THE GEOLOGY OF THE CENTRAL PART OF THE
PAVANT RANGE, UTAH

DISSERTATION

Presented in Partial Fulfillment of the Requirements
for the Degree Doctor of Philosophy in the
Graduate School of The Ohio State
University

OHIO STATE UNIVERSITY

By
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1952

Approved by:

[Signature]
Adviser
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INTRODUCTION

The geologic investigation of the central part of the Pavant Range is one of a series in the Ohio State University Geology Department program concerned with the detailed geologic study and mapping of central Utah. This paper is an attempt to describe comprehensively the geology of an area of nearly 300 square miles in south central Utah.

The most spectacular geologic feature in the Pavant Range is the Pavant thrust fault, on which Cambrian and Ordovician beds have been thrust over Jurassic and older beds. Exposures of the thrust fault extend for 17 miles along the west side of the Pavant Range between Fillmore Peak northeast of Fillmore and Corn Creek southeast of Kanosh.

Perhaps the most significant contribution of this paper is the definition of the extent of the Green River lake. In the adjacent Valley Mountains the Green River formation is more than 1100 feet thick. In the southern part of the Pavant Range, 15 miles to the south, the formation has disappeared by tonguing out. Thus a part of the shore of the Green River lake in southern Utah is established.
LOCATION AND ACCESSIBILITY

The Pavant Range, approximately 140 miles south of Salt Lake City, is one of the high plateaus of central Utah. The area discussed is bounded on the north and south respectively by 39° 00' and 38° 45' N. Lat., on the west by 112° 15' W. Long., and on the east by 112° 00' W. Long. and the Sevier River.

Sevier Valley, the Valley Mountains, and Round Valley border the Pavant Range on the east. The Canyon Range is on the northwest; Pavant Valley, the west; and the Tushar Mountains, the south.

United States Highway 89 follows the Sevier Valley and United States Highway 91 follows Pavant Valley. These major routes of travel are connected at both the northern and southern ends of the Pavant Range. On the north, Utah Highway 63 parallels Denmark Wash and descends Round Valley to Scipio where it meets United States Highway 91. On the south, Utah Highway 13 crosses the Clear Creek pass from Sevier to Cove Fort. No roads cross the Pavant Range. On the east, United States Forest Service roads ascend the range at Willow Creek and Richfield, and at the crest they join a ridge road that extends nearly the length of the range. On the west, one road enters the south fork of Chalk Creek, but it soon gives way to a horse trail.

Roads approach the mouths of most of the canyons, but
INDEX MAP OF UTAH showing the location of the area described in this report (black)
further headway must be gained on horseback or on foot.

The Denver and Rio Grande Western Railroad follows the Sanpete and Sevier Valleys as far south as Marysvale. A spur of the Union Pacific Railroad connects Fillmore with the main line at Delta.

FIELD WORK AND MAPPING

The field work necessary to describe the area discussed in this report was done during the periods June 19 to September 25, 1950 and June 18 to September 6, 1951.

Geologic and geographic information was located on United States Bureau of Reclamation and Soil Conservation Department aerial photographs having a scale of approximately 1:20,000. A part of the United States Coast and Geodetic Survey triangulation net covering the Fish Lake National Forest was reoccupied and secondary points were added by plane table triangulation. The triangulation points were placed on a polyconic projection and then aerial photograph centers and wing points were located by means of an Abram's Lazy Daizy Mechanical Triangulator. Geologic and geographic information then was transferred from the aerial photographs to the polyconic projection with a Radial Planometric Plotter.
PREVIOUS WORK

In the past, geologic work in the Pavant Range has been limited to reconnaissance. Wheeler (1875, p. 59) employed the geology of the "Pahvan" Range as evidence for major uplifts at the end of the Jurassic and at the end of the Eocene. Dutton (1880, p. 3) questioned the classification of the Pavant as either a Basin Range or a plateau and concluded that the line separating the two provinces should be drawn at the Paleozoic-Mesozoic contact in the Pavant Range. As opposed to Wheeler's views, Dutton believed the time of great uplift to have been during the Pliocene or later. E. E. Howell drew several cross-sections through central Utah that were incorporated in Dutton's report (1880, pl. 3). Much work and keen observation was necessary to produce the generally correct stratigraphic and structural relations shown by Howell's cross-sections. In 1884 von Rath made a trip from Salt Lake City to the sulphur deposits at Sulphurdale southwest of the Pavant Range. The description of his journey mentions several of the geologic features of the Pavant area. The groundwater studies of Richardson (1906) in the Sanpete and Sevier Valleys included parts of the adjacent mountainous area. Butler (1920) and Callaghan (1938, 1939) merely mentioned the Pavant in connection with their respective areas of study. Dennis (1946) and Maxey (1946)
did detailed work in the Pavant Valley and on the western slopes of the Pavant Range between Holden and Kanosh, but the area of overlap with this paper is confined to a small area on the west side of the range.

Geologic work in adjoining areas is designated by number on the index map (see fig. 1). The publications describing that work are as follows:

1. This report (shown in black)
2. Babisak (1949)
3. Hardy (1948)
4. Hunt (1948)
5. Zeller (1949)
6. Hardy (1949)
7. Muessig (1951)
8. Spiker (1931, 1946, 1949a, 1949b); Spiker and Baker (1928); Spiker and Billings (1940); Spiker and Reeside (1925, 1926); Bonar (1948); Fagadau (1949); Faulk (1948); Gill (1950); Johnson (1949); Washburn (1948); Wilson (1949).
9. Katich (1951)
10. Gilliland (1951)
11. Tucker (in preparation)
12. Christiansen (1951)
13. Hunt (1950); Katherman (1948); Taylor (1949)
14. Schoff (1951)
PHYSICAL FEATURES

The major portion of the area under consideration is occupied by the Pavant Range, which is one of the large mountain ranges in central Utah, about 40 miles long and about 15 miles wide. The general alignment of the southern part of the range is north-northeast. In the north where the Valley Mountains parallel the Pavant Range, the alignment is approximately north-south. The Tushar Mountains on the south and the Canyon Range on the north are parts of the same mountain system, being separated from the Pavant only by low passes.

The Pavant Range may not be placed readily in either the Basin and Range Province or the High Plateaus. Dutton (1880, p. 3) observed that the Pavant "is a curious admixture of plateau and sierra." This is understandable if the range is observed from the adjacent valleys. From Pavant Valley, the mountains resemble the ranges of the Great Basin. From Sevier Valley, the topographic and
structural form of the Pavant is similar to the other plateaus that border the Sevier and Sanpete Valleys. Fenneman (1931, p. 297) placed the Pavant in the High Plateaus of central Utah, but he also included a map by Guy Harold Smith (1931, p. 327) that extends the eastern boundary of the Great Basin to the east side of the Pavant. In the text Fenneman admits that the Pavant Range and the Tushar Mountains are poor examples of the High Plateaus. As Dutton (1880, p. 3) suggests, perhaps the boundary would be better placed at the Paleozoic-Mesozoic contact since there the change from sierra to plateau takes place.

Part of Sevier Valley, east of the Pavant Range, occupies the remainder of the area mapped. Sevier Valley is part of a closed basin occupied by the Sevier River which drains the entire area except the closed Round Valley basin. However, surface drainage does not extend more than a few miles beyond the mountain front into Pavant Valley and the west-flowing streams of the range are not actually tributaries of the Sevier River.

The floor of Sevier Valley is nearly flat. Gentle slopes approach the mountain front where there is an abrupt change in elevation of from 3000 to 4000 feet within a few miles. Sevier Valley slopes to the north with elevations on the order of 5300 feet. White Pine Peak, the highest point on the Pavant Range, is 10,230 feet above sea level.
It is outside the area mapped and about a mile northwest of No. 6 triangulation station which is 10,226 feet above sea level.

ACKNOWLEDGMENTS

The writer takes this opportunity to thank the many people who have freely contributed their time and efforts during the completion of this investigation.

The aid and counsel of Dr. Edmund M. Spieker of the Ohio State University under whose guidance this work was undertaken, is sincerely appreciated. Suggestions offered while the field work was in progress as well as during the preparation of this report have proved invaluable.

Dr. Carl A. Lamey and Dr. Aurèle La Rocque critically read the manuscript and offered many valuable suggestions.

Dr. Richard P. Goldthwait critically read the portion on geomorphology. Dr. La Rocque identified the Tertiary fossils. Dr. Lamey aided in the petrographic determinations and read the portion on igneous rocks. Dr. Charles H. Summerson gave advice in the preparation of the accompanying geologic map.

Dr. Christina L. Balk of the Walker Museum, University of Chicago, identified the Cambrian trilobites. Dr. James M. Schopf of the United States Geological Survey Coal Laboratory examined the paleobotanical material from
the pyroclastic beds.

William Shafer and Paul V. Hoovler served ably as assistants during the 1950 field season. Their aid and cooperation added much to the information herein contained.

Financial aid from the Bownocker Fund of the Geology Department of the Ohio State University made the project possible. Transportation and field and camping equipment were furnished by the Geology Department of the Ohio State University.

Much help and cooperation were given by the residents of the area during the execution of the field work. Particular mention is made for help given by Mr. Walter Esklund of Scipio, Utah, Mr. Vaun Herbert of Salina, Utah, and Ranger Kenneth Bowers of Fillmore, Utah.
The rocks of the Pavant Range may be divided into three major groups. Along the western front, the pre-Laramide marine Paleozoic and continental Mesozoic formations crop out. Along the crest and eastern front, the late Cretaceous and Tertiary fluviatile and lacustrine beds are exposed. To the south, Tertiary lava flows conceal the older formations.

In earlier investigations the Paleozoic formations of the Pavant Range and adjacent areas have been assigned to various ages. Davis (1905, p. 33) thought the quartzite in the Canyon Range to the north was Carboniferous. Christiansen (1951), in the course of detailed mapping in the Canyon Range, identified the quartzite as Tintic and the overlying shale as Ophir. However, he assigned the overlying thick sequence of limestones and dolomites to the Upper Cambrian and Ordovician (?) without distinguishing individual formations. Maxey (1946) recognized the Tintic quartzite in the Pavant Range, but made no attempt to subdivide the overlying limestone and dolomite sequence. Hintze (1951) described two Ordovician sections in the Pavant Range; one near Escalante Pass in the northern part of the range and the other southwest of Kanosh in
# Generalized Section of Rocks Exposed in the Central Part of the Pavant Range

## Table 1

<table>
<thead>
<tr>
<th>Age</th>
<th>Formation and Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td><strong>Alluvium</strong> — Fine- to coarse-grained sands and gravels.</td>
</tr>
<tr>
<td></td>
<td><strong>Glacial drift</strong> — Till and outwash, mainly sandstone blocks and silt-size material.</td>
</tr>
<tr>
<td></td>
<td><strong>Axtell formation</strong> — Buff conglomerate, coarse sands, and silts, poorly consolidated and poorly sorted.</td>
</tr>
<tr>
<td></td>
<td><strong>Pullion Canyon volcanics</strong> — Brown porphyritic andesite flows.</td>
</tr>
<tr>
<td></td>
<td><strong>Gray Gulch (?)</strong> formation — White, green, and orange buff with local gypsum concentrations.</td>
</tr>
<tr>
<td></td>
<td><strong>Bald Knoll formation</strong> — White, light-green, and tan shale and limestone.</td>
</tr>
<tr>
<td>Tertiary</td>
<td><strong>Crazy Hollow formation</strong> — Brick-red thin-bedded sandstones, siltstones, and shales and massive buff coarse-grained sandstones</td>
</tr>
<tr>
<td></td>
<td><strong>Green River formation</strong> — Thin- to thick-bedded buff or light-gray limestones, oolitic and siliceous in part, with thin interbedded gray-green shales.</td>
</tr>
<tr>
<td></td>
<td><strong>Flagstaff formation</strong> — Light-gray, purple, and red shale to siltstone at top, brick red siltstone, silty limestone, and shale underlain by light-gray silty limestone and interbedded gray shale in northeastern outcrop areas.</td>
</tr>
<tr>
<td></td>
<td><strong>North Horn formation</strong> — Dominantly buff to brown sandstone and siltstone with interbedded gray and tan shale. Minor amount of purple and red siltstone and light-gray conglomerate.</td>
</tr>
<tr>
<td>Cretaceous</td>
<td><strong>Price River formation</strong> — Massive reddish-gray conglomerate with some interbedded sandstone lenses. Unconformity at base.</td>
</tr>
<tr>
<td>Jurassic (?)</td>
<td><strong>Navajo sandstones</strong> — Dark-red cross-bedded massive sandstones. Thrust fault at top.</td>
</tr>
<tr>
<td>Cambrian</td>
<td><strong>Opox dolomite</strong> — Dark-gray dolomite, with red and white calcite spiloches or tan argillaceous bands. Unconformity at top.</td>
</tr>
<tr>
<td></td>
<td><strong>Cole Canyon dolomite</strong> — Dark-gray dolomite interbedded with light-gray laminated dolomite and brownish-green shale.</td>
</tr>
<tr>
<td></td>
<td><strong>Bluebird dolomite</strong> — Blue-gray dolomite and limestone with white calcite spangles.</td>
</tr>
<tr>
<td></td>
<td><strong>Marlimes limestones</strong> — Medium to dark-gray limestone with light-gray bands.</td>
</tr>
<tr>
<td></td>
<td><strong>Dasopar limestones</strong> — Light-gray laminated dolomitic limestone.</td>
</tr>
<tr>
<td></td>
<td><strong>Tontonico limestones</strong> — Dark-gray limestone with many white calcite veinlets.</td>
</tr>
<tr>
<td></td>
<td><strong>Ophir formation</strong> — Light-gray limestone at top; brownish-green shale and quartzite below.</td>
</tr>
<tr>
<td></td>
<td><strong>Tintic quartzite</strong> — White quartzite in medium to thick beds; weathers greenish-brown. Thrust fault at base.</td>
</tr>
</tbody>
</table>
Baker Canyon in the southern part of the Pavant. By comparing lithologies of the Tintic district with those of the Pavant Range, and with the aid of fossils, the writer found that a subdivision of the limestone and dolomite sequence could be made.

The Paleozoic formations are confined to the western part of the Pavant Range. They are limited below by a thrust fault on which they overlie Mesozoic sandstones and shales. The mass of Paleozoic rocks is overlain in angular unconformity by Mesozoic conglomerates and sandstones.

Earlier geologic investigations have referred to the thick series of conglomerate, sandstone, shale and freshwater limestone on the east side of the Pavant Range as the Wasatch formation. Callaghan (1938, 1939) mentioned the outcrops of Wasatch sandstones and shales west of Richfield, Utah. Maxey (1946) mapped a portion of the Pavant Range between Kanosh and Holden, Utah, but he did not differentiate between the formations of the Wasatch group as has been done in the Wasatch Plateau (Spieker, 1946), the Gunnison Plateau (Hunt, 1948, 1950; Hardy, 1948; Zeller, 1949), and the Valley Mountains (Gilliland, 1951). Also Maxey did not recognize the Price River as a distinct formation, but included it in his Wasatch formation. To translate the previous usage of the term Wasatch formation to present day terminology, we find that
earlier workers included the North Horn, Flagstaff, and Colton formations of the Wasatch group and the Price River formation in their Wasatch formation. The three formations (North Horn, Flagstaff, and Colton) that make up the Wasatch group can be traced to the northern part of the Pavant Range. There the Colton formation loses its identity, but the other two formations may be distinguished throughout the Pavant.

The basis for mapping the igneous rocks is taken from work done by Callaghan (1939) in the Tushar Mountains to the south.

**Cambrian System**

**Tintic Quartzite**

**Definition:** The Tintic quartzite was defined by Loughlin (1919, p. 23) to include over 6000 feet of grayish-white to pale-pink quartzite below the Ophir formation near Eureka, Utah. The Tintic quartzite, the oldest formation in the type area is well-exposed on Quartzite ridge, but at no place in the Tintic district is the base of the formation exposed. Individual beds typically range from a few inches to 2 or 3 feet in thickness and are made up of nearly pure quartz.

**Distribution and lithology:** In the Pavant Range, the Tintic quartzite crops out along the western front and in the area under consideration, the quartzite forms the
Table 2

<table>
<thead>
<tr>
<th>Pioche District, Nevada</th>
<th>House Range, Utah</th>
<th>This Paper</th>
<th>Tintic District, Utah</th>
<th>Logan Quadrangle, Utah</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dome ls.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Burnt Canyon ls.</td>
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<tr>
<td>Burrows ls.</td>
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</tr>
<tr>
<td>Peasley ls.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Chisholm sh.</td>
<td></td>
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</tr>
<tr>
<td>Lyndon ls.</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>busby quartzite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pioche sh.</td>
<td></td>
<td></td>
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<tr>
<td>Prospect Mountain quartzite</td>
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<td>Prospect Mountain quartzite</td>
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</tr>
</tbody>
</table>
A. Pioneer Canyon and the north slope of Fillmore Peak.

Tintic quartzite forms the ridge in the foreground. Teeples Canyon, behind the quartzite ridge, was cut in the easily eroded Ophir formation. The second ridge is made up of Cambrian limestones. Price River and North Horn formations crop out in the background.

B. Fillmore Peak.

Fillmore Peak is the prominent mountain on the left skyline and is made up of Tintic quartzite. Ophir formation crops out in the high saddle to the right of Fillmore Peak. The Cambrian limestone sequence crops out in the background on Pioneer Peak. Navajo sandstone is present below the thrust fault in the lower left on the opposite side of the north fork of Chalk Creek.
abrupt slopes and the high peaks of the west side of the range.

The formation resembles the type both in bedding and lithology. A small amount of iron produces a yellow to brown stain on the weathered surface. There is some cross-bedding and a few conglomerate beds are scattered throughout the formation. Near the top of the formation, thin green and brown micaceous shales are intercalated between the more massive quartzite beds. The quartzite is 2620 feet thick on Fillmore Peak.

**Stratigraphic relationships:** The Tintic quartzite is the lowest formation in the plate that was thrust over the Navajo sandstone. Thus the complete thickness and the basal stratigraphic relationships are unknown in the Pa-vant area. The contact with the overlying Ophir formation is gradational.

**Age and correlation:** The similar sequence of quartzite, shale, and limestone in the ranges of eastern Nevada and western Utah suggests lithogenetic equivalence of the Cambrian beds of the Great Basin area. Fossils have not been found in the Tintic quartzite nor have they been found in the Prospect Mountain quartzite of western Utah and Nevada nor in the Brigham quartzite of northern Utah and southern Idaho. Fossils found in the overlying Pioche and Ophir formations, however, establish a minimum age for the
quartzite. In the Eureka district in Nevada (Wheeler, 1943), the Pioche shale is Lower Cambrian so that the Prospect Mountain quartzite is Lower Cambrian and perhaps older. From the Eureka district toward the east, the fossils of the Pioche and Ophir formations show that these formations become younger in that direction. In the Tintic district the Ophir formation is entirely Middle Cambrian and the underlying Tintic quartzite is considered both Middle and Lower Cambrian in age. Thus the Tintic quartzite of the Pavant Range may be considered Middle and Lower Cambrian in age.

In the Great Basin the quartzite beds lie above an erosion surface cut in pre-Cambrian igneous and metamorphic rocks where the contact is exposed. Although the same physical relations are everywhere similar, the temporal relations may be shown to differ. Wheeler (1947, pp. 153-156) portrayed the differences in time of deposition of the basal Cambrian beds by drawing a cross-section from the Nopah Range in southeastern California to the eastern end of the Grand Canyon using the base of the Olenellus zone as a fixed point in time. The results of his work showed that the basal Cambrian beds in California are stratigraphically 10,000 feet below those at the east end of the Grand Canyon showing that the progressively higher position of the basal Cambrian quartzite,
as it is traced from west to east, was deposited as a littoral marine sand by the encroaching Cambrian sea.

**Ophir Formation**

**Definition:** Butler (1920, p. 374) described the Ophir formation from exposures in Ophir Canyon in the Oquirrh Range in northern Utah. The formation is predominantly shale with some interbedded light and dark limestones. The Ophir and its lithogenic equivalents overlie the massive quartzite and are subjacent to the thick calcareous sequence throughout the Great Basin.

**Distribution and lithology:** The outcrops of the Ophir formation form the back slopes of the quartzite peaks along the western front of the central Pavant Range. The easily eroded shales are responsible for the north-south alignment of the western drainage channels.

Green and brown micaceous shales comprise the dominant rocks of the formation. In the basal portion, quartzite beds resembling the Tintic are present and massive light and dark limestones occur in the upper part of the formation. There are some thin white calcite veinlets throughout the limestone beds.

In the south fork of Chalk Creek the Ophir formation is 349 feet thick, compared to 312 feet in Pioneer Canyon.

**Stratigraphic relationships:** The relations with the underlying Tintic quartzite have already been described.
The upper boundary is more abrupt. The dominantly clastic Ophir formation is conformably overlain by the Teutonic limestone.

**Age and correlation:** The similarity of the lithology and the position of the shale in the Pavant Range and the other ranges of the Great Basin suggest that the Ophir formation may be correlated with the Pioche shale to the west and the Ophir formation to the north. The eastern location of the shale suggests a Middle Cambrian age.

In the Wah Wah, House, and Deep Creek Ranges the Busby quartzite lies conformably above the Pioche. The bed is lens-shaped and thins to the south and east from the Deep Creek Range. A thin quartzite bed near the top of the Ophir formation is possibly the equivalent of the Busby quartzite wedge.

**Teutonic Limestone**

**Definition:** The Teutonic limestone was named for Teutonic Ridge in the Tintic district, Utah (Loughlin, 1919, p. 27). There the formation is overlain by the Dagmar limestone and underlain by the Ophir formation. Typically, the beds are dark-gray to dark bluish-gray. A distinctive feature is the presence of many white calcite veinlets that form a polygonal pattern resembling chicken wire.

**Distribution and lithology:** The Teutonic limestone occurs in the western part of the Pavant Range. Within the limits
of study, the beds form a band that parallels the north-south valleys east of the quartzite peaks.

Lithologically the beds are similar to those at the type locality. Thin to massive, dark-gray to bluish-gray beds containing tan argillaceous bands or "chicken wire" partings of white calcite are dominant. There are some wavy laminations in the upper part of the formation.

The formation is 528 feet thick in Shingle Mill Canyon in the Pavant Range and 460 feet thick at the type locality in the Tintic district.

**Stratigraphic relationships:** The Teutonic limestone is bounded conformably by the Ophir formation below and the Dagmar dolomite above. The contact between the underlying Ophir formation and the Teutonic limestone is an abrupt change from shale to limestone. The contact between the Teutonic limestone and the Dagmar limestone is marked only by a color change on their weathered surfaces. Both formations are dark-gray, but the surface of the Dagmar weathers to very light-gray.

**Age and correlation:** In the Pavant Range as well as in the Tintic district, no fossils have been found in the Teutonic limestone. In the Tintic district its Middle Cambrian age is determined by its position between beds of known Middle Cambrian age. In the Pavant, the Teutonic is no younger than Middle Cambrian since fossils in the Cole Canyon
dolomite of the upper part of the section are Middle Cambrian. The formation might be Lower Cambrian, but because of the location of the section and the position of the formation in the section, it is more likely Middle Cambrian.

Dagmar Limestone

Definition: Loughlin (1919, p. 27) named the Dagmar limestone for exposures of a series of dolomitic limestones above the Teutonic limestone and below the Herkimer limestone at the Dagmar mine in the Tintic district. The type exposures are tan to grayish-white, thinly laminated, dolomitic limestone, but the fresh surface of the rock is dark-gray. The weathering of the dark-colored rock to very light shades makes these beds the best stratigraphic marker among the lower formations of the district.

Distribution and lithology: Outcrops of the Dagmar limestone are found on the west side of the Pavant Range. The outcrop pattern is similar to that of the other Cambrian formations (see pl. 26).

The lithology of the Dagmar limestone is not as distinctive in the Pavant Range as in the Tintic district. Some of the beds are thinly laminated, but the fresh surface is light- to medium-gray instead of dark-gray as at Tintic. However, just as in the Tintic district, the beds are very dolomitic.
In Shingle Mill Canyon the formation is 84 feet thick and 82 feet of Dagmar limestone was measured in Pioneer Canyon compared to a variable thickness ranging up to 100 feet in the Tintic district.

Stratigraphic relationships: The Dagmar limestone lies conformably between the Teutonic limestone below and the Herkimer limestone above. The beds above and below the Dagmar limestone are dark- to bluish-gray in sharp contrast to the lighter colored beds between, but the change in lithology is not distinctive.

Age and correlation: For the same reasons as are given for the Teutonic limestone, the Dagmar limestone is considered to be Middle Cambrian in age.

Herkimer Limestone

Definition: Loughlin (1919, p. 28) named the Herkimer limestone after the Herkimer shaft in the Tintic district, Utah, and he defined it to include the limestone between the underlying Dagmar limestone and the overlying Bluebird dolomite. The Herkimer limestone typically consists of dark-gray to blue-gray, partly dolomitic, irregularly banded limestone. The irregular yellowish-brown ferruginous and argillaceous bands weather to various shades of red.

Distribution and lithology: The Herkimer limestone crops out in the western part of the Pavant Range in a manner
similar to the other Cambrian formations (see pl. 26).

In the Pavant Range, the Herkimer limestone is medium to dark-gray, irregularly banded, and has some white calcite partings. The surface of the beds weathers to reddish shades as in the Tintic district.

The thickness of the Herkimer limestone in Shingle Mill Canyon is 103 feet and in Pioneer Canyon, 62 feet. **Stratigraphic relationships:** The relations between the underlying Dagmar limestone and the overlying Bluebird dolomite are conformable. The dark color of the Herkimer beds contrasts sharply with the underlying light-colored Dagmar limestone. The upper boundary is not as easily drawn. The lithology and color of these two formations are similar and the presence of the white calcite spangles of the Bluebird dolomite is the only indication that a formational boundary has been crossed.

**Age and correlation:** The evidence for assigning the Teutonic limestone to the Middle Cambrian applies also to the Herkimer limestone.

**Bluebird Dolomite**

**Definition:** Loughlin (1919, p. 28) used the term Bluebird dolomite to denote a series of massive blue-gray limestones and dolomites between the underlying Herkimer limestone and the overlying Cole Canyon dolomite. It was named after Bluebird Spur where the formation is well ex-
posed. A portion of the beds shows distinctive white calcite spangles or rods which differentiate the Bluebird from the adjacent formations.

**Distribution and lithology:** The outcrop pattern of the Bluebird dolomite is similar to that of the other Cambrian formations on the west side of the Pavant Range (see pl. 26).

Medium to dark bluish-gray dolomites and limestones are the dominant rocks of the formation in the Pavant Range. White calcite rods which give the rock a spangled or vermicular appearance set the beds off from the other formations of the section. A thin, banded, oolitic bed near the base of the formation resembles thicker beds in the Teutonic limestone.

In Shingle Mill Canyon the Bluebird dolomite is 267 feet thick; in Pioneer Canyon, 169 feet; and in the Tintic district, 189 feet.

**Stratigraphic relationships:** The Bluebird dolomite lies conformably above the Herkimer limestone and below the Cole Canyon dolomite. The lower boundary has already been discussed in the section describing the Herkimer limestone. The contact between the Bluebird dolomite and the overlying Cole Canyon dolomite is well shown by an abrupt color change from dark-gray below to light-gray above. Also the Bluebird beds are more massive than the thinly
laminated Cole Canyon beds. In addition, at the contact there is a change from limestone to dolomite.

**Age and correlation:** The Bluebird dolomite is considered Middle Cambrian in age for reasons given in preceding sections.

### Cole Canyon Dolomite

**Definition:** Loughlin (1919, p. 29) described a series of alternating light- and dark-gray dolomites and limestones from 10 to 25 feet thick and set them off as the Cole Canyon dolomite. The formation was named for exposures in Cole Canyon in the Tintic district, Utah, that lie above the Bluebird dolomite and below the Opex dolomite. An arbitrary formational boundary was drawn at the base of the first and at the top of the last light-gray bed. In outward appearance some of the light-gray beds resemble the Dagmar limestone, but in contrast to the Dagmar, the fresh surface is nearly the same color as the weathered exterior.

**Distribution and lithology:** The Cole Canyon dolomite occurs along the ridge east of Shingle Mill Canyon and near the crest of Pioneer Peak.

The lithology of the Cole Canyon is easily distinguished from that of the formations above and below it. As in the Tintic district, the nearly white beds of dolomite and limestone stand out in sharp contrast to the
dark-gray and nearly black beds above and below. Some of the white beds are thinly laminated, as are the Dagmar beds, but the fresh surface of the light-colored Cole Canyon beds is nearly the same shade as the weathered one. The dark-gray beds are medium to coarsely crystalline. Near the top of the formation, thin shales are encountered, some of which are sparsely fossiliferous.

On the ridge east of Shingle Mill Canyon, the Cole Canyon dolomite is 951 feet thick, and in Pioneer Canyon, the formation is 912 feet thick.

**Stratigraphic relationships:** No breaks are observable either at the top or at the base of the Cole Canyon dolomite but because the formation is set off arbitrarily by color changes, the upper and lower boundaries are readily defined.

**Age and correlation:** Specimens of *Eldoradia prospectensis* (Walcott) were collected by the writer from the shales of the upper part of the formation and they were identified by Christina L. Balk. This species is also found in the Secret Canyon shale of upper Middle Cambrian age in the Eureka district, Nevada (Wheeler, 1939). The type species was originally described by Walcott (1884, p. 46, pl. 9, fig. 20) as *Ptychoparia ? prospectensis* and later (Walcott, 1916, p. 186, pl. 25, fig. 8) as *Alokistocare ? prospectense*. Resser (1935, p. 26) changed the name to
**Eldoradia prospectensis** (Walcott).

The "Marjum" limestone of the House Range (Wheeler, 1948) and the Abercrombie formation of the Deep Creek Range (Nolan, 1935) contain shales that are probably correlative with the shales of the Cole Canyon of the Pavant Range. In the Tintic district, the only identified fossil is *Obolus mcconnelli* (Loughlin, 1919, p. 29) and from this evidence, Walcott (1912, pp. 156, 197) correlated the formation with the G member of the "Marjum" limestone in the House Range.

In northern Utah shales become increasingly common in the upper part of the Middle Cambrian section. In the Oquirrh Range, Utah, the Bowman limestone (Gilluly, 1932), the Bloomington formation of the Blacksmith Fork section, Utah (Walcott, 1908; Deiss, 1938) and of the Bear River Range, Idaho (Mansfield, 1927) are made up of limestones and interbedded shales that are probably the same age as the Cole Canyon in the Pavant Range.

**Opex Dolomite**

**Definition:** The Opex dolomite was named from the Opex mine by Loughlin (1919, p. 29). At the type locality the Opex dolomite lies above the Cole Canyon dolomite and below the Ajax limestone. The formation is dominantly dark-gray or blue-gray limestone and dolomite. In contrast to the beds above and below, the Opex is rather nondescript
and does not have distinctive features as the other formations have. It can be set apart only by virtue of the stratigraphic markers of the Cole Canyon dolomite below or the Ajax limestone above.

**Distribution and lithology:** The Opex dolomite crops out east of the ridge above Shingle Mill Canyon and in the south fork of Chalk Creek.

The limestones and dolomites are dominantly dark-gray. Some beds have vermicular markings similar to the Bluebird dolomite; others weather with reddish blotches as in the Herkimer. The individual beds are thin to massive and finely to coarsely crystalline.

In Shingle Mill Canyon 467 feet of Opex dolomite were measured. In Pioneer Canyon to the north, 681 feet of the formation is exposed.

**Stratigraphic relationships:** The Opex dolomite conformably overlies the Cole Canyon dolomite. It is in turn overlain by the Price River or the North Horn formation in angular unconformity.

**Age and correlation:** The age of the Opex dolomite is uncertain. Its position above beds containing known uppermost Middle Cambrian fossils suggests that it is in at least the lower part of the Upper Cambrian. At places where Ordovician beds overlie the Opex dolomite in other areas, the Cambro-Ordovician boundary is drawn at a ques-
tionable disconformity. This is coupled with the variable thickness and local omission of the Upper Cambrian beds to suggest uplift and erosion prior to the deposition of the lower Ordovician beds. In the Pavant area a similar break was not observed which would seem to imply that the Opex is entirely Upper Cambrian and that it does not extend upward into the Ordovician, but because of the uncertainty associated with the systemic boundary in other areas, this is a weak conclusion. However, the Opex does lie beneath beds of known Lower Ordovician age suggesting a probable Upper Cambrian age for the formation.

In the Eureka district, Nevada, the Hamburg dolomite overlies the upper Middle Cambrian Secret Canyon shale and in the Deep Creek Range, Utah, the Young Peak dolomite overlies the Abercrombie formation. In the Oquirrh Range, Utah, the Upper Cambrian Lynch dolomite overlies the Middle Cambrian Bowman limestone. In the Blacksmith Fork section, Utah, the Nounan dolomite is Dresbach in age and equivalent to the Hamburg dolomite of the Eureka district (personal communication, Christina L. Balk). From the thicknesses of the above mentioned formations, the Opex is probably lower Upper Cambrian and almost certainly not Ordovician.

Because of a northern component of dip in the Paleozoic formations north of Pioneer Canyon, more of the upper
formations and less of the lower formations is exposed as one travels north. Near Escalante Pass a section of Ordovician formations has been described by Hintze (1951). Reconnaissance in this area showed that the underlying beds are similar to the Opex and that none of the Ordovician formations is represented in the area under consideration here.

**Jurassic (?) System**

**Navajo Sandstone**

**Definition:** Gregory (1915, pp. 102, 112) mentioned the Navajo sandstone as a member of the La Plata group. Later (1916) he assigned the group to the Jurassic and mentioned the Navajo as the upper formation of the group. In 1917, Gregory (p. 153) formally adopted the term Navajo sandstone and defined it as the upper formation of the La Plata group, lying above the Todilto formation and beneath the McElmo formation. The formation was assigned to the Jurassic on the basis of its stratigraphic position. The most significant features of the formation are its cross-bedding, uniform grain size, and light-red color.

Baker, Dane, and Reeside (1936) redefined the Navajo definition and placed it in the Glen Canyon group. Later work by the same authors (1947) resulted in the revision of the stratigraphy of the Four Corners Country.
Their conclusions were:

<table>
<thead>
<tr>
<th>Utah</th>
<th>Arizona</th>
<th>New Mexico</th>
<th>Colorado</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summerville</td>
<td>Todilto</td>
<td>Todilto</td>
<td>Middle La Plata</td>
</tr>
<tr>
<td>Curtis</td>
<td>Entrada</td>
<td>&quot;Wingate&quot;</td>
<td>Lower La Plata</td>
</tr>
</tbody>
</table>
| Carmel  | Navajo  | Callaghan (1939) has recognized the Navajo sandstone in correct stratigraphic position in the Tushar Mountains. Maxey (1946) extended the use of the term, with reservations, to the western part of the Pavant Range. **Distribution and lithology:** The outcrops of the Navajo sandstone are found south of Pioneer Canyon along the base of the west side of the Pavant Range. In the area under consideration the formation occurs in the vicinity of the forks of Chalk Creek.

The sandstone is composed of light-red to pink, rounded quartz grains of uniform size. The massive beds form steep cliffs. Cross-bedding is common. Upon weathering the exposed surface becomes black or dark brownish-red.

In the south fork of Chalk Creek, the formation is 2019 feet thick.
Plate 2

A. Navajo sandstone.

Exposure of Navajo sandstone in the south fork of Chalk Creek showing the characteristic steep cliffs and irregular weathered forms.

B. North Horn formation.

Beds of North Horn formation on the north wall of Amos Canyon. Note the massive conglomerates in the middle foreground.
Stratigraphic relationships: The normal stratigraphic sequence is not present in the central part of the Pavant Range. West of the mapped area, the Navajo is physically beneath but stratigraphically above shales of the Chinle formation. In the area that was mapped, the sandstone has been overthrust by the Cambrian plate.

In the Tushar Mountains (Callaghan, 1939) to the south a normal section shows the Chinle-Moenkopi-Ankareh undifferentiated shales below and the Carmel formation above the Navajo sandstone.

Age and correlation: No fossils have been found in the Navajo sandstone. It is placed in the Jurassic solely upon stratigraphic evidence.

Cretaceous System

Price River Formation

Definition: The Price River formation was defined by Spieker and Reeside (1925, p. 445) to include the clastic sequence above the Black Hawk formation and below the North Horn formation. At the type locality in Price Canyon, the formation consists of sandstone, conglomerate, and some shale and the lower cliff-forming sandstone member is set off as the Castlegate sandstone. As the formation is traced westward toward its source, the Castlegate sandstone member loses its identity in the facies change to conglomerate so that west of the Wasatch Plateau,
## CORRELATION OF MESOZOIC AND TERTIARY UNITS

Modified after Spieker (personal communication), Wood, et al. (1941), Hunt (1950), and Kitchi, (1951).

<table>
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### Table 3

- Castle Gate
- Black Hawk
- Star Point
- Nashuk
- Emsary
- Sixmile Canyon
- Blue Gate
- Punch Valley
- Indianola
- Allen Valley
- Sampete
- Dakota (?)
- Cedar Mountain
- Buckhorn
- Morrison
- Stump
- Twist Gulch
- Sammerville
- Prewitt
- Arapahoe
- San Rafael
- Entrada
- Carmel
- Twin Creek
- Navajo
- Lewis
- Mescalero
- Carlile
- Frontier
- Morriss
- Thermopolis
- Clovis
the division into members is not possible.

**Distribution and lithology:** North of the area under consideration, in the northern part of the Pavant Range between Rock Creek and Scipio along the west side of Round Valley, an estimated 5000 feet of Price River conglomerate is exposed. On the west side of the Pavant Range, where the formation is present, it has an extremely variable thickness. In the area here described, the Price River is exposed only in Chokecherry Canyon, on the ridge east of Shingle Mill Canyon, and in the north fork of Chalk Creek. In those localities it is 550, 70 and 200 feet thick respectively.

In the Pavant Range the beds assigned to the Price River formation consist entirely of conglomerate and coarse sandstone. From a distance the weathered surface of the rock appears dark purplish-red in color, but the fresh surface shows the sandstone and the matrix of the conglomerate to be made up of thin alternating bands of red and white quartz grains. The pebbles and boulders range between 1 and 6 inches in diameter in the upper part of the formation, but toward the base, the boulders range up to 1 foot in diameter. Most of the pebbles and boulders are white or purplish-red quartzite, but minor amounts of red sandstone and dark-gray limestone pebbles are also present. The white quartzite is similar to that
of the Tintic formation whereas the purplish-red quartzite boulders resemble the pre-Cambrian (?) quartzites that are exposed in the Canyon Range. The red sandstone is probably Navajo and the limestones have been derived from the Cambrian and Ordovician carbonate sequence.

**Stratigraphic relationships:** Where present, the Price River formation overlies the early Laramide post-orogenic erosion surface. Where this surface is exposed on the west side of the Pavant Range the underlying formations are Cambrian or Ordovician and relief on the surface is as much as 500 feet, so that the Price River formation varies greatly in thickness and occurrence. Since there is considerable relief on the erosion surface and since no exposures of the Price River formation are known to the west, it is believed that these irregular patches are near the source and that the axis of the early Laramide mountains was not far to the west of the present Pavant Range.

Sandstones of the North Horn formation lie conformably on the Price River formation. The color change from light-red in the Price River to dark-red in the basal North Horn beds is abrupt, but the overall textural change across the formational boundary is gradational, the coarser texture being present in the Price River beds. The Price River conglomerates and sandstone lenses appear to have been deposited as alluvial fans, but the overlying
North Horn sandstones and shales are uniformly bedded as though they were deposited in quiet bodies of water. Thus the type of erosional debris did not vary greatly during the upper Price River and lower North Horn time, but the depositional environment probably changed entirely.

**Age and correlation:** Strata in the Pavant Range are assigned to the Price River formation on the basis of their stratigraphic position and conformable relations beneath the North Horn formation. Fossils found in fine sediments in the middle part of the Price River formation in the Wasatch Plateau (Spieker, 1946, p. 132) are considered to be late Montana in age, but in the coarser beds to the west in the Gunnison Plateau and the Pavant Range, fossils have not been found and the age of the formation is not as well established. The fanglomerate nature of the Price River sediments suggests that the formation is younger near its source in the Pavant Range than to the east in the Wasatch Plateau, and in the Pavant Range the Price River formation may well be equivalent in age (Lance) to the lower part of the overlying North Horn formation in the Wasatch Plateau.

**Cretaceous (?) and Tertiary Systems**

**North Horn Formation**

**Definition:** The fluviatile and lacustrine sandstones and shales above the Price River formation were defined by Spieker and Reeside (1925, p. 448) as the North Horn mem-
ber of the Wasatch formation. In 1946 (pp. 132-133), Spieker elevated the three members of the Wasatch forma-
tion to formational rank and named them in ascending order the North Horn formation, the Flagstaff limestone, and the Colton formation.

At the type locality on North Horn Mountain, the for-
mation is divided into four units of alternating fluvia-
tile and lacustrine shales, sandstones, conglomerates, and freshwater limestones.

**Distribution and lithology:** In the Pavant Range, the area of North Horn outcrop is controlled largely by the homo-
clinal dip of those beds. From the northern boundary of the area here described to Red Canyon on the east side of the Pavant Range, the North Horn formation crops out from the floor of Round Valley to the crest of the range. Far-
ther south, some of the streams have eroded the overlying Flagstaff formation exposing the North Horn beds in the canyon walls. West of the main divide of the range, the North Horn outcrop area is bounded by the early Laramide erosion surface.

The dominant lithologic sequence of the North Horn formation in the Pavant Range is alternating brown to buff sandstones and siltstones and buff to gray shales. The individual beds of sandstone and siltstone are ordinarily 3 to 4 feet thick, whereas the shale beds are usually
thinner. In the upper third of the section, several beds of conglomerate are present. These beds are strikingly persistent and may be traced on both sides of the Pavant Range divide from the south side of Pharo Creek to the north wall of Red Canyon. Minor lithologic types include pink, red, and purple siltstones and a thin algal-ball limestone near the top of the formation. Upon being cracked open, the algal-balls were found to contain small pebbles, shell fragments, or even whole pelecypod valves. Identification of the pelecypods was not possible, but the shape of the shells resembles that of known freshwater species.

The North Horn formation is 3270 feet thick east of the divide and between Rock Creek and North Willow Creek. Near triangulation station No. 6, the formation is estimated to be about 2000 feet thick.

Stratigraphic relationships: The North Horn formation normally overlies the Price River formation conformably, but since the Price River is not everywhere present, at many places the North Horn formation overlies Cambrian limestones in angular unconformity.

In the Pavant Range, all exposures of the contact between the North Horn formation and the overlying Flagstaff formation show the stratigraphic relations between these formations to be conformable. From the head of
Willow Creek to Strawberry Canyon, the upper boundary of the North Horn formation is readily drawn. There the change from sandstone and siltstone of the North Horn formation to white limestone of the Flagstaff formation is abrupt, but farther south and southwest, the distinction is not so readily made. Seen at a distance the brown sandstones of the North Horn formation change to brilliant red siltstones, silty limestones, and shales. Close at hand both the lithologic and color changes are gradational so that there is not a sharp division between the two formations.

**Age and correlation:** Distinguishing fossils have not been found in the Pavant Range so that the age of the lower part of the North Horn formation is not definitely known. Fossils found in the basal portion of the Flagstaff formation indicate a medial or late Paleocene age so that the conformably underlying North Horn formation is certainly Paleocene and probably extends downward into the Upper Cretaceous. Since there is some doubt as to the latter, the age designation of Gilliland (1951, p. 24), Cretaceous (?) Tertiary, is followed here.

At the type locality on North Horn Mountain, the formation is known to be late Cretaceous and early Paleocene in age (Spieker, 1946; Gilmore, 1946).
Tertiary System

Flagstaff Formation

**Definition:** The term Flagstaff limestone was given to a thick sequence of white to gray limestones exposed typically at Flagstaff Peak in the Wasatch Plateau by Spieker and Reeside (1925, p. 448). In the original definition, the Flagstaff limestone was the middle member of the Wasatch formation. In later work, Spieker (1946, pp. 135-136) revised the terminology giving the beds formational rank. In present usage the Flagstaff limestone is a formation lying above the North Horn formation and below the Colton formation and the three formations make up the Wasatch group. Gilliland (1951, p. 25) attempted to follow the earlier nomenclature, but was forced to revise the term to fit the sequence of limestone, shale and sandstone in the Valley Mountains that is the equivalent of the Flagstaff limestone. Nearshore and offshore facies in the Pavant Range also necessitate the use of the term Flagstaff formation in this report. In the Valley Mountains, Gilliland was able to subdivide the Flagstaff formation into five lithologic units some of which are present in the Pavant Range. A description of the lateral relations of the Flagstaff formation between these two areas is given in the paragraphs concerning age and correlation.
Plate 3

A. Red Pyramid.

Basal beds of the Flagstaff formation crop out just above the trees in the center at the base of the peak.

B. Flagstaff formation in Newt's Canyon.

Typical exposures of the Flagstaff formation showing the homoclinal dip in the central part of the Pavant Range.
Plate 4

Flagstaff formation in South Cedar Ridge Canyon.

View of a typical steep-walled canyon formed in the alternating siltstones and shales of the Flagstaff formation.
Plate 5

A. Brick-red Flagstaff beds between North and South Cedar Ridge Canyons.

View of the outcrop of the middle portion of the Flagstaff formation. The upper light-colored beds are exposed at the left. The dark hills at the lower left and right are made up of Bullion Canyon lavas. Note the fault marked by the abrupt color change in the left center along the mountain front.

B. Flagstaff and Green River formations along the east front of the Pavant Range.

Entire face of the range is Flagstaff except the perched buttes of Green River formation at the upper right and left foreground. View is south of South Cedar Ridge Canyon.
Plate 6

Conglomerate in the Flagstaff formation at the head of Mill Canyon.

Note the irregular surface on which the conglomerate was deposited. The low ridge in the background is also made up of the same conglomerate bed.
Distribution and lithology: For the most part the Flagstaff outcrops are confined to the east side of the Pavant divide. The northernmost exposure is at the head of North Willow Creek and Amos Canyon. To the south as far as Cottonwood Creek, the dominant part of the range is Flagstaff. In the central part of the range and south and west of Meadow Creek within the area here described, the Flagstaff is the only formation that crops out.

Brightly colored siltstones, shales and silty limestones make up the major portion of the Flagstaff sequence. White lacustrine limestone and brown conglomerate are present in minor amounts.

From the head of North Willow Creek to the north side of North Cedar Ridge Canyon, a series of massive white limestones is exposed at the base of the formation. Above these lacustrine beds is a thick series of flaming red alternating siltstones, silty limestones, and shales. The bedding is uniform and persistent so as to form long benches and cliffs arranged in steep steps. Pastel shades of pink, lavender, and yellow succeed the brilliant colors below. These light-colored beds are made up predominantly of shale and siltstone, but the siltstones do not occur as frequently nor as regularly as in the brightly-colored beds below so that in the light-colored beds, rounded rather than angular erosional forms result. This succes-
sion is finally broken by the prominent ledge formed by the overlying Green River limestone.

The conglomerate beds are confined to the thick section of bright-red siltstones and shales. The beds are comparatively thin, 8 to 15 feet thick, yet they are surprisingly persistent, extending for several miles along the length of the range and from the crest of the range to its eastern margin. The upper part of the conglomerate beds are gradational upward into sandstones and shales and uniform bedding continues upward. The lower conglomerate contact is disconformable with the underlying beds (pl. 6) indicating a period of at least local uplift and erosion prior to the deposition of the conglomerate beds.

Due to the gentle dip of the beds, much faulting, and the steep mountain front and canyon walls, a complete section of the Flagstaff formation could not be measured at one place. However, by combining parts of sections no. 6, 7, 8, and 9 (see appendix) the Flagstaff beds are found to be over 2800 feet thick.

**Stratigraphic relationships:** The relations between the Flagstaff formation and the underlying North Horn formation are conformable. These relations have already been discussed in the foregoing section concerning the North Horn formation and will not be repeated here. The upper boundary of the Flagstaff formation is marked sharply by
the abrupt change in lithology from shale to light-gray limestone. The Green River limestones rest conformably on the shales of the upper Flagstaff without a break in sedimentation showing only a change in environmental conditions due to the flooding of the area by the Green River lake. In the southern part of the Pavant, Green River beds form a tongue that thins gradually and finally disappears southeast of Little Valley. Where the Green River beds are absent, Crazy Hollow beds overlie the Flagstaff formation in apparent conformable relations. Outcrops of the contact are poor, but no features suggesting erosion prior to the deposition of the Crazy Hollow beds were observed.

In the Valley Mountains, 5 miles to the north, the variegated shales of the Colton formation are readily distinguished from the underlying calcareous Flagstaff formation. In the Pavant Range, the Colton is no longer a mappable unit and the equivalent beds are here included in the Flagstaff formation.

Age and correlation: Gill (1950) divided the Flagstaff limestone of the Wasatch Plateau into seven fossil zones. Katherman (1949) working on the east front of the Gunnison Plateau, was unable to make the same subdivision but he had five lithologic divisions. Later and more comprehensive work enabled A. La Rocque (1951, p. 1457) to divide
the Flagstaff of the Wasatch Plateau into three parts. He used quantities of the various species and faunal assemblages as the basis for his subdivision. This work resulted in dating the formation as medial and late Paleocene and possibly extending upward into the early Eocene.

Gilliland (1951, p. 26) divided the Flagstaff formation of the Valley Mountains into five lithologic parts from the base upward as follows: yellow limestone, gray limestone, red limestone, buff limestone, and gray limestone. The two lower units thin from north to south. The buff limestone is thin and comparatively local. The third and fifth units thicken toward the south.

In the Pavant Range the Flagstaff formation is made up of lithologies equivalent to the second, third, and fifth units of Gilliland's Valley Mountain section. The second or lower gray unit is present locally in the northeastern part of the range as a thin tongue of light-gray limestone extending between the adjacent beds of the North Horn formation below and the third or red unit of Flagstaff formation above. The tongue of limestone represents a short period of inundation and the maximum southwest expansion of the Flagstaff lake in central Utah. The third or red limestone unit is present in the Pavant as a thick sequence of bright-red siltstones, silty limestones, shales, and a few comparatively thin beds of brown con-
glomerate. The southward thickening of this unit is continued in the Pavant where more than 2000 feet of strata was measured. The fifth or gray limestone unit is represented in the Pavant Range by a series of pale-colored shales and siltstones and as in the red unit beneath, it is much thicker here than in the Valley Mountains. Nearly 700 feet of the upper pale beds was measured in the mountain front north of Dry Canyon.

The following fossils were collected from the basal gray limestone on Sweet Creek:

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<td><em>Viviparus trochiformis</em> (Meek and Hayden)</td>
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<tr>
<td>6</td>
<td><em>Physa cf. longiuscula</em> (Meek and Hayden)</td>
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<tr>
<td>14</td>
<td>&quot;Helix&quot; <em>riparia</em> White</td>
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<tr>
<td>2</td>
<td>&quot;Helix&quot; sp.</td>
</tr>
<tr>
<td>2</td>
<td>&quot;Helix&quot; sp.</td>
</tr>
<tr>
<td>1</td>
<td>&quot;Macrocyclis&quot; <em>spatiosa</em> Meek and Hayden</td>
</tr>
<tr>
<td>1</td>
<td><em>Discus cf. ralstonensis</em> (Cockerell)</td>
</tr>
<tr>
<td>few</td>
<td>Fish scales</td>
</tr>
<tr>
<td>few</td>
<td>Ostracodes</td>
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The assemblage is considered middle Flagstaff (A. La Rocque, personal communication) with respect to the more comprehensive section of the Wasatch Plateau. Hence the basal portion of the Flagstaff formation here is equivalent to the middle part of the formation in the central Wasatch Plateau and the lower Wasatch Plateau Flagstaff is equivalent to the upper part of the North Horn beds in the Pavant Range. Based on these relations, the Pavant
Flagstaff beds are late Paleocene in age and they probably extend upward into the early Eocene.

Green River Formation

**Definition:** Hayden (1869, p. 190) described the freshwater beds along the Green River west of Rock Spring, Wyoming. He called them the Green River shales and assigned them to the middle Tertiary. Later, Bradley (1929a, 1929b, 1931) extended the term to include the beds deposited in the Gosiute Lake in Wyoming and Uinta Lake in Colorado and Utah during the late Eocene. Spieker and Reeside (1925, p. 451) recognized Green River beds in the Wasatch Plateau. Cope (1880, p. 303) had termed them simply "the Manti beds." Subsequent work has shown that the Green River formation is also present in the Gunnison Plateau (Babisak, 1949; Hardy, 1948; Hunt, 1948, 1950; Taylor, 1948; Zeller, 1949), the Valley Mountains (Gilliland, 1951), Long Ridge (Muessig, 1951), and the Pavant Range (this paper).

**Distribution and lithology:** Green River beds are present in the low hills northwest of Aurora and on the mountain on the north side of North Cedar Ridge Canyon. The formation caps the plateau at four places near the eastern front of the range. Table Mountain is a typical example of this type of occurrence. West of Richfield, Green River crops out in the canyon walls, notably on Cottonwood Creek.
Plate 7

A. Green River formation.

View showing the alternating limestones and shales of the Green River formation broken by small faults to form a graben in Aurora Canyon.

B. Sage Flat hogbacks.

View of the low Green River monoclines that form the transition area between the Pavant Range and the Valley Mountains. The hogbacks dip toward the left rear of this view. Sevier Plateau is in the background. North Horn beds in Middle Canyon crop out in the foreground.
Typically the Green River formation consists of limestone, shale, oil shale, and some sandstone. Near the upper part of the formation it becomes siliceous. In the Valley Mountains, Gilliland (1951, p. 38) divided the formation into a lower limestone unit, a middle shale unit, and an upper siliceous limestone unit. A complete section showing the tripartite division is not present in the Pavant due to structure and erosion. The low hills northwest of Aurora are composed of the upper unit. The block north of North Cedar Ridge Canyon and the perched buttes to the south along the east front of the Pavant Range consist of a part of the lower unit. West of Richfield, the entire thickness of the formation is made up of siliceous limestone resembling the upper unit. The middle shale was not recognized in the Pavant Range.

Gilliland (1951, p. 96) measured more than 1150 feet of Green River strata in the southern part of the Valley Mountains. Sections of the upper siliceous limestone unit measured in the low hills northwest of Aurora indicate the presence of a comparable thickness of Green River beds if it is assumed that the lower two units are present but are merely faulted from view below the present surface. In Cottonwood Canyon, 57 feet of siliceous limestone represents the entire Green River formation. Farther south near the Forest Service road west of Richfield, the forma-
tion has thinned to 4 feet. As the formation is traced along the east side of the graben that forms Little Valley, it disappears completely.

**Stratigraphic relationships:** The Green River beds are conformable with the underlying Flagstaff formation where their contact is observable in the Pavant Range. To the west and southwest of Aurora, the overlying Crazy Hollow formation is present at various stratigraphic levels and in small irregular patches that give evidence of a short period of erosion between the times of deposition of the two formations. To the south, east of Little Valley, erosion is not evident. Here the Green River forms a tongue between the adjacent formations and thins southward until it disappears. The outcrops west of Richfield are the westernmost and southernmost occurrences of the Green River formation in south central Utah. This, coupled with the tonguing-out relations of the formation, affords strong evidence that delimits the boundary of the Green River lake.

**Age and correlation:** In Wyoming, the Green River formation is Wasatchian (Wood, 1941, pl. 1). As the beds are traced to the west into eastern Utah, they rise in the section, transcending the lower Eocene-middle Eocene boundary and become Bridgerian in age, but in the northern Wasatch Plateau the Green River spans the entire lower
Eocene (Spieker, personal communication). The nearshore beds in the southern Pavant should be at least Bridgerian in age and possibly Uintan.

Ganoid type fish scales and Chorellopsis (?) were the only fossils found in the Green River of the Pavant Range. The algae are distinctive of nothing but sedimentation conditions. Bradley (1929a) has compared Green River algae with modern forms to show that they indicate water depths of between 6 and 15 feet.

Crazy Hollow Formation

**Definition:** In 1949, Spieker (1949b, p. 36) proposed that a series of clastic beds above the Green River formation and beneath the Gray Gulch formation be called the Crazy Hollow formation. The formation is exposed typically in Crazy Hollow 2½ miles from Salina on the south side of Salina Canyon. The formation consists of red and orange sandstone, siltstone, and shale, white sandstone, and pepper and salt sandstone.

**Distribution and lithology:** The Crazy Hollow formation is exposed in the low hills northwest of Aurora and on the mountain proper west of Richfield. Near Aurora, the outcrops are small, thin, and patchy. At Richfield, the outcrop makes up the major portion of the rocks exposed between the mountain front and Little Valley.

The lithology in both outcrop areas is similar to
that of the type, but there is some variation in thickness. The Crazy Hollow beds consist mainly of alternating units of brick-red shale and sandstone ranging up to 6 feet in thickness. Standing in sharp contrast to the fine- to medium-grained red sandstones and shales are massive buff coarse-grained sandstones ranging from 20 to 50 feet in thickness. The distribution of these beds is irregular both areally and vertically, because they were deposited in local basins and channels (pl. 8, fig. A). Exposures of the massive buff sandstone beds are characteristically either pock-marked showing excellent examples of honeycomb weathering (pl. 9) or they are irregularly indented by a maze of shallow unconnected niches.

The largest section measured in the northern area was 161 feet, but the base is not exposed and the upper part of the formation has been eroded. The complete section measured west of Richfield is 366 feet thick.

**Stratigraphic relationships:** Where the base is exposed the Crazy Hollow formation overlies the Green River formation conformably except southeast of Little Valley where Green River is not present. There it overlies the Flagstaff formation in apparent conformity as discussed in the description of the Flagstaff relationships. The contact between the Crazy Hollow formation and the overlying Bald Knoll formation is exposed northwest of Aurora and south-
A. Channel sandstones in Crazy Hollow beds.

Outcrop of Crazy Hollow formation southwest of Richfield. The buff sandstone at the top of the cliff is more persistent than the channel sand in the middle foreground.

B. Crazy Hollow and Bald Knoll beds north of Utah Highway 63.

The dark beds in the second ridge are Crazy Hollow. Bald Knoll beds are in the foreground and to the left of the Crazy Hollow outcrop. Salina triangulation station is at the highest point on the skyline.
Plate 9

Cavernous and honey-comb weathering in the Crazy Hollow formation southwest of Richfield.
west of Richfield. In both areas the color change from the brick-red Crazy Hollow beds to the light-colored Bald Knoll beds is abrupt, but there is little change in lithology. Beds above and below the contact are parallel and no evidence of a sedimentary break was observed. Small isolated exposures of Crazy Hollow beds north of Utah Highway 63 are overlain unconformably by Axtell gravels. The angle between the beds above and below the contact averages 50°. At one small exposure northwest of Aurora, Green River beds overlie Crazy Hollow beds, but the relation is structural rather than depositional. This occurrence is discussed under the heading Green River thrusting.

Age and correlation: No fossils were found in the Crazy Hollow formation. The position of the Crazy Hollow beds above Green River beds of probable middle Eocene age limits the maximum age of the Crazy Hollow to middle Eocene. The Crazy Hollow beds are older than the lava flows and pyroclastic beds which Callaghan (1939, p. 447) considers to be early Tertiary and probably Oligocene. Bounded by these age limits the Crazy Hollow formation is probably late Eocene or early Oligocene in age.

Bald Knoll Formation

Definition: Gilliland (1951, p. 43) used the term Bald Knoll to denote a sequence of light-colored clays, silt-
stones, shales, limestones, and sandstones at the mouth of Bald Knoll Canyon in the Valley Mountains. Since the original definition, pyroclastic beds have been found in the middle and at the top of the formation at the type locality. Also pebbles of blue flint from the Green River formation have been found in conglomeratic beds in the lower part of the formation. The beds are green, tan, or white, but always in pale shades.

**Distribution and lithology:** The outcrop areas are nearly continuous from the type locality to the area northwest of Aurora, where Bald Knoll beds form low hills. The beds there are so poorly consolidated that they are easily susceptible to rill wash and thus support little vegetation. In this area an incomplete section 320 feet thick was measured. Gilliland (1951, p. 44) postulates 800 to 1000 feet of Bald Knoll strata in the vicinity. Southwest of Richfield the complete section is 277 feet thick.

In the Pavant area and in the type area, the Bald Knoll is made up predominantly of light-colored shales. Thin limestone and conglomerate beds are interspersed throughout the shale sequence.

**Stratigraphic relationships:** The relations between the Bald Knoll formation and the underlying Crazy Hollow formation are clearly shown in the areas southwest of Richfield and northwest of Aurora. At these localities the
contact is conformable. The contact between the Bald Knoll formation and the overlying Gray Gulch (?) pyroclastic beds is transitional. The amount of pyroclastic material increases in the upper part of the Bald Knoll beds to a maximum at the base of the Gray Gulch (?) pyroclastics. Both the Bald Knoll and the overlying Gray Gulch (?) formations appear to have been deposited in freshwater lakes and they differ only in mineral composition, a distinction not casually made during field study. However the high percentage of volcanic glass in the pyroclastic beds does facilitate differentiation between the two formations.

**Age and correlation:** Southwest of Richfield, the following species were collected by the writer from the basal limestone in the Bald Knoll formation and identified by Dr. Aurèlé La Rocque of the Ohio State University:

- "*Helix* (Glyptostoma?) *spatiosa* Meek and Hayden
- *Lymnaea* (sensu lato) sp. undet.
- "*Planorbis* *cirrus* White

Ostracodes

Fossils have not been found in the Bald Knoll beds previously and unfortunately this assemblage is too small to be indicative of a definite age. In addition, these species have been found in the lower unit of the freshwater Flagstaff formation in the Valley Mountains (Gilliland, 1951,
p. 31) which presents a vertical range too large to be of value in an age assignment of the Bald Knoll formation.

Reverting to the stratigraphic position of the Bald Knoll beds between the probable late Eocene Crazy Hollow formation and the probable Oligocene Gray Gulch (?) formation, the Bald Knoll formation was probably deposited during the late Eocene or early Oligocene with emphasis on the later age.

Gray Gulch (?) Formation

Definition: Spieker (1949b, p. 37) provisionally assigned the pyroclastic beds that lie above the Crazy Hollow formation in the Salina district to the Gray Gulch formation. The similar stratigraphic position of the pyroclastic beds in the Pavant area to that of the Salina district Gray Gulch formation suggests equivalence and on that basis the Pavant pyroclastics are tentatively assigned to the Gray Gulch formation.

Distribution and lithology: The Gray Gulch (?) beds consist of tan, gray, gray-green, and orange tuffs and a few beds of white "sandstone." Some of the tuffs contain much satinspar and many gypsum rosettes. Tests for the type of clay present were carried out according to the procedure outlined by the American Petroleum Institute Committee on Clay Minerals (1951, pp. 135-160) and according to Leroy and Crain (1949, p. 166). Tests with benzidine; san-
franine "y", and malachite green showed that all the
tuffs contain some montmorillonite and two samples also
contain some kaolinite. It was found that the white
"sandstone" is composed of poorly cemented shards of vol-
canic glass.

The Gray Gulch (?) beds crop out above the Bald
Knoll formation and beneath the Axtell formation or the
Bullion Canyon volcanics in a north-south band from the
mouth of Aurora Canyon to the northern edge of the area
mapped. Another outcrop area lies southwest of Richfield
on the Pavant Range. There the beds are exposed above the
Bald Knoll formation and below the Bullion Canyon volcan-
ics. The outcrop on the Pavant Range indicates a much
more extensive distribution of the pyroclastics prior to
erosion than exists at present.

Table 4 (p. 74) is presented to show the relative
amounts of volcanic glass and clay minerals in the pyro-
clastic beds, and because these beds have previously been
included as shales in the Bald Knoll formation (Gilliland,
1951, pl. 11), to justify their differentiation as a sep-
ate formation. Percentages are estimated after acid-
ization.

Stratigraphic relationships: The Gray Gulch (?) formation
is set off sharply from the overlying Axtell formation or
Bullion Canyon lavas, but the lower boundary is grada-
### TABLE 4

**MINERAL COMPOSITION OF SELECTED SAMPLES OF GRAY GULCH (?) FORMATION**

<table>
<thead>
<tr>
<th>Locality</th>
<th>Glass</th>
<th>Montmorillonite</th>
<th>Kaolinite</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 feet from the southwest corner of sec. 17, R. 1 W., T. 21 S.</td>
<td>100</td>
<td>--</td>
<td>Trace</td>
<td>--</td>
</tr>
<tr>
<td>Quarry of the Western Clay and Metals Co., northwest of Aurora.</td>
<td>10</td>
<td>60</td>
<td>30</td>
<td>--</td>
</tr>
<tr>
<td>Base of lava hill southwest of Aurora.</td>
<td>10</td>
<td>60</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td>Base of unit 4, section 1. (see appendix)</td>
<td>70</td>
<td>20</td>
<td>--</td>
<td>10</td>
</tr>
<tr>
<td>57 feet above base of unit 4, section 1.</td>
<td>50</td>
<td>10</td>
<td>--</td>
<td>40</td>
</tr>
<tr>
<td>Base of unit 3, section 1.</td>
<td>55</td>
<td>20</td>
<td>--</td>
<td>25</td>
</tr>
<tr>
<td>23 feet above base of unit 3, section 1.</td>
<td>80</td>
<td>20</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>
tional. Volcanic glass is present in some of the middle Bald Knoll beds and its occurrence is more frequent toward the top. The contact between the pyroclastic beds and the underlying Bald Knoll formation and the overlying Bullion Canyon lavas is conformable, but where the pyroclastics are overlain by the Axtell formation the contact is disconformable.

Age and correlation: The age of the pyroclastic beds is not definitely known, but their stratigraphic position above the Bald Knoll formation and beneath part of the Bullion Canyon volcanics indicates that they are probably Oligocene in age. The beds were deposited in freshwater lakes while volcanoes were erupting in the vicinity of the Tushar Mountains to the south. The volcanoes were probably pouring out the Bullion Canyon volcanics, but the flows did not extend as far north as the Pavant until after the pyroclastic beds were deposited. Callaghan (1939, p. 447) assigned the Bullion Canyon lavas to the early or middle Tertiary which is probably the age of the pyroclastic beds.

A specimen of wood was collected in the quarry of the Western Clay and Metals Company 1 mile northwest of Aurora. Dr. J. M. Schopf of the United States Geological Coal Laboratory at Ohio State University described the specimen as follows:
Charred angiospermous wood—
Brief micro-study shows the wood to be
diffuse and porous. Spring wood of
annual rays usually is badly distorted.
Vessels have oblique end walls with retic­
ulate perforation. Rays are prominent,
numerous, fusiform, tri- or quadri-seriate.
Tracheids or fibres are irregularly and
sparsely pitted on the radial walls.
Foliar traces (?) appear in one tan­
gential section.

The occurrence of the fragment about
6 inches in diameter, roughly equi­
dimensional, the contortion of cellular
structure and uniform black coloration
(some cell walls are brown translucent
under the microscope) leads me to be­
lieve this piece is probably charred
rather than fusinized. It obviously
has been moved from its site of growth,
perhaps during a period shortly following
volcanic activity when charring occurred.
It was probably mineralized (silicified)
in its present location where soluble
silicates would be abundant. The shrinkage
cracks, formed in charring, rendered the
wood easily permeable and facilitated dis­
dislocation and distortion within the tissues
before the wood was mineralized."

Tertiary and Quaternary Systems
Axtell Formation

Definition: Spieker (1949b, p. 38) defined the Axtell
formation to include the partially consolidated conglom­
erates 2 miles east of Axtell. The pebbles, cobbles, and
boulders are derived from all older rocks in the area.
Gilliland (1951, p. 51) concluded that the formation is
equivalent to the high level gravels on the eastern slopes
of the Valley Mountains and this interpretation is ac­
Plate 10

A. Gray Gulch (?) pyroclastic beds.

Ledge of ordinarily soft tuff held up by a concentration of gypsum veinlets. Note contrast to the slope in foreground.

B. Flat Canyon.

View of Gray Gulch (?) formation capped by dark lavas of Bullion Canyon formation. Richfield is at the extreme left in the valley.
cepted here.

**Distribution and lithology:** The Axtell formation is confined to the area north and west of Aurora. If the formation is present to the south, it has been covered by alluvium. Gilliland (1951, pl. 11) has mapped nearly continuous deposits of the Axtell formation along the east side of the Valley Mountains and scattered deposits on the east side of the Sevier Valley north of Salina.

The lithology of the Axtell formation is suggestive of the Price River lithology in that there is a large proportion of quartzite pebbles and boulders in it. However, there are also many sandstone, limestone, and lava boulders that have been derived from the younger formations. Generally the formation is poorly sorted. The matrix contains much silt and there is a great variation in the size of the boulders.

**Stratigraphic relationships:** Half a mile northwest of Aurora, the Axtell formation overlies the Bullion Canyon in angular unconformity (see pl. 11). The conglomerate beds overlap the lava. Farther north the Axtell overlies the Bald Knoll and the Crazy Hollow formations. Relations between the Axtell and the alluvium show only a gradation upward and a lateral variation toward the center of the valley.

**Age and correlation:** The Axtell formation is similar to
Axtell and Bullion Canyon formations.

Axtell formation (right) overlaps the Bullion Canyon lavas (left) northwest of Aurora.
the Sevier River formation of the Tushar Mountains in that both formations contain pebbles of all older formations in their respective areas and both lie immediately above the same extrusive sequence. Callaghan (1938) traced the Sevier River formation to lacustrine beds containing diatoms that indicate a late Pliocene or early Pleistocene age. Gregory (1945) found a similar sequence in the upper Sevier River Valley. The Parunuweap formation overlies the Brian Head formation, the probable equivalent of the Bald Knoll formation, and is found beneath Quaternary basalts.

The Axtell formation forms pediments that have been dissected, probably during the pluvial periods of the ice ages. Thus a late Pliocene or an early Pleistocene age fits the evidence available.

**Quaternary System**

**Pleistocene Drift**

**Distribution and lithology:** Glacial deposits are limited to stream valleys north and east of smooth high peaks and to altitudes above 9000 feet. Cirques are clearly evident near the head of Pharo Creek, Eagle Hollow, Paradise Creek and Three Forks. Terminal and recessional moraines are closely associated. In nearly all cases, the zone of accumulation and ablation was within the boundaries of the North Horn formation. As a result, the till is made up
of waste products of the sandstone, siltstone, and shale of that formation. Angular to subangular slabs of sandstone and siltstone up to 2 feet in diameter surrounded by a matrix of finer material make up the till fabric. The exception is in Paradise Canyon where the bedrock is Cambrian limestone.

**Age and correlation:** Just one period of glaciation is evident in the Pavant Range. Ives (1946, p. 335) found evidence of only one period of glaciation in the Deep Creek, Snake, and Stansbury Ranges. However, the glacial deposits in the Stansbury Range appear much older than those of the other ranges. Atwood (1909) recognized an older and a younger period of glaciation in the Wasatch and the Uinta Mountains. Other investigators propose from two to five ice advances in the various high areas of the Cordilleran and Rocky Mountain regions. The Wasatch Plateau (Spieker and Billings, 1940) and the Tushar Mountains (Callaghan, 1939) were subjected to glaciation during the last (Wisconsin) ice age. The Wasatch moraines have now been shown to indicate two ice advances (E. M. Spieker and R. P. Goldthwait, personal communication). Multiple ice stages separated by interglacial times are still questioned.

The glaciation of the Pavant Range is probably correlative with that of the Tushar Mountains and with the
later advance of the Wasatch Plateau. The deposits in all three cases are comparatively fresh and the features are dissected very little. With this in mind, correlation with one of the multiple glaciations of the other ranges becomes difficult. Spieker and Billings have already discussed the problems involved and have partly solved the problem. The postulation that earlier glaciations were not as extensive in some areas as the last one in central Utah seems likely. Also any earlier deposits could have been destroyed by erosion. Atwood (1909, p. 68) did not find evidence of two glacial periods in all localities in the Wasatch Mountains. Some valleys contained moraines of only the later and apparently less extensive advance.

In all likelihood the local conditions played a major role in determining whether glaciation could take place. Altitude, precipitation, and latitude were all critical factors. If precipitation were the major factor, the size and location of Lake Bonneville along with the prevailing wind direction would locally influence the accumulation of snow needed to form glaciers.

Alluvium

Alluvium covers the surfaces of Sevier and Round Valleys and Sage Flat. Near the center of the valleys, the sediment is very fine-grained. As the mountains are approached, the grain size increases and near the mountain
front, coarse poorly sorted gravel is dominant.

Wells have not been drilled to bedrock in the valleys. A well in the Sevier Valley (Richardson, 1907, p. 13) was drilled to a depth of 530 feet without reaching bedrock.

Northwest of this area and west of Holden, Utah, the C. H. Erickson well, sec. 27, T. 20 S., R. 5 W. (Dennis, p. 87), penetrated the Sevier River (?) formation at a depth of 560 feet.

IGNEOUS ROCKS

Bullion Canyon Volcanics

Definition: The term Bullion Canyon volcanics was given to a series of flows in the Tushar Mountains by Callaghan (1939, p. 447). He divided the volcanic sequence into an earlier and a later Tertiary series on the basis of an erosional interval between the two series of flows, and assigned the Bullion Canyon group to the earlier Tertiary or Oligocene series. In the Tushar Mountains and surrounding areas, the Bullion Canyon group varies widely from place to place making an exact measurement of the thickness impossible, but the total thickness in the Marysvale region is over 5000 feet (Callaghan, 1939, p. 441). The Bullion Canyon volcanics overlie the Permian, Triassic, and Jurassic sedimentary sequence and they are
intruded by a quartz monzonite and an intrusive latite. The Bullion Canyon sequence is overlain by the Roger Park volcanic breccia (Callaghan, 1939, p. 440).

**Distribution and lithology:** Small isolated outcrops of Bullion Canyon volcanics occur along the east front of the Pavant Range between Richfield and Aurora. Southwest of Richfield the lava caps the mountain and extends to the south into the Tushar Mountains. Near the west side of the Sevier Plateau about 1 mile east of Glenwood, an isolated lava hill rises prominently out of Sevier Valley.

The character of the lava changes from porphyritic in the lower flows to scoriaceous in the upper part of the series. Representative samples were selected for detailed study and are described below.

(1) DIOPSIDE ANDESITE: The specimen was collected from the south end of the elongate lava hill southeast of South Cedar Ridge Canyon.

The rock is dark reddish-brown in color and has a distinct porphyritic texture with an aphanitic groundmass. Euhedral white feldspar laths (average length 2 mm., maximum 5 mm.) form about 30 percent of the rock; iddingsite 2 mm. in maximum length constitutes 5 percent. Microscopic examination shows the euhedral feldspar crystals as well as the microlites to be andesine. The iddingsite grains are pseudomorphs after olivine and a few grains still contain a central core of olivine. Diopside is present in minor amounts. Hematite, probably an alteration product of the olivine, and apatite occur as accessories. The groundmass, constituting about 60 percent of the rock, is glass. Flow structure is plainly shown, particularly by the microlites (see pl. 12, fig. B).
Plate 12 Photomicrograph of Diopside Andesite

A. Plane-polarized light.

The white grains are andesine. The large grain with a dark outline at the right and the euhedral grain in the lower left are iddingsite pseudomorphs after olivine. The black grain at the left edge is hematite. (X 30).

B. Crossed nicols.
Plate 13 Photomicrograph of Olivine-Diopside Andesite

A. Plane-polarized light.

White grains are andesine. Grain at upper center and large grain at right are iddingsite with central olivine cores. Large grain on left border is diopside. (X 30).

B. Crossed nicols.

Note twinned diopside grain on left.
(2) DIOPSIDE-OLIVINE ANDESITE: The specimen was collected south of Flat Canyon on the west slope of the hill called M-7 in the United States Coast and Geodetic Survey triangulation net of the Fish Lake National Forest.

The rock is dark bluish-gray in color and has a scoriaceous texture. The vesicles are drawn out to elongated shapes and are aligned to show good flow structure. Individual minerals are not distinguishable in the hand specimen, but microscopic examination shows the mineral assemblage to be essentially the same as in the specimen described above, differing only in the percentages of the minerals. Andesine is the dominant mineral, but forms only about 20 percent of the rock. All of the andesine grains are deeply embayed. Diopside, commonly twinned, constitutes about 10 percent of the rock. Frequently, olivine occurs with only the edge of the grain altered. A few small crystals of apatite and some hematite, probably an alteration product of the olivine, occur as accessories.

**Stratigraphic relationships:** The Bullion Canyon volcanics overlie the Gray Gulch (?) formation in apparent conformity. The change in lithology from water-laid pyroclastics to lava is abrupt, but the time relation between the two formations is not the same everywhere. The basal Bullion Canyon flows of the Tushar Mountains are apparently contemporaneous with the Gray Gulch (?) formation of the Pa-vant area.

The Axtell formation overlies the Bullion Canyon volcanics in angular unconformity. This relation has already been discussed under the description of the Axtell formation.

**Age and correlation:** The Bullion Canyon volcanics can be traced to the Tushar Mountains where Callaghan (1939, p.
447) assigned them to the early or middle Tertiary. No evidence is present in the Pavant area to substantiate or oppose that age designation, and Callaghan's conclusions are accepted here.
STRUCTURE

GENERAL SETTING

The Pavant Range is bordered on the east and west by normal faults of great displacement. On the east, Sevier Valley is a structural trough with the Sevier fault bordering the west side of the Sevier Plateau and monoclinal step faults bordering the Pavant. Farther north, Round Valley, a graben, separates the Pavant Range from the Valley Mountains to the east. Pavant Valley, a flat plain nearly 40 miles wide, borders the range on the west. The Hurricane fault is inferred at the west boundary of the Pavant.

The structure within the Pavant Range includes both the complex folding and faulting typical of the Basin Ranges and the simpler normal and reverse faulting common in the plateau areas. These diverse types of structure are separated roughly by the erosional contact at the base of the Cretaceous formations, but neither type of structure is found in one group of beds to the exclusion of the other. Some normal faulting is found in the older folded beds and some of the younger beds have been folded and broken by thrust faults.
THRUST FAULTING AND ASSOCIATED FOLDING

The Pavant Thrust Fault

The Pavant thrust fault is exposed on the west side of the Pavant Range between Fillmore Peak northeast of Fillmore and Corn Creek southeast of Kanosh. The position of the fault is emphasized by the striking contrast between red sandstone below and white quartzite above the thrust plane. The position of the fault is further accentuated by an abrupt change in slope at the thrust contact. The average dip of the thrust plane is 20° to the east in both forks of Chalk Creek where the fault is well exposed.

The exposed part of the autochthon is composed of late Paleozoic and early Mesozoic formations. Maxey (1946, pl. 1) mapped the Kaibab, Moenkopi, Shinarump, Chinle, and Navajo formations in the block that is below the thrust contact. Older formations do not crop out in the Pavant area except in the thrust plate. Of the formations listed, only the Navajo crops out in the area considered here. The structure of the Navajo sandstone in both forks of Chalk Creek is anticlinal. At the eastern border of White Sage Flat the beds dip 20° SE. The inclination of the beds increases to the east. A maximum southeastward dip of 44° was measured at the easternmost
exposure of the formation in the south fork of Chalk Creek. West of the area included on the geologic map, the dip of the Navajo beds decreases and gradually changes to a westward inclination. West of White Sage Flat, a normal fault cuts off a part of the west limb of the anticline and abuts it against the west limb of an overturned asymmetric syncline composed of the Permian and Triassic formations listed above. The beds in the autochthon were probably folded during the thrusting and the normal faulting occurred much later.

The allochthon consists at least of Cambrian and Ordovician formations, and of these only the Cambrian formations are present in the central part of the Pavant. The Tintic quartzite is the basal formation in the thrust plate except in the vicinity of Corn Creek where the Tintic was cut out by thrusting and the overlying limestones form the basal part of the thrust plate (Maxey, 1946, p. 353).

In the north fork of Chalk Creek and the main tributary streams of the south fork, the structure of the Cambrian beds is an asymmetric anticline. The anticline is displayed clearly on the south side of Fillmore Peak where the north fork of Chalk Creek has breached the structure. On the west slope and near the base of Fillmore Peak, the Tintic quartzite beds dip 14° SW. As one proceeds east-
ward climbing the peak, the Tintic beds are horizontal about half way up the slope and dip toward the east on the upper part of the slope. Just east of the summit the beds are nearly vertical. The easily eroded shales of the Ophir formation are present in the saddle between Fillmore and Pioneer Peaks. The west slope of Pioneer Peak is composed of Cambrian limestones dipping 43° NE. The angular unconformity between the Cambrian and Cretaceous formations is a few hundred feet west of the summit of Pioneer Peak.

In the south fork of Chalk Creek between Shingle Mill Canyon and the mouth of Chokecherry Canyon, the east limb of the asymmetric anticline is overturned and minor imbricate thrusting is associated with the major structure (see pl. 27; pl. 17, fig. A). The axis of the anticline is approximately one-fourth mile west of the saddle at the head of Shingle Mill Canyon. Near the mouth of Shingle Mill Canyon, overturned beds in the Ophir formation dip 34° NW. East of Paradise Creek, and in Chokecherry and Three Forks Canyons, the asymmetric anticlinal structure is again present as is shown by the increase in dip from the floors of the canyons to the ridges above them and along the walls of the west-flowing streams.

As stated above, the thrust plane dips to the east and the relative movement of the allochthon with respect
to the autochthon was to the east, yet in all examples cited by Billings (1942, pp. 172-191), the thrust plane dips in the opposite direction to that of the movement of the overthrust block except where the thrust plane has been subsequently tilted or folded. There has been some tilting since thrusting took place as is evidenced by the uniform 14° dip to the southeast of the Cretaceous and Tertiary beds which were deposited after the thrust faulting. The great areal extent and the uniform thickness of the individual lacustrine beds of the North Horn and Flagstaff formations suggests that they were deposited at a horizontal attitude. However, after restoration of these beds to a horizontal attitude by means of the method suggested by Spieker (1938), the thrust plane still dips slightly to the east, indicating tilting or folding of the thrust plane after movement along it had occurred. If the synclinal form of the thrust plane in the Canyon Range (Christiansen, 1951, pl. 2) is used analogously, the Pavant thrust was subsequently folded.

Quaternary deposits in Pavant Valley conceal the bedrock to the west and prohibit accurate measurement of the displacement of the thrust fault. The order of outcrop of the formations beneath the thrust plane is youngest on the east and oldest on the west, but the oldest exposed beds are Permian. If Cambrian and Ordovician formations are in
A. Tintic quartzite above thrust contact in the south fork of Chalk Creek.

The thrust contact and the underlying Navajo sandstone are concealed by the weathered slopes. Note the jagged ledges formed by the quartzite.

B. Tintic quartzite thrust over Navajo sandstone.

Navajo outcrops in the left foreground in the south fork of Chalk Creek. Tintic is above the Navajo and in the background.
Plate 15

A. Anticlinal structure in the Tintic quartzite.

Tintic quartzite folded sharply into an anticline in the south fork of Chalk Creek.

B. Overturned asymmetric anticline in the south fork of Chalk Creek.
Folded Tintic quartzite beds in the south fork of Chalk Creek.
Plate 17

A. Imbricate thrust in Teutonic limestone.

Small thrust fault in overturned Teutonic limestone beds in the south fork of Chalk Creek.

B. Overturned Teutonic limestone in south fork of Chalk Creek.

Note normal fault of small displacement in lower center. Beds in background are upright and dip away from observer.
their correct stratigraphic position, they are concealed by alluvium and based on this the minimum breadth of the thrust fault is 11 miles. If the older beds have been removed by thrusting, the minimum displacement of the thrust fault is 11 miles. These distances are based on the position of Kaibab limestone outcrops beneath the thrust fault and 11 miles west of the easternmost outcrop of Cambrian beds.

Although major thrust features are common, minor ones are not. A singular lack of contortion was noted in the beds immediately above and below the fault plane.

In the Pavant Range, the youngest beds beneath the thrust fault are Jurassic and the oldest beds that have been deposited on the thrust block are Upper Cretaceous, a relation that does not permit an accurate age assignment to the time of orogeny. To the east in the Sevier and Wasatch Plateaus tremendous thicknesses of sediments were deposited during this interval, and the base of the lowest formation, the Arapien shale, is not exposed. Presumably the Arapien is underlain there by the Navajo sandstone, but proof is not extant. In the Pavant, the upper boundary of the Navajo is a structural contact. Three interpretations may be conceived to explain the absence of the Arapien and Twist Gulch formations in the Pavant Range; (1) nondeposition, (2) deposition and subsequent erosion,
or (3) stripping of the formations by the forward movement of the thrust block.

(1) Nondeposition is possible, but the chief objection to this hypothesis is the presence of nearly 10,000 feet of Arapien and Twist Gulch formations less than 20 miles to the east in the Sevier and Wasatch Plateaus. It seems somewhat unlikely, but not impossible, that the marine Arapien and Twist Gulch formations should thin so rapidly to the west whereas they are much more extensive in other directions.

(2) Deposition and subsequent erosion of the Arapien and Twist Gulch formations is entirely possible. Probably the Arapien and Twist Gulch seas extended west of the present site of the Pavant Range and in the light of the thick section farther east, the deposition of several thousand feet of sediments is not beyond reason. Assuming the lithology to have been the same as the variegated shales exposed in the Sevier and Wasatch Plateaus, erosion of the "Pavant Arapien" would have produced sediments of similar lithology. The variegated shales of the lower part of the Morrison (?) beds may well be the products of such an erosion. Exposures of the contact between the Twist Gulch and the Morrison (?) formations are scarce and where that contact has been observed, it is gradational and suggests intertonguing (Spieker, 1946, pp.
124-125). At other places as on both the east and west sides of the Gunnison Plateau, the overlying Indianola formation includes beds equivalent to the Morrison (?) formation which are not readily distinguished from the Indianola beds and thus have not as yet been mapped. (E. M. Spieker, personal communication.) If the Arapien and Twist Gulch formations had been deposited in the Pavant area, uplift would have been necessary to effect their erosion. Orogeny at that time has already been suggested by Spieker (1949b, p. 78). Thus the arguments for deposition and subsequent erosion are not beyond reason when considered regionally.

(3) The process of stripping an underlying formation from an area by a thrust block is complex and of the three hypotheses offered, is the most difficult to accept. However, regional relations require some consideration of the hypothesis. It has been shown above that the time occupied by the deposition of a thick section of sediments in other places is represented in the Pavant area by orogeny. In the Gunnison, Wasatch, and Sevier Plateaus, the Arapien and Twist Gulch formations are intricately folded, yet in places where the formations are deeply eroded as in Deep Canyon in the west central part of the Gunnison Plateau, the underlying formations are not exposed (Hunt, 1950, p. 119). Spieker (1949b, p. 68) has suggested that the Arapien
and Twist Gulch formations were folded independently of the underlying formations. If such were the case, greater shortening would be necessary in the Arapien and Twist Gulch formations than in the older formations. Stripping would produce the necessary shortening, would account for the absence of the Arapien and Twist Gulch formations in the Pavant area, and would explain their complex structure in the areas to the east.

**Green River Thrusting**

South of Utah Highway 63 and northwest of Aurora in the low Green River hills, there is a small exposure that shows the Green River formation thrust over Crazy Hollow beds. The lateral extent of the exposure is too small to permit an estimate of displacement. Its proximity and possible relation to the thrusting in the Salina district warrants some discussion.

Although this small exposure does not show younger beds thrust over older beds as in the strip thrusts in the Salina district (Spieker, 1949b, p. 58; Billings, 1933, p. 154), it does resemble some of the imbricate thrusts that resulted from that strip thrusting. Just as in the imbricate thrusts of the Salina district, here older beds have been thrust over younger beds, but attempts to draw closer relations between the two areas rest on shaky
Green River thrusting.

Base of Green River beds is at head of the hammer. Note drag folds in Green River beds and blocks of Green River in fault zone below.
A. Green River thrusting.

Note blocks of Green River formation in thrust zone. Crazy Hollow beds below are red shales.

B. Little Valley graben.

Center of graben is in center of view and strikes left and away from observer.
ground. In the light of the covered area that separates the two thrust outcrops and the small exposure of the thrust described here, one can safely do little more than list the similarities between the two areas.

The Crazy Hollow beds were not affected by the movement except immediately below the thrust contact. In the thrust zone, the soft shales of the Crazy Hollow formation are mixed indiscriminately with pieces and blocks of the overlying Green River formation and no semblance of bedding has been preserved (see pl. 18; pl. 19, fig. A).

The general structure of the thrust block is synclinal. At the easternmost exposure of the Green River beds, the dip is 55° SW. whereas a few feet to the west, the dip changes to 60° NE. The strike of the beds at each outcrop is N. 36° W. and is normal to the probable direction of movement.

Many small asymmetric drag folds immediately above the thrust zone indicate that the movement of the overthrust block was toward the northeast with respect to the underthrust block (pl. 18).

NORMAL FAULTING

Little Valley Graben

The graben that forms Little Valley west of Richfield is the counterpart of the group of en echelon graben on
the Wasatch Plateau. It is possibly related to the graben of Japs Valley and South Valley, in the central part of the Valley Mountains, and to Round Valley.

The faults are essentially parallel and strike approximately N. 35° E. Dip measurements on the faults were not possible, but the movement was probably not far from vertical. The graben is 6 miles long and 1½ miles wide.

The western part of the graben is made up of a series of step faults. In the eastern part of the graben, two faults account for the entire displacement. Light-colored beds of the upper part of the Flagstaff formation have been dropped below the brick-red beds of that formation in the westernmost fault indicating a displacement of over 1000 feet. The faults in the central part of the graben have dropped the Bald Knoll formation down to a position adjacent to the upper Flagstaff beds and have thus undergone an additional 500 to 600 feet of movement.

**Aurora Horst**

The horst southwest of Aurora consists of a narrow northwest-trending wedge of Flagstaff formation bordered on both sides by Green River beds. The fault plane on the southwest side of the horst strikes N. 36° W. and dips 59° SW. The northeast fault has approximately the same strike,
Plate 20

A. Aurora horst.

Dark-colored beds in center make up Flagstaff horst. Beds to left and right are Green River. Round Valley and northern part of Pavant Range are in background.

B. Southwest fault of Aurora horst.

Fault zone is shown by abrupt color change in the foreground.
but exposures of the fault plane are too poor to permit a dip measurement. The Green River beds are turned up to an almost vertical attitude on the northeast side of the horst. The Flagstaff and Green River beds strike parallel to the faults, but the Flagstaff beds dip only 12° NE compared to 26° NE for the Green River beds. The relations at the northwest end of the horst are concealed by the alluvium of Sage Flat, but it is believed that the uplifted block has undergone rotation about a northeast-southwest axis.

At the bordering faults, upper Green River beds abut against beds in the lower part of the Flagstaff formation accounting for a displacement of over 2000 feet. If the Colton formation is present as it is a few miles to the north, the displacement is even greater.

**Sage Flat Hogbacks**

The term Sage Flat hogbacks is used here to denote the low hills underlain by the Green River formation east of Sage Flat and northwest of Aurora. This series of hills trends northwest in the transition area between the Pavant Range and the Valley Mountains. They lie immediately south of the Valley Mountains and off the northeast side of the north central part of the Pavant Range. They are intimately related to both mountain ranges and form a
cross-structure between them.

The long parallel hills are all down-faulted on the southwest side. A transverse section through the hills is asymmetric with the bevelled edges of the beds forming the steep southwest side and the dip slope forming the smooth gentle northeast side. The faults and the Green River beds strike approximately N. 40° W. The dip of the Green River beds averages 18° NE. and displacement along the faults ranges from 300 to 700 feet.

The faults are parallel to and may be aligned with the scarplets in Round Valley and with some of the large faults that cut the northern part of the Pavant Range. The movement along the faults has probably been synchronous with that of the Round Valley graben.

**Basin and Range Faulting**

The abrupt mountain front of both the east and west sides of the Pavant Range indicates that the last great series of movements were comparatively recent events. The fault on the west side, mapped as an extension of the Hurricane fault by Butler (1920, pl. 4), is outside the area considered here. Maxey (1946, p. 354) has found evidence for movement before and after the deposition of the Sevier River formation in that area. A minimum displacement of 3000 feet is necessary to account for the present eleva-
Normal faulting in North Horn beds.

Displacement is measured by offset in sandstone bed above the conglomerate.
tion of the mountain range. A subsequent displacement of several hundred feet must be acknowledged to account for the occurrence of the Sevier River formation at the surface along the mountain front and at a depth of 560 feet in the C. H. Erickson well (Dennis, 1946, p. 87).

On the east side and in the southern part of the Pavant Range, the trend of the major zone of displacement is northeast. North of North Cedar Ridge Canyon the trend turns northwest and follows the west side of Round Valley. For short distances along the eastern front of the range only one fault is exposed, but for the greater length of the range, the mountain front is bordered by a series of parallel faults in which each fault block has been dropped lower and is tilted more to the southeast than its neighbor to the west. The general picture assumes that of a faulted monocline with the total displacement distributed among the step faults. The general inclination of the beds in the mountain range proper is 12° SE. whereas that of the east-bordering fault blocks is as much as 62° SE. Isolated blocks of lava that are tilted more steeply than the blocks in the mountain front indicate that faults concealed by alluvium are present in the low area bordering the mountain front. The spring at the Richfield water-works is several hundred feet from the mountain front and the temperature of the water is 74° F. (Richardson, 1907,
A. Synthetic faulting along east front of Pavant Range.

Green River beds in foreground dip 47° SE. and Green River beds in middle ground dip 31° SE. Flagstaff in background dip 14° SE.

B. Recent faulting.

Faulted alluvial fan near Maple Grove (middle of the picture). Cliff in background is typical exposure of Price River formation along eastern front of the northern Pavant. Smooth slopes on the skyline are in North Horn beds.
p. 25) indicating either magmatic heating or a deep source for the water if the temperature is due to the geothermal gradient.

The faults along the mountain front dip to the southeast at angles higher than 70° where the fault zone can be observed. South of North Cedar Ridge Canyon, most of the faults strike approximately N. 35° E. whereas farther north the strike changes to about N. 20° W. A second group of faults, localized mainly between North and South Cedar Ridge Canyons, strikes about N. 20° E. Their location and their deviation from the general trend farther south reflect the influence of the major structural lines of the region. A third group of faults, striking about N. 55° W., is normal to the mountain front and its bordering faults.

At some time during the period of normal faulting, probably during the time of greatest displacement, the mountain block was tilted as a unit to produce a uniform 14° dip to the southeast in the Cretaceous and Tertiary formations.

**Quaternary Faulting**

Evidence for Quaternary faulting is present just north of the area mapped. From Herbert's ranch to Maple Grove, a series of scarplets cut off the alluvial fans.
Displacement varies from 3 to 30 feet. The scarplets and the Sage Flat faults are parallel and are probably connected.

**EPISODES OF FAULTING AND FOLDING**

Orogenic and epeirogenic forces have probably affected the Pavant area from pre-Cambrian time to the present. The rocks exposed show only a partial record of the events.

**Early Laramide Orogeny**

In areas adjacent to the Pavant, orogenic movements are known to have started in the late Jurassic or early Cretaceous and to have continued at least at intervals into the upper Cretaceous. In the Pavant, this period is represented by a long period of erosion as is shown by Price River conglomerate and North Horn sandstones lying in angular unconformity on Cambrian formations that have been thrust over Navajo sandstone. Positive evidence of only the early Laramide orogeny is shown by Price River conglomerate overlying the angular unconformity whereas negative evidence of earlier orogenies is shown by the absence of the thick series of conglomerates that should overlie the Navajo sandstone. In the Wasatch Plateau (Spieker, 1949b, pp. 78-79) and in the Gunnison Plateau
(Hunt, 1950, p. 147) there is evidence that four additional orogenic pulses occurred after the deposition of the Navajo sandstone and before the deposition of the Price River formation. Conglomerates in the Morrison (?), Indianola, and South Flat formations imply individual orogenies. Further, the westernmost exposures of the formations listed above are east of the Pavant Range. From this it may be assumed that the early Laramide mountains extended farther to the east than the present Pavant Range and that the sedimentary basins were in the vicinity of the Gunnison and Wasatch Plateaus. Repeated movements along established structural lines coupled with subsidence in the sedimentary basins produced the record of the orogenies there, but left no clear evidence in the upland area to the west. As the positive area was eroded and the basins to the east were filled, the east front of the mountains retreated westward and finally Price River sediments lapped up on the erosion surface that is not exposed. The latter part of the history is preserved in the Pavant Range.

Evidence supporting multiple movements is found in the Canyon Range to the north where Christiansen (1951, p. 12) found Indianola (?) conglomerates involved in the thrusting.
Pre-Flagstaff Movement

The pre-Flagstaff movement has already been discussed in considerable detail (Spieker, 1946, p. 155; 1949b, pp. 48-52). So far evidence has been found only in Sixmile Canyon in the Wasatch Plateau. Although the Pavant is comparatively distant to show any relation to this local feature, the possibility of correlation should not be overlooked.

As one examines the North Horn formation, a thick monotonous sequence of sandstones, siltstones, and shales is encountered in the lower and middle portion of the formation. In the upper part of the formation there is a sudden change to conglomerate and then the lithology reverts to that of the lower beds. The conglomerate with interbedded coarse-grained sandstones, is over 300 feet thick. It can be traced from the crest of the range in the north to its disappearance 7 miles to the south where its dip takes it out of sight under younger beds. To be of significance, it must be remembered that based upon paleontologic evidence (p. 57), the upper part of the North Horn formation in the Pavant is the same age as the lower part of the Flagstaff limestone in the Sixmile Canyon area.

The correlation is certainly not exact and the two movements may be entirely unrelated, but if future inves-
tigators are more aware of the existence of the pre-Flagstaff movement, their observations may show that it is not as local as is now believed.

**Late Tertiary (?) Basin and Range Faulting**

From evidence present in the Pavant Range, the Basin and Range faulting cannot be accurately dated. Late Tertiary lava, probably Miocene in age, is the youngest formation involved in the faulting. The movements have probably continued episodically to the present resulting in both the deposition and the tilting of the Axtell formation.

**Quaternary Faulting**

Scarplets in the alluvium in Round Valley and tilted Axtell and Sevier River formations indicate comparatively recent movement.
GEOLOGIC HISTORY

The geologic history of Utah and the surrounding areas has been described in detail by many writers. The Great Basin has been summarized by Nolan (1943) and the Colorado Plateaus by Spieker (1946). Minor details that are lacking may be filled in by consulting the bibliographies in these books. A summary of the events that have taken place in the Pavant Range and the adjacent areas is included here.

The encroaching Cambrian sea moved into the Pavant area from the west in the latter part of the early Cambrian. Littoral sand deposition was followed by offshore muds and fine clastics. Interbedded shales and quartzites show a slightly shifting strand. A long period of subsidence followed during which thick calcareous beds and occasional thin offshore muds were deposited.

Deposition of calcareous beds continued into the Ordovician. An erosional break between the two periods of deposition is reported in most of the Great Basin studies, but in the Pavant area beds of both systems have essentially the same attitude and lithology. In the upper part of the Ordovician section, a massive quartzite bed represents a brief regression and transgression of the sea.

The long interval from Ordovician to Permian is unrepresented in the Pavant area. The missing interval is
present in the San Francisco Mountains (Butler, 1920, p. 511) to the southwest and in most of the ranges in northern Utah (Gilluly, 1932; Eardley, 1934; Baker, 1947; and many others). Seas probably covered the Pavant area during Silurian to Permian time, but either the deposits have been eroded or the structure of the region conceals them. The latter possibility must be entertained because the sequence is oldest at the western border of the range and the oldest beds exposed are Permian (Kaibab). Thus for at least a part of Permian time, the Pavant area was submerged and a thick series of limestone beds was deposited.

During the Triassic and the early part of the Jurassic, the Pavant area was inundated, but there was a distinct change in sedimentary environment. Shallow water and littoral sediments were being deposited rather than the trough sediments of the Paleozoic. Muds, coarse sands and silty limes were deposited as Moenkopi, Shinarump, and Chinle formations (Maxey, 1946, pp. 335-337). Aeolian sands were deposited during Navajo time.

No beds have been found in the vicinity that are the equivalent of the upper part of the Glen Canyon group nor is there any representative of the entire San Rafael group. During the latter part of the Jurassic the area was probably flooded again. It is not certain that the sea extended over the Pavant area during the time of Arapien and
Twist Gulch deposition, but regional relationships make it a possibility. A few miles to the east in the Sevier and Wasatch Plateaus, the Arapien and Twist Gulch formations are so intricately folded and faulted that they could be unraveled only with great difficulty (Hardy, 1949). It has been suggested above that the whole thickness of Arapien and Twist Gulch was stripped off the rigid Navajo sandstone and pushed before the thrust plate, as snow before a plow, to its present location. A much simpler explanation would be nondeposition or erosion in the Pavant area, but this would not explain the complex structure of the jumbled formations in the Wasatch and Sevier Plateaus.

Mountain-building accompanied by thrusting probably began in the early part of the Cretaceous and continued throughout most of the Upper Cretaceous. The upland area extended for at least several miles both east and west of the present site of the Pavant Range. The record of the uplifts is preserved in the thick conglomerates of the Morrison (?), Indianola, South Flat, and Price River formations of the Gunnison and Wasatch Plateaus. The Morrison (?) and the Indianola conglomerates are conformable, but the relations between the Indianola, South Flat, and Price River formations are angular. It is hard to conceive of a mechanism other than episodic orogeny that
could produce beds of conglomerate thousands of feet thick and in angular contact. Supporting evidence is present in the Canyon Range where the Indianola (?) conglomerate is involved in thrusting (Christiansen, 1951, pl. 3); orogeny producing the conglomerates and subsequent movement displacing it. It seems almost certain that uplift was necessary to produce the conglomerates and that thick conglomerates in angular contact required continued uplift in pulses. By late Montana time (upper Price River) the mountainous area had been reduced considerably and orogenic pulses occurred only infrequently. The sea was retreating to the east, but its place was taken by mud flats and by lakes. Fluviatile and lacustrine sands and muds were deposited without a break in sedimentation during the Lance and early Paleocene. In the early part of the Paleocene, a local disturbance produced conglomerates in the Pavant. A similar movement in the Wasatch Plateau produced an angular unconformity between the times of deposition of the North Horn and Flagstaff sediments.

In the Wasatch Plateau area, a broad lake was formed in the medial Paleocene. Calcareous precipitates and muds were deposited in the lake proper. During the late Paleocene the lake expanded and for a brief period extended as far south and west as the Pavant area. In the early Eocene the lake contracted and muds and sands were deposited
near its shores. The upper part of these beds makes up the Colton formation in other areas, but they are not distinguishable from the underlying Flagstaff beds in the Pavant Range.

During medial Eocene the vast Green River lake spread over central Utah and at one time extended as far south and west as the southern Pavant. Limestones and calcareous muds were dominant. Vulcanism started before the end of the lime deposition (Muessig, 1951, p. 82). In the Pavant area, the lake soon contracted and the littoral and fluviatile sands and muds of the Crazy Hollow formation were deposited. After the short period of continental deposition, a second lake expanded at least in the vicinity of the present Sevier Valley. Again muds and calcareous precipitates were deposited. There was a renewal of volcanic activity and pyroclastics were interbedded with the Bald Knoll muds and limes. In the early Oligocene pyroclastics were dominant. To the south in the Tushar Range, volcanoes were erupting. Thousands of feet of lava were being poured out on the surface (Callaghan, 1939). The vulcanism continued throughout the Miocene (?) and some of the flows were extensive enough to reach the southeastern part of the Pavant area.

No events are recorded for the early part of the Pliocene. Probably the lava fields were being eroded.
Near the end of the Pliocene major faulting began and the present structural units began to take form. Fans were built at the base of the growing mountains (Axtell formation) during the late Pliocene and early Pleistocene. Erosion and renewed movement continued throughout the Pleistocene to the present. Pediments were formed and dissected at the base of the mountains. The cause of dissection may be attributed to either renewed uplift or an increase in precipitation. Glaciation during the latter part of the Pleistocene accomplished minor erosion on the highest peaks. At present the highlands are being eroded and the intervening basins are being filled.
Parts of the crest of the Pavant Range indicate that the area was eroded before it reached its present elevation. Gently, rolling, poorly dissected areas in the vicinity of Mount Catherine, Indian Spring, Hans Ridge, and Burnt Hollow have a net relief of less than 1000 feet. The topography is subdued compared to the immediately adjacent areas on either side of the main divide where the streams are actively engaged in canyon-cutting. The areas listed above are located in places where the streams have not yet destroyed the upper surface of the range. The headward-cutting streams in these places have not yet interfingered to form a sinuous comb ridge.

Mount Catherine is one of the highest mountains in the range, yet it is one of the least impressive. The general profile of the mountain is broad and rounded. The low relief makes it difficult to determine exactly where the highest point of the summit is. On all sides of the summit area canyons were started before the Pleistocene glaciation and cutting has continued to the present. The rounded top of Mount Catherine stands in sharp contrast to the adjacent deep canyons.

The triangular-shaped area of low relief in the vi-
Cinity of Indian Spring is bounded by the north fork of Chalk Creek, Shingle Mill Canyon, and Chokecherry Creek. The relief is somewhat greater and the area is smaller, but the elevation is less than that of Mount Catherine.

Hans Ridge is the upland area between Chokecherry Creek and Three Forks. It extends from the main divide of the range toward the northwest to the juncture of its bordering streams. The ridge is broad and loaf-shaped and it has little relief compared to the deep canyons on either side of it.

The topography of Burnt Hollow and the surrounding 3 to 4 square miles is extremely subdued and rolling. The low relief is accented because the area has not yet recovered from a fire in 1935. Drainage is poorly developed. The streams follow sinuous courses of low gradient. In places where the view of Pavant or Sevier Valley is blocked, the region appears to be a lowland rather than the crest of the mountain.

There are three types of topography in the central part of the Pavant Range. On the west in the Cambrian formations, the peaks are sierra-like. On the east in the Mesozoic and Cenozoic formations, the topography is of badlands type. At places along the crest as described above, the topography is rounded and gently rolling. At first glance the topography seems to be controlled en-
entirely by bedrock. Mount Catherine, Indian Spring, and Hans Ridge involve parts of the North Horn formation. It would seem that the North Horn formation tends to produce rounded erosional forms of low relief. Yet Amos Canyon, the steepest and most difficult of all the canyons in the range to traverse, is carved entirely in North Horn sandstone and siltstone. Further, the Flagstaff is the superficial formation in Burnt Hollow, but this same formation comprises the major portion of the badlands area of the central part of the Pavant Range.

From the evidence cited above, the diverse types of topography become logical when a period of erosion prior to major uplift is recognized.

PEDIMENTATION

Good examples of pediments are prominent in the northeastern part of the area under consideration here. At least two changes in base level have produced three levels and have also provided a good cross-section of the formations underlying the first and second surfaces.

The inclination of the pediment levels is to the east at 7° to 10°. The lateral planation has bevelled beds of the Green River, Crazy Hollow, and Bald Knoll formations and the pyroclastic beds in that order from west to east. A thin veneer of partially consolidated gravel lies on
A. Twin cirques on Mount Catherine.

Terminal moraines are on either side of medial ridge leading up to Mount Catherine (right skyline). Eagle Hollow is at right.

B. Pediments northwest of Aurora.

Pediment surfaces are Axtell formation (foreground and right background). Younger pediment levels in Bald Knoll formation are at the left.
much of the planed surface of the two older pediments. The lower surface is covered by alluvium.

The initial period of uplift of the Pavant Range and the Valley Mountains probably provided the upland surface for the formation of the oldest pediment surface. Subsequent uplifts or wetter climates caused the dissection of the first surface and the formation of the later ones.

**VALLEY PLAIN TERRACES**

Many of the major stream valleys contain thick alluvial deposits. The alluvial fill is the result of a period in the past when there was a greater amount of precipitation than now so that more rock waste was produced than could be carried away by the streams. The alluvium has since been channelled to produce deep gorges and matching terraces, classified by Cotton (1940, p. 28) as valley plain terraces. Some of the gorges are 50 feet deep, but most of them are 30 feet deep or less. The walls are vertical except where slumping has modified them.

The gorges are probably the result of overgrazing. Nearly 70 years ago the alluvium extended continuously from wall to wall in the floor of the canyons. In the 1890's and later, migrant flocks of sheep numbering in the hundreds of thousands were driven through the area.
A. Erosion control on White Pine Mountain.

The United States Forest Service has cut terraces in the steep slopes to arrest rainfall runoff in an effort to halt cloudburst floods.

B. Gullying in Denmark Wash.

Deep channel cut in alluvium south of Utah Highway 63. Note pediment levels at left and in middle background.
Local flocks supplemented the numbers of the itinerant sheep. Every blade of grass was eaten as fast as it grew. Leaves were stripped from the trees as high as the sheep could reach. Many springs went dry. In 1909 when the United States Forest Service assumed control, there was one small patch of grass left on the entire mountain range. It was on a ledge in a box canyon that was inaccessible to the sheep. The decrease in vegetation increased the immediate runoff. Flash floods became common. Perennial streams became ephemeral. The gorges were cut in the alluvium producing the terraces.

Controlled grazing is now in effect. The major result has been to increase the period of flow of the streams so that now several of them may be classed as perennial. Observable alluviation has not yet begun.

Good examples of valley plain terraces may be observed in Pharo Creek, Willow Creek, and both forks of Chalk Creek.

WHITE SAGE FLAT

The area between the forks of Chalk Creek near their juncture is a broad upland rock terrace called White Sage Flat. The terrace is in the general vicinity of Lake Bonneville shore features so that wave erosion suggests itself as the principal agency of origin. However, White
Sage Flat is at an elevation of nearly 6000 feet whereas the elevation of the Bonneville level is approximately 5100 feet making any relation between the two features unreasonable. Besides, similar benches at the same level which would indicate wave erosion were not observed.

An examination of the bedrock helps to explain the phenomenon. White Sage Flat is underlain entirely by Navajo sandstone. The upper surface is the thrust plane of the Pavant thrust and it has been bevelled by the thrust movement. At the eastern border of the flat, the profile takes a sharp upward turn as it crosses the thrust fault contact. Understandably the Tintic quartzite above the thrust contact is more resistant than the sandstone and it forms a steeper slope. As the sandstone is exposed by the erosion of the quartzite, it is quickly removed. At the western border the lithology changes from comparatively resistant sandstone to easily eroded shales and sandstones of the Moenkopi, Shinarump, and Chinle formations. The result has been to leave a broad bench of Navajo sandstone at the foot of the mountain range.

**CHALK CREEK GORGE**

Both forks of Chalk Creek flow through deep gorges that have been cut in the Navajo sandstone. The cut in the north fork is the more spectacular of the two. The
vertical-walled narrow channel has been cut to a depth of over 300 feet. Upstream in the Cambrian and North Horn formations, the canyon is V-shaped with rather steep walls. Downstream from the Navajo outcrop, the streams emerge from the gorge and soft shales and limestones form broad low slopes rising from the creek bottoms of both the north and south forks of Chalk Creek.

GLACIAL FEATURES

Cirques, moraines and associated outwash are evidences of past glaciation in the Pavant Range. The glacial features are well shown in Pharo Creek, Eagle Hollow, Paradise Creek and White Pine Creek.

Two cirques have been formed by glacial action at the head of Pharo Creek. A ridge separates the cirques so that they are classified as twin cirques. Moraines nearly 100 feet high were deposited a short distance below the cirques. Meltwater and subsequent runoff has cut narrow trenches through both the terminal moraines. Outwash deposits extend farther down the valley for a short distance. The area upstream from the terminal moraines is basin-shaped and has the typical down-at-the-heel appearance of glacial cirques.

The western cirque in Paradise Creek is a single cirque with a large terminal moraine and several low re-
cessional moraines. The features associated with it are better developed than at other places in the range. It is likely that the western Paradise Creek glacier was the largest one on the mountain.

The three small glaciers that were present in the east branch of Paradise Creek joined and flowed down the main drainage line. The group would have been classified as a dendritic glacier.

The small cirque and associated drift in White Pine Creek was probably not caused by actual ice movement, but rather by meltwater, frost wedging and solifluction. Flint (1947, p. 94) refers to cirques of this type as nivation cirques.

Numerous high areas in the Pavant appear to have been subjected to snow and meltwater action. However, snow accumulates in these areas during the winter and remains until mid-July so that the modern erosion cannot be distinguished from that of the Pleistocene.

The age and correlation of the glacial deposits are discussed in the section on stratigraphy.

STREAMS

Several of the streams on the Pavant Range are classed as perennial. Pharo Creek, North Willow Creek, and Cottonwood Creek in the eastern drainage flow all
year. On the west side of the Pavant, both forks of Chalk Creek, Meadow Creek, and Corn Creek are perennial. Although some of the remaining streams are fed by springs, they are ephemeral.

Little of the original upland surface of the mountain remains so that the region is in the late youth or early maturity stage of dissection. All stream valleys have narrow V-shaped cross-sections and steep gradients and are thus to be classified as youthful.

The eastern portion of the area considered here is in a rain shadow. Prevailing winds from the southwest bring rain to the western or windward side of the range and furnish little precipitation to the eastern or leeward side. It would be expected then that the windward streams would be longer than their leeward counterparts. An examination of the geologic map (pl. 26) shows this not to be the case except in the northern part of the area. The discrepancy is explained by the difference in resistance to erosion of the rocks on the two sides of the range. The west-flowing drainage has had to cut through resistant Cambrian limestones and quartzites whereas the east-flowing streams have had comparatively soft late Cretaceous and Tertiary sandstones and shales to erode. As a result, the east-flowing streams are longer than the streams on the opposite side of the moun-
tain range. The east-flowing streams in the northern part of the area have cut their canyons in conglomerate and sandstone, a task almost as difficult as that accomplished by the west-flowing streams. The expected ratio of stream lengths to precipitation occurs in the area of more or less equal rock resistance.

Most of the streams emerge from their canyons normal to the mountain front. Generally the main direction of flow is normal to the mountain front also. Exceptions are noted in four areas: (1) Paradise, Shingle Mill, Reece, and Teeple's Canyons are oriented northeast-southwest. The locations of the canyons and the directions of flow were established on the soft, easily erodable Ophir shale. (2) The location of Flat Canyon at the southern border of the area was controlled by the presence of the lava flows. (3) In the southwestern part of the area (see pl. 26), the streams both east and west of the Pavant divide flow in a general southern direction before changing to a direction of flow normal to the mountain front. Two factors, bedrock resistance to erosion and faulting, have contributed to this incongruity. The flow directions are part of the radial pattern developed around the high resistant White Pine Mountain of which No. 6 triangulation station is a part. Faulting to produce the Little Valley graben has caused much piracy and many drainage changes (see pl. 26).
(4) Faulting in the Sage Flat hogbacks northwest of Aurora has produced stream-flow parallel to the structure of the area.

Most of the main streams on the east side of the Pavant Range are consequent or subsequent. The upper sections of South Willow Creek, Cottonwood Creek, and Deer Creek are subsequent. On the west side of the Pavant Range, parts of both forks of Chalk Creek are consequent, subsequent, or superimposed. The upper portions of the north fork of Chalk Creek, Chokecherry Creek, and Three Forks are consequent. Paradise Creek and part of the south fork of Chalk Creek are subsequent. The lower part of the two forks of Chalk Creek are superimposed. Small tributaries of Paradise Creek and of part of the south fork of Chalk Creek are obsequent.

**The Sevier River**

In describing the Sevier River, Dutton (1880, p. 212) said, "In any ordinary region, the Sevier would not be dignified by the name of a river." Though the Sevier is insignificant by comparison, its meanders are as impressive as those of the Mississippi River. The meander belt is about one-half mile wide and scars and oxbow lakes show that old courses swung to either side of the present one an additional half a mile. At Rocky Ford and south
Plate 25

Sevier River meanders.

Note oxbow lake (middle) and old channels (foreground).
Plate 25

Photo by C. T. Hardy
of the road to Loa, streams emerging from the Sevier Plateau have built fans which crowd the Sevier against its west bank narrowing the floodplain to a width of less than one-half mile. In the area northeast of Glenwood the floodplain extends across the valley floor a distance of nearly 3 miles.

Some of the features associated with the Sevier River are characteristic of mature streams whereas others indicate old age. The features are listed below:

Mature feature

Much of the valley is less than three times the width of the meander belt.

Old age features

The average gradient of the stream is over 4 feet per mile.
The floodplain is swampy
Oxbow lakes are common.
Cutting is negligible.
Many meander turns are greater than 180°.

After considering the features that indicate the stage of development in the geomorphic cycle, the Sevier River seems to fit the old age characteristics better than any of the other stages. Other factors that have influenced the development of the valley are irrigation dams, its structural nature, and its location in an arid region.
ECONOMIC PRODUCTS

There is a paucity of economic products in the Pa­vant Range. The principal value of the range now lies in grazing, and there is some lumbering. Permits for a limited number of cattle, horses, and a few sheep issued by the United States Forest Service, allow owners to graze their stock at specified intervals within marked boundaries. Four men operate a sawmill during the summer months. Utilizing timber from private land, they carried on logging operations in Strawberry Canyon in the summer of 1950 and in Newt's Canyon in 1951. Within the National Forest, logging operations are under the supervision of the forest officials.

Water is the most important single commodity in central Utah. Carefully controlled grazing on the highlands is increasing the stream-flow and decreasing the amount of water lost by too rapid runoff of the precious rain when it does fall. Dams have been built along the Sevier River at intervals to store the available water. An extensive network of canals and ditches has been built in the lowland area to distribute the stored water.

Fullers earth is quarried from the pyroclastic beds northwest of Aurora by the Western Clay and Metals Company. The material is crushed and shipped to oil refineries where it is used to filter oil.
Gravel for road metal is quarried from the Axtell formation along Utah Highway 63.

The Navajo sandstone is used locally as building stone. The first capitol building of Utah territory at Fillmore is a notable example.

A claim has been staked at the forks of Chalk Creek and several small prospects started. Iron-bearing quartzite is evidently the cause of the activity. A drift has been dug for at least 250 feet in the base of the Price River formation on the south side of Three Forks. Samples taken along the length of the tunnel walls were pure sandstone. Many "gopher holes" have been dug along the east side of the range where limonite concentrations crop out. None of the holes is more than a few feet deep and none has been productive.
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Section No. 1
Section measured in sec. 33, T. 23 S., R. 2 W. southwest of Richfield

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>138</td>
<td></td>
</tr>
</tbody>
</table>

**Bullion Canyon volcanics**

**Gray Gulch formation**

1. Tuff, light-gray  
2. Tuff, tan  
3. Tuff, greenish-gray  
4. Tuff, alternating pink, orange, greenish-gray, and dull red; contains gypsum rosettes and much satinspar.  
5. Tuff, greenish-gray

Total Gray Gulch formation 209 9

**Bald Knoll formation**

6. Shale, tan  
7. Limestone, purplish-brown, very fine-grained, contains calcite crystals; fractures irregularly and jagged.  
8. Shale, tan  
9. Shale, reddish-brown  
10. Shale, tan  
11. Shale, reddish-brown and greenish-gray  
12. Shale, light-brown  
13. Limestone, brown, like unit 7.  
14. Shale, grayish-tan  
15. Shale, greenish-gray  
16. Limestone, white to tan  
17. Shale, light-gray  
18. Limestone, tan, fine-grained, siliceous  
19. Shale, tan  
20. Shale, light-gray  
21. Shale, dark-gray  
22. Shale, light-gray  
23. Shale, tan  
24. Shale, gray  
25. Limestone, light-brown, silty, fossiliferous

Total Bald Knoll formation 277 7
Crazy Hollow formation

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shale, gray</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Shale, reddish-brown</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Sandstone, white, fine-grained, white quartz grains with a few black and brown chert grains, silty</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Shale, bluish-gray and reddish-brown mottled</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Sandstone, tan, fine-grained, cross-bedded, limonite streaked, white quartz grains with black and brown chert grains</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Shale, light-brown</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Shale, gray</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Shale, brownish-red</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>Shale, brownish-purple</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>Shale, brownish-red</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Shale, reddish-gray</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Shale, dull brownish-red</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>13</td>
<td>Sandstone, dull brownish-red, medium-grained, white quartz grains with some black chert grains, silty</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>14</td>
<td>Shale, dull brownish-red</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Sandstone, like unit 13</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>Shale and siltstone; shale, dull brick red; siltstone, dull brick red, beds up to 2 feet thick, weathers to rounded blocky forms.</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>17</td>
<td>Sandstone, tan, very coarse-grained, limonite streaked, cross-bedded, white quartz grains with some black and brown chert grains. This unit is the same as unit 1 of section measured in sec. 26, T. 23 S., R. 2 W.</td>
<td>103</td>
<td>4</td>
</tr>
</tbody>
</table>
Section No. 2

Section of Bald Knoll formation measured in sec. 23,
T. 21 S., R. 2 W. south of Utah Highway 63.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unconsolidated gravel

Bald Knoll formation

1. Conglomerate; pebbles, 1 inch maximum,
silty limestone and blue and gray
chalcedony; matrix, pink and white
quartz, green shale. 32

2. Shale, buff and gray-green with thin
(up to 6 inches) interbedded
light-gray limestone. 111

3. Conglomerate, like unit 1 with thin
beds of buff to gray sandstone. 23

4. Shale, buff 11
5. Shale, gray 6
6. Conglomerate, like unit 1. 1
7. Shale, buff 7
8. Conglomerate, like unit 1. 1
9. Shale, gray 2
10. Shale, light-brown 4
11. Shale, gray 3
12. Conglomerate, like unit 1 9
13. Limestone, pale gray, oolitic 6
14. Shale, gray-green 9 6
15. Conglomerate, like unit 1. 7
16. Shale, greenish-gray 3
17. Shale, pale brown 6 4
18. Conglomerate, like unit 1. 1 5
19. Shale, buff 1
20. Shale, gray 9
21. Conglomerate, like unit 1. 2
22. Shale, brown, sandy, some one-fourth
inch pebbles, resembles a soil
zone. 4 6
23. Shale, gray 6
24. Conglomerate, like unit 1. 1 3
25. Shale, white 3
26. Shale, pale gray 5
27. Shale, pale brown 4
28. Shale, pale gray 2 7
29. Shale, brown, sandy 2 5
30. Conglomerate, like unit 1 1
31. Limestone, pale greenish-gray, silty. 8
32. Conglomerate, like unit 1.
33. Limestone, pale-gray, oolitic.
34. Conglomerate, like unit 1, but pebbles up to 2 inches and averaging half an inch in diameter.
35. Limestone, pale, greenish-gray, silty, with thin gray shale beds.
36. Shale, pale-gray
37. Limestone, like unit 31.
38. Conglomerate, like unit 1.
39. Limestone, like unit 31.

Total Bald Knoll formation

Crazy Hollow formation
Section No. 3

Section of Crazy Hollow formation measured in sec. 26, T. 23 S., R. 2 W. west of Richfield.

Feet Inches

1. Sandstone, tan, very coarse-grained, limonite streaked, cross-bedded, massive, white quartz grains with some black and brown chert grains.  61

2. Sandstone and shale; sandstone, gray, fine-grained, silty; shale, brick red, silty.  23

3. Sandstone, red, coarse-grained, massive, cross-bedded; with thin beds of red shale up to 4 inches.  68

4. Shale and siltstone, brick red  26  3

5. Sandstone, red, coarse-grained, massive, cross-bedded, very silty.  4  6

6. Shale, brick red.  18

7. Sandstone, gray, limonite streaked, coarse-grained.  2

8. Shale and siltstone, brick red  23  6

9. Sandstone, like unit 5, but less silty, massive.  21

10. Shale, brick red, silty.  15  10

11. Sandstone, gray, fine-grained with a few coarse grains of white quartz and black chert.  2  8

12. Shale, brick red, silty.  4

13. Sandstone, gray, fine-grained, silty.  9

14. Shale, brick red, silty.  11

15. Sandstone, red and gray variegated, fine-grained, silty.  5

16. Shale, brick red, silty  9  6

Total Crazy Hollow formation  262  9

Green River formation

1. Limestone, purplish-gray, siliceous  4  7

Flagstaff formation
Section No. 4

Section of Crazy Hollow formation measured in sec. 13, T. 21 S., R. 2 W. north of Utah Highway 63.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>161</td>
<td>6</td>
</tr>
</tbody>
</table>

Unconsolidated gravel

Crazy Hollow formation

1. Sandstone, purplish-red, cross-bedded 6
2. Shale, brick red 8
3. Sandstone, brick red, medium-grained, silty, massive, weathers to rounded forms. 4
4. Shale, brick red 7
5. Shale, dark blue-gray 9
6. Siltstone, purplish-red, weathers to blocky forms. 7
7. Siltstone, brick red 26
8. Sandstone, like unit 3 14
9. Siltstone, brick red, sandy 32
10. Sandstone, like unit 3 with thin, brick red, sandy siltstones interbedded 8
11. Siltstone, brick red, sandy 5
12. Sandstone, purplish-red, silty, weathers to blocky forms. 3
13. Siltstone, brick red, sandy 19
14. Sandstone, like unit 12 2
15. Sandstone and siltstone like unit 10, with beds varying from 6 inches to 1 foot in thickness. 5
16. Siltstone, brick red 1
17. Sandstone, like unit 3 5

Total Crazy Hollow formation 161

Cover
Section No. 5

Section measured at northwest end of Flagstaff horst, sec. 12, T. 22 S., R. 2 W., southwest of Aurora.

Feet Inches

Green River formation

1. Limestone, purplish-gray, siliceous, thin-bedded, weathers out in blocks 6 inches to 1 foot thick; with thin beds of green shale between. 22 5

2. Limestone and siltstone; limestone, white, silty; siltstone, buff, calcareous, many quartz grains, becoming more sandy at the top. 28

3. Siltstone, light-gray, calcareous, sandy, with some calcite crystals. 2

4. Limestone and siltstone, like unit 2. 28

5. Limestone, gray, with chert stringers; chert is iron-stained. 2 6

6. Limestone, gray, fine-grained 22

7. Limestone, like unit 5. 7 6

8. Siltstone and shale; siltstone, buff, calcareous, with many quartz grains; shale, pale gray-green. 151

9. Limestone, pale blue, cherty 2 5

10. Limestone and siltstone, like unit 2. 96

11. Siltstone, like unit 3. 18 8

12. Limestone and shale; limestone, white, silty; shale, pale gray-green 23 5

13. Sandstone, buff, medium-grained, thin-bedded 2 4

14. Siltstone, like unit 3. 24 5

15. Siltstone, reddish-purple 6

16. Limestone, white, silty. 12 2

17. Sandstone, like unit 13. 1

18. Limestone and shale, like unit 12. 39 1

19. Sandstone and shale; sandstone, buff to gray, fine-grained, somewhat platy, weathers to blocky forms; shale, pale gray-green. 11 6

20. Sandstone and shale, buff to gray, thin-bedded, platy 28
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Limestone and shale, like unit 12.</td>
<td>39</td>
<td>2</td>
</tr>
<tr>
<td>22</td>
<td>Sandstone, buff to gray, white and pink quartz grains and black chert grains, coarse-grained, silty, weathers to rounded forms.</td>
<td>.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Shale, pale gray-green</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>24</td>
<td>Sandstone, gray, coarse-grained, conglomeratic, a few quartzite and black limestone pebbles up to 3 inches maximum.</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>Limestone and shale, like unit 12.</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>26</td>
<td>Sandstone and shale, like unit 20.</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>27</td>
<td>Sandstone, like unit 24.</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Limestone, like unit 12.</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>29</td>
<td>Sandstone and shale, like unit 20.</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>30</td>
<td>Sandstone, like unit 22, but more massive.</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>31</td>
<td>Shale and sandstone, like unit 19; mainly shale with a few thin sandstone beds up to 1 foot thick: chert stringers at 11 to 14 feet.</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>32</td>
<td>Limestone, pale blue with much chert in bands.</td>
<td>.</td>
<td>8</td>
</tr>
<tr>
<td>33</td>
<td>Shale and sandstone, like unit 31.</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>34</td>
<td>Limestone, white, silty</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>35</td>
<td>Shale and sandstone, like unit 31.</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>36</td>
<td>Sandstone, like unit 22, but medium-grained and with fewer limestone grains.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Shale, pale gray-green</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>38</td>
<td>Sandstone, buff to gray, fine-grained, somewhat platy, weathers blocky.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Shale, white to pale gray grading upward into drab green.</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>40</td>
<td>Sandstone, like unit 22.</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

Total Green River formation: 706 feet 8 inches

Alluvium
Section No. 6

Section measured in Cottonwood Canyon, sec. 23, T. 23 S.,
R. 2 W. from the valley floor to the top of the can­
yon wall toward the south.

Feet Inches

Crazy Hollow formation

1. Sandstone, gray to yellow, limonite-
   streaked, white quartz and black
   chert grains, coarse-grained,
   cross-bedded, massive. 72
2. Siltstone and sandstone, red;
   sandstone is coarse-grained. 17 6

Green River formation

3. Limestone, light-gray, siliceous 57

Flagstaff formation

4. Shale, greenish-gray 11 9
5. Shale, brownish-red 38
6. Sandstone, gray, medium-grained,
   silty, calcareous 7 6
7. Shale, reddish-purple 26 3
8. Limestone, white to light-purple,
   very fine-grained, some thin
   silty layers becoming more
   frequent toward the top. 1 6
9. Shale, reddish-purple 2 6
10. Siltstone, gray and red mottled,
    sandy, calcareous, massive. 3 3
11. Shale, light-gray 6 6
12. Limestone, like unit 8. 27
13. Siltstone, like unit 10. 19 6
14. Sandstone, dark reddish-brown,
    very silty, calcareous. 4
15. Shale, brilliant orange-red 2 6
16. Sandstone, like unit 14. 3 7
17. Shale, like unit 15. 3
18. Sandstone, like unit 14. 8
19. Shale, brilliant orange-red 1 10
20. Sandstone, like unit 14. 6
21. Shale, brilliant orange-red 12
22. Shale, dull purple 8 2
23. Shale, brilliant orange-red 3
24. Siltstone and shale, light-red 16 7
25. Sandstone, light-gray, somewhat silty, calcareous, fine-grained, with an occasional black limestone pebble near the top. 3
26. Shale and siltstone, alternating, dull red, beds 2 to 3 feet thick. 21 8
27. Siltstone, brilliant orange-red, sandy 8
28. Shale, brilliant, orange-red 5 6
29. Sandstone, dark reddish-brown, silty, calcareous. 2 3
30. Siltstone, brilliant orange-red 4
31. Shale, brilliant orange-red 3 4
32. Siltstone, brilliant orange-red 2
33. Shale, brick red 8 6
34. Siltstone, brick red, weathers blocky. 10 9
35. Shale, brick red 11 4
36. Sandstone, light-gray, somewhat silty, calcareous, medium-grained. 3 6
37. Shale, brick red 3 6
38. Sandstone, like unit 36. 2
39. Shale, brick red 9
40. Siltstone, light-gray to purple, thin shale partings up to 6 inches thick. 12 7
41. Shale, dull purple 2 3
42. Sandstone, like unit 36, but fine-grained. 9
43. Shale, dull purple 4 4
44. Sandstone, dull purple, silty coarse-grained, white, brown, and reddish quartz and black chert grains, massive, weathers to rounded blocky forms. 11 8

Total Flagstaff 337 9
### Section No. 7

Section of Flagstaff formation measured on the north side of Dry Canyon, sec. 32, T. 22 S., R. 2 W.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Green River formation</strong></td>
<td></td>
</tr>
<tr>
<td>1. Limestone, gray, massive, siliceous, oolitic; with some thin buff to gray shale beds.</td>
<td>105</td>
</tr>
<tr>
<td><strong>Flagstaff formation</strong></td>
<td></td>
</tr>
<tr>
<td>2. Shale, gray to purplish-gray</td>
<td>66</td>
</tr>
<tr>
<td>3. Limestone, white to light-purple, fine-grained, somewhat argillaceous</td>
<td>34</td>
</tr>
<tr>
<td>4. Shale, light-purple, with thin siltstones.</td>
<td>51</td>
</tr>
<tr>
<td>5. Sandstone, shale, and siltstone, mainly shale, brownish-red to brick red; sandstone, thin-bedded, argillaceous.</td>
<td>525</td>
</tr>
<tr>
<td>6. Limestone, light-gray, massive</td>
<td>50</td>
</tr>
<tr>
<td>7. Shale, light-purple</td>
<td>25</td>
</tr>
<tr>
<td>8. Limestone, gray, weathers yellowish, silty, thin shale beds, 6 to 12 inches thick, increasing in number toward the top.</td>
<td>191</td>
</tr>
<tr>
<td>9. Siltstone and shale, light-purple, siltstones are 4 to 8 feet thick.</td>
<td>126</td>
</tr>
<tr>
<td>10. Siltstone and shale, purplish-red, alternating beds, 5 to 12 feet thick.</td>
<td>158</td>
</tr>
<tr>
<td>11. Siltstone and shale, brick red, alternating beds, 10 to 25 feet thick.</td>
<td>405</td>
</tr>
<tr>
<td><strong>Total Flagstaff formation</strong></td>
<td>1652</td>
</tr>
</tbody>
</table>
Section No. 8

Section of Flagstaff formation measured on the north wall of Strawberry Canyon, sec. 13, T. 22 S., R. 3 W.

Flagstaff formation

Feet Inches

1. Sandstone and siltstone, brick red, alternating beds, 10 to 25 feet thick. 287

2. Conglomerate, pink, gray, white quartzite, dark-gray limestone, average 6 inches, maximum 2 feet; matrix, pink and white quartz grains, medium-grained. 8

3. Sandstone and some siltstone, like unit 1. 176

4. Sandstone, like matrix of unit 2, with thin red shale partings up to 6 inches thick. 27 6

5. Conglomerate, like unit 2. 11

6. Sandstone, light-gray, fine-grained, argillaceous. 58

7. Sandstone and siltstone, alternating brick red, 2 to 5 foot beds. 61

8. Shale, brick red 39 6

9. Limestone, gray, mottled with purplish-red 33

10. Shale, orange-red 32

11. Siltstone, purplish-gray and red mottled 11

12. Limestone, like unit 9. 34

13. Shale, orange-red 16 6

14. Siltstone, gray and purplish-red mottled 33

15. Siltstone, light-gray, sandy, calcareous 3 6

16. Siltstone, red, orange, and gray mottled 37 6

17. Shale, orange-red 23

18. Limestone, gray and mottled, coarse-grained 16

Total Flagstaff formation 907 6

Cover
Section No. 9

Section measured at the base of the Red Pyramid, sec. 36, T. 21 S., R. 2½ W.

Flagstaff formation

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shale, brick red</td>
<td></td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>Limestone, light purplish-gray, silty</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Shale, purplish-red</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Siltstone, purplish-red, calcareous</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Shale, purplish-red</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Limestone, light-gray to buff, massive</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Shale, brick red</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Limestone, white to buff, silty, massive</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Siltstone and shale, brick red</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Sandstone, buff, coarse-grained</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Siltstone, brownish-red</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Limestone, white, silty, fossiliferous</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Siltstone, pink, calcareous, limonitic</td>
<td>43</td>
<td></td>
</tr>
</tbody>
</table>

Total Flagstaff 286

North Horn formation
Section No. 10

Section of North Horn formation measured in Rock Creek, across Mt. Catherine to the head of Willow Creek, sec. 12, T. 21 S., R. 3 W.

Feet Inches

Flagstaff formation

North Horn formation

1. Algae ball conglomerate, limestone
2. Sandstone and siltstone;
   sandstone, yellowish-brown, medium-grained, limonite stained;
   grains are subround, cross-bedded, massive, weathers blocky, with thin gray shale partings;
   siltstone, yellowish-brown, sandy.
3. Siltstone and sandstone;
   mottled, purple, sandstone is fine-grained.
4. Sandstone and siltstone, like unit 2.
5. Sandstone, white, coarse-grained, cross-bedded, quartz grains.
6. Sandstone and siltstone, like unit 2.
7. Conglomerate and sandstone lenses;
   conglomerate, red, pink and white quartzite pebbles with some dark-gray limestone pebbles, averaging 1 to 2 inches, with an occasional boulder up to 6 inches. Massive. Matrix is same as the sandstone. Sandstone, brick red, sub-angular quartz grains, fine-grained, cross-bedded, much stained by limonite. Beds from 6 to 12 inches.
8. Sandstone and siltstone, like unit 2.
9. Siltstone and sandstone, like unit 3.
10. Sandstone and siltstone, like unit 2.
    Sandstone is very coarse at the base, massive, blocky. Siltstone is rounded and not so well consolidated.
11. Sandstone and siltstone, red and light-purple mottled, some limonite staining, thin-bedded, argillaceous, fine-grained.
12. Limestone, algae ball conglomerate
13. Sandstone with conglomerate lenses.
   Lithology like unit 7.
15. Sandstone, like that in unit 11.
16. Conglomerate, pale-purple, strong difference in sizes, pebbles and cobbles one-half inch to 6 inches, 2 to 3 inch average size. Matrix, medium-grained quartz grains, no intermediate sizes. In the upper part, boulders increase in size to 8 to 10 inches maximum.
17. Sandstone, white, coarse-grained, a little limonite stain; comparatively pure quartz.
18. Sandstone, mottled, red and light-purple, some limonite stain, thin-bedded, argillaceous, fine-grained.
20. Sandstone, like unit 17.
21. Conglomerate, like the basal portion of unit 16.
22. Sandstone, like unit 11, but somewhat argillaceous.
23. Conglomerate and sandstone; conglomerate, red, pink, and white quartzite, dark-gray limestone pebbles and boulders, 3 to 4 inches average, few sandstone lenses, some beds with only occasional pebbles; sandstone, like unit 17.
24. Sandstone, red, subangular quartz grains, much iron stain, cross-bedded
25. Conglomerate and sandstone lenses, like unit 23.
26. Sandstone, like unit 18.
27. Conglomerate, like unit 7.
28. Sandstone, siltstone, and shale, like unit 2.
29. Sandstone and siltstone, mottled, purplish-red
30. Sandstone, siltstone, and shale, like unit 2.
31. Siltstone, mottled, red and yellow
32. Sandstone, siltstone, and shale, like unit 2.
### North Horn formation

33. Sandstone, with thin gray shales, like unit 2.  
34. Sandstone, light-brown, medium-grained, much limonite  
35. Sandstone, like unit 33.  
36. Sandstone, yellowish-brown, some limonite, massive  
37. Conglomerate, mainly white, quartzite pebbles and cobbles, 1 to 10 inches, with 4 to 5 inch average, some pink and red quartzite, and some well-cemented red sandstone pebbles. Matrix, white quartz grains, fairly well-rounded, not well-cemented.  
38. Sandstone, like that in unit 2.  
39. Shale, red, thin-bedded  
40. Sandstone, red, coarse-grained, cross-bedded

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>74</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

Total North Horn formation 3270 2

### Price River formation

41. Conglomerate and sandstone, same as unit 43, but more sandstone, and those beds are thicker.  
42. Conglomerate and sandstone lenses, same as unit 42, but cobbles up to 4 inches.  
43. Conglomerate and sandstone lenses; conglomerate, red, pink, and white quartzite, red sandstone, and black and dark-gray limestone, 1 inch average, 2 inch maximum; matrix, red and white rounded quartz grains, well-cemented, coarse-grained. Sandstone lenses, red and white banded quartz grains as in matrix.

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>499</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td></td>
</tr>
<tr>
<td>315</td>
<td></td>
</tr>
</tbody>
</table>

Total Price River formation 866

Alluvium
Section 12

Section measured in Shingle Mill Canyon from creek bottom east to the ridge, sec. 5, T. 22 S., R. 3 W.

Price River formation

Unconformity

Opex dolomite

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Limestone, dark-gray, finely crystalline, thin-bedded, with thin calcite partings.</td>
<td>382</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Limestone, medium brownish-gray, coarsely crystalline.</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Limestone, dark-gray, finely crystalline, thin-bedded; with many red splotches for 22 feet near center of unit.</td>
<td>74</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total Opex dolomite</td>
<td>467</td>
<td></td>
</tr>
</tbody>
</table>

Cole Canyon dolomite

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Limestone, light-gray, weathers white, thinly laminated with thin beds of gray shale interbedded.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Limestone, light-gray, weathers white, thinly laminated.</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Limestone, dark blue-gray and light-gray, thinly laminated.</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Shale, light-gray, calcareous, weathers brown.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Limestone, dark-gray, finely crystalline, thin white calcite partings.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Limestone, purplish-gray, very thin-bedded, shaly, weathers tan.</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Limestone, medium-gray, thin-bedded, conglomeratic.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Limestone, medium-gray, medium-bedded, weathers reddish-brown.</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Limestone, medium-gray, thin-bedded.</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>13</td>
<td>Dolomite, light-gray, weathers white, thinly laminated.</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Number</td>
<td>Description</td>
<td>Feet</td>
<td>Inches</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>14</td>
<td>Limestone, medium-gray, finely crystalline, thin-bedded.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Limestone, light-gray, and medium-gray bands 1 to 12 inches thick, both with many white calcite flecks so as to form a secondary banding.</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>Limestone, light-gray to white, finely crystalline, with white calcite flecks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Limestone, medium-gray, coarsely crystalline.</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Dolomite, white, fine to medium crystalline (like Emerald), weathers white.</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>19</td>
<td>Dolomite, blue-gray, coarsely crystalline, pink and red calcite partings with white calcite flecks, weathers brownish-gray, blocky.</td>
<td>27</td>
<td>6</td>
</tr>
<tr>
<td>20</td>
<td>Limestone, blue-gray, finely crystalline, compact. Conglomeratic bed 11 inches thick at 7 feet from the base.</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Dolomite, medium-gray, coarsely crystalline, massive.</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Dolomite, very light-gray, coarsely crystalline, massive.</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Dolomite, medium blue-gray, coarsely crystalline, massive.</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Dolomite, light-gray, medium crystalline.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Limestone, medium-gray, thin white calcite partings. Prominent cliff.</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Limestone, light-gray, conglomeratic.</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Limestone, light to medium-gray, dolomitic.</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Limestone, dark-gray, medium to thick-bedded, conglomeratic.</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Limestone, dark-gray, thin beds 1 to 2 inches thick.</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Limestone, dark-gray, conglomeratic.</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Dolomite, light-tan to gray, finely crystalline, thinly laminated, thin-bedded, weathers brown.</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Dolomite, medium-gray, medium crystalline.</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>
Feet Inches

33. Dolomite, medium-gray, finely crystalline, some pink calcite in joints. 15
34. Dolomite, brownish-gray, very finely crystalline, compact, flinty, thinly laminated, almost like Cole Canyon on weathered surface. 4
35. Dolomite, brownish-gray and white, with white calcite partings and flecks. 11
36. Dolomite, light-gray, medium crystalline, limonite flecks, minute cavities partially filled with calcite. 7
37. Dolomite, medium-gray, sucrose. 22
38. Dolomite, medium-gray, medium crystalline, white calcite flecks. 36
39. Dolomite, light-gray, medium crystalline, somewhat thin-bedded. 64
40. Dolomite, medium-gray, coarsely crystalline, sandy appearance on weathered surface. 12
41. Dolomite, light-gray, weathers very light-gray with white flecks. 49 6

Total Cole Canyon dolomite 950 3

Bluebird dolomite

42. Limestone, dark bluish-gray, intraformational conglomerate with pink calcite interstitial material. 2
43. Limestone, dark bluish-gray, finely crystalline, white and pink calcite partings. 115 6
44. Limestone, brownish-gray, dolomitic, finely crystalline, white calcite partings somewhat vermicular. 4
45. Limestone, medium-gray, intraformational conglomerate, dark-gray limestone pebbles up to half an inch and pink calcite concentrated in thin bands. 16 6
46. Limestone, like unit 45, but white to light-gray.

47. Dolomite, light to medium-gray, coarsely crystalline, with white and pink calcite flecks.

48. Dolomite, light-gray, coarsely crystalline, somewhat pinkish appearance because of pink calcite on weathered surface.

49. Limestone, medium to light-gray, black oolites, coarsely crystalline, some thin bands of brownish-gray very finely crystalline limestone one-fourth to one-half inch thick.

50. Limestone, dark-gray, fine to medium crystalline, white calcite partings, vermicular.

51. Limestone, dark-gray, fine to medium crystalline, pitted irregularly banded surface.

52. Limestone, light to medium-gray, coarsely crystalline; sandy on weathered surface; some light-gray bands and white calcite partings.

53. Limestone, medium to dark-gray, finely crystalline, with many white calcite partings, some of which weather red; also weathers with some light-gray bands.

54. Limestone, dark-gray, very finely crystalline, flinty.

55. Limestone, like unit 53.

Total Bluebird dolomite 267 6

Herkimer limestone

51. Limestone, dark-gray, fine to medium crystalline, pitted irregularly banded surface.

52. Limestone, light to medium-gray, coarsely crystalline; sandy on weathered surface; some light-gray bands and white calcite partings.

53. Limestone, medium to dark-gray, finely crystalline, with many white calcite partings, some of which weather red; also weathers with some light-gray bands.

54. Limestone, dark-gray, very finely crystalline, flinty.

55. Limestone, like unit 53.

Total Herkimer limestone 103
### Dagmar limestone

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>56.</td>
<td>Limestone, medium-gray, dolomitic, medium to coarsely crystalline, weathers blocky with sandy appearance.</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>57.</td>
<td>Limestone, light to medium-gray, dolomitic, coarsely crystalline, with small tan and white calcite flecks.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>58.</td>
<td>Limestone, like unit 56, but light-gray.</td>
<td>60</td>
<td>6</td>
</tr>
</tbody>
</table>

Total Dagmar limestone: 34 Feet, 6 Inches

### Teutonic limestone

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>59.</td>
<td>Limestone, dark-gray, finely crystalline, with thin light-gray bands that stand out upon weathering.</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>60.</td>
<td>Limestone, dark-gray, thin-bedded, with red and white calcite splotches.</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>61.</td>
<td>Limestone, dark-gray to black, finely crystalline, thin-bedded, up to 6 inches thick, some curved laminations at top; red and white calcite splotches in lower part.</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>62.</td>
<td>Limestone, dark-gray to black, finely crystalline, massive, with thin white calcite partings.</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>63.</td>
<td>Limestone, dark-gray, finely crystalline, very thin-bedded.</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>64.</td>
<td>Limestone, dark-gray to black, finely crystalline, with thin tan partings, massive.</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>65.</td>
<td>Limestone, bluish-gray, coarsely crystalline, many white calcite veinlets, massive.</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>66.</td>
<td>Cover</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>67.</td>
<td>Limestone, dark-gray, finely crystalline, with red and white calcite splotches.</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>68.</td>
<td>Limestone, like unit 59.</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>69.</td>
<td>Limestone, bluish-gray, medium to coarsely crystalline, many white calcite veinlets in a polygonal pattern, massive.</td>
<td>42</td>
<td></td>
</tr>
</tbody>
</table>
70. Limestone, dark-gray, finely crystalline, with red and white calcite splotches.
71. Limestone, like unit 62.
72. Limestone, dark-gray, finely crystalline, some thin gray bands.
73. Limestone, like unit 60.
74. Limestone, dark-gray, thin-bedded, some curved laminations.
75. Limestone, like unit 69.

Total Teutonic limestone

<table>
<thead>
<tr>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>527</td>
<td>11</td>
</tr>
</tbody>
</table>

Ophir formation
Section No. 13

Section of Navajo sandstone exposed between the forks of Chalk Creek.

Feet

Tintic quartzite

Thrust fault

Navajo sandstone

Sandstone, light-red to pale-pink, coarse-to medium-grained, massive beds; weathers dark brownish-red; white and pink quartz grains are rounded and frosted.

Chinle formation

Section No. 14

Section of Tintic quartzite on south side of Fillmore Peak.

Feet

Ophir formation

Tintic quartzite

Quartzite, white, medium- to coarse-grained, massive to medium-bedded, some thin conglomeratic throughout section, weathers brown; weathers to angular forms and steep slopes.

Thrust fault

Navajo sandstone
Section No. 15

Section measured in south fork of Chalk Creek, sec. 8, T. 22 S., R. 3 W.

Teutonic limestone

<table>
<thead>
<tr>
<th>Ophir formation</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shale, olive-green, micaceous.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>2. Limestone, light bluish-gray, thin-bedded, argillaceous.</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>3. Shale, olive-green, micaceous.</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>4. Limestone, medium-gray, single bed, algae-balls (?) at top and at base, some vertical white calcite veinlets.</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. Shale, light-brown, fissile.</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>6. Limestone, medium-gray, finely crystalline, with tan argillaceous splotches.</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>7. Shale, light-brown, fissile.</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>8. Limestone, medium-gray, massive, with many white calcite veinlets.</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>9. Shale and quartzite; shale, olive-green, micaceous; quartzite, white, thin-bedded, weathers dark brownish-green.</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>10. Quartzite, like that in unit 9, but massive.</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>11. Shale and quartzite, like unit 9.</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>12. Quartzite, like unit 10.</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>13. Shale and quartzite, like unit 9.</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

Total Ophir formation 349 4

Tintic quartzite
I, Herman Kenneth Lautenschlager, was born in Sebring, Ohio on June 5, 1918. After receiving my primary and secondary education in the public schools of Sebring, Ohio, I entered Miami University, Oxford, Ohio and received the degree Bachelor of Arts (Geology) in 1942. While at Miami University I served as laboratory assistant for the academic years 1940-42. In March 1943 I was commissioned an electronics officer in the U. S. Air Forces. During the years 1945-1948 I was employed as geologist by The Ohio Fuel Gas Co., Columbus, Ohio. I entered the Ohio State University in the autumn of 1948. While in graduate school I served as graduate assistant for the years 1949-1951. For the academic year 1951-1952, I held the position of Bownocker Fellow while completing the requirements for the degree Doctor of Philosophy.
STRUCTURE SECTIONS OF THE CENTRAL PART OF THE PAVANT RANGE, UTAH.

Refer to geologic map for legend and location.

H. E. Ludersboe, 1928
DIAGRAMMATIC SKETCH OF THE SEDIMENTARY AND STRUCTURAL DEVELOPMENT OF THE PAVANT AREA

Middle Cambrian

Upper Jurassic

Lower Cretaceous

Upper Pliocene

Present