GEOLOGY OF THE COVE CREEK AREA
MILLARD COUNTY AND BEAVER COUNTY, UTAH

by

James T. Zimmerman

A thesis submitted to the faculty
of the University of Utah
in partial fulfillment of the requirements
for the degree of

Master of Science
Department of Geology
University of Utah

June 1961

LIBRARY
UNIVERSITY OF UTAH
This thesis for a Master of Science degree

by

James T. Zimmerman

has been approved by

Chairman, Supervisory Committee

Reader, Supervisory Committee

Reader, Supervisory Committee

Reader, Supervisory Committee

Head, Major Department

Dean, Graduate School
# LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Plate</th>
<th>Illustration Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Geologic Map and Cross Sections of the Cove Creek Area</td>
<td>pocket</td>
</tr>
<tr>
<td>2.</td>
<td>Utah Index Map</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Location Index Map</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>Southwestern View, Paleozoic Outcrops</td>
<td>9</td>
</tr>
<tr>
<td>5.</td>
<td>Figure 1.—Eureka Quartzite</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Figure 2.—Mississippian Limestone</td>
<td>25</td>
</tr>
<tr>
<td>6.</td>
<td>Figure 3.—Deseret Limestone—zones and nodules</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Figure 4.—Calcite Filled Veinlets</td>
<td>32</td>
</tr>
<tr>
<td>7.</td>
<td>Sevier River Limestone Exposure</td>
<td>38</td>
</tr>
<tr>
<td>8.</td>
<td>Figure 5.—Sevier River Limestone Exposure</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Figure 6.—Sevier River Marls</td>
<td>43</td>
</tr>
<tr>
<td>9.</td>
<td>Pleistocene (?) Basalts—Gypsum Sands</td>
<td>45</td>
</tr>
<tr>
<td>10.</td>
<td>Figure 7.—Gently Titled Sevier River Strata</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Figure 8.—Tertiary Andesite Overlying Kaibab Limestone</td>
<td>47</td>
</tr>
<tr>
<td>11.</td>
<td>Hornblende Rhyolite Petrographic Diagram</td>
<td>50</td>
</tr>
<tr>
<td>12.</td>
<td>Weathered Hornblende Rhyolite Petrographic Diagram</td>
<td>53</td>
</tr>
<tr>
<td>13.</td>
<td>Augite Andesite Petrographic Diagram</td>
<td>55</td>
</tr>
<tr>
<td>14.</td>
<td>Labradorite Vitrophyre Petrographic Diagram</td>
<td>58</td>
</tr>
<tr>
<td>15.</td>
<td>Pleistocene (?) Basalt—Gypsum Sand Exposures</td>
<td>62</td>
</tr>
<tr>
<td>16.</td>
<td>Exfoliation</td>
<td>64</td>
</tr>
<tr>
<td>17.</td>
<td>Basalt Unit 2 Petrographic Diagram</td>
<td>66</td>
</tr>
<tr>
<td>Plate</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>18.</td>
<td>Basalt Unit 2 Petrographic Diagram (specimen from coarse textured zones)</td>
<td>68</td>
</tr>
<tr>
<td>19.</td>
<td>Sevier River Marl and Pleistocene (?) Basalt Exposures</td>
<td>70</td>
</tr>
<tr>
<td>20.</td>
<td>Figure 9.—&quot;Breccia Dike&quot;</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Figure 10.—Quartzite Alteration</td>
<td>73</td>
</tr>
<tr>
<td>21.</td>
<td>&quot;Breccia&quot; Zone Petrographic Diagram</td>
<td>75</td>
</tr>
<tr>
<td>22.</td>
<td>Eureka Quartzite Alteration Petrographic Diagram</td>
<td>77</td>
</tr>
<tr>
<td>23.</td>
<td>Thrust Fault</td>
<td>85</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF ILLUSTRATIONS</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>viii</td>
</tr>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>I. Purpose and Scope</td>
<td>1</td>
</tr>
<tr>
<td>II. Location</td>
<td>1</td>
</tr>
<tr>
<td>III. Accessibility</td>
<td>3</td>
</tr>
<tr>
<td>IV. Topography and Drainage</td>
<td>3</td>
</tr>
<tr>
<td>V. Field Work</td>
<td>4</td>
</tr>
<tr>
<td>VI. Previous Work</td>
<td>6</td>
</tr>
<tr>
<td>VII. Acknowledgments</td>
<td>7</td>
</tr>
<tr>
<td>STRATIGRAPHY</td>
<td>10</td>
</tr>
<tr>
<td>I. General Statement</td>
<td>10</td>
</tr>
<tr>
<td>II. Paleozoic Stratigraphy</td>
<td>11</td>
</tr>
<tr>
<td>Ordovician System</td>
<td>11</td>
</tr>
<tr>
<td>Pogonip Group</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>11</td>
</tr>
<tr>
<td>Lithology</td>
<td>12</td>
</tr>
<tr>
<td>Age and correlation</td>
<td>12</td>
</tr>
<tr>
<td>Measured section</td>
<td>13</td>
</tr>
<tr>
<td>Eureka Quartzite</td>
<td>14</td>
</tr>
<tr>
<td>Name</td>
<td>14</td>
</tr>
<tr>
<td>Lithology</td>
<td>14</td>
</tr>
<tr>
<td>Age and correlation</td>
<td>15</td>
</tr>
<tr>
<td>Measured section</td>
<td>15</td>
</tr>
<tr>
<td>Fish Haven Dolomite</td>
<td>16</td>
</tr>
<tr>
<td>Name</td>
<td>16</td>
</tr>
<tr>
<td>Lithology</td>
<td>16</td>
</tr>
<tr>
<td>Age and correlation</td>
<td>17</td>
</tr>
<tr>
<td>Measured section</td>
<td>18</td>
</tr>
<tr>
<td>System</td>
<td>Formations</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Devonian System</td>
<td>Sevy Dolomite</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Lithology</td>
</tr>
<tr>
<td></td>
<td>Age and correlation</td>
</tr>
<tr>
<td></td>
<td>Measured Section</td>
</tr>
<tr>
<td></td>
<td>Guilmette (?) Formation</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Lithology</td>
</tr>
<tr>
<td></td>
<td>Age and correlation</td>
</tr>
<tr>
<td></td>
<td>Measured section</td>
</tr>
<tr>
<td>Mississippian System</td>
<td>Deseret Limestone</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Lithology</td>
</tr>
<tr>
<td></td>
<td>Age and correlation</td>
</tr>
<tr>
<td></td>
<td>Measured section</td>
</tr>
<tr>
<td>Pennsylvanian System</td>
<td>Oquirrh Formation</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Lithology</td>
</tr>
<tr>
<td></td>
<td>Age and correlation</td>
</tr>
<tr>
<td></td>
<td>Measured section</td>
</tr>
<tr>
<td>Permian System</td>
<td>Kaibab Limestone</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Lithology</td>
</tr>
<tr>
<td></td>
<td>Age and correlation</td>
</tr>
<tr>
<td></td>
<td>Measured section</td>
</tr>
<tr>
<td>III. Cenozoic Stratigraphy</td>
<td></td>
</tr>
<tr>
<td>Tertiary System</td>
<td>Sevier River Formation</td>
</tr>
<tr>
<td></td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Lithology</td>
</tr>
<tr>
<td></td>
<td>Age and correlation</td>
</tr>
<tr>
<td></td>
<td>Measured section</td>
</tr>
<tr>
<td></td>
<td>Quaternary Sedimentary Deposits</td>
</tr>
<tr>
<td></td>
<td>Gypsum sands</td>
</tr>
<tr>
<td></td>
<td>Quaternary alluvium and gravel deposits</td>
</tr>
<tr>
<td>IGNEOUS ROCKS</td>
<td>I. General Statement</td>
</tr>
<tr>
<td>Topic</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>II. Extrusive Rocks</td>
<td>49</td>
</tr>
<tr>
<td>Hornblende Rhyolite</td>
<td>49</td>
</tr>
<tr>
<td>Field occurrences</td>
<td>49</td>
</tr>
<tr>
<td>Petrographic description</td>
<td>49</td>
</tr>
<tr>
<td>Age and correlation</td>
<td>52</td>
</tr>
<tr>
<td>Augite Andesite</td>
<td>54</td>
</tr>
<tr>
<td>Field occurrences</td>
<td>54</td>
</tr>
<tr>
<td>Petrographic description</td>
<td>54</td>
</tr>
<tr>
<td>Age and correlation</td>
<td>56</td>
</tr>
<tr>
<td>Labradorite Vitrophyre</td>
<td>57</td>
</tr>
<tr>
<td>Field occurrence</td>
<td>57</td>
</tr>
<tr>
<td>Petrographic description</td>
<td>57</td>
</tr>
<tr>
<td>Age and correlation</td>
<td>59</td>
</tr>
<tr>
<td>Basalts</td>
<td>60</td>
</tr>
<tr>
<td>Field occurrence</td>
<td>60</td>
</tr>
<tr>
<td>Description</td>
<td>63</td>
</tr>
<tr>
<td>Petrography</td>
<td>65</td>
</tr>
<tr>
<td>Age and correlation</td>
<td>69</td>
</tr>
<tr>
<td>ALTERATION</td>
<td>72</td>
</tr>
<tr>
<td>I. General Statement</td>
<td>72</td>
</tr>
<tr>
<td>STRUCTURE</td>
<td>79</td>
</tr>
<tr>
<td>I. General Statement</td>
<td>79</td>
</tr>
<tr>
<td>II. Folds</td>
<td>80</td>
</tr>
<tr>
<td>Postulated Late Jurassic to Early Tertiary (?) Folds</td>
<td>80</td>
</tr>
<tr>
<td>Postulated Recent Doming</td>
<td>81</td>
</tr>
<tr>
<td>III. Faults</td>
<td>82</td>
</tr>
<tr>
<td>Thrust Faults</td>
<td>82</td>
</tr>
<tr>
<td>Postulated Northeast-striking thrust faults</td>
<td>82</td>
</tr>
<tr>
<td>North-striking thrust fault</td>
<td>84</td>
</tr>
<tr>
<td>GEOLOGIC HISTORY</td>
<td>86</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>88</td>
</tr>
</tbody>
</table>

vii
ABSTRACT

The Cove Creek area is near the eastern border of the Basin and Range province, 150 airline miles south-southeast of Salt Lake City, Utah, in the southeastern portion of Millard County, Utah. The sedimentary rocks consist of the Ordovician Pogonip Group (112'), Eureka Quartzite (104'), and the Fish Haven Dolomite (583'); the Devonian Sevy Dolomite (183'), and the Guilmette (?) Formation (137'); the Mississippian Deseret Limestone (234'); the Pennsylvanian Oquirrh Formation (441'); the Permian Kaibab Limestone (271'); the Pliocene to early (?) Pleistocene Sevier River Formation (262'); and the Quaternary gypsum sands, gravels, and alluvium.

Late Tertiary rhyolites and andesites, Pleistocene (?) vitrophyre outcrops, and Quaternary basalts cover approximately 25 per cent of the Cove Creek area.

Alteration consists of (1) a postulated baked contact zone immediately underlying a Pleistocene (?) basalt and (2) deposition of oxides and hydroxides of iron in the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian strata and in the late Tertiary rhyolites and andesites. These iron deposits are postulated to be a result of late Tertiary iron-bearing solutions which moved through the rocks by means of a network of fault planes, joints, and fractures.

It is postulated that the following sequence of events...
have taken place in the Cove Creek area.

(1) Regional upwarp(s) in the Cordilleran miogeosyncline during the Paleozoic Era are partially revealed today by unconformities between the Pogonip Group and the Eureka Quartzite, between the Eureka Quartzite and the Fish Haven Dolomite, between the Fish Haven Dolomite and the Sevy Dolomite, between the Guilmette (?) Formation and the Deseret Limestone, between the Deseret Limestone and the Oquirrh Formation, and between the Oquirrh Formation and the Kaibab Limestone.

(2) Uplift, folding, and thrusting occurred between the late Jurassic (?) and early Tertiary (?) and is probably Laramide. Subsequent uplift and erosion has exposed rocks as old as early Ordovician.

(3) Extrusion of the hornblende rhyolite during late Tertiary time was followed by the extrusion of the augite andesite. Extrusion of the augite andesite was accompanied by iron-bearing solutions which altered the rocks along faults, joints, and fractures in the rhyolites and andesite and in the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian strata.

(4) Deposition of the Pliocene to early (?) Pleistocene Sevier River Formation occurred in an early to medial Tertiary (?) tectonic basin. During the interval between late Tertiary (?) and early Pleistocene (?), volcanism occurring simultaneously with
deposition of the Sevier River Formation resulted in an interbedding of basalt units I and II with the Sevier River sediments. Basalt unit III was extruded following deposition of the Sevier River Formation, but before deposition of Lake Bonneville sediments.

(5) Even though normal faulting may have been continuous in this portion of the Great Basin from late (?) Miocene time, the normal faults that appear in the mapped area are postulated to have been initiated some time during late (?) Tertiary and Pleistocene (?) time.

(6) Lake Bonneville developed during Pleistocene time. With desiccation of this lake, terraces were formed and gypsum sands accumulated in the Cove Creek area through evaporation of playa lakes and wind deposition.

(7) The recurrence of volcanism after deposition of the gypsum sands resulted in the building of the Cove Fort volcano and extrusion of the basalts of unit IV.

(8) Erosion and dissection of the older rocks with simultaneous development of post-Bonneville basalts and alluvial deposits in the southern portions of the area continued from late Tertiary time to the present.
INTRODUCTION

I. Purpose and Scope

The purpose of this study was to make a detailed geologic map of the Cove Creek area and to describe the stratigraphy, structure, and geologic history of the area. Tentative correlations were made between the stratigraphic units and structures of this area with those in adjacent areas.

The geology of the Cove Creek area was mapped on aerial photographs and then transferred from these photographs to a base map. Samples and fossils from the various stratigraphic units were collected and identified in the laboratory along with the igneous rock samples. Several field conferences were helpful in the solution of some of the problems that were encountered.

II. Location

The Cove Creek area is located in the eastern part of the Basin and Range province approximately 150 airline miles south-southwest of Salt Lake City, Utah, and in the southeastern portion of Millard County. (See Index Map, Plate 2, page 2). The area consists of about 100 square miles and includes the southern part of T. 24 S., R. 7 W., and T. 24 S., R. 8 W., nearly all of T. 25 S., R. 7 W., and T. 25 S., R. 8 W., and the northern part of T. 26 S., R. 7 W., and T. 26 S., R. 8 W., of Salt Lake Base and Meridian. (Plate 1, pocket.)
The boundary between two major physiographic provinces, the Colorado Plateau province and the Basin and Range province, lies just to the east of the Cove Creek area at the western base of the north trending Pavant Range and Tushar Mountains. This boundary zone is characterized by west-facing scarps and scarplets along a zone of normal faulting.

III. Accessibility

The area mapped may be reached via U. S. Highway 91, which from Fillmore, through Cove Fort, to Beaver City, Utah, roughly parallels the western base of the northward trending Pavant Range and Tushar Mountains. Approximately one mile northwest of Cove Fort, Utah a graded dirt road extends westward from U. S. Highway 91, for 24 miles, to Black Rock, Utah. The eastern border of the Cove Creek area is approximately one-half mile west of the junction between U. S. Highway 91 and the Black Rock road. (Plate 3, page 4).

From the Black Rock road, which extends through the mapped area, branch numerous trails that are used infrequently by local ranchers. By means of these trails limited accessibility by sedan is permitted into the area, with further investigation possible only on foot, horseback, or with four wheel drive vehicles. Most of these roads and trails are passable when dry, but during late winter and early spring they become muddy and impassable.

IV. Topography and Drainage

The Cove Creek area, in comparison to the Pavant Range and Tushar Mountains to the east and the Mineral Mountains to the
PLATE 3

Scale 1:250,000
Contour Interval 200'

LOCATION INDEX MAP

The above reproduction was taken from the U.S. Army RICHFIELD MAP which was prepared by the Army Map Service (FSGE), Corps of Engineers, U.S. Army, Washington, D. C. Compiled in 1955 by photogrammetric methods and from United States Quadrangles 1:24,000 and 1:62,500, U.S. Geological Survey, 1932-1953.
southwest, consists of low, rolling hills and cuesta ridges (Plate 5, page 10). The elevations in the mapped area do not exceed 6,600 feet and the relief no more than 500 feet.

All the streams in the mapped area are intermittent, with water finding its way into the channels only during the run off of melting winter snow, spring rains, or summer torrential storms.

A westward trending intermittent stream, Cove Creek, which roughly parallels and is immediately south of the Black Rock road, is the largest in the mapped area. Because of its size and therefore its distinctiveness, the name of this intermittent stream was used as a means of designating the mapped area.

There are but two sources of culinary water near the mapped area. One is located along the Black Rock road at Antelope Springs, approximately five miles from the western border of the thesis area. The other source of water is at Cove Fort, Utah, about one mile to the southeast of the southeastern corner of the map.

V. Field Work

Field work in the Cove Creek area was begun in July, 1958; however, several additional field trips were necessary during the following autumn and winter, as additional problems arose which required further observations.

Aerial photographs, with a scale of 1:20,000, were used in the field for mapping purposes and in compilation of the geologic map. The basic horizontal control for the map was assembled by means of slotted templates and details were added by the use of the radial line plotter. Ground control for this map consisted of a
number of plotted section corners and two United States Coast and Geodetic Survey triangulation stations.

Whenever section corners were located in the field they were plotted on the aerial photographs. Where the section corners could not be found, their positions were located by extrapolations from known section corners.

VI. Previous Work

Until this study was undertaken, a complete examination of the mapped area had never been made, although some years ago the Standard Oil Company of California had made a preliminary reconnaissance of the region. The results of this reconnaissance study, however, have not been published.

The geology of adjacent areas was studied by Lee (1907), Butler (1913, 1920), Eardley (1932), Callaghan (1937), Crawford and Buranek (1941-43, 1942), Maxey (1946), Thomas (1946), Christiansen (1951), East (1956), Liese (1957), Earll (1957), Levy (1959), and Crosby (1959).

Studies unrelated to geologic features have been completed by the Department of the Interior through its Bureau of Land Management in the form of land cultivation research and grazing studies. The United States Coast and Geodetic Survey has established level lines and triangulation stations for vertical and horizontal control in several localities in the general region.

A well log was obtained from the Utah State Engineer, Department of Water and Water Rights. The well is located
approximately eight miles west of U. S. Highway 91, 100 feet south of the Black Rock road, and in Section 21, T. 25 S., R. 8 W. It was drilled in 1936; however, only a few years later the well was capped, as it began to fill with silt and became too expensive to operate.

The well log data are relatively incomplete and contain data suitable only as a generalized subsurface section of the igneous and sedimentary rocks encountered in the well; consequently, correlation with the rocks in the mapped area could not be made.

### Driller’s Well Log

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Depth</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand-gravel</td>
<td>0-20'</td>
<td>20'</td>
</tr>
<tr>
<td>Black lava rock</td>
<td>20-104'</td>
<td>84'</td>
</tr>
<tr>
<td>Sandy formation</td>
<td>104-116'</td>
<td>12'</td>
</tr>
<tr>
<td>Black lava rock</td>
<td>116-220'</td>
<td>104'</td>
</tr>
<tr>
<td>White marls (water)</td>
<td>220-270'</td>
<td>50'</td>
</tr>
<tr>
<td>Congl. lens (much water)</td>
<td>270-280'</td>
<td>10'</td>
</tr>
<tr>
<td>White marls (shells)</td>
<td>280-320'</td>
<td>40'</td>
</tr>
</tbody>
</table>

### VII. Acknowledgments

The writer is indebted to Dr. F. W. Christiansen for his assistance and supervision during the preparation of this thesis. Sincere appreciation is extended to Dr. A. J. Eardley and Dr. Wm. Lee Stokes and to the supervisory committee for the financial assistance they obtained for the writer during the field work period.

A special thanks is expressed to Dr. Bronson Stringham and...
Professor M. P. Erickson of the Mineralogy Department, for the help
they provided during the microscopic identification of the igneous
and sedimentary rocks.

Acknowledgments are extended to Dr. D. J. Jones, Mr. Walter
Sadlick, and Mr. D. David Stone, for their assistance in fossil
identification. Also, thanks are due to Mr. and Mrs. Lyman of Kanosh,
Utah; to the personnel of the Bureau of Land Management and Grazing
Service of Fillmore, Utah; to the Standard Oil Company of California
in Salt Lake City, Utah for the use of their aerial photographs;
and to the writer's friends who helped immeasureably with their
criticisms and suggestions in preparation of this manuscript.

The geologic map was drafted by Lanny Kay of the Humble
Oil Company whose ready cooperation with drafting problems greatly
facilitated and assured completion of the final maps.
A view looking southwestward across the Cove Creek area showing the low rolling hills in the center and foreground, composed of faulted, jointed, and fractured Ordovician, Devonian, Mississippian, and Pennsylvanian sedimentary rocks and the Northern Mineral Mountains (upper left background).
STRATIGRAPHY

I. General Statement

Sedimentary rocks of Paleozoic age, which make up approximately 30 per cent of the exposed sedimentary rocks, crop out in the center of the Cove Creek area and strike to the east-northeast in two nearly parallel belts. These rocks consist of a sequence of highly fractured, jointed, and brecciated arenaceous calcisiltites, quartzites, limestones, and dolostones.

The Paleozoic sedimentary rocks in the Cove Creek area consist of the Ordovician Pogonip Group, Eureka Quartzite, and the Fish Haven Dolomite; the Devonian Sevy Dolomite and the Guilmette (?) Formation; the Mississippian Deseret Limestone; the Pennsylvanian Oquirrh Formation; and the Permian Kaibab Limestone.

By paleontological means the oldest Cenozoic sedimentary deposit in the Cove Creek area was assigned to the Pliocene to early Pleistocene (?) Sevier River Formation. This formation is exposed in the north and western portions of the mapped area. The measured section of this sedimentary deposit consists of 262 feet of poorly consolidated lacustrine marls. As the base of the Sevier River Formation was not exposed in the mapped area, it would be expected that the measured section represented only a portion of the formation. The marlstones are uniform in lithology with variations only in thickness of the strata and occasional pebble lenses.
An unconsolidated limy deposit of late Pleistocene (?) age unconformably overlies the Sevier River Formation and is exposed in the south central portions of the mapped area. This sedimentary deposit has a variable thickness and is characteristically a sand with notable amounts of gypsum (45 per cent).

The remaining sedimentary deposits of the area consist of unconsolidated Quaternary deposits of gravels and alluvium. These sediments mantle approximately 50 per cent of the Cove Creek area.

II. Paleozoic Stratigraphy

Ordovician System

Pogonip Group

Name.—In 1976, King first described this group as the Pogonip Limestone which included all the beds between the Prospect Mountain Quartzite (early Cambrian) and the Eureka Quartzite (medial Ordovician). This study was followed by a report of Hague in 1883, wherein the Pogonip Limestone was more clearly defined and restricted to include only the rocks between the overlying Eureka Quartzite and the underlying Dundenberg Shale (late Cambrian). Since Hague's work on the Pogonip Limestone it has been given group status and only recently (Hintze, 1949) was subdivided into six formations. These six, beginning with the basal member, are the House Limestone, Fillmore Limestone, Wahwah Limestone, Juab Limestone, Kanosh Shale, and the Lehman Formation.
Lithology.—The limestones found in Section 34 and in the N 1/2, Section 35 of T. 24 S., R. 7 W. are believed to be portions of the medial limestones (Wahwah Limestone, Juab Limestone) of the Pogonip Group.

The Pogonip limestones are composed of a sequence of reddish medium gray colored, thin bedded, argillaceous limestones. The argillaceous material weathers to a reddish-brown, consequently giving the weathered limestones a dull, reddish-gray color.

Veinlets of calcite, similar to those found in the Mississippian Deseret Limestone, are a dominant secondary feature of the limestone. (See Mississippian Deseret Limestone section.)

Age and correlation.—Actual identification and specific differentiation of exposed parts of the Pogonip limestones was not possible, since these rocks were mostly covered.

In the mapped area a few deformed trilobite, gastropod, and brachiopod remains were found in the limestones. Because these fossil remains were poorly preserved and thus unidentifiable, correlation and age determination proved inadequate by this means.

Hintze (1949), in his study of the Pogonip Group, measured a 1,110 foot section of this early Ordovician group near the Cove Creek area in Baker Canyon (see Hintze's Kanosh section, 1949). This section may be found along a road cut of U. S. Highway 91, in section 26, T. 24 S., R. 7 W.

Directly overlying Hintze's Pogonip section Webb (1949) measured a section of the Eureka Quartzite.
Upon tracing the Pogonip Group and the overlying Eureka Quartzite into the Cove Creek area from these localities studied by Hintze and Webb, it was observed that the upper two units of the Pogonip Group, the Lehman Formation and the Kanosh Shale, were absent and did not crop out in the mapped area. The more resistant limestones immediately beneath the Kanosh Shale, however, locally crops out and is exposed only in small patches where the gravels and alluvium have been removed. The reader is referred to Plate 1, pocket, and Section 34, T. 24 S., R. 7 W.

**Measured section.**—The following measured section of the Pogonip Group is located in the NW 1/4, Section 35, T. 24 S., R. 7 W.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>112</td>
</tr>
</tbody>
</table>

*medial Ordovician — Eureka Quartzite — (unconformable)*

*early Ordovician — Pogonip Group:*

Limestone: medium bluish-gray, weathers lighter gray, fine to medium crystalline; interlacing calcite filled veinlets and pods; oxides and hydroxides of iron stain unit red; minute veinlets of orange-brown argillaceous material weathers to a dark brown masking the bluish-gray color of the limestone.

Total measured section of the Pogonip Group .......................... 112

Interval between limestone and overlying Eureka Quartzite covered by alluvium .......................... 120
Ordovician System

Eureka Quartzite

Name.—The Eureka Quartzite was first described by Hague (1883) at Eureka, Nevada, as consisting of "a compact, white to blue, vitreous quartzite, which underlies the Lone Mountain Limestone (late Ordovician) and overlies the Pogonip Limestone (early Ordovician)." Kirk (1933) redefined the boundaries of the Eureka Quartzite and subdivided this formation into three units which are, from top to bottom: "(1) 0 to 3 feet of saccharoidal sandstone, probably late Ordovician in age; (2) the main Eureka quartzite mass with a vitreous lithology; and (3) the basal beds composed of dolomitic sands, and argillaceous material, the last two of which were believed to be middle Ordovician in age."

The origin, distribution, and significance of the Eureka Quartzite is discussed more fully by Webb, and for a more complete regional understanding of the Eureka Quartzite the reader is referred to Webb’s paper (1958).

Lithology.—In the mapped area the Eureka Quartzite is massive, granular, and has a vitreous luster. The color ranges from a light brown to a white or white-gray and varies from a poorly indurated, saccharoidal quartzose sand to a dense, hard, vitreous quartzite.

Upon examination with a petrographic microscope it was observed that the Eureka Quartzite is composed almost entirely of quartz grains, that are tightly compacted together, which average
between 12 mm and .3 mm in size. The grains do not present rounded outlines, but irregular shapes that seem to fit into one another. A siliceous groundmass between the grains firmly cements them together.

**Age and correlation.**—Webb (1958), in his study of the Ordovician quartzites in the Great Basin, measured a medial Ordovician section along U. S. Highway 91, east and south of the Cove Creek area. This measured section was later identified by Webb as the Eureka Quartzite. (See Webb's Kanosh section, 1951.)

With Webb's description of the distinctive lithology of the Eureka Quartzite (Kanosh section) it was possible to trace this unit into the Cove Creek area and correlate it with the quartzite which crops out there.

**Measured section.**—The following section of the Eureka Quartzite was measured in the SW 1/4, Section 35, T. 24 S., R. 7 W. This section has been fractured, jointed, brecciated, and faulted; but it represents the most complete section that is exposed. This section correlates well with Kirk's second unit of the Eureka Quartzite.
late Ordovician — Fish Haven Dolomite — (unconformable):
medial Ordovician — Eureka Quartzite:

Unit 2 Quartzite: light gray to white; weathering from gray to white; dense, hard, vitreous luster, siliceous groundmass, uniformly fine grained arenaceous; bedding indistinct, fractured, jointed, and brecciated; iron oxides and hydroxides stain the quartzite; contact sharp at unit's top.

Total measured section of the Eureka Quartzite 104

Ordovician System

Fish Haven Dolomite

Name.—This dolostone was first named for exposures on Fish Haven Creek, Bear Lake County, Idaho, by G. B. Richardson in 1913. It was described by Richardson as being composed of a "fine textured medium bedded, dark gray dolomite, 500 feet thick, which underlies the Laketown Dolomite (Silurian) and overlies (unconformably ?) the Swan Peak Quartzite (early Ordovician)."

Lithology. In the Cove Creek area the Fish Haven Dolomite is a dark gray to black, fine to medium crystalline dolostone with massive to thick bedded units that weather to a light gray.

The lithology of the Fish Haven is nearly constant throughout the section, with the only deviation being scattered
zones of nodular and algal-like structures in this dolostone. These structures within the Fish Haven were composed of chert and dense dolostone. Both of these types of concretions are resistant to weathering and are etched into relief, creating a rough, gnarly surface.

Locally the color of the dolostone is due to disseminated oxides and hydroxides of iron. These iron deposits, upon weathering, have given the dolostones a red to brownish red color. (See discussion of alteration.)

The Fish Haven dolomite possesses a random network of fine to medium sized (approximately 0.1 cm. to 3.0 cm. in width) white, calcite filled veinlets (Plate 6, Figure 4, page 32).

Age and correlation.—The dolostones in the Cove Creek area which immediately overlie the Eureka Quartzite are correlated with the Fish Haven Dolomite that was previously identified by Hintze (1951) and Webb (1951, 1956, 1958) at their Kanosh section. The actual correlation was accomplished by tracing these dolostones into the mapped area, since no diagnostic fossils were discovered.

Webb (1956) described the dolostones that overlie the Eureka Quartzite as "several hundred feet of late Ordovician dolostones," but later (1958), he stated that this dolostone should be definitely correlated with the Fish Haven Dolomite.

In summary, correlation of the dolostone in the mapped area was established with the late Ordovician Fish Haven Dolomite by lithology and its stratigraphic position in relation to the underlying
Eureka Quartzite.

The only identifiable fossil found in this formation was a coral (*Calepocia (?) sp.*). This fossil whose range is from Ordovician to Silurian, therefore, did not provide an absolute means of correlation but did, however, help to limit the formation's age.

The dolostone described in this section has been mapped as Fish Haven. However, there is a possibility that the upper part of the formation may be correlated with the Silurian Laketown Dolomite. A very gradual lithologic change was observed within the formation from the typical Fish Haven at the bottom to the Sevy-like lithology above, but as no diagnostic fossils were found this dolostone interval was mapped as Fish Haven rather than Laketown.

**Measured section.**—The following section of the Fish Haven Dolomite was measured in the SW 1/4, Section 35, T. 24 S., R 7 W.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Feet</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 10</td>
<td>68</td>
<td>Dolostone: dark bluish-gray; weathers medium bluish-gray; dense, medium to fine crystalline; less resistant than overlying unit; bedding indistinct, jointed, fractured; network of interlacing calcite filled veinlets; oxides and hydroxides of iron stain unit; a patchy veneer of alluvium covers unit.</td>
</tr>
<tr>
<td>Unit 9</td>
<td>33</td>
<td>Dolostone: dark gray; weathers medium gray; dense, resistant, massive; medium crystalline; bedding indistinct, jointed, fractured; network of interlacing calcite filled veinlets; oxides and hydroxides stain unit; patchy veneer alluvium covers unit.</td>
</tr>
<tr>
<td>Unit</td>
<td>Dolostone:</td>
<td>Details</td>
</tr>
<tr>
<td>-------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>8</td>
<td>dark gray; weathers medium gray; dense, resistant; fine crystalline; jointed, fractured; white to dark gray chart filled stringers and knobby nodules; stringers vary in size up to five inches thick; oxides and hydroxides of iron stain unit; patchy veneer of alluvium covers unit.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>similar to Unit 9.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>black; weathers dark gray to medium gray; fine to medium crystalline; dense, resistant; massive; bedding indistinct, jointed, fractured; network of interlacing calcite filled veinlets; oxides and hydroxides of iron stain unit; zones of reddish-brown chert and dolostone nodular and algal-like structures weather in relief to a rough, gnarly surface; patchy veneer of alluvium covers unit.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>dark gray; weathers a medium gray; fine crystalline, dense, resistant; bedding indistinct, jointed, fractured; network of interlacing calcite filled veinlets; oxides and hydroxides of iron stain unit; zones of reddish-brown chert and dolostone nodular and algal-like structures weather in relief to rough gnarly surface; patchy veneer of alluvium cover unit.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>dark-bluish gray; weathers to medium bluish gray; dense, resistant; fine to medium crystalline; network of interlacing calcite filled veinlets; zones of reddish-brown chert and dolostone nodular structures weather in relief to rough gnarly surface; oxides and hydroxides of iron stain unit; patchy veneer of alluvium covers unit.</td>
<td></td>
</tr>
</tbody>
</table>
Unit 3 Quartzitic dolostone: bluish-dark gray; weathers bluish-medium gray; dense, resistant; massive; sugary texture at base becomes less dominant upward in unit, changes from an arenaceous dolostone at unit's base to medium crystalline dolostone at top; oxides and hydroxides of iron stain unit; patchy veneer of alluvium covers unit.

Total measured section of the Fish Haven Dolomite . . . . . . 583

Devonian System

Sevy Dolomite

Name.--In 1930, T. B. Nolan named the Sevy Dolomite for exposures in Sevy Canyon on the west side of Deep Creek Range, Gold Hill region.

The Sevy was described by Nolan as 450 feet of nearly homogeneous dolostones that are well bedded, devoid of any diagnostic fossils, light gray on fresh fractures, and which weather to a very light-gray almost white color.

Nolan in his discussion indicated that the Sevy Dolomite graded upward into the overlying (medial Devonian) Simonson Dolomite and that it overlies unconformably the (Silurian) Laketown Dolomite.

Lithology.--The description of Nolan's Sevy Dolomite fits
very well with the dolostone found in the Cove Creek area.

These Cove Creek dolostones are dense, aphanitic, and they fracture subconchoidally. The freshly fractured surfaces present a reddish tinted, medium gray color. However, in the field the general appearance of the dolostone is more diagnostic, as it weathers to a very light-gray to white color.

Near the contact with the Fish Haven Dolomite a finely crystalline dolomitic interval of approximately 50 feet was observed. This type of dolomitic rock grades upward into the more diagnostic aphanitic Sevy dolostone.

Age and correlation.—No fossils were found in the Sevy Dolomite, and since no diagnostic fossils have been recovered from this formation in nearby areas, its age is not definitely known. However, upon using both Nolan's description of the Sevy Dolomite in the Gold Hill district and Crosby's description of the Sevy Dolomite in the Southern Pavant Range, plus the dolostone's stratigraphic relationship to the units above and below, this Cove Creek dolomite has been correlated with the Sevy and may be either lower or medial Devonian in age.

Nolan in the Gold Hill district preferred a medial Devonian age, and Crosby (1959) in the Southern Pavant Range also indicated a medial Devonian age for the Sevy Dolomite.

Measured section.—The Sevy Dolomite was measured in the NE 1/4, Section 3, T. 25 S., R. 7 W. It forms a retreating slope and is capped by the more resistant Fish Haven Dolomite.
**Devonian System**

<table>
<thead>
<tr>
<th>Unit</th>
<th>Dolomite:</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>dull, medium bluish-gray; weathers pale bluish gray to light gray; aphanitic; subconchoidal fracture; thin lamination; fractured, jointed; reddish tint; oxides and hydroxides of iron stain unit.</td>
<td>183</td>
</tr>
</tbody>
</table>

Total measured section of the Sevy Dolomite . . . . . . . . . 183

Base of measured Sevy section covered with alluvium.

**Guilmette (?) Formation**

*Name.*—T. B. Nolan, in 1930, named this formation for exposure in Guilmette Gulch, Gold Hill district. The Guilmette Formation was described as chiefly a dolostone that is fine grained and presents a dark to medium gray color on fresh fractures. Upon weathering this dolostone takes on a lighter shade of gray. As described, the Guilmette Formation also contains a number of thick limestone beds and several lenticular brownish sandstones.

At the type locality the Guilmette Formation was found to be approximately 1,000 feet thick where it is unconformably overlain by the (Mississippian) Madison Limestone and unconformably overlies the (medial Devonian) Simonson Dolomite.
Lithology.—The Guilmette (?) Formation exposed in the Cove Creek area consists of a light brown sandstone unit and a younger white to gray indurated quartzite unit.

The sandstone unit which has a "sugary" texture consists of a thin-bedded rock that weathers to a tan to brown color. A dolomite and siliceous groundmass firmly cements the sand grains together, but a uniformity of grain size is lacking, and upon microscopic examination the average grain appeared to be larger and more angular when compared with the Eureka Quartzite.

The second, but younger, quartzite unit is separated from the sandstone unit by a 90 foot interval of alluvial cover. The younger unit may be divided into two additional subunits.

The basal subunit of the quartzite is white or white gray in color, massive, and has a vitreous luster. Upon microscopic examination the characteristics of the quartzite were found to be similar to the Eureka Quartzite, as it is uniformly granular, well indurated, and saccharoidal with the sand grains being firmly cemented together with a siliceous groundmass.

The basal quartzite subunit grades upward into a quartzite which contains lenticular zones of angular quartzite and limestone fragments. Both calcite and silica furnish the cementing materials of the quartzite breccia. The uppermost few feet of the subunit has a "sugary" texture and is very poorly cemented together.

Age and correlation.—No fossils were found in either the sandstone or the quartzite unit. Because of the absence of
fossil remains, correlation and tentative age determination was based upon the lithology and stratigraphic position relative to a more complete sequence involving the (Devonian) Sevy Dolomite, Simonson Dolomite, Guilmette Formation, and the (Mississippian) Deseret Limestone in the Pavant Range to the east.

The quartzite unit proved to be a good, consistent marker unit, approximately 75 feet thick, cropping out in the Southern Pavant Range (Crosby, 1959) south of Kanosh, Utah and extending the length of these mountains in a westerly direction into the Cove Creek area.

The quartzite and sandstone unit lie unconformably below the (Mississippian) Deseret Limestone and have been considered by Crosby (1959) in the Southern Pavant Range to the east of the mapped area as medial to upper Devonian in age.

Measured section.—The following section of the Guilmette (?) Formation was measured in the NE 1/4, Section 3, T. 25 S., R. 7 W.

lower Mississippian (Osagian) - Deseret Limestone - (unconformable: medial to upper Devonian) - Guilmette (?) Formation:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
</tr>
</tbody>
</table>

Unit 4 Quartzite-quartzite breccia: white to gray; poorly indurated, sugary textured surface, lenses of quartz sand grains cemented by calcite; jointed, fractured; oxides and hydroxides of iron stain unit; patchy veneer of alluvium covers unit.

Unit 3 Quartzite: gray to white; dense; well indurated; siliceous groundmass; resistant; bedding indistinct, jointed, fractured; oxides and hydroxides of iron stain unit.
FIGURE 1: An exposure of the Devonian quartzite showing attitude of outcrop, fractures, joints, and in the center foreground a quartzite breccia zone.

FIGURE 2: Mississippian limestone showing dark nodular concretions, fractures, and joints.
Alluvial cover 90

Unit 2 Sandstone: tan; weathers a mottled brown; sugary surface; siliceous groundmass, well indurated; thin to medium bedded; jointed, fractured; oxides and hydroxides of iron stain unit; patchy veneer of alluvium cover unit.

Total measured Guilmette (?) Formation section . . . . 137

Base and top of Unit 2 covered by alluvium.

Mississippian System

Deseret Limestone

Name.—The Deseret Limestone was first described and named by Gilluly (1932), at the Deseret mine, Dry Canyon, Stockton quadrangle, Utah, as a "blue gray limestone with cherty beds which conformably underlies the Humbug Formation and rests unconformably on the Madison Limestone." The fossils from the Deseret Limestone in the Cove Creek area are early Mississippian in age and very similar to the fossils from the Deseret Formation of the type area.

Lithology.—In the Cove Creek area the Deseret Limestone is dark, fine to medium-crystalline, and weathers to a dark gray.
The color of the weathered Mississippian limestone has been changed from its characteristic dark gray color to one that has a red to brownish red tint. This change in color is due to deposition through the limestone of iron oxides and hydroxides. (See discussion of alteration.)

Special features noted in the Deseret Limestone were:

1. In some sections there is a general horizontal alignment resistant, nodular, and algal-like concretions, which weather to a reddish-brown. (Plates 5, 6; Figures 2, 3; pages 25 and 32.)

2. In the nodular sections occurs light and dark band of limestone zones. These zones tend to give the sections of limestone a "zebra" like appearance. (Plate 6; Figure 3; page 32.)

3. The limestone has a pervasive network of veinlets, some of which are filled with chert, though the calcite-filled veinlets predominate. (Plate 6; Figure 4; page 32.)

Age and correlation.—Through the efforts of Mr. Walter Sadlick and Mr. D. David Stone the fossils collected from this limestone were identified. The fossils are: *Spirifer haydeniansis* (?)*Girty*, *Spirifer "centronatus," Dictyoclostus of burlingtonensis*, *Triplophyllites* ? sp. and/or *Homalophyllites* (?) sp., *Camarotoochia* ? sp., *Leptaena of analoga*, and crinoid plates. From this collection of fossils it was suggested by Mr. Sadlick that the limestone should
be correlated temporally with the Mississippian (Osage) Deseret Lime-
stone of central and northern Utah.

Measured section.—The Mississippian limestone section was
measured in the SE 1/4, Section 3, T. 25 S., R. 7 W.

Pennsylvanian — Oquirrh Formation — (unconformable);
early Mississippian (Osagian) — Deseret Limestone:

Unit 3 Limestone: dark bluish gray; weathers
medium bluish-gray; fine to medium
crystalline; uppermost 7 feet of unit
an arenaceous limestone; network of
interlacing veinlets filled with calcite;
zones of horizontally elongate, resistant
limestone and chert nodules and algal-like
structures weather in relief to a rough
surface; bedding indistinct, jointed,
fractured; oxides and hydroxides of iron
stain unit; patchy veneer of alluvium
covers unit.

Unit 2 Limestone: black, weathers to a dark gray;
fine crystalline; bedding indistinct,
jointed, fractured; minute veinlets of
brownish weathering argillaceous material
masks units gray color; network of inter-
lacing veinlets filled with calcite and
chert; oxides and hydroxides of iron stain
unit; patchy veneer of alluvium covers unit.

Unit 1 Limestone: black, weathers to a dark gray;
fine crystalline; thin to medium bedded;
jointed, fractured; brownish weathering
argillaceous material masks limestone's gray
color; oxides and hydroxides of iron stain
unit; basal contact with underlying quartzite
sharp; patchy veneer of alluvium covers unit.

Total measured section of the Deseret Limestone . . . . . . . . 234
Pennsylvanian System

Oquirrh Formation

Name.—In 1932, J. Gilluly, during his work in the Stockton and Fairfield quadrangles, measured between 16,000 feet and 18,000 feet of interbedded lenticular quartzites and limestones with the upper portion being characterized by subordinate thin beds of shale and dolostones and a dominance of quartzites. As this sequence of rock was measured in the Oquirrh Mountains of north-central Utah, the name "Oquirrh Formation" was applied.

In the Oquirrh Mountains the Oquirrh Formation grades into the underlying (Pennsylvanian and Upper Mississippian) Manning Canyon Shale and is overlain unconformably by Tertiary age conglomerates and grits.

Lithology.—In the Cove Creek area the lower portion of the Oquirrh Formation is composed of a basal white to gray, uniformly fine grained and dense quartzite bed. Overlying the quartzite is a dense dark-bluish gray, medium crystalline, limestone. The limestone is resistant and weathers to a medium bluish gray.

The upper portion of the formation consists of dense black to medium gray, medium crystalline arenaceous dolostones. Lenticular gray to white saccharoidal quartzites and medium gray, fine to medium crystalline limestones are found in this interval also.

The color of the Oquirrh Formation has been changed locally to a red and brownish tinted rock. The red and brown paints and crust of the oxides and hydroxides of iron are concentrated along fractures,
joints, and on slickensides. The reader is referred to a later topic on page 72 for a more complete discussion on alteration.

**Age and correlation.**—The basal dolostone unit of the Oquirrh Formation which overlies unconformably the (Mississippian) Deseret Limestone yields corals (Favosites sp., Syringopora sp.) and at several intervals fusulinids. These corals and the occurrence of fusulinids, the stratigraphic relationship of the unit to the formations above and below, and the ability of being able to trace the dolostone into the mapped area from the Southern Pavant Range (Crosby, 1959) indicates that this stratigraphic unit may be correlated with the Pennsylvanian age Oquirrh Formation.

This same Oquirrh Formation interval was considered by Crosby (1959) as medial to upper Pennsylvanian in age in the Southern Pavant Range, Millard County, Utah.

**Measured section.**—The following portion of the Oquirrh Formation was measured in the SW 1/4, Section 2, R. 25 S., T. 7 W.

<table>
<thead>
<tr>
<th>Permian</th>
<th>Kaibab Limestone</th>
<th>(unconformable):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pennsylvanian</td>
<td>Oquirrh Formation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Quartzite: gray to dark gray; weathers same; fine grained; siliceous ground-</td>
</tr>
<tr>
<td></td>
<td>mass; dense, resistant; weathers to a sugary textured surface; transition</td>
</tr>
<tr>
<td></td>
<td>from unit 6 to unit 5 gradual; jointed, fractured; iron oxides and hydroxides;</td>
</tr>
<tr>
<td></td>
<td>patchy veneer of alluvium covers unit; base of unit covered by alluvium.</td>
</tr>
<tr>
<td>5</td>
<td>Dolostone: dark bluish-gray, weathers bluish-gray and with a rough sugary</td>
</tr>
<tr>
<td></td>
<td>textured surface; arenaceous; medium crystalline; calcareous; interstratified,</td>
</tr>
<tr>
<td></td>
<td>dense, medium gray to gray quartzites</td>
</tr>
</tbody>
</table>
Unit 5
lenses, siliceous groundmass; network of interlacing chert and calcite filled veinlets in dolostone unit; bedding indistinct; jointed, fractured; weathered argillaceous materials in dolostone and oxides and hydroxides of iron stain unit; patchy veneer of alluvium covers unit.

Unit 4
Dolostone: black, weathers medium gray; arenaceous; fine to medium crystalline; gray to dark-gray chert seams and nodules; zones of dolomite and chert nodules and algal-like structures weather in relief to rough gnarly surface; bedding indistinct, jointed, fractured; iron oxides and hydroxides stain unit; patchy veneer of alluvium covers unit.

Unit 3
Quartzite: white to dark gray, weathers same; fine grained siliceous groundmass; dense, resistant; jointed, fractured; iron oxides and hydroxides stain unit; patchy veneer of alluvium covers unit.

Unit 2
Limy dolostone: dark gray, weathers bluish-gray with rough surface; arenaceous; fine to medium crystalline; gray to dark gray chert seams and nodules; zones of resistant dolomite and chert nodules and/or algal-like structures weather in relief to rough gnarly surface; oxides and hydroxides of iron stain unit; patchy veneer of alluvium covers unit.

Unit 1
Quartzite: same as Unit 3.

Total measured section of the Oquirrh Formation . . . . . . 441
FIGURE 3: An outcrop of the Deseret Limestone showing the dark and light limestone bands and the nature of the nodular concretions.

FIGURE 4: Deseret Limestone exposure shows a network of the white, crystalline calcite veins.
Permian System

Kaibab Limestone

Name.--During the interval between 1870 and 1910, Gilbert, Walcott, and Darton all measured sections of the Kaibab Limestone in the Grand Canyon area. Later, however, in 1928, L. F. Noble measured another section of this limestone in Kaibab Gulch of the Grand Canyon. Noble's section, though not as thick as those measured by Gilbert, Walcott, and Darton, is now considered by the U. S. G. S. as the type section, for it is the only section of the Kaibab Limestone in the type area which is complete.

At Noble's section, the Kaibab Limestone consists of approximately 675 feet (maximum) of massive, cherty, blue-gray limestones which alternate with thin beds of yellowish limestones, shales, and sandstones.

The Kaibab Limestone is overlain by the (Triassic) Moenkopi Shale and underlain by the (Permian) Hermit Shale at the type section.

Lithology.--The Kaibab Limestone that crops out in the Cove Creek area is a uniform massive, light gray medium crystalline limestone. The exposures of the limestone weather to a light gray, rough surfaced rock.

The only variation in the limestone formation shows up as discontinuous stringers of chert that range from approximately one to five inches in width.
The scattered exposures of the Kaibab Limestone are characterized by an abundance of fossils. These fossils appear as weathered-out forms and as beds of fragmental fossil hash.

The Kaibab Limestone has been altered by hydrothermal solutions. These solutions have introduced iron oxides and hydroxides along fractures and joints, causing dissemination of these oxides and hydroxides throughout the rock. The reader is referred to a later topic which discusses this type of alteration. (See page 72.)

**Age and correlation.**—As already stated, the Kaibab Limestone which crops out in the mapped area is very fossiliferous. The fossils generally occur in a fragmental "hash" and, as such, are hard to extract as identifiable forms. The weathered-out fossils, on the other hand, were easily collected for study and age determination.

The fossils, *Dictyoclostus bassi*, *Derbya sp.*, *Composita sp.*, and fragments of bryozoans, productids, and spiriferids were identified by Mr. Walter Sadlick. It was noted by Mr. Sadlick that the widespread Kaibab productid, *Dictyoclostus bassi*, occurs in both the Leonard and lower Guadelupian of the Permian System.

**Measured section.**—The Kaibab Limestone was measured NE 1/4, in Section 2, R. 25 S., T. 7 W.
late Tertiary Extrusives (unconformable): feet
Permian - Kaibab Limestone:

Unit 4 Limestone: same as Unit 1; base of Unit 4 covered by alluvium and Tertiary extrusives. 65

Unit 3 Quartzite: gray to white; weathers same; zones well indurated, vitreous while other zones are dull and possess a sugary textured surface; siliceous groundmass, uniformly fine to medium grained; oxides and hydroxides of iron stain unit; fractured, jointed; patchy veneer of alluvium covers unit. 13

Unit 2 Limestone: medium bluish-gray, weathers to a bluish-gray; medium to coarse crystalline; lenses of fossil hash, are fractured and poorly consolidated by secondary calcite; gray to dark gray chert seams and pods; scattered, reddish-brown resistant limestone and chert nodules and algal-like structures weather in relief; network of interlacing calcite filled veinlets; iron oxides and hydroxides stain unit; jointed fractured, medium bedded, patchy veneer of alluvium covers unit. 141

Unit 1 Limestone: dark bluish-gray, weathers to a medium bluish-gray; fine to medium crystalline; dense resistant medium bedded, jointed, fractured; scattered, reddish-brown, chert and limestone nodules and algal-like structures weather in relief; gray to dark gray chert seams and nodules; network of interlacing calcite filled veinlets; patchy veneer of alluvium covers unit. 52

Total measured section of the Kaibab Limestone ................ 271
III. Cenozoic Stratigraphy

Tertiary System

Sevier River Formation

Name.--In 1937, at the junction of Clear Creek and the Sevier River in south central Utah, Callaghan named and described this formation and from ostracods and fresh water snails determined its age as Pliocene to early Pleistocene (?). The Sevier River Formation is described by Callaghan (1937) as "variable in composition, consisting of fanglomerates, conglomerates, sands, silts, and white lacustrine, diatomaceous marls."

In 1946, both Maxey and Thomas correlated 900 feet of sediments in the Pavant Valley with Callaghan's Sevier River Formation of south central Utah. These Pavant Valley Sevier River sections of Maxey and Thomas lie approximately ten miles north-northeast of the Cove Creek area.

Lithology.--The Sevier River Formation is exposed throughout the western two-thirds of the Cove Creek area. The Sevier River section is predominantly a fine, friable, white, calcareous marlstone. Throughout the marlstone section are distributed buff to white, poorly consolidated sand and pebble lenses. The lenses are composed of subangular to rounded quartz, limestone, rhyolite, andesite, and basalt pebbles and sands in a matrix of flaky calcareous clay.

A six to ten foot resistant, buff to white, limestone unit
will be found at the top of this measured Sevier River section. (See Plates 7 and 8, pages 38 and 43.)

Age and correlation.—Age determination and correlation of the Sevier River Formation was established on the basis of the following information:

1. Abundant Cypridicean ostracods, charophyte stems and oogonia, diatoms, fish vertebrae, and fresh water snails (Fluminicola (?) sp.; Yen, 1946) were collected from the measured marlstone section. Some of the collected ostracods Candona candida, Candona kingsleyi, and Cypris pubira were identified by Dr. D. J. Jones and Mr. D. David Stone, who suggested the ostracods indicated a Pliocene to Pleistocene age.

2. In the Lower Beaver Valley, approximately five miles west of the mapped area, Liese (1957) recognized lacustrine marlstone exposures. These marlstones, which have a lithology similar to those in the Cove Creek area, were identified by Liese as late Tertiary to early Quaternary (?).

3. Ten to fifteen miles northeast of the mapped area, Maxey (1946) described marlstones of Pliocene age in the Pavant Valley and correlated them with Callaghan's Sevier River Formation.

4. Thomas (1946) identified and described marlstone exposures of Pliocene age ten miles north of the
An exposure of the dense and hard Sevier River limestone that changes downward into a cavernous, arenaceous marlstone.
mapped area during his study of the water supply problem in Millard County, Utah. These marls were correlated by Thomas with the Sevier River Formation of south central Utah.

Therefore, through dating of the ostracods as Pliocene to Pleistocene (?), through the abundance of fossil remains (i.e., ostracods, diatoms, snails, charophyte oogonia and stems) which Callaghan stated were present in the Sevier River Formation, and because exposures of similar marlstones close to the Cove Creek area have been dated as Pliocene to Pleistocene (?), the marlstones of the Cove Creek area have been correlated with Callaghan's Pliocene to early Pleistocene (?) Sevier River Formation of south central Utah.

Measured section.—The Sevier River section was measured in the NW 1/4, Section 3, T. 25 S., R. 8 W.

<table>
<thead>
<tr>
<th>Quaternary</th>
<th>Late Pleistocene (?) gypsum sands</th>
<th>(unconformable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary</td>
<td>Quaternary</td>
<td>Pliocene to early Sevier River Pleistocene (?)</td>
</tr>
</tbody>
</table>

Feet

Unit 18 | Limestone-arenaceous marlstone: buff to light gray colored, hard, dense, vuggy limestone; cliff former; limestone stained red to yellow; limestone varies downward into a cavernous, arenaceous marlstone; arenaceous material consists of angular to rounded quartz, limestone, rhyolite, andesite, and basalt fragments; limestone interval approximately 4 feet thick; marlstone interval approximately 5 feet thick. | 9 |
**Unit 17** Soft marlstone: white to light gray; friable; lens of arenaceous material composed of angular to rounded fragments of quartz, limestone, rhyolite, andesite, and basalt.

**Unit 16** Limestone: buff; poorly consolidated; arenaceous; surficial red to yellow iron oxide staining; composition of arenaceous fragments similar to those found in Unit 17.

**Unit 15** Soft marlstone: white to light gray; friable; arenaceous; at base of unit a gray to arenaceous lens with a flaky calcareous clay matrix; unconsolidated; composition of lens fragments similar to those of Unit 17.

**Unit 14** Limestone: buff, hard, dense, resistant, and vuggy; unit varies downward into a cavernous, arenaceous marlstone; arenaceous material similar in composition to fragments found in Unit 17; limestone interval approximately 2 feet thick; marlstone interval approximately 4 feet thick.

**Unit 13** Cover: alluvial mantle consists of arenaceous materials mentioned in Unit 17, calcareous clays, and limestone blocks from above; 2 feet to 3 feet thick arenaceous marlstone ledges appear through alluvial cover.

**Unit 12** Marlstone: buff to white marlstone lens 2 feet to 4 feet thick, alternates with thinner 1 foot, drab, flaky, marlstone lens throughout unit; 2 foot, poorly consolidated to arenaceous lens at base of unit; lens has a flaky calcareous clay matrix; root-like concretions weather-out at surface of measured section; composition of angular to rounded pebble and arenaceous fragments similar to those of Unit 17.

**Unit 11** Soft marlstone: buff to light gray; arenaceous; root-like concretions weather-out at surface of measured section; angular to rounded arenaceous fragments arenaceous similar in composition to those of Unit 17.
<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Cover: alluvial mantle of arenaceous material, calcareous clay, and limestone blocks; no exposures.</td>
</tr>
<tr>
<td>9</td>
<td>Limestone: similar to Unit 15</td>
</tr>
<tr>
<td>8</td>
<td>Soft marlstone: drab, flaky; poorly consolidated; vertical jointed; arenaceous; angular to rounded fragments similar in composition to those of Unit 17.</td>
</tr>
<tr>
<td>7</td>
<td>Cover: similar to Unit 10.</td>
</tr>
<tr>
<td>6</td>
<td>Marlstone: buff to light gray; poorly consolidated; friable; arenaceous; vertical jointed; root-like concretions weather-out at surface of measured section; pebble and arenaceous lens, light gray in color and 1 foot thick at base of unit; poorly consolidated; angular to rounded pebble and arenaceous fragments similar in composition to those of Unit 17.</td>
</tr>
<tr>
<td>5</td>
<td>Soft marlstone: light gray; friable; arenaceous; vertical jointed; arenaceous material similar in composition to fragments of Unit 17.</td>
</tr>
<tr>
<td>4</td>
<td>Marlstone: buff to white; friable; arenaceous; vertical jointed; arenaceous lens at base of unit, approximately 1 foot thick; lens matrix of light gray flaky calcareous clay; poorly consolidated; angular to rounded arenaceous fragments similar in composition to those fragments of Unit 17.</td>
</tr>
<tr>
<td>3</td>
<td>Marlstone: similar to Unit 12.</td>
</tr>
<tr>
<td>2</td>
<td>Marlstone: buff to light gray; arenaceous; friable; vertical jointed; pebble and arenaceous lens at base of unit approximately 2 feet thick; lens poorly consolidated, with matrix of calcareous, flaky clay; angular to rounded pebble and arenaceous fragments similar in composition to fragments of Unit 17.</td>
</tr>
</tbody>
</table>
Unit 1 Marlstone: red to pink; poorly consolidated; arenaceous; 1 foot to 5 inch lenses throughout unit are composed of pebble and arenaceous fragments similar in composition to fragments of Unit 17.

Total measured Sevier River section . . . . . . . . . . . . 262

Base of Unit 1 rests upon the surface of a vesicular basalt. The reader is referred to a later topic discussing the sequence of basalts in the Cove Creek area.

Quaternary Sedimentary Deposits

Gypsum sands.—The gypsum sands are exposed only in the south central portion of the Cove Creek area. This deposit ranges up to 15 feet in thickness and is composed of gypsum aggregates (45 per cent), quartz sand fragments (30 per cent), calcareous clay (20 per cent), and organic material (i.e., vegetation) (5 per cent). Although this sand is unconsolidated, calcareous clays do cement some of the quartz grains and gypsum fragments together. None of the observed calcareous clay accumulations exceeded 10 mm. in size.

Boutwell (1904) explains the occurrence of these gypsum deposits as follows:

The gypsum contained in these deposits are believed to have been transported by streams from its original position
FIGURE 5: - A view of the Sevier River limestone showing the porous or "spongy" weathering characteristic.

FIGURE 6: - A view of the Sevier River marls. Geologist's hammer rests upon a fault plane that developed during tilting of the Sevier River strata.
in the mountains to the east (Pavant Range and Tushar Mountains) and redeposited with detritus in playas. Some of the gypsum deposits have to a considerable extent been freed from enclosing sediments by desiccation, reconcentrated by wind, and collected into dunes of pure gypsum.

Several playas mark localities where the drainage was checked, but not completely imprisoned. It is probable that these gypsum deposits are independent of any special chemical reaction and is due simply to discharge by evaporation of a mineral dissolved from the rocks.

The gypsum sands unconformably overlie basalt unit III (Plate 9; page 45). In the western Cove Creek area this same basalt unconformably overlies the Pliocene to early Pleistocene (?) Sevier River Formation. Therefore, the gypsum sands are at the oldest, early Pleistocene (?) in age. The same gypsum sand deposit is unconformably overlapped by basalt unit IV. This basalt is a portion of the lava field associated with the Cove Fort Volcano, both of which have in the past been postulated as being late Pleistocene to Recent in age by Gilbert (1883), Lee (1907), and Liese (1957). Thus, the gypsum sands were deposited prior to these overlying basalts.

Boutwell (1904) has ascribed the accumulation of these gypsum sands to the last stages of Lake Bonneville or during late Pleistocene time.

Quaternary alluvium and gravel deposits.—Approximately 40 per cent of the mapped area is covered by alluvium. These Quaternary deposits not only are the result of erosion of both sedimentary and igneous rocks within the mapped area, but also represent the remnants of alluvial fans and/or bahadas that were
View looking southwest at the Pleistocene (?) gypsum sands that lie unconformably on basalts. The Central and Northern Mineral Mountains are in the background.
formed during erosion to the east of the Pavant Range and Tushar Mountains.
FIGURE 7: Gently tilted strata of the Sevier River Formation (background) of post-Sevier River tilting.

FIGURE 8: View looking southwest at the Tertiary andesite (above line) and the Kaibab Limestone (below line). In the background is the Cove Fort Volcano and associated basalt (center background) and the Central Mineral Mountains (right background).
IGNEOUS ROCKS

I. General Statement

Approximately 25 per cent of the surface rock in the Cove Creek area are extrusives. These igneous rocks are found in nearly every section of the thesis area and consist of rhyolites, andesites, basalts, and three vitrophyre exposures.

The oldest extrusives in the mapped area are the late Tertiary rhyolites and andesites. These igneous rocks crop out in the east-central portion of the mapped area. The oldest of these two flows, a hornblende rhyolite, is overlain by the younger augite andesite. Good outcrops of the andesite exist in the mapped area, but the rhyolite is largely covered by alluvium and the overlying andesite.

The vitrophyre occurs as three scattered outcrops in the thesis area. One of the vitrophyre flows which crops out in the northeastern part of the mapped area, rests upon the Ordovician Pogonip limestones. The other two vitrophyre flows, where they crop out in the east central part of the Cove Creek area, lie upon the augite andesite. As these flows are discontinuous, it was not possible to prove their equivalent age relationships.

The basalts that make up the lava field in the south and western portions of the Cove Creek area are by far the most prominent of the extrusives. These basalts consist of at least four different flows. Each of these basalts was observed to vary from the others in
Hornblende Rhyolite

Field occurrences.—The hornblende rhyolite is exposed in the extreme east central portion of the thesis area. This extrusive, however, crops out in only scattered localities, as it is partly overlain by a younger andesite and partially buried in andesite debris.

A reconnaissance indicated that this rhyolite extends into the Cove Creek area from the east where the main body of the flow is found in the Tushar Mountains.

Petrographic description.—In the field, unaltered exposures of the rhyolite are gray in color. Close inspection of hand specimens from the extrusive shows a light colored aphanitic groundmass in which there are dispersed phenocrysts of orthoclase, plagioclase, hornblende, and biotite.

Upon microscopic examination of the rhyolite the following diagnostic minerals were identified. These minerals are: quartz (10 per cent), orthoclase (25 per cent), andesine (17 per cent), biotite (5 per cent), and hornblende (5 per cent). The minor accessory minerals apatite, chlorite, and magnetite comprise another 5 per cent of the rhyolite with the feldspar groundmass making up the remaining 35 per cent of the extrusive.
PLATE 11

PETROGRAPHIC DIAGRAM

Hornblende rhyolite:

Phenocrysts of orthoclase (a), andesine (b), hornblende (c), biotite (d), and magnetite (e).

Groundmass of glass and microlites of orthoclase, andesine, and magnetite (i).

Alteration and replacement products of magnetite (f), hematite (g), and calcite (h).
The texture of the rhyolite may be described as hemicrystalline-porphyritic. The groundmass is composed largely of a felt of lath-shaped microlites. A fluidal structure is indicated, as these microlites of the groundmass possess a preferred orientation.

Percentage-wise the most prominent constituent of the rhyolite is the plagioclase, andesine (Ab$_{60}$An$_{40}$), which appears as microlites and as euhedral and subhedral phenocrysts. Oscillatory zoning and wedge twinning were observed in the phenocrysts. Phenocrysts of biotite and hornblende are distributed throughout the rhyolite. The scattered arrangement of these darker minerals in the rhyolite gives it a salt and pepper appearance.

The phenocrysts of plagioclase frequently show good subhedral crystals and range in size from approximately 0.5 mm. to 2.0 mm. in length. The hornblende, orthoclase, and biotite phenocrysts vary in length from 0.1 mm. to 2.0 mm. (Plate 11, page 50).

Weathering has affected the hornblende rhyolite to a greater degree than any of the other flows in the mapped area. The rhyolite is the oldest flow in the mapped area and is also extensively fractured. It is believed that these two factors have contributed largely to this complete and deep weathering of the rhyolite.

The weathered rhyolite is composed of products of weathering which comprise nearly 50 per cent of the rock. As a result of this weathering, clay and calcite fill fractures, due to solutions, voids in the phenocrysts have developed, and orthoclase, plagioclase, hornblende, and biotite phenocrysts show less than 25 per cent of the original mineral. These alteration and replacement processes
have rendered the weathered rhyolite soft and crumbly to the touch. (See Plate 12, page 53.)

Age and correlation.—Kerr, et al. (1957, page 24) applied the term Mount Belknap to a series of late (?) Tertiary rhyolite flows, tuffs, and agglomerates in the Marysvale area. Callaghan (1937) had earlier termed these flows as "later Tertiary" volcanic rock to distinguish them from another series of medial (?) Tertiary flows. Kerr, et al. (1957) also found that the Mount Belknap extrusive series could be differentiated on the basis of their red and gray colors.

Following these studies by Kerr, et al. (1957) and Callaghan (1937), Crosby (1959) mapped the rhyolites in the Southern Pavant Range and in the Northern Tushar Mountains as late (?) Tertiary in age and belonging to the Mount Belknap volcanic series.

Age determination of the Mount Belknap volcanic series in the Marysvale area was made on the basis of radioactive dating (Kerr, et al., 1957) of uranium minerals. This method of dating gave the extrusives an age of ten million years or giving the Pliocene as a minimal age. Furthermore, it was found by Crosby (1957) that the late (?) Tertiary to early (?) Pleistocene Sevier River Formation in his area rested unconformably upon the Mount Belknap volcanic series.

The rhyolite that crops out in the Cove Creek area is a small representation of the larger extrusive body mapped by Crosby (1959) in the Tushar Mountains to the east. The rhyolite
Weathered hornblende rhyolite:

Phenocrysts of orthoclase (a), andesine (b), hornblende (c), biotite (d), and magnetite (f).

Groundmass of glass and microlites of orthoclase, andesine, and magnetite (i).

Alteration and replacement products of magnetite (h), hematite (e), and calcite (g).
in the thesis area must, therefore, be correlated with the late Tertiary extrusives mapped by Crosby (1959) and consequently with the late (?) Tertiary Mount Belknap volcanic series of Kerr's Marysvale area.

**Augite Andesite**

**Field occurrence.**—The augite andesite is the most extensive of the two older flows and is exposed only in the eastern portion of the Cove Creek area where it overlies the hornblende rhyolite.

Again a reconnaissance shows that the main body of the andesite lies in the Tushar Mountains to the east and that the andesite in the thesis area is but a small part of this flow.

**Petrographic description.**—In the field the rounded exposures of this andesite have a characteristic dark red color. Hand specimens reveal a stony, dark red to dark reddish-purple colored groundmass throughout which there are scattered phenocrysts of pyroxene, plagioclase, and orthoclase.

Upon microscopic examination of the andesite the following diagnostic minerals were identified. These minerals are: orthoclase (10 per cent), andesine (25 per cent), augite (15 per cent), and magnetite (10 per cent). A glassy groundmass makes up the remaining 35 per cent of the andesite.

The texture of the andesite is considered to be hyalopilitic, as the extrusive is hypocrystalline-porphyritic and possesses a glassy base. The phenocrysts and microlites of the minerals show a
PLATE 13

Petrographic Diagram

Diameter - 2 mm.

Augite andesite:

Phenocrysts of andesine (a), magnetite (b), and augite (c).

Groundmass of glass with andesine microlites and magnetite dust-like particles (d).

Microscopic fractures filled with hematite and glass (e).

Alteration and replacement products of magnetite (f), and hematite (g).
preferred orientation with the glassy groundmass or base exhibiting
flow lines that spread around these crystal forms.

The primary minerals of andesine (Ab$_{60}$An$_{40}$), orthoclase, and
augite occur as phenocrysts and make up approximately 50 per cent of
the flow. Wedge twinning and oscillatory zoning may frequently be
seen in the andesine phenocrysts. Good subhedral crystal forms
are a characteristic of the andesine phenocrysts.

Augite is the only mineral in the andesite that shows any
real effects of weathering. This weathering is revealed through
pitting of the augite crystal faces and edges. Where this pitting
has taken place there now is found alteration and replacement minerals
in the form of chlorite, calcite, and oxides and hydroxides of iron.

Phenocrysts of andesine, orthoclase, and augite are 2 mm.
to 3.0 mm. in length. A notable amount of magnetite is present and
some of the magnetite phenocrysts are surprisingly large, as a number
reach sizes of approximately 0.6 mm. (Plate 13, page 55).

Age and correlation.—Significant geologic relationships
are lacking for precise age determination of the andesite; however,
in the Cove Creek area the following, general, field relationships
were noted.

The andesite to the south dips beneath the basalts associated
with the Cove Creek area and so must, therefore, be older than these
basalts. The andesite is older than the vitrophyre flows, as two of
the vitrophyre flows rest upon this andesite. The andesite overlies
the rhyolite and in so doing follows the sequence of flows of the
Marysvale Mount Belknap volcanic series.

Using this information a general Tertiary age may be concluded; although, as previously mentioned, extrusives of similar composition and sequence relationships have been dated as late (?) Tertiary Mount Belknap volcanic series by Kerr, et al. (1957) and Crosby (1959).

**Labradorite Vitrophyre**

**Field occurrence.**—The vitrophyre occurs in three areas. One is found to the northeast, in the SW 1/4, Section 34, T. 24 S., R. 7 W., as a small flow partially mantled by gravels. The second exposure of the vitrophyre is found in the NW 1/4, Section 14, T. 25 S., T. 7 W., and the third in the NW 1/4, Section 23, T. 25 S., R. 7 W. The latter two flows are only partially exposed, as they are mantled by andesite debris.

**Petrographic description.**—In the field, exposures of the vitrophyre show a fractured dull, black appearance. However, in hand specimens broken from the flow, the freshly fractured surfaces show a black, glassy rock with lighter phenocrysts of both plagioclase and pyroxene dispersed moderately throughout the groundmass.

Upon microscopic examination of the vitrophyre, the following diagnostic minerals were identified. These minerals are: labradorite (30 per cent), augite (10 per cent), glass (55 per cent), and magnetite (5 per cent).
PLATE 14

PETROGRAPHIC DIAGRAM

Diameter - 2 mm.

Labradorite vitrophyre:

Phenocrysts of labradorite (a), augite (b), and magnetite (c).

Groundmass of glass with andesine microlites and magnetite dust-like particles (d).

Blebs of glass in labradorite crystal (e).
The groundmass of the vitrophyre is considered by the writer to be hypohyline as the crystalline constituents (i.e., phenocrysts, microlites) are found in an amorphous or non-crystalline glassy base. The phenocrysts and microlites show a preferred orientation with the glassy base exhibiting flow lines that spread around the crystal forms.

The primary minerals of labradorite (Ab$_{60}$An$_{40}$) and augite are found as phenocrysts and microlites and make up approximately 35 per cent of the vitrophyre. Wedge twinning and oscillatory zoning are present in the labradorite phenocrysts. The phenocrysts of augite appear to show only the initial effects of alteration and/or replacement; as calcite and the hydroxides and oxides of iron apparently have just begun to form upon the augite crystal faces and edges.

Upon microscopic examination of the vitrophyre it was found that a significant portion (55 per cent) of the flow is composed of glass. Black cryptocrystalline to microcrystalline dust-like particles which very probably are specks of magnetite have given the glass, and consequently the vitrophyre, its black color.

Phenocrysts of labradorite are large, varying from 0.3 mm. to 3.0 mm. in length. The phenocrysts of augite are somewhat smaller, varying in size from 0.5 mm. to 1.0 mm. (See Plate 14, page 58.)

**Age and correlation.**—As each of these vitrophyre flows is similar petrographically in composition and appearance, the
probability that each of the three vitrophyre flows is of a different age seems remote. Rather, it is postulated that these three flows originated from the same source and were extruded into the Cove Creek area at approximately the same time.

Field relationships of the three flows do not indicate whether the vitrophyre flows are older or younger than the Quaternary basalts of the thesis area, but they are definitely younger than the andesite, as the vitrophyre occurs unconformably above andesite and, therefore, must post date it. These same vitrophyre flows, however, may be correlated with the Quaternary basalts of the Cove Creek area and similar Pleistocene (?) vitrophyre flows near Millard, Utah, at the southern end of the Mineral Mountains (Earll, 1957), as the Cove Creek vitrophyre flows are similar in composition, texture, and color to these two types of extrusives. On this basis a late (?) Tertiary to Pleistocene (?) age is postulated for the three vitrophyre flows in the mapped area.

**Basalts**

**Field occurrence.**--The basalts of the Cove Creek area are the most extensive and recent of the flows. Four distinct and separate basalts were found and mapped in the thesis area. These four flows are listed below in a sequence that begins with the oldest.

**Unit I.** The oldest basalt crops out in the SW 1/4, Section 3, T. 25 S., R. 8 W. This flow is dark brown in color and is
exposed in only scattered outcrops, as it is partially covered by alluvium and another basalt. The thickness of this basalt is unknown as its base was not exposed.

Unit II: Overlying basalt unit I is another basalt which is also exposed in the SW 1/4, Section 3, T. 25 S., R 8 W. This basalt is dark brown to black in color, approximately 15 feet thick, and partially mantled by alluvium and overlain by the Sevier River Formation.

Unit III: A black basalt, which ranges up to approximately 25 feet in thickness, covers the northern and western portions of the Cove Creek area. Erosion and alluvium has prevented the basalt from being exposed in its entirety and so the basalt now appears as only scattered remnants.

Unit IV: The youngest basalt in this sequence has a black color and appears only in the southern portion of the mapped area. Here, it overlies the gypsum sands and has only a patchy mantle of the most recent alluvium. This basalt, which may be traced south to the Cove Fort volcano, completely surrounds the volcano.

The Cove Fort volcano is just west of U. S. Highway 91 and about two miles southwest of Cove Fort, Utah. (See Plate 1, pocket, Plate 19, page 70.) The sides of the volcano have angles of approximately 30 to 35 degrees with the horizontal and was classified in the past (Gilbert, 1883) as a cindercone.
View looking southeast at one of the Pleistocene (?) basalt exposures which has been partially exposed by Cove Creek (dry erosion channel to right). To the right of the view this basalt is capped by gypsum sands (see plate 10). In the (right) background the Recent age basalts overlie these gypsum sands.
Description.—Special features common to the basalts are shrinkage cracks, sheet jointing, zones of numerous vesicules, and amygdules. Gas cavities in the basalts give the rock a spongy appearance. The greatest concentration of these cavities is found at or near the surface of the flow.

A special feature of basalt unit II is its amygdules. These amygdules generally are sparsely scattered throughout the basalt, for in any specific portion of the flow they may be concentrated or grouped, or conversely, entirely lacking. The amygdules, which only appear in the lower ten-foot portion of the flow that is exposed, are elongated or almond shaped, range in size from 2.0 cm. to 6.0 cm., and are filled with crystalline calcite.

Another feature of basalt unit II are the zones and lenses of textural change. These zones have the same composition as the rest of the basalt but have a coarser texture. These changes in texture occur below approximately the first five to seven feet of the vesicular basalt, and it is in these zones and lenses that the calcite amygdules appear.

The zones and lenses range in size from bodies approximately six inches thick to about six feet long, to zones and lenses deeper in the flow that encompass the entire basal ten-foot exposed portion of the basalt.

The contact between these zones and surrounding portion of the flow is considered to be sharp. This contact is represented by an approximate one and one-half inch transformation interval from
A view of exfoliation at the base of the oldest basalt. The basalt locally rests upon the Sevier River Formation and a baked calcareous rock is often found at the contact of these two rock types.
one rock type to the other.

Petrography.—Weathered outcrops of the two older basalt units are dull, dark brown in color. Phenocrysts of plagioclase and pyroxene may be distinguished in hand specimens with the aid of a lens.

Outcrops of the last two basalt units, units III and IV, have a typical dull black color. Phenocrysts of plagioclase and pyroxene may also be seen upon very close examination of these basalts with the aid of a hand lens.

Upon microscopic examination of the basalts the following diagnostic minerals were identified. The minerals are: labradorite (50 to 55 per cent), augite (25 to 30 per cent), magnetite (10 per cent), glass (5 to 10 per cent), and olivine (trace to 3 per cent).

The texture of all the basalts may be described as intergranular, for in these flows the grains of augite appear between subparallelly aligned labradorite laths and also are not in parallel optical continuity. The subparallel arrangement of the phenocrysts and microlites gives the basalt a fluidal structure.

The predominant constituents of the four flows are labradorite and augite. These two minerals appear as microlites and phenocrysts and comprise approximately 80 per cent of the total minerals present. The crystal forms of both augite and labradorite are euhedral to subhedral. Wedge twinning may be seen in the microlites and phenocrysts of labradorite.

Hematite occurs in the older basalt as both a primary and
PLATE 17

PETROGRAPHIC DIAGRAM

Diameter - 2 mm.

Basalt unit 2:

Phenocrysts of labradorite (a), augite (b), and magnetite (c).

Labradorite microlites (d).

Groundmass of glass with dust-like particles of magnetite (e).
a secondary mineral. Upon microscopic examination the hematite content in the oldest basalts was found to be sufficient enough to cause the reddish color of the extrusive.

Only a very small percentage of olivine (less than 1 per cent) was found in the two younger basalts. The percentage of olivine, however, is greater in the two older basalts (5 per cent). As a result of weathering the crystal faces and edges of the olivine phenocrysts are pitted. Where this pitting occurs, there is now magnetite and hematite.

Further microscopic examination of the basalts revealed that a portion (10 per cent) of the younger basalts is composed of glass. The glass is similar in composition and color to the glass in the vitrophyre. Black cryptocrystalline to microcrystalline dust-like particles, which are very probably specks of magnetite, have given the glass, and consequently the basalt, its black color.

In the four basalt units the phenocrysts of labradorite and augite range in size from 0.5 mm. to 1.0 mm. There was, however, a difference between the basalts in the average size of the microlites in their groundmass. The reader is referred to the petrographic diagrams at this time for the purpose of comparison. (See Plates 17 and 18, pages 66 and 68.)

The more coarse textured zones and lenses in the older basalt present larger phenocrysts and a larger average microlites size for the groundmass. The phenocrysts of labradorite, augite, and olivine range in length from 0.5 mm. to 2.0 mm. (See Plate 18, page 68.)
Basalt unit 2: Specimen taken from the coarse textured zones in basalt unit 2.

Phenocrysts of labradorite (a) and augite (b).

Alteration products of magnetite (c), hematite (d), and calcite (e).

Introduced calcite (f).
**Age and correlation.**—The youngest basalt, Unit IV, appears in the southern portion of the thesis area and overlies all igneous and sedimentary rocks there. (Plate 1, pocket.) This basalt has previously been studied by Gilbert (1883), Lee (1908), Earl (1957), and Liese (1957). In each of these studies this basalt has been assigned a late Pleistocene to Recent age.

In the basalt sequence the next youngest basalt, unit III, appears as scattered outcrops in the north and western portions of the mapped area where they cap the Pliocene to early (?) Pleistocene Sevier River Formation. (See Plates 15 and 19, pages 62 and 70.)

Basalt, unit III, may be traced southward to where it is overlain by the gypsum sands and basalt unit IV. The gypsum sands and basalt unit IV are dated respectively as late (?) Pleistocene and Recent in age.

This information shows that basalt unit III was extruded into the mapped area prior to deposition of the gypsum sands but after deposition of the Sevier River Formation. Basing the age of basalt unit III on these facts, only a general early (?) Pleistocene age may be given for this extrusive.

**Dating of the two oldest basalts is based upon the following information:** (1) The oldest basalt, unit I, is overlain by a portion of the Sevier River Formation. This basalt apparently was extruded sometime during deposition of the Sevier River Formation; and it therefore can only be given a general age of late Pliocene to early Pleistocene (?). (2) The next oldest basalt in the sequence of flows, unit II, overlies the oldest basalt and is in turn overlain
View looking southwest across the Cove Creek area. Pleistocene (?) basalt and scoriaceous flows (above dashed line) that overlie the Sevier River Formation are shown in the foreground. In the right background the Cove Fort Volcano and lava field is shown. The Tushar Mountains may be seen in the background.
by basalt unit III. This second oldest basalt may, therefore, also be considered late Tertiary (?) to Pleistocene (?) in age.
ALTERATION

I. General Statement

In the Cove Creek area alteration has occurred in the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian sedimentary rocks, in the Tertiary rhyolites and andesites, and in the Pliocene to early (?) Pleistocene Sevier River Formation. Specifically, this alteration consists of (1) deposition iron bearing minerals along fractures, joints, and fault planes, and (2) a contact zone immediately underlying Pleistocene (?) basalt Unit III.

The faults, fractures, and joints in the rocks of the thesis area, a result of the forces responsible for the faults and the overturned and tilted attitude of the strata in the Cove Creek area and in the Tushar Mountains to the east, provided a means by which the iron-bearing solutions moved through and mineralized the rock. These iron deposits not only fill fractures, but appear also as a cementing material and as a staining agent.

Locally, brecciated zones are found within the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian limestones and dolostones. It is postulated that these brecciated zones have formed along fault planes and with subsequent differential erosion they have been left in relief. (See Plate 20, page 73.)

Field examination of the brecciated zones and the other brecciated rock which surrounds them shows that they are composed
FIGURE 9: - A "breccia" zone in the Fish Haven Dolomite.

FIGURE 10: - The sharp dark contacts mark the extent of iron oxides and hydroxides in the Bureska Quartzite.
of angular, sand, pebble, and cobble size carbonate fragments, cemented together by a fine, red colored carbonate groundmass. Microscopic examination of the material reveals that the groundmass is composed of a microcrystalline to cryptocrystalline granular carbonate mass, also cemented together by iron oxides and hydroxides. (See Plate 21, page 75.)

The fractures are best shown in exposures of both the rhyolite and andesite. The completeness of this fracturing is further represented in these flows by a microscopic network of fractures. (See Plate 13, page 55.)

Upon close examination of rhyolite and andesite specimens a number of episodes of deformation resulting in fracturing of the extrusives occurred, each of which were followed by subsequent filling of the fractures with iron oxides and hydroxides. In support of this statement it was noticed that veinlets dissected still others which were also filled with these iron deposits. Additional episodes of deformation with fracturing, occurred as the iron oxides and hydroxides filled veinlets are dissected still further by other but unfilled fractures.

The effects of these postulated iron-bearing solutions upon the rhyolite has given its exposures a gray and red mottled appearance. Also, the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian strata and the rhyolite and andesite, the only rocks that were affected by the postulated iron-bearing solutions, are the only rocks in the thesis area which have a characteristic
"Breccia" zone:

- Carbonate fragments (a).
- Carbonate-hematite groundmass (b).
- Oolitic structures (c).
alliaceous odor. This odor is best revealed when these sedimentary and igneous rocks are struck a sharp blow.

The three vitrophyre exposures show none of the iron deposits attributed to the postulated iron-bearing solutions. These outcrops, therefore, were apparently extruded at some time after the postulated iron-bearing solutions were active in the Cove Creek area. Like the Paleozoic sedimentary rocks and the late Tertiary rhyolites and andesites, each of the vitrophyre exposures is also fractured.

In summary, it is postulated that the iron oxide and hydroxide deposits which appear in the Tertiary extrusives and the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian strata were implaced during a number of episodes in the late Tertiary (?) at which time iron-bearing solutions penetrated into the rocks by means of a network of joints, fault planes, and fractures.

In the western portion of the Cove Creek area marlstones of the Sevier River Formation rests upon basalt unit II. Erosion and weathering of this basalt, prior to and during deposition of the basal 50-foot interval of the Sevier River Formation, is postulated to have been sufficient enough to give the marlstone its reddish color. A study of the marlstone unit shows that the red color is due to the combined influence of disseminated iron oxides and hydroxides and subangular to rounded arenaceous and lutaceous basalt fragments.

Where the basalt rests upon the Quaternary marls and alluvium, a variable, but approximate, six-inch zone of calcareous
Eureka Quartzite:

Extent of iron oxide and hydroxide staining in the quartzite (a).

Quartz grains - note: uniform granular size of grains, silica cement, and grains fit well into one another (b).

Iron oxide and hydroxide staining of the silica cement and quartz grains (c).
cinder is present. Wherever this cinder is found it consists of a consolidated and baked, calcareous clinker. It is infrequently located in the field, however, as mantling debris from the overlying basalt prevents its exposure. This calcareous cinder, found immediately below the basalt, is postulated to have developed during extrusion of the basalt, as it flowed over these marlstones and alluvium during Pleistocene (?) time; however, it cannot be ruled out that this cinder may be a result of a later calcification.
STRUCTURE

I. General Statement

The structure, stratigraphy, and geologic history of the Cove Creek area is considered by the writer to be similar to that of the Basin and Range province and, therefore, before any further discussion, a general statement regarding this province seems necessary.

Nolan (1943) describes the sequence of structural events in the Great Basin as follows:

The Precambrian structural history is little known at present, as the scattered regions in which the Precambrian rocks are exposed have been inadequately studied for purposes of correlation.

The record beginning with Cambrian time is much more complete. The geosynclinal sea, which in the early part of the Paleozoic Era covered most of the province and in which many thousands of feet of sediments were deposited, was divided in late Devonian time by a rising arch or geanticline in western Nevada. . . . Coincidentally with the degradation of this geanticline during the Permian Period a similar uplift began in eastern Nevada and a land mass between two seas persisted there until early Jurassic time.

This younger geanticlinal area, instead of subsiding, like the earlier one, became the site of intense diastrophism in early Jurassic time. To judge from the relatively meager evidence, similar deformation continued recurrently into the early part of the Tertiary Period, affecting an area that considerably exceeded that of the Great Basin. No regular pattern in space or time, can yet be discerned for these epochs of deformation within the province; in one area there may be evidence of only one episode, but in another nearby area, there may have been several. . . . These epochs of deformation can be approximately dated at only a few localities in the province, but at one of these places, strangely enough, it has been shown that deformation took place either during late Jurassic time or during the
transition from Cretaceous to Eocene time.

Along most of the thrust faults so far described, the upper plate has clearly moved eastward relative to the lower plate, and this fact, combined with the apparent westward increase in the intensity of folding, suggests that the active forces causing the deformation came from the west.

The Mesozoic and early Tertiary folding and thrusting were succeeded closely by the initiation of the block faulting that is the cause, directly or indirectly, of the present relief of the province. The faulting appears to have begun at least by early Oligocene time and to have continued up to the present day.

II. Folds

Postulated Late Jurassic to Early Tertiary (?) Folds

Some folding may have occurred in the Cove Creek area prior to the postulated laramide (?) eastward thrusting (Maxey, 1946; Christiansen, 1951; Liese, 1957; Crosby, 1959). The actual development of these folds, however, may only be suggested, as field evidence supporting this was not observed in the mapped area.

Later, folding and thrusting of the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian sedimentary rocks in the Cove Creek area did occur during the late Cretaceous to early Tertiary Laramide orogeny.

This folding is revealed through:

1. In the Cove Creek area the east striking northward dipping Paleozoic sedimentary rocks occur in an eroded limb of an overturned fold.

2. A reconnaissance to the east, along the base of the Pavant Range, revealed that the overturned limb,
composed of Paleozoic strata, extended from a point where it crops out in the central part of the mapped area, to near Kanosh, Utah, about 15 miles to the east-northeast. The general attitude of the structure suggests that it may have been derived by gravity sliding from the Sevier Arch; however, Crosby, 1959, postulated that the resulting fold(s) were caused by north-south compressional forces.

As the exposed sedimentary units of the fold(s) are Paleozoic in age, it was impossible to specifically date the development of the fold(s). Studies in adjacent areas (Maxey, 1946; Christiansen, 1951; Liese, 1957; Crosby, 1959) have indicated that the structure could only be determined generally as Laramide.

**Postulated Recent Doming**

Open folding of the Sevier River Formation and the basalts which overlie this formation has formed a broad anticline located in the western portion of the mapped area. (See Plate 1, pocket.) The anticline trends in a north-south direction and plunges to the north and south. The Sevier River Formation and the capping basalts dip gently (5 to 10 degrees) away from the axial zone of the fold. (See Plate 1, pocket.)

The anticline is dissected by a number of intermittent streams. These streams are probably controlled by joints and faults which developed within the Sevier River Formation during the time of folding. (See Plate 1, pocket.)
The cause of this folding can only be postulated as being the results of either east-west compressional forces or vertically upward forces that developed in the Cove Creek area during Quaternary time. It should be mentioned that this anticline may be dated relatively as having developed after the third basalt (see basalt sequence, pages 60 and 61) was extruded (early Pleistocene (?)).

III. Faults

The age and specific nature of the faults in the Cove Creek area, and their chronological sequence of development, may only be postulated, as field evidence was inadequate. Because of this, adjacent areas with more complete sedimentary, igneous, and tectonic histories were used to supplement dating of the faults which occur in the Cove Creek area.

Thrust Faults

Postulated Northeast-striking Thrust Faults: In the valley between the two nearly parallel, east-northeast trending, belts of Ordovician, Devonian, Mississippian, and Pennsylvanian strata, the omission of portions of the (Devonian) Sevy Dolomite and (Devonian) Guilmette (?) Formation plus the total absence of the (Devonian) Simonson Dolomite, cannot be satisfactorily explained by unconformities. Further structural complications are indicated in the mapped area by the omission of parts of Pennsylvanian and Permian strata between the (Pennsylvanian) Oquirrh Formation and the (Permian)
Kaibab Limestone.

In explaining the omission of the sedimentary units and the general nature of the Cove Creek structure, unconformities probably offer the least plausible explanation. Thrust faults were found to be responsible for similar structural and stratigraphic relationships in the mapped area to the east (Crosby, 1959); and since the Cove Creek structure is essentially continuous with the one to the east, it is concluded that thrust faults have omitted beds in the Cove Creek area.

Thrusting and folding in the Cove Creek area followed erosion and is tentatively suggested as being responsible for the structure and outcrop pattern which the Paleozoic strata now possess, even though the thrust(s) were actually never observed in the field. The postulated fault(s) are assumed to have northward dips with strikes approximately east-northeast.

No evidence was found in the folds of adjacent areas or in the thesis area which would definitely date this faulting; therefore, the deformation may only be given a general late Jurassic (?) to early Tertiary (?) age. On the basis alone that the attitude of the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian strata in the mapped area and in the adjacent mountains to the east could not have been formed by the major eastward thrusting of the Laramide orogeny (see Maxey, 1946; Christiansen, 1951; Liese, 1957; Crosby, 1959), a later episode of thrusting, very probably during some later portion of the Laramide (?) orogeny, is suggested.
North-striking thrust fault.—The most recent observed thrust fault has developed in but one small exposure of the Fish Haven Dolomite. In the NW 1/4, Section 7, T. 25 S., R. 7 W., where this fault appears, the orientation of the striations and "chatter marks" upon the fault plane gives the impression that the upper block has moved to the west and over the lower block. Due to the relative movement of the two blocks the fault apparently was caused by east-west compressional forces.

The thrust fault has a strike which is approximately north and a dip of 35 degrees to the east. There was no way in which either the vertical or horizontal displacement of the fault could be determined, as it occurs entirely within the Fish Haven Dolomite, and no discernible units could be found. (See Plate 23, page 85.)

All that may be said about the age of the north-striking thrust fault is that it occurred before deposition of the Sevier River Formation, as the Sevier River has not been tilted or displaced because of this fault; and so as a result the fault can only be dated generally as Tertiary.
Fault plane in the Fish Haven Dolomite
Fault plane strikes approximately north
and has a dip of 35° NE. Relative move­ments are: upper block moved to the
west (left); lower block moved to the
east (right).
GEOLOGIC HISTORY

In the Cove Creek area absences of portions of the sedimentary and igneous record introduced problems in interpretation of the geologic history. The general geologic history was, therefore, supplemented by utilizing information gleaned from adjacent and related areas.

During the Paleozoic Era miogeosynclinal sediments were deposited in the Cove Creek area. Regional upwarps in this portion of the Cordilleran geosyncline are partially revealed today by unconformities between the Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian sedimentary rocks.

During the Mesozoic Era termination of the Cordilleran geosyncline and consequential miogeosynclinal sedimentation was followed by deposition of the dominant and characteristic continental and marine sediments of the Jurassic and Triassic Periods.

Uplift, folding, and thrusting during the interval between the late Jurassic (?) and early Tertiary (?), coupled with subsequent normal faulting and erosion, stripped away all but the rocks of Ordovician, Devonian, Mississippian, Pennsylvanian, and Permian sedimentary ages and has developed the present attitude and outcrop pattern of these Paleozoic strata.
The extensive late Tertiary extrusion of, first, the hornblende rhyolite and then the augite andesite from vents centered in the Pavant Range to the east, extended into the eastern portion of the Cove Creek area. Hydrothermal solutions rich in iron mineralized the joints, fault planes, and fractures following the extrusion of the augite andesite.

Extrusion of the basalts (unit III) and vitrophyres in the northern and western portions of the Cove Creek area followed deposition of the Pliocene to early Pleistocene Sevier River Formation and interbedded basalt units I and II in an early (?) to medial (?) Tertiary tectonic basin.

Desiccation of Lake Bonneville during the late (?) Pleistocene resulted in accumulation of the gypsum sands through evaporation of playa lakes and wind action.

The recurrence of volcanism resulted in the building of the Cove Fort volcano and extrusion of basalt unit IV which surrounds this volcano.

Since Lake Bonneville receded from the Cove Creek area intermittent streams have cut channels into the igneous and sedimentary rocks developing the present topography.
BIBLIOGRAPHY


Butler, B. S., 1913, Geology and Ore Deposits of the San Francisco Mountains and Adjacent Districts, Utah, U. S. G. S. Prof. Paper 80.

, 1920, The Ore Deposits of Utah, U. S. G. S. Prof. Paper 111.


Christiansen, F. W., 1951, A Summary of the Structure and Stratigraphy of the Canyon Range, IAPG, Guidebook 6, pp. 5-18.


Dennis, P. E., 1944, Shorelines of the Escalante Bay of Lake Bonneville, Utah Academy of Science, Pro., pp. 19-20.


———, 1949, Structural Evolution of Utah, Utah Geol. and Min. Soc., Oil and Gas Possibilities of Utah.


Gilbert, G. K., 1890, Lake Bonneville, U. S. G. S. Mon. 1.


Hintze, L. F., 1949, Ordovician System of Utah; Utah Geol. and Min. Surv., Oil and Gas Possibilities of Utah, Salt Lake City, Utah.


__, 1951, Lower Ordovician Detailed Stratigraphic Sections of Western Utah, Utah Geol. and Min. Surv., Bull. 39, Salt Lake City, Utah.


Kerr, P. F., et al., 1957, Marysvale, Utah, Uranium Area, Geol. Soc. of Am., Special Paper 64.


Marsell, R. E., 1932, Geology of the Jordan Narrows Region, Traverse Mountains, Utah, Unpublished Master's Thesis, University of Utah.

__, 1946, The Quaternary System of Utah, Utah Geol. and Min. Surv., Oil and Gas Possibilities of Utah, pp. 109-118.


Nolan, T. B., 1943, The Basin and Range Province in Utah, Nevada, and California, U. S. G. S. Prof. Paper 197-D.


———, 1946, Late Mesozoic and Early Cenozoic History of Central Utah, U. S. G. S. Prof. Paper 205-D.


Webb, G. W., 1956, Middle Ordovician for Western Utah and Central Nevada, Utah Geol. and Min. Surv., Bull. 57, Salt Lake City, Utah.


