University of Texas Bulletin
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By
Emil Böse

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

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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 CONDITIONS NEAR BRIDGEPORT AND CHICO, WISE COUNTY, TEXAS, WITH SPECIAL REFERENCE TO THE OCCURRENCE OF OIL*

BY

Emil Böse

INTRODUCTION

Very little is known about the geology of the surroundings of Bridgeport and Chico. The boundary line between the Cretaceous and the Carboniferous has been fixed, at least approximately and schematically, since a long time ago. We find this boundary marked, for example, in the well known map published

*The field work for the present paper was done by Dr. Bose as a private piece of work four years ago. It is due to the generosity and to the public-spirited attitude of Mr. W. H. John, of Bridgeport, Texas, now assistant District Representative of the U. S. Fuel Administration, that this report can be published at a time when our country is specially interested in the development of our natural resources, among which petroleum is especially important.

J. A. UDDEN.

Austin, Texas, July 2, 1918.

by R. T. Hill,[1] who probably utilizes in his work many observations of other authors.

Our knowledge of the development of the system of the Carboniferous in this region is nearly exclusively based on the observations of Cummins,[2] who visited the region described here, at the time of his studies on the Carboniferous in northwestern Texas. The most important result of Cummins's work is probably his observation of the line of outcrops of the coal vein to the west of the Cretaceous boundary line.

During my investigations made in the time from the 7th of July to the 18th of August, 1915, I found that the representation of the distribution of the Cretaceous system in the older maps is extremely schematic, and that especially the so-called Basal Conglomerate of the Cretaceous, and in part also the Basal Sands, extend much farther toward the west. The distribution of the Cretaceous is of a certain importance because in this region we can hope to find oil only in the Carboniferous system and the covering of these by the Cretaceous strata would render the interpretation of their tectonic structure more difficult, or even prevent it altogether. This is especially the case in those parts where the existence of extensive woods impedes the survey of the locality.

The non-existence of a topographic map is another obstacle for detailed investigation. The county map is absolutely insufficient for geological studies, because it does not show the configuration of the region, and the hydrographical system is not very well presented.

The determination of fossils cited in this report is only provisional. Apparently the fauna contains quite a number of new species and deserves a detailed study.

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[1]R. T. Hill, Geography and Geology of the Black and Grand Prairies, Texas. U. S. Geol. Surv. Ann. Report XXI, 1901.

[2]W. F. Cummins, Report on the Geology of Northwestern Texas, 2nd Ann. Report of Geol. Surv. of Texas, 1891.

TOPOGRAPHY OF THE REGION

The region studied by me belongs entirely to the hydrographical basin of the West Fork of the Trinity River, and in its larger part is situated to the west of the line of the Chicago and Rock Island Railway. Towards the east of this railway, an immensely thick covering of Cretaceous rocks hides the structure of the older strata.

The West Fork follows the strike of the strata only in part, and often crosses the strata at a right angle to their direction. The valley made by the river is generally several miles wide and filled up by alluvial matter and thus frequently interrupts the series of the older deposits. The present channel is rather narrow and deep, but it shows generally very few exposures of the Carboniferous rocks. The course of its principal tributary, the Big Creek, shows quite similar conditions. This creek, in a great part of its course, crosses the strata nearly at an angle of 90 degrees to their strike. Only in its lower part it follows more or less the direction of the strike. The conditions of the rest of the principal creeks—Hunt Creek and Ventioner Creek—are somewhat different. These follow nearly exactly the strike of the strata and thus form longitudinal valleys. But they also have deposited considerable masses of alluvial material, so that they render the interpretation of the structural conditions rather difficult.

The region studied by me shows three ranges of hills and between them, two tectonic valley systems. These ranges run in general parallel to the strike, i. e., in their greater length SW-NE, and in part also S-N.

On the eastern range, the town of Bridgeport is situated; towards the southwest the range is interrupted by the West Fork, but we find its continuation in the hills to the west and the south of the so called Martin Lake, which in reality is an abandoned channel of the West Fork. Farther towards the south a broad spur of the Cretaceous system hides the Carboniferous strata of this ridge and thus causes a broadening of the hilly country. In another part of this report we will have to refer to the details of these conditions.

To the west-southwest of Bridgeport, several lower hills lie west of this ridge. They are caused principally by the greater resistance of the stratum of limestone above the Bridgeport coal.

Towards the west of this ridge, we find a broad tectonic valley, crossed by the West Fork and thus separated in a southern and a northern part. This valley is bounded on the west by the second range of hills. This range begins at the south on the Waggoner ranch near the socalled ranch-house. Its direction approximates SW-NE, and the hill grows quickly in height and breadth. We shall call it the Rock Hill, a name that is really used only for the middle part. Farther to the northeast the range is interrupted by the gorge-like valley of the West Fork, but it continues on the other side of the river. Already in the northeastern part of the Rock Hill, we observe an indication of plateau formation and the range becomes generally broader. On the other side of the West Fork, the plateau becomes considerably broader and takes a triangular form. The eastern border of the ridge has here a NE-SW direction, while the western border has a nearly N-S course. Between both we find a broad tableland tapering towards the south and in its western part cut by the Village Creek. Later on we shall see that the formation of this tableland is occasioned by a change of the strike.

The eastern border of the ridge becomes lower and lower towards the northeast, till it becomes quite indistinct northeast of the Alvord crusher and finally is hidden by Cretaceous deposits.

We shall discuss the western border of this range in connection with the course of the depression west of it. This valley is traversed by different creeks and rivers. In the south, we find west of the Rock Hill the valley of the Hunt Creek, a depression about 2 miles broad, which shows in its bottom several small ranges of hills. This valley has a NE-SW direction to the point where the Hunt Creek, with its tributary, the Jasper Creek, empties in the West Fork, near the place where this river cuts off the Rock Hill towards the north. From here, the direction of the valley changes and becomes N-S, following thus the direction of the western border of the tableland mentioned above. The West Fork flows through this section of the valley. The river has in this part a N-S course, but changes its direction

farther upwards, near the mouth of the Big Creek, and from that place it cuts the strike of the strata in an approximately east and west direction. The tectonic depression described above continues farther to the north. For a short distance it becomes indistinct in consequence of the covering of Cretaceous strata, but farther on we see the same depression again in the valley of the Ventioner Creek, and its tributary, the Willow Creek, the eastern border of which represents the geological continuation of the western limit of the tableland. Farther to the north the depression disappears below a thick cover of Cretaceous deposits.

The western border of the depression described above, the valley of Hunt Creek, is formed by the steep slope of the Jim Ned Mountains. These descend gently towards the northwest where they form the border of a valley through part of which runs again the West Fork. We have seen that the upper course of the West Fork enters this depression in an east-west direction, cutting off the Jim Ned Mountains towards the north, and forming a broad valley. Its bottom is mostly formed by alluvial material and only a few hills rise from it. The geological continuation of the Jim Ned Mountains towards the north is represented by the range of the Sand Flats. This range is bounded in the west by the Big Creek and towards the north it is cut off by the upper course of the same creek. The continuation of the range in the northern direction is formed by a low hilly country to the west of the Ventioner Creek. Farther on, this is covered by Cretaceous strata, which increase more and more in thickness till at last the topographical character of the range disappears altogether. Towards the west the range of the Sand Flats is bounded by the steep but very low slope of a limestone tableland near the line of Jack County. This slope becomes more distinct towards the south, where it forms the northwestern border of the upper valley of the West Fork.

Having finished this short summary of the topographical elements of the region, we shall now describe the strata which compose it.

STRATIGRAPHICAL CONDITIONS

The region of Bridgeport is formed by strata that belong to two systems entirely different in age; i. e., the Carboniferous and the Cretaceous. The Cretaceous lies unconformably upon the Carboniferous, so that an enormous series of strata composed of the upper Palaeozoic, the lower and the middle Mesozoic, is missing completely.

CARBONIFEROUS

According to Cummins[1] the lower part of the strata near Bridgeport belongs to the Millsap division, so that the strata above the coal should be referred to the Strawn division, while the highest limestones should perhaps be considered as belonging to the Canyon division. In this report, the question of how the strata should be subdivided is of little consequence; the really important matter is the local subdivision of the strata, about which nothing is published.

We cannot give an entirely complete cross-section of the strata, because the Carboniferous deposits to the north of the West Fork and to the east of Bridgeport are covered with a thick series of Cretaceous strata in such a manner that the older rocks are exposed only in isolated localities; but we shall at least mention these exposures.

1. The oldest strata I have been able to distinguish exist in the socalled Rockdale on the West Fork (Porter ranch). There we observe a yellowish brown limestone full of crinoids and carrying numerous brachiopods, mostly Composita subtilita Hall. Neither the base nor the top of the limestone can be observed, so that its thickness remains unknown.
2. Probably the limestone is overlain by marls or shales, but I have not been able to actually observe them. Farther up the river a series of brown and yellow sandstones with marls in its upper part is exposed. Also in this case, the base and the top of

[1]W. F. Cummins, Report on the Geology of Northwestern Texas. 2nd An. Rep. Geol. Surv. of Texas, 1890 (1891), pages 516, 436.

the series is not visible, but the higher part of the sandstone is well exposed in a quarry.

To the northwest of the sandstone we find a yellowish brown limestone full of crinoids, also isolated from any other rocks. This limestone corresponds perhaps to the lowest limestone stratum south of Martin Lake, which will be described farther on (No. 3). The limestone is apparently only a few feet thick.

We shall describe now the region south of the West Fork of the Trinity River. There the exposures are much better, so that we are able to establish a nearly complete series of the existing Carboniferous strata.

2a We find the lowest strata to the south of Martin Lake. They are light colored, thinly laminated sandstones alternating with thin layers of the same rock. Their thickness is not determinable because the base is not visible, but we may suppose that this sandstone corresponds to a part of the series mentioned under No. 2 above.

2b Above these sandstones follows a brown calcareous sandstone and sandy limestone full of Productus aff. nebrascensis Owen, and about 2 feet thick.

2c On the top of these strata we observe a series of gray marls with intercalated yellow-brown sandstones, not very well uncovered. Their thickness is approximately 20 feet.

3. These marls are overlain by a limestone in thick beds of yellowish brown, reddish to purple color, about 2-3 feet thick. This limestone contains numerous crinoids, also large bivalves (Myalina?, Pinna?) and in some parts quite a number of brachiopods (Spirifer aff. cameratus Mort.).

While the foregoing strata (2a-2c) are limited to a narrow space near the house of the Carter ranch, we find the limestone described here on the whole slope towards the southern border of the Martin Lake, with a dip towards the northwest. It disappears below the younger strata shortly before we reach the road along the western border of the lake.

4. Above this limestone we find about 15 feet of badly exposed gray marly shales. I have found no fossils in them. They follow above the limestone No. 3 along the slope south to the Martin Lake, to near the road going north-south on the western shore of the lake, where they disappear below the next limestone.

5. Above the shales we observe a bed of yellowish-gray limestone, about 4 feet thick, containing big crinoids. We find it on the slope south of the Martin Lake, dipping towards the northwest,

crossing the north-south road on the western shore and continuing for a short distance on the slope southwest of the lake, where it dips below the younger strata.

6. Above this limestone we find a thin series of brown sandstones and gray marly shales without fossils. On the whole, they are not thicker than 10 feet. They are nowhere very well uncovered. We find this series on the slope to the south, to the southwest and to the west of the Martin Lake, generally covered by vegetation.
7. Overlying the shales we observe a gray limestone containing big crinoids and above it a yellowish-brown limestone in thinner layers. This one contains numerous smaller and larger crinoids and quite frequently brachiopods (Spirifer aff. cameratus Mort.).

   The calcareous strata are about 6 feet thick. This limestone is very characteristic and can be followed on the whole slope to the west of the lake. In the northern part below the Aken ranch house, we find it directly on and near the north-south road; towards the south it rises slowly and disappears on the hill west of that road.
8. On top of this limestone we find a very characteristic series of gray marly shales, which contains layers of rusty brown to red concretions. The series is easily recognized from far away by its reddish color. It is about 65 feet thick and very fossiliferous, especially in its lower part. It contains principally gastropods (Worthenia group of W. tabulata Conr. sp., Trepospira group of Tr. sphaerulata Conr, sp., Belleraphon aff. percarinatus Conr., Euphemus aff. carbonarius Cox, sp., Euomphalus aff. subquadratus M. and W., etc.), bivalves (Nucula aff. ventricosa Hall, Leda aff. bellistriata Stevens, Astartella aff. vera Hall, etc.), rare cephalopods (Goniolobocerας aff. Welleri Smith, Nautilus sp., Orthoceras sp.), rare brachiopods (Productus aff. nebrascensis Owen, Spirifer aff. cameratus Mort.), very numerous crinoids, etc.
9. Above these shales we find a light, soft sandstone, sometimes of conglomeratic or breccioid structure, in moderately thick layers. Its thickness is not much more than 15 feet. We find this sandstone along the upper part of the slope southwest of the Martin Lake, nearly everywhere well exposed.
10. This sandstone is covered by a thin stratum of a rough gray limestone, only 1 foot thick. We find it directly below the lower boundary of the timber covering the higher part of the slope. Its extension is about the same as that of No. 9.
11. Above this limestone we observe again a brown sandstone in rather thick beds, which towards the west is covered by vegeta-

tion. I presume that it is not much thicker than 20 feet, but the top is nowhere exposed. The sandstone forms the subsoil of a flattened hill west of the Martin Lake. In a small creek bed we find a brown, fine-grained soft sandstone, which probably forms the highest part of this series.

12. Directly on top of this last mentioned sandstone, we observe in the same creek bed, in a slight depression that crosses the western part of the Aken ranch, a bed of gray and somewhat marly limestone, about 2 feet thick. It contains numerous large and small crinoids. Above this bed lies another one, a little farther south, but in the same creek bed, composed of a yellow, rather marly limestone, with numerous crinoids. This bed is approximately 15 inches thick. The lower bed of limestone seems to become thinner towards the south, its thickness being gradually reduced from 2 feet to 1 foot, and in the last exposure, even to 1 inch. These limestone beds are to be seen only in the above-mentioned creek bed; towards the south they are covered by Cretaceous sands.
13. The limestone is overlain by thick beds of a brown and reddish sandstone, in part of brecciated structure, which towards the west is covered by Cretaceous sands. This sandstone probably underlies the whole country between the limestone No. 12 and the Nealy ranch. In this case it must form a mass at least 80 feet thick. It is probable that a thin limestone bed divides it in two parts; this is indicated by a few fragments of limestone with crinoids found halfway between its lower and its highest part. Towards the east of the house on the Nealy ranch we find again a red, coarse-grained sandstone in position, and the same can be observed also towards the northeast on the slope of the hill. The upper part is formed by a thin-bedded brown sandstone and, perhaps, a thin mass of gray shales.
14. To the northwest of the house on the Nealy ranch we find a thin bed of yellow and gray limestone, with crinoids, generally not more than 1 foot thick, and very frequently destroyed by erosion, so that only the fragments of limestone on the fields indicate that formerly it existed in that locality. The conditions of the exposure are very unfavorable, but it seems that the layer of limestone is a lenticular mass of very limited extension; at least, I could not observe even a trace of it on the north side of the hill, notwithstanding that the exposures are by no means bad.
15. This limestone is covered by a series of sandstones at least 100 feet thick. In their lower part they appear in thin beds of yellowish brown color. In the middle there are thick beds of

dark brown and reddish color, containing, frequently, breccias. The upper part is composed of thin bedded light brown and reddish sandstones, with intercalations of gray clay in some parts.

This sandstone forms the western part of the range on which the Nealy ranch is situated. It continues towards the northeast to near Bridgeport, where it disappears to the southwest of the town. In a southwestern direction the sandstone continues only for a short distance, becoming soon covered by Cretaceous sands. We find it again to the south of the West Mound, where it forms the region to the east of Coal-Bed Creek.

16. Above this sandstone we find a gray plastic clay, with nearly no indication of stratification. This is locally known as "fireclay." Its thickness is probably not more than 20 feet, and in some parts it is even less. We observe this clay on the surface, and it is well exposed in a creek bed on the Grisham ranch (west of the Nealy ranch). Between this place and Middle Mound we find it again; likewise, in Coal-Bed Creek, south of West Mound. Towards the northeast, it is generally covered by alluvial material, but in one place it is visible in a creek bed on the southwestern slope of the Bridgeport hill.
17. Above this clay nearly everywhere appears the coal seam worked in the different mines of Bridgeport. There and on Grisham ranch it is 20 inches thick. In Coal-Bed Creek, south of the West Mound, it is only 9 inches thick, and the same thickness was found in drillings on the Waggoner ranch.
18. Above the coal we find a gray marly shale, about 30 feet thick. These shales are well exposed in Coal-Bed Creek south of West Mound, and between this hill and the Grisham ranch; farther to the northeast on the hill of Bridgeport; and in the coal mines.
19. Above these shales we find everywhere a layer of thick bedded gray and yellowish limestone, full of crinoids. Near Bridgeport, it is about 3 feet thick, but it increases in thickness towards the southwest, and near the ranch house of the Waggoner ranch we find it about 5 feet thick. This limestone being an excellent leading horizon, or key rock, we call it from here on the Bridgeport limestone.

It is exposed in numerous places. We find it exposed in the western part of east Bridgeport. Towards the southwest it is eroded, but we find it again on Grisham ranch, where it forms the cover of a series of small hills that extend far towards the west. Further south it continues in a broad space to the foot of the Middle Mound. There it is hidden by the Cretaceous sands, but appears again to the south and west of West Mound, and extends as far as the ranch house on Waggoner ranch and even a

little more to the west of that point. We find it again farther to the southwest in the upper course of Hunt Creek, where it disappears below the younger shales.

20. On top of the Bridgeport limestone we observe a series of gray marly shales, of a very uniform character. It is not possible to determine their exact thickness, because in the upper part beds of sandstone are intercalated. The shales are about 100 feet thick. The upper part, formed by alternating shales and sandstones, we consider as belonging to the next division, but the dividing line is entirely artificial. These shales are nowhere very well exposed on the surface in their entire thickness, because generally they are eroded by the water; or, as in the broad valley of the West Fork, they are covered by alluvial material. Part of these shales are found on the foot of the Rockhill range and on the hills and in the creeks of the valley east of it, further in the region where the West Fork cuts the Rockhill range off towards the north. The best and most complete exposures are to be found in the coal mines of Bridgeport, especially in those west of the town, where the whole series is cut by the shafts.

21. We find that beds of gray and yellowish sandstone are intercalated in the upper part of the shales described above. Farther up the sandstones displace the shales entirely. This sandstone is of red, brown and yellow color, partly in thin beds, partly in thick strata. This sandstone is moderately well exposed at the side of the roadbed of the Chicago & Rock Island railroad, but we can follow it also towards the northeast to the Alvord crusher, where it disappears below the Cretaceous strata. From the Rock Island railroad towards the southwest the sandstone forms the slope of the tableland. There and in the Rock Island railroad the sandstone is divided in two parts by the intercalation of about 20 feet of gray-blue shales, with reddish brown layers of clay. The whole sandstone and shale series is about 80 feet thick. We find fairly good exposures also on the slope from the MacKibben ranch to the gorge of the West Fork. These we observe in the lowest part to be coarse-grained reddish brown, thick bedded sandstone, above this about 20 feet of gray shales, on top of these thick-bedded brown sandstone, and finally a thin deposit of gray shales with intercalated layers of sandstones; and on top, a bed of marly shales not very well exposed. The lower part of the sandstone is in contact with the shales of No. 20, and is very well exposed on the other (southern) side of the West Fork. The sandstone series exists on both slopes of the Rockhill range, continuing as far south as the ranch house of the Waggoner ranch.

The upper part of the series is well exposed in the cut of the Rock Island railroad. We find a thick-bedded sandstone in Fox's quarry; above it, thin bedded light sandstones; higher up, gray-blue shales without fossils; above these, an alternation of sandstones and shales (in the railway cut). Above the last bed of shales, which, like the lower ones, is only a few feet thick, follow thin-bedded light-brown sandstones with intercalations of lenticular masses of a dark brown colored sandstone. Farther to the northwest these soon displace the thin-bedded sandstones and form a solid stratum of dark brown sandstone. On the top of these strata follows a bed of argillaceous sand, about 3 feet thick.

22. Above the described series of sandstones and shales we find a mass of limestone; in places, of considerable thickness. This limestone represents a very good leading horizon, and for that reason we give it the special name of Rockhill limestone. The character and development of this limestone is so variable that we shall have to describe it in detail.

In the northeastern part of our region we find above the sandstones and shales (No. 21) a considerable mass of limestone. This is particularly well exposed in the Dry Creek (near the Alvord crusher). Generally it is a light gray or dark gray limestone and contains in certain parts numerous crinoids and brachiopods (Composita subtilita Hall) and occurs in layers of moderate size. The thickness of this limestone increases rapidly from its eastern limit towards the west. In the middle part (between Chico and the Alvord crusher) it is probably as much as 150 feet thick, perhaps even more. It is not possible to determine the entire thickness, because the base and the top are not visible in the same locality. A good exposure of the base exists in the above-mentioned railway cut of the Rock Island railroad. Above the argillaceous sands of the lower division we see the lowest part of the Rockhill limestone, with a dip of 3 to 5 degrees towards the northwest. No marly intercalations exist in the limestone.

Towards the southwest a mass of 25-30 feet of gray marls is intercalated in the lower part of the limestone. On the MacKibben ranch the base is formed by a mass of limestone about 10 feet thick, of grayish-brown color, and full of crinoids and brachiopods. Above it lies a layer of thin-bedded brown sandstone, and on this we find gray marls with rusty brown layers of concretions. The sandstone and marl together are approximately 25 feet thick, and covered by several layers of gray limestone, about 3-5 feet thick. The shales contain a great number of crinoids, corals, sponges, a few spines of sea-urchins (Archaeo-

cidaris sp.), some brachiopods (Ambocoelia planoconvexa Shum. sp.), rare gastropods (Bellerophon aff. percarinatus Conr., Euphemus aff. carbonarius Cox sp., Worthenia group of W. tabulata Conr. sp., Trepospira group of Tr. sphaerulata Conr. sp.). The same marly shales exist also at the spring of the MacKibben ranch near the West Fork.

A similar development of this rock we find in the northeast continuation, especially in the higher part of the first eastern tributary of the Village Creek and in the valley of this latter creek; but the mass of limestone attains there a thickness of at least 100 feet. The marls between the two limestone masses contain here also a great number of crinoids and corals, a few spines of sea-urchins (Archaeocidaris sp.), and rare brachiopods (Spirifer aff. cameratus Mort.).

Farther west the limestone thins out considerably. Near the Sanders ranch the mass of limestone, together with the intercalated marls, is only some 45 feet thick; base and top are very well exposed. The lower limestone is about 10 feet thick, the upper one 10 feet, but the thickness diminishes apparently, still farther to the west, and the lower limestone is divided in two by another layer of marls. In the upper mass of marly shales a coal seam develops in this region. The coal is found in several wells (Hanna ranch) and about 20 inches thick.[1] The marls below the upper limestone contain principally large crinoids and very frequent fragments of bivalves (Myalina cfr. subquadrata Shum.), also pieces of brachiopods (Productus sp.).

Farther north the marls seem to disappear entirely. In the region of the Ventioner Creek and Willow Creek, we find only a mass of limestone 30 feet thick, which is very well exposed in Hampton Hollow (Bearry ranch). It is a thin-to thick-bedded light gray limestone, which contains rare cephalopods (Nautilus sp.) and quite numerous brachiopods (Productus aff. nebrascensis Owen, Composita subtilita Hall). In the upper part of the Ventioner Creek, a thin bed of marls is intercalated between the highest beds of the limestone; the upper limestone bed is much thinner than the principal mass.

In the southwestern region the limestone is divided by a quite considerable mass of marls. The lower bed is not much thicker than two feet, and well exposed on the Jacksboro road where it crosses the Rockhill. Above it follow 30 feet of gray marly shales, which contain layers of rusty-brown and red concretions, especially in the middle part, while the upper four feet are

[1] I have seen only a sample of the coal; I obtained the above-mentioned data from Mr. Hanna.

formed by uniform gray (yellowish by weathering) marls. This is overlain by a thick-bedded limestone 5 feet thick; it increases considerably in thickness towards the north, but decreases towards the west, and on the western side of the Hunt Creek it is sometimes only 2 to 3 feet thick. The marls are well exposed and very fossiliferous on the western slope of the Rockhill and on the eastern bank of the Hunt Creek (one mile south of Cactus Hill on the Ingraham ranch). On the Rockhill crinoids and corals predominate, but not so on the Hunt Creek; besides them, we find several cephalopods (Goniolobоceras aff. Welleri Smith, Tainoceras nov. sp., Nautilus sp., Orthoceras sp.), numerous Gastropods (Worthenia group of W. tabulata Conr. sp., Trepospira group of Tr. sphaerulata Conr. sp., Bellerophon aff. percarinatus Conr., Euphemus aff. carbonarius Cox sp.), rare bivalves (Leda aff. bellistriata Stevens, Nucula aff. venticrosa Hall, Myalina aff. cuneiformis Gurley, Myalina cfr. subquadrata Shum.), rare brachiopods (Spirifer sp., Composita subtilita Hall) and still rarer fragments of trilobites (Phillipsia sp.).

The distribution of the Rockhill limestone is shown in the above description. It forms the covering of the large tableland to the west of the Bridgeport valley and continues to the neighborhood of Chico (where the limestone is hidden by Cretaceous conglomerates and sands). Its western limit we find in the valley of the West Fork, north of the mouth of Hunt Creek. The limestone crosses the Big Creek, but disappears soon at the south foot of the Sand Flat range. It can be followed about halfway in the north-south course of the Big Creek; later on we find it again crossing the Big Creek on the Brackenridge ranch. It forms the cover of a series of hills in the lower Ventioner Creek, disappears below Cretaceous conglomerate, but is again exposed in the Hampton Hollow, a tributary of Big Creek, as well as in the upper course of the Ventioner and the Willow Creek.

In the southwest region this limestone forms the high part of the Rockhill range and appears also in a narrow strip on the western bank of Hunt Creek and farther north in the bottom of Jasper Creek.

23. Above the Rockhill limestone we find again a series of sandstones with intercalations of shales. The best exposure of this series is found on the eastern slope of the Jim Ned Mountains and in the valley of Hunt Creek. Above the Rockhill limestone we find there about 20 feet of thin-bedded yellowish and brown sandstones, and above these some 60 feet of gray shales with thin layers of brown and red sandstone. These are very well exposed at the southeast foot of a low hill in the Hunt Creek valley, about one mile from Cactus Hill. We find the same shales

at the foot of the Jim Ned Mountains, especially in the southern part of the valley.

On the slope of the Jim Ned Mountains those shales are overlain by about 130 feet of thick-bedded brown sandstones, which grow more yellowish in the upper part and occur in thinner beds. Above this sandstone we find 95 feet of gray marly shales with intercalations of brown and yellowish thin-bedded sandstones in the upper and the lower part. These are covered by the Devil's Den limestone described in No. 24. About 46 feet below this limestone we find a bed of gray or yellowish marly limestone, a few feet thick, which contains numerous crinoids and many specimens of Myalina cfr. subquadrata Shum. This bed of limestone is very characteristic and can be followed along the whole eastern slope of the Jim Ned Mountains; it is always found 45 to 50 feet below the limit of the higher limestone mass.

The series of sandstones and shales described constitute the eastern slope of the Jim Ned Mountains. Toward the north it is again exposed on the eastern slope of the Sand Flat range. Farther to the north we find it on the western border of the Ventioner Creek and on the banks of Big Creek, as well as in the hilly country north of it; but there it is covered in a great part by Cretaceous conglomerate and sand.

24. We have already mentioned that the series No. 23 is covered by a mass of limestone, which we shall call the Devil's Den limestone. This is a quite uniform gray or dark-bluish, hard limestone, which contains rare crinoids and parts of brachiopods. In the Devil's Den it attains a thickness of about 50 feet, but its top is not visible in that locality.

The limestone covers the western side of the Jim Ned Mountains, which slope softly towards the northwest. Farther on we find it to the north of the West Fork on the Boyd and Blocker ranches to the south of the northernmost part of the Sand Flat range. It is impossible to state how far it continues to the north. It seems to be a considerable lenticular mass of limestone, which thins out and disappears to the north; at least, I have not been able to find a trace of this limestone on the northern foot of the Sand Flat range or in the upper part of the Big Creek.

25. The Devil's Den limestone is overlain by a series of yellow, brown and reddish, moderately thick-bedded sandstones. As we do not find the Devil's Den limestone on the north side of the Sand Flat range, we can not distinguish this sandstone from that below the Devil's Den limestone, but it is probably not thicker than 100 feet. The sandstone is well exposed in the Big Creek and forms in part steep walls. Above it lie about 30 to

40 feet of badly exposed gray shales with intercalations of sandstone. In the highest part of these shales occur some fossils (Productus aff. nebrascensis Hall) and crinoids. These sandstones and shales continue towards the south in the slope to the west of the valley of West Fork, near Vineyard, and form the northern part of the Sand Flat range. We find it also in the middle part of Big Creek, but it disappears farther to the north below a covering of Cretaceous conglomerates and sands.

26. Above this series we find 8 feet of light gray limestone, which, being an excellent leading horizon, we shall call the Elm Creek limestone. It occurs in thin to moderately thick beds, with an irregular surface. We find it in the middle part of Elm Creek; farther to the west it is well exposed in the lower part of Indian Creek, and in the upper part of Big Creek and farther to the south it forms an extensive plain, slanting towards the northwest (west of the Jack County line). The limestone contains in several places fossils, especially crinoids and brachiopods (Composita subtilita Hall in large specimens).
27. Above this limestone we find 20 feet of gray shales with rare fossils, principally crinoids. These shales are well exposed in the Elm Creek, and to the west of it. They can be followed only for a short distance.
28. The shales are covered by from one and a half to two feet of brown, very characteristic limestone, containing numerous crinoids. This bed is also found in the Elm Creek and southwest and west of it.
29. Above the brown limestone we find 20 feet of gray and purple marly shales with rusty brown concretions. These shales occur in many parts of the small depression on the Smith Drew Survey and the region near it (Parr ranch), also in the Elm Creek. They contain an extraordinarily rich fauna, principally of brachiopods (Chonetes cfr. granulifer Owen, Spirifer cfr. cameratus Mort., Spirifer cfr. texanus Mort., Spiriferina aff. kentuckiensis Shum. sp., Productus aff. nebrascensis Hall), quite numerous gastropods (Worthenia group of W. tabulata Conr. sp., Trepospira group of Tr. sphaerulata Cox sp., Euomphalus aff. subquadratus M. and W., Bellerophon aff. percarinatus Conr., Euphemus aff. carbonarius Cox sp., etc.), relatively rare bivalves (Astartella aff. vera Hall, Leda aff. bellistriata Stevens, Nucula aff. ventricosa Hall, etc.), many crinoids (among these Zeacrinus sp.), many corals, and a very few Cephalopods (Nautilus sp., Orthoceras sp.).
30. The marly shales are overlain by thin-bedded gray sandstones, and upon these we find gray and partly sandy shales with intercalations of a thin-bedded gray sandstone. The thickness can

not be determined on account of the unfavorable exposure. Finally, we find above this series a reddish brown sandstone in thick beds. These strata can be observed in Elm Creek, on the Parr ranch and farther to the west in the upper course of the Big Creek (in Jack County), and on the range of hills cut by this creek. This is the youngest division of the Carboniferous studied by me.

CRETACEOUS

The Cretaceous deposits of this region do not need to be described in detail, because, for our purpose, they are only of negative importance, inasmuch as they render difficult or entirely impede the study of the structure of the older strata.

Basal Conglomerate:

The lowest part of the Cretaceous consists of a reddish quartzitic conglomerate, called the Basal Conglomerate. It is of a variable thickness. Locally it is known as "Concrete." It appears in the form of a loose conglomerate, as well as in that of indurated and very hard beds; frequently erosion has changed it into an accumulation of loose pebbles, in which form we find it rests nearly everywhere in the studied region on top of the most different strata of the Carboniferous. Good exposures of this basal conglomerate are to be found in a creek to the northeast of the Alvord crusher and also between the Ventioner and the Willow Creeks. Frequently it contains remains of silicified trunks of trees. To the south of West Mound I found a well preserved Cycas.

The Basal Conglomerate covers mostly the hills between the Jack County line and the Ventioner Creek. It forms a solid covering from Ventioner Creek to east of Chico and the Alvord crusher; from this point towards the east all the Carboniferous strata are covered by considerable masses of the Cretaceous. Farther to the south, between the Jim Ned Mountains and Bridgeport, we find hardly more than traces of the Basal Conglomerate, but to the east of Bridgeport it covers the Carboniferous and is overlain by the higher Basal Sands. Still farther south the Basal Conglomerate extends a long spur towards the west, which forms the base of the region between East Mound and West Mound. In part, the Basal Conglomerate is displaced by yellowish and white sands that can not be distinguished from the higher Basal Sands.

Basal Sands:

Above this conglomerate follow the Basal Sands, which in places seem to displace the conglomerate. They have a thickness of several hundred feet. The lower part is of pure white, farther up of purple color, and still higher up, again, of white color. In the middle and the upper portions we find frequently intercalations of gray and red, somewhat sandy shales or marls.

The Basal Sands are little shown in the northern part of our region, but they become extremely thick in the southern and eastern districts, especially east and south of Bridgeport. They cover the hills to the south of Martin Lake and form the base of the region between East and West Mound, as well as the country to the east of this.

I have not found fossils in these sands, but have really paid little attention to these strata, so that fossils may well have been overlooked by me.

Glenrose Beds:

Above the Basal Sands we find Calcareous deposits exclusively in the southern portion of our region. There the sands are overlain by blue-gray clays, above which we find about 6 feet of hard gray thick-bedded limestone; above this follows a series of thin-bedded, yellowish-white, marly, knolly limestones, 30 feet thick, which are covered by 5 feet of hard, gray, thick-bedded limestone. The marly limestones, as well as the upper hard layers, contain a great many badly preserved bivalves and gastropods; a very slender Nerinea is quite frequent in the highest limestone.

These beds are found only in the extreme south of our region, where they form the summit of a series of seven table mountains. The eastern one of these is called the East Mound, the middle one Middle Mound, and the western one West Mound. These form the last solid spur of the Cretaceous formation in this region.

STRUCTURAL GEOLOGY

Having described the character of the rock we shall now occupy ourselves with their tectonic structure, this being the decisive factor for the accumulation of petroleum.

In general, the structure of the strata in our region is monoclinal, i. e., all the strata dip more or less feebly towards the northwest or west, so that in the southeast we find the oldest deposits and in the northeast, the youngest. The strike of the

strata is in general northeast-southwest. But deviations exist. It is not always very easy in our region to determine the strike and the dip of the strata, because frequently the harder layers break up superficially on account of the erosion of the softer ones below them on the border of creeks and cuts. The harder rocks then appear to have a steeper dip and a different strike from what really is the case. These local dips are naturally without any importance, being of an entirely superficial character.

We shall describe the structure in detail, proceeding from the east to the west.

The whole southeastern part of our region formed by the hills around Bridgeport, and the broad depression east of them, which in part is filled up by the alluvial material accumulated by the West Fork and its tributaries, show a normal dip towards the northwest, a dip which is generally 50 feet to the mile. This structure is clearly shown in the eastern part of our cross-sections to near the foot of Rock Hill. Only in one place I have been able to observe an exception and that was on the western foot of the hill on which the Nealy ranch is situated. In this locality, the strike direction seems to turn around and to follow approximately the lower outline of the hill. We find there on the west side a very variable dip towards the northwest (5 to 25 degrees); towards the south, the strike changes from NE-SW to E-W, and finally to N 40° W. But the exposures are so unfavorable that I have not been able to decide if these changes in strike and dip are only of a local character caused by breaks in consequence of erosion, or if it really is a case of complicated tectonic structure. A similar change in the dip exists also quite locally in a creek bed on the tableland between the Nealy ranch and Martin Lake. We find there in one place, a strike of N 80° E, with a dip of 28° S, while a little farther west the dip is towards the north.

All this is of a local nature, and a detailed study of its causes is rendered difficult by the heavy covering of Cretaceous sands and alluvial material. In the whole depression, including the low hills in the south, we find a slight dip towards the northwest. This is shown principally by the dip of the different lime-

stones and especially by that of the Bridgeport limestone, which has a wide distribution in this part of the country.

The conditions are somewhat different in the western part of the depression, in the portion immediately to the west of the foot of the Rock Hill and its northeastern continuation; that is to say, from the ranch house of the Waggoner ranch to the shaft No. 3 and shaft No. 2 of the Bridgeport Coal Company, and to the region immediately south of the Alvord crusher. In this zone, the angle of the dip becomes very small, in some places we even find small dome-like anticlines; that is, anticlines with a very short longitudinal axis.

Such an indication of formation of anticlines we observe near the ranch house on Waggoner ranch to the east and northeast, farther in the western part of the coal mines of the Bridgeport Coal Company. In general these are of a small diameter. Between the two localities mentioned above, we find the strata in a practically horizontal position. This zone becomes especially broad in the region where the West Fork cuts the Rock Hill range off towards the north, on the lands of the Powers ranch and the Monk ranch. As a guide line for this observation, I used the contact between the shales above the Bridgeport limestone and the higher series of sandstones. We find this contact on the whole tract from the eastern point of the hills near which the house of Powers ranch is situated, to near (within a quarter of a mile) the house on the Monk ranch; so that there exists a zone at least 2 miles broad, of strata in a practically horizontal position. This zone continues towards the north hill near the mines of the Bridgeport Coal Company. From here on, the zone narrows. This is clearly to be seen near the Rock Island railroad between the Bridgeport Coal Company mines and Fox's quarry. Farther to the northeast exposures are very unfavorable, the country being covered with vegetation. Near the Alvord crusher we find again an indication of horizontal strata, especially southeast of the quarries and in the creek north of the crusher, where it reaches the railroad track. Unfortunately, the covering of Cretaceous rocks is so heavy, that we cannot decide if the zone of horizontal strata broadens to any extent. Direct observations are limited to a distance of about a quarter of a mile.

We turn again our attention to the south. There the zone of horizontal position is followed to the west by one of stronger dip towards the northwest in the range of Rock Hill. According to my measurements, taking the Rock Hill limestone as leading horizon, the northwest dip is at least 120 feet to the mile, and this dip continues to a point about half a mile west of Cactus Hill, where a new zone of nearly, or entirely, horizontal position, with indications of local anticlinal structure exists. We shall discuss this later on.

The stronger dip may be observed on the whole western border of the Rock Hill as well as farther northeast on the other side of the West Fork in the eastern border of the triangular tableland covered by the Rock Hill limestone. In the railway cut of the Rock Island railroad and a little farther to the northeast in a rather deep creek, I could measure a dip of 3 to 5 degrees northwest. This circumstance explains the rapid increase of thickness in the Rock Hill limestone in the tableland. Observations in Dry Creek near the Alvord crusher gave a similar result.

This zone of stronger dip suffers a change to the north of the locality where the West Fork intersects the Rock Hill. We have mentioned already that the geological continuation of the Hunt Creek valley shows a change of direction, passing from SW-NE to a S-N direction. This is connected with a change of strike in the strata. From the gorge of the West Fork to the north the Rock Hill limestone shows nearly exactly a N-S strike, and a strong dip to the west. This strike continues at least to the Sanders ranch. The conditions farther north are not very clear, but the zone continues probably as far as the region west of Chico.

This change of the strike of the strata causes the existence of that triangular tableland which is bounded on the west side by the depression of the N-S course of the West Fork and on the southeast side by a SW-NE line between Dr. Buckner's ranch and the Alvord crusher.

This change of strike naturally must have its consequences also within the tableland itself, because the different direction of the dip must have originated a zone of compensation. Ascending the valley of the Village Creek we find that there exists a

horizontal position of the strata on a rather long tract, and even in some places an anticlinal uplift. Unfortunately the exposures in the creek bed are not sufficient to show the breadth of this zone, but it does not seem to be very broad. These conditions are illustrated by the accompanying cross-sections. On account of a heavy cover of Cretaceous conglomerate and sand it is not possible to prove what conditions exist in the north between Chico and the Alvord crusher.

We have already mentioned that in Hunt Creek Valley a new zone of horizontal position of the strata is indicated. In this region I have used the contact between the shales above the Rock Hill limestone and the higher sandstones as a leading horizon. The exposures are not very favorable, insofar as a thick alluvial cover exists in that depression. The horizontal position is still visible on the different roads and creeks leading to the summit of the Jim Ned Mountains. The position of the coal in different well drillings in the Hunt Creek valley also indicates a horizontal or anticlinal position of the strata, but unfortunately no logs of these borings are in existence and my data on them do not come directly from the drillers. For this reason, I cannot attribute that importance to these data which they deserved. if records of the wells existed. A slight syncline in the valley to the west of Hunt Creek is perhaps indicated by the circumstance that a well in that region gives artesian water; the overflow, though very feeble, exists still today. This syncline should be followed by an anticline towards the west. Such a structure would be well in accord with my own observations.

Farther to the north the exposures become still more deficient, especially in the valley of the north-south course of the West Fork. Not before the turn of the West Fork to the west in the vicinity of Sanders ranch, do the conditions become more favorable. Following the road from the MacKibben ranch to Mt. Horeb church and Sanders ranch, we see everywhere the strong western dip of the Rock Hill limestone. On the MacKibben ranch, we observe that the lower stratum of limestone and the marls upon it descend rapidly from the house to the West Fork where they are very well exposed near a spring, and on the embankment of the river. Something quite similar may be seen

on Sanders ranch, where the angle of the slope nearly corresponds to the western dip of the Rock Hill limestone. This dip continues west of the road, which comes from Chico and crosses the West Fork on a bridge a little farther south. If the monoclinic structure continues farther to the west, the limestone should soon disappear below the higher sandstones and shales. But west from a small creek about a quarter of a mile from the above mentioned road, the western dip changes into an eastern one, the creek forming approximately the axis of a syncline. The dip is about 80 feet to the mile. We observe this same eastern dip till we come to a hill crest on which the house of Mr. Peary Sanders is built, about a good half mile from the axis of the syncline. From this point towards the west the strata have a nearly horizontal position for a half mile more, perhaps there is even a very feeble eastern dip; this is not easily to be discovered on account of the woods which cover this part of the country. Near the point where the road from Sanders ranch to the mouth of Big Creek begins to descend rapidly towards the bank of the West Fork, the strike begins to turn again slightly to the west. The angle of the dip becomes a little larger farther to the west and especially on the other side of Big Creek. From the axis of the syncline to a point of the same height on the western bank of the anticline is approximately at least 2 to 2½ miles. The anticline seems to be closed towards the south, but the cover of vegetation does not allow exact observation. Towards the north the anticline appears to continue for one or two miles more, but here also the woods make exact observations impossible, as no detailed topographical map of this locality exists. Nevertheless, I have been able to discover the Rock Hill limestone in two creek beds about exactly at the same height as in the crest of the anticline; this indicates the continuation of the Cretaceous conglomerate and sands.

In the woods following farther to the north exact observations are nearly impossible, but the exposures are more favorable in the lower part of the Ventioner Creek. There the zone of horizontal or even anticlinal position seems to continue. In the lower part of Ventioner Creek in front of the Yoakum Spring we find a bed of limestone which probably constitutes the con-

tinuation of the Rock Hill limestone. This bed dips strongly towards the southwest, 159 feet to the mile. The strike changes to NW-SE. The shales below the limestone in different places indicate a very slight anticlinal structure; in several localities I could observe a northeast dip. There is no possibility of proving how broad this anticlinal or horizontal structure is, the exposures on the eastern border of Ventioner Creek being very unfavorable. Farther to the north the limestone is covered by Cretaceous conglomerates and sands.

In the upper part of the Ventioner and Willow Creeks we find again an excellent key rock in a limestone that probably corresponds to our southern Rock Hill limestone. According to my measurements, this limestone is horizontal or dips very slightly to the east on a tract of at least half a mile between Ventioner and Willow creeks. Unfortunately, this limestone is hidden towards the West Fork by younger sandstones and then by Cretaceous deposits, which impede direct observation. Only in the Hampton Hollow we find this limestone again for a short distance, after which it disappears below the higher shales and sandstones. It appears certain that a horizontal structure exists between Ventioner and Willow Creeks, but it is impossible to say how broad this zone is. The strike is here again SW-NE.

We shall turn now to the westernmost portion of our region and we begin again with the description of the south. After crossing the zone of horizontal structure in the valley of Hunt Creek and the eastern slope of the Jim Ned Mountains, we find again a zone of heavier northwest dip near the summit line of this range. The northwest slope of the Jim Ned Mountains does not correspond entirely to the angle of the dip, the limestone being quite thin near the summit line, attaining a thickness of about 50 feet in the Devil's Den. The real dip is here at least 120 feet to the mile. This inclination continues certainly farther to the west, where I have not been able to make any observations.

Conditions are very similar farther to the north in the Sand Flat range. There the Devil's Den limestone seems to disappear and we find a uniform but moderate dip towards the west or northwest. This can be observed on both sides, south and north

of the Sand Flat range, and especially well in the middle course of Big Creek. This dip continues far to the other side of the Jack County line, where it becomes especially clear on the slanting plain formed by the Elm Creek limestone. Nowhere do we see even the least irregularity in the structure; from the Ventioner Creek until several miles to the west of the Jack County line, the dip is towards the northwest, and the structure is purely monoclinic.

THE POSSIBILITY OF FINDING OIL

Our studies of the geology of the region have been made with the purpose of deciding if there is any probability of finding oil in some place, and which locality is the most favorable for a test drilling.

We have seen that the greater part of the region is composed of Carboniferous strata and we know that even the lower portions of the Upper Carboniferous contain oil and gas in several places; as for example, near Strawn and Mineral Wells. The strata of those localities probably correspond in age to a great part of those near Bridgeport and Chico. We know also that in the strata of Jacksboro, which possibly are a little higher than those in our region, or perhaps correspond to our Elm Creek limestone and the sandstones below it, oil of a very good quality is found. The richer oil deposits of the northern Texan Carboniferous belong to higher divisions of the Upper Carboniferous. As far as our present knowledge goes, we can therefore not expect to open large gushers of oil in this region, but the possibility of smaller oil wells exists. We may also mention that at Paradise[1] oil has been found in small quantities at a depth of 1,870 feet; that is to say, in strata much older than those which are described in this report.

Thus the probability exists that oil and perhaps gas have been formed in our strata or in those below them; but the question is if this oil has had an opportunity to accumulate in some place in large quantities, and if this place is accessible by a well.

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[1]This well was not drilled on an anticlinal or terrace structure, but on a place where the oil could not accumulate.

The possibility of the accumulation of oil in large quantities depends principally on two conditions; first, on the character of the rocks which form the ground below the surface; and second, on the tectonic structure of these strata.

Like every other liquid, oil can accumulate only in porous rocks, such as sands, sandstones, porous limestone, conglomerate, tuffs, etc.; but never in impermeable rocks such as shales, marls, structureless clays, etc. The same may be said of gas.

With regard to the second point, we must keep in mind that oil and gas, unlike water, never sink into the ground; on the contrary, the oil in consequence of its specific weight and on account of the gas it contains always tends to rise. As long as we find strata with a uniform dip towards a certain direction, we cannot expect an accumulation of oil or gas, because nothing prevents them from rising on the inclined plane until they come to the surface of the earth somewhere. An exception we would find only where a lateral change of the character of the rock begins, for example, where a sandstone is displaced laterally by clays or shales. Under such a condition, the porous rock is closed towards the side and towards the top, so that an accumulation of oil and gas can very well take place. This case is probably very rare. Another exception would be where large faults cut through the strata and displace them to a different level.

If, therefore, gas and oil shall accumulate, a change in the dip must take place in the form of a dome-like or anticlinal uplift. This is by far the most favorable condition, and the broader the anticlinal structure, the larger will be the quantity of the accumulated oil and gas. Besides this structure, there exists another one, less favorable, but still practically important. Oil and gas accumulate even where a double change of the angle of a dip occurs, producing a central horizontal zone. According to our present knowledge, this horizontal zone should be at least several miles broad, so that a sufficient quantity of liquid or gas can accumulate.

We can say at once that the first of these two principal conditions exists in our region; that is, there exist some permeable strata. In our description of the rocks, we have shown that sand-

stones of different grade of solidity compose a great part of the series of strata, and that they are separated from each other by impermeable shales and marls or clays. The character of the rocks which compose the underlying ground in our region is thus entirely favorable for the accumulation of oil and gas.

With regard to the tectonic structure of the strata we have seen that at least one place exists near Bridgeport and Chico, where the second one of the principal conditions is also fulfilled. We have been able to recognize the existence of a sufficiently broad anticline near the road from Sanders ranch to the mouth of Big Creek. On account of the non-existence of a detailed topographical map this anticline cannot be circumscribed in its whole extension; but its highest part, its axis, can very well be fixed. This highest part of the anticline seems to be flattened and extends between the hill on which the house of Mr. Peary Sanders is built, and the point where the road between Sanders ranch and the mouth of Big Creek descends rapidly towards the bank of West Fork. *This highest portion of the anticline would be the most favorable part of the whole region for the drilling of a test well.* Supposing that the conditions of the thickness of the strata are the same as in the localities where they reach the surface farther east, a well would go to the first sandstone (100 feet thick) at a depth of 265 feet; to a second, 80 feet thick, at a depth of 365 feet; to a third, 20 feet thick, at a depth of 450 feet; a fourth, 15 feet thick, at 470 feet; and a last one of considerable thickness which cannot exactly be determined, at a depth of 605 feet. With regard to the strata lower down, we know nothing at the present time, because the region where these should reach the surface is completely covered by Cretaceous rocks.

The depths of the different sandstones mentioned have naturally only an approximative value, insofar as we have seen that the thickness of the different strata changes considerably, and often in a very short distance; and all our measurements have been taken in localities several miles away from the described anticline.

Should the test well show a favorable result, that is to say, if there is enough oil in the deeper strata to fill up the anticline,

then a few more localities could be considered as favorable for the accumulation of oil and gas.

The next best locality exists in the region where the West Fork cuts the Rock Hill off towards the north. There we find a zone about 2 miles broad where the strata are nearly or entirely horizontal, while towards the northwest and the southeast, we observe a strong dip to the northwest. A favorable locality for a test well exists in the plains on Dr. Buckner's ranch, a little to the east of the mouth of the creek which descends from the eastern part of the MacKibben ranch to the gorge of the West Fork, and another one about half a mile east of the house on Powers ranch. In these places sandstones would be reached at a depth of approximately 155 feet, 256 feet, 340 feet, 350 feet, and 490 feet. Nothing is known about the strata below the last one.

Another locality of secondary importance exists near the foot of the Jim Ned Mountains, a little west of the schoolhouse of the Ingraham ranch. There sandstones would be found at a depth of approximately 345, 445, 530, 550 and 690 feet.

Similar conditions exist probably in the upper Ventioner Creek, where a deep well could be drilled on the M. B. Smith survey; but the result remains somewhat doubtful.

But all these points could only be considered if a test well on the described anticline had given a good result.

Finally, I would like to mention that superficial occurrences of oil are nowhere known in this region. I have visited numerous localities where it was said that oil occurred on the water of wells; but nowhere I have been able to discover even a trace of oil. The rainbow colors on the surface of the water could be always referred to a thin cover of segregated salts. Similar results I obtained by the investigation of the creeks. Everywhere I found a segregation of iron oxides causing these iridescent colors, while the accumulation of a dark material was caused by the decomposition of vegetable material. Only in one place—a well near the schoolhouse on the Ingraham ranch—oil is said to have been found in some quantity, at a depth of about 300 feet; and really the dirt of the well shows still, today, in some places, the trace of some oxidized oil. But it is not

possible to decide if this oil really came out of the well or if it is some lubricating oil used for the machinery.

My investigation of the wells and creeks with regard to gas has likewise had a negative result. The bubbles on the bottom or the banks of different creeks do not show inflammable gas, with the exception of marsh gas, that is found in the West Fork near Old Bridgeport. Generally, those bubbles are caused by air contained in the water, a case quite frequently observed in many localities elsewhere. The data about the so called whistling well on the Edwards ranch are too indefinite to allow any conclusion with regard to the nature and cause of the phenomenon.