypsum	0.2
Shale, red-brown, weakly indurated, platy	0.3
Shale, red-brown and greenish-gray, gypsiferous, thin-bedded, crinkly bedded; alternating well-indurated to weakly indurated layers	0.6
Shale, red-brown, blocky; with some greenish-gray shale spots and thin seams of satin spar	5.25
Siltstone, greenish-gray, argillaceous, weakly indurated, platy	0.2
Shale, red-brown, blocky; with many thin greenish-gray shale layers and satin spar seams; at base of extremely gypsiferous section	4.2
Shale, red-brown, blocky, weakly indurated	2.6
Shale, greenish-gray, silty, selenitic, blocky, weakly indurated	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; eroding into a ledge; composed of (in percent) 2.2 sand, 75.8 silt, 2.6 clay, and 19.4 carbonate and gypsum	0.25
Shale, red-brown, blocky; with some greenish-gray spots and gypsum nodules	2.75
Unit 5:	
Siltstone, greenish-gray, mottled red-brown, dolomitic, gypsiferous, moderately indurated, thinly laminated; composed of (in percent) 5.0 sand, 83.7 silt, 5.0 clay, and 6.3 carbonate and gypsum	0.9
Unnamed Beds:	
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-bedded satin spar layers	1.6
Siltstone, greenish-gray, mottled red-brown, gypsiferous, argillaceous, massive, well-indurated, crinkly bedded; eroding into a ledge	0.6
Shale, red-brown, blocky, weakly indurated	1.2
Shale, greenish-gray, blocky, weakly indurated	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 of section	6.0

SECTION 13.
WHITEHORSE CREEK, WOODS COUNTY, OKLAHOMA

Beginning at top in Doe Creek Lentil of Marlow Formation, type area for the Whitehorse Group, in NE¼ NE¼ NW¼ sec. 29, T. 27 N., R. 16 W., north of U. S. Highway 64, and proceeding down section along Whitehorse Creek for Blaine portion in S½ SW¼ sec. 20, T. 27 N., R. 16 W., ending in the Flowerpot Shale in SE¼ SE¼ NW¼ sec. 6, T. 26 N., R. 16 W., just west of Whitehorse Creek.

	Thickness (feet)
CUSTERIAN SERIES	
WHITEHORSE GROUP	
MARLOW FORMATION (top not exposed)	
Doe Creek Lentil:	
Sandstone, moderate reddish-brown to moderate reddish-orange, arenaceous, algal, quartzose; with many medium to coarse subrounded to well-rounded grains, well-cemented, with many fossil clams, snails, brachiopods, bryozoans, and other fossils in middle 3 inches; clastic material abundant near base and algae abundant near top; cross-bedded, lenticular, with fossiliferous portion composed of (in percent) 22.9 sand, 18.7 silt, 2.5 clay, and 55.9 carbonate. The heavy-mineral fraction, comprising 0.42 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 52.79 ilmenite-magnetite, 10.24 sphene-leucoxene, 0.93 orange opaque, 17.39 garnet, 13.04 zircon, 1.55 brown to gray tourmaline, 0.62 blue tourmaline, 0.31 biotite, 1.24 epidote, and 1.89 yellow rutile. The light-mineral fraction consists of (in percent) 86.20 quartz, 6.20 chert, 5.63 orthoclase, 1.69 plagioclase, and 0.28 microcline. The lower contact appears conformable with beds below	1.75
CIMARRONIAN SERIES	
EL RENO GROUP	
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; eroding into a ledge; composed of (in percent) 16.2 sand, 77.5 silt, 2.9 clay, and 3.3 carbonate	0.3
Shale, greenish-gray, blocky	0.1
Shale, red-brown, silty, blocky	4.5
Siltstone, moderate reddish-brown to moderate reddish-orange, arenaceous, well-indurated, massive; eroding into a ledge; composed of (in percent) 37.9 sand, 52.5 silt, 2.0 clay, and 7.6 carbonate. The heavy-mineral fraction, comprising 0.02 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 13.91 ilmenite-magnetite, 32.25 sphene-leucoxene, 4.73 orange opaque, 1.78 garnet, 7.99 zircon, 3.85 brown to gray tourmaline, 0.30 blue tourmaline, 3.55 biotite, 25.44 chlorite-muscovite, 3.25 epidote, 0.89 riebeckite, 0.59 red rutile, and 1.48 yellow rutile. The light-mineral fraction consists of (in percent) 81.61 quartz, 6.77 chert, 10.00 orthoclase, 0.97 plagioclase, and 0.65 microcline	0.5
Shale, red-brown, silty, blocky; with some greenish-gray layers at base	10.25
Dolomite, dusky red-purple, platy, silty, argillaceous, thin-bedded; composed of (in percent) 0.8 sand, 18.2 silt, 16.7 clay, and 64.3 carbonate	0.2
Shale, red-brown, silty, blocky	4.0
Dolomite, light-brown, fine-grained, dense, well-indurated, massive; eroding into a ledge; composed of (in percent) 0.02 sand, 13.31 silt, 8.55 clay, and 78.12 carbonate	0.1
Shale, red-brown, silty, blocky	2.7
Southard Dolomite Bed:	
Dolomite, greenish-gray, silty, argillaceous, well-indurated, platy; composed of (in percent) 0.03 sand, 23.12 silt, 16.68 clay, and 60.17 carbonate	0.1
Unnamed Beds:	
Siltstone and dolomite, dusky red-purple, well-indurated, massive, blocky; composed of (in percent) 0.03 sand, 27.68 silt, 16.34	

	Thickness (feet)
clay, and 55.95 carbonate	0.9
Shale, dark red-brown, blocky	3.75
Dolomite, mottled greenish-gray and dusky red-purple, silty, fine-grained, dense, well-indurated, massive; composed of (in percent) 0.8 sand, 32.3 silt, 8.8 clay, and 58.1 carbonate	0.1
Siltstone, red-brown, argillaceous, well-indurated, wavy bedded, massive	0.8
Shale, red-brown, blocky	1.2
Siltstone, greenish-gray, mottled red-brown, argillaceous, weakly indurated	0.25
Shale, red-brown, silty, blocky; with some greenish-gray spots and layers	6.0
Sandstone, red-brown, mottled greenish-gray, silty, fine- to medium-grained, thin-bedded; eroding into a ledge; composed of (in percent) 51.9 sand, 38.1 silt, 1.9 clay, and 8.1 carbonate. The heavy-mineral fraction, comprising 0.23 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 45.12 ilmenite-magnetite, 17.21 sphene-leucoxene, 4.65 orange opaque, 15.12 garnet, 7.91 zircon, 2.56 brown to gray tourmaline, 1.40 biotite, 0.70 chlorite-muscovite, 1.63 epidote, 0.23 red rutile, and 3.49 yellow rutile. The light-mineral fraction consists of (in percent) 78.63 quartz, 9.40 chert, 8.83 orthoclase, 1.71 plagioclase, and 1.42 microcline	9.0
Siltstone, greenish-gray, dolomitic, well-indurated, thin-bedded; composed of (in percent) 0.7 sand, 68.1 silt, 4.8 clay, and 26.4 carbonate	0.1
Shale, red-brown, blocky	0.75
Siltstone, light-gray to greenish-gray, dolomitic, fine-grained, dense, well-indurated; composed of (in percent) 0.07 sand, 48.67 silt, 6.82 clay, and 44.44 carbonate	0.1
Siltstone, red-brown, mottled greenish-gray, thin-bedded, weakly indurated	1.0
Shale, greenish-gray, mottled red-brown, thin-bedded, weakly indurated	0.2
Shale, red-brown, blocky; gradational 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 Beds:	
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 boxworks; eroding into a ledge; composed of (in percent) 0.3 sand, 3.2 silt. 2.4 clay, and 94.1 carbonate	1.0
Unnamed Bed:	
Shale, red-brown, mottled greenish-gray, blocky; covered in part	11.0
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; gradational into siltstone at base; weathering coarsely selenitic; eroding into a ledge	11.0
Magpie Dolomite Bed:	
Siltstone, light-gray, dolomitic, fine-grained, oölitic; composed of	

	Thickness (feet)
(in percent) 0.5 sand, 79.3 silt, 2.6 clay, and 17.6 carbonate	0.75
Unnamed Bed:	
Shale, red-brown, blocky; mottled with greenish-gray shale spots; with mean of 8.43 phi, deviation 3.20, skewness 0.40, and kurtosis 0.85. The clay minerals are illite (peaks at 3.31, 4.93, 9.80a) and chlorite (peaks at 3.54, 7.02a)	10.0
Medicine Lodge Gypsum Member:	
Gypsum, white, mottled light-gray, fine-grained, massive; weathering coarsely selenitic; eroding into prominent mappable escarpment	22.0
Cedar Springs Dolomite Bed:	
Dolomite, light-gray to light-brown, fine-grained, oölitic, medium-bedded; massive where weathered; composed of (in percent) 0.03 sand, 0.85 silt, 1.24 clay, and 97.88 carbonate	0.3
FLOWERPOT SHALE (base not seen, exposed thickness 113.1 feet)	
Shale, greenish-gray, mottled red-brown, blocky	0.75
Shale, red-brown, selenitic, blocky	0.5
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
Siltstone, red-brown, mottled greenish-gray; with many 1- to 3-inch selenite patches	1.5
Siltstone, greenish-gray, dolomitic, argillaceous, thin-bedded, weakly indurated; composed of (in percent) 0.4 sand, 55.4 silt, 11.0 clay, and 33.2 carbonate	1.75
Shale, red-brown, silty, blocky	1.9
Unit 6:	
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
Unnamed Beds:	
Siltstone, red-brown, argillaceous; as above; with many moderate reddish-orange gypsum nodules	2.9
Shale, greenish-gray, blocky	0.2
(*Section extrapolated to NW¼ sec. 6, T. 26 N., R. 16 W., in hill west of Whitehorse Creek*)	
Shale, red-brown, selenitic, blocky; mottled with greenish-gray spots; partly covered	6.25
Siltstone, greenish-gray, fine-grained; well-indurated at top; composed of (in percent) 2.7 sand, 89.9 silt, 4.7 clay, and 2.7 carbonate	0.2
Shale, red-brown, blocky; with much selenite	3.0
Siltstone, greenish-gray, argillaceous, weakly indurated, massive	0.2
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

	Thickness (feet)
Shale, red-brown, blocky; with many greenish-gray shale layers and much nodular and selenitic gypsum; eroding into a ledge; at base of extremely gypsiferous section	2.5
Shale, greenish-gray, blocky	0.25
Shale, red-brown, blocky	0.6
Shale, greenish-gray, selenitic, thin-bedded, blocky	0.1
Shale, red-brown, blocky; with many satin spar veins	5.0
Siltstone, greenish-gray, dolomitic, moderately indurated, crinkly bedded; composed of (in percent) 7.4 sand, 75.7 silt, 5.5 clay, and 11.4 carbonate	0.3
Shale, red-brown, blocky; with some selenite crystals	2.0
Unit 5:	
Siltstone, greenish-gray, gypsiferous, dolomitic, arenaceous, well-indurated, crinkly bedded, thin-bedded; eroding into an escarpment; composed of (in percent) 13.9 sand, 59.1 silt, 8.7 clay, and 18.3 carbonate	0.8
Unnamed Beds:	
Shale, red-brown, blocky; with some thin selenite veins	3.3
Siltstone, mottled greenish-gray and red-brown, gypsiferous, thin-bedded, weakly indurated	0.75
Shale, red-brown, thin-bedded, platy	0.25
Shale, greenish-gray, weakly indurated, blocky; with mean of 8.33 phi, deviation 3.39, skewness 0.34, and kurtosis 0.56. The clay minerals are illite (peaks at 3.32, 4.95, 9.90a) and chlorite (peaks at 3.52, 7.03, and 13.8a)	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; eroding into 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 red-brown, arenaceous, thin-bedded; light brown at base; with alternating well-indurated and weakly indurated layers; composed of (in percent) 21.6 sand, 66.7 silt, 3.4 clay, and 8.3 carbonate. The heavy-mineral fraction, comprising 0.03 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 1.27 ilmenite-magnetite, 17.20 sphene-leucoxene, 67.52 orange opaque, 3.50 garnet, 0.64 zircon, 4.78 brown to gray tourmaline, 0.64 biotite, 2.55 chlorite muscovite, 1.27 epidote, and 0.64 anhydrite. The light-mineral fraction consists of (in percent) 81.40 quartz, 12.79 chert, 2.91 orthoclase, 1.16 plagioclase, and 1.74 microcline	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
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

	Thickness (feet)
Shale, red-brown, blocky; with some greenish-gray layers	2.0
Shale, greenish-gray, selenitic, silty, blocky	0.7
Shale, red-brown, selenitic, blocky	5.25
Unit 4:	
Siltstone, greenish-gray, gypsiferous, dolomitic, weakly indurated, massive; eroding into a prominent light-colored band in region; composed of (in percent) 4.9 sand, 69.2 silt, 5.6 clay, and 20.3 carbonate and gypsum	1.75
Unnamed Beds:	
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; forming marker bed in region	3.0
Shale, red-brown, blocky; exposed to base	10.0

SECTION 14.
TURKEY CREEK, WOODS COUNTY, OKLAHOMA

Beginning at top of Flowerpot Shale and proceeding down section through the Flowerpot along the road in SW¼ NW¼ sec. 12, T. 27 N., R. 16 W., for upper 106 feet, then extrapolated to SE¼ NE¼ sec. 8, T. 27 N., R. 15 W., for section to Unit 3. Then extrapolated to SW¼ SW¼ sec. 4, T. 27 N., R. 15 W., for portion to Unit 2; then NE¼ SE¼ sec. 34, and NW¼ SW¼ sec. 35, T. 28 N., R. 15 W., along road, to 15 feet below Unit 1; then N½ NE¼ NW¼ sec. 9, T. 27 N., R. 14 W., and SE¼ SE¼ SW¼ sec. 4, T. 27 N., R. 14 W., to base of Flowerpot Shale. The top of the Cedar Hills Member was measured in NW¼ SW¼ sec. 23, T. 27 N., R. 14 W., in west Alva, Oklahoma, to C SW¼ NW¼ sec. 23, T. 27 N., R. 14 W., in Hatfield Park to 12 feet below Unit 4; then extrapolated to NW¼ NW¼ sec. 26 and SW¼ SW¼ sec. 23, T. 27 N., R. 13 W., along creek, down to Unit 2. Then extrapolated to NE¼ NE¼ NW¼ sec. 23 and S½ SW¼ sec. 14, T. 27 N., R. 13 W., along creek, ending in SW¼ SE¼ SW¼ sec. 13 and NW¼ NW¼ SE¼ sec. 13, T. 27 N., R. 13 W., at base of Cedar Hills Member.

	Thickness (feet)
BLAINE FORMATION (not measured)	
Cedar Springs Dolomite Member:	
Dolomite, light-tan to light-gray, finely granular, well-cemented, blocky; oölitic in places	0.3
FLOWERPOT SHALE (total thickness, 272 feet)	
Shale, red-brown, blocky, weakly indurated	0.5
Shale, greenish-gray, blocky, weakly indurated	0.2
Shale, red-brown, blocky	0.5
Shale, greenish-gray, blocky	0.3
Shale, red-brown, blocky	0.6
Shale, greenish-gray, blocky	0.25
Siltstone, orange-brown, argillaceous, weakly indurated	0.25
Shale, red-brown, gypsiferous, blocky, weakly indurated; with some 2- to 3-inch well-indurated gypsum layers	3.5
Shale, greenish-gray, dolomitic, thin-bedded, moderately indurated	0.3

	Thickness (feet)
Shale, red-brown, blocky	0.2
Shale, greenish-gray, gypsiferous, blocky, weakly indurated; with some thin red-brown shale layers	1.25
Shale, red-brown, gypsiferous, blocky	1.1
Unit 6:	
Sandstone and siltstone, light-tan to orange-brown, fine-grained, gypsiferous, thin-bedded, weakly indurated; moderately indurated at top; eroding into prominent escarpment in region	6.75
Siltstone, greenish-gray and orange-brown, gypsiferous, argillaceous, weakly indurated	0.5
Unnamed Beds:	
Shale, red-brown, silty, blocky; with some thin greenish-gray shale layers	3.0
Siltstone and sandstone, light-tan, very fine-grained, gypsiferous, mottled greenish-gray, weakly indurated; with a 3- to 4-inch greenish-gray band at top and one at base	2.5
Shale, red-brown, gypsiferous, blocky, weakly indurated	3.2
Shale, greenish-gray, gypsiferous, moderately indurated; eroding into a small escarpment	0.75
Shale, red-brown, gypsiferous, blocky; with some greenish-gray spots and layers	3.5
Shale, greenish-gray, gypsiferous, moderately indurated; eroding into a small escarpment	0.6
Shale, red-brown, gypsiferous, blocky, weakly indurated	1.0
Shale, greenish-gray, silty, gypsiferous, moderately indurated	0.4
Shale, red-brown, gypsiferous, blocky, weakly indurated	1.0
Shale, greenish-gray and chocolate-brown, blocky, weakly indurated	0.9
Shale, red-brown, blocky, weakly indurated; with some 0.5- to 1-inch greenish-gray spots	5.5
Siltstone, light greenish-gray, gypsiferous, platy, thin-bedded, crinkly bedded, well-indurated; argillaceous at top and base; arenaceous in middle; eroding into a prominent light-colored regional escarpment	1.1
Shale, red-brown, silty, blocky	1.6
Siltstone, orange-brown, gypsiferous, thin-bedded, moderately indurated; eroding into a small ledge	0.75
Shale, red-brown, silty, blocky, gypsiferous, weakly indurated	0.3
Shale, greenish-gray, silty, blocky, weakly indurated	0.3
Shale, red-brown, selenitic, blocky, weakly indurated	3.0
Unit 5:	
Siltstone, greenish-gray, gypsiferous, platy, well-indurated; eroding into a ledge	0.2
Siltstone, orange-brown, argillaceous, thin-bedded, weakly indurated	1.2
Shale, red-brown, silty, blocky	0.25
Siltstone, greenish-gray, argillaceous, thin-bedded, weakly indurated	0.6
Unnamed Beds:	
Shale, red-brown, silty, blocky, weakly indurated; mottled with greenish-gray spots; section extrapolated to road	1.1
Siltstone, greenish-gray, argillaceous, gypsiferous, platy, well-indurated	0.2
Shale, red-brown, gypsiferous, blocky, weakly indurated	0.7
Shale, greenish-gray, gypsiferous, mottled orange-brown, well-indurated	0.7
Shale, greenish-gray, blocky, weakly indurated; alternating with some red-brown shale layers	1.0
Shale, red-brown, blocky, weakly indurated	1.5
Shale, greenish-gray, gypsiferous, platy, crinkly bedded, well-indurated	0.2
Shale, red-brown, blocky; with greenish-gray spots	0.75

	Thickness (feet)
Shale, greenish-gray, blocky, weakly indurated; with some reddish-brown shale layers	0.6
Shale, red-brown, blocky, weakly indurated; with some 0.5-inch greenish-gray shale layers	4.5
Shale, greenish-gray, blocky, weakly indurated; with many 0.5-inch white gypsum nodules	0.2
Shale, red-brown, selenitic, blocky	2.0
Shale, greenish-gray, selenitic, platy, moderately indurated; with some satin spar	0.3
Shale, red-brown, blocky, weakly indurated; with 0.25-inch satin spar layers	1.5
Shale, greenish-gray, selenitic, platy, moderately indurated, mottled chocolate-brown; eroding into a ledge	0.5
Shale, red-brown, gypsiferous, blocky, weakly indurated; with some 0.5-inch greenish-gray beds	8.5
Unit 4:	
Siltstone, light greenish-gray, gypsiferous, moderately to weakly indurated; eroding into a prominent escarpment	1.5
Unnamed Beds:	
Shale, red-brown, blocky, weakly indurated; becoming chocolate brown in basal 6 inches	3.0
Shale, greenish-gray, platy, weakly indurated	0.5
Shale, red-brown, blocky, weakly indurated; with some paper-thin satin spar	2.25
Shale, greenish-gray, platy, moderately indurated	0.2
Shale, red-brown, selenitic, blocky, weakly indurated	0.5
Shale, chocolate-brown, blocky, weakly indurated; with some greenish-gray streaks; mottled red-brown in basal 2 feet	3.75
Shale, red-brown, selenitic, blocky; with some paper-thin satin spar	1.5
Shale, greenish-gray, selenitic, platy, well-indurated	0.1
Shale, red-brown, selenitic, blocky	1.1
Shale, greenish-gray, mottled chocolate-brown, gypsiferous, platy, moderately indurated; eroding into a ledge	0.7
Shale, red-brown, mottled chocolate-brown, blocky, weakly indurated	1.5
Shale, greenish-gray, mottled chocolate-brown, blocky, weakly indurated	0.5
Shale, red-brown, mottled chocolate-brown, blocky, weakly indurated; with paper-thin satin spar	2.75
Shale, greenish-gray, gypsiferous, platy, moderately indurated	0.2
Shale, red-brown, blocky, weakly indurated; with thin satin spar veins	3.0
Shale, greenish-gray, silty, gypsiferous, platy, moderately indurated; eroding into a ledge	0.6
Shale, red-brown, blocky, weakly indurated; with paper-thin satin spar veins	3.5
Siltstone, greenish-gray, argillaceous, gypsiferous, blocky, weakly indurated	0.4
Shale, red-brown, blocky, weakly indurated; with some satin spar veins	2.2
Shale, greenish-gray, gypsiferous, silty, platy, moderately indurated; eroding into a ledge	0.4
Shale, red-brown, blocky; with some satin spar; partly covered	5.25
Unit 3-4:	
Siltstone, light greenish-gray, mottled orange-brown, dolomitic, gypsiferous, moderately indurated; eroding into a prominent light-colored escarpment	2.5
Shale, red-brown, selenitic, blocky, weakly indurated	1.0
Siltstone, light greenish-gray, gypsiferous, platy, moderately indurated; with many 1-inch white gypsum nodules; gradational into shale; eroding into a ledge	0.75

	Thickness (feet)
(Section extrapolated to SE¼ NE¼ sec. 8, T. 27 N., R. 15 W.)	
Unnamed Beds:	
Shale, red-brown, gypsiferous, blocky; with some greenish-gray spots	5.25
Shale, greenish-gray, gypsiferous, platy, well-indurated; eroding into a ledge	0.25
Shale, red-brown, gypsiferous, blocky, weakly indurated; with some 1- to 2-inch greenish-gray gypsiferous shale beds	16.25
Shale, greenish-gray, dolomitic, gypsiferous, blocky to platy, moderately indurated; eroding into a ledge	1.0
Shale, red-brown, gypsiferous, blocky, weakly indurated	1.75
Shale, greenish-gray and red-brown, gypsiferous, thin-bedded, platy, crinkly bedded, moderately indurated; with much satin spar; eroding into a prominent ledge	3.75
Shale, red-brown, blocky, weakly indurated; with some satin spar, and with a 2-inch greenish-gray gypsiferous shale zone 6 feet below top	12.0
Shale, greenish-gray, gypsiferous, moderately indurated; with much 0.5-inch satin spar; eroding into a ledge	0.3
Shale, red-brown, blocky, weakly indurated; with some satin spar	5.25
Unit 3:	
Siltstone, greenish-gray, gypsiferous, argillaceous; well-indurated at top; eroding into a prominent light-colored escarpment in region	1.0
Unnamed Beds:	
Shale, red-brown, blocky, weakly indurated; with some greenish-gray spots	4.25
(Section extrapolated to SW¼ SW¼ sec. 4, T. 27 N., R. 15 W.)	
Shale, greenish-gray, blocky, weakly indurated; with many 1-inch gypsum nodules and many satin spar veins	0.75
Shale, red-brown, blocky, weakly indurated; with some satin spar	1.0
Shale, greenish-gray, mottled red-brown, gypsiferous, moderately indurated, crinkly bedded; with much satin spar	0.4
Shale, red-brown, blocky; with some satin spar, and a dolomitic shale 2 feet above base; partly covered	8.35
Shale, greenish-gray, gypsiferous, dolomitic, platy, moderately indurated	0.3
Shale, red-brown, blocky, weakly indurated; with some satin spar	4.0
Shale, greenish-gray, gypsiferous, platy; with many white gypsum nodules; well-indurated in places	0.7
Shale, red-brown, blocky, weakly indurated; with some satin spar	5.3
Shale, greenish-gray, gypsiferous, silty, moderately indurated; eroding into a ledge	0.25
Shale, red-brown, blocky, weakly indurated	2.5
Shale, mottled light-tan and greenish-gray, thin-bedded, weakly indurated	1.2
Shale, red-brown, blocky, weakly indurated	2.0
Shale, greenish-gray, gypsiferous, platy, crinkly bedded, moderately indurated; with some red-brown shale beds; eroding into a ledge	0.75
Shale, red-brown, blocky, weakly indurated; silty in basal 2 feet	6.25
Unit 2:	
Siltstone, gypsiferous, medium- to thin-bedded, well-indurated; light-greenish gray in top foot; mottled orange brown below; with many 1- to 2-inch gypsum nodules; with 1-inch dolomite at top; eroding into prominent regional escarpment	3.5
(Section extrapolated to NE¼ SE¼ sec. 34, and NW¼ SW¼ sec. 35, T. 28 N., R. 15 W.)	
Unnamed Beds:	
Shale, red-brown, blocky, weakly indurated; with some thin greenish-gray gypsiferous beds	1.75

	Thickness (feet)
Shale and gypsum, greenish-gray, well-indurated, crinkly bedded; eroding into a ledge	0.1
Shale, red-brown; as above; with some paper-thin satin spar	3.0
Shale and gypsum, greenish-gray, moderately indurated; as above	0.25
Shale, red-brown, blocky, weakly indurated	0.3
Shale and gypsum, greenish-gray, well-indurated; as above; with some interbedded orange-brown gypsum and shale; eroding into a ledge	1.0
Shale, red-brown, blocky, weakly indurated	2.5
Shale and gypsum, greenish-gray, well-indurated; as above	0.2
Shale, red-brown; as above	1.75
Shale and gypsum, greenish-gray, well-indurated; as above; eroding into a prominent ledge	0.2
Shale, red-brown, blocky; with much satin spar	1.25
Siltstone, greenish-gray and orange-brown, gypsiferous, argillaceous, well-indurated	0.8
Shale, red-brown, blocky, weakly indurated	0.3
Siltstone, orange-brown, argillaceous, gypsiferous, blocky, weakly indurated; with interbedded red-brown shale	2.0
Siltstone, greenish-gray and orange-brown, argillaceous, crinkly bedded, well-indurated; with many 2- to 3-inch white to yellow-green gypsum nodules; eroding into a ledge in basal 1 foot	3.0
Shale, red-brown, blocky, weakly indurated; with yellow-green gypsum nodules in middle	1.75
Shale and gypsum, greenish-gray, crinkly bedded, well-indurated; eroding into a ledge	0.75
Shale, red-brown, blocky; with much satin spar	2.5
Unit 1:	
Sandstone and siltstone, greenish-gray, very fine-grained, thin-bedded, moderately to well-indurated; with many 2- to 10-inch orange-brown gypsum nodules; eroding into a ledge of large gypsum nodules	1.5
Unnamed Beds:	
Shale, red-brown, blocky; with some satin spar veins	6.25
Sandstone, greenish-gray, very fine-grained, gypsiferous, well-indurated, massive; with many 1-inch white gypsum nodules; eroding into a prominent ledge	0.25
Siltstone, orange-brown, argillaceous, weakly indurated	0.5
Sandstone, greenish-gray, very fine-grained, gypsiferous; as above; eroding into a prominent ledge	0.25
Shale, red-brown, silty, blocky; interbedded with orange-brown siltstone	1.0
Gypsum nodules, greenish-gray to white, well-indurated	0.25
Siltstone, orange-brown, argillaceous to arenaceous, weakly indurated; with some 0.5-inch greenish-gray gypsum nodules; gradational into very fine-grained sandstone	4.2
Siltstone, greenish-gray, arenaceous, weakly indurated; mottled with orange-brown spots; gradational into very fine-grained sandstone	1.1
Siltstone, orange-brown, arenaceous, weakly indurated; gradational into very fine-grained sandstone	2.75
Shale, greenish-gray, gypsiferous, crinkly bedded, well-indurated; with many 1- to 2-inch greenish-gray and orange-brown gypsum nodules; eroding into a ledge	0.5
Shale, red-brown, blocky; with some satin spar	3.0
Satin spar, white, crinkly bedded	0.1
Shale, red-brown, blocky, weakly indurated; with some satin spar	1.2
Siltstone, greenish-gray, mottled orange-brown, argillaceous, moderately indurated, crinkly bedded	0.1
Shale, red-brown, blocky, weakly indurated; with much satin spar	1.5

(*Section extrapolated to N½ NE¼ NW¼ sec. 9, T. 27 N., R. 14 W.,*

	Thickness (feet)
and SE¼ SE¼ SW¼ sec. 4, T. 27 N., R. 14 W., along road and north of road)	
Siltstone, greenish-gray, gypsiferous, crinkly bedded, moderately indurated; as above	0.3
Siltstone, orange-brown, argillaceous; mottled with greenish-gray spots	0.8
Siltstone, greenish-gray; as above	0.4
Shale, red-brown, silty, blocky, weakly indurated; with much satin spar	1.0
Siltstone, greenish-gray; as above	0.2
Shale, red-brown, silty; as above	0.9
Siltstone, greenish-gray; as above	0.4
Shale, red-brown; as above	1.2
Siltstone, orange-brown, mottled greenish-gray, gypsiferous, argillaceous, moderately indurated, massive	1.9
Siltstone, greenish-gray; as above	0.2
Shale, red-brown, blocky; as above	0.75
Siltstone, greenish-gray; as above	0.2
Shale, red-brown, silty, blocky; with some greenish-gray gypsiferous shale layers	2.5
Siltstone, greenish-gray, gypsiferous, well-indurated; with many yellow-green gypsum nodules; eroding into a ledge; forming prominent marker bed in region together with 4 beds below	0.25
Shale, red-brown, blocky, weakly indurated; with much satin spar	0.75
Shale and gypsum, greenish-gray, silty, crinkly bedded, thin-bedded, well-indurated; eroding into a prominent ledge	0.5
Shale, red-brown; as above	1.2
Shale and gypsum, greenish-gray; as above; eroding into a ledge	0.4
Shale, red-brown, blocky, weakly indurated	3.0
Siltstone, greenish-gray, mottled orange-brown, argillaceous, thin-bedded, weakly indurated	1.0
Shale, red-brown, silty, blocky; gradational into orange-brown siltstone	1.75
Siltstone, orange-brown, mottled greenish-gray, well-indurated, massive	0.3
Shale, red-brown, silty, weakly indurated	4.2
(Section extrapolated to NW¼ SW¼ sec. 23, T. 27 N., R. 14 W., on west side of football field)	
HENNESSEY FORMATION (base not exposed)	
Cedar Hills Sandstone Member: (total thickness, 181 feet)	
Unit 5:	
Sandstone, light greenish-gray, mottled orange-brown, very fine-grained, silty, thin-bedded, weakly indurated, massive; with many 1- to 3-inch white gypsum nodules; eroding into a ledge	2.0
Unnamed Beds:	
Sandstone, orange-brown, silty, thinly laminated, weakly indurated; mottled with greenish-gray spots	16.25
Sandstone, light greenish-gray, silty, weakly indurated, thinly laminated; mottled with orange-brown spots	0.75
Sandstone, orange-brown; as above	2.5
Sandstone, light greenish-gray; as above	1.0
Sandstone, orange-brown; as above	7.6
Siltstone, orange-brown, argillaceous, platy, weakly indurated	1.8
Unit 4:	
Siltstone, greenish-gray, micaceous, thinly laminated, platy, weakly indurated; eroding into a prominent light-colored band	0.75
Siltstone, orange-brown, argillaceous, blocky, moderately indurated; mottled with greenish-gray spots	1.5
Siltstone, greenish-gray, mottled orange-brown; as above; eroding into a prominent light-colored band	0.9

	Thickness (feet)
Unnamed Beds:	
Siltstone, orange-brown, argillaceous, weakly indurated	1.0
Siltstone, mottled greenish-gray and orange-brown, argillaceous, weakly indurated, thinly laminated, platy; with a 0.5-inch orange-brown gypsiferous nodular bed at top and a 1-inch orange-brown gypsiferous shale at base	2.2
Siltstone, orange-brown, thinly laminated; as above	4.0
Gypsum nodules, white to orange-brown, flattened; eroding into a ledge	0.2
Shale, orange-brown, silty, platy, weakly indurated	0.4
Gypsum nodules, white; as above	0.2
Shale, orange-brown, silty; as above	0.6
Shale and gypsum, greenish-gray, silty, platy, crinkly bedded, well-indurated; eroding into a prominent ledge	0.5
Siltstone, greenish-gray and orange-brown, argillaceous, blocky, weakly indurated; with some satin spar	2.1
Siltstone, greenish-gray, gypsiferous, argillaceous, platy, well-indurated; eroding into most prominet ledge in region below top	0.6
Siltstone, orange-brown, argillaceous, blocky, weakly indurated	0.5
Siltstone, greenish-gray, mottled orange-brown, gypsiferous, moderately indurated	0.5
Siltstone, orange-brown, argillaceous, blocky, weakly indurated	1.75
Gypsum nodules, yellow-green to light-orange, flattened; eroding into a prominent ledge	0.25
Sandstone, mottled greenish-gray and orange-brown, very fine-grained, silty, gypsiferous, thin-bedded, well-indurated; eroding into a prominent ledge	0.5
Sandstone, mottled greenish-gray and orange-brown, very fine-grained, silty, weakly indurated	0.9
Sandstone, orange-brown, very fine-grained, silty, weakly to well-indurated; eroding into a ledge	0.7
Shale, red-brown, mottled greenish-gray, silty, platy, weakly indurated; with 3-inch orange-brown siltstone ledge at base	2.5
Siltstone, orange-brown, mottled greenish-gray, argillaceous, blocky, moderately indurated	1.0
Gypsum nodules, yellow-green, flat	0.1
(Section extrapolated to C SW¼ NW¼ sec. 23, T. 27 N., R. 14 W.)	
Shale, orange-brown to red-brown, silty, blocky, weakly indurated; mottled with some greenish-gray spots and with 1-inch yellow-green gypsum nodules, interbedded with orange-brown siltstone	3.9
Unit 3:	
Sandstone and siltstone, greenish-gray, mottled orange-brown, very fine-grained, gypsiferous, well-indurated; eroding into prominent ledge	1.6
Unnamed Beds:	
Shale and siltstone, red-brown, platy, weakly indurated; mottled with greenish-gray layers; with some 0.5-inch yellow-green gypsum nodules	3.0
Siltstone, mottled orange-brown and greenish-gray, massive, crinkly bedded, moderately indurated	1.0
Shale, red-brown, silty, blocky; with some satin spar veins and 1-inch greenish-gray gypsiferous shale layers	4.25
Shale and siltstone, greenish-gray, mottled red-brown, platy, weakly indurated; weathering greenish-gray	0.75
Shale and siltstone, red-brown, blocky, weakly indurated; with some greenish-gray spots and layers	3.5
(Section extrapolated to NW¼ NW¼ sec. 26 and SW¼ SW¼ sec. 23, T. 27 N., R. 13 W., along creek)	
Sandstone, mottled greenish-gray and orange-brown, fine-grained, silty, friable, weakly indurated; eroding into a ledge	6.0

	Thickness (feet)
Shale, red-brown, silty, blocky, weakly indurated; with some 2- to 3-inch greenish-gray shale layers	6.25
Siltstone, greenish-gray, argillaceous, moderately indurated; mottled orange brown below; eroding into a ledge	2.9
Siltstone, orange-brown, argillaceous, blocky, moderately to weakly indurated; becoming greenish gray at base	1.0
Siltstone, orange-brown, argillaceous, blocky, massive, well-indurated; eroding into a ledge	0.2
Shale, red-brown, silty, platy	1.4
Siltstone, greenish-gray and orange-brown, argillaceous, platy, moderately indurated	0.2
Siltstone and shale, red-brown, mottled orange-brown, platy, weakly indurated	1.5
Siltstone, orange-brown, argillaceous, blocky, massive, well-indurated; eroding into a ledge	0.25
Shale, red-brown, silty, blocky, weakly indurated	1.2
Shale, greenish-gray, silty, blocky, weakly indurated	0.4
Shale, red-brown, silty, blocky	0.6
Peace Treaty Bed:	
Sandstone and siltstone, orange-brown, very fine-grained, weakly indurated, thinly laminated; mottled with some greenish-gray spots	4.75
Unnamed Beds:	
Shale, red-brown, silty, platy, weakly indurated	1.75
Shale, greenish-gray, mottled orange-brown, silty, platy, weakly indurated	0.2
Shale, red-brown, silty, blocky, weakly indurated	0.3
Siltstone, mottled orange-brown and greenish-gray, argillaceous, massive, weakly indurated; gradational into very fine-grained friable sandstone; partly covered	15.0
Siltstone and shale, orange-brown, platy, weakly indurated	5.0
Unit 2:	
Sandstone, orange-brown, mottled greenish-gray, very fine-grained, silty, friable, weakly indurated; with greenish-gray zone at top, a 2-inch greenish-gray zone about 6 feet above base, and greenish gray in basal foot; section extrapolated to S½ SW¼ sec. 14, T. 27 N., R. 13 W.	18.0
Unnamed Beds:	
Shale and siltstone, orange-brown, blocky, weakly indurated	4.75
Sandstone, greenish-gray and orange-brown, very fine-grained, silty, thin-bedded, weakly indurated; greenish gray in top 3 inches	5.25
(*Section extrapolated to SW¼ SE¼ SW¼ sec. 13, T. 27 N., R. 13 W., to NW¼ NW¼ SE¼ sec. 13, T. 27 N., R. 13 W.*)	
Siltstone, orange-brown, argillaceous, thin-bedded, platy, weakly indurated; mottled with greenish-gray spots; with interbedded red-brown shale; partly covered	14.75
Sandstone, orange-brown, very fine-grained, silty, thinly laminated, friable, weakly to moderately indurated; mottled with greenish-gray spots; with some 1- to 6-inch greenish-gray layers, the basal part of which includes Unit 1	16.0
Bison Member: (mostly covered down to Salt Fork River)	
Shale, red-brown to orange-brown, silty, weakly indurated; eroding into a slope	5.0

SECTION 15.
CHIMNEY CREEK, WOODWARD COUNTY, OKLAHOMA
EAGLE CHIEF CREEK, WOODS COUNTY, OKLAHOMA

Beginning at top in Big Basin Member of Cloud Chief For-

mation and proceeding down section to Day Creek Dolomite Bed, Kiger Member, and Moccasin Creek Bed of the Cloud Chief, into the Rush Springs Formation, Emanuel Bed, Relay Creek Bed, remnants of the Doe Creek Lentil, and the remainder of the Marlow Formation along a branch of Chimney Creek in C sec. 17, T. 24 N., R. 18 W., east of road. Section then extrapolated to NW¼ sec. 17 and NE¼ sec. 18, T. 23 N., R. 17 W., for Dog Creek Shale 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, Woodward County. The Blaine Formation was measured south of Avard, Woods County, beginning at top in Altona Dolomite (Shimer missing) and proceeding down section along road in W½ NW¼ sec. 25, T. 25 N., R. 15 W., and ravines on either side of road to Flowerpot Shale Unit 4. Then section extrapolated to N½ NE¼ sec. 25, T. 25 N., R. 15 W., along road and E½ SE¼ sec. 24 and NE¼ SE¼ NE¼ sec. 24, T. 25 N., R. 15 W., to Unit 3-4. Then extrapolated to W½ SW¼ sec. 18, T. 25 N., R. 14 W., and along creek in NW¼ sec. 18, T. 25 N., R. 14 W., to Unit 3. Then extrapolated to SW¼ SE¼ sec. 33, T. 26 N., R. 15 W., and SE¼ NW¼ sec. 3, T. 25 N., R. 15 W., and SW¼ SE¼ sec. 34, T. 26 N., R. 15 W., to Unit 2. Then extrapolated to S½ SE¼ sec. 14 and NE¼ NW¼ NE¼ sec. 23, T. 26 N., R. 15 W., to Unit 1. Then extrapolated to SE¼ SE¼ sec. 24, T. 26 N., R. 15 W., to ledge 12 to 15 feet above base, then SW¼ NW¼ NW¼ sec. 23, T. 26 N., R. 14 W., ending at top of Cedar Hills Sandstone in C NW¼ sec. 34 and NW¼ SW¼ NE¼ sec. 34, T. 26 N., R. 14 W., along Eagle Chief Creek, Woods County.

	Thickness (feet)
CUSTERIAN SERIES	
CLOUD CHIEF FORMATION (top not exposed, exposed thickness 78.45 feet)	
Big Basin Member: (top not exposed, exposed thickness 47.9 feet)	
Dolomite, light greenish-gray to light-gray, very fine-grained, silty, vuggy, well-indurated, thin-bedded; eroding into a ledge; capping highest hills in region	1.5
Sandstone, orange-brown, mottled greenish-gray, fine-grained, calcitic; gradational into dolomite above	1.5
Shale, red-brown, mottled greenish-gray, silty, blocky, weakly indurated	5.25
Dolomite, light greenish-gray, fine-grained, arenaceous, well-indurated, platy, thin-bedded; eroding into a ledge	0.25
Sandstone, light greenish-gray, quartzose, micaceous, medium- to fine-grained, calcitic, weakly indurated	4.0
Shale, light greenish-gray, blocky, weakly indurated	0.4
Shale, red-brown, blocky, weakly indurated; with some 0.5-inch calcite veins; eroding into a slope	10.5
Sandstone, light greenish-gray, mottled orange-brown, fine-grained, calcitic, moderately indurated, massive	1.25
Shale, red-brown, mottled greenish-gray, silty, blocky, weakly indurated	2.5
Sandstone, light greenish-gray, fine-grained, calcitic, quartzose, moderately indurated, massive; eroding into a ledge	1.75
Shale, red-brown; as above	13.5
Dolomite, maroon to light greenish-gray, fine-grained, thinly laminated, well-indurated; eroding into a ledge	0.25

	Thickness (feet)
Shale, red-brown; as above	3.5
Shale, greenish-gray, mottled red-brown, silty, blocky, weakly indurated	1.75
Day Creek Bed: (1.7 feet thick)	
Dolomite, white to pink, fine-grained, compact, thinly laminated, well-indurated; arenaceous in lower 9 inches; eroding into a prominent escarpment	1.7
Kiger Member: (total thickness, 24.25 feet)	
Shale, light greenish-gray, mottled yellow, blocky, weakly indurated	0.75
Siltstone, orange-brown, argillaceous, blocky, weakly indurated; section extrapolated to north side of hill	0.4
Sandstone, light greenish-gray, very fine-grained, quartzose, calcitic, silty, mottled orange-brown, moderately to weakly indurated	1.0
Siltstone, orange-brown; as above	1.5
Shale, light greenish-gray, blocky, weakly indurated	0.5
Shale, red-brown, silty, blocky; with some 0.25-inch platy calcitic beds	2.25
Sandstone, light greenish-gray, very fine-grained, quartzose, calcitic, weakly indurated	1.25
Shale, red-brown; as above	1.6
Sandstone, light greenish-gray; as above	0.25
Shale, red-brown; as above	7.0
Sandstone, mottled light greenish-gray and orange-brown, fine-grained, quartzose, calcitic, thin-bedded, weakly indurated	1.0
Shale, red-brown; as above; with some greenish-gray spots	6.75
Moccasin Creek Bed: (total thickness, 4.6 feet)	
Dolomite, light-pink to white, mottled greenish-gray, very fine-grained, well-indurated, crinkly bedded; eroding into a ledge	0.1
Siltstone, orange-brown, arenaceous, blocky, weakly indurated; with interbedded red-brown shale	1.0
Sandstone, mottled greenish-gray and orange-brown, medium- to fine-grained, quartzose, calcitic, weakly indurated, friable; with some 2- to 4-inch beds of red-brown shale	3.5
WHITEHORSE GROUP (total thickness, 196.7 feet)	
RUSH SPRINGS SANDSTONE FORMATION (total thickness, 92.7 feet)	
Sandstone, orange-brown, medium- to fine-grained, quartzose, moderately to weakly indurated; mottled greenish-gray in basal 1.5 feet	10.0
Siltstone and sandstone, red-brown to orange-brown, weakly indurated, platy; eroding into a slope	13.75
Sandstone, orange-brown, fine-grained, quartzose, calcitic, massive, well-indurated; with a 1-foot siltstone 2 feet above base; eroding into a regional escarpment	16.75
Shale, red-brown, silty, blocky, weakly indurated; with a 1-inch greenish-gray shale at base; section extrapolated to north side of next ravine to north	1.5
Siltstone, orange-brown, argillaceous, platy, weakly indurated	8.5
Sandstone, orange-brown, mottled greenish-gray, silty, moderately indurated	1.0
Shale, red-brown, silty, blocky, weakly indurated; with some interbedded orange-brown siltstone and sandstone	10.5
Sandstone, orange-brown, fine-grained, quartzose, calcitic, massive to thin-bedded, well-indurated; eroding into a ledge	6.25
Sandstone, orange-brown, silty, thin-bedded, moderately to weakly indurated; with interbedded orange-brown siltstone	6.25
Shale, orange-brown, silty, blocky, weakly indurated	2.8
Sandstone, orange-brown, quartzose, massive, moderately indurated	1.7

	Thickness (feet)
Shale, red-brown, weakly indurated; as above	1.5
Sandstone, orange-brown, moderately indurated; as above	2.7
Shale, red-brown; as above	2.0
Siltstone, orange-brown; as above; with interbedded red-brown shale	7.5
MARLOW FORMATION (total thickness, 104 feet)	
Emanuel Bed:	
Dolomite, maroon to light-pink, fine-grained, well-indurated, thinly laminated; mottled with black specks; eroding into a ledge	0.1
Unnamed Beds:	
Sandstone, orange-brown to light-pink, medium-grained, quartzose, friable, weakly indurated	0.75
Sandstone, orange-brown, fine-grained, weakly indurated, partly covered	10.0
Siltstone and shale, red-brown, blocky, weakly indurated	2.0
Sandstone, orange-brown, fine-grained, moderately indurated; eroding into a ledge	1.0
Siltstone and shale, red-brown, blocky, weakly indurated	1.0
Shale, red-brown, silty, platy, weakly indurated; with 1-inch greenish-gray bed at top; eroding into a slope	5.0
Sandstone, orange-brown, quartzose, calcitic, moderately indurated; as above; with 2- to 3-inch greenish-gray streaks at base; eroding into a ledge	7.0
Siltstone, orange-brown, arenaceous, blocky, weakly indurated	9.25
Relay Creek Bed:	
Dolomite, maroon to pink, fine-grained, well-indurated, thinly laminated, crinkly bedded; eroding into a ledge	0.1
Unnamed Beds:	
Sandstone, orange-brown, fine-grained, quartzose, calcitic, silty, thin-bedded, even-bedded, moderately to weakly indurated; gradational one mile to north into Doe Creek Lentil in upper 15 feet where it is a purple to greenish-gray calcitic sandstone and conglomerate with fossils	68.0
(In next section, the basal 20 feet of the Marlow has a mean grain size of 3.40, deviation 0.41, skewness 0.00, and kurtosis 1.15.)	
(*Section extrapolated to NW¼ sec. 17 and NE¼ sec. 18, T. 23 N., R. 17 W.*)	
CIMARRONIAN SERIES	
EL RENO GROUP (total thickness, 465 feet)	
DOG CREEK SHALE (total thickness, 67.5 feet)	
Siltstone, dark red-brown to very dark-red, arenaceous, dolomitic, platy, thin-bedded, crinkly bedded; composed of (in percent) 29.4 sand, 36.0 silt, 5.2 clay, and 29.4 carbonate	1.2
Siltstone, moderate reddish-orange, mottled red-brown, argillaceous, dolomitic, well-indurated, blocky, massive; becoming greenish gray and dolomitic in basal 1 inch, composed of (in percent) 30.4 sand, 37.9 silt, 6.5 clay, and 25.2 carbonate. The heavy-mineral fraction, comprising 0.16 percent of the sand-sized portion of the insoluble residue, consists of (in percent) 37.85 ilmenite-magnetite, 9.23 sphene-leucoxene, 0.31 orange opaque, 30.46 garnet, 14.77 zircon, 4.62 brown to gray tourmaline, 1.85 biotite, 0.62 epidote, 0.31 yellow rutile, and 0.31 anhydrite. The light-mineral fraction consists of (in percent) 79.68 quartz, 9.03 chert, 8.71 orthoclase, 1.29 plagioclase, and 1.29 microcline	0.7
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
Siltstone, moderate reddish-orange, argillaceous, thin-bedded; gradational into fine-grained quartzose sandstone	8.0

	Thickness (feet)
Shale, red-brown, silty, blocky, moderately indurated	4.0
Siltstone, red-brown, argillaceous, well-indurated, massive; eroding into a ledge	0.2
Shale, red-brown, silty, blocky	3.75
Siltstone, greenish-gray, mottled red-brown, argillaceous, dolomitic, moderately indurated, thin-bedded; composed of (in percent) 2.5 sand, 83.8 silt, 6.4 clay, and 7.3 carbonate	0.5
Shale, red-brown, silty, blocky	3.6
Shale, mottled greenish-gray and red-brown, silty, blocky	0.75
Shale, red-brown, blocky	7.0
Siltstone, greenish-gray, mottled moderate reddish-orange, thin-bedded, crinkly bedded; composed of (in percent) 1.6 sand, 62.7 silt, 4.5 clay, and 31.2 carbonate	0.25
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
Shale, greenish-gray, dolomitic, blocky	0.1
Shale, dark red-brown, blocky	1.0
Dolomite, greenish-gray, silty, argillaceous, fine-grained, massive, well-indurated	0.1
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
(*Section extrapolated to Copeland Ranch, SW¼ NW¼ NW¼ sec. 22, T. 24 N., R. 18 W.*)	
Unnamed Beds:	
Shale, greenish-gray, mottled red-brown, thinly laminated, platy; with some thin dolomite beds	5.0
Dolomite, light-gray, fine-grained, dense, massive, crinkly bedded, blocky; composed of (in percent) 1.5 sand, 42.5 silt, 5.1 clay, and 50.9 carbonate	0.3
Shale, red-brown, blocky; with some greenish-gray spots	1.0
Shale, greenish-gray, silty, blocky, weakly indurated	0.2
Shale, red-brown, blocky; with some greenish-gray streaks	7.5
Siltstone, light-brown, gypsiferous, massive, weakly indurated	3.0
Siltstone and gypsum, interbedded, red-brown, argillaceous, well-indurated, thin-bedded, crinkly bedded; probably containing Watonga equivalent at top and Haskew equivalent at base	4.5
Siltstone, greenish-gray, mottled red-brown, gypsiferous, dolomitic, well-indurated, thin-bedded, crinkly bedded; composed of (in percent) 3.0 sand, 70.5 silt, 4.7 clay, and 21.8 carbonate	3.0
(*Section extrapolated to W½ NW¼ sec. 25, T. 25 N., R. 15 W., south of Avard, Woods County*)	
BLAINE FORMATION (total thickness, 46.5 feet)	
Altona Dolomite Bed:	
Dolomite, light-gray to tan, fine- to medium-crystalline, well-indurated, massive; oölitic in places; gradational into greenish-gray shale at base; eroding into a ledge; Shimer Gypsum missing	1.0
Unnamed Beds:	
Shale, red-brown, blocky; with some greenish-gray layers; mostly covered	17.0
Magpie Dolomite Bed:	
Dolomite, light-gray to tan; as above; eroding into a ledge	1.0
Unnamed Beds:	
Shale, red-brown, blocky; as above; partly covered	10.0

	Thickness (feet)
Medicine Lodge Gypsum Member:	
Gypsum, white, coarsely selenitic, well-indurated, massive; eroding into a ledge	15.0
Cedar Springs Dolomite Bed:	
Dolomite, light-gray to tan; as above; with prominent light greenish-gray dolomitic shale in basal 1.5 feet; eroding into a prominent ledge	2.5
FLOWERPOT SHALE (total thickness, 351.5 feet)	
Shale, red-brown, blocky	2.0
Gypsum, red-brown and white, argillaceous, coarsely selenitic, well-indurated; eroding into a ledge	0.5
Shale, dark greenish-gray, blocky, weakly indurated	0.2
Shale, red-brown, blocky, weakly indurated, with a 3-inch dark greenish-gray shale bed in middle	3.0
Dolomite, light-gray, very fine-grained, platy, well-indurated; weathering tan; eroding into a ledge	0.2
Shale, red-brown, blocky, weakly indurated	1.0
Shale, greenish-gray, blocky, weakly indurated	3.25
Dolomite, light greenish-gray, very fine-grained, dense, thinly laminated, well-indurated; with many salt casts; eroding into a ledge	0.3
Shale, greenish-gray; as above	1.2
Shale, red-brown; as above	1.0
Shale, greenish-gray; as above	1.2
Shale, red-brown; as above	2.1
Siltstone and shale, light greenish-gray, platy, weakly indurated	0.2
Shale, red-brown, blocky; as above	0.8
Unit 6:	
Siltstone and sandstone, orange-brown, mottled greenish-gray, weakly indurated; with 6-inch greenish-gray zone at base, and some 0.5-inch orange-brown gypsum nodules; eroding into a prominent escarpment	8.25
Unnamed Beds:	
Shale, red-brown, blocky; with some 1- to 2-inch greenish-gray shale layers	4.75
Gypsum and shale, mottled red-brown and greenish-gray, thinly laminated, crinkly bedded, well-indurated; eroding into a ledge	1.25
Shale, red-brown, blocky, weakly indurated	3.0
Siltstone, orange brown and greenish-gray, gypsiferous, thinly laminated; well-indurated at top; eroding into a prominent ledge	2.2
Shale, red-brown, blocky; with much paper-thin satin spar	5.1
Shale, chocolate-brown, mottled greenish-gray, blocky, weakly indurated	2.0
Shale, greenish-gray, blocky, weakly indurated	0.6
Shale, red-brown, blocky; with much satin spar; with some 1-inch greenish-gray gypsiferous shale beds in basal 6 inches	1.5
Shale, greenish-gray, gypsiferous, crinkly bedded, well-indurated; eroding into a ledge	0.2
Shale, red-brown, blocky, weakly indurated; with some 1- to 2-inch greenish-gray gypsiferous shale beds	4.25
Shale, dark greenish-gray, gypsiferous, blocky, moderately indurated; eroding into a ledge	0.5
Shale, red-brown, blocky, weakly indurated; with some paper-thin satin spar	1.0
Siltstone, greenish-gray, mottled orange-brown, gypsiferous, well-indurated, crinkly bedded; eroding into a ledge	0.2
Shale, red-brown; as above	0.5
Shale, greenish-gray, blocky, weakly indurated	0.2
Shale, red-brown blocky; as above	1.9
Shale, greenish-gray; as above; eroding into a ledge	0.4

	Thickness (feet)
Shale, red-brown; as above	2.0
Shale, greenish-gray, moderately indurated; as above; eroding into a ledge	0.1
Shale, red-brown; as above	4.75
Shale, greenish-gray, gypsiferous, moderately indurated, platy; eroding into a ledge	0.1
Shale, red-brown; as above; with many 0.5- to 1-inch white gypsum nodules in basal foot	2.2
Shale, greenish-gray, dolomitic, gypsiferous, silty, well-indurated; eroding into a prominent ledge	0.8
Shale, red-brown, blocky; as above	4.0
Unit 5:	
Siltstone, greenish-gray, mottled orange-brown, argillaceous, gypsiferous, moderately indurated; with some 3- to 6-inch white gypsum nodules; eroding ino a ledge	2.0
Unnamed Beds:	
Shale, red-brown; as above; with some 1- to 2-inch greenish-gray gypsiferous shale layers	3.5
Shale, greenish-gray, blocky; with many 0.5- to 1-inch white gypsum nodules; eroding into a ledge	0.2
Shale, red-brown; as above	2.75
Shale, greenish-gray, mottled orange-brown, gypsiferous, blocky, well-indurated; with many 1- to 2-inch white gypsum nodules; eroding into a ledge	0.5
Shale, red-brown, weakly indurated; as above; with many 1- to 2-inch greenish-gray layers	1.0
Shale, greenish-gray, blocky, weakly indurated	0.25
Shale, red-brown, blocky, weakly indurated	0.75
Shale, greenish-gray; as above	0.2
Shale, red-brown; as above	0.6
Shale, greenish-gray, gypsiferous, moderately indurated; as above; with many 2- to 3-inch white gypsum nodules; eroding into a ledge	0.4
Shale, red-brown; as above; with a 1-inch greenish-gray bed in middle	2.25
Shale, greenish-gray, well-indurated; with interbedded red-brown shale; eroding into a ledge	0.5
Shale, red-brown; as above	3.0
Shale, greenish-gray, blocky, weakly indurated	0.5
Shale, red-brown; as above	2.0
Shale, greenish-gray; as above; with much satin spar	0.6
Shale, red-brown; as above; with much satin spar and some 1- to 2-inch greenish-gray gypsiferous shale beds	8.0
Shale, greenish-gray, silty, gypsiferous, weakly indurated	0.2
Shale, red-brown; as above	3.25
(*Section extrapolated to N½ NE¼ sec. 25 T. 25 N., R. 15 W., along road*)	
Unit 4:	
Siltstone and shale, greenish-gray, gypsiferous, moderately indurated; eroding into a ledge	1.5
Unnamed Beds:	
Shale, red-brown; as above	2.75
Shale, greenish-gray, gypsiferous, silty, blocky, weakly indurated	1.0
Shale, red-brown; as above	3.25
(*Section extrapolated to E½ SE¼ sec. 24 and NE¼ SE¼ NE¼ sec. 24, T. 25 N., R. 15 W.*)	
Shale, greenish-gray, gypsiferous; as above	0.25
Shale, red-brown; as above; with much satin spar	5.25
Shale, greenish-gray; as above; with some 1- to 4-inch white gypsum nodules at base	1.0
Shale, red-brown; as above	3.25

	Thickness (feet)
Shale and gypsum, light greenish-gray, selenitic, moderately indurated	0.2
Shale, red-brown; as above; with some 1- to 2-inch greenish-gray gypsiferous shale beds	3.9
Shale, greenish-gray, mottled orange-brown, gypsiferous, silty; moderately indurated at top; with some 0.5- to 1-inch white gypsum nodules; eroding into a ledge	1.0
Shale, red-brown; as above; with many 0.5- to 1-inch white gypsum nodules	3.75
Shale, greenish-gray, mottled orange-brown, gypsiferous, blocky, weakly indurated	0.5
Shale, red-brown; as above; with some 1- to 2-inch white gypsum nodules	4.0
Shale, greenish-gray, blocky, weakly indurated	0.5
Shale, red-brown, blocky, weakly indurated	1.75
Shale, greenish-gray; as above	0.25
Shale, red-brown; as above; with some 2- to 3-inch greenish-gray gypsiferous shale layers	8.5
(Section extrapolated to W½ SW¼ sec. 18, T. 25 N., R. 14 W.)	
Unit 3-4:	
Siltstone, greenish-gray, mottled orange-brown, gypsiferous, moderately indurated; eroding into a prominent ledge	2.0
Unnamed Beds:	
Shale, red-brown; as above	0.75
Shale and gypsum, greenish-gray and red-brown, platy, moderately indurated; eroding into a ledge	0.4
Shale, red-brown; as above; greenish-gray in basal 0.5-inch bed	0.5
Shale, red-brown; as above; with some paper-thin satin spar	4.5
Shale, greenish-gray and orange-brown, blocky; with much paper-thin satin spar; eroding into a ledge	0.6
Shale, red-brown; as above	5.0
Shale and gypsum, light greenish-gray, selenitic, moderately indurated; eroding into a ledge	0.2
Shale, red-brown, mottled greenish-gray; as above	1.0
Shale, chocolate-brown, mottled greenish-gray; with much selenite and many 2- to 3-inch white gypsum nodules	1.0
(Section extrapolated to NW¼ sec. 18, T. 25 N., R. 14 W., along creek)	
Shale and siltstone, greenish-gray, gypsiferous, platy, moderately indurated; with many 1-inch white gypsum nodules	2.0
Shale, red-brown; as above; with some 1- to 2-inch gypsum nodules	10.5
Shale, greenish-gray, dolomitic, blocky, moderately indurated	0.75
Shale, red-brown, blocky; as above	4.5
Shale, greenish-gray, mottled red-brown, platy, weakly indurated	0.4
Shale, red-brown; as above	2.0
Shale, greenish-gray, gypsiferous, platy	0.2
Shale, red-brown; as above	7.0
Shale, greenish-gray and orange-brown, silty, blocky, thinly laminated; with much satin spar	4.1
Shale, red-brown, silty, blocky; with some paper-thin satin spar	4.5
Shale and gypsum, greenish-gray, silty, blocky, moderately indurated	0.5
Shale, red-brown; as above	3.75
Shale and gypsum, orange-brown and greenish-gray, silty, blocky; with some 1- to 3-inch gypsum nodules; eroding in several ledges	3.0
Shale, red-brown, blocky, weakly indurated; as above; with some 1- to 2-inch light greenish-gray gypsiferous shale beds	9.8
Dolomite, light greenish-gray, very fine-grained, dense, thin-bedded, well-indurated; eroding into a ledge	0.1
Shale, red-brown, blocky; as above; with 6-inch greenish-gray	

	Thickness (feet)
shale at top	2.0
Shale, chocolate-brown, gypsiferous, blocky, weakly indurated; gradational into greenish-gray shale at top	1.0
Dolomite, light greenish-gray, very fine-grained, dense, argillaceous, platy, well-indurated, gypsiferous; with interbedded greenish-gray shale; eroding into a ledge	0.1
Shale, red-brown; as above	1.9
(Section extrapolated to SW¼ SE¼ sec. 33, T. 26 N., R. 15 W.)	
Unit 3:	
Siltstone, light greenish-gray, mottled orange-brown, gypsiferous, argillaceous, moderately indurated; eroding into a prominent escarpment	2.2
Unnamed beds:	
Shale, red-brown, blocky; as above	0.5
Siltstone, greenish-gray, argillaceous, blocky, weakly indurated	0.5
(Section extrapolated to SE¼ NW¼ sec. 3, T. 25 N., R. 15 W., and SW¼ SE¼ sec. 34, T. 26 N., R. 15 .W)	
Shale, red-brown, silty, blocky, weakly indurated; with some satin spar layers; with some 0.5- to 1-inch greenish-gray gypsum nodules	17.0
Shale, greenish-gray, silty, gypsiferous, blocky; with many 1- to 2-inch greenish-gray gypsum nodules; eroding into a ledge	0.75
Shale, red-brown; as above	3.75
Shale, greenish-gray, gypsiferous, blocky, weakly indurated	0.25
Shale, red-brown; as above	2.0
Shale and gypsum, greenish-gray, selenitic, thin-bedded, well-indurated; with many 0.25-inch satin spar layers; eroding into a ledge	0.5
Shale, red-brown, blocky; as above	5.25
Shale and gypsum, greenish-gray, crinkly bedded, platy; as above; with interbedded red-brown shale	1.25
Shale, red-brown; as above; with much satin spar	10.5
(Section extrapolated to S½ SE¼ sec. 14 and NE¼ NW¼ NW¼ sec. 23, T. 26 N., R. 15 W.)	
Unit 2:	
Siltstone and sandstone, light greenish-gray, very fine-grained, gypsiferous, thin-bedded, platy; well-indurated in basal 2 feet; eroding into a prominent ledge	3.75
Unnamed Beds:	
Shale, red-brown, silty, blocky, weakly indurated; with some satin spar layers and some 1- to 2-inch greenish-gray shale layers	20 0
Shale, light greenish-gray, silty, gypsiferous, platy, weakly indurated; mottled orange-brown in middle	2.2
Shale, red-brown, blocky; with some satin spar	6.25
Unit 1:	
Siltstone, light greenish-gray, mottled orange-brown, gypsiferous, argillaceous, moderately indurated; with many large 6- to 8-inch white gypsum nodules; eroding into a nodular ledge	1.5
Unnamed Beds:	
Shale, red-brown, blocky, weakly indurated	2.0
Siltstone, orange-brown, mottled greenish-gray, weakly indurated	1.2
(Section extrapolated to SE¼ SE¼ sec. 24, T. 26 N., R. 15 W., along Eagle Chief Creek, to creek bed)	
Siltstone and gypsum, greenish-gray, thin-bedded, crinkly bedded, well-indurated; eroding into a ledge	0.25
Shale, red-brown, silty, blocky, weakly indurated	1.75
Siltstone and gypsum, light greenish-gray, massive, well-indurated; eroding into a ledge	0.2
Siltstone, orange-brown, gypsiferous, arenaceous, thin-bedded, moderately indurated; with many 0.25- to 0.5-inch gypsum nodules	2.5

	Thickness (feet)
Siltstone and gypsum, light greenish-gray; as above; eroding into a ledge	0.2
Siltstone and sandstone, light-tan to orange-brown, very fine-grained, thinly laminated, weakly indurated; mottled with greenish-gray streaks	5.25
Siltstone and sandstone, light-tan to orange-brown; as above; with many 0.5-inch white gypsum nodules	1.5
Siltstone and sandstone, light-tan to orange-brown; with some indurated greenish-gray gypsiferous beds	2.5
Siltstone and gypsum, light greenish-gray, thin-bedded, crinkly bedded; eroding into a ledge	2.0
Shale, red-brown, gypsiferous, platy, moderately to weakly indurated; with much satin spar and many 0.5- to 1-inch greenish-gray beds	2.0
Siltstone, light greenish-gray, gypsiferous; eroding into a ledge	0.5
Shale, red-brown; as above	1.5
Siltstone, light greenish-gray; as above	0.75
Shale, red-brown; as above	0.7
Siltstone, light greenish-gray; as above	0.75
Shale, red-brown; as above	0.75
Siltstone, light greenish-gray; as above	0.75
Shale, red-brown; as above	1.5
Siltstone, light greenish-gray; as above	0.5
Shale, red-brown; as above	1.3
Siltstone, light greenish-gray; as above	0.4
Shale, red-brown; as above	0.5
Siltstone, light greenish-gray; as above	0.25
Shale, red-brown; as above	0.9
Siltstone, light greenish-gray; as above	0.2
Shale, red-brown; as above	1.25
Siltstone, light greenish-gray; as above	0.5
Shale, red-brown; as above	1.0
Siltstone, light greenish-gray; as above	0.3
Shale, red-brown; as above	0.9
Siltstone, light greenish-ray; as above	0.2
Shale, red-brown; as above	0.6
Gypsum, white, mottled orange-brown, well-indurated; forming a marker bed; eroding into a ledge	0.3
Shale, red-brown; as above	1.0
Siltstone, light greenish-gray; as above; eroding into a ledge	0.4
Shale, red-brown; as above; in creek bottom	0.9
(*Section extrapolated to SW¼ NW¼ NW¼ sec. 23, T. 26 N., R. 14 W., on north side of Eagle Chief Creek*)	
Siltstone, light greenish-gray; as above; eroding into a ledge	1.0
Shale, red-brown, blocky; with many 0.5- to 1-inch satin spar layers	7.75
Siltstone, light greenish-gray; as above; eroding into a ledge	0.5
Shale and siltstone, red-brown to orange-brown, gypsiferous, blocky, moderately to well-indurated; mottled with greenish-gray spots; eroding into a ledge	1.4
Shale, red-brown, mottled greenish-gray, silty, blocky, weakly indurated; with many 0.5-inch satin spar layers	1.5
(*Section extrapolated to C NW¼ sec. 34 and NW¼ SW¼ NE¼ sec. 34, T. 26 N., R. 14 W., along south bluff of Eagle Chief creek*)	
Siltstone, light-tan, mottled greenish-gray, arenaceous, moderately to well-indurated; with many 0.5-inch white gypsum nodules	3.5

CIMARRONIAN SERIES
HENNESSEY FORMATION
Cedar Hills Sandstone Member: (top 9.5 feet exposed)

	Thickness (feet)
Unit 5:	
Sandstone, light greenish-gray, very fine-grained, silty, gypsiferous, well-indurated; with many 0.5- to 1-inch white gypsum nodules; eroding into a ledge	1.5
Unnamed Beds:	
Sandstone and siltstone, orange-brown, mottled greenish-gray, argillaceous, weakly indurated; exposed	8.0
(This upper zone persists as a ledge along the sides of Eagle Chief Creek to the mouth of the creek in Major County; apparently the creek has adjusted to the dip of the beds.)	

SECTION 16.
SEILING AREA, DEWEY COUNTY, OKLAHOMA
CHESTER-ORIENTA AREA, MAJOR COUNTY, OKLAHOMA
HENNESSEY AREA, KINGFISHER COUNTY, OKLAHOMA

Beginning at top in Day Creek Dolomite Bed of Cloud Chief Formation on north side of Canadian Triangulation Station south of Seiling, Dewey County, in SE¼ sec. 23, T. 19 N., R. 16 W., and proceeding down section through Moccasin Creek Bed and Rush Springs Formation to Relay Creek Bed of Marlow Formation along road in NE¼ NW¼ sec. 11, T. 19 N., R. 16 W., where a pink shale is also exposed 6 feet above the Relay Creek Bed. Section then extrapolated to U. S. Highway 281 north of Chester, Major County, and along Griever Creek, in NE¼ sec. 8, NW¼ sec. 9, and NW¼ sec. 10, T. 21 N., R. 16 W., for section 24 feet above Emanuel Bed (poorly developed) to base of Marlow Formation. The Dog Creek Shale was measured in SE¼ SE¼ SW¼ sec. 35, T. 22 N., R. 16 W., including Blaine section to Altona Dolomite. The Blaine section was then extrapolated to SW¼ SW¼ NE¼ sec. 29, T. 22 N., R. 15 W. The Flowerpot was measured in the Glass Mountains, west of Orienta, Major County, SE¼ sec. 22, T. 22 N., R. 13 W., to 270 feet below top; then extrapolated to SE¼ SE¼ sec. 29, T. 21 N., R. 11 W., and east side of road along sections 34 and 27, T. 21 N., R. 11 W., for lower 106 feet. The Cedar Hills Sandstone was measured in NW¼ sec. 1, T. 22 N., R. 10 W., and S½ sec. 2, T. 22 N., R. 10 W., for upper 75 feet; then NW¼ sec. 33, T. 23 N., R. 9 W., for next 20 feet; then W½ sec. 28, T. 23 N., R. 9 W., for next 10 feet; then W½ sec. 21, T. 23 N., R. 9 W., to 142 feet below top. Section then extrapolated to high hill 0.5 mile northwest of Bison, Garfield County, in NW¼ sec. 24, T. 20 N., R. 7 W., for next 39 feet; then SE¼ sec. 14, T. 19 N., R. 7 W., for next 14 feet; ending in the type Hennessey Shale (including lower part of Cedar Hills Member and upper 64 feet of Bison Member) in quarry 0.5 mile west of Hennessey, in SE¼ sec. 23, T. 19 N., R. 7 W., northern Kingfisher County.

	Thickness (feet)
CUSTERIAN SERIES	
CLOUD CHIEF FORMATION (top not exposed, exposed thickness 31.15 feet)	
Day Creek Dolomite Bed:	

	Thickness (feet)
Dolomite, light-pink and white, very fine-grained, well-indurated, vuggy, thinly laminated, crinkly bedded; eroding into a prominent escarpment capping hills 5 miles eastward	1.0
Kiger Member (total thickness, 27.75 feet):	
Sandstone, orange-brown, very fine-grained, quartzose, thinly laminated, weakly indurated	5.0
Shale and siltstone, red-brown to orange-brown, blocky, weakly indurated; mottled with some 0.25-inch greenish-gray streaks	3.0
Sandstone, orange-brown, weakly indurated; as above	2.5
Shale and siltstone, red-brown to orange-brown; as above	3.25
Shale and siltstone, greenish-gray, blocky, weakly indurated	0.5
Shale and siltstone, red-brown to orange-brown, thinly laminated, weakly indurated; as above; with some 0.5- to 1-inch greenish-gray beds	13.5
Moccasin Creek Bed (total thickness, 2.4 feet):	
Dolomite, maroon to light-pink, fine-grained, thinly laminated, crinkly bedded, well-indurated; eroding into a ledge	0.2
Shale and siltstone, red-brown to orange-brown; as above	2.0
Dolomite, white to light-pink; arenaceous, thinly laminated, well-indurated, crinkly bedded; eroding into a ledge	0.2
WHITEHORSE GROUP (total thickness, 295.1 feet)	
RUSH SPRINGS FORMATION (total thickness, 186.35 feet)	
Sandstone, orange-brown, mottled greenish-gray, fine-grained, quartzose, weakly indurated	1.0
Sandstone, orange-brown, fine- to medium-grained, quartzose, weakly indurated; with some 1- to 2-inch gypsiferous beds at base; weathering into sand balls on the surface	9.5
Shale and siltstone, orange-brown to red-brown; as above; mottled with some 0.5-inch greenish-gray bands	1.5
Sandstone, orange-brown, fine-grained, quartzose, weakly indurated	2.5
Shale and siltstone, orange-brown to red-brown; as above	1.5
Sandstone, orange-brown; as above; covered in lower part; section measured to Relay Creek Bed in NE¼ NW¼ sec. 11, T. 19 N., R. 16 W., along north side of road; using regional dip of about 7 feet per mile southward, this interval is 214.85 feet thick	146.35
(*Section extrapolated to U. S. Highway 281, in NE¼ sec. 8, NW¼ sec. 9, ending in NW¼ sec. 10, T. 21 N., R. 16 W.*)	
Sandstone, orange-brown, fine-grained, quartzose, moderately indurated	8.0
Siltstone and sandstone, orange-brown to red-brown, fine-grained, thinly laminated, weakly indurated	16.0
MARLOW FORMATION (total thickness, 108.75 feet)	
Emanuel Bed:	
Sandstone, light orange-brown, fine- to medium-grained, moderately to weakly indurated; eroding into an even-bedded ledge	1.0
Unnamed Beds:	
Sandstone, orange-brown, fine-grained, gypsiferous, weakly indurated; with a 2- to 3-inch white gypsum 6 feet above base	26.5
Relay Creek Bed:	
Gypsum, white, fine-grained, arenaceous, weakly indurated; eroding into a prominent ledge in many places	1.0
Unnamed Beds:	
Sandstone, orange-brown, fine-grained, gypsiferous, weakly indurated; weathering with a gypsiferous crust on surface	9.0
Gypsum and sandstone, orange-brown and white, fine-grained, thinly laminated, moderately indurated; eroding into a ledge	5.0
Sandstone, orange-brown, fine-grained, quartzose, weakly indurated, thinly laminated; with many 1- to 2-inch impure gypsum beds	22.0

	Thickness (feet)
Gypsum and sandstone, orange-brown, fine-grained, well-indurated; eroding into a ledge	5.0
Gypsum, white, mottled pink, fine-grained, thinly laminated, well-indurated; eroding into a ledge	2.5
Sandstone, orange-brown, quartzose, fine-grained, cross-bedded; with impure gypsum cement	15.75
Sandstone, orange-brown, fine-grained, quartzose; mottled with many small greenish-gray specks	20.5
(Section extrapolated to SE¼ SE¼ SW¼ sec. 35, T. 22 N., R. 16 W.)	
Sandstone, greenish-gray and moderate reddish-orange, silty, fine-grained, weakly indurated, friable; with mean size of 3.30 phi, deviation 0.46, skewness 0.09, and kurtosis 0.25. The heavy-mineral fraction, comprising 0.78 percent of the sand-sized portion of the washed residue, consists of (in percent) 40.78 ilmenite-magnetite, 8.10 sphene-leucoxene, 1.95 orange opaque, 26.25 garnet, 9.21 zircon, 4.74 brown to gray tourmaline, 1.95 biotite, 0.55 chlorite, 5.58 epidote, and 0.55 yellow rutile. The light-mineral fraction consists of (in percent) 87.94 quartz, 4.56 chert, 2.93 orthoclase, 0.97 plagioclase, 1.95 microcline, and 1.62 carbonate. The clay minerals consist of illite (peaks at 3.33 and 10.04a) and chlorite (peaks at 3.51 and 7.13a)	0.5
CIMARRONIAN SERIES	
EL RENO GROUP (total thickness, 557.65 feet)	
DOG CREEK SHALE FORMATION (total thickness, 106.9 feet)	
Shale, red-brown, silty, blocky; with some 1- to 2-inch greenish-gray spots; conformable with beds above	9.0
Dolomite, red-brown, silty, mottled moderate reddish-orange, massive, well-indurated; composed of (in percent) 0.5 sand, 31.9 silt, 6.4 clay, and 61.2 carbonate	0.1
Shale, red-brown silty, blocky, weakly indurated; with interbedded orange-brown siltstone and some 0.5-inch red-brown gypsum nodules; covered in part	58.75
Southard Dolomite Bed:	
Dolomite, gray, silty, argillaceous, fine-grained, dense, massive; composed of (in percent) 0.03 sand, 11.48 silt, 7.23 clay, and 81.26 carbonate	0.2
Unnamed Beds:	
Shale, greenish-gray, weakly indurated, blocky; with some gypsum nodules and dolomite stringers	5.1
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, well-indurated, crinkly bedded	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
Siltstone, greenish-gray, mottled red-brown, gypsiferous, dolomitic at top, well-indurated, crinkly bedded; eroding into a ledge; composed of (in percent) 0.9 sand, 54.2 silt, 13.2 clay, and 31.7 carbonate and gypsum	4.25
Shale, red-brown, silty, thinly laminated; greenish gray at top	6.25
Watonga Dolomite Bed:	
Dolomite, greenish-gray, fine-grained, dense, crinkly bedded; composed of (in percent) 0.2 sand, 17.8 silt, 6.7 clay, and 75.3 carbonate	0.1

	Thickness (feet)
Unnamed Beds:	
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 the upper ledge of the Haskew	0.25
Unnamed Beds:	
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; eroding into a ledge	14.0
Altona Dolomite Bed:	
Dolomite, light-brown, fine-grained, oölitic, medium-bedded, massive; weathering light-brown; composed of (in percent) 0.5 sand, 2.0 silt, 1.4 clay, and 96.1 carbonate	2.2
Unnamed Beds:	
Shale, greenish-gray, weakly indurated, blocky	1.1
(Section extrapolated to NE¼ sec. 29, T. 22 N., R. 15 W., east of road)	
Shale, red-brown, blocky; with some thin greenish-gray shale streaks; partly covered	13.0
Nescatunga Gypsum Member:	
Gypsum, white, fine-grained, massive; weathering coarsely selenitic; eroding into an escarpment	17.0
Magpie Dolomite Bed:	
Dolomite, light-gray, fine-grained, oölitic, well-cemented, thin-bedded; composed of (in percent) 0.02 sand, 4.47 silt, 9.38 clay, and 86.13 carbonate	1.0
Unnamed Beds:	
Shale, greenish-gray, blocky	0.2
Shale, red-brown, selenitic, blocky	3.6
Kingfisher Creek Bed:	
Gypsum, light red-brown, argillaceous, well-indurated, fine-grained, thinly laminated, crinkly bedded	0.4
Unnamed Beds:	
Shale, red-brown, selenitic, blocky; greenish gray at top	3.25
Medicine Lodge Gypsum Member:	
Gypsum, white, fine-rained, massive; weathering coarsely selenitic; eroding into a prominent escarpment	16.0
Cedar Springs Dolomite Bed:	
Dolomite, light-gray, fine-grained, oölitic, thin-bedded to laminated; weathering massive at top; composed of (in percent) 0.05 sand, 2.33 silt, 2.78 clay, and 94.84 carbonate	2.5
(Section extrapolated to Glass Mountains, in SW¼ SE¼ sec. 22, T. 22 N., R. 13 W., on east side)	
FLOWERPOT SHALE (total thickness, 376.45 feet)	
Shale, light greenish-gray, calcitic, blocky, weakly indurated	2.0
Shale and gypsum, light greenish-gray, mottled dark red-brown to maroon, well-indurated, crinkly bedded, thinly laminated; eroding into a ledge	1.2
Shale, greenish-gray, highly gypsiferous, blocky, weakly indurated	0.5
Shale and gypsum, mottled dark red-brown and greenish-gray, thin-bedded, well-indurated; eroding into a ledge	0.2
Shale, dark red-brown, gypsiferous, blocky, weakly indurated; with some 2- to 3-inch greenish-gray beds in middle	4.75

	Thickness (feet)
Gypsum, light greenish-gray, mottled red-brown, crinkly bedded, thin-bedded, well-indurated; with some interbedded red-brown shale; eroding into a ledge	1.0
Shale, dark red-brown; as above	2.0
Gypsum, light greenish-gray, argillaceous, thin-bedded, well-indurated; eroding into a ledge	0.3
Shale, dark red-brown, silty, gypsiferous, blocky, moderatley indurated	2.0
Dolomite, light-tan, very fine-grained, dense, medium-bedded, well-indurated; with salt casts; eroding into a ledge	0.75
Shale, dark greenish-gray, blocky, weakly indurated	0.2
Shale, dark red-brown, mottled chocolate-brown; as above	3.0
Shale, dark greenish-gray, blocky, weakly indurated; with some interbedded red-brown shale	2.3
Shale, dark red-brown; as above	0.5
Shale, dark greenish-gray; as above	0.2
Shale, dark red-brown; as above	0.5
Gypsum and siltstone, light-tan to light greenish-gray, thin-bedded, well-indurated; eroding into a ledge	0.8
Shale, red-brown, silty, blocky, weakly indurated; mottled with many light greenish-gray spots	1.2
Gypsum, white, nodular, well-indurated; eroding into a ledge	0.25
Unit 6:	
Siltstone, orange-brown, gypsiferous, mottled light-tan to greenish-gray, weakly indurated, thinly laminated; with two prominent greenish-gray beds near base; eroding into a ledge with an almost vertical cliff face	10.75
Unnamed Beds:	
Shale, moderate red-brown, gypsiferous, blocky, weakly indurated; with some 1- to 2-inch greenish-gray gypsiferous shale zones in middle	8.25
Shale, light greenish-gray, mottled red-brown, highly gypsiferous, well-indurated, crinkly bedded; eroding into a ledge	1.2
Shale, red-brown, blocky, gypsiferous	6.0
Siltstone, light greenish-gray, mottled orange-brown, gypsiferous, thin-bedded, crinkly bedded, well-indurated; eroding into a ledge	2.3
Shale, red-brown; as above	29.25
Gypsum, light greenish-gray, nodular, well-indurated; eroding into a ledge	0.25
Shale, red-brown; as above	4.75
Gypsum and shale, light greenish-gray, blocky, moderately indurated; eroding into a ledge	0.25
Shale, red-brown; as above	8.5
Shale, light greenish-gray, mottled red-brown, gypsiferous, blocky, weakly indurated; with some satin spar and greenish-gray gypsum nodules	0.8
Shale, red-brown; as above	5.3
Gypsum and shale, light greenish-gray, crinkly bedded, well-indurated; eroding into a ledge	0.2
Shale, red-brown; as above	1.75
Gypsum and shale, light greenish-gray; as above	0.2
Shale, red-brown; as above	4.25
Unit 4:	
Gypsum and siltstone, light greenish-gray and red-brown, well-indurated; with many white gypsum nodules and interbedded greenish-gray shale; eroding into a ledge	1.1
Unnamed Beds:	
Shale, red-brown; as above	1.0
Shale and gypsum, light greenish-gray, moderately indurated; as above	0.3
Shale, red-brown; as above	2.3

	Thickness (feet)
Shale and gypsum, light greenish-gray; as above	0.2
Shale, red-brown; as above	6.25
Gypsum, white to light greenish-gray, nodular	0.2
Shale, red-brown; as above	3.75
Gypsum, light greenish-gray, nodular; eroding into a ledge	0.1
Shale, red-brown; as above	5.3
Gypsum, light greenish-gray; as above	0.1
Shale, red-brown; as above	10.25
Gypsum, light greenish-gray, nodular; as above	0.1
Shale, red-brown; as above	10.15
Gypsum, light greenish-gray, nodular; as above	0.25
Shale, red-brown; as above	5.25
Gypsum, light greenish-gray; as above	0.3
Shale, red-brown; as above	4.5
Unit 3-4:	
Shale, greenish-gray and chocolate-brown, gypsiferous, blocky, weakly indurated	2.0
Unnamed Beds:	
Shale, red-brown; as above	3.25
Gypsum, light greenish-gray, nodular; eroding into a ledge	0.2
Shale, red-brown; as above	3.2
Gypsum, light greenish-gray to white, nodular; eroding into a ledge	0.75
Shale, red-brown; as above	7.0
Gypsum, white to red-brown, nodular; eroding into a ledge	0.2
Shale, red-brown; as above	4.75
Siltstone, light greenish-gray, argillaceous, gypsiferous, blocky, thin-bedded, moderately to well-indurated; eroding into a prominent light-colored band in region	1.5
Shale, red-brown, silty, blocky, weakly indurated; mottled with light greenish-gray specks	4.25
Gypsum, white to red-brown, nodular; eroding into a ledge	0.2
Shale, red-brown; as above	3.5
Gypsum, white to red-brown, nodular; eroding into a ledge	0.25
Shale, red-brown; as above	6.25
Gypsum, white to red-brown, nodular; eroding into a ledge	0.2
Shale, red-brown; as above	4.5
Siltstone, light greenish-gray; eroding into a prominent light zone in region	1.5
Shale, red-brown; as above	12.25
Gypsum, white to red-brown, nodular; eroding into a ledge; gradational into greenish-gray shale	0.25
Shale, red-brown; as above	16.8
Gypsum, white to greenish-gray, nodular; eroding into a ledge	0.3
Shale, red-brown; as above; mottled chocolate brown in basal 3 feet	8.0
Unit 3:	
Siltstone, light greenish-gray; as above; with much nodular gypsum in basal part; eroding into third prominent light-colored band below top of formaton	2.0
Unnamed Beds:	
Shale, red-brown; as above	5.4
Gypsum, white to greenish-gray, nodular; as above	0.25
Shale, red-brown; as above	2.75
Siltstone, light greenish-gray, platy; as above	0.1
Shale, red-brown; as above; mottled with many greenish-gray spots	2.0
Shale, red-brown; with some 1- to 2-inch gypsum nodules	5.0
Gypsum, greenish-gray, nodular; eroding into a ledge	0.2
Shale, red-brown; as above	2.0
Gypsum, greenish-gray and red-brown, nodular; eroding into a ledge	0.2
Shale, red-brown; as above; with some 1-inch gypsum nodules	5.0

	Thickness (feet)
Gypsum, greenish-gray, nodular; eroding into a ledge	0.2
Shale, red-brown; as above; with many large gypsum nodules in basal part	5.0
(*Section extrapolated to SE¼ SE¼ sec. 29, and section-line road along secs. 27 and 34 (east side), T. 21 N., R. 11 W.*)	
Siltstone, greenish-gray, selenitic; with many gypsum nodules; eroding into a ledge	1.75
Shale, red-brown, silty, blocky	2.2
Sandstone, light greenish-gray, very fine-grained, silty, thinly laminated; moderately indurated in places	2.25
Shale, red-brown, silty, blocky; with some 1- to 2-inch orange-brown siltstone beds and greenish-gray nodular gypsum beds	52.5
Siltstone and sandstone, greenish-gray, mottled orange-brown, very fine-grained, moderately indurated	0.25
Shale, red-brown, silty, blocky	9.5
Siltstone and shale, greenish-gray and orange-brown, arenaceous, platy, weakly indurated	2.25
Shale, red-brown, silty, blocky, weakly indurated	10.0
Siltstone, light greenish-gray and orange-brown, blocky, moderately indurated; eroding into a ledge	1.0
Shale, red-brown, silty, blocky	2.0
Siltstone, mottled greenish-gray and orange-brown, argillaceous, blocky, moderately indurated; eroding into a ledge	1.5
Shale, red-brown, silty, blocky, partly covered	21.0
CIMARRONIAN SERIES	
HENNESSEY FORMATION (base not examined)	
Cedar Hills Member (total thickness, 200 feet):	
Unit 5:	
Siltstone and sandstone, greenish-gray, very fine-grained; with some nodular gypsum	1.0
Unnamed Beds:	
Sandstone and siltstone, orange-brown, very fine-grained, argillaceous, platy, weakly indurated; eroding into a ledge above Cimarron River	22.5
(*Section extrapolated to NW¼ sec. 1, T. 22 N., R. 10 W., into S½ sec. 2, T. 22 N., R. 10 W., along stream*)	
Sandstone, greenish-gray, silty, friable, weakly indurated	2.0
Shale, red-brown, silty, blocky, weakly indurated	3.5
Unit 4:	
Sandstone, greenish-gray, mottled orange-brown, silty, platy, moderately indurated	1.5
Unnamed Beds:	
Shale, red-brown, silty, blocky, weakly indurated; with a greenish-gray band near top	14.3
Siltstone, orange-brown, mottled greenish-gray, moderately indurated	0.5
Shale, red-brown; as above	1.0
Siltstone, greenish-gray, arenaceous, platy, moderately indurated	0.6
Shale, red-brown; as above	12.4
Unit 3:	
Siltstone, greenish-gray, arenaceous, weakly indurated	0.5
Unnamed Beds:	
Shale, red-brown, silty; as above	3.0
Siltstone, greenish-gray, arenaceous, moderately indurated	0.7
Shale, red-brown; as above	5.25
Sandstone, light greenish-gray, very fine-grained, silty, friable, weakly indurated; mapped as Bed 2 in Blaine County; weathering as first thick light-green unit below top of formation	2.5
Shale, red-brown; as above	9.35
Sandstone, light greenish-gray, silty; as above	0.5

	Thickness (feet)
Shale, red-brown; as above	1.0
Sandstone, light greenish-gray, mottled orange-brown; well indurated at top and base; weathering as second light-colored band below top; mapped as Bed 1 in Blaine County	2.5
Siltstone, orange-brown, argillaceous, platy, weakly indurated; gradational into shale	2.8
(Section extrapolated to NW¼ sec. 33, T. 23 N., R. 9 W.)	
Sandstone, orange-brown, silty, platy, crinkly bedded, well-indurated; mottled with greenish-gray spots; eroding into a ledge	0.5
Siltstone, orange-brown; as above; gradational into shale	4.75
Peace Treaty Bed:	
Sandstone, orange-brown, moderately indurated, massive; mottled with greenish-gray spots and greenish gray in basal part; eroding into a ledge	8.65
Unnamed Beds:	
Shale, red-brown, silty, blocky, weakly indurated; with some interbedded greenish-gray shale and siltstone beds	7.25
Siltstone, orange-brown, argillaceous, massive, blocky, well-indurated; with many quartz-lined vugs; eroding into a ledge	0.75
(Section extrapolated to W½ sec. 28, T. 23 N., R. 9 W., along section-line road)	
Shale, red-brown, weakly indurated; as above; with some 1- to 2-inch greenish-gray layers	4.25
Siltstone, orange-brown, platy, weakly indurated	0.5
Siltstone, orange-brown, well-indurated, vuggy, massive; mottled with greenish-gray spots; eroding into a prominent ledge	0.75
Siltstone, orange-brown, arenaceous, moderately indurated; mottled with greenish-gray spots	1.2
Shale, red-brown; as above; with some greenish-gray spots	3.0
(Section extrapolated to W½ sec. 21, T. 23 N., R. 9 W.)	
Siltstone, orange-brown; as above; eroding into a ledge	0.25
Sandstone and siltstone, orange-brown, friable, weakly indurated; gradational into red-brown shale; with some greenish-gray layers	8.5
Siltstone, orange-brown, platy, moderately indurated; eroding into a ledge	0.5
Siltstone, orange-brown, argillaceous, blocky, moderately indurated	2.0
Shale, red-brown, mottled greenish-gray, silty, weakly indurated	0.2
Siltstone, orange-brown, argillaceous; as above	1.0
Sandstone and siltstone, orange-brown, mottled greenish-gray, very fine-grained, thin-bedded; moderately indurated at top; eroding into a ledge	1.25
Siltstone, orange-brown, arenaceous, weakly indurated; mottled with greenish-gray spots	2.5
Siltstone, orange-brown, fine-grained, massive, blocky, well-indurated; mottled with greenish-gray spots; eroding into a ledge	0.5
Siltstone, orange-brown, mottled red-brown, argillaceous, blocky, moderately indurated; with many greenish-gray specks	6.5
Siltstone, orange-brown, very fine-grained, argillaceous, blocky, well-indurated; mottled with greenish-gray spots; eroding into a prominent ledge	1.0
Siltstone, orange-brown, argillaceous, weakly indurated; mottled with greenish-gray spots; with 6-inch greenish-gray zone at base; gradational into red-brown shale	3.25
(Section extrapolated to hill about 0.5 mile northwest of Bison, Garfield County, in NW¼ sec. 24, T. 20 N., R. 7 W.)	
Unit 2:	
Sandstone, orange-brown, mottled greenish-gray, silty, calcitic, thinly laminated, weakly indurated; capping hill	12.75
Sandstone, light greenish-gray, mottled orange-brown, silty, platy, thin-bedded, moderately indurated; with many ripple marks;	

	Thickness (feet)
eroding into a ledge	0.5
Siltstone and sandstone, orange-brown, very fine-grained, argillaceous, mottled greenish-gray, weakly indurated	3.2
Siltstone, light greenish-gray, mottled orange-brown, argillaceous, platy, weakly indurated	2.5
Unnamed Beds:	
Shale, red-brown, silty, blocky, weakly indurated	20.0
Sandstone, light greenish-gray, very fine-grained, silty, well-indurated; eroding into a ledge; section extrapolated to 1 mile northwest of Hennessey, in SE¼ sec. 14, T. 19 N., R. 7 W.	0.2
Shale, red-brown, silty, blocky, weakly indurated	2.5
Siltstone, light greenish-gray, mottled red-brown, friable, weakly indurated	0.4
Shale, dark red-brown, silty, platy, weakly indurated; gradational into siltstone	1.5
Sandstone, light greenish-gray, very fine-grained, well-indurated; argillaceous in top part	9.0
(*Section extrapolated to quarry 0.5 mile west of Hennessey, Kingfisher County, in SE¼ sec. 23, T. 19 N., R. 7 W., including the type locality for the Hennessey Formation*)	
Sandstone, red-brown, fine-grained, silty, thinly laminated, cross-bedded, platy, well-indurated; eroding into a ledge	0.3
Shale, red-brown, silty, blocky, weakly indurated	0.5
Sandstone, red-brown; as above; eroding into a ledge	0.25
Shale, red-brown, weakly indurated; as above	0.2
Unit 1:	
Sandstone and siltstone, light greenish-gray, very fine-grained, thin-bedded, weakly indurated; mottled orange brown at top	3.0
Bison Member: (exposed thickness, 64 feet)	
Shale, dark red-brown, silty, platy, thinly laminated, weakly indurated, arenaceous in upper part	2.75
Shale, light red-brown to orange-brown, silty, blocky, weakly indurated; with many greenish-gray spots and layers	11.0
Siltstone, light greenish-gray, mottled orange-brown, thin-bedded, platy, moderately indurated; eroding into a ledge	1.25
Shale, red-brown, silty, blocky, weakly indurated	0.25
Siltstone, orange-brown, argillaceous, platy, moderately indurated; with interbedded red-brown shale	1.0
Shale, red-brown, silty, blocky, weakly indurated; with a thin greenish-gray siltstone bed in middle	2.5
Siltstone, orange-brown, micaceous, arenaceous, well-indurated; eroding into a ledge	0.75
Siltstone, light greenish-gray, thinly laminated, weakly indurated	0.6
Shale, dark red-brown, silty, blocky, weakly indurated	0.2
Siltstone, orange-brown, argillaceous, platy, weakly indurated	1.3
Shale, red-brown, silty, blocky, weakly indurated; with some paper-thin siltstone and calcitic layers	12.25
Siltstone, orange-brown, argillaceous, blocky; mottled greenish gray at top; well indurated at base	1.0
Shale, red-brown, silty, blocky; mottled with many greenish-gray specks	6.25
Siltstone, greenish-gray and orange-brown, argillaceous, platy, weakly indurated	0.5
Shale, red-brown, silty, blocky, weakly indurated; with some greenish-gray spots	7.0
Siltstone, greenish-gray and orange-brown, platy, weakly indurated	0.75
Shale, red-brown, silty, blocky, weakly indurated	3.1
Siltstone, orange-brown, argillaceous, blocky, moderately indurated; eroding into a ledge	0.25
Shale, red-brown to orange-brown, silty, blocky, weakly indurated; with some small greenish-gray specks	4.2
Siltstone, orange-brown, argillaceous, platy, moderately indurated; with many greenish-gray spots at top	2.0
Shale, red-brown; as above; exposed in creek	5.0

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(*Italic number* indicates main reference)

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