Paleozic Stratigraphy of the James Peak Quadrangle, Utah

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PALEOZOIC STRATIGRAPHY OF THE
JAMES PEAK QUADRANGLE, UTAH
by
Harley D. King

A thesis submitted in partial fulfillment
of the requirements for the degree
of
MASTER OF SCIENCE
in
Geology

Approved:

UTAH STATE UNIVERSITY
Logan, Utah
1965
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Harley D. King
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INTRODUCTION

General statement

The James Peak quadrangle is a topographic map unit of the Geological Survey of the U. S. Department of Interior (Plate 1). It covers 7 1/2 minutes of latitude and longitude at a scale of 1:24,000 or 1 inch to 2,000 feet. It is bounded by lat 41°22'30" N. and lat 41°30' N. and long 111°45' W. and long 111°52'30" W. The quadrangle includes 56 square miles and has maximum relief of about 4,300 feet.

The James Peak quadrangle is located in northern Utah between the Wasatch Range on the west and the Bear River Range on the east (Figure 1). The eastern part includes the western flank of the Bear River Range. James Peak, 9,500 feet in elevation, is in the southeastern part of the quadrangle and forms an imposing landmark as seen from Cache Valley to the north and Ogden Valley to the south.

The area of the James Peak quadrangle is represented on various generalized geologic maps (Hardy and Williams, 1953; Stokes, 1963); however, no concerted attempt has been made to study the Paleozoic stratigraphy of the area. Such an investigation is basic to an understanding of the geologic structure of northern central Utah and might also help resolve numerous stratigraphic problems of the region. The purpose of this investigation is to
Figure 1. Index map of part of north-central Utah, showing location of James Peak quadrangle.
determine the lithology and thickness of the Paleozoic stratigraphic units present within the James Peak quadrangle.

Previous investigations

A preliminary map constructed by Ezell (1953, plate 9) includes the northwestern corner of the quadrangle but unfortunately leaves an internal area unmapped. The entire quadrangle was represented on a regional geologic map of northern Utah prepared by Hardy and Williams (1953). Certain aspects of the structure have been discussed briefly by Hardy (1957). None of these studies are based on an adequate analysis of the Paleozoic stratigraphy.

The stratigraphy of certain surrounding areas is known in considerable detail. Williams (1948, 1958) studied the Paleozoic rocks of the Logan quadrangle, Utah-Idaho, to the north and also mapped the quadrangle at a scale of 1:125,000. The Paradise quadrangle, within the Logan quadrangle and just north of the James Peak quadrangle, has recently been mapped by Mullens and Izett (1964). The higher parts of the Wasatch Range to the west of the James Peak quadrangle have been described in general terms by Blackwelder (1910) and Eardley (1944). Finally, the quadrangle immediately east of the James Peak quadrangle is the subject of a thesis by Hafen (1961).

Present understanding of regional Paleozoic stratigraphy is based on a great many detailed studies of more distant areas except for Blacksmith Fork Canyon which is a classic area of Cambrian stratigraphy. This locality is within the Logan quadrangle. Reference is made to many of these reports in the discussion of individual formations of the James Peak quadrangle.
Geologic features

Stratigraphic units of Paleozoic age are known largely from outcrops in the central and northwestern parts of the James Peak quadrangle (Plate 1). A succession, which dips generally northward, is found on both the eastern and western sides of the South Fork of Little Bear River (Table 1). It extends from Middle Mountain northward nearly to the margin of the quadrangle and from Public Grove Hollow northward to the lower part of Fourmile Canyon and to the northwestern corner of the quadrangle. A narrow area of Paleozoic rocks, in general poorly exposed and structurally complex, is present along the eastern margin of the quadrangle. James Peak and the southwestern part of the quadrangle are underlain by quartzites of presumed Precambrian age.

The James Peak quadrangle is divided into three blocks by two north-south faults or fault zones: (1) western block, (2) central block, and (3) eastern block. James Peak is in the southern part of the central block; Middle Mountain is in the middle part of this same block near the western side. A fault or fault zone extends north-south along both the western side of James Peak and Middle Mountain. The eastern block forms the flank of the Bear River Range with McKenzie Mountain near the northern end. The front of the Bear River Range is distinctly limited by a fault or fault zone which extends southward between the main part of the range and James Peak to the west.

Precambrian rocks, striking about east-west and dipping northward, are found in the southern part of the western block. The Prospect Mountain
Table 1. Stratigraphic units of Paleozoic age

<table>
<thead>
<tr>
<th>Unit</th>
<th>Lithology</th>
<th>Thickness (feet)</th>
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<tbody>
<tr>
<td><strong>Mississippian</strong></td>
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<td>Great Blue limestone</td>
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<td>Humbug formation</td>
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<td>Deseret formation</td>
<td>Siltstone, sandstone, and limestone</td>
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<td>Lodgepole limestone</td>
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<td><strong>Devonian</strong></td>
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<td></td>
</tr>
<tr>
<td>Jefferson formation</td>
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<tr>
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<td>Water Canyon formation</td>
<td>Dolostone and intraformational breccia</td>
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<tr>
<td><strong>Silurian</strong></td>
<td></td>
<td></td>
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<tr>
<td>Laketown dolostone</td>
<td>Dolostone</td>
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<td><strong>Ordovician</strong></td>
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<td>153</td>
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<td>Swan Peak formation</td>
<td>Quartzite and shale</td>
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<tr>
<td>Garden City formation</td>
<td>Limestone and dolostone</td>
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<td><strong>Cambrian</strong></td>
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<td>Nounan formation</td>
<td>Dolostone</td>
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<tr>
<td>Ute formation</td>
<td>Shale, limestone, and siltstone</td>
<td>874</td>
</tr>
<tr>
<td>Langston formation</td>
<td>Limestone, shale, and dolostone</td>
<td>207</td>
</tr>
<tr>
<td>Pioche(?) formation</td>
<td>Siltstone, sandstone, and silty quartzite</td>
<td>225</td>
</tr>
<tr>
<td>Prospect Mountain quartzite</td>
<td>Quartzite and shale</td>
<td>1,100</td>
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</table>
quartzite of Cambrian age, with essentially the same strike and dip as the Precambrian units, extends across the block from west to east; however, it is covered at the eastern side by the Salt Lake formation of Tertiary age.

The Prospect Mountain is followed in normal stratigraphic succession by the Pioche(?) formation and younger Cambrian units. These are limited by an east-west fault, in Dips Hollow, which probably extends completely across the block. The Prospect Mountain is at the surface again north of this fault at the eastern side of the block. The Prospect Mountain, north of the fault, is overlain by the Pioche(?) formation and 16 younger units of Paleozoic age. The northern part of the block, however, is largely covered by the Salt Lake formation.

The southern part of the central block, James Peak, is formed of Precambrian rock but with north-south strike and east dip. A broad valley which extends across the block just north of James Peak and northward to the edge of the quadrangle is underlain by the Salt Lake formation which certainly covers various units of Paleozoic age. Middle Mountain, therefore, is isolated by a cover of the Salt Lake formation, except at its western side where it is bounded by a north-south fault separating the central and western blocks. The Prospect Mountain quartzite crops out at the southern end of Middle Mountain and is overlain in turn northward by 11 formations of Paleozoic age. The youngest unit, at the northern end, is the Laketown dolostone of Silurian age. The rocks of Middle Mountain strike west-northwest and dip northward.
The part of the eastern block, south of Davenport Creek and east of James Peak, is not fully understood. Here unidentified Cambrian units, Laketown dolostone, and Garden City formation are separated by several more or less vertical north-south faults. North of Davenport Creek is a small syncline, with north-south axis, in the Garden City formation of Ordovician age. The Garden City is followed northward by the Swan Peak formation, Lodgepole limestone, and finally, making the higher part of McKenzie Mountain, the Great Blue limestone. These units, for the most part, strike north-south and dip gently westward.

Field work

The major part of the field work was done in a two-month period during the summer of 1962. Additional time was spent in the field during the summer of 1963.

The stratigraphic sections were measured with a 50-foot steel tape. A Brunton compass was used to determine dip, slope, and azimuth. Thicknesses were subsequently computed.

The terminology for bedding, used in this report, is that of McKee and Weir (1953, p. 381-389) as modified by Ingram (1954, p. 938). The Wentworth grade scale was used to describe clastic rocks. It was also used, as adapted by Payne (1942, p. 1, 706), for the crystalline carbonate rocks. Color was determined with reference to the Rock-Color Chart (Goddard, 1951).
CAMBRIAN SYSTEM

Prospect Mountain quartzite

The Prospect Mountain quartzite was named by Hague (1883, p. 254) for exposures on the west slope of Prospect Peak near Eureka, Nevada. The formation has been recognized in sections throughout Utah, southeastern Idaho, northern Arizona, Nevada, and eastern California (Maxey, 1958, p. 667). In northeastern Utah and southeastern Idaho this formation has been named Brigham quartzite (Walcott, 1908, p. 8-9). Walcott designated the western front of the Wasatch Mountains northeast of Brigham City, Utah, as the type locality of the Brigham quartzite. Descriptions of the Brigham quartzite have included shale beds near the top (Mansfield, 1927, p. 53; Williams, 1948, p. 1,132). According to Maxey (1958, p. 667), the lower part of the Brigham is Prospect Mountain and the upper shaly part is probably Pioche formation. The writer follows Maxey's usage in this paper.

The Prospect Mountain quartzite was studied on the southeast-facing slope of Bald Mountain, 1.7 miles west of the South Fork of Little Bear River (NE 1/4 sec. 19, T. 8 N., R. 1 E. to NW 1/4 sec. 20, T. 8 N., R. 1 E.). It consists predominantly of medium- to coarse-grained medium- to thick-bedded light-brown quartzite, which rests with apparent conformity on a thick succession of reddish-purple and light-gray quartzite of presumed Precambrian age. The formation also contains lenticular beds of dusky-yellow shale
with maximum thickness of about 8 inches. These occur sporadically through­
out the formation but account for a small percentage of the total thickness.
A dark-gray quartzite, about 15 feet thick, is interbedded in the lower part.
Cross-stratification is common (Figure 2). Conglomerate lenses were not
observed.

The thickness in the James Peak quadrangle, measured roughly by
pacing, is about 1,100 feet. Along the western front of the Wasatch Mountains
east of Willard, Utah, Maxey (1958, p. 663) estimated the thickness to range
from 700 to 1,500 feet within 1 mile. Eardley and Hatch (1940, p. 811)
measured a section nearly 1,800 feet thick 2 miles north of Brigham City,
Utah, in Wellsville Mountain.

The age of the formation at the type locality is generally accepted as
Early Cambrian (Nolan, Merriam, and Williams, 1956, p. 7). In north­
eastern Utah the formation, being a transgressive deposit, is somewhat
younger. Walcott (1912, footnote, p. 153) asserted that the boundary between
Lower and Middle Cambrian is within the quartzite at Blacksmith Fork.
Wheeler (1943, p. 1,810), in considering the regional thickness, concluded
that most of the formation must have been deposited in Early Cambrian time.
Williams and Maxey (1941, p. 277) found Albertella and Kochaspis in the
basal beds of the Langston formation at Blacksmith Fork, Utah, and therefore
concluded that the Prospect Mountain is probably Early Cambrian in age.
Lochman-Balk (1960, p. 100, fig. 2), however, placed the top of the
Albertella zone near the base of the Langston formation and recognized
beneath this another Middle Cambrian zone, the Plagiura-Poliella. She stated
Figure 2. Cross-stratification in Prospect Mountain quartzite. Photograph taken in NE 1/4 sec. 16, T. 8 N., R. 1 E., about a quarter of a mile west of road along the South Fork of Little Bear River and about 1 mile south of Threemile Canyon.
(Lochman-Balk, 1960, p. 99-100) that since species of the basal Middle Cambrian Wenkchemnia-Stephenaspid and Plagiura-Kochaspid faunules of Rasetti (1951, p. 87-93) are not known, and because diagnostic fossils are not found within the Prospect Mountain, it need not be older than earliest Middle Cambrian.

The only fossils found in the Prospect Mountain quartzite in the James Peak quadrangle are vertical tubes which probably represent Scolithus. These are abundant in the upper 100 feet of the formation.

**Pioche(?) formation**

The Pioche formation was named by Walcott (1908, p. 11-12), with type locality near Pioche, Nevada. In the Pioche district the formation consists of greenish-yellow, brown, and buff, micaceous shales intercalated with a moderate amount of quartzite, sandstone, and limestone (Wheeler, 1943, p. 1,788). The thickness at the type locality is 1,120 feet (Westgate and Knopf, 1932, pl. 2). Maxey (1958, p. 668) stated that in northeastern Utah and southeastern Idaho, where arenaceous beds predominate over argillaceous beds, the formation is only arbitrarily distinguishable from the Prospect Mountain quartzite.

The Pioche(?) formation was examined on the north side of an unnamed hollow midway between Dips Hollow and Shingle Mill Hollow and about half a mile west of the South Fork of Little Bear River (NE 1/4 NW 1/4 sec. 16, T. 8 N., R. 1 E. to SW 1/4 SE 1/4 sec. 9, T. 8 N., R. 1 E.). The Pioche(?) overlies the Prospect Mountain quartzite and underlies the
Langston formation. It is 225 feet thick and consists of interbedded light-olive-gray sandstone, quartzite, and moderate-brown siltstone. Shale beds are either absent or were not observed due to cover. This unit is therefore questionably referred to the Pioche.

In the basal beds, the quartzite is similar to that of the Prospect Mountain. The sandstone is silty, calcareous, and micaceous. The formation is capped by a few feet of thin-bedded sandy limestone interbedded with fine-grained sandstone.

Worm tubes are common in the basal quartzites. Worm trails, about 10 mm wide, were observed on sandstone beds about 10 feet below the top of the formation.

The Pioche formation is presumed to be entirely Lower Cambrian at Eureka, Nevada (Nolan, Merriam, and Williams, 1956, p. 8). At the type area it is both Lower and Middle Cambrian (Wheeler, 1943, p. 1,811). Lochman-Balk (1960, p. 99) placed the northeastern Utah sequence entirely within the Middle Cambrian.

**Langston formation**

The Langston formation was named by Walcott (1908, p. 8) from exposures in the valley of Langston Creek, Bear Lake County, Idaho. At Blacksmith Fork Canyon, Utah, the type locality, the formation is 380 feet thick and is composed of two tan-weathering dolostone units separated by a limestone unit. The lower dolostone is 280 feet thick and the middle and upper units are each 50 feet thick (Williams and Maxey, 1941, p. 279).
To the northwest the thick basal dolostone thins and is replaced by the basal Naomi Peak limestone member and the overlying Spence shale member (Maxey, 1958, p. 669).

The Langston formation was studied in a conspicuous outcrop on the north side of an unnamed hollow midway between Dips Hollow and Shingle Mill Hollow and about half a mile west of the South Fork of Little Bear River (SW 1/4 SE 1/4 sec. 9, T. 8 N., R. 1 E.). It rests on the Pioche(?) formation and underlies the Ute formation (Figure 3).

The Langston is 207 feet thick in the James Peak quadrangle. The basal 92 feet consists predominantly of thin- to medium-bedded medium-dark-gray aphanitic limestone. Very light-gray medium- to coarse-crystalline dolostone occurs locally along fracture zones between 37 and 92 feet above the base. The next 27 feet consists of grayish-orange aphanitic silty limestone in thin laminations.

Above the grayish-orange limestone is 36 feet of interbedded pale-yellowish-brown shale and siltstone. This sequence also contains a few thin beds of aphanitic limestone with abundant fossil fragments.

The upper 52 feet of the formation consists of medium-bedded and thick-bedded dolostone, which is clastic in the lower part. The clastic beds are composed of rounded fragments of dark-gray dolostone averaging three-eighths inch in diameter in a pale-yellowish-brown matrix. This entire unit weathers pale yellowish brown.

The two abundantly fossiliferous members of the Langston formation, the Naomi Peak limestone member and the Spence shale member, were not
Figure 3. Prospect Mountain quartzite, Pioche(?) formation, and Langston formation. The Prospect Mountain quartzite crops out in the relatively bare area on the left. The Pioche(?) formation is found in the brush-covered valley; resistant units of the Langston formation are evident in the hill on the right. The light-colored ledges are limestone and the hill top is a dolomite which forms the uppermost unit of the Langston. The photograph was taken toward the west-northwest in NE 1/4 sec. 16, T. 8 N., R. 1 E., about a quarter of a mile west of road along the South Fork of Little Bear River and about 1 mile south of Threemile Canyon.
recognized within the James Peak quadrangle; however, they appear a short distance to the north (Maxey, 1958, p. 669). The following trilobites were found in the James Peak quadrangle within the shale-siltstone sequence between 52 and 88 feet below the upper contact of the formation: Bathyuriscus, Glossopleura.

Lochman-Balk (1960, p. 100) assigned the Naomi Peak member to the uppermost part of the Albertella zone and the remainder of the Langston formation including the Spence shale member to the Glossopleura zone. This places the formation in the lower Middle Cambrian.

Ute formation

Members of the Fortieth Parallel Survey (King, 1876, p. 477) assigned the name Ute limestone to a 2,000 foot interval consisting chiefly of limestone overlying the Cambrian shales and underlying the Ordovician quartzites. Walcott (1908, p. 7) restricted this usage and defined the Ute formation within the lower part. He measured and described a section in Blacksmith Fork Canyon and designated nearby Ute Peak as the type locality. Deiss (1938, p. 1, 120-1, 121) emended Walcott's definition and assigned a new type locality in Blacksmith Fork Canyon where he measured a section 675 feet thick.

Maxey (1958, p. 672) stated that the maximum measured thickness of the Ute is 745 feet at High Creek, in the Bear River Range about 18 miles north of Logan, Utah. Hafen (1961, p. 17) reported 1,090 feet in the Sharp Mountain area, just east of the James Peak quadrangle, but he explained that
the excess thickness was probably due to bedding plane slippage. In the James Peak quadrangle the thickness is 874 feet; however, evidence of bedding plane slippage is found in the form of slickensides on numerous shale beds in the lower part of the formation. The slickensides indicate movement in approximately the dip direction. The section is possibly thickened by bedding plane faults which in places cut across the beds.

The Ute formation was measured on the east side of South Canyon near the middle of the James Peak quadrangle (NW 1/4 NW 1/4 sec. 15, T. 8 N., R. 1 E. to SW 1/4 SW 1/4 sec. 10, T. 8 N., R. 1 E.). It overlies the Langston formation and underlies the Blacksmith formation. The Ute consists of alternating silty limestone, siltstone, and very fine-crystalline thin-bedded limestone. In the basal 200 feet of the formation, grayish-orange siltstone alternates with thin units of dark-gray limestone and grayish-red silty limestone. Two siltstone units, each about 50 feet thick, occur in the lower part of the formation and are separated by about 60 feet of dark-gray limestone containing pisolites. The upper siltstone is light-olive-gray while the lower is conspicuously pale yellowish brown and pale reddish brown.

In the upper part of the formation 242 feet of dark-gray limestone is overlain by 277 feet of medium-gray silty limestone interbedded with light-brownish-gray silty limestone. The limestone beds, throughout most of the formation, are separated by thin layers of pale-brown or grayish-orange siltstone.

Maxey (1958, p. 672) assigned the basal beds of the Ute to the *Glossopleura-Zacanthoides* zone and the upper beds to the *Bathyuriscus-*
Elrathina zone, both Middle Cambrian. The writer collected and identified the following fossils from the lower half of the formation:

- Brachiopoda
  - Lingulella

- Trilobita
  - Glossopleura
  - Elrathina
  - Ehmaniella
  - Elrathia

Blacksmith formation

The Blacksmith formation was named by Walcott (1908, p. 7) from exposures in Blacksmith Fork Canyon, Utah. Walcott described the formation as consisting of massive layers of gray arenaceous limestone, 570 feet thick. Deiss (1938, p. 1, 121) emended this definition and stated that the formation is 450 feet thick in the type section and consists of nearly pure dolostone, except for some limestone in the lower third and in the upper 60 feet. The formation thickens westward and is 805 feet thick at Call's Fort on the west side of Wellsville Mountain (Maxey, 1958, p. 660-661, 672).

The Blacksmith formation was studied on the east side of South Canyon (NW 1/4 SW 1/4 sec. 10, T. 8 N., R. 1 E.). It rests on the Ute formation and underlies the Bloomington formation. The Blacksmith is 483 feet thick and consists of 301 feet of aphanitic limestone overlain by 182 feet of dolostone. The limestone is dark gray and thin bedded in the lower and upper parts with light-gray laminated limestone in the middle. The limestone beds are separated by thin irregular layers of siltstone which are moderate red and
stand out in relief on weathered surfaces in the upper part. The dolostone is medium dark gray and medium light gray and weathers medium bluish gray and brownish gray, respectively. Near the base the dolostone is light gray and oolitic.

The Blacksmith formation is Middle Cambrian in age (Williams, 1948, p. 1, 133). Maxey (1958, p. 678) assigned the lower beds to the Bathyuriscus-Elrathina zone and the upper beds to the Thompsonaspis zone. The writer identified Elrathia from near the base.

Bloomington formation

The Bloomington formation was named by Walcott (1908, p. 7) with type locality about 6 miles west of Bloomington, Bear Lake County, Idaho. Within the Logan quadrangle (Williams, 1948, p. 1, 134) the formation is composed of four members as follows: (1) the basal Hodges shale member, (2) a lower limestone member, (3) the Call's Fort shale member, and (4) an upper limestone member. The thickness at Blacksmith Fork is 1,275 feet (Deiss, 1938, p. 1, 122).

The Bloomington formation was measured on the east side of South Canyon from south to north across a small canyon which is directly east of the junction of Threemile Creek and the South Fork of the Little Bear River (NW 1/4 sec. 10, T. 8 N., R. 1 E.). The Bloomington overlies the Blacksmith formation and underlies the Nounan formation. It is 1,363 feet thick and all four members are present. Here the basal Hodges shale member consists of pale-yellowish-brown siltstone and shale. The siltstone and shale
alternate at irregular intervals with thin units of medium-bluish-gray to
dark-gray aphanitic to very fine-crystalline limestone. The limestone beds
are in turn separated by thin irregular layers of siltstone which weather
grayish orange and pale brown and stand out in relief on weathered surfaces.
An 8-foot thick interval of oolitic limestone occurs at the base. The thickness
of the Hodges shale member is 379 feet.

The lower limestone member is represented in the James Peak quad­
rangle by 666 feet of thin- to medium-bedded limestone, frequently inter­
bedded with grayish-orange siltstone, and a thick unit of pale-reddish-brown
and grayish-yellow siltstone in the lower part. The limestone ranges through
various shades of gray from light to dark and is aphanitic to fine-crystalline.
About 20 feet of medium-light-gray aphanitic laminated dolostone occurs near
the top of the member. It weathers conspicuous light gray and very light gray.

The Call's Fort shale member is 260 feet thick and consists of pale-
red, pale-yellowish-brown, and greenish-gray siltstone. A distinctive feature
in this member is the occurrence of rounded and irregular nodules and
stringers of medium-light-gray limestone intermingled with the siltstone. On
well-weathered exposures the nodules have been destroyed leaving rounded
holes.

The upper limestone member consists of medium-dark and dark-gray
aphanitic limestone and is 58 feet thick. The beds are separated by thin
irregular layers of siltstone which are generally pale red or pale reddish
brown in color.
Maxey (1958, p. 678) designated the beds of the Bloomington formation as the *Asaphiscus-Bolaspidella* zone which is the uppermost zone of the Middle Cambrian. The only fossils found in the James Peak quadrangle are inarticulate brachiopods. Among these the writer identified *Acrotreta* and *Acrothele*.

**Nounan formation**

The Nounan formation was named by Walcott (1908, p. 6) for exposures on the east slope of Soda Peak, west of Nounan, Bear Lake County, Idaho. Generally the formation is composed of light-gray dolostone with thin beds of dark-gray fossiliferous limestone in the upper third (Williams, 1948, p. 1, 134). The thickness at High Creek, about 18 miles north of Logan, Utah, in the Bear River Range is 1,125 feet (Maxey, 1958, p. 651).

The Nounan formation was studied on the north side of the small canyon which extends eastward from the junction of Threemile Creek and the South Fork of Little Bear River (SE 1/4 SW 1/4 sec. 3, T. 8 N., R. 1 E.). It rests on the Bloomington formation and underlies the Worm Creek quartzite member of the St. Charles formation. The Nounan is 695 feet thick and consists of thin- to thick-bedded fine-crystalline and medium-crystalline dolostone. The color is mainly medium dark gray although near the base light and medium grays alternate. A thick unit of very light-gray dolostone occurs in the upper half. Within this unit there are a few feet of intraformational breccia with a calcareous matrix.
Numerous thick beds within the basal 400 feet contain fossil fragments. On weathered surfaces the fragments appear white and are thereby conspicuous on the medium-dark-gray background.

Some of the beds in this interval, medium dark gray on fresh surfaces, nevertheless are banded light and medium dark gray on weathered surfaces. The bands are wavy, discontinuous, and less than 1 inch thick at most.

Near the upper contact of the formation thin beds of sandstone and dolostone alternate. The sandstone beds range in thickness from less than one-sixteenth inch up to three-fourths inch. On weathered surfaces the sandstone beds stand out prominently. These beds grade into the overlying Worm Creek quartzite member of the St. Charles formation.

The Nounan formation is within the Lower Cedaria zone of Late Cambrian age (Maxey, 1958, p. 678). Abundant fossil fragments were observed in the Nounan within the James Peak quadrangle; however, they were not subject to accurate identification. Some of the fragments are thought to represent trilobites.

St. Charles formation

The St. Charles formation, named by Walcott (1908, p. 6) from exposures west of St. Charles, Bear Lake County, Idaho, is the uppermost formation of the Cambrian succession in this region. He described the formation as gray arenaceous limestone with brown sandstone at the base. Richardson (1913, p. 407-408) distinguished the basal "sandstones" as the Worm Creek quartzite member. In the Logan quadrangle, the St. Charles formation
consists of three members (Williams, 1948, p. 1, 134-1, 135). These are: (1) the basal Worm Creek member, (2) a middle member of thin-beded limestones, and (3) an upper member of massive dark-gray dolostone. The thickness at Call's Fort, Wellsville Mountain, is 1,130 feet (Maxey, 1941, p. 17).

The St. Charles was studied, in part, in two nearby areas on the west and east sides of South Canyon. The basal Worm Creek quartzite member was measured on the south-facing slope of Threemile Canyon at a point three-tenths of a mile west of the South Fork of Little Bear River (SE 1/4 sec. 4, T. 8 N., R. 1 E.). Here the contact with the underlying Nounan formation is well exposed. The upper part of the St. Charles, to the base of the Garden City formation, was measured on the east side of South Canyon about half a mile northeast of the former locality (SW 1/4 sec. 3, T. 8 N., R. 1 E.).

The St. Charles formation is 1,405 feet thick in the James Peak quadrangle. The basal Worm Creek quartzite member is only 125 feet thick and consists chiefly of thin- to medium-bedded fine-crystalline dolostone with a few thin beds of pale-yellowish-brown very fine-grained quartzite near the base. The dolostone beds are frequently interbedded with thin layers of siltstone which weather pale reddish brown and stand out up to half an inch on weathered surfaces. The member is capped by about 26 feet of dark-yellowish-orange siltstone and shale. Outcrops of this member form typical blocky ledges.

Overlying the Worm Creek is about 85 feet of thin-beded light-gray very fine-crystalline dolostone interbedded with thin irregular layers of
grayish-orange siltstone. Occasionally the siltstone layers stand out on weathered surfaces and have a crinkly appearance. A breccia occurs locally in the upper part of this interval. It consists of plates and assorted pieces of the above described beds which are widely interspersed and irregularly imbedded in a dolomite matrix. The top of this unit marks the uppermost occurrence of any appreciable quantity of clastic material in the formation.

The remainder of the formation, 1,200 feet, consists of a series of very fine- to fine-crystalline dolostones in alternating shades of gray from light to medium dark. A 133-foot thick interval of light-gray vuggy dolostone occurs in the lower part. The other units, somewhat thinner, are set apart by contrasting shades of gray on weathered exposures.

The dolostones of the St. Charles formation are generally unfossiliferous; however, the middle limestone member which occurs in the region to the north yields Upper Cambrian fossils (Williams, 1948, p. 1, 135). The Cambrian-Ordovician boundary is conveniently placed at the top of the St. Charles formation; however, it may be within the upper dolostones (Hanson, 1953, p. 20).

The only fossils found in the St. Charles formation, in the James Peak quadrangle, are inarticulate brachiopods. These occur in sparse numbers in the argillaceous beds of the Worm Creek member. Two of these were identified as *Dicellomus* and *Lingulepis*. 
ORDOVICIAN SYSTEM

Garden City formation

The Garden City formation was named by Richardson (1913, p. 408) from Garden City Canyon in the Bear River Range, Rich County, Utah. He described the formation as 1,000 feet of gray limestone containing a conglomerate or breccia composed of elongated pieces of limestone.

Ross (1951, p. 7-8) divided the Garden City formation into two members as follows: (1) a lower member, which includes about two-thirds of the formation, consisting of a complex of interbedded layers of muddy limestone, crystalline limestone, and intraformational conglomerate, and (2) an upper member consisting of thick beds of dark-gray limestone in thin laminae with a high content of black chert. He also noted the occurrence of coarse-crystalline dolostone at the top of the formation in several localities. The lower member compares closely with Richardson's original description (Ross, 1953, p. 23).

The Garden City formation is widespread in northeastern Utah and southeastern Idaho. The thickness ranges from 1,760 feet at Clarkston Mountain, about 20 miles northwest of Logan, Utah, to about 1,180 feet at Davenport Hollow in the southern part of the Bear River Range (Ross, 1951, p. 5). Ross (1951, p. 4) stated that the formation is not well known south of lat 41°30' N.
The Garden City formation was measured on the west side of South Canyon where it crops out in prominent north-dipping ledges (NW 1/4 NW 1/4 sec. 3, T. 8 N., R. 1 E. to SW 1/4 SW 1/4 sec. 34, T. 9 N., R. 1 E.). The lower contact with the St. Charles formation as well as the upper contact with the Swan Peak formation are both readily identified. The Garden City is 1,238 feet thick in the James Peak quadrangle and both members are well represented. The lower member is 936 feet thick and consists mainly of units of medium- to thick-bedded limestone alternating with units of limestone containing thin anastomosing layers of moderate-orange-pink siltstone, both interbedded with intraformational conglomerate. The units generally consist of one to four beds.

In the basal 240 feet the limestone is very dense, aphanitic, and medium light gray and pinkish gray in color. Massive beds are common in this interval. In the 150 feet above this the limestone is thin-bedded, aphanitic- to fine-crystalline, and medium gray in color. The next 163 feet are generally covered; however, the float reveals that a large part of this interval is composed of intraformational conglomerate. The remaining 383 feet of the lower member consists of thick and massive beds of light- to medium-gray aphanitic limestone.

The units containing the thin anastomosing layers of siltstone were observed mainly in the lower half of the lower member, below the covered interval. The interweaving pattern formed by these layers gives, on casual observation, the incorrect impression of thin beddedness. Many of these
units are fractured at low angles to the bedding planes. These units are continuous over short distances along the strike direction.

The beds of intraformational conglomerate occur throughout the member. They are widely interspersed in the lower part and increase in abundance upward. The conglomerate is composed of spheroidal and elongate pebbles and irregular pieces of dense aphanitic limestone. The elongate pebbles are as much as 3 inches in length and average about half an inch in width. In the lower part of the member these beds are predominantly matrix but upward the matrix becomes subordinate; in the upper part the matrix is commonly composed in large part of fossil fragments many of which can be recognized as parts of trilobites.

The upper member, 302 feet thick, is composed of medium- to thick-bedded medium-dark-gray very fine- to fine-crystalline dolostone, which sometimes contains layers of very fine-grained light-brown sand. Nodules and stringers of grayish-black chert occur within the lower 131 feet. These are commonly in parallel alignment with the bedding. A channel-fill conglomerate, about 3 feet thick and 15 feet wide, was noted within the upper member.

Ross (1949, 1951) described a remarkably well-preserved trilobite fauna in the Garden City formation and designated 12 faunal zones, A through L, based on faunal assemblages. In the James Peak quadrangle, as noted above, trilobite fragments were observed in the matrices of the intraformational conglomerates, however, no attempt was made to identify them. The other fossils found by the writer are brachiopods and cephalopods. One of the cephalopods was identified by Rousseau H. Flower (personal communication,
letter, 1963) as Rossoceras lameliferum ams. sp. It was found within 2 feet of the upper contact. Cephalopods were also collected between 364 and 390 feet above the base.

Ross (1953, p. 23) placed the division between Lower and Middle Ordovician within the Garden City formation. He believed that the uppermost beds of the formation are of earliest Middle Ordovician age.

**Swan Peak formation**

The Swan Peak formation was named from Swan Peak in the Bear River Range, Utah (Richardson, 1913, p. 409). In the Logan quadrangle, the formation consists of three thin and persistent units. A typical occurrence is found at Green Canyon where the formation consists of the following: (1) a lower unit consisting of 174 feet of black shale with widely interspersed beds of sandy limestone, (2) a 28-foot thick middle unit composed of brown quartzite with fucoidal structures, and (3) an upper unit 137 feet thick consisting of thick-bedded light-gray quartzite with fucoidal markings. The total thickness is 339 feet (Williams, 1948, p. 1, 136). Ross (1953, p. 24) stated that the Swan Peak formation appears to thicken northward, northwestward, and southwestward from a central area near the southeastern corner of the Logan quadrangle. At Blacksmith Fork Canyon the upper quartzites are absent and the formation is represented by the basal beds of sandy limestone only (Williams, 1948, p. 1, 136). Ross (1953, p. 24) suggested that the thinning of the Swan Peak formation towards the southeast corner of the Logan
quadrangle may be due to conditions of original deposition rather than subsequent erosion.

The Swan Peak formation was measured on the west side of South Canyon near the north end (SW 1/4 SW 1/4 sec. 34, T. 9 N., R. 1 E.). It overlies conspicuous ledges of the Garden City formation and underlies the equally prominent Fish Haven dolostone. Here the Swan Peak is 148 feet thick. The lower part consists of thin-bedded, very fine-grained quartzite and quartzitic sandstone interbedded with arenaceous shale. The formation becomes less quartzitic upward and greenish-gray and yellowish-orange shale predominate in the upper beds. The quartzite and quartzitic sandstone are pale red and dark yellowish orange in color. Cross sections of individual beds commonly show these colors alternating in irregular wavy bands. Bedding surfaces are irregular but fucoidal structures, where present, are inconspicuous.

The trilobite *Eleutherocentrus petersoni* Clark was found in abundance in the basal beds at one locality along with the brachiopod *Orthis swanensis* Ulrich and Cooper. These forms belong to faunal zone M of Ross (1949), which is the only zone he designated for the Swan Peak formation. According to Ross (1951, p. 23) the Swan Peak formation is earliest Middle Ordovician.

**Fish Haven dolostone**

The Fish Haven dolostone was named by Richardson (1913, p. 409-410) from Fish Haven Creek in the Bear River Range, Idaho. The formation consists of about 500 feet of dark-gray to blue-black dolostone with chert in
places, and it contains a Richmond fauna. The formation has a uniform thickness and lithology throughout the Logan quadrangle. The thickness at Green Canyon is about 140 feet (Williams, 1948, p. 1, 137).

The Fish Haven dolostone is readily located on the top of a hill on the west side of South Canyon near the north end (SW 1/4 SW 1/4 sec. 34, T. 9 N., R. 1 E.). The basal contact with the less resistant Swan Peak formation is well defined and the upper contact with the Laketown dolostone is fixed as explained below.

In the James Peak quadrangle, the Fish Haven dolostone is 153 feet thick and consists of medium- to thick-bedded medium-dark-gray fine-crystalline dolostone that weathers dark gray. Chert nodules are abundant in the basal 20 feet and again in the upper 54 feet. The chert is pale yellowish brown, very light gray, and dark gray in color, all weathering pale yellowish brown. Locally, chert predominate over dolomite.

Some workers in the region have encountered difficulty in determining the contact between the Fish Haven and Laketown dolostones and have therefore mapped these formations together. In the James Peak quadrangle the upper contact was placed at the top of the uppermost bed of dark-gray-weathering cherty dolostone. Above this point the beds are more characteristic of the Laketown, being medium gray in color and weathering medium light gray.

The Fish Haven dolostone is Cincinnatian in age (Richardson, 1913, p. 410; Williams, 1948, p. 1, 137). The following fossils were collected in the James Peak quadrangle: Columnaria, Catenipora, rugose corals,
brachiopods. The rugose corals and brachiopods are small and poorly preserved; no attempt was made to identify them. The rugose corals, however, are suggestive of Streptelasma.
SILURIAN SYSTEM

Laketown dolostone

The Laketown dolostone was named by Richardson (1913, p. 410) from Laketown Canyon in the Randolph quadrangle, Utah-Wyoming. He described the formation as about 1,000 feet of massive light-gray to whitish dolostone, with lenses of calcareous sandstone. The thickness at Green Canyon is 1,150 feet (Williams, 1948, p. 1,138).

The Laketown dolostone was examined on the ridge west of the upper part of Fourmile Canyon in the northwestern part of the James Peak quadrangle (SE 1/4 sec. 31, T. 9 N., R. 1 E.). The lower contact with the Fish Haven is exposed; the upper limit seems to be at a fault against the Water Canyon formation; however, it is thought that most, if not all, of the Laketown is present. Here the Laketown is 1,459 feet thick and consists of medium- to thick-bedded aphanitic- to fine-crystalline dolostone with some clastic dolostone beds in the upper half. The color ranges from light to dark gray and weathers lighter.

The lower third of the formation contains abundant chert nodules. These are generally in parallel alignment with the bedding. The chert nodules are medium gray, pale yellowish brown, and moderate yellowish brown in color.
Occasional beds of intraformational breccia occur between about 200 and 400 feet above the base of the formation. These consist of small fragments of dolostone enclosed in a similar matrix.

Nodules and stringers of light-gray chert and dolomitic chert occur between 524 and 649 feet above the base along with thin veins of quartz and vugs containing quartz crystals.

The clastic beds occur between about 209 and 400 feet below the top of the formation. They consist of medium- to very thick-bedded light-gray and medium-light-gray fine- to medium-grained poorly consolidated dolostone. The grains are angular and are cemented with dolomite.

Most of the fossils found in the Laketown dolostone in the James Peak quadrangle are poorly preserved and not subject to accurate identification. Crinoid stems and columnals occur throughout the formation. Small rugose corals are found at wide intervals in the lower portion. Fossil cavities are very abundant in beds between 822 and 1,250 feet above the base. Many of these are suggestive of pentameroid brachiopods. The writer identified the following: cephalopoda, Favosites, Syringopora.

Poorly preserved fossils are characteristic of the Laketown dolostone in the region. Consequently an accurate age determination for the formation has not been definitely established. The Roberts Mountain formation of Nevada, however, is correlative with part or all of the Laketown dolostone of Utah and contains a Niagaran fauna (Nolan, Merriam, and Williams, 1956, p. 37).
DEVONIAN SYSTEM

Water Canyon formation

The Water Canyon formation derives its name from a tributary of Green Canyon in the Bear River Range northeast of Logan, Utah (Williams, 1948, p. 1, 138-1, 139). Williams described two members in the formation which have recently been named by Taylor (1963, p. 9-10) as the lower Card member and the upper Grassy Flat member. The Card member consists of argillaceous dolostone that weathers light gray and intraformational breccia; the upper Grassy Flat member consists of calcareous sandstone, intraformational breccia, arenaceous dolostone, and argillaceous dolostone, all interbedded. The Card member is 251 feet thick in Logan Canyon and the Grassy Flat member ranges in thickness in northeastern Utah from 150 to 530 feet (Taylor, 1963, p. 9-22). The Water Canyon formation is 683 feet thick at Coldwater Canyon in Wellsville Mountain, about 5 miles southeast of Deweyville, Utah, and it thins to the east and south (Taylor, 1963, p. 25). It is about 400 feet thick near the mouth of Blacksmith Fork Canyon (Mullens and Izett, 1964, p. 3).

In the northwestern part of the James Peak quadrangle, a section of the Water Canyon is apparently faulted against the Laketown dolostone; however, it seems to underlie the Hyrum dolostone member of the Jefferson
formation. The outcrop is on the ridge west of the upper part of Fourmile Canyon (SW 1/4 NE 1/4 sec. 31, T. 9 N., R. 1 E.).

The measured thickness of the Water Canyon is 51 feet. This is abnormally thin in view of the 350 feet reported by Ezell (1953, p. 19) a short distance to the west near the southeast corner of Clay Valley. The measured section consists of light-gray-weathering dolostone and intraformational breccia and is considered to represent the Card member. The dolostone is predominantly medium light gray and aphanitic. Near the base it is medium bedded; higher in the section it is both medium bedded and laminated. Some of the laminations show cross-stratification. Intraformational breccia is found in the lower part of the section where it is interbedded with the laminated dolostones. This breccia consists of light-gray laminated dolostone imbedded in a matrix of similar composition.

The upper 5 feet of the section consists of one bed of breccia. It is composed of angular fragments of very light-gray dolostone and greenish-gray chert set in a pale-reddish-brown silty and calcareous matrix. A few beds of light-olive-gray chert, as much as 3 inches thick, are present just beneath the breccia.

The writer found no fossils within the Water Canyon formation of the James Peak quadrangle. This agrees with Taylor (1963, p. 28) who stated that the Card member is unfossiliferous. According to Taylor the fish fauna of the Water Canyon formation occurs within the basal 10 feet of the Grassy Flat member. The Water Canyon formation is Early Devonian in age (Williams, 1948, p. 1,138; Osmond, 1962, p. 2,049).
Jefferson formation

The Jefferson formation was named by Peale (1893, p. 26) for exposures in the vicinity of Three Forks, Montana. The formation is widespread in Idaho, western Wyoming, and northern Utah. In the Bear River Range, in the Logan quadrangle, the formation consists of two members which were named and described by Williams (1948, p. 1, 139-1, 141). They are: (1) the lower Hyrum dolostone member consisting chiefly of dark-gray dolostone and named for exposures in the mouth of Blacksmith Fork Canyon, and (2) the upper Beirdneau sandstone member consisting entirely of buff-weathering sandstone and named for exposures near the base of Beirdneau Peak. The contact between the members is gradational. At Beirdneau Peak, the Hyrum member is 1,108 feet thick and the Beirdneau member is 740 feet thick (Williams, 1948, p. 1, 140). The Jefferson formation ranges in thickness between 1,700 and 2,000 feet in the Bear River Range (Williams, 1958, p. 27-28).

The Jefferson formation is represented in the northwestern part of the James Peak quadrangle (NE 1/4 sec. 31, T. 9 N., R. 1 E.) by the basal part of the lower Hyrum member which overlies the Water Canyon formation. The Hyrum member ranges in thickness from about 50 to 150 feet in a short distance and the Beirdneau member is absent. The range in thickness is due to an unconformable contact with the Mississippian Lodgepole limestone. Ezell (1953, p. 18, 19-20) reported that the Jefferson formation is absent just west of the northwest corner of the James Peak quadrangle, but that it appears a
short distance to the south, on the west side of Sink Valley, where it is 950 feet thick. Here the Beirdneau member is present. This unconformity has been noted to the north and west at Mantua Valley, at Dry Lake, and in Wellsville Mountain (Williams, 1948, p. 1, 141). Rigby (1959, p. 211-212, 215) associated it with regional uplift, during Late Devonian time, which affected a large area in central and northeastern Utah. According to Rigby the Mantua area probably remained relatively high until Osagian time. He considered the uplifted area to be the source area of the Beirdneau sandstone (Rigby, 1959, p. 217).

The 150-foot thick section of Hyrum in the James Peak quadrangle consists predominantly of thick-bedded medium-gray and medium-dark-gray medium-crystalline dolostone. The basal 10 feet is composed of fine-crystalline dolostone containing nodules of pale-yellowish-brown chert. Sandy dolostone is common in the lower half of the section. The upper half of the section contains a few beds of medium-gray very fine-crystalline dolostone that weathers light gray.

The fossils found by the writer include several small solitary rugose corals and a few brachiopods. Most of these occur within the sandy dolostone beds. They are, however, poorly preserved and have not been identified.

Williams (1958, p. 27) reported the occurrence of the following fossils from the Jefferson formation in the Bear River Range: Tenticospirifer utahensis, Atrypa cf. A. missouriensis, and Favosites limitaris. These occur in the beds above a basal massive limestone intraformational breccia. These forms belong to the Spirifer argentarius zone of the Devils Gate
formation of Nevada (Merriam, 1940, p. 67-68) and indicate a Late Devonian age. Nolan, Merriam, and Williams (1956, p. 51) suggested that an arbitrary boundary between Middle and Upper Devonian strata could be placed below the *Spirifer argentarius* fauna in the Cordilleran area.
Lodgepole limestone

The Lodgepole limestone was named by Collier and Cathcart (1922, p. 173) from its exposure in Lodgepole Canyon in the Little Rocky Mountain region, Montana. There the Lodgepole is the lower formation of the Madison group. The upper formation of the Madison group is the Mission Canyon limestone. In northeastern Utah lower Mississippian rocks previously referred to as Madison limestone are currently recognized as Lodgepole limestone (Williams, 1958, p. 31; Sando, Dutro, and Gere, 1959, p. 2, 746). In the Bear River Range the Lodgepole is about 850 feet thick and consists of thin-bedded cherty limestone containing an abundance of fossils (Williams, 1958, p. 31). Along the western front of the Bear River Range, between Blacksmith Fork and East Canyon, the Lodgepole is only 500 feet thick (Mullens and Izett, 1964, p. 6-7). Exposures of this formation are commonly characterized by two prominent cliffs known locally as the "Lower Chinese Wall" and the "Upper Chinese Wall." The formation maintains a rather uniform thickness throughout the region.

In the northwest corner of the James Peak quadrangle, the Lodgepole limestone unconformably overlies the Hyrum member of the Jefferson formation due to regional uplift during Late Devonian time which affected a large area in central and northeastern Utah (Rigby, 1959, p. 211-212, 215-216).
In the east wall of Mantua Valley, about 2 miles west of the James Peak quadrangle, the Lodgepole limestone rests on the Silurian Laketown dolostone (Williams, 1948, p. 1, 141). Rigby (1959, p. 211) stated that the Mantua area probably remained relatively high until Osagean time.

The Leatham formation (Holland, 1952), which occurs at the base of the Mississippian system in the Bear River Range, was not recognized in the James Peak quadrangle. Furthermore, it is not present at Mantua and Dry Lake. The Leatham was separated from the lower part of the Lodgepole limestone at Leatham Hollow and described as 76 feet of shale, sandy shale, and nodular limestone (Holland, 1952, p. 1, 719). According to Rigby (1959, p. 211), the Leatham represents a gradation from the Beirdneau sandstone member of the Jefferson formation to the Lodgepole limestone. The presence of the Leatham should, therefore, not be expected in areas of the uplift where the Beirdneau is not present.

The Lodgepole limestone was measured at a locality immediately west of the James Peak quadrangle near the northwestern corner (SW 1/4 NE 1/4 sec. 30, T. 9 N., R. 1 E.). The section is only 209 feet thick. The lower part seems to be missing due to faulting; however, the upper part dips beneath the overlying Deseret formation. The Lodgepole consists chiefly of thin- to thick-bedded medium-dark-gray medium-crystalline limestone that weathers medium gray. Weathered surfaces show laminations. Some aphanitic and coarse-crystalline limestone occurs in the basal 50 feet. The upper 101 feet contain nodules and beds of grayish-black chert. The chert beds are as much as half a foot thick.
Fossils occur throughout the formation but are less abundant in the upper cherty beds. Some beds are highly fossiliferous but most beds contain relatively few or no fossils. The most abundant fossils are solitary rugose corals and high-spired gastropods. The writer identified the following:

**Brachiopoda**
- *Spirifer centronatus* Winchell

**Corals**
- Solitary rugose corals
  - *Syringopora*
  - *Lithostrotonella*

**Crinoid columnals**

**Gastropoda**
- Euomphalid gastropods
  - *Straparolus*
- High-spired gastropods
- Ovoid-shelled gastropod

Zeller (1957, p. 690, 693-694) identified two endothyroid foraminifera zones in the Lodgepole limestone at Blacksmith Fork Canyon. The lower, the *Granuliferella* zone, includes the lower and middle parts of the Lodgepole and is considered to be Kinderhookian in age. The upper, the *Plectogyra tumula* zone includes the upper part of the Lodgepole and is probably Osagean in age.

Sando and Dutro (1960, p. 121) tentatively proposed a coral zonation for the Madison (group and formation) and the Brazer dolostone in the northern Cordilleran region. The zones of the Lodgepole are as follows: Zone A, the lowermost, includes the lower 10 to 50 feet of the formation and is characterized by small solitary corals. Zone B, overlying zone A, is poorly fossiliferous and is characterized by "Amplexus." Zone C1 includes the middle and upper Lodgepole and contains representatives of *Vesiculophyllum*. 
Homalophyllites, Zaphrentites, and Rylstonia in addition to three colonial genera, Cleistopora, Michelinia, and Lithostrotionella. Cleistopora and Michelinia occur only in zone $C_1$. Lithostrotionella and Rylstonia are rarely found above zone $C_1$ in zone $C_2$. Zone $C_2$ was designated for the Brazer dolostone (Sando and Dutro, 1960, p. 121).

Zone $C_1$ of Sando and Dutro (1960) contains fossils belonging to the Cleistopora type fauna as delineated by Bowsher (1961, p. 960). Bowsher (1961, p. 961) stated that this fauna seems to be both Kinderhook and Osage in age. Sadlick (personal communication, letter, 1962) found Cleistopora about 20 feet above the base of the Lodgepole limestone on the northwest side of Wellsville Mountain, near Deweyville. He considered this occurrence as suggestive evidence that the Lodgepole of the Logan area is correlative to the upper part of the type Lodgepole and indicative of an upper Kinderhook and possibly lower Osage age. He stated also that the Lodgepole of the Logan, Utah, area correlates with the Gardison formation of the Tintic mining district (Morris and Lovering, 1961, p. 89-93).

Deseret formation

The Deseret formation was named by Gilluly (1932, p. 25) for exposures at the Deseret mine in Dry Canyon in the Oquirrh Mountains. He described it as 650 feet of cherty limestone with a thin black shale, phosphatic in part, at the base. In the East Tintic Mountains the Deseret consists of three members (Morris and Lovering, 1961, p. 94-95). They are: (1) the basal phosphatic shale member with a variable thickness up to 150 feet,
(2) the Tetro member, about 475 feet thick, and (3) the Uncle Joe member, 544 feet thick. The upper two members, composed of limestone, are not easily distinguished outside of the Tintic mining district (Morris and Lovering, 1961, p. 95). Rigby (1958, p. 45) considered the upper two units of the Pine Canyon formation of the Stansbury Mountains equivalent to the Deseret. The lower unit, about 450 feet thick, consists of sandstone, siltstone, and argillaceous limestone, and the upper unit, about 170 feet thick, consists of cherty limestone (Rigby, 1958, p. 44). The unit thicknesses were interpreted by the writer from Rigby's stratigraphic column (Rigby, 1958, p. 38, fig. 5).

The name Deseret has not heretofore been extended into the region of this report. The Deseret is however commonly correlated with the basal part of the Brazer formation (Sadlick, 1956, p. 71). The phosphatic horizon at the base of the Brazer formation in northeastern Utah has long been considered as the same phosphatic horizon occurring in the Oquirrh Mountains (Finch in Mansfield, 1927, p. 209; Girty in Gilluly, 1932, p. 26; Williams, 1939, p. 30; Cheney, 1957, p. 13). Sadlick (1955, p. 51) suggested that strata equivalent to the Deseret probably have been included in the Brazer or Madison formations in the area of Logan, Utah, based on the presence or absence of the phosphatic beds.

Based on the preceding and on the following considerations the writer applies the name Deseret to strata occurring in the James Peak quadrangle which overlie the Lodgepole limestone and underlie the Humbug formation:

(1) The use of the name Brazer should be restricted to the Mississippian dolostone sequence developed in the Crawford Mountains (Sando, Dutro, and
Gere, 1959, p. 2, 768). (2) The strata herein referred to as Deseret, exposed in the James Peak quadrangle, occur in the same stratigraphic position as the Deseret at its type locality. (3) As noted above, the Deseret is correlative with the basal part of the Brazer. (4) The strata herein described as Deseret closely resemble the Deseret equivalent described by Rigby (1958, p. 43-45) in the Stansbury Range.

The Deseret formation was measured at a point immediately west of the James Peak quadrangle and near the northwestern corner (NW 1/4 NE 1/4 sec. 30, T. 9 N., R. 1 E.). It is well exposed on the northwest side of a northeast-trending valley and clearly overlies the Lodgepole limestone and underlies the Humbug formation. The Deseret formation is 338 feet thick and is divisible into two units. The lower unit, 272 feet thick, is mainly covered and only a few beds are exposed near the top. The lithologic description is therefore based, for the most part, on float. Near the base the float is limited to small pieces but upward they increase in size. Siltstone is found throughout the unit and it appears to be the predominant rock type. It occurs in a variety of colors including pale red, pale red purple, medium bluish gray, and brownish gray. An appreciable amount of the float consists of grayish-black chert in small blocks about 2 to 3 inches thick. In the lower two-thirds of the unit weathered surfaces of the chert show minute bluish-white particles which are suggestive of phosphate. In the upper third the chert is marked by light-gray wavy laminations. The lower two-thirds of the unit also contains an abundance of grayish-orange sandstone and shale. The shale is colored similar to the siltstone. The upper third of the unit is
composed, in large part, of medium-dark-gray very fine-crystalline limestone. It occurs in beds about 6 inches thick alternating with beds about half an inch thick that weather out as thin irregular plates. The limestone of the thicker beds is silty and weathers light brownish gray. The thin beds weather pale red purple.

A single piece of phosphate rock was found at about 100 feet above the base of the unit. It consists of black ovules about 1 mm in diameter mixed with other unidentified particles in a layer about half an inch thick. One ovule is about 5 mm in diameter. The rock displays a bluish-white bloom on weathered surfaces. The ovulitic texture and the bluish-white bloom are evidence of phosphate. The term "ovule" as used herein applies to phosphatic pellets lacking a concentric structure as in ooids (Lowell, 1952, p. 5).

The upper unit of the Deseret, 66 feet thick, consists of dark-gray dense aphanitic limestone interbedded with grayish-black chert. The limestone weathers medium gray. It occurs in beds about 0.5 to 1.5 feet thick and the chert is in discontinuous beds about 0.05 to 1.0 feet thick. The unit stands out as a distinct marker between less resistant beds of the overlying Humbug formation and the underlying unit.

The Deseret formation is sparsely fossiliferous in the James Peak quadrangle. The upper cherty limestone unit contains numerous small crinoid stems. A few poorly preserved brachiopods were found in the lower unit.

Sadlick (1956, p. 66, table 1) considered the following brachiopods as guide fossils to the Deseret: Spirifer cf. Haydenensis, Leptaena analoga?, Spirifer cf. grimesi. He (Sadlick, 1955, p. 51) collected specimens of the
latter two at about 150 feet above the base of the Deseret in the Uinta Mountains and noted that both are typical Osagean forms. He concluded that the Deseret is entirely Osagean in age. Morris and Lovering (1961, p. 99) considered the Deseret to be no older than early Meramec in the East Tintic Mountains and therefore entirely Late Mississippian in age.

**Humbug formation**

The Humbug formation was named by Tower and Smith (1899, p. 625-626) for exposures in the vicinity of the Humbug mine in the East Tintic Mountains southeast of Eureka, Utah. In the East Tintic Mountains the Humbug consists of alternating quartzitic sandstone and limestone and also contains a few beds of shale and dolostone (Morris and Lovering, 1961, p. 104).

Unit 1 of the Brazer formation as used by Williams (1943, p. 596) and by Williams and Yolton (1945, p. 1, 145) in the Logan quadrangle has been tentatively correlated with the Humbug formation of the Oquirrh Mountains by Sadlick (1955, p. 51) and by Williams (1958, p. 33). Sadlick (1956, p. 74) recommended that the use of the name Brazer in the Logan quadrangle be abandoned and Sando, Dutro, and Gere (1959, p. 2, 768) recommended that the name Brazer be restricted to use in the Crawford Mountains.

The writer now applies the name Humbug to strata exposed in the James Peak quadrangle, overlying the Deseret formation and underlying the Great Blue limestone. Reasons for this usage are as follows: (1) the strata herein described as Humbug occur at the same stratigraphic position as unit 1
of the Brazer of Williams (1943, p. 596) and Williams and Yolton (1945, p. 1, 145), and (2) these strata are similar in lithology to unit 1 of the Brazer of Williams and Yolton (1945, p. 1, 145).

The Humbug formation was measured at a locality on the western margin of the James Peak quadrangle near the northwestern corner (SE 1/4 sec. 19, T. 9 N., R. 1 E.). The lower contact with the Deseret formation is reasonably well exposed and the upper contact with the overlying Great Blue formation is easily located; however, part of the middle section is obscured by a strike valley. The Humbug formation is 1,345 feet thick. Characteristic exposures consist of smooth slopes with little vegetation and with few beds exposed. The slopes are generally covered with platy and angular fragments as large as 6 inches in diameter along with occasional small- to medium-sized boulders. Various rock types, as described below, are represented by the fragments and an interbedded relationship of these rock types is interpreted.

The formation consists chiefly of calcareous siltstone, sandstone, and quartzite. All three occur throughout the formation; however, the calcareous siltstone is predominate in the lower half and the sandstone and quartzite are predominate in the upper half. The calcareous siltstone is mostly medium gray in color and weathers pale yellowish brown. The sandstone is mostly yellowish gray or pale yellowish brown in color and weathers moderate yellowish brown. The quartzite is mainly light gray and medium light gray in color and is fine to medium grained. Weathered surfaces on the quartzite are stained pale yellowish brown and light brown. The formation also contains a
minor amount of medium-dark-gray very fine-crystalline limestone that weathers medium gray. It occurs at wide intervals throughout the formation.

A unit consisting predominantly of thick-bedded light-gray fine- to medium-grained cross-bedded quartzite, 63 feet thick, occurs between 1,081 and 1,144 feet above the base of the formation.

Identifiable fossils are rare in the Humbug formation in the James Peak quadrangle. Fossil fragments are common in the calcareous siltstone. Brachiopod impressions are found in the siltstone near the base of the formation. A few thin beds of limestone containing an abundance of crinoid columnals along with bryozoan and a few small brachiopods are found in the upper half of the formation. A horn coral identified by the writer as *Ekvasophyllum inclinatum* Parks was found at about 1,050 feet above the base. *Lithostrotion* and *Triplophyllites* were collected at about 1,150 feet above the base.

The lowest coral zone designated by Parks (1951, p. 182) of the Brazer formation at Dry Lake and at Leatham Hollow is the *Ekvasophyllum inclinatum* zone. According to Parks, this zone occurs between 952 and 1,223 feet above the base of the formation at Leatham Hollow. The fauna of this zone includes: *Ekvasophyllum inclinatum* Parks, *Lithostrotionella* sp., *Triplophyllites* sp. B, and *Syringopora* spp. Sadlick (1956, p. 73) considered the basal 950 feet of Parks' Leatham Hollow section to be Humbug formation. *Ekvasophyllum inclinatum* and "*Spirifer*" aff. *S. bifurcatus* were designated as guide fossils to the Humbug formation by Sadlick (1956, p. 66).

The age of the Humbug formation is generally accepted as Iowan. Williams and Yolton (1945, p. 1,148) regarded unit 1 of the Dry Lake section
of the Brazer formation, herein taken as Humbug formation, as Iowan in age and probably equivalent to the Warsaw formation.

Great Blue limestone

The name Great Blue limestone was originally applied by Spurr (1895, p. 374-376) to about 5,000 feet of strata exposed in the Mercur mining district in the Oquirrh Mountains. Gilluly (1932, p. 7, 29-31) redefined the Great Blue limestone and distinguished the Manning Canyon shale within the upper fourth of Spurr's Great Blue limestone. Neither Spurr nor Gilluly designated a type locality. The name Great Blue does not apply to any particular geographic locality. Gilluly described the Great Blue limestone as consisting of three units as follows: (1) a lower limestone about 500 feet thick, (2) the Long Trail shale member, and (3) an upper limestone containing chert layers with an estimated thickness of 3,000 feet.

Sadlick (1955, p. 51) and Williams (1958, p. 33) tentatively correlated units 2, 3, and 4 of the Brazer formation as used by Williams (1943, p. 596) and by Williams and Yolton (1945, p. 1, 145) with the Great Blue limestone of the Oquirrh Mountains. Sando, Dutro, and Gere (1959, p. 2, 768) recommended that the term Brazer be restricted to the Crawford Mountains. The writer now applies the name Great Blue limestone to strata exposed in the James Peak quadrangle which overlie the Humbug formation and underlie strata suggestive of Manning Canyon shale. Justification for this usage is based largely upon whether the unit herein described as Great Blue is the same as the one exposed in the Logan quadrangle and tentatively correlated
with the Great Blue of the Oquirrh Mountains by Williams and by Sadlick.

The evidence is as follows: (1) both units occur at the same stratigraphic position, (2) the units are similar in lithology, and (3) the units are paleontologically similar.

The Great Blue limestone was studied near the northwestern corner of the James Peak quadrangle (SE 1/4 sec 19, T. 9 N., R. 1 E. to SW 1/4 sec. 20, T. 9 N., R. 1 E.). Here the lower 1,167 feet is well exposed, above the Humbug formation, on the southeastern side of a prominent hill. The upper part is covered by the Salt Lake formation. The Great Blue, at this locality, consists predominantly of medium- to thick-bedded medium-dark-gray medium-crystalline limestone which weathers medium gray. A single bed of pale-red silty limestone is found at about 50 feet above the base. A few beds of dark-yellowish-orange arenaceous limestone are interbedded with the medium-dark-gray limestone between about 300 and 350 feet above the base of the formation along with a few beds of pale-yellowish-brown silty limestone. Dark-gray aphanitic laminated limestone which weathers light gray occurs in thin beds between about 1,000 and 1,050 feet above the base. The laminations are due to parallel layers of very fine sand.

An occasional nodule of grayish-black chert is found in the middle third of the formation. These nodules increase in abundance in the upper third. Grayish-black chert is estimated to constitute close to 50 percent of the top 50 feet of the formation. It occurs both in nodules and in discontinuous beds up to about 8 inches in thickness.
Fossils are found throughout most of the Great Blue limestone in the James Peak quadrangle. The most common are horn corals. These are abundant in the lower third and again in the upper third. The following fossils from the northwest corner of the quadrangle were identified by the writer:

**Corals**
- *Turbophyllum multiconum* Parks
- *Faberophyllum occultum* Parks
- *Faberophyllum arenosum* Parks
- *Faberophyllum languidum* Parks
- *Faberophyllum pisgahense* Parks
- *Caninia*?
- *Lithostrotion*
- *Syringopora*
- *Triplophyllites*

**Brachiopoda**
- *Composita sulcata* Weller

**Gastropoda**

**Crinoid columnals**

Lithostrotion, Triplophyllites, and Faberophyllum occultum were collected near the base of the formation. Turbophyllum multiconum, Faberophyllum pisgahense, F. arenosum, and Composita sulcata were collected from the middle third. Faberophyllum languidum was found at about 1,000 feet above the base. Approximately the upper third of the formation contains large horn corals which were roughly identified in the field as Caninia. Syringopora occurs throughout the formation and is abundant in the upper 100 feet.

Two, possibly three, coral zones and one unnamed faunal zone of the Brazer limestone, herein taken as Great Blue, were recognized by Parks (1951, p. 182-183) at Dry Lake and at Leatham Hollow and may be represented by the assemblage noted above. These zones are in ascending order:
(1) *Faberophyllum occultum*–*F. arenosum* zone, (2) *Lithostrotion whitneyi–Faberophyllum leathamense* zone, (3) the unnamed zone, and (4) the *Caninia* zone.

Williams and Yolton (1945, p. 1, 148–1, 149) concluded that units 2 and 4 of the Brazer formation at Dry Lake are Iowan and Chesterian, respectively, and that the boundary lies within unit 3.
SUMMARY

Stratigraphic units of Paleozoic age in the James Peak quadrangle represent the Cambrian, Ordovician, Silurian, Devonian, and Mississippian periods. The Prospect Mountain quartzite, commonly called Brigham, seems to rest conformably on a thick section of reddish-purple and light-gray quartzites presumed to be of Precambrian age. It is succeeded by six Cambrian formations, all of which are widely recognized in northern Utah, in addition to the Pioche(?) which is here regarded as a separate formation overlying the basal quartzite. The total thickness of Cambrian formations in the James Peak quadrangle is 6,352 feet.

Three Ordovician formations, with a total thickness of 1,639 feet, are recognized. An unconformity of regional importance may separate two of these; however, an alternative explanation for the observed stratigraphic relations has been offered (Ross, 1953, p. 24). The Silurian period is represented by the Laketown dolostone which is 1,459 feet thick. The Water Canyon formation which normally overlies Laketown is apparently faulted against the latter in the northwestern part of the James Peak quadrangle. The Jefferson formation, also of Devonian age, is represented only by the lower-most part of the Hyrum member due to erosion associated with the regionally significant unconformity at the base of the overlying Lodgepole limestone of
Mississippian age. The Deseret formation rests on the Lodgepole and is overlain, in turn, by the Humbug and Great Blue formations, all of Mississippian age. The lower part of the Lodgepole seems to be cut out by a fault. Only the lower 1,167 feet of Great Blue is found, in the northwestern part of the quadrangle, because of cover by the Salt Lake formation of Tertiary age.
LITERATURE CITED


Section of Deseret formation, measured along crest of northeast-trending hill in NW 1/4 NE 1/4 sec. 30, T. 9 N., R. 1 E.

Humbug formation

Deseret formation

<table>
<thead>
<tr>
<th>Thickness (feet)</th>
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<td>65.7</td>
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</table>

1. Covered, a few beds of limestone exposed near top. Float is sparse near base and increases upward in size and abundance. Float consists mainly of siltstone mixed with shale, sandstone, chert, limestone, and rare phosphate rock. Siltstone and shale, usually hard and dense; colors include: pale red, pale red purple, medium bluish gray, brownish gray, grayish orange. Sandstone, grayish orange, very fine to fine grained. Chert, grayish black, in small blocks 2 to 3 inches thick, weathered surfaces of chert show minute bluish-white particles in lower two-thirds of unit and light-gray wavy laminations in upper third. Phosphate rock consists of black ovules about 1 mm in diameter mixed with other unidentified particles in a layer half an inch thick with bluish-white bloom on weathered surfaces. Upper third of unit is largely medium-dark-gray very fine-crystalline limestone in 6-inch beds alternating with beds half an inch thick. The latter weather out as thin irregular plates which are pale red purple in color. A few poorly preserved brachiopods and crinoid stems occur

<table>
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<tr>
<th>Thickness (feet)</th>
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<td>272.1</td>
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Total 337.8

Lodgepole limestone
Great Blue limestone

<table>
<thead>
<tr>
<th>Humbug formation</th>
<th>Thickness (feet)</th>
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<tr>
<td>4. Mostly covered, few outcrops. Lithology derived largely from float. Unit consists of sandstone, quartzite, siltstone, and limestone as follows: sandstone, yellowish gray, very fine grained, weathers dark yellowish brown, forms most of unit; quartzite, pale reddish brown and pale yellowish brown, medium grained, about 10 percent of unit; siltstone, sandy, moderate reddish brown, forms upper part of unit; limestone, dark gray, very fine crystalline, weathers medium gray, one bed observed. Fossils include crinoid stems and a rugose coral</td>
<td>201.2</td>
</tr>
<tr>
<td>3. Quartzite, light gray with light brown stain, fine to medium grained, beds 1.0 to 2.0 feet thick; prominent cross-bedding; includes a few beds of pale-yellowish-brown moderate-yellowish-brown-weathering sandstone</td>
<td>63.1</td>
</tr>
<tr>
<td>2. Covered slope, very few outcrops. Abundant float, in platy and angular fragments, as follows: sandstone, pale yellowish brown, very fine grained, weathers moderate yellowish brown; siltstone, light gray, weathers pale yellowish brown; quartzite, light gray with moderate reddish brown stain, medium grained. Float suggests that sandstone and siltstone are interbedded with subordinate amounts of quartzite. A few medium-dark-gray limestone beds occur in upper part of unit. These are very fine crystalline and medium to coarse crystalline and weather medium dark gray and medium gray, respectively. Some limestone beds are crinoidal and also contain brachiopods, bryozoans, and corals</td>
<td>883.4</td>
</tr>
</tbody>
</table>
Humbug formation (continued)

1. Covered, very few outcrops. Float includes the following:
siltstone, light gray and pale yellowish brown, weathers
dark yellowish orange; sandstone, light brownish
gray and moderate yellowish brown, very fine to fine
grained, weathers dark yellowish brown. Siltstones occur
at base of unit. Fossils include brachiopods and crinoid
stems

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<tr>
<th>Thickness (feet)</th>
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<tbody>
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<td>197.2</td>
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Total 1,344.9

Deseret formation