DESCRIPTION OF THE DEVILS TOWER QUADRANGLE.

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

GEOGRAPHY.

Position and extent.—The Devils Tower quadrangle embraces the quarter of a degree in width which lies between the parallels 44° 30' and 45° 30' north latitude and the meridians 106° 30' and 107° west longitude. It measures approximately 341 miles from north to south and 25 miles from east to west, and its area is very nearly 650 square miles. It comprises a portion of the northeastern part of Crook County, Wyo., its northern limit is the Wyoming-Montana state line. The southestern two-thirds of the quadrangle lie on the northeastern extension of the Black Hills uplift and its northwestern portion extends onto the Great Plains. It embraces a portion of the Belle Fourche and Little Missouri valleys, including the head of the latter. Being a part of the Black Hills and the Great Plains province, the Devils Tower quadrangle exhibits many features of both, and a general account of these provinces will be given before the detailed description of the quadrangle is presented.

GREAT PLAINS province.

General features.—The Great Plains province is that part of the continental slope which extends from the eastern foot of the Rocky Mountains to about 1000 feet above sea level. It occupies the valley of the Missouri, extending from near the north end of the Laramie Mountains into deep canyons with precipitous walls of limestone plateau, extending southward, swings around to the eastern side of the hills, where, having abundant rainfall, it attains altitudes of slightly more than 7000 feet, in the southeast corner of the quadrangle and 3640 feet at the eastern limit.

The general features of the Great Plains are the red beds of the Spearfish formation. The region is divided into two main parts: one, the high ridges and mountains of the adjacent Rocky Mountains, the other, the plains, the latter capped by masses of Lakota or Pierre sandstone and gravel, the former by the yellow anteclise of the great uplift. The western section is more extensive than its eastern, and is broad interrupted by many local breaks due to the cutting of small streams. On the top of the plains rise the Missouri Buttes—a mass of igneous rock, forming a small group of prominent summits, of which the highest reaches an altitude of 3572 feet. The most notable feature in the region is Devils Tower, which rises on one of the ridges west of Belle Fourche River. It has a toweike form (see fig. 1 and 2), nearly circular, and is about 100 feet in diameter at the top. Its sides are nearly vertical and it attains an altitude of 5117 feet, or about 900 feet above the plateau platform from which it rises. In height above the river a short distance from its base is a little less than 1200 feet.

Features pertaining to the Great Plains.—The southwestern upland of the uppermost sandstones of the Black Hills series carries them beneath soft slopes, and in the southwestern third of the quadrangle there is a wide area underlain by soft rocks containing characteristic topography of the Great Plains. The valleys are wide and most of the slopes are gentle or null. Here and there a broad plateau stands out with a few scattered hills on its very flat top, but it is an insignificant feature as compared with the higher ridges and mountains of the adjacent Black Hills. The elevation of the plains portion of the Devils Tower quadrangle ranges from 3500 to 4600 feet in greater part, with a general downward slope to the north and east. The principal stream is Little Missouri River, which rises in the southwestern corner of the quadrangle and flows northward for the first 15 miles and then northwestern, its course being closely parallel in the strike of the rocks. In volcanic rocks of the plateau the upper course of the river is often interrupted by many local breaks due to the cutting of small streams. On the top of the plains rise the Missouri Buttes—a mass of igneous rock, forming a small group of prominent summits, of which the highest reaches an altitude of 3572 feet. The most notable feature in the region is Devils Tower, which rises on one of the ridges west of Belle Fourche River. It has a toweike form (see fig. 1 and 2), nearly circular, and is about 100 feet in diameter at the top. Its sides are nearly vertical and it attains an altitude of 5117 feet, or about 900 feet above the plateau platform from which it rises. In height above the river a short distance from its base is a little less than 1200 feet.

Features pertaining to the Great Plains.—The southwestern upland of the uppermost sandstones of the Black Hills series carries them beneath soft slopes, and in the southwestern third of the quadrangle there is a wide area underlain by soft rocks containing characteristic topography of the Great Plains. The valleys are wide and most of the slopes are gentle or null. Here and there a broad plateau stands out with a few scattered hills on its very flat top, but it is an insignificant feature as compared with the higher ridges and mountains of the adjacent Black Hills. The elevation of the plains portion of the Devils Tower quadrangle ranges from 3500 to 4600 feet in greater part, with a general downward slope to the north and east. The principal stream is Little Missouri River, which rises in the southwestern corner of the quadrangle and flows northward for the first 15 miles and then northwestern, its course being closely parallel in the strike of the rocks. In volcanic rocks of the plateau the upper course of the river is often interrupted by many local breaks due to the cutting of small streams.
Devils Tower. The thickness of the Spearfish formation here is approximately 200 feet. In the disturbed area near the head of Lytle Creek, in the southeastern portion of the quadrangle, the thickness of the exposed beds is apparently greater than at the mouth of Barlow Canyon, but the vestiges of the dips and the warped condition of the area prevent accurate determination. Between Hellit and Devils Tower the formation outcrops extensively in steps, but there are cliffs where the formation is cut by the river or is protected by the mass of the mountains. The Sundance formation. Along the smaller valleys the exposures are for the most part in steep canyon walls, the heightened color of which is in striking contrast to the somber tint of the Sundance formation seen above.

The formation consists largely of a mixture of fine clay and sand in somewhat variable proportions, but the sand is in few places, if anywhere, in sufficient amount to give the rock the nature of a sandstone. At many horizons fresh surfaces show an indurated character sufficient to indicate preconcentrated development. The color of the beds varies between light pink and red, the exact shade depending in fresh exposures. Here and there green laminae are observed, but these have not been commonly found, and are in few places more than an inch or two thick. Several thin beds of gypsum, most of them less than 2 feet thick, occur in the formation, interbedded with soft shales. Gypsum of secondary deposition occurs in this area and smaller veins. The line of division between the Spearfish and overlying Sundance beds is distinct, owing to the great difference in age, but there is no marked evidence of erosional unconformity between them, although they are separated by a long hiatus.

The formation is nearly horizontal in much of the outcrop area, but there is a prevailing dip to the north-northeast. The most striking feature is a ridge, occurring in the southeastern part of the quadrangle, at an altitude of more than 5000 feet, due to uplift by the igneous intrusions of the central Bear Lodge area. The lowest exposure is on Black Creek at the eastern edge of the quadrangle, at 3000 feet above sea level. Throughout the greater part of the outcrop area along Belle Fourche River the formation preserves a gently inclined level, reaching in general a height of about 4000 feet. It passes beneath the Sundance formation and the alluvium of the river bottoms at a point about 2 miles from the southern limit of the quadrangle. There is but little contact between the Spearfish and Sundance formations, the formation, and the following section, made on the southeastern side of the base of Devil's Tower, is representative.

Sections of Spearfish formation on Belle Fourche River at base of Devil's Tower.

Red shale, strongly cemented.
Gypsum, 1 to 3 feet thick, with thin red shale interbeds.
Red shale, nodular and sandy in upper part...
Massive and nearly cemented bed of red shale...
Very soft, thin, red shale...
Soft, red shale with some arenaceous layers....
Massive red sandstone layer...
Very soft, thick, red shale, slightly green near top...
Very soft, thin, red shale, slightly arenaceous layers...
Massive red sandstone...
Arenaceous red sandstone, bleached to nodular...
Very soft, thin red shale...
This arenaceous red shale...
Very soft, thin red shale...
Very soft, red shale with some arenaceous layers...
Massive red sandstone layer...
Very soft, thin red shale...
Massive red sandstone...
Arenaceous red sandstone, bleached to nodular...
Very soft, thin, red shale...
This arenaceous red shale...

Age—Throughout the Black Hills uplift the Spearfish deposits are distinctly separated from the Permian (Morrison) shales below by an abrupt change of material. No fossils have been discovered in the Spearfish formation, and its precise age is unknown. From the fact that it lies between supposed Permian and Triassic, it is probable that the Triassic age enjoyed by both the Spearfish and the underlying Sundance formations represents all of earlier Jurassic and probably part at least of Triassic time.

JURASSIC SYSTEM.

SUNDAE FORMATION.

General relations. — The Sundance formation is exposed in a wide area in the southeastern portion of the quadrangle. The upper and middle beds are characterized by gently sloping hillsides and broadly undulating or flat surfaces. A heavy massive sandstone in the lower beds gives rise to striking contrast to the somber tint of the Sundance formation.

In the disturbed area near the head of Lytle Creek, in the southeastern portion of the quadrangle, the thickness of the exposed beds is approximately 200 feet. The unconsolidated nature of the ground prevents accurate determination.

The shales which so greatly predominate in the Sundance formation are characterized by gently sloping hillsides and in many places very fossiliferous, occurring abundantly in the upper portion of the formation.

The greatest thickness observed is 40 feet, midway between Devils Tower and the Missouri Buttes. The thickness of individual beds, however, is not everywhere practicable to determine the nature of the rocks from the weathered surface. The thicknesses vary from a few inches to 10 feet, but mostly from 5 to 6 feet, and the beds are from 5 to 40 feet or more apart. Most of them are highly fossiliferous, especially in the upper portion of the formation, but some fossiliferous layers occur through the Sundance formation.

The Sundance formation is yellowish and probably represents the upper part of the Morrison system. It is characterized by gently undulating or flat surfaces, and is also the weathered individual fossils, particularly Belemnites, which is in places very abundant. Locally this fossil occurs in profusion among the fossils of the massive, sparingly fossiliferous quartzitic sandstone.

The greatest thickness observed is 40 feet, midway between Devils Tower and the Missouri Buttes. The thicknesses vary from a few inches to 10 feet, but mostly from 5 to 6 feet, and the beds are from 5 to 40 feet or more apart. Most of them are highly fossiliferous, especially in the upper portion of the formation, but some fossiliferous layers occur through the Sundance formation.

The Sundance formation is yellowish and probably represents the upper part of the Morrison system. It is characterized by gently undulating or flat surfaces, and is also the weathered individual fossils, particularly Belemnites, which is in places very abundant. Locally this fossil occurs in profusion among the fossils of the massive, sparingly fossiliferous quartzitic sandstone.

The greatest thickness observed is 40 feet, midway between Devils Tower and the Missouri Buttes. The thicknesses vary from a few inches to 10 feet, but mostly from 5 to 6 feet, and the beds are from 5 to 40 feet or more apart. Most of them are highly fossiliferous, especially in the upper portion of the formation, but some fossiliferous layers occur through the Sundance formation.

The Sundance formation is yellowish and probably represents the upper part of the Morrison system. It is characterized by gently undulating or flat surfaces, and is also the weathered individual fossils, particularly Belemnites, which is in places very abundant. Locally this fossil occurs in profusion among the fossils of the massive, sparingly fossiliferous quartzitic sandstone.

The greatest thickness observed is 40 feet, midway between Devils Tower and the Missouri Buttes. The thicknesses vary from a few inches to 10 feet, but mostly from 5 to 6 feet, and the beds are from 5 to 40 feet or more apart. Most of them are highly fossiliferous, especially in the upper portion of the formation, but some fossiliferous layers occur through the Sundance formation.
Fossils and age.—The Morrison shale contains many large bones, and in other areas it has yielded a variety of vertebrate fossils, constituting in many cases a nearly complete series of dinosaurs, some of which are of huge size, and of primitive forms of small mammals. This fauna, which is often called the Judasaurus fauna, is thought by some paleontologists to be of early Cretaceous age, and by others somewhat older. This fauna is usually referred to the Jurassic. The invertebrate fossils are all fresh-water forms which furnish no positive evidence as to age.

Local sections.—The following sections illustrate a variety of representative exposures.

Section of Morroin formation on north side of South Creek, 8 miles north of Belle Fourche.

<table>
<thead>
<tr>
<th>Formation</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black shale</td>
<td>12 feet</td>
</tr>
<tr>
<td>Gray shales</td>
<td>30 feet</td>
</tr>
<tr>
<td>Green shales</td>
<td>20 feet</td>
</tr>
<tr>
<td>Purple shales</td>
<td>10 feet</td>
</tr>
<tr>
<td>Massive sandstone</td>
<td>30 feet</td>
</tr>
</tbody>
</table>

Fossil flora.—The shales of the Morrison formation contain many large bones, and in other areas it has yielded a variety of vertebrate fossils, constituting in many cases a nearly complete series of dinosaurs, some of which are of huge size, and of primitive forms of small mammals. This fauna, which is often called the Judasaurus fauna, is thought by some paleontologists to be of early Cretaceous age, and by others somewhat older. This fauna is usually referred to the Jurassic. The invertebrate fossils are all fresh-water forms which furnish no positive evidence as to age.
The next section was measured in a mile east of the present line on the west side of the canyon.

**Section of Dakota sandstone in Big Horn Canyon.**

**Conormal shales.**

*Massive sandstone, slightly slaty at bottom.*

*Massive sandstone with iron-oxide and slime concretions.*

**Massive sandstone.**

*Fine gray sandstone with iron-oxide and slime concretions.*

**Massive sandstone, lying on Prismo formation.*

The following section is on the north side of Bighorn Hollow, near the head:

**Section of Dakota sandstone in Bighorn Hollow.**

*Soft muddy clay.*

*Massive yellowish gray sandstone.*

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone with vinegar concretions.*

*Platy gray sandstone.*

*Shaly sandstone.*

*Tuff.*

*Massive sandstone.*

*Massive sandstone, lying on Prismo formation.*

The following section is near the mouth of Government Canyon, 8 miles above the mouth of the creek and 3 miles west of the eastern edge of the quadrangle.

**Section of Dakota sandstone near mouth of Government Canyon.**

*Platy gray sandstone at top of formation.*

*Massive sandstone.*

*Dark sandy shales.*

*Iron-oxidation bands.*

*Ropy gray shales.*

*Shaly sandstone.*

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone with vinegar concretions.*

**Massive sandstone with iron-oxide and slime concretions.**

*Shaly sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone, lying on Prismo formation.*

**Shales and sandstones:**

*Massive sandstone, lying on Prismo formation.*

**Flaggy and sandy shales:**

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone, lying on Prismo formation.*

**Limestones and shales:**

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone, lying on Prismo formation.*

**Flaggy and sandy shales:**

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone, lying on Prismo formation.*

**Limestones and shales:**

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone.*

*Massive sandstone with iron-oxide and slime concretions.*

*Massive sandstone, lying on Prismo formation.*

**Flaggy and sandy shales**

Inoceramus labiatus. Inoceramus labiatus occurs west of the main peak of the Missouri Buttes, where the formation is thickest near the top of the Missouri Valley. In the southern half of the quadrangle, as measured between Prickly Pear and Battle creeks, the limits are somewhat indistinct. The accompanying section, as measured between Prickly Pear and Battle creeks, amounts to 78 feet. The thickness midway between Mud and Driscoll creeks is 60 feet. The outcrop of the formation occupies a narrow south-north zone that extends across the western part of the quadrangle, in the northwest corner being deflected somewhat toward the northwest.

**Fossils and age.** In this region the Dakota has yielded very few fossil remains, but in other portions of the Black Hills it has been found containing remains of distinctively shaped plants of late Cretaceous age.

**Graneros shale.**

**Composition.** The Graneros formation in this quadrangle consists of four distinct members—the lower black shale, a massive sandstone, the Mowry beds, and the upper shales—the total thickness being about 1320 feet. These divisions are clearly defined lithologically and widely exposed. They are also distinct topographically, the massive sandstone and the overlying Mowry beds rising in ridges of moderate prominence from valleys of the adjoining shales. The massive sandstone is apparently identically exposed along the west side of the Buttes of Black Hawk, but it is confined to the west slope of the Missouri Valley. In the southern half of the quadrangle, as measured between Prickly Pear and Battle creeks, the thickness is about 300 feet thick, and is nearly all shale; few concretions are present and these occur at indefinite horizons. The upper division is not thickest, but it is distinguished from the intermediate by the concretions and shales, the concretions being of considerable size. It is not possible to account for the concretions being observed. The middle division much

<table>
<thead>
<tr>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massive black shale</td>
<td>4</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>38</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>40</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>22</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>8</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>8</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>36</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>10</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Primo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
<tr>
<td>Massive black shale, lying on Prismo formation</td>
<td>16</td>
</tr>
</tbody>
</table>
| Massive black shale, lying on Prismo forma
resembles the Greenhorn formation, but lacks the distinctive *Eosurus*. A section measured between Mud and Devils creek is as follows:

_Section of Carlii shale near Mud Creek._

- Fine light-gray shale...
- Yellow and dark-gray shale...
- Grayish-yellow shale... (with a few inches of white porous clay...)
- Fine black shale... (with a few quartz concretions... 1 foot in diameter.)

_Large quartz concretions in black shale; a few feet in the same._

_Poorly bedded black shale with a few small concretions._

_Br)

**Correlation.**—This formation is overlain by the Carlii shale of other portions of the Black Hills uplift by its facies, especially *Prionosaurus* nodosus.

**FOX HILLS SANDSTONE.**

The outcrop of the Niobrara formation lies next west of that of the Carlii shale, extending north and south in a narrow zone across the western portion of the quadrangle. In general this limestone, which appears to be between Mud and Devils... is as follows:

_In the numerous concretions which occur in the Niobrara at various horizons there are in many a few of small extent occur near and east of the Belle Fourche._

_Mass of igneous rock known as Devils Tower is one of the most conspicuous and notable features in the Black Hills province._

**QUATERNARY SYSTEM.**

_Terrace deposits._—High terrace deposits, products of another drainage system, are present in many places in the quadrangle. Their thickness is nowhere great and in some cases the deposits consist of isolated boulders and pebbles scattered among the stream gravels. A number of areas is shown on the geologic map, but these do not fully represent the extent of the deposits. Many of the northwest corner of the quadrangle are intersected by several masses of small area. Between the two occur scattered flanges of talus, remnants of a connection which existed between the deposits at a dis tant time.

**Correlation.**—No fossils were found in the Tertiary deposits; and there is no basis for correlating the two in the adjacent gullies.

_Claystone structures and sediments._—The great columns of the Niobrara are mostly protopod in shape, but some are fluted or sided. The average diameter is 6 feet and in general the columns taper slightly toward the top. In places several columns unite in their upper portion to form a large fluted column. The columns are not perpendicular, but slope toward the top, often 4° to 5° on the west side and 10° to 15° on the east side. They are not much jointed, but are marked horizontally by fine ridges or swells, which give the rock a somewhat wavy appearance. This is especially pronounced near the top of the tower. The upper 20 feet or so of the tower are covered with talus, consisting of boulders and blocks of varying size and shape. A number of large boulders and blocks of various sizes are scattered over the surface. A number of areas is shown on the geologic map, but these do not fully represent the extent of the deposits. Many of the northwest corner of the quadrangle are intersected by several masses of small area. Between the two occur scattered flanges of talus, remnants of a connection which existed between the deposits at a dis tant time.

**Correlation.**—No fossils were found in the Tertiary deposits, and there is no basis for correlating the two in the adjacent gullies.

**Fossiliferous deposits._—The Tertiary is represented by small outcrops in the southwestern and southeast corner of the quadrangle.**

_Terrace deposits._—High terrace deposits, products of another drainage system, are present in many places in the quadrangle. Their thickness is nowhere great and in some cases the deposits consist of isolated boulders and pebbles scattered among the stream gravels. A number of areas is shown on the geologic map, but these do not fully represent the extent of the deposits. Many of the northwest corner of the quadrangle are intersected by several masses of small area. Between the two occur scattered flanges of talus, remnants of a connection which existed between the deposits at a dis tant time.

**Correlation.**—No fossils were found in the Tertiary deposits; and there is no basis for correlating the two in the adjacent gullies.
lith has been eroded, but the original [term] and extent can only be conjectured. There is no evidence that the vent is under the tower or the talus, for the most of the material is agglutinate. The distinctive feature of the cone is the presence of a lenticular extending from the Missouri Buttes, but the exposure is too limited to make an accurate estimate of the amount of erosion and numerous overliths.

* Petrographic description.*—The rock from Devils Tower has been described by Pearsall (Am. Jour. Sci., 3d ser., vol. 47, 1898, pp. 341–344) as a sodic-basalt with a mafic groundmass. The rock from the Missouri Buttes, but columns appear at some of the talus. According to T. A. Jaggar, jr., elsewhere in the vicinity, although it may underlie the buttes.

The rock has a very fine aphanitic groundmass, full of small lath-shaped white feldspar phenocrysts from the texture is seen to be porphyritic, the phenocrysts comprising anorthoclase, augite, and oligoclase-augite, locally with anorthoclase or oligoclase as a minor constituent. The texture is very fine in grains and is in high relief. The rock is composed mainly of alkali-feldspar laths, together with more or less segirite or segirite-augite, or both, and a small amount of magnetite, and here and there a little spathoid. As a rule, only one feldspar is noted, most commonly a generation of the one occurring among the phenocrysts. Spathoid occurs in the groundmass of some of the rock, being locally abundant, in clots, columellar, and septarian forms.

**Lycette.**—On one of the spurs of the ridge of Lycette sandstone in the northeast corner of T. 53 N., R. 64 E., the Missouri shale is traversed by three narrow parallel ridges of lycette sandstone. These lycettes are of a beautiful yellow color, in general with a slight greenish tinge. It is a porphyritic, containing coarse tabular feldspar crystals, many of which have a length of 3 cm. as a lower form (or perhaps soda orthoclase), the phenocrysts comprise anorthoclase, augite, and oligoclase-augite, locally with anorthoclase or oligoclase as a minor constituent. The texture is very fine in grains and is in high relief. The rock is composed mainly of alkali-feldspar laths, together with more or less segirite or segirite-augite, or both, and a small amount of magnetite, and here and there a little spathoid. As a rule, only one feldspar is noted, most commonly a generation of the one occurring among the phenocrysts. Spathoid occurs in the groundmass of some of the rock, being locally abundant, in clots, columellar, and septarian forms.

**Lycette.**—On one of the spurs of the ridge of Lycette sandstone in the northeast corner of T. 53 N., R. 64 E., the Missouri shale is traversed by three narrow parallel ridges of lycette sandstone. These lycettes are of a beautiful yellow color, in general with a slight greenish tinge. It is a porphyritic, containing coarse tabular feldspar crystals, many of which have a length of 3 cm. as a lower form (or perhaps soda orthoclase), the phenocrysts comprise anorthoclase, augite, and oligoclase-augite, locally with anorthoclase or oligoclase as a minor constituent. The texture is very fine in grains and is in high relief. The rock is composed mainly of alkali-feldspar laths, together with more or less segirite or segirite-augite, or both, and a small amount of magnetite, and here and there a little spathoid. As a rule, only one feldspar is noted, most commonly a generation of the one occurring among the phenocrysts. Spathoid occurs in the groundmass of some of the rock, being locally abundant, in clots, columellar, and septarian forms.

**Lycette.**—On one of the spurs of the ridge of Lycette sandstone in the northeast corner of T. 53 N., R. 64 E., the Missouri shale is traversed by three narrow parallel ridges of lycette sandstone. These lycettes are of a beautiful yellow color, in general with a slight greenish tinge. It is a porphyritic, containing coarse tabular feldspar crystals, many of which have a length of 3 cm. as a lower form (or perhaps soda orthoclase), the phenocrysts comprise anorthoclase, augite, and oligoclase-augite, locally with anorthoclase or oligoclase as a minor constituent. The texture is very fine in grains and is in high relief. The rock is composed mainly of alkali-feldspar laths, together with more or less segirite or segirite-augite, or both, and a small amount of magnetite, and here and there a little spathoid. As a rule, only one feldspar is noted, most commonly a generation of the one occurring among the phenocrysts. Spathoid occurs in the groundmass of some of the rock, being locally abundant, in clots, columellar, and septarian forms.

**Lycette.**—On one of the spurs of the ridge of Lycette sandstone in the northeast corner of T. 53 N., R. 64 E., the Missouri shale is traversed by three narrow parallel ridges of lycette sandstone. These lycettes are of a beautiful yellow color, in general with a slight greenish tinge. It is a porphyritic, containing coarse tabular feldspar crystals, many of which have a length of 3 cm. as a lower form (or perhaps soda orthoclase), the phenocrysts comprise anorthoclase, augite, and oligoclase-augite, locally with anorthoclase or oligoclase as a minor constituent. The texture is very fine in grains and is in high relief. The rock is composed mainly of alkali-feldspar laths, together with more or less segirite or segirite-augite, or both, and a small amount of magnetite, and here and there a little spathoid. As a rule, only one feldspar is noted, most commonly a generation of the one occurring among the phenocrysts. Spathoid occurs in the groundmass of some of the rock, being locally abundant, in clots, columellar, and septarian forms.
of the main uplift there is a south, and run out with declining pitch to the south.

The igneous masses have dislocated the strata and the monoclinal structure, consisting mainly of the Ordovician beds. The only portion of the northwestern margin of the Black Hills uplift, with rocks dipping to the west and southeast. There are several local irregularities in the region east of Little Missouri River give place farther south, it increases to 60°. Midway between Thompson Creek, on the Little Missouri, and the western portion of this ridge, the land surface of crystalline rocks was buried beneath the sediments. Formations of early Carboniferous time there were laid down in thin layers, to a thickness now represented by the shales that occur in the upper portion of the Spearfish formation. Saurian deposition is believed to have been followed by extensive uplift, without local structural deformation, but with some peneplanation and occasional channeling, which presents a portion of Triassic-Jurassic time of unknown duration. It was succeeded by the deposition of later Jurassic sediments.

During the Creataceous period deposits of various kinds, but generally uniform in character, were laid down over wide areas, gathered in a great series, beginning with such as are characterized of shallow seas and estuaries along a coastal plain, passing into deposits from fresh-water lakes, and changing toward the end to fresh-water sands and clays with marsh vegetation. The earliest of these deposits, the Belle Fourche Valley, is believed to be of Jurassic epoch, constitutes the Morrison formation, a widespread mantle of sandstone and shale, which probably originally lay deposited in a greater or less thickness and then removed by erosion in consequence of the uplift which initiated the next epoch. The extent of this degradation is not known, but it has given rise to a general eustatic unconformity at the base of the Morrison sandstone, the next succeeding deposit. The material of this formation consists mostly of coarse sands spread by strong currents in beds 50 to 40 feet thick, but includes several thin layers of clay and local accumulations of vegetable matter. Next there was deposited a thin colorless series, represented by the Minnewaska limestones, and it was laid down only in a local basin in the eastern portion of the Black Hills area, but thinner or absent elsewhere.

Cretaceous era—During the Cretaceous period deposits of various kinds, but generally uniform in character, were laid down over wide areas, gathered in a great series, beginning with such as are characterized of shallow seas and estuaries along a coastal plain, passing into deposits from fresh-water lakes, and changing toward the end to fresh-water sands and clays with marsh vegetation. The earliest of these deposits, the Belle Fourche Valley, is believed to be of Jurassic epoch, constitutes the Morrison formation, a widespread mantle of sandstone and shale, which probably originally lay deposited in a greater or less thickness and then removed by erosion in consequence of the uplift which initiated the next epoch. The extent of this degradation is not known, but it has given rise to a general eustatic unconformity at the base of the Morrison sandstone, the next succeeding deposit. The material of this formation consists mostly of coarse sands spread by strong currents in beds 50 to 40 feet thick, but includes several thin layers of clay and local accumulations of vegetable matter. Next there was deposited a thin colorless series, represented by the Minnewaska limestones, and it was laid down only in a local basin in the eastern portion of the Black Hills area, but thinner or absent elsewhere.

Cretaceous era—During the Cretaceous period deposits of various kinds, but generally uniform in character, were laid down over wide areas, gathered in a great series, beginning with such as are characterized of shallow seas and estuaries along a coastal plain, passing into deposits from fresh-water lakes, and changing toward the end to fresh-water sands and clays with marsh vegetation. The earliest of these deposits, the Belle Fourche Valley, is believed to be of Jurassic epoch, constitutes the Morrison formation, a widespread mantle of sandstone and shale, which probably originally lay deposited in a greater or less thickness and then removed by erosion in consequence of the uplift which initiated the next epoch. The extent of this degradation is not known, but it has given rise to a general eustatic unconformity at the base of the Morrison sandstone, the next succeeding deposit. The material of this formation consists mostly of coarse sands spread by strong currents in beds 50 to 40 feet thick, but includes several thin layers of clay and local accumulations of vegetable matter. Next there was deposited a thin colorless series, represented by the Minnewaska limestones, and it was laid down only in a local basin in the eastern portion of the Black Hills area, but thinner or absent elsewhere.

Cretaceous era—During the Cretaceous period deposits of various kinds, but generally uniform in character, were laid down over wide areas, gathered in a great series, beginning with such as are characterized of shallow seas and estuaries along a coastal plain, passing into deposits from fresh-water lakes, and changing toward the end to fresh-water sands and clays with marsh vegetation. The earliest of these deposits, the Belle Fourche Valley, is believed to be of Jurassic epoch, constitutes the Morrison formation, a widespread mantle of sandstone and shale, which probably originally lay deposited in a greater or less thickness and then removed by erosion in consequence of the uplift which initiated the next epoch. The extent of this degradation is not known, but it has given rise to a general eustatic unconformity at the base of the Morrison sandstone, the next succeeding deposit. The material of this formation consists mostly of coarse sands spread by strong currents in beds 50 to 40 feet thick, but includes several thin layers of clay and local accumulations of vegetable matter. Next there was deposited a thin colorless series, represented by the Minnewaska limestones, and it was laid down only in a local basin in the eastern portion of the Black Hills area, but thinner or absent elsewhere.
is not definitely known, but it is possible that they
of the Niobrara formation, and this in turn
sediments. The clay of Benton time was followed
in the east and southeast there are no early Eocene
Hills dome developed early in Tertiary time or
any of the area now occupied by the Black Hills
was laid down by streams and in local lakes
Basin.

Prior to the Oligocene, the area now occupied by the Black Hills
was slow but continuous. Some of the material that was contributed
up north at the outcrop and the overlying
coal is present. Moreover, coal often crumbles or
is seldom possible to ascertain whether or not
formations can be seen in association with coal, but there is not
sufficiently carbonaceous to burn for a few minutes.
The Lakota formation, but no coal has been observed
lakota and Dakota sandstones, but they have not as yet been utilized to any great
stock is in the Graneros, and overlying formations can
be used for rough work. Portions of the Dakota
a deep soil. If the calcareous cement is present in
a dry weather the only branches from it are small streams. The flow in the river is sustained
by springs which rise at intervals along its bed.

Quaternary uplift and erosion. — During the
early part of the Quaternary period there was widespread denudation of the plateau, and many of the old valleys were, with
much rearrangement of the drainage, which on the
western side of the Black Hills was caused by mainly increased tilting to the northeast. This
resulted in the formation of the immediate vicinity of the hills which has not been scrutinized.

Modern streams. — Several thin beds of gypsum are present near the
roof of the Sparfields formation, but their thickness in two places exceeds 3 feet and they are interbed-
ded with siltstone and silt. Placer gold is prepared from gypsum by calcining it to drive off part of the chemically combined water, and then pulverizing
it. The material is of no value, however, unless near to a mill.

Gypsum. — The area now occupied by the Black Hills is generally
level, and the streams run north to south, except near the
foot of the hills, where they turn to the east and southeast. The
amount of water varies from about 2 to 15 second-feet,
and in the higher mountains it may be less. Evaporation in the region is about 6 feet each
year, so that there is a great need for irrigation. The
Bear Lodge Mountains, which extend to a
high altitude, catch many showers that do not
fall on the adjacent plains and have also a greatly increased snowfall. At this season, the
lowest temperature recorded has been over 100 degrees F. and the snow remains on the ground until
late in the summer, and is not removed until the
next spring, except in the higher mountains.

distribution. — The arable lands of the Devil's Tower quadrangle are irregularly distributed and
occur in several formations. The most extensive areas available for farms are in the alluvial deposits
during the Pleistocene and Belle Fourche river valleys. These are also available for farms, and are
of high quality, and can be saved by dams and made available for irriga-
tion. There are many excellent dam sites along the creeks flowing into the Belle Fourche, but, to judge by the results obtained with small dams in the plains
region farther southeast, more or less water can be held in almost all portions of the area.

Belle Fourche River carries a large volume of water at times of flood, but it is a very insignificant
stream during the dry periods of midsummer. Its normal flow varies from about 2 to 15 second-feet,
so far as observed, and occasionally portions of its course are covered by sand dunes. This river
is large. Its course is winding, and although there are alluvial flats within most of its bends, there
are many excellent dam sites along the creeks flowing into the Belle Fourche, but, to judge by the results obtained with small dams in the plains
region farther southeast, more or less water can be held in almost all portions of the area.

The Bear Lodge Mountains, which extend to a
high altitude, catch many showers that do not
fall on the adjacent plains and have also a greatly increased snowfall. At this season, the
lowest temperature recorded has been over 100 degrees F. and the snow remains on the ground until
late in the summer, and is not removed until the
next spring, except in the higher mountains.

Distribution. — The arable lands of the Devil's Tower quadrangle are irregularly distributed and
occur in several formations. The most extensive areas available for farms are in the alluvial deposits
during the Pleistocene and Belle Fourche river valleys. These are also available for farms, and are
of high quality, and can be saved by dams and made available for irriga-
tion. There are many excellent dam sites along the creeks flowing into the Belle Fourche, but, to judge by the results obtained with small dams in the plains
region farther southeast, more or less water can be held in almost all portions of the area.

Belle Fourche River carries a large volume of water at times of flood, but it is a very insignificant
stream during the dry periods of midsummer. Its normal flow varies from about 2 to 15 second-feet,
so far as observed, and occasionally portions of its course are covered by sand dunes. This river
is large. Its course is winding, and although there are alluvial flats within most of its bends, there
are many excellent dam sites along the creeks flowing into the Belle Fourche, but, to judge by the results obtained with small dams in the plains
region farther southeast, more or less water can be held in almost all portions of the area.

Belle Fourche River carries a large volume of water at times of flood, but it is a very insignificant
stream during the dry periods of midsummer. Its normal flow varies from about 2 to 15 second-feet,
so far as observed, and occasionally portions of its course are covered by sand dunes. This river
is large. Its course is winding, and although there are alluvial flats within most of its bends, there
are many excellent dam sites along the creeks flowing into the Belle Fourche, but, to judge by the results obtained with small dams in the plains
region farther southeast, more or less water can be held in almost all portions of the area.

Belle Fourche River carries a large volume of water at times of flood, but it is a very insignificant
stream during the dry periods of midsummer. Its normal flow varies from about 2 to 15 second-feet,
Except Blacktail, Lytle, and Miller creeks, the many small branches flowing into the Belle Fourche are dry in summer or carry only a very small volume of water, mainly in scattered pools. All the ordinary streams in the western and northern portions of the quadrangle have very scanty water supplies, and in dry weather many of them contain no water at all. Thompson Creek is an exception, for ordinarily it carries a small amount of water, mostly in pools with feeble overflow from one to another.

### Underground Waters

**Source.**—Throughout the quadrangle there are prospects of water supplies from wells of greater or lesser depth. The series of formations, as shown in the columnar section, includes several beds of water-bearing sandstone which receive water at the surface in the higher ridges and slopes of the Black Hills. These sandstones are carried underground in the general outward dip on the flanks of the hills, and within a short distance, owing to the relative steepness of the dip, attain considerable depth. In most of the near water-bearing beds at one horizon or another lies a depth that is within reach of the well borer. As the region is arid, with surface waters inadequate or of bad quality in most localities, there is considerable need for underground waters. The principal water-bearing strata rise to the surface on the slopes of the Black Hills in regular succession, as already described. They outcrop in wide zones encircling the uplift, and receive a large amount of water not only from the rainfall on their surface but from streams which at many points sink into them wholly or in part in crossing their outcrops. The sinking of the streams in this manner is observed in almost every valley leading out of the central area. Few of the streams carry into Cheyenne River more than a small portion of the original run-off of their drainage basins, for much of it sinks underground in crossing the sandstones, particularly those of the Minnelusa, Latah, and Dakota formations. The water thus absorbed by the sandstone passes for beneath the surface as the water-bearing beds descend on the slopes of the uplift.

**Dakota-Latoka sandstones.**—The Dakotas and Lakotas sandstones are the principal formations in which water supplies are to be expected in the western and northern, or plains portion, of the Devil’s Tower quadrangle. As shown on the stratum-section sheet, they pass beneath the overlying shales with varying dips that carry them to a depth of about 3,700 feet along the western margin of the quadrangle. The depth to the top of the Dakota sandstone is indicated approximately on the artesian water sheet. In various portions of the country surrounding the Black Hills the Dakota-Lakota sandstones have been penetrated by wells, most of which obtain flows of greater or less volume and of satisfactory quality. The nearest wells to the Devil’s Tower quadrangle are those in the vicinity of the Bear Lodge uplift, this formation lies far below the surface in the western and northern portions of the quadrangle.

**Pahasapa limestone.**—As shown on the structure-section sheet, the Dakota-Latoka sandstones are underlain by the Pahasapa limestone, but, except in the vicinity of the Bear Lodge uplift, this formation lies at great depth. A large supply of water was obtained from it in a deep boring at Cambria, and possibly the water-bearing stratum continues to this region. Its depth in the Belle Fourche Valley ranges from 900 to 1100 feet, but toward the northwest greatly increases, so that the formation lies far below the surface in the western and northern portions of the quadrangle.

**Minnelusa sandstone.**—Below the Pahasapa limestone is a series of shales and sandstones which probably contain a water supply, but in this quadrangle they are too deeply buried beneath the surface to be reached by ordinary boring operations.

### Timber

There is little merchantable timber in the Devils Tower quadrangle but portions of the area contain abundant supplies for firewood and other local use. Scattered pine grow along the slopes of most of the canyons on either side of the Belle Fourche Valley and in moderately large bodies on the higher ridges in the southeastern portion of the Devil’s Tower quadrangle. Along the Belle Fourche there is an almost continuous border of cottonwoods, many of them attaining large size. In the plains region of the western and northern portions of the quadrangle wood is very scarce. The ridge due to the outcrop of the Mowry beds is covered thinly with small pines, but farther west, in the wide shale outcrops, there are no trees, except a cottonwood here and there along the streams.

**January, 1906.**