DESCRIPTION OF BELLE FOURCHE QUADRANGLE

By N. H. Barton and C. C. O'Hara.

PHYSIOGRAPHY. The Belle Fourche quadrangle embraces the northern part of Riley County, Kansas, and is bounded on the south and west by the Kansas River, on the north and east by the Smoky Hill River, the latter of which is the boundary between Kansas and Nebraska.

The surface of the region is formed by the alluvium of the Missouri and Platte rivers and their tributaries, and is as level as the soil and the precipitation permit. The greatest portion of the quadrangle belongs to the Great Plains, and the remainder to the Black Hills. The area of the Great Plains is about 1200 square miles, and that of the Black Hills is about 200 square miles.

The Great Plains extend from the Rocky Mountains in the west to the Laramie Mountains in the east, and from the Platte River in the north to the Republican River in the south. They are divided into two main divisions, the Northern Plains and the Southern Plains, and are further subdivided into the following sub-divisions:

1. The Northern Plains:
   a. The High Plains
   b. The Low Plains

2. The Southern Plains:
   a. The High Plains
   b. The Low Plains

The Northern Plains are characterized by their level surface, their extensive grasslands, and their limited forests. The Southern Plains, on the other hand, are characterized by their rolling hills, their prairies, and their extensive forests.

The Black Hills are a range of mountains located in southwestern South Dakota, and are composed of crystalline rocks. They are bounded on the north by the Missouri River, on the south by the Platte River, on the east by the Republican River, and on the west by the Laramie Mountains.

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The Belle Fourche-Owl River divide passes diagonally across the northern part of the quadrangle. It consists of a low ridge on which rises several buttes and short ridges separated by wide gaps, most of them about 3200 feet in altitude.

The most prominent of these buttes are in the ridge of which Two Top Peak is one of the summits. The end of the ridge has an altitude of 3471 feet, or nearly 500 feet above the adjacent gap.

One of the most remarkable features of the area is the great width and depth of the valley of the Indian and Owl creeks in
compared with that of Belle Fourche River. This condition is
reservoir ditches will convey water to an extensive area of the
Missouri, and the present stream was very small above the
altitude in the valleys is that the present Belle Fourche River
is of very recent development. Originally its headwaters
were near Stud moclt Plnt into Missouri, and the present stream was very small above the
mouth of Redwater Creek. Before the change of Creek.

The Black Hills uplift is an irregular, dome-shaped antcline,
emerging an oval area 125 miles long and 60 miles wide, with
its longer dimension trending northwest and southeast.
It is situated in a wide area of almost horizontal beds and has
brought above the general level of the plains an area of pre-
Cambrian crystalline rocks about which there is upturned a
nearly complete sequence of sedimentary formations ranging in
age from pre-Cambrian to later Cretaceous, all dipping
southwest of Hermosa. There is everywhere a basal sandstone,
generally conformable in attitude, with the exception of the overlap­
ning Tertiary deposits, which extend across the edges of the older
rocks. The stratigraphy presents many points of similar­
ity to that of the Rocky Mountains in Colorado and Wyo-
ming, but possesses numerous distinctive local features.

The Cretaceous system is represented by the Deadwood sandstone, which reaches a thickness of 400 feet in the north­
erly hills, but decreases to 4 to 6 feet or possibly less in the region
southwest of Hermosa. There is everywhere a basal sandstone,
generally conformable, lying on a nearly unaltered eroded
surface of the Algonkian schists and gneisses. Where its forma­
tion is thin it consists entirely of this member, but as it thickens to the north it includes also overlying gray shale and
shaly sandstones, partly glauconitic. These beds grade locally
into shaly limestones, mostly in the form of a flat-foled inter­
calated sandy beds surrounding the shales, all of which are
massively conformable in attitude, with the exception of the overlap­
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In the Black Hills the Carboniferous system comprises
several formations apparently representing continuous depo­
siton throughout the period. Limestone predominates, but some
sandstones also occur in the higher formations. Everywhere at
the base is the Englewood limestone, 23 to 50 feet thick. It
consists of shaly beds of pinkish or buff color, with Chaunet's or earlier Kidderbrook fossils. The Englewood grades up into the
Fuson formation, which occurs small areas near Deadwood and in the Bear liverd uplift. On Whitecliff Creek its thickness is 80 feet,
and it thins rapidly to the south. The rock is a mass of tough
tough limestones of buff color, with brownish spots or mottings.
It is overlain by several feet of greenish shale of unknown age.

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The funny shaped object appears to be a stone or rock.

or and. In this area the formation is made up of soft red sandstones mainly in beds from 1 to 4 inches thick interbedded with red sandy shale, all evenly laminated. At the top of the formation the shale is thin, which is explainable as having a calcarious horizon within. Ordinarily the formation is somewhat more unevenly bedded in its lower portion. It lies conformably on the Minnekahta sandstone, but begins with an abrupt change in material.

Age.—The age of the Opechee formation has not been definitely determined, as it has yielded no fossils. The overlying Minnekahta limestone contains fossils of supposed Permian age, and the underlying sandstone is believed to be Pennsylvanian.

**MINNEKAHA LIMESTONE.**

Outcrop.—The Minnekahta limestone, about 35 feet thick, constitutes the slopes and crest of the high ridge lying between Crow and Spearfish valleys in the southwest quadrant of the range. It rises steeply from the surrounding Badlands and is nearly bare and rocky except for scattered ledges and pineries. The formation is cut through by various canyons and has been removed by erosion along portions of the slope of the higher part of the ridge near Crow Creek. In those places it presents precipices from 30 to 40 feet in height, and at the mouths of the canyons it usually forms a narrow neck, or "gulf," which is a characteristic feature. The type locality of the formation is at the Minnekahta Springs, near Hot Springs, in the southern Black Hills.

Character.—The rock is of light-gray color, but in general it has a light pinkish or purple tinge from which the old name "Purple limestone" was derived. In the cliffs it appears to be massive, but close examination shows that the layers are thin and almost indistinguishable by slight differences of color. On weathering it breaks into slabs, generally from 2 to 3 inches in thickness. It consists largely of carbonate of lime, a considerable proportion of a base of magnesia, and a small admixture of clay and sand.

Fossils.—Fossils obtained in the Minnekahta limestone at various localities in the Black Hills indicate a probable Permian age, in the sense in which that term is used in the Mississippi Valley.

**TERTIARY (?) SYSTEM.**

All the rocks that are regarded as possibly of Triassic age in the Black Hills are included in the Spearfish formation. The type locality is at Spearfish, just south of this quadrangle.

**SPARSEFISH FORMATION.**

Outcrop.—The Spearfish formation, formerly called the "Red Beds," consists of red sandy shale with interbedded beds of gypsum. It averages 650 feet thick. It outcrops in an area of considerable size in the southwest corner of the quadrangle, where it underlies portions of the valleys of Redwater, Spearfish, and Crow creeks. A few outlying areas occur on the limestone ridge east of Crow Creek. Along Redwater, Spearfish, and Crow creeks and their larger branches the formation is covered by loose deposits of alluvium and in some places by slight deposits of clay and sandy loam. The entire width of the Spearfish Valley is covered by terrace deposits. Outcrops, however, are numerous on the slopes, and as a rule they are conspicuous on account of the bright-colored color of the shale and the snowy whiteness of the gypsum. In places the formation is cut through by various canyons and has been removed by erosion along portions of the slope of the higher part of the ridge near Crow Creek. Along Redwater, Spearfish, and Crow creeks and their larger branches the formation is covered by loose deposits of alluvium and in some places by slight deposits of clay and sandy loam.

Character.—The sedimentary material is almost entirely sandy red shale, generally thin bedded, evenly laminated, and without any marked stratigraphic features. The gypsum occurs at several horizons in beds varying in thickness from 15 feet to 100 feet or more above the base of the formation. Most of the gypsum is pure white, but some of it is gray to dirty blue. It is nearly all massive in structure. The formation averages 650 feet in thickness but in the Redwater Valley where the western border of the quadrangle the thickness is approximately 680 feet. A horst or mile east of Spearfish which began considerably below the top of the formation penetrated red beds to a depth of 450 feet, reaching a limestone supposed to be the underlying Minnekhada. The exposures of the upper part of the formation on the north side of Redwater Valley near the mouth of Crow Creek exhibit the following beds:

<table>
<thead>
<tr>
<th>Section of Upper Portion of Spearfish Formation in Redwater Valley</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gypsum</strong></td>
</tr>
<tr>
<td><strong>Massive gypsum</strong></td>
</tr>
<tr>
<td><strong>Light gray and green sandstones</strong></td>
</tr>
<tr>
<td><strong>Light gray sandy shale</strong></td>
</tr>
<tr>
<td><strong>Light gray sandstone</strong></td>
</tr>
<tr>
<td><strong>Light gray sandy shale</strong></td>
</tr>
<tr>
<td><strong>Red sandy shale</strong></td>
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</tr>
</tbody>
</table>

Below these beds are 235 feet of red sandy shale and argillaceous sandstone containing a 5-foot bed of gypsum 120 feet above the base of the formation. In places this gypsum occurs in two or three beds separated by red sandstone at many places in the Black Hills and elsewhere. They have been regarded as late Jursacian age, but some eminent palaeontologists now believe

**Fossil Formed in these beds are as follows:**

<table>
<thead>
<tr>
<th>Fossil Formed</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ostrea strigilecula</strong></td>
<td>Close to Spearfish Creek; and at intervals along the high ridge northeast of Spearfish. The formation crosses Pahk Bottom Creek about 3 miles south of St. Onge.</td>
</tr>
<tr>
<td><strong>Tancredia postica</strong></td>
<td>Close to Spearfish Creek; and at intervals along the high ridge northeast of Spearfish. The formation crosses Pahk Bottom Creek about 3 miles south of St. Onge.</td>
</tr>
</tbody>
</table>

**MORRISON SHALE.**

Outcrop.—The Morrison formation consists mostly of red sandy shale, with interbedded beds of gypsum. It is exposed in the upper part of the formation on the slopes below cliffs of Lakota sandstone. Owing to the softness of its material and the talus from the cliffs above it is thin and generally not complete. The most extensive exposures are in the high ridge between the Redwater and Crow Creek valleys, next the western margin of the quadrangle; along the north side of the Redwater Valley below the mouth of Spearfish Creek; and at intervals along the high ridge northeast of Spearfish. The formation crosses Pahk Bottom Creek about 3 miles south of St. Onge and it also appears in the uplift 6 miles southeast of St. Onge on the southern margin of the quadrangle. An overlapping area occurs on the ridge a mile southeast of the northern part of Spearfish.

Character.—The prevailing color of the formation on weathered slopes is greenish gray or yellowish gray, but pink and purple tints are uncommon and in places the color is brown or pink. Some exposures show distinctly darker shales and at a number of localities the upper beds are black and carbonaceous. Thin layers of carbonaceous clay nodules are common, and locally these develop into thin beds of impure limonite. Sandstone beds are present in most places but are as a rule not conspicuous. There are many local variations in character, but the most characteristic feature is the dark appearance of the shale serve to distinguish it from the Sundance formation. The thickness of the sandstone below the sandstone below the sandstone varies from about 50 feet. Along the slopes north of the Redwater Valley it is 50 feet and on the small uplift northeast of Spearfish it appears to be nearly 100 feet. In general the Morrison formation contains the characteristics which it has in the type locality about Morrison, Colo.

**Fossils and Age.**—Numerous bones of large dinosaurs have been found in the Morrison formation at many places in the Black Hills and elsewhere. They have been regarded as late Jurassic age, but some eminent palaeontologists now believe...
that they are early Cretaceous. As the stratigraphic relations in some regions sustain this view the formation is here provisionally assigned to the Cretaceous. The thin limestone members in the formation in some areas contain fresh-water shells and algae.

**LAKOTA SANDSTONE.**

Ooze bed. — The Lakota sandstone appears in cliffs at or near the crest of a north-northeast-south-southwest hogback range which extends across the southwestern portion of the quadrangle. These cliffs surround rounded slopes of the Sundance and Morrison formation and rise in places considerable extent and prominence. The sandstone constitutes the crest and a portion of the eastern slopes of the range extending from a point east of False Bottom Creek to Redwater Creek, but west of the Redwater, where the crest of the range consists of Dakota sandstone, the Lakota appears as a cliff in the middle slopes. The Lakota also appears in the upper 6 miles southeast of St. Onge, and small outliers extend the high summits a mile northeast of the northern part of the Sundance. Other outliers occur in cliffs in the hogback range between the Redwater and Hay Creek valleys near the western margin of the quadrangle. 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and, especially in the Indian Creek-Owl Creek valley in Re, 3, 4, and 5 E. Extensive exposures occur in the Owl Creek valley along the southwest slope of Belle Fourche but mostly less than half a mile wide in the new member of the valley above that city. The alluvial area is especially wide along Indian Creek below the mouth of Hills­brand Creek, and this area extends southward across the divide and down the Owl Creek valley in the center of T. 9 N., R. 4 E. The alluvium averages more than 300 feet above the present streams, and many of the streams enter the valley at a point several miles east of Twin Buttes. The type locality of this formation is on Missouri River at the mouth of the Niobrara.

The rocks consist of soft pale-buff slabby sandstone at the top of the formation there are lenses of porous dull-gray limestone, mostly from 5 to 6 feet in diameter. The formation appears to merge down into deposits of more than 300 feet above the present streams, and many of the streams enter the valley at a point several miles east of Twin Buttes. The type locality of this formation is on Missouri River at the mouth of the Niobrara.

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of Pierre shale near Mad Butte. It causes the prominent
way coextensive with the present Rocky Mountain province,
deflection of the outcrop of Greenhorn limestone about Susie
between St. Onge and Baldy peaks. Southeast of the village
are continuous over a vast area. The land surfaces were prob­
character of the sediments derived from its waste. The quartz
mined for any one epoch, and the relations of land and sea
but the peripheral shores are not even approximately deter­
in thick but regular beds, apparently with much calcareous
submergence on the other hand, if deposited near the shore, indicate that the
off coarse material, the sea receiving only fine sediment and
laid down in shallow water and probably at a time when sedi­
formation. The Spearfish beds appear to show a truncation to arid conditions similar to those under which the Spearfish formation was laid down. An extensive marine fauna and the limestone in the upper slope of the Sundance formation indicate that deeper water followed. After this stage widespread uplift gave rise to fresh-water bodies. The first product was the thin body of fine sand of the Enk­
now a prominent feature along the east side of the Black Hills but shiner or shallower elsewhere.
Cretaceous is.—During the Cretaceous period deposits of various kinds, but generally uniform over wide areas, gathered in a great series, beginning with those as characteristic of shallow seas and ancient seas along a coastal plain, passing into sediments from marine waters, and changing toward the end to fresh-water deposits. The earliest of these deposits, beginning possibly in late Jurassic time, are the so-called condensed section of the White River beds, the basaltic shales and sandy shales of the Lance formation, the later part of which is known as the Lance Formation. As no coarse deposits of this age occur, it is probable that no crystalline rocks were then exposed in this area, although elsewhere the limestone, or some stratigraphic equivalent, was deposited immediately upon them. In the later part of the Cretaceous time, the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were increased so that the rock formations that have been uplifted into mountains, and the area of erosion, were 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ECONOMIC PRODUCTS.

With the exception of the underground water, the economic products found in this quadrangle are of no great value. They are described under the following headings—gypsum, bentonite, limestones, clay, coal, building stones, surface water, underground water.

GYPSUM.

The Spearfish formation carries deposits of gypsum, a hydrous sulphate of lime, of various thickness, and the mineral occurs in beds sufficiently thick and pure to be of value if it were nearer to market. When gypsum is calcined at a moderate heat to drive off the greater portion of the chemically combined water, and is then ground, the product is plaster of Paris. The principal gypsum deposit in the Belle Fourche quadrangle is in the upper portion of the Spearfish formation exposed in the ridges east and west of Spearfish. One bed reaches a thickness of 18 to 20 feet but has an average thickness of 12 feet in an area of several square miles. It is mostly white or light gray in color, massive in structure, and nearly pure. Another bed which occurs 120 feet above the bottom of the formation is about 5 feet thick and occurs in all the slopes adjoining the limestone ridge in the southwest corner of the quadrangle. The mineral has not yet been utilized in this region but it has been worked to some extent at other localities in the Black Hills, where, however, the distance from market has proved to be too great to make the industry profitable.

BENTONITE.

Bentonite is a light-colored clay which has the peculiarity of being highly absorbent. When dry the material is a soft, massive rock of light-gray or very pale greenish color, with conchoidal structure when broken. Owing to its absorbent quality, and its absorption, it adheres strongly when placed on the tongue. When wet the mineral becomes a pasty-like mass or soft soap, and milky pink known as "soap holes" occur at some points along its outcrop. The bentonite occurs as a bed in the Green River shale a short distance above the top of the Mowry shale member. It varies in thickness from a thin layer to 3 feet, but is possibly more, but appears in nearly all portions of the area. The most extensive exposures are in the ridge extending along the north side of Belle Fourche River west of Belle Fourche, where the deposit has a thickness of about 3 feet and lies 8 feet above the top of the Mowry shale. Bentonite is mined at various localities in Wyoming, and its value is such that it can be shipped to long distances. It is used as an absorbent packing for horses' heads, as a filler for paper, as a medium in certain drugs, and as an asphaltic binder.

LIMESTONE.

Limestones for lime or other purposes can be obtained in abundance from the Miocene limestones in the southwest part of the quadrangle, but on the market, contain a large amount of the quadrangle the soil is thin and much interrupted by rock ledges, but it is fertile and in some cases has yielded crops of the harder grains.

GENERAL CONDITIONS.

The average annual rainfall in the Belle Fourche region is probably somewhere between 15 inches, except in the high ridge in the southwest corner of the quadrangle, where the amount may be slightly greater. Part of the precipitation is in the form of snow and the winter falls mostly in heavy showers of short duration during the spring and early summer months. As most of the surface of the country has this soil as its only soil product the present area presents perfect rock beds. The water of rains and melting snows runs off rapidly, usually in freshets that follow storms or the melting of snow during warm spells in the spring. In the central and northern portions of the area there is a rule no continuous snow cover for any considerable length of time. In consequence of these conditions the minor valley soils contain but little running water during the greater portion of the year and springs are few and nearly small in the lower kinks. A large amount of the load run-off in this region could be saved by dams and made available for stock and local irrigation. There are many suitable dam sites and at several places north of Belle Fourche considerable water has been impounded by small earth dams across draws. As evaporation of standing water in this region is about 1 foot a year, a large amount of water has to be collected to compensate for this loss.

The works in course of construction by the United States Reclamation Service below Belle Fourche will consist of a dam in secs. 18 and 19, T. 9 N., R. 4 E., and a canal to deflect the waters of Belle Fourche River at a point about a mile and a half below Belle Fourche. The dam will create a large reservoir, extending for some distance up the valleys of Owl and Dry creeks, into which the river water will be conveyed by the canal. By means a water supply will be obtained for irrigating a large area in the valleys of Owl and Dry creeks and of Belle Fourche south of the Black Hills.

BELLE FOURCHE RIVER.

This river has a drainage basin above Belle Fourche and above the mouth of Whitewood Creek of about 2520 square miles. The river has been gauged at Belle Fourche above the mouth of Redwater Creek since 1903 and found to vary from a minimum of practically zero in June, 1903, to a maximum of nearly 6000 second-feet in June, 1904. Ordinarily it ranges from 50 to 200 second-feet, but the mean for twenty-seven months in the years 1903 to 1906 was 100 second-feet. In 1906 the river was gauged at the intake station of the United States Reclamation Service, 11 miles below Belle Fourche and below the mouth of Redwater Creek. After the usual flood in May and June the flow at that place varied in August from 72 to 775 second-feet. The mean flow for August, September, October, and November ranged from 225 to 265 feet.

REDWATER CREEK.

This stream rises on the east slope of the Black Hills and has a drainage basin of about 2000 miles. It has a constant flow varying from 100 to 300 feet through most of the season and averaging 250 feet for twenty-seven months in the years 1903 to 1906. Several gaging reports have been made at Redwater Creek, and its flow is reported as about 100 second-feet in June, 1904, a flow of 0.16 feet was recorded at Spearfish. The river has been gauged at Little Belle Fourche, which is a point about three miles below the mouth of Redwater Creek, and below the mouth of Belle Fourche. After the usual flood in May and June and a period of eighteen months in August the flow at Redwater Creek was reported as about 400 second-feet. The mean flow for August, September, October, and November was about 250 feet.

BELLE FOURCHE RIVER.

This river has a drainage basin above Belle Fourche and above the mouth of Whitewood Creek of about 2500 square miles. The flow of this river varies from 50 to 100 second-feet, and rarely has been recorded as exceeding 120 second-feet. The mean flow for twenty-seven months in the years 1903 to 1906 was about 100 second-feet. In June, 1904, a flow of 450 feet was reported and in July, 1905, there was a flow of 100 second-feet.
ECONOMIC PRODUCTS.

With the exception of the underground water, the economic products found in this quadrangle are of no great value. They are described under the following headings—sand, gypsum, bentonite, lime, clay, building stone, surface water, underground water.

SOILS.

Derivation.—The soils in this region are closely related to the underlying rock formation, on which they are re-aided by soil and underlying rocks, the latter of which contain re-aided by soil and underlying rocks, the latter of which are of two kinds, sandy and calcareous, and are usually composed of sand, silt, and clay. The calcareous material is mostly alluvial, but on the topography. On the limestone ridge in the southwest corner of the quadrangle, there are usually fertile, but some of them contain much sand and sandy and much of the surface is scarcely level enough for agricultural use. The Fox Hills souls are of good quality and color for coarse work. In the northern part of the quadrangle large supplies of rough rock may be obtained from the Fox Hills sandstone.

GYPSEUM.

The Spearfish formation carries deposits of gypsum, a hydrous sulphate of lime, throughout its extent, and the mineral occurs in the form of minute white particles, in small amounts, and as larger masses when the mineral is in the form of pseudomorphs. The principal gypsum deposit in the Belle Fourche quadrangle is in the upper portion of the Spearfish formation, as exposed in the ridge east and north of Spearfish. One bed reaches a thickness of 18 to 20 feet but has an average thickness of 16 to 25 feet in areas of several square miles. It is mostly white or light gray in color, massive in structure, and nearly pure. Another bed which occurs 120 feet below the bottom of the formation is about 5 feet thick and outcrops in all the slopes adjoining the limestone ridge in the southeastern corner of the quadrangle. The mineral has not yet been studied at this thickness, extending for some distance up the valleys of Owl and Dry creeks, into which the water will be carried by the canal. By this means, a water supply will be obtained for irrigating a large area in the valley of Indian and Owl creeks and of the Whitewater River drainage. It carries a remarkably regular discharge of water which will be supplied for agricultural purposes. In consequence of these conditions the minor overflow from the reservoir will be saved by dams and made available for stock and local irrigation. There are many suitable dam sites and at several places north of Belle Fourche, considerable water has been impounded by small earth dams across draw. As evaporation of standing water in this region is about 6 feet a year, a large amount of water has to be collected to compensate for this loss.

The works in course of construction by the United States Reclamation Service below Belle Fourche will consist of a dam in secs. 18 and 19, T. 9 N., R. 4 E., and a canal to divert the water of the Belle Fourche River at a point about a mile and a half below Belle Fourche. The dam will create a large reservoir, extending for some distance up the valleys of Owl and Whitewater, and the oil will be carried by the canal. In consequence of these conditions the minor overflow from the reservoir will be saved by dams and made available for agricultural purposes.

Bentonite.—A light-colored clay with the peculiarities of being highly absorbent. When dry the material is a soft massive rock of high value for coarse work. In the northern part of the quadrangle the soil is thin and much interposed by rock ledges, but it is fertile and in some areas has yielded crops of the harder grains.

LIMESTONE.

The limestone in the northern part of the quadrangle is presented than some thin carbonaceous shales and a limestone member. It varies in thickness from a thin layer to 3 feet or possibly more, but appears in nearly all parts of the area. The most extensive exposures are in the ridge extending along the north side of Belle Fourche River west of Belle Fourche, where the deposit has a thickness of about 3 feet and rises 5 feet above the top of the Shale Member. Bentonite is mined near the main headwaters of Wyoming, and its value is less that it can be shipped in this area. It is used as an absorbent for home's, as a filling for paper, as a medicament in certain drugs, and as an adhesiob.

CLAY.

Large deposits of clay for bricks and other purposes are available in nearly all portions of the quadrangle, notably in the area of the Cretaceous rocks, where it is at its thickest. Most of the shale gives rise to a clay soil which is not only barren but is also a very poor in quality for agricultural purposes. In the northern part of the quadrangle the soil is thin and much interposed by rock ledges, but it is fertile and in some areas has yielded crops of the harder grains.

COAL.

Coal deposits of moderate extent in the lower portion of the Lakota sandstone are worked at Ablin, a short distance west of Indian Creek. The coal beds are narrow and discontinuous, and the coal is of small thickness. The deposits have been worked only to a slight extent for brickmaking. Some of the Fens formation appears to be fine clay, but no test has yet been made in this area as to its fire-resisting qualities.

WATER SUPPLY.

SURFACE WATER.

General outline.—The average annual rainfall in the Belle Fourche region is probably somewhat less than 15 inches, except in the high north, where the average is about 20 inches. The water in the southwest corner of the quadrangle, where the amount may be slightly greater. The proportion of the precipitation is in the form of snow in winter and rain in summer. Snowfall occurs mostly in heavy showers of short duration during the spring and early summer months. As most of the surface of the country has thin soil and underlying rocks, the snows pass over with little storage in the snows, and snows melt off rapidly, usually in freshets that follow storms or the melting of snow during warm spells in the spring. In the central and northern portions of the area there is a rule no continuous snow cover for any considerable length of time. In consequence of these conditions the minor valleys contain little running water during the greater portion of the year and springs are few and mostly small in the lower lands. A large range of local rainfall in this region can be avoided by dams and made available for stock and local irrigation. There are many suitable dam sites and at several places north of Belle Fourche, considerable water has been impounded by small earth dams across draw. As evaporation of standing water in this region is about 6 feet a year, a large amount of water has to be collected to compensate for this loss.

This stream rises on the east slope of the Bearlodge Mountains and has a drainage basin of about 1020 square miles. It has a coarse flow carrying on about 100 to 300 cubic feet per second through most of the season and averaging 250 cubic feet per second for twenty-seven months in the years 1903 to 1906. In some years in midsummer the flood diminishes to less than 100 cubic feet per second for a short period, and in time of flood the flow reaches 2000 cubic feet per second. In June, 1904, it reached a point of 3500 feet. The stream has been regularly gaged for the past five years near its mouth in Belle Fourche. There is an additional gaging station at Spearfish, which gives an average of about 400 cubic feet per second, and gaging station at Spearfish, which gives an average of about 400 cubic feet per second, and gaging station at Spearfish, which gives an average of about 400 cubic feet per second. In May, 1904, a flood of 1200 cubic feet per second was reported and in July, 1906, there was a flood of 3170 cubic feet per second.

Stem Creek.—Stem Creek is a tributary of the high limestone plateau and adjacent slopes in the northern Black Hills, and a canal to deflect the flow of water from the gaging station at Spearfish. It carries a remarkably regular discharge of water which will be supplied for agricultural purposes. The irrigation that follows storms or the melting of snow during warm spells in the spring. In the central and northern portions of the area there is a rule no continuous snow cover for any considerable length of time. In consequence of these conditions the minor valleys contain little running water during the greater portion of the year and springs are few and mostly small in the lower lands. A large range of local rainfall in this region can be avoided by dams and made available for stock and local irrigation. There are many suitable dam sites and at several places north of Belle Fourche, considerable water has been impounded by small earth dams across draw. As evaporation of standing water in this region is about 6 feet a year, a large amount of water has to be collected to compensate for this loss.

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formations, as shown in the columnar section, includes several beds of water-bearing sandstones which sheet above surface waters in their outcrop zones in the higher ridges and slopes of the Black Hills. The sandstones are underlain on the sides of the uplift and, owing to the relative steepness of the dip, attain considerable depth within short distances. In most of the area water-bearing beds are at horizons in the artesian bed sequence which probably contain water, but in most of the Belle Fourche establishments, there are two artesian wells on property of the Belle Fourche Land and Cattle Company in the NW. 1/4, 11, T. 8 N., R. 2 E., a mile north of Belle Fourche. The first, which was sunk in 1902, has a depth of 400 feet. It flows from the second flow, at 635 feet. The water is somewhat hard and the pressure is 35 pounds. A flow of 450 feet was found at a depth of 485 feet, which is the following record:

List of wells.

<table>
<thead>
<tr>
<th>Location</th>
<th>Depth (feet)</th>
<th>Flow (gallons per minute)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. A. Scotney, NE. 1/4 sec. 20, T. 8 N., R. 2 E.</td>
<td>1013</td>
<td>15</td>
</tr>
<tr>
<td>J. A. Scotney, NE. 1/4 sec. 17, T. 8 N., R. 2 E.</td>
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<tr>
<td>W. R. Glassie, NE. 1/4 sec. 28, T. 8 N., R. 2 E.</td>
<td>1020</td>
<td>15</td>
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<tr>
<td>S. Johnson, SW. 1/4 sec. 13, T. 8 N., R. 2 E.</td>
<td>1020</td>
<td>15</td>
</tr>
<tr>
<td>G. H. Ray, SE. 1/4 sec. 14, T. 8 N., R. 2 E.</td>
<td>1020</td>
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<tr>
<td>Orman and Crook, NE. 1/4 sec. 14, T. 8 N., R. 2 E.</td>
<td>1020</td>
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<tr>
<td>Newland ranch, SW. 1/4 sec. 4, T. 8 N., R. 3 E.</td>
<td>1013</td>
<td>15</td>
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<tr>
<td>F. A. Durst, NW. 1/4 sec. 14, T. 8 N., R. 3 E.</td>
<td>1013</td>
<td>15</td>
</tr>
<tr>
<td>J. A. Scotney, NE. 1/4 sec. 14, T. 8 N., R. 3 E.</td>
<td>1013</td>
<td>15</td>
</tr>
</tbody>
</table>

Artesian wells and deep borings in the Belle Fourche quadrangle.

**Belle Fourche city wells:**

- First well, bored in 1903 to a depth of 881 feet, found water-bearing sand grains so closely cemented by lime that the interstices probably too compact to yield water.
- Second flow at 560 feet shows a pressure of 40 pounds. A small flow was found at a depth of 580 feet.

**Belle Fourche river wells:**

- First well, bored in 1903, to a depth of 525 feet and flowed 60 gallons a minute. The well finally got out of sure.
- Second flow at 525 feet and yielded a flow of 60 gallons a minute. In valley.

**Sandstone (Dakota):**

- Hard sandstone (Dakota), small flow 600-612 feet.
- Hard sandstone (Dakota), small flow 600-612 feet.
- Hard sandstone (Dakota), small flow 600-612 feet.

**Sandstone (Lakota):**

- Hard sandstone (Lakota), small flow 600-612 feet.
- Hard sandstone (Lakota), small flow 600-612 feet.

**Sandy clay and shale (Fuson):**

- Sandy clay and shale (Fuson), small flow 600-612 feet.
- Sandy clay and shale (Fuson), small flow 600-612 feet.

**Clay and shale:**

- Clay and shale at 900 feet.

**Hard rock:**

- Hard rock at 450 feet.

**Shoreline:**

- Shoreline at 500 feet.

**Diaphragm:**

- Diaphragm at 550 feet.

**Clay and shale (Fuson):**

- Clay and shale (Fuson) at 900 feet.

**Sandstone:**

- Sandstone at 600 feet.

**Sandy clay and shale (Fuson):**

- Sandy clay and shale (Fuson) at 600 feet.

**Clay and shale:**

- Clay and shale at 900 feet.

**Shoreline:**

- Shoreline at 450 feet.

**Diaphragm:**

- Diaphragm at 550 feet.

**Clay and shale (Fuson):**

- Clay and shale (Fuson) at 900 feet.

**Sandstone:**

- Sandstone at 600 feet.

**Sandy clay and shale (Fuson):**

- Sandy clay and shale (Fuson) at 600 feet.

**Clay and shale:**

- Clay and shale at 900 feet.

**Shoreline:**

- Shoreline at 450 feet.

**Diaphragm:**

- Diaphragm at 550 feet.

**Clay and shale (Fuson):**

- Clay and shale (Fuson) at 900 feet.

**Sandstone:**

- Sandstone at 600 feet.

**Sandy clay and shale (Fuson):**

- Sandy clay and shale (Fuson) at 600 feet.

**Clay and shale:**

- Clay and shale at 900 feet.

**Shoreline:**

- Shoreline at 450 feet.

**Diaphragm:**

- Diaphragm at 550 feet.

**Clay and shale (Fuson):**

- Clay and shale (Fuson) at 900 feet.

**Sandstone:**

- Sandstone at 600 feet.
Reclamation project—The United States Reclamation Service has drilled two artesian wells in connection with the Belle Fourche project—one at the dam site on Owl Creek, in the SE. 1/4 SW. 1/4, T. 9 N., R. 4 E., the other at the intake of the diversion canal 1/2 miles below Belle Fourche. The well at the dam site is 1390 feet deep and 2 inches in bore and has a 10-gallon flow under pressure sufficient to raise the water 30 feet or more above the surface. The boring was in Carlile and Greenhorn shales, with hard streaks at 250, 680, 940, 900, and 1339 feet, that at 250 feet probably representing a portion of the Greenhorn limestone. The Dakota sandstone was entered near the bottom, so the well is supplied by the first flow.

The following is given:

Analysis of water from well at dam site on Owl Creek.

<table>
<thead>
<tr>
<th>Parts per million</th>
<th>Analysis</th>
<th>Parts per million</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids</td>
<td>1,087</td>
<td>Calcium (Ca)</td>
<td>295</td>
</tr>
<tr>
<td>Sodium and potassium (Na+K)</td>
<td>755</td>
<td>Magnesium (Mg)</td>
<td>6</td>
</tr>
<tr>
<td>Oxides of iron and aluminium (Fe3O4 + A12O3)</td>
<td>1.8</td>
<td>Sulphate radicle</td>
<td>0.034</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.001</td>
<td>Chloride (Cl)</td>
<td>80</td>
</tr>
<tr>
<td>Magnesium carbonate</td>
<td>0.001</td>
<td>Sulfate radicle</td>
<td>0.044</td>
</tr>
<tr>
<td>Sodium carbonate</td>
<td>0.001</td>
<td>Carbonate radicle</td>
<td>0.001</td>
</tr>
<tr>
<td>Total carbonates</td>
<td>0.001</td>
<td>Nitrite radicle</td>
<td>0.001</td>
</tr>
<tr>
<td>Total carbonates</td>
<td>0.001</td>
<td>Total hardness</td>
<td>0.86</td>
</tr>
</tbody>
</table>

Orman well—The Orman well is in the SE. 1/4 SW. 1/4, T. 9 N., R. 4 E., at the south end of the Owl Creek dam. It was completed on October 16th. The diameter of the well is 5 inches and the depth 1417 feet. The water-bearing bed was entered at a depth of 1225 feet and is a very coarse sandstone 40 feet thick. The flow at an altitude of 1907 feet, or 18 feet above the ground, is 50 gallons a minute, and 36 feet higher it is 22 gallons. The temperature of the water is 74°. Another well 6 inches in diameter is now being drilled on ground 45 feet higher a few rods farther south, and in May, 1907, it had reached a depth of 1200 feet. An analysis of the water from the 6-inch well by W. A. Converse is as follows:

Analysis of water from well on Orman.

<table>
<thead>
<tr>
<th>Parts per million</th>
<th>Analysis</th>
<th>Parts per million</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids</td>
<td>1,000</td>
<td>Calcium (Ca)</td>
<td>205</td>
</tr>
<tr>
<td>Sodium and potassium (Na+K)</td>
<td>750</td>
<td>Magnesium (Mg)</td>
<td>6</td>
</tr>
<tr>
<td>Oxides of iron and aluminium (Fe3O4 + A12O3)</td>
<td>1.8</td>
<td>Sulphate radicle</td>
<td>0.034</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>0.001</td>
<td>Chloride (Cl)</td>
<td>80</td>
</tr>
<tr>
<td>Magnesium carbonate</td>
<td>0.001</td>
<td>Sulfate radicle</td>
<td>0.044</td>
</tr>
<tr>
<td>Sodium carbonate</td>
<td>0.001</td>
<td>Carbonate radicle</td>
<td>0.001</td>
</tr>
<tr>
<td>Total carbonates</td>
<td>0.001</td>
<td>Total hardness</td>
<td>0.86</td>
</tr>
</tbody>
</table>

The well at the intake of the diversion canal is on the north bank of Belle Fourche River, in the SW. 1/4, T. 9 N., R. 2 E. It is 627 feet deep and 2 inches in diameter, and obtains its supply from a depth of 625 feet. A first flow was obtained at a depth of 625 feet. The boring was in Carlile shale.

The well at the Ross ranch, however, indicates that the head is less than 3200 feet. The flow at Brant's road ranch, in the Owl Creek valley north of Belle Fourche, indicates that in that vicinity the water will rise to an altitude of more than 3000 feet. Unfortunately the pressure of this well was not ascertained, so that the maximum altitude of head cannot be calculated. Flowing with a short distance south of the southeast corner of the quadrangle afforded data for determining the altitude of head in that direction, and the flowing 2 miles south of St. Onge aided confirmatory evidence to the belief that flows may be obtained up to the base of the hogback range. Doubtless also the flow area will be found to extend up some of the valleys part way across the hogback ranges, to the line along which the base of the Dakota sandstone passes underground. It is probable that artesian flows may be obtained from the upper part of the Minnelaxis sandstone in the Red Valley area and adjoining slopes, as explained in a previous paragraph.

April, 1907.

Generalized section for the Belle Fourche quadrangle.