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The Devonian of the Bear River Range, Utah

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THE DEVONIAN OF THE BEAR RIVER RANGE, UTAH

A DISSERTATION SUBMITTED TO THE GRADUATE FACULTY
IN CANDIDACY FOR THE DEGREE OF MASTER OF SCIENCE.

DEPARTMENT OF GEOLOGY

BY

I. LAVELL COOLEY

LOGAN, UTAH

JULY, 1928.
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With columnar section, graphic sections and photographs
INTRODUCTION

The geological column in northern Utah has had very little detailed study. Those who have made reports on this section have done so only in a very general way, making no detailed sections of any part of the column, excepting that of the Cambrian made by Walcott. Other work has been done by Mansfield in southeastern Idaho and a general section of the Devonian made in Green Canyon, Bear River Range, Utah by Kindle.

Due to the lack of any detailed work of this nature being done in the Bear River Range, suggested the matter of making a section and describing the Devonian System of this range, because, probably less is known of this system than of any other one.

Stratigraphic relations were studied in several sections where outcrops were good. Conditions for the study of these outcrops are very favorable, because, within a very short distance of 6 or 7 miles there are 6 canyons cutting the range at approximately right angles to the general trend of the structure, giving satisfactory sections of the greater part of the Paleozoic Era. Blacksmith Fork Canyon gives the best

1 Smithsonian Miscellaneous Papers # 53.
2 Professional Paper # 152.
3 Bul. Am. Paleontology, vol. 4, No. 20, 1908, pp. 5-24; (a) pp. 10-13; (b) pp. 15-16.
section of the Devonian System in the area studied. Because of easy access and good exposures, this canyon was chosen for a graphic section. Another section was made in Logan Canyon as a matter of comparison.

A - A is a general graphic section of the front ridge of the Bear River Range, showing the structure on the north side of Logan Canyon, situated almost directly east of the city of Logan, Utah. B - B is a general graphic section of the front ridge showing the structure on the north side of Blacksmith Fork Canyon. These graphic sections constitute the general lithological character of that portion of the Paleozoic Era which makes up this part of the Bear River Range. The eastern portion of the range is a faulted anticline and is capped, unconformably, by Tertiary deposits.
PHYSIOGRAPHY

The Bear River Range is a relatively rugged mass with the exception of the eastern portion which constitutes a more or less plateau-like topography. The range is continuous with the Wasatch Range proper, and is really a branch of the northern extremity of that range. Geologically and physiographically that portion of the Wasatch Range from a position in the vicinity of Huntsville, Utah, about latitude 41° 15', and runs in an almost true north-south direction along the east side of Cache Valley and terminates at Sheep Rock just south of the sharp bend of Bear River near Alexander, Idaho, is termed the Bear River Range (Plate I and I-A). The other main branch of the Wasatch which forks off from about the same latitude and runs in the same direction, but borders the west side of Cache Valley, and terminates in a low, rolling topography at the point where Bear River passes through a gorge from Cache Valley on its way to Great Salt Lake, is the Wellsville Range (Plate III.). This range has a very sharp crest line which is almost impassable in places. The east slope of the range is almost a dip slope.

The Bear River Range as described above, has a length of about 95 miles and varies in width from 2 to 22 miles; the maximum width being along the line be-
between Tps 15 and 16 So. in southern Idaho. North of this line it grows narrower and terminates at Sheep Rock. The range consists of two roughly parallel ridges; the more rugged on the west called the Bear River front ridge, the lower plateau-like mass to the east, the Wasatch Range. These ridges merge to the south in the Wasatch Range proper. The Bear River front ridge is formed from a broad, shallow, syncline with the highest portion along the axis of the syncline. The lower plateau-like Wasatch Range to the east is a badly faulted anticline which is in part unconformably overlain with Tertiary conglomerate, sandstone and limestone.

The front ridge takes on a rugged topography with serrate crest line, steep slopes, gorge-like canyons, glaciated valley heads and presents a steep and rugged front toward Cache Valley.

The highest peaks in the range are from north to south; Paris Peak 9,572 feet, Sherman Peak 9,669 feet, in southern Idaho; Naomi Peak 9,980 feet, Logan Peak 9,713 feet, in northern Utah.
STRUCTURE

Over the immediate vicinity of the Bear River Range with which this paper is concerned, the rock outcrops of the Paleozoic are very abundant and well defined. This condition is due partly to the Bear River Range gravity fault and subsequent erosion, which has exposed the strata ranging from Cambrian to Pennsylvanian.

One very interesting feature which comes to the attention of the observer and which arouses his curiosity is the structure of the strata on the west limb of the broad shallow syncline, which makes up the front ridge of the range. The strata have an average dip of 18-20 degrees. At the mouth of Logan and Dry Canyons, the gentle easterly dip of the strata is abruptly changed, being sharply bent to a vertical and partially overturned position, making the Ordovician and Silurian beds occur in a reverse order (Plate IV a and b). Not only is this spectacle of natural architecture of great interest, but associated with it is a zone in which the rocks have lost their original form and are very badly brecciated and fractured. This impressive feature, together with the finer observations of local folding and buckling of the thin-bedded incompetent formations bring a-
bout a conclusion that this area was subject to intense compression, which obviously came before the breaking of the Bear River Range gravity fault. This zone of fracture and folding extends up Logan Canyon approximately 1000 feet.

Another impressive feature of the range is the clean-cut gorges which the major streams have made through the front ridge, exposing on both sides bare rock ledges of which form a great part of the Paleozoic Era. These continuous outcrops, layer upon layer, gently folded to form the broad and shallow syncline, interrupted here and there where local faulting has occurred, reveals to one the great phenomena of mountain building and architecture. Most of the streams in this portion of the Bear River Range have their source in the lower, eastern section and flow west through the higher front ridge at almost right angles to its trend. A considerable amount of up-lifting of the range must have occurred after the streams had their courses pretty well defined. This condition is explained by the entrenched meanders occurring in the left fork of Logan Canyon, in the vicinity of Temple Fork and the superimposed appearance of the front ridge.
STRATIGRAPHY

The systems represented in the Bear River Range show little differentiation lithologically; the rock being predominantly limestone and dolomite, with small amounts of sandstone, shales and quartzite. The Devonian system shows a high degree of lithological differentiation.

The transition from one system to the next throughout the whole range, shows no great physical breaks. There are no observable erosional or structural unconformities and in some cases the change from one system to the next takes place in a limestone series; such an example being the contact between the Mississippian and Pennsylvanian, the break is detected only by fossils.

The contacts between systems have been determined with quite a degree of accuracy, by means of fossils. It is noticed that where these division lines are placed that lithological differences also occur, which can be seen for quite a distance. The contact between the Ordovician and Silurian systems is placed at the top of the Swan Peak quartzite. This formation with its characteristic buff to purple color is a good horizon marker for that division: The contact between the Silurian and Devonian systems is placed between the dark-gray and the
very light-gray dolomite above (Plate VI). A characteristic weathered appearance associates with the lower and upper divisions of the Devonian system; the more massive dolomite of the Silurian and the massive precipitous ledge of the Mississippian is more resistant to weathering and stands out in contrast to the thin-bedded Devonian outcrops, which weather to extensive detrital slopes. The Mississippian and Pennsylvanian outcrops are very massive and weather into precipitous ledges. These two systems cap the highest portion of the range in this immediate area. This precipitous nature is especially noticed in the lower Mississippian formation, the Madison limestone, which in places is three or four hundred feet high. This ledge is locally known as the Chinese Wall (Plate V). It surely does justice to its name because of its marked similarity to that wall, being very uniform in height and very continuous. The reason for this ledge standing out as it does in defiance of the processes of weathering is due, probably, to its massiveness and uniform texture and the large amount of chert which it contains.

Generally speaking, most of the formations making up the range are quite fossiliferous, however, very unequally distributed; being lavish in some formations and very scarce in others. The Mississippian and Penn-
sylvanian systems contain an abundance of **Brachiopods**, **Cup Corals**, **Bryozoans**, **Crynoïdes**, **Blastoids** and other invertebrates. The Devonian system is very meager in fossil remains, with a small **Brachiopod**, small **Gastropods** and **Crynoïd** stems in a very limited horizon and the most important of all, the fish fragments found in the lower member. The Silurian and Ordovician systems contain few fossils which are more or less local. **Halyites**, **Favositès**, and **Syringopora** are the most important fossils contained in the Silurian beds. In the Ordovician the fossils appear mostly in the Upper Ordovician, Swan/ Peak shales and quartzite. **Fucoides** occur in great abundance in the quartzite; **Brachiopods**, **Trilobites** and **Graptolites** appear in the shales.
Devonian System

The Devonian system in the area studies is represented by a single formation, the Jefferson. This formation was studied by Kindle and derives its name from the locality in Montana in which the type section occurs. It is often called the Jefferson limestone, but contains much dolomite and will be called the Jefferson formation in this report.

Location

The description and columnar section of the Jefferson formation was made in Blacksmith Fork Canyon, Logan Quadrangle; section 3 and 4 of township 10 N, section 33 and 34 of township 11 N, range 2 east, Salt Lake Meridian.

Distribution

The dark-gray dolomites and limestones of the Jefferson formation answer the description which Kindle gives of that formation in this locality. He has recently shown that the Jefferson formation of Montana with Devonian fauna, extends southward into the mountains of Utah, and he has traced it along the east side of Cache Valley, in the Bear River range. He has also identified in the same locality a dolomite containing Silurian fossils con-

1. Fauna and Stratigraphy of the Jefferson limestone in the Northern Rocky Mountain region; Bul. Am. Paleontology, bol. 4, No. 20, 1908, pp. 5-24; (a) pp. 10-13; (b) pp. 15-16.
formable beneath the Jefferson formation. This formation as described by Kindle is no doubt the upper Silurian dolomite. It is found that the Jefferson formation outcrops on the west side of Cache Valley in the Wellsville range. Between the identifiable Ordovician quartzite and the Mississippian limestones, a succession of dark limestones, with some gray brittle dolomites having a thickness of about 1500 feet occurs. This formation corresponds satisfactorily with the Jefferson formation in the Bear River range. Extending farther south, however, into the Wasatch range proper, as shown by outcrops in Ogden, Weber and canyons farther south, the Jefferson, together with the Ordovician and Silurian systems are entirely lacking, Mississippian lying unconformably on Cambrian strata.

In the Bear River range the Jefferson formation is well represented in the Front Ridge from a position east of Richmond, south to a position east of Avon, Utah.

Thickness and Lithology.

The Jefferson formation in the Bear River Range has a uniform thickness, averaging from 2,000 feet north of Logan, Utah, to 2400 feet south in the Black-
smith Fork region. This formation is quite differentiated lithologically. Due to this differentiation and the thin-bedded incompetent strata, a characteristic topography is associated with this formation wherever it outcrops. The thin-bedded strata rapidly weathers into slopes of talus and detrital material leaving a few more massive ledges exposed (Plate VII, a and b). These ledges range from two or three feet to fifty feet. Only three or four of these outstanding ledges are more or less continuous through the formation (Plate VII, b). Most of the formation, however, is covered with occasional outcrops, especially on the ridges where the detrital material has not been allowed to accumulate.

The weathered constituents of the solid rock, forming the extensive detrital slopes of this formation show a characteristic gray to buff color; this being the predominant tint of the weathered surface of the solid rock itself.

On the north side of Blacksmith Fork Canyon, beginning at the mouth and extending approximately three miles up the canyon, the character of the Jefferson outcrops are quite different from the usual appear-
ance associated with that formation. The rock strata are well exposed and stand out as prominent ledges, showing the relatively thin-bedded character of the rock. These ledges are not continuous, but are interrupted at intervals where erosion has cut through them, forming small ravines in which a considerable amount of talus is formed (Plate VIII).

Scattered throughout the formation are zones of local faulting and folding. The folding is confined almost wholly to the thin-bedded incompetent layers; the more massive ones show a distinct fault plane (Plate IX).

The whole formation is characterized throughout as being much jointed; joints being predominantly vertical with occasional oblique planes in the incompetent beds.

An interesting feature is associated with one of the lower members of this formation, occurring stratigraphically about 200 ft. up from the lower Jefferson contact. In Blacksmith Fork Canyon, this bed is a porous intraformational breccia, cemented by coarsely-crystalline calcite, with a buff to rose color. Associated with this breccia are peculiar radial structures, more or less hexagonal in shape, averaging an eighth of
an inch across and radiating from a common center. A very peculiar topography is associated with this breccia. Because of its poor resistance it weathers very easily beneath the more massive bed above, forming a very continuous overhanging ledge with its characteristic buff-rose color (Plate X b). The same breccia outcrops in Logan Canyon but differs in texture, color and composition to that found in Blacksmith Fork Canyon. It is more resistant, contains larger pebbles, dark-gray in color and is very dense; the cementing material is calcareous and silicious. The bottom of the more massive bed under which the breccis weathers out, is quite irregular; this is also the case with the breccia itself. This irregularity and the intraformational character of the bed, shows the incompetency of that bed to hold up under the stress of folding. The strain imposed on the weak bed has caused it to crumble and later cemented by calcite and iron oxide brought in by percolating waters.

In the upper-middle section of this formation is found a zone three to four hundred feet thick which is very badly fractured. The fractures occur along the bedding planes and in two directions at right angles to the bedding planes, forming block-like structures. These fractures have been filled with calcite, much of it appearing
as the Dog-tooth Spar variety. Immediately above this member the limestone becomes sandy and grades into a relatively pure calcareous sandstone which contains sun-cracks, ripple-marks and cross-bedding (Plate XI). The strata above this member is a relatively thin-bedded argillaceous limestone containing some sand and continues on up to the top member of the Jefferson formation which is a continuous resistant ledge of limestone (Plate Xa).

**Conditions of Deposition**

The general lithological features of the Jefferson formation wherever it has been studied in the Bear River Range, show very little change from one section to another, however, a more detailed observation of the finer constituents shows quite a change in the conditions of deposition incurred during Devonian times. This change, together with the thin-bedded character of the formation, sun-cracks, ripple-marks and cross-bedding suggests a relatively shallow Devonian sea in which a large part of the Devonian sediments accumulated.

A very interesting feature of this formation, associated especially with the middle and upper portions, is the occurrence within the dolomite and limestone members
a considerable amount of sand. This sand varies from very small (.1 to .3 mm.) to relatively large (.3 to 1. mm.) well rounded, frosted grains; well spaced and evenly disseminated through the limestone or dolomite mass. The grains of sand occurring in the dolomite and limestone members are very small, which, together with their position and shape suggests them to be of wind-blown origin. The large grains occur as an almost pure sandstone and are in close contact. They are also less frosted and less rounded than the smaller grains occurring in the dolomite and limestone. The position, shape and size of these larger sand grains and the cross-bedding and ripple marks contained in these sandstone beds, suggests these grains to be of water born origin, deposited in shallow water. The smaller sand grains occurring in the limestone and dolomite appear more or less spasmodically as to amount, which vary from a few grains per cu. inch to about half sand and half limestone or dolomite. The sandy phases extending through such a thickness of sediments and varying as they do in amounts, suggests that they were not due entirely to wind, but to a greater probability by wave agitation which kept the finer grains in suspension and by the aid of oscillating currents were deposited farther
out in the limestone oozes.

The absence of any true shales in the Jefferson formation, together with the alternate occurrence of sand with limestone and a very small amount of argillaceous material, suggests an arid climate, especially in the latter half of the period. There must have been an extensive sandy, desert condition surrounding part of this western Devonian sea to have contributed so much sand. Conditions of deposition which occurred during Devonian times seem to have been like those occurring today along the northern coast of Africa; the arid, desert conditions of Devonian times corresponding to the present arid conditions of northern Africa. The few rivers flowing into this arm of the sea seem to have flown over extensive, sandy areas.

An interesting feature associated with the first half of the Devonian sea in this section is the occurrence of great quantities of Magnesium Carbonate, which caused the deposition of so much dolomite. It would be no easy matter to infer the source of such a quantity of Magnesium Carbonate.

**Fossils.**

The main difficulty encountered in studying the Jefferson formation in this area is the scarcity of fossil remains. The Madison limestone above is very
fossiliferous and the Silurian deposits below contain a relative abundance of *Halysites*, few *Favosites* and *Syringopora*.

The lower and upper contacts of the Jefferson formation were more or less arbitrary at first, being based almost wholly on the position of the strata. A continued, detailed search, however about the lower contact revealed a great find as far as fossil remains were concerned. In the talus material associated around this lower contact was found small fragments of boney plates, spines and teeth of fish (Plate XIII). On close examination the position of this float rock, its texture and color showed it to come from the lower Jefferson formation; composed of a fine-grained, light-gray dolomite. This lower member of the Jefferson formation crosses the canyon from this position and occurs as a thin veneer on the other side, resting upon Silurian strata and extending almost to the top of the mountain (Plate XII). The dip of the strata at this position is 25° West, which is a trifle less than the slope of the mountain. Because of this fact, as one ascends the mountain he also ascends the column slightly. The fish fragments were again found in the float as well as in place in this thin veneer and just a few feet a-
above Halysites in the Silurian formation below.

Close to the top, fish fragments were found in a sandstone which was later correlated across the canyon as being a bed occurring 200 feet up in the formation. Here more fragments were found in place. No fish fragments were found above this sandstone member which suggests they were confined wholly to the lower 200 feet of the formation. These fragments are very interesting, however, so few different parts were found that an identification could not be made. The only identifiable species is that of Ptyctodus Calceolus which was identified alone by teeth, this being the only part of its anatomy which has yet been found. This species has not been reported previous to this time, west of Iowa. Newberry¹ states that the zoological relations of Ptyctodus still remains uncertain and he thinks that there is little doubt that it was an Elasmobranch, and probably a Chimaeroid. The teeth are excavated below which suggests that they were set upon a cartilaginous jaw, as in Rynchochus Chimaera; They are usually the shape of a shoe and are from one to five inches long; the ones found in this locality are not more than one inch long. The teeth have an enameled surface which is transversely ridged.

¹. House Miscellaneous Documents 1889-90 Vol. 37 Newberry.
In some teeth this enamel portion is raised and in others depressed, as though one fitted into the other. The grinding surface seems to be as complete as that possessed by the elephant, which suggests a backward and forward movement of the jaws. The teeth of Ptery­todus Calceolus has been found in the Devonian Rocks of Russia, Illinois and Iowa, in which they are quite numerous. They occur in the east in the Hamilton for­mation, which probably correlates with the Jefferson formation of the west.

At least four other species of fish have been found in the Jefferson formation; two species of Din­ichthys, one species of Shark and one species of Pter­aspis. A bone fragment found resembles the dorsal shield from above of Dinichthys Minor, described by Newberry. Another fragment resembles a cephalic plate, bearing spine, of Acanthaspis Armatus, Newberry. (Plate XIV.)

Associated with the fish fragments in the lower dolomite member are unidentifiable clams. At a position 250 feet up in the column, contained in a dolomite ledge are very small Crynoid stems. On top of this bed in a very thin-bedded shaley material is a very small Brachiopod, very smooth and identified as Martia Maia; also some very small, unidentifiable Gastropods, averaging an eighth of an inch long. A-

2. Same as Ref. 1. pp. 36.
above this horizon no other fossils have been found until the very fossiliferous Madison limestone is reached.

Age and Correlation.

In the west the Devonian outcrops indicate such a different succession of physical events, that its subdivisions can seldom be correlated with those of the east. The Great Plains and the eastern section of Colorado appears to have been a land area, because of the absence of any known Devonian strata. In the plateau region, from Arizona to Montana extending north into the Canadian Rockies are many Devonian outcrops, which indicates that much or all of this region was submerged at one epoch or another of the period. In the Nevada trough of the Devonian sea, deposition seems to have been unbroken, for here is found 2000 feet of shale and 6000 feet of limestone assigned to this system. In the Bear River Range the Devonian is represented by 2400 feet of dolomite and limestone. This thickness suggests the absence of some of the formations of this system in this locality, in fact the Jefferson is the only formation which seems to be present. The faunas of the west differ from those of the east and have more affinity with those of Europe and Asia which corresponds with the Helderberg, Onondaga, and Hamilton.
The occurrence of Ptotodus Calceolus in the Jefferson fauna in this locality, suggests this formation as correlating with the Hamilton formation of the east.
Relief map of Utah showing the position of the Bear River Range in the north.
The southern portion of the Bear River Range, where the Jefferson formation was studied. Mount Logan at extreme left; Blacksmith Fork Canyon at right of center.
Logan Canyon in which the graphic cross-section of the Bear River Range was made. This canyon shows the character of the Canyons cutting this Range.
The Wellsville Range.
(a) Partially over-turned strata at mouth of Logan Canyon (north side).

(b) Same structure as above, mouth of Logan Canyon (south side).
The lower-Mississippian precipitous ledge (Chinese Wall), and the character of the Devonian outcrops (below).
At forks of Blacksmith Fork Canyon where columnar section of Devonian was started, showing precipitous Silurian outcrops (below) and Jefferson formation, Devonian. (above)
(a) Looking north up Left Fork from same position as (a) and (b) Plate XII, showing typical Devonian outcrops. The canyon is considerably wider and slopes more gentle, which is the usual condition throughout the entire range, wherever the river is cutting through Devonian outcrops, it's thinner beds yielding more readily to erosion.

(b) Lower Mississippian (above). The usual weathered appearance of Devonian strata showing the weathering out of the thinner-incompe- tent beds.
(a and b) Outcrops of Jefferson formation in Blacksmith Fork Canyon showing the weathering of the strata at intervals into ravines and talus slopes.
(a) Folding of the incompetent thin-bedded layers of the Jefferson formation, showing competent beds below and above, which haven't yielded to the folding.

(b) Weathered, cave-like appearance of Jefferson strata.
(a) Massive limestone ledges of upper Jefferson formation with very thin-bedded strata beneath.

(b) Irregular under surface of massive ledge above the intraformational breccia. Breccia is weathered out, leaving under surface well exposed. Upper part of photo shows characteristic vertical jointing of the Jefferson strata.
(a) Ripple-marks in sandstone in the upper-middle Jefferson formation.

(b) Sun-cracks in the same section of the formation as above ripple-marks.
(a) Looking south along strike of contact between Silurian and Jefferson formation at forks of Blacksmith Fork Canyon. Showing weathered dip slope of the contact across Canyon.

(b) Looking east from same position as (a) showing thin veneer of the Jefferson formation (on the left) lying on top of Silurian Strata (right).
PLATE XIII.

A variety of boney-plates found in the lower Jefferson member.
Fragment resembling a cephalic plate, bearing spine, of *Acanthaspis Armatus*, Newberry.
CROSS-SECTION OF NORTH SIDE OF BLACKSMITH FORK CANYON

HORIZONTAL = VERTICAL SCALE THE SAME  1/8 in. = 1 MILE
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<th>NO.</th>
<th>THICKNESS</th>
<th>DESCRIPTION</th>
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<td>45</td>
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<td>19</td>
<td>43</td>
<td>Medium-gray, fine-grained, limestone; weathered to gray buff; surface somewhat irregular, especially along the bedding planes.</td>
</tr>
<tr>
<td>20</td>
<td>42</td>
<td>Medium-gray, fine-grained, limestone; weathered to gray buff; surface somewhat irregular, especially along the bedding planes.</td>
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<td>21</td>
<td>41</td>
<td>Light-gray, fine-grained, arenaceous limestone; weathered to a light-gray surface.</td>
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<td>22</td>
<td>40</td>
<td>Light-gray, fine-grained, arenaceous limestone; weathered to a light-gray surface.</td>
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<tr>
<td>23</td>
<td>39</td>
<td>Medium-gray, fine-grained, limestone; weathered to a light-gray surface; very thinly bedded; mass of gray buff; hard and compact.</td>
</tr>
<tr>
<td>24</td>
<td>38</td>
<td>Medium-gray, fine-grained, limestone; weathered to a light-gray surface; very thinly bedded; mass of gray buff; hard and compact.</td>
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<tr>
<td>25</td>
<td>37</td>
<td>Light-gray, fine-grained, arenaceous limestone; weathered to a light-gray surface.</td>
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<td>26</td>
<td>36</td>
<td>Light-gray, fine-grained, arenaceous limestone; weathered to a light-gray surface.</td>
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<td>Medium-gray, fine-grained, dolomite; weathered to medium-gray; massive to relatively massive; very highly jointed with vertical, joint planes; outcrop nearly covered.</td>
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<td>Medium-gray, fine-grained, dolomite; weathered to medium-gray; massive to relatively massive; very highly jointed with vertical, joint planes; outcrop nearly covered.</td>
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</tbody>
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Scale: 1 in. = 20 feet