OKLAHOMA GEOLOGICAL SURVEY

Chas. N. Gould, Director

Bulletin No. 49

DOLOMITES OF WESTERN OKLAHOMA

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NORMAN

January, 1930

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DOLOMITES OF WESTERN OKLAHOMA

ACKNOWLEDGMENTS

The following work on the Permian dolomites of western Oklahoma was made possible by the co-operation of the Oklahoma Geological Survey, enabling the writer to spend over two months in the field during the summer of 1928. The Survey has subsequently given all possible aid in the preparation of this report. The writer is particularly indebted to Dr. Chas. N. Gould, director, who was the first geologist to make any detailed observations in the region concerned. Mr. John S. Redfield, assistant geologist, has also been very helpful and thanks are due for many favors.

Mr. G. D. Putnam, of the Trees Oil Company, Wichita, Kansas, has been of great assistance. Mr. Putnam has been working independently on the stratigraphy of the Day Creek, in his spare time, and has freely given much unpublished information including preliminary maps, which are included in this report, with only minor changes. Without these maps it would have been impossible to cover all of the region, even in a preliminary way. It is hoped that their appearance will not detract in any way from Mr. Putnam's finished work. It should be distinctly understood that they do not represent his final results.

The laboratory work in connection with the study of the dolomites has been conducted in the mineralogical laboratories of the Department of Geology, Stanford University. The writer is particularly indebted to Dr. A. F. Rogers in this connection. A large number of thin sections, obtained through his courtesy, have been particularly important in this study.

Five new analyses included in this report are due to Monsieur A. Rouma, Bruxelles-Jette, Belgium. All the samples were carefully picked to exclude any detectable secondary calcite.

Two papers have been especially helpful in the preparation of this report and it has been found necessary to refer to them frequently. These are the Geology and Water Resources of Oklahoma, U. S. Geol. Survey, Water-Supply Paper 148 (1905) by Gould, and the Gypsum and Salt of Oklahoma, Okla. Geol. Survey, Bull. 11 (1913), by Snider. Circular 13, Okla. Geol. Survey, The Permian of Western Oklahoma and the Panhandle of Texas (1926), by Gould and Lewis, has also been very useful as well as Bull. 40-Y, Geology of Harmon, Greer, Jackson and Tillman counties by Clifton.

INTRODUCTION

Thin dolomite members were noted in the Permian red beds of western Oklahoma by the earliest investigators. Being by far the hardest rocks in a series of rather soft sandstones, shales and gypsums, they commanded attention at once, not only because prominently exposed, but also because they provided quite definite stratigraphic horizons in an exceedingly irregular and little understood system. For many years the meagre information given by early workers was accepted with little modification or addition, partly because the region was not attractive to economic geologists, and the discovery of rich oil fields in other parts of the State commanded more urgent attention. It is the purpose of this report to present what is already known about these dolomites and to add thereto the results of over two months observation in the field during 1928 and of a subsequent petrographic study which the writer has made of material collected.

Although this paper is fairly comprehensive, most of the districts are very summarily considered. The Blaine dolomites of the southwestern part of the State were most thoroughly studied and considerable attention was also given the Weatherford district, but on the whole, the study of these formations is only a preliminary one. However, it has been the writer's aim to include everything in the literature of western Oklahoma which has a bearing on the study of the dolomites, as well as his own observations. It is sincerely hoped that the paper will enable some future worker, even though unfamiliar with the field, to take up the study where the writer has stopped—a study which will undoubtedly lead to a clearer understanding of the Permian system of this region.

DEFINITION OF TERM

In this paper the term dolomite is used in two senses. First, it is used as a petrographic name for those rocks predominantly made up of the mineral dolomite with various minor impurities, and also the closely associated local phases of the same member which appear to be largely calcite. As a mineral name, it is applied to those carbonates which are only slightly or not at all stained by Lemberg's[1] solution, and which are slowly soluble in cold dilute hydrochloric acid but rapidly soluble in warm acid.

No attempt will be made to discuss the question of the composition of the mineral or the limits of magnesium content within which the name is properly applied. Ideally, it will be considered a definite double salt of calcium and magnesium with the latter capable of being replaced by iron, $Ca(Mg, Fe)(CO_3)_2$.

1. Lemberg, J.,—Zeitschr. Deutsch. Geol. Gesell: vol. 40, p. 357, 1888.
Steidtman, E.,—Origin of dolomite as disclosed by stains and other methods: Bull. Geol. Soc. America, vol. 28, pp. 431-450, 1924.

DISTRIBUTION OF DOLOMITES

The dolomites are found within a comparatively narrow, but almost continuous belt, which extends from southern Kansas between the 90th and 100th meridian in a general southeasterly direction across western Oklahoma to northern Washita, Caddo and Canadian counties (see fig. 1). Some ten to twenty miles farther south, dolomite may again be found north of the Wichita Mountains, in Kiowa County, and traced around their western extremity and thence south to Red River.

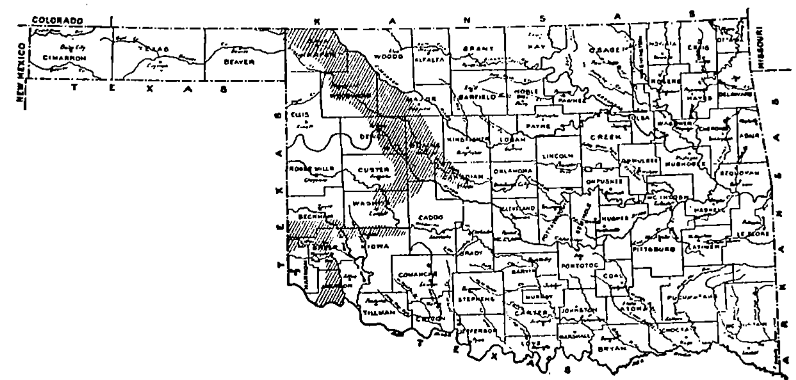


Figure 1.—Index map of Oklahoma showing general distribution of the dolomites.

METHODS OF EXAMINATION

The stratigraphic relations and occurrence of a large part of the dolomites have been intensively studied during the last few years by several economic geologists in search of favorable structures for oil. Since the general results of their work will probably be published, this work while intended to be fairly comprehensive, will deal more particularly with the petrographic character of the dolomites, a phase of study which appears to have been neglected.

The dolomites of one area were mapped in detail and general field data obtained from the whole region. It is very much regretted that neither time nor money was available to procure more chemical analyses, a necessary and important aid to a complete study of these rocks. However, a large number of hand specimens and thin sections were profitably examined. The well-known Lemberg's solution proved to be an indispensable aid, both in the examination of fragments and of thin sections. It was not found necessary to dilute the stain as Steidtman[2] suggested.

2. Steidtman, E.,—Origin of dolomite as disclosed by stains and other methods: Bull. Geol. Soc. America, vol. 28, pp. 431-450, 1924.

In examining fragments, only those between 15 and 30 mesh were examined. A small portion was treated with stain for three minutes, then carefully washed, dried at a low heat, and examined with a binocular microscope. Experience has shown that care must be exercised in the use of this test for dolomite, the influence of porosity and size of grain being prominent. Coarsely crystalline calcite will hardly take any stain while a rather common type of finely porous, fine-grained dolomite almost invariably will take a light lilac stain. For purposes of comparison, it is important that all samples be treated for the same length of time, and that the fragments be the same size.

It has been found very useful to test a portion of the same sized sample with a standard solution of cold dilute hydrochloric acid. Contrary to common teaching, practically all the dolomites examined effervesce at once. In the case of the very fine grained dense ones, however, a lens is usually necessary to notice it. The more porous ones may effervesce very violently but usually take a few seconds to start, whereas calcite effervesces with larger bubbles and at once.

The main difficulties were found when intimate mixtures of the two carbonates were present. The two can commonly be plainly differentiated by examining stained fragments with a medium-power binocular microscope. Usually the per cent calcite can be estimated with sufficient accuracy by a count of grains.[3]

In several instances, however, no information could be gained by examination of fragments, and it was necessary to resort to thin sections.

Thin sections are best stained when made and before a cover glass is put on, as it is almost impossible to remove the cover glass and grind a new surface without destroying the section. Whereas fragments are sufficiently stained in three minutes, sections are best stained for fifteen to twenty minutes. Almost invariably the structure of calcite and dolomite can be clearly seen by examining the section with binoculars on a white background, but is not easily made out with the polarizing microscope and transmitted light. This was quite satisfactorily overcome by raising the section above the stage slightly, holding one end of the slide tightly on the upper side of a second glass slide and at right angles to it, which leaves room to slip a white card under the thin section and remove it at will, without losing sight of even minute grains.

The examination of fragments containing both calcite and dolomite with acid may be misleading. The presence of dolomite may be suspected if the effervescence dies down somewhat in a few seconds and is renewed on warming. Also the acid may be washed off when the carbonate is partly dissolved and the residue stained.

3. Decker, Charles E., and Merritt, Clifford A.,—Physical characteristics of the Arbuckle limestone: Oklahoma Geol. Survey, Circular 15, p. 47, 1928.

The great majority of the dolomites are more or less porous, the pores commonly containing a small amount of calcite. This fact, together with the effect of texture on the action of acid, renders the time-honored test of putting a drop of acid on the hand specimen all but valueless. It has been the writer's experience that the composition of many of the types of carbonate rock found in this region cannot be defined without more or less detailed examination. Many specimens collected as dolomite turned out to be calcite, while not a few, thought to be partly or wholly calcite, were found to be exceptionally pure dolomite.

PHYSIOGRAPHY AND GEOLOGY OF THE DOLOMITE REGION

Since the area in which the dolomites are found stretches for a distance of nearly 200 miles across the entire western end of the State, it will be necessary to describe this region in a general way.

TOPOGRAPHY

As a whole this part of western Oklahoma is a plain with a regional slope to the southeast. The plain is underlain by sedimentary rocks with a very low dip to the west, a feature which is expressed in a series of low escarpments, due to the resistance to erosion of the harder members. By far the most prominent of these escarpments is formed by the Blaine gypsums and associated dolomites and may be traced almost continuously across the State from Kansas to Texas. It is often considered a separate physiographic unit separating that of the Low Plains to the east from the High Plains to the west.[4] The relief along this escarpment is rarely over 200 feet, locally fading out altogether. The region is known as the "Gypsum Hills region" or more locally as the "Gyp Hills" or "the Breaks." Another physiographic unit which cannot escape notice is that of the Wichita Mountains in the southwestern part of the State. They are the eroded peaks of a range of igneous mountains once covered with sediments, now partially uncovered and sticking up through the sedimentary cover to a height of as much as 1,200 feet[5].

Closely associated with the Blaine escarpment in the northern part of the State is that produced by the Day Creek dolomite and the Whitehorse sandstone. In the central-western part a less definite escarpment is produced by the so-called "second line of gypsum hills",[6] particu-

4. Gould, Chas N.,—The geology and water resources of Oklahoma: U. S. Geol. Survey, Water-Supply Paper 148, p. 14, 1905.
Snider, L. C.,—Geography of Oklahoma: Oklahoma Geol. Survey, Bull. 27, pp. 82-92, 1917.
Fenneman, N. M.,—Physiographic provinces and sections in western Oklahoma and adjacent parts of Texas: U. S. Geol. Survey, Bull. 730, pp. 103-115, 1922.
5. Taff, Joseph A.,—Preliminary report on the geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma: U. S. Geol. Survey, Prof. Paper 31, 1904.
6. Snider, L. C.,—The gypsum and salt of Oklahoma: Oklahoma Geol. Survey, Bull. 11, pp. 127-175, 1913.

larly in Custer, Caddo, and Washita counties. Along these three escarpments are found practically all the Permian dolomites of the State.

DRAINAGE

Five major rivers are encountered in studying the dolomites of this region. From north to south these are the Cimarron, North Canadian, Canadian or South Canadian, Washita, and Red rivers. All of these flow in an easterly and southeasterly direction in the western half of the State. North Fork of Red river is also an important drainage channel, originating in the central Panhandle of Texas, flowing east into Oklahoma and then south along the west side of the Wichita Mountains to join Red River.

On the whole these rivers carry a small amount of water in proportion to the size of their valleys which are very broad in most places, and choked with sand. Dunes are commonly found along the north shores where the sand is blown from the river bottom during the dry weather by the prevailing southwest winds. The rivers are subject to violent floods, but most of the time are very shallow streams, following a meandering or braided course over broad flat bottoms.

The Washita River is an exception to the above, having steep mud banks, with no sand hills.

Solid rocks are not commonly exposed near the main streams, particularly on the north shores, but are more often found along the numerous short tributaries, the headwaters of which ordinarily form steep-sided canyons in the harder members.

A much more detailed description of the drainage of this region has been given by Gould[7] and also by Snider.[8]

HISTORY OF GEOLOGICAL WORK

As previously intimated, the dolomites are found entirely in rocks of Permian age. These are part of a larger belt, the well-known red beds, extending from southwestern Kansas to western Texas, and including most of the western half of Oklahoma. About the very earliest mention of the red beds was by C. G. Shumard in 1852. In the early days these beds were variously considered to be Upper Carboniferous, Permian, Cretaceous or Triassic, and until some indicative fossils were found, no agreement was reached. G. C. Swallow was the first to mention Permian fossils, in February, 1858.[9]

7. Op. cit. pp. 69-94.
8. Op. cit. pp. 102-105.
9. Prosser, Charles S.,—Classification of the Upper Paleozoic rocks of central Kansas: Jour. Geol., vol. 13, pp. 682-705, and 764-796, 1895.

STRATIGRAPHY AND AREAL GEOLOGY

The following table gives the age and character of the surface rocks in western Oklahoma. The Permian section is adopted from that of Gould and Lewis.

Stratigraphy of the Dolomite Region

QUATERNARY — Dune sand, terrace deposits, and alluvium.

TERTIARY — Mantle of sand, gravel, clay, conglomerate and caliche.

CRETACEOUS — Isolated outliers.

PERMIAN —

QUARTERMASTER—300 feet or more of red cross-bedded sandstone with some clay or shale.

WOODWARD GROUP:
- CLOUD CHIEF—60 feet of hard pink to white dolomite.
- DAY CREEK—A few feet of hard pink to white dolomite.
- WHITEHORSE—100 feet or more of soft red sandstone.
- DOG CREEK—As much as 500 feet of red sandy shale.

BLAINE—50 to 200 feet of massive white gypsum with interbedded red to gray arenaceous clays or shaly rock and dolomite.

ENID GROUP:
- CHICKASHA—275 to 350 feet of red shale with some limestone or gypsum.
- DUNCAN—100 to 250 feet of red sandstone.
- CLEAR FORK {Hennessey, Garber} and WICHITA {Wellington, Stillwater} — Shales and sandstones

PRE-CAMBRIAN —Granite, granite porphyry, and gabbro of the Wichita Mountains.

For a comprehensive summary of the early work on the red beds and the discussion of their age, the reader is referred to the writings of Peede.[10]

The earliest comprehensive work of any importance in western Oklahoma was done by Chas. N. Gould. The results are contained in Water-Supply Paper, 148, U. S. Geol. Survey (1905), and partly in somewhat earlier publications.[11] For many years after this very little was added to our knowledge of the Oklahoma red beds. In 1918 oil was discovered in the Permain of Potter County in the Texas Panhandle and interest in the red beds was greatly stimulated. However, nothing of importance was published with regard to the Oklahoma beds until 1924 when the great structural trough in the southwestern part of the State, the Anadarko basin,[12] was first outlined and the previous correlation of the gypsum beds radically changed. Our undertanding of the geology of western Oklahoma previous to this has been well summarized by Snider[13] in a readily accessible publication. A more brief statement of the same, together with the results of later work up to the spring of 1926, has been admirably given by Gould and Lewis.[14]

The distribution of the Permian formations may be gathered from the accompanying map (fig. 2) reproduced from the paper by Gould and Lewis.[15] A more detailed conception of the geology of western Oklahoma may be gained from the map of the State by H. D. Miser.[16]

For a discussion of the correlation of these formations with those of Kansas and Texas, the reader is referred to the articles by Gould and Lewis and Gould and Willis.[17]

The sandstones and shales of this region are, almost without exception, very friable, lenticular, and commonly show marked lateral gradation and cross-bedding. The sand grains on the whole are very small and rounded. The color varies from vermilion to maroon or very deep

10. Beede, J. W.,—Invertebrate paleontology of the upper Permian beds of Oklahoma and the Panhandle of Texas: Kansas Univ. Sc. Bull., vol. 4, no. 3 pp. 116-171, 1907.
11. Gould, Chas. N.,—Oklahoma gypsum; Second Bien. Rept. Oklahoma Dept. Geol. and Natural Hist., pp. 75-137. Also, General geology of Oklahoma: pp. 17-74, 1902.
———, —Gypsum deposits in Oklahoma: U. S. Geol. Survey, Bull. 223, pp. 60-67, 1904.
12. This basin was briefly described as the "Washita syncline" by J. V. Howell: Some structural features in the accumulation of oil in southwestern Oklahoma: Econ. Geol., vol. 17, no. 1, pp. 15-33, 1922.
Also see Gould, Chas. N.,—A new classification of the Permian red beds of Oklahoma: Bull. Am. Assoc. Pet. Geol., vol. 8, no. 3, pp. 322-341, 1924.
13. Op. Cit. ch. iv.
14. Gould, Chas. N.,and Lewis, Frank E.,—The Permian of western Oklahoma and the Panhandle of Texas: Oklahoma Geol. Survey, Circ. 13, 1926.
15. Op. cit.
16. Miser, H. D., Geol. map of Oklahoma, 1926.
17. Gould, Chas. N., and Willis, Robin,—Tentative correlation of the Permian formations of the southern Great Plains: Bull. Geol. Soc. America, vol. 38, pp. 431-442, 1927.

THE PERMIAN OF WESTERN OKLAHOMA AND THE PANHANDLE OF TEXAS

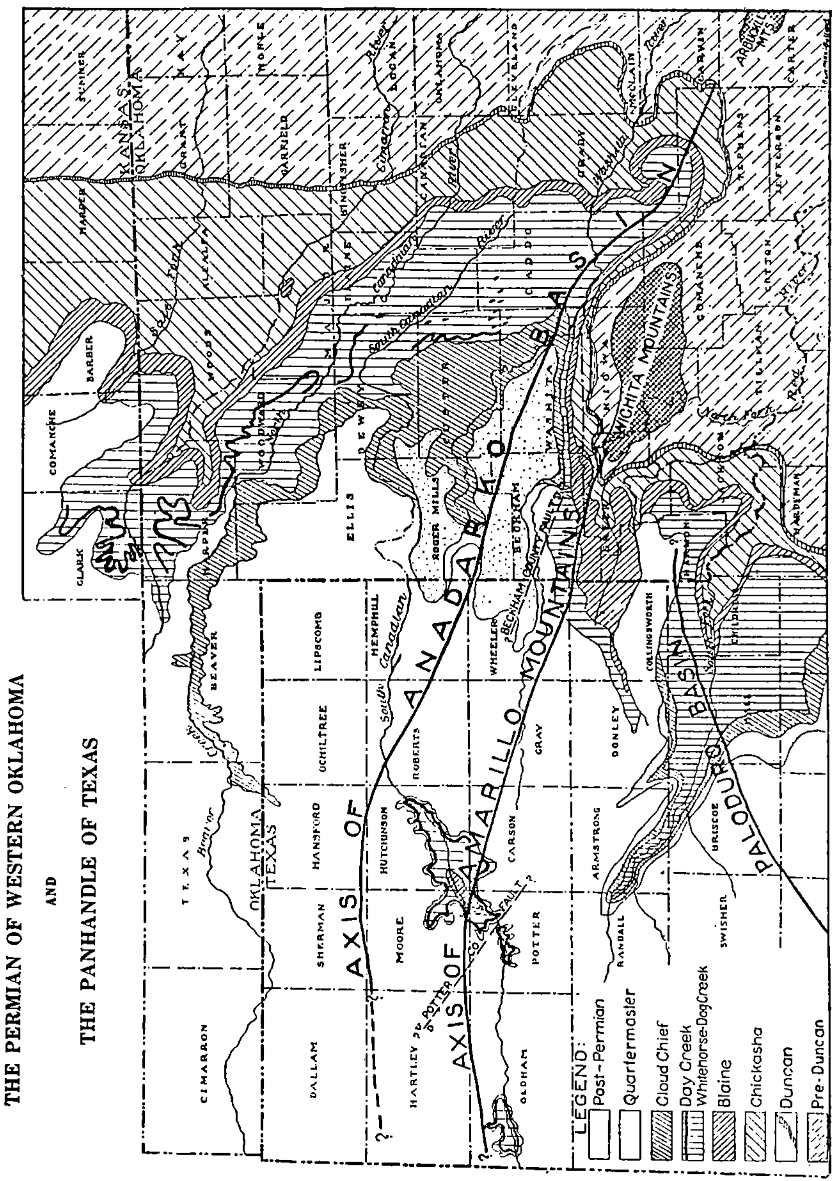


Figure 2

reddish-brown, often within short distances. The color is due to iron oxide (possibly turyite), or iron-stained silt, which for the most part, adheres to the surface of the sand grains. The very bright colors indicate that clay minerals are largely absent. The sandstones and shales associated with the gypsums are commonly light greenish- to bluish-gray.

Since fossils are almost entirely absent in these rocks, and slumping is very prevalent, the dolomites and massive gypsum members are exceedingly important as horizon markers, being practically the only hard ledges to be found on the surface and the only ones which can be traced with any ease from place to place.

In a study of the dolomites of this region, one is directly concerned only with the formations from the Quartermaster to the Blaine inclusive. Of these the Day Creek and the Blaine contain nearly all the dolomite. They will be described in detail later, only a short reference being made to them at this point. The other formations will be more fully discussed.

BLAINE FORMATION

The Blaine gypsum is one of the most persistent and wide-spread formations of the American red beds. It may be traced fairly continuously on the surface from Barber County, Kansas, across Oklahoma for over 600 miles to the Colorado River in Texas. It is typically exposed in Blaine County, Oklahoma, where it is about 200 feet thick and consists of three massive gypsum members in a series of red clay shales. This formation was named by Gould.[18]

The Blaine formation in Oklahoma may be divided into two areas, the northern area which may be traced on the surface from Kansas southward to a point near El Reno in Canadian County, and the southwestern area covering parts of Beckham, Kiowa, Greer, Harmon, and Jackson counties in the southwestern corner of the State. The beds are thought to extend across the intervening region,[19] but are certainly most difficult to trace on the surface.

For many years the somewhat isolated but prominent gypsums of the southwestern area were assigned to the Greer formation and were thought to be equivalent to what is now known as the Cloud Chief, well exposed near Weatherford. These were known respectively as the western and eastern areas of the Greer formation.

In 1920 Greene[20] suggested that the western area of the Greer

18. Gould, Chas. N.,—Oklahoma gypsum; Second Bien. Rept. Oklahoma Dept. Geol. and Natural Hist., pp. 75-137. Also, General geology of Oklahoma: pp. 17-74. 1902.
19. Gould, Chas. N.,—A new classification of the Permian red beds of Oklahoma: Bull. Am. Assoc. Pet. Geol., vol. 8, no. 3, pp. 322-341, 1924.
20. Greene, F. C.—Oklahoma's stratigraphic problem: Oil and Gas Journal, vol. 18, no. 49, pp. 54-56, 1920.

might be the Blaine formation, a fact definitely established in 1924, the name "Greer formation" being discarded.

The distribution of the Blaine formation will be described in detail later.

DOG CREEK

This formation was originally described by Cragin[21] and named from Dog or Monument Creek in Barber County, Kansas. Part of his original description follows.

> The Dog Creek * * * consists of some thirty feet, or locally of a less or greater thickness of dull-red argillaceous shales, with laminae of gypsum in the basal part and one or two ledges of unevenly lithified dolomite in the upper * * *. The dolomite varies from light-gray to dark-gray, and clay-impregnated portions may partake of the red color of the including shales. In lithological character, it varies from solid stone which serves a fair purpose as a building-stone for the rougher uses, to that which is so contaminated with clay as to be soft and worthless. It is often cellular or cancellated * * *

In a later paper,[22] Cragin wrote as follows:

> * * * In central Oklahoma it is a great dolomite formation, laminated dolomites occupying a considerable part of its thickness. It is well displayed at the eastern border of the Cimarron-North Canadian Jack sands of Blaine County, particularly so in Chapman's amphitheatre at the head of Salt creek, where it presents a thickness of apparently not less than 100 feet. At this locality a large body of light gray laminated dolomites forms its upper or Chapman member, its middle and lower parts consisting chiefly of dull red shales with laminae and one laminae-built amphitheatre ledge of dolomite. The amphitheatre forms a sort of terrace, or low secondary brow, below the middle of the formation. At the Stony hills, east of Watonga, the thickness of the Dog Creek is at least equal to that shown at the head of Salt Creek and the bodies of thin-bedded to laminated dolomite are similar to those seen at that locality, though perhaps containing some thicker courses and developed more at the expense of the shale * * *.

Professor Cragin plainly fell into error here as the Dog Creek is not a great dolomite formation in any part of Oklahoma, and the dolomites described as the Chapman and Amphitheatre members as well as those of the Stony hills are undoubtedly those of the Blaine formation as it is now recognized.

Gould[23] has added to the above description as follows:

21. Cragin, F. W.—The Permian system in Kansas: Colorado College Studies, vol. VI, 1896.
22. Cragin, F. W.,—Observations on the Cimarron series: The American Geologist, vol. 19, pp. 351-363, 1897.
23. Gould, Chas. N.,—The geology and water resources of Oklahoma: U. S. Geol. Survey, Water-Supply Paper 148, 1905.

> * * * the thickness of the Dog Creek is much greater than that given by Professor Cragin. Near Quinlan, in eastern Woodward County, the aneroid readings indicate 225 feet as the thickness of these beds, measured from the top of the underlying gypsums of the Blaine formation to the sandstone of the next higher formation of this member, the Whitehorse, and in a number of localities 150 and 175 feet were recorded. Exposures are common along the top of the Gypsum Hills from Canadian County to the Kansas line and beyond.

The thickness of the Dog Creek in Blaine and adjoining counties is now believed to be as much as 400 to 500 feet.

An unusual phase of the Dog Creek known as the Verden or Channel sandstone has been described by Reed and Meland.[24]

While the writer did not explore the Dog Creek areas for possible dolomite, only one doubtful case of it was observed. Along the Washita-Kiowa County line and some 25 feet above the Blaine dolomite a very thin light gray carbonate member was observed, notably in the northwest corner of sec. 9, T. 7 N., R. 19 W. What appears to be the same rock may be noticed in Dog Creek(?) shale a little farther north in Washita County. It is probable that this is the same rock which may be seen in very small patches in the soils of the level plain southwest of Mangum and in other places over the Blaine of the southwestern area.

WHITEHORSE

This formation was originally described by Cragin[25] as the Red Bluff beds, named after a former post office near the Clark-Comanche County line in Kansas. The name was later changed to Whitehorse by Gould, from Whitehorse Springs in northwestern Woods County, the previous name being pre-occupied.

Cragin described this sandstone as follows:

> This formation consists of some 175 or 200 feet of light-red sandstones and shales * * *. Viewed as a whole, it is very irregularly stratified, the component beds, while consisting of nearly parallel laminae being in some cases considerably inclined, in others curved, and this oblique and irregular bedding, being on a much larger scale than that of ordinary cross-bedding, at first glance gives the impression of dips, anticlines and synclines that have been produced by lateral pressure, the dips being, however, in various directions * * *. The Red Bluff beds exhibit the most intense coloration of any of the rocks of the Cimarron series * * *. A marked characteristic of most of these sandstones is their unusually fine texture * * *.

24. Reed, R. D., and Meland, Norman,—The Verden sandstone: Jour. Geol., vol. 32, pp. 150-167, 1924.
25. Op. cit., p. 40.

Gould[26] added to this description as follows:

> In Oklahoma the Whitehorse member often weathers into conspicuous buttes and mesas. For instance, in eastern Woodward and western Woods counties a row of these buttes, which rise 100 to 200 feet above the surrounding country, extends from the vicinity of Whitehorse Springs, whence the name, southwest across the Cimarron, to the high divides beyond * * *. The noted Red Hill, between Watonga and Geary in southern Blaine County is composed chiefly of the Whitehorse formation. South of South Canadian River this sandstone thickens and on weathering often forms conspicuous bluffs, such as the famous Caddo County Buttes, southwest of Bridgeport * * *. Ledges which probably belong to the same general horizon outcrop north of the Wichita Mountains in the vicinity of Hobart and Harrison, and it is not impossible that further studies may demonstrate that the same beds extend under the upper gypsums across Greer County.

It has, of course, been shown in more recent years that the beds in the locality last mentioned are considerably above the gypsums of Greer County and dip toward the north.

The Whitehorse of Kansas, Oklahoma, and Texas, has been recently described by Clifton[27] who gives a map of the formation. In Oklahoma it may be traced from Clark County, Kansas, southeastward to northern Stephens County, Oklahoma, and is found also as a thin fringe along the south side of the Anadarko Basin.

It is generally believed that there is a continuous unconformity at the base of the Whitehorse.

The occurrence of dolomites in this formation will be considered later along with the detailed discussion of the Day Creek.

DAY CREEK

The Day Creek dolomite is a persistent ledge of hard, white to pink dolomite under five feet in thickness, also first described by Professor Cragin from Clark County, Kansas.

There has been some discussion as to whether the Day Creek is at or near the top of the Whitehorse sandstone or represents the base of the Cloud Chief.

To the writer's knowledge, it has never been shown to be unconformable to the Whitehorse, and in some places it appears to be below its top. Evans[28] believes that the so-called Day Creek of the Weatherford district is as much as 60 feet below the top of the Whitehorse. The latter occurrence cannot be regarded as typical, however, and there does not appear to be any widespread concordance of opinion with

26. Op. cit., p. 56.
27. Clifton, R. L.,—Stratigraphy of the Whitehorse sandstone: Oil and Gas Jour., vol. 25, no. 2, p. 70, 1926.
28. Evans, Noel,—Stratigraphy of the Weatherford area, Oklahoma: Bull. Am. Assoc. Pet. Geol., vol. 12, no. 7, pp. 705-714, 1928.

regard to it. The writer prefers to regard the Day Creek as an independent formation or a member of the Whitehorse, but the question is of little importance in this discussion.

The Day Creek will be discussed in detail later.

CLOUD CHIEF

Until 1924, the Greer formation occupied the position now held by the Cloud Chief in the classification. At this time, it was recognized that the "western area of the Greer" was in fact the Blaine. Since the correctly placed part of the Greer, "the eastern area", did not occur near Greer County, it was renamed by Gould[29] after the small town of Cloud Chief in eastern Washita County close to which the gypsum is well exposed.

Part of the original description of this formation is as follows:[30]

> * * * The eastern area extends from the southern part of Woodward County southeast through Dewey, Custer, Washita, Caddo, and Comanche Counties into the Chickasaw Nation * * *. The rocks * * * are chiefly red clay shale, interstratified at several horizons with red sandstone and gypsums, which are, however, very irregularly bedded and can rarely be traced as continuous or definite ledges. Nevertheless the thickest ledge of gypsum known in the red beds is found in this area. Thus five miles northwest of Weatherford a ledge 60 feet thick was measured * * * in the vicinity of Cloud Chief beds 50 feet thick are not uncommon * * * But these beds are not constant, thickening rapidly or disappearing without apparent regularity * * * a section would usually not answer for a point half a mile away.

Gould[31] has described the formation more recently. Some interesting additional points are quoted:

> The Cloud Chief consists of ledges of massive gypsum embedded in red shales * * *
>
> * * * in some places, there are two beds separated by 15 to 20 feet of gypsiferous shale * * * In other localities three or more gypsums, separated by clay shales, outcrop on the surface.
>
> The maximum development of the gypsums of the Cloud Chief is along the axis of the Anadarko Basin in eastern Washita County where near Cloud Chief and Colony, ledges 100 feet thick have been measured on the surfaces * * *
>
> The Cloud Chief is exposed along the axis of the Anadarko Basin from a point about 6 miles south of Cement in southeastern Caddo County as far as eastern Washita County. The line of outcrop crosses the Washita River near Fort Cobb. Throughout this area, however, the exposures on the surface are not continuous, erosion having removed the Cloud Chief over considerable areas * * *
>
> In eastern Washita County the surface exposures of the Cloud Chief divide, one limb passing north, the other west, along the two sides of the Anadarko Basin. The northern limb continues across Washita, Custer, and Dewey counties as far as southern Woodward.

29. Op. cit., p. 35, 1924.
30. Gould, Chas. N.—op. cit., pp. 59-63, 1905.
31. Op. cit., pp. 337-339, 1924.

> The southern limb of the Cloud Chief passes west across southern Washita County, being exposed on the surface in a few scattered localities a few miles north of Rocky and Sentinel, and passes beneath the sandhills in southeastern Beckham County. It was the attempt to trace this gypsum bed across this region of few exposures and connect with the conspicuous gypsum ledges, now known to be Blaine, at Cedartop, that caused the confusion in the correlation of the red beds in this part of Oklahoma. Dr. Beede states that core-drilling in the Sentinel-Rocky country shows five distinct ledges of Cloud Chief gypsum interbedded with sandy shale * * *.

QUARTERMASTER

This sandstone formation was named by Gould in 1902. It occurs typically on Quartermaster Creek, Roger Mills County. It is the highest formation of the Oklahoma red beds, lying unconformably on the lower ones. Little has been added to our knowledge of this formation since Gould[32] described it in 1905 in part as follows:

> In the lower part of the formation the rocks are chiefly shales, typically red, but sometimes containing greenish bands and layers. The shales become more arenaceous above, and in places form a strong consolidated sandstone, which is rather thin-bedded and prone to break into small rectangular blocks, and weather queerly into long and narrow buttresses or rounded, conical or nipple-shaped mounds from 10 to 50 feet or more high. These mounds may be solitary but in some areas hundreds of them occur in a single quarter-section. The sandstone is further characterized by the marked and very peculiar dip of the rocks in certain directions * * *.
>
> Except where covered by younger rocks, the Quartermaster outcrops over practically all of Day and Roger Mills counties, and is also extensively developed in the western part of Dewey, Custer, and Washita counties * * *.

The question of the occurrence of dolomites in the Oklahoma Quartermaster will be considered in the discussion of the Weatherford area.

STRUCTURAL GEOLOGY

The general structure of the region in which the dolomites are found has already been indicated in one way or another. It remains only to sum it up in a little more detail.

In the northern half of the region the strata are flat-lying to the eye but have a low regional dip to the west or southwest. Locally, slumping may give the appearance of rather steep dips. Slight original flexures may also be present, found only by detailed mapping.

Just north of the Wichita Mountains and roughly parallel to their long axis (strike about 110 degrees), is the Anadarko Basin, a structural trough, the eastern end of which is not far west of the Arbuckle Moun-

32. Op. cit., p. 22.

tains and with its west end in the Texas Panhandle. The dips along the south side of the trough are steeper than those on the north. Greene's[33] map on the base of the Enid group shows a broad shallow syncline trending north from the Basin in western Oklahoma, and gives a good idea of the general structure.

In general the strata in the southwestern corner of the State dip away from the flanks of the Wichita Mountains at low angles, but are steeper close to the mountains.

Buried hills or mountains, the Amarillo Mountains, continue into Texas from the west end of the Wichita group and along the strike of their axis.

For further discussion of structure the reader is referred to the paper by Gould and Lewis[34] and also that of Greene cited above. Articles referring to minor structures have also have been written by Clifton[35] (1926 and 1928), Becker (1927), Kite (1927), Gouin (1927) and others.[36]

ECONOMIC GEOLOGY

A few remarks with respect to the economic aspects of the geology of the dolomite region may not be out of place at this point.

The problem of the water supply is undoubtedly the most important phase, as this will be of primary interest to those living in the country long after all the oil fields are discovered and exhausted. Some districts, notably those getting their water from the upper sandstones, have as good water as could be desired, but many are forced to use cistern water, due to the large mineral content of water which has passed through the gypsiferous or saline formations. Gould has written comprehensively on this subject.[37]

The possibilities of the enormous gypsum deposits of this region have long been realized and they have been exploited to a greater or less extent for many years. While the industry cannot be said to have become a major one, yet the deposits are one of the world's greatest and will be of increasing importance. Snider[38] has written at length on these deposits.

33. Greene, F. C.,—Subsurface stratigraphy of western Oklahoma: Oklahoma Geol. Survey, Bull. 40-D, 1926.
34. Op. cit.
35. Clifton, R. L.—op. cit., and Oil and gas geology of Harmon, Greer, Jackson, and Tillman counties: Oklahoma Geol. Survey, Bull. 40-Y, 1928.
36. Becker, Clyde M.,—Oil and gas geology of Caddo and Grady counties: Oklahoma Geol. Survey, Bull. 40-I, 1927.
Kite, W. C.—Oil and gas geology of Kingfisher and Canadian counties: Oklahoma Geol. Survey, Bull. 40-O, 1927.
Gouin, Frank,—Geology of Beckham county: Oklahoma Geol. Survey, Bull. 40-M, 1927.
37. Op. cit., 1905.
38. Snider, L. C.,—The gypsum and salt of Oklahoma: Oklahoma Geol. Survey, Bull. 11, 1913.

The possibility of securing oil from the red beds was not seriously considered for many years. More recently, however, the region discussed has been rather thoroughly looked over for possible oil structures with quite encouraging results, although no great field has yet been discovered. The Sayre oil field in Beckham County had the only producing wells in the region visited in 1928. However, the important oil and gas fields of Caddo and Grady counties[39] are hardly outside the region to be covered in the study of the dolomites.

The granites of the Wichita Mountains are extensively used as monumental and structural material and also for road metal.[40] Certain sandstones have been used in the past as building stone, and the dolomites have considerable local importance as a structural material.

From the foregoing description of the geology, it will be seen that the dolomites belong to two distinct formations, the Day Creek and the Blaine. This furnishes a natural basis for the division of the dolomites for the purpose of description and discussion. It is true that parts of what were originally regarded as Day Creek have been rather recently shown to be at somewhat different horizons, but they can be most conveniently treated along with it.

THE DOLOMITES OF THE BLAINE FORMATION

DIVISION OF THE BLAINE

As previously mentioned, the surface exposures of the Blaine formation may be divided into two areas, that south of the Anadarko Basin and in the extreme southwest corner of the State, the southwestern area, and that from El Reno north to the Kansas line, the northern area.

Not only are these areas separated by a section of country in which outcrops are lacking or poor, but the stratigraphy is quite different as to succession of beds and amount of dolomite present. The character and general appearance of the formation is very much the same in both, however.

Since the Blaine is so definitely divided the two areas will be considered separately.

THE SOUTHWESTERN AREA

GENERAL DESCRIPTION

Here the dolomites found in Jackson, Greer, Harmon, and Beckham counties, the southwestern area of Snider, and in addition those found in a strip roughly parallel to the boundary between Washita and

39. Becker, Clyde M.,—Op. cit., 1927.
40. Taylor, C. H.,—Granites of Oklahoma: Oklahoma Geol. Survey, Bull. 20, p. 31 et seq., 1915.

Kiowa counties, will be discussed. Figure 3 is a map of Oklahoma west of the Indian Meridian showing the area covered in mapping these dolomites.

POSITION AND TOPOGRAPHY OF THE GYPSUM HILLS

The region immediately concerned is that of the Gypsum Hills, the east-facing escarpment of varying relief, up to about 200 feet, which may be traced from Red River west of Salt Fork in a general northerly direction, almost to the village of Delhi, or about seven miles south of Sayre. The escarpment is rather deeply embayed by several streams, notably Boggy Creek, Turkey Creek, Salt Fork, Elm Fork, and Haystack Creek (see fig. 4). The Gypsum Hills separate

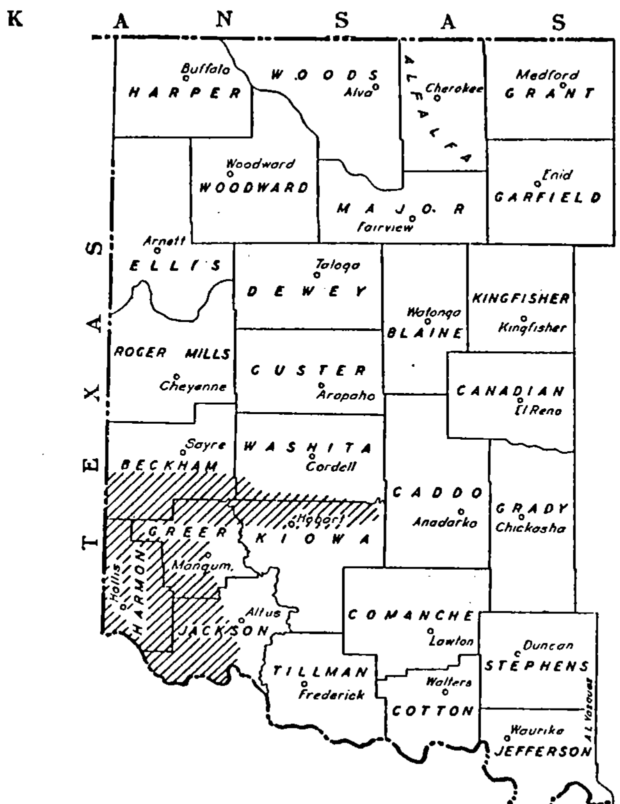


Figure 3.—Map of southwestern area of this report.

the higher, flat to rolling country to the west, the high plains, from the lower, predominantly flat country to the east, the low plains.

To the above must be added a narrow strip of country along the boundary between Washita and Kiowa counties between North Fork on the west and the Washita River on the east. Here is found a series of low ridges and buttes with predominantly flat land both north and south. The western extension of this strip, for about ten miles in southeastern Beckham County is a very prominent gypsum escarpment along the north side of North Fork of Red River.

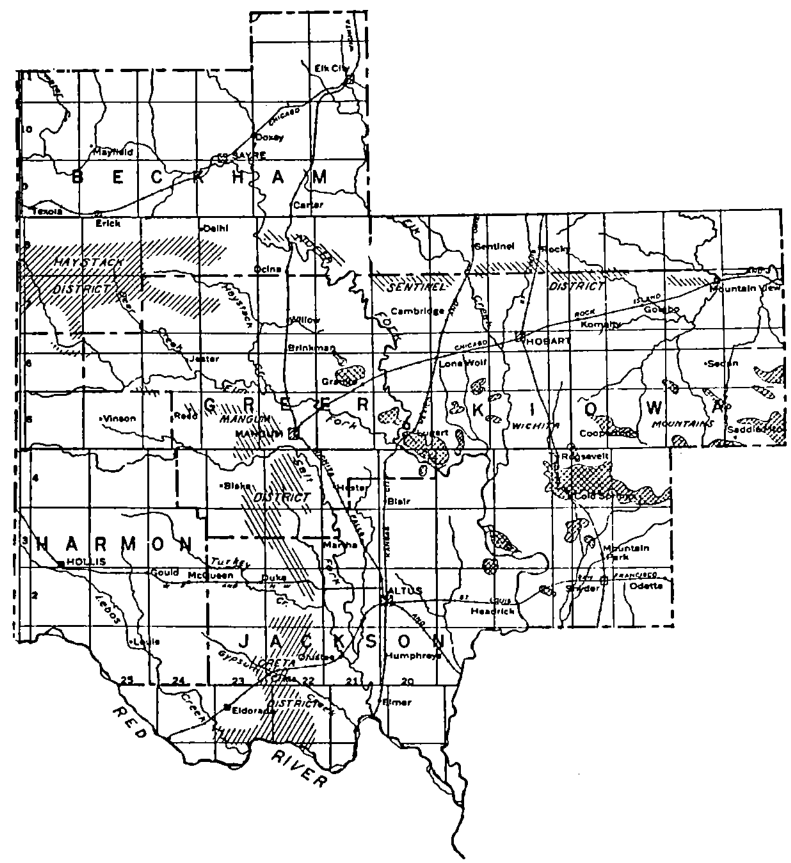


Figure 4.—Distribution of dolomites in the southwestern area.

DRAINAGE

The area under consideration is drained by Red River and its tributaries, Salt Fork and North Fork and by Elm Creek, the main tributary of North Fork. The creeks into the Washita River also drain a small portion. On the whole, the drainage is toward the southeast.

STRATIGRAPHY

In a general way the geology of this southwestern area has been discussed before and will be mentioned later in connection with the various districts described. A somewhat more particular discussion of the Blaine formation of the southwestern area is necessary at this point.

It has been previously explained how the gypsums of this area were known for many years as the "western area" of the Greer formation and were correlated with the "eastern area," which is at a higher horizon than the typical Blaine of the northwestern part of the State. When the true position of the gypsums of the southwest as equivalent to the Blaine was shown[41] the gypsum of the "eastern area" became known as the Cloud Chief.

The general stratigraphy of the gypsums was described in some detail by Gould as early as 1905. At this time the occurrence north of the North Fork, now in southeastern Beckham County, was regarded as a connecting link between the western and the eastern areas of the Greer. Of this exposure, and the various members of the gypsum series in the southwestern area, Gould said as follows:

> This is, perhaps the finest exposure in Oklahoma, the gypsum members, here appearing in four separate ledges, having a thickness of 75 feet. The river cuts through the formation west of these bluffs, and the gypsums again appear at Haystack Butte in Greer County about 20 miles northwest of Granite. The rocks of the Greer form conspicuous bluffs on both sides of Haystack Creek and on Elm Fork of Red River and its tributaries as far as Collingsworth County, Texas. The gypsums which occur in such abundance in southern Greer County in the vicinity of Duke and Eldorado also belong to the Greer formation.
>
> The rocks of the western area of the Greer consist of red clay shales, heavy gypsum members, and a ledge of dolomite or magnesian limestone. At the base of the formation is an unknown thickness of red gypsiferous and saliferous shales and sandstones. These shales contain occasional local ledges of gypsum a foot or two thick, and beds of white and greenish shales are not uncommon. In the region of the heavy gypsum formations there are several salt plains fed by springs that issue from below the gypsums, or in one instance from shales between the gypsums. These shales between the gypsum beds do not differ materially from those at the base of the formation, nor from those between the gypum ledges of the Blaine formation. Immediately beneath the heavy gypsum beds there is often a foot or two of bluish or greenish clay or shales. There are five prominent ledges of the Greer formation outcropping in this region, the three upper ones being thickest and most conspicuous. In general, neither of the two lower members is more than 4 feet thick, and because of their position near the foot of the bluff they are frequently inconspicuous. The various members are described below.
>
> **Chaney gypsum member.**—This gypsum is well exposed along the south side of Elm Fork from Mangum northwest to the Texas line. It is also seen on Haystack Creek, but on North Fork, in Roger Mills County it loses its characteristic structure and becomes simply a gypsiferous band in the red clay. On Elm Fork at the mouth of Hackberry Creek and also at the Kiser and Chaney salt plains near the Texas line it is a hard massive stratum 3 to 5 feet thick, usually white, but sometimes gray or bluish. It is often distinctly stratified or apparently cross-bedded, or it may be that the lines of stratification are wanting. The formation derives its name from the Chaney Salt Plain on Elm Fork of Red River, 4 miles east of the Texas line.
>
> **Kiser gypsum member.**—This member is exposed throughout the western area of the Greer formation. It is rarely white and in this regard differs from all other ledges of the Greer. It varies from a decidedly bluish or greenish tint to drab or gray. On the North Fork it is composed of greenish gypsum and gypsiferous shales, becoming hard locally, and on Haystack Creek of bluish and drab gypsum, grading into gypsiferous rock and clay. On Elm Fork, at both the Kiser and Chaney salt plains it is composed of soft, bluish to greenish, selenitic gypsum, and at the mouth of Hackberry, 10 miles down Elm Fork, it is a bluish stratified gypsum. These occurrences show that while the general character is fairly constant, the stratum varies considerably in local sections. The softness of the rock renders it particularly susceptible to weathering, and it is frequently inconspicuous. Its thickness varies from 1 to 3 feet. The name is from the Kiser Salt Plain on Elm Fork, Greer County, where the ledge is well exposed.
>
> **Haystack gypsum member.**—The upper part of the Greer formation consists of three layers of massive gypsum and one of dolomite, interstratified between beds of red clay shale. The lowermost of the three thicker layers, the third gypsum member from the bottom of the formation, consists of the typically massive gypsum, almost pure white or occasionally grayish in places, with a few thin bands of gypsiferous sandstone. This ledge is often cut by joints which separate the rocks into rectangular blocks. These blocks frequently weather out and roll down the slope and in places render it conspicuously white for miles. The Haystack varies locally from 18 to 25 feet in thickness, and so far as known is the thickest gypsum member in the western area of the Greer. It is exposed along all the bluffs on North Fork and Elm Fork and is particularly conspicuous on Haystack Creek and in the vicinity of Haystack Butte, whence the name.
>
> **Cedartop gypsum member.**—The Cedartop is a massive white gypsum, very similar in appearance to the Haystack. It has a constant thickness of 18 to 20 feet throughout the region of outcrop. It is very conspicuous on North Fork, Haystack, and Elm Fork and forms the caps of a number of buttes and bluffs throughout the region. It is called "Cedartop," from a prominent butte on the North Fork of Red River, in the extreme southeastern corner of Roger Mills County. This rock forms the upper ledge of

41. Gould, Chas. N.,—A new classification of the Permian red beds of Oklahoma: Bull. Am. Assoc. Pet. Geol., vol. 8, no. 3, p. 325, 1924.

this butte, and may be seen from a great distance up and down the river and even from Headquarters Mountain at Granite, 15 miles away.

Collingsworth gypsum member.—This is the upper gypsum ledge of the Greer formation, and it does not differ materially in lithological appearance from the Haystack or Cedartop. Like them, it is massive and white throughout, and like them also, it is cut by a series of master joints into rectangular blocks. Where exposed, the thickness varies from 18 to 20 feet, being approximately that of the Cedartop and not so great as the Haystack. As it is the upper gypsum member it has often been eroded, and for that reason does not always appear in a section. Near the heads of the various creeks, however, it is the prominent ledge, and it is also exposed on a number of the conspicuous bluffs, as along North Fork. It is named from Collingsworth County, Texas, just west of Greer County, Oklahoma, where the gypsum is well exposed.

Mangum dolomite member[42].—Above the Collingsworth and separated from it by about 20 feet of red clay shale is a very persistent 3-foot bed of more or less dolomitic limestone. In places it is true dolomite; while at others it contains only a small per cent of magnesia and is a magnesian limestone. The character of the rock varies considerably. In places it is arenaceous and soft, in other localities cavernous or honeycombed. Often, however, it is firm and solid and forms an excellent building stone. Its color is white, drab, or sometimes yellowish. The underlying clays have often been eroded and the rock frequently covers slopes at a considerable distance below its original position. While the thickness averages 3 feet, it varies from 1 foot to 5 feet. This member is exposed on the hills north of North Fork, in Roger Mills County, and on practically all the divides of Elm Fork and Haystack, Bull, and Fish creeks in Greer County. The name of Mangum is that of the county seat of Greer County, near which the dolomite is well exposed.

With regard to the correlation of the members of this area with those of the type locality, Gould has tentatively grouped the Collingsworth with the Shimer, the Cedartop with the Medicine Lodge, and the Haystack with the Ferguson.

Since 1905, the base of the Blaine has been more or less definitely placed in this area but little more has been contributed to the stratigraphy of the Blaine itself. Snider[43] has written in an informing way on the area but most of his geologic data was taken from Gould's work. The recent work of Clifton is brief and chiefly concerned with oil and gas possibilities.

The following analysis of Mangum dolomite has recently appeared.[44] No other information is given.

42. As first described, (Gould, 1902) this dolomite was termed the Delhi dolomite (not Delphi as has been stated) but was later changed to its present name by Gould in 1905.
43. Op. cit., pp. 188-201.
44. Shead, A. C.,—Chemical analyses of Oklahoma mineral raw materials: Oklahoma Geol. Survey, Bull. 14, p. 78, number 99, 1929.

Analysis of Mangum Dolomite.

	Per cent
SiO_2	5.71
$Al_2O_3 + Fe_2O_3$	2.00
MgO	19.35
CaO	28.79
CO_2	44.11
	99.96

It has been common to speak of the Blaine as a series of several discontinuous gypsum beds, with interbedded horizons of dolomite, red clay and shale, or in a similar fashion. The Mangum dolomite has been noted at the top of the section many times and its approximate thickness and general character occasionally added. However, little specific information has been given about it, and the mention of other dolomites has been exceedingly vague.

The writer has mapped three dolomite members in this area (Plate I). The Mangum dolomite, to the writer's belief at least, follows the Blaine escarpment across practically the whole area. South of Elm Fork, a second member, the Creta dolomite, may be found about 30 feet below it. North of Elm Fork, a probable third member, the Jester dolomite, was located in a number of places between Haystack and Cedartop gypsums. This may eventually prove to be equivalent to the Creta dolomite. These dolomites will be described in detail later.

The map is thought to be fairly accurate and no dolomites are shown which cannot actually be traced in the field. The writer doubtless missed many outcrops, but it is felt that only the very inconspicuous ones are lacking. With this map, the geological map of the area by Clifton should be used, also the map of Beckham County by Gouin.

STRUCTURE

The Permian beds, on the whole, are flat-lying to the eye, except for local variations, particularly in the Blaine, where the undersapping of the more porous and soluble rocks from beneath the harder massive gypsums and dolomites is undoubtedly the cause in most cases.

Regionally, the Permian dips away from the area of the Wichita uplift, (roughly the Wichita Mountains). In Jackson County the dip is low and toward the southwest. In Greer County, the dips are steeper, to the southwest over much of the county, but to the northeast in the northeastern part. Along the south side of Washita County the dips are toward the north to northwest and comparatively steep, being on the south side of the Anadarko basin.

The surface structure in Beckham County is outlined by Gouin[45] as follows:

> The dip of the surface rocks in the county averages about fifty feet to the mile in a direction slightly east of north away from the axis of the Wichita Mountains. This dip is interrupted by the anticline in the southern part of T. 8 N., Rs. 23, 24, and 25 W. From T. 9 N. to the north end of the county the structure of the surface rocks is not known due to lack of satisfactory surface exposures upon which to obtain definite control. However, in the main the dip continues to the northward as shown by the contacts of the various surface formations. This north dip continues until the axis of the Anadarko Basin is reached.

A normal fault has been discovered in Beckham County trending about N. 70° W. (see fig. 2) and having a downthrow of 300 to 500 feet toward the north according to Gouin. Its eastern end appears to be at the bend of North Fork in sec. 12, T. 8 N., R. 23 W., and it probably extends westward into Wheeler County, Texas.

For a further general discussion of the structures of the southwestern area see Greene, Gouin, Clifton, also Gould,[45] pp. 9-14.

ECONOMIC VALUE OF DOLOMITES

It may be mentioned here that the dolomites are of considerable local value as structural material. Several business blocks at Mangum have been reported to have been built of dolomite. The writer noticed a few farm houses built of it. Plate II, fig. 1, shows the back of a schoolhouse in northern Jackson County, evidently far from new, yet with the stonework in excellent condition. As foundations for building, and as a support for fence posts (see plate II, fig. 2) it is very extensively used, being the only hard durable rock to be found locally. Its characteristic occurrence as compact slabs or blocks lying loose on the slopes makes it available in suitable form without quarrying, and such are often carried many miles for various uses.

DIVISION OF AREA

For the purpose of describing the dolomites, this area has been divided into four districts, more or less arbitrarily, but not altogether so, the districts being separated by more or less broad valleys where dolomite outcrops are poor or lacking. These are as follows:

1. The Mangum district.
2. The Creta district.
3. The Haystack district.
4. The Sentinel district.

Three of the districts are named from towns or stations on the railroad, near or around which the most prominent outcrops of the dolomite may be found. The remaining one is named for Haystack butte or mountain, the best known locality in the district concerned, although the butte itself has no important dolomite member.

45. See footnotes 36, 33, 14.

Figure 4 shows Beckham, Greer, Harmon, Jackson, and Kiowa counties with the above districts outlined and also the position of the western outliers of the Wichita Mountains.

The districts will be discussed in detail in the order named.

THE MANGUM DISTRICT

Definition.—This district arbitrarily includes northwestern Jackson County,—that part north of Turkey Creek and west of the Salt Fork, southwestern Greer County west and south of the Salt Fork, and the part of Greer County west of Mangum and between the Salt and Elm Forks of Red River.

Topography.—The northwest part of Jackson County is predominantly flat agricultural land. The outcrops show little relief and the creek valleys are rather shallow. In southwest Greer County, however, the gypsum and dolomite ledges form a prominent escarpment facing the concave side of the decided curve in the Salt Fork where it turns from east to south. This escarpment is in the neighborhood of 200 feet above the river bottom in some places. It is indented by the headwaters of various small creeks and there are buttes and outliers east of Horse Branch. This escarpment seems to fade out into broad fan slopes north and west of Ladessa but where the road south from Reed crosses the Salt Fork, gypsum ledges are quite prominently exposed on both sides of the river.

The north side of the valley east of Mangum is quite rugged also, but toward the west rock exposures become poorer and are mostly sand covered about 6 miles west of the town.

The south side of the valley of Elm Fork in Greer County is largely rolling country with no marked relief but passes into rough gypsum hills toward Harmon County.

Areal Geology.—The Blaine formation covers the greatest portion of this district. Recent stream sands choke the bottoms of the valleys of Salt Fork, Elm Fork and Turkey Creek. Some of the Chickasha-Duncan formation is found along Horse Branch for about 3 miles north of Victory, and also as a narrow strip south of Elm Fork, along the south side of T. 6 N., R. 23 W., and in the northwest quarter of T. 5 N., R. 22 W. Quaternary to Recent deposits also cover part of the east half of T. 4 N., R. 24 W., a continuation of the extensive deposits in Harmon County.

Stratigraphy.—To the writer's knoweldge, little has been published on the detailed stratigraphy of this district. Snider[46] stated that the section by Gould taken at the junction of Salt Fork and Horse Branch is typical. This is given on page 41. No one appears to have

46. Op. cit., p. 194, 1913.

expressed an opinion as to whether the massive gypsum members there are the equivalents of the Collingsworth, Cedartop and Haystack or not.

The bluffs on the south side of the Salt Fork are readily observed, and possibly present the best exposures in this district. Here the section, as roughly recorded by the writer, does not agree very closely with that referred to above:

Section South of Mangum on South Side of Salt Fork.

		Ft.	in.
9.	Mangum dolomite	4	0
8.	Soils and red clays	26	0
7.	Creta dolomite	1	9
6.	Massive gypsum (soft blue clay in places)	3	0
5.	Gypsiferous shales, etc.	46	0
4.	Heavy, massive, white gypsum	8	0
3.	Gypsum, shales, and clays	40	0
2.	Massive white gypsum	2-3	0
1.	Gypsum shales, etc., above high water mark at Mangum bridge	50	0

The minor dolomite, named after the station of Creta, in western Jackson County, has never been noted before, to the writer's knowledge. Gould[47], however, intimates the presence of a second dolomite farther west. Plate II, figs. 3 and 4 plainly show member 4, a massive white gypsum. The next step in the rise is caused by the Creta dolomite and the underlying gypsum. The level skyline is due to the Mangum dolomite.

The massive gypsum beds, while often exceedingly uniform over short distances, vary in thickness and disappear in a very irregular fashion over a large area, no doubt due to solution. The dolomites, however, can be traced with considerable certainty and ease after one becomes accustomed to their appearance, although they commonly show an advanced degree of weathering also.

Distribution of Dolomites.—The distribution of the dolomites can be best appreciated by a study of the accompanying map, Plate I. Where the dolomites are scarp-forming members, both of them are almost always found. In the more level country back from the main streams, only remnants of the upper one are commonly found. In general, they occur in a broad area extending from between Duke and Victory in north Jackson County, northward, passing just west of Mangum to the valley of the Elm Fork and then may be traced westward to the vicinity of Reed.

47. Gould, Chas. N.—The geology and water resources of the eastern portion of the Panhandle of Texas: U. S. Geol. Survey, Water-Supply Paper 154, 1906.

In southern Greer and northern Jackson counties the dolomite is never far below the surface and both east and west extremities may be roughly followed. In the vicinity of Russel and westward no more outcrops were seen and they appear to have been eroded away entirely.

North of Duke, the dolomites "pave" a considerable area, that is, they occur on or a little below the surface. This is true of the Creta dolomite for a mile or so on each side of the county line directly north of Duke and of the Mangum dolomite a little farther north and west in secs. 1, 2, 11, and 12, T. 3 N., R. 23 W.

Mangum Dolomite.—The Mangum dolomite is quite variable in thickness appearance, and composition, and it is difficult to cite any particular spot that may be regarded as typical.

The thickest section measured in this district is 4 feet, in the SW. ¼, sec. 9, T. 4 N., R. 22 W. Unfortunately nothing further was noted about it and the nearest outcrop examined in detail, one mile to the west appears to be predominantly calcite. and only 33 inches thick.

It may be mentioned that in measuring sections only those places where the whole thickness appeared to be present were considered. There is no doubt that even in these localities some material has been weathered off the top and possibly dissolved from the bottom also.

The dolomite is 34 to 35 inches thick near CEL. sec. 21, T. 4 N., R. 22 W. In the SW. cor. sec. 21, T. 5 N., R. 22 W., it does not appear to be over 22 inches. One mile north and one west of here it is not over 14 inches. The thinner members are usually difficult to trace and may only be exposed in cuts. It seems probable that the thinning is due mostly to weathering as the thickest parts are found where products of weathering are rapidly removed.

A quite pure dolomite was found at the top of the 35-inch section, first mentioned above. It is a light-gray, fine-grained rock with very numerous rounded cavities about 2 mm. across. It weathers to a very soft earthy material. It looks very much like a limestone but appears to be only about 4 per cent calcite and the rest dolomite except for an insoluble part of approximately 5 per cent, very fine quartz sand about 0.02 mm. in diameter with some gray silt. This rock does not appear to be very typical.

In the middle western part of sec. 26, T. 4 N., R. 23 W., the top of the Mangum dolomite is peculiarly mottled. This rock is predominantly dark-gray, fine-grained, with numerous irregular small cavities, some lined with fine-grained calcite. Throughout are irregular island-like patches of light-gray, fine-grained pulverulent carbonate, veined by a complicated and fine network of thin dark-gray dolomitic stringers noticeably more dominant in a direction at right angles to the bedding, and evidently the same material as the main mass of the rock. A sample of this dark-gray appears to be about 25 per cent calcite and has some gray silt and quartz averaging about 0.02 mm. in diameter. The insoluble residue from the light-gray, which appears to be all dolomite, is very small, mostly quartz in the order of 0.03 mm.

This evidently represents a surface rearrangement of the dolomite. The same sort of rock is seen in the NW. corner sec. 13, T. 3 N., R. 23 W., along with the banded red veining to be mentioned later. The fine-grained, powdery material may represent the original rock. Similar structures have been described by Trechmann[48] in English dolomites. They are not dissimilar to structures observed at some localities in the soft red shales of the Oklahoma red beds, where they are intimately intersected by fine veinlets and porous masses of calcite.

A specimen from the NE. NE. 1/4 sec 19, T. 5 N., R. 22 W., probably represents the low outcrops of the Mangum dolomite westward from Mangum. It is medium-grained, gray, porous, with a thick sprinkling of brownish-black specks, probably manganese oxide. Staining shows a high percentage of calcite, possibly 75 per cent, but it is difficult to estimate.

The occurrences which seem to be fairly pure, fine-grained, light-gray dolomite cannot be said to be entirely typical. The phase most often found is a very much weathered, porous, medium- to coarse-grained, dark-gray, calcite rock with a peculiar honey-combed knobby structure, due in part to dense fine-grained red material as a network through it. Iron-stained to earthy surfaces are common and the fresher parts may show numerous specks, sometimes dendritic, no doubt manganese oxide.

Such "dolomite" may be seen on the main road southwest from Mangum, where Mangum and Creta dolomites are exposed, although somewhat poorly, about 1/4 mi. E. of cen. sec. 8, T. 4 N., R. 22 W. The major one is 3 feet thick. One 33 inch section measured as follows:

Section of Dolomites in Sec. 8, T. 4. N., R. 22 W.

	Inches
Porous gray rock with red lenses and veinings of calcite, particularly near the top	15
Rather shaly rock	5-6
Dolomite, quite massive	8
Shaly dolomite	5
Bluish- to greenish-gray soft shale	....

48. Trechmann, C. T.—On the lithology and composition of Durham magnesian limestones: Quart. Jour. Geol. Soc., vol. 70, pt. 2, pp. 232-265, 1914.

The ordinary type is a gray to brownish speckled rock, hardly to be found fresh anywhere, weathering through a very porous stage to a sandy material, which finally becomes earthy and limonitic.

The uppermost dolomite is very variable in thickness, porosity, amount of red marking present, and apparently in composition also. The writer believes this is more probably due to variation in extent of weathering than to an original variation.

The part containing the red markings usually seems to be predominantly calcite, either because it was so originally or because the solutions which brought in the red calcite have altered it. This seems to be a possibility, but some thin sections from other localities show dolomite in sharp contact with the red calcite. This rock has an insoluble residue of about 10 per cent, mostly white sand, largely subangular to angular quartz, 0.08 mm. and smaller, possibly 0.03 mm. on the average. There is also some brown iron oxide and grayish silt.

A specimen of as fresh looking material as could be had is medium-to coarse-grained, light yellowish gray showing some stratification due to leaching and iron stain. It is quite finely porous in some parts. Fragments take a light stain with Lemberg's solution, and it is almost sure that some is dolomite but hard to say how much. An insoluble residue of around 5 per cent is a quartz sand, grains averaging about 0.03 mm. in diameter.

A thin section shows carbonate grains in the order of 0.25 mm. across, mostly rounded in outline, but some are rhombic or subrhombic. They have a rough appearance, are full of brownish included material and there are some sand grains. Many carbonate grains have rather indefinite rims with little or no inclusions. Little is revealed by staining except that the rock is predominantly calcite, the large grains apparently finely speckled with dolomite.

The red markings are probably the most prominent feature. Although they have no significance that the writer has observed with respect to the origin of the dolomite, they are very widespread in the dolomites of the southwestern area, particularly so in the Mangum member, and are worthy of some attention.

The markings are commonly lenticular to irregular, mostly small, with very sharp boundaries and may be rudely arranged in beds. They are very fine grained, and usually dark-red, but may be more of a brick-red. They are always calcite with a considerable insoluble residue, apparently up to 25 per cent, mostly red silt, but with a little quartz sand in the order of 0.08 mm. in diameter. A thin section shows the carbonate grains to be about 0.008 mm. in diameter.

One would indeed be puzzled to explain these markings, were it not for a few localities where one may observe their real character.

Plate IV, fig. 5, shows a specimen from the highway, north side of the northeast quarter, sec. 19, T. 5 N., R. 22 W., with a vertical joint coated with red carbonate as in a vein, and having stringers leading out from it into the main rock parallel to the bedding, plainly showing its later origin. It is from the top of a 14 inch member.

A specimen from the NW. cor. sec. 13, T. 3 N., R. 23 W., shows the red calcite coating one side of an elongated cavity, distinctly and finely banded, It also distinctly veins a fine-grained, light yellowish gray dolomite.

It was repeatedly noticed that the red carbonate withstands weathering better than the containing rock, probably due to its exceedingly fine grained and dense character. Also it appears to have indurated the dolomite near its borders.

Many features about these markings appear to indicate replacement. A few cases have been noticed where the interior of the red part contains irregular remnants of gray speckled carbonate, and the border is indistinct, looking much like replacement (SL. SE. 1/4 sec. 18, T. 8 N., R. 24 W.). The predominant absence of any trace of banding may also indicate this. However, a thin section, while showing features indicating replacement, shows also the absolute removal of the noticeable bands of quartz sand found in the dolomite,—a fact which undoubtedly indicates that the calcite represents the filling of cavities. (See plate IX, *A*).

The logical explanation of these markings is that they are the result of deposition by downward percolating water from the red beds which formerly covered the Blaine and supplied the requisite iron oxide to color it. This appears to be why they are found almost wholly in the upper part of the ledge, which is at or near the top of the Blaine section. The uniform and extremely fine grain of the calcite is difficult to explain. It may be noted that soft, red, clay-like material was found in cracks in the massive gypsum of some gypsum caves.

Creta Dolomite.—The Creta dolomite is less conspicuous than the major member as it is thinner and seldom has the prominent red markings which are rather typical of the latter. However, it is probably more constant in thickness, composition and appearance than the Mangum member, and better merits the name of dolomite, in this district at least, having little calcite in it.

Just north of the Mangum member in the northeast quarter sec. 8. T. 4 N., R. 22 W., the minor member is 21 inches thick, rather hard, gray, fine-grained, quite porous in places, uniform from top to bottom except that the top is rather platy and weathers more easily. In at least one place it is underlain by soft blue clay-like material.

A specimen from the bottom of the member at this place is fairly massive, quite fine grained and light-gray. A little banding is brought out in places by the development of fine pores. On staining it is estimated that 2 to 3 per cent is calcite. The insoluble material constitutes around 5 per cent, mostly a gray silt with subangular quartz grains up to 0.12 mm. in diameter. A thin section shows the carbonate grains to be about 0.02 mm. across. A "sub-oolitic" structure is revealed, closely spaced, rounded dark patches with indefinite borders having a lighter network between them. (Plate VII, *A*).

A partial analysis of this dolomite follows:

	Per cent
CaO	27.82
MgO	17.67
Insoluble in HCl	8.31

A loose block here shows a locally hardened or cemented area on each side of a vertical crack, lined with calcite. The rock is tannish-gray closely speckled with brown, no doubt manganese oxide. It is dusty to the touch. This rock contains much more calcite than the former, probably as much as 30 per cent in intimate relation to the dolomite.

A thin section taken next to this crack and at right angles to it shows coarsely crystalline calcite on one side with hardly any on the other. The dolomite is oolitic, the spherules having no concentric structure. It seems to have been recrystallized, all grains being about 0.02 mm. across.

The calcite forms a very fine network between these grains, fading out away from the calcite side and coalescing into definite patches toward it. Some spherules seem to have more calcite than the matrix.

There can be no doubt that calcite has replaced the dolomite in this case.

The oolitic character is not well shown here and will be described later.

About the middle of the EL. SE. 1/4, sec. 21, T. 4 N., R. 22 W., this member is 21 inches thick, as before. A specimen from near the bottom is fine-grained, but looks rather coarse-grained due to its oolitic character. No undoubted calcite was detected. There are some angular quartz grains but not as nuclei. The insoluble part seemed small and consists of gray silt with a little angular quartz up to 0 08 mm. in diameter.

An analysis of this rock is as follows:

	Per cent
CaO	25.60
MgO	15.31
Insoluble	13.88

A thin section shows closely spaced spherules of several types. First, there are numerous smaller dense ones of various ovoid shapes (Plate VII, B), commonly elongated with long axes fairly parallel. Many have a yellowish tinge, while others are dark gray. They vary from about .4 to 0.08 mm. in diameter. The smaller ones, of course, may be transverse cross-sections of elongated spherules. Some have a more or less dark, massive core, surrounded by numerous very thin concentric shells (Plate VII, *C* and *D*). These are the largest seen and tend to be round although in some cases two coalesce to form an elongated one. Ones with single cores were observed as large as 1.0 mm. in long diameter. A few have a fairly light-colored massive interior and a thin dark rim (Plate VII, *D*). Plate VIII, *A* shows several spherules with massive dark interiors and a thin, light rim, some of which are irregular in shape and interlock. In addition there are a few oddly shaped ones, sharply angular, flatly lenticular, long rod-shaped, and others, but they are not common. The matrix is almost colorless with grains in the order of 0.015 to 0.05 mm.

At the SL. SE. ¼ sec. 32, T. 4 N., R. 22 W., the Creta dolomite is 25 inches thick, the upper three inches being very shaly.

On the NL. NW. ¼, sec. 11, T. 2 N., R. 22 W., it is about 18 inches thick with some 6 inches of weathered platy material underneath. A piece typical of the 18 inches, is massive, fine-grained, rather soft and a light buff in color. It is very highly and finely porous and sticks to the tongue slightly. It does not look at all like dolomite, yet only some 3 or 4 per cent is calcite. The insoluble part of 1 to 2 per cent is mostly angular quartz from 0.13 mm. in diameter to very small, with a little silt.

Along the north side of the valley of Salt Fork and just west of Mangum, the lower dolomite may readily be examined. The freshest parts are about 22 inches thick, but most of it is badly slumped and weathered. Red nodules are plentiful, particularly in the top. They were also noted along the NL. NW. ¼, sec. 28, T. 5 N., R. 22 W. A hard specimen from the bottom of the member first mentioned is a fairly massive, medium-grained, medium-gray rock, with yellowish, rather porous lenses. On careful examination of stained fragments it seems about 30 per cent calcite as fine seams around dolomite grains. The rather small insoluble residue is a yellowish-gray silt with some subangular quartz, largely about 0.06 mm. in diameter. A thin section is very uniform, shows roundish to sub-rhombic grains in the order of 0.11 mm. in diameter, apparently recrystallized, thickly speckled with small round gray spots. On staining the section, the latter appear to be calcite and the rest dolomite. If this is a uniform condition the rock is probably well over 30 per cent calcite. A second section shows an even-grained rock, probably in the order of 0.03 mm. and consists of rounded specks of dolomite thickly set in a calcite matrix. Some of the tiny grains seem rhombic. There are some irregular nests of dolomite 1 to 2 mm. across and having about the same size of grain.

It is uncertain whether this type represents dolomitization or alteration to calcite. In view of numerous undoubted cases of the latter, the writer is inclined to think the rock has previously been a pure dolomite. Also it seems improbable that dolomitization would proceed from these innumerable and uniformly distributed centers.

In the creek bottom, EL. NE. ¼, sec. 26, T. 5 N., R. 23 W., the minor dolomite is 20 to 25 inches thick.

The dolomites are progressively harder to trace as one follows westward along the south side of Elm Fork valley, as the country becomes rougher, roads are fewer, and the outcrops are poor. In the limited time the writer had to spend, he probably missed seeing considerable of the two members.

About 2.2 miles south of Reed, only one platy dolomite was found in a quite well exposed section of gypsum beds and its position could not be fixed. It is a light-gray, fine-grained rock with some banding brought out by weathering. It is a very pure dolomite with a small, insoluble portion of gray silt and some extremely fine quartz.

Summary.—The Mangum district includes northern Jackson County, and that part of southern Greer County west of Mangum and south of Elm Fork.

Most of the dolomite is found along the Blaine escarpment, which faces Salt Fork of Red River, and reaches its maximum relief south of Mangum. There are two dolomite members, the Mangum dolomite about 4 feet in maximum thickness, which caps the Blaine section, and the Creta dolomite about 30 feet below it and somewhat under 2 feet thick.

The Mangum dolomite is variable in thickness, appearance, and composition. While some specimens examined were very pure dolomite, many were indefinite mixtures of calcite and dolomite and some perhaps wholly calcite. Some specimens show networks of fine dolomite stringers, probably rearrangement of the dolomite under surface conditions. Typical material is a gray to brownish, medium-grained rock, much weathered and speckled with manganese oxide. Very fine-grained impure red calcite veinings are characteristic of the upper parts and give the weathered dolomite a peculiar honey-combed, knobby appearance. The insoluble material is not commonly over 5 per cent and is largely a fine quartz sand, the grains averaging about 0.03 mm. in diameter.

The history of the calcite-dolomite mixtures is not plain in this district. It appears that the calcite may be later than the dolomite.

The Creta dolomite, in contrast to the Mangum member, is rather uniform both in thickness, where well exposed, and in composition.

It is commonly a very pure dolomite, light-gray in shade, fine-grained, porous and in some places, platy. Its most remarkable feature is its oolitic character, which appears in many places, but is not noticed unless very closely examined. The spherules are mostly under 0.5 mm. in diameter, show no radiating structure and many show no concentric arrangement. They do not appear to have any quartz nuclei. The insoluble part is small, mostly a gray silt with some quartz grains, largely under 0.01 mm. in diameter. Specimens of the Creta dolomite were observed which have been partially replaced by calcite. However, the interpretation of others containing both calcite and dolomite is more doubtful.

THE CRETA DISTRICT

Definition.—This district is wholly in Jackson County and includes that part south of Turkey Creek and west of Salt Fork. The station of Creta on the St. Louis and San Francisco Railroad is in the center of the district.

Topography.—The southeastern part of the district is quite flat with no dolomite exposed, and this holds also for the northwestern part. For a few miles northwest, north, and southeast of Creta, however, there are hills of considerable relief, the railroad passing through a natural gap. The country east and west of Eldorado is flat farming land, but the north side of the valley of Red River south of there is rough, with large deposits of dune sand.

Areal Geology.—Concerning the geology of that part of Jackson County pertinent to this report, Clifton[49] says as follows:

> There occurs, extending through the central part of the county, an area of exposures belonging to the Duncan and the Chickasha formations. Beginning at the Red River, near the town of Elmer, the Duncan beds can be traced in a nearly continuous line across the county * * *.
>
> Excellent exposures of the Chickasha appear above the Duncan, in its outcrops across the county. Southwest of Olustee and along Red River prominent exposures of the Chickasha occur.
>
> The western one-third of the county is included in the area of the Blaine gypsums. Due to erosion and possibly solution and slumping, no one of the three or more beds of the Blaine can be traced across the county without difficulty. The Blaine formation in Jackson County presents a series of three or more discontinuous gypsum beds, with interbedded horizons of dolomite, red clay and shale.

49. Op. cit., p. 17.

Having confined his attention to the dolomites, the writer is in no position to discuss the general geology of the county. However, comparisons of Clifton's map with Plate I of this report will show plainly that Clifton has assigned too much area to the Chickasha and Duncan, most noticeably in the vicinity of Creta. This is readily appreciated as the general outcrop of the Creta dolomite outlines the most westerly possible boundary of the Chickasha. Although the two dolomite members found here are separated from those of the Mangum district by Turkey Creek, there is no reason to believe they represent different horizons as their outcrops can be traced to within two or three miles of each other.

Stratigraphy.—Snider[50] credits the following sections to Gould.

Section of Bluff Between Salt Fork and Horse Branch Near Olustee.

(10 Miles S. of Mangum)

		Feet
12.	Hard rock, dolomite, forming the cap of the hill	3
11.	Red and blue clay	12
10.	Massive, white gypsum	8
9.	Red clay with ledges of gypsum	24
8.	Massive, white gypsum	12
7.	Red and blue clay	15
6.	Red and blue soft, shaly rock and gypsum	5
5.	Red and blue shaly clay	22
4.	Bluish gypsiferous rock	10
3.	Red and blue clay	8
2.	Massive, white gypsum	3
1.	Red clay slope from Horse Branch	100

Section on Boggy Creek 9 Miles Northeast of Eldorado.

8.	Hard, massive rock, dolomite, forming the cap of the bluffs	5
7.	Red and green shale and clay	30
6.	Massive gypsum	10
5.	Red clay	5
4.	Clay and hard rock	5
3.	Massive, white gypsum	15
2.	Red and blue clay	25
1.	Massive gypsum exposed in creek bed	15

Of the gypsum of Jackson County, Snider[51] said, in part, as follows:

> * * * The gypsums are more prominent than those in southern Harmon County but much less so than those of northern Greer and Harmon Counties. The stratigraphy is usually irregular. The best exposures are on the Horse Branch and Boggy Creek.
>
> In the hills just west of Creta on the St. Louis and San Francisco Railroad, two massive ledges of white gypsum are exposed. The lower is about 15 feet thick and upper about 12 feet. The upper ledge is covered by about 30 feet of red shale and 6 to 20 feet of dolomite * * *

50. Op. cit., p. 196.
51. Op. cit., pp. 198-199.

Availability of the Gypsums.—The principal exposures of rock gypsum in Jackson County can be easily reached from the St. Louis and San Francisco Railroad. The main hindrance to their development is the thick cover due to the Mangum dolomite capping the hills and preventing the erosion of the shale from above the gypsum * * *.

The thickness of dolomite mentioned may be exaggerated. Gould[52] also gives the thickness at Creta as 15 feet. About a mile and a half south of Creta the Mangum dolomite is only 2 feet thick, and a mile southwest of Creta the Creta dolomite is only 13 inches thick. The slumping of the face of the dolomite members below the general level commonly gives the impression that they are much thicker than is actually the case.

Snider[53] reported that specimens of *Pleurophorus* and *Schizodus* have been found in dolomite near Eldorado.

Distribution of Dolomites.—As previously mentioned, both the Mangum and Creta dolomites are well exposed in this district. They may be traced in a rather discontinuous fashion from about a mile south of Turkey Creek in sec. 26, T. 2 N., R. 22 W., south and west to Creta, then east and south to the shore of Red River in sec. 4, T. 2 S., R. 22 W. Outcrops may be found at intervals westward to Lebos Creek and beyond, but none were located west of Eldorado.

Mangum Dolomite.—Between Turkey and Boggy creeks, the Mangum dolomite is poorly exposed and fresh specimens and sections are difficult to find. It occurs as a weathered ledge in the roads or as rows of blocks at the edges of low bluffs or escarpments. These blocks have a typical, weathered, knobby appearance seldom seen in the Creta dolomite, which tends to weather into loose platy or sandy material, or occurs as large flagstones on the slopes.

Near CWL. sec. 17, T. 1 N., R. 22 W., the Mangum member is 3½ feet thick, weathered and underlain by red and blue clay. This looks very much like that exposed south of Mangum. A specimen of the weathered, knobby part proved to be very complex. In general the specimen is medium- to light-gray with a very rough weathered surface and cavities, covered with reddish earthy material. The freshest part is medium-grained with small cavities lined with small rhombohedral crystals of dolomite. It is hard to determine how much dolomite this type contains, possibly about 50 per cent or more. The insoluble residue of some 10 to 15 per cent is silt and quartz, the latter rather uniformly about 0.08 mm. in diameter.

The bottom part of the specimen shows a reticulate mass of veinlets, very thin and composed of dolomite, some with small rude crystals

52. Gould, Chas. N.—Preliminary report on the structural materials of Oklahoma: Okla. Geol. Survey, Bull. 5, p. 154, 1911.
53 Op. cit., p. 111.

on their outsides, looking like steep rhombohedrons. The enclosed spaces are largely weathered and contain soft, fine-grained, light-gray silt and carbonate, probably dolomite in part. The writer believes this rearrangement was accomplished at or near the surface.

A very remarkable occurrence of the upper dolomite was seen in the SW. cor. sec. 4, T. 1 S., R. 22 W. Capping the bluffs in this district and on a level with the escarpment to the northwest and the more indistinct one to the southwest, is a hard member, at least 4 feet 4 inches thick[54] and roughly divided into four parts on one good face. However, its appearance varies greatly from place to place.

The lowest 10 inches is rather finely laminated, hard, fine-grained, gray rock on the whole but some parts are quite sugary and soft. The weathered surface shows hard flinty patches and layers which are more or less characteristic of the whole ledge, (see fig. 5).

The 16 inches above this is very similar except that the parts weathering out in relief are larger and more varied in appearance.

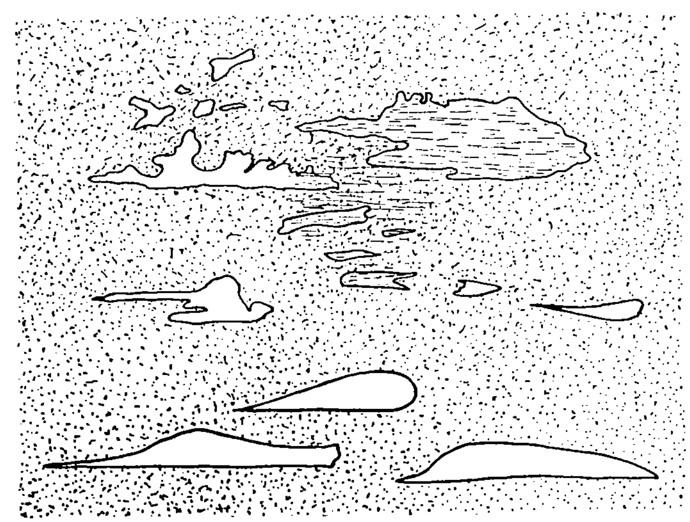


Figure 5. A sketch from field notes showing irregular patches of dense dolomite, some plainly banded, in more sugary dolomite which is at least partly oolitic. Mangum dolomite, southwest corner, sec. 4, T. 1 S., R. 22 W. Approximately ¼ natural size.

54. The unusual thickness of the Mangum member at this place is interesting. Exactly 2 miles to the south what appears to be the same member is not much over 20 inches thick and very platy.

Some are layers 2 feet or more long and irregular in outline, but many are lens shaped. These are commonly very massive, but others may show fine irregular banding.

Above this the member is more uniform with fewer surface markings, but some were observed 3 to 6 inches long, flat on top and convex on the under surface. The flat side evidently represents a bedding plane.

One loose block showed very distinct ripple marks.

A specimen from one of the most massive parts of the bottom section is fine-grained, light-gray, not very porous and fairly massive, although a somewhat weathered part shows rough laminations about 4 mm. thick. Fragments appear to be about 2 per cent calcite and there is an insoluble residue of 3 to 5 per cent, mostly gray silt with a minor amount of quartz, very little of it being over 0.03 mm. in diameter.

A rather poor specimen of the 16 inch section shows the hard dense parts weathering light-gray against a dark ground of softer material. It is exceedingly irregular and the banding of the dense parts is truncated by and grades into soft material which never seems to retain it. Some of the softer rock seems to be sub-oolitic.

Some other small specimens show typical contacts of hard, uniform, dense dolomite with the softer rock, which in these specimens is undoubtedly oolitic, and definitely cuts across fine bedding in the dense. The dense contains no calcite and the insoluble part of possibly 5 per cent contains little or no silt, but is an angular to sub-angular quartz sand and from 0.15 mm. to very minute, largely about 0.06 mm. The oolitic is quite porous and fairly friable in most specimens. The spherules are commonly hollow, in the order of 0.3 to 0.4 mm. in diameter and closely packed. On staining they are always dolomite where solid, but when hollow may have spongy-looking calcite inside. The matrix is also calcite but does not fill the interstices. It is doubtful whether there is any dolomite matrix or not. The spherules stick tightly together, however, where no calcite is present. The insoluble portion is probably only 2 per cent, and contains silt with only a little quartz of about the same size as that from the dense.

A thin section of the dense, banded part is entirely gray dolomite of exceeding fine and uniform grain, probably a few thousandths of a millimeter in diameter. A few small dark spots averaging about 0.03 mm. across may represent an incipient stage in the formation of the oolite. The banding is due to angular quartz about 0.03 mm. in diameter and smaller (see plate VIII *B*).

A section showing both dense and ooltic parts shows the dense part to be oolitic or sub-oolitic, but with a considerable groundmass with no structure, (plate VIII, *C*). The spherules are usually round. commonly very indistinct, grading into the matrix, and are about 0.55 mm. in diameter. Some have a coarser grained core also dolomite, but quartz grains although common are seldom found in the dense rims of spherules and do not seem to have acted as nuclei. A very few structures look like fossils and appear to be still calcite.

In the more porous part, the spherules are much more definite, closer together and vary more in size and shape. Concentric structure is more prominent. Elongated or cucumber-shaped spherules are rather common, usually found to have a dark massive core with thin concentric rims (see plate VIII, *D*). Probably the majority of the spherules are hollow or partially filled with calcite. However, many are uniform to the center with no cores or concentric structure and many others show only a suggestion of it. In the loose-textured parts the matrix has been largely removed, the spherules being in contact or held together by scattered calcite.

There is no doubt that the formation of the oolite has taken place later than the deposition of the fine-grained sediment represented by the banded remnants, probably while still an unconsolidated mud. No doubt many geologists would claim that the oolite was largely originally aragonite, and that dolomitization has taken place later. The very fine grain of the dense banded dolomite together with the absolute absence of any residual calcite satisfies the writer that this rock is similar in origin to that of the fine-grained limestones, and that it has been a dolomite since deposition.

Some 60 feet below the top of this member is a pure dolomite 8 to 10 inches thick and directly at the base of a few feet of massive gypsum. It is quite massive, yellowish- and brownish-gray, rather fine grained and is not porous. It may be finely oolitic. The insoluble part of 10 per cent or less is sub-angular quartz sand, the grains mostly under 0.08 mm., with some brownish silt.

In some places at this locality it seems almost certain that there is another hard ledge some 15 to 20 feet above the base of the gypsum mentioned. If so, the upper one is probably the Creta member.

At the CSL. sec. 20, T. 1 N., R. 22 W., a very good section may be seen, the heavy gypsum with a hard ledge at the bottom, the Creta dolomite some 15 to 20 feet above, and the Mangum in an escarpment to the north. The extent of the third member is not known, but it was not recognized elsewhere.

Over 2 feet of the Mangum dolomite is exposed on the WL. SW. ¼, sec. 6, T. 1 S., R. 22 W. This is probably typical of a good exposure. It appears that much has been weathered off the top and to some extent off the bottom. The lower 9 inches is much like the Creta member in this district. It is light-gray, fine-grained, very finely porous, quite massive, and is a pure dolomite. The insoluble part of 3 to 5 per cent is brownish silt with considerable angular quartz up to 0.13 mm. A thin section shows this rock to be decidedly sub-oolitic or oolitic. The spherules are mostly indistinct, a little finer grained and darker than the groundmass, but a few show definite rounded outline and faint concentric structure. This appears to be an oolite in its initial stage of formation, yet wholly dolomite. Angular quartz is scattered throughout irrespective of spherules.

An analysis of the above type follows:

	Per cent
CaO	27.43
MgO	17.96
$Al_2O_3 + Fe_2O_3$	3.39
SiO_2 (white)	5.63

The rest of the member is the honey-combed, knobby weathered material with red markings. The red is plainly a late introduction. Some pieces, as fresh as could be obtained, were examined in detail. The main part of the rock is coarse-grained, quite porous and weathered, somewhat banded, and on the whole a dark gray. The red markings show no features not described above. They appear to be calcite with about 25 per cent red silt and only a little very fine quartz.

The dark-gray porous rock is largely calcite also, but after dissolving fragments in cold dilute hydrochloric acid for a short time, the residue does seem to contain some dolomite. Fragments from a lighter gray and fresher looking part showed a considerable but indefinite portion of dolomite, probably about two-thirds. The residue from the weathered part is rather large, perhaps 15 per cent brown silt with much quartz from 0.15 mm. in diameter to very small.

A thin section showing both sides of a red calcite vein, reveals an exceedingly sharp contact, the dolomite in this case being quite pure except for sand grains, which are entirely lacking in the calcite (see plate IX, A). This shows conclusively that the red calcite is a late mineral deposited in cavities. The dolomite is only a little coarser than the very fine grained calcite.

It is plain that the upper part of the Mangum is very irregular in composition and on the whole predominantly calcite. Whether this is an original condition or not (except for the red parts) remains to be shown, but it appears that the more weathered and disintegrated it is, the less dolomite is to be found.

Along the road on the EL. SE. 1/4, sec. 7, T. 1 S., R. 22 W., is an outcrop which may be a remnant of the type of the Mangum member, which shows dense and oolitic parts. It is fairly massive, light-gray, finely porous, rather friable, soft oolitic dolomite about 18 inches thick. The lower 6 inches, however, shows plainly that this has been derived from a dense, hard, medium-gray, fine-grained part, which

occurs as irregular remnants of these beds and grades laterally and vertically into the softer rock. This dense dolomite contains no calcite.

What is undoubtedly a remnant of the above member occurs along the roadside 2.5 miles east of Eldorado, an 18 inch section with the lower 6 inches quite solid. The latter appears to be a pure dolomite.

A platy gray rock, 16 inches or more thick, probably at the same horizon as the above may be found along the south side of sec. 18, T. 1 S., R. 22 W. The correlation of these outlying fragmentary beds is, of course, quite an uncertain matter.

In travelling from Eldorado to Gould, loose blocks of weathered rock were noted at intervals until about 4 miles south of Gould. These look very much like part of the Mangum dolomite at Mangum, and seem to be largely calcite. Along the WL. NW. 1/4 sec. 12, T. 1 S. R. 23 W., the Mangum dolomite occurs up to 30 inches thick, is honeycombed with red markings, and dips under soils to the west and south. As knobby blocks similar in appearance to those mentioned above are found on the hill a half mile south of there and other places, it appears that they are remnants of a still higher, hard member almost wholly removed. This also appears to be the case with blocks found at CWL. sec. 35, T. 1 N., R. 23 W. Here also may be observed pebbly, light-gray carbonate fragments. These were again noticed along the south side of section 13, in the township south of the above location and remind one of the light-gray, thin dolomite found in northwestern Greer County near the Harmon County line.

Creta Dolomite.—The Creta dolomite being more uniform in character was not examined in such detail in this district.

Along the WL. SW 1/4, sec. 30, T. 1 N., R. 22 W., it is well exposed and measured 13 inches, a quite fresh bluish-gray rock, inclined to be platy. A typical specimen is light-gray, fine-grained and with a lens appears oolitic. It is full of very fine pores. Probable bedding is revealed by very minute reddish stringers. It is rather soft, but not very friable. Fragments seem almost wholly dolomite; about 1 per cent may be calcite, occurring in the cavities.

The insoluble part is small, silt with some angular quartz, mostly about 0.08 mm. in diameter but some is extremely fine. In thin section, the pore space is about 5 per cent. An analysis follows:

	Per cent
CaO	27.93
MgO	17.48
Insoluble	7.38

The most prominent feature in thin section is that the rock is almost wholly composed of spherulitic brownish masses, which in no case show any concentric structure (see plate IX, *B*). Their long axes are roughly parallel and they fit rather closely together, the "matrix" being more like a fine network separating the darker spherules. Most of the network has a slightly brownish shade and is inclined to have grains about 0.02 mm. in diameter. The grain of the spherules is exceedingly fine. The writer cannot see how this could have been dolomitized or recrystallized in the least since the formation of the present texture.

There is an appreciable amount of detrital quartz in this section, mostly about 0.07 mm. in diameter and angular. It does not appear to have acted as a nucleus for the spherules. A few rather large nearly colorless crystals and some small coarse-grained veinlets are probably calcite, but are unimportant in amount.

In the NE. cor. sec. 19, T. 1 N., R. 22 W., the Creta member is 16 inches thick.

Summary.—The Creta district includes that part of Jackson County west of Salt Fork and south Turkey Creek. Both Mangum and Creta dolomites are present and are particularly well exposed in the central part of the district.

The Mangum dolomite, as is common elsewhere, shows great variation. In composition it appears to vary from a very pure dolomite to one more than half calcite. The thickness of good exposures is from 2 to over 4 feet. The insoluble matter is, perhaps, less than 5 per cent on the average, and consists of silt and angular quartz, nearly always less than 0.1 mm. in diameter. A secondary rearrangement of the dolomite as crystals lining cavities and as veinlets cutting the original rock was observed.

A most interesting locality was found where the Mangum is unusually fresh and over 4 feet thick. An exceedingly fine-grained, pure, dense banded dolomite occurs as irregular to lens-shaped remnants in a more porous, massive rock, of which parts at least are finely oolitic. The oolite appears to represent a post-depositional change in texture. The notable fineness of grain and purity of the banded, dense parts strongly indicates an original dolomite. Some ripple marks were found.

Red markings are found in the Mangum member in this district also. They have been shown to be a secondary deposit in cavities.

The Creta dolomite is more uniform in character than the Mangum, a quite pure dolomite, oolitic in part at least, and not much over 1 foot thick. Typically, it is fine-grained, light-gray, finely porous, and inclined to be platy.

A third dolomite was observed about 20 feet below the Creta in one or two localities.

THE HAYSTACK DISTRICT

Definition.—Under this head will be considered the dolomites of Greer and Beckham counties north of Elm Fork and west of Haystack butte, and also south of the river in northern Harmon County. No dolomite was found north of the middle of T. 8 N.

Areal Geology.—The part of this district immediately concerned belongs entirely to the Blaine formation. According to maps by Clifton and Gouin, the south boundary of the Blaine follows closely along the north side of Elm Fork as far east as a point south of Jester where it swings north and east around Haystack butte. The contact then turns sharply northwest to the headwaters of Haystack Creek, then northeast to a point a little east of Delhi where it turns sharply west to the State boundary. To the east of this area is rolling to level farming land on the Chickasha-Duncan formation. To the north is a narrow strip of the Wooward group separating the Blaine from the Quaternary and Recent deposits of the valley of the North Fork of Red River.

Topography.—The district around Jester is flat, but gypsum escarpments are found in the north part of T. 6 N., R. 25 W., and continue westward, most of this district being rather inaccessible by road. A less rugged escarpment curves around the head of Deer Creek and east to near Haystack butte. Along the extremity of this eastward projection of the Blaine, the country is exceedingly rugged and picturesque with a relief of well over 100 feet, due to the massive Haystack and other gypsums. The escarpments may be traced around the headwaters of Haystack Creek but they are not nearly so prominent and fade out to the south and east of Delhi.

The general district from Delhi west to the Texas boundary is flat with few or no outcrops.

Stratigraphy.—Clifton[55] says of the Blaine of Greer County:

> The Blaine formation overlying the Chickasha, consists of five or more beds of gypsum and dolomite interbedded with red clays and shales * * *

Writing with regard to the Blaine in Beckham County, Gouin,[56] contrary to some writers, reports the Blaine to be a consistent formation over wide areas, averaging 200 feet in thickness. The following general section is given.

55. Clifton, R. L.,—Oil and gas geology of Harmon, Greer, Jackson and Tillman counties: Oklahoma Geol. Survey, Bull. 40-Y, p.14, 1928.
56. Op. cit., p. 8.

Section of Upper Part of the Blaine Gypsum, Beckham County, Oklahoma.

	Feet
Dolomite, honeycombed	3
Shale, red and blue	20
Gypsum, massive, white	18
Shale, red	5
Gypsum, massive, white	15

Gould[57] gives the following section from west of Haystack butte.

Section near Beckham County Line along Haystack Creek, 6 Miles South of Delhi

		Feet
11.	Red clay	50
10.	Hard sandy rock	3
9.	Red and green clay	20
8.	Massive, white gypsum	16
7.	Red and green clay	8
6.	Massive, white gypsum	18
5.	Red and green clay	20
4.	Bluish and drab gypsum	4
3.	Red clay	15
2.	Gypsum and hard rock	5
1.	Red clay	100

Concerning the stratigraphy of northwestern Greer County, Snider[58] says as follows:

> The gypsums of the southwestern area are well exposed in the extreme northwestern part of Greer County along Elm Fork and its tributaries. All five ledges are usually present and they outcrop on bold bluffs which are usually capped by a thick ledge of dolomite. On the north side of Elm Fork the gypsums become noticeable in the vicinity of Haystack butte in sec. 14, T. 7 N., R. 23 W. This butte is an outlier of a pronounced range of hills to the west. The butte and hills are capped by the Haystack gypsum which is 10 to 20 feet thick. The Kiser gypsum outcrops twenty feet lower on the slope and is 3 to 4 feet thick. The Chaney gypsum does not appear to be present. From Haystack butte the bluff extends westward up Elm Fork. All the streams flowing into the river from the north have cut canyons into the gypsums and indent the line of bluffs deeply. At the mouth of Hackberry Creek[59] the following section was measured:

57. Op. cit., p. 103, 1911.
58. Op. cit., pp. 193-194, 1913.
59. This creek does not appear on any maps the writer has seen. The locality is probably in the SE. ¼, T. 6 N., R. 25 W.

Section on Elm Fork at Mouth of Hackberry Creek.

		Feet
12.	Hard cap rock, dolomite	3
11.	Red clay	20
10.	Massive, white gypsum (Collingsworth)	18
9.	Red and blue clay	8
8.	Massive, white gypsum (Cedartop)	20
7.	Red and blue clay	5
6.	White gypsum, separated into thin beds by sandy dolomite (Haystack)	18
5.	Red and blue clay	12
4.	Bluish stratified gypsum (Kiser)	4
3.	Red and blue clay	15
2.	White and bluish gypsum (Chaney)	4
1.	Red and blue clay	8

To these may be added a very rough section of Haystack butte noted by the writer. (See plate III, fig. 1).

Section of Haystack Butte, Sec. 23, T. 7 N., R. 23 W.

		Feet
7.	Massive, white gypsum (Haystack)	15 to 20
6.	Bluish gypsum shales	20
5.	Soft red and gray shales	15 to 20
4.	Massive bluish gypsum (Chaney)	3 to 4
3.	Gray gypsum shale and gypsiferous red and gray earthy shales	65
2.	Hard gray dolomite (inches)	1 to 2
1.	Gypsite, shale, etc.	25

The Kiser gypsum could no doubt be located between the Haystack and Chaney with a little care.

The dolomite noted above is massive, fine-grained, medium-gray, dense and contains no calcite at all. The insoluble part (5 to 10 per cent) is brownish-gray silt with considerable angular quartz in the order of 0.03 mm. Although thin it is quite persistent and covers considerable of the low land in this vicinity.

Snider[60] gives the following section from northern Harmon County:

Section of Bluff on Elm Fork in Sec. 10, T. 6 N., R. 26 W.

		Feet
12.	Dolomite	1 to 3
11.	Red clay	16
10.	Gypsum (Collingsworth)	14
9.	Red and blue clay	6
8.	Gypsum (Cedartop)	16
7.	Red and blue clay	5
6.	Gypsum (Kiser)	20
5.	Red and blue clay	15
4.	Gypsum	2
3.	Red clay	12
2.	Gypsum	3
1.	Gypsiferous, red and blue clay (about)	60

This differs materially from the section formerly given by Gould[61] from the section north of the above.

60. Op. cit., 1913, p. 196.
61. Gould, Chas. N.—The geology and water resources of Oklahoma: U. S. Geol. Survey, Water-Supply Paper 148, p. 68, 1905.

Section at Salton, Harmon County.

		Feet
14.	Dolomite (Mangum)	3
13.	Red clay	20
12.	Massive, white gypsum (Collingsworth)	12
11.	Red and blue clay	6
10.	Massive, white gypsum (Cedartop)	18
9.	White and green and red clay	6
8.	Massive, white gypsum (Haystack)	20
7.	Red and greenish clay	15
6.	Greenish selenitic gypsum (Kiser)	3
5.	Red clay	12
4.	Hard stratified gypsum (Chaney)	4
3.	Bluish and red clay	5
2.	Hard gypsum	2
1.	Red and bluish shale	75

The writer sees no reason why the Haystack gypsum should not occur as shown above and in place of the Kiser gypsum of Snider's section.

It will be seen from the sections given that only one dolomite has been noted previously. The writer has found that there are undoubtedly two in some localities and probably in many. However, due to the irregular character of the gypsums and with no accurate means of determining elevations he could not be sure that the lower ones are always at the same horizon. They have been temporarily grouped together on the map under the name of Jester dolomite, admittedly a poor name but no better suggests itself. It seems better not to name members or formations after minor creeks as they commonly bear several names, changing with time.

The dolomite noted by previous writers is at the top of the Blaine sections, or nearly so. It is commonly exposed some distance back from the gypsum bluffs and more or less deeply weathered and obscured by soils. Its character and stratigraphic position are such that the writer sees no reason at present why it is not the exact equivalent of the Mangum dolomite and it will be so called in this report.

Distribution of Dolomites.—The Mangum dolomite is probably best exposed 2 to 4 miles west of Haystack butte but is not prominent in any other part of this section of Greer County. It was not found at all in that part west of Jester but may be traced from the vicinity of Haystack butte into the extreme northwest corner of the county. Here and in neighboring parts of Beckham County to the north and west, it is quite prominent causing a rough topography. Toward Delhi the outcrops are less noticeable again and fade out about 2 miles southeast of the town.

Considerable parts of T. 7 N., R. 26 W., the southern part of T. 8 N., R. 26 W., and the south half of T. 7 N., R. 25 W., are very rugged due to the indentations of the gypsum escarpments by the tributaries of Elm Fork, and are quite inaccessible to one with a small amount of time to spend. It is quite possible that much more dolomite will be found here than is indicaated on the writer's map.

It is in this extreme southern part of Beckham County that much of the lower dolomite member was found. The rest is in Greer County, west of Haystack butte.

Mangum Dolomite.—The Mangum dolomite is quite well exposed near the middle of sec 18. T. 7 N., R. 23 W. This cannot be far from where the section given by Gould was obtain (see p. 50).

Variation due to weathering is very evident here, two sections measuring 14 inches and 28 inches not 100 feet apart. The thickest one is about as follows:

	Inches
Honeycombed, knobby material with red markings, commonly as loose blocks	8
Weathered calcareous rock	2-3
Platy, gray dolomite	6
Massive, gray dolomite	14

The lowest 14 inches, where fresh, is massive, fine-grained, light-gray, rather soft and powdery. The rock is largely dolomite, but there does seem to be a small and indefinite amount of calcite as minute veinlets and coatings. The insoluble part is dark-gray silt (10 to 15 per cent) with a little quartz about 0.08 mm. in diameter.

A comparatively fresh specimen from the actual base of the same dolomite appears to contain very minute specks of calcite, probably 5 per cent or less. The insoluble part of possibly 5 to 10 per cent is gray silt with a large proportion of quartz from 0.15 mm. in diameter down to very small.

A thin section of the above shows no calcite whatever. Banding is very evident and is due to angular quartz grains from 0.15 mm. in diameter to very minute. The grain of the carbonate is exceedingly fine. An interesting structure is revealed, represented by fig. 6. The beds are diagonally truncated by similar material but containing little or no sand. The separated parts do not appear to fit.

A specimen of the platy dolomite is little different from the above. It is roughly 10 per cent calcite with a small residue (1 to 2 per cent), largely sub-angular quartz averaging about 0.04 mm. in diameter.

The freshest dolomite seen was observed to grade directly by weathering into a fine calcareous sand or soil.

The three heavy gypsum members were noted below the dolomite, the four members spaced roughly 10 to 25 feet apart.

A specimen from the top of the honeycombed part was obtained near the SW. cor. sec. 19, T. 7 N., R. 23 W., where red markings were prominent. It is medium-gray, medium-grained, full of fine pores except close to thin, red, fine-grained veinlets, apparently parallel to bedding. Fragments show about one-third calcite, intimately shot through them. The insoluble residue is probably less than 5 per cent, brownish-gray silt with considerable quartz in the order of 0.03 mm.

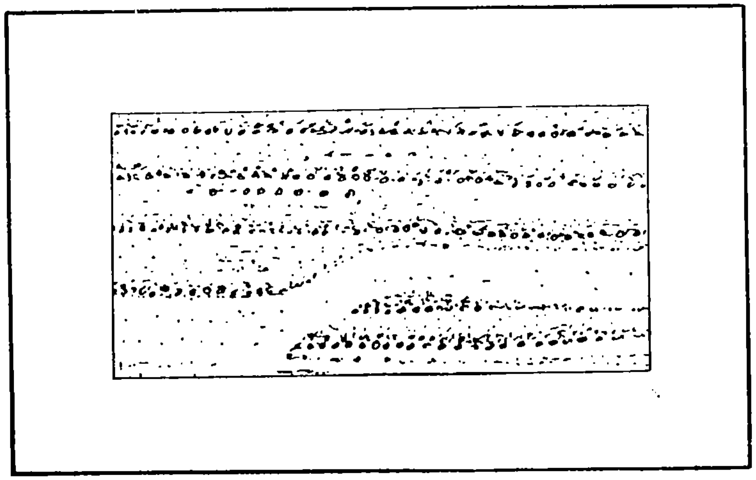


Figure 6. Sketch of thin section from base of Mangum dolomite, sec. 18, T. 7 N., R. 23 W., showing structure. x 2.

On the SL. SE. 1/4 sec. 18, T. 8 N., R. 24 W., some exceptionally fresh looking specimens were obtained from a large block of the Mangum member with a red calcite vein in the center. Curiously enough no dolomite could be found for certain in this rock. Whether the dolomite grades into limestone or whether dolomite is actually replaced by calcite forming a massive rock is a question. A crust of calcite, three-quarters of an inch thick, and later than the red vein material coats the outside of some blocks.

A stained section of the above gave little additional information. The carbonate seems mostly if not entirely stained but is dark brownish gray like the dolomites, with an indefinite lighter network. The grains are indistinct and recrystallized, but some appear to be rhombic or sub-rhombic in outline.

Along the WL. SW. 1/4 sec. 34, T. 8 N., R. 25 W., 26 inches of the Mangum dolomite are rather well exposed. The top 2 to 3 inches seemed harder and fresher than most of the rest. It is massive, medium-grained, medium-gray in shade, with minute rusty specks.

It appears to be roughly three-quarters dolomite, intimately permeated with calcite. The insoluble residue is small, (1 to 2 per cent) and made up largely of a sub-angular quartz sand under 0.08 mm., with a little gray silt. A specimen of the lower part is more porous and may contain more calcite, but otherwise is about the same. Some small red markings were noted. The ledge is underlain by a couple of feet of bluish-gray clay followed by red earth. The gray band immediately under dolomite beds is a common feature of the Blaine.

A thin section shows a very complex arrangement, on the whole appearing to be less than half dolomite as angular to irregular fragments in calcite. There are some definite nests and stringers of clear calcite.

In the south part of sec. 12, T. 6 N., R. 26 W., (Harmon County) what appeared to be two dolomite members were seen, but there is no great certainty about the correlation of the lower one. In the CSL. of section 10 of the same township, what is probably the upper member was seen but not the lower one.

A more intensive exploration of the rough country near the Texas border would no doubt reveal more dolomite. Clifton[62] reports finding specimens of *Schizodus* and *Pleurophorus* in dolomite along the Texas line in Tps. 3, 5, and 6 N., Harmon County.

Jester Dolomite.—Where the road from Jester crosses the heavy gypsums at the SE. cor, sec. 25, T. 7 N., R. 24 W., a 9-inch dolomite member is found about midway between the Haystack and Cedartop gypsums. It is slightly platy, medium- to fine-grained, brownish-gray and contains only 1 to 2 per cent calcite. The insoluble part (about 5 per cent) is gray silt with a little quartz about 0.03 mm. in diameter.

At this locality are found two hard thin layers apparently unconformable to the gypsums, and at the top of 10 inches of sandy material. One massive, very fine grained, light-gray, brittle layer appears to be almost wholly dolomite. Another brownish-yellow, somewhat laminated, fine-grained one appears to be roughly 50 per cent dolomite. To what horizon these belong is very uncertain, although it seems possible that they are Tertiary.

The 9-inch member was also located about the middle of the south part of sec. 20, T. 7 N., R. 23W., and also in the NE. 1/4 of section 18 of the same township. However, it was not observed below the Mangum member between secs. 10 and 11, T. 7 N., R. 24 W., nor any other place in Greer County.

In southwestern Beckham County the dolomite occurring below the Mangum is well shown in the canyon north of Elm Fork on the

62. Op. cit., p. 8.

county line, sec. 36, T. 7 N., R. 26 W. What appears to be the same member may be found in the low land in sections 8, 9, 16 and 17 in the township east of the above.

In the NE. cor. sec. 23, T. 7 N., R. 26 W., what is no doubt the same ledge is at least 24 inches thick and not less than 50 feet below the Mangum dolomite immediately to the north. It is very much weathered and does not show red markings. About 0.7 miles farther south what appears to be the same member resembles the Creta dolomite as seen north of Red River.

This dolomite underlies a considerable thickness of gypsum ledges in some places, but they are commonly removed by weathering. It is not more than 40 feet above a massive gypsum, which is exposed in a good section north of Elm Fork directly to the south. There is little doubt that this is the Haystack member. If so, the dolomite corresponds closely to the position of the 9-inch member, north of Jester.

Specimens are coarse- to medium-grained, highly porous, gray to brownish-gray, with bedding faintly shown by arrangement of cavities. Fragments are an intimate mixture of calcite and dolomite, the latter roughly 50 to 75 per cent. The insoluble residue is about 5 per cent, mostly gray silt but some sub-angular quartz, all under .08 mm. but mostly much smaller.

A thin section shows some colorless, rounded spherules and other less definite brownish ones indicating a sort of oolitic texture. On staining, small grains of dolomite about 0.03 mm. across are shown to be completely surrounded by thin threads of calcite or set in a calcite matrix. The calcite in a few cases has apparently recrystallized as rhombs inclosing the dolomite grains. One rhomb has an irregular core of dolomite. It may be debatable whether this represents alteration of dolomite to calcite or dolomitization of limestone. The writer favors the former view, on account of the analogy with more definite cases. One is tempted to infer that this dolomite is contemporaneous with the Creta member, but this still remains to be proved.

Along the WL. NW. 1/4 of section 13, T. 6 N., R. 26 W., an appreciable area of a thin, hard, brittle, fine-grained light-gray rock is found. It is inclined to be platy. This rock appears to be wholly dolomite with the exception of a rather bulky insoluble part, perhaps 10 per cent, of about equal parts gray silt and fine quartz mostly below 0.03 mm. in diameter. While this rock occurs only locally it is found in many small spots. It was noted north of the natural bridge in the vicinity of the middle south part of sec. 29, T. 6 N., R. 25 W., (Greer County) and what may be the same rock was seen along the west side of sec. 6, T. 5 N., R. 24 W., (Harmon County). This rock is no doubt post-Blaine.

Summary.—The Haystack district comprises the region covered by the Blaine formation in Greer and Beckham counties, north of Elm Fork and west of Haystack butte.

Two important dolomite members occur in this district. The one previously mentioned by several authors caps the Blaine section and is undoubtedly the Mangum dolomite. A second one, noted in some places between the Haystack and Cedartop gypsums, is here called the Jester dolomite. The Creta member is not present, unless the Jester represents it in this district.

The Mangum dolomite, on the whole, is poorly exposed, and the effect of weathering is pronounced. It may probably be best observed 4 miles west of Haystack butte, where it is over 2 feet thick in some places. The top is honeycombed with the typical red markings and, as in other districts, the rock contains much calcite. The rest of the member is a fine-grained, gray dolomite with little calcite and a variable amount of insoluble matter, probably not more than 15 per cent, gray silt and quartz grains as large 0.15 mm. in diameter.

The Jester dolomite, found typically in the escarpment a few miles west of Haystack butte, is doubtless much more extensive than shown in Plate I. The dolomite varies from 9 to 24 inches in thickness, is gray to brownish-gray, variable in grain, in places very pure dolomite but contains considerable calcite in others. The insoluble matter does not appear to be over 5 per cent, and consists of silt with a little very fine quartz.

THE SENTINEL DISTRICT

Definition.—This district is included in a narrow strip of country, trending approximately east and west, from the North Fork of Red River southwest of Carter in Beckham County, along the Kiowa-Washita boundary to a point east of Mountain View, south of the Washita River.

Geology.—The dolomite follows the outcrop of the Blaine gypsums which is narrow in this region, partly due to their comparatively steep dip to the north, being quite close to the flank of the Wichita Mountains. According to the State map, by Miser, it is bordered on the south by a narrow strip of the Chickasha and Duncan formations, and on the north by an even narrower strip of Dog Creek shale.

Topography.—In southeastern Beckham County, the gypsum bluffs are prominent and close to the North Fork, usually from a quarter to one and a half miles away. They reach a height of 150 to 200 feet. In the rest of the district the gypsum is not prominent or absent on the surface. The dolomite may be found on predominantly low and discontinuous bluffs. Flat soil-covered country is found north of the

Blaine practically every place, and east of North Fork this is true, on the whole, for the country to the south also.

The low relief is due to the proximity of the North Fork and Washita rivers (about 6 miles apart) and also of their branching tributaries, Elk and Rainy Mountain creeks respectively.

Stratigraphy.—The following section, with minor modifications, is given by Gould[63] and is probably as complete as could be obtained.

Section of Bluff on North Side of North Fork of Red River, 3 Miles South of Carter.

		Feet
10.	Rough, weathered sandy dolomite capping the high hills	3
9.	Red and green gypsiferous shale	24
8.	Massive, white gypsum	23
7.	Red and green shale	6
6.	Massive white gypsum	18
5.	Red and green shale	15
4.	Massive, white gypsum, occasional thin ledges of sandstone	25
3.	Reddish and green shale	24
2.	Greenish gypsums and gypsiferous shale, becoming hard locally	5
1.	Red and green gypsiferous shale from the base of the hill	30

The lowest heavy gypsum, bed 4, probably the Haystack, is the chief cliff-maker. The dolomite is usually seen back some distance from the southern tips of the bluffs, but is quite discontinuous.

It may be stretching a point to call this the Mangum dolomite, but at least there seems to be no evidence to the contrary at present. Only one dolomite of importance appears.

Description of Dolomite.—In the southeast corner of sec. 9, T. 8 N., R. 22 W., west of the railroad, the dolomite is 30 inches thick and is very crumbly and weathered. Some red markings may be seen in the top. Immediately under it are a few inches of bluish-gray clay grading into red lower down, a common arrangement in this district and elsewhere.

In the most extreme southeast corner of Beckham County all that can be seen of the dolomite are fragments 2 to 4 inches thick with red markings.

In northwestern Kiowa County, northwest of Cambridge, a low outcrop of dolomite is rather continuous across five sections. Red markings are noted here. In the NW. cor. sec. 9, T 7 N., R. 19 W., the dolomite shows a prominent layer with red markings but has immediately above it a hard, fine-grained, massive, light-gray layer which also appears north of the road half a mile to the east. It is a very pure dolomite, shown in thin section to be oolitic.

63. Op. cit., p. 66.

At the two localities mentioned above there occurs about 25 feet above the dolomite a thin gray platy carbonate member. It may also be noted in secs. 27 and 28, T. 8 N., R. 18 W., southwest of Rocky. It seems possible that this belongs to the Dog Creek.

In the NW. cor. sec. 1, T. 7 N., R. 19 W., the dolomite appears different from any previously described. Red markings are few and the knobby, honeycombed appearance and sandy weathering are wanting. On the whole it resembles the Creta dolomite as seen near Mangum more than the Mangum member. The most striking feature, however, is the occurrence of fossils[64] (pelecypods) in a hard massive ledge about 6 inches thick apparently at the top of the rather poorly exposed member. The fossils are still calcite or aragonite, mostly leached out in part.

The member seems quite uniform. Specimens are very massive, medium- to fine-grained, light-gray and rather finely porous, with a somewhat powdery feeling. A hand lens shows small gray rounded to sub-angular closely packed grains in a somewhat darker gray matrix. The whole rock appears to be dolomite. The insoluble part is small.

In thin section, this rock is shown to be oolitic. The spherules are closely packed, vary from 0.075 to 0.22 mm. in diameter, and most of them show a suggestion of concentric structure, commonly a thin rim of somewhat coarser grain than the very fine grained, dark interior. The matrix is usually lighter in color, but this condition is reversed in a few spots. Considerable angular quartz sand is present, about 0.05 mm. in diameter, only rarely found in the spherules. One valve of a shell is present, the only calcite in the section, but is completely recrystallized and would not be recognized in thin section alone. Plate IX, C shows part of the valve and the character of the spherules. The calcite appears to cut across the spherules, possibly a result of the recrystallization of the calcite.

In the NW. cor. sec. 8, T. 7 N., R. 17 W., the same member is rather poorly exposed, but large hard flagstones cover the slopes. The same thin ledge noted to the north and west is found some 20 to 30 feet above it. A specimen typical of the harder blocks of the former is light-gray, massive, rather fine grained with a decayed look due to small brownish black specks, probably dendritic pyrolusite, spaced 2 to 3 mm. apart. Under a lens this rock shows the "grained" oolitic

64. Several specimens containing pelecypods, mostly from this horizon in Kiowa County, were sent to Dr. J. W. Beede for examination. His remarks, in a letter of June 24, 1929, are as follows:

"These pelecypods belong to the general horizon of the Whitehorse sandstone of Oklahoma or the beds near Quanah, Texas, which occupy virtually the same horizon. They are **Pleurophorus** cf. **albequus**, but probably do not belong to that species since the prolongation of the shell in front of the beak is a little too great and the radiating ridges are too faint. The specimens are too poorly preserved to be used as types of new species."

texture noted above. The rock is dolomite with probably 5 per cent calcite and about 3 per cent insoluble quartz sand, largely 0.08 mm. in diameter, and some very fine silt. A thin section showed no calcite.

A specimen from north of the road showed fossils plainly, also the oolitic texture. Stained fragments show a dolomite full of small rounded to sub-angular calcitic spots, some with concentric structure, most of which are partially leached out. A small per cent of fine-grained, creamy-gray fragments are wholly dolomite. The rock is possibly 30 to 40 per cent calcite.

A specimen from the SE. cor. sec. 4, T. 7 N., R. 17 W., just east of the above locality is similar but only 8 to 10 per cent calcite. It is full of small pores. The ledge there is 2 feet thick and is prominently exposed some 115 feet above gray shaly rocks in the road. About three-quarters of a mile to the north what appears to be the same ledge may be found on both sides of a small creek. It is, however, about 150 feet below the former one. Fossils were found in the base of the northern ledge. The exposure just south of the creek is 37 inches thick and in the ditch dips at an angle of 15 to 25 degrees toward the creek. Although it seems rather impossible at first, the writer believes this to be the same member as found on the higher ground, greatly slumped into the creek valley. It will be shown later that such slumping has taken place near here.

The gray shales mentioned above seem to be the same series as that noted west of Gotebo, in the southeastern part of sec. 13, T. 7 N., R. 17 W., and in section 12 of the same township, also south of the road 2½ miles east of Cambridge, and in sec. 11, T. 7 N., R. 16 W., where it has a thin covering of medium-sized conglomerate with red matrix. The massive parts of these gray platy rocks have been mistaken for dolomites and are not unlike them on superficial examination. The writer finds them to be 75 to 80 per cent sub-angular to roughly rounded sand, quite well sized, mostly quartz, about 0.08 mm. in diameter. The matrix is largely calcite and probably entirely so. Surfaces with a satin-like reflection are due to recrystallization of the cement into large crystals showing cleavage and are commonly noted. This rock is undoubtedly lower than the Blaine and is probably the Duncan[65], but also has been considered pre-Duncan.[66]

A very noteworthy occurrence of the dolomite in this district is found in the NE. ¼, sec. 1, T. 7 N., R. 17 W. Slumping has occurred here to a rather unique extent, causing a distinct duplication of the dolomite, which has been displaced about 36 feet. The northern exposure has evidently been lowered into the creek valley to the north

65. Sawyer, Roger W.—Areal geology of a part of southwestern Oklahoma: Bull. Am. Assoc. Pet. Geol., vol. 8, no. 3, p. 312, 1924.
66. Becker, Clyde M.,—Op. cit., p. 6.

without any great disturbance. It is the same type of rock as seen above and the ledge appears to curve upward to the east and west. This phenomenon has been noted in connection with gypsum ledges.[67] The upper bed shows at least 6 feet of massive, light-gray dolomite, very brittle and quite uniform from top to bottom. Ripple marks are quite noticeable and some blocks show what looks like cross-bedding. Fossils are plentifully found in some blocks, the same as those previously noted. A peculiar feature here is a distinct rampart along the edge of the solid dolomite, from 1 to 2 feet high, and 2 to 3 feet wide extending for many yards. Very large blocks have broken off and slumped away from this face.

A typical specimen is very fine grained, massive, dense, light-gray with a shade of buff or tan. It appears to be only about 2 per cent calcite and the insoluble part is very small (1 to 2 per cent), a little very fine quartz and some brownish silt.

A thin section shows no calcite whatever, but reveals a sub-oolitic texture. Exceedingly fine grained dark gray spherules of rather indefinite outline, are closely spaced in a coarser matrix, with grains averaging about 0.015 mm. The spherules are mostly from 0.08 to 0.15 mm. in diameter, a few elongated ones being larger (see Plate IX, *D*).

The easternmost exposure of dolomite which the writer located was in the SE. cor. sec. 12, T. 7 N., R. 15 W., just southeast of Mountain View. The dolomite there is oolitic, showing best on weathered surfaces, indistinct on fresh ones. The rock is faintly and irregularly banded in shades of gray, some more porous than others. The spherules are dolomite but the matrix, partly filling the interstices is largely calcite. The insoluble residue is small, quartz from 0.13 mm. in diameter to very small, with some brownish silt. This is no doubt the same ledge mentioned by Gould[68] and referred to the Day Creek.

A thin section shows two distinct kinds of material. One is a fine-grained, brownish-gray dolomite with considerable quartz sand throughout, mostly 0.035 mm. in diameter. The carbonate grains possibly average 0.02 mm. This grades into undoubted oolitic dolomite of the same nature. The spherules are small, rather closely packed in a coarser grained matrix which is calcite but occupies only about half the space. They are of various shapes, sizes, and character. A few have a single sand grain as a nucleus, but it is too rare to be considered general, even allowing for sections not centrally cut. Sand grains are also scattered through spherules showing no concentric structure. Some spherules are uniformly brownish-gray throughout but others have a dark core, rounded or elongated. Some have a dark rim around a light core. Certain elongated or cucumber-shaped ones undoubtedly

67. Snider, L. C.—Op. cit., pp. 136, 139, and also 141, where such a duplication is pictured from Harper County.
68. Op. cit., p. 58, 1905.

contain fossils, probably a piece of shell serving as a nucleus for concretionary growth. In one or two cases the fossil-like sliver seemed still calcite. Plate X, A, shows one with the shell removed. The ordinary spherule averages about 0.25 mm. in diameter. Only a few show more than two or three concentric shells. The calcite matrix is probably secondary and formed at the surface.

Summary.—The Sentinel district is included in a narrow strip of country along the boundary between Kiowa and Washita counties, which extends for a few miles into southeastern Beckham County.

The Mangum dolomite is the only one of importance in this district. In Beckham County it is similar to that found near Mangum and has the red markings. As one goes eastward in Kiowa County the dolomite looks more and more like the Creta dolomite. Red markings are fewer and the honeycombed character is not noticeable. Fossils are noted in several places. A fine oolitic character seems quite typical. The fossils, although mostly leached out leaving a cast, appear to be calcite when present, the matrix being more or less pure dolomite. The insoluble part of the rock is probably always under 5 per cent, gray silt and quartz grains mostly under 0.1 mm. in diameter. The thickness is ordinarily 2 to 3 feet, but in sec. 1, T. 7 N., R. 17 W., it reaches the unique thickness of 6 feet and is very hard and fresh.

SUMMARY AND CONCLUSIONS

Occurrence of Dolomites.—Generally speaking, the Blaine dolomites of southwestern Oklahoma are found along the serrate gypsum escarpment which marks the dividing line between the Blaine and lower formations or Recent stream deposits. This escarpment rises in places as bluffs over 200 feet high, but in other places practically disappears. It may be traced from Red River in southwestern Jackson County north to Elm Fork in Greer County. From there it may be followed around the headwaters of Elm Fork and tributaries in Greer, Harmon, and Beckham counties, across North Fork in southeastern Beckham County and eastward as a narrow fringe along the Kiowa-Washita boundary to Mountain View, the easternmost point where dolomite was noted.

Stratigraphy.—Three dolomites occur as more or less thin beds in the upper part of the Blaine section. The Mangum dolomite is the highest member of the formation, and may be found, more or less discontinuously, along the whole length of the escarpment in this area. South of Elm Fork in Greer and Jackson counties a second member occurs about 30 feet below the Mangum. The writer has called this the Creta dolomite. In Beckham County a somewhat similar dolomite was found in several places between the two massive gypsum members, the Cedartop and Haystack, which are respectively the second and third ones found below the Mangum dolomite. This

member has been tentatively called the Jester dolomite. The Creta dolomite does not seem to be present. It appears that the Jester is below the Creta horizon, but at present their relations to each other are doubtful. They may prove to be equivalent.

Mangum Dolomite.—The Mangum dolomite was named by Gould in 1905. Although a very persistent member, it is quite variable in thickness, appearance, and composition, a fact which the writer attributes more to variation in extent of weathering and superficial alteration than to its original condition.

This dolomite, as measured by the writer, is as much as 6 feet thick, but in only a few places was it found to be over 2 to 3 feet thick. The ledge is typically capped by a honeycombed, knobby-weathering, dark-gray rock of very variable composition, veined by fine-grained dense red calcite, apparently deposited in solution cavities. This phase is commonly all that remains in poor exposures. It usually contains a large percentage of calcite and has a very noticeable development of small dendrites of manganese oxide. Where thicker exposures are found, rather pure, platy to massive, gray, fine-grained dolomite may be found below it. However, the rock with red markings is not present every place and pure, platy or massive, gray dolomite may constitute the whole section. A rearrangement of the dolomite has taken place within the bed in some cases. Pelecypods were found in this member in several places in Kiowa and Washita counties. It is oolitic in many places, particularly in Kiowa County, but this phase is not nearly so typical of the Mangum dolomite as it is of the Creta. Ripple marks were observed in a few places.

Creta Dolomite.—Although apparently not so persistent as the Mangum, the Creta dolomite is more uniform in thickness and character, probably due in part to the protection from weathering it has received due to overlying beds.

As commonly observed, it is between 1 and 2 feet in thickness, light gray, very fine grained, porous, thinly laminated and platy or sandy in weathered exposures. On close examination, the rock is often found to be finely oolitic, a characteristic particularly noticeable in thin sections. The spherules are commonly under 0.5 mm. in diameter and are of many types, shapes, and sizes, grading from ones with circular cross-section to ones having elongated or irregular form and from ones with concentric structure and clear-cut rims to uniform, structureless masses with indefinite borders, forming a rock which can hardly be called an oolite at all. It is commonly a very pure dolomite, but in places is definitely replaced by calcite which has entered along cracks and worked its way between spherules and grains.

Jester Dolomite.—The Jester dolomite is rather poorly exposed, is difficult to trace, and has not been very extensively studied. Exposures are from 9 to 24 inches in thickness. In general, it resembles the Creta dolomite, but is possibly more variable, and definite oolitic texture was not observed.

In places it is a pure dolomite, brownish-gray, medium- to fine-grained and somewhat platy. However, calcite surrounds the dolomite grains and forms much of the rock in other localities.

Alteration of Dolomite.—One of the problems which presents itself at once in a study of the dolomites of this as well as other areas is the origin of the calcite commonly present in them, which varies in amount from a trace to over half, and possibly composes the entire ledge in a few places.

Where the amount is not over 5 per cent it can nearly always be explained by the presence of coarsely crystalline calcite, visible to the naked eye, which occurs in small veinlets or lines cavities, plainly a recent deposit.

In other cases, however, calcite is so intimately related to the dolomite that the mode of its occurrence is not plain even in thin sections, and dolomite may even be lacking or present in very small amount. Such occurrences by themselves are difficult to interpret.

However, the writer has observed every gradation between pure dolomite and rocks that are largely calcite. Occurring first in joints, bedding planes, pore spaces, and solution cavities, the calcite appears to work its way into even the densest dolomite, surrounding the coarse grains and spherules, as a network at first, then penetrating between the very fine grains and gradually replacing them. With the recrystallization of the calcite, a medium- to coarse-grained rock results, the individual crystals flecked with microscopic grains of dolomite. Dolomitic limestones of complex nature and even quite pure calcite rocks appear to be a final stage of the process.

However, although the writer is convinced that the dolomites are actually replaced by calcite, he would not go so far as to say that none of the calcite rock is original. This still remains to be proved.

Circulating surface waters, containing several times more calcium than magnesium appear to be fully capable of replacing dolomite. Such waters, with a high percentage of dissolved salts, are found in the region at present. The action of such water is, of course, highly dependent on carbon dioxide content and the proportion of other ions present.

Formation of Oolitic Texture.—One of the most interesting features of the Blaine dolomites is the presence of an oolitic or sub-oolitic texture, scarcely noticeable to the naked eye. Oolitic dolomite is widespread, but it does not appear to be confined to any definite layer or member and grades within a few feet or inches to dolomite which shows no trace of spherules. Little information can be obtained about them without thin-sections as almost all the spherules are under 1 mm. in diameter and the great majority of them are very much smaller.

In a study of a considerable number of oolitic specimens, the writer has been impressed with the variety they present, and yet appear to be different phases of the same rock and presumably formed by the same process. The variation in shape of the spherules has been previously pointed out as well as the difference in their structure. Many types are commonly seen in one thin-section and in one field. A few appear to have a nucleus of quartz grains, but commonly the quartz is distributed irrespective of the structure. A very few spherules certainly have part of a fossil as a nucleus, apparently still calcite. The shapes of others are suggestive of a fossil nucleus but if so, the calcite has been altered to dolomite. No definite case of replacement of nucleus was observed. Calcite may be found both inside hollow spherules and as a sort of matrix but in every case it is in a loose textured, weathered rock and is regarded as secondary.

In certain places the oolitic phase is observed to grade into remnants of an exceedingly fine grained dolomite, in which banding is brought out by minute sand grains, and which appear to represent the original deposit, undisturbed in position or character.

Considering the evidence as observed so far, the writer is inclined to believe the texture of these dolomites has been developed, for the most part, after their deposition, but before consolidation. However, this is only an opinion. A complete study of these interesting rocks will involve much more work and is a problem in itself.

Origin of Dolomite.—The writer does not believe that sufficient data has yet been accumulated with regard to these dolomites to draw any definite conclusions as to origin. A thorough study of the oolitic phase will undoubtedly give much more definite information than we now possess.

However, no instance has yet been noted which points conclusively to replacement of calcite by dolomite, although many occurrences may, it seems, be interpreted in this or other ways. On the other hand, many things indicate that the dolomite was originally deposited as such, in some places at least, in the same manner as many fine-grained limestones. Some points in favor of this view are:

1. The lack of any calcite in the freshest material obtainable.
2. The widespread fineness of grain and the preservation of very fine laminations.
3. The lack of any sign of recrystallization of the spherules in the oolitic phase, or in any of the unweathered dolomites.
4. The presence of calcite fossils in a dolomite matrix.
5. The lack of residual nests of calcite in the field or in laboratory specimens.
6. The improbability of uniform dolomitization over such a wide area.
7. The absence of any comparatively extensive limestone beds in the Permian of Oklahoma.

However, the question must be regarded as open until further detailed information can be obtained.

THE NORTHERN AREA

INTRODUCTION

In this part will be considered the dolomites found in the Blaine formation of northwestern Oklahoma, which extends as a long narrow strip from El Reno in Canadian County northwestward to the Kansas boundary. Figure 7 is a map of western Oklahoma showing the position of the area.

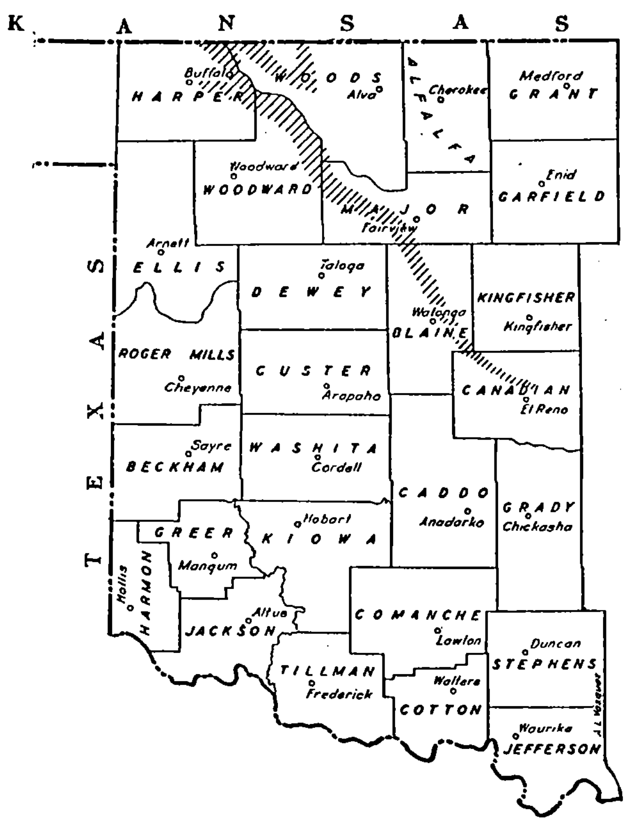


Figure 7. Map of part of western Oklahoma showing the northern area of the Blaine formation.

The writer spent little time in examining these dolomites, which at best are not very prominent, nor are they as extensive as other members described. For the sake of completeness, however, the scattered information already published about them has been collected and is presented here together with some observations made by the writer.

POSITION OF THE BLAINE ESCARPMENT

As in the southwestern area, the dolomites are found in the escarpment formed by the gypsum ledges, in this case a very prominent one, facing east to northeast, called by Gould the main line of gypsum hills. Plate XVI shows the position of this escarpment, taken from various maps by Snider.[68] It will be observed that it occurs in northwestern Woods County north of the Cimarron River as a crescent-shaped area, and along the southwest side of the valley extends from the State boundary in eastern Harper County in a southeasterly direction across parts of Woodward and Major counties to the vicinity of Fairview. There it turns southward away from the Cimarron, crosses Blaine County parallel to the North Canadian River and continues so across the southwestern corner of Kingfisher County and into Canadian County, becoming less and less conspicuous, and practically disappearing a few miles north of El Reno.[69] The width of the outcrop of the gypsums varies from about 1 to 10 miles.

TOPOGRAPHY AND DRAINAGE

The difference in elevation between the lower country east of the escarpment and the "high plains" to the west is marked (about 200 feet) in nearly all parts except the southern extremity. However, the high plains must be considered as a very broad term as the country west of the escarpment slopes more or less gently into the valley of the North Canadian River, except, of course, in northern Woods County.

The drainage is practically entirely into the Cimarron River, although the area is nearer the North Canadian over much of its length. The heads of a large number of minor creeks running northeast and east have cut wall-canyons into the escarpment, producing an exceedingly rugged strip of country particularly as viewed from the eastern side.

Gould[70] gives the following description:

68. Op. cit., 1913.
69. According to Snider five miles north of El Reno but Gould has placed it at five miles south of the town
70. Op. cit., p. 45, 1905.

From the east the Gypsum Hills appear as a wall crowned with a white band, but the sky line is not continuous, as numerous breaks occur where the gypsum ledge has been dissolved by water and carried away. The general appearance is rather that of an uneven row of flat-topped buttes or mesas of various sizes than a single hill with a continuous escarpment. To these buttes the name "Mansard Mounds" has been given by one writer, in fancied resemblance to a mansard roof. Not infrequently a few bold points stand out at a distance east of the main range, and these outliers being more conspicuous have sometimes received distinct names, as Glass Mountains, Mount Heman, Cedar Hill, and Henquenets Butte. Particular names have been given to certain parts of the range, as Stony Hills, in Blaine County, east of Watonga, and Chatauqua Mountains for the same range farther north, extending to the Glass Mountains. The name Marcy Range has been proposed for the entire section of hills. These names, however, probably will never supersede the much-used term, "Gyp Hills."

Detailed descriptions of the Gypsum Hills by counties have been given by Snider.[71]

AREAL GEOLOGY

It need only be mentioned here that the red shales of the Enid group are found below the Blaine and to the east, and the Woodward group is found to the west. The Dog Creek and Whitehorse are not satisfactorily separable. The Enid group, being every easily eroded, contributes to the formation of the peculiar and varied erosional forms. In the northern part of the area, the extensive Quaternary deposits north of the Cimarron are very noticeable.

GENERAL STRATIGRAPHY

The stratigraphy of the Blaine of this area was first briefly mentioned by Cragin in 1896 in connection with his description of the Kansas gypsums. It was not until the following year, however, after a short visit to Oklahoma, that some direct observations were made and the presence of dolomite noted.[72] The classification of his "Salt Fork division" at that time is given below.

Classification of Cragin's "Salt Fork Division."

Salt Fork Division	DOG CREEK (STONY HILLS)	Chapman dolomite
		Amphitheatre dolomite
	CAVE CREEK	Shimer gypsum
		Jenkins clay
		Medicine Lodge gypsum
	GLASS MOUNTAIN	Flower-pot shales
		Cedar Hills sandstone
	KINGFISHER	Salt Plain
		Harper

71. Op. cit., pp. 132-175, 1913.
72. Cragin, F. W.,—Observations on the Cimarron series: The American Geologist, vol. 19, p. 358, 1897.

The two dolomites appear to be the same as the ones shown above the Shimer by Gould, (see p. 74) the lower one at least being included in the Blaine section as now understood. His correlation of these dolomites with those of the Stony hills east of Watonga was an error as previously explained, the latter belonging to the Blaine formatio nbelow the Shimer (see plate XVI). The names applied to these dolomites have not been retained.

A few years later Gould made the first comprehensive observation on the gypsums of Oklahoma, and finding it necessary to make a considerable change in Cragin's classification, introduced the present rame for the gypsum formation and classified it as we now know it,[73] dropping the "Jenkins clay" of Cragin's classification and adding the Ferguson gypsum to the bottom, as follows.

BLAINE FORMATION	Shimer gypsum member
	Medicine Lodge gypsum member
	Ferguson gypsum member

A typical occurrence of the three members is shown in Plate V. In 1905 the Blaine was described in part as follows:

> The Blaine formation consists of red shales with interbedded strata of gypsum and thin ledges of dolomite. It includes the portion of Professor Cragin's Flowerpot formation above the base of the Ferguson gypsum and all of his Cave Creek formation. It is named from Blaine County, Oklahoma, where it is typically developed.
>
> * * * The bottom of the lowest massive gypsum bed—the Ferguson gypsum member—is the base of the formation throughout its occurrence northwest from Darlington, Canadian County. Where it disappears the shales of the Enid continue up to the base of the Medicine Lodge gypsum member, which necessarily becomes the basal member of the formation. The top is the Shimer gypsum member * * *
>
> The Blaine formation consists of three ledges of massive gypsum interstratified with red shale and an occasional local ledge of more or less arenaceous and argillaceous dolomite, which usually occurs at the base of the heavy gypsum * * * the dolomites are too local to deserve formation rank.
>
> **Ferguson gypsum member.** * * * In Canadian, Kingfisher, and southern Blaine counties it is the thickest of the three gypsum members, but it thins out in the north and disappears in the region of the Glass Mountains * * *.
>
> **Medicine Lodge gypsum member.**—The Medicine Lodge gypsum is the most conspicuous gypsum deposit in the red beds * * * and is in most places the ledge which forms the cap of the Gypsum Hills.

A phase of the Medicine Lodge in the vicinity of Salt and Bitter creeks is known as the Salt Creek marble. It appears to be largely anhydrite.

73. In 1902, when this classification first appeared, two dolomites, the Altona and Magpie members, were placed beneath the Shimer and Medicine Lodge respectively. These were left out in 1905, being regarded as too local to deserve a name.

> **Shimer gypsum member.**—* * * It is typically exposed either as the highest gypsum outcrop somewhat back from the brow of the hills, or as the cap rock of occasional bluffs and buttes overlooking the slopes below. * * *
>
> In some localities the shale member which separates the Medicine Lodge from the Shimer thins out and the two massive gypsum ledges are practically continuous * * *.
>
> The thickness of the Blaine formation * * * averages about 75 feet.

Although Gould reports the Ferguson to disappear in the vicinity of the Glass Mountains, Snider observed three members in Woods County. Uncertain about their correlation, he tentatively gave them the same names as the members of the type locality.

As now defined the typical Blaine section includes 60 to 80 feet of gypsiferous shales and other soft rocks below the Ferguson as well as about 40 feet of clays and sandy shale above the Shimer, making a total thickness of close to 200 feet.

STRATIGRAPHY AND DESCRIPTION OF THE DOLOMITES

The Blaine dolomites of this area have not been described in any detail. They have, however, been placed in numerous sections by Gould and also Snider, commonly described as soft sandy dolomite or gray dolomitic sandstone, in places said to be honeycombed or fossiliferous. Obtaining his information chiefly from these sections, the writer has indicated on the accompanying map of the Blaine the districts in which the dolomite outcrops. (Plate XVI). The various localities about which the author has any information will be discussed individually, taking them, in general, from north to south.

The most northerly occurrence of dolomite noted in the Blaine is in Woodward County just west of Chimney Butte (sec. 27, T. 25 N., R. 17 W.), where Snider reports a dolomitic sandstone, 3 feet thick, beneath the Shimer. It is not shown, however, in a section by Gould taken at the southwest corner of the Salt Plain.

In Major County several "dolomitic sandstones" have been reported. Snider[74] gives the following sections:

Section at head of Crook Creek Canyon, Sec. 14, T. 22 N., R. 16 W.

		Feet
5.	Shimer gypsum	10
4.	Red and green selenitic shales with some sandstone	15
3.	Medicine Lodge gypsum	15
2.	Red and green selenitic shales with dolomitic sandstone	10
1.	Ferguson gypsum	15

74. Op. cit., pp. 147-148, 1913.

Section of East Side of East Griever Creek Canyon, Sec. 28, T. 22 N., R. 15 W.

		Feet
12.	Medicine Lodge gypsum	16
11.	Greenish sandstone	1
10.	Red and green gypsiferous shale	8
9.	Ferguson gypsum	15
8.	Greenish, shaly sandstone	1
7.	Green shale, very selenitic	1¼
6.	Greenish dolomitic sandstone	¼
5.	Red shale with bands of green shale and satin spar	26
4.	Shaly, cross-bedded, selenitic sandstone	7
3.	Red shale, with bands of green shale and satin spar	6
2.	Shaly, cross-bedded, selenitic sandstone	1
1.	Red shale containing many thin bands of green shale and satin spar from East Griever Creek	93

A heavy honeycombed sandstone was noted about 20 feet above the Medicine Lodge at the above locality. This probably represents the dolomite commonly found below the Shimer.

Section on West Barney Creek, Sec. 25, T. 22 N., R. 15 W.

		Feet
13.	Shimer gypsum	8
12.	Honey-combed dolomitic sandstone	2
11.	Covered, probably shale	17
10.	Medicine Lodge gypsum ...about	10
9.	Covered, probably shale	13
8.	Ferguson gypsum	11
7.	Greenish dolomitic sandstone	½
6.	Green, sandy shale	3½
5.	Red shale with many thin bands of green shale and satin spar	14
4.	Selenitic sandstone	½
3.	Red and green shales	8
2.	Shale and soft sandstone, red and green, cross-bedded, gypsiferous	8½
1.	Covered, probably shale	41

In section 22 of the above township Snider notes 10 inches of greenish dolomitic and selenitic sandstone below the Ferguson.

Section on Gypsum Creek, Sec. 33, T. 21 N., R. 13 W.

		Feet
7.	Shimer gypsum—top removed	15
6.	Honeycombed dolomitic sandstone, at least	2
5.	Covered, probably shale	25
4.	Medicine Lodge gypsum including at least one foot of anhydrite exposed	6
3.	Greenish dolomitic sandstone	1
2.	Covered, probably shale	13
1.	Ferguson gypsum, base not exposed	6

About the northwest corner of sec. 22, T. 21 N., R. 13 W., Gould notes 2 feet of dolomite below the Shimer and 1 foot of soft sandy dolomite below the Medicine Lodge. His Glass Mountain section is given below:

Glass Mountain Section, on the Northwest Side of the Mountain

		Feet
11.	Massive, white gypsum (Shimer)	13
10.	Fossiliferous dolomite	1
9.	Red clay	15
8.	Massive, white gypsum (Medicine Lodge)	18
7.	Greenish clay	4
6.	Red clay	8
5.	Gypsum concretions and satin spar	1
4.	Red clay	3
3.	Bluish dolomite rock, hard	⅔
2.	Red clay	4
1.	Gypsiferous rock, satin spar	4

Gould also notes fossiliferous dolomite beneath the Shimer from 1 mile east of Granton (sec. 1, T. 21 N., R. 14 W.) and sandy gypsiferous rock from beneath the Medicine Lodge.

About 3 miles west of Fairview the writer observed the following section.

Section in the NE. ¼, Sec. 25, T. 21 N., R. 13 W.

		Ft.	in.
14.	Massive gypsum (Ferguson)	6	......
13.	Dolomite	......	3-4
12.	Red, earth, gypsiferous shales	25-30	......
11.	Blue-gray dolomite	......	5
10.	Blue and gray shale	9	......
9.	Hard gray dolomitic sandstone, probably local	......	3-10
8.	Greenish gypsiferous shale	......	16
7.	Gypsum	......	6-8
6.	Shale	9	......
5.	Green, shaly gypsum	......	4
4.	Shale	3	......
3.	Gypsum	......	6
2.	Soft shale	8	......
1.	Gypsiferous shale with harder greenish capping	5	......
	Unmeasured, bluish-green shale with thin beds of gypsum		

It will be noted that there are three dolomitic rocks here. Bed 9 is probably local and is not at all noticeable. Bed 11, however, is easily found and fragments of it are scattered over the whole slope below. What may be the same rock is found in the soil in the northwest corner of the section.

It is a very dense, fine-grained, slightly laminated, medium-gray rock with sub-conchoidal fracture. In thin section, it is very fine grained even under high magnification and contains a small proportion of very small angular quartz grains, some elongated and very sharp.

The dolomite immediately beneath the gypsum is hard, rather dense, dark-gray, massive where fresh but an oolitic character is revealed on the weathered top. This rock appears to be a pure dolomite. The insoluble part is small and consists of gray silt with little or no quartz.

In thin section, this rock appears to be somewhat different from other oolites examined, the brownish spherules being thickly set in coarsely crystalline colorless matrix. Some fit together like a mosaic, see Plate X, *B*. They are commonly rounded, but many have irregular blocky forms. There is little indication of concentric structure.

It seems certain that there are two generations of dolomite here, the colorless being later. Whether it represents replacement or simply recrystallization remains to be shown. However, this oolite does not appear to be a separate type.

What was thought to be a fresh specimen of the gypsum above proved to be thickly studded with small dolomite spherules. The matrix is medium- to coarse-grained gray gypsum with large selenitic plates.

A thin section shows that the gypsum has undoubtedly replaced the dolomite. Plate X, *C* shows clearly the relation of the two. Many spherules are quite well preserved and have a fringe of matrix still attached. The most distinct ones are about 0.35 mm. in diameter, but there are smaller spherules down to about half that size with much fragmentary material. The dolomite is brownish in color, very fine-grained and shows little or no concentric structure. The matrix consists of large crystals of gypsum inclosing the dolomite fragments and contains a rather thick sprinkling of small, fairly clear, carbonate particles, in addition to the larger spherules and fragments. The section contains no calcite.

This dolomite may be the one that is found in the road just west of the northwest corner of this section.

In Blaine County, the three gypsum members are well exposed. Dolomite, sandy dolomite or sandstone have been reported below all three but in some cases they have apparently not been noted.

Snider gives the following sections, some of which were measured by Gould.

Section in the SE. ¼, Sec. 9, T. 19 N., R. 12 W.

		Feet
5.	Medicine Lodge	
	Gypsum—top removed	4
	Anhydrite	3
	Gypsum	8½
4.	Greenish sandy shale and dolomitic sandstones	¾
3.	Red and green shale with selenite and satin spar bands	16
2.	Ferguson gypsum	6½
1.	Greenish dolomitic sandstone	½

Section in NW. ¼, Sec. 11, T. 18 N., R. 12 W., One Mile East of Southard.

		Feet
11.	Anhydrite, at top of hill ....about	4
10.	Gypsum, white, massive	5
9.	Greenish grey sandstone	½
8.	Red shale with green bands	9
7.	Red and green shale with satin spar and green selenite bands	11
6.	Ferguson gypsum, mottled	7
5.	Greenish dolomitic sandstone	½
4.	Red and green shale	8
3.	Green selenite in clay, satin spar	1½
2.	Red shale with thin bands of satin spar	7
1.	Red and green shale with some selenite	30

The "greenish gray sandstone" is probably dolomite.

The following section is adapted from one by Gould:

Section from South Canyon, Head of Salt Creek, West of Ferguson.

		Feet
11.	Red clay ....about	40
10.	Dolomite ....about	1
9.	Red clay ....about	30
8.	Dolomite ....about	2
7.	Red clay ....about	25
6.	Massive, white gypsum (Shimer)	15
5.	Soft, sandy dolomite	1
4.	Red, gypsiferous clay	27
3.	Massive, white gypsum (Medicine Lodge)	17
2.	Red clay with bands of selenite	25
1.	Pinkish, mottled gypsum (Ferguson)	4

Gould assigned the portion of the section above the Shimer to the Woodward group. As the Blaine is now understood, the lower dolomite at least and possibly both of them come within its limits. These are, no doubt, the Chapman and Amphitheatre dolomites of Cragin, previously mentioned.

Gould reports that Dr. Beede found *Pleurophorus subcuneatus* Meek and *Schizodus*(?) like *S. Wheeleri*, near Ferguson underneath the Medicine Lodge gypsum. However, most of the fossils observed appear to be in the dolomite below the Shimer.

A section from near Bickford in the SE ¼, sec. 18, T. 17 N., R. 11 W., shows no dolomite at all but, as Snider remarks, this may be due to the hidden lower contacts of the gypsum ledges. (See pl. V).

Section along the Chicago, Rock Island and Pacific Railway, Four Miles South of Hitchcock.

		Feet
8.	Massive, white gypsum, the Shimer	8
7.	Gray, dolomitic sandstone	1
6.	Red clay	45
5.	White, massive gypsum, the Medicine Lodge	12
4.	Gray, dolomitic sandstone	2
3.	Red clay shales with greenish bands	17
2.	Massive, white gypsum, the Ferguson	3
1.	Red clay shales with bands of gypsum	90

Section in SW. ¼, Sec. 19, T. 16 N., R. 10 W.

		Feet
8.	Shimer gypsum	6
7.	Dolomitic	½
6.	Red and green shales with thin dolomitic layers	42
5.	Medicine Lodge gypsum	7
4.	Covered, probably shale	20
3.	Gypsum, selenitic	2
2.	Covered, probably shale	25
1.	Ferguson gypsum	3

Snider notes that the dolomitic layer beneath the Shimer contains large numbers of pelecypods. Farther to the southeast the Shimer disappears. The dolomite continues, however, and is locally fossiliferous.

Practically the same locality, what appeared to be the northeast corner of section 30, was visited by the writer. The fossiliferous dolomite below the Shimer was observed. About 25 feet below it and immediately below the Medicine Lodge gypsum is a carbonate member about 17 inches thick, a soft, light-gray, crumbly rock. The basal 3 to 4 inches is much harder than the rest.

On close examination, this rock is distinctly oolitic, the weathered surface showing a very fine cellular structure, many of the spherules being hollow or weathered out. It contains no perceptible calcite, a fact one would hardly suspect, and very little insoluble matter.

The sandy weathering of these dolomites, so commonly observed, appears to be generally due to their oolitic character, possibly wholly so.

A specimen from the base of this member is fairly dense, very fine grained and hard, but very finely oolitic. It is medium-gray in shade with a faint reddish mottling. This rock appears to be a pure dolomite.

In the road about 5.2 miles west of Watonga and near the above place at least two thin carbonate ledges may be observed, possibly grading into shale. They are about 40 feet above the fossil horizon.

The lower one is about 8 inches thick, light-gray, brittle, and fine-grained. It grades into shaly and gypsiferous material. About 4 feet above this and some 2 inches thick is a very dense brittle layer. It is exceedingly fine grained and light-gray in shade. The weathered surface is finely banded. This rock is undoubtedly a very pure dolomite. The insoluble portion is small, although greater than that of the oolitic types, and part of it is a brownish gray silt.

To the previous sections may be added two more given by Gould from Blaine County:

Section near Watonga, Sec. 32, T. 16 N., R. 10 W.

		Feet
7.	Massive, white gypsum (Shimer)	4
6.	Gray, sandy dolomite	2
5.	Red clay with conspicuous green bands near the top	41
4.	Massive, white gypsum (Medicine Lodge)	10
3.	Grayish, sandy dolomite	1
2.	Red clay	13
1.	Massive, white gypsum (Ferguson)	3

Cedar Hill Section in SW ¼, Sec. 18, T. 16 N., R. 10 W.

		Feet
6.	Massive, white gypsum (Shimer)	12
5.	Fossiliferous, sandy dolomite	2
4.	Red clay with selenite bands	18
3.	Massive, white gypsum (Medicine Lodge)	3
2.	Red clay with seams of selenite	17
1.	Massive, pinkish to white gypsum (Ferguson)	5

The following general section was given the writer by G. D. Putnam[75] and represents the Blaine northeast of Watonga. It agrees roughly with that recorded by Gould south of Hitchcock, except that the base of the Blaine at that time was defined as the base of the lowest massive gypsum.

Generalized Section of the Blaine, applying to the District lying a few Miles NE. of Watonga.

		Ft.	In
10.	Thin, hard dolomite	......	2-5
9.	(Concealed)	40	......
8.	Massive gypsum (Shimer)	10-15	......
7.	Fossiliferous dolomite	......	8-18
6.	(Concealed)	about 60	......
5.	Pure gypsum (Medicine Lodge)	8-10	......
4.	Fairly hard, slightly sandy dolomite	......	18
3	(Concealed)	6-10	......
2.	Gray gypsum (Ferguson)	2-4	......
1.	(Concealed)	60-80	......
	Base of Blaine formation.		

The character of the undescribed members may be gathered from the previous sections.

The following section is from one mile west of the line between Blaine and Kingfisher counties.

Section in NE. ¼, Sec. 14, T. 15 N., R. 10 W., Two Miles West of Altona.

		Feet
7.	Medicine Lodge gypsum, top removed by erosion	3
6.	White dolomitic sandstone	2
5.	Red and green shales	16
4.	Gypsum, anhydrite, white satin spar beneath	3
3.	Red and green shale	18
2.	Ferguson gypsum, selenitic	3
1.	Red and green shale	21

75. Geologist, Trees Oil Company: Wichita, Kans.

Just one mile west of where the above section was taken, the writer observed three marked gypsum ledges about 10 to 20 feet apart. Below the top one, probably the Medicine Lodge, is a sandy carbonate ledge, about 11 inches of which are quite compact, but there may be more crumbly material above and below. There did not appear to be any fossils.

A specimen of this rock is creamy gray, very fine grained, but has a loose sandy texture and is probably oolitic. It is indistinctly banded. This rock is doubtless typical of the "sandy dolomite" so frequently mentioned in the sections. It appears to be a very pure dolomite with only a very small insoluble part.

The fossiliferous ledge appears to occur west of this place.

According to Snider, the gypsums fade out or are covered near the Blaine-Kingfisher line but reappear in the southwest corner of Kingfisher County continuing southward into Canadian County almost to Darlington. The outcrops, however, become discontinuous and the individual ledges cannot be followed. The following section is given.

Section in NW. ¼, Sec. 29, T. 15 N., R. 9 W.

		Feet
6.	Medicine Lodge gypsum, pink, top eroded	4
5.	Sandy, white dolomite	2
4.	Covered, probably shale	16
3.	Gypsum, with satin spar immediately underneath	2
2.	Covered, probably shale	16
1.	Ferguson gypsum	5

In the NW. cor. sec. 13, T. 14 N., R. 9 W., the writer saw a fossiliferous dolomite, 11 inches thick, aparently the ledge found below the Shimer farther north. It is a platy, porous, rather uniform gray rock, with dark streaks and lenses. The fossils occur in bands.

Close examination shows the ordinary porous material to be oolitic, the spherules in the order of 0.5 to 0.25 mm. This seems to grade sharply into a very fine grained, medium-gray dolomite showing no spherules. It is in this phase that the fossils are observed.

The spherules are ordinarily dolomite. Some are hollow and these appear to have a coating of calcite inside and occasionally a solid core. They are closely spaced and have little matrix.

The dense type of dolomite is very pure, but contains a small insoluble part of quartz sand as large as 0.08 mm. in diameter with some brownish silt. It appears to contain more and coarser material than does the oolitic type.

A thin section shows uniform dolomite grains about 0.01 mm. in diameter in both types. The dense contains some spherules near where it grades into the porous oolitic material. Many of the spherules are irregular in shape and indefinite in outline. Many are uniform throughout, but others show a dark rim. Some small curved cavities appear to be pelecypod casts (Plate X, *D*).

The same ledge as the above is somewhat better preserved along the NL. NW. 1/4 sec. 14, T. 14 N., R. 9 W., but shows no new features.

The southernmost exposure of the fossiliferous dolomite known to the writer is in an abandoned quarry in connection with an old brick-yard near El Reno.

SUMMARY AND CONCLUSIONS

The Northern area of the Blaine formation extends from the Kansas line, the north line of Harper and Woods counties, in a general southeasterly direction into central Canadian County, a distance of about 150 miles.

The presence of dolomite in the gypsum series composing the escarpment, was noted in the earliest descriptions. Since 1897, dolomite has been located at intervals from northeastern Woodward County to the vicinity of El Reno in Canadian County, and occurs at several horizons. Although a number of sections taken along this part of the escarpment show no dolomite, it seems safe to assume that one or other of the ledges are present along the whole front, within the limits named. That the dolomites have not been more generally observed is due, no doubt, to their comparative thinness and tendency to weather into inconspicuous granular material, commonly obscured by talus.

Four dolomite horizons have been noted. Three occur directly beneath the three massive gypsum members, the Shimer, Medicine Lodge, and Ferguson (named in descending order) and the fourth consists of one or two beds, probably very thin, which occur about 40 feet above the Shimer, and at or near the top of the Blaine section. The last horizon is inconspicuous and seldom noted.

The most persistent horizon, at least the one which has been most often observed is that below the Shimer. As reported in published sections, it varies from 10 inches to 3 feet, but 2 feet is the most common thickness given. It has been described as dolomitic sandstone and sandy dolomite, occasionally, as fossiliferous dolomite.

Slightly less frequently noted is a sandy dolomite or dolomitic sandstone beneath the Medicine Lodge, which seems to be between 1 and 2 feet thick on the average. It has also been reported to be fossiliferous.

Much less commonly, a dolomitic sandstone under 1 foot thick has been observed beneath the Ferguson gypsum.

The term sandy dolomite or dolomitic sandstone, almost exclusively used heretofore, is distinctly misleading. To the writer's mind, it implies a detrital sandstone with more or less dolomite cement, or possibly a saccharoidal, coarse grained rock. As a matter of fact, these dolomites are neither one nor the other. On the whole, they are exceedingly fine grained with only a small per cent of insoluble matter, and are quite pure dolomite. The "sandy" character, so commonly noted, is due, as far as the writer has observed, solely to a fine oolitic or sub-oolitic texture, and is brought out only by weathering. It seems much more appropriate to describe these rocks as "sandy-weathering" or oolitic dolomite.

The dolomites are typically gray in color, varying in shade with the amount of weathering. As far as the writer has observed, there are two types which grade into each other.

One type, when fresh, is very dense, dark gray, somewhat brittle with a smooth, sub-conchoidal fracture. It is very fine grained dolomite with only a small amount of gray silt and fine quartz as impurity. It may show fine laminations.

The more commonly observed type weathers into a friable, light-gray rock with granular texture. Thin sections show that this is due to small spherules of fine-grained dolomite, less than 0.5 mm. in diameter, not noticeably different from those described in some detail from the southwestern part of the State. The replacement of this oolitic type of dolomite by gypsum in one instance is a notable feature.

Pelecypods have been frequently noticed in these dolomites, particularly the one occurring below the Shimer. In places they are very abundant although poorly preserved, commonly as casts.

In general the dolomites of the Northern area show no striking difference from those of the Southwestern area, particularly the fossiliferous and oolitic phases. They are especially comparable to typical occurrences of the Creta dolomite.

THE DAY CREEK AND CLOSELY RELATED DOLOMITES

GENERAL DESCRIPTION

INTRODUCTION

The dolomites described in this chapter are those originally regarded as one formation, the Day Creek, but shown in recent years to comprise more than one stratigraphic horizon. As the correlation of some of these dolomites appears to be a matter still in question, and as they all have more or less the same appearance and composition, it is thought best to treat them as a unit in contradistinction to the Blaine dolomites, with which they have little in common.

Although the Day Creek dolomite has been known for at least thirty-five years, our information about it has been rather scanty. During the last few years considerable work has been done on the stratigraphy of the region involved, but not very much has been published and no map of the formation has appeared heretofore. In this chapter, the writer presents practically all that has previously been written about it, together with preliminary maps very kindly given him by G. D. Putnam. To this is added the results of a rather general personal examination in the field and laboratory examination of the dolomites which gives new data as to their character. However, much

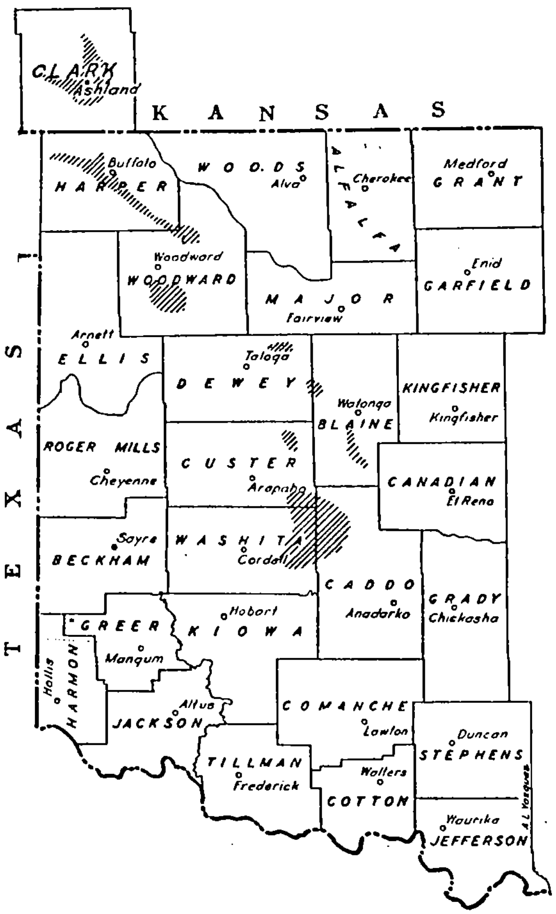


Figure 8.—Map of western Oklahoma showing Day Creek and related dolomites.

remains to be discovered about these interesting rocks. With the publication of more of the detailed stratigraphic information being accumulated by a number of economic geologists a thorough study of them will be much more easily executed.

DISTRIBUTION OF DOLOMITES

The dolomites considered in this section are situated in northwestern Oklahoma, and extend across the State boundary into Clark County, Kansas. All occurrences are west of the Blaine escarpment, outlined in the previous section, but in Harper and northern Woodward counties, the escarpment formed by the Day Creek follows that of the Blaine very closely.

Figure 8 shows the distribution and location of the dolomites. North of the Cimarron, they occupy a considerable portion of central Clark County. South of the Cimarron in Oklahoma, they stretch diagonally across Harper County and into northeast Woodward County. South of the town of Woodward dolomite may also be found. The Red Hills between Watonga and Geary in Blaine County are capped with dolomite. The Day Creek has been reported to occur near Thomas in northeastern Custer County. In the general vicinity of Weatherford in the southeast corner of the county, particularly south and southeast of the town, very interesting dolomites occur. These districts include all the prominent dolomites found in western Oklahoma above the Blaine.

TOPOGRAPHY

The topography produced by the Day Creek and associated dolomites is quite comparable to that due to the Blaine gypsums. Being by far the hardest rocks in this part of the State, prominent escarpments, buttes, and outliers are common. Although the contrast of light and dark colored rocks seen in the Blaine is lacking, the various shades of brilliant to dark red observed in the underlying Whitehorse sandstone gives the escarpment an almost equally remarkable appearance.

The relief varies greatly from place to place along the escarpment, probably being greatest in parts of Clark County and in certain sections southwest of the Cimarron River. Roughly, it is not thought to exceed 250 feet at any point along the immediate front.

The drainage need scarcely be mentioned here, having been previously described for the most part. South of Canadian River, the drainage is almost entirely toward the south. Deer Creek joins the Canadian River west of Bridgeport, but most of the creeks drain into the Washita River which crosses Custer, Washita, and Caddo counties in a general southeasterly direction, and is the southern boundary of the region concerned in this section.

STRATIGRAPHY

The Day Creek has previously been mentioned in several places and its position in the stratigraphic column given (see p. 13). As originally described by Cragin[75], it was included in his Kiger division of the Cimarron series as follows:

KIGER DIVISION	Big Basin sandstone Hackberry shales Day Creek dolomite Red Bluff sandstone Dog Creek shales

Without following the three or more changes since made in the classification, the Oklahoma section corresponding to the Kiger division (see p. 13), is given here.

Woodward Group	Quartermaster Cloud Chief Day Creek Whitehorse Dog Creek

Whether the Day Creek represents the base of the Cloud Chief or the top of the Whitehorse, is not important in this discussion.

As will be mentioned later, certain dolomites which were long regarded as Day Creek are now placed either above or below the top of the Whitehorse. To the writer's knowledge the correlation of the beds found near Thomas and the dolomites of the prominent butte a few miles southwest of Canton is a more or less disputed matter and in the Weatherford district there are dolomites about which no general agreement has been reached. It appears then, that the only dolomites which are Day Creek beyond any question are the typical ones of Clark County, Kansas, and northwestern Oklahoma north of Taloga, and certain dolomites in the Weatherford district which appear to separate the Cloud Chief and Whitehorse. It may even be questioned whether the latter are contemporaneous with those of Clark County. The final solution of the problem probably rests with the several oil geologists who have been working in this region more or less recently.

HISTORY OF EARLY INVESTIGATION OF THE DAY CREEK

The Day Creek was first mentioned by Orestes St. John[76] in 1886, who described it as a "gray, cherty, sometimes gypsiferous limestone" where he saw it at the head of Day Creek in Clark County. It was left to F. W. Cragin[77], however, to recognize this formation as a dolomite of rather exceptional purity, and to give it the name, Day Creek. His original description follows in full:

75. Op. cit., p. 363. 1896.
76. St. John, Orestes,—Notes on the geology of southwestern Kansas: **Fifth Bien. Rept. of the Kansas State Board of Agriculture, p. 141, 1886.**
77. Cragin, F. W.,—The Permian system in Kansas: **Colorado College Studies, Vol. VI, pp. 44-46, 1896.**

Upon the latest of the Red Bluff beds rests a persistent stratum of dolomite, varying from less than a foot to five feet or more in thickness. This is the same as the "gray, cherty, sometimes gypsiferous limestone" noticed by Professor St. John as occurring in Clark County at the head of Day Creek. It is a true dolomite, containing with the carbonate of lime an equal or even greater percentage of carbonate of magnesia, as indicated by a qualitative analysis kindly made for the writer by Prof. William Strieby of Colorado College. Though not of great thickness, it is an important member of the upper Permian of southern Kansas and northern Oklahoma owing to its persistence, which makes it a convenient horizon of reference. It may therefore be considered a formation by itself and, to distinguish it from other and less important dolomites of the Cimarron series, be called the Day Creek dolomite, after the above-named locality of its occurrence.

The stone is nearly white in fresh fracture, weathers gray, and often has a streaked and gnarly grain crudely resembling that of fossil wood. It is more or less cellular and, in places, cancellated. Irregular nodules of limonite are here and there imbedded in it. Its cherty hardness and fracture are not due to the presence of silica, as one is tempted to infer, but are characters belonging to it as a dolomite. It is a durable building-stone as shown by the old buildings and corral-walls of the Fares ranch on West Bear Creek, which are built of it; but it is somewhat difficult to trim to desired shapes owing to its erratic fracture, and Mr. Fares informed the writer that when fires were made in the fireplace that was built of it, the stone began to "pop" and crack in pieces, showing its unfitness for use where it would be subjected to much heat. From the skirt of Mount Prospect and the region of the junction of Hackberry and Bluff creeks, the exposures of the Day Creek dolomite extend almost uninterruptedly westward, past East and West Bear creeks, including the vicinity of the Fares place, to Little Sand Creek, west of which they are less continuous. The formation appears, however, in the ravine that heads just west of Little Basin, and it seems probable that the ledges recorded (l. c., page 142) by Professor St. John "on Gypsum Creek a few miles above Cash City, on the borders of Clark and Meade counties," as well as a less characteristic ledge which the writer recently observed on Crooked Creek near the present location of Odee postoffice, should be referred to the Day Creek formation. A number of years ago, the writer observed a stratum of dolomite capping the so-called Centennial mound[78] on the old trail from Kinsley to the Salt plain, in what is now Woodward County, Oklahoma. Some of the field notes of that reconnaissance have been lost; but if it be remembered correctly, this Centennial mound dolomite was correlated with that which is here called the Day Creek.

At one locality in Clark County, a point on the Little Sand Creek drainage passed by the road from Fares ranch to "St. Jacob's Well," the Day Creek stratum presents a peculiar variation. It there becomes a homogeneous, semi-translucent white rock of remarkably pure aspect, unlike any other rock with which the writer is acquainted, but bearing more or less resemblance to fine-grained marble, or to onyx or chalcedony. In honor of Mr. Henry Fares, formerly of the Fares ranch, to whom the writer is indebted for most enthusiastic and valuable assistance in sev-

78. Formerly called Sentinel mound.

eral of his earlier geological reconnaissances of Clark County and the formerly so-called Public Lands, it is proposed to call this interesting lithologic occurrence, or rock-variety, Faresite.

In the following year Cragin noted the persistent north and south extent of the Day Creek and described it as follows:

> In the western part of Clark and in Meade County, Kansas, the Day Creek formation loses its typical character. It is there represented by a band of greenish-gray to red and gray sandstone with occasional streaks of dolomite. This band * * * appears as a soft greenish-gray sandstone in a deep right-hand canyon of Big Sandy Creek * * * a little below the junction of Big Sandy and Gyp creeks. On Two-mile Creek, farther southwest, it appears as a two-foot bed of red and gray sandstone * * *
>
> From this loss of typical character which befalls it in the most westerly outcrops of the Kiger division in Kansas and from its moderate thickness, one might be ready to infer that the Day Creek is an unimportant formation. Such a conclusion would be erroneous, as the extent of this dolomite in essentially its typical phase is very much greater in the general southwesterly course of the Cimarron outcrops than east and west, and it is probable that the horizon of its modified western extension in Kansas can usually, if not always, be identified where its position is exposed and where due care is exercised in the observations. The brow of the Red Hills near Watonga, Oklahoma, is coped with the Day Creek dolomite, which there presents itself as a compact stratum of gray, somewhat pinkish or reddish tinged, cherty-hard rock, little different from the typical ledge that skirts the flanks of Mount Lookout in Clark County, Kansas. The stratum has a thickness of three feet.

About 1900 Gould took up the work of the geological pioneer in western Oklahoma. In 1905 he said of the Day Creek:

> The line of outcrop of the Day Creek in Oklahoma is not continuous; nevertheless, it is found in numerous localities, and on account of its distinctive lithological appearance it is always easily recognized. It is displayed on many of the hills of Woodward County, not only north of the Cimarron, but also between the Cimarron and the North Canadian and south of the latter stream. In Blaine County it forms the caps of a number of the prominent hills, notably the Red Hills between Geary and Watonga. South of South Canadian River in Caddo County the dolomite covers the Whitehorse Buttes southwest of Bridgeport and outcrops southwestward as far as the headwaters of Cobb Creek and on the west side of that creek past Colony. In the vicinity of Mountain View, in the valley of the Washita River, a ledge of dolomite appears at the same general level as that occupied by Day Creek, and another dolomite ledge in the hills north of Harrison may provisionally be referred to this horizon.[79]

It may be mentioned here that in 1907, Gould described the Alibates dolomite in the central Panhandle of Texas, which is very similar in appearance and occurrence to the Day Creek. Opinions

79. It has been previously shown that the dolomites at the last two localities belong to the Blaine formation, and are probably the Mangum member (see pp. 58-63). Harrison was formerly on the Chicago, Rock Island and Pacific railroad about 9 miles west of Mountain View.

differed as to its position, but in 1926 Clifton[80] suggested that it be correlated with the Oklahoma dolomite. More recently it has been recommended that the name Alibates be discarded and Day Creek be used.[81]

STATEMENT OF LATER WORK

The above descriptions give practically all that had been published until 1924 about the Day Creek. During the last five years, however, at least two revolutionary changes have been made in our ideas of the stratigraphy of what was formerly regarded as one formation.

In 1924, Gould stated that the dolomite of the Red Hills, in Blaine County, was not at the top of the Whitehorse, but not far above its base. This is now generally recognized and the dolomite of this district is known as the Greenfield.

In July, 1928, Evans[82] published his views on the stratigraphy of the Weatherford district and stated that the dolomite of the Caddo County Buttes was not Day Creek but was at a horizon near the base of the Quartermaster and unconformable on the Whitehorse, Day Creek and Cloud Chief.

DIVISION OF DOLOMITES

Considering the results of the more or less recent work given above, as well as the distribution of the dolomites, it seems advisable to treat the Day Creek, as understood by Cragin and Gould in the early days, in three separate parts, as follows:

The Day Creek north of Canadian River.
The Greenfield dolomite.
The dolomites of the Weatherford district.

The work of recent years, briefly mentioned above, will be considered in detail in connection with the districts concerned.

THE DAY CREEK NORTH OF CANADIAN RIVER

INTRODUCTION

The Day Creek north of Canadian River may be regarded as typical, as it includes the type locality, and in good exposures is more or less uniform in character. The occurrence of the Day Creek in this area is easily seen on the accompanying map, Plate XVII by Putnam. This map is not an exact duplicate of Putnam's original one, but the outcrops are essentially the same.

80. Clifton, R. L.,—Stratigraphy of the Whitehorse sandstone: The Oil and Gas Journal, vol. 25, no. 2, p. 70, 1926.
81. Gould, Chas. N., and Lewis, Frank E.,—The Permian of western Oklahoma and the Panhandle of Texas: Oklahoma Geol. Survey, Circ. 13, p. 23, 1926.
82. Evans, Noel, op. cit., 1928.

DISTRIBUTION OF DOLOMITES

As has been previously mentioned, dolomite is found in central Clark County and occurs both north and west of Ashland. South of the Cimarron in Oklahoma the escarpment may be followed from the northwest to the southeast corner of Harper County from where it extends for a few miles into northeastern Woodward County. Other occurrences are found between the North Canadian and Canadian rivers. South of Woodward, a rather low and inconspicuous escarpment has been traced for a few miles. Another outcrop has been mapped southeast of Seiling. Still farther southeast and a few miles southwest of Canton, a prominent butte occurs exposing at least three dolomite members, one of which is doubtless Day Creek.

The writer's observations on the occurrence and character of the dolomites will be recorded in detail by counties considering them from north to south.

CLARK COUNTY, KANSAS

This county adjoins Oklahoma directly north of Harper County. As stated before, it from here that the Day Creek dolomite was first described. Day Creek is a tributary of the Cimarron, flowing south from near Mount Lookout past the village of Sitka.

The escarpment bearing the Day Creek may be found about 3 miles north of Ashland, from which point it may be traced both north and west for about 10 miles, having a serrate front over all its length. Outliers may be found northeast of the town and there are also some a few miles to the south and southwest.

Two localities in Clark County were examined and gave considerable information about the typical dolomite. Although one was at the head of Day Creek, the dolomite there was not very well exposed.

A good exposure of the Day Creek was visited in the N ½. sec. 2, T. 35 S., R. 24 W. On the west side of Little Sand Creek, two prominent ledges were found, separated by a red sandstone, the lower one being dolomite.

The highest ground is capped by a whitish limestone at least 8 feet thick. It contains no dolomite. This is no doubt the ledge which caps Mount Lookout and Mount Jesus.

Some 90 to 100 feet below this member is the Day Creek dolomite having a maximum thickness of about 21 inches. The top 6 inches is full of irregularly massed cherty material, then follows 3 to 4 inches of reddish, thinly banded rock with a rather platy cleavage. The lowest part resembles the second, but weathers differently. The banding is very wavy.

The cherty material occurs as nodules weathering in relief, some like well rounded pebbles, others very irregular, but with very definite boundaries. It is also found as thin horizontal layers, as well as indefinite networks of chert in carbonate. Some seems to coat the sides of vertical intersecting joints.

A specimen from 6 to 10 inches below the top of the ledge seemed to contain 1 to 2 per cent calcite, but none could be detected on a polished surface by staining. The weathered surface is "sandy" and composed of tiny rhombohedral grains of dolomite. The color bands are somewhat indistinct, grade into each in some cases, thicken and thin, and some seemed to dip into each other at low angles. They are roughly 1 to 5 mm. in thickness and vary from reddish-pink to a very faint pink. A variation in the size of grains is not apparent.

A specimen of the white weathering rock, from the bottom of the member, is perhaps finer grained and paler in color on a fresh fracture, mostly faint pinkish gray. It is quite fine grained even with a hand lens. It is plainly but faintly banded, most of the bands visible to the naked eye being a millimeter or two thick. The bands did not seem to be continuous nor strictly parallel and in some instances seemed to pinch out or dip into each other. Some of the small layers are marked by cavities up to 3 to 4 mm. in length. The fine bands show no contortion.

In thin section this rock is remarkably pure and consists of fine-grained carbonate with small lenses of coarser (about 0.08 to 0.16 mm.) arranged in rows roughly 0.5 to 2 mm. apart. Cavities appear in many of these lenses. The grains are subhedral to euhedral rhombohedrons. On close examination, the fine-grained part seemed to consist of two sizes of grain, minute ones from 0.004 to 0.008 mm. and larger ones about 0.04 mm., the latter without any definite shape. With high magnification some small angular grains of quartz were found about 0.02 mm. in diameter.

With Lemberg's solution this rock appears to be wholly dolomite, but there is certainly some calcite in the small cavities.

The so-called chert presents some interesting petrographic features. A specimen containing a couple of rounded concretions about 1¼ inches in diameter was examined in some detail. One of the latter was broken and showed a faint brown core with a bluish rim. The line of demarcation is very sharp, particularly on the weathered surface. The exterior is gray. Both parts are very fine grained, resistant to a knife blade, have a dull lustre, and irregular fracture.

A thin section shows the contact between a concretion and its exterior. It shows a *U*-shaped core of carbonate with grains averaging about 0.03 mm. in diameter. The one side and end of this has a distinct border consisting of a network of chalcedony. The inner edge is very sharp, but it feathers out into and includes the surrounding carbonate, as shown in Plate XI, *A*. The other side has only a trace of a chalcedonic band, but the interior is very uniform while the exterior contains swarms of euhedral quartz crystals and a vug lined with chalcedony and later vein quartz.

The quartz crystals are subhedral to sharply euhedral, showing four and six-sided sections as in Plate XI, B, ranging from 0.08 to 0.20 mm. in greatest diameter. Practically all include one or more minute specks of carbonate. The shape of the sections indicates that the quartz crystals have a short hexagonal prism and one rhombohedron predominant.

In contrast, then, to what one would expect on hasty examination, this material has a subordinate amount of silica in it. The carbonate effervesces readily with cold dilute *HCl* and is no doubt calcite. The concretions owe their resisting qualities mostly to thin shells of chalcedony. The euhedral quartz, on account of its lack of abrasion or corrosion, the universal inclusion of carbonate, and the similarity of all the crystals observed, is undoubtedly a replacement, probably by the same solutions which formed the concretionary shells of chalcedony.

The chert which follows the bedding seemed to contain little carbonate. Fragments under the microscope appear to be fine-grained quartz. On polishing a face at right angles to the bedding, the siliceous layer showed a gradation into carbonate below, which as nearly as the writer could determine is wholly calcite.

It appears then that the top of this member contains considerable calcite, and the silica may have replaced it by preference. However, on examining the irregular networks of silica and carbonate, it evidently attacked the dolomite also.

A specimen of the latter shows irregular, fine masses of silica weathered in low relief above a fine granular dolomite, revealed by a lens to have subhedral to euhedral rhombic grains. A fresh surface is quite uniform, the more siliceous parts being distinguishable with difficulty. The weathered silica seems to have a rude arrangement parallel to the bedding, in one spot showing a rough crustified structure grading from gray silica out to white carbonate.

A thin section cut to show both silica and carbonate revealed a distinct boundary between what is mostly fine-grained quartz and chalcedony and mostly dolomite, in one place shot through with small (0.08 to 0.2 mm.) subhedral and some euhedral quartz crystals, many with included specks of carbonate, as in Plate XI, *C*. Some of the chalcedony is in distinct spherulites and they are cut by a later clear vein quartz. The spherulites themselves seem later than the main mass of the quartz which has corroded and included much dolomite (as in Plate XI, D), and also the euhedral quartz crystals. Some of this quartz shows clear "phantoms" of dolomite rhombs which still have a few specks of carbonate in the center. The chalcedony has grown around and on dolomite crystals without a trace of replacement, although it has grown on some corroded grains also. Some euhedral grains were noticed surrounded by chalcedony, interpreted as a cavity cut near the wall. For the most part, it seems to have grown in cavities and as spherulites.

It appears then that euhedral quartz crystals grew by replacement in the dolomite ahead of the main front of replacement, and were later included in the more massive quartz, some of which shows a somewhat radiating structure. A later development was the growth of chalcedony predominantly in the open spaces. Lastly small quartz veinlets cut the whole.

These observations show conclusively that the chert has been formed by replacement after the formation of dolomite and also, it seems, after the formation of joint planes. Surface waters were probably the agents.

In the SE. cor. sec. 16, T. 32 S., R. 22 W., at the head of Day Creek, some fresh blocks of dolomite were observed, although the exposure in place is not very good. These blocks measured as much as 21 inches thick, and contained many chert concretions and lenses.

Typical of this dolomite was a massive, fine-grained, very light brownish pink rock with a somewhat sub-conchoidal fracture, containing no detectable calcite.

A thin section showed the rock to be uniform in grain (mostly from 0.013 to 0.04 mm.) except for small irregular spots where the grain size is larger. A few small quartz grains (0.06 to 0.11 mm.) are scattered throughout and are no doubt detrital.

A rather pure white carbonate rock occurring in the same blocks, rather massive and coarse grained, turned out to be pure calcite except for some quartz grains. Unfortunately the writer does not recall the relations of this to the dolomite. However, it seems that we have calcite and dolomite interbedded or more probably a bed of calcite over the dolomite which has proved suitable for replacement by silica-bearing solution. Below this member is red sandstone, shaly in places.

It may be said here that the writer spent some time in examining the capping of Mount Lookout and Mount Jesus but found no dolomite, even in the hard nodules from the upper part.

HARPER COUNTY, OKLAHOMA

South of the Cimarron River, in Harper County, the escarpment of the Day Creek extends, according to Putnam, from the NW. cor.

T. 28 N., R. 25 W., east and north to a point 5 miles east of Willard, then south and west around the headwaters of Buffalo Creek, between Doby Springs and Buffalo, then to a point half a mile southeast of Buffalo where it turns south for 10 miles. From that point it continues eastward with a serrate front to the extreme southeast corner of the county.

About 2½ miles due west of Kibby, near the NC. sec. 20, T. 26 N., R. 22 W., a single member may be found. In general it appears hard, massive, quite uniform and varies between 20 and 30 inches in thickness.

A specimen from the top of this member shows from 1 to 3 inches of very dense, fine-grained, massive, hard, creamy-white rock, which seems to be a very pure dolomite. Beneath this is a thin gray layer mottled with pink, the latter being calcite and forming stalactitic material on the bottom. The gray seems to be calcite too. In addition, this mottled material veins the dolomite above it in short gashes. This appears to be the result of secondary surface changes and seems to have proceeded from the vertical weathered surface. The specific gravity of the white dolomite is 2.78.

Below the hard dense cap of this ledge is more porous and disintegrated material. A specimen from near the middle of the bed shows a medium-grained dolomite, white with coarse indistinct pink bands, which are cut through by somewhat indistinct veinlets of quartz and perhaps some calcite. Cavities contain these secondary minerals also and the whole rock may be impregnated with calcite between the dolomite grains.

A thin section shows carbonate distinctly replaced by silica, some certainly chalcedony, but in other places it appeared to be quartz. Later than this and filling the centers of veins and cavities is clear vein quartz. Just how much, if any, of the carbonate is calcite appears uncertain. Anhedral interlocking grains are interspersed with more subhedral ones. They include small perfect rhombohedral crystals with different orientation and also "phantom" markings, rhombic in shape, as in Plate XII, A, having parallel orientation with the enclosing anhedral grains. Some phantoms have hexagonal or trangular outline. The coarse anhedra are roughly 0.5 mm. in diameter.

A specimen from near the base of the dolomite member shows unusual and puzzling features. A number of rather fine grained red dolomite fragments about an inch or more across are sharply angular as well as somewhat rounded and are set rather closely in a white matrix which veins through them in some instances. The matrix also contains many more indefinite smaller pink patches, seemingly remnants of larger fragments which it has partly replaced. On the weathered surfaces the larger red ones are distinctly banded and variously oriented. The matrix seemed predominantly quartz, but there is much rather medium grained white dolomite, surrounding and veining the pink, also as nests in the quartz. The quartz lines cavities and seems to be the latest mineral. On a weathered surface and in some small cavities small rhombohedrons may be seen also, but this may be due only to the weathering of the massive dolomite. This weathered dolomite has calcite as fine spots and seams between the grains.

The writer did not observe any dolomite in passing from Kibby to Supply.

Near the NC. sec. 32, T. 25 N., R. 20 W., a single dolomite ledge was observed. This is about 16 inches thick with about the same thickness of quite compact sandstone directly underneath. A thin gray and pink bed 2 to 3 inches thick and several feet below is entirely calcite.

Capping the 16-inch member is a medium-grained, hard, heavy, fairly massive rock, grayish-white on fresh fracture. A rather crude rusty banding is characteristic of parts of this type. Small cavities are common, usually lined with coarse calcite. This rock can be only faintly scratched with a knife, leaving a scratch hardly seen without a lens.

In thin section, faint stratification shows to the naked eye. A few small nests of quartz may be found consisting of a few anhedral interlocking crystals each,—certainly not detrital. The carbonate appears uniform but the grains vary from 0.32 to probably 0.05 mm. in diameter. The main mass of the carbonate has a distinct tendency to be subhedral and some is euhedral, and consists of dolomite with a small percentage of calcite occurring, no doubt, in the cavity linings. Perfect small rhombs are noted in much larger subhedral or anhedral grains.

A specimen from the lower half appears very similar to the former, possibly whiter and a little softer and more porous. It seems to be entirely calcite, however, and effervesces freely with cold HCl. An interesting feature of this rock in thin section is a few rhombic sections with somewhat ragged edges, one with a long diameter of 0.32 mm., in a matrix of much finer grain.

Another specimen from the lower half is quite coarsely crystalline, brownish-gray dolomite with considerable clear calcite in small spots and cracks. A weathered surface shows black dendritic markings. The relations of the limestone to the dolomite in the lower part of this bed was not observed.

Locally, the top part of the ledge contains hard, fine-grained, gray, chert-like portions. On the surface these are weathered in a sort of mud-cracked pattern, the cracks being about 2 inches deep in some instances. In thin section this material is chiefly an intergrowth of quartz and chalcedony. Some euhedral quartz crystals with a sort of zonal structure were observed, about 0.25 mm. in diameter. Many other patches of quartz about the same size are scattered throughout and they all seem to have numerous inclusions. Chalcedony radiates from these crystals in many places. This no doubt represents the extreme of the process of replacement by silica as indicated in the specimens from Clark County.

Some exceedingly hard and tough nodules 3 to 4 inches in diameter which were associated with the above, appear to be over 5 per cent silica and the rest dolomite, except for marked brown and black staining. On dissolving the carbonate the silica is left as delicate skeletal masses. Its presence is not at all apparent in the hand specimen.

This same member crosses the highway in two places at about 4 and 5 miles respectively north and west of the above locality. The thickness does not seem to be over a foot. The upper part is decidedly pink with some indistinct white mottling. It is quite massive and medium-grained with a few small cavities. Both pink and white grains are dolomite. The gray chert and dark stained nodules are present also. An irregularly shaped piece of dark red jasper was picked from among them. Its lower surface is very irregular and has a thin somewhat loosely attached crust of white colloform chalcedony.

WOODWARD COUNTY

From the southeast corner of Harper County the escarpment of the Day Creek extends southeasterly across T. 24 N., R. 19 W., and presents a very serrate front in T. 24 N., R. 18 W., at the headwaters of Chimney and Doe creeks. This district is exceedingly rough and picturesque. The ledge disappears to the southward among the sand hills north of North Canadian River.

The writer did not observe any dolomite on the promirent butte about a mile west of Quinlan. Some ledges, joint and fault planes are cemented with carbonate which proved to be calcite. These are particularly noticeable at a place on the crest where the red sandy beds are curiously and highly contorted and broken.

A small and inconspicuous occurrence of Day Creek has been reported from near Fort Supply.

About the CE. ½ sec. 7, T. 24 N., R. 18 W., is a rather poor exposure of dolomite on the front of a steep escarpment facing east. A ledge about 26 inches thick is well defined. It is rather uniform, whitish, cherty-looking material. Some is light gray and pulverulent, probably due to weathering.

A specimen typical of the fresh material is wholly dolomite, fine-grained, massive and whitish with a faint pink tint. The rock is noticeably porous, the small cavities being from very small to 3 or 4 mm. in diameter. They are quite evenly but rather sparingly distributed and are inclined to be round or oval. The writer thinks these represent the first stages of decay of a massive and resistant rock.

In thin section the above specimen shows no banding, is very uniform, practically all carbonate and the little quartz found is almost certainly not detrital. The dolomite grains are anhedral to subhedral and grade from 0.18 mm. to very small, probably averaging about 0.10 mm. in diameter.

Some 25 feet above the top of this bed is a light-gray, pulverulent carbonate member about a foot thick. It proved to be entirely calcite.

The dolomite was examined again at a point about 12 miles northward from the railroad at Mooreland on the "OK" Hy. 50. In this vicinity the thickness varies from 12 to 21 inches, probably due to weathering. The ledge weathers into irregular knobby dark blocks. Most of the fresher material is light-gray with small, irregular, dark markings. Chert is very noticeable here and in places much of the member is silicified, commonly banded parallel to the bedding.

As far as the writer has discovered, much of the member is composed of calcite. A very fine grained, light-gray, massive specimen seemed to be entirely fine-grained calcite with a small percentage of quartz and chalcedony. Another specimen from the same block of material is largely silica, irregular patches of bluish-to brownish-gray chalcedony, mostly having indistinct contacts with the carbonate which again seemed entirely calcite. Some small cavities are lined with chalcedony showing colloform structure. The association of calcite and silica may be significant.

A specimen that probably represents much of the above ledge in this district, although perhaps less friable than most, is a medium-grained rock, coarsely banded pink and gray, rather porous, and so closely packed with dark, presumably dendritic specks that color and structure are rather masked. This rock effervesces violently in all parts with cold *HCl* and takes what appears to the naked eye as a fairly deep, uniform stain with Lemberg's solution. This shows how one may easily fall into error, for on examining with considerable magnification the stained parts are not easily discernible, but are apparently fine-grained coats between the coarser grains which show cleavage faces. On treating the fragments with cold *HCl* violet effervescence ensues for several seconds then nearly dies out. The residue is nearly all dolomite, which dissolves slowly on heating.

A specimen which seemed to represent the rock before weathering, has a fresh layer about 1¼ inches wide, faint pinkish white, medium-grained, which in one place is pure dolomite. In thin section it is very uniform. The grains average about 0.13 mm. across and tend to be subhedral, as shown in Plate XII, *B*. Within a few inches this layer grades laterally into what the writer regards as superficially altered dolomite, showing thin, closely spaced, dark laminae and what seemed to be an increasing percentage of calcite upwards. This may be caused by the development of fine porosity and the deposition of calcite around and between the grains of dolomite.

A thin-section of this material in contact with a thin chalcedony lamina above it shows remarkably well the replacement of the carbonate by the chalcedony from the top down, as in Plate XII, *C* and *D*. The carbonate itself appears very much like that in the section of pure dolomite, except for a few small lenses near the chalcedony border which are coarser grained.

The sandstone at the above locality is light red and not noticeably cross-bedded. Coarsely crystalline calcite crusts were observed as a thin bed about 30 feet below the dolomite in one place.

South of the North Canadian River and a few miles southeast of Woodward, what appears to be true Day Creek dolomite occurs also. The exposures are rather poor and few, however, with no pronounced scarps.

In the EC. sec. 4, T. 22 N., R. 20 W., near the road, is a white sandy-appearing ledge, 15 inches thick in some places. A specimen is rather massive, faint creamy white, medium-to fine-grained, with numerous small irregular cavities. Faint gray dendritic markings are plentiful. The rock has a distinct sandy feeling on both fresh and weathered surfaces. It appears to be pure dolomite.

In thin section the rock is quite porous, and consists entirely of carbonate and quartz. Some of the dolomite grains are subhedral but mostly shapeless to rounded. They are as large as 0.16 mm. in diameter, mostly about 0.05 mm. Quartz is quite freely scattered throughout, much of it euhedral to subhedral but some rather round or irregular. Practically all includes fine carbonate and some shows serrate edges. No doubt this is due to replacement, but there may be some detrital grains also. The diameters vary from 0.15 to 0.45 mm.

Some 16 feet below this and exposed by road grading is a thin weathered ledge as much as 6 inches thick in light-red soil. A specimen looks much like the dolomites, medium-grained, pink and white mottled, with numerous black dendritic spots scattered throughout. It is, however, soft, easily crushed, quite friable and is apparently all calcite. A small per cent which is insoluble in cold acid seemed mostly silica.

A little north of the above locality, both ledges are more poorly exposed in the road. The dolomite is about a foot thick. A typical specimen is quite uniform, massive, medium-grained and light pink in color. A few small irregular spots are now composed of clear cleavable calcite, probably cavity fillings. Gray dendritic markings are present except in the most massive parts. Thin flakes of this rock are quite translucent. Except for the later calcite, it is a pure dolomite.

A similar specimen but with more apparent calcite and dendrites, and somewhat brecciated, appeared at first to contain little or no dolomite. On examining the most promising looking material under high magnification, after staining, the calcite appears to occur only as scales and coats intimately associated with coarse-grained dolomite. On dissolving this out with cold acid and staining, the residue seemed entriely dolomite. On account of the undoubted secondary nature of the calcite visible with the naked eye, the writer regards this also as a secondary superficial product.

DEWEY COUNTY

In this county, the only dolomites that occur to the writer's knowledge are located a few miles southwest of Canton, where an isolated butte is a prominent landmark.

In addition, Putnam shows on his map an outcrop a few miles southeast of Seiling (from about sec. 14, T. 19 N., R. 17 W., east to sec. 21, T. 19 N., R. 16 W.) An escarpment occurs there which faces toward North Canadian River. On examining it at a point about the south-central part of sec. 17, T. 19 N., R. 15 W., only one hard ledge could be found. It is on the face of a red sandstone bluff, the top of which is covered with a gravel mantle in places. The thickness varies from 10 to 16 inches. No dolomite whatever was found in specimens collected.

However, the rock looks very much like dolomite. It is predominantly pink with white banding, commonly much contorted. A specimen having angular to irregular white calcite spots and also small bodies of red shale or clay appears to be a sort of breccia, with subsequent rearrangement of the carbonate. It may be that the writer, in a somewhat hurried examination did not find the dolomite, or that this represents a local replacement of dolomite by calcite, but it seems improbable. As to what exact horizon this ledge occupies, the author has no information.

Shead[83] gives an analysis of "Taloga dolomite" without any additional data. The member described above appears to be nearer Taloga than any other carbonate ledge.

In the SE. cor. sec. 1, T. 17 N., R. 14 W., a butte of red sandstone and a few adjacent low outcrops provided one of the most interesting single localities that the author saw in the field.

The butte itself shows three dolomite members, best observed on the east side. The top is capped by a hard, fresh, whitish member about 35 inches thick. From the top of this member it is 25 feet to the top of the middle member, which is uniformly 48 to 50 inches thick. About 57 feet below the top of the middle ledge is a third, 12 to 14 inches thick, but not very well exposed here. Between the ledges is red sandstone.

83. Op. cit., p. 79, No. 116.

Specimens from the upper ledge appear to be very pure dolomite. They are hard, non-porous and fine-grained. Color banding is observed, dull pink to whitish, but the bands are not very well defined. They seem to vary from an eighth to one inch, are wavy in some cases and run into each other, showing in a small way phenomena similar to cross-bedding or unconformity. The specific gravity of a fresh piece was 2.79. The insoluble portion is very small, quartz grains, some of which suggest a euhedral form, and some particles of iron oxide.

In thin section the rock appears quite uniform. The grains are rather subhedral and about 0.05 to 0.10 mm. in diameter. Somewhat larger ones form a few laminae and a very few scattered through the fine are much larger and sub-rhombic, probably due to recrystallization. A rather perfect one is shown in plate XIII, A. With ordinary light the grains show somewhat brownish apparently due to very fine opaque inclusions, no doubt iron oxide. A little quartz may be found, probably not detrital.

In one spot this ledge shows distinct flexure of the bed as a whole without any brecciation (see pl. III, fig. 2). This may easily be due to deposition on an uneven floor, but in view of features observed here and elsewhere which will be mentioned later, it seems more probable it is due to a disturbance of the bed while it was still in a semi-plastic condition. In this bed and near the same spot extraordinary crenulations of the fine bands may be observed. This can only be explained by disturbance while in a plastic state, if we regard the color bands as being formed contemporaneously with the deposition of the original carbonate, and there seems no other alternative. The color is plainly due to fine silt-like flecks of iron oxide. There seems no reason to believe that this was introduced in any different manner than in the red sandy carbonates, in which the red is due to iron oxide as coatings around the detrital quartz grains and in the closely associated carbonate crystals, plainly having been swept in with the sand.

The dark red sandstone below this dolomite cap shows some interesting features—the one which bears on the subject in hand being the presence of irregular ledges, stringers and nodules which seemed to be dolomite. One piece from a small lens about 2 inches wide, is almost wholly dolomite, fine-grained, massive and light-gray with fine pink markings. Some associated crusts of crystals with rather indistinct forms are apparently entirely dolomite also. The massive material contains only about 10 per cent of very fine quartz grains. Another spot shows several feet of what looks like a vein, or thin bed of dolomitic material from 1 to 3 inches thick folded into a rough *U*-shape. The writer believes these are secondary dolomites deposited in favorable spaces in the sandstone by solutions deriving their magnesium from the ledge above.

The middle ledge is remarkable for the sharp lower boundary and gradational upper one and also for the lateral change from dolomite to calcite particularly noticeable in passing from the east to the west side of the butte.

Rather typical material from this ledge is quite pure, hard dolomite, showing marked color bands from a rather dark reddish pink to almost white. One color grades into the other and no clear-cut bands were observed, but they vary roughly from a few millimeters up to 1½ inches. The lighter colored bands show dark dendritic specks. The writer believes these always indicate decay, either solution or replacement by calcite. Some thin veinlets across the bedding have calcite in them, which is accompanied by dendrites.

In thin section the above type is uniform with grains about 0.05 mm. in diameter but rather indistinct. Many seem to have minute inclusions. Very little quartz was observed. Some dolomite grains have a small core that is dark under crossed nicols.

Another specimen representing part of the middle ledge is very massive, hard, fine-grained and white, hardly scratched by a knife, even under a lens. It is rather brittle and is somewhat closely fractured. The cracks are very narrow and filled with white calcite. This rock is very pure dolomite with a quite small percentage of fine quartz.

A specimen from the top of the middle ledge on the west side of the butte consists of a white calcite matrix, uniformly and thickly set with small, rounded, black dendrites a millimeter and less in diameter. These dendrites were concentrated and found to be manganese oxide (pyrolusite). At present the writer regards this as a surface alteration of dolomite. It grades into less altered material on the south side of the butte.

A specimen showing the lower contact of the middle member reveals a very sharp undulating boundary between a hard flinty white dolomite and a fine-grained red sandstone. A piece from the upper border is very complex, however. It shows red sandstone intimately cut by thin, irregular and closely spaced dolomite stringers, white and fine grained, often enclosing small cavities, many of which are lined with clear calcite. Some fine-grained, creamy-white dolomite in this specimen is clearly in the form of a vein about 6 inches by ½ to 1 inch. There is also some clear calcite in the center of the vein and in small cavities. This seems to be only an extreme result of the process which has caused the fine network intersecting the whole.

In thin section, somewhat brownish gray dolomite appears as the cement for sandstone, as fragments without any sand grains as in Plate XIII, *B* and also as irregular and indistinct veinings shown in Plate XIII *C*. The dolomite grains are very small and indefinite in shape. Some thin radiating fibrous coats, about more granular centers are thought to be concretionary. Lining some of the cavities is a very thin, clear, crystalline crust, possibly dolomite. Calcite, which came later, is clear and coarsely crystalline.

The sand is poorly sorted, almost wholly quartz with a little microcline, plagioclase and an opaque mineral (about 0.08 mm. in diameter) possibly magnetite. The quartz grains vary from practically circular cross-section to very irregular, sliver-like or angular pieces and from 0.6 mm. in diameter to 0.03. The coloring matter for the sandy parts is a very fine oxide powder clinging to the exterior of the grains, apparently coating them before they were introduced.

At a small spot on the east side of the butte a marked local brecciation of the carbonate was observed in the middle member, mostly on the weathered surface. A part, now weathered away, was evidently dropped a few inches with respect to that still left, leaving a breccia of angular fragments about ½-inch thick and varying in size from 5 inches long down to very small fragments. The beds on a fresh fracture are dark gray with thin pinkish white laminae. They seem to be uniformly calcite. This displacement may have taken place at an early stage in the history of the rock. Whether it was once dolomite or not is a moot question, but it seems probable in view of the processes which seem to have taken place in this same ledge and locality as well as elsewhere.

Further evidence of displacement while the carbonate was in the process of deposition was obtained from a specimen of dolomite which shows a lower white and an upper pink band. Projecting into the pink from the white is an angular piece of white about 1 by ½ inch with bedding at about 45 degrees to that of the contact of the two beds. The bedding of the pink is undisturbed.

Just east of the section line from the butte, the lowest member is better exposed. It is a massive pink dolomite, 12 to 14 inches thick, with a very irregular lower contact, which is possibly gradational.

Some 24 feet above this occurs another ledge, poorly exposed The weathered blocks of this are about 8 inches thick. It is a dense flinty, somewhat cellular dolomite, white and light pink banded. Al parts noted were very hard. A specimen from the top shows thir leaf-like cavities parallel to the bedding.

This ledge, while only about a quarter of a mile from the butte certainly does not appear on its flank. The only explanation which occurs to the author is that it represents the most resistant part of the thick middle ledge, lowered by removal of the fine friable sandstone underlying it, and with its more soluble and coarser-grained parts removed. All that may be observed of it now is of the most resistant

character and seems very pure dolomite,—rock capable of withstanding such intense weathering. The surrounding country for some miles is flatly rolling agricultural land.

To the writer's knowledge, the correlation of these interesting beds remains in doubt.

SUMMARY AND CONCLUSIONS

The Day Creek as found north of the Canadian River may be regarded as typical. It is prominently exposed in central Clark County, Kansas, from where it was first described. South of the Cimarron River in Oklahoma it occurs as a more or less conspicuous escarpment extending from northwest Harper County in a southeasterly direction across the county and into northeastern Woodward County. Between North Canadian and Canadian rivers, more or less typical Day Creek may be found southeast of Woodward and it has also been reported from southeast of Seiling. A prominent butte southwest of Canton has several ledges of uncertain correlation.

As observed in Clark County, the Day Creek is about 21 inches thick. The dolomite is rather thinly and indistinctly banded in various tones of pink or red grading to white. In thin section the dolomite is shown to be very pure, fairly colorless, with grains, for the most part, less than 0.1 mm. in diameter.

The top 6 inches of the member is remarkable for the amount of silica it contains. It occurs as nodules, vein-like stringers, horizontal layers and networks of both chalcedony and quartz. It is intimately mixed with carbonate, however, and the amount of silica present is not as great as appears at first glance. Thin sections show plainly that it has formed by replacement of carbonate, part of which appears to be calcite. There are at least four types of silica, namely:—small euhedral crystals under 0.2 mm. in cross-section; fine-grained quartz of complex character; chalcedony as spherulities, crusts and radiating growths; and vein quartz. These are formed, in some places at least, in the order named.

In Harper County, the dolomite is not radically different from that observed in Clark County. It appears to vary from 12 to 30 inches thick. Some phases of the dolomite are exceedingly pure and hard, and it is difficult to make any perceptible scratch on them with a knife. Several instances of replacement by silica were noticed. Calcite was seen in cavities, veinlets, and as very fine seams between grains of dolomite. Some parts of the ledges were observed which were wholly calcite. Whether these represent an extreme phase of replacement and impregnation of dolomite or were originally calcite has not been determined. A puzzling feature was observed at the base of the dolomite in one locality where red dolomite fragments, both angular and somewhat rounded, some banded, and variously oriented, are apparently included in and partly replaced by white dolomite, which in turn has been partly replaced by quartz and possibly calcite.

In Woodward County, the dolomite is most conspicuous around the heads of Chimney and Doe creeks, where it varies from 12 to 26 inches in thickness. In places much of the member is silicified. The carbonate seems to be largely calcite in such places. In others intimate mixtures of calcite and dolomite are found, the former occurring as very fine coatings around and between the dolomite grains. One specimen showed a definite layer of carbonate which graded laterally from pure dolomite to a mixture of dolomite and calcite, the latter apparently closely connected in origin with a band of chalcedony.

Southeast of Woodward a pure creamy white to light pink dolomite occurs in places.

In Dewey County, three dolomite members were noted in a butte a few miles southwest of Canton. Capping the butte is a hard, white dolomite, 3 feet thick, locally showing flexure of the beds as a whole as well as extraordinary crenulations in the thin laminae. Vein like dolomite stringers were noted in the sandstone beneath. The middle member is about 4 feet thick. It has a sharp lower contact and a gradational upper one. Several types were found in this ledge ranging from a pure, very hard, white dolomite to a soft calcitic rock full of dendrites of manganese oxide. Marked local brecciation of the bed was noticed in one spot. The third and lowest member is about 1 foot thick.

In general, then, the typical Day Creek is a single ledge of dolomite, about 2 feet thick, commonly very pure, hard, medium-to fine-grained. It is massive and white in places, but commonly is banded with pink or red. Silicification by quartz and chalcedony is a common feature. The writer believes this is due to a surface process, accompanied in most cases by a replacement of the dolomite by calcite. The occurrence of rather coarsely crystalline calcite in veinlets and cavities as well as microscopic crusts and stringers between the grains probably represents an initial stage of the latter process. Whatever view one may adopt, there is no doubt that dolomite has been removed and calcite has taken its place. Whether the process is truly metasomatic may be open to question.

The writer has seen no indication that the dolomite has replaced calcite, but the relations of certain more or less pure calcite portions of the ledge to the dolomite has not been accurately determined. They may be original.

The development of minute dendrites or specks of manganese oxide is typical of disintegrated dolomite and commonly accompanies the calcite. The breaking down of the dolomite to a pulverulent granular rock is characteristic of the coarser grained varieties.

THE GREENFIELD DOLOMITE

INTRODUCTION

As previously stated, the dolomite of the Red Hills in Blaine County, long regarded as Day Creek, was recognized in 1924 as being within the Whitehorse sandstone and not far above its base.[84] It has

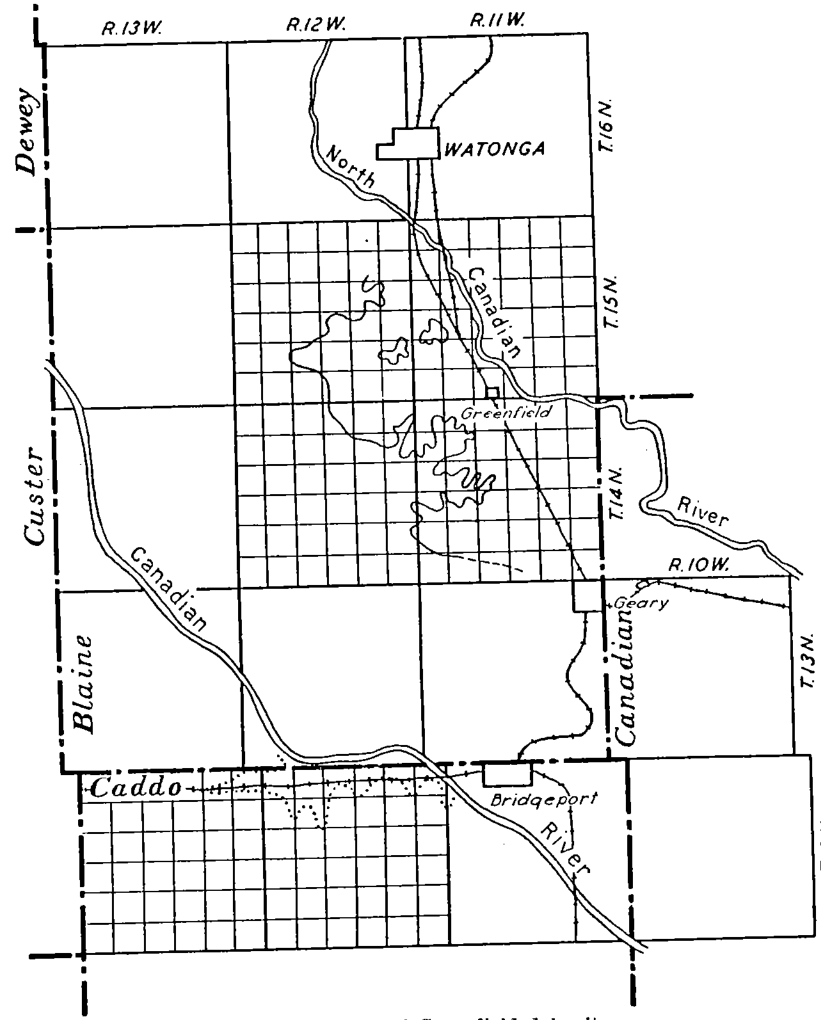


Figure 9.—Map of Greenfield dolomite.

84. Gould, Chas. N.,—A new classification of the Permian red beds of Oklahoma: Bull. Am. Assoc. Pet. Geol., vol. 8, no. 3, p. 336, 1924.

since been given the name of Greenfield dolomite, from the village of Greenfield, midway between Watonga and Geary. Its presence in this locality was first noted by Cragin.

OCCURRENCE OF DOLOMITE

The Greenfield dolomite is found in Tps. 14 and 15 N., Rs. 11 and 12 W., the central part being just west of the village of Greenfield (see fig. 9). The dolomite caps a rather pronounced escarpment facing the North Canadian River. A prominent outlier is crossed by the highway between Geary and Watonga and dolomite may be found on either side of the road. The accompanying map of the dolomite is due largely to G. D. Putnam. Evans is responsible for the Greenfield dolomite shown west of Bridgeport (see fig. 11). The dolomite there is not conspicuous and the writer has no observations on it.

STRATIGRAPHY AND DESCRIPTION OF DOLOMITE

Reports which have reached the writer as to the dolomites of this district have been conflicting. Putnam has stated that there are three ledges as in the following section.

General Section near Greenfield, Blaine County.

	Feet
Whitehorse sandstone	350
Greenfield dolomite	?
Sandstone	27
"Twin dolomites" separated by 7 feet of sandstone	?
Sandstone	110-130
Thin white sandstone seam	?
Dog Creek shales	185

This section should be compared with the one by Evans, see fig. 12, who notes only one dolomite near this horizon.

The writer observed only two dolomite ledges, such as are quite well exposed on the hill between Watonga and Geary previously mentioned, about six miles south of Watonga. In this paper they will be called the upper and lower Greenfield dolomite respectively. The lower ledge doubtless represents Putnam's twin dolomites.

The upper member is not very well exposed, but is probably 6 inches thick. It is a light pink, banded rock, rather widely spaced pink bands alternating with mottled pink and white ones.

This rock is a very pure dolomite except for an appreciable amount of quartz sand, quite well rounded and sorted in one specimen, grains averaging about 0.15 mm. in diameter, but in another appears to be angular with grains from 0.05 to 0.16 mm. A little very fresh and angular microcline and plagioclase were observed. In thin section the red color is observed to be due to iron oxide which follows the distribution of the sand, adhering closely to the grains for the most part.

A composite sample of this rock gave 5.8 per cent insoluble residue. The dolomite grains are uniformly about .13 mm. in diameter, and many of them are subhedral, as in plate XIII, *D*.

About 22 feet below the top member is a much more prominent one about 16 inches thick. It weathers into noticeably banded blocks which are not very different on fresh surfaces from the upper member. Plate III, fig. 3, shows a typical outcrop.

This member is even purer than the upper one as it contains very little quartz. It is various shades of delicate pink in color, which is partly responsible for the banded appearance, also brought out by arrangement of cavities. In thin section the cavities appear to occur along laminae of coarser grain than the rest, (about 0.08 to 0.15 mm.) the finer parts having grains from 0.03 to 0.08 mm. in diameter. The grains have no marked tendency to be subhedral.

This rock is very hard and small parts of it are very dense. A piece of uniform, very fine grained, pink dolomite was found to have a specific gravity of 2.79.

Shead[85] gives an analysis of dolomite from at or near the above locality and one from a few miles farther south. No doubt both are from the lower member. The thicknesses given are greater than any observed by the writer.

Analyses of Greenfield Dolomite, Blaine County

	A	B
SiO_2	0.88	1.82
Al_2O_3	0.00	.....
Fe_2O_3	0.05	1.35
FeO	0.08	.....
MgO	20.08	25.28
CaO	31 96	23.79
H_2O	0.16	1.82
CO_2	45.72	46.26
TiO_2	0.00	.....
P_2O_5	0.59	.....
MMO	trace	
Organic	0.51	.....
	100.03	100.32

A.—NW.¼ sec. 25, T. 15 N., R. 12 W. Bed is 18 inches to 2 feet thick (evidently the lower of the two beds). Analyst, A. C. Shead. Collected by Malcolm Oakes.

B.—Summit of Red Hills, 6 miles NW. of Geary. Bed is 3 feet thick. First published by Gould (1905, p. 59).

On recalculating the above analyses, it appears that the first one is about 92 per cent theoretically pure dolomite and about 7.5 per cent calcite. An interpretation of the second analysis is more difficult, as it contains an unusually large percentage of magnesia.

85. Op. cit., p. 75, nos. 63 and 64.

At the NW. cor. sec. 2, T. 14 N., R. 12 W., a very hard and somewhat brittle ledge, at least 15 inches thick was observed, no doubt the lower Greenfield dolomite. It is finely banded, pink and white.

A specimen is light pink with some very thin, fairly parallel reddish laminae. It is medium-grained, somewhat porous, contains no calcite and only a small percentage of fine insoluble matter, red iron oxide or silt with some quartz.

SUMMARY

The dolomite ledges occurring in Blaine County, west of Greenfield and between Watonga and Geary, were regarded as Day Creek until 1924, when they were shown to be within the lower half of the Whitehorse sandstone. Two ledges are found in some places. They may be called the upper and lower Greenfield dolomite, respectively.

The upper ledge is not prominent, being only 6 inches thick. It is rather fine grained, banded, pink dolomite with about 6 per cent sand, the grains being as large as 0.16 mm. in diameter.

About 22 feet below the upper member is the lower Greenfield dolomite. It is about 16 inches thick and not dissimilar to the upper ledge, but contains very little quartz. Calcite is very uncommon in either of the Greenfield dolomites.

DOLOMITES OF THE WEATHERFORD DISTRICT

INTRODUCTION

Particular interest was aroused with regard to the stratigraphy of the Weatherford district in 1926-27 by the reported possibility of favorable structure for the accumulation of oil. As a result, a number of geologists have done very detailed work there and the district has been shown to be much more complex than was formerly realized. The conclusions of Evans have been previously mentioned (see p. 85). His paper, with the subsequent remarks by Schweer, appears to be the only recent information we have about the district.

The writer visited a number of interesting localities near Weatherford, enough to realize the complexity of the problem. The information obtained will be given along with a review and discussion of previous work. The writer's very limited acquaintance with the district compared with that of others who have worked there precludes drawing any very general conclusions, but considerable information has been gained with respect to the character of the dolomites previously referred to.

OCCURRENCE OF DOLOMITE

Figure 10 shows a map of the Weatherford district as given the writer by Putnam, with only a few minor changes. It will be noted that dolomite forms an escarpment south of Weatherford in T. 12 N.,

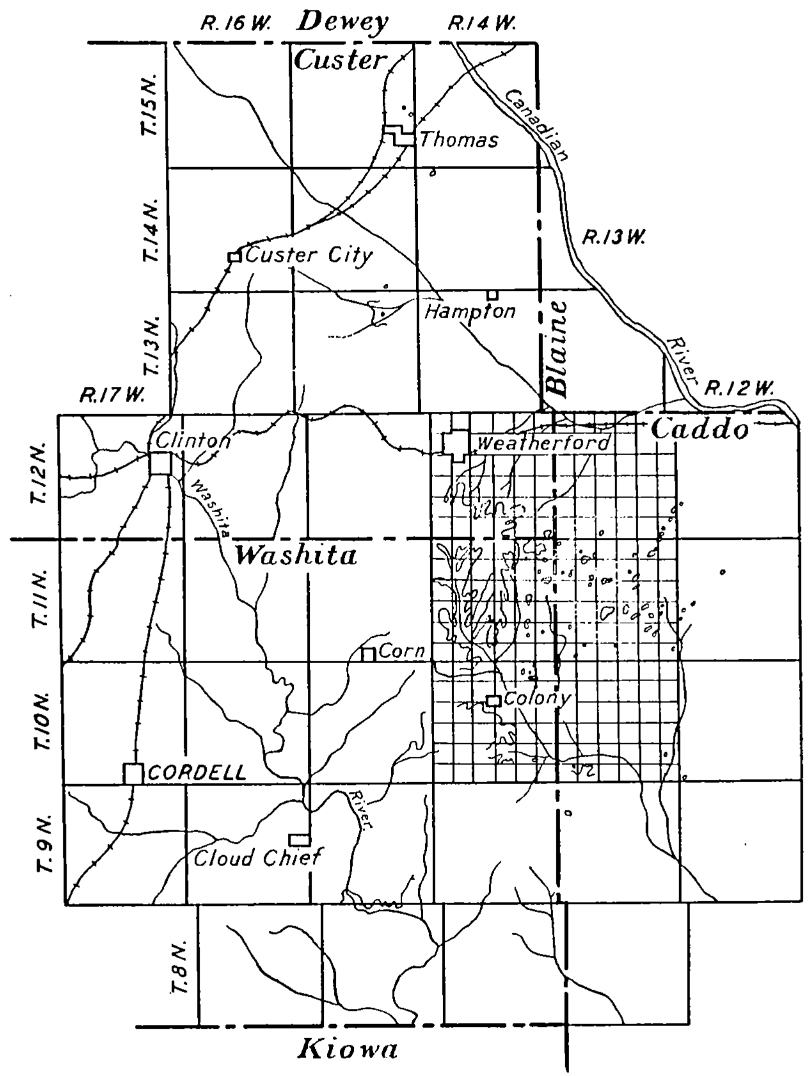


Figure 10.—Map of dolomites of the Weatherford district.

R. 14 W., which continues, very much embayed, across the next township to the south and on to a point northwest of Colony. Other outcrops may be found south of Colony and also southeast of Cloud Chief, north of the Washita River.

East of the main escarpment is a large number of buttes capped with dolomite, not less than 50 of them having been mapped, mostly in Caddo County.

Other dolomites have been located north of Thomas, and also south of Thomas and southeast of Custer City.

Our understanding of the dolomites south of Weatherford in 1924, may be gathered from the following description of the Day Creek by Gould[86], all dolomites at that time being regarded as one formation.

> * * * In thickness it varies up to 5 feet, or occasionally there are two distinct ledges of dolomite 2 to 4 feet thick each, separated by red shales. In color the dolomite is usually white, sometimes pinkish.
>
> In the region under discussion, the most conspicuous exposures of the Day Creek dolomite are on the Caddo County buttes, located in northern Caddo County, chiefly along the divide between Washita and South Canadian rivers. These buttes, more than a score in number, are formed of Whitehorse sandstone capped with Day Creek dolomite. The formation is also found in the hills near Weatherford, where it marks the boundary between the Whitehorse and the Cloud Chief. Farther southwest in southern Washita County, the Day Creek is absent, or at best is represented by an inconspicuous dolomite zone at the top of the Whitehorse.

STRATIGRAPHY AND PREVIOUS DESCRIPTION OF DOLOMITES

Figure 11 shows a sketch map of the Weatherford district as given by Evans.[87] It will be noticed that the dolomite concerned here is divided into two members, as previously intimated, the Day Creek and the Quartermaster dolomites, the latter found capping the Caddo County buttes.

The stratigraphy of the district as interpreted by Evans is shown in fig. 12. In this part it will not be necessary to deal with any beds below the Day Creek.

The Day Creek is described by Evans as follows:

> The Day Creek dolomite is typically a hard, light gray dolomite with a maximum thickness of 3 feet, but in most places approximately 1 foot thick. It is commonly laminated or banded and in places the lamination planes are distorted or folded, resembling fossil wood. The contact with the Whitehorse is regular and is conformable to beds that are 40 feet below * * *.

86. Op. cit., p. 336.
87. Evans, Noel,—Stratigraphy of the Weatherford area, Oklahoma: Bull: Am. Assoc. Pet. Geol., vol. 12, no. 7, p. 706, 1928.

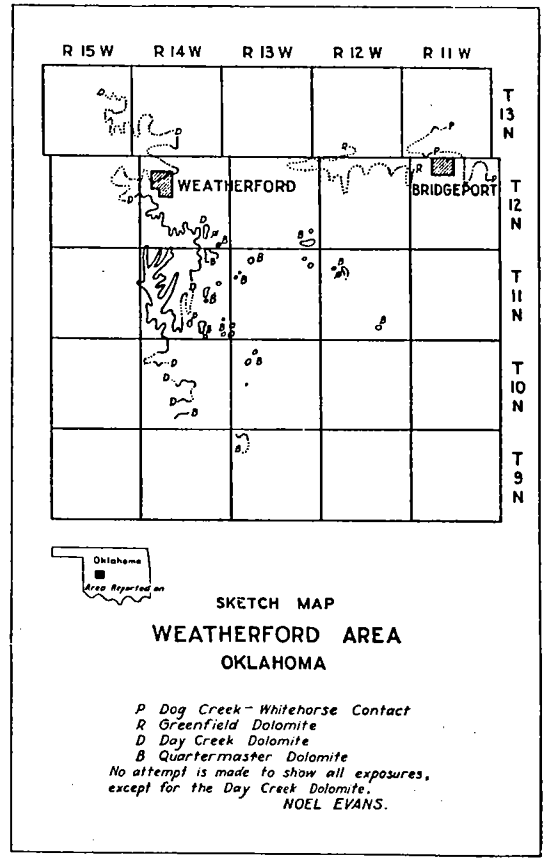


Figure 11. Sketch map of Weatherford district, showing the chief occurrences of the Day Creek and Quartermaster dolomites.

From the town of Weatherford west and northwest the Day Creek horizon is represented by a gypsum bed ranging from 3 to 10 feet in thickness * * *. The bed is well exposed on the main highway at the northeast corner of Weatherford.

Sandstone in position, and below the massive Cloud Chief gypsum occurs above the Day Creek dolomite. This sandstone is, apparently, the Whitehorse. At Weatherford this sandstone contains some gypsum lentils and occupies a zone of about 60 feet between the Day Creek horizon and the massive Cloud Chief gypsum * * * *.

The fact that sandstone occurs above the dolomite may cause some geologists to question the identity of this dolomite with the Day Creek. However, this condition proves that the bed occupies a true stratigraphical position at or near the top of the latest Whitehorse. The writer holds the opinion that the dolomite here described is the true Day Creek.

Practically all of Evans' comment on the Quartermaster is important to a study of the dolomite of this district. His remarks are quoted as briefly as possible.

The Quartermaster formation consists of about 150 feet of red sandstones and shales * * *. This formation presents a real problem in this area. It is unconformable over the lower beds, in some places resting directly on Whitehorse sandstone, and in other places occurring at higher elevations than the Cloud Chief gypsum.

In the SW.¼, sec. 29, T. 11 N., R. 14 W., the Quartermaster rests directly on the Day Creek dolomite * * *.

Quartermaster beds occur in sec. 5, T. 9 N., R. 13 W. Here they rest directly and unconformably on the Whitehorse sandstone and the unconformity is easily seen along the contact. Immediately above this contact is a dolomite that, to some extent, resembles the Day Creek. At about the same horizon as the dolomite there occurs in places a zone of purple slaty beds about 2 feet in thickness * * * well developed in some places although entirely absent only a few yards away. Just above the dolomite occurs irregularly a variable thickness of a peculiar, pinkish, conglomeratic bed, which is calcareous and probably dolomitic. In other places * * * this pinkish formation attains as much as 15 feet in thickness. The presence of unmistakable Quartermaster rocks occurring only a few feet above this dolomite, and the unconformity at its base, constitute the evidence for correlating this dolomite with the Quartermaster rather than with the Day Creek.

About a quarter of a mile south of the northwest corner of sec. 36, T. 11 N., R. 14 W., is another place where typical Quartermaster beds occur. Near the southeast corner of this same section can be found a more or less irregular contact at the top of the Whitehorse sandstone. The beds above this contact consist of about 15 feet of gray to pinkish, hard dolomite, which looks very much like ordinary limestone. It differs greatly within short distances, and in places contains much calcite and is conglomeratic * * *. Other buttes north of this exposure are capped by the same dolomite.

In sec. 16, T. 11 N., R. 14 W., are two prominent beds. The lower bed is the Day Creek dolomite and the upper is an irregular bed occurring at an interval above the Day Creek dolomite. This interval ranges from 6 to 58 feet in thickness in a little more than a quarter of a mile * * *. The pinkish, conglomeratic,

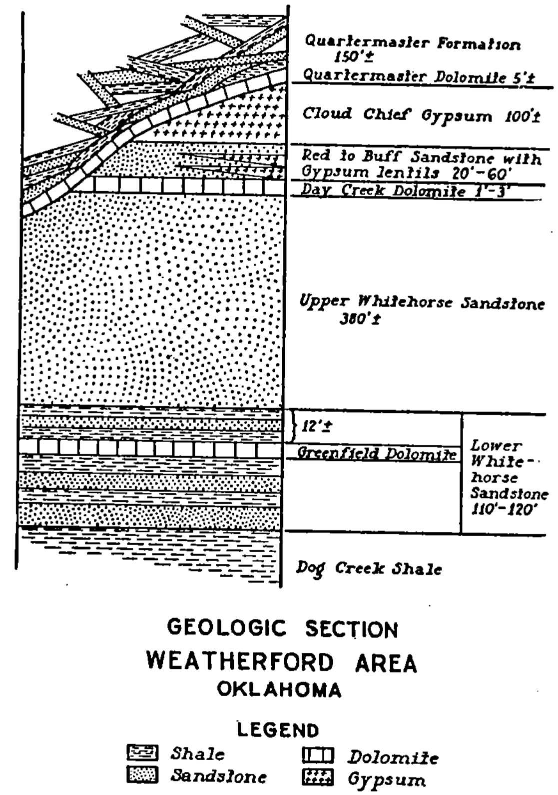


Figure 12. Section showing the stratigraphy of the Weatherford district (Evans, 1928, p. 708).

limy formation, which occurs above the Quartermaster dolomite in sec. 5, T. 9 N., Range 13 W., lies above this contact. This same condition exists in the W.½ NE.¼ sec. 28, T. 11 N., R. 14 W.

Near the south quarter corner of sec. 14, T. 11 N., R. 14 W., is an outlier, composed of strata which must belong to this same irregular formation, which the writer refers to the Quartermaster. Here occur 20 feet or more of irregular sandstone and limy sandstone beds. The dips are high and the contact at the base is so irregular that there can be little doubt of an unconformity. Whitehorse sandstone, or sandstone belonging to the zone between the Day Creek and the Cloud Chief, underlies this contact. A thin dolomitic stringer, 50 or 60 feet below the contact, may represent the Day Creek. On the south side of this outlier, along the north side of sec. 23, occurs a conglomerate bed with boulders as large as a man's fist * * * only a few feet above the contact.

Just north of the east quarter corner of sec. 35, T. 12 N., R. 13 W., is a butte capped by a dolomite bed. Here the section exposed is, from the top down:

1. A variable thickness of a pinkish, conglomeratic, dolomitic bed containing geodes.
2. About 5 feet of hard, light gray dolomite.
3. Thinly laminated, reddish sandstone, 4 feet thick, grading to purplish and slaty at the top. This formation differs locally and its contact with the underlying Whitehorse is somewhat irregular.
4. Whitehorse sandstone. The upper part of the Whitehorse here is hard and slightly limy. About 40 feet of the Whitehorse is exposed.

The writer wishes to call particular attention to the pinkish, dolomitic bed and the purplish, slaty beds exposed here, and the same type of beds occurring similarly in sec. 5, T. 9 N., R. 13 W., which the writer calls Quartermaster.

Evans concluded, then, that the Quartermaster dolomite is very different from the Day Creek of this district and occurs near the base of the Quartermaster formation which rests directly and unconformably on Whitehorse, Day Creek, and Cloud Chief.

In a discussion of the paper by Evans, H. F. Schweer[88] gives some additional points, chiefly in support of an eastward lensing-out of the Day Creek as the Quartermaster "breccia-conglomerate" becomes more prominent. The "thin dolomitic stringer" mentioned by Evans, is thought to be about the easternmost appearance of the Day Creek. Probably another occurrence is a friable greenish gray layer from ½ to 2 inches thick, found in sec. 11, T. 11 N., R. 14 W. While Evans attributes the difference in interval between Day Creek and Quartermaster wholly to unconformity, Schweer thinks part of it may be due to slumping of the upper dolomite.

Three distinct dolomite strata of uncertain correlation are mentioned occurring near the center of sec. 36, T. 12 N., R. 14 W. The top one appears to be the equivalent of a well-laminated dolomite at or near the base of Evans' Quartermaster conglomerate. Twenty-four

88. Geologist, Shell Pet. Corp.

feet under this is another about 6 inches thick and a third is 23 feet farther down in the section. All three macroscopically resemble the Day Creek. It has been suggested[89] that the near basal Quartermaster conglomerate is the result of re-worked Cloud Chief gypsum.

SUMMARY OF PREVIOUS WORK

It is evident from the results published by Evans and Schweer that in the district south and southeast of Weatherford there are at least two dolomite horizons where there was formerly thought to be only one. The lower dolomite is thought to be true Day Creek and to occur in the Whitehorse about 60 feet below its top in some places. However, the latter points do not appear to be accepted by all those who have worked in this field. It is generally held that this dolomite is represented by a gypsum ledge northeast of the town of Weatherford. The upper dolomite, occurring at or near the base of the Quartermaster is quite different in character and thickness and is found almost exclusively east of the main body of the Day Creek, and in very few places does it actually occur above it. It is thought that the Day Creek thins rapidly to the east. The nature and origin of the "conglomerate", or "breccia-conglomerate" of Schweer, is little understood.

DESCRIPTION OF DOLOMITES

Having reviewed the previous work on the dolomites of this district, the writer will here give his observations with particular reference to their nature and composition.

The one locality where Cloud Chief gypsums have been found almost directly above the Day Creek[90] is about the NE. cor. sec. 19, T. 11 N., R. 14 W. The dolomite there is as much as 13 inches thick. Over 60 feet of red sandstone and soil are exposed in the creek valley directly below the ledge and at least 18 feet of red sandstone occur above it also. The gypsum appears 20 to 25 feet above the ledge, at least 40 feet of it being exposed on the gentle slope west of the dolomite outcrop.

A specimen representing the above ledge is rather heterogeneous, predominantly light reddish pink with rather thin, closely spaced laminations, which are somewhat wavy. Small black spots and patches occur, also a coarsely crystalline white mineral as streaks parallel to the bedding. The pink material is about 20 per cent calcite as fine specks.

A thin section shows the rock to be composed of dolomite, calcite, celestite and quartz. The celestite probably composes 20 per cent of the

89. U. R. Laves and Hastings Moore.
90. As previously intimated, some geologists doubt whether the true Day Creek occurs in this district. The writer is of the opinion that it has not yet been proved, but at the same time thinks it better to continue calling the ledge described at this point Day Creek until it has been definitely shown to be at a different horizon.

rock, and occurs as large blocky crystals, many with rectangular cleavage, as well as smaller particles. It is very definitely replaced by the dolomite, as shown in Plate XIV, *A* and *B*. The calcite occurs as small irregular patches throughout the dolomite. Its relation to the dolomite is not certain, but it seems quite probable that it is earlier. Some of the quartz is euhedral.

It has not been determined whether this occurrence of celestite is local or widespread. It may prove to be more or less typical of the Day Creek in this district.

About ½ mile to the east, a ledge occurs in the road, 6 inches being prominent, very platy, coarsely banded in shades of pinkish-gray. The weathered parts have large numbers of black dendrites.

A rather typical specimen shows a "knot" in the bands, an eye-shaped mass about 2 inches long and 1 inch wide. As nearly as the writer could make out, it has been caused by a compression of some of the laminae and shows no sign of introduction of any material, or growth of crystals. No faulting of the laminae was visible and the movement seems to have preceded consolidation. The carbonate is largely calcite, seemingly as an impregnation of all grains. Black dendrites are very numerous. However, the carbonate outside the knot does not appear to be over 15 per cent calcite. The insoluble part of this rock is ill-sorted, sub-angular to rounded sand grains from 0.15 mm. in diameter to very small, largely quartz but other minerals are present also.

In the SW. ¼ sec. 16, T. 11 N., R. 14 W., the Day Creek is also about 1 foot thick, very platy and banded. A very fresh, fine-grained, dense specimen is reddish-pink, thinly banded and appears to be 8 to 10 per cent calcite as parts of some grains. The insoluble part is very small, quartz grains about 0.08 mm. in diameter.

About 25 to 40 feet above the dolomite just mentioned is a second member, probably not over 2 feet thick. It is no doubt the Quartermaster dolomite.

In the SE. cor. sec. 5, T. 11 N., R. 14 W., a good exposure of the Day Creek may be seen. It varies greatly in thickness within a few feet, from 10 to 18 inches in 3 or 4 feet being a common variation. The top in particular is uneven, and does not appear to be due to weathering, being covered by red sandstone. Very irregular banding is characteristic, and some large "knots" occur a foot or more across.

About 14 feet above the Day Creek at this point is a red carbonate ledge, at least 32 inches thick in one place, mostly sandy with much white calcite as druses and veins between laminae, lenses and irregular masses of the main rock. It probably does not contain dolomite.

A little farther north, just south of the middle of the east side of section 5, the two ledges also appear, the tops 15 to 16 feet apart.

The upper calcitic member, about 30 inches thick, may also be seen about ¼ mile farther north, but the Day Creek appears to be absent. A very thin sandy carbonate layer occurs in the creek bottom about 50 feet below.

About 1.3 miles south of Weatherford, between secs. 19 and 20, the Day Creek occurs in the road as a hard ledge, 6 to 9 inches thick and very porous. In this part of the district the rocks are chiefly exposed in the creek valleys or bottoms.

The exposures near Colony are poor, on the whole, occurring on buttes or bluffs of low relief. However, in the NW. cor. sec. 5, T. 10 N., R. 14 W., the Day Creek occurs showing a sharp contact above and below with red sandstone. It is at least 1 foot thick, fine-grained and brittle. It is rather irregularly banded, the laminae showing contortions.

A typical specimen is entirely dolomite except for about 20 per cent, possibly, of fine sand about 0.08 mm. in diameter. In thin section the dolomite occurs as irregular interlocking grains, about 0.15 mm. across and smaller but has a much finer granular texture possibly due to cleavage.

A more massive, faint reddish pink specimen, from what appeared to be the top of the ledge, is quite similar to the above, very dense and fine grained. It shows some 3 to 5 thin, closely spaced laminations parallel to joint planes, evidently due to weathering but in no way different from many which are parallel to bedding planes. However, if weathering were the cause of any appreciable amount of banding, definite cases of the phenomenon would undoubtedly be more common.

In its purity, fineness of grain, and lack of porosity this dolomite is so different from that south of Weatherford that one is inclined to doubt if they are at the same horizon.

However, other occurrences of "dolomite" west and south of Colony are very different from the typical Day Creek also. Some light red carbonate blocks found in the road 1.3 miles west of Colony are distinctly fragmental in nature. Fragments of various sizes, some more than an inch across, are irregularly placed in and cut by a matrix of similar material. Some of the fragments are angular, some rounded and some are distinctly banded pink and red. The rock seems entirely calcite detrital quartz and red silt.

About CSL. sec. 34, T. 9 N., R. 15 W., east of the Washita River, a red carbonate ledge at least 30 inches thick may be found. Much of it is veined by more or less coarsely crystalline calcite, in places forming a sort of vein breccia, angular blocks of the red rock being entirely surrounded by radiating, columnar, white calcite, with crystals as long as 2 inches. The calcite was also noticed as more or less crustified bands roughly parallel to the bedding.

The inclosed red rock appears to be largely calcite with some fine sand about 0.05 mm. in diameter. However, a thin section shows calcite as minute patches of more or less equal size (about 0.06 mm. in diameter), separated by a very thin, clear, network of dolomite, discernible with difficulty, which appears to lead into small nests of clear dolomite of several crystals each. This is plainly shown in Plate XIV, C, and appears to indicate that calcite has been partially replaced by dolomite. The amount of dolomite in the ledge as a whole is very small, however.

A ledge of very similar appearance to the above, with coarse calcite veinings, was examined along the east side of sec. 14, T. 11 N., R. 14 W. However, no dolomite was detected in any part of this rock.

The coarse calcite in these rocks seems to have formed by replacement as well as simple vein formation. This is shown along the inner borders of some of the more definite masses, and by remnants of original red rock which appear scattered through a matrix of quite coarsely crystalline calcite, apparently an extreme case of the process.

Calcitic red carbonate ledges, pseudo-brecciated by numerous coarse calcite veins, are not uncommon in the Weatherford district and need to be investigated further. Some may be equivalent to the upper Quartermaster dolomite, while others appear to represent the Day Creek horizon.

About 1.4 miles east of Rocky a weathered calcitic member appears which looks much like the Day Creek. On the whole it is rather medium grained, pinkish-gray with minute black specks, but fine-grained, light-red layers are present. It appears to contain a small amount of dolomite.

It may be mentioned here that Gouin[91] has found the "Day Creek" in southeastern Beckham County as a thin ledge of dolomite at the base of 100 feet of Cloud Chief. It seems doubtful if this can be definitely correlated with that south of Weatherford.

The Quartermaster dolomite is exceptionally well exposed in the CSL. sec. 25, T. 12 N., R. 13 W. It is at least 6 feet thick and may be a foot or two more. The bed rests on red sandstone. The lowest 17 inches are platy and banded, probably the equivalent of Evans' "purple shale". There is a very sharp division between these and the beds above which have a brecciated appearance, the fragments arranged in irregular wavy bands. At one place the lower part shows flow structure, the base being perfectly flat while the upper laminae are buckled without showing any sign of fracture, as shown in pl. III, fig. 4. The movement has evidently extended into the upper part of the member also. On top of the butte the upper beds seem to stand on edge in places, giving the effect of highly tilted strata, although they are very flat along the side of the butte. Such local disturbance has been noted in many places and appears to be due to movement previous to consolidation.

91. Gouin, Frank, Geology of Beckham County: Oklahoma Geol. Survey, Bull. 40-M, p. 9, 1927.

A banded, pinkish-red block from the lower part of the dolomite shows very interesting markings on the weathered surface. Some almost certainly are the imprints of brachiopods. Others look somewhat like rain-prints. Some elongated cavities in the rock are very probably fossil casts. Some show very fine indentations, evidently the cast of the outer shell structure. The containing rock has a little calcite in cavities, but the dense parts are quite pure dolomite. The insoluble part of one sample was 3.3 per cent, mostly angular quartz grains and iron oxide. A concentration of heavy minerals with bromoform showed considerable tourmaline, probably rutile and zircon as well as other minerals not recognized.

An analysis of the type of Quartermaster dolomite described above follows:

	Per cent
CaO	27.77
MgO	17.40
Fe_2O_3 Al_2O_3	4.75
SiO_2	3.77

A thin section of this rock shows fine banding, due to sand grains as large as 0.1 mm. in diameter and distinctly angular. The dolomite is very fine grained (0.03 mm.) and shows no sign of recrystallization or replacement, (see Plate XIV, *D*).

A good exposure of the Quartermaster dolomite occurs on a bluff facing northwest in the NW. cor. sec. 21, T. 11 N., R. 13 W. In one place it is over 6 feet thick. It is in quite sharp contact with platy sandstone below and cross-bedded sandstone is on the slopes and in the bed of the creek. Red sandstone also occurs above the member. The dolomite on the whole is roughly banded and red or pinkish in color.

A specimen from a platy, almost fissile block has thin, definite bands, very straight and parallel, red, pink and gray in color. It is a pure dolomite with grains over 0.5 mm. in diameter, interlocking and showing prominent cleavage in thin section. The quartz, evidently responsible for the banding, is angular, quite well sized and about 0.05 mm. in diameter. Coarse calcite occurs in some specimens as streaks or gashes.

A specimen more typical of the whole ledge is fine-grained, massive, red dolomite with numerous cavities partly or wholly filled with calcite. The sand grains are under 0.08 mm. in diameter, mostly subangular, and have a heavy red coating.

A rather unusual type from the actual base of the section is medium- to coarse-grained, white or pinkish white, massive, rather porous and hard. It is very pure dolomite. The insoluble residue does not appear to be detrital and consists of clear quartz as indistinct masses and groups of crystals, and some euhedral doubly terminated ones measuring 0.25 to 0.06 mm. across.

Some light on the character of the brecciated dolomite was obtained from blocks on top of a low ridge about the middle of the north side of sec. 23, T. 11 N., R. 13 W., near the eastern limit of the dolomite outcrops. There appears to be no evidence that the ledge was over 2 feet thick at this point.

A typical specimen from this ledge is shown in plate IV, fig. 4. Light reddish pink dolomite lenses and fragments are rather thickly distributed in a dark red matrix, also dolomite. On the whole they are very much elongated parallel to the bedding. Some are 3 inches long and one-quarter to one-eighth inch thick. Some of the large pieces are definitely cut by very thin stringers of the matrix, both parallel and at right angles to their elongation. The closely parallel position of many of the fragments indicate that they were originally one piece, and it may be that some of the thin stringers parallel to their long axes are original laminae. In addition to the larger, more definite patches there are many smaller ones of the same nature down to ones hardly visible on a polished surface. The fragments of all sizes commonly feather out at the ends into the groundmass. The structure in this rock is strongly suggestive of flowage, as seen, for instance, in certain metamorphic rocks.

A thin section shows a band of pure white dolomite, and a band of red with numerous long stringers and specks of white dolomite more or less parallel to the contact. Both red and white dolomite contain fine angular quartz sand (grains under 0.1 mm. in diameter), but it is several times more abundant in the red. The white dolomite grains are about 0.08 mm. across and smaller.

Another type from the above locality shows more blocky individuals, mostly banded on a weathered surface, which have certainly been corroded or partly replaced by the containing rock. Plate IV, fig. 6 shows a piece about an inch square, which may in itself be composite in nature, having one corner eaten out leaving a delicate hook-shaped filament projecting into the groundmass. Plate IV, fig. 1 shows a somewhat similar piece with a thin stringer of red penetrating toward its center from a very finely corroded edge.

Plate IV, fig. 2, represents an unusual case in which fragments can still be identified as from the same bed by thin purple laminae. Apparently they have not been displaced more than an inch or two yet show no evidence of ever having fitted together.

A somewhat different type from any of the above is shown in plate IV, fig. 3. Although closely related to the breccias, definitely bounded fragments are not noticeable and the structure is indefinite and complex on the whole. A wavy boundary across the center of the specimen appears to represent a bedding plane. Along the lower side may be seen structures which plainly indicate movement and brecciation within the bed. A thin section does not show two distinct types, but only thin red streaks in a fine-grained dolomite (0.05 mm.). In this type it seems quite evident that the structures are due to flowage, probably moderate, in a rather plastic rock which had no definite laminae or any part brittle enough to form angular fragments as in other specimens.

In one place at the last named locality the beds seemed to be actually folded, one limb being almost vertical and the other, a few feet away, being at about 45 degrees. It did not appear to be due to recent slumping.

In the SW. ¼ sec. 36, T. 12 N., R. 13 W., the clastic structure is remarkably prominent. A fine, irregular, contorted banding not like any previously seen was observed in one small spot. The rock is a fine grained, light-pink dolomite with thin red laminae having a complex structure. A polished surface shows considerable fracturing and faulting yet the fragments appear much the same as those previously described.

About ¼-mile north of the above locality over 4 feet of banded dolomite is exposed resting on finely laminated, red, sandy shale, apparently grading into it. Local disorder of the beds may be observed here also. The beds are quite flat only a few feet away.

The general appearance of the buttes near the vicinity mentioned above is shown in plate VI. The eastern outcrops of the Quartermaster dolomite form the caps of such buttes as these.

From about the NE. cor. sec. 7, T. 10 N., R. 13 W., two types of dolomite were obtained. One is a medium-grained light reddish pink dolomite with thin straight laminations. The other is the clastic dolomite similar to others described. Fragments are distinctly embayed by the groundmass in some cases and feather out into delicate filaments in others, giving many of the fragments an irregular outline wholly impossible if they were detrital. The parallelism of the long axes is noticeable.

The fragments are quite pure dolomite with less than 5 per cent angular quartz. The red matrix, however, contains possibly 50 per cent insoluble matter, round quartz grains about 0.35 to 0.5 mm. in diameter and sub-angular to angular fragments, .20 mm. across and smaller. Plate XV, *A* shows a thin red sandy band between pink dolomite bands and also one of the rounded pink fragments which it includes, evidently the same material as that on either side. The dolomite grains in the pink are quite euhedral, about 0.15 mm. in long diameter. The dolomite in the red part is not markedly different.

At the CWL. sec. 7, T. 11 N., R. 13 W., is a red sandstone butte about 60 feet high capped by at least 45 inches of dolomite. A few inches on top is very brittle and platy with fine parallel reddish-pink bands. It contains no calcite. In thin section the dolomite grains average roughly 0.25 mm. in diameter, are rather cloudy, subhedral to euhedral and show prominent cleavage. The remainder of the ledge is rather massive, porous red and white mottled rock. A fresh specimen is fine-grained, dark red, with irregular cavities, some lined with calcite. The rock is mostly dolomite, both red and white grains, with about 5 per cent of fine sand.

In the NW. cor. sec. 22, T. 11 N., R. 14 W., a weathered and slumped carbonate ledge was noted, apparently Quartermaster, although it contains much calcite. It is at least 3 feet thick and possibly more. The brecciated phase appears to be present in some spots.

A typical fresh specimen is quite massive, very uniform, fairly fine grained, reddish-pink rock. It appears to be nearly 75 per cent calcite. In thin section considerable dolomite appears as small specks and irregularly shaped residue in the calcite. Some of it occurs as rhombic or subrhombic sections, many of which are partly replaced by calcite. The dolomite is clear but the calcite is in indefinite turbid grains.

If the Quartermaster dolomite has been altered to calcite in the western part of this district, its absence above the Day Creek in most places can be readily explained. Weathering would readily remove such rock and some of the calcitic ledges found, above the Day Creek in places, may be the direct equivalent of the Quartermaster.

The outcrop which shows the conglomerate described by Evans (see p. 110) was examined in some detail. In one place a carbonate member, 5 to 6 feet thick occurs, uniformly pink and white, the pink as angular, spongy spots, the white forming a matrix. However, the ledge on the whole is very irregular and appears to grade into sandstone in part.

In one spot only the base of the member resembles a conglomerate, 1 to 3 feet thick. Pieces of carbonate from small fragments up to "boulders" 1½ feet in diameter occur and also some blocks of banded sandstone. However, individuals are commonly angular and any roundness they possess appears to be due to solution. The carbonate is

exactly the same as that of the ledge directly above, which is quite uniform. Moreover, the latter shows distinct evidence of having been broken into angular blocks, probably averaging 6 inches across, which were later recemented, after slumping somewhat. Cavities still remain between some of the blocks, lined by crystal druses. In general, the writer is not convinced that this occurrence is a true conglomerate but is inclined to think it is some form of breccia. Several specimens of the carbonate were examined but in only one was any dolomite found and that in a thin section. The white appears to be wholly calcite. The pink fragments, however, may contain a little dolomite.

About 10 feet below the base of the carbonate ledge is a lens in the sandstone, about 10 to 20 feet wide and 2 feet thick, which appears to be a former stream channel. It contains many carbonate fragments similar to those described above, mostly angular, but some are quite flat. Sandstone fragments also occur. The sandstone above this lens is very irregular, the laminae curiously broken and twisted. There appears to be good evidence of an unconfomity here even if the material at the base of the carbonate is not a true conglomerate.

The writer also examined the three dolomites mentioned by Schweer (see p. 110). They occur on the south side of a rounded hill just south of the center of sec. 36, T. 12 N., R. 14 W.

Capping the hill is a dolomite member at least 14 inches thick. A particularly fresh specimen from the top is exceedingly fine grained, massive, dark-red, brittle with sub-conchoidal fracture. The rock is entirely dolomite except for a considerable amount of fine sand, mostly under 0.05 mm. in diameter, but some is as large as 0.15 mm. Some banding is brought out by thin dark streaks.

A less fresh specimen is lighter red in color and distinctly banded, the layers parallel and about 2 to 5 mm. thick. The banding is made more prominent by the leaching of some of the bands which also brings out a peculiar structure in many of them. Thin, closely spaced, parallel plates are set at a high angle to the bedding. They are very uniform in a number of laminae and always quite parallel to each other. They may possibly be the result of slight shearing or flow between the beds before complete consolidation. There is little doubt that this rock is the Quartermaster dolomite.

About 18 to 20 feet below is a rather irregular dolomitic sandstone varying in thickness but averaging about 6 inches. It is fairly massive but has white carbonate streaks and cavity linings. It appears to grade into ordinary sandstone. Fresh specimens are about 50 per cent fine, red-coated, sand grains averaging about 0.01 mm.

The third dolomite, over 20 feet farther down, is not very prominent and varies in thickness, probably from 2 to 6 inches. It is characterized by sub-colloform, gray dolomite crusts, several millimeters thick, which are quite numerous in places. They occur in a red dolomitic sandstone, in places as crustified veins parallel to the bedding, having indefinite walls but occasionally a very definite medium plane. They may completely surround a block or small piece of the red rock, which is commonly very indefinite in outline. Plate XV, B, shows part of one of these crusts in thin section. The dolomite is truly fibrous, and resembled chalcedony in many ways. Some of the gray dolomite is more massive and shows, in places, small curved crystal surfaces. It also appears to be later than the red dolomite.

The red rock contains a rather large amount of sand, probably over 50 per cent angular quartz grains up to 0.15 mm. in diameter. The dolomite cement is fine-grained and brownish. A remarkable feature is the occurrence of nests of large dolomite rhombs as well as isolated crystals, nearly all of which show an indefinite rim, in some cases retaining the cleavage, as shown in Plate XV, *C*. Some are 1¼ mm. in long diameter.

The sub-colloform dolomite must have formed at a distinctly later period than the cement for the sandstone which may be original. It is not plain why the edges of the large crystals in the sandstone have been replaced or re-crystallized. The solutions which have deposited the dolomite crusts may have been responsible.

Below the crustified material is a compact dolomitic sandstone of variable thickness, averaging about 1 foot. It is light-red, massive, with a little coarse calcite. The insoluble part consists of red-coated quartz grains roughly 0.06 to 0.2 mm. in diameter and fine red silt.

Below the member described above is about 40 feet of strongly cross-bedded, dark-red sandstone. This stops abruptly and is in contact with quite regularly banded sandstone at least 35 feet thick.

It is a question whether either of the two dolomitic horizons last described represents the Day Creek. Certainly neither of them looks like it lithologically.

In the SE. cor. sec. 28, T. 10 N., R. 14 W., south of Colony, is a poor exposure of red "dolomite" nearly 3 feet thick. Thin white carbonate veinlets intersect the whole. The fresh material is dark-red, medium- to fine-grained and massive. This rock is 50 to 75 per cent quartz sand, the grains having a coat of red oxide. They seem to be of two sorts, some larger, well rounded ones from 0.24 to 0.65 mm. in diameter and a much greater percentage a smaller angular to sub-angular ones from very small up to 0.15 mm. The cement is entirely very fine grained dolomite.

The dolomite of the above locality has been mapped as Quartermaster by Evans (see fig. 11). It certainly does not resemble any phase of the Day Creek.

Northeast of Thomas, dolomites occur which have been correlated with the Day Creek.[92] Along EL. NE. ¼ sec. 24, T. 15 N., R. 15 W., two ledges of dolomite occur, separated by 25 feet of red sandstone. They are not noticeably different from the typical Day Creek or Greenfield dolomites.

The upper dolomite is at least 3 feet thick. A particularly fresh and hard specimen is very fine grained, massive, and white with a few thin indistinct reddish bands. It is a very pure dolomite.

The lower dolomite is about 18 inches thick, with some cherty white or pink parts near the top. It appears to grade into the sandstone above, although rather sharply.

One of the two members is probably Day Creek, but there is no certainty about it. They remind one strongly of the upper and middle members previously described from the butte southwest of Canton.

There are a number of outcrops along the north side of T. 13 N., R. 15 W., about which the writer has little information. The exposures are rather poor. In the NE. cor. section 10, two members appear to be present on a knoll. Typical dolomite is quite pure, medium-grained, finely mottled white and light red, pink as a whole. It contains thin calcite veinlets.

Dolomites occurring west of Weatherford have not been noted previously. The writer's attention was called to some interesting localities by geologists familiar with the region.

At a locality not definitely placed but about sec. 23, T. 12 N., R. 16 W., a thick ledge of dolomite may be found along a small creek. The thickness is irregular due to weathering, commonly 2½ to 3 feet but some is 6 feet thick and possibly more. It is rather uniform, coarsely banded, pink and white dolomite. The bands are crenulated in places.

A common type is fine-grained, light-pink to creamy-white with fine, rather indistinct bands of dark red. It looks much like some kinds of massive gypsum. A thin section shows the rock to consist of definite but very irregular patches of dolomite and calcite each embaying and surrounding the other in a very complex fashion. The patches are roughly elongated parallel to bedding, shown by red filaments and markings. The calcite, in places, shows the reticulate structure as previously shown in Plate XIV, *C*, with the dolomite as the net. A phantom of the same structure appears to be present in the dolomite. Both are rather fine grained but the dolomite appears to be coarser.

92. Gould, Chas. N.,—Op. cit., p. 336, 1924.

A specimen very much like the one described above appears to be entirely calcite. It is very massive and has a smooth, sub-conchoidal fracture in places, much like some of the purest dolomites.

A noticeable feature of this member is thin lenses and bands of red dolomitic sandstone. In one place a lens about 6 inches thick cuts across the bedding like a vein. It has quite sharp boundaries. A fresh piece has a large percentage of fine red-coated sand grains from 0.2 mm. in diameter to very small, mostly angular. The cement is entirely fine-grained dolomite. Several larger dolomite rhombohedrons with prominent cleavage are present, containing some sand but very much less than the exterior. One of these is shown in Plate XV, *D*.

A specimen taken from near the above lens and 2 to 3 feet below the top of the section is a massive, fine-grained, red dolomite with very fine white mottling and numerous pores and small cavities. It contains little or no calcite but an appreciable amount of very fine sand and red silt.

In the sandstone of the creek bed below the outcrop described above, much carbonate may be found. Exceedingly irregular warped lenses of calcite pinch out or change to sandstone within a few feet. They are probably similar in origin to the numerous calcite veins, commonly crustified and coarsely crystalline, which intersect the sandstone in all directions. Individual veins are as much as 4 inches thick but they may be grouped together to form thicker masses.

Two irregular beds of carbonate, which appear to be similar in origin to the above, were found dipping at a high angle westward into the creek bed. The lower one, about 6 inches thick, is fairly massive, fine grained and white. The fresh parts are very pure dolomite. About 2 to 5 feet above this, a similar bed varies from 6 inches to 3 feet in thickness and has some narrow faint pink bands, with crustified calcite veinlets parallel to them. The fresh white part is mostly dolomite with some calcite as minute veinlets and coatings.

It is difficult to believe that these irregular, probably lenticular dolomites have had a different origin from the numerous calcite veins and lenses described above, which are plainly much later than the sandstone and due to diagenetic processes.

A. P. Castile[93] described to the writer an occurrence near Clinton where the Day Creek occurs between two beds of gypsum. While in search of this place the writer found an outcrop which corresponded to the description given. It is evidently not at the same locality but is situated 1 mile west of the club house at the Clinton golf links, in the bed of a small creek.

93. Geologist, Indian Territory Illuminating Oil Co.

At this locality a fault is quite apparent, trending roughly 110 degrees, the plane dipping about 45 degrees to the southwest. On the upper side is a complex carbonate member, very much disturbed, the base showing a sharp fold a few feet across.

The base is composed of 8 inches of very fine grained, white to pinkish-white, massive carbonate with some drusy cavities. It resembles some pure dolomites and is semi-translucent as some of the statuary marbles. It is entirely calcite, however.

A few inches above this is a calcite rock also resembling dolomite, irregularly banded pink and white, about 7 inches thick.

Above this is 8 inches or more of very massive, medium- to fine-grained white rock which looks very much like gypsum. It is about 80 per cent dolomite, with grains about 0.03 mm. in diameter. In thin section, calcite occurs in small cavities and veinlets and as irregular masses apparently later than the dolomite. This rock does not resemble any of the Day Creek as seen at Weatherford. It seems more comparable to that described on page 122 from below the thick dolomite member.

SUMMARY AND CONCLUSIONS

The dolomites found south and southeast of the town of Weatherford, in southeastern Custer County, have been known for many years and classed as Day Creek. Not until recently, however, have they been intensively studied. Noel Evans and H. F. Schweer have shown that they are much more complex than previously supposed.

There are two definite dolomite horizons in the Weatherford district, one 60 feet and less below the top of the Whitehorse, and a second at or near the base of the Quartermaster. The former is believed by some to be true Day Creek. Others, however, are doubtful, but the name is still applied until it can be more certainly correlated with known outcrops.

The Day Creek is found in Tps. 11 and 12 N., R. 14 W., as a rather inconspicuous ledge under 3 feet thick, commonly about 1 foot. Occurrences of dolomite or dolomitic rock south of Colony, southeast of Cloud Chief and in places between Clinton and Weatherford may be Day Creek but have not been fully investigated. One of the ledges found southeast of Custer City in the vicinity of Thomas may also be Day Creek. It is generally believed that the member is represented by a bed of massive gypsum north and northwest of Weatherford.

As typically exposed a few miles south of Weatherford, the Day Creek is a distinctly laminated rock, commonly platy. The bands are various shades of pinkish gray to light red. Coarse calcite and innumerable dendrites of manganese oxide mask the color and banding in places. Distortions or "knots" in the banding appear to have developed before consolidation. On the whole the composition seems variable. The very incomplete information available at present indicates that the dolomite has originated by replacement of a limestone. The very definite replacement of celestite by dolomite in one locality lends support to this view.

The Quartermaster[94] dolomite is best exposed on the Caddo County buttes, mentioned many times in the literature, particularly in T. 11 N., R. 13 W. In places it occurs directly above thin dolomite beds correlated with the Day Creek but in only a very few localities has it been found above typical exposures, a condition largely responsible for its previous correlation with the Day Creek.

The Quartermaster appears to be the thickest dolomite in the red beds. Evans reports over 15 feet in some places and the writer has observed over 6 feet of solid dolomite in several localities. This is rather remarkable considering its limited areal extent, and noticeable irregularities.

Typical Quartermaster dolomite contains very little calcite but commonly has a considerable percentage of sand with accompanying red silt, evidenced by the deep red color of most exposures. There appears to be some evidence that the westernmost equivalents of the dolomite horizon are largely calcite or calcareous sandstone.

It is difficult to cite any typical occurrence of the Quartermaster, as it is rarely found to be the same in any two localities. However, certain features are quite typical, on the whole. A platy, thinly laminated, pinkish or purplish dolomite, 1 to 2 feet thick, may be noted at the base of the section in many localities. This dolomite, in places, appears to grade into soft, red, shaly rock underneath and in others may be entirely absent. The dolomite above this is commonly massive and dark red, but may be gray. The most typical and striking feature of the Quartermaster, however, is a peculiar brecciated dolomite of irregular character found, in places, directly above the platy bed but in others on top of the section only, or is lacking altogether. Occasionally all the outcrop consists of this type.

This brecciated dolomite has been called conglomerate and breccia-conglomerate but neither name is wholly suitable and it is difficult to suggest one. Sub-breccia is an appropriate term in many ways. It presents many phases, but the most common, perhaps, is a dark red sandy dolomite in which are set tabular pieces of quite pure pink dolomite with angular corners, arranged in more or less parallel position, in places showirg banding on a weathered surface. These fragments range from ones several inches long down to small pieces only seen on a polished surface. However, not all are angular and many

94. This dolomite deserves a specific name as the Quartermaster sandstone is a widespread formation rarely containing dolomite. It is difficult to suggest a suitable one however, Caddo, being preoccupied.

show corroded edges and feather out at the ends into long filaments. The parallelism of the long axes of these fragments is a noticeable feature, but some are placed at random. The fact that fragments seldom fit together or can be identified as from the same bed is a peculiar feature of this breccia.

The writer has come to the conclusion that this rock has been formed by sub-aqueous gliding or flowage while the rock was partly or wholly plastic. It appears to resemble typical "edgewise conglomerate" or even the more extreme "intraformational breccias."[95] There seems to be a complete gradation from massive dolomite or dolomite with undisturbed banding through types showing flowage to definitely brecciated dolomite with long, slender, broken or twisted fragments, and finally ones which have evidently been greatly disturbed and show only rough parallel arrangement of coarse fragments. It seems peculiar, however, that few or none of the fragments yet observed are of the dark red sandy type. The corrosion of the fragments is also difficult to explain.

A typical feature of the Quartermaster dolomite is the local disturbance or buckling of the beds, more or less as a whole. It appears to be due to flowage previous to consolidation and corroborates other evidence pointing to disturbance and irregularity of sedimentation during early Quartermaster time. The buckling, however, is not sufficient to account for the marked brecciation of the bed and apparent wide displacement of fragments of the same layer.

Whatever may be the exact mode of origin of the breccia, it is quite certain that the fragments are not pieces of an earlier dolomite and it is equally obvious that they are not replaced fragments of Cloud Chief gypsum.

It may also be mentioned here that evidence of a rearrangement of dolomite under sub-aerial conditions is given by more or less colloform crusts of fibrous dolomite found in a dolomitic sandstone beneath the Quartermaster in one place. Certain irregular warped lenses of quite pure, massive, white dolomite associated with similar ones of calcite were found in sandstone west of Weatherford. It seems possible that these are diagenetic in origin also.

SUMMARY

The dolomites discussed in this section are those found at several horizons above the base of the Whitehorse sandstone, occurring in various parts of western Oklahoma from the Washita River in Washita County north and northwest to Clark County, Kansas. Being by far the hardest rocks found in the red beds, and prominently exposed on the whole, they were noticed by the earliest observers. However, until

95. Grabau, Amadeus W.,—Principles of stratigraphy, 1924.

recent years they have received no particular attention. More intensive study is showing that they are more complex than previously supposed and present very interesting problems concerning their correlation and stratigraphy.

OCCURRENCE OF DOLOMITES

The most prominent outcrops of dolomite occur in the northwestern part of the State capping the prominent escarpment of sandstone which faces northeast toward the Cimarron River, in Harper and northern Woodward counties.

Equally prominent exposures may be found in central Clark County, Kansas, which adjoins Harper County, Oklahoma, on the north. Other outcrops, more scattered and less prominent, may be found in central Woodward, northeastern Dewey, southern Blaine (the Red Hills), and in northeastern Custer counties. Very interesting occurrences are found south and southeast of the town of Weatherford in southeastern Custer County, eastern Washita County and a small adjoining part of Caddo County. Here the outcrops are found on a low escarpment, and outlying buttes, commonly of no marked relief.

STRATIGRAPHY

For many years the dolomites considered in this chapter were regarded as one formation, the Day Creek, first described by Cragin in 1896. It occurs typically in Clark County, Kansas, also in Harper and Woodward counties, Oklahoma, as a persistent ledge about 2 feet thick separating the Whitehorse from later formations.

In 1924, Gould pointed out that the dolomite of the Red Hills in Blaine County was not at the top of the Whitehorse, but, in fact, nearer its base. The two ledges which are found there may be called the upper and lower Greenfield dolomite respectively. They are about 110 to 130 feet above the base of the Whitehorse, and separated by about 25 feet of sandstone. The upper member is probably not over 6 inches thick, but the lower Greenfield has been reported from 16 inches to 3 feet thick.

In 1928, Noel Evans concluded that, in the Weatherford district, the so-called Day Creek is actually at two horizons. One dolomite, which he regarded as true Day Creek, is about 60 feet or less below the Cloud Chief in Whitehorse sandstone, and a second occurs very near the base of the Quartermaster sandstone, which is unconformable on lower formations. This view was corroborated by H. F. Schweer, who also pointed out that the Day Creek probably lenses out toward the east as the Quartermaster becomes more prominent.

However, it has never been suggested that Whitehorse sandstone occurs above the typical Day Creek of Clark, Harper and Woodward counties. That of the Weatherford district may be slighty different in age and origin.

The exact position and correlation of dolomite ledges found a few miles southwest of Canton between Blaine and Dewey counties, also near and south of Thomas in eastern Custer County as well as that of several occurrences in the Weatherford district is still more or less debatable.

DAY CREEK DOLOMITE

The typical Day Creek as exposed at the type locality in Clark County and in Harper and Woodward counties is a single ledge of dolomite about 2 feet thick. Commonly, several types may be found in any locality, ranging from massive, fine-grained, abnormally hard, white dolomite to fine- or medium-grained varieties, more or less indistinctly banded with pink or red. Diagenetic silicification is characteristic of the upper part of the ledge in many places. The silica is commonly accompanied by calcite, apparently formed by the same solutions. Calcite is also found in cavities, veinlets, and as very thin crusts between the dolomite grains, particularly in the more disintegrated specimens, which commonly contain innumerable small dendrites of manganese oxide.

The origin of the typical Day Creek is still a question. The relationship between certain calcitic parts of the member and the dolomite may furnish a clue. They undoubtedly represent either an undolomitized portion of an original limestone, or an extreme case of replacement by calcite. The writer has not obtained sufficient information to express an opinion. Calcitic portions of the member may be more common than formerly believed. It is necessary to remember that the calcite would be much more easily removed by weathering and in many places along the line of outcrop the ledge is thin or entirely lacking.

As observed in the Weatherford district the so-called Day Creek appears to occur below the top of the Whitehorse. It is variable in character and thickness within short distances.

There seems to be little doubt that the dolomite in this ledge has originated by replacement of a limestone. The large amount of calcite in the ledge as a whole, the remains of celestite crystals replaced by dolomite, and small nests of dolomite in limestone which appear to be centers of replacement, all point toward this origin.

Insufficient evidence makes it doubtful whether this is an argument for placing the Weatherford Day Creek at a different horizon from that of the typical dolomite, or for assuming that the typical dolomite has originated by replacement. The exact relationship of the two occurrences will prove most interesting, if it is possible to determine it.

THE GREENFIELD DOLOMITE

The Greenfield dolomites are hard, fine grained, white to pink, banded rocks. In themselves, they have not yet shown anything of exceptional interest unless it be their purity. Analyses of material known to contain no calcite are very desirable. Judging from the two analyses already published, they may prove to contain more magnesia than present in normal dolomite.

THE QUARTERMASTER DOLOMITE

This dolomite is remarkable for its unusual thickness in proportion to its areal extent, and for the evidence which it gives of extensive disturbance during its deposition, or not long after, particularly as shown by a remarkable sub-brecciated phase.

Typical exposures are commonly 6 feet or more thick, and Evans reports as much as 15 feet. The lower foot or so, in many places, is a thinly laminated, platy, pinkish dolomite, which appears to grade into shaly sandstone. The upper part is commonly dark-red, more or less massive, sandy dolomite, but is partly or wholly replaced by the brecciated phase in many places.

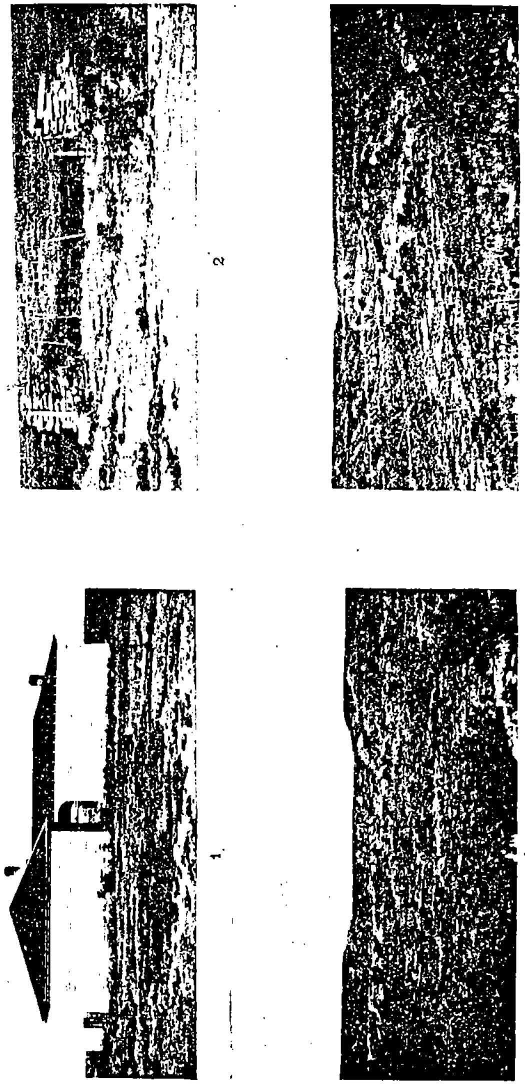
The brecciated dolomite consists typically of more or less pure, light-pink dolomite fragments, in a more sandy red dolomite matrix. They are occasionally well banded, and vary from definite tabular or blocky fragments a few inches long to thin, distorted, lenticular bodies. The parallel arrangement of these fragments is very noticeable. A type with a streaked or gnarled structure plainly shows flowage with minor brecciation in an imperfectly banded rock which must have been semi-plastic. A study of the fragments on polished surfaces shows conclusively that they are not part of an older dolomite. This interesting structure appears to have been formed by sub-aqueous flowage of the bed after or during deposition. The apparently great displacements of fragments of the same layer and their marked corrosion in certain cases are unusual features of this rock. Small local folds or buckles in the bed as a whole are found in many places, almost certainly developed before consolidation.

DOLOMITES OF UNCERTAIN CORRELATION

Several more or less isolated occurrences of dolomite are known. They present interesting problems of correlation and may throw light on the origin, variation, original extent and other problems of the more definitely placed dolomites.

Three beds and possibly four occur on an isolated butte in sec. 1, T. 17 N., R. 14 W., southwest of Canton. Two beds occur in the vicinity of Thomas separated by about 25 feet of sandstone. Dolomite is known to occur in at least two rather isolated localities between Clinton and Weatherford. Several outcrops of dolomite or dolomitic rock south of Weatherford need further study. There are doubtless many other inconspicuous and more or less isolated occurrences which will add much to our knowledge of these interesting and important rocks.

BULL. 49 PL. II



OKLAHOMA GEOLOGICAL SURVEY

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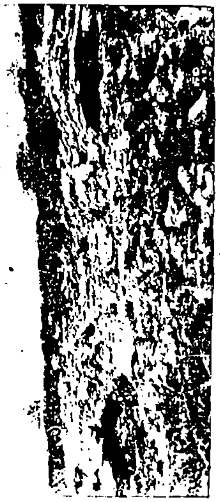
OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PL. III

1



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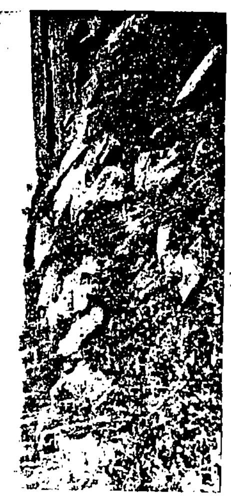

3

4

EXPLANATION OF PLATE III

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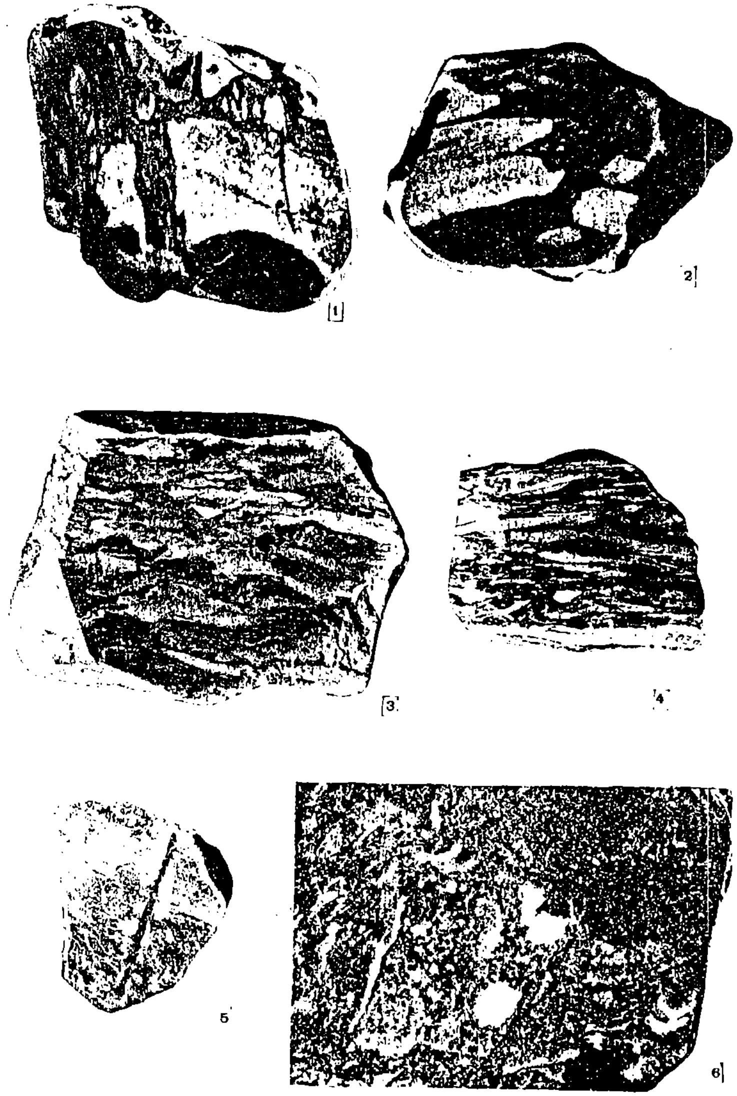
OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE IV



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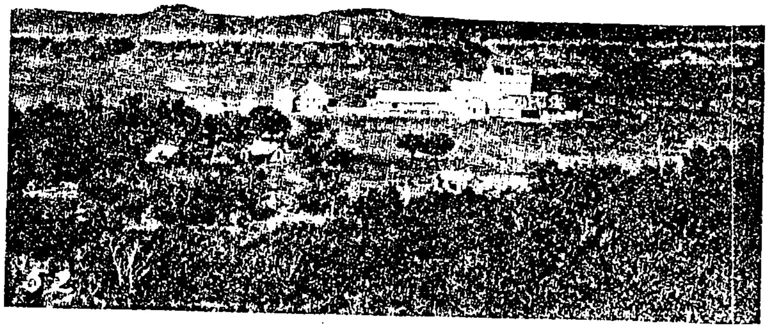

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Caddo County Buttes, typically capped by the Quartermaster dolomite. Sec. 36, T. 12 N., R. 13 W. 117

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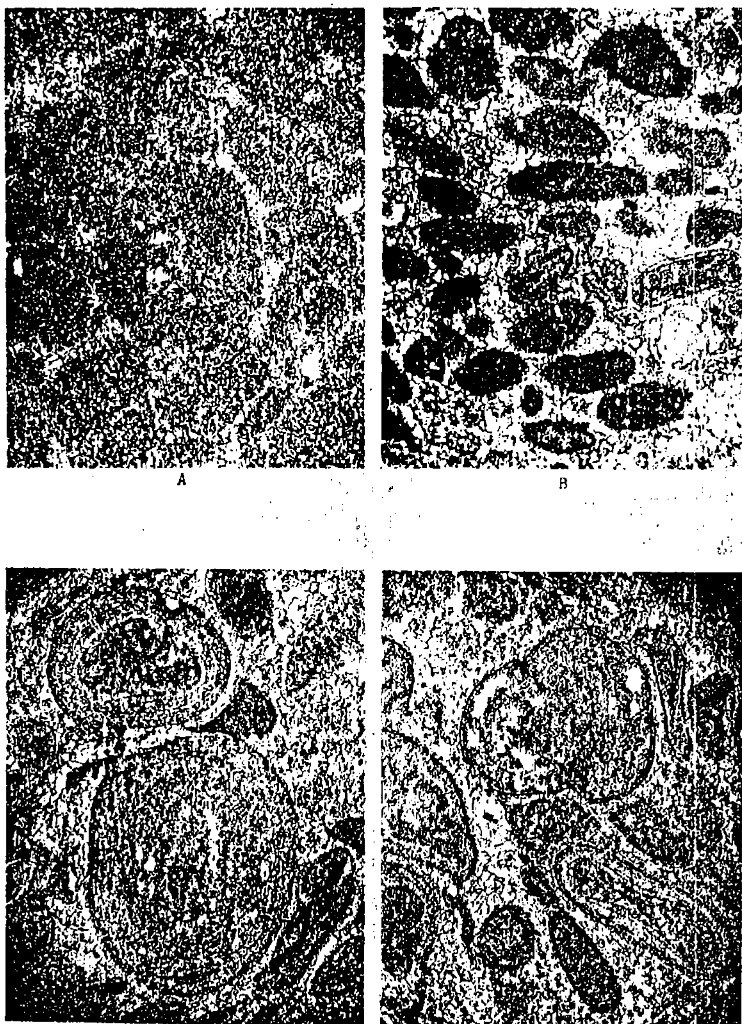

A B C D

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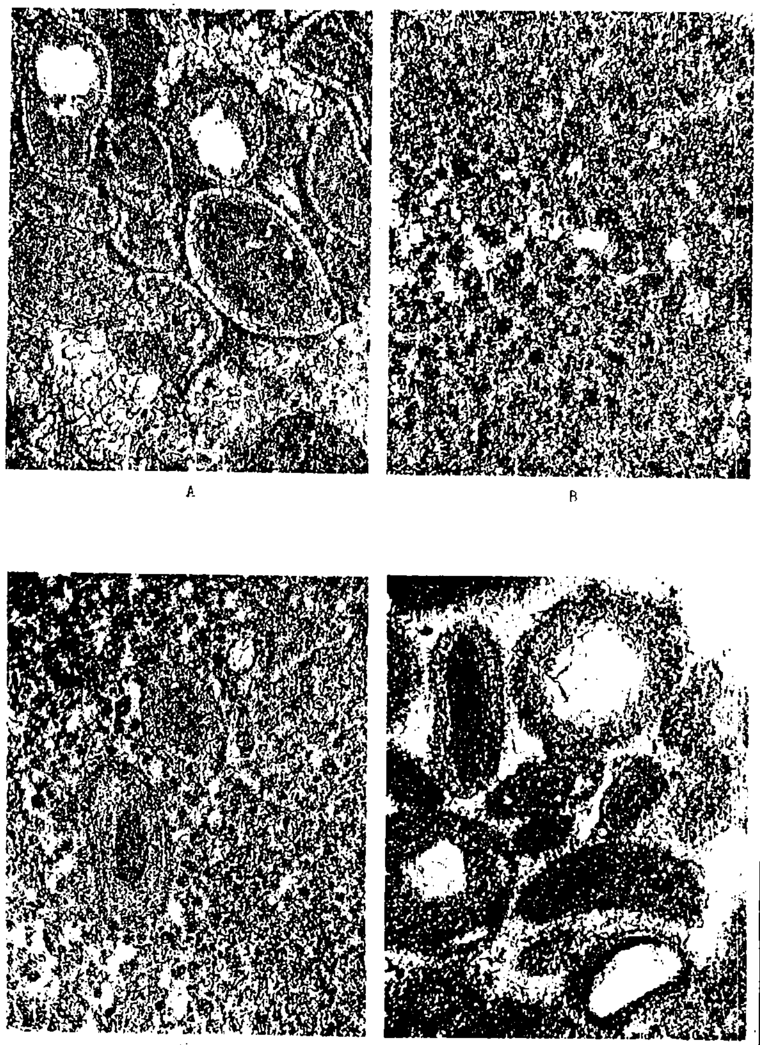

A B D

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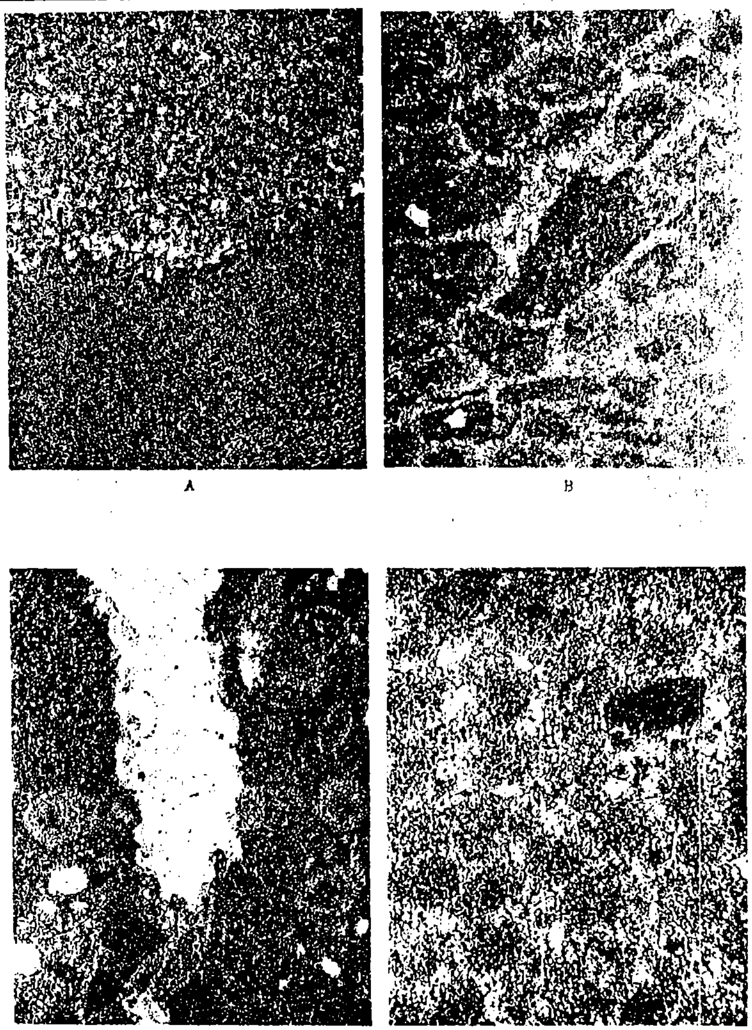
OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE IX



A B C D

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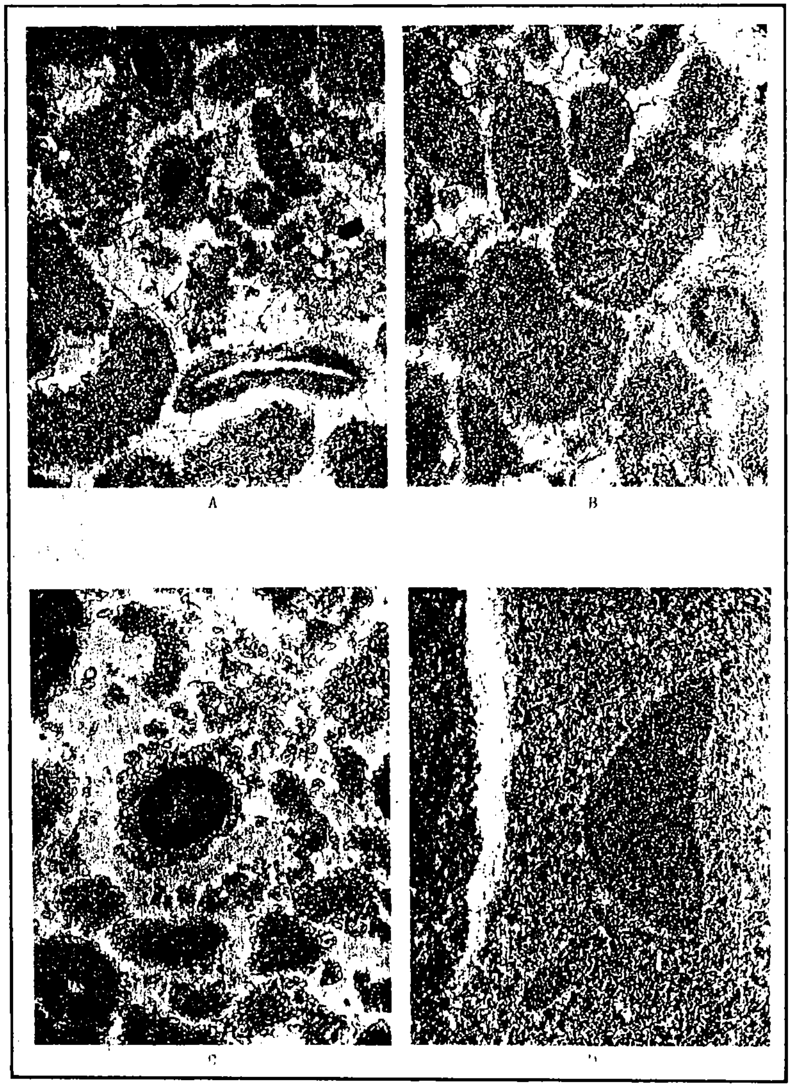
Figure D. "Sub-oolitic" texture in Mangum dolomite. There is no quartz or calcite in this section. x 62. 61

OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE X



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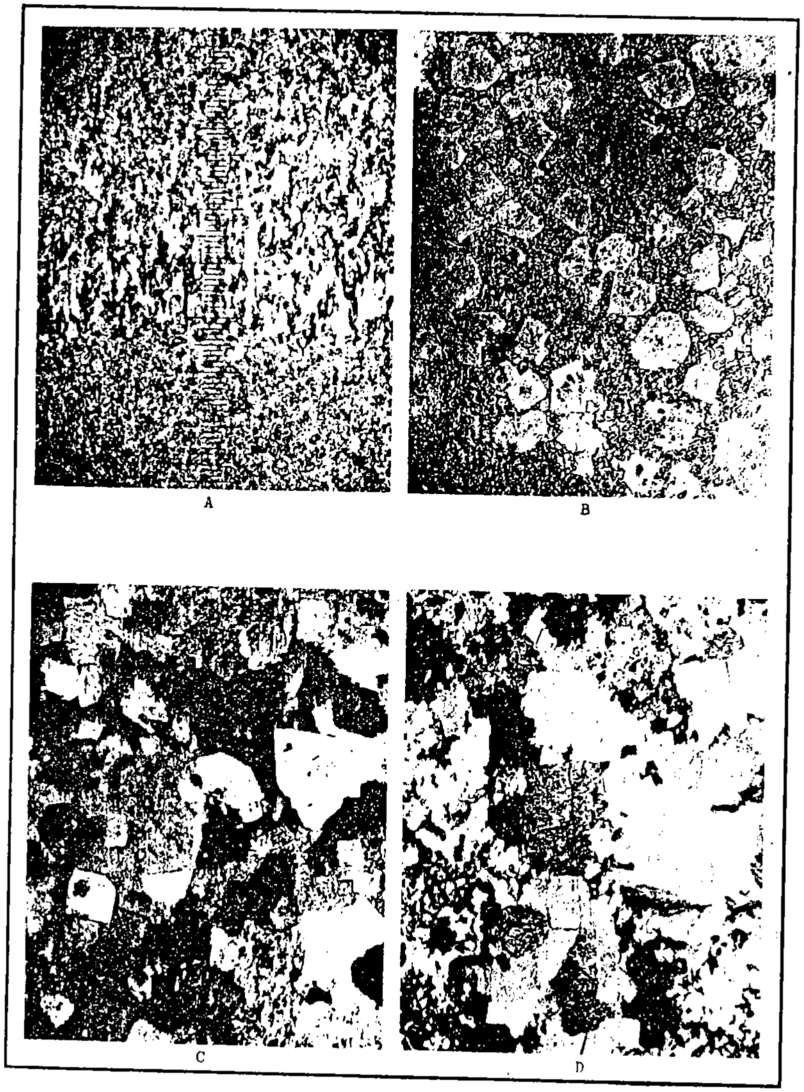
OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE XI



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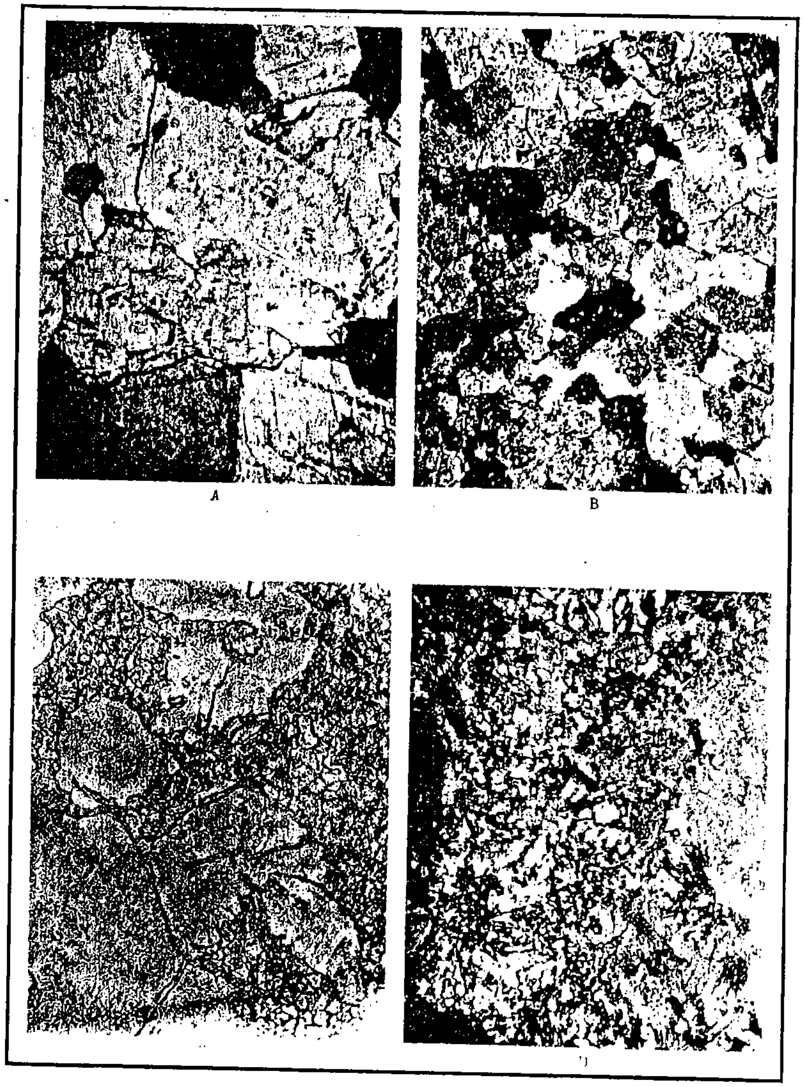
OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE XII



EXPLANATION OF PLATE XII

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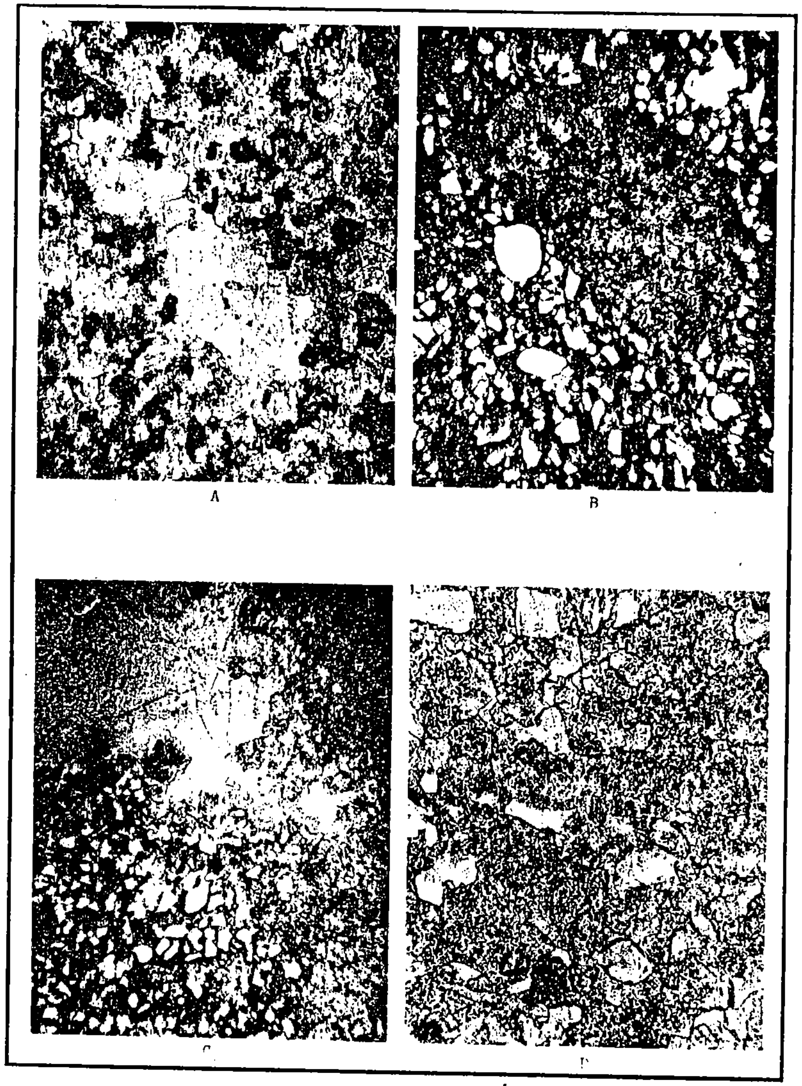
OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE XIII



EXPLANATION OF PLATE XIII

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Figure A. Euhedral crystal of dolomite in a ground-mass of smaller anhedral grains, Dewey County. This is doubtless due to recrystallization. Crossed nicols, x 62. 96

Figure B. Dolomitic, red sandstone with fragment of dolomite without sand. Dewey County, x 20. 97

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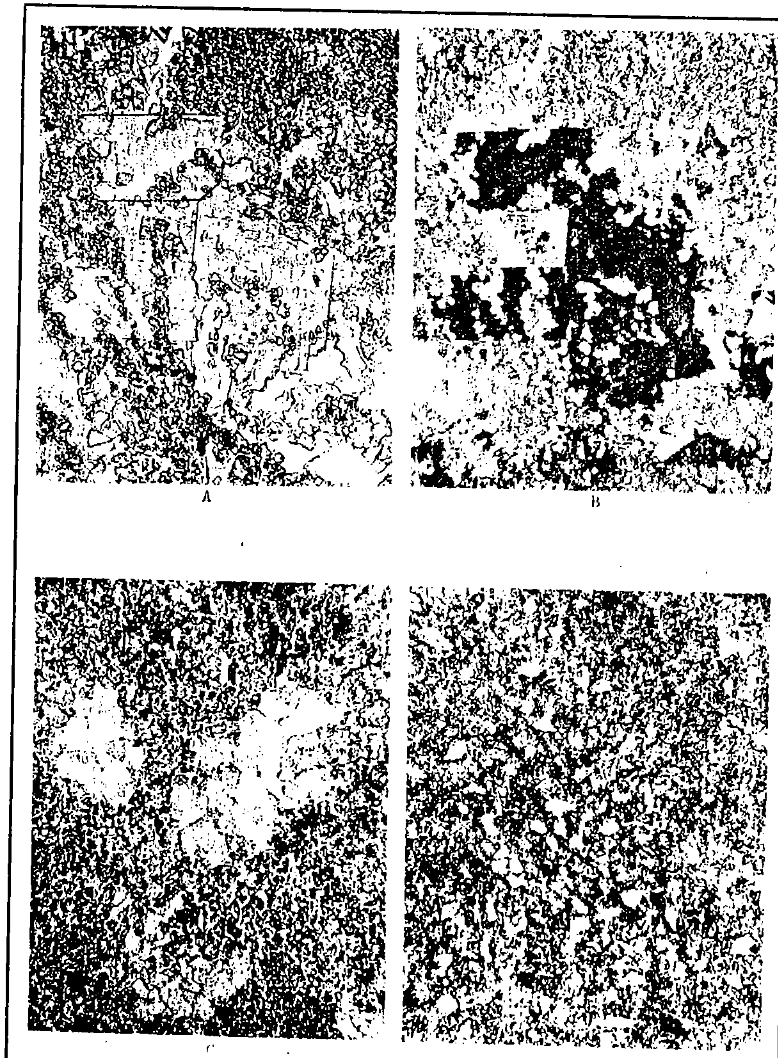
Figure D. Lower Greenfield dolomite with angular quartz sand grains, x 52. 103

OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE XIV



A B C

EXPLANATION OF PLATE XIV

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Figure A. Day Creek south of Weatherford showing crystals of celestite partly replaced by dolomite. Note the rectangular cleavage and apparent twinning of the celestite, x 49. 112

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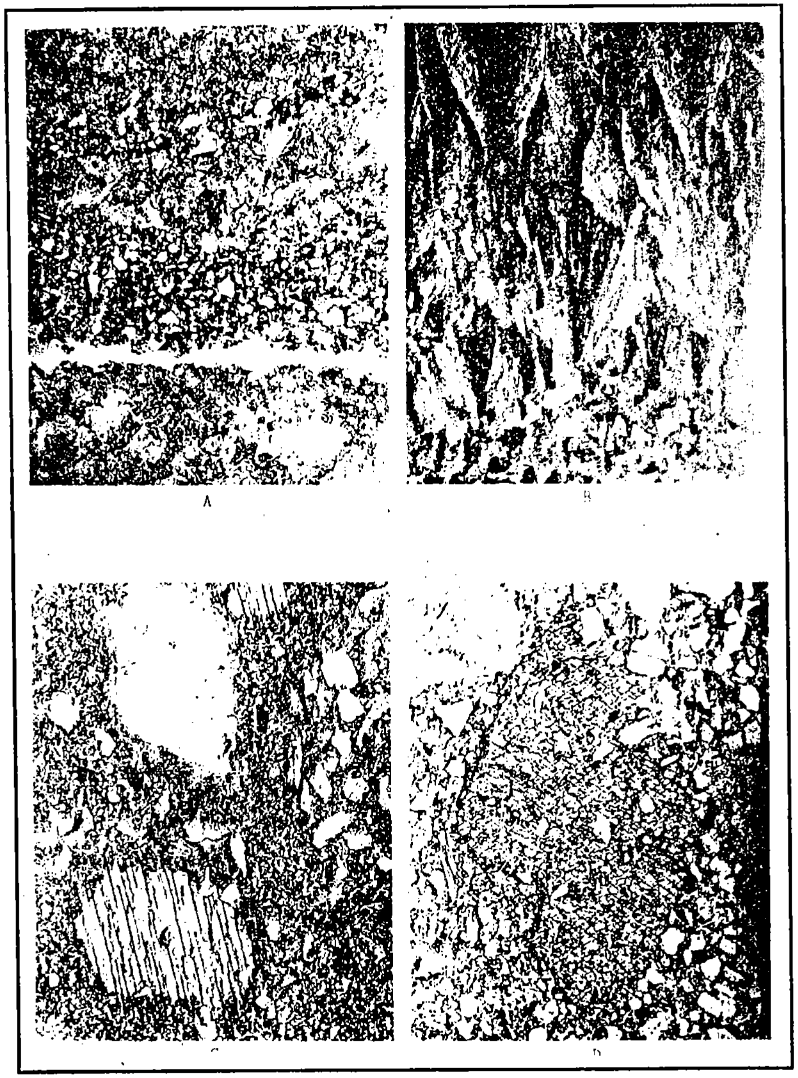
Figure C. Nests of clear dolomite in calcitic rock, with reticular dolomite between the calcite grains of the groundmass. Supposed Day Creek southeast of Cloud Chief, x 49. 121

Figure D. Quartermaster dolomite from laminated block containing supposed brachiopods. x 62. 115

OKLAHOMA GEOLOGICAL SURVEY BULL. 49 PLATE XV



EXPLANATION OF PLATE XV

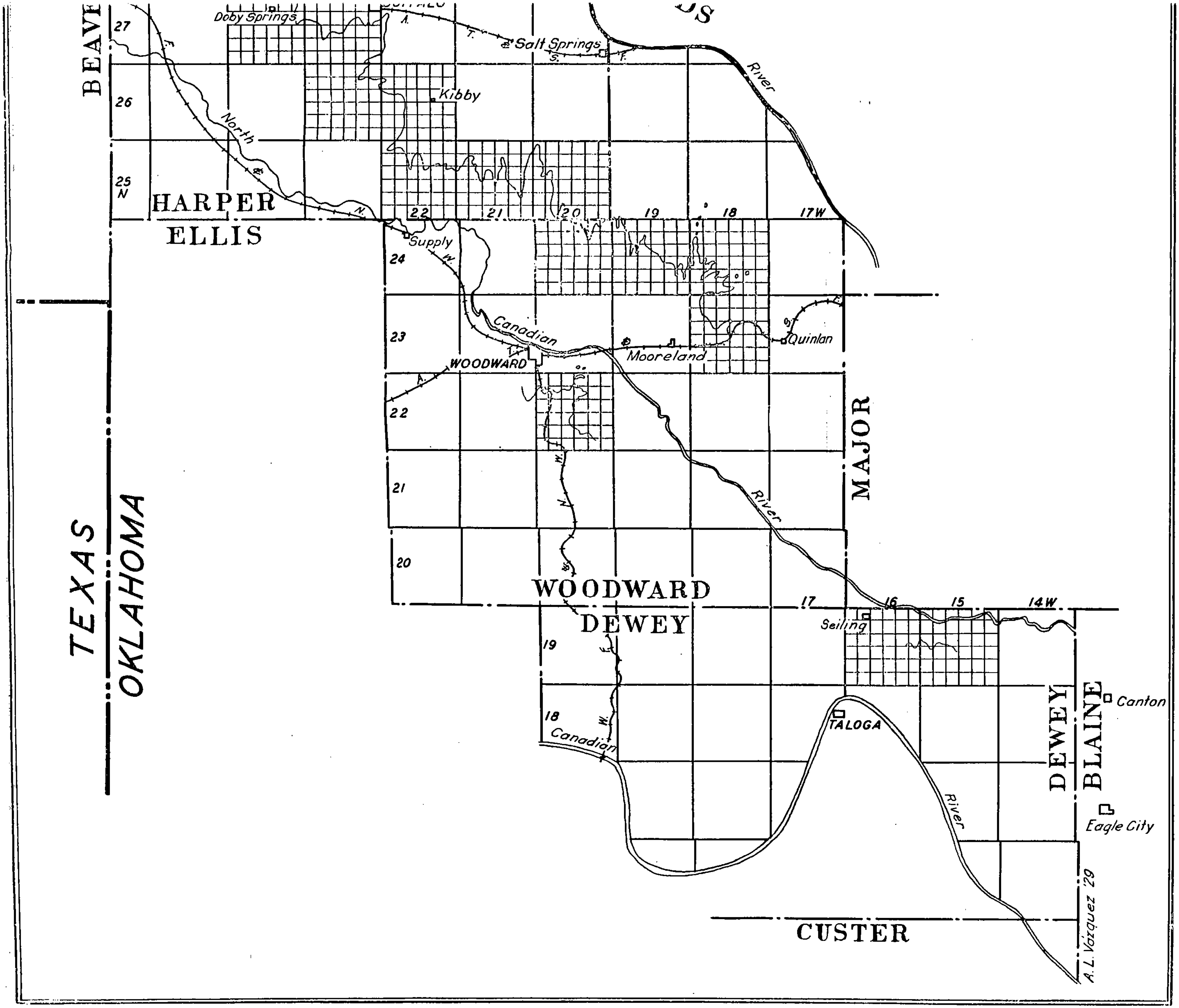
Page

Figure A. Red dolomitic sandstone band in gray dolomite. Specimen taken from the sub-brecciated phase of the Quartermaster. Note the piece of white dolomite included in the sandstone. Such sandy bands appear to occur as original laminae in the fragments, but the majority are part of the massive matrix, x 46. 118

Figure B. Gray colloform or sub-colloform dolomite as a crust on red dolomitic sandstone. Weatherford district. Crossed nicols. x 46. 120

Figure C. Dolomite crystals in dolomitic sandstone. Weatherford district. Note the comparative lack of sand grains in the crystals, the recrystallized rims around each and the prominent cleavage still retained in them. x 52. 120

Figure D. Dolomite crystal in dolomitic sandstone showing comparatively few sand grains. Weatherford district. x 46. 122



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ELLIS
Doby Springs
Salt Springs
Kibby
North
River
Supply
Canadian
WOODWARD
Mooreland
Quinlan
MAJOR
TEXAS
OKLAHOMA
WOODWARD
DEWEY
Seiling
TALOGA
Canadian
River
DEWEY
BLAINE
Canton
Eagle City
CUSTER
A. L. Vazquez '29
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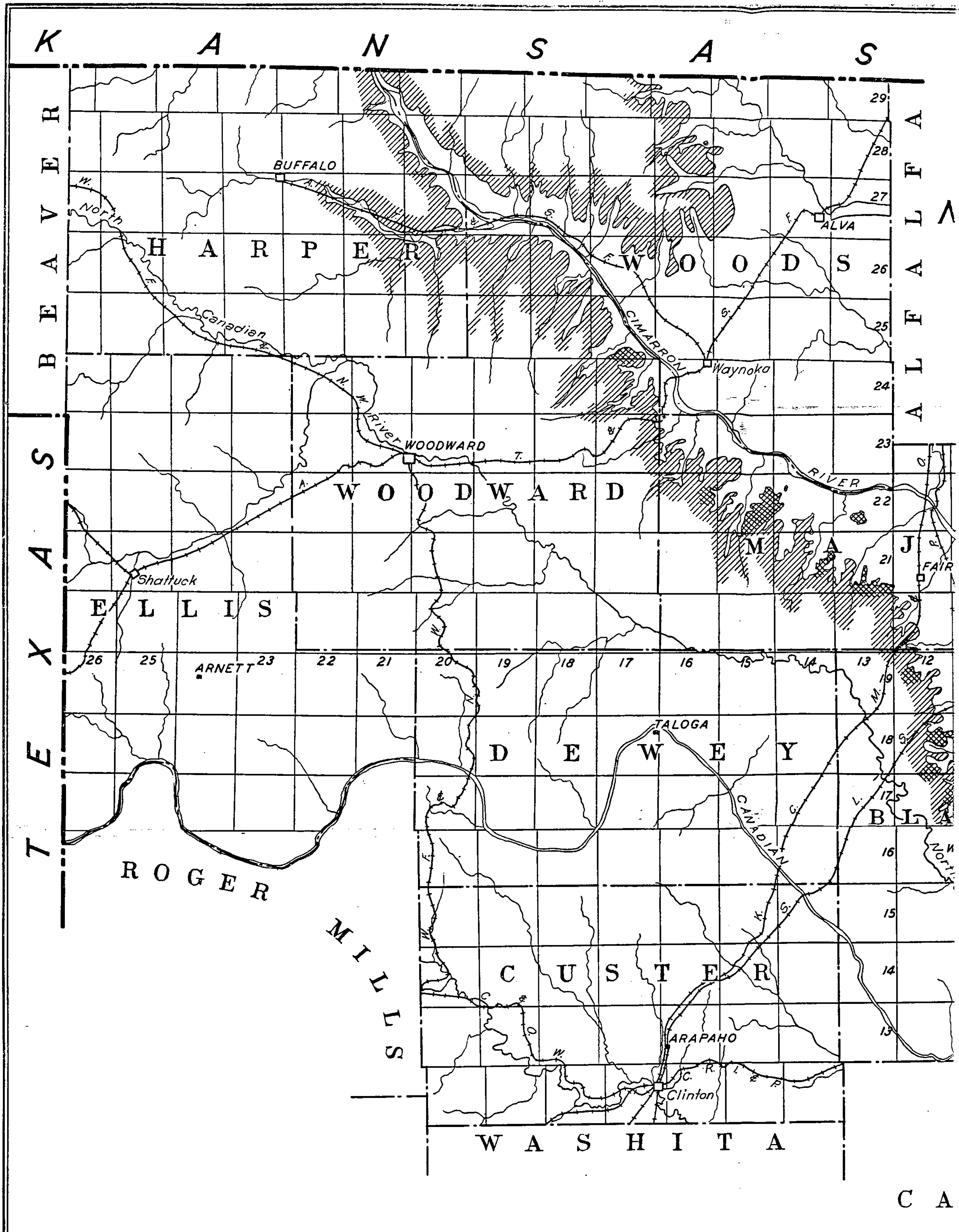
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BEAVER
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ELLIS
DEWEY
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CUSTER
WASHITA
BLA
CA
BUFFALO
ALVA
Waynoka
WOODWARD
Shattuck
ARNETT
TALOGA
ARAPAHO
Clinton
FAIR
North Canadian River
CIMARRON RIVER
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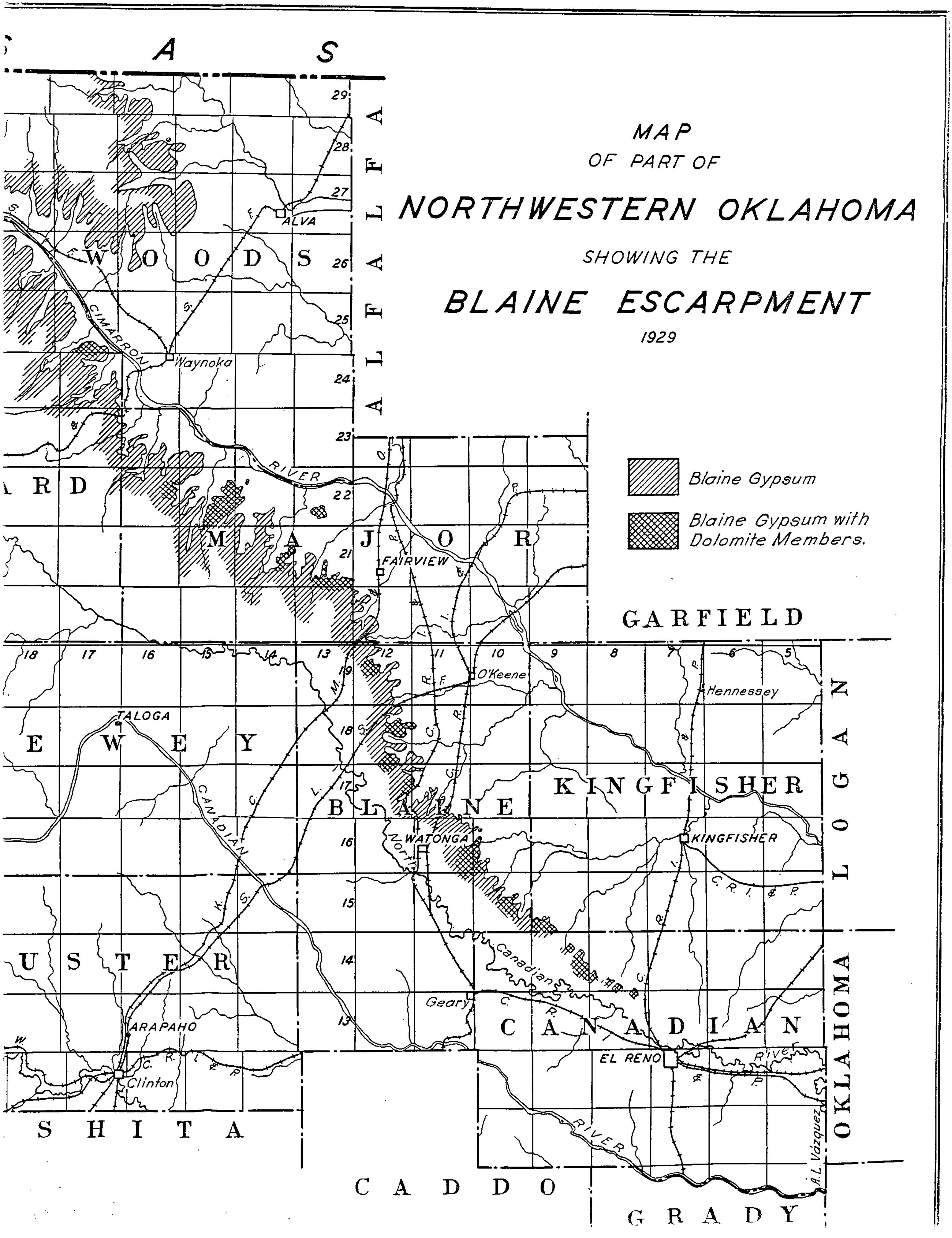
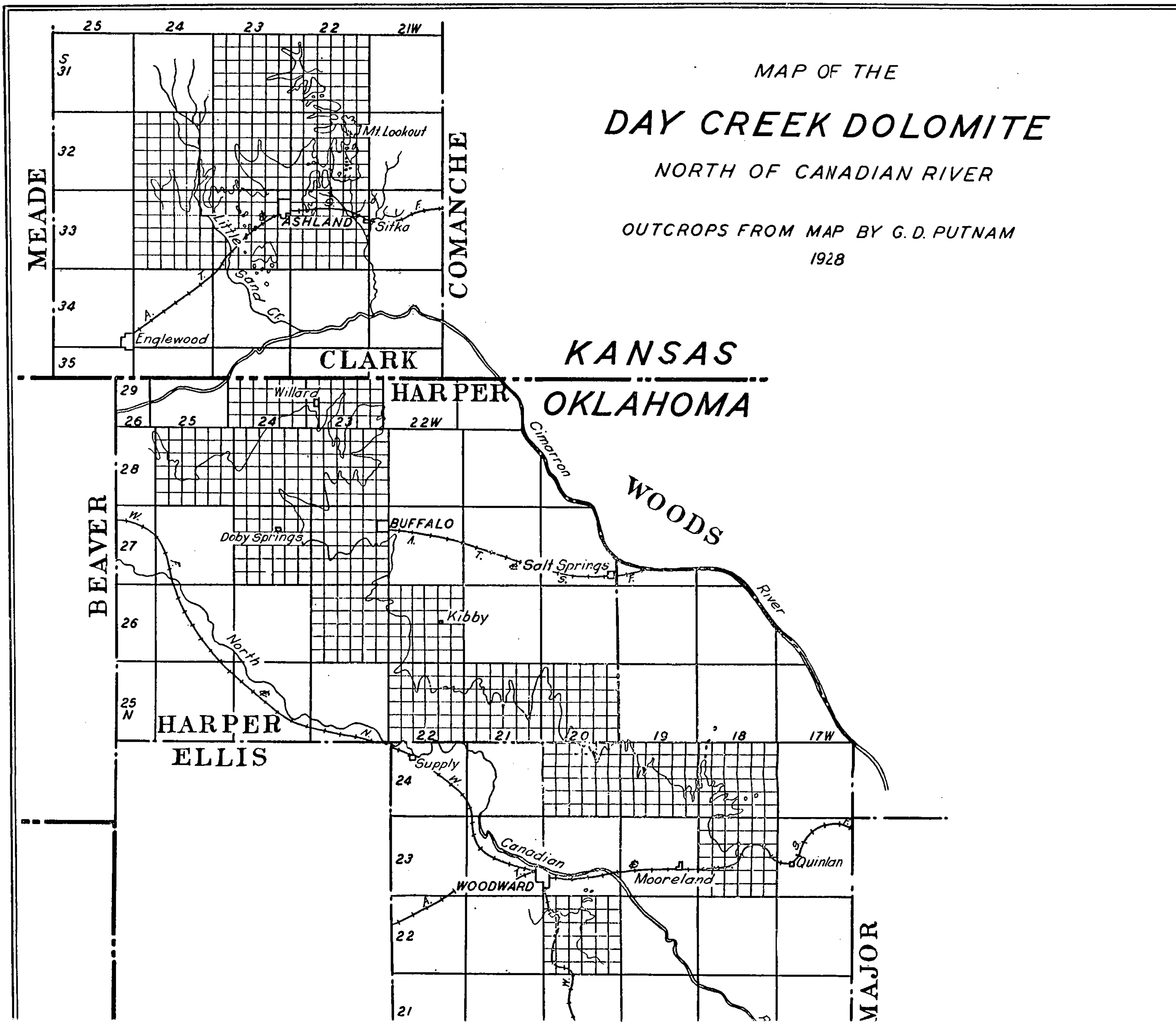


MAP
OF PART OF
NORTHWESTERN OKLAHOMA
SHOWING THE
BLAINE ESCARPMENT
1929
Blaine Gypsum
Blaine Gypsum with Dolomite Members.
W O O D S
A L F A L F A
M A J O R
GARFIELD
B L A I N E
K I N G F I S H E R
L O G A N
C A N A D I A N
OKLAHOMA
C A D D O
G R A D Y
S H I T A
U S T E R
E W E Y
A R D
A S
ALVA
Waynoka
FAIRVIEW
O'Keene
Hennessey
TALOGA
WATONGA
KINGFISHER
Geary
EL RENO
ARAPAHO
Clinton
CIMARRON
RIVER
CANADIAN
Canadian
North
River
C.R.I.&P.
A.L. Vázquez


MAP OF THE
DAY CREEK DOLOMITE
NORTH OF CANADIAN RIVER
OUTCROPS FROM MAP BY G. D. PUTNAM
1928
KANSAS
OKLAHOMA
MEADE
CLARK
COMANCHE
HARPER
WOODS
BEAVER
HARPER
ELLIS
MAJOR
Mt. Lookout
ASHLAND
Sitka
Englewood
Little Sand Cr.
Willard
BUFFALO
Doby Springs
Salt Springs
Kibby
Cimarron
River
North
Supply
Canadian
WOODWARD
Mooreland
Quinlan
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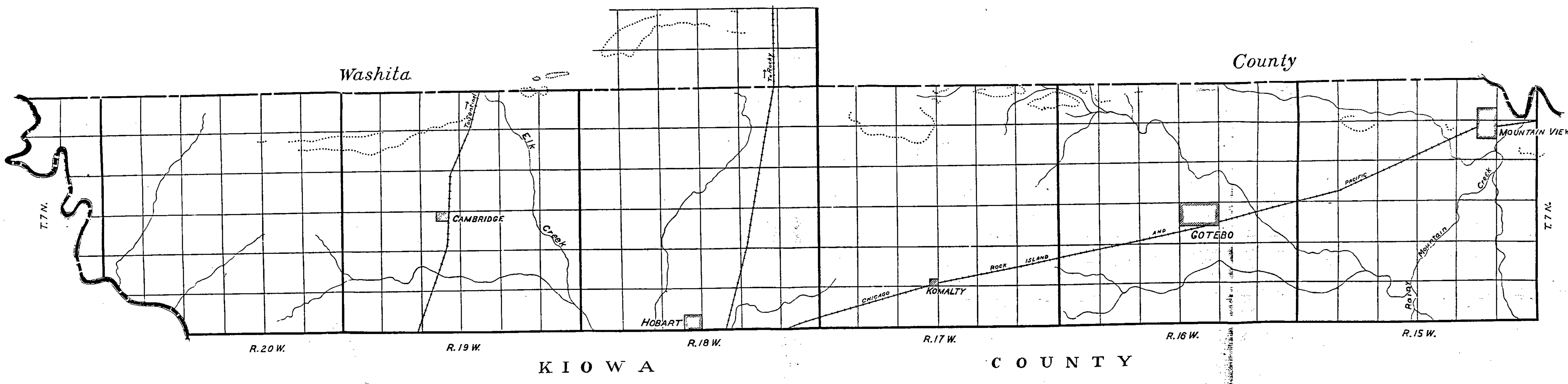
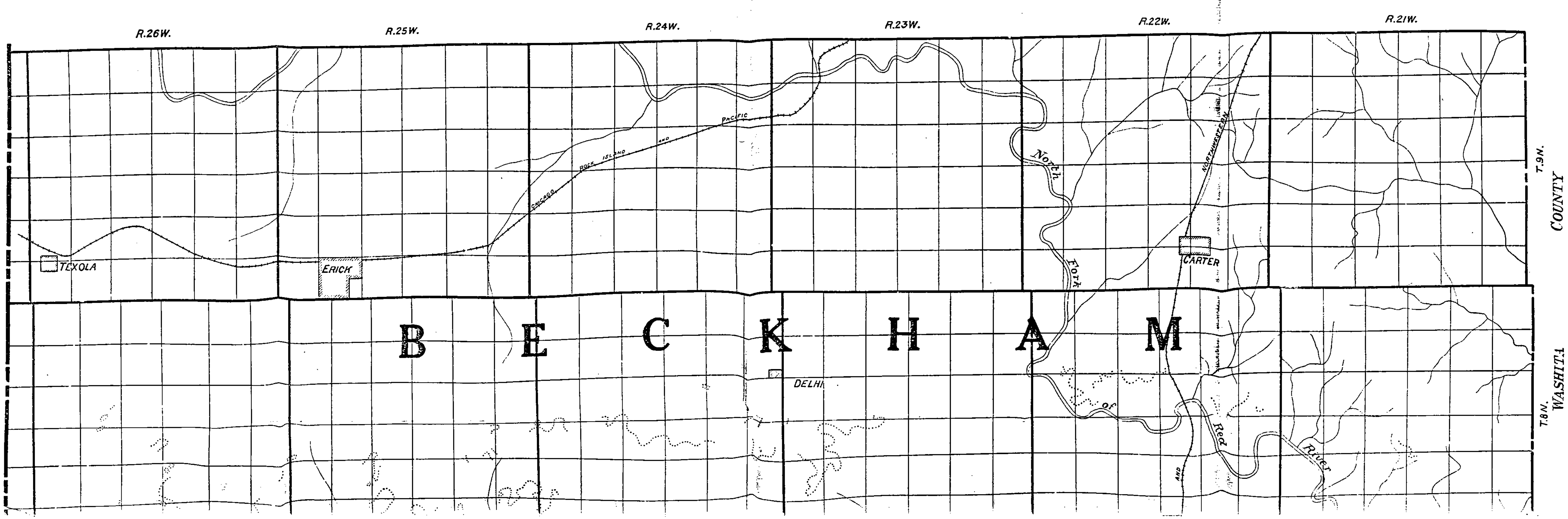
DOLOMITE MEMBERS
OF THE
BLAINE FORMATION
Mangum Dolomite
Creta Dolomite
Jester Dolomite
JACKSON
TEXAS
DUKE
VICTORY
OLUSTEE
CRETA
ELDORADO
T.3N.
T.2N.
T.1N.
T.1S.
R.25W.
R.24W.
R.23W.
R.22W.
R.21W.
Red
River
Turkey
Creek
Branch
Creek
Gypsum
Creek
Creek


Washita
County
KIOWA COUNTY
T.7N.
T.7N.
R.20 W.
R.19 W.
R.18 W.
R.17 W.
R.16 W.
R.15 W.
CAMBRIDGE
HOBART
KOMALTY
GOTEBO
MOUNTAIN VIEW
Elk Creek
Rainy Mountain Creek
CHICAGO ROCK ISLAND AND PACIFIC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R.24W.
R.23W.
R.22W.
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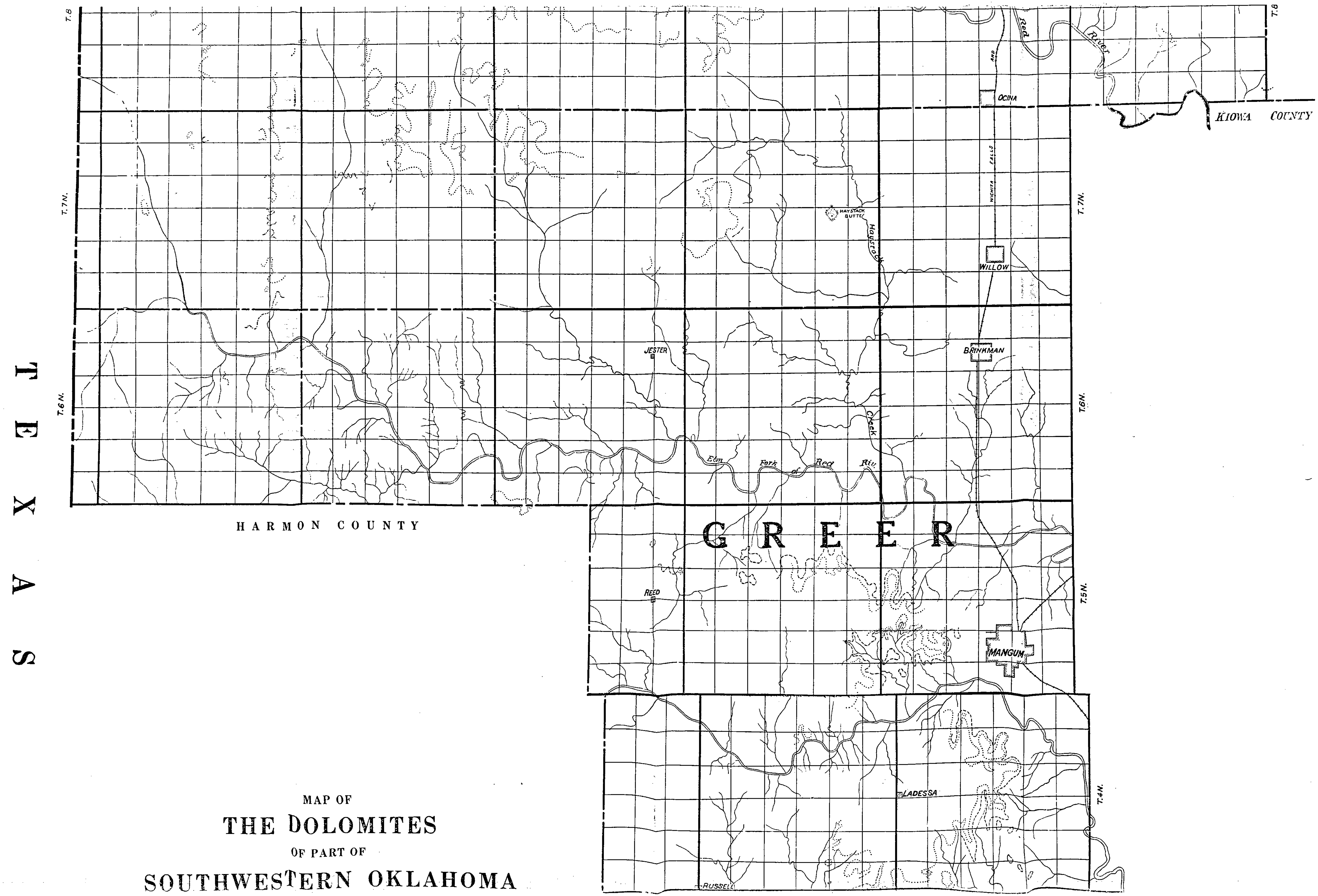
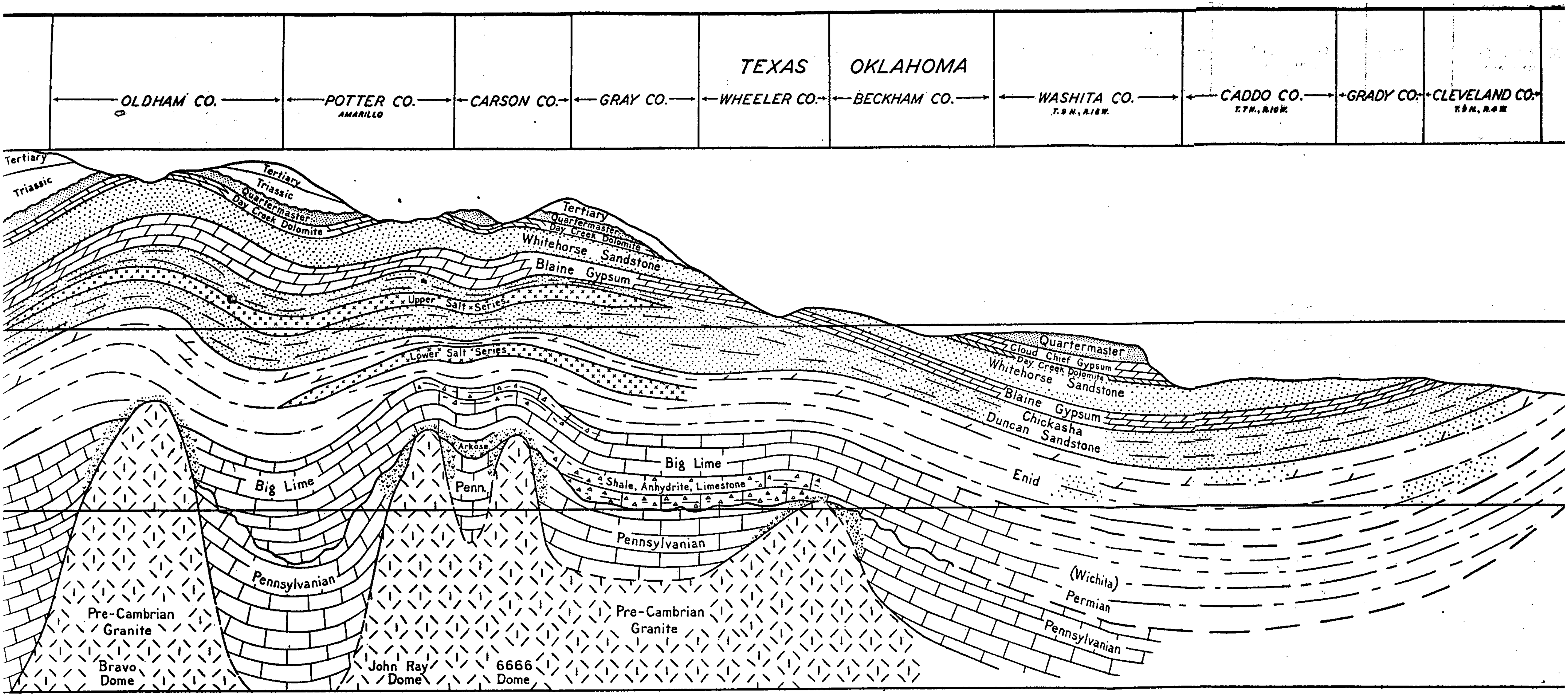
T.9N.
T.9N.
T.8N.
T.8N.
TEXOLA
ERICK
CARTER
DELHI
CHICAGO ROCK ISLAND AND PACIFIC
North Fork of Red River
NORTHWESTERN
BECKHAM
WASHITA COUNTY



MAP OF
THE DOLOMITES
OF PART OF
SOUTHWESTERN OKLAHOMA



GENERALIZED EAST-WEST CROSS-SECTION THROUGH ANADARKO BASIN
FROM
CLEVELAND CO., OKLAHOMA THROUGH AMARILLO, TEXAS
TO
OLDHAM CO., TEXAS
TEXAS PANHANDLE SECTION AFTER C. DON HUGHES

OKLAHOMA GEOLOGICAL SURVEY
CHAS. N. GOULD, DIRECTOR
NORMAN, OKLA.