South Dakota
Geological and Natural History Survey

Freeman Ward, State Geologist

CIRCULAR 12

# The Possibilities of Oil in Eastern Harding County

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## EXPLANATION

The Survey issues two series of publications as follows:

BULLETINS.—Some subjects have been investigated a longer time, full data have been gathered, such preparatory or experimental work as was necessary has been entirely or nearly finished. In other words, the study of the subject is actually completed or so nearly so that the results can be relied on and published with a degree of confidence as to their value; and the treatment is full and thorough. In such a case the matter is published as a bulletin.

CIRCULARS.—But often during the progress of the work enough information is at hand to be of value to those interested, yet not enough for a complete treatise. A part of a county or a part of a certain subject may be finished, perhaps, and publication waiting for the complete investigation of the whole county or the whole subject. There may be a demand for statistical matter, or lists of references, or current information, etc., which would hardly do for a formal bulletin. Such partial reports, summary reports, reports of progress, lists, or unit fragments of larger subjects, etc., are handled in circulars.

It is planned to publish the circulars frequently and the bulletins at longer intervals. With this arrangement much information will reach the public with a minimum of delay.

Inquiries may be addressed to the State Geologist, Vermillion, S. D.

## LOCATION

The area under discussion is located in that part of eastern Harding County, South Dakota, known as the Slim Buttes. It includes the following townships: 17, 18, and the south half of 19 N., Range 8, and the west half of Range 9 east of the Black Hills meridian. The region is without direct railroad connections. Two postoffice stations are within the area, Reva in the north central part, and Gill in the south central. The town of Buffalo, county seat of Harding County, is seventeen miles west of the northwest corner of the mapped area.

The nearest railroad point is Reeder, North Dakota, sixty-five miles to the north, on the C., M. & St. P. R. R. The nearest railheads in South Dakota are Isabel, Faith and Newell, approximately 90 miles to the east, southeast and southwest respectively. The western portion of the region is included in the Slim Buttes Division of the Sioux National Forest. (The position of the area in reference to the rest of the State is shown on the index map, Figure 1.)

## ACKNOWLEDGMENTS

The settlers and ranchers in the region have been of considerable help to the Survey during the conduct of the field work. They have very gladly furnished necessary camp supplies, have aided in the location of camp sites, have pointed out places of

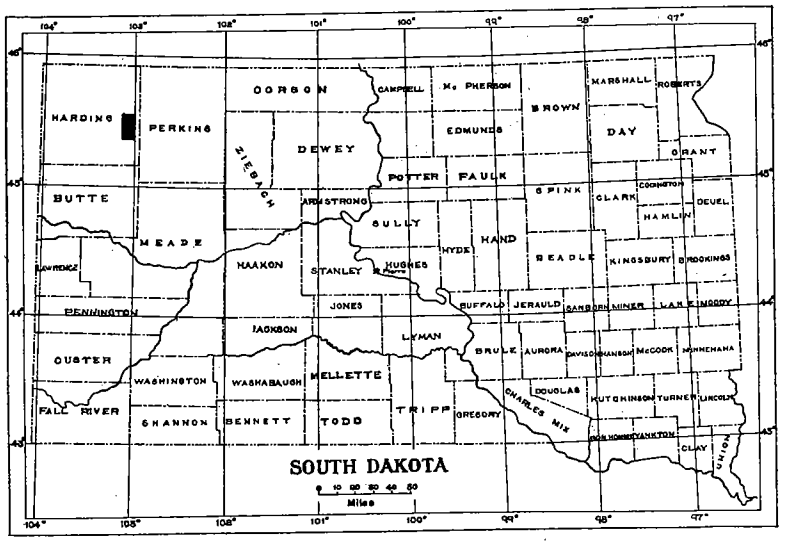



**Figure 1. Index Map.**

Black portion shows area covered by this report.

interest and have contrived in all ways to expedite the work. Particularly have the people about Reva P. O. been generous in giving aid to the party and in keeping it in communication with the railroad, bringing in the camp outfit and such materials needed in the work, but not available in the Reva store.

## PREVIOUS GEOLOGICAL WORK IN THE AREA

The first geologist to visit the region, Mr. H. N. Winchell, accompanied Captain Ludlow on his military expedition to the Black Hills in 1874. Prof. J. E. Todd, State Geologist, made a reconnaissance trip through the territory in 1893, his results being published in Bulletin No. 2, South Dakota Geological and Natural History Survey. During the field seasons of 1911 and 1912, the United States Geological Survey sent two parties into the region for the purpose of studying the lignite deposits. The report of this work is available as Bulletin No. 627 of the Survey. More recently a number of geologists have visited the region in the investigation of its oil possibilities, but no published results of their work are available. During the summer of 1921, Dr. R. A. Wilson of the State Survey covered the area in his preliminary survey of the oil possibilities of the State. Survey Bulletin No. 10 contains a brief statement of his findings.

## FIELD WORK

The present field work covered a period of two months during the summer of 1922. The area was mapped on a scale of four inches to the mile, the original land survey and Forest Service corners being used for the horizontal control. A plane table and telescopic alidade were used constantly. All outcrops and the formational boundaries were mapped in the field. For low dips exhibited by the strata stadia measurements were made; the sharper dips found locally in slump areas were measured with the clinometer and Brunton's compass. Practically every "forty" in the whole area was visited and in most cases traversed. In the Slim Buttes proper, a continuous traverse was made along the contacts of the Ludlow, White River, and Arikaree(?) formations.

The lack of topographic maps and good vertical control has proved a distinct handicap to the work and has tended to retard the completion of the mapping. But a single bench mark is found in the vicinity. Since no favorable structures for oil accumulation were discovered, no attempt was made to carry true elevations into the area mapped.

## GEOLOGICAL COLUMN

Formations of Cretaceous, Oligocene and probable Miocene age are exposed. These are shown in the accompanying table (Columnar Section).



Columnar Section

| | | | |
|---|---|---|---|
| Tertiary | Miocene(?) | Arikaree(?) | 240 |
| | Oligocene | White River | 150 |
| Cretaceous | Lance | Ludlow lignitic | 300 |
| | | Lower | 60 |

Only the general nature of these beds will be given in this paper, the details being reserved for a later complete discussion.

### CRETACEOUS

**Lance.**—In this part of northwestern South Dakota the Lance formation has been divided into three more or less distinct members: the Lower Lance or Lance proper, the Cannonball marine member, and the Ludlow lignitic member at the top. The Cannonball member has not been recognized in the region mapped, the sea in which the sediments were deposited apparently not having extended so far west.

**Lower Lance.**—The basal member of the Lance is well exposed only in the valleys of the larger creeks in the southeastern part of the area. But few good exposures occur, the beds breaking down readily into soil which is sod covered. The outcrops along the streams consist of irregularly bedded, somber, brownish and dark gray shale, sandy shale and brown to gray friable fine-grained sandstone. In a few places, slabs of a firm quartzitic light gray sandstone are found on the surface in the area of outcrop of this member.

The total thickness exposed does not exceed 60 feet and not all of this is in one section. To the east and southeast, the maximum thickness is said to reach 425 feet. The chief characteristic of the formation is the practical absence of lignite beds, except in the extreme upper part, and the presence of dinosaur remains. None of the latter were found in the area mapped.

**Ludlow Lignitic Member.**—The Ludlow is separated from the above chiefly on the basis of abundant lignite beds and the predominating yellow colors. A complete gradation occurs between the two members. In the mapping, the practice of the U. S. G. S. employed in the coal survey was followed, and the contact placed at the plane where the somber dark brown of the Lower Lance gave way to the yellow of the Ludlow. In the few places where the supposed contact was actually exposed, this plane was marked by a thin bed of impure lignite.

The Ludlow consists of alternating beds of yellow brown to brown lignitic shale, yellowish sandy shale and soft friable yellow

to light gray sandstone. Lignite occurs at intervals throughout the whole section, the beds varying from less than an inch to slightly over 4.5 feet in thickness. Individual beds do not extend over wide areas and hence do not make good guide horizons. The sandstones are the most resistant beds of the sections and commonly cap the smaller flat topped buttes east of the Slim Buttes proper. In several places the beds attain a thickness of nearly 15 feet.

Locally, where the lignite has been burned, the overlying beds have been highly altered and slacked, so that they have the appearance of furnace slag. The colors are changed to brilliant reds and pinks.

The greatest thickness of the Ludlow is a few feet less than 300 feet near the Slim Buttes, whence it thins slowly eastward to 125 feet at the border of the map.

## OLIGOCENE

**White River Formation.**—The White River formation is the most interesting of the whole section because of the fact that the attitude of the beds in several places, particularly near Reva Gap, has given rise to reports of diastrophic movement. Later the features were described as cross bedding by Winchester. The present report interprets these phenomena as slumping. (See under Structure.)

The formation in most places overlies the Ludlow and is sharply contrasted from it in color and texture as well as being separated by a distinct erosional unconformity. The average thickness in undisturbed outcrops hardly exceeds 60 feet. In these sections the formation consists of 10 to 20 feet of coarse, dazzling white sandstone with, at the base, numerous rounded feldspar crystals and pebbles up to three-fourths of an inch in diameter, overlain by three to eight feet of gray to olive green plastic clay, and twenty to forty feet of alternating gray, greenish, pinkish, and white clay, sandy clay and fine to coarse gray sand in beds from a few inches to two feet thick, all partially consolidated. At several places to the south of Reva Gap much thicker sections are exposed. In every case the beds are tilted at angles of from six to thirty degrees. The basal 60 feet correspond to the normal horizontal beds. The alternating clay and sand series may persist for an additional 20 to 60 feet, and are overlain by massive pink nodular clays without distinct bedding planes. The maximum thickness the latter measured was nearly sixty feet in Sec. 32, T. 18 N., R. 8 E. In this outcrop a total section of about 150 feet occurs.

In several places, notably in the west half of township 18 N., R. 8 E., the White River is absent and the Arikaree(?) is in contact with the Ludlow.



The basal sandstone and overlying green clay seem to represent the Titanothere beds, the alternating sands and clays the Oreodon, and the upper part of the massive pink clays the Protoceras beds of the type section along the White River. Fossils are, however, much less abundant in this region and no exact correlation can be made.

## MIOCENE(?)

**Arikaree(?).**—The exact stratigraphic age of the uppermost beds in the section is open to more or less doubt. They were called the Loup Fork by Todd and referred to the Arikaree by Darton. There is, however, no faunal evidence to establish the age, the only fossils known being fragmentary water-worn bones of White River species.

Except at the base the formation is remarkably constant over the entire outcrop area. The thickness varies up to a maximum of 240 feet in the southwestern part of the region. The beds are disconformable upon the White River except in slump areas where the White River is truncated. Locally as in Township 18 N., R. 8 E., the latter is absent and the Ludlow is in direct contact with the Arikaree(?). The base of the latter is almost a plane and indicates a complete base level between Oligocene and Arikaree(?) times.

As indicated above, the basal portion is variable from place to place. In the southwestern part of Township 17 N., R. 8 E., the formation begins with 5 to 25 feet of coarse buff conglomerate made up of water-worn fragments of White River material; small pockets of almost perfectly laminated fine whitish sandstone are included in the conglomerate. In the middle of the same township (in the large butte north of Gill P. O.), no trace of White River material is present in the 20 feet of greenish conglomeratic sandstone which marks the base. The material here consists wholly of quartz and other siliceous pellets in a coarse sand matrix. Lenses of finer soft, green, massive sandstone replace the coarser rock locally. To the north the base is less easily distinguished, except in a few places where several inches of green, gravelly sandstone occur. The separation between the Arikaree(?) and the White River is then best made on the basis of lamination, which is absent in the latter but well developed in the former.

The remaining thickness of the formation may be divided roughly into three parts, which are best developed again in Township 17. Immediately above the conglomerate are 80 to 90 feet of exceedingly fine-grained white to pinkish sandstone with very fine beds and laminae. The next 50 feet is more massive, gray to light green sandy shale and sandstone, with less perfect bedding and some cross-bedding on a small scale. These two divisions occur in most outcrops over the entire area covered by the Arikaree(?) and only slight variations occur. The upper 100 feet

in the thickest sections consists of predominantly gray to light green fine-grained thin bedded sandstone, with, near the top, several thin beds of almost pure white material resembling volcanic ash.

Throughout the entire area the beds vary but little in resistance. Steep cliffs are the rule in the Arikaree(?) area. The recent slumping is most pronounced in this formation and seems

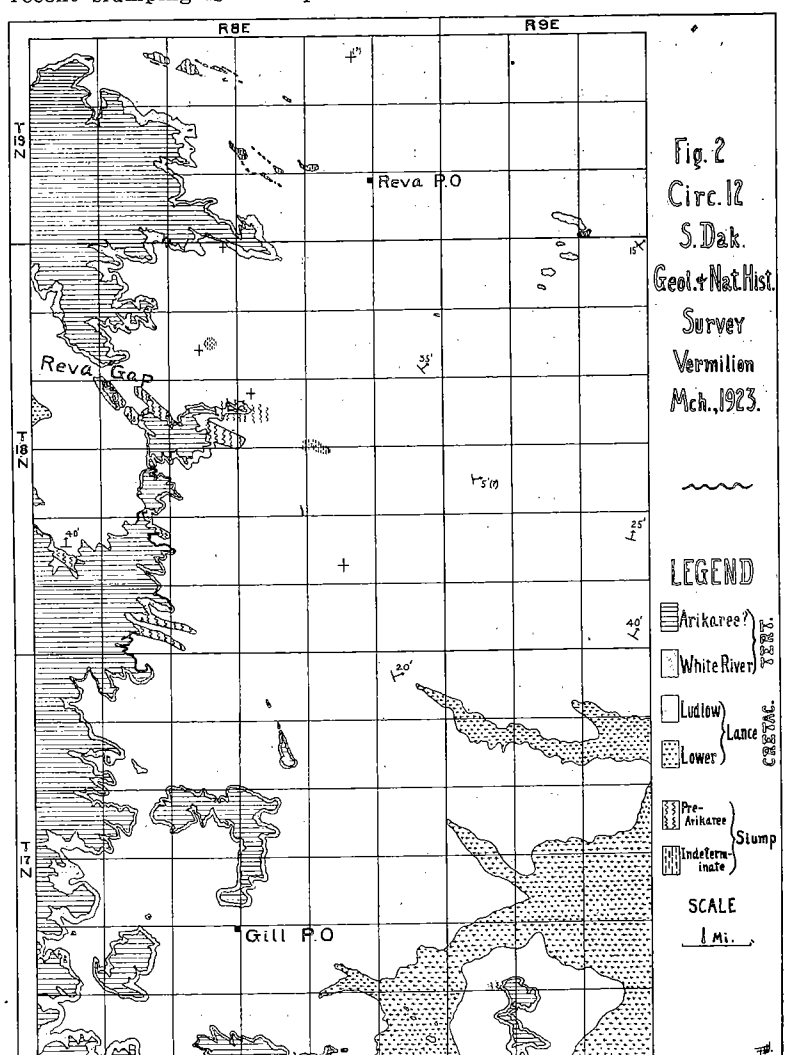



**Figure 2.**
Distribution of Formations.



to be determined largely by the vertical jointing developed in the beds. The forest cover, likewise, is found practically only in Arikaree(?) covered regions.

The distribution of these formations can be seen by reference to the geological map (Figure 2).

## STRUCTURE

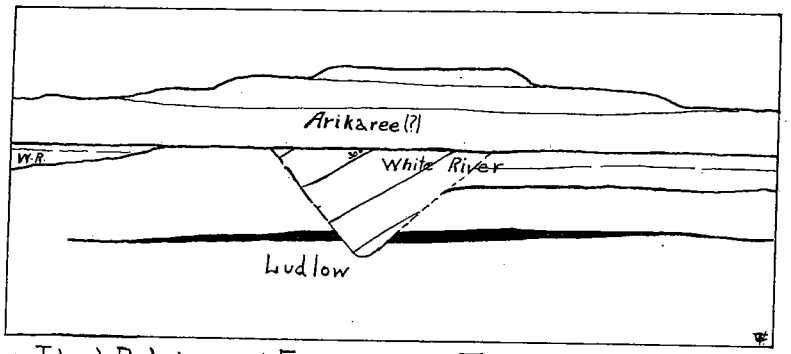
One of the important aims of the field work was to determine so far as possible whether any structures favorable for the accumulation of oil existed in the region. The realization of this aim has proved somewhat difficult because of the almost complete absence of reliable key or index horizons over the whole region. The very nature and rather limited outcrop area of the Arikaree(?) at once precluded any possibility of using it in the work. The White River is much better bedded, but like the overlying formation, its outcrop is limited and the nature is extremely variable from outcrop to outcrop. No one bed or group of beds can be traced for any considerable distance. It is this formation, however, which has been the basis for reports of "oil structures" in the area, because of the high angle dips occurring in several places, notably at Reva Gap and Flat Top Butte (Sec. 30, T. 17 N., R. 9 E.), both of which are easily accessible to the reconnaissance worker. Along the eastern border of the Slim Buttes south from the Gap, there are, however, numerous other extensive outcrops of steeply dipping White River beds, which proved extremely important in the interpretation of the structures. These will be discussed in more detail below.

The Ludlow member of the Lance formation furnished the best guide horizons because of the numerous coal beds. These occur throughout the formation but are rarely continuous for great distances and the outcrops are poor and few. Near the Slim Buttes the coals have been involved in a recent slumping or have been covered by other beds through it, so that it is difficult and often impossible to correlate beds across stream divides. One series of beds does outcrop more or less continuously along the buttes, but except in places it cannot be relied on because of recent slumping or contortion induced by slumping.

East of the Slim Buttes plane table levels were run in all places where sufficient outcrops occurred. Evidences of slumping occur some miles out from the buttes and might easily be taken for true dip on first observation. Where undisturbed it was found that the Ludlow beds dip from a few to 65 feet per mile in a general northeasterly direction. The average is about 25 feet, so that in single outcrops the beds seem essentially horizontal. The highest dip, 65 feet, occurs just north of the northern edge of the map and is not plotted. The observations of Winchester and others as reported in Bulletin 627 of the U. S. G. S. are in full accord with those of the present work. Absolutely no evi-

dence for the existence of "structures" favorable for accumulation was discovered.

Because of the fact that the tilted beds of the White River have been assigned several origins, it seems necessary to discuss in some detail the reasons for considering them as slump. Todd's determination of the phenomena as diastrophism was successfully refuted by Winchester in the work cited above. Winchester's[1] interpretation of the tilting as cross-bedding is, however, open to certain objections based upon observations during the past summer. As indicated upon the map, dips as high as 30 degrees are found in numerous White River outcrops along the east side of the Slim Buttes. In nearly every case, the section exhibiting the dips is much thicker than the undisturbed White River nearby. The beds seem to fill valley-like depressions in the Ludlow, a fact borne out by the linear extent of the disturbed members. Furthermore, the bedding is very regular and the basal 60 feet of the section in the bottom of these valleys is almost exactly like the normal section of White River over the whole region. The




Ideal Relations of Formations in Township 18N, R8E.

**Figure 3.**

base of the latter is, however, from 60 to 80 feet higher stratigraphically. The probability that the beds might be channel fillings is eliminated by the fact that the dipping beds terminate abruptly along distinct planes, which on first sight suggest fault planes, dipping at high angles (about 50 degrees) toward the valley bottoms.[2] The surrounding Ludlow is, however, not affected, since in several places sandstone and lignite beds can be traced across the valleys below the White River. In other places, particularly in Sec. 32, T. 18 N., R. 8 E., coal beds some distance above the base of the White River are found at essentially the same elevation on two or more sides of the tilted beds. It seems,

[1]Winchester, D E., Crossbedding in the White River Formation of Northwestern South Dakota: Jour. Geology, Vol. 21, pp. 550-556, 1913.

[2]The extremely wet season had caused these planes to be exposed by removal of wash.



therefore, that the planes can best be interpreted as slump planes and that the apparent deformation of the White River is due to tilted slump blocks filling pre-Miocene valleys.

Another argument may be urged against the theory of cross-bedding. In Sec. 32, T. 18 N., R. 8 E., in the bottom of a creek are found White River beds dipping in exactly opposite directions. The change is abrupt and indicates that the material has slipped down from each side of the old valley. Immediately to the south, the White River is wholly absent, as it is also in Sec. 30 in the same township. This seems to indicate that there is an irregular erosion surface between the Ludlow and White River in this area at least, only the slumps into the valleys being preserved.

It would perhaps be well to add a word concerning several bands of slumped White River in the south half of Township 19, Range 8 East. All of these masses are some 200 to 220 feet lower than the nearest undisturbed outcrops below the Arikaree(?). Except for two large masses in Sections 20 and 21, the blocks are 60 feet or less in thickness and occur in the bottom of modern valleys. The dip is invariably toward the outcrop area some one-half to one and a half miles westward. The more or less parallel bands are separated by Ludlow ridges. The exact age of the slumping is, therefore, difficult to determine, but because of the fact that the large areas in Sections 20 and 21 are made up of 125 to 150 feet of White River beds identical with those described in slump areas to the south and also because no such thickness is exposed anywhere immediately below the Arikaree(?), it seems best to consider the age of all of the slumps mapped as pre-Miocene.

Except in the west half of Section 15, Township 18, Range 8, the pre-Miocene slumping does not seem to have affected the Ludlow greatly. In this section, however, Ludlow beds are tilted at angles up to 45 degrees to the south and southwest. Traced westward, it is found the Ludlow is overlain by White River exhibiting similar dips. Recent slumping has obscured the structure to the north and south. The nearest undisturbed Ludlow to the east and north, at distances up to one-half mile away, is practically horizontal.

The recent slumping, which has been mentioned several times, is prevalent over the whole region. The beds involved invariably dip toward the cliffs of the Arikaree(?) and include all the formations. Undoubtedly some of the reports of folding and faulting were based upon these features. Clear cut evidence of rather recent slumping is found a mile or more out on the rolling plains. More obscure indications occur as much as six miles east of the Slim Buttes proper. In some places the beds dip distinctly toward the buttes and small, poorly drained depressions between hillocks. The occurrence of these blocks has suggested

the theory that the Slim Buttes have reached their present position chiefly by slumping.

The causes of the slumping are not always clear and will not be dealt with in this paper.

## CONCLUSIONS AND SUMMARY

1. There is no field evidence in the area to prove the existence of favorable oil structure.

2. The steeply dipping beds are entirely superficial and are due to slumping extending over several periods of time.

3. The region lies upon the flanks of a large structural basin, the center of which is near the town of Lemmon, South Dakota. (This is the so-called Lemmon Basin shown by Darton and others in government reports.)

4. It is the writer's opinion that it is entirely useless to attempt a search for oil, unless the rocks far below the surface do not conform in structure to those exposed. This does not seem likely in view of the fact that the Cretaceous system is very thick and where completely exposed exhibits almost continuous deposition from beginning to end.

THE END