Geology of the Rendezvous Peak Area, Cache and Box Elder Counties, Utah

Robert L. Ezell
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GEOLOGY OF THE RENDEZVOUS PEAK AREA, CACHE AND FOX ELDER COUNTIES, UTAH

by

Robert L. Ezell

A thesis submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

Geology

UTAH STATE AGRICULTURAL COLLEGE
Logan, Utah

1953
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I am grateful to Dr. J. Stewart Williams and Dr. Clyde T. Hardy for their assistance both in the field work and in the preparation of this manuscript.

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Robert L. Ezell
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>General statement</td>
<td>1</td>
</tr>
<tr>
<td>Previous geologic work</td>
<td>4</td>
</tr>
<tr>
<td>Field work</td>
<td>4</td>
</tr>
<tr>
<td>Stratigraphic geology</td>
<td>5</td>
</tr>
<tr>
<td>General statement</td>
<td>5</td>
</tr>
<tr>
<td>Paleozoic rocks</td>
<td>7</td>
</tr>
<tr>
<td>Cambrian system</td>
<td>7</td>
</tr>
<tr>
<td>Brigham quartzite</td>
<td>7</td>
</tr>
<tr>
<td>Langston formation</td>
<td>7</td>
</tr>
<tr>
<td>Ute formation</td>
<td>8</td>
</tr>
<tr>
<td>Blacksmith dolomite</td>
<td>9</td>
</tr>
<tr>
<td>Bloomington formation</td>
<td>9</td>
</tr>
<tr>
<td>Nounan formation</td>
<td>12</td>
</tr>
<tr>
<td>St. Charles formation</td>
<td>12</td>
</tr>
<tr>
<td>Ordovician system</td>
<td>13</td>
</tr>
<tr>
<td>Garden City limestone</td>
<td>13</td>
</tr>
<tr>
<td>Swan Peak formation</td>
<td>14</td>
</tr>
<tr>
<td>Fish Haven dolomite</td>
<td>17</td>
</tr>
<tr>
<td>Silurian system</td>
<td>17</td>
</tr>
<tr>
<td>Laketown dolomite</td>
<td>17</td>
</tr>
<tr>
<td>Devonian system</td>
<td>18</td>
</tr>
<tr>
<td>General statement</td>
<td>18</td>
</tr>
<tr>
<td>Water Canyon formation</td>
<td>18</td>
</tr>
<tr>
<td>Jefferson formation</td>
<td>19</td>
</tr>
<tr>
<td>Mississippian system</td>
<td>20</td>
</tr>
<tr>
<td>Leatham formation</td>
<td>20</td>
</tr>
<tr>
<td>Madison formation</td>
<td>20</td>
</tr>
<tr>
<td>Brazer formation</td>
<td>21</td>
</tr>
<tr>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>Cenozoic rocks</td>
<td>21</td>
</tr>
<tr>
<td>Tertiary system</td>
<td>21</td>
</tr>
<tr>
<td>Tertiary boulders</td>
<td>21</td>
</tr>
<tr>
<td>Salt Lake group</td>
<td>22</td>
</tr>
<tr>
<td>Structural geology</td>
<td>25</td>
</tr>
<tr>
<td>Major structural features</td>
<td>25</td>
</tr>
<tr>
<td>Laramide structure</td>
<td>26</td>
</tr>
<tr>
<td>Basin and Range structure</td>
<td>26</td>
</tr>
<tr>
<td>Regional relationships</td>
<td>33</td>
</tr>
<tr>
<td>Physiographic geology</td>
<td>35</td>
</tr>
<tr>
<td>General statement</td>
<td>35</td>
</tr>
<tr>
<td>Erosion surfaces</td>
<td>37</td>
</tr>
<tr>
<td>General statement</td>
<td>37</td>
</tr>
<tr>
<td>Rendezvous Peak erosion surface</td>
<td>39</td>
</tr>
<tr>
<td>McKenzie Flat erosion surface</td>
<td>41</td>
</tr>
<tr>
<td>Sink valleys</td>
<td>42</td>
</tr>
<tr>
<td>Geologic history</td>
<td>44</td>
</tr>
<tr>
<td>Paleozoic events</td>
<td>44</td>
</tr>
<tr>
<td>Mesozoic events</td>
<td>45</td>
</tr>
<tr>
<td>Cenozoic events</td>
<td>45</td>
</tr>
<tr>
<td>Literature cited</td>
<td>47</td>
</tr>
<tr>
<td>Appendix</td>
<td>49</td>
</tr>
<tr>
<td>Index of stratigraphic sections</td>
<td>49</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table

1. Stratigraphic units ........................................ 6

LIST OF FIGURES

Figure

1. Index map of the Northern Wasatch Mountains showing location of area mapped ......... 2
2. Index map of the Rendezvous Peak area ........................................ 3
3. Schematic diagram showing structure of the Rendezvous Peak area ....................... 27

LIST OF PLATES

Plate

1. (A) Upper shale member of the Bloomington formation at mouth of Three-mile Canyon showing holes weathered in surface ........................................ 11
   (B) Oolites in the lower part of the Blacksmith dolomite .................................... 11
2. (A) Outcrop of Swan Peak formation east of Mantua ........................................ 15
   (B) Fucoids on quartzite bed of the Swan Peak formation ...................................... 15
3. Quartzite boulders and cobbles of Tertiary age near the crest of Rendezvous Peak .......... 23
4. West face of Rendezvous Peak showing north-south faults .................................. 29
5. North-south fault in spur extending into southern Sink Valley ............................... 30
6. East side of Mantua Valley showing numerous east-west faults ............................ 32
7. View of Rendezvous Peak from the north ......................................................... 40
8. View of Sink Valley from the east ........................................................................ 43
9. Geologic map of the Rendezvous Peak area, Utah
INTRODUCTION

General statement

This thesis presents the results of a geologic investigation of the Rendezvous Peak area, Cache and Box Elder Counties, Utah (Figure 1). The area lies between the Bear River Range on the east and the Northern Wasatch Mountains on the west (Figure 2). It is south of Cache Valley in which Logan, Utah, is located and north of Ogden Valley, east of the Wasatch Range near Ogden, Utah.

The Rendezvous Peak area is centrally located in a little known and critical area between the Logan Peak syncline in the Bear River Range and the more complex structures in the Wasatch Range. Rocks of all periods of the Paleozoic era except Pennsylvanian and Permian crop out in the Rendezvous Peak area. Rocks of Tertiary age overlap the Paleozoic rocks in the northeastern part of the mapped area. A conspicuous syncline in Paleozoic rocks, which plunges north-northeast, as well as many high-angle faults of Basin and Range are are found in the area. The high-angle faults trend mostly north-south as do the major faults of the Logan Quadrangle to the north (Williams, 1948, pl.1). Other high-angle faults in the Rendezvous Peak area trend east-west. One major fault, however, extends northeast-southwest. Two high-level erosion surfaces are recognized. The Rendezvous Peak erosion surface is found on the higher peaks of the area which are composed
Figure 1. Index map of the Northern Wasatch Mountains showing location of area mapped
Figure 2. Index map of the Rendezvous Peak area
of Paleozoic rocks. It slopes eastward toward the southern part of Cache Valley. The McKenzie Flat surface, which is lower than the Rendezvous Peak surface, truncates Tertiary and adjacent Paleozoic rocks in the northeastern part of the mapped area.

Previous geologic work

The earliest important geologic exploration in the general area was that of the 40th Parallel Survey led by King in 1867-1877. Hague, one of the members of the expedition, made a preliminary reconnaissance of Cache Valley (King, 1877, p. 408-409). At a later date Peale visited Cache Valley interpreting the valley as a syncline (1879, p. 605). Gilbert, in his monograph on Lake Bonneville, mentioned the Tertiary deposits in the southern part of Cache Valley and noted that they were derived from an older lake than Bonneville (1890, p. 99). Bailey studied the Tertiary formations of Cache Valley and noted their relationship to the major faults (1937, p. 500). Williams (1948) made reconnaissance studies of the mountains between Cache and Ogden Valleys while mapping the Logan Quadrangle.

Field work

The major part of the field work was completed in the summer and fall of 1952. Aerial photographs were used for field mapping and the data were plotted on a base map obtained from the United States Forest Service. No sections were measured because of poor exposures and structural complexity. An index to well-exposed sections in nearby areas is included in the appendix.
General statement

Paleozoic rocks, Cambrian to Mississippian in age, and a lesser thickness of overlapping Tertiary rocks, mostly Salt Lake group, comprise the stratigraphic section in the Rendezvous Peak area. The Brigham quartzite of Cambrian age, which appears in the southern part of the mapped area, is the oldest formation present although pre-Cambrian rocks crop out a short distance to the south beyond the limits of the mapped area. The youngest Paleozoic rocks crop out in the northeastern part of the area as a result of the northern dip on the east limb of the syncline in the Rendezvous Peak area. Limestone and dolomite are the predominant types of rocks in the Paleozoic succession; in addition, a small amount of sandstone and quartzite also occurs.

During Paleozoic time a great thickness of sediments accumulated in the Rendezvous Peak area. Nearly continuous deposition extended from Cambrian to Permian time. Several periods of emergence and erosion are indicated by unconformities in the Paleozoic succession. These unconformities are discussed later. In early Mesozoic time thick beds of sandstone, limestone, and shale were deposited in northeastern Utah and probably in the Rendezvous Peak area (Williams, 1948, p. 1158). During late Mesozoic time the Rendezvous Peak area was elevated and erosion stripped the Mesozoic
Table 1. Stratigraphic units

<table>
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<th>Unit</th>
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</thead>
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</tr>
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</tr>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Blacksmith dol.</td>
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</tr>
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</tr>
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<td>Quartzite</td>
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</tr>
</tbody>
</table>

1. Not measured
2. Two lower members only
3. Included in Laketown dol.
sediments. Tertiary beds were then deposited on the surface of the Paleozoic rocks.

Paleozoic rocks

Cambrian system

Brigham quartzite. The Brigham quartzite crops out in the extreme southern part of the Rendezvous Peak area. It is a brown, green, cream, and pink, medium- to coarse-grained, thin- to medium-bedded quartzite and quartzite conglomerate. Worm burrows are common in the upper part of the section. The exposures are easily recognized from a distance as very little soil has developed on the quartzite and the outcrops are barren. The section is repeated approximately a half mile to the north as a result of an east-west fault. A complete section is not found within the limits of the mapped area although pre-Cambrian occurs a short distance to the south.

Hartley and Hatch measured a nearly complete section of Brigham a few miles to the northwest (1940, p. 811). This section is near Walcott's type section (1908, p. 8) and is 1775 feet thick. The age of the Brigham quartzite, according to Williams and Maxey, is Lower Cambrian (1941, p. 277).

Langston formation. The Langston formation, in the Rendezvous Peak area, is conformable with the Brigham quartzite and is about 400 feet thick along the South Fork of Little Bear River (Figure 2). The basal member of the Langston is the Ptarmigania limestone which consists of light-grey, medium-crystalline, massive, sandy limestone.
Some of the limestone is oolitic. The overlying member, the Spence shale, is an olive-brown, slightly calcareous shale. Above this is a thin unit of grey, finely-crystalline, thin- to medium-bedded limestone with some silty layers. The upper member is a light-grey, medium-crystalline, massive dolomite which weathers tan. The members of the Langston formation in the Rendezvous Peak area are similar to those in the Call's Fort section in the Lozan quadrangle described by Williams and Maxey (1941, p. 279).

The Langston formation crops out just north of the Brigham quartzite in the southern part of the Rendezvous Peak area and has also been repeated as a result of the east-west fault. The upper dolomite member is exposed in the west end of a small hill just south of the town of Mantua. The formation was originally named by Walcott (1908) at Blacksmith Fork Canyon, about 10 miles northeast of the Rendezvous Peak area.

**Ute formation.** The Ute formation conformably overlies the Langston formation and is found in the same areas as the Langston. It consists of alternate beds of blue-grey, thin-bedded, limestone and greenish-brown shales. Much of the limestone is oolitic, stromatolitic, sandy, and silty with layers of the clastic material weathering into relief. The formation is about 600 feet thick in the low hills just south of Mantua. The Ute formation was named by Walcott (1908), the type locality being in Blacksmith Fork Canyon.
Blacksmith dolomite. The Blacksmith dolomite, conformable with the Ute formation, is a neutral- to dark-grey, fine- to medium-crystalline, massive dolomite and dolomitic limestone. Oolites are common (Plate 1). The Blacksmith is overlain discomformably by the Bloomington formation. Both the Ute and Bloomington formations are shaley and weather to smooth slopes. The Blacksmith stands out between these two formations as massive, resistant ledges. The thickness, measured in the low hills just south of Mantua, is about 875 feet.

The Blacksmith crops out just north of the Langston formation in the southern part of the Rendezvous Peak area. It has been repeated as a result of the major east-west fault in this area and crops out again just south of Three-mile Canyon (Figure 2). It also appears in the low hills just south of Mantua Valley.

Bloomington formation. The Bloomington formation crops out on both sides of Three-mile Canyon and in the low hills south of Mantua. It is composed of two limestone and two shale members. Part of the limestone is oolitic. The percentage of oolites is smaller in this formation than in the preceding Ute and Blacksmith formations. The formation is approximately 2100 feet thick, measured at the mouth of Three-mile Canyon.

The basal member of the Bloomington formation in the Rendezvous Peak area is the Hodges shale, an olive-green shale with some interbedded layers of thin-bedded, dark-grey, finely-crystalline limestone. A thin-bedded, dark-
to light-grey, finely crystalline limestone with thin layers of interbedded siltstone and shale lies above the Hodges shale. A second shale member occurs above this limestone member. This shale member, thinner than the Hodges shale, is olive-green in color and contains a small amount of interbedded limestone and limestone nodules. The nodules weather out leaving holes in the surface (Plate 1). Maxey described a similar feature in this shale at the Call's Fort Section (1941, p. 19). The upper member of the Bloomington formation is a dark grey, fine- to medium-crystalline, thin- to medium-bedded limestone and silty limestone with a small amount of interbedded siltstone and shale. Bands of light brown silt stand out in relief in the silty limestone. The upper limestone member forms most of the north side of Three-mile Canyon. The canyon bottom and part of the south side is underlain by the upper shale member. This upper shale member is well exposed at the mouth of Three-mile Canyon and can be easily recognized by the numerous holes in the weathered surfaces. The lower limestone member and the Hodges shale member crop out in road cuts along the South Fork of Little Bear River south of Three-mile Canyon.

The Bloomington formation was named by Walcott (1908) and the type locality is near Bloomington, Idaho. The upper limestone member of the formation has been correlated with the Montana Park Shale of Albertan time (Williams and Maxey, 1941, p. 284).
Plate 1. (A) Upper shale member of the Bloomington formation at mouth of Three-mile Canyon showing holes weathered in surface

Plate 1. (B) Oolites in the lower part of the Blacksmith dolomite
Nounan formation. The major part of the Nounan formation is a light grey, finely-crystalline, thin- to medium-bedded dolomite that appears sandy on weathered surfaces. A small amount of light and dark grey, finely-crystalline, thin- to medium-bedded limestone occurs near the top of the unit. This formation is conformable with the Bloomington formation and is about 900 feet thick just north of Three-mile Canyon along the South Fork of Little Bear River.

The Nounan formation is exposed near the top of the south slope of Rendezvous Peak and extends east to the South Fork of Little Bear River. It is also exposed south of Mantua along Box Elder Creek Valley. The type locality of the Nounan formation, named by Walcott (1908), is near the town of Nounan, Idaho.

St. Charles formation. The St. Charles formation in the Rendezvous Peak area consists of a basal quartzite member overlain by a limestone member which is in turn overlain by a dolomite member. The Worm Creek quartzite (Richardson, 1913, p. 408) is the basal member. This quartzite is a light-brown, fine- to medium-grained, medium-bedded orthoquartzite. The average thickness, measured one and a half miles up Three-mile Canyon on the north side, is 15 feet. The thickness varies greatly in the surrounding region. Maxey measured six feet at Call's Fort, approximately seven miles to the northwest (1941, p. 17). Williams measured 75 feet on High Creek, north of Logan, Utah, in the Bear River Range (1948, p. 1135). Richardson, in the Randolph quadrangle, measured 400 feet (1941, p. 13). The middle member of the
St. Charles formation is composed of dark- and light-grey, thin-bedded limestones and dolomites. Some of the beds are silty and sandy. The upper member is dark-grey, massive, cherty dolomites. The total thickness of the St. Charles formation measured just north of Three-mile Canyon along the South Fork of Little Bear River is about 1075 feet. The St. Charles type section was described by Walcott (1908) in Bear Lake County, Idaho.

In the Rendezvous Peak area the St. Charles formation can be seen running from Sink Valley diagonally up the west side of Rendezvous Peak and then along the ridge from the peak to the South Fork of the Little Bear River. It also crops out along the north side of Box Elder Creek.

Ordovician system

Garden City limestone. The Garden City limestone, in northeastern Utah, has been divided lithologically into a lower section composed predominately of intraformational limestone conglomerate and an upper section composed of very cherty limestone (Ross, 1951, p. 7). This division is also found in the Rendezvous Peak area. Here the lower part of the formation is a blue-grey, finely-crystalline, thin-bedded limestone and limestone conglomerate. The lower part of the formation contains some interbedded olive-green shale. The upper part of the Garden City limestone is a blue-grey, finely-crystalline, thin-bedded, cherty limestone. The beds in the Garden City limestone thicken and wedge out in short distances making it difficult to correlate beds.
over a very extensive region (Ross, 1951, p. 7). The Garden City lies unconformably above the St. Charles formation and is approximately 1475 feet thick along the South Fork of Little Bear River.

The formation was named by Richardson in 1913 and the type section is located near Garden City, Utah (1913, p. 100). Ross, as a result of faunal studies, concluded that the age of the lower Garden City is Canadian and the upper 30-50 feet of the Garden City is Champlainian (1951, p. 32).

The Garden City formation is exposed in the lower part of the east side of Mantua Valley and extends south along Box Elder Creek. It crops out through the alluvium in several places between Devil's Gate and Sink Valleys (Figure 2). The Garden City also crops out along the north flank of Rendezvous Peak.

**Swan Peak formation.** The Swan Peak formation, consisting of three members, is a thin but conspicuous unit in the Paleozoic succession of the Rendezvous Peak area. The lower member is a black fuscous shale with some interbedded dark-grey, finely-crystalline, thin-bedded limestone. The middle member is a light-brown, fine-grained, thin-bedded fusoidal quartzite with thin beds of grey shale between some of the quartzite beds. Above this is a light-grey, fine-grained, medium- to thick-bedded fusoidal quartzite. The fusoidal nature of the quartzites in the Swan Peak formation effectively sets them apart from all other quartzites in the region (Plate 2).
Plate 2. (A) Outcrop of Swan Peak formation east of Mantua. The quartzite beds stand out as resistant ledges. The basal shale members is beneath the cover in foreground.

Plate 2. (B) Fucoids on quartzite bed of the Swan Peak formation.
The lower shale member of the Swan Peak has been placed in the upper Garden City limestone by workers prior to 1948 (Ross, 1951, p. 10). Ulrich and Cooper obtained part of their fossil collection from a location in this shale member between Mantua Valley and Clay Valley (1938, p. 118, 129, 130, 150). They placed this member in the Canadian series. Later research by Williams (1948, p. 1136), substantiated by faunal studies by Ross (1951, p. 10), proved this to be Champlainian.

A major unconformity exists between the Swan Peak formation and the overlying Fish Haven dolomite in the Rendezvous Peak area. As a result, the Swan Peak formation varies greatly in thickness. All three members crop out on the slopes east of Mantua Valley and are well exposed in road cuts. The formation is about 200 feet thick in this locality. Most of the upper quartzite member is missing in the exposure on the south side of the ridge between Sink Valley and Devil's Gate Valley (Figure 2). Here the thickness is about 150 feet. North of Rendezvous Peak the formation consists of only the basal shale and a small amount of brown quartzite. Further east in the vicinity of the South Fork of the Little Bear River only the basal shale crops out. The Swan Peak is about 50 feet thick at this point.

Ross believes the Swan Peak formation is part of the Champlainian series (1951, p. 32). It lies conformably on the Garden City. An unconformity exists between the Swan Peak and the overlying Fish Haven dolomite of Cincinnati age.
Fish Haven dolomite. The Fish Haven dolomite of the Rendezvous Peak area is a dark-grey, thick-bedded, medium-crystalline, cherty dolomite. It is Cincinnatian in age, lies unconformably on the Swan Peak formation. The Fish Haven dolomite and the Laketown dolomite of Silurian age have been mapped and measured together because of difficulty of separating the two units. Location of exposures will be described in conjunction with the Laketown dolomite. The Fish Haven dolomite was named by Richardson and the type locality is near Bear Lake, Idaho. Richardson considered the age to be Cincinnatian (1913, p. 410).

Laketown dolomite. The Laketown dolomite is a light and dark grey, medium- to coarsely-crystalline, thin-bedded to massive, wavy dolomite. Much nodular chert is found in the formation. Dolomitization has destroyed all but a few fossils preserved by silicification. Corals, stromatoporoids, and poorly preserved brachiopods were all that were observed.

Much of the north slope of Rendezvous Peak is underlain by this formation. It also crops out around three sides of Clay Valley and in the higher slopes along the east side of Box Elder Creek. The thickness of the Laketown dolomite and the Fish Haven dolomite, measured together just east of Mantua, is approximately 1250 feet.

The dolomite was originally named by Richardson in the Randolph quadrangle (1913, p. 410). Williams, on the basis
of faunal correlation, determined the age of the dolomite as Niagaran (1948, p. 1137). This age requires a hiatus of considerable extent, both above and below the formation.

**Devonian system**

**General statement.** An unconformity exists between the Devonian and Mississippian rocks in the Rendezvous Peak area. The Laketown dolomite of Silurian age is overlain by the Madison formation of Mississippian age along the east side of Mantua Valley; no Devonian rocks being present (Plate 6). The Water Canyon formation of Lower Devonian age first appears in the upthrown block east of the fault near the northeast corner of Clay Valley. Here it is overlain by the Madison limestone. A short distance to the south the lower Hyrum dolomite member of the Jefferson formation of Devonian age appears in the section above the Water Canyon. The Hyrum dolomite thickens rapidly to the south. The Beirdneau sandstone, the upper member of the Jefferson formation, appears in the section further south along the west wall of Sink Valley. Thus it is apparent that this unconformity was of great magnitude and brought rocks of widely different ages into contact in relatively short distances.

**Water Canyon formation.** This formation is composed of light-grey, finely-crystalline, thin-bedded dolomite and light-brown, fine-grained, thin-bedded sandstones and quartzites. The dolomite is sandy and silty in places and often weathers to a white sandy appearing surface. Fish
fauna taken from this formation in Blacksmith Fork Canyon are lower Devonian in age (Williams, 1948, p. 1139).

The formation, as is mentioned above, appears in the section near the northeast corner of Clay Valley and is found in all of the Devonian outcrops. The thickness of the Water Canyon formation near the southeast corner of Clay Valley is approximately 350 feet.

**Jefferson formation.** The Jefferson formation consists of two members, the lower Kyrum dolomite and the upper Beirdneau sandstone. The Kyrum dolomite is composed of light- and dark-grey, finely-crystalline, thin-bedded to massive dolomite with scattered beds of black and dark-grey limestone and olive-brown, fine- to medium-grained sandstone. Some of the dolomite is sandy. The contact between the Beirdneau sandstone and the Kyrum dolomite is gradational. The Beirdneau sandstone is composed of light- and olive-brown, fine-grained, thin-bedded sandstone with some quartzite.

The Jefferson formation appears in the section below the unconformity between Devonian and Mississippian rocks shortly after the Water Canyon formation appears. It thickens to several hundred feet in approximately one mile. The Jefferson crops out along the east side of Clay Valley and the west side of Sink Valley. Only the Kyrum dolomite is exposed east of Clay Valley. The Beirdneau sandstone appears beneath the unconformity between the Devonian and Mississippian rock further to the south along the edge of
Sink Valley. Here the Jefferson formation is about 950 feet thick. The Jefferson lies unconformably on the Water Canyon formation.

**Mississippian System**

**Leatham Formation.** The Mississippian rocks in the Logan, Utah area have recently been restudied by Holland, Jr. (1952). Sections were measured at Leatham Hollow, about three miles east of the Rendezvous Peak area. The Leatham formation was named and found to correlate both faunally and lithologically with the Sappington sandstone which underlies the Madison formation at the type locality in Montana (Holland, Jr., 1952, p. 1720-1723). The Leatham formation which lies unconformably above the Jefferson formation is Kinderhookian in age. It is 76 feet thick at the type section and is composed of shale, sandy shale and nodular limestone (Holland, Jr., 1952, p. 1710).

**Madison formation.** The Madison formation in the Rendezvous Peak area, conformable with the Leatham formation, is a blue-grey, crystalline, thin- to medium-bedded, cherty, fossiliferous limestone. To the north, in the Bear River Range, the basal member is a thin shale (Williams, 1948, p. 1141) (Holland, Jr., 1952, p. 1723), but this was not found in the area covered by this paper. The formation is about 800 feet thick just east of Clay Valley. The Madison has been placed in the Kinderhookian series (Holland, Jr., 1952, p. 1722).

The Madison limestone extends continuously northward into the Logan quadrangle along the east side of Mantua.
Valley. It is exposed in the northwest corner of Sink Valley and in the ridge that extends out into the center of the valley. It also appears in the northeastern part of the Rendezvous Peak area where it is overlapped by Tertiary Salt Lake group rocks.

Brazer formation. The Brazer formation crops out along the northern border of the Rendezvous Peak area. The base of the formation lies within the limits of the mapped area but most of the upper members crop out north of the mapped area in the Loran quadrangle. The basal phosphatic shale member found in other areas (Williams, 1948, p. 1142) is not present at this locality. This member is also absent in the Pisgah Hills a few miles north (Williams and Yolton, 1945, p. 1147) and in Leatham Hollow about three miles to the east (Holland, Jr., 1952, p. 1727). The basal member, cropping out in the northern part of the Rendezvous Peak area, is a grey-brown, fine-grained, thin-bedded sandstone with a small amount of interbedded limestone. Above this is a dark-grey, thick-bedded limestone which extends to the northern boundary of the Rendezvous Peak area. The thickness of the two members cropping out within the limits of the Rendezvous Peak area is about 1250 feet.

Cenozoic rocks

Tertiary system

Tertiary boulders. Parts of the Rendezvous Peak area are covered with quartzite boulders and cobbles. The boulders and cobbles are composed of Brigham quartzite.
and possibly a small amount of pre-Cambrian quartzites. The boulders and cobbles are found on the top of Rendezvous Peak (Plate 3) as well as on several other high peaks in the area. They are also found in scattered localities on the lower slopes. Extensive Brigham quartzite and pre-Cambrian outcrops to the south and east of the Rendezvous Peak area provided the source material for the quartzite boulders and cobbles which were deposited on the high-level erosion surface. The boulder and cobble deposits must have been laid down early in the history of the Rendezvous Peak area, before dissection of the high-level erosion surface, to occur on the crest of Rendezvous Peak. The age of this boulder and cobble deposit, determined by the relationship of the deposit to the low- and high-level erosion surfaces, must be pre-Salt Lake group. This relationship will be discussed later in this paper in conjunction with the two erosion surfaces. The thickness of the boulder and cobble deposit could not be determined.

**Salt Lake group.** The Salt Lake group, crops out in the northeastern corner of the mapped area and is composed of oolitic limestone, tuff, marl, and well rounded fragments derived from earlier formations and cemented with calcium carbonate. The Salt Lake group in the Rendezvous Peak area, except for detrital material derived from early formations, is white. The fragments are composed of limestone and some sandstone.

The Salt Lake group in Cache Valley has been divided into three formations: (1) the basal Collinston conglomerate,
Plate 3. Quartzite boulders and cobbles of Tertiary age near the crest of Rendezvous Peak
(2) the West Spring formation, and (3) the Cache Valley formation (Williams, unpublished). Only the conglomerate facies of the Cache Valley formation crop out in the Rendezvous Peak area. This conglomerate facies, described above, was laid down by stream action along the margins of an early lake in Cache Valley. Yen (1947) determined the age of the upper Salt Lake group to be Miocene from a study of fossil mollusks from the Cache Valley formation. Brown (1949), on the basis of fossil plants collected on Hyrum Bench, approximately six miles north of the Rendezvous Peak area, believes the age of the Salt Lake group to be late Pliocene. The thickness of this formation was not determined as the greater part of it is covered by soil and alluvium.
Major structural features

The Rendezvous Peak area lies between the major folds of the Bear River Range to the east and the more complex structure in the Wasatch Mountains to the west. This region was folded and thrust faulted during the Laramide orogeny. Several major north-south trending folds as well as at least one eastward overthrust are found in the Bear River Range northeast of the Rendezvous Peak area (Williams, 1948). Wellsville Mountain, northwest of the Rendezvous Peak area, is a homocline with a strike of N. 30° W. and a dip of 30° northeast (Williams, 1948, p. 1140). The Wasatch Mountains, south of the area studied, contain folds which trend similar to those of the Bear River Range as well as folds with east-west trends (Bardley, 1944). Three major overthrusts have been mapped in this area (Bardley, 1944). Lansfield, in southeastern Idaho, has also mapped folds of Laramide age as well as a major overthrust (Lansfield, 1927). Richardson (1941) traced the overthrust mapped by Lansfield south into Randolph Quadrangle (Figure 1). In the Rendezvous Peak area the Laramide stresses folded the Paleozoic rocks and formed a northeast trending syncline in the central part of the area.

Faulting of Basin and Range age has followed the Laramide folding in the Rendezvous Peak area and surrounding...
region. The Wasatch Mountains (Figure 1) are bounded on
the west by the Wasatch fault zone. This fault zone extends
north almost to the Idaho-Utah State Line. Cache Valley,
just north of the Rendezvous Peak area, is bordered by
north-south trending faults of this area (Williams, 1940).
The faults of greatest displacement in the Rendezvous Peak
area have approximately the same trend as the Cache Valley
boundary faults and may be southern extensions of several
of these faults. Faults with an east-west trend are also
common in Rendezvous Peak area.

Laramide structure

An east-northeast trending syncline in the Paleozoic
rocks in the central part of the Rendezvous Peak area
plunges 40 degrees to the northeast. The syncline disappears
beneath rocks of the Salt Lake group of Tertiary age at
the southern end of Cache Valley. Paleozoic rocks on the
southeast limb of the syncline have a strike of N. 75° W.
and a dip of 35° to 55° northeast. On the northwest limb
of the syncline the Paleozoic rocks strike N. 30° W. and
dip 30° to 50° east.

Basin and Range structures

The Rendezvous Peak area is cut by a number of high-
angle faults of Basin and Range age. The faults trend in
three major directions, north-south, east-west, and
northeast-southwest. These faults are shown diagramatically
in figure 3.
Figure 3. Schematic diagram showing structure of the Rendezvous Peak area.
The north-south trending faults are oriented in the same general direction as the major Basin and Range faults along the margins of Cache Valley (Williams, 1948, p. 1). The four major faults of the north-south group are located in the immediate vicinity of Sink Valley and Rendezvous Peak. The westernmost of the four faults cuts the spur extending into the west side of Sink Valley (Plate 5). This fault, downthrown on the east, is exposed for only a short distance and disappears to the north beneath a cover of Tertiary boulders. Another north-south fault occurs east of the above fault, near the eastern margin of Sink Valley. Undifferentiated Fish Haven and Laketown dolomite oppose the Swan Peak formation across this fault at the northern edge of Sink Valley, the apparent stratigraphic displacement at this point being about 1500 feet. The downthrown block of this fault is on the west. The lower west face of Rendezvous Peak is cut by another fault in the group (Plate 4). This fault, downthrown on the west, brings the Garden City formation in fault contact with the Bloomington and Nounan formations. The stratigraphic displacement is approximately 1500 feet. The easternmost major fault in this set is just east of the crest of Rendezvous Peak (Plate 4). This fault is downthrown on the west near Rendezvous Peak and on the east further north. The stratigraphic displacement in the vicinity of Rendezvous Peak is 500 to 700 feet. Other faults of less displacement with this same trend are found in the area mapped and
Plate 4. West face of Rendezvous Peak showing north-south faults: C, Cambrian; O, Ordovician; S, Silurian; D, Devonian; Tb, Tertiary boulders.
Plate 5. North-south fault in spur extending into southern Sink Valley: D, Devonian; M, Mississippian; Tb, Tertiary boulders
are shown on plate 9 and figure 3.

A major east-west trending fault is located approximately a half mile south of Mantua Valley (Plate 6) and extends eastward from Box Elder Creek to the divide between Sink and Clay valleys, where it disappears beneath a cover of Tertiary boulders. This fault brings the Swan Peak formation of Ordovician age into fault contact with the Wounan formation of Cambrian age near the southeast corner of Mantua Valley. The stratigraphic displacement at this place is approximately 1900 feet. Another fault of this same general trend is found near the southeast corner of the mapped area. This fault has resulted in a repetition of the Brigham quartzite, Langston formation, Blacksmith dolomite, and Bloomington formation. Several other faults of this general trend, but of smaller displacement, are shown on plate 9 and figure 3.

A major northeast-southwest fault runs along the southeastern margin of Clay Valley and disappears to the northeast beneath Salt Lake group rocks of Tertiary age. This fault, downthrown on the south, brings undifferentiated Fish Haven and Laketown dolomite in faulted contact with the Water Canyon and Jefferson formations in the southeast corner of Clay Valley. The stratigraphic displacement at this point is approximately 2000 feet. No indication of a continuation of the major north-south trending faults in the area was found north of this fault. All faulting in the area is believed to have occurred at about the same time.
Plate 6. East side of Mantua Valley showing numerous east-west faults. Note Devonian rocks appearing above Silurian in right hand side of plate. No Devonian rocks occur above Silurian on left hand side of plate. C, Cambrian; O, Ordovician; S, Silurian; D, Devonian; M, Mississippian
The faults in the Rendezvous Peak area appear to be the same age as those along the margins of Cache Valley and do not seem to be related to the Laramide folding. Cache Valley was downfaulted before the deposition of the Salt Lake group, although some faults have had later movement deforming the Salt Lake group rocks (Williams, unpublished). Therefore, the Basin and Range faulting in the Rendezvous Peak area is probably largely pre-Salt Lake group in age. Recurrent movement and the formation of new faults have occurred to a small extent in the region in Post-Salt Lake group time.

Regional relationships

The Rendezvous Peak area is located in a region characterized by many thrusts. South, in the Ochre area, Hardley has mapped three thrusts. The Willard thrust, the uppermost of the three, crops out just a few miles to the southeast of the mapped area (Hardley, 1944, fig. 3, p. 220). A large overthrust along the west face of the Bear River Range adjacent to Cache Valley is believed to exist by Williams (1949, p. 1149). He thinks that the unusually steep dips along the west face of the syncline in the Bear River Range have been caused by the drag of this large eastward thrust and that subsequent erosion has removed the overriding block. The trace of the fault would be buried beneath the alluvium of Cache Valley (Williams, unpublished). Williams also believes that Wellsville Mountain is part of another large eastward overthrust block. The entire Rendezvous Peak area might have been thrust eastward if the
overthrusting postulated by Williams exists. The syncline in the Rendezvous Peak area could easily have resulted from such forces of thrusting, although it may have been formed during the period of east-west folding which followed the Willard thrusting in the Ogden area (Eardley, 1944, p. 855). This folding formed an anticline in the Ogden Canyon area which closely parallels the syncline in the Rendezvous Peak area.

The relationship of the Basin and Range faults in the Rendezvous Peak area to those along the margins of Cache Valley has already been mentioned. East of the mapped area, between the South Fork and the Southeast Fork of the Little Bear River (Figure 2), several large north-south trending faults offset the Paleozoic rocks north. East of the Southeast Fork, the southern continuation of the East Cache Fault, the eastern boundary fault of Cache Valley (Williams, 1949, p. 1154), brings early Paleozoic rocks east of the fault in contact with late Paleozoic rocks west of the fault. This fault is just west of the axis of the Logan Peak syncline (Williams, 1949, p. 1148).
General statement

The Rendezvous Peak area is located in the Basin and Range physiographic province which is characterized by high-angle faults of early Tertiary-Recent age. Two different interpretations, however, exist as to the exact location of the boundary between the Basin and Range province and the Middle Rocky Mountain province. Penneman, in Physiography of the Western United States, emphasizes alluvium-filled valleys, bordered by high angle faults, as the primary Basin and Range feature. He places the boundary between the two provinces along the eastern margin of the easternmost alluvium-filled valley bordered by high-angle faults (Penneman, 1931, in Pocket). This would place the boundary between the provinces along the faults bordering Cache Valley. Most of the Rendezvous Peak area would be in the Middle Rocky Mountain province if this definition were followed. Nolan believes that the boundaries of the Basin and Range province should be extended to include all areas characterized by Basin and Range faults. He does not believe that alluvium-filled valleys are the most essential criterion (Nolan, 1943). This allows the Basin and Range boundary to be extended east and to include most of the Bear River Range. Nolan's boundary places the Rendezvous Peak area completely in the Basin and Range
province.

The Rendezvous Peak area includes part of the mountains which form the southern border of Cache Valley and a small part of the valley itself. The area can be sub-divided into two major topographic units. The smaller northeastern unit is underlain by rocks of the Salt Lake group of Tertiary age and a lesser area of Paleozoic rocks. This unit has a low relief and is at a lower elevation than the larger unit, situated to the south and west of the northeastern unit. The larger unit is underlain by rocks of Paleozoic age and is characterized by greater relief at higher altitudes than the smaller unit. Remnants of the Rendezvous Peak erosion surface (Williams, 1940, p. 1160) are found on several of the high peaks in the larger topographic unit. The surface of the lower unit is a dissected pediment of low relief, the McKenzie Flat erosion surface of Williams (1940, p. 1155).

Several valleys in the Rendezvous Peak area are structurally controlled. Three-mile Canyon is controlled by the strike of the beds of the Bloomington formation of Cambrian age and trends east-west. A valley has been developed along the northeast-southwest trending fault extending through southern Clay Valley. This valley extends both east and west of Clay Valley following the fault.

Drainage in the Rendezvous Peak area is primarily intermittent. The major streams in the area are Box Elder Creek and the South Fork of the Little Bear River. Both
of these streams are perennial in the lower parts. Mantua Valley contains several small perennial streams supplied by springs around the edge of the valley. Drainage in Sink Valley and in parts of Devil's Gate Valley is through sinks.

The land in the Rendezvous Peak area is used in part for range land and in part for farming. The higher mountainous land is used for sheep and cattle range in the summer months. The comparatively flat Hyrum Bench (Figure 2) in the southern end of Cache Valley is dry farmed. Several small valleys south of Mantua Valley also contain dry farms. Mantua Valley itself contains irrigated farms, water being supplied by large springs located in the valley.

Erosion surfaces

General statement. Two erosion surfaces occur within the limits of the Rendezvous Peak area. The earliest surface, the Rendezvous Peak erosion surface, has been almost completely destroyed by later erosion. Only a few scattered remnants remain. The younger surface, the McKenzie Flat erosion surface, is found at a lower elevation and has been eroded to the stage of maturity.

Several ideas exist as to the date of formation of high-level erosion surfaces in the region, and the relationship of these high-level surfaces to the Salt Lake group. Eardley (1944, p. 677) and Keller (1952, p. 30) believe that the high-level erosion surface in the areas which they mapped was formed after deposition of the Salt Lake group. Mansfield (1927, p. 359) and Williams (1946, p. 1160) believe
that the high-level surface in the areas which they mapped was formed before the Salt Lake group was deposited.

Hardley believes that the high-level Herd Mountain surface in the Ogden area is post-Norwood tuff (Salt Lake group). He thinks that this surface could not have persisted while the Norwood tuff was deformed if it were pre-Salt Lake group in age. Hardley states that deposition of the Norwood tuff occurred in very shallow synclines which existed at the present sites of Morgan and Ogden Valleys. These synclines, he believes, were accentuated by later folding which also folded the Norwood tuff (Hardley, 1944, p. 672). Keller, in his paper on the "Mink Creek" area, also believes that the folding in the Mink Creek formation (Salt Lake group) has been too intense for an erosion surface to survive. He accordingly dates the high-level erosion surface as post-Salt Lake group on this basis (Keller, 1952, p. 30).

Mansfield states that the high-level Snowdrift peneplain is pre-Salt Lake group in age (1927, p. 359) and implies that the post-Salt Lake group deformation was not great enough to destroy this peneplain. Williams recognizes a high-level surface in the Logan quadrangle which he correlates with Mansfield's Snowdrift peneplain and Herdley's Herd Mountain Surface (Williams, 1948, p. 1159). Cache Valley was developed before the Salt Lake group was deposited (Williams, 1948, p. 1160) and in that respect is similar to features of Mansfield's area. The
high-level erosion surface, following Mansfield's reasoning, is pre-Salt Lake group in age (Williams, 1948, p. 1160).

The Rendezvous Peak erosion surface, the high-level surface in the Rendezvous Peak area, lies approximately 2,000 feet below the high-level surface described by Williams in the Logan quadrangle. However, the relationship of the Rendezvous Peak erosion surface to Cache Valley and to the Salt Lake group is similar to that of the higher surface. The Rendezvous Peak erosion surface was formed immediately after the initial faulting which formed Cache Valley. The surface was dissected before deposition of the Salt Lake group and is therefore pre-Salt Lake group in age (Williams, 1948, p. 1160).

**Rendezvous Peak erosion surface.** The Rendezvous Peak erosion surface formed around the margins of Cache Valley shortly after the valley was created by faults of Basin and Range age (Williams, 1948, p. 1160). The erosion surface slopes towards Cache Valley and is found in the Rendezvous Peak area between the elevations of 6000 and 7500 feet. Although most of the Rendezvous Peak erosion surface has been dissected and almost completely removed by subsequent erosion, it is well preserved along the crest of Rendezvous Peak (Figure 2) and was named by Williams from this exposure (1948, p. 1160). This surface sloping east towards the South Fork of the Little Bear River is shown on plate 7. The area immediately south of Rendezvous Peak contains remnants of this erosion surface. A deposit of quartzite
Plate 7. View of Rendezvous Peak from the north. Line shows Rendezvous Peak erosion surface. McKenzie flat erosion surface is on low hills in foreground.
boulders, eroded from nearby Brigham and pre-Cambrian outcrops, was deposited on the beveled Rendezvous Peak surface shortly after the surface was formed and before the surface was dissected. Remnants of this deposit can be seen in scattered localities in the Rendezvous Peak area.

**McKenzie Flat erosion surface.** The McKenzie Flat erosion surface is found on Hyrum Bench (Figure 2) and nearby areas in the northeast corner of the Rendezvous Peak area. It is formed on Tertiary Salt Lake group rocks adjacent to the Little Bear River and extends onto the lower part of the nearby Paleozoic rocks. The erosion surface is comparatively flat on the Salt Lake group rocks. The slope increases on the Paleozoic rocks as result of the greater rock hardness. The surface has been dissected by stream action but is still easy to recognize. The age of the McKenzie Flat surface is post-Salt Lake group. The surface was named by Williams, the type locality being located approximately a half mile to the northeast of the mapped area (Figure 2) (Williams, 1942, p. 1161).

Keller describes the McKenzie Flat erosion surface in the Mink Creek area, just north of the area mapped by Williams (See figure 2) (Keller, 1932, p. 30). In this area the erosion surface has been covered in many places by a thick layer of quartzite boulders which Keller calls the Strawberry fanglomerate. The description of the fanglomerate is almost identical with that of the Tertiary quartzite boulders in the Rendezvous Peak area. In the Rendezvous
Peak area, however, the major part of the quartzite boulders are found on the higher Rendezvous Peak erosion surface. A thin veneer of quartzite boulders is found on part of the "McKenzie Flat erosion surface that is underlain by Paleozoic rocks near the southwest corner of Hyrum Bench (Figure 2). However, these boulders have apparently been eroded from their former position on the Rendezvous Peak erosion surface.

Sink Valleys

Several valleys in the Rendezvous Peak area were created in part by the formation of sinks in the soluble carbonate rocks. Sink Valley, located in the central part of the Rendezvous Peak area, takes its name from several large sinks developed on Ordovician, Devonian, and Mississippian formations. Plate 8 is a view of Sink Valley showing the location of the two major sinks. All drainage leaves Sink Valley through the sinks, there being no surface outflow. Devil's Gate Valley, three miles south of Vantua, also contains several sinks.

An attempt was made 25 years ago to dam Box Elder Creek which drains a part of Devil's Gate Valley. The water was to be used for irrigation. The dam site was located on Box Elder Creek just south of the outcrop of Garden City limestone in the northeast part of Devil's Gate Valley (Plate 9). The Garden City limestone underlies this part of the valley. After completion of the dam it was found that water escaped through solution cavities in the Garden City limestone. The loss of water was so great that the project was abandoned.
Plate E. View of Sink Valley from the east. Locations of the two major sinks are shown.
GEOLeGIC HISTORY

Paleozoic events

Great thicknesses of sediments accumulated in the Cordilleran reosyncline in the Rendezvous Peak area during Paleozoic time. Nearly continuous deposition extended from the Brigham quartzite of Cambrian age to the Swan Peak formation of Ordovician age. Uplift, following the deposition of the Swan Peak formation, resulted in a large unconformity between the Swan Peak formation and the Fish Haven dolomite, which is also of Ordovician age. In places most of the Swan Peak was eroded away. Deposition of the Fish Haven dolomite, Laketown dolomite, Water Canyon formation, and the Jefferson formation of Devonian age followed. The area was then uplifted and erosion removed the Water Canyon formation and the Jefferson formation, both of Devonian age, in parts of the area. The Leathan formation and the Madison limestone, both of Mississippian age, were deposited unconformably on this eroded surface. The basal Brazer formation, of Mississippian age, was then deposited unconformably on the Madison. Pennsylvanian and Permian rocks were probably deposited in the Rendezvous Peak area since outcrops of rocks assigned to these two periods are found on all sides of the area. Later erosion, largely pre-Tertiary, removed them from the Rendezvous Peak area.
Mesozoic events

A thick succession of rocks was deposited in the Rendezvous Peak area during Mesozoic time. Bardley, in *Structural Geology of North America*, shows Mesozoic seas over the northeastern part of Utah including the Rendezvous Peak area (1951, p. 20-22). Mesozoic sections are found both to the north and to the south in the surrounding region. All Mesozoic formations, however, were eroded from the Rendezvous Peak area when it was elevated in late Mesozoic time.

The Laramide orogeny, which began in late Mesozoic time and continued into early Cenozoic time, deformed the Paleozoic rocks of the Rendezvous Peak area. The northeast plunging syncline in the central part of the area was formed at this time. Folding and thrusting in the surrounding region also occurred during this orogeny (Varefield, 1927; Bardley, 1944; Williams, 1937).

Cenozoic events

Faulting of Basin and Range area was initiated in the Rendezvous Peak area in early Tertiary time, before the deposition of the Salt Lake group. The major faults trend north-south; some appear to be continuations of the north-south faults along the margins of Cache Valley. As faulting continued quartzite boulders and cobbles, derived from erosion of pre-Cambrian and Cambrian quartzites south and west of the area, were deposited on an erosion surface, the Rendezvous Peak. Extensive dissection of the Rendezvous
Peaks surface then occurred. The Salt Lake group, composed of both lacustrine and fluvial sediments, was then deposited on the Rendezvous Peak surface; the Wasatch group is not found in the Rendezvous Peak area. Later the McKenzie Flat erosion surface was formed on the Salt Lake group and adjacent Paleozoic rocks. This surface is now dissected to the stage of maturity. Basin and Range faulting continued into post-Salt Lake group time as is evidenced by the disturbance of the Salt Lake group beds.
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**APPENDIX**

**Index of stratigraphic sections**

- Bakers Canyon (two miles north of Brigham City)
  - Ardley and Batch (1940) p. 809-811 -- Brigham (type locality?)

- Blacksmith Fork
  - Deiss (1935) p. 1107-1116 (along north side from South Cottonwood Canyon to one mile east of Left Fork) -- Ordovician (part), St. Charles (see also Williams (1945) p. 1135), Nunnan, Bloomington, Flacks 4th (type locality).
  - Williams (1945) p. 539 -- Frazer.

- Blacksmith Fork (Leatham Hollow)

- Blacksmith Fork (Left Fork)
  - Maxey (1941) p. 44-47 -- Bloomington (not measured), Blacksmith, Nunnan, Brigham (not measured).

- Blacksmith Fork (South Cottonwood Creek)
  - Maxey (1941) p. 49-50 -- Lamston, Brigham (not measured).

- Blacksmith Fork

- Vache Valley
  - Williams, E. Stewart (unpublished) -- Salt Lake Group.

- Callis Fort (west side of Wellsville Mountain)
  - Maxey (1941) p. 15-25 -- Garden City (not measured), St. Charles, Nunnan, Bloomington, Blacksmith, Nunnan, Brigham (not measured).

- Dry Lake (Wellsville Mountain)
  - Williams (1945) p. 1145 -- Frazer.

- Green Canyon (four miles northeast of Logan)
  - Ross (1981) p. 11-13 -- Swan Peak (part, type locality), Garden City (type locality).
  - Williams (1945) -- Water Canyon (p. 1139), Laketown (p. 1138), Fish Haven (p. 1137)(no detailed section), Swan Peak (p. 1136).

- High Creek (seven miles northeast of Richmond, Utah)
  - Maxey (1941) p. 26-41 -- Garden City (not measured),
St. Charles, Mounan, Bloomington, Blocksmith, Ute, Langston, Brigian (not measured).

Logan Canyon
Ross (1951) p. 20 -- Swan Peak, Garden City (part).
Williams (1943) p. 595 -- Madison (see also Holland, Jr. (1952) p. 1718).
Williams (1941) p. 1140 -- Jefferson.

Mantua (north of Mantua)
Ross (1951) p. 23-24 -- Swan Peak, Garden City.

"Mink Creek (north of Logan across Idaho border)
Keller (1922) p. 15-17 -- "Mink Creek formation, Strawberry tuff-lomoratic (not measured).