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E. P. Rothrock, State Geologist.

REPORT OF INVESTIGATIONS
No. 6.

THE
FAIRBURN
STRUCTURE

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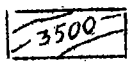
October, 1930

FAIRBURN
STRUCTURE

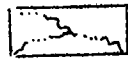
LEGEND



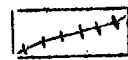
Outcrop



Contours Interval
20 ft. Datum on
Greenhorn Ls.



Drainage



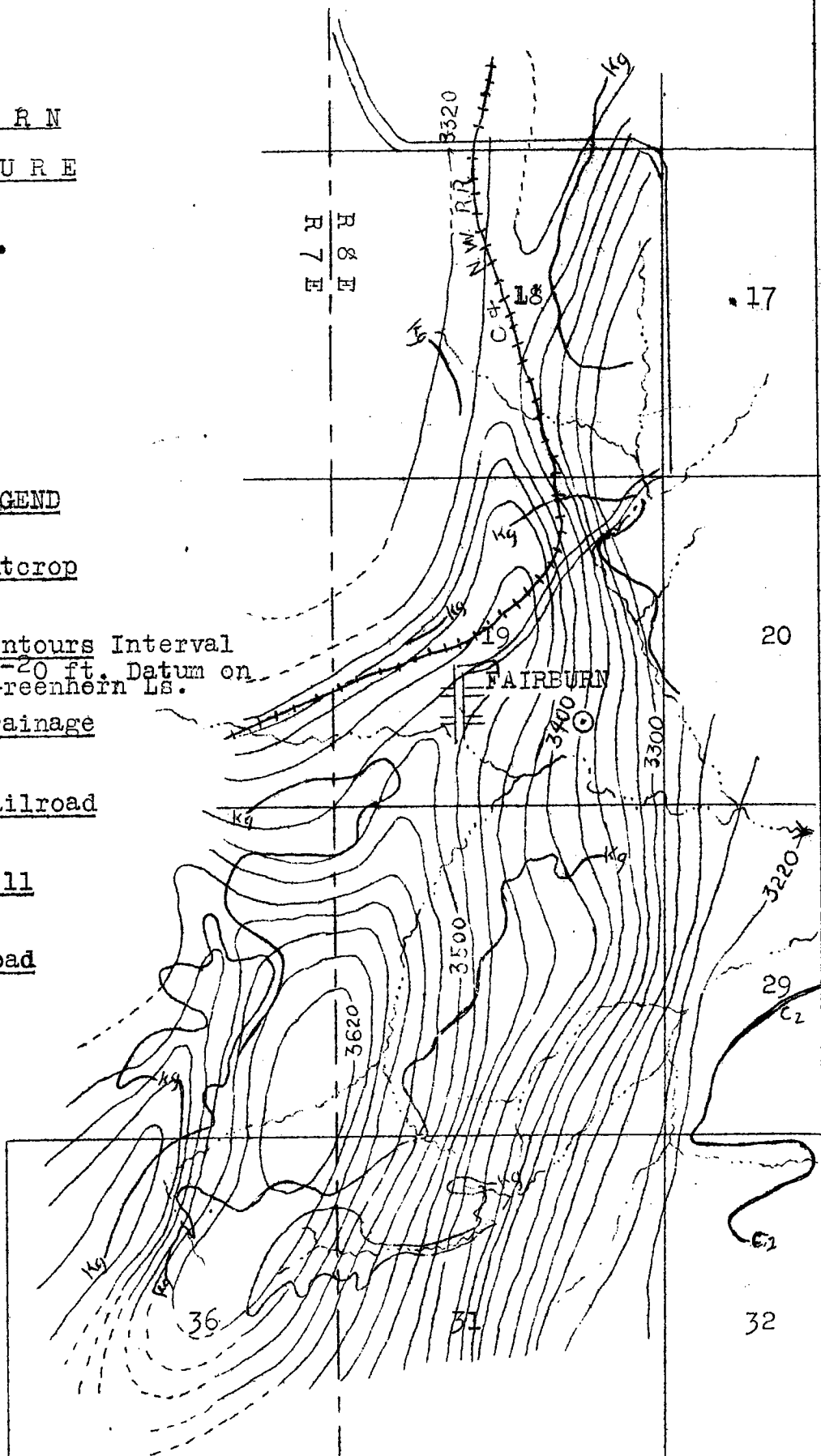
Railroad



Well



Road



T 4 S
T 5 S

FIGURE I

THE FAIRBURN STRUCTURE

PURPOSE OF THE REPORT

The limestone ridges which tower above the highway south of the town of Fairburn in Custer County, have been of considerable interest to geologists and oil prospectors for some years. Recent interest in oil development has brought this region to the front again. The Fairburn survey was undertaken, therefore, to get information of sufficient detail to determine whether a structure existed in the region which might be interesting as an oil possibility.

The following map and report is the result of a plane table survey made during the summer of 1930, by a party from the State Geological Survey. This party consisted of E. P. Rothrock, State Geologist; Messrs. M. E. Kirby, Ben W. Heiss, Robert W. Parrott, and Lester K. Olson, assistants. The author wishes to express his appreciation of the painstaking work of his assistants, and also of the courtesy accorded the party by the citizens of Fairburn and others interested in the oil possibilities of the region.

STRUCTURE

The structure is a long, narrow, anticlinal fold, whose crest trends slightly east of north, paralleling the folds of the Black Hills, which lie only a few miles to the west. Its axis is exposed for a distance of nearly four miles, the north

end being lost beneath Tertiary sediments about two and one half miles north of Fairburn, and the southern end disappearing beneath Tertiary sediments about three miles south of the same town. It is about two miles wide at its widest point and dwindles to about a quarter of a mile at its narrowest.

The important feature of the structure is a large dome at the southern end, which drops into a saddle at the northern end. The highest point is a mile and a half south of Fairburn in the southeast quarter of Section 25, T. 4 S., R. 7 E., B.H.M. Its crest rises about one hundred feet above the trough one half mile west of it, and slopes steeply to the east for at least a mile. This east slope was mapped until it was 400 ft., below the crest of the structure. The axis of the structure slopes northward from the high point for about two miles and a half. Here it runs into the saddle mentioned above which is about 200 to 250 feet lower than the crest.

South of the crest there is evidently a slope but its extent could not be determined because this end of the fold is lost beneath Tertiary sands and gravels. Elevations were obtained, however, which proved a drop of twenty feet in the axis and the trend of the flanks in this part of the structure indicate that the slope of the axis is much greater. A closure of more than twenty feet is assured and an estimate of fifty to one hundred feet would not be unreasonable.

Drilling locations:

Petroleum and natural gas tend to collect in the tops of anticlinal structures. In spite of the exceptions to this

rule, the general practice followed in exploring untried territory is to drill on top of the structures if possible. The best locations for test wells on the Fairburn structure, therefore, will be found on the southern end near the axis.

STRATIGRAPHY AND POSSIBLE OIL SANDS

Formations exposed in and about the structure are of interest only because they were used to determine the character of that part of the fold which lies underground. Any possible petroleum or gas contained in the structure has to be produced from rocks which are not exposed in the vicinity. There are about thirty one hundred feet of sedimentary formations lying beneath the top of the structure, and a number of these carry sands which will be of interest to anyone testing the structure. The position and relative thickness of these sands are shown in the accompanying columnar section (figure 2).

Formations Exposed

Tertiary:

The folded Cretaceous rocks are overlaid by gravel, sands and clay of Tertiary age, which in places are sufficiently well cemented to make solid rock. There is no difficulty in distinguishing the Tertiary from the older formations, because it is all light colored. No matter whether the exposure be gravel, sand or clay the color is always light gray or chalky white. The general cast is much like the color of the same formations which outcrops in the White River Badlands. Irregular bedding and lack of uniformity of composition characterize this formation wherever exposed.

SECTION OF CRETACEOUS FORMATIONS EXPOSED

IN FAIRBURN STRUCTURE

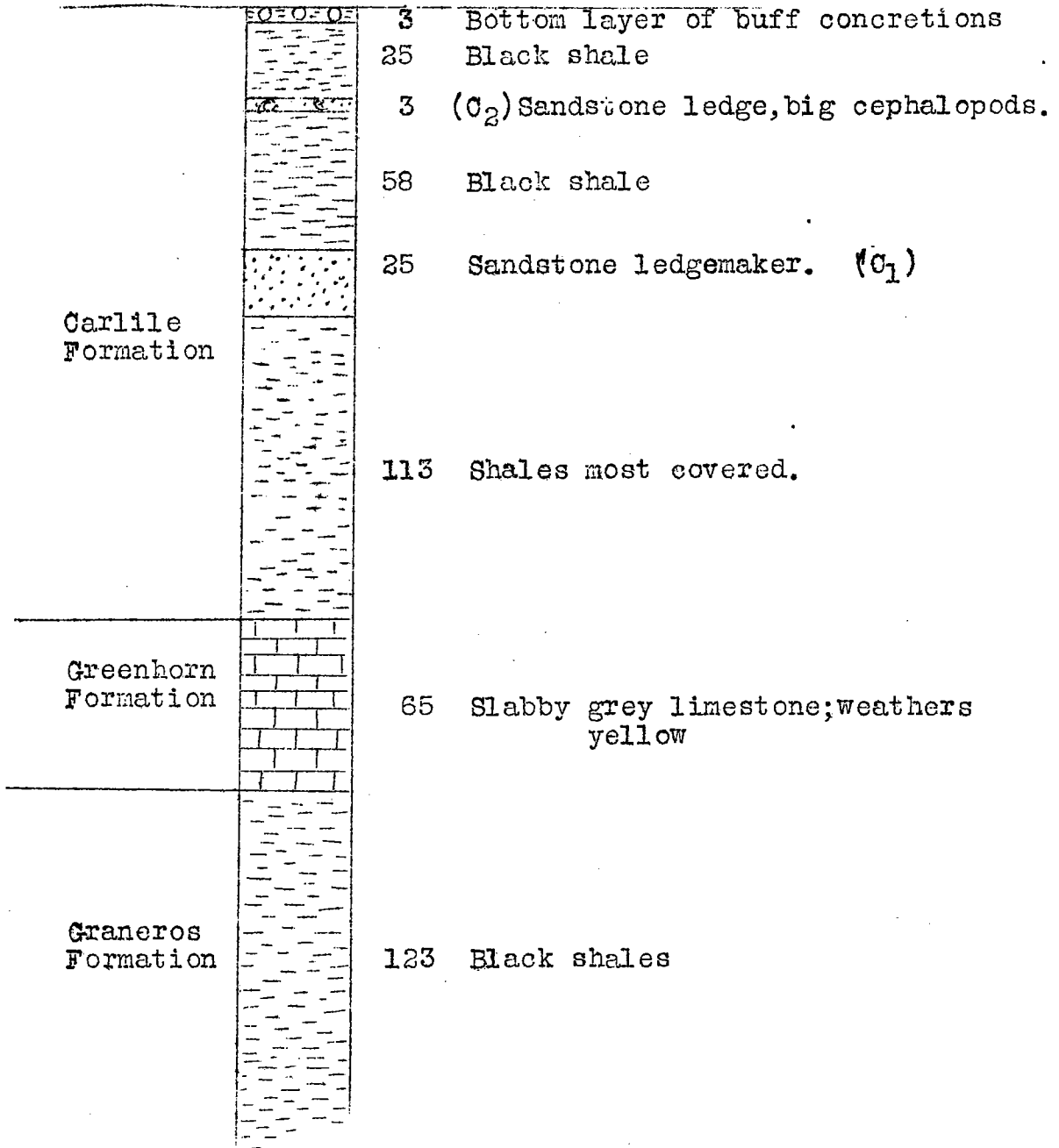


FIGURE 2

These rocks surround the structure, overlying the older Cretaceous rocks with a marked angular unconformity.

Carlile:

The lowest 250 feet of this formation are exposed on the flank of the structure outside of the Greenhorn Limestone brakes. The sand which corresponds to the Wall Creek member of this formation in Wyoming, makes several ledges which were used in mapping the southeast part of the structure. The most distinct of these ledges is the highest one, which is composed of one to four feet of soft sand. At the top of this is a thin calcareous, sandy layer, which weathers a distinctively brown color. This ledge is quite conspicuous where the slope of the surface is not too gentle, and is easily recognized since it carries fauna characterized by large cephalopods. The fossils are quite abundant and it requires very little searching to identify the ledge.

The lower sand horizon is much thicker averaging 25 feet in the area studied. It probably corresponds to the main Wall Creek sand of Wyoming. The rest of the formation is composed of black shale.

The following section was taken southeast of Fairburn:

Carlile Formation

In SW $\frac{1}{4}$, Sec. 28, T. 4 S., R. 8 E., Custer Co.

Feet	
3	Layer of buff concretions imbedded in black shale. Concretions cracked and cavities drused with calcite.
29	Black shale
2-3	Brown cross bedded sandstone, which makes ledge on weathering. Abundant fana of large cephalopods and many small fossils characteristic of this ledge.

58 Black shale

25 Ledge-making sandstone. Fine grained, weathers yellow. Only 6 feet exposed, but float indicates 25 feet as total thickness.

113 Mostly covered, black shale where exposed.

Greenhorn Limestone:

The Greenhorn Formation is the most striking of the formations exposed in the structure, for it stands out on prominent scarps on both sides of the structure south of Fairburn. The outcrop weathers to a slabby limestone and therefore, protrudes sharply from the shales which surround it. The formation carries the characteristic fossil, *Inoceramus liabiatus*, in great abundance. Near the base is a zone of brown limestone, which contains oyster beds in several exposures. This is an important horizon as it was necessary to map on the base of the formation in the northern part of the area. A section taken on the west side of the structure shows the thickness of the formation to be 65 feet.

Greenhorn Section

East of the center of Sec. 25, T. 4 S, R. 7 E.,
Custer County, 1½ miles southwest of Fairburn

Feet

- 65 Typical slabby gray limestone, weathering to a bright yellow. *Inoceramus* abundant in most beds, base marked by thin brown oyster bearing limestone, prominent in places, but absent in others. Two to three feet above this limestone lie concretionary layers, very fossiliferous, with *Graphaea* and long spined *Prinnotropsis*. Sharp contact with shales below where cliffs are steep and no wash or slump is present.
- 123 Black shales of the Graneros formation. No ledges exposed in the section.

Graneros Formation:

The Graneros Formation is the oldest one which is exposed on the structure. Since not more than about 200 feet of the top of the formation is exposed, about 700 feet still remain under ground.

The formation is composed of black shale which can be seen in the cliffs below the Greenhorn. No sand beds, layers of concretions or other irregularities were seen in the exposures.

FORMATIONS UNDERGROUND

Graneros:

This formation is the first to be penetrated in drilling on top of the structure. About 700 feet of this formation will be passed before reaching the sands of the Fall River (Dakota) formation, most of it black shale. There are several zones of iron carbonate concretions which carry some manganese in the lower part of the Graneros, where it is exposed farther south along the Black Hills, and some of these probably will be struck in drilling the Fairburn structure. Some of the concretions reach thicknesses of one to two feet and probably will be reported as limestone by the driller.

About 350 feet from the bottom of the formation there appears, in places, a sandstone known as the Newcastle sand. In Wyoming it produces oil, and would be of interest as an oil horizon if it occurs at this place. Its occurrence, however, is rather patchy and it is not possible to predict whether this sand occurs under the Fairburn structure.

GENERALIZED SECTION
of
Which may be expected under the
FAIRBURN STRUCTURE

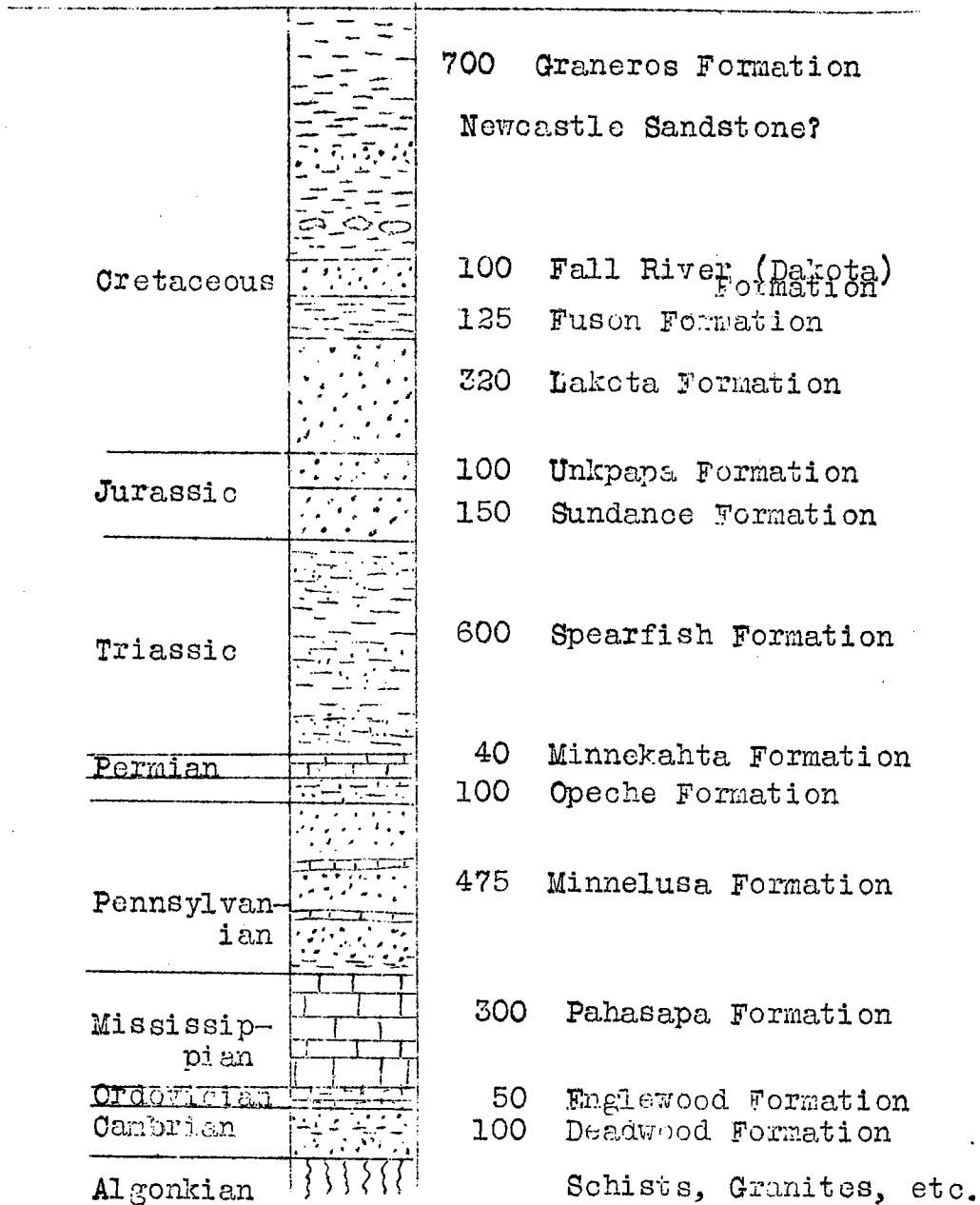


FIGURE 3

Fall River (Dakota) Formation:

This is the first sand that can be predicted with certainty. It is of interest as it may be a reservoir rock for oil and gas. The formation is a medium grained sandstone with the possible exception of some shale partings which may occur in the upper and lower part. It is a famous water horizon and will doubtless give the driller water troubles.

Its thickness varies somewhat. The outcrop on Wall Creek, ten miles to the north, shows 28 feet. At Hermosa, twelve miles to the southwest, it is 200 feet thick. At Fairburn, therefore, the thickness to be expected is about 100 to 150 feet.

Fuson Formation:

This formation should be about 125 feet thick in the Fairburn region. It is a shale formation of various colors from white through grays and browns to blues and purples. In a number of exposures it shows two or three sandstone horizons from three to ten feet in thickness. The thickest of these occur near the top and near the base of the formation. So far as it is now known these sands have not produced shows of petroleum either on the outcrop or where penetrated by the drill.

The Minnewaste limestone which lies between the Fuson and Lakota formation will probably be missing, as it is found in the outcrop south of this locality only.

Lakota Formation:

The Lakota Formation is the second thick sandstone which will be encountered. It is usually lighter in color than the

Fall River and much thicker. A section exposed on French Creek, west of Fairburn; shows 320 feet of sandstone. This formation also carried water in most places where it has been penetrated by the drill.

The Morrison formation which underlies the Lakota farther north is probably missing or very thin near Fairburn.

Unkpapa Formation:

This formation is characterized as a soft, massive, fine, grained sandstone and it is usually of a light gray or white, to purple or buff color. Its composition and character make it a suitable reservoir rock, although it has not produced shows of oil in any of the regions immediately surrounding the Black Hills.

Ninety feet of the formation are exposed on Dry Creek and 100 feet on French Creek, it is probable, therefore, that about 100 feet underly the formation at Fairburn.

Sundance Formation:

This formation also offers some chance of being a reservoir rock, although only about one half of the formation is sandstone. The other half is made entirely of shale. The following section taken south of French Creek will illustrate its character:

Section of Sundance Formation

1 Mile south of French Creek
(U.S.G.S. Folio 219--page 10)

Feet

25 Shale, dark, and sandstone, gray, with reddish layers.

- 25 Sandstone, buff, ripple marks
- 8 Sandstone and dark gray shale alternating, ripple marks
- 30 Shale, dirty gray, buff, thin layers of sandstone; contains fossils.
- 24 Sandstone, buff with ripple marks, some thin beds and reddish layers, rests unconformably on Spearfish red shale.

112

The thickness on French Creek near to the structure is 150 feet. It is probable, therefore, that the thickness at Fairburn will be nearer 150 feet than the 112 feet shown in the section.

Spearfish Formation:

Underlying the Sundance Formation are 600 to 700 feet of red beds belonging to the Spearfish Formation. These are mostly fine sands and shales with beds of gypsum scattered through them. These beds have never produced oil nor shows of oil in neighboring regions. It is not likely, therefore, that they will produce at Fairburn. Their thickness and color, however, make them important as a horizon indicator for they are easily recognized in well cuttings.

Minnekahta Formation:

This formation is a very thin limestone of a light gray color, with pinkish or purplish tinge at the outcrop. It is too dense to be considered as a reservoir rock, but there is a suggestion that it might be the source of petroleum in a statement made by Darton that, "Much of the rock has a bituminous odor when struck or broken". (U.S.G.S. Folio 219-p. 9)

This formation is quite uniform in thickness in all parts

of the Black Hills and in the vicinity of Fairburn it should be about 40 feet.

Opeche Formation:

The lower red bed formation is called the Opeche Formation. In composition it is much like the Spearfish beds, being made of red shale and sandstone with gypsum beds scattered through it. No showings of oil have been produced from this formation and it will probably be barren at Fairburn. Its thickness varies from 70-115 feet in various parts of the Hills. A section on French Creek west of Fairburn shows 100 feet of these red beds, and this figure probably represents its thickness under the Fairburn structure.

The Minnelusa Formation:

This formation is perhaps the most interesting in the section from the standpoint of oil production, for it has produced showings at several places in South Dakota, and seems to be a most promising horizon. Where exposed, it is largely a sandstone, but contains some shale and limestone layers. The latter are very conspicuous in the outcrop. The formation has three parts which are recognized in most places from which it is described; a massive sandstone, up to 110 feet thick, at the top; a zone of alternating sand, shale and limestone, lying below it, and 20 to 25 feet of red shale at the base.

The thickness of this formation at Fairburn should be about 475 feet.

Pahasapa Formation:

This is the "Mississippi lime" or Madison lime which is found in the Rocky Mountain region. It is a thick formation of very dense, massive, light gray to dove colored limestone. In many exposures in the Black Hills the rock contains many small cavities, which are abundant enough to make it a possible oil reservoir, in spite of the lack of porosity of the formation as a whole. Because of its density this is not an easy formation to drill but if the structure is to be thoroughly tested it should not be disregarded as a possible oil horizon.

In parts of the Black Hills the Pahasapa reaches thicknesses of 600 feet and more. The thickness for the Fairburn region, however, will be in the neighborhood of 300 feet as that is its thickness in the nearest outcrop on French Creek.

Englewood Formation:

This is a slabby limestone formation lying directly beneath the Pahasapa. On the outcrop it is usually pale pinkish to buff in color. In some localities, however, it is decidedly purplish. What its character is in the vicinity of Fairburn is not known as there are no outcrops near. From the thickness in other parts of the Black Hills it is estimated that about 50 feet of this formation should be encountered.

Deadwood Formation:

The Whitewood limestone which lies between the Englewood and the Deadwood in other parts of the Black Hills is missing

near Fairburn. The drill will go directly from the Englewood into the Deadwood Formation. This is the last formation worth testing as it lies directly upon Pre-Cambrian rocks which hold no oil possibilities.

The Deadwood is primarily a sandstone formation. Its color on the outcrop is brown or dusky buff. At the northern part of the Black Hills the middle third of the formation is made up of limey shale, and it is very probable that some of this shale will be found in the formation at Fairburn. This zone, however, is very thin towards the south and doubtless will be only a few feet thick at Fairburn.

Under this structure the Deadwood formation should not be more than 100 feet thick.

DRILLING CONDITIONS

The Fairburn structure is easily accessible due to the fact that it lies so near to the town of Fairburn, which is served by the Chicago and Northwestern Railroad. A good highway follows the axis of the structure both to the south and north from Fairburn, making it easy to reach all parts by truck.

Fuel will have to be imported as there is no supply in the immediate vicinity. French Creek offers an abundant supply of water. A sufficient supply might also be obtained by building a dam across the small stream which flows northward along the axis of the structure.