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Freeman Ward, State Geologist

CIRCULAR 8

The Possibilities of Oil in Eastern Pennington County

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PREFATORY NOTE

The Badland area in eastern Pennington and western Jackson counties has been examined and mapped in considerable detail by the State Survey during the past several seasons. It is planned to publish a bulletin containing a full geological report covering this region. However, there have been so many inquiries concerning the oil possibilities of the region that it has been thought best to publish a brief discussion of this in advance of the larger and more complete bulletin. The present circular has been prepared to meet this demand. It discusses only a portion of the region covered.

LOCATION OF AREA

The particular area discussed in this circular is in eastern Pennington County, South Dakota. As shown in the sketch map (Fig. 1), it is a rectangular piece of country lying between Interior and Conata, and north of White River. It includes parts of townships 3 and 4 south, ranges 16 and 17 east; it is approximately six miles wide (north and south) by eight miles long (east and west).

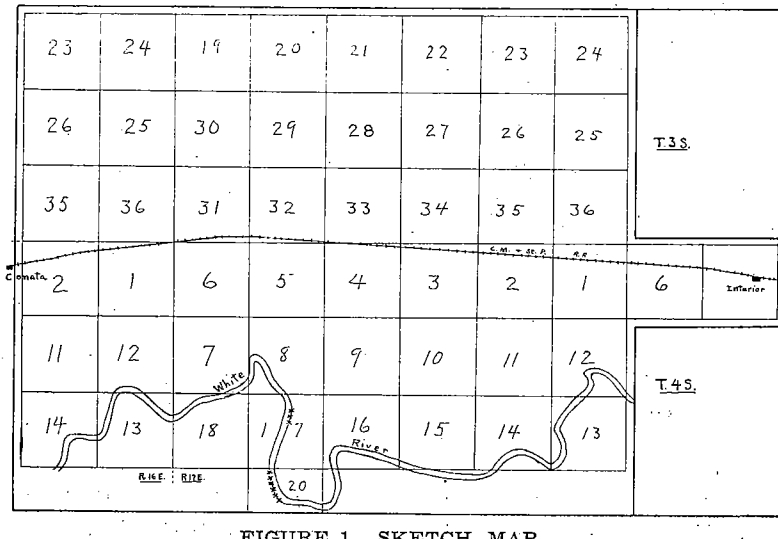

FIGURE 1. SKETCH MAP.
Crosses Indicate Outcrops of Pierre.

FIELD WORK

Very nearly four weeks' time was consumed in the field, with a rodman and two geologists at work. Plane table and telescopic alidade were used both for boundaries and levels. All measurements were made with stadia rod, reference points being the land survey corners. All mapping was done on a scale of fifteen hundred feet to the inch. A car was used continually to save time in getting about.

ADVANCE SUMMARY

There are several points that must be kept in mind when considering the possibilities of oil in this region, as follows:

1. No surface evidence of oil—oil seepages, gas, asphalt, bitumen, etc.—have been found in the area.
2. The nearest producing oil field is more than one hundred miles distant.
3. The nearest authentic oil showing is but little closer. (The oil reported at Scenic is yet to be proved.)
4. There are no deep wells in this area. The nearest one (at Wasta) is 35 miles away. No oil or gas has been reported from this.
5. On theoretical grounds, while there are arguments pro and con, the conditions are less favorable for oil in South Dakota than farther west, because so many of the producing sands thin out towards the east.
6. A test well southwest of Edgemont on favorable structure was drilled to the Lakota and got no oil.
7. The whole matter sifts down to the location of a suitable oil structure. But even if such structure can be located the drill is the only thing that can prove the presence or absence of oil.

THE FORMATIONS

The formations are largely Tertiary: there is some Cretaceous. The accompanying columnar section gives the name, age, relative position, and thickness of each formation.

Tertiary (Oligocene)	Oreodon	150+
	Titanotherium	70
Cretaceous	Fox Hills (?)	30
	Pierre	25

In the adjoining territory (highest parts of the "Wall") the Protoceros, the next higher member above the Oreodon, is present. Recent deposits, sands, gravels, wash, etc. occur freely throughout the area.

A brief description of the formations follows:—

Oreodon

Fine textured sandstone, light gray in color, alternating with pink shale. Formation as a whole has a well-bedded appearance. Locally coarser, cross-bedded sandstone. Weathers and erodes to steep slopes and peaks. It occurs as the upper parts of the buttes, such as the Herley Butte, and makes up the upper two-thirds or more of the "Wall" and its outlying extension to the south. Also occurs as the upper parts of the river bluffs.

Titanotherium

Massive shale. Color prevailingly gray with a slight greenish cast; occasional indistinct pinkish bands. Base has purplish to red-brown color and often contains secondary gypsum. Locally there are lenses of cherty limestone. Weathers and erodes to gentle slopes and rounded, billowy forms. Cherty limestone makes small, flat-topped buttes or benches. It is the lower member of the "Wall", buttes, and river bluffs, and occupies most of the flatter and rolling land from the base of the "Wall" to the river.

Fox Hills

(This classification is only provisional; it may be a phase of the Pierre). Thin-bedded, sandy shale, prevailingly yellow-brown in color but variegated with browner and purpler colors in the upper portion. Occasional fine sandstone a few inches thick. Thin streaks and veins of material rather higher in iron oxide, which give a rusty appearance to outcrops in many localities. Yields subdued topographic forms. It occurs almost entirely in the southern half of the area, especially along the White River Valley; only narrow extensions of this formation follow the creek beds north of the railroad.

Pierre

Typical dark gray shale, with a few narrow, harder layers. It occurs only in two localities along White River, in sections 17 and 20. These places are marked on the sketch map (Fig. 1). At low water a maximum of some twenty-five feet of it is exposed in the river bluff.

STRUCTURE

Since the structure is the chief interest in the problem, it merits some thorough discussion.

The Oreodon has some well defined beds, which are suitable to run structure on if they can be followed continually; but they cannot be easily correlated across separated outcrops. Allowance must be made for the fact that they are lenses, when distances over a half mile are considered. In the particular area under consideration the outcrops of the Oreodon were not abundant enough nor well enough placed to give much help.

The Titanotherium is too massive and uniform to furnish index beds. It was hoped that the cherty limestone beds might be used as index beds in the places where other evidence was lacking, especially to compare one small flat-topped butte with another. But it was found that there are two—and in one place three—horizons where these lenses occur. And there is nothing in the limestone to indicate which is which.

The beds in the Fox Hills are plain enough in the individual outcrop to work out the dip and strike; but they cannot be correlated between outcrops even for short distances. It was found too that cross-bedding was present, which will throw some doubt on the dips worked out in the smaller exposures. The structure, as revealed by the dips and strikes in this formation, has no definite trend in any particular direction, nor is any progressive, persistent raising or lowering of the strata indicated. This is shown by a glance at the accompanying map (Fig. 2), where a series of

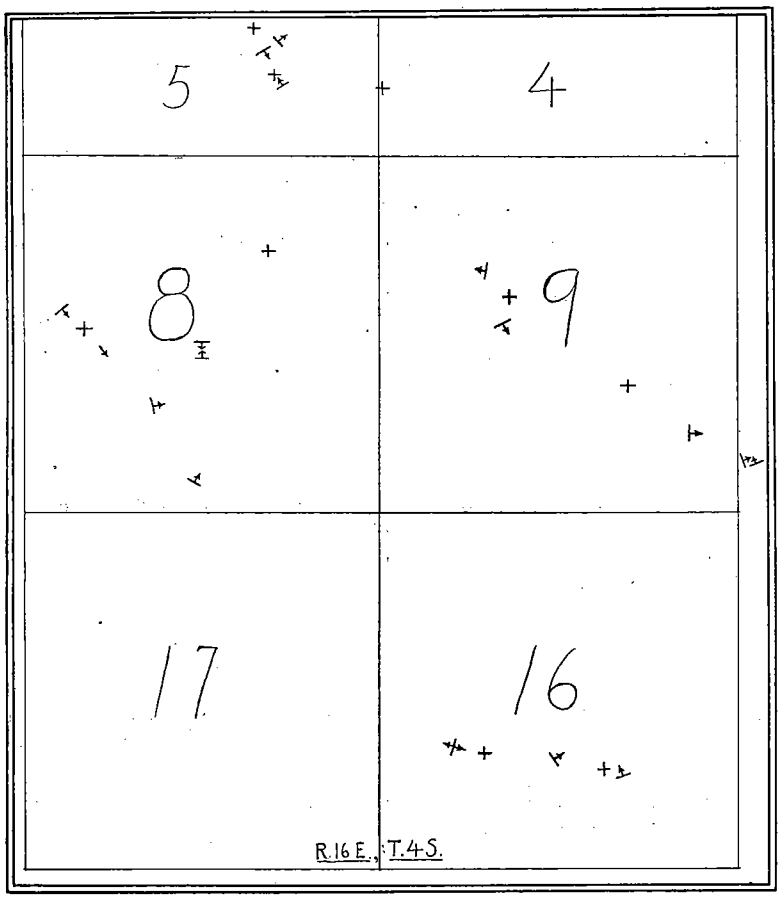

FIGURE 2. DIPS AND STRIKES OF FOX HILLS.

dips and strikes is plotted for several sections on a large scale. The dips are all low, five degrees being considered high. It is apparent that a study of the dips and strikes in the Fox Hills formation reveals only minor undulations rather than large regional structure.

The Pierre, as has been pointed out, occurs only in two places in the whole area. While the dips could be worked out in each outcrop, there was altogether too little of the formation exposed to work out the structure of even a portion of the area.

However, the very presence of the Pierre is suggestive of structure. Normally it is below the Tertiary and Fox Hills. Since the Fox Hills is a thin formation, the Pierre should be rather near the surface in the south half of the area, but it is reported in only one well. It does not appear at the surface outside the area for twenty miles down the river, twenty-five miles up the river, and a much greater distance to the south. The nearest place where the Pierre outcrops outside the area is thirteen miles northeast, where the regional slope brings it up.

Its presence on the surface in this area may be accounted for in one of two ways:—

(a) As a higher portion of the old surface, developed on the Cretaceous by erosion before the Tertiary formations were deposited. The Fox Hills is thoroughly conformable with the Pierre; in fact the contact is gradational. If the old Cretaceous surface had a rolling topography and this particular spot marks one of the ridges or knolls, then one would expect the Tertiary cover to show some overlap. The facilities for observing this feature are limited by the number of outcrops. However, the Titanotherium overlies the Fox Hills for more than a quarter of a mile at the point where Pierre is below. As far as the eye could judge it has a conformable position, giving no evidence of overlap; the contact is a disconformity rather than an angular unconformity. The same relation holds between Titanotherium and Fox Hills at many other places where the Pierre does not show below. Hence the explanation of the presence of the Pierre as a higher point in the pre-Tertiary landscape is not convincing.

(b) Brought up by anticlinal warping. This seems to be the logical alternative. It fits the facts better than the first explanation. Other evidence of regional disturbance consists of the minor undulations of the Fox Hills; the disturbed condition of the butte in the S. W. quarter of section 11, R. 16, the presence of faults with throws up to 25 feet; the broad, uniform undulation and steady regional rise to the north, with dips as high as three degrees, as shown by the Tertiary outside the area nearby.

But even if the presence of the Pierre does strongly suggest a regional upward warping, yet there is not enough evidence exposed to prove a closed structure.

Because of the lack of sufficient and proper evidence it has been impossible to get enough data for the construction of a structure map by the usual system of structure contours.

There is one other phase of the structural problem, viz.,—Do the Tertiary structures properly represent the deeper and more fundamental structures? In no place in this region has it been possible to compare the structure of the two, except at the one Pierre outcrop. Wherever the Oreodon is present the Fox Hills is lacking or shows too little, or vice versa. In the northwest part of South Dakota and in Montana the two are deformed together and are so nearly conformable that either may indicate the deeper structure. Probably it is safe to make the same assumption for this part of the state.

HORIZONS

If drilling for oil is to be undertaken, it is pertinent to discuss the possible horizons and their probable depth below the surface. The discussion may be prefaced by stating that since there are no deep well records in the area the figures given for the thicknesses of the formations cannot be exact; they represent the most probable estimates in round numbers.

In central Wyoming the horizons where oil has been found are as follows:

(a) Teapot, Parkman, Shannon sandstones, which are sandy members of the Pierre formation. These thin out in eastern Wyoming and in the Big Muddy dome the Shannon is absent.

(b) Frontier, Wall Creek, Torchlight, Peay sandstones, which are equivalent in position to the Greenhorn limestone. The Wall Creek is the one which is recognized in eastern Wyoming.

(c) The Mowry member of the Graneros shows oil but is usually not a producing horizon.

(d) The Thermopolis of central Wyoming is the equivalent of the Newcastle sandstone in eastern Wyoming. This is the main source of oil in the Moorcroft field.

(e) The Dakota sandstone, sandy members of the Fuson shale, and the Lakota sandstone have yielded oil in many parts of Wyoming, mainly under the group name "Cloverly" and must be considered as possible horizons, especially since the Lakota is the chief producing horizon in the Mule Creek field.

Deeper formations have produced oil in central and western Wyoming, but there is much doubt as to their value in eastern Wyoming.

For easier comparison there is given (Page 10) in tabulated form the relative position and thickness of the formations of eastern Wyoming and in South Dakota, also three of the nearest deep well records available.

None of the sandstone members of the Pierre has been reported in western South Dakota thus far. The Shannon cannot be expected, for it is absent in eastern Wyoming. The equivalents of the Teapot or Parkman may be looked for, but no assurance of their presence can be given. The log of the well at Wasta would be instructive if it had been accurately kept and was now available. Certainly if oil had been found in paying quantities it would have been noticed in that particular hole.

Near the top of the Carlile there is a water-bearing horizon in parts of western South Dakota Such a reservoir could hold oil—if oil is present. It should be struck approximately 1,400 feet below the surface.

The Greenhorn along the eastern edge of the Black Hills is described as a thin-bedded limestone, in places somewhat shaly. No sandstone member is reported. Therefore nothing can be expected from it here.

The Newcastle is the first serious possibility, since it is oil bearing in one of the two fields nearest South Dakota (Moorcroft). It should be reached approximately 2,400 feet from the surface. Not much production can be expected from this bed, however, for it is not a strong producer, even in eastern Wyoming.

The Dakota sandstone should be struck at a depth of approximately 2,600 feet.

The Lakota sandstone should be struck at a depth of approximately 2,800 feet. The Lakota is the best chance in the series, for it is the producing horizon in the Mule Creek field just over the line in eastern Wyoming. But the failure of a well southwest of Edgemont, and located on favorable structure, to get oil from this horizon throws much doubt on the prospects from the Lakota here.

The deeper formations are practically unknown; it would take an additional 1,000 or more feet to prove them one way or the other. In the Mule Creek field two wells have been sunk some 500 feet below the Lakota. Both are well located in respect to the axis of the anticline and are dry holes.

The most favorable place for putting down a hole is that portion of the area on or near the outcrop of the Pierre shale.

It should be emphasized that the chances for securing a flowing artesian well are very good along White River valley and the adjacent low-lying territory.

			Eastern Wyoming	Eastern Black Hills	Wasta	Nowlin	Capa	Eastern So. Dak.	This Area
TERT.	TITANOTHERIUM								
CRETACEOUS	FOX HILLS (?)								30
	PIERRE		400	1200 to 1500	Well 2,287 feet deep; starts in Pierre; complete log not available; water from sandstone in Benton; Dakota sandstone probably 2,500—2,600 feet from surface.	Well 1,842 feet deep; starts in Pierre; complete log not available; Dakota sandstone struck at 1,770; some gas; temperature 121 degrees F.	Well 1,690 feet deep; starts in Pierre; complete log not available; Dakota sandstone struck at 1,500; gas struck at 1,560; temperature 118 degrees F.	1000	1200
		Teapot	150—175						
			325						
		Parkman	325						
			50—100						
		Shannon	?						
			1000 to 2000						
	NIOBRARA		100—200	150—225				100—200	150
	CARLILE		600—800	400—800				200	450
	GREENHORN (WALL CREEK)		50—100	50				25—50	50
	GRANEROS		550—650	900 to 1100				65—105	700
		Mowry	100						
			25						
		Newcastle	5—35						
			175—250						
	DAKOTA	Cloverly	60	35—150				150—400	150
COMANCHEAN	FUSON		50	30—100				?	25
	MINNEWASTA		0—30	0—30					0
	LAKOTA		50—200	100—350					250

SUMMARY

1. The field is an entirely new one. No oil showings have been found anywhere near the area. No deep well records anywhere near.

2. Surface evidence of oil is entirely lacking in the area. This signifies little if anything either for or against oil.

3. No well marked domes or closed structures have been located in the area.

4. The presence of the Pierre shale in the midst of the Tertiary area is believed to indicate an anticlinal arching of the formations. The portion of the area on or near the Pierre is the only place where there is a possibility of "structure."

5. The Dakota sandstone is approximately 2,600 and the Lakota 2,800 feet below the surface in the most favorable portion of the area. Other possible sandstone horizons have been indicated in the preceding discussion.

6. There is a good chance for a flowing artesian well, even if no oil is obtained.

7. If neither oil nor water is secured, it is probably of little use to go deeper than 3,000 feet.