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**SOUTH DAKOTA  
GEOLOGICAL AND NATURAL HISTORY SURVEY  
E. P. Rothrock, State Geologist**

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**REPORT OF INVESTIGATIONS  
No. 9**

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**THE  
CHILSON  
ANTICLINE**

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**By  
E. P. Rothrock**

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**University of South Dakota  
Vermillion, South Dakota**

**March, 1931  
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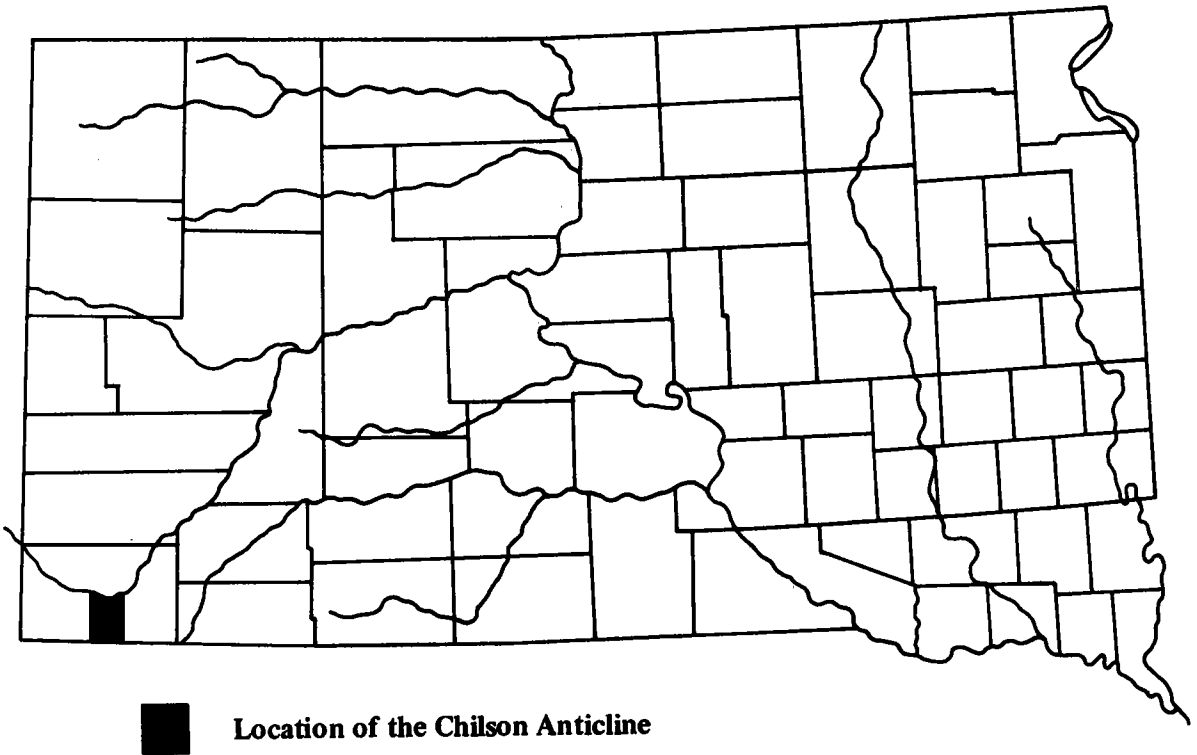
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A report  
on  
**THE CHILSON ANTICLINE**

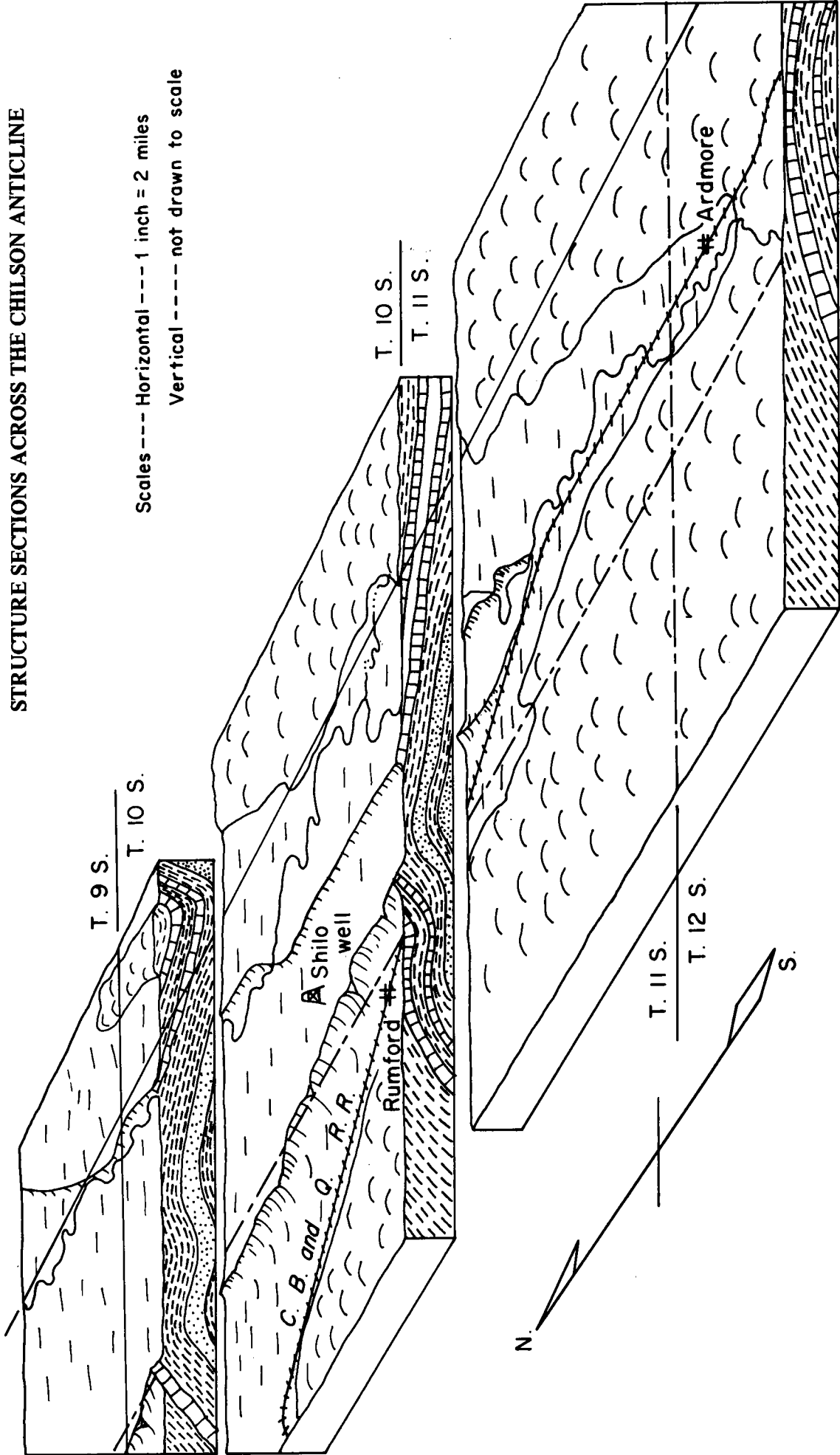
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**E. P. Rothrock**  
1931



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STRUCTURE SECTIONS ACROSS THE CHILSON ANTICLINE



Scales ---- Horizontal ---- 1 inch = 2 miles  
Vertical ---- not drawn to scale

# THE CHILSON ANTICLINE

## INTRODUCTION

### Location:

The Chilson Anticline is the largest known structure in the State, outside of the Black Hills. Though its presence has been known for a long time and some generalized maps have been published, information of sufficient detail has not been available to warrant recommendations for testing the structure for oil or gas. The present survey was undertaken, therefore, for the purpose of mapping it in sufficient detail to make this information available.

This structure extends north and south across the middle of Fall River County. Most of it lies in Range 4, though the northern end spreads out into Range 2 on the West and Range 5 in the East. The City of Ardmore is located on top of it at the southern end, and its axis roughly parallels Hat Creek. The fold has been followed into the mountains for about nine miles north of the Cheyenne River. Some years ago Mr. W. W. Rubey of the U. S. Geological Survey mapped this part of the structure. His map and report have been published as U.S.G.S. Press Bulletin 8508.

The region covered by the present report lies entirely south of the Cheyenne River, extending from this river to the southern boundary of South Dakota. It covers a triangular area, ten miles wide at the northern end, and tapering to two miles wide at its southern end. The total length from the Cheyenne River to the state line is eighteen miles, the area covered in this report is ninety square miles of the structure.

### Acknowledgements:

Credit for the successful completion of the map must be given Messrs. M. E. Kirby, B. W. Heiss, R. W. Parrott, and L. K. Olson, without whose valuable help as instrument men and geological assistants the work could not have been carried to completion.

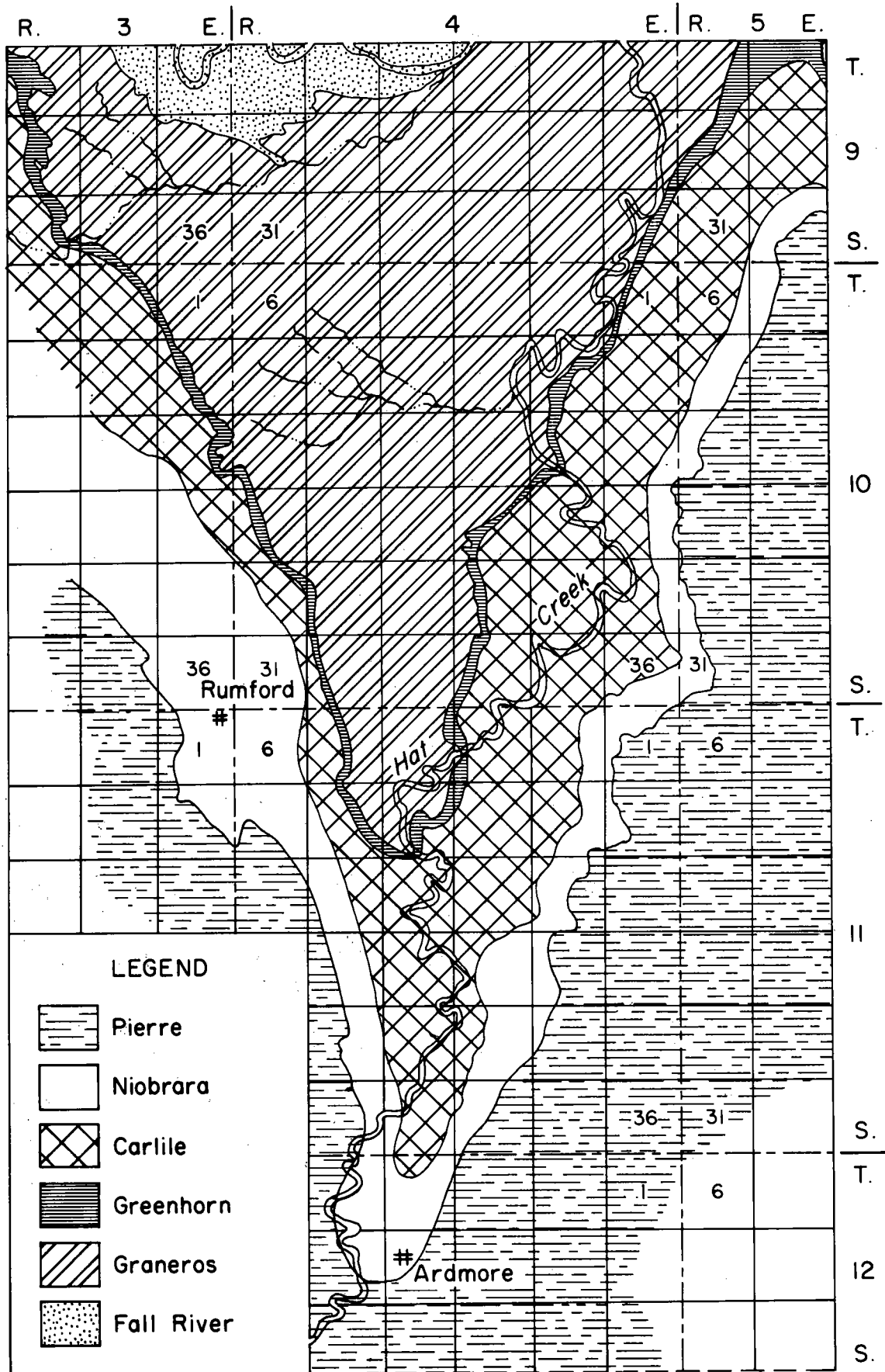
## STRUCTURE

The Chilson Anticline is an extension of the folds of the Black Hills, which points southward from the main folds of the mountains like a long finger. It tapers rather sharply from the northern end for about half its length, and from this point continues as a narrow fold of about uniform width beyond the southern state line. North of the Cheyenne River, the axis plunges sharply and this plunge continues for about two miles south of the river. From this point, however, the plunge becomes much less pronounced, though it is still an important feature of the anticline throughout its entire length. The Fall River (Dakota) sandstone, which outcrops at the Cheyenne River, will be found about 1600 feet beneath the surface in the vicinity of Ardmore. This makes an average plunge of about ninety feet per mile in this part of the structure.







The structure is notably asymmetrical [sic]. All the dips on the west side are much more pronounced than those on the east, except in the immediate vicinity of Ardmore. The steepest dips are to be found in the western flank. In Township 10 notably steep dips occur along five miles of the structure, the maximum recorded being 22°. These dips are readily seen in hogbacks formed by the Greenhorn limestone. Lesser dips can be followed for many miles in the hogbacks which form a great wall along the western flank of the structure. Dips decrease toward the north and also toward the south. The following were taken at the extreme north, the middle, and the southern end of the western flank of the anticline, and will illustrate the change:

N.E.¼, Sec. 23, T. 9 S., R. 3 E.	7°
S.W.¼, Sec. 18, T. 10 S., R. 4 E.	22°
N.E.¼, Sec. 8, T. 12 S., R. 4 E. (West of Ardmore)	6°

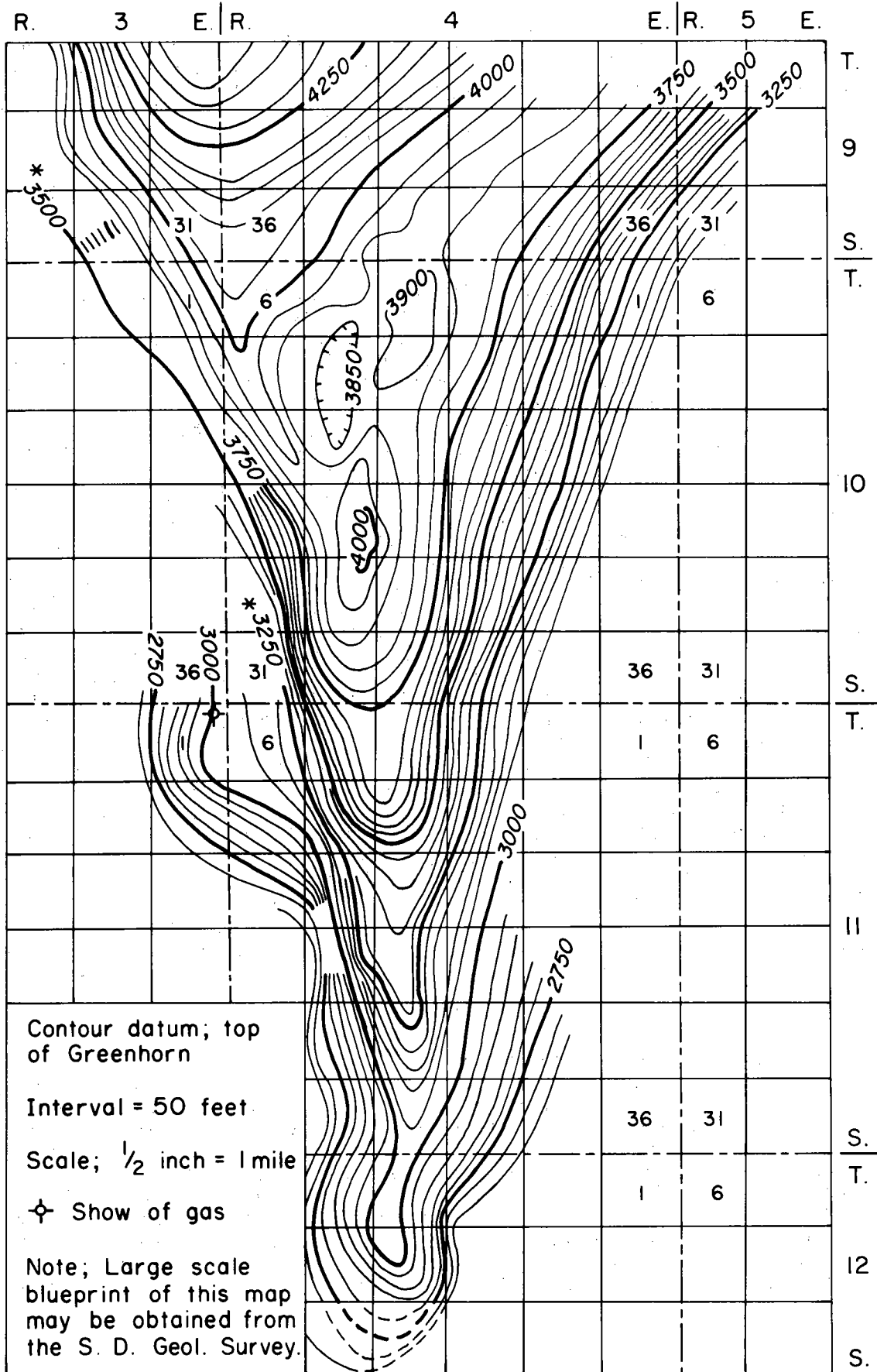
# GEOLOGIC MAP OF THE CHILSON ANTICLINE



## LEGEND

-  Pierre
-  Niobrara
-  Carlile
-  Greenhorn
-  Graneros
-  Fall River

**STRUCTURE MAP OF THE CHILSON ANTICLINE\***  
(South of the Cheyenne River)



Contour datum; top of Greenhorn

Interval = 50 feet

Scale; 1/2 inch = 1 mile

⊕ Show of gas

Note; Large scale blueprint of this map may be obtained from the S. D. Geol. Survey.

\* Numbers changed to correct drafting errors on original (1931) map. Township corner numbers added for clarity.



The dips on the eastern flank, are much less steep. They have a tendency to steepen, however, toward the south, so that in the vicinity of Ardmore the dips on both sides of the structure are nearly the same. The southern end is much more likely the textbook type of anticline, than the northern end. The following dips were measured on the east flank of the structure, two near the middle, and two at the southern end:

Sec. 9, T. 10 S., R. 4 E.	3°
East side of Sec. 21, T. 10 S., R. 4 E.	3°
S.E.¼, Sec. 16, T. 11 S., R. 4 E.	4°
S.E.¼, Sec. 4, T. 12 S., R. 4 E.	6°

The accompanying cross-sections are drawn to show these differences in structure.

The top of the structure in Township 10 South, Range 4 East, is of interest because of two secondary folds or domes which occupy it. The axis of the structure lies well to the western flank, at a point where it is extremely steep. From this axis, however, the eastern slope is long and quite gentle. On this slope a depression has been formed in Sections 5, 8, and 17 with corresponding elevations to the east and south of it.

There are two such elevations, the northern one occupying a large part of Sections 4 and 9. It is, apparently, a long flat dome whose top rises between fifty and one hundred feet above the bottom of the depression just mentioned and has a closure of fifty feet or more. The second dome is much sharper than the first, and lies to the south and east of the depression. It is really a bulge on the main axis of the anticline, occupying a large part of Sections 20 and 29. Its highest part is in the southeast quarter of Section 20. Its minimum closure is between fifty and one hundred feet.

In the southern end of the structure, in Townships 11 and 12, South, the plunge of the axis is broken by three steps in which the slope is reduced to less than fifty feet per mile. A steeper slope of one hundred and fifty to two hundred and fifty feet per mile separate these flats. The northernmost flat is a mile and a quarter in length, and about half a mile in width. It occupies parts of Sections 4 and 5, Township 11 South, Range 4 East. The second flat lies about two miles south of the first in Sections 21 and 28 of the same township. It also has about the same length but is slightly narrower. The third flat lies in the vicinity of Ardmore, and is about two miles in length by a half a mile in width. It occupies parts of Section 33, Township 11 South, Range 4 East., and Sections 4 and 9, Township 12 South, Range 4 East. The plunge of the axis on this flat is less than 25 feet per mile. These shoulders or flats are of interest because similar structures have been the cause of oil accumulations.

A small fold extends westward from the anticline in the vicinity of Rumford. This fold was not completely mapped, but enough of it was covered to show that it is a small shoulder, apparently bulged from the bottom of the syncline, which lies west of the main Chilson structure. A 3500-foot slope lies to the west of it, and behind it lies the steep flank of the Chilson Anticline. The flat top of the structure is a half mile to three-quarters of a mile across. Its area is about a square mile. Shows of gas at Rumford make this structure interesting as a possible producer.

#### Drilling Sites:

The condition of the sands, presence or absence of source rock and water conditions may make even the best structure barren of oil or gas. In spite of these possibilities, however, it has been found that structural traps offer by far the least chances of failure. If this practice is followed in drilling the Chilson Anticline, therefore, it will be necessary to drill on some of the domes or shoulders mentioned above. The domes on the broad northern end in Township 10 North [sic], which have been described, would offer good locations; the northern one in Sections 4 and 9 lies above a rather notable change of slope in the eastern flank of the structure, and does not have a sharp rise to the north of it. The southern one in Section 20 is much smaller and more pronounced. It is now (1930) being drilled by the Lakota Development Company.

The Rumford structure is particularly interesting because of small amounts of gas which

have been struck at the base of the Niobrara in all wells drilled in Rumford. From the mapping that was done, it is evident that there is a structural cause for this accumulation, and this lends encouragement to the idea that there might be commercial pools of oil and gas in the deeper reservoir rocks.

Whether the flats along the axis in Townships 11 and 12 are favorable drilling sites is not certain. Such structures are not as favorable positions to test as are the domes or large shoulders like the one at Rumford. They offer interesting possibilities for exploration, however, if the more favorable sites give production. A well drilled by the city of Ardmore on the eastern flank of the southern flat reached a depth of 1740 feet, without reporting shows of oil or gas. Its position on the structure and the fact that it stopped in the Lakota Formation, may account for this however. As stated above, there are three of these shoulders, the northern one in Section 4 and 5, and the central one in Section 21, Township 11 South, Range 4 East, and the third and largest in the vicinity of Ardmore occupying portions of Sections 4 and 9 in Township 12 South, Range 4 East and Section 33, Township 11 South, Range 4 East.

### FORMATIONS EXPOSED

North of the Cheyenne River, older formations are exposed in the Chilson Anticline, but in the area covered by this report, all rocks are of Cretaceous age. Lower Benton rocks outcrop in the vicinity of the Cheyenne River. Southward, however, the plunge of the axis carries the older formations beneath the surface, and progressively younger ones are exposed along the axis until the southern end is reached. The Fall River Sandstone (Dakota) was used as a key horizon in mapping along the bluffs of the Cheyenne canyon. In the cliffs of the Canyon older formations are exposed, but none below the Lakota. At the southern end in the vicinity of Ardmore, the base of the Pierre Shale is at the surface, while two or three hundred feet of this formation is exposed in the Hills bordering Hat Creek valley.

Due to the plunge of the anticline, the outcrops of these formations form a V-shaped pattern open to the north. They follow down the west side of the anticline toward the southeast, then crossing it turn back north following the eastern flank of the structure. Possibly the only exceptions to this rule are the Fall River Sandstone and the Graneros Formations. The first formation is exposed in only a small patch in the vicinity of the Cheyenne River, and the second in a large, wedge-shaped area occupying the northern half of the structure. It forms the floor across the top of the Anticline from the Cheyenne River to the southern line of Township 10. The formation on the flanks of the structure, therefore, are progressively younger as the distance from the axis east and west increases.

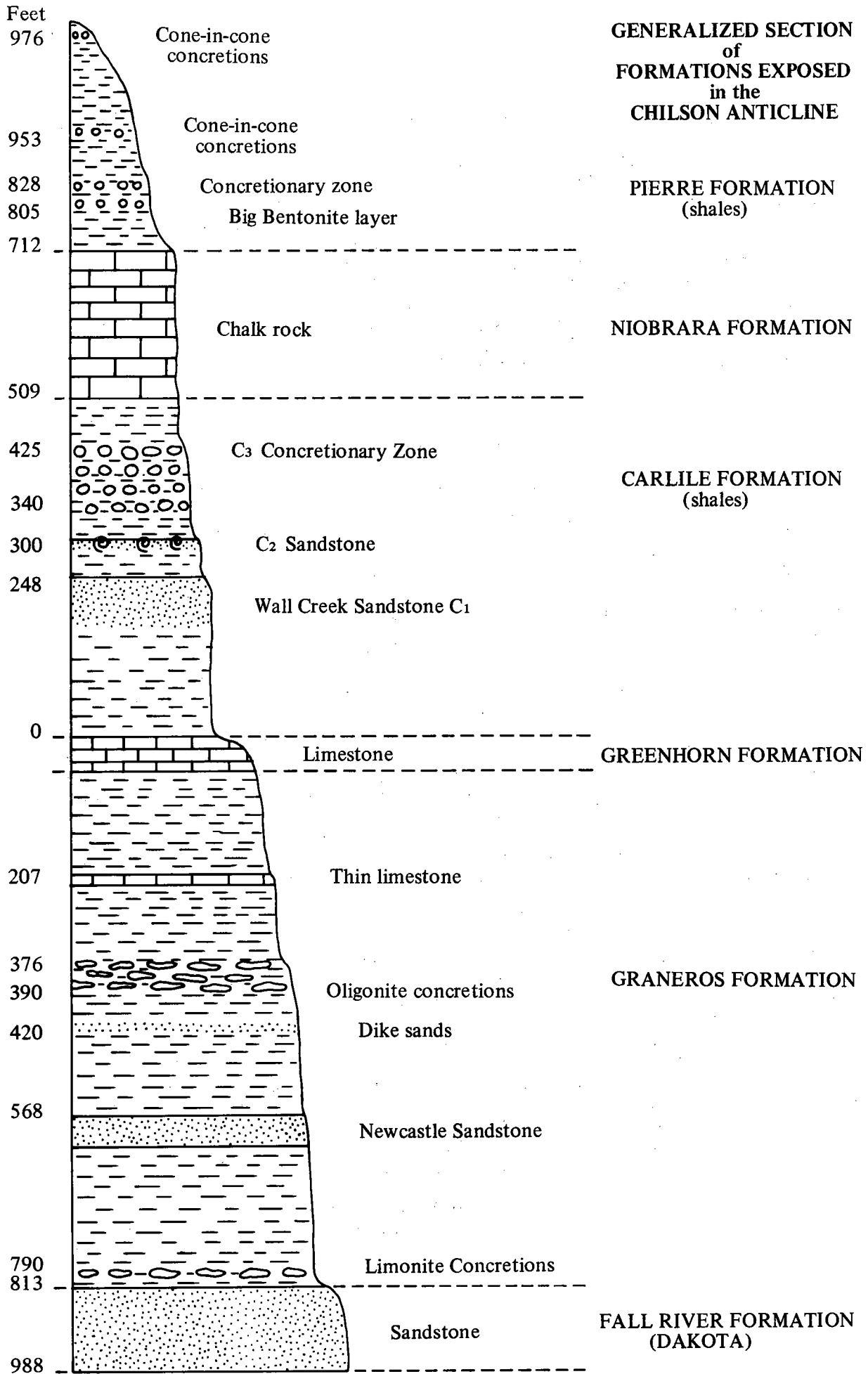
A description of the formations which are exposed, indicating the key horizons which were found useful in mapping this structure, may be helpful in interpreting the map.

#### Pierre Formation

This formation is the youngest exposed in the structure and surrounds the lower half of it. Its shales make the highland on both sides of Hat Creek Valley near Ardmore. From this place they separate widely, but can be easily traced with the eye for they make prominent bluffs, which can be seen for many miles.

On the west side they can be traced from Ardmore to Rumford, at which place they are all well exposed. From Rumford the bluffs take a sharp northwestern trend which rapidly takes them away from the vicinity of the anticline. The Pierre bluffs on the eastern side are quite well marked in the vicinity of Ardmore, and can be traced northward for a good many miles. They are not as conspicuous as the bluff west of Rumford, however, until they reach a point about three miles north of the southwest corner of Township 10 South, Range 5 East. Northward from this point they stand out as very prominent bluffs, which can be seen from the Oelrichs road.

The Pierre Formation is composed of a very sticky heavy shale, which weathers to a gumbo soil of the worst variety. When fresh they are very dark blue or bluish-black, and this is the predominant color of the outcrop. Where the shales have had a chance to weather slowly, however, there tends to be a brownish cast.



This formation is so thick, and of such uniform character that it has been impossible to separate it into recognizable horizons. Therefore, no attempt was made to map far away from the axis of the anticline, especially in the southern part. Some key horizons, however, do exist in the lower two or three hundred feet, which were found to be fairly persistent, and therefore useful. Four such horizons were noted, the lowest known as the Big Bentonite layer occurred about 100 feet above the base of the Pierre Formation. This was the lowest bed of a series of Bentonite beds. As it was three or four feet thick, it could easily be separated from the other Bentonites, which were all much thinner. It also lay at the base of the Bentonite series, wherever it was found. This Bentonite zone was traced from Rumford south through Ardmore, where it is quarried on a commercial scale, and then northward to Section 3 in Township 10 South, Range 5 East. The same zone can be found on the Cascade Anticline in the same stratigraphic position.

The Bentonite zone is in the lower part of a zone of large gray limestone concretions, which were designated by the party as "elephant eggs", because they commonly reached three or more feet in diameter. This concretionary zone starts a foot or two below the Bentonite zone, with one layer of concretions. They are found sparingly among the layers of Bentonite. They increase in size and abundance, however, toward the top of the zone, above the bentonite. The total thickness of the concretionary zone is about 30 feet. Intervals taken at several places give a remarkable uniformity for the top of this zone, so that it could be used as a horizon marker where other horizons were absent.

About 65 feet above the top of the Elephant Egg zone there is a second zone of straw-colored concretions, one to two feet in diameter, which show a pronounced cone-in-cone structure. As these cone-in-cones occurred near the top of the hills in the area mapped, it was not possible to get good figures on the thickness of the zone or to find the top of it. There are evidently two zones thirty or forty feet apart, which might be of use if there was a sufficient demand for their services to warrant locating them accurately in this section.

The following sections were taken near Ardmore:

Section of Lower Pierre on East Side of  
Hat Creek, Near Ardmore, S. Dak.,  
N.E.¼, Sec. 34, T. 11 S., R. 4 E.

	Base of Upper Concretionary Cone-in-cone Layer
23 ft.	Shale, black.
58 ft.	Lower Cone-in-cone concretionary Zone, straw colored cone-in-cone concretions in the matrix of Black Shale.
67 ft.	Black Shale.
28 ft.	Black Shale with large gray concretions three to four feet in diameter. Bentonite streaks near the lower part of this section.
3 ft.	Bentonite. One layer of grey concretions below the bentonite.
93 ft.	Black shale. Niobrara Chalk Rock.

Section at Bentonite Pit west of Ardmore,  
S. Dak., N.E.¼, Sec. 8, T. 12 S., R. 4 E.

12 ft.	Black Shale with large grey concretions three or more feet in diameter. Bentonite at the base.
4 ft.	Big Bentonite layer. Layer of grey concretions beneath the Bentonite.
100 ft.	Black Shale. Niobrara Chalk.

The interval between the Niobrara Chalk and the Big Bentonite layer is greater near Ardmore than it is to the northeast. These sections give an interval of about 100 feet while those on the Cascade Anticline give only 75 feet.

### Niobrara Formation

The Niobrara Formation weathers more easily than most of the formations in this series. It, therefore, is found in the bottom of the synclinal valleys on both sides of the structure. The large open valley in the vicinity of Rumford is made entirely in Niobrara. South of Rumford some of the outcrops are on the side hills, but very few of them make conspicuous bluffs. On the eastern side of the structure the Niobrara lies entirely at the base of the bluff formed by the Pierre Shale. The outcrops are usually narrow, averaging about a half mile across. In the vicinity of Rumford, however, due to the small structure at this place, they spread out until they occupy a width of nearly two miles. This is the most southerly of the formations forming a V-shaped outcrop, mentioned above.

The general character of the rock in Fall River County is much like that of the Niobrara Formation, which is exposed along the Missouri River. It is composed entirely of chalk rock, with the exception of thin beds of oysters which have cemented into a limestone. These oyster beds are scattered through the formation, but are no where of sufficient abundance to be an important rock forming member of the formation. The unweathered exposures are light grey, probably due to organic matter contained in the chalk. The rock becomes conspicuous, however, upon weathering, due to the fact that it bleaches to a very white residue, which in some places is a very bright yellow, due to the oxidation of included iron.

The soft character of the rock causes it to weather down to gentle slopes which are usually grassed over and fail to show an outcrop. Through much of its length, however, small streams have cut valleys across the outcrop, and the weathered material shows in patches near the tops of their bluffs. It is therefore, possible to trace the outcrop from a distance quite easily.

Though the formation is thick there are no horizons within it which can be used as key beds. All parts of the formation are essentially the same, making it impossible to tell the position of an exposure in the formation unless either the top or bottom contact is available. Both top and bottom, however, do make good horizon markers where they can be found. The light colored chalk changes abruptly to the black shales of the Pierre above, and the Carlile below, making it easy to locate the contact quite accurately.

The only place where it was possible to measure the thickness of this formation was in the S.E.  $\frac{1}{4}$  of Section 33, Township 9 South, Range 5 East. At this point the thickness was 217 feet.

### Carlile Formation

Outcrops of the Carlile Formation also form a V about the structure, the southernmost exposures lying about two miles north of Ardmore. From this point it can be traced on both sides of the structure nearly to the Cheyenne River. On the west side, due to a sharp dip the outcrops are narrow, averaging perhaps three-quarters of a mile to one mile in width. On the east side they are much wider, occupying a band nearly two miles wide. Darton (Darton, N. H., "Artesian Waters in the Vicinity of the Black Hills, South Dakota", U.S.G.S. Water Supply Paper No. 227) describes the Carlile Formation as follows: "The Carlile shale, the uppermost of Benton Age, consists of dark fissil shale that contains concretions, thin sandstones, and impure limestone layers, lying between the Greenhorn limestone and the Niobrara Formation. Near the top of the formation, numerous oval concretions contain *Prionotropis*, *Prionocyclus*, and other fossils." A study of the formation shows that these generalizations hold of this region. The black shale, forming the bulk of the formation, is not unlike the shales of the overlying Pierre formation, and concretions and limy sand layers occur.

Near the top of the lower half of the formation lie sands which correspond to the Wall Creek sands of the Wyoming oil fields. In the extreme northeastern corner of the structure, three separate sand beds were recognized, each of which acted as a ledge-maker. These three beds, however, thicken toward the west and south until the lower two unite into a thick sandy zone which make the Wall Creek. This member of the formation is composed of extremely thin beds of a fine grained gray sand which are separated by layers of black clay or loam. These beds are so thin, (1/16th to 1/32nd of an inch) that it gives the outcrop the

appearance of lamination. About fifty-three feet of this sand was measured in the S.E.¼ of Section 16, Township 11 South, Range 4 East. The black clay partings are evidently colored by organic matter and suggest an origin for the oil found in this sand farther west. The Wall Creek sands will not be penetrated in the northern part of the anticline, but offer a possible oil horizon in the vicinity of Rumford and Ardmore.

About 50 feet above the top of the Wall Creek sand comes the second sand, characterized by weathering into thin slabs of a very brown color, and having very smooth surfaces. This second sand is also characterized by a prolific fauna which includes a striking number of large cephalopods of the genus *Prionocyclus*. The fossils are most abundant in calcareous patches in the sandstone. These are not typical concretions, but are places where the formation of limestone exceeded the formation of sand, making slabs of nearly pure limestone embedded in the sand. This layer is the only one which carries the large *Prionocyclus*, a fact which serves to distinguish it from other Carlile sands in this area. Associated with the large *Prionocyclus* was a large number of smaller forms from which fauna the following were noted. The following fossils were identified as members of this fauna:

*Prionotropsis woolgari* (Mantell).  
*Prionotropsis woolgari* var.  
*Prionotropsis* sp.  
*Prionocyclus wyomingensis*, Meek.  
*Acanthoceras?* sp.  
*Scaphites warreni*, var. *wyomingensis*, Meek.  
*Scaphites warreni*, Meek and Hayden.  
*Gyrodes depressa*, Meek  
*Inoceramus fragilis*, Hall and Meek  
*Fusus shumardi*, Whitfield  
*Radiolaria*, undet.

(Identified by C. W. Espe, in the Laboratories of the Department of Geology, University of South Dakota, Vermillion, South Dakota.)

The two sections following were taken to show the character and thickness of the Wall Creek Sand. They also show the relation of the Wall Creek to the upper ledge, which was designated as C<sub>2</sub> in mapping.

Section of the Carlile in S.E.¼, Sec. 16,  
 T. 11 S., R. 4 E., Fall River County,  
 South Dakota.

40 ft.	Base of C <sub>3</sub> Large gray limestone concretions in black shale
	Shale
1 to 2 ft.	Sand layer. Brown on top. This is C <sub>2</sub> and carries the typical fauna.
12 ft.	Shales and sandy shales grading into sands above.
1 to 2 ft.	Lower C <sub>2</sub> . Just like above. Probably slump.
45 ft.	Shales
	Note: The following zone is C <sub>1</sub> or Wall Creek sands. The section was measured with a tape line.
0.4 ft.	Coarse gray sandstone
14.0 ft.	Thin bedded (½ inch) sandstone with thin shale partings
8 ft.	Black shale
5 ft.	Fine grained, thin bedded (sand with thin clay partings. Sand beds 1/16th inch. Clay partings 1/32 inch to ¼ inch. General color is a salt and pepper grey. Fresh face looks laminated from a distance.
1 ft.	Dark gray limestone concretions. Lense shaped and continuous the length of the outcrop.

- 5½ ft. Sand and clay partings like above.
- 1½ ft. Dark gray lime concretions. Lensey.
- 7 ft. Sand and clay partings like above.
- 2 ft. Zone of gray lime concretions not continuous.
- 10 ft. Mostly talus covered by [sic] probably sand like above.

Section of Carlile, Wall Creek Sand Horizon,  
in S.W.¼, Sec. 31, T. 9 S., R. 5 E., Fall  
River County, South Dakota.

- 2-3 ft. Dark Brown sandstone some limy, carrying characteristic C<sub>2</sub> fauna with big *Prionocyclus*.
- 5 ft. Black shale
- 3-5 ft. Brown Sandstone like above. Lower C<sub>2</sub>.
- 45 ft. Black shale
- 0.6 ft. Heavy coarse sandstone layer such as usually occurs above C<sub>1</sub>
- 10 ft. Light grey slabby sandstone. Bedding ½-2" thick. Evenly fine grained. Black streaks of shale mark bedding planes.
- 5 ft. Brown shelly sandstone, characteristic color, grain, and general appearance of C<sub>1</sub>. Lower part grades into brown argillaceous sandstone.
- 6 ft. Brown, shaley [sic] sandstone grading into sandy shale. Ends abruptly at lower contact.
- 6 ft. Black shale.

About forty or fifty feet above the top of the upper fossiliferous sandstone is a zone of large lime concretions. These are usually spherical in shape, and three or four feet in diameter. Most of them are cracked, the cracks being drused with calcite crystals. Near the outside, the crystals have completely filled the crack, making veins, but toward the center of the concretions there is usually an opening between the walls, into which the crystals protrude. The concretions are arranged in rows parallel to the bedding. Four such rows were noted in some outcrops, while others had a lesser number. A thickness of 52 feet was measured for this zone in the southwest quarter of Section 18, Township 10 South, Range 4 East.

The relation of these sand zones to the underlying Greenhorn Formation is shown in the following sections:

Section of the Carlile Formation in S.W.¼, Sec. 18,  
T. 10 S., R. 4 E., Fall River County, S. Dak.  
(N.E. of Rumford)

- 52 ft. Black shale with large (3-4 feet) concretions, with much calcite drusing in cracks. C<sub>3</sub> Zone.
- 29 ft. Black shale
- 1 to 2 ft. Sandstone. Brown on top, lighter below. Calcareous and carried abundant fauna. C<sub>2</sub>.
- 45 ft. Shale
- 38 ft. Sand zone. Top 6 to 12 inches is heavy bed of coarse sandstone. Under beds of finer sand, light grey to buff on outcrop. This includes the Wall Creek sands and the C<sub>1</sub> and possibly C<sub>x</sub> zones.
- 225 ft. Shales  
Greenhorn Limestone.

#### Key Horizons.

The fossil-bearing sandstone between the concretionary zone described above and the Wall Creek Sand is by far the best marker in the Formation. It is very easily identified

because of its color, and the fauna it carries, particularly the large cephalopods. It makes ledges which are not difficult to trace where the formations are not dipping too steeply. It can be traced completely around the structure, except for a short distance along the western flank in Township 10 South, Range 4 East, where the steep dips meet gentle topographic slopes and have been entirely grassed over. Even in this stretch, however, it is possible to find it with a little careful searching.

There appears to be too large a variation in thickness of the concretionary beds and in the position of the top and bottom to make the concretionary (C<sub>3</sub>) zone a very good horizon marker.

The only other horizon which might be used as a key is the top of the Wall Creek Sand. In most places it is indicated by a coarse gray sandstone, about six inches thick, which lies within a foot of the top.

### The Greenhorn Formation

The Greenhorn Formation is the most prominent formation in the exposed section. It surrounds the northern half of the structure forming a large and very prominent V. Being more resistant to erosion than the surrounding formations, it stands up in very prominent hogbacks, especially along the western side. Lower hog-backs are also prominent on the eastern side in the northern end of the outcrop, but are not so large as those on the west, because the dip is not so steep. The hogbacks disappear at the southern end of the outcrop, where the limestone is found only as cliffs in the valley of Hat Creek.

The Greenhorn Limestone displays the same general characters in this region that it does in the regions of the Black Hills from which it has been described. It is composed almost entirely of slabby limestone, grey on fresh surfaces, weathering to a buff wherever exposed. The slabby character allows weathering to penetrate deeply into the formation so that all surfaces of the slabs show the weathered color. This gives a buff or tan appearance to the entire outcrop and all the loose pieces which can be easily turned up from the outcrop. It is necessary to break one of the slabs in order to see the coloring of the fresh rock.

Perhaps the most notably [sic] characteristic aside from the composition of the rock is the abundance of fossils. The beds are full of shells of the pelecopod *Inoceramus labiatus*. In fact some of the beds are made entirely of these shells. It is scarcely possible to pick up any piece of the limestone lying on the outcrop without finding at least a portion of one of these shells. Most of the shells were badly crushed and broken in the compacting of the sediments. This fossil occurs in other Cretaceous formations in the vicinity, but nowhere in such striking abundance as in the Greenhorn. Other fossils are very uncommon, and probably absent from large portions of the formation.

Some shales are to be found near the base of the Greenhorn formation which must be included in it, because they separate limestone layers which are identical in character of rock and fossil content. These are well shown in the following sections.

#### Section of Greenhorn Ledge Makers, In Section 14, T. 9 S., R. 5 E., Fall River County, S. Dak.

- |             |   |
|-------------|---|
| 9 ft.       | Shelly limestone which has the typical bedding and <i>Inoceramus</i> . Beds 1/16–1 inch thick but bedding planes are irregular. This makes rock break into slabs ½ to 12 inches in diameter. Limestone probably impure; feels gritty to the hand but leaves only fine clay residue when weathered. A very few limonite concretions. <i>Inoceramus</i> shells much broken as though broken at the time of deposition. Might be by compacting of mud. |
| 5 in.       | Massive limestone like above.   |
| 1 ft. 3 in. | Limy shale, same buff color on weathering but is streaked with blue. Shells here too.   |
| 3 in.       | Massive limestone with fossils.   |
| 8 in.       | Lime shells like top.   |



4 in.	Massive limestone like top.
2 ft. 3 in.	Limy shale of bluish cast.
6 in.	Massive limestone
1 ft.	Shelly limestone like above
3 ft.	Blue shale, probably Carlile.
	Bottom of exposure.

The thickness of the Greenhorn is given in the Edgemont Folio as about 50 feet. Two sections measured in Township 10 South, Range 4 East, however, did not give as great a thickness. One which did not reach quite the top of the Formation gave 24 feet, and the second 34 feet. Part of this is due to the upper contact which grades more or less through a series of transition beds into the Carlile.

### Graneros Formation

The Graneros Formation outcrops across the entire structure covering approximately the northern half of the area. It occupies the entire area within the Greenhorn hogbacks, with the exception of a few square miles along the Cheyenne River. Striking topography is not developed on this formation though some of its members make minor hogbacks and ridges. The part of the structure occupied by this formation therefore, is easily accessible.

The Graneros is another black shale formation much like the Pierre and Carlile in general appearance. It can be divided, however, into three distinct zones, and contains several layers of limestone and sandstone which make good horizon markers. The upper and lower zones are composed of black sticky shale and between these lie a dark siliceous shale, which sometimes has a silvery cast. This middle zone is usually correlated with the Mowry member of the Graneros Formation in the Rocky Mountain District. According to Russell (W. L. Russell, "The Origin of Sandstone Dikes in the Black Hills", American Journal of Science, XIV, 1927.) The top member is 420 feet thick, the Mowry, 150 feet thick, and the lower shale member 300 feet thick.

#### Upper member:

Both top and bottom limits of the upper zone are easily identified. The upper limit is marked by an abrupt change from the typical black shale to the buff or grey very fossiliferous limestone of the Greenhorn, the bottom is marked by a zone of oligonite concretions. These are large, rather flattish concretions of manganese bearing iron carbonate, anywhere from a few inches to two or three feet in thickness, and ranging up to ten or twenty feet across. In some places they make pavements while in others they are separated by several feet of shale. They disintegrate readily upon exposure, forming a black rubble of small angular pieces. Good exposures showing the thickness of this zone are very rare, although the top is easily found. The best information at hand indicates that it is at least 20 feet thick.

A thin limestone ledge maker occurs about 200 feet below the top of the Greenhorn, which can be traced over a large area. It is found near the Cheyenne River, on both sides of the structure. About the middle of the structure, it made an excellent key bed. It is never more than six or eight inches thick, and weathers out in smooth brown slabs, four or five inches across, and about an inch in thickness. It resembles very much the limestone ledge found at the same horizon on the Cascade Anticline farther east. The following sections illustrate the character of the upper member:

#### Section of the Graneros Formation in the N.W.¼, Sec. 18, T. 10 S., R. 4 E., Fall River County, South Dakota

82 feet	Blue-black Shale. Little to distinguish it, though there are some small scattered concretions.
¼' to ½'	Bed of grey limestone which weathers brown and carries a good many

- scattered oysters. One *prionocyclus* (?) noted.
- 209 ft. Blue-black shale. Few bentonite layers near the top of this section.  
1' to 2' Shelly grey limestone, weathers to smooth surfaced, brown slabs  
2" to 2' across. This is the ledge maker which is used in mapping  
this structure.  
Blue-black shale.

Section of the Graneros Formation in  
N.W.¼, Sec. 1, T. 10 S., R. 3 E.,  
Fall River County, South Dakota

- 222 ft. Top of Greenhorn to Lower Brown limestone ledge maker. This  
includes the Greenhorn Limestone and shales, which should be about  
30 feet, and the underlying black shales.
- ¼' to ½' Brown limestone ledge maker. Dark grey when fresh, brown on weathering.
- 36 ft. Black shale with thin zone of cone-in-cone concretions at bottom.
- 71 ft. Shales
- 47 ft. Oligonite concretions in black shales.

**The Mowry (middle) Member:**

The Mowry member of the Graneros Formation is characterized by siliceous shales, which often have a silvery cast, and do not become muddy in wet weather. Part of its outcrop is marked by a growth of evergreen trees, which for some reason do not grow on surrounding formations. The fish scales so prominent in the Mowry in many localities are not abundant here, though a search in almost any locality will reveal some. Its top is immediately below the base of the oligonite zone mentioned above and its base lies at the top of a 30-foot sandstone member which is evidently the Newcastle Sandstone of Wyoming.

About the middle of the Mowry member is a soft yellow-white sand, which has been largely forced into cracks of the shale to form sandstone dikes. While the position of these dikes can be readily followed, they occupy too wide a zone in the formation to make a reliable horizon marker.

The Newcastle Sandstone is grey or buff, loosely cemented rock. Good outcrops are rare, though the sandstone makes a very definite horizon. It occupies the floor of the structure near its middle in Township 10 South, Range 4 East. The best outcrops are in the extreme northwestern corner of the structure near the Cheyenne River, where the steeply dipping west flank exposes the entire thickness of the sandstone. The sandstone is not a good key bed, but can be used in the absence of better horizons.

A section measured in the northwest quarter of Section 26, Township 9 South, Range 3 East will illustrate the character of the Mowry:

- 10 ft. Oligonite zone (not good place to get top of zone)
- 14 ft. Silvery grey Mowry shale.
- ½ ft. Thin sandstone with plant remains
- 24 ft. Silver grey shale like above.
- 7 ft. Dike making sandstone at top of this section, shale below.
- 67 ft. Dark shales
- 9 ft. Newcastle Sandstone.

**Lower Member:**

The lower zone of the Graneros Formation is exposed only in the extreme northwestern part of the area mapped. It is much like the upper zone in composition, in that it is made primarily of black shales, but it contains very few horizon markers. Some scattered concretionary zones are the only variation in this part of the Formation. The following section of the lower portion of the Graneros Formation is fairly representative.

Section of the Graneros (Dakota-Newcastle)  
in the N.E.¼, Sec. 23, T. 9 S., R. 3 E., in  
Fall River County, S. Dak.

9 ft.	Newcastle sandstone. Soft, light grey to white.
215 ft.	Shale with scattered cone in cone concretions.
5 ft.	Zone of limonite concretions.
16 ft.	Shales
	Fall River (Dakota) sandstone.

The thickness for the Graneros Formation given by Darton (Edgemont Folio, U.S.G.S., 108, p. 5) is 850 feet. No single outcrop gave the total thickness of Graneros in the area mapped, therefore, its thickness can only be computed by piecing together sections from several different places. The thickness computed by this method is 775 feet.

### Fall River Formation

(Dakota Sandstone)

Outcrop of the Fall River Formation occupies about five square miles along the Cheyenne River in the extreme northern end of the area mapped. As only the contact between it and the Graneros Formation was used in mapping, no sections were measured, nor was the formation studied. Darton (Darton, N. H., Edgemont Folio, U.S.G.S. Folio 108, p. 5) gives the following description of the formation: "The formation rarely exceeds 125 feet in thickness, being about half as thick as the Lakota Sandstone. It generally consists of hard, coarse sandstone from sixty to eighty feet thick overlain by a thin series of purplish and thinner bedded buff sandstone with a variable series of sandstones thirty to forty feet thick at the top. The basal member usually is very massive, giving rise to cliffs in which the jointing gives a rude palisadal effect, and its color on weathering is a characteristic dull reddish brown."

### FORMATIONS UNDERGROUND

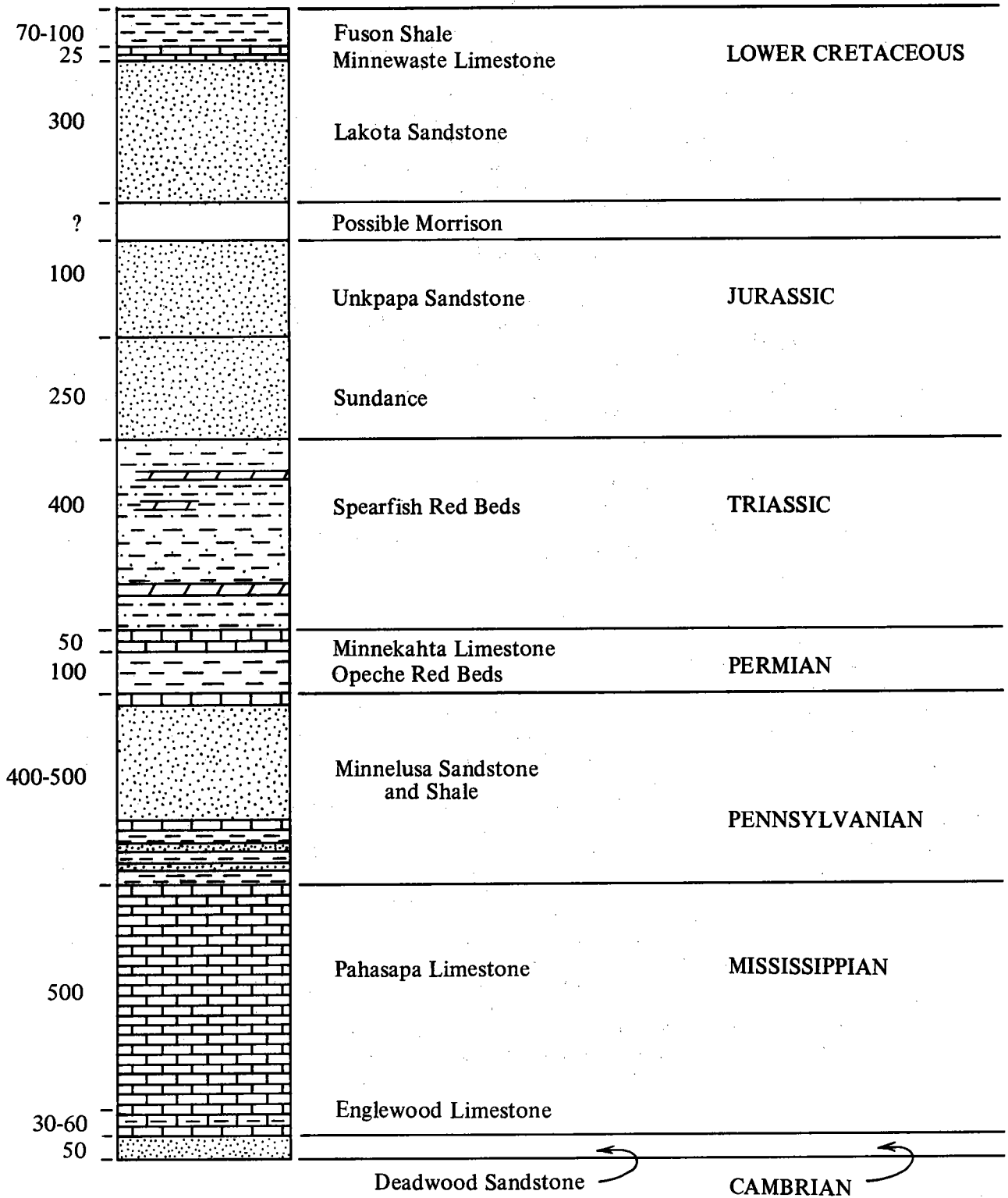
Six formations carrying sands which might act as reservoirs for oil and gas underlie the Chilson Anticline. From the information at present available, however, it is impossible to say whether all of these formations underlie all of the structure. Sand formations are notably given to thinning out and even disappearing within short distances and the nearest outcrops of these rocks are in the flanks of the mountains eighteen miles from the southern end of the structure. The persistence of many of them, however, make it assured that a sufficient number will be found under any part of the structure to make it worthwhile to drill for them.

The depth at which they lie will vary greatly in different parts of the structure due to the plunge of the anticline which carries them deeper as the southern end is approached. For instance, in the vicinity of Ardmore and Rumford, a well would start in the Niobrara Formation. At these places, therefore, the Wall Creek sands would be under cover, and would be considered as a possible reservoir rock. North of the southern part of Township 10 on the main structure, however, the Wall Creek sands have been eroded away, and only the lower formations would be available. The depth of drilling to reach any sand may be computed by using the general columnar section and, adding the thicknesses of formations below the one which outcropped at the well site.

It must be remembered, however, that this is a generalized section based largely on the thickness of the formations at the outcrops in the Black Hills. In so great a distance as that covered by the Chilson Anticline, considerable variations in thickness may occur. In a well kept log, however, it is very easy to identify certain of the limestone formations, such as the Minnekahta and Pahasapa and the red bed formations of the Spearfish and Opeche, which make horizons which are unmistakable. As all of these formations are fairly persistent, it should be possible to correlate a well drilled on any part of the structure with the general

**GENERALIZED SECTION  
OF THE  
SEDIMENTARY FORMATIONS  
UNDERLYING THE CHILSON ANTICLINE**

Approximate  
thickness  
in feet



sedimentary section which is given below. The following descriptions of the formations will also serve as guides to their identification.

### **Fuson Formation**

The Fuson is a shale formation lying directly beneath the Fall River Formation. It is described as a fine grained deposit consisting of fine grained sandstones and clays. The latter is usually massively bedded, and weathers out in small chunky pieces like dry starch. Some of the sandstones are coarse, but most of them constitute only thin "shells". A section 132 feet thick at Cheyenne Falls in Township 8 South, Range 6 East, gives thirteen divisions of sands and clays, averaging about six feet in thickness. One clay and the bottom sandstone member reach thicknesses of twenty-five feet (Oelrichs Folio, U.S.G.S. Folio, No. 85).

Most of the formation is grey in color, but there are conspicuous sections showing maroon and purple. These may be of interest as they will serve to identify the formation.

The formation outcrops entirely around the Black Hills, and therefore can be expected to extend for some distance under the plains. In the outcrop its thickness varies from 30 to 188 feet, with an average of about 70 to 100 feet. As most of the outcrops in the southern Black Hills have thicknesses very near this average, it is probable that the same thicknesses continue under the Cascade Anticline.

### **Minnewaste Formation**

In the outcrops from Buffalo Gap to Hot Springs and Cascade Springs, a dense limestone underlies the Fuson Formation. Traces of lime are found at this horizon west of Edgemont. Forty feet of lime was reported at this horizon in the well at Edgemont, and limy shale reported from about this horizon from the well in Section 20, Township 10 South, Range 4 East. A city well drilled at Ardmore, however, reports no lime whatever. This is apparently a local formation, therefore, that will be found in the northern part of the Cascade Anticline only. The meager information at present available does not permit drawing more accurate outlines of its location.

It is described as nearly pure light grey limestone, very uniform in character throughout its outcrop. Careful search has been made for fossils, but no fossils have been found in it. Thicknesses up to 25 feet have been measured. This figure, however, seems to be about the average for the thicker part of the formation, and probably persists in a considerable part of the formation.

### **Lakota Formation**

The Lakota Formation is a thick sand formation, and like the overlying Fall River carries an abundance of water in many parts of the state. It is the water sand at the city of Ardmore, and gave water trouble in the well in Section 20, Township 10 South, Range 4 East. It is probable, therefore, it will give water on any part of the structure which is drilled. It has not produced shows of gas or oil in the vicinity of the Black Hills, though physically it should make an excellent reservoir rock.

The Lakota Formation is described as being composed of hard, coarse grained, cross-bedded and massive sandstone, with occasional thin partings of shale. Streaks of conglomerate occur in the lower part. This portion of the formation also contains scattered coal beds, varying from thin streaks to four or five feet in thickness. On the outcrop the color of the sands is usually buff, but cuttings from this formation will probably appear as light grey or white sand, because of the absence of weathering underground.

This formation contains an abundance of fossils, particularly petrified wood. On the outcrops entire logs of this wood are often seen. In some places fossil cycads occur in great abundance and bones have been reported from the vicinity of Buffalo Gap. It is doubtful whether such material will always be struck in penetrating this formation, and if encountered it may be destroyed beyond recognition by the drill bit. If recognizable pieces of these materials are found, however, they may aid in identifying the formation.

Thicknesses measured on the outcrops of the Lakota in the southern end of the Black

Hills vary from 200 to 500 feet. The formation, therefore should average about 250 to 300 feet thick under the Chilson Anticline. It is unfortunate that the Ardmore Well did not penetrate the Lakota, but a sufficient supply of water was encountered in the top 20 feet and the well stopped there.

### Morrison Formation

It is impossible to say whether the Morrison Formation underlies the Chilson Anticline or not. It outcrops in all parts of the Black Hills except in the southeastern quarter. A very few feet of shale which may be referred to this formation underlie the Lakota at Hot Springs, but west of that city it thickens up rapidly until it reaches thickness of 80 and 100 feet in ten miles. A well drilled in Edgemont encountered 150 feet of shale which have been referred to the Morrison. It is, therefore, possible that extensions of this formation may cross the structure at some of the southern points, but it is certain that it will be very thin or lacking in the northern part of the structure.

It is described in the Edgemont Folio (U.S.G.S. Folio No. 108, p. 4) as consisting of "massive shales or hard clays, mainly of light grey or pale greenish-grey color, but generally in part also red or maroon, with occasional layers of fine grained white sandstone." Its position at the base of the Lakota, and the colored shale should identify the formation if it is present.

Obviously, no figure for the thickness of the formation can be given.

### Unkpapa Formation

If the Morrison is missing, a well penetrating the Lakota will immediately enter another sand formation, known as the Unkpapa Formation. This formation is fine grained, but is easily recognizable because of its striking color. Much of it is very pure white, but purple and buff, or even yellow colors are common. The brilliancy of these colors is in sharp contrast with the ordinary coloring of rock, and should make this sand an easy one to recognize. In the vicinity of Buffalo Gap this formation produces the famous calico sandstones.

The formation varies in thickness, ranging up to 225 feet. This figure occurs in Shep's Canyon just northeast of the Chilson Anticline. At Cascade Springs, about four miles west of Shep's Canyon, a thickness of 100 feet is reported, and two miles west of that, 80 feet. These three thicknesses are nearest to the structure. It is possible, therefore, that this sand continues on southward under the Chilson Anticline. About 100 feet should be encountered at the northern end of the structure. It is impossible to tell how much lies under the southern end as such formations are apt to thin out and disappear.

### Sundance Formation

Beneath the sands of the Unkpapa Formation lie the sands and shales of the Sundance Formation. This formation is divided roughly into two sections, the upper half being predominantly shale with here and there streaks of limestone, which probably will appear as shells in the drillers logs. These lime shells carry abundant fossils in places, perhaps the most easily recognized of which are the quills of the fossil Belemnites. The shales are greenish or reddish, the former color being predominant in most places.

The lower half of the formation is predominantly sand. Sections in the southwestern part of the Black Hills show cliffs of sandstones 75 feet in height. In the southeastern part, however, the sands are much thinner and are separated by shales. These sands are in general soft, sometimes slabby, and on the outcrops show abundant ripple marks, and other evidences of shallow water deposition. Part of them, especially near the upper part of this member, are buff or even red, resembling the red beds somewhat in color.

Near Hot Springs this formation is 242 feet thick, and 10 miles to the west it measures 308 feet. Like most sand formations there is apt to be considerable variation in thickness, but it will be safe to expect 250 feet for the thickness of this formation at least in the northern half of the structure.

No oil has been produced from the formation in the vicinity of the southern Black Hills. An outcrop on the northwestern side of the Black Hills, however, shows a bituminous residue in the sand, indicating that oil once existed in it. It is possible, therefore, that oil may occur in it under the Chilson Anticline.

### **Spearfish Formation**

The Spearfish is perhaps the most easily recognized formation in the series, because of its brick red color. This color shows not only on the outcrop, but very characteristically in well cuttings. The character of the material is also of aid in distinguishing it because it is almost uniformly a fine shaly sandstone. This character and the great thickness of the formation serves amply to distinguish it from all other red rocks of the series. A further distinguishing character, however, is available in the presence of gypsum beds, notably abundant at the top and the bottom of the formations. The white of the gypsum stands out in startling contrast to the red of the sandy shales. Gypsum beds occur in all thicknesses from that of tiny stringers up to twenty feet. Most of them, however, are not over four or five feet in thickness.

The Spearfish Formation might be known as the big red beds on account of the great and uniform thickness. In the northern flanks of the Black Hills it is nearly 700 feet thick in places. The thicknesses measured in the vicinity of the Chilson Anticline are much less, averaging about 400 feet. Since these beds are so widespread and so thick there is no question but that they will be encountered in drilling the Chilson Anticline. Between 350 and 400 feet may be expected in this structure.

### **Minnekahta Formation**

The Minnekahta Formation is a dense limestone which acts as a parting between two red bed formations. Over it lies the thick Spearfish beds, and beneath it the thinner red beds of the Opeche Formation. It is very dense limestone when unweathered, but can be distinguished on the outcrop by very thin beds. Upon weathering, these beds break into slabs two or three inches in thickness. This bedding is of considerable assistance in quarrying the rock, but will probably be of little help in drilling. The formation will be undoubtedly recognized as one which is difficult to drill.

This has been called the purple limestone because of the purplish tinge which is common to the fresh rock in all places. Even where the general appearance is grey, a purplish tinge is always noticeable.

As the rock is not porous it would not act as an oil reservoir. It is interesting to note, however, that when broken it frequently gives off a bituminous odor. It might, therefore, be the source rock for oil pools in neighboring sandstones. In the outcrop it averages between forty and fifty feet in thickness, and as there is no sign of thinning toward the south, it is probable that the formation continues under the Chilson Anticline with about the same thickness.

### **Opeche Formation**

The lower red beds or the Opeche Formation lie immediately below the Minnekahta Limestone. The color and general appearance of this formation is much like that of the overlying Spearfish red beds, but differs in that gypsum has not been reported from it. It consists primarily of soft red sandstone, containing variable amounts of clay. Most of it is thin bedded. A zone of purple shale marks its upper limit and the base is made of layers of red sandstone. A section reported from Cold Brook, 4 miles northwest of Hot Springs, (Edgemont Folio, No. 108, p. 3) gives the following:

- 9 ft. Purple Shale
- 50 ft. Red sandy clay
- 60 ft. Deep red sandstone in beds 1 to 4 feet thick, with red clay partings.

Outcrops in the vicinity of Hot Springs measure 115 to 135 feet in thickness. Along the eastern side of the Black Hills, south of Rapid City, the formation is uniformly about 100 feet thick. On the western side of the Hills it thin [sic] to about 70 or 80 feet. It is very probable that this formation will be found under the Chilson Anticline. It is not unreasonable to expect that at least 100 feet of it will be encountered.

### Minnelusa Formation

The Minnelusa Formation is of particular interest because it has given encouraging shows of oil in a number of places in western South Dakota.

It is a thick formation composed of alternating sands and shales with some beds of limestone. In the vicinity of Hot Springs, the top is marked by a ten-foot layer of gray limestone. In other outcrops, however, the top is composed of gray or sometimes salmon-colored sandstone. Probably the chief distinction noted in drilling will be the change of color from the red of the Opeche to the grey of the Minnelusa.

There are two striking divisions in this formation, an upper one, 150 to 200 feet thick, made of massive sandstone; and a lower one, 250 to 300 feet of alternating layers of sandstone, limestone and shale. The limestone and sandstone out notably as ledges which are separated by covered slopes underlain with shale. In the vicinity of Hot Springs there are several beds of limestone in the upper member, however, and it is possible that they will be encountered in this part of the formation under the Chilson Anticline.

The base of the formation is marked by a few feet of red shale in many localities. It is not necessary to seek this red shale, however, to locate the base, for there is little chance of mistaking the underlying Pahasapa Limestone.

The following section taken at Hot Brook near Hot Springs will show which may be expected from the formation under the Chilson Anticline.

	Red Opeche sandstone at top
10 ft.	Gray limestone
20 ft.	Soft red limestone
15 ft.	Limestone breccia, red to buff matrix
15 ft.	Yellow arenaceous limestone
5 ft.	Red limestone
5 ft.	Yellow arenaceous limestone
5 ft.	Red arenaceous limestone
15 ft.	Gray limestone breccia, red matrix
25 ft.	Red sandstone
5 ft.	Greenish-gray limestone
50 ft.	Soft red sandstone
10 ft.	Gray limestone
10 ft.	Red sandstone
10 ft.	Gray sandstone
6 ft.	Red sandstone
30 ft.	Red shale
20 ft.	Pale red sandstone, thin coaly shale partings
15 ft.	Light buff and gray sandstones
3 ft.	Breccia
25 ft.	Reddish-gray sandstone
1 ft.	Green shale
12 ft.	Gray to buff sandstone
2 ft.	Black shale
15 ft.	Light buff, soft sandstone
2 ft.	Dark shale
30 ft.	Gray calcareous sandstone with coaly shale partings
376 ft.	Total



All published sections of this formation, except the one just given shown thicknesses from 400 to 500 feet. It is very probable, therefore, that this same thickness will continue under the Chilson Anticline.

### **Pahasapa Formation**

The Pahasapa Formation is a dense massive limestone. The color of the fresh rock is light grey, but on weathering it often darkens to a dove color, a buff or even to a white. A little chert is reported from the upper part of the formation in some places, but it is not in sufficient quantities to be an important part of the formation. A feature which makes the Pahasapa of interest to oil prospectors is its cavernous character. Many large caves are found in the formation in the outcrops about the Black Hills. Smaller openings, including cracks and holes a small fraction of an inch in diameter, make the rock very porous in many places. This character is conspicuous in all outcrops of the formation, and it may occur underground beneath the Chilson Anticline. If this be true the limestone might serve as an oil reservoir.

The maximum measured section of this formation has a thickness of 630 feet. In the outcrops on the eastern side of the Black Hills most of the thicknesses recorded are between 300 and 350 feet. The sections on the western side of the mountains, however, average 500 feet. It is probable, therefore, that 500 feet would be about a maximum for the thickness of the formation under the Chilson Anticline.

### **Englewood Formation**

Beneath the Pahasapa Limestone lies the Englewood Formation, another limestone from thirty to sixty feet thick. It is slabby and of a buff color, which has a decided purplish tinge in most places. So far as is known, it will be of no interest to oil drillers, except that it must be penetrated to reach the underlying Deadwood Sandstone.

### **Deadwood Formation**

The Deadwood Formation is the lowest of the sedimentary series, and the last one worth testing for oil. Below it lie Pre-Cambrian Schists or Granites, which never carry oil.

It is impossible to say how much of this formation lies beneath the Chilson Anticline. The nearest outcrop gives the probable thickness as about 56 to 60 feet. It, however, thins considerably from the northern to the southern part of the Black Hills, due probably to erosion, and therefore, may be entirely missing under the southern part of the Chilson structure.

In this part of the Black Hills the formation consists entirely of sandstone of a very dark buff or red color. Some portions of the sandstone are described as being shaley [sic], and near the base it nearly always carries some conglomerate. Its dark color, the presence of conglomerate, or coarse sand, and its [sic] position beneath the thick limestones of the Pahasapa, or possibly the purple limestones of the Englewood, make it an easy formation to recognize from well cuttings.

### **Pre-Cambrian Rock**

The rocks below the Deadwood Formation are commonly known to the drillers as "granite" and are not of interest to the oil prospector, because they never carry oil or gas. In the outcrops of the Black Hills there are two notable series of Pre-Cambrian Rocks, one the true Granite, a volcanic rock which is extremely hard to drill, and the other the schists. These are fine grained rocks not so hard to drill as the granite, but characterized by large quantities of mica and other minerals which are not found in the sedimentary rocks above. When these rocks are encountered, the well is past all possible chances of production.

## DRILLING CONDITIONS

### Access:

This structure is easily reached over the Chicago, Burlington and Quincy Railroad, which follows its axis for five miles north of Ardmore. It then turns toward the northwest, passing through Rumford. From either of these stations to any point of the structure can be reached by good roads or trails, making the maximum haul for materials not over nine miles. It is about twelve miles from Edgemont to the northern part of the structure by road, and a good graded road between Edgemont and Oelrichs passes just south of the Cheyenne River. Hauling by truck or team, therefore, can be done easily and at a minimum of expense.

### Fuels:

All fuel for drilling operations will have to be hauled in as there are no sources of fuel in the immediate vicinity. Lignite coal can be obtained from the northern part of South Dakota, and from adjoining parts of Wyoming. Bituminous coals must be hauled in, either from the eastern coal fields, or the Rocky Mountain fields. Some small seams have been mined in the Lakota Formation, but it is doubtful whether they could be re-opened and mined at less expense than that for which coal could be hauled in. It is doubtful whether it would be possible to cut wood in the Black Hills and haul it to the drilling sites more cheaply than coal could be imported.

### Water:

Hat Creek is the largest stream in the region, and follows the axis of the Anticline for about half its distance. It contains water part of the year, but is very apt to go dry in the summer time. There are tributaries to this stream which might be dammed and afford a sufficient supply for drilling. The only alternative is a water supply from wells tapping the Fall River or the Lakota sandstones. This has been used, but has made trouble in the boilers as the water is quite hard. The Cheyenne River at the northern end of the structure carries water most of the time, but is not very close to favorable drilling sites. Water would have to be hauled from this source by truck or pumped several miles through a pipe line.