Auriferous Tertiary Gravels Near Rocker, in Silver Bow County, Montana

William C. McLaughlin

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AURIFEROUS TERTIARY GRAVELS
NEAR ROCKER, IN SILVER BOW COUNTY, MONTANA

by
WILLIAM C. McLAUGHLIN
of Butte, Montana

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Geological Engineering

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BUTTE, MONTANA
May 20, 1934
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>1</td>
</tr>
<tr>
<td>Bibliography</td>
<td>2</td>
</tr>
<tr>
<td>Location</td>
<td>2</td>
</tr>
<tr>
<td>Physiography</td>
<td>4</td>
</tr>
<tr>
<td>Climate and vegetation</td>
<td>4</td>
</tr>
<tr>
<td>Topography</td>
<td>4</td>
</tr>
<tr>
<td>Surface of the Butte district</td>
<td>4</td>
</tr>
<tr>
<td>Surface near the Rocker placers</td>
<td>7</td>
</tr>
<tr>
<td>Drainage</td>
<td>9</td>
</tr>
<tr>
<td>Rocks of the area</td>
<td>9</td>
</tr>
<tr>
<td>The valley fill</td>
<td>10</td>
</tr>
<tr>
<td>Outlying igneous bodies</td>
<td>12</td>
</tr>
<tr>
<td>Petrography of the valley fill</td>
<td>13</td>
</tr>
<tr>
<td>Geological history</td>
<td>17</td>
</tr>
<tr>
<td>Outline</td>
<td>17</td>
</tr>
<tr>
<td>Glaciation in the Butte district</td>
<td>21</td>
</tr>
<tr>
<td>Structure of the lake beds</td>
<td>25</td>
</tr>
<tr>
<td>Structure near the Neocene Placer</td>
<td>25</td>
</tr>
<tr>
<td>Structure south of Crystal Springs</td>
<td>26</td>
</tr>
<tr>
<td>Economic Geology</td>
<td>28</td>
</tr>
<tr>
<td>Mining history</td>
<td>28</td>
</tr>
<tr>
<td>Assay values of auriferous gravel</td>
<td>29</td>
</tr>
<tr>
<td>Discussion</td>
<td>30</td>
</tr>
</tbody>
</table>
ILLUSTRATIONS

Figure 1. Index map of Montana.......................... 3
2. Silver Bow Valley, looking eastward........... 8
3. Glacial till south of Crystal Springs........ 22
4. Glacial moraine, 2 miles west of Buxton.... 24
5. Volcanic ash near Butte-Dillon highway..... 26
6. Large placer south of Crystal Springs..... 27

Plate 1. Sketch map of the placer area lying between Rocker and Crystal Springs......... i
2. Geological map of a portion of the valley fill south of Rocker................. ii
AURIFEROUS TERTIARY GRAVELS

NEAR ROCKER, IN SILVER BOW COUNTY, MONTANA

by

William C. McLaughlin

INTRODUCTION

Between the villages of Rocker and Silver Bow, in southwestern Montana, are found an interesting group of placers. Gold occurs in Tertiary gravel beds that are interstratified with beds of rhyolitic volcanic ash. A field investigation of the gravels was carried out by the writer during two afternoons a week for the school year 1932-33, and the results of the study are here presented in the form of an undergraduate thesis in the Department of Geology at the Montana School of Mines. With the aid of a plane table and open-sight alidade, a small portion of the lake-bed area near Rocker was mapped; all distances were paced, but numerous checks assure a fairly accurate map.

Although the field work was largely individual, the writer gratefully acknowledges the assistance and advice of the following members of the engineering profession: Dr. Eugene S. Perry, Head of the Department of Geology at the Montana School of Mines; Murl S. Gidel, Asst. Chief Geologist for the Anaconda Copper Mining Company; William D. McLaughlin, E. M.; Alex. M. McDonald; and Prof. Andrew V. Corry.
Very little has been written about the geology of the Tertiary in southwestern Montana, but some information can be obtained, nevertheless. Each of the following publications make some reference to the valley fill west of Rocker:

3. Atwood, Wallace W., "The Physiographic Conditions at Butte, Montana and Bingham Canyon, "Utah When The Copper Ores in These Districts Were Enriched", Econ. Geol. vol. 11, no. 8, 1916.
5. Umpleby, J. B., "The Old Erosion Surface in Idaho," Jour. Geol. vol. 21, no. 2, pp. 139-147, 1912.

Location

The area to be discussed lies a few miles west of the city of Butte, in Silver Bow County, Montana. The Butte mining district is located near the southern edge of a large intrusion of quartz monzonite, which forms a batholith approximately 70 miles long by 40 miles wide, with its long axis north and south. This intrusive rock is a granular type of granite known
locally as 'Butte Granite'.

The Union Pacific, the B. A. and P., the Milwaukee, and the Northern Pacific Railroads traverse the valley between Rocker and Silver Bow. U. S. Highway No. 10, connecting Butte and Anaconda, and forming a part of the transcontinental highway system, also crosses the lake-bed area. Numerous branch roads connect the different parts of the valley with the paved highway.

Figure 1--Index map of Montana showing location of the Tertiary gravels.
PHYSIOGRAPHY

Climate and Vegetation

The semi-arid climate of the area in the vicinity of Butte is typical of most of western Montana. Because of the high elevations - 5400 feet above sea level at the Rocker placers, up to 10,000 feet in some the high peaks - the winters are long and cold, and the snowfall is heavy. During the winter months the temperature frequently falls below 0°, Fahrenheit, and even during the hottest months of July and August the nights are comfortably cool. The annual precipitation is not great, but heavy cloudbursts frequently occur in the summer.

Silver Bow Creek is the only continuous stream of the Rocker-Silver Bow Valley, but its waters sustain but little vegetation because it carries most of the mine-water from the Butte Hill. A sparse growth of sagebrush forms the only vegetation of the valley, but the mountains to the west support a fairly heavy stand of fir and pine. The outlying andesitic area to the north of the valley is scantily covered by junipers, while the ridge of aplite and quartz monzonite to the east is bare of any plant life.

TOPOGRAPHY

Surface of The Butte District

In order to interpret the geologic events of the Rocker-Silver Bow Valley, it is necessary to consider first the broader features of the district. The Butte district embraces practically all of a wide intermontane valley, 20 miles long (north and south) by 10 miles wide. The average elevation of the trough is about 5500 feet above sea level. North of the valley,
a broad summit region rises to an elevation of 8000 feet. The Continental Divide (locally called 'East Ridge'), which rises about 2000 feet above the valley floor, flanks the trough on the east. Westward, the Mount Fleecer ridge \(^1\) forms the limits of the intermontane valley. To the south, the basin is terminated by the rugged Highland Mountains, which dominate the surrounding country from an altitude of 10,000 feet above sea level.

The flanking mountains of the depression, East Ridge and the Mount Fleecer ridge, strike approximately north and south. About midway between these two, and striking about parallel to them, is a lower ridge that rises 500 feet above the floor of the valley. In this report, the author has taken the liberty of coining the name "Basin Creek ridge" for this remnant of an ancient peneplain of erosion. Summit Valley lies between the Basin ridge and the Continental Divide to the east. West of the Basin ridge is a broad valley which contains the auriferous gravel beds that are the subject of this discussion. In lieu of any other name by which this valley has been termed in previous papers, the author will refer to it as the Silver Bow Valley. Summit Valley is about 5500 feet above sea level, while the elevations in the Silver Bow Valley vary from 5400 feet, near Silver Bow Creek, to 5900 feet on the Continental Divide, at the railroad station of Feeley.

The crest of East Ridge is quite uniform in height, from the northern junction with the high summit region to its southern termination in the Highland Mountains. Most geologists have

\(^1\) - A name used by the writer, in view of the fact that there is no name for the ridge, in the literature.
agreed that East Ridge is a fault escarpment; the steep slope faces westward, while the east side of the escarpment slopes gradually downward to the Boulder and Jefferson Valleys. The east slope is marked by swamps, near Lake Delmo, and by meandering stream courses, which are common in the Elk Park basin. Because of these two physiographic features, in addition to the flat character of the surface, the writer presumes that at one time East Ridge may have been a portion of an old erosion surface.

North of Summit Valley, the Butte Hill rises abruptly from the valley floor to an elevation of 6500 feet, then the surface slopes slowly upward to the summit level, at 8000 feet. The Hill strikes approximately east and west, but an arm of the valley separates it from East Ridge.

The top of the Basin Creek ridge is broad and flat. Its uniform character suggests an old surface of erosion; in fact, most authorities of the subject of peneplanation in the Rocky Mountains correlate the surface with the summit peneplain. This erosion level is discussed by Lindgren and Umpleby, in Idaho, and in Montana by Calkins. The general strike of the Basin ridge is southward, where it merges with the lower slopes of Red Mountain (one of the peaks in the Highlands,) which is commonly called, in the literature, a monadnock above the summit peneplain.

Remnants of an intermediate, or bench level, are preserved in the surface lying about a hundred feet below, and east of, the Basin Creek ridge. Both the summit and bench levels can be
traced across the mountainous tract south of the Summit Valley. Near the Teddy Bear Inn, on Roosevelt Drive, the broad, level surface may be a remnant of one of these plains of erosion.

Two sharp peaks, separated by flat Table Mountain, are the dominant features of the Highland Mountains. During Wisconsin times, of the late Pleistocene, alpine glaciers covered these peaks, and carved out great cirques on their northern slopes. Red Mountain, reputed to have been a monadnock above the summit peneplain, has been greatly dissected by the mountain glaciers.

Surface Near The Rocker Placers

The surface of the Silver Bow Valley is a relatively low, hummocky plain, cut by several stream courses the chief of which is that of Silver Bow Creek. The topography may be classed as typical valley bench, of western Montana. The gently rolling surface slopes upward from Silver Bow Creek to the Continental Divide at Feeley, 10 miles south of the creek.

The Basin Creek ridge, to the east of the valley, rises abruptly from the basin to a height of 600 feet above the Rocker placers. Silver Bow Creek flows westward and cuts this divide just east of the town of Rocker (see plate 1.) North of the valley the character of the surface is similar to that of the summit region lying north of the city of Butte.

The Mount Fleecer ridge is of a uniform height, with the mountain of that name rising above the rest of the unit to an elevation of over 9000 feet. Remnants of the summit peneplain and the intermediate level are preserved in the range, with Mount Fleecer as a monadnock above the former surface.
The character of the surface of the valley fill varies but little, from Rocker southward to the Continental Divide. The fill can be traced from a point 2 miles north of Rocker to the town of Divide, in the Big Hole Valley, 25 miles to the south.

Figure 2 (below) is a photograph of the Silver Bow Valley, taken from the base of the Mount Fleecer ridge and looking eastward across the valley. The valley fill lies in the foreground, with the Basin Creek ridge on the right horizon, and East Ridge showing dimly on the left horizon. The white spots in the middle right foreground are outcrops of volcanic ash. The Rocker placers are west, and at the base of the Basin Creek ridge, at the extreme left of the picture.
DRAINAGE

As mentioned previously, the only continuous stream of the valley is Silver Bow Creek. A small, intermittent creek flows southward from the vicinity of Brown's Gulch to join the main stream, near Crystal Springs (see plate 1). Another creek flows during the early spring months in the gulch just north of Rocker.

Numerous dry gulches, striking approximately north-south, occupy the valley, south of Silver Bow Creek (note plate 1). Wherever the auriferous gravel bed, or beds, was cut by a drainage course, the gold was sufficiently concentrated by the water to encourage placer mining. In practically every stream bed south of the main creek, between Rocker and Silver Bow, there is evidence of placer mining. These placer diggings are sketched in on the small-scale map of the valley (plate 1).

THE ROCKS OF THE AREA

The valley fill consists of bedded volcanic ash, sand, and gravel. The formations lie beneath a covering of alluvium and boulders of aplite and quartz monzonite. In association with the fill are outlying areas of igneous rock, to the east, north, and west of the basin. The bedded deposits extend from a few miles north of Rocker, southward over the present Continental Divide for about 30 miles, to the vicinity of Moose Creek; here, a transition is noted when the beds of volcanic ash give way to sorted sands and fine gravels.
THE VALLEY FILL

When the Snake River drainage system was blocked in the lower Miocene, a group of large lakes was formed in the principal intermontane valleys of southwestern Montana. One arm of the main Bozeman Lake extended from Drummond, southward through the Deer Lodge, Silver Bow, Feeley, and Big Hole Valleys, and probably connected with the main body of fresh water somewhere south of the present site of Dillon.

A period of widespread volcanic activity followed the damming of the south-flowing drainage, and tons of volcanic ash were scattered over the western section of the state. Some of the ash fell into the large bodies of standing water then in existence, forming thick beds of the material, near the base of the Bozeman formation. Vertebrate fossils of the upper Miocene have been uncovered in the ash\(^2\), tentatively correlating the beds with the Loup Fork and Madison Valley of Montana, and their Western Plains equivalent - the Clar- endon.

The stratigraphic column near the location point of the Neocene Placer (see plate 2), a half-mile southwest of Rocker, shows beds of comparatively pure volcanic ash overlain by sand and gravel, which in turn is overlain by intermixed sand and fine gravel. In the following pages, the latter material will be referred to as re-worked lake-bed deposits. The total thickness of the fill exceeds 1200 feet, because exploration work at

The British Butte shaft, a half-mile north of Rocker (plate 1) was carried on for that distance below the surface, without reaching bedrock.

The column at the Neocene Placer is as follows:

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface gravel</td>
<td>1-2 feet</td>
</tr>
<tr>
<td>and alluvium</td>
<td></td>
</tr>
<tr>
<td>Re-worked lake</td>
<td>20 &quot; A bed of impure volcanic ash, containing three distinct lenses of sand, each about 1 foot in thickness.</td>
</tr>
<tr>
<td>bed material</td>
<td></td>
</tr>
<tr>
<td>Volcanic ash,</td>
<td>5 &quot; Comparitively pure rhyolitic ash, compact but unconsolidated. Rhyolite consists of platy fragments, cut by cracks and capillary openings.</td>
</tr>
<tr>
<td>white to grey</td>
<td></td>
</tr>
<tr>
<td>in color</td>
<td></td>
</tr>
<tr>
<td>Auriferous gravel</td>
<td>6-8 &quot; Contains bowlders, gravel, sand, and clay. Bowlders are of aplite and decomposed quartz monzonite; pebbles of rhyolite.</td>
</tr>
<tr>
<td>bed</td>
<td></td>
</tr>
<tr>
<td>White volcanic</td>
<td>Unknown</td>
</tr>
<tr>
<td>ash</td>
<td>Comparitively pure rhyolitic ash.</td>
</tr>
<tr>
<td>Thickness</td>
<td>Thickness unknown, but probably measured in hundreds of feet.</td>
</tr>
</tbody>
</table>

The material of the gold-bearing formation is unstratified and unsorted, consisting of small bowlders, sand, gravel, and fine clay scattered throughout the 8-foot stratum. The contact between the gravel and the underlying ash is quite conformable. As the surface gravels have been almost completely removed by erosion, the original thickness cannot be determined. Assays of this gravel have not been made to determine whether or not it is gold bearing. The 20-foot layer of impure volcanic ash contains sand grains scattered throughout the bed.
OUTLYING IGNEOUS BODIES

East, north, and west of the Silver Bow Valley are bodies of igneous rock, whose resistant nature has caused them to persist as mountainous masses. East of Rocker, and south of Silver Bow Creek, the northernmost portion of the Basin Creek ridge is well rounded and is composed of quartz monzonite. The granite continues southward along the ridge for a distance of 8 or 10 miles, and is mineralized to the southeast of the Rocker placers. Strong structures have been observed by the writer, in the granite, but he has no knowledge of any important producing mines in this particular body.

In the same locality, but north of the creek, hills of aplite extend from the valley towards the city of Butte. Veins of silver-bearing copper, zinc, lead, and manganese ores have been profitably worked in the aplite. The Bluebird mine, a half-mile northeast of Rocker, was a rich silver producer in the district, about 50 years ago.

The hills to the north and northwest of the valley are red in color and composed of rhyolite and andesite. These rocks were extruded from the earth's crust as flows, and are probably the oldest, geologically, of any in the Butte district. A small portion of the andesite area is shown on plate 1, where the rock crops out north of the Butte-Anaconda highway, near Crystal Springs.

Granite is the chief rock of the Mount Fleecer ridge, although a few intrusions of rhyolite have been observed by the writer, west of the railroad station of Buxton. Aplite dikes, from a fraction of an inch up to 2 feet in thickness, cut the quartz monzonite in great numbers, but, as yet, little mineralization has been discovered in the range.

PETROGRAPHY OF THE VALLEY FILL

The lower formation of volcanic ash noted on the Neocene Placer consists of flat, platy fragments of rhyolite. The angularity of the particles is very marked, and under the microscope, minute fragments of mica, quartz, and feldspar are visible. The particles are much smaller in one dimension than the other two, and the individual plates show capillary openings at right angles to the least dimension. An analysis of the ash showed the following chemical composition:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>1.06%</td>
</tr>
<tr>
<td>K₂O</td>
<td>14.84%</td>
</tr>
<tr>
<td>Na₂O</td>
<td>1.52%</td>
</tr>
<tr>
<td>SiO₂</td>
<td>67.33%</td>
</tr>
<tr>
<td>Al₂O₃ &amp; Fe₂O₃</td>
<td>12.00% (approx.)</td>
</tr>
<tr>
<td>MgO and Water</td>
<td>3.00% (&quot;&quot;&quot;)</td>
</tr>
</tbody>
</table>

4 - In the above table, the values for sodium, calcium, potassium, and silicon, oxides have been accurately determined by W.H. Weed. The percentages of alumina, magnesia, water, and iron oxide have been inserted by the author from other analyses of the same ash.
The chief impurities in the ash are grains of sand and small pebbles. The amount of iron contained determines the color, which ranges from almost white to buff and brown. The bulk of the material shows little decomposition and is very compact. The size of individual grains varies from a very fine dust to particles as large as a pea. Some of the ash beds near the western boundary of the Silver Bow Valley are very compact, the plates of rhyolite being partly cemented together by calcite. On the other hand, in other parts of the valley the ash is quite friable and crumbles easily when touched.

On the surface of the ground near the Neocene Placer, some of the ash has weathered to a clay. William P. Ryan, student at the Montana School of Mines, tested this clay and reported that it possessed some of the properties of commercial Fuller's Earth.

The auriferous bed, as mentioned previously, is made up of unstratified and unsorted rock material. The formation is 6 to 8 feet thick, but the granite boulders do not exceed 3 feet in diameter, and are much decomposed. The aplite fragments are smaller than the boulders of granite and show but little decomposition. The larger rocks are well rounded while the smaller ones are angular to sub-angular. Small particles of pegmatitic quartz, feldspar, and rhyolite are present in the gravel, but the total absence of andesite, quartzite, schists and gneisses, and argillite is significant. The fact that these latter rocks are totally lacking in the gravel eliminates the

5 - Bachelor's Thesis, Montana School of Mines, 1933.
the andesitic area to the north of the valley and the High-
lands to the south as possible sources of the gravel. It seems
logical to the writer to presume, with the evidence at hand,
that the material in the auriferous gravel came from the east
and northeast where the country rock is granite, cut by intrus-
ions of rhyolite and aplite, and covered in places by flows of
rhyolite. The pegmatites were probably derived from the vein
outcrops on the Butte Hill.

The clay is light in color, of a very fine texture, and is
peculiar in that it is associated with the larger material in
the gravel bed, rather than with the sand. The principal con-
stituents of the sand - quartz, feldspar, biotite, muscovite,
pyrite, magnetite, ilmenite, limonite, and hematite - occur as
sub-angular particles and show but little rounding. Because of
the lack of sorting of the gravel, the presence of fine clay
throughout the 8-foot bed, the angularity of the small sand
grains, and the persistant nature of the formation from Rocker
to Silver Bow, the writer is willing to accept the theory of
a glacial origin for the gravels.

A grab sample of a thin layer of reddish-purple sand near
the base of the gravel assayed as follows:

<table>
<thead>
<tr>
<th>Gold</th>
<th>Silver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace</td>
<td>0.10 ounces per ton</td>
</tr>
</tbody>
</table>

At the Neocene, as shown by plate 2, both the gravel and the
ash beds have a dip of about 8° to the east. An adit follows
the gravel down the dip for about 150 feet into the hill.

The volcanic ash that lies above the auriferous forma-
tion is essentially the same, both in size and shape of par-
ticles and in chemical composition, as the ash in the lower bed. This formation indicates another period of volcanic activity succeeding the laying down of the glacial gravels.

In the re-worked lake bed deposit, the particles of rhyolite show more rounding than those of the two lower ash beds. In contrast with the angularity of the sand in the gold-bearing gravel, the sand grains in the re-worked ash have been rounded and polished by the action of water. In the sand lenses rhyolite is the chief constituent, associated with mica and clay.

The sands of the dry stream courses in the Silver Bow Valley have been investigated by the writer, with the aid of a binocular microscope, and have been found to contain quartz, feldspar, hornblende, mica, magnetite, and corundum. The percentage of magnetite, even on the surface of the sands, is high; the particles show little rounding, and retain the common octahedral crystal form.

Small Montana sapphires have been reported from the stream sands near the village of Silver Bow. Their color is usually blue or yellow, and the hexagonal-rhombohedral crystal form is commonly retained by the particles, because of the extreme hardness of this oxide of aluminum (9 in Dana's Table). Commercial gems are known to occur in the placers to the north of Silver Bow.
GEOLeOlC HISTORY
Outline of Geologic Events in The Butte District

UPPER CRETACEOUS... Beginning of Rocky Mountain folding.
                       Pre-peneplain erosional stage.

PALAEOCENE-EOCENE... Andesite flows north and northwest of
                        Rocker.
                        Intrusion of Boulder batholith. Aplite and
                        rhyolite associated with the granite.
                        First cycle of erosion, climaxcd by the
                        development of the summit peneplain.

                       Uplift and warping of the summit peneplain.
                       Fissure development on the Butte Hill.

OLIGOCENE........... Development of intermontane troughs, and a
                       mature topography in the mountains.
                       Second cycle of erosion, in which the Butte
                       drainage was southward to the Snake River.
                       Deposition of lower Bozeman Beds.
                       Vein formation in the Butte district.

                       Crustal warping, and basalt flows, closing
                       the Snake River drainage.

MIocene............... Rhyolite flows northeast of Rocker.
                       Widespread vulcanism in southwestern Mont-
                       tana, and deposition of the ash in the
                       Bozeman Lakes.
                       Third erosion cycle in the mountains, ag-
                       gradation in the lowlands.
                       Development of the intermediate level.
                       Mountain glaciation?

                       Renewed mountain growth and tilting of the
                       Bozeman Beds.
                       Block faulting; formation of East Ridge and
                       Basin Creek ridge fault escarpments?
                       Fault fissures developed on Butte Hill.

PLIOCENE............. Draining of the Bozeman Lakes.
                       Fourth erosion cycle in the mountains;
                       dissection of the Bozeman Beds.
                       Superimposed drainage.

PLEISTOCENE......... Pre-Wisconsin glacial stage.
                       Interglacial interval; faulting and erosion
                       Wisconsin glacial stage.

                       Post-glacial erosional interval.

RECENT.............. Stream erosion and alluvial deposition.
For the purposes of this paper it is unnecessary to trace the geological history in the Butte district farther back than the upper Cretaceous. Near the close of the Mesozoic, the Rocky Mountain folding began, and continued throughout the early Tertiary to the close of the Miocene. This period of Mountain making, known as the Laramide Revolution, was accompanied by large-scale block faulting and intense igneous activity. As quickly as the gently rolling land surface of the Cretaceous was elevated, the Fort Union and Lance formations were laid down to the east of the rising mountains.

During the long erosion interval that followed the initial uplift, it is quite evident that a great thickness of sediments was removed from the rising surface. In the Highlands, for example, although there are a few scattered areas of Mississippian limestone to the north of the range, the rocks on Table and Red Mountains are mainly Pre-Cambrian schists, gneisses, and argillites. Table Mountain owes its flat top to a capping of Pre-Cambrian or Cambrian quartzite.

Earth deformation continued through out the Palaeocene, and in the early Eocene flows the andesite pored out of the earth's crust, followed by the intrusion of the Boulder batholith and its magmatic differentiates. Following the batholithic intrusion, during the dying stages of igneous activity, aplite and rhyolite were forced into breaks and fissures in the granite to form stocks and dikes.

A long period of erosion followed the intrusion of the igneous body, and during this time most of the western por-
tion of Montana was reduced to an almost level surface. It is thought that this surface extended over most of western Montana and eastern Idaho, and has been termed the 'summit peneplain' by Atwood. The elevations of the surface ranged between 6000 and 7500 feet above sea level. The writer believes it can be traced over a number of different geological formations, and that the development of this surface was quite positive. For example, in the Butte district, it can be traced over the metamorphic rocks of the Highlands, northward over the granite and aplite of the Basin creek ridge to the andesite area north of Rocker and Silver Bow, and thence over the granite and rhyolite of the Mount Fleecer range.

The eastern slope of East Ridge, with its numerous swamps and meandering streams, is a remnant of the summit peneplain that has been faulted upward since its formation. Because of the thick sediments to the east of the mountains, it has been suggested that the drainage of the Butte area was toward the east, during the Eocene.

Mountain making forces elevated the first peneplain and defined the great intermontane troughs of southwestern Montana. During the erosional cycle that followed the warping and uplift, the mountains were dissected and a mature topography was developed. The Continental Divide was far to the east of the Butte district, in the Big Belt Mountains, and the main streams flowed southward to join the Snake River, in what is now eastern Idaho, and thence to the Pacific Ocean. It is possible that the position of Silver Bow Creek at that
time was farther to the south, where it crossed the Summit Valley. The stream flowed westward from the vicinity of Butte to the Silver Bow Valley, and then made a bend to the south, flowing through the Silver Bow-Feley intermontane valley to join the Big Hole River near the present town of Divide. During the second cycle of erosion the summit peneplain was much dissected and alluviation began in the intermontane troughs, forming the lower portions of the Bozeman Beds.

The second erosion cycle was interrupted at the close of the Oligocene when the south-flowing drainage was blocked by earth movements and lava flows, in the Snake River region. Southwestern Montana became an area of fresh-water lakes in the intermontane valleys, separated by the principal mountain ranges. Northwest of the city of Butte, and northeast of Rocker, outpourings of rhyolite and dacite are attributed to the period following the closing of the drainage and preceding the filling of the basins. Alluvial fans were deposited in the valleys, but it is certain that some deposits were laid down in the lakes that filled the closed basins.

Widespread vulcanism was inaugurated by the outpourings of basalt in the Snake River area, and rhyolite in the Butte district, resulting in great quantities of volcanic ash being deposited in the Miocene lakes. The comparatively pure ash found in the Silver Bow Valley, and noted on the Neocene Placer, was laid down in an arm of the main Bozeman Lake that occupied this and adjacent valleys.

Because of the filling of the main drainage courses, the mountain streams developed temporary base-levels, and an
intermediate or bench level was carved out of the dissected summit peneplain. The Montana School of Mines is at the approximate elevation of the intermediate level. Timber Butte, near the western edge of Summit Valley, was a monadnock above this level.

With the renewal of mountain growth near the close of the Miocene, the Bozeman Beds were tilted and the lakes were drained. The drainage of these large bodies of fresh water, however, was to the northwest. The Continental Divide was forced westward from the vicinity of Helena to East Ridge, and the immediate area around Butte became a part of the Columbia River drainage system. The Elk Park drainage, which had been to the west and south since the beginning of the Eocene, was reversed by the East Ridge faulting and became a part of the Missouri River system. Block faulting on the east side of the Silver Bow Valley is probably closely connected with the faulting of East Ridge.

The fourth cycle of erosion in the mountains was inaugurated upon the opening up of the main drainage courses. The dissection of the valley fill was quite rapid and has continued to the present.

Since the beginning of the last cycle of erosion, there have been at least two, and possibly more, periods of glaciation in the Butte district. The till deposit south of Crystal Springs (see plate 1) contains large boulders of aplite and granite, and still retains a faint resemblance to a moraine. Figure 3 is a photograph of a large boulder of quartz monzonite surrounded by smaller boulders of aplite, taken about
2 miles south of Crystal Springs on the Butte-Dillon highway. The Basin Creek ridge lies in the right background and East Ridge can be seen on the left horizon.

Figure 3

This glacial material belongs to an earlier, or Pre-Wisconsin stage; Atwood\(^7\) states that the deposit of till may be correlated with the Cerro stage. Although Atwood states that the ice covered the entire area between the Highlands and Silver Bow Creek, and thence eastward to Butte, the writer is not inclined to agree with this statement because of the failure to find any of the rocks peculiar to the Highland Mountains, in the moraine. In view of the fact that all rocks found in the till are present in and around the Butte Hill, it seems more logical to assume that the glacier covered the area to the north and east of the Silver Bow Valley, and discharged material into the valley south of Rocker and Silver Bow.

6 and 7 - Econ. Geol. vol. 11, no. 8, 1916.
Fresh moraines and cirques (geologically speaking) on the northern slope of Red Mountain, and in the higher peaks of the Anaconda Range furnish ample evidence of a later, or Wisconsin, glacial stage. These moraines are very well preserved and appear much younger than those found to the south of Silver Bow. A few miles north of Anaconda, a typical U-shaped valley has been carved out of the sediments in Lost Creek Canyon. Lateral and ground moraines cover the valley floor near its union with the Deer Lodge Valley. During Wisconsin times, it is doubtful if the ice covered any of the placer area discussed in this report. The dry stream courses south of Rocker and Silver Bow probably owe much of their development to streams discharged from the melting ice of the Highland alpine glaciers which flowed northward to Silver Bow Creek.

The auriferous gravel bed on the Neocene Placer, if of glacial origin as the evidence tends to show, may represent a still earlier stage of mountain glaciation in the Butte district. If the age of the upper bed of volcanic ash, 5 feet in thickness and comparatively free of sand and other impurities, (see page 11 of the text) can be definitely correlated by means of fossil remains, then the age of the gravels directly below will be determined. There is a possibility that the upper bed of ash belongs to a post-Pleistocene period of vulcanism, but the evidence in other parts of Montana does not substantiate this theory. As the boulders in the auriferous gravels do not exceed 3 feet in diameter, the writer concludes that the larger boulders that dot the surface of the Silver Bow Valley have been let down from a higher elevation by erosion of the soft
lake-bed material, and do not belong to the gold-bearing stratum. The age of the auriferous gravels will be tentatively taken, then, as pre-Cerro.

Since the close of the Wisconsin glacial stage, erosion of the valley fill has proceeded rapidly and much of the morainic material of the Pre-Wisconsin stage has been removed. Figure 4 (below) shows a remnant of the Pre-Wisconsin moraine. The photograph was taken about 2 miles west of Buxton in the Silver Bow Valley, near the base of the Mount Fleecer ridge. The large boulder in the center of the picture is hard, resistant aplite.
STRUCTURE OF THE LAKE BEDS

Evidence gathered near the town of Rocker shows a fault separating the Basin Creek ridge from the valley fill to the west. The fault, striking approximately north and south, cuts through the site of Rocker and lies just to the east of the Rocker placers (see plate 1). The sudden transition from igneous rock in place to lake-bed deposits over 1200 feet thick is fairly conclusive proof of major faulting. This structure will be referred to as the "Rocker Fault" in subsequent paragraphs of the report.

As shown on plate 2, the beds lying south of Rocker and near the location notice of the Neocene Placer have a dip of approximately 8° to the east, or toward the Rocker Fault. Because of the extensive placer mining in the principal valleys of the district, most of the original structure has been obliterated by the miners of a half-century ago. In the gulch of the Butte Gun Club (plate 2) the writer was unable to determine the dip of the sedimentary beds, but Mr. Murl Gidel states that the dip of the formations here is toward the west, showing that a synclinal structure exists between the Neocene Gulch and the Butte Gun Club. However, it is the writer's personal opinion that the deformation of the lake beds and auriferous gravels is due to step-faulting closely related to the Basin Creek ridge fault escarpment, rather than folding of the sediments. The dip of the ash beds to the east, in the dry wash lying between the Neocene Gulch and the gulch in which the Butte Gun Club is located, tends to indicate block faulting rather than folding.
In the west-central portion of the Silver Bow Valley, at a point 2 miles south of Crystal Springs and 3 miles west of Rocker, near the Butte-Dillon highway, the lake beds have a uniform dip of $80^\circ$ towards the east. The same formations are encountered here as were observed on the Neocene Placer, 3 miles to the east. Figure 5 is a photograph of the volcanic ash beds taken in this locality, showing the regional dip of the formations to be toward the east, or toward the Rocker Fault.

![Figure 5](image)

A large placer lies in the area discussed in the preceding paragraph, and is shown on plate 1. In between the placer and the Neocene Gulch to the east, the valley bench slopes in to a large amphitheater which contains numerous placer diggings. As practically every dry wash in this basin has been worked over in the search for gold by the early-day
miners, the outcrops are almost entirely covered by placer gravels, and it is very difficult to obtain readings on the dip and strike of the beds. However, that the auriferous bed or beds was exposed on the surface over the greater portion of this basin, is apparent from the placers in every gulch. The dip of the beds, where observed by the writer, is generally eastward across the Silver Bow Valley. Figure 6 is a photograph of the large placer that lies south of Crystal Springs along the main highway south. Its elevation is at least 100 feet above the present course of Silver Bow Creek. The small juniper trees in the left foreground of the picture are about 3 feet high.

West of the area just discussed, at the base of the Mount Fleecer ridge, a 100-foot layer of volcanic ash crops out. The dip of the bed is about 25° to the east, and the ash has been compacted considerably more than that on the eastern
side of the valley. As the dip is away from the granite, the steep angle may be due to the deposition of the ash near the shore of the ancient lake, or subsequent slumping of the ash, or to both of these occurrences.

**ECONOMIC GEOLOGY**

**Mining History of District**

In the spring of 1864, a party of prospectors discovered placer gold in Missoula Gulch near the present city of Butte. Within a few months the gulch had been placered from its source to Silver Bow Creek, and in the latter stream rich gold sands were uncovered. From 1864 to 1867 during the period of active placer mining, Silver Bow Creek was worked from Summit Valley to its junction with the Deer Lodge River, over a distance of 25 miles. Gold valued at $1,500,000 was won from the streams of the district during this three-year period. The percentage of this total supplied by the Rocker-Silver Bow placers is unknown, and the writer has been unable to secure an approximation from any of the "old timers", but judging from the vast quantity of gravel worked in the Silver Bow Valley, this percentage was probably high.

The large area covered by the placer diggings near Rocker and Silver Bow attests to a great deal of hard labor performed by the miners, in the middle 60's, in their search for the yellow metal. Workings are observed on almost every drainage course, in spite of the fact that water was scarce and placer mining could be carried on only in the early spring, in the dry washes south of Silver Bow Creek. A deep ditch was dug from Mount Fleeceer to the placer south of Crystal Springs.
(see figure 6) to carry water from Divide Creek, 10 miles away.

The discovery of rich gold and silver lodes in the Butte Hill, in 1865, caused the exodus of the placer miners to the new "strike". The abandonment of the placers proved to be permanent, and placer mining in the district has not been resumed on a large scale, since 1865. Within the last four or five years, a few of the old placers along Silver Bow Creek have been worked on a small scale, but the yield has been comparatively insignificant during this period.

Assay Values of Auriferous Gravels

A sample of the gold-bearing gravel on the Neocene Placer was assayed for gold and silver, showing the following values:

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<tr>
<th></th>
<th>Gold</th>
<th>Silver</th>
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<tbody>
<tr>
<td></td>
<td>Trace</td>
<td>Trace to 0.1 ounces per ton</td>
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These values show that the gravel cannot be worked at a profit, unless local concentrations of the gold in the gravel are discovered. The possibility of finding buried stream channels in the valley fill, in which the gold would be more concentrated, is very good. The writer believes the expenditure of a little money for prospecting by geophysical methods, in the Silver Bow Valley, would be warranted by the geological conditions.
DISCUSSION

Because of the limited time available to study the valley fill between Rocker and Silver Bow, the writer is not prepared to state any definite conclusions. However, it is hoped that this paper will prove of value to anyone who makes a more detailed study of the structure and geological age of the sediments of the Silver Bow Valley, in the future.

Economically, the auriferous gravels are of small significance in the light of present knowledge. However, it is the writer's opinion that there is a good possibility of local concentrations of enriched gold-bearing material occurring in the valley fill. Extensive exploration work would be necessary to uncover such zones of enrichment, and geophysical methods of prospecting would have to be employed.
Sketch Map of The Placer Area
Lying Between Rocker and Crystal Springs
Scale: 1 in. = ½ mile

LEGEND:

- Andesite
- Aplitie
- Quartz Monzonite
- Placer Diggings
GEOLOGICAL MAP OF A PORTION OF THE VALLEY FILL SOUTH OF ROCKER

Scale: 1 in. = 200 ft.

Legend:
- Placers
- Auriferous Gravel
- Volcanic Ash
- Re-worked Ash

Neocene Claim