

South Dakota  
Geological and Natural History Survey

Freeman Ward, State Geologist

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CIRCULAR 13

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The  
Possibilities of Oil  
in  
Northern Ziebach County

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By  
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and  
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Bulletin, University of South Dakota, Published by the University, Vermillion

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Series XXIII

April, 1923

No. 5

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Entered as Second Class Matter, May 3, 1902, at the  
Post Office at Vermillion, S. D., under Act of  
July 16, 1894

## 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.

## INTRODUCTION

During the field season of 1922 the State Geological and Natural History Survey made a detailed study of the geologic and structural features of eight townships in the general vicinity of Isabel, South Dakota. The primary purpose of the work was to determine the oil possibilities of this district—in so far as the working out of structural features from surface studies bears upon this problem.

A report on the four townships comprising the eastern half of the area mapped has already been issued as Circular 9, "The Possibilities of Oil in Western Dewey County." The following report deals with the four townships which lie in the western half of the area mapped, or in the northern part of Ziebach County.

## LOCATION

The area included in this report lies in the northeastern part of Ziebach County and includes the following townships: T. 15 and 16 N., R. 20 and 21 E.

Isabel, the terminal town of a branch line of the C. M. & St. P. R. R. running out from Mobridge, lies near the northeast corner of the area.

The index map (Fig. 1) shows the location of the area in the State.

## RELATION TO PREVIOUS WORK

The reconnaissance studies made during the field season of 1921 indicated that the strata over the plains region of the State

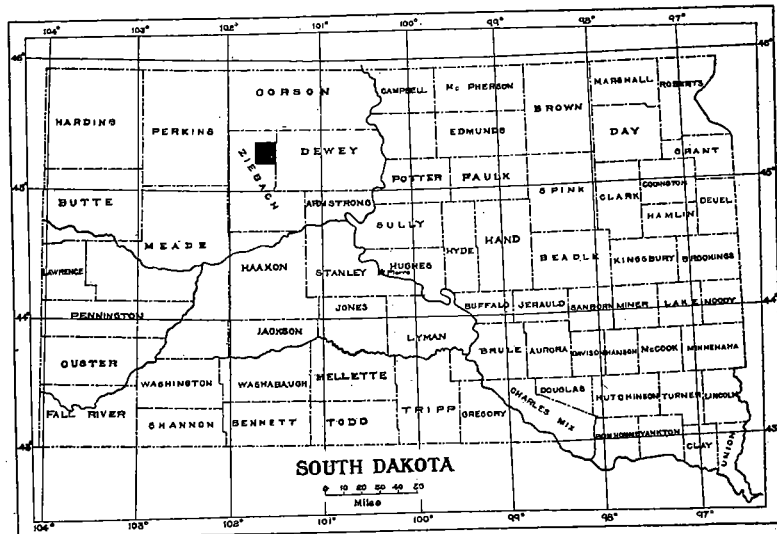


Fig. 1. Index Map

Black square shows location of area.

are but slightly folded. The work also showed that little reliance could be placed upon local dip readings, inasmuch as the major portion of such dips was found to represent structures of local or surficial origin. Such structures bear little if any relation to regional folding. The results of these studies are incorporated in Bulletin 10 of the State Geological and Natural History Survey.

In view of these facts, the accurate determination of detailed structural features in the plains region of the State is only possible by running carefully determined elevations upon some recognizable and sufficiently widespread stratum or key bed, such elevations showing the rise and fall of the key bed with reference to sea level and hence the character of the folding in which it is involved. Structural mapping by this method would, of necessity, be confined to those regions where satisfactory key beds were developed. This factor has determined the location of the areas where the State Geological Survey is now mapping.

### ACKNOWLEDGMENTS

The following extract from Circular 9 applies as directly to the area under consideration here: "The citizens of Isabel have been of decided help to the Survey in carrying on the work. They have

very generously given the services of a car and driver for daily use. They have also furnished a helper when needed and have supplied noonday lunch almost continuously. Since the Survey is not financially able to own a car or hire one, except for occasional service, that part of the aid was especially appreciated. This work could not possibly have gone on successfully without this adequate transportation.

"A unique character of this community is their sane point of view. Their extreme interest in the possibilities of oil has been tempered by common sense. Nothing savoring of the spectacular has been tolerated. They have understood and appreciated what the Survey was trying to do, and the spirit of cooperation in the search for truth has always been maintained. Their thoughtfulness in regard to delivery of mail, doing errands, offering special trips on the side, etc. is worthy of comment."

### FIELD WORK

The statement in Circular 9 relative to field work also applies to this area: "The area has been mapped section by section on a scale of two inches to the mile, the land survey corners being taken as horizontal control. A plane table and telescopic alidade were used continually, all important outcrops and boundaries being located and drawn in the field. All measurements were made by stadia.

"Elevations were determined almost entirely by barometer. With the railroad station at Isabel as a base, flying barometric levels were run by automobile along the main roads; these were always checked by re-reading. From these base lines of levels shorter lines were run to the key beds. From time to time the work was checked by level lines run with a spirit level. It is believed that the maximum error in elevation is ten feet, with a probable error of only five feet.

"Every quarter section was visited, and over much of the area every forty was examined. In a few localities it was necessary to spend an entire day in a single section."

### THE FORMATIONS

The Pierre, Fox Hills, and Lance formations are exposed in this area. The position of these formations in the stratigraphic column is shown in the appended table (Fig. 4). Their distribution is shown on the geologic map (Fig. 2).

**The Pierre Formation.**—Outcrops of this formation are restricted to the southern part of the area along the banks of the Moreau River and its immediate tributaries. The formation is essentially a uniform blue gray shale which becomes somewhat sandy as it passes upward into the overlying dark basal shales of the Fox

Hills formation. Since the Fox Hills and Pierre formations are transitional, it is difficult to draw any sharp line of demarcation between them. Approximately 100 feet of the Pierre is exposed along the banks of the Moreau River in the southeastern part of the area, but in the southwestern part nearly all of the Pierre is under cover, the basal Fox Hills beds lying near the river level.

**The Fox Hills Formation.**—The Fox Hills formation as developed in this area may be divided into three phases:—

The lower phase, which is transitional into the underlying Pierre formation, is made up of dark sandy shales with thin, interbedded sand layers. These shales become increasingly somber downward as they pass into the typical Pierre. About 50 feet of strata are represented in this phase.

The middle phase consists of banded, sandy shales of medium to light gray color, the color becoming increasingly lighter up-

stone are irregularly distributed through this general horizon. In general, this middle part of the Fox Hills formation can be distinguished by the banded appearance of the outcrops. The average thickness of this phase of the formation is 80 feet.

The upper phase is largely composed of sandstone with some interbedded sandy shale. In general, the sections of this part of the Fox Hills formation show about 35 feet of light gray and yellowish gray shaly sandstone, which passes upward into ten to fifteen feet of massive yellowish gray sandstone—the latter sandstone tending to weather out in large, rounded masses. It is these rounded masses of sandstone, outcropping at fairly frequent intervals over the area, which have served so satisfactorily as a key bed for structure mapping. This harder sandstone was found to be restricted to the same definite horizon everywhere. Above this “key bed” sandstone lies about 35 feet of light gray and yellowish gray sandstone. Iron concretions are common and the upper part of this last mentioned sandstone was found to contain a bed of fossil oyster shells which was more or less developed over the entire area.

The contact of the typical Fox Hills formation with the Lance is transitional, the change being represented by the above described shaly sandstones becoming interbedded with thin coal seams and carbonaceous shale layers. The first layer of coal or carbonaceous shale generally occurs just above the previously described oyster bed.

The average total thickness of the Fox Hills formation as exposed over this area is 210 feet.

**The Lance Formation.**—From 75 to 100 feet of the Lance formation is exposed over this area. The exposures are largely restricted to the northern half of the district. In general, the Lance consists of a varying series of sand, shale, clay, coal, and carbonaceous shale beds. The coal and carbonaceous shale are largely confined to the lower fifty feet of the formation. The upper 25 to 50 feet of the Lance as exposed in this area consists mainly of soft, yellowish gray sandstone and sandy shale.

The lower part of the formation, owing to the numerous layers of coal and carbonaceous shale, has a dark or somber color, which is broken here and there by light gray layers of sandstone that stand out in marked contrast.

The individual beds of the Lance lens out over short distances and any given section shows a rapid vertical alternation in the character of the deposits. Cross-bedded sandstones are common.

## STRUCTURAL FEATURES

The necessity of mapping structure in this territory by running elevations upon satisfactory key beds has already been indicated. The hard sandstone stratum developed near the top of the Fox Hills

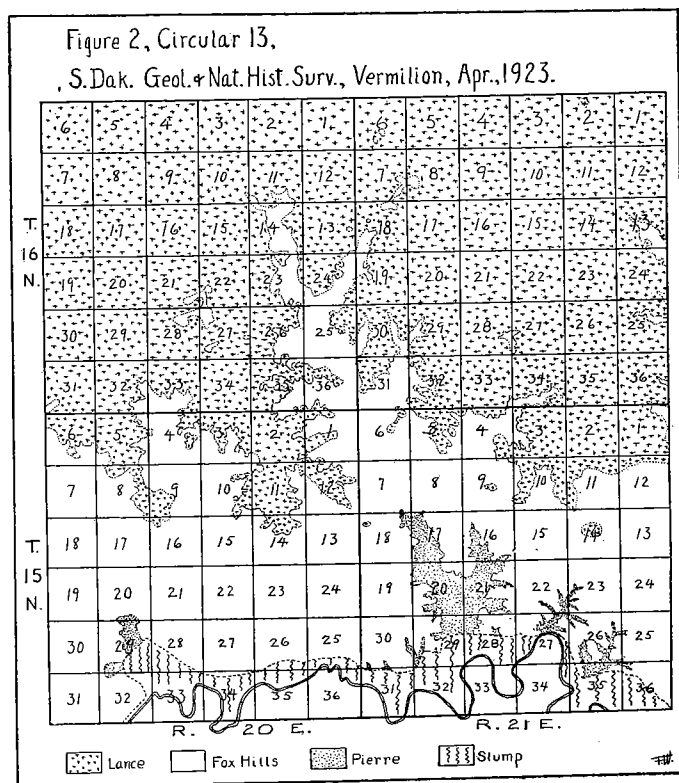


Fig. 2. Geologic Map

ward. The individual strata tend to be thin and uniform. Biscuit-shaped concretions of ferruginous clay and thin beds of pure sand-

formation, and which erodes out into large, rounded masses was found to be the most satisfactory key horizon. In the areas where the Fox Hills formation is developed, this key horizon was found to be exposed with sufficient frequency to give a fairly detailed knowledge of the structural conditions.

The determination of structure in the areas where the Lance constitutes the surface formation is more involved. Since individual coal beds, owing to their lenticular character, could not be recognized or followed over any appreciable area, the group of coal beds occurring in the lower fifty feet of the Lance were taken collectively and rated as a key bed fifty feet thick. In any given area where the Lance key horizon was used, the mean elevation of the beds was determined. In constructing the structure map this elevation was reduced to that of the underlying Fox Hills key bed which was found to lie at a fairly uniform distance below the Lance coal series.

**Results.**—By running levels on the key beds the following information was derived concerning the structural features of the region:

The formations in general lie in a relatively horizontal position, the dips only occasionally exceeding one degree. Locally the dips may be somewhat higher—as great as four or five degrees, but this is exceptional. In regions where the dips are very low, the axes of any folds which may be present tend to be very irregular in trend. The strata are warped and the strikes may show extreme variation. This is strikingly shown on the completed structure map (Fig. 3) of the area under discussion. It is in such areas that dips must be read with great caution. The plane table method of structure mapping is the only one that can be used even for the attaining of approximately accurate results.

The strata of the area may be said to be warped irregularly rather than thrown into any series of distinct folds. A plotting of the axes of the more noticeable folds shows a tendency for northeasterly and northwesterly trends, although there are numerous undulations with other directions of trend.

The mapping of the structure in this area showed one fold with closure worthy of mention. This is located in T. 15 N., R. 20 E. The general position, form and size is shown on the structure map (Fig. 3). As indicated on the map the most favorable structure lies in sections 8, 9, 16, 17, 20 and 21. The closure appears to be at least 50 feet, although lack of data on the southwest side of the fold does not absolutely prove this. The crest of this anticline is in the eastern half of section 17. From all the evidence in hand this structure is the most favorable for testing out the region for oil and gas.

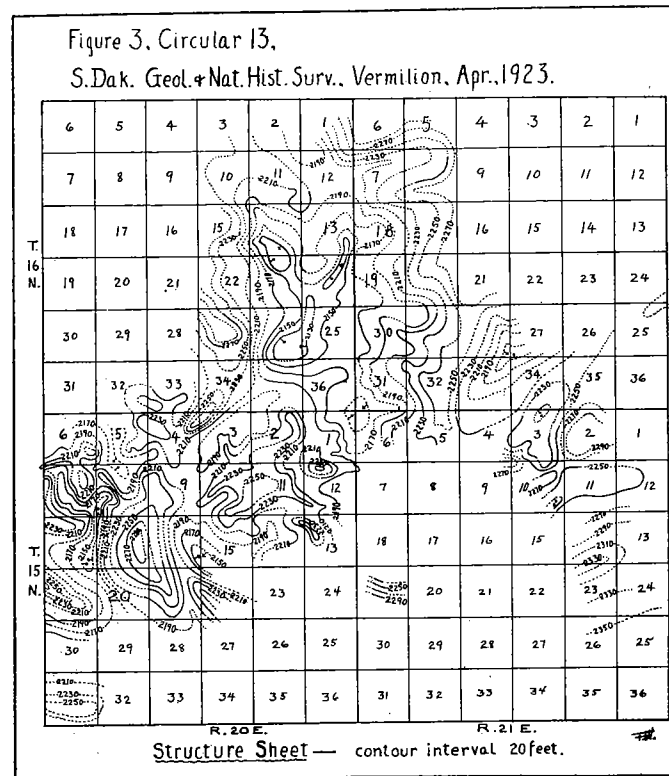


Fig. 3

It is probable that with more key bed evidence other undulating folds will be found with more or less closure.

A number of small faults were observed but in no case are the faults of sufficient magnitude to interfere with the oil possibilities.

In a number of localities the top beds of the Fox Hills formation were found to dip at angles, sometimes exceeding five degrees, a feature suggesting fairly marked folding at the close of Fox Hills times. A detailed study of these localities, however, has shown these folded masses of Fox Hills sand and shale to be slump blocks along the sides of channels which were eroded by Lance rivers. In a number of places the channel sides with their filled-in Lance deposits can be clearly seen.

## POSSIBLE OIL HORIZONS

The statement in Circular 9 is also applicable to this area and is here quoted in full: "Although a suitable oil structure has been located, the two other necessary conditions for oil have not been proved to exist. If there is no source of oil below or reservoir rock in which oil may accumulate, the dome has no value. Since there are no deep well records available for the area, nor, indeed, for any of the region nearer than 45 miles to the southeast and several times that distance in other directions, very little definite information is at hand concerning the deep underground conditions. But from a study of the nearest available evidence it is believed that the following table (Fig. 4) gives in a general way the most probable conditions:

Cretaceous	Lance		75-100	
	Fox Hills		210	
	Pierre		1200	
	Niobrara		200	
	Carlile		300	
	Greenhorn		25	
	Graneros	400		225
			Mowry	25
				25
			Newcastle (Muddy)	25
			100	
Dakota		150		
Comanchian	Fuson		50	
	Lakota		200	

Fig. 4

"It is not believed that there are sands of any consequence in the Pierre.

"The first possible horizon which may act as a reservoir rock is the Graneros. The Mowry member of that formation often contains a sandstone. The Newcastle, also known as the Thermopolis or Muddy, is another sandy member of the Graneros. Sometimes a water-bearing bed is encountered above the Mowry. Very little can be expected from any of these horizons.

"The Dakota and Lakota are well developed sandstones and would make excellent reservoir rocks under suitable conditions. The latter has the most favorable prospects of the whole series.

"The uncertainty concerning the formations below the Lakota is so great that it does not seem worth while to consider them.

"While it may be disheartening yet it must be admitted that the expectations concerning the productivity of the several possible horizons of the State are on the whole rather low. This matter is fully discussed in Bulletin 10, to which the reader is referred. In brief the reasons are as follows: The thickness, number and productivity of the oil sands diminish from central to eastern Wyoming and Montana. Many of these sands are completely absent in eastern and central South Dakota and no oil has been found in the thousands of artesian wells drilled in that part of the State. Western South Dakota is intermediate in position between the entire absence of production in eastern South Dakota and the moderate production of eastern Wyoming.

"However, the matter can only be proved one way or the other by drilling on suitable structures."

### DEPTH OF DRILLING

The depth to the several horizons mentioned above will depend upon the locality chosen for drilling. If the structure lying in Section 17, T. 15, N., R. 20 E. is chosen for testing, there would be at least 180 feet of Fox Hills to be drilled through.

On this basis the Mowry should be struck at 2,130 feet, the Newcastle at 2,155 to 2,180 feet, the Dakota at 2,300 feet and the Lakota at 2,500 feet.

It must be remembered that these figures are very approximate.

### SUMMARY

#### FAVORABLE FEATURES

- (a) The area is in western rather than eastern South Dakota.
- (b) A well defined closed structure of fair size has been located.
- (c) The depth of drilling needed to prove the structure is not excessive.
- (d) The structure is fairly accessible to the railroad.
- (e) Roads are fair, and fuel and water for operating purposes are within easy reach.

#### UNFAVORABLE FEATURES

- (a) The South Dakota field as a whole is entirely unproved.
- (b) The deep underground conditions are extremely uncertain.