1816

University of Texas Bulletin

No. 1816: March 15, 1918

THE GEOLOGY OF RUNNELS COUNTY

By

J. W. Beede and V. V. Waite

BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY
DIVISION OF ECONOMIC GEOLOGY
J. A. Udden, Director of the Bureau and Head of the Division

Published by the University six times a month and entered as second-class matter at the postoffice at AUSTIN, TEXAS

Publications of the University of Texas

num-
ar of
r ex-
These
ations
y the
icipa
duca-
any
All
e ad-
Uni-

B321-1112-1816-4M

University of Texas Bulletin

No. 1816: March 15, 1918

THE GEOLOGY OF RUNNELS COUNTY

By

J. W. Beede and V. V. Waite

BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY
DIVISION OF ECONOMIC GEOLOGY
J. A. Udden, Director of the Bureau and Head of the Division

Published by the University six times a month and entered as second-class matter at the postoffice at AUSTIN, TEXAS

The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

GEOLOGICAL MAP OF RUNNELS COUNTY

BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY, J.A. UDDEN, DIRECTOR, J.W. BEEDE, GEOLOGIST, V.V. WAITE, ASSISTANT.
BOUNDARIES OF GRAPE CREEK, TALPA, AND PAINT ROCK FORMATIONS MODIFIED FROM DRAKE. MOST OF OTHER MAPPING BY WAITE.
AUSTIN, 1918.

Plate I

THE GEOLOGY OF RUNNELS COUNTY

By J. W. Beede and V. V. Waite

INTRODUCTION

Runnels County is situated near the center of the State of Texas, in what is usually referred to as "West Texas." The rocks of the county belong to the Lower Permian division of the Paleozoic Group, the Comanchean System of the Mesozoic Group, and the Tertiary (?) and Pleistocene divisions of the Cenozoic Group. The geology of this county was done in connection with the making of a section of the Permian rocks along the Colorado River. The areal work was largely done by Mr. Waite, who also assisted in making certain parts of the section.

GEOGRAPHY AND PHYSIOGRAPHY

The Colorado River flows south of east across the southern third of the county, passing out at the southeast corner, at the mouth of the Concho River. The main tributaries from the north are Mustang, Elm, Valley, and Oak creeks. The main tributaries from the south, above the mouth of the Concho River, are Pony, Redbank, and Mule creeks.

The southwestern corner of the county drains into the Concho River. The Little Concho rises just southwest of Rowena and flows southeast, and Willow Creek flows across the southwest corner of the county past Miles. Fuzzy Creek rises close to Pony Creek and flows into the Concho.

In general, the bottom lands of the Colorado River are relatively narrow, and steep bluffs occur at most of the larger bends. In the western part of the county the rocks are less resistant and the bottoms are wider, and steep bluffs are less common. The river runs on bed rock through this county, as do many of the creeks.

From fifty to a hundred feet above the large stream beds are wide terraces usually with a layer of silt on top and a coarse conglomerate ("concrete") beneath it. Where not cleared it is

usually mesquite land. The high land back of these terraces, which are sometimes a mile wide, is frequently covered with gravels of still greater age. North of the Colorado River in the region west of the main stream of Elm Creek, the lower conglomerate covers a very large area, and in some localities furnishes excellent water sufficient for domestic purposes. Its limits are rather indistinct. It may grade into the upper gravels near the divide between Elm Creek and Valley Creek.

On the whole, the region north of the Colorado River is more rugged and has greater relief than the region south of it. Some of the roughest parts of the county are found in the northwest part within the drainage basin of Oak Creek. Church Peak and another peak just to the west of it, rise in the northwest corner of the county and extend northwestwardly into Nolan County. These peaks have a maximum elevation of 2,450 feet, but only 2,300 feet within the county. In the northeast part of the county, Moro and Table mountains reach an elevation of 2,300 feet. These mountains are a part of the Callahan Divide which is formed by the remnants of what was once a continuous layer of Cretaceous marine deposits over the whole of this region. Hill states the history of this part of the region as follows:

"Collectively the summits, escarpments, and plateaus thus composed of the horizontal Edwards limestone represent a wide topographic level which once extended over nearly the entire Coastward Slope, from the mountain front to the eastern edge of the Grand Prairie and the Balcones Fault scarp line. This was a plain . . . . and occupied nearly a hundred thousand square miles of the Texas region."*

HISTORY

In 1890, Professor W. F. Cummins and Dr. Otto Lerch† published a brief review of the tier of counties west of Runnels County extending south past Tom Green County, with a geologic map showing the Permian, Cretaceous, and more recent forma-

*Physical Geography of the Texas Region. U. S. Geol. Surv., Topographic Atlas, Folio No. 3, 1900.

†A Geological Survey of the Concho Country, State of Texas. Amer. Geol., V, pp. 321-325, map, 1890.

tions. This discussion does not cover any of the area of Runnels County, but does mention in a general way the rocks found in the western part of the county.

Dr. Lerch goes into more detail in a later paper, and discusses the geology of the same region, in 1891.* He describes the gypsums in the San Angelo section, and names a thick sandstone and conglomerate the "San Angelo beds." The San Angelo beds are the equivalent of the Blowout Mountain sandstone of Wrather**, named from its occurrence near the Texas and Pacific Railway. Dr. Lerch describes the San Angelo section and the conglomerate beds as follows:

"Near the top of the Permian exposed at Ben Ficklin on the bank of the Middle Concho River lies a deposit of argillaceous magnesian limestone of a yellowish color, containing a number of well preserved fossils enumerated in the formerly mentioned article*** which leave no doubt that the strata below are of Permian origin.

"Above this fossiliferous limestone rests a quartz conglomerate about twelve feet thick. The pebbles are well water-worn, of small size and bound with a siliceous irony cement. The conglomerate is stratified, dips toward the northwest, under a steeper angle, however, than the underlying deposits, and is occasionally interspersed with large blocks of green and red speckled quartzite. The conglomerate is very hard, takes an excellent polish and is of a yellowish red color. Above it lies a series of red and yellow colored clays and sandstones about one hundred feet thick, overlaid by lighter buff and whitish-colored, thin beds of loose, friable sandstone and clays about fifty feet thick, followed unconformably by the Trinity sands. . . . . I have traced this conglomerate for nearly twenty miles toward the north and its stratigraphic position with the beds above, below the Trinity

*Remarks on the Geology of the Concho Country, State of Texas. Amer. Geol., VII, pp. 73-77, 1891.

**Bull. Southwestern Assn. Pet. Geol., 1917, p. 98.

***Goniatites baylorensis White.
Medlicottia copei White.
Orthoceras rushensis McChes.
Nautilus winslowi M. & W.
Aviculopecten ———?
Murchisonia ———?
Euomphalus subquadratus M. & W.
Bellerophon Crassus M. & W.
Pleurophorous ———?
Myalina permiana Swall.
Productus ———?
Fenestella ———?

sands . . . . and propose for them the name San Angelo beds."

Twenty miles northward from San Angelo would practically connect this conglomerate with the Tennyson-Cedar Mountain outcrop of the Blowout Mountain sandstone. The description of the conglomerate and sandstone is apt, and the term San Angelo will replace Blowout Mountain as the name of this formation. The mass of this conglomerate seen by Lerch near Ben Ficklin was in all probability a detached mass which had settled from a considerably higher altitude. However, the beds which he traced north were certainly the beds here referred to the Blowout Mountain sandstone, which were correlated by Mr. Riney, and which were traced with him to the Taylor County line. The conglomerate phase of the stone disappears in the northeast.

Aside from the work of Drake, Hill and Lerch, little detailed work on the rocks of Runnels County has been published. Hill gives a brief resume of the geology of the region in a general way, with a bibliography of the more important references.*

The names of a number of prominent geologists are among the list of those who have studied the geology of the region around Runnels County. The following names are now at hand, but the list is probably incomplete: Shumard, Roemer, Stolley, Hill, Boll, Cummins, C. A. White, I. C. White, Dumble, Drake, Cope, Hyatt, Tarr, Taff, Marcou, D. White, and others.

It is impossible to review the work of these men in this brief sketch of the geology of the county, and such a review is reserved for the description of the Permian rocks of the Colorado River section, as a whole. The part of Drake's work which deals with the geology of Runnels County has been freely used, as have his boundaries of the Bead Mountain, Grape Creek, Talpa, and Paintrock beds, in making the map; except for a few minor modifications along the river.**

---

*Hill, R. T., Geography and Geology of the Black and Grand Prairies, U. S. Geol. Surv., 21st Ann. Rep., Pt. VII, pp. 99-103; 1901.

**Drake, N. F., Report on the Colorado Coal Field of Texas Geol. Surv. Tex., 4th Ann. Rep., pp. 357-446; 1893.

STRATIGRAPHY

The oldest rocks of the geologic section in Runnels County are of Permian age and belong to the Wichita stage of Cummins, which is now regarded as the oldest of the Permian rocks in central and northern Texas. The oldest beds exposed in the county are the Bead Mountain Beds of Drake. Resting on these beds, as one passes up the river, are the Grape Creek, Talpa, Paintrock, Lueders, and Arroyo formations, which are tentatively referred to the Wichita stage.

Above these formations come those now referred to the Clear Fork stage. These consist of the Vale and Choza formations. Above this comes an undetermined thickness of red shales and thin, platy streaks of dolomite, provisionally referred to the Double Mountain stage described by Cummins and Dumble.*

Upon the Permian rest the Comanchean rocks in eastern Runnels County and the San Angelo conglomerate in the western part, which is in turn overlain by the Comanchean rocks.

THE PERMIAN

SECTIONS ALONG THE COLORADO RIVER

The best geologic sections of the Permian rocks in Runnels County are to be found in the bluffs of the Colorado River. The sections of these bluffs were measured and fossils collected from the different beds. These sections are usually sufficiently close together for some of the beds of one section to extend into the next section. In measuring the sections an effort was made to so correlate them that a continuous section of all the beds could be constructed. In those sections which are given below, the strata are numbered from bottom to top in the order of stratigraphic succession. The strata dip upstream and the sections begin with the lowest beds exposed in the southeast corner of the county and follow in regular order upstream. It will be

*Cummins, W. F., 2nd Ann. Rep., Geol. Surv. Tex., pp. 401-402. 1891.

noted that two sets of numbers are used, in numbering the beds of the sections. Those on the right indicate the serial number of the beds in the individual section. Those on the left give the number of the bed or beds in the general section and correspond with the numbers given in the plate showing the general section. Thus any bed shown in the general section can be located specifically in the detailed section from which it was taken, and its description found. In the first section only the general numbers are used.

The Wichita Stage

Section of Bluff at the East Side of Coffey Flat, Brazoria School Land Survey No. 226, in southwestern Coleman County

		Feet	Inches
37	Concealed. Apparently marls and irresistant limestones	15	+
36	Limestone, tending to weather shaly, composed of "Syringopora"		8
35	Shaly material, largely "Syringopora" colonies which weather down into single tubes, or clusters of them. One colony about half exposed measured 15 feet in diameter. Deltopecten, Eumicrotus	3	
34	Limestone, strong bed of "Syringopora," gray, frequently marked with long iron streaks	1	
33	Limestone, nodular	2	+
32	Limestone, persistent, flesh-gray, weathers rather smooth, some "Syringopora" colonies. Rock is composed of crushed worm tubes	1	+
31	Interval. Limestone four inches thick near base, blue, semi-lithographic, weathers into large "blue biscuits," persistent, followed by marls and large colonies of "Syringoporas." Platy limestone near the top	5	
30	Limestone, massive, weathers into rounded blocks. Composed of small thin shells and micro fauna. "Bellerophon," "Orthoceras"	2	
29	Marl, buff, platy	1	

		Feet	Inches
28	Limestone, hard, brittle, fine-grained, buff to brown-gray, breaks into angular blocks; micro fauna and fragments of shells; 3-inch layer above	2	
27	Shales, soft, calcareous, buff-gray with soft limestone	1	8
26	Limestone, massive, hard, fine-grained, brownish, micro fauna, fragments of shells, pelecypods	2	2
25	Limestone, lower half carrying worms and worm colonies, upper half shaly; buff on exposure	1	
24	Limestone, hard, massive, blue, fine-grained	1	3
23	Shales and limestone pieces, yellowish	1	3
22	Limestone, rather firm, somewhat platy, brownish within, rough, weathers dirty brown-gray	0	11
21	Shale, carrying minutely fractured, thin, lithographic limestone	0	8
20	Limestone, soft, shaly above, buff, firmer and gray below, grades into shale	2	
19	Shale, buff, 6 inches to	1	
18	Limestone, soft and other soft stuff, coarse worm tubes	2	
17	Shale, blue-gray, with 3 to 4 inches lithographic limestone in lower part. Contains "Syringopora" colonies	5	
16	Limestone, coarse, soft, buff, granular on exposure	1	4
15	Shale, olive, and limestone plates	2	
14	Limestone, two layers, soft, earthy, finely vermicular, buff	1	4
13	Shale with thin plates of vermicular limestone	1	8
12	Limestone, coarse, red-brown, worm tubes on top; some masses of worm tubes or "Syringopora"		6
11	Shale, cone-in-cone, with a thin limestone plate	1	8
10	Limestone, two layers, lower one coarse-grained, composed of crushed worm tubes; upper one gray, minutely vermicular and foraminiferal, top a mass of worm tubes		9

		Feet	Inches
9	Shales, clayey, buff to olive.....		7
8	Limestone, three thin layers, lower one coarse and conglomeratic, the others seamed, semi-lithographic stone, ripple-marked on top.....		9
7	Limestone, earthy, soft, fine-grained, buff, solution holes, pelecypods and worm tubes below, finer-grained with shell fragments and "Bellerophon" above.....	1	8
6	Shales, brownish to greenish-gray, red at the top of the lower half, upper half buff and firm, grading into limestone....	5	2
5	Limestone, earthy, upper 10 inches shaly, with cone-in-cone; large head of "Syringopora" in upper part.....	2	
4	Concealed	32	
3	Limestone, thin beds, six or seven layers, coarsely granular or crystalline on exposed surface, basal beds buff, porous, coarse worm tubes. Next beds rotten, porous, yellow to gray; upper bed buff-gray, seams of crystals.....	2	3
2	Concealed	6	9
1	Limestone, four layers, basal part yellow, granular, some fragments of fossils; middle part buff-gray, some worm tubes and fragments of fossils; top, crushed worm tubes, buff-gray; all rather coarse.....	2	1
	Concealed from water in the river to base of No. 1.....	5	0

Bead Mountain Formation

It seems that number 5 of this section was regarded as the base of Drake's Bead Mountain beds. However, there are at least two limestones and two shale beds below it which might be included in the section. Beginning with the top of the Jagger Bend beds, which is the second formation below the section described above, the worm tubes and reefs set in along the Colorado River. Directly over the Jagger Bend limestones at Jagger Bend, is a shale sixteen feet or more in thickness which is probably the Valera shale bed. On account of creep, it appears to be but about eight feet thick at the W. O. Gann Bluff, above Leaday. Over this is a limestone which is below num-

ber 1 of the section just given. It is followed by about thirty-five feet or more of shales, and still another limestone. It is probable that this last limestone is number 3 of our general section, though this cannot be positively stated, since there are lithologic differences in the beds at the two places.

It seems probable that the strata of this section which are numbered 5 to 36, inclusive, constitute Drake's Bead Mountain beds. They have a thickness of 55 feet 6 inches, which is practically the thickness which he ascribed to the formation.

The rocks from the top of the Jagger Bend beds to the top of the Bead Mountain beds form a striking paleontological unit along the Colorado River in southwestern Coleman and southeastern Runnels counties, and probably should be included in a single formation. Throughout the entire thickness of these rocks, the dominating fossils are worm remains. Even the so called "Syringopora" colonies are suspected of being elongated worm tubes. Not only are worm tubes the characteristic fossils of the Bead Mountain beds at this locality, but, save for local streaks of limestones and marls containing minute gastropods and pelecypods, they constitute almost the whole fauna. Just east of the corner of Runnels County, the uppermost beds of the Bead Mountain formation, numbers 35 and 36 of the section are composed of marls filled with "Syringopora" which frequently weather out into separate tubes or clusters of them, and a thin limestone which is practically composed of them. One elliptical, basin-shaped colony measured fifteen feet in diameter. There is an almost total absence of brachiopods from the beds of the formation, though they are common in the rocks above and below them.

Cedar Bluff Section

		Feet	Inches
22	Limestone, weathers to marls and nodules, mostly concealed	5	0
21	Limestone, rather fine-grained, gray on surface, buff within, weathers to angular and rounded fragments	1	0
20	Marls and marly limestones, break down easily	7	0

			Feet	Inches
	19	Limestones. Marly partings. Break down into more angular pieces and are firmer than No. 18. Top of bluff.....	3+	
54	18	Marls and marly limestones, weather to nodules, fossiliferous, light buff to lemon yellow	9	0
53	17	Limestone, marly, fossiliferous, marly partings, weathers deep buff.....	2	0
52	16	Limestone, bluish, with buff particles in it, surface buff to gray, very nodular and irregularly bedded, fossiliferous, uppermost of the heavier limestones in this immediate section.....	2	6
51	15	Marls and marly limestones, beautiful fossils	2	0
50	14	Limestone, massive, quite conspicuous, very large blocks with rounded edges, fossiliferous	2	6
49	13	Limestone, rather nodular, buffish-gray on surface, blue to buff within, fine-grained, soft shaly streaks, and some burrows at the top, weathers into one or several layers; top very fossiliferous in places; "Pinna," Productus, Euomphalus.....	6	6
48	12	Limestone, poorly exposed, earthy, buff-gray	1	0
47	11	Interval. Contains beds of more or less earthy limestones, two of which are 4 and 6 inches thick, respectively; extent to which this bed has been thinned by slumping unknown.....	10	0
46	10	Limestone, hard, brittle, steel-gray, weathers buff or gray-brown on top, angular blocks, tops literally covered with Meekechinus spines and plates, which are also scattered throughout the mass. Meekechinus bed..	1	6
45	9	Concealed, a foot and a half to.....	4	0
44	8	Limestone, four layers, two thin shale partings, buff to blue-gray, firm to earthy....	1	8
43	7	Limestone, massive, locally weathering into two layers, buff-gray, fine-grained, composed of fine pieces of fossils.....	1	6
42	6	Limestone, marly, rather fine-grained, buffish shade, weathers somewhat shaly in places; Pinnas, minute worm tubes (Foraminifera?)	1	0

			Feet	Inches
41	5	Limestone, six layers, with some marly partings, lower part fossiliferous, top of basal layer with very coarse worm tubes. Gray-buff, rather coarse-grained, with fragments of small fossils	4	7
40	4	Limestone, massive, dark bluish, with fine buff grains in it. Small stylolitic areas on upper surface	1	4
39	3	Shales and argillaceous, bluish-black limestones in about ten layers; Eumicrotus and Deltopecten	4 ±	0
38	2	Limestone (basal limestone of Grape Creek beds?) fine-grained, buff, earthy	2 ±	0
	1	Concealed, from river bed to base of Number 2. Barometer	65	0

The occurrence of many large masses of "Syringopora" about 15 feet below the base of number 2 of this section makes it fairly certain that this bed is the base of the Grape Creek limestones. This is about the interval above the top of the Bead Mountain formation on the west side of the Coffey flat previously given. This section, beginning with number 2, including below it about fifteen feet of shales or marls, may be regarded as resting on top of the previous section and continuous with it.

Brushy Bluff Section

In a notch in the bluff some 200 yards east of the conspicuous ledge high in the bluff. Apparently near the corner of the F. H. Lochte Survey No. 79 and the Wm. Williams land.

		Feet	Inches
34	Limestone, massive, weathers into large blocks with rounded edges. Rests upon a knotty, quite fossiliferous ledge. Top of main bluff. Ten feet to fifteen feet more up gradual slope to top of hill	2	4
33	Limestone, mostly. Some of the firmer layers tend to make faint terraces on the slope	12	0
32	Concealed. Faint terrace formed by thin limestone at the top. Largely marls and marly limestones, quite fossiliferous; Gastropoda, Spongia, etc	5	0

		Feet	Inches
31	Limestones, thin and marly, upper three feet a heavy gray limestone. Lower part containing large "Bellerophon," Turritellas?, Productus, Derbya, Strophalosia, Alloriisma, Bryozoa, etc.	5	0
30	Concealed	5+	
29	Limestone, gray, more or less nodular, great "Pinnae"	2	0
28	Interval. Largely limestone; one a foot thick appears just above the middle	5±	
27	Limestone, nodular, compact, blue-gray, large Pinnae, etc.	2	6
26	Concealed. Apparently very fossiliferous chalky material	10	0
25	Limestone, weathers gray and nodular; upper layer thicker than the two lower, undulating surface. Productus. Twenty inches to	2	0
24	Concealed	2	0
23	Limestone, two layers, tough, gray, weathers into rounded pieces, Euomphalus, Productus, Pinna, etc.	1	6
22	Concealed	2	6
21	Limestones, nodular, lower one a limestone conglomerate. They weather gray, same shade within. "Pinnas," one 15 inches long by 2½ inches across at larger end	2	0
20	Interval. Apparently shaly material which weathers buff. There are also some nodular, irresistant limestones and a 4-inch layer of yellow shale at the base, two nodular and two heavy limestones near the top	10±	
19	Limestone, two layers, fine-grained, blue, occasional minute worm tube, weathers into large angular blocks, the top a mass of Meekechinus remains. Meekechinus bed	2	0
18	Limestone, seven or eight layers, blue to buff, lower layers form good ledges; upper ledge thin, nodular, irresistant, one 8-inch bed shaly and olive-colored	5	0
17	Limestone, two beds, some minute worm tubes, and some large ones, drab with red particles, small shell fragments, weathers to gray nodules	2	4

		Feet	Inches
16	Shale, rubbly limestone in thin beds, some masses of shell fragments.....	4+	
15	Limestone, drab-gray, fine-grained, massive, resistant, corners of blocks rounded...	1	10
14	Limestone and shaly material.....	1	0
13	Concealed, considerable creep. Thickness 5 feet or.....	6	0
12	Limestone, blue-gray, nodular, earthy.....	0	7
11	Limestone, lower part nodular and irregular, breaks down easily; upper part more massive, blue, with brown specks, tough, minute and coarse worm tubes.....	1	10
10	Limestone, blue-gray, fine-grained, some shaly stuff.....	1	0
9	Limestone, lower part minutely wormy, upper part with coarse worm tubes.....	1	2
8	Limestone, two layers, weathers to nodules, shaly partings between them at the base. Blue, somewhat wormy, lower parting wormy	1	0
7	Limestone, nearly made up of worm masses, bluish- to buffish-gray.....		9
6	Concealed	2	0
5	Limestone, bluish-gray with buff specks, firm, minutely vermicular, top of layer locally weathers into "biscuits." Omphalotrochus?	1	3
4	Limestone, blue-gray with buff tinge, sparsely minutely vermicular (Foraminiferal?) Cephalopod	1	6
3	Limestone, bluish with brown particles. Pleurophorus casts.....		8
2	Limestone, blue-gray, massive, minutely vermicular, tough, weathers to large rounded blocks	2	4
1	Concealed. River to base of section. 20 to 30 feet.....	25±	

The numbering of the general section is carried forward from Cedar Bluff section to Dead Man's Bluff section because a better exposure is to be had at the latter place than at Brushy Bluff. To a certain extent the same beds are exposed at all three sections. Cedar Bluff and Dead Man's Bluff show fresh exposures, while Brushy Bluff is very much older and more disintegrated with interrupted exposures.

The rocks at Brushy Bluff appear to dip down the hill. This is probably caused by the creep of the shales which makes the limestones of the section appear relatively much more important than they are.

The top of the Bead Mountain beds is probably represented by number 12 of the section, possibly as low as number 9. The shales of the actual section may have been washed completely from beneath the outer edges of the limestones, permitting them to come practically into contact in the ravine studied. The top of the Bead Mountain beds passes under the river a little distance above the place where the river turns east and flows along the base of the bluff.

Number 19 of this section is equivalent to number 10 of the Cedar Bluff section.

Dead Man's Bluff Section

			Feet	Inches
86	41	Limestones, top of hill, all upper beds alike	1±	
85	40	Concealed. Shaly slump	2	0
84	39	Limestone, two beds, soft, buff, very fossiliferous, fossils weathering out	4	8
83	38	Concealed, partly. Shales and some soft limestones, Gastropoda, fragments of large nautiloid, giant Allorisma, large crinoid stem segments	8	0
82	37	Limestones, several beds, one thin one at base and thicker one at top with several thinner ones between. Somewhat crystalline, some fossils	2	6
81	36	Limestone, gray, rather soft, fossiliferous, upper part finer-grained and containing sponges. Great variety of fossils	5±	
80	35	Concealed, apparently rotten limestones	3±	
80	34	Limestone, soft, fossiliferous, Omphalotrochus. Base of Talpa Beds		5
79	33	Limestone like Numbers 31 and 32. Very long Solenomya, etc	2	6
79	32	Limestone like Number 31, 2 feet 6 inches with 4 to 6 inches of other material	2	6
79	31	Limestone, much more regularly bedded than those below, fossiliferous, fossils breaking out well, 20 inches to	2	0

			Feet	Inches
78	30	Limestone, frequently crystalline above and below, like Number 29	1	3
77	29	Limestone, very irregularly bedded, very coarse-grained and very fossiliferous. Top and base very irregular with 6- to 8-inch depressions of about the same diameter	2	0
76	28	Limestone, massive, many large fossils, coarse-grained, blue-gray, very irregular on top, contains shale streak ½-inch to 4 inches thick	2	0
75	27	Limestone, massive, irregularly bedded, blue-gray, coarse-grained, fossiliferous, weathers buff to gray	2	6
74	26	Concealed	1	3
73	25	Limestone, beds like Number 24, but more regular and less crystalline at this place	2	0
73	24	Limestone, varying number of beds, composed of limestone fragments in marl and shale (Conglomerate), all very nodular and fossiliferous; burrows in the matrix	2	10
73	23	Limestone, thin, and limestone conglomerate, micro fauna, one layer weathers buff	1	0
72	22	Limestone, buff-gray, upper part locally a Productus conglomerate, top stylolitic in in places	1	0
72	21	Limestone conglomerate and thin beds in shale matrix	1	6
71	20	Limestone, blue-gray, fossiliferous layer, large Allorisma, sea urchin plates, shell fragments, worm tubes, etc.; coarse-grained	0	10
70	19	Limestone, coarse, blue-gray, very irregularly bedded and "chippy," more or less shaly (shale 4 inches thick in places) shale at top. Fossiliferous, specimens breaking out well	3	6
69	18	Limestone, massive bed, sometimes has thin marl streaks near the top, blue-gray, fine-grained, great blocks with rounded edges, fossiliferous. "Six-foot bed"	6	0
68	17	Limestone, very fossiliferous, thin coarse beds, except near the top where one more massive occurs	3	0
67	16	Limestone in four layers, more or less irregularly bedded with some shale streaks. Base a mat of well preserved Bryozoa	3	6

			Feet	Inches
66	15	Limestone, two or three beds, suture bedded, these sutures 6 inches or more deep. An occasional stylolite is seen, but these have no relation to the "suture bedding".....	4	0
65	14	Conglomerate. A mass of shale, marl, large fossils, burrows and large limestone lumps. Bryozoa, "Pinna," etc.....	2	0
64	13	Limestone, two irregular beds, shale partings, the upper bed the thicker, which locally weathers into two beds.....	2	0
63	12	Shale, bituminous below, marly above, full of burrows, Productus, Pinna, and a few other fossils.....	1	0
62	11	Limestone, very irregular, one to three beds, usually two with a very thin shale between; top and middle beds sutured and base very undulating. Gastropoda, "Pinna" and Bryozoa.....	3	4
61	10	Limestone, extremely irregular, undulatory surface above and below. "Bellerophon," Euomphalus, etc.....	1	6
60	9	Limestone, earthy, weathers gray, sponges and other fossils; 2 to 4 inches of gray shale with minute fossils.....		9
60	8	Marl, gray, limestone streaks and knots....		6
59	7	Limestone, coarse, gray, fossiliferous, many Bryozoa on top.....	1	6
58	6	Shale, blue-black, bituminous, fossiliferous; rests on three to four inches of limestone in the water where river turns south to flow along the bluff; Myalina, Strophalosia, Allorisma, Bryozoa, etc.....	1	8
57	5	Limestone, blue-gray, coarse, fossiliferous, clay streaks.....		8
57	4	Limestone, blue-gray, coarse-grained, fossiliferous, resistant, undulating surface....		7
56	3	Limestone, blue-gray, hard, fossiliferous, undulating	2	6
55	2	Limestone, two layers, thin shaly partings below and above, very fossiliferous.....	1	3
54	1	Limestone, blue-gray with buff tinge, fine-grained, "Pinna," Productus, Euomphalus, Cephalopod, etc.....	2	0

Numbers 1 and 2 of this section are usually under water. The base of the section is about 25 feet above the Meekechinus layer

of Brushy and Cedar Bluff sections. The shale over the Meekechinus layer would occupy some 10 feet of this space, leaving about 15 feet of the limestones of those sections to connect with the base of this one. The six foot bed (number 18) of this section would come in at about the top of the Cedar Bluff section, possibly numbers 20 or 22. This bed would correspond nearly with numbers 33 or 34 of the Brushy Bluff section; or, near its top. Number 33 of this section, number *79* of the general section, is the top of the Grape Creek beds. In the first section described, there is an interval, number *37*, of about fifteen feet, probably composed of marls and irresistant limestones. This may be bed number 12 described by Drake, but it is uncertain, and can only be determined by tracing the horizon occupied by that bed farther north down to the river. This has not been done.

Grape Creek Formation

The Grape Creek formation as shown in the accompanying sections is 130 feet thick. Drake assigned a thickness of 100 to 150 feet or more to it. These beds are distinguished from the Bead Mountain beds by the paucity of worm and "Syringopora" remains, the introduction of mollusca and molluscoidea, and most noticeably by the nature of the bedding of the rocks. The Grape Creek formation as seen along the fresh river exposures is remarkable for the peculiar stratification of the limestone beds. They are largely composed of boulders or large and small pieces of limestone up to two feet or more in diameter. In fact, they vary from the usually even-bedded limestones to conglomerates of limestones in a shale matrix. Usually the matrix is a rather firm marl or even rather firm marly limestone. These marls are coarse, with curved, almost laminated beddings, and contain burrows of various sorts and large "Aviculopinnas," etc. The limestone masses are much finer-grained, very firm, and relatively quite impervious. Both are bituminous. The fossils in the marls are little compressed or distorted, and on the whole differ from those in the limestone masses. There is little evidence of crushing or movement of any kind in the beds. The tops as well as the bottoms of these layers are usually quite un-

even, the depressions and elevations of the surface corresponding to the limestone masses and marl fillings. If the shale or marl partings are very thin, not infrequently the bottom of the overlying bed fits into the irregularities of the top of the one below. This has been referred to in the description of the beds in the sections, as "suture bedding." Usually the marl beds between the layers reduce these irregularities. In only one or two cases was any evidence of movement noted, and that was an occasional tiny stylolite which was utterly inadequate to account for the conditions found in the beds containing them. As a result of this peculiar composition of the beds, their thickness varies from place to place, and they appear quite rough on their weathered faces.

The following section largely duplicates the one above:

Section about one mile west of Dead Man's Bluff, on south side of the river

			Feet	Inches
92	23	Limestone and marls, blue, in places weathers shaly, highest layer well exposed; Gastropoda, Productus, Cephalopoda.....	1	0
92	22	Shale and marls, sparingly fossiliferous; Omphalotrochus, Productus.....	2	0
92	21	Limestone, not very resistant.....	1	8
91	20	Limestone and marls, less resistant than that below, a considerable part of it concealed. Many Omphalotrochus.....	7	0
90	19	Limestone, massive, fossiliferous, weathers blotched buff and gray (these more prominent beds weather into blocks with well rounded edges and corners).....	1	10
89	18	Interval. Apparently containing marls and shaly limestones with a foot of limestone near the top.....	5	0
88	17	Limestone, two layers, upper one thicker and more prominent, locally the lower is as thick as the upper one, in such places they both reach a thickness of 3 feet. The lower weathers more rapidly.....	1	10
87	16	Interval. Contains at least one or two limestone layers, the remainder is less resistant material.....	15	0

		Feet	Inches
15	Limestone, two layers, massive, steel-gray, resistant, and rather firm. The upper one of finer-grain than the lower.....	4	2
14	Limestone, gray, rather soft, weathers chippy, buff-gray, coarse; shale at top, fossiliferous	2+	
13	Interval. Apparently marly, fossiliferous limestone with Productus, Euomphalus, Omphalotrochus, Bryozoa, burrows, etc..	3+	
12	Limestone, hard, steel-gray, more resistant than one below. Two beds.....	2	6
11	Limestone, shaly, fossiliferous, Productus, Euomphalus	4	0
10	Concealed. Apparently hard, fossiliferous marls, etc.....	8	0
9	Limestone, four layers, thickness of whole variable like Number 8, but uppermost is regular and smooth on top.....	7+	
8	Limestone, coarse, buff-gray, somewhat crystalline, top weathers very coarsely cellular; extremely variable in thickness, due to undulatory upper and lower surfaces..	2	6
7	Limestone, two very irregular beds, probably conglomerate of limestone boulders; somewhat fossiliferous.....	3	0
6	Limestone, two layers of nearly equal thickness, separated by an inch or two of coarse, irresistant limestone. These beds are of about the same color as the others of the section, but weather a little redder.....	3	0
5	Limestone, blue-gray, fine-grained, hard, with two or three inches of coarse gray material full of Productus.....	1	6
4	Concealed. Weathered back.....	1	0
3	Limestone, hard, blue-gray, very irregularly bedded, undulatory surface, fossiliferous, minute fauna.....	1	6
2	Limestone, massive, blue, mottled with drab, hard, rather crystalline and coarse; sea urchin fragments, otherwise fossiliferous; choppy surface.....	3	0
1	Concealed, river bed to base of Number 2...	7+	

Not more than ten or fifteen feet of rocks come out of the river in going from this section downstream to Dead Man's

Bluff, so that the sections are duplicates of each other in a large part of the exposures. Much of this section is an older and more weathered cliff than the one at Dead Man's Bluff, which is comparatively fresh.

Section two and one-fourth miles west of Dead Man's Bluff

		Feet	Inches
12	Limestone, top of cliff (Number 10 of next section)	1	8
11	Limestone in three beds, upper bed 11 inches thick	2	10
10	Limestone	1	2
9	Limestone, thin, about seven layers, with marly partings	5	0
8	Limestone		6
7	Concealed	1	8
6	Limestone and covered slope, probably one heavy ledge about 5 feet above the base, 13 inches thick	9	0
5	Limestones and shale partings	1	6
4	Limestone, two layers	1	6
3	Concealed	1	5
2	Limestone, two layers, shale parting	2	6
1	Limestone, hard, blue, in ravine bed, several feet above very low water level in river	2	10

The top of this section is about nine feet below number 12 of the following section. Numbers 1 and 2 of this section are below base of the following section.

Section about two and one-half miles west of Dead Man's Bluff

			Feet	Inches
	17	Concealed to top of hill, covered with water-worn chert	10	0
	16	Limestone, light, more or less finely crystalline. Minute worms or Foraminifera	1+	
	15	Concealed	15	0
	14	Limestone, thin, drab-gray, in places nearly composed of Ostracoda		6
	13	Marls and rotten limestone, fossiliferous, not well exposed	20	0
99	12	Limestone, much like those below, many large molluscs; forms prominent terrace, top of rather high cliff along south side of the river; most conspicuous cliff-maker in this bend of river	1	3

			Feet	Inches
99	11	Limestones, thin-bedded, fine- to coarse-grained, blue-gray, much like the one below them, fossiliferous; beds weather into rounded edged blocks and ledges, rather even-bedded	10	0
99	10	Limestone, rather massive layer, irregular base, dark-gray, fossiliferous	1	6
99	9	Limestone, light-gray, fossiliferous, irregularly bedded, earthy, in six to eight layers, which come in and pinch out	4	0
98	8	Concealed	1	0
97	7	Limestone, hard, blue, upper part almost composed of small fossils which do not come out		9
97	6	Limestones and marls, rotten, fossiliferous	1	4
97	5	Limestone, blue-gray, massive, fairly regularly textured	1	3
96	4	Interval, with rather even-bedded limestone near center	9	0
	3	Limestone, much like Number 1, but finer-grained, rather evenly-bedded, minute tubular organisms	1	3
	2	Interval. Shaly limestone at bottom	1	3
	1	Limestone, blue-gray, hard, rather coarse, weathers chippy in ravines. Bryozoa, Pinnas, etc. Distance to river bed about 15 feet	1	3

The Composita horizon is in number 13, fifteen feet above number 12. Some specimens were seen on number 12 and a few on the escarpment 35 feet above it.

Traced up the river number 12 of this section is seen in the limestone at the base of Little Bluff. The Composita horizon occurs 15 feet above it at the latter locality. Specimens can be found in most of the horizons from here up for a great distance, but not in the profusion in which they occupy this thin bed.

Section of Little Bluff.

			Feet	Inches
103	12	Limestone with silicified fossils	10	0
103	11	Limestone, rotten, and marls; very fossiliferous	10	0
103	10	Limestones, rotten, and marls; very fossiliferous	8	0

			Feet	Inches
103	9	Limestone in five layers, some of them rotten, upper layer about a foot thick, next layer below rotten and full of fossils	4	0
102	8	Concealed	20	0
101	7	Limestone, firm	2	6
101	6	Shale, or marl, gray-blue, weathers yellow, Composita zone	2	0
101	5	Limestone, double bedded, shaly limestone between	2	6
100	4	Concealed, 12 to 15 feet	12	0
	3	Limestone, hard, blue-gray, stained with brown	1	7
	2	Limestone, blue, hard, fossiliferous, fine-grained	3	10
	1	Concealed	7	0

The upper 20 feet of this section is very fossiliferous with many Meekellae, Producti, Nautiloidea, Pelecypoda, and Gastropoda.

The following section of Big Bluff, joining Little Bluff on the west, goes somewhat higher, but is an older and more poorly exposed section. The whole section is given here to get the higher beds shown there.

Hasty Section of Big Bluff

			Feet	Inches
104	14	Limestone, heavy, nodular-bedded, with rusty streaks, forms top of bluff	2	0
104	13	Concealed, shales and limestones, about four beds forming terraces at the end of the bluff. The top of the previous section is about 14 feet above the base of these beds	30	0
	12	Limestone, apparently in place, but probably somewhat slumped, three or four or more beds in ledge	4	0
	11	Concealed, about 14 feet	14	0
	10	Limestone in three beds, top and bottom ones heavy, middle one irregular with considerable marl on top of it	3	6
	9	Covered	3	9
	8	Limestone, massive, even-bedded	1	11
	7	Concealed	11	0
	6	Limestone, firm, apparently about in place		6

			Feet	Inches
	5	Concealed. Apparently marls	10	0
	4	Limestone, extremely irregularly bedded, very fossiliferous, top and base practically marls	3	8
	3	Concealed. Apparently marls and nodular limestones	9	3
	2	Limestone in nine or ten beds	13	0
	1	Limestone in four beds, solid, top forming quite a bare terrace at the foot of the bluff, base forming the river bed	7	6

The top of number 2 of this section is the same as the top of number 3 of the preceding section. Fifteen feet over it the Composita horizon comes in. The lower part of number 13 is probably equivalent to some part of numbers 11 to 12 of the Little Bluff section.

Section of Herrings Bluff on north side of the Colorado River below the mouth of Mustang Creek

			Feet	Inches
127	41	Limestone, two layers, upper one 2 feet thick, lower one 1 foot, marly parting, dark gray within, forms top of cliff. Few feet of weathered stuff farther back in the hill	3	6
127	40	Limestone, soft, and shales	3	0
127	39	Limestones with marl partings, the two upper beds even, the lowest one very irregular; all firm, fossiliferous, 4 to 6 feet thick	5	0
127	38	Limestone, one to three thick beds, composed like Number 27, but most of the marls are hard, though less resistant than the limestone	5	0
127	37	Marls, yellowish, with large boulders of limestone, in some places mostly marl and in others mostly limestone, fossiliferous	2	0
126	36b	Limestone, 5 feet, in four beds, separated by shales which weather buff, and which are very calcareous and firm. The second bed of limestone is 2 feet thick. The third is very irregular in thickness, varying from 5 inches to 1 foot. The upper layer is soft, very fossiliferous, weathers into small buff pieces	5	0

			Feet	Inches
125	36a	Limestone beds, poorly shown, 1 foot with silicified fossils; some other marls and limestones	4	0
124	35	Shales and nodular limestones, limestones near the base	13	0
124	34	Limestone, finer than Number 33, very dark blue or blue-black, fossiliferous	1	2
124	33	Shale, buffish and calcareous, containing nodular limestone, especially in the upper half, fossiliferous	10	0
124	32	Limestone, soft, weathers into rounded nodules, quite fossiliferous	1	
123	31	Interval, largely yellowish shale and nodular limestone	5	0
122	30	Limestone in three layers, perhaps some shale partings, weathers into gray, rounded blocks of considerable dimensions. The main (second) layer is nearly 15 inches thick, all fossiliferous, large Gastropoda, Pelecypoda, Productus, etc	5	0
121	29	Shales, yellowish, 4 feet to	5	0
120	28	Limestone in two layers, soft, gray to buff, 1 or 2 inches, gray to dark shale with micro fauna		10
120	27	Limestone, minutely vermicular, hard, brownish on top, blue with white dots within		6
120	26	Shale		6
120	25	Limestone in three layers, lowest is gray limestone with fossils, Gastropoda, break out well; two upper layers blue, lower one with micro fauna, Foraminifera	1	8
119	24	Concealed	10	0
118	23	Limestone, blue, fine-grained, fossiliferous, weathers into small rounded blocks, 9 inches to	1	0
118	22	Limestone, soft, blue, weathers into small gray rounded stones		8
117	21	Shale, yellowish, some Bryozoa, etc	4	0
116	20	Limestone, hard, even, 6-inch layer, steel-gray, somewhat fossiliferous, forms top of falls in little ravine. Numbers 15 to 20 form the section at the falls in ravine cutting the bluff		6
116	19	Shale		4

			Feet	Inches
116	18	Limestone conglomerate like Number 17 with little calcareous, hard shale; upper part more shaly than the base; gray calcareous material with Ostracoda and other minute organisms	4	6
116	17	Limestone conglomerate in shale matrix, much of it shale	1	8
116	16	Limestone, two layers with an inch or so of shale between them, gray, fossiliferous		10
116	15	Limestone, blue-gray, knotty, very irregular upper and lower surfaces; some of it seems to be made up of masses or pieces of imbedded limestone, a coarse conglomerate with Productus and an occasional sponge	1	8
115	14	At the place where this section was taken (where the river flows against the north end of the bluff) this space is concealed. A ravine farther south shows the following section: Shales, buffish, and nodular limestone, a fossil conglomerate, breaks into small blocks and individual fossils. Productus, Myalina, Strophalosia, Derbya, Bryozoa, etc.	5±	
114		Limestones, four thin layers, fine fossils and ground-up fossils, thin shale parting	2	2
114		Shales, blue to olive or yellow, fossiliferous, with occasional masses of fossiliferous nodular limestone	1	3
114		Limestone, hard, gray, forming a little fall		6
114		Limestone, platy, and shale at the base	1	0
113		Concealed, about	8	0
112	13	Limestone, hard, blue, like Number 12, but coarser and more crystalline	1	0
112	12	Limestone, hard, blue, very irregular on top and bottom, chippy in this exposure	1	8
112	11	Limestone, thin-bedded, bituminous, shaly partings, new Gastropoda, Pelecypoda, etc.	2	0
112	10	Limestone, three layers, bituminous, large Euomphalus	1	0
112	9	Limestone flags, shale partings, sponges in lower shale, which is 4 to 5 inches thick	1	6
112	8	Limestone, hard, large joint blocks, blue-gray, large fossils, in places shaly on top		8
112	7	Limestone in three or more beds, all alike, 6-inch shale partings	2	8

			Feet	Inches
112	6	Shale	1	0
112	5	Limestone, buff, weathers shaly, fossiliferous, very large Myalinas, sponges, Cephalopod-like fossils, etc.		8
111	4	Shale, bluish to buff, 5 feet to	8	0
110	3	Limestone in two layers, dark brown, very fossiliferous, great Myalinas	1	3
110	2	Limestone, two layers like above, but filled with many species of Gastropoda		8
110	1	Concealed to river bed	10+	

Number 2 of this section is the Gastropod horizon in the hills and bluff two or three miles farther south.

The top of this section is approximately the top of the Talpa beds.

Section of the low bluff extending east from Buffalo Bluff

		Feet	Inches
10	Limestone	1	0
9	Limestone, one layer, top foot sometimes weathers into a separate layer	3	3
8	Marls and marly limestones, burrows and few fossils	2	0
7	Limestone, massive, blue-black	1	3
6	Marls, platy, 4 inches to	1	0
5	Limestone, hard, 1 foot to 16 inches	1	3
4	Limestone in two beds with irregular surfaces	2	0
3	Limestones, rubbly and conglomeratic, some shaly partings, all beds wavy	6	0
2	Concealed down to heavy ledge, 25 or 30 feet	25	0
1	Concealed to river bed below	15	0

Talpa Formation

The top of this section is the top of the Talpa beds. They extend from the base of number *80* to bed *127* of the general section, and have a thickness of 400 feet. This formation is especially characterized by the larger amount of shales in the section and some thicker beds of limestone than are found in the Grape Creek beds; and the bedding of the limestone is quite as irregular. The fossils become much more abundant and varied in the Talpa beds which furnish a very rich molluscan and molluscoid fauna with a wealth of sponges and minute organisms.

It is especially characterized by large species of Omphalotrochus, Allorisma, and Myalina shells. Probably fifty species of gastropods have been collected from the formation.

Section connecting Big Bluff with Herring Bluff

The connection between the two bluffs is determined by following the beds across country from Big Bluff to Bronson Thicket, where the gastropod limestone, number 2 of the Herring Bluff section, *110* of the general section, is seen with a foot of sandstone a little distance below it. Patching the exposures together, the section is as follows:

			Feet	Inches
110	20	Limestone, Number 2 of Herring's Bluff section, filled with gastropods and other molluscs	1	0
109	19	Shale, bluish	6±	
109	18	Sandstone and sandy shale, weathering yellowish buff	1	0
109	17	Limestone, buff, shaly	2	6
109	16	Shale	2	0
108	15	Limestone, five layers, lower one thick and massive, upper four thinner with marly partings about equalling the thickness of the beds. Top one is in large thin slabs	6	0
108	14	Limestone, massive, nodular, with marly streaks	1	6
107	13	Shale, with thin rotten limestone	2	6
107	12	Limestone	2	0
107	11	Shale, blue, clayey, Bryozoa, etc	1	4
107	9	Shale, 1 foot and probably more	1	0
107	8	Limestone, evenly bedded, two layers	1	6
107	7	Shale, blue, rotten, fossiliferous limestone in the middle	2	2
107	6	Limestone, rotten, fossiliferous		6
107	5	Shale, literally filled with fragments and whole specimens of Productus of the semireticulatus type, but very small species	1	0
107	4	Limestones, two layers, evenly bedded, the lower one giving way to shale	1	6
107	3	Shale		8
107	2	Limestone, blue, bituminous, and small interval		10

			Feet	Inches
107	1	Limestone, two double beds with 8 or 10 inches of shale in the middle. Mouth of Skunk Hollow in the river	4	2

Below these beds there appears to be:

106	2	Shale with limestone cap	5±	
105	1	Concealed	14	0

This lower part of the section is shown above Big Bluff.

Buffalo Bluff Section

		Feet	Inches
19	Limestone and marl. Limestone even-bedded, weathers in great slabs much like the one below, quite bituminous, 4 to 8 inches of marl above it; forms top of the cliff	1	8
18	Limestone in two beds, thin marl parting, drab-gray, lower one with uneven base, contains many sponges; upper layer forms great slabs	3	0
17	Limestone, crystalline, cellular, yellow, and some rather fossiliferous buff shales	1	3
16	Limestone much like Number 11. Cephalopods show on smooth joint face	2	0
15	Shales, yellow, marly, laminated, some fossils, 1 foot to	1	3
14	Limestone like Number 13, but lighter-colored, and coarser		10
13	Limestone, even-bedded, blue, earthy, 4 in. shales above it	1	9
12	Marls, platy and marly limestones, partly covered	12±	
11	Limestone, hard, even-bedded, brittle, massive, made up of minute worm tubes or Foraminifera	1	6
10	Shale, 6 inches to 1 foot 4 inches	1	0
9	Limestone, gray, upper third containing many sponges, large and small. Bed 18 inches to 2 feet thick	2	0
8	Shale, drab, calcareous, resting on 1 foot of limestone of the same shade; bituminous, all partially concealed	7	0
7	Limestone, laminated, weathers shaly in old exposures, drab, grades into shale above	2	6

			Feet	Inches
	6	Limestones, two thin, and two thicker marl beds which are laminated, blue, bituminous. Ostracoda	2	0
	5	Limestones, nodular, and blue shales and marls. Ostracoda	2	0
	4	Limestone, blue-drab, marly below		10
	3	Limestone, blue, nodular and blue marls	1	0
	2	Limestone, laminated, gray, almost shaly, on weathered surface. Hard and blue when fresh	5	6
128	1	Concealed. Base of Paintrock beds	10	0

Number 1 of this section is the dividing line between the Talpa and Paintrock beds, and rests upon number 10 of the preceding section, which forms the base of the bluff.

Section of Colorado River Ford, west of the mouth of Mustang Creek. (V. V. Waite)

		Feet	Inches
10	Limestones, suture-bedded	6	0
9	Limestone, thin-bedded, shale partings, partly covered, allowing three feet for slumping	20±	
8	Limestone, silicified fossils, irregular bedding-planes	2±	
7	Shale, black, 3 inches to		6
6	Limestone, blue-gray, irregularly bedded		5
5	Shale, black to dark gray, with bed of nodular limestone at the top		8
4	Limestone, very fine-grained		3
3	Shale, black, bituminous		4
2	Limestone, dark blue-gray, fine-grained		6
1	Limestone, dark blue, at water level	±	

Section from the Mustang ford to the mouth of Spur Creek, beginning at top of Waite's Section

			Feet	Inches
117	52	Limestone about like Number 50	1±	
117	51	Concealed, nodular limestone near the middle. About	8	0
117	50	Limestone, buff, coarse, irregular, gray, weathers to large and small rounded blocks. Made up of fragments of fossils	1	0

			Feet	Inches
147	49	Interval, apparently marls, one streak of soft limestone	5	0
147	48	Limestone, coarse, gray, pocket of teeth and other fossils	1	0
147	47	Shaly, marly	1	0
147	46	Limestone, weathers to rounded blocks, coarse-grained, texture very irregular, composed of ground fossils; contains Cephalopoda and other molluscs	1	0
147	45	Marl. About	1	6
146	44	Limestone, five thin beds, weathers crumbly, two beds of marl near base and one below top bed, fossils	5	0
146	43	Limestone, massive, coarse, weathers into large blocks and boulders with rounded edges, fossiliferous	1	3
145	42	Interval. One limestone near the top and one near the middle. Upper part apparently a shale or marl, weathers to an olive shade	8	0
144	41	Limestone, coarse-grained, largely made up of fragments of fossils which occur in masses through the bed	1±	
144	40	Shale and marl	1	3
144	39	Limestone, coarse, rather massive, composed of minute organisms, coarse algal (?) markings on its base		8
144	38	Limestones, thin-bedded, close-textured, flaggy, four or five beds, weather to dark or light buff, or even gray	1	6
144	37	Shale or marl. Six inches to	1	0
144	36	Limestones, thin-bedded, two or three beds, gray, upper bed contains many Pelecypoda	1	6
144	35	Concealed, mostly, some earthy limestones and marls	2	6
144	34	Limestone in two layers, pale blue, upper part very nodular and very fossiliferous. Myalina, pelecypods	1	3
143	33	Shale, blue, calcareous		6
143	32	Limestone, blue, earthy		6
143	31	Shale	2	6
143	30	Limestone, earthy, blue-gray, texture irregular, fossils, algae (?)	1	0
143	29	Marl, blue-gray, shaly, about	1	3
142	28	Limestone, brecciated, fossiliferous		6

			Feet	Inches
142	27	Limestone breccia, weathers yellow to gray, or even blue. Location approximate, due to slumping	1	0
141	26	Concealed	12±	
140	25	Limestone, massive, weathers into large slabs, light blue, Derbya, Productus, sponge, etc.	1±	
140	24	Interval. Apparently shales and marls with some blue shale	4	0
140	23	Limestone, blue, knotty, fossiliferous. Top of lower section		9
139	22	Limestone, heavy, in rather thick beds with thicker and thinner marl partings. The top bed is in very large blocks with rounded edges, more conspicuous than the rest; beds blue-gray, fossiliferous; sponges, Cephalopoda, etc.	9	0
138	21	Marls and thin limestones	3	6
138	20	Limestone. Many silicified fossils		6
137	19	Limestone, nodular, marly, Cephalopoda, Euomphalus	2	6
136	18	Marls, weather yellowish	3	0
136	17	Limestone, fossiliferous		6
135	16	Interval, apparently rather firm marls with at least three beds of limestone	12±	
134	15	Limestones, four or five beds, all weather platy, marly partings, some fossils. Phacoceras	3	6
133	14	Interval, contains a layer of limestone, dark blue and cellular	8	6
132	13	Limestone, upper part very shaly, slumped out of position, lower part concealed	2	4
131	12	Limestone, upper 20 inches weathers into large rounded blocks, metallic ring. At falls it weathers platy; molluscs	2	0
130	11	Marls with at least one layer of soft, nodular limestone, a little above the middle	8	0
129	10	Limestone in two layers, marl above and below containing limestone nodules and some fossils. Slumped slightly out of position	3	0
128	9	Concealed	5	0
	8	Limestone, weathers nodular, somewhat fossiliferous. Some marl	1	3
	7	Limestone, three beds, fine- to coarse-grained, fossiliferous, bluish-drab, fairly		

		Feet	Inches
	evenly bedded, marl partings. Upper marl 18 inches thick locally, quite fossiliferous	3	0
6	Concealed, probably marls	3	0
5	Limestone in three thin layers, marl partings. Lower limestone weathers into nodules, upper more platy, all fossiliferous, drab-mottled with yellowish streaks	3	0
4	Marls, weather yellowish brown, 8 inches to	1	0
3	Limestone, about like Number 1, Strophalosia, Ostracoda		9
2	Marl, few Ostracoda		6
1	Limestone, six beds, very irregularly bedded, some marl partings, dark blue, weathers buff, sponges, small worms	5	0

This section is taken from well-weathered exposures. The top part was from somewhat fresher ones.

The limestones (number 22) at the top of the first hill are the same beds that form the top of the Buffalo Bluff section.

Paintrock Formation

The Paintrock formation as here considered begins with number *128* of the general section. The upper limit is rather hard to determine before the fauna of the whole section is worked out, since the lithologic changes are not sharp at any point in the section, though the change is rather rapid at some horizons. It is here drawn at the top of number *111* of the general section. This leaves a thickness of 81 feet for the formation. Drake's statement of the thickness of the formation was 150 feet. He began the section of the Paintrock beds much lower than the beds here used, judging from his map showing the lower limit of the beds along Pony Creek. The rocks of this formation are at once more evenly bedded and apparently somewhat more resistant than those of the two underlying formations. The fauna is more sparse and less varied. Omphalotrochus is rare or wanting, as are many other species. Ostracods become very prominent, as are nautiloids, and sponges, though the last are less abundant and varied than they are in the Talpa formation.

Section on the north bank of Spur Creek

		Feet	Inches
4	Limestone, massive, coarse-grained, weathers to dirty-brown shade, large blocks, fossiliferous	1	10
3	Interval, one marly limestone	3	0
2	Limestone, 1 foot or more of shaly marls near the middle, limestone fossiliferous, large nautiloids	6	6
1	Limestone, marly	1	0

This section begins with number 43 of the previous section. The difference in appearance of the interval common to both sections is the difference in the freshness of the exposures and in their orientation. Under these conditions, some beds prominent in one slope disappear from the surface, while others, inconspicuous in the first slope, come into prominence.

Section in ravine at Giesecke's Ranch house

			Feet	Inches
1/8	27	Limestone, earthy, weathers into nodules or rounded blocks, surface dark gray to brown according to exposure, somewhat fossiliferous	1	0
1/8	26	Interval. Upper five feet probably marl with limestone nodules	25+	
	25	Limestone, massive, weathers like Number 23	1	3
	24	Limestone and marls, not well exposed	9	0
	23	Limestone, very large blocks with rounded edges, massive, dirty-brown to gray, rusty streaks	1	0
	22	Limestone, nodular, some marls	5	0
	21	Limestone, massive, in large blocks	1	0
	20	Shale	2	0
	19	Limestone, nodular and marly, with marly shales. One of the limestones when followed west becomes firm and forms the top of the bluff for some distance	5	0
	18	Limestone, four layers, thin shaly partings, fossiliferous, three lower layers firm and even-bedded, blue-gray, base of one of them has strong algal markings. Top layers marly and nodular, whole section above		

		Feet	Inches
	Number 2 somewhat slumped and relation of beds uncertain	2	9
17	Limestone, gray, rather uneven, on top; 6 inches to	1	0
16	Shale	5+	
15	Limestone, dark blue-gray		5
14	Shale, probably four or five feet, very fossiliferous, contains nodular limestone	4±	
13	Limestone, massive, blue-gray, mottled with lighter shade		11
12	Limestone in four layers, rusty specks in it.	2	0
11	Shaly material partly concealed	1	0
10	Limestone, very fossiliferous	1	1
9	Shale, about	1	3
8	Limestone, blue-gray, mottled, coarse- and fine-grained	1	6
7	Shale, blue, weathers gray, 7 or 8 inches of nodular limestone below the middle	7	6
6	Limestone, two beds, coarse, gray, marly		9
5	Marl, rather firm, limestone lumps	1	0
4	Limestone, crystalline, cellular, and brecciated, with undulating surface	1	6
3	Limestone, even-bedded, texture irregular, blue-gray		7
2	Shale or marl, blue		6
1	Concealed, water level to base of section		

Number 4 of this section is number 27 of section west of Mustang Ford (base number *115*). Some of the marls of this section appear as limestones in fresh sections.

Number 27 forms the basal member of the limestones on Elm Creek below the wagon bridge at Ballinger.

Some of the beds of the Giesecke section are better exposed in the river bed on the northeast corner of the Chris. Schulenberger survey, on the south side of the river, below Ballinger. This section follows:

Section of the river bed on northeast corner of Chris. Schulenberger Survey

		Feet	Inches
21	Concealed, 25 or 30 feet, perhaps more	30±	
20	Limestone, blue-gray, weathering brown, coarse, Ostracoda, little marl concretions	1	3
19	Concealed	5	0

		Feet	Inches
18	Covered slope with 6 inches to a foot of marly limestone with large Deltopecten, Eumicrotus (?), etc.	4	2
17	Limestone, weathers buff-gray, forms upper prominent terrace around bend of river.		9
16	Marls and limestone lumps, Pelecypoda and Bryozoa	1	6
15	Limestones, firmer and softer, fossiliferous, large Eumicrotus	3	2
14	Limestone, firm, even-grained, forms terrace around the bend		10
13	Shale and marl, 15 inches to	1	0
12	Limestone in two layers, hard, unevenly textured, blue-gray, fossiliferous		11
11	Marls, blue, fossiliferous, with limestone plates which are very fossiliferous	2	2
10	Limestone, three beds, hard, unevenly textured, weathers blue-gray, fossiliferous	1	7
9	Marl, fossiliferous	1	2
8	Limestone, weathers blue-gray		6
7	Limestone, firm, coarse, fossiliferous, large numbers of Myalina; farther north it forms the top of a firm limestone 14 inches thick and on beyond that point it splits off again		5
6	Limestone, marly, and marls filled with Myalinas	4	0
5	Limestone, hard, blue, rectangular slabs, 7 to 10 ft. long, and 15 in. to 6 or 8 ft. wide	1	0
4	Limestone, marly, blue, very fossiliferous	3	6
3	Concealed	2	6
2	Limestone, blue-gray, in about eight layers	2	11
1	Limestone, hard, blue, fine-grained, in deeper river bed	1	4

The whole section from number 17 down is here swept clean by the river. Nearly all the beds are fossiliferous, some of them extremely so, and the section is an excellent one to collect from.

The next rocks above these are those exposed below the wagon bridge across Elm Creek on the southeast side of Ballinger.

Over the limestone exposed in Elm Creek comes the rest of the Ballinger section. This whole section is given below.

Section at Ballinger

			Feet	Inches
157	31	Limestone in large blocks	1	6
157	30	Concealed	2±	
157	29	Limestone, hard, yellowish to drab, made up of ground fossils		8
156	28	Shale, marly, concretionary, weathers yellowish	7±	
156	27	Limestone, coarse, blue-gray, made up of ground fossils		6
156	26	Marl, hard, knotty	1	8
156	25	Limestone, earthy, unevenly textured, gray, weathers into three layers, composed of ground fossils, 9 inches to 1 foot		9
156	24	Marl, blue, argillaceous, many fossils, harder parts change into firm limestone in short distance	1	6
155	23	Limestone, four to seven courses, the uppermost is best defined; 13 inches thick. Though blue-gray within, they soon weather to a pleasing buff and make excellent building stone	3	8
155	22	Limestone flags, two beds, lower one 5 inches thick, upper one 8 inches thick, lower one quite coarsely fossiliferous, upper one somewhat less so; buff, unevenly textured, slabs 4 feet by 4 feet to 8 feet by 10 feet	1	1
154	21	Marls, hard, shaly, fossiliferous		10
154	20	Limestone, blue, weathers buff, lower 6 inches is bituminous, splits off and is not used for building purposes. Upper part somewhat crystalline, fossil fragments in fine earthy matrix, all vertically jointed in 2- to 6-foot blocks; good building stone	2	0
154	19	Limestone flag, coarse, slightly uneven surface, composed of fossil fragments		5
153	18	Marl and shale, blue when fresh, base much firmer than upper part, top laminated, all might well be interpreted "limestone" in drill record	2	11
153	17	Limestone, blue, earthy, fine-grained with fossil fragments, very evenly bedded, and jointed in fair-sized blocks	1	0
152	16	Shale, green	10	0
152	15	Limestone, very soft and earthy, would not show on gentle slope	2	6

			Feet	Inches
152	14	Shale, greenish	2	0
152	13	Limestone, very soft and earthy, would not show in old exposure	1	3
152	12	Shale, blue-green with 1 foot nodular limestone about 4 feet above the base	15	0
151	11	Limestone in five beds, weathers into large nodules, lower bed about 8 inches thick, hard, finer-grained than the others	2	6
151	10	Shale, blue, with nodules of limestone, very fossiliferous, many Composita, Bryozoa, etc.	2	0
151	9	Limestone, compact, firm, mottled drab and yellowish and somewhat iron-stained	1+	
150	8	Concealed	15±	
150	7	Marls, firm, and soft limestone, varying to a sort of conglomerate	1	6
149	6	Limestones with marl partings	1	8
149	5	Shales, marls, and marly limestones	2	3
149	4	Limestone, shaly, fragments of fossils with coarse marls in upper part	2	7
149	3	Limestone, massive	3	6
149	2	Limestone and shale	1	6
149	1	Limestone, hard, massive, in creek bed	1	8

Numbers 1 to 7 are the limestones exposed in Elm Creek below the wagon bridge. Numbers 8 to 16 represent the shales between the beds in Elm Creek and the limestones in the bluffs and quarries in Ballinger. The remainder of the top of the section constitutes the limestones in Ballinger and those exposed in Elm Creek at the Upper Dam.

Between the Ballinger section and the Los Arroyo section, the following beds seem to be interpolated:

		Feet	Inches
158	Concealed, with limestone at top, exposed in road north of Ballinger	5+	
158	Concealed, with limestone at top, exposed in road north of Ballinger	18	0

Luders Formation

Over the top of the Paintrock formation is a series of rocks with a larger proportion of shale and marly impure limestones, which weather down rather easily, except in the upper part

which is formed by the Ballinger limestones. The shales below these limestones are frequently marly and very fossiliferous; in fact, they are coarse fossil conglomerates, made up mainly of Myalinas and other pelecypods with many gastropods and Bryozoa. The limestones at Ballinger are quite fossiliferous, and the beds are relatively thick and massive, and most of them are buff. The Lueders formation is here regarded as beginning with number *142* and extending to the top of number *158* of the general section. As thus defined it has a thickness of 194 feet. It is uncertain how the Lueders formation as used here will check out with the section at Lueders, but according to Wrather, they are in general equivalent.* The Lueders formation as a whole naturally breaks into an upper and a lower part with rather distinct characteristics, and further study may necessitate its subdivision.

Los Arroyo Section

A. Section beginning in river bed at east end of bluff east of the mouth of Los Arroyo

			Feet	Inches
159	14	Limestone, dirty dark-brown, some marls below	2	6
159	13	Limestone, flaggy	1	0
159	12	Marls and thin soft limestone	2	0
159	11	Limestone, soft, gray		7
159	10	Marls, blue to gray	1	6
159	9	Limestone, soft, earthy, dirty gray, weathers to rounded blocks	2	0
159	8	Concealed	3	0
159	7	Limestone beds, very thin, platy or shaly, top filled with Pleurophorus	2	8
159	6	Limestone, soft, earthy, buff, 9 inches; rotten, brown, 1 foot to 1 foot 4 inches	2	0
159	5	Limestone, hard, blue, fossiliferous, texture uneven, two beds		8
159	4	Marls and shales	1	3
159	3	Limestone, shaly, fossiliferous	1	6
159	2	Concealed	20	0
	1	Limestone, hard, buff-gray, large fossils	1	6

*Notes on the Texas Permian. Bull. S. W. Assn. Pet. Geol., 1917, p. 94.

B. Section in river bed below the mouth of Los Arroyo

			Feet	Inches
163	14	Limestone and marls, Productus horizon....	2	0
162	13	Marls, crusty, and some limestone and shale	6	0
161	12	Limestone, pink in some places, 2 inches to		4
161	11	Marl, hard, concretionary.....		6
161	10	Marls, with marly limestone, drab, at top...	5	0
161	9	Limestone, drab, irregular.....		6
160	8	Concealed	8	0
159	7	Marl, ashy.....		7
159	6	Limestone, laminated, firmer than the rest, large blocks, parts of it filled with Pleurophorus casts.....	1	6
159	5	Limestone, thin-bedded, gray, locally sun-cracked, cracks filled with blue stuff, top of bed covered with Pleurophorous casts..	1	8
159	4	Concealed	1±	
159	3	Limestone, blue, shaly, micro fauna.....		8
159	2	Concealed	1	0
159	1	Limestone, shaly, earthy, blue-gray.....		6

C. Section at Los Arroyo from creek beneath the bridge to the top of the limestone in river bluff one-half mile southwest

			Feet	Inches
167	8	Shale with thin sheets of limestone one-eighth inch to three inches thick, and some crystalline, cellular limestone.....	7	6
166	7	Limestone in two beds aggregating 11 inches in thickness, with shales and marls between them, makes an escarpment locally on account of the firm hard upper ledge which weathers in small angular blocks, somewhat crystalline; Spirorbis.....	3	0
166	6	Shales, blue, weather olive, and thin sheets of limestone an inch to 6 inches thick which are dark buff to pink. Somewhat fossiliferous, base of lower limestone forming gentle terrace. Gypsum bed near base	16	5
164	5	Limestone, firm ledge.....		9
164	4	Shale, blue, weathers olive, little rotten limestone	7	0
	3	Shale, blue with 16 inches rotten limestone. Productus	5	0
	2	Limestone, black shale and marly material..	1	6
	1	Concealed in creek bed.....	1	0

Transferring to the river bluff, the limestone and higher beds are seen.

			Feet	Inches
169	4	Limestone, soft, earthy		4
169	3	Crystalline, cellular limestone	2	2
169	2	Shale, with little limestone in lowest part	7	0
168	1	Limestone, many beds of firmer and softer earthy limestone and marl streaks. Micro fauna, Productus, and other fossils. The full thickness of the limestone is shown at little waterfall by a house	11	6

Section of rocks in bed of river east of the James' house

			Feet	Inches
	4	Limestones which weather shaly and platy, blue-gray	1	4
	3	Limestone, flaggy, and marls	3	2
	2	Marls and shaly limestones, blue, fossiliferous, some gypsum	1	6±
165	1	Gypsum, massive, from 1 to 3 feet thick	1±	

In places, the limestone over this ledge of gypsum becomes quite firm. This seems to be the case in the wells near Rowena.

Section of the Valley Creek Bluff (Waite)

			Feet	Inches
172	24	Limestone in three beds, flaggy, rather coarse-grained, blotched, weathers into uneven small blocks; one 8-inch bed of greenish-gray limestone, ocherized fossils, forms pillar-like blocks, weathers brownish	1	10
172	23	Shale, blue	5+	
172	22	Limestone, light gray, fine-grained, two beds, uneven surface		6
172	21	Shale, blue	6+	
172	20	Limestone, cellular, crystalline, marly	1	1
172	19	Limestone, softer, weathers nodular	1	2
172	18	Limestone, persistent bed, light-gray, fossils turned to ochre, large flags, 6 feet across, has been quarried		8
172	17	Shale and limestone	3	0
172	16	Shale with 3 or 4 inches of limestone near top that weathers brown, very hard, fossil-		

			Feet	Inches
		iferous; another bed above it is cobble-like limestone, not quite so hard but otherwise like first bed	5±	
172	15	Limestone, weathers to plates and flags		5
172	14	Shale	4±	
172	13	Limestone, upper part crystalline		8
171	12	Shales, marls and thin beds of limestones (mostly red and green shales)	25±	
171	11	Limestone, rather hard, mottled yellow and blue, weathers to flags 2 by 3 feet and smaller pieces		8
171	10	Shale and marl, olive-green, with several layers of nodular and flaky limestone	17±	
170	9	Limestone, softer and coarser than Number 7, almost flaky after weathering		8
170	8	Shale, blue-green	5±	
170	7	Limestone, fine-grained, weathers into nodules		9
170	6	Shale, blue-green	5	0
170	5	Limestone, two beds, upper one 7 inches		10
170	4	Marl or shale, probably blue-gray	3	0
170	3	Limestone, blocks with rounded edges		5
170	2	Limestone, rotten, and shale	2	7
169	1	Concealed	35±	

Approximate Section up face of bluff at Ferguson's Ford

			Feet	Inches
172	8	Limestone, weathers to dirty buff shade, flesh-gray within, crystalline, rather fine-grained		10
172	7	Concealed	10	0
172	6	Limestone, dark buff, massive, gray to buff within	1	3
172	5	Concealed. (Around hill, shows olive shale)	6	0
172	4	Limestone, platy, blue-gray		6
172	3	Shale, bluish	5	0
172	2	Limestone, three layers, crystalline stuff on top, gray to buff	1	10
172	1	Concealed from river bed to Number 2	25	0

According to Waite, number 2 of this section would be number 25 of his section of Valley Creek Bluff.

Arroyo Formation

The term Arroyo formation is given to a series of limestones, marls, shales, and gypsum (numbers *159* to *172* of the general

section, with a thickness of about 260 feet) occurring on and near Los Arroyo, two and a quarter miles west of Ballinger. It is apparently the same set of rocks to which Wrather applied the term Abilene formation* in Taylor County, but that name had already been used for other formations and Arroyo is substituted for it. The correlation of the upper part of the formation with the limestone at the standpipe at Abilene was substantiated by Mr. W. A. Riney. The rocks of this formation differ considerably from those below. All of them are irresistant, except the highest ones, and have a very limited fauna, the conspicuous species belonging to Productus, Eumicrotus, and a few other pelecypods. The highest occurrence of a small Composita is recorded in these beds. The limestones are soft and change to marls and back again if traced for any considerable distance. There is one persistent gypsum bed in the lower part of the formation, and some of the shales are red. The limestones at the top of the formation are more persistent than those below. This formation is tentatively placed at the top of the Wichita stage.

The quantity of calcareous material in this formation diminishes toward the north so that in Taylor County there is much less limestone and more shale in the section. If the Coleman Junction bed is used as its base, and the Arroyo formation for its top, the thickness of the Wichita stage is 1690 feet on the Colorado River. Less than twenty feet of sandstones are recorded in the whole thickness of the formation and only ten of them are in Runnels County!

The Clear Fork Stage

Section at the Smith place on Bull Hollow

			Feet	Inches
174	15	Shales with cellular, crystalline limestone, and thin nodular limestones	5	0
174	14	Limestone, massive	1	0
174	13	Shales, crystalline, cellular, limestone, and thin limestone	10—	0
174	12	Limestone, three beds with two beds of marls containing nodules. Limestones gray, weathering nearly white, upper one buff on top	3	6

*Section accompanying the article previously mentioned.

			Feet	Inches
174	11	Crystalline limestone, yellow	1	3
174	10	Limestone, massive, gray		10
174	9	Concealed	5	0
174	8	Limestone, gray		10
174	7	Shales, blue to gray, calcareous, fossils	1	6
174	6	Limestone, thin-bedded, somewhat laminated, crystalline material below	1	3
174	5	Shale, blue-green, to base of limestone above	5+	
174	4	Shales, greenish to blue with three or four streaks of impure limestone	3	6
174	3	Limestone, light gray, base shaling up considerably, thins locally to 10 inches and crystalline material replaces the basal part	1	3
174	2	Shales, green and gray, with soft nodular limestone	4	0
173	1	Red shales from top of Ferguson's Ford section to base of this section, exposed on both sides of the river	150+	

Vale Formation

Wrather places his Tye formation which corresponds to number 1 of this section, in the Clear Fork Stage.* The name Tye formation was used for an igneous formation on the Pacific Coast, and Tye for a sedimentary formation. In view of these facts, it is well to use another term to designate the beds under consideration. This is unfortunate, but there seems to be no help for it. The term Vale is proposed for it, which is the name of an old post-office on the Ballinger-Maverick road on the east side of Valley Creek, in Runnels County. So far as seen, the whole formation in Runnels County is shale, some of it quite sandy, 154 feet thick, the thickness being estimated. In Taylor County, along the Texas and Pacific Railway, it has, according to Wrather, a thickness of 340 feet. The Vale formation is number *173* of the general section.

Bullwagon Formation

The Bullwagon dolomite was named by Wrather, in the article mentioned, from its outcrop on Bull Wagon Creek. West of Abilene it is composed of two layers and has a thickness of

*Bull. S. W. Assn. of Petro. Geol., 1917. Section.

five feet with a three foot shale parting. On the Colorado River it is 36 feet thick and is represented by a number of thin dolomites and blue shales. It is number *171* of the general section. It was provisionally correlated with the Taylor County section by Mr. Rincy. Since the whole northern part of the outcrop of the Bullwagon dolomite in Runnels County is concealed beneath an extensive deposit of surface conglomerate, the actual correlation of this bed with Taylor County beds is provisional.

Sections of bluffs and hills west of the Smith Place, on the south side of the river

			Feet	Inches
182	23	Dolomite, thin layer. On river, 8 feet shale and 8 inches dolomite above this layer....		4
182	22	Shale, and concealed material.....	4	0
182	21	Dolomite, two layers, main layer rough and soft	1	3
181	20	Shale, red.....	35	0
180	19	Shale, red with 6 ins. gray to pink dolomite	6	6
180	18	Dolomite, buff, gray, or pink, locally.....		6
180	17	Shale, red.....	6	0
180	16	Dolomite, lower weathers smooth, upper one rough	1	8
180	15	Shales, red, somewhat sandy, 1 foot gray shale at top.....	2±	
180	14	Dolomite	1	2
180	13	Interval, thin limestone in middle.....	4	0
180	12	Dolomite, blocky.....	1	3
180	11	Dolomite, thin-bedded, 2 feet 6 inches to...	3	0
179	10	Shale, red, dolomite lens with ammonoids 3 feet above base.....	45±	
178	9	Dolomite, rotten.....	1	0
178	8	Dolomite, gray 6 inches, pink 1 foot.....	1	6
178	7	Shale, and thin gray dolomite.....	6	0
178	6	Dolomite, ash-gray, geodes, with 6-inch shales and dolomite below.....	2	6
177	5	Shale, red and green.....	8	0
177	4	Shale, red.....	35	0
177	3	Shale, green band at top with green streaks	6	0
176	2	Shale, red, three small lenses of sandstone, and layer with pink gypsum with darker pink crystals in large lumps and sheets; probably is remainder of a large bed of the material	20	0

			Feet	Inches
175	1	Concealed from top of Smith place (Bullwagon dolomite)	85±	

Section at Choza Mountain, Coke County

186	10	Dolomite, rough, two layers	2	0
186	9	Concealed	5	0
186	8	Dolomite, breaking into small pieces		6
186	7	Concealed	4	0
186	6	Interval, some thin limestones	2	4
186	5	Dolomite, two layers 15 inches apart	2	8
185	4	Shale, red, and concealed	43	0
184	3	Dolomite, two to four layers, Nautiloid	2	0
183	2	Shale, red, with few green streaks and thin sheets of dolomite	35	0
183	1	Concealed from Mule Creek	80±	

Choza Formation

The Choza formation is named from Choza Mountain, near Tennyson, Coke County. It is barely across the Runnels County line. It includes the rocks from the top of the Bullwagon dolomite of the Vale formation to the San Angelo beds of Lerch. It consists of a series of red shales separated by groups of thin dolomite beds, some of which are fossiliferous.

With the exception of the Merkel dolomite which Wrather has traced nearly to the Red River, these dolomites all disappear before reaching the Texas and Pacific Railway in Taylor County, and their position is occupied by shales. The highest dolomite in this formation is the Merkel dolomite of Wrather, correlated by Mr. Riney, with the Taylor County locality. The thickness of the whole formation on the Colorado River is about 870 feet.

There are 270 feet of shales with thin sheets of dolomitic limestone above top of the Merkel dolomite.

The Double Mountain Stage

At Margaret Peak, still higher rocks are seen which outcrop in the northwest corner of Runnels County. Roughly, they are as follows:

			Feet	Inches
189	3	Red Shale	45	0
188	2	Sandstone and coarse quartz conglomerate	130±	
187	1	Shales, red and concealed to top of Merkel dolomite as shown at Choza Mountain, 50 feet to	200±	

San Angelo Formation

In his section of the Permian rocks from Abilene to Sweetwater, Wrather used the Merkel dolomite as the top of the Clear Fork beds. This is probably near to the limit fixed by Cummins for this series. The San Angelo conglomerate and sandstone, over a hundred and seventy-five feet thick on the Colorado River, is heavily conglomeratic with large polished quartz pebbles two to five inches in diameter, showing a very radical change in conditions of deposition.

On account of the radical change in the condition of deposition the San Angelo beds are here regarded as the base of the Double Mountain stage.

THE COMANCHEAN

Rocks of the Comanchean system, or Comanchean division of the Cretaceous system, occupy a very small area in the northwestern part of the county and a considerably larger area in the northeastern part. These rocks, composed of sandstones, limestones, and marls, probably have an aggregate thickness of 185 feet or more. They form the "mountains" of the two northern corners of the county, and are the remnants of the former existence over the whole area of the county of these Comanchean beds, nearly all of which have now been removed by erosion. Two sections of these rocks are given, as follows:

Section of Cretaceous rocks in the southeast corner of Table Gap Mountain

		Feet	Inches
27	Limestone, similar to the one below, in two beds	4±	
26	Limestone, massive, fine-grained, cream-colored, single bed, hard, few fossils	4	8

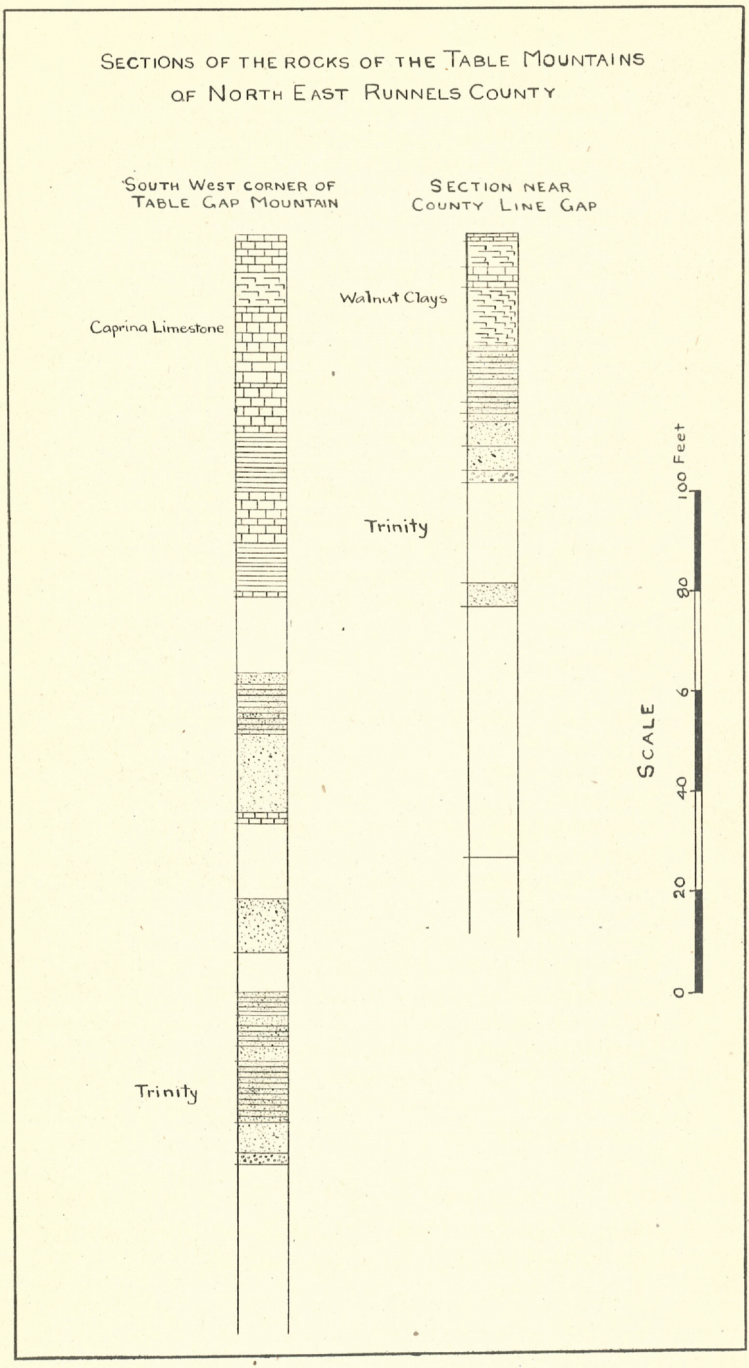
SECTIONS OF THE ROCKS OF THE TABLE MOUNTAINS
OF NORTH EAST RUNNELS COUNTY
SOUTH WEST CORNER OF
TABLE GAP MOUNTAIN
SECTION NEAR
COUNTY LINE GAP
Caprina Limestone
Walnut Clays
Trinity
Trinity
SCALE
0
20
40
60
80
100 Feet

Plate IV

		Feet	Inches
25	Marls, largely amorphous, ashen, few fossils, grades into Number 26	6	6
24	Limestone, massive, single bed, very fossiliferous, with large fossils. Top two feet literally a mass of fossils	9	0
23	Limestone, hard, massive bed, fine-grained, even-textured, creamy white, weathers gray, grades into bed below	6	0
22	Limestone conglomerate apparently composed of cylindrical sponges, or Algae?		7
21	Limestone, coarse fossil conglomerate with Caprina and other large fossils	8+	
20	Limestone, firmer	2	0
19	Marls, filled with Exogyra texana and other fossils. Beds rather coarse-grained, buff	11	0
18	Limestone, massive, weathering into nodules. Seems to be composed of small ellipsoidal masses a few inches across	10	0
17	Shales. Slope literally covered with fossils	10	0
16	Conglomerate of Gryphaea shells. Yellowish		4
15	Concealed	15	0
14	Sandstone, apparently yellowish	2	0
13	Shales, very sandy, or shaly sandstone	10±	
12	Sandstone, massive, cross-bedded, friable, yellowish	16	0
11	Sandstone, very calcareous, white	2	0
10	Concealed	15	0
9	Sand, light gray, weathers to pale buff shade	10	0
8	Concealed	8	0
7	Sandstone, shaly, and sandy shale, some of it pink	5	0
6	Sandstone, cross-bedded	2	0
5	Shale, sandy buff to purplish	4	0
4	Sandstone, gray, minutely concretionary	3	0
3	Clay, red, sandy	12	0
2	Sandstone, clean, nearly white, friable	6	0
1	Conglomerate, rather coarse, composed of thoroughly rounded red and white quartz pebbles, and some black ones	2	0

The Permian beds appeared a short distance below this bed. It is not improbable that there is a little sandstone below the conglomerate before the red beds are reached.

Section of a low mountain near County Line Gap

		Feet	Inches
12	Limestone, hard, irregular-textured, weathers craggy. A remnant of a thicker bed..	1	8
11	Marls, cream-colored to white (possibly a disintegrated limestone), fossiliferous....	5	0
10	Limestone, weathers into nodules, occasional geode	4	0
9	Partly concealed, partly coarse, rotten, sandy limestone, buff.....	17±	
8	Sandstone, buff.....		4
7	Sandy clay, weathering buff.....	11	0
6	Clay, pinkish, quite sandy.....	2	0
5	Sand, yellowish.....	2	0
4	Sandstone, rather coherent, clean, white....	5	0
3	Conglomerate, quartz, red and white and black pebbles.....	2	0
2	Sandstone, massive, cross-bedded, nearly white	5	0
1	Concealed	25	0
0	Sandstone and sand, light buff.....	5±	

The highest red beds or Permian rocks seen were about fifty-five feet below this exposure. They probably reach within a few feet of the lowest sandstone.

THE PLEISTOCENE

Very little attention could be given to the study of the Pleistocene and possible late Tertiary deposits of the county. There are the usual silts, sands, and gravels in the valleys of the present creeks and larger streams, and there are remnants of earlier fluviatile deposits left in some places on more elevated tracts of land, such as gravel and sand. These will readily be noted by local students and may, perhaps, be better understood after more extensive observations have been made in this and adjacent parts of the State.

ECONOMIC GEOLOGY

The geologic resources of present value in Runnels County are confined to the non-metallic products. They are sand, clay, gypsum, structural stone, lime, road metal, oil, and gas. Under

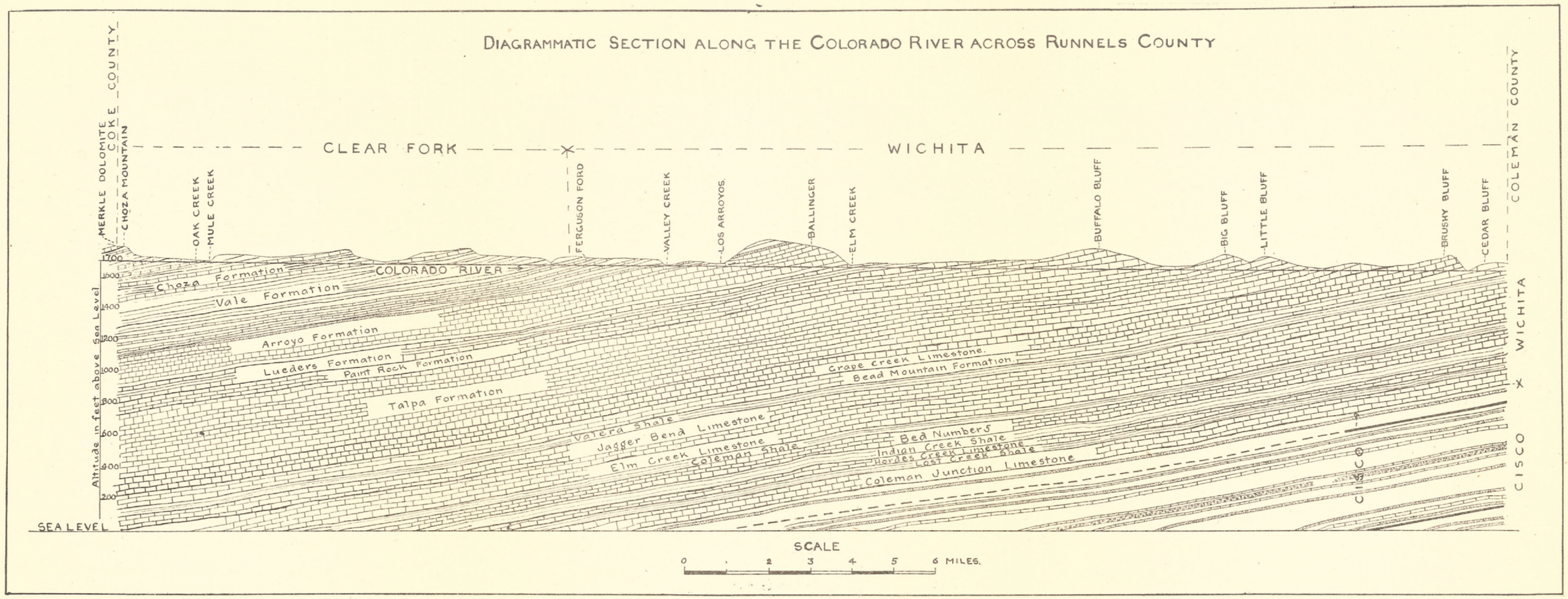
DIAGRAMMATIC SECTION ALONG THE COLORADO RIVER ACROSS RUNNELS COUNTY
CLEAR FORK
WICHITA
MERKLE DOLOMITE
COKE COUNTY
CHOZA MOUNTAIN
OAK CREEK
MULE CREEK
FERGUSON FORD
VALLEY CREEK
LOS ARROYOS
BALLINGER
ELM CREEK
BUFFALO BLUFF
BIG BLUFF
LITTLE BLUFF
BRUSHY BLUFF
CEDAR BLUFF
COLEMAN COUNTY
COLORADO RIVER
Choza Formation
Vale Formation
Arroyo Formation
Lueders Formation
Paint Rock Formation
Talpa Formation
Vaterá Shale
Jagger Bend Limestone
Elm Creek Limestone
Coleman Shale
Grape Creek Limestone
Bead Mountain Formation
Bed Numbers
Indian Creek Shale
Hordes Creek Limestone
Lost Creek Shale
Coleman Junction Limestone
CISCO
WICHITA
Altitude in feet above Sea Level
1600
1400
1200
1000
800
600
400
200
SEA LEVEL
SCALE
0 1 2 3 4 5 6 MILES.

Plate II

favorable conditions a number of these may be utilized locally and some of them in a broader way.

SAND

There are three sources of sand in Runnels County. First, the river sand of the Colorado River, as at Ferguson's Ford, Ballinger and numerous other places. This is readily obtainable without considerable excavation. Second, older river sands on the high terraces, such as south of Ballinger in the Spring Hill region, and between Maverick and the river. These beds are easily accessible and relatively clean. They also make favorable fruit lands and serve as reservoirs for potable water. Third, the sands at the bases of the "mountains." These Trinity sands are thick and clean, save for some lime and iron. There are doubtless places where sand sufficiently pure for glass-sand may be found in deposits thick enough to be profitably worked. Some calcareous (limy) cement in the sand would not spoil it for that purpose. In case cheap fuel develops, it may pay to examine these deposits more closely.

CLAY

Clay is not abundant in Runnels County except in the western part, where beds of red clay may be found from which brick and tile can be made. In the eastern part of the county most of the shale beds between the limestone are thin, and they are frequently quite limy. Perhaps the best shales available are to be found on the west side of Elm Creek near the railroad junction in Ballinger and the same beds in the bluff south of the causeway.

One of the citizens of Ballinger called attention to a deposit of Fuller's earth about three and a half miles from Ballinger on the Maverick Road. This deposit was not sufficiently opened up to demonstrate its commercial importance. Considerable excavation will be necessary in order to do this.

GYPSUM

One bed of gypsum of considerable extent occurs just west of Ballinger. It is exposed in the Colorado River bed east of

Mr. James' house, is recorded in wells about Rowena, and is found in the bluffs west of Hatchell. Should cheap fuel from natural gas or crude oil be available, it might be possible to find places where this bed is of sufficient thickness to be mined and calcined for plaster of Paris, and cement plasters.

LIMESTONE AND DOLOMITE

One of the valuable resources of the county is its limestones, which are excellent building material, easily accessible, durable, and of pleasing color. The buildings in Ballinger are excellent proof of their utility and attractiveness. The best and most accessible beds are found in the upper Lueders formation from which stone is quarried in Ballinger and near it. They extend from the vicinity of Olfen to Oxien and the county line southeast of the Mud Creek school. These beds are well located geographically with respect to transportation and the more densely inhabited part of the county. The thickness and character of the beds are given in the description of the Ballinger section in the preceding pages of this report. The rich buff shade of the stone, the large blocks in which it occurs, its firmness and durability combine to make it a stone of unusual quality. The spalls may be burned into lime.

Other limestones well suited to domestic use are well distributed over the county, especially along the river and the creeks; and the harder limestones of the mountains are of especial value for lime.

One of the great values of limestone and sandstone for building purposes is that they may be quarried at times when farm or ranch work is least pressing, and accumulated until a sufficient amount is at hand in large-sized blocks, to build a good house, barn, or other building. Excellent houses may be constructed in this way with hardly any cash outlay for the basement and walls of the building. These houses, when properly built, are cool in summer and warm in winter, extremely durable, and may be made very attractive in appearance. Three things are always necessary to secure satisfactory results: First, well selected blocks of sufficient size, especially allowing length for considerable overlap in breaking joints; second, a wide, firm

foundation, preferably of concrete, well sunk, to prevent all settling; and third, proper masonry in laying up the walls. Unfirm foundations are the most common cause of the cracking of stone houses and barns. There must be no settling. Another cause which is almost as common is the use of too small pieces of stone and the improper laying of them. Small stones of all sorts may be used with very pleasing and durable results if laid in Portland cement mortar. Dirty sand in the mortar will cause any cement structure to crumble.

ROAD METAL

The firm limestones of the southeastern part of the county and the harder dolomites of the western part, when crushed and properly laid and compacted, make good roads. This stone is easily available in the portion of the county where it occurs. The white Comanchean rocks of the mountains are of little value for road purposes on account of their softness.

The best road material of the county is the conglomerate ("concrete") which occurs along the Colorado River and larger creeks. These beds are found from 40 to 100 feet above the streams and occasionally nearly down to stream level. They usually have a reddish appearance from the iron with which the gravel is partially cemented together. Where this material is used the best roads of the county are found. A third source of road material is the loose gravel found along the river and the larger streams. The larger pebbles should be screened out and the addition of a little clay for binder is a material improvement.

OIL AND GAS

At the time of this writing no well has been drilled within the county which has produced oil or gas in commercial quantities, though at least two such wells may come in some time before this bulletin is off the press. No deep test has been drilled. On account of the lack of deep wells in the immediate vicinity, with accurate logs available, it is impossible to make a safe forecast of the conditions which will be encountered in the deeper strata.

Surface Structure

The dip of the surface rocks of the county is low and in a northwesterly direction. North of the Colorado River in the eastern part of the county the dip seems to have a stronger northern component than over the rest of the county. South of the river the map shows a stronger western component than north of it. It may be that this is in part due to the more rapid rise of the surface of the ground north of the river, but it seems to throw the river along the crest of a very low, broad structure. Plane-tabling the outcrops will determine whether this is a fact or an appearance.

The county was not examined to find structures, though three have been worked out, and conditions indicate that there are probably several others.

One of the first things to be noted is that the local dips are veering and inconstant and that exposures over a considerable area have to be worked out to determine the true trend of the dips. When continuous exposures are available the matter is simple enough. One other precaution is necessary in determining the structures in the southeastern part of the county. The section there is nearly all limestone of varying texture and of varying resistance to each of the numerous agents of weathering; so that on a south slope certain beds weather back, producing slopes resembling those formed by shale beds, and others stand out rather prominently. In following the salient beds around an east or west prominence, it is sometimes found that the scarp becomes dim for a little distance and then resumes its prominence again; and the same thing may occur on rounding to a north slope. It will frequently be found that the ledge followed on the south slope is a different one from that on the west and that one still different forms the terrace on the north side of the hill or ravine, though they may have almost identical appearances. It was found necessary in some cases, and safe in all, to carefully walk every foot of the outcrop to avoid stepping up or down stratigraphically. Since dips are low and closures slight, when present, it may be an easy matter to get a closure where none exists or to miss one when present if care is not taken by the rodman in following the beds.

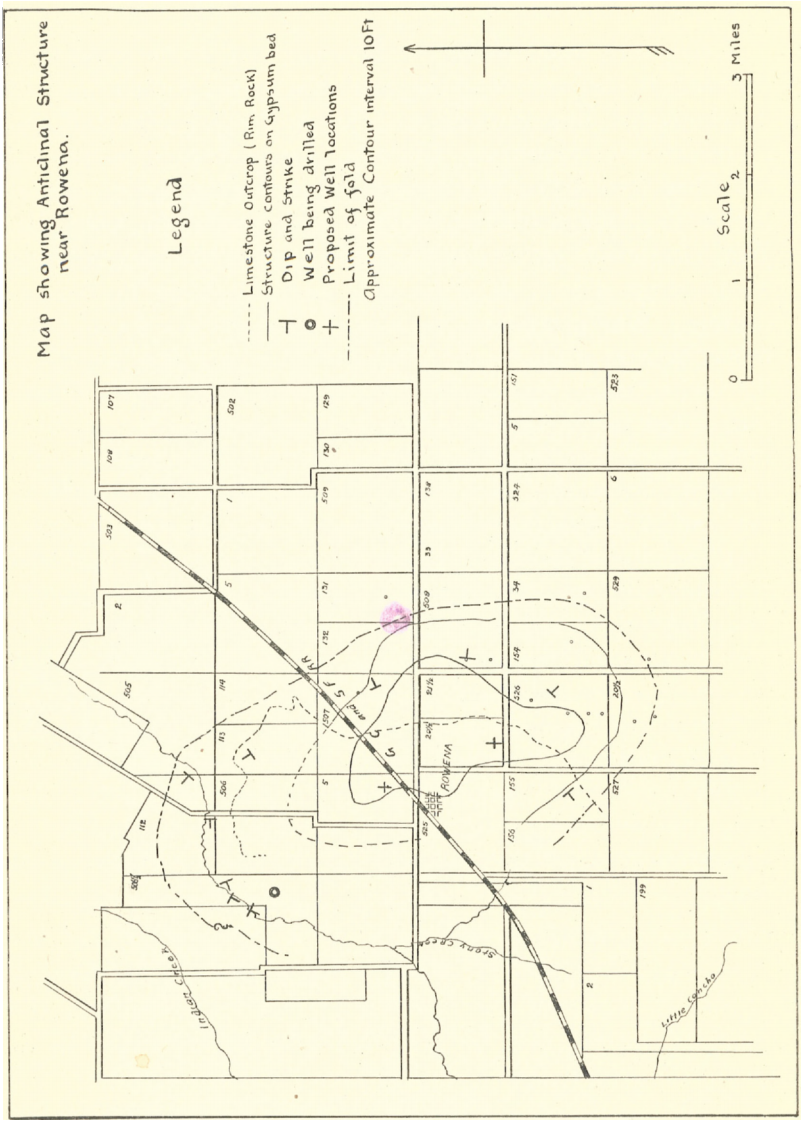

Figure 1.

The steep dips shown on the surface are just northwest of the well.

Observed Structures

A structure was observed at Rowena, that seems to be well-defined. It is closed off on the northwest by the normal dip, and in places by dips running as high as 2° 30′. On the east there are few exposures. However, a considerable number of wells has been drilled in the past few years in the flats east of the town. An examination of these wells in company with Mr. Wm. Halamicek revealed a uniformity of depth and a gypsum water that seemed to make the evidence furnished by the borings reliable. Where accurate data were available, the water was found beneath a limestone. This, together with the geology of the region, made it probable that the wells penetrated the gypsum shown in the Colorado River at the James place (number 165 of the general section). This gypsum bed extends beneath Rowena. From this data, we deduce that there is a closure on the east. The general outline of the field is shown on the map.

In the city of Ballinger, and west of it, is a well-defined fold of a different type. It is a nose with steep northwest and southwest dips which nearly close just northeast of the concrete bridge over the river on Seventh street. A sketch of the outline of this field is shown on the map.

Another fold occurs on Gap Creek, below the mouth of Long Branch, southeast of Winters. It is somewhat similar to the one at Rowena, but has the closure on the east visible. The northwest side has not been defined, but is closed off by the normal dip as observed some distance away. Its outline is sketched on the map.

Sub-surface Geology

The rocks to be penetrated by the drill at the various localities mentioned, based on the thickness of their outcrop along the Colorado, farther east, as worked out by Drake, would be as follows:

Locality	Depth to Top of the Cisco	Depth to Top of the Canyon	Depth to Top of the Bend
	Feet	Feet	Feet
Rowena	1600	2560	3220
Ballinger	1350	2300	2850
Winters	1500	2460	3120
Russell well	700	1660	2310

VERTICAL SECTION OF SURFACE EXPOSURES OF THE ROCKS OF THE COLORADO RIVER SECTION IN RUNNELS COUNTY

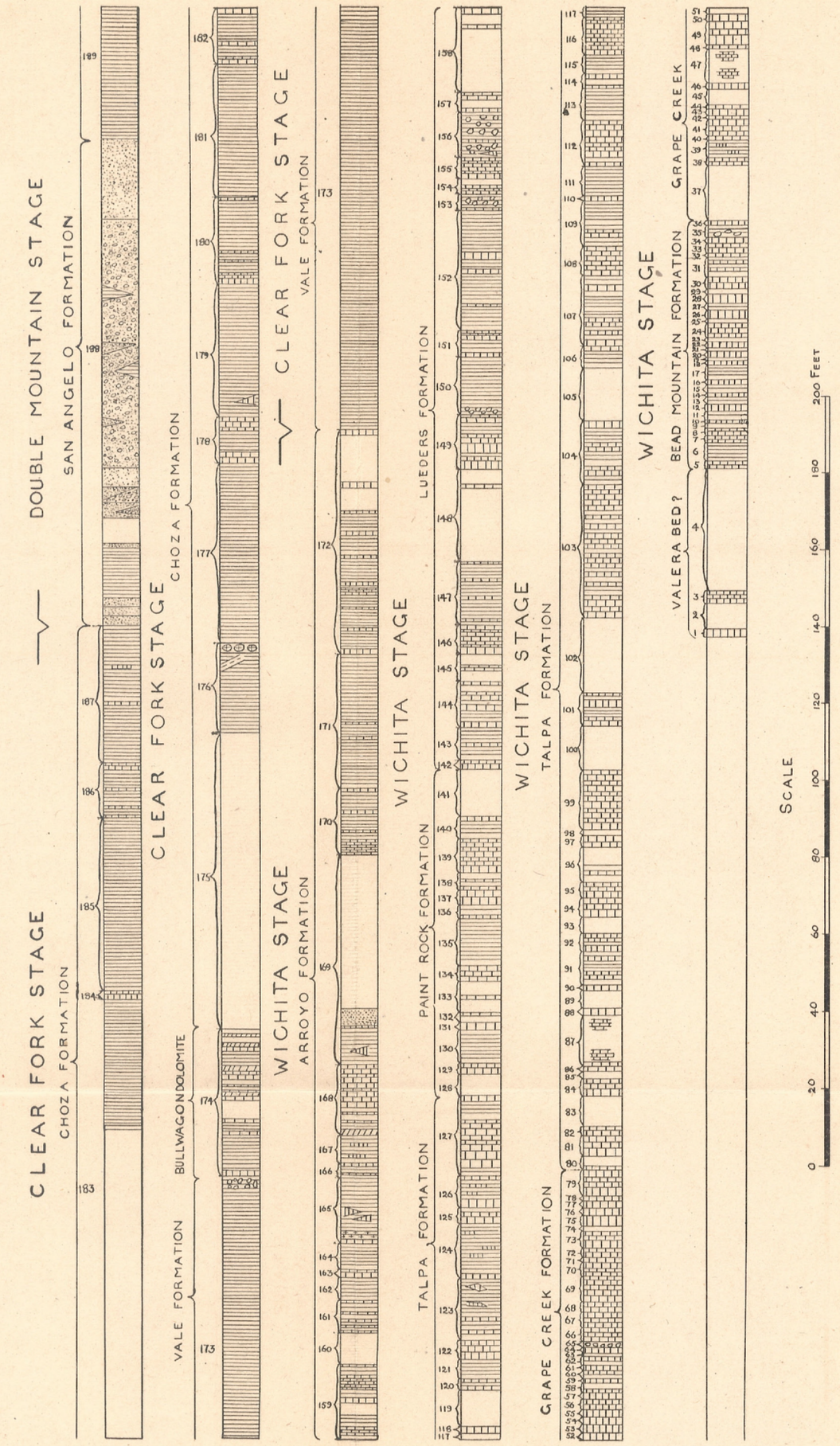

Plate III

These figures are approximations, based upon the thickness of the exposed beds farther east, and may be either too small or too large. They also take it for granted that the Strawn formation is absent below Runnels County, which seems probable, but which has not been demonstrated. If the Strawn is present, it will increase the depth to the Bend by whatever thickness it may have. It may require as much as a thousand feet of drilling to penetrate the whole thickness of the Bend, if it is present. The Bend formation is one of the most important oil-bearing formations in Texas. Both the Cisco and the Canyon may contain pay sands, but that any production is to be had from the rocks of the Wichita Stage in this county is nearly impossible, on account of the lack of porous layers within it, to serve as reservoirs for oil and gas.

However, in this connection it is necessary to take into account the fact that as the formations are traced southwest from their northeasternmost outcrop, sandstones pinch out, shales thin, and limestones set in and grow thicker. To what extent the rocks beneath Runnels County are made up of porous and impervious material remains to be determined by drilling. The porous beds are necessary for the collection of oil and gas in commercial quantities and to permit their free movement to the wells. For this reason the presence or absence of such beds is of vital importance to the future development of the oil resources. In this connection the fact should not be lost sight of that some of the large fields of the world are found in porous limestone.

COPPER

Copper in some of its forms has been found in the basal sands of the Comanchean formations which are represented in the mountains of northern Runnels County, and also in some of the shales of the Vale formation. These finds occur over a large part of West Texas, but in no case have commercial deposits been found. Some copper has been found in Runnels County, but here, as elsewhere, it will probably be found to be too sparingly disseminated to be worth working, even with the present high price of the product. While some very pure ore is to be found, in this case the economic importance rests more on the quantity of it per cubic yard of earth than upon its purity.

INDEX

CONTENTS

LIST OF ILLUSTRATIONS