University of Texas Bulletin

No. 1847: August 20, 1918

Further Notes on the Structure Near Robert Lee, Coke County, Texas

BY

J. W. BEEDE

The Marathon Fold and Its Influence on Petroleum Accumulation

BY

R. A. LIDDLE

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 OF TEXAS

AUSTIN

Publications of the University of Texas

The University publishes bulletins six times a month, so numbered that the first two digits of the number show the year of issue; the last two the position in the yearly series. (For example, No. 1701 is the first bulletin of the year 1917.) These comprise the official publications of the University, publications on humanistic and scientific subjects, bulletins prepared by the Department of Extension and by the Bureau of Municipal Research and Reference, and other bulletins of general educational interest. With the exception of special numbers, any bulletin will be sent to a citizen of Texas free on request. All communications about University publications should be addressed to the Chairman of the Publications Committee, University of Texas, Austin.

University of Texas Bulletin

No. 1847: August 20, 1918

Further Notes on the Structure Near Robert Lee, Coke County, Texas

BY

J. W. BEEDE

The Marathon Fold and Its Influence on Petroleum Accumulation

BY

R. A. LIDDLE

Bureau of Economic Geology and Technology

Division of Economic Geology

J. A. Udden, Director of the Bureau and Head of the Division

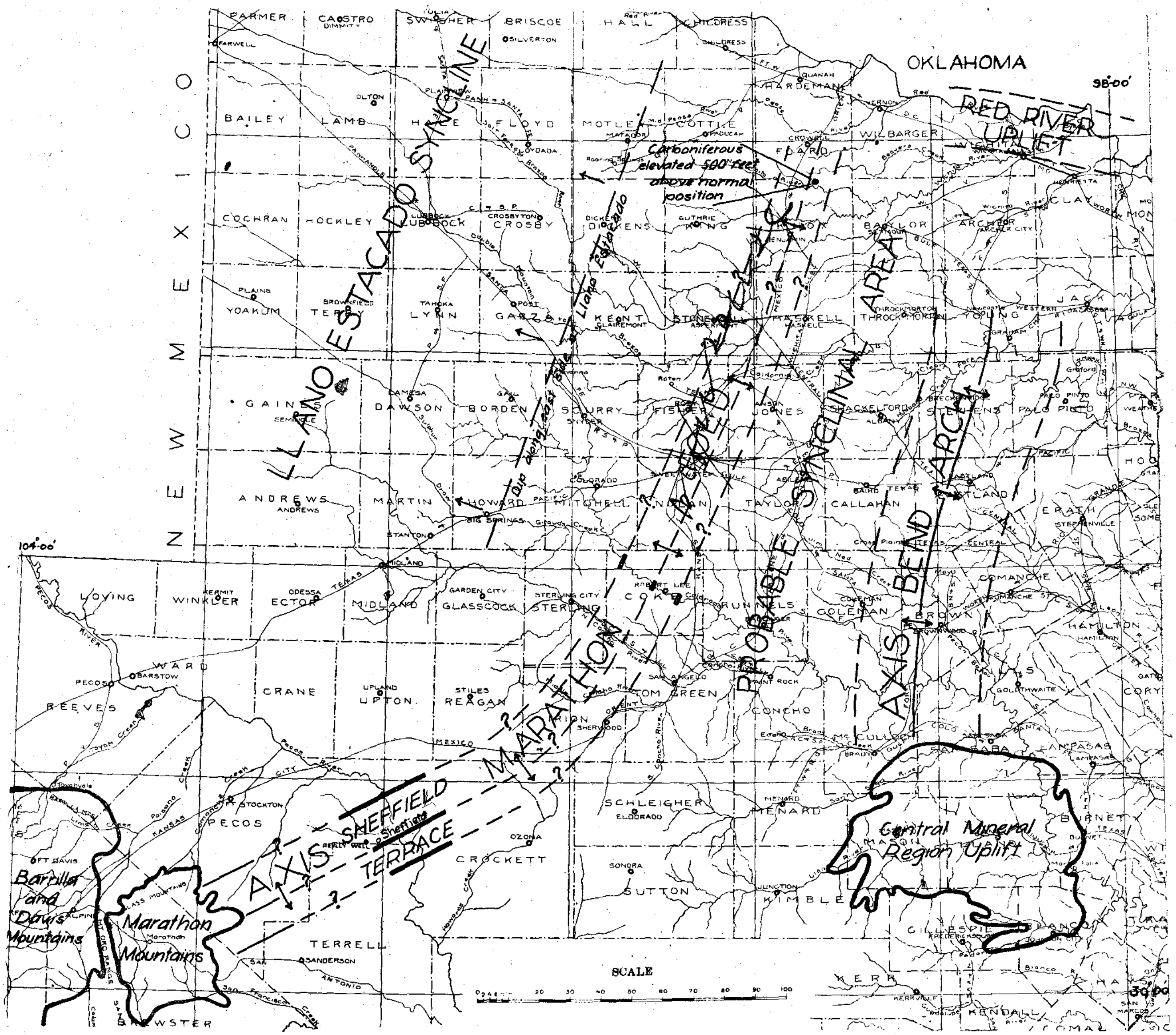
PUBLISHED BY THE UNIVERSITY SIX TIMES A MONTH, AND ENTERED AS SECOND-CLASS MATTER AT THE POSTOFFICE AT AUSTIN, TEXAS UNDER THE ACT OF AUGUST 24, 1912

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



MAP OF THE PROBABLE COURSE OF THE MARATHON FOLD

Showing the structural features of Texas, north of latitude 30° N. and between longitudes 98° and 104° W. Marathon Fold north of Irion County located by J. W. Beede, south of Irion County, by R. A. Liddle. Other data furnished by both writers. Solid lines define positions of known disturbances. Broken lines denote possible locations of disturbed areas.

FURTHER NOTES ON THE STRUCTURE NEAR ROBERT LEE, COKE COUNTY, TEXAS[1]

By J. W. Beede

Observations in Coke County reveal some peculiarly interesting structural conditions, and it is the purpose here to set forth our present knowledge of them. The data are necessarily incomplete, owing to a lack of deep wells in the western part of the county.

The Locke Well No. 1, and the Stroud Well No. 1, of the Robert Lee Oil Company, clearly reveal a strong subsurface structure, as shown by the cuttings, which is but faintly indicated by the surface rocks. The reason for the discordance was not apparent until the unconformity at the base of the San Angelo beds was plotted. The well logs revealed beneath the unconformity, eastward dipping beds, due either to a truncated fold or a fault with downthrow to the east. The structure was formed and deeply eroded before the San Angelo formation was deposited.

A study of this unconformity and its extent makes apparent the occurrence of obscured structures over so wide an area that it is deemed advisable to publish some observations upon it.

Age and Extent of the Unconformity

This unconformity lies at the base of the San Angelo formation of the Double Mountain stage of the Permian system of Texas. The Double Mountain is the highest stage of the Permian rocks in northwest Texas and is divisible into at least three distinct formations of considerable thickness. At the base is the San Angelo formation, composed of 400 feet of conglomerate, shales and sandstones, with, locally, some sheets of gypsum and dolomite. Over this formation is a series of very fine, friable, clayey

[1]Both manuscripts submitted January, 1920.

sandstones and sandy shales with a number of thick gypsum beds, and in some regions thin limestones or dolomites. This formation has been correlated by Wrather with the Greer formation of western Oklahoma and the eastern Panhandle of Texas. Above the Greer is a series of sandstones and some shales called the Quartermaster formation. This formation is not found in Coke County.

The rocks below the unconformity at the base of the San Angelo beds belong to the Clear Fork stage which is composed of two formations: the Vale formation at its base, composed of red shale, and the Choza formation constituting the upper part, composed of dolomites and shales. The Choza formation extends into the eastern part of Coke County. Beneath the Clear Fork beds occurs the Wichita Stage with its seventeen recognized formations. The rocks of the Wichita Stage rest on those of the Cisco Stage of Pennsylvanian age.

After an examination of the Ammonoid fauna of the Clear Fork beds, Böse states that the rocks from which the fossils came "may possibly" represent the lower Leonard beds of the Glass Mountains, while the fossils from a horizon near the top of the Greer formation "certainly correspond exactly to the horizon of *Perrinites vidriensis*, or the upper Leonard formation."[1]

The Leonard formation in the Glass Mountains has a profound erosional unconformity at its base cutting out more than 4,000 feet of underlying strata in a short distance. Conglomerates are common throughout the Leonard formation. Taking all this into account it seems very probable that the Coke County unconformity is continuous with that at the base of the Leonard or one just above its base.

Likewise, there is an unconformity in the Hueco Mountains followed by a hundred feet of conglomerate with cuts diagonally across some of the Permian beds and across the Diablo Plateau to the west edge of the Salt Flat, and passes

[1]The Permo-carboniferous Ammonoids of the Glass Mountains, etc., Univ. of Texas Bull. 1762, p. 207. 1919.

beneath rocks apparently belonging to the Leonard formation.

In both the Glass Mountains and in the Diablo Plateau the conglomerates were less folded than the formation upon which they rested. In other words, the underlying rocks were folded and then eroded to a considerable extent prior to the deposition of the conglomerates. This feature also characterizes the unconformity in Coke County and in all cases the stronger sub-surface structures are more faintly shown at the surface.

If this correlation of the unconformity is correct, its outcrop extends from the northern Salt Flat through the Diablo Plateau to the Glass Mountains and from there northeastward to San Angelo, eastern Coke County, and to the Red River. Indeed, the section of the Woodward and Greer formations of western Oklahoma and the eastern Panhandle of Texas is startlingly similar to the Coke County section, and there is a strong probability that the White Horse sandstone is unconformable with the underlying shales. The length of the outcrop of this unconformity in the main part of the state would be about 700 miles, not counting the sinuosities.

It is probable that the Permian sea in the State of Texas was very much restricted at this time and later expanded until it approached its former extent. During this period of elevation of the land and constriction of the sea considerable erosion was accomplished reducing very materially the existing structures. The deposition of the newer sediments masked these older structures. This obscuring of the older structures is of great importance in the exploitation of the oil resources of the whole region affected.

Significance of the Unconformity to the Petroleum Industry

This may be better understood by using the Coke County region as a concrete illustration.

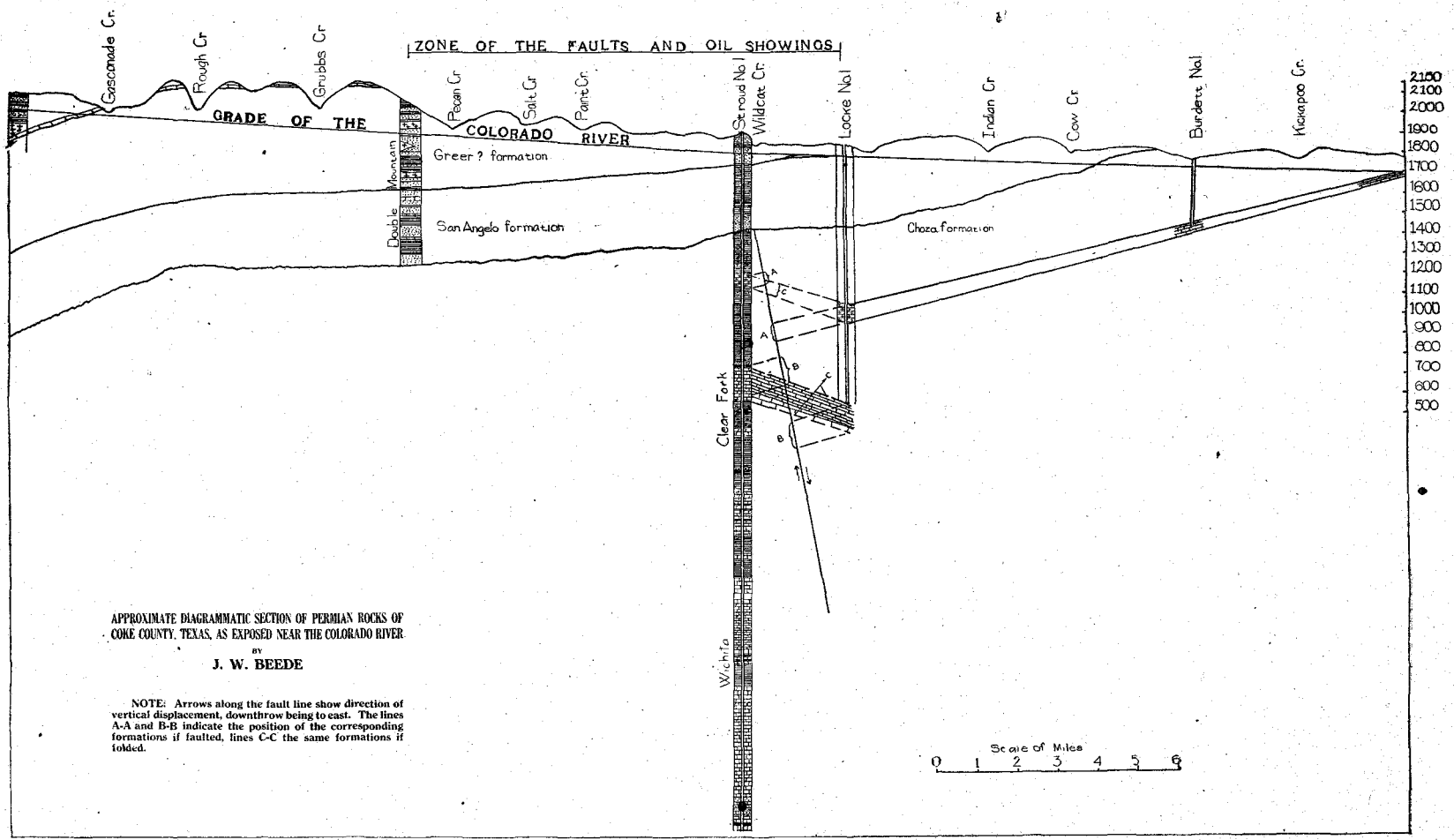
In the region of Pecan Creek, west of Edith, is a series of faults and crushed zones. Some of these disturbances appear as far east as Wildcat Creek if not to Robert Lee

itself. There are normal faults, one of which, with smaller faults beside it, apparently has a throw of 75 or 80 feet, and small reversed faults, together with numerous vertical zones from ten to thirty feet wide where the soft sandstones are crushed to an unknown depth without much displacement of the beds on either side. Near the crushed zones and normal faults the deep red sandstones and shales are leached to a buffish shade. In some instances this leaching extends for some fifty feet on either side of the disturbance, and in other cases it may be but a few feet. Where reversed faulting occurs there is no leaching. There are oil showings in the coarser sandstones occurring in this region.

From the accompanying diagram (Plate 2) it is clear that the underlying structure is not well shown in the surface formations except for slight inconspicuous faulting which is very easily overlooked. However, the dip of the beds to the north of west along the Colorado River in western Runnels and eastern Coke counties to the vicinity of Robert Lee is about fifty feet to the mile. At Robert Lee, it becomes much less steep and continues with a very slight dip to the northwest corner of the county, where a steep dip is resumed.

This area with slight dip apparently represents the whole width of the top of the underlying eroded structure. From the diagram it will be apparent that a very considerable thickness, 500 feet or more of strata, forming the top of this structure has been eroded away, bringing any possible oil-bearing beds that much closer to the surface.

It is still questionable whether the basal beds are folded or faulted on the eastern side of this structure. The fact that the surface beds are slightly fractured might be due quite as much to their character as to the nature of the movements of the sub-surface structure. The surface rocks are friable and fine-grained and therefore slight movements would be likely to produce rupture and faulting of the type found in this region. However, the presence of oil in the surface red beds would suggest a deeper-seated origin than



APPROXIMATE DIAGRAMMATIC SECTION OF PERMIAN ROCKS OF COKE COUNTY, TEXAS, AS EXPOSED NEAR THE COLORADO RIVER

BY

J. W. BEEDE

NOTE: Arrows along the fault line show direction of vertical displacement, downthrow being to east. The lines A-A and B-B indicate the position of the corresponding formations if faulted, lines C-C the same formations if folded.

the beds in which it occurs and lead to a strong supposition of faulting.

Furthermore, it seems rather probable that the Coke County structure, considering its apparent size and character, may represent a northeastward continuance or an outlier of the complicated folding of the Pennsylvanian rocks of the Marathon region to which Dr. Udden has already called attention.[1] If so, it probably passes northeastward in a gentle curve concave to the northwest.

It is worthy of note from the standpoint of the oil operator that the rather complicated conditions of this structure are likely to be repeated, and other different structures are likely to occur beneath any slight structure or area of flattened dip throughout the whole of west and northwest Texas, where the Double Mountain beds are found.

---

[1]Notes on the Geology of the Glass Mountains, Univ. of Texas Bull. 1753, pp. 55-8. 1917.

THE MARATHON FOLD AND ITS INFLUENCE ON PETROLEUM ACCUMULATION

By R. A. Liddle

The northeastward extension of the Marathon Mountains of Brewster County, in the nature of a large buried fold, sharply inclined in the lower formations, and faintly indicated at the surface, is of considerable scientific interest and of possible economic significance. Though the absence of collected data makes it impossible to determine in detail the nature and extent of this fold, general conclusions are possible.

Brief Geologic History

Following the deposition of the petroleum-bearing Carboniferous sediments in southwest Texas, tectonic activity was most pronounced in the area which is now occupied by the Marathon Mountains. This greater regional disturbance is evinced by the amount of movement which has taken place, locally producing steep folding and faulting in the surface formations. To the northeast of this area the activity was of a less violent nature, and along a line of weakness in pre-Carboniferous rocks movements took place with sufficient force to arch the Carboniferous sediments without faulting or fracturing them to such a great extent. Later erosion before deposition of more recent formations truncated the top of this fold, so that all horizons can be reached at a shallower depth along the axis of the Marathon Fold, than elsewhere. Due to the probable conditions under which the disturbance occurred along the line of the Marathon fold, it is improbable that structural regularity will be encountered. A comparison of the relative length and breadth of the Marathon fold, together with the evidence of the more steeply inclined strata on the southeastern flexure indicate that the dynamic forces which were accountable for the entire fold, were not concentrated at a single point of origin,

as in the Marathon Mountains, but distributed more or less unequally along the entire disturbed zone. The area of greatest disturbance lies in and to the west of the Marathon Mountains, from which the fold plunges to the northeast probably in a series of relative anticlines or "noses" and synclines. Whether or not there is a continuous fold along the entire line of weakness is not known. It is more probable, though, that this is not the case, but that local and more or less disconnected areas of folding overlie places of extreme weakness below. Between such points the underlying strata may be very little disturbed. Under these conditions the plunge of the fold from the mountains would continue only for a limited distance. If the reverse were true, the Carboniferous sediments, a number of miles from the mountains, would be carried much deeper than the elevation which they actually occupy. In this event the area designated as the Marathon fold could be more correctly referred to as the Marathon fold zone or fault zone, along which surface disturbances mark points of greater weakness and folding in the lower formations.

Petroleum Possibilities

Although geologically more complicated and more steeply folded in the lower formations, the Marathon fold is somewhat similar to the Bend Arch of north-central Texas. The presence of the Bend Arch is indicated at the surface by plunging arrested anticlines or "noses" and small inclined terraces, while the surface indications of the Marathon fold are confined to extensive terraces observed in the overlying Comanchean formations. More detailed work, however, may also reveal smaller and more sharply defined superficial structures.

The terracing or flattening of the dip in the surface formations along the axis of the Marathon fold is due to the last slight movement along a line of weakness previously developed by excessive folding in the underlying strata. At the point of origin, in the Marathon Mountains, the strata

are more steeply inclined and this decreases in amount, as the distance from the Marathon Mountains increases.

An examination of the Pecos River has shown that the axis of the Marathon fold crosses the Pecos River just above the steel highway bridge three and a half miles east of Sheffield. The general trend of the fold lies between north 40 degrees east to north 60 degrees east.

The Sheffield terrace, which is the largest surface disturbance observed in the region, has its longer axis coincident with the trend of the Marathon fold, and extends for at least fifteen miles into Crockett County. The width of the terrace is approximately 12 miles. The extent into Pecos County has not been traced, but it has been observed to continue for five or six miles. Other terraces and flattened areas undoubtedly occur both to the southwest and northeast of the Sheffield terrace, and a location of these will establish the fold more in detail.

Overlying the Carboniferous sediments are 250 feet of Triassic and an average of 500 feet of Comanchean Cretaceous deposits.

Surface structures along the Marathon fold have little value as concentrators of indigenous petroleum as there are no petroliferous horizons above the uppermost angular unconformity. However, they are of great importance in indicating where there has been greater folding below in the possibly oil-bearing formations. These surface structures will continue with little increase or decrease in size to the top of the Carboniferous. Below this they will increase both in extent and amount of disturbance.

The Carboniferous sediments along the Marathon fold are known to be oil-bearing and commercial deposits of petroleum, if present in the area northeast of the Marathon Mountains, will be found associated with points which are relatively structurally higher, along the fold zone. Such places will afford not only localities for maximum concentration, but over these areas the horizons can be reached at a shallower depth than at any other places. The folding and later erosion of sediments along the axis of this fold, or the truncation of the older formations before the

later deposition, have not only elevated the horizons over this area, above the normal level, but have decreased the thickness of the overlying sediments. The greatest amount of folding and erosion has likewise taken place along the axis of this folded area.

With the very limited sub-surface data, it is impossible to determine the exact places which are the most promising for investigation, but in all probability such places will be found at points of greatest disturbances in the surface formations. These terraced or flattened areas very likely overlie the relatively highest points on the fold below, or in case the fold is not continuous, they are above the more folded portions of the disturbed zone, and for this reason should be investigated first. For between the areas of greatest flattening at the surface, there is a great possibility of synclinal areas on the fold; or of regions of little disturbance, if the fold is discontinuous.

As the lower formations for some distance from the Marathon Mountains are extremely folded and broken, testing should be begun far enough away from that area to insure folding with little fracturing of formations. The location of the Sheffield terrace is far enough removed from the region of extreme activity so that its formations should be folded sufficiently to induce petroleum accumulation without escape through excessive fracturing and faulting.

On the accompanying map (Plate 1) the location and trend of the fold are shown. Regarding the width, however, it can be correctly considered as extending over a greater area. Only the area of surface disturbance has been mapped as the width of the folded zone. The flexures of the fold are known to continue farther to the northwest and southeast underneath relatively little disturbed Cretaceous sediments.

The solid oblique lines show the known extent of the Sheffield terrace. Its continuation, however, farther to the northeast and southwest, is very probable.

As will be noted the crest lies nearer to the southeastern side of the fold and this undoubtedly should be an important factor for consideration in the location of a test.

A specific application to the Sheffield terrace will be more explanatory. To the northwest of the axis of the Sheffield terrace, the surface formation is practically horizontal; while to the southeast of it the dip increases steeply over the normal regional dip to the southeast. Such a condition indicates that in the fold underlying the terrace the northwestern flexure is gently inclined, while to the southeast it is steeply tilted and possibly faulted. These facts suggest the advisability of drilling to the northwest of the axis.

Only an approximate depth to which a test should be carried can be given, as few drilling data are available. The information afforded by the deep tests near Sheffield and San Angelo indicates that in the vicinity of the Sheffield terrace and in general along the axis of the Marathon fold, a test should be carried 4000 feet. This depth, in most instances, should carry the hole well down into the Carboniferous formations.

There is little doubt but that the Word formation of the Carboniferous has been penetrated in Reilly No. 1 of the Texas Acreage Company, located one and a half miles west of Sheffield in Pecos County. The lithologic changes which the formations undergo toward the west make it impossible, with our present knowledge, to correlate the series in the Reilly well with that of north-central Texas. To the southwest also, rapid horizontal changes take place before the Marathon Mountains are reached, where the formations outcrop, and it is hazardous to positively identify them with those in the Reilly well. The upper 2000 feet of material penetrated in the Reilly test consists in general of sandstone, red clay, with some salt, and a greater amount of dolomitic limestone and anhydrite. Below 2000 feet, however, the material is mostly a dark gray to black bituminous limestone with carbonaceous sandy shales. Most of the samples show the presence of bituminous matter, and some carry oil and gas. There is no reason why, under proper concentrating conditions, there should not be commercial deposits of petroleum. The Reilly test at present has reached no producing horizon, but there is no reason why one should not be expected. Should the test be dry upon

completion, it can only be considered as proving the absence of commercial quantities of oil in the particular area of the test. The great amount of bituminous matter, with shows of oil and gas, observed in the test at Sheffield, indicates that under favorable structural conditions there should be commercial deposits of petroleum.

General Structural Relationship of the Bend Arch and the Marathon Fold

In presenting a structural feature of such magnitude as the Marathon fold, upon the necessarily limited data, there is considerable hesitation. However, as described and mapped, no attempt has been made at finality. The known evidence has been presented and the remaining suggestions merely offered as possibilities. From these seemingly logical conclusions have been reached. From the field work of the writer in the area under discussion, and from all other available information, the following brief general summary of the structural features can be given.

Plunging east of north from the Central Mineral Region is the Bend Arch, its axis bearing almost due north practically through Brown County, and thereafter slightly concave to northwest as far as known in Young County. Associated with points which are structurally high along this fold, are commercial deposits of petroleum. To the west of the area of greatest production, in western Coleman, Callahan and Shackelford counties and in Concho, Runnels and Taylor counties, there is evidence of a large syncline. The exact boundary between the Bend Arch and the adjacent syncline, of course, is more or less arbitrary. Over this synclinal area the middle and lower Bend and Ellenburger are found at lower elevations than elsewhere. The structures also in the counties named are apparently small folds in a large syncline. Their production is small and wells drilled on them soon develop water trouble even where it is not encountered at the beginning. A number of the wells in this synclinal area either have only

a showing of oil or gas, or, obtaining production, develop water trouble soon after drilling.

Plunging away from the Marathon Mountains, between north 40 degrees east and north 60 degrees east, is the Marathon fold. Its course is marked by slight surface disturbances as is the Bend Arch. In the vicinity of Sheffield, as shown on the map, its presence is indicated by the Sheffield Terrace. No sub-surface data are available to show the amount of folding in the lower Carboniferous formations under the terrace. It is very probable, however, that it is considerable, judging by the comparative disturbance in surface and sub-surface formations along the Colorado River in Coke County.

In Coke County a slight terracing or flattening in dip in the surface formations is underlain by a strong sub-surface fold, greater in extent than the surface terrace. This is evident from the sub-surface information afforded by the tests Locke No. 1 and Stroud No. 1 of the Robert Lee Oil Company (Plate 2). In Coke County, as at the Sheffield Terrace, the axis of the Marathon fold lies closer to the southeastern limb, indicating steeper folding, if not faulting, along the southeastern flexure of the Marathon fold. The course of the Marathon fold through Sterling County is determined by the relative positions of the Bend in the Cain and Richardson tests. The Bend occupies an elevation considerably higher than normal in the Richardson test, southeast Sterling County, compared with the position of the same formation in the Cain test, near San Angelo, Tom Green County.

In Foard County, as shown, the Carboniferous is known to be at least 500 feet above its normal undisturbed position. Between these two points practically nothing is known of the conditions, but they are considered to be as indicated. It is possible, however, that the elevation of the Carboniferous in Foard County is associated with the Red River uplift. As this is not definitely known, and the Bend Arch is known to extend nearly as far to the north, it is not improbable that the Marathon fold is accountable for the disturbance. In Coke County, to the west of the axis of the

Marathon fold, the surface formations dip to the northwest and no area of elevation is known till the western side of the Llano Estacado is reached. The axis of the Llano Syncline and the direction of dip along its eastern side are at best only an approximation. The syncline axis, though perhaps bearing more nearly north and south, is given the same general trend as the other structural features with which it is probably connected. The northward flexure of the Marathon fold north of Coke County may be the beginning of the westward dip of the eastern side of the Llano Estacado syncline.

Much detailed work, both surface and sub-surface, is needed to study more in detail the nature of the Marathon fold. Especially is such needed between the Sheffield Terrace and the disturbance in Coke County, and along the probable position of the fold between Coke and Foard counties. There is no known reason why commercial deposits of petroleum should not be found along the Marathon fold under conditions similar to those existing along the Bend Arch, if reservoirs are present.

Aside from unpublished field notes of the writer, the principal discussions relating to the Bend Arch, the Red River Uplift, and the Marathon Fold are:

M. G. Cheney: Oil Trade Journal, April and May, 1918.

Dorsey Hager: "Geology of North Central Texas," Bull. 138, Amer. Inst. Min. Eng., June, 1918.

W. G. Matteson: "A Review of the Development in North Central Texas Oil Fields during 1918," Economic Geology, March-April, 1919.

Lee Hager: "Red River Uplift," Oil and Gas Journal, October 17, 1919.

J. A. Udden: "Notes on the Geology of the Glass Mountains," Univ. of Texas Bull. 1753, September 20, 1917.

J. W. Beede: "Notes on the Structure and Oil Showings in the Red Beds of Coke County, Texas," Proc. Amer. Assn. Petr. Geologists, Norman, Okla. 1919.

J. W. Beede: "Geology of Coke County," Univ. of Texas Bull. (in preparation).

R. A. Liddle and T. M. Prettyman: "Geology and Mineral Resources of Crockett County with Notes on the Stratigraphy, Structure, and Oil Prospects of the Central Pecos Valley and University Lands," Univ. of Texas Bull. (in preparation).