5-1940

The Geology and Mineralogy of the Independence Mining District

Alan Kuhlman

Follow this and additional works at: http://digitalcommons.mtech.edu/bach_theses

Part of the Ceramic Materials Commons, Environmental Engineering Commons, Geology Commons, Geophysics and Seismology Commons, Metallurgy Commons, Other Engineering Commons, and the Other Materials Science and Engineering Commons

Recommended Citation

http://digitalcommons.mtech.edu/bach_theses/111

This Bachelors Thesis is brought to you for free and open access by the Student Scholarship at Digital Commons @ Montana Tech. It has been accepted for inclusion in Bachelors Theses and Reports, 1928 - 1970 by an authorized administrator of Digital Commons @ Montana Tech. For more information, please contact sjuskiewicz@mtech.edu.
THE GEOLOGY AND MINERALOGY OF THE INDEPENDENCE MINING DISTRICT

By

Alan Kuhlman

A Thesis
Submitted to the Department of Geology
in partial fulfillment of the
Requirements of the degree of
Bachelor of Science in Geological Engineering

Montana School of Mines
Butte, Montana
May, 1940
THE GEOLOGY AND MINERALOGY OF THE INDEPENDENCE MINING DISTRICT

By
Alan Kuhlman

A Thesis
Submitted to the Department of Geology
in partial fulfillment of the
Requirements of the degree of
Bachelor of Science in Geological Engineering

Montana School of Mines
Butte, Montana
May, 1940
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Location</td>
<td>1</td>
</tr>
<tr>
<td>History and Past Production</td>
<td>1</td>
</tr>
<tr>
<td>Previous Work</td>
<td>3</td>
</tr>
<tr>
<td>Physiography</td>
<td>4</td>
</tr>
<tr>
<td>General Geology</td>
<td>7</td>
</tr>
<tr>
<td>Sedimentary Rocks</td>
<td>7</td>
</tr>
<tr>
<td>Pre-Cambrian</td>
<td>7</td>
</tr>
<tr>
<td>Cambrian</td>
<td>8</td>
</tr>
<tr>
<td>Argillite</td>
<td>9</td>
</tr>
<tr>
<td>Extrusive Rock</td>
<td>10</td>
</tr>
<tr>
<td>Intrusive Rock</td>
<td>11</td>
</tr>
<tr>
<td>Haystack Stock</td>
<td>11</td>
</tr>
<tr>
<td>Petrography</td>
<td>12</td>
</tr>
<tr>
<td>Economic Geology</td>
<td>14</td>
</tr>
<tr>
<td>Vein System</td>
<td>14</td>
</tr>
<tr>
<td>Mineralogy of the Veins</td>
<td>15</td>
</tr>
<tr>
<td>The Independence Veins</td>
<td>15</td>
</tr>
<tr>
<td>The Duffy Vein</td>
<td>17</td>
</tr>
<tr>
<td>Pyrite</td>
<td>17</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>20</td>
</tr>
<tr>
<td>Gold</td>
<td>21</td>
</tr>
<tr>
<td>Character</td>
<td>21</td>
</tr>
<tr>
<td>Horses</td>
<td>22</td>
</tr>
<tr>
<td>Structure</td>
<td>23</td>
</tr>
<tr>
<td>The Hidden Treasure Vein</td>
<td>23</td>
</tr>
<tr>
<td>Other Veins</td>
<td>24</td>
</tr>
<tr>
<td>Alteration and Enrichment</td>
<td>25</td>
</tr>
<tr>
<td>Genesis</td>
<td>26</td>
</tr>
<tr>
<td>Description of the Various Properties</td>
<td>28</td>
</tr>
<tr>
<td>Placers</td>
<td>28</td>
</tr>
<tr>
<td>Independence Group</td>
<td>29</td>
</tr>
<tr>
<td>Duffy #4 Claim</td>
<td>31</td>
</tr>
<tr>
<td>Hidden Treasure Group</td>
<td>33</td>
</tr>
<tr>
<td>Other Properties</td>
<td>34</td>
</tr>
<tr>
<td>Summary</td>
<td>35</td>
</tr>
</tbody>
</table>

## ILLUSTRATIONS

- **Plate 1.** Map of Sweetgrass County ........................................... 1
- **2.**
  - a. View taken from head of Basin Creek looking west ................. 4
  - b. View taken from top of Baboon Peak, ................................. 4
  - c. Haystack Peak .......................................................... 4
3. General Geologic Map of the Independence Mining District.Pocket
4. Composite of several areal photographs of the district. 6
5. Profile of Working on the Independence Veins. Pocket
6. a. Pyrite 125 feet below the outcrop 18
    b. Pyrite from the outcrop 18
    c. This shows relationship between chalcopyrite, pyrite and quartz at the surface 18
    d. This shows the relationship between chalcopyrite and the pyrite 125 feet below the outcrop 18
7. a. Gold grain 0.08 mm. by 0.01 mm. 21
    b. Gold grain 0.075 mm. by 0.075 mm. 21
    c. Gold grain 0.225 mm. by 0.075 mm. 21
    d. Gold grain 0.08 mm. by 0.05 mm. 21
    e. Gold grain not measured 21
    f. Gold grain not measured 21
8. a. Duffy vein 125 feet below surface 22
    b. Duffy vein at surface 22
    c. Horse in the duffy vein 125 feet below surface 22
9. a. Pyrite in the outcrop of the Hidden Treasure vein 24
    b. Pyrite in the outcrop of the Duffy vein 24
    c. Vein matter in the Hidden treasure vein at the outcrop 24
10. a. Showing alteration of Chalcopyrite to covellite and the replacement of pyrite with quartz 26
    b. Showing alteration of chalcopyrite, covellite, and development of quartz 26
    c. Showing alteration of chalcopyrite to covellite and limonite 26
    d. Showing alteration of chalcopyrite to covellite and development of quartz 26

Figure 1. Thin section of argillite. 9
2. Vein rock of the Independence Vein 16
3. Hand specimen 125 feet below the outcrop 13
4. Hand specimen from the surface 18
5. Alteration of chalcopyrite to covellite 20
6. Showing galena with slight alteration 25
7. This view shows the dumps of the upper and lower adits of the Duffy Vein 32
by
Alan Kuhlman

LOCATION

The Independence Mining district is located 57 miles south of Big Timber, Montana. The accompanying map (Plate 1) shows the location of the area. The camp is reached from Big Timber by fairly good mountain roads and the distance can be driven in less than three hours.

HISTORY

The district was first discovered in 1872 by Professor Hayden and party when gold float was found in the upper Boulder river. The gold was traced to the veins in the district by following the auriferous gravels up Basin Creek. This party was not interested in low grade placers, nor were they interested in lode deposits, and, therefore, they did not stake out any claims on the veins.

Later, in 1879, William Langford, Seth Parker, and Albert Schmidt prospected on the veins and opened up a few leads. Little was done, however, until 1882 when the Crow Indian Reserve, in which this district lay, was opened to prospecting and homesteading.
PLATE I

MEAGHER COUNTY

WHEATLAND COUNTY

GOLDEN VALLEY COUNTY

PARK COUNTY

STILLWATER COUNTY

SCALE - MILES

Main Highways
Unimproved Roads
Railroads
Power Lines
Rivers and Creeks

AREA MAPPED

LEGEND

SWEETGRASS COUNTY
From 1888 until 1893 the district was a booming mining camp. Seven stamp mills were running and ore was being mined from the Independence, King Solomon, Poorman, Golden, Hidden Treasure and Crown claims. The town of Independence, which was on the Boulder River at the fork of Basin Creek, boasted a population of 400 people.

The depression of 1893, and the fact that most of the oxidized ore within reach was mined out, coupled with poor management, all put a stop to operations in the camp. At the time the sulphides were encountered, no known method of extracting the gold from the pyrite was known. In one report it was said that the mill was recovering only 52% of the values. Concentration was attempted on vanners, but the cost of transporting these to Big Timber was excessive. Some data on transportation costs are of interest here. It took 5 days to make the trip from Big Timber to the camp. Freight rates were $1.50 per 100 pounds for supplies hauled to Independence, and ore was hauled to the railroad at Livingston for the same price per ton. This freighting was done in 1800 pound wagons pulled by four horses. All power at this time was steam, and the fuel used was cut from the surrounding forests.

In 1896 the Duffy #4 claim was opened and a ten stamp mill was installed. Electric power was generated on the East Fork of the main Boulder River by a water wheel, a
distance of two and a half miles from the mill. Here the free milling ore was stoped out and when the sulphide zone was encountered, concentration was again tried, but with little or no success.

In 1897 Ethan H. Cowles opened up the Poorman, Yellow Jacket, and the Hidden Treasure claims. A ten stamp steam mill was built and some placer workings were also developed. The same difficulties of concentration and transportation were again encountered and operations stopped.

Mint returns show that the Independence Mill, which was working from 1890 to 1893, produced $42,000 in gold bullion ($20.67 per ounce). No other data is available as to how much gold the other companies and individuals produced.

In summarizing the past efforts to mine in this district, the following conclusions can be drawn for the failure of all ventures. First, the gold could not be recovered from the sulphides by any known method at that time; second, the cost of transportation and concentration was too high to be economical; third, poor management was responsible for the failure of the properties in the majority of the cases.

PREVIOUS WORK

The only geologic work that has been done on the district was the petrologic and petrographic work by
William H. Emmons. He published his findings in the Journal of Geology, Volume 16, 1908. The geologic map which accompanies this paper was traced directly from Emmons' article; however, section lines, vein pattern, and drainage were added by the author. The discussion of the petrology of the district, with a few additions, will follow Emmons' work closely.

Other information was obtained for this paper from reports of two mining engineers, H. C. Freeman, and J. F. Armstrong. These reports were made in 1894 and 1898 respectively, and gave some information on the Independence Mine. This will also be presented later in the article.

Thanks is here given to John M. Conrow, of the Montana Bureau of Mines and Geology, for his report and oral information on the district.

**Physiography**

The area included within the limits of the map is part of a high plateau. The mountains in which the district lies are locally called the Absaroka range. The general elevation of the plateau is 9,000 to 10,000 feet above sea level, with some peaks higher. Among these shown on the map is Haystack Peak, which is 10,935 feet above sea level, Independence Peak, and Baboon Mountain. Many canyons cut the plateau and are 2,000 feet to 3,000 feet deep. These are typical U-shaped, glacial valleys with steep
Plate II

a. View taken from head of Basin Creek looking west.

b. View taken from top of Baboon Peak, showing the Oligocene peneplanation and later glacial erosion.

walls and hanging streams. The trees are mainly spruce-lodge pine and some fir. Quaking asp and willows grow in the marshes and stream bottoms. All vegetation above 9,500 feet is stunted.

The Boulder River is the most important stream in this district. It rises about seven miles South of the area, mapped and flows into the Yellowstone River at Big Timber. Several small streams join the Boulder from the west, and, from the east, its tributaries are the East Fork and Basin Creek.

The coarse grained Haystack stock is more susceptible to erosion than the fine grained effusive rocks. For this reason the stock is exposed in a basin bounded on the north and south by high ridges, and on the east and west forms gentle slopes to the Boulder and East Fork respectively. The sedimentary rocks have only a small areal extent and they form no marked expression on the topography. They outcrop on the sides of the Boulder canyon, and only two members are present. Quartzite forms a bench, above which is a ledge of limestone.

Glaciation has played a major part in the erosion in the district. Because of the high elevation of the area much snow falls, and some drifts persist throughout the year. Numerous cirques are present in the area and most streams head in these basins. Some cirque lakes are present, of which the biggest is Blue Lake. Erosion is fast
in the area because of ice and snow action, also because of the steep gradient of the streams. Many rock talus slopes exist, and two noteworthy rock glaciers are present. A reproduction of some areal photographs taken by the U.S. Forest Service gives one an idea of the roughness of the country. (Plate IV)
Plate IV

Composite of several areal photographs of the district. (Courtesy of U.S. Forest Service)
GENERAL GEOLOGY

SEDIMENTARY ROCKS

Plate III shows the areal geology of the Independence Mining District.

Pre-Cambrian

The oldest rocks in the district are the pre-Cambrian schists and gneisses. The gneisses at most places are coarse grained, and are composed of feldspar, quartz, biotite, and muscovite. They show typical banding and in some places contain large lenses of quartz which vary in width from a few inches to several feet. The schists transverse the gneisses in various directions, and bands differ in width from less than an inch to more than fifty feet. In this district phyllites are very common. The contacts between the schists and the gneiss are not distinct as the two seem to grade into one another. Seen from a distance the contacts are distinct because of the sharp contrast between the light gneiss and the darker schists.

This crystalline complex is cut by pegmatitic dikes. These are composed largely of feldspar, quartz, and mica. The feldspar crystals in some localities are large, about two inches in length, and are separated by plates of white
to pink mica. These pegmatites do not cut the overlying Cambrian sediments, and are of pre-Cambrian age.

The pre-Cambrian series exposed here looks very similar to the Pony schists and gneiss which are exposed in the South Boulder canyon of the Three Forks Folio area. Correlation of these two series has not been attempted, but a marked similarity does exist between the two.

Cambrian

Resting unconformably on the pre-Cambrian series are beds of Cambrian quartzite, limestone, and a thin shale. The quartzite is pink to gray, crystalline, and very pure. It is 200 to 300 feet thick, and contains some pebbles of crystalline schists at its base. This formation is undoubtedly the Flathead quartzite which is the basal member of the Montana series of Cambrian sediments.

Lying conformably on top of the quartzite is a dark blue to gray limestone. It is sometimes massive, more often thin bedded, and contains cherty layers. Some beds are composed of weathered limestone pebbles in a matrix of dark limestone. The formation is 200 to 300 feet thick with a few feet of black shale at its base. This limestone can be correlated with the Meagher Limestone found in other sections of the State on the basis of its appearance and its position above the Flathead formation.
Argillite

A rock herein identified as argillite was mapped and identified by Emmons as andesite. He states that the rock is very fine grained and attributes its origin to volcanic dust deposited in a shallow sea. In thin section (Figure 1) much calcite appears with some very fine quartz grains. The fineness of the particles prohibits identification of the separate minerals. This rock looks more like an argillite than a volcanic type. No shards appear in the specimen sectioned, but some thin layers of tuff occur in the formation. In some places the rock shows rather weak bedding planes with thin layers of chert. Large fragments of gneiss and schist are present at the base of the formation.
The formation is 1500 feet thick. At the contact of the argillite and the Haystack stock the argillite becomes very hard and resistant, forming the high ridges of Baboon Mountain and Haystack Peak. On the west side of Haystack Peak silicified trunks of trees are found in an upright position.

The age of this formation is rather hard to determine since no fossils are present. It lies unconformably on the Cambrian and on the pre-Cambrian. About all that can be said of its age is that it is older than the overlying basalt.

EXTRUSIVE ROCK

Dark gray basalt lies above the argillite. A few beds of tuff appear in the formation, but for the most part it consists of basaltic lava flows. These flows show no columnar structure like that shown in some of the lavas of Yellowstone Park. The thickness of this formation is not known because it is the highest in the area and erosion has removed an undetermined amount. However, the thickness is greater than 3000 feet for in one place, south of the area mapped, Hell Roaring Creek cuts through 3000 feet of the basalt.

The age of these lavas is probably of late Cretaceous or early Tertiary time to correlate with the Livingston volcanics which are exposed only sixty miles to the south of the area at Livingston, Montana.
INTRUSIVE ROCKS

Andesite sills occur between the Cambrian quartzite and the limestone at the base of the shale, these sills being exposed wherever the Cambrian rocks are present. In some places these sills are 200 feet thick and several sills occur where the sedimentary beds are the thickest. The andesite is dark gray to brown and contains phenocrysts of feldspar, hornblende, quartz, and biotite. These sills are the oldest volcanic rocks in the district as they do not cut the argillite which overlay the Cambrian beds.

The Haystack Stock

The Haystack stock is about three square miles in area and is the youngest rock in the district. It cuts the schists and gneisses, the andesite sills, and intrudes into the argillite. It is composed entirely of granitic rocks which vary in composition from a granite to a quartz-monzonite. At the border of this intrusion the rock is dark, fine grained, and contains feldspar, quartz, hornblende, and mica. In the center of the stock the rock becomes coarse grained and darker in color with the ferromagnesian minerals equal to the light colored constituents. These facies grade into one another and the change from one to the other is gradual. All the rocks of the
stock are massive, jointing is in several directions. The central portion of the stock is intruded by small aplite dikes which never exceed two inches in width. There is no evidence that the stock ever reached the surface and it is likely that it did not. It only intrudes a short distance into the argillite and at the time of intrusion this formation was probably overlain by at least 3,000 feet of basalt. Upon cooling, this stock became fractured and left openings for later mineralization. It is of interest to note from the map that these fractures extended into the overlaying argillite and that they are more or less parallel and about the same distance apart. Undoubtedly more of this fracturing is present than shown on the map, in fact the author has seen more extensive fissuring than indicated. Some later movement along these cracks has taken place since cooling as indicated by the development of slickensides in the veins.

Petrography.--The gradation from granite to quartz-monzonite is shown by a study of two thin sections taken from different places in the area of the stock.

One specimen taken near the border of the intrusive contains 55% plagioclase (Ab90 An10), 25% quartz, 10% orthoclase, 5% biotite, with apatite, zircon, small grains of magnetite and pyrite. Another specimen taken at the center of the stock contains 30% plagioclase (Ab70 An30).
20% orthoclase, 20% biotite, 20% quartz, with apatite, zircon, and a high percentage of pyrite and magnetite.

The first rock would be called a soda-granite, and the second a quartz-monzonite.

Emmons noted this segregation and took seven samples on which he made chemical analyses rather than petrographic observations.
VEIN SYSTEM

The vein system in the Independence Mining district is shown on Plate III. This pattern was compiled from the various claim maps, which showed the outcrops of the veins, the discovery shafts, and in some cases, offshoots from the main veins. It will be admitted here that the continuation of the various veins was assumed by the writer, but he feels confident that such assumptions are justifiable under the circumstances, as the numerous shafts and prospect holes in the district support the conclusions drawn. Future prospecting in the district will undoubtedly bring forth more information on the structure, nature, and mineralization of the veins. The offshoots shown on some claim maps indicate that the fracturing of the Haystack stock was severe.

The pattern of the veins shows interesting sets. It will be noted from the map that the strike of most of the veins averages about N. 25° W., with two veins at almost right angles to these. The 13 veins mapped are on an average of about 600 feet apart. Beginning on the west side of the map and going eastward across the area of mineralization, the dips range from vertical in the Independence veins to 45° NE. on the Duffy vein, and almost horizontal.
on the veins in the eastern portion of the area. The two cross veins stand almost vertical. This structure would suggest systematic fissuring.

It is also noted that the openings extend into the overlying and adjacent rocks, and mineralization follows this fissuring without interruption while passing from one type of rock to the other.

The numerous shoots that occur in the veins suggests that movement has taken place along the planes of the fissures, this being supported by the slickensides and gouge found between the veins and the walls. As is the case with all fissures, these are not perfectly flat planes, and any lateral movement along these planes leaves openings for later mineralization. The economic importance of any one vein not only depends on its mineralization, but also on the amount and distance between the ore shoots.

MINERALOGY OF THE VEINS

The Independence Veins

The mineralization of three of the veins in the district was studied in detail for this paper.

Considering the Independence veins first, the samples were taken mostly from the surface and from that part of the vein in the argillite.

Figure 2 is a photograph of a thin section of the vein matter in the Independence vein. This rock contains
approximately 30% pyrite, and shows much alteration of the fine-grained particles. Much calcite is present and the mass of the rock is stained with iron. Sericite is the alteration mineral present.

Figure 2. Vein rock of the Independence vein. X-Nichols. X 80

Polished sections of this vein show that the pyrite is present as small particles disseminated throughout the argillite. No gold was found in any of the sections polished.

Samples taken from the ore bin at the mill on the Boulder River show very small veinlets of pyrite in the vein matter, and pyrite not associated with these veinlets is spread throughout the whole of the rock.

In the Independence veins the mineralization has not been a massive deposition of pyrite, but rather a replacement of minerals with pyrite. The pyrite is yellow and
well crystallized. The average crystal is about one and a half millimeters in diameter. Very little copper is present in the vein matter, but when present it is chalcopyrite. In the samples taken, which were from the surface, this chalcopyrite is very much altered. Fixed limonite and casts of pyrite crystals suggest that copper was present in the original vein before oxidation.

Duffy Vein

Most of the samples taken and examined for this paper were taken from the Duffy vein. At the time, this was the only vein which was exposed below the outcrop and afforded the only opportunity to study both the outcrop of a vein and its character below the weathered zone.

Figures 3 and 4 show the typical occurrence of the minerals in small veinlets throughout the vein proper. The rock in the vein is a light green color and is in this way distinguished from the wall rock, and from the horses which occur in the vein. Small cubic pyrite crystals occur in the matrix between these veinlets.

Two minerals, pyrite and chalcopyrite, and their alteration products are the important minerals which go to make up the mass of the vein.

Pyrite.—Megascopically the crystals of pyrite are well formed and striations are very prominent. The pyrite forms on the walls of the openings, which are from one
half to three inches wide, and many cavities are left between the crystals. The average crystal is about one-fourth to one-half inch in diameter.

Figure 3. Hand specimen 125 feet below the outcrop. Figure 4. Hand specimen from the surface.

Microscopically the pyrite below the oxidized zone shows slight fracturing (Plate VI a.) with the crystals separated by only slight spaces. The pyrite occurs in massive crystalline groups with little or no mineralization between the separate crystals. The other minerals present occur as compact masses between these groups.

In the oxidized zone the pyrite shows much fracturing (Plate VI b), but these cracks seem to be solution cracks rather than fissures resulting from directed pressures.
Plate VI

a. Pyrite 125 feet below the outcrop. X 80.

b. Pyrite from the outcrop. X 80.

c. This shows relationship between chalcopyrite (c), pyrite (p), and quartz at the surface.

d. This shows the relationship between chalcopyrite (c) and the pyrite (p) 125 feet below the outcrop.
The boundaries are not sharp, but well rounded. Secondary quartz and covellite, with small amounts of residual chalcopyrite, occur along these openings.

Pyrite also occurs as well rounded particles in the chalcopyrite and most of these crystals are hollow. (Plate VI c). The center is composed of quartz and the pyrite has many solution channels radiating from the center, which are filled with covellite. In all places where the pyrite and the chalcopyrite occur together, they are separated by a thin band of covellite and quartz (Plate VI d). Near the surface, much of the pyrite has been attacked by destructive solutions. At about eighty to one hundred feet below the outcrop of the vein, the pyrite shows none of this alteration.

Megascopically there is a difference between the pyrite that occurs in the veinlets and the vein matter. That which occurs in the veinlets is well striated and yellow. The crystals are octahedral, large, and seem to have grown into one another. The pyrite which occurs in the vein matter is not striated. The crystals are separated, each a cube about two to four millimeters on a side. This pyrite is almost steel color, or the color of marcasite.
Chalcopyrite.--Megascopically the chalcopyrite occurs as massive (uncrystalline) masses between the crystals of pyrite. It is "vuggy" and friable. Its color is a very greenish-yellow and almost everywhere has an oxidized film. This iridescent film gives a play of rich purple, brilliant green, and violet.

Microscopically the chalcopyrite appears massive with no crystal faces whoeing. Very few cracks occur in the chalcopyrite and all of these show alteration of the chalcopyrite to covellite (Figure 5). This alteration is seen everywhere, but the degree of alteration increases at the surface. The chalcopyrite is "vuggy" in polished section and many inclusions of rounded and altered pyrite occur in the chalcopyrite. No other minerals were found in the chalcopyrite.

Figure 5. This shows the alteration of chalcopyrite (c) to covellite (cv).
Gold.--The gold content of the ore is small, so high-grade samples were selected and these were polished. Out of forty sections polished only five sections showed any gold. Plate VII shows this gold.

All the gold found was in the pyrite or closely associated with the pyrite. No gold was found in the chalcopyrite, and none in the fissures and alteration cracks that occur in the pyrite and in the chalcopyrite. No gold was found in the samples taken in the oxidized zone, although selected samples of this ore will show a few colors in a pan if crushed fine enough.

Five of the gold particles were measured microscopically, and these averaged 0.095 mm. in the largest diameter. The biggest of these particles measured 0.225 mm. by 0.075 mm., and the smallest measured 0.03 mm. by 0.01 mm.

Character.--Two thin sections were made of the rock which makes up the Duffy vein. One sample was taken about 125 feet below the outcrop, the other at the outcrop.

Plate VIII a) is a photograph of a thin section of the sample taken below the outcrop. This rock contains about 15% pyrite and magnetite. All the plagioclase and biotite has been almost completely sericitized or replaced with pyrite and quartz. The rock also contains about 55% of the altered plagioclase, 25% quartz, and a small percentage of calcite. The quartz here is coarse and the pyrite contains inclusions of calcite.
Plate VII

a. Gold grain 0.03 mm. by 0.01 mm.

b. Gold grain 0.075 mm. by 0.075 mm.

c. Gold grain 0.225 mm. by 0.075 mm.

d. Gold grain 0.08 mm. by 0.05 mm.

e. Gold grain not measured.

f. Gold grain not measured.
Plate VIII b shows the thin section of the sample taken at the outcrop of the vein. Here the plagioclase and the biotite have been completely altered. Some sericite is noted and about half of the alteration of the feldspars has gone to a white mica or muscovite. The rock also contains about 40% quartz, which is much finer grained than that in the above vein matter. Only 15% of pyrite occurs in this sample.

Horses.—Numerous horses, or fragments of wall-rock included within the vein, are present in the Duffy vein. This rock is stained with the same light bluish-green that distinguishes the vein from the wall rock. The difference is, however, that the vein matter contains no biotite, while all of the horses contain small particles of biotite. In mining this ore, distinction between ore and horse-rock is made on the presence or absence of biotite. These horses differ in size; some may be four feet wide and 20 to 30 feet long. The vein splits around these. The horses are not mineable ore, but an average assay shows 0.10 oz. of gold per ton.

Plate VIII c is a photograph of a thin section of a sample taken from one of these horses 125 feet below the outcrop. The rock contains about 55% plagioclase, which has been partly altered to sericite; 3% biotite, which
Plate VIII


b. Duffy vein at surface. Note complete sericitization of plagioclase and fine grained quartz. X-Nicols. X 80.

c. Horse in the duffy vein 125 feet below surface. X-Nicols. X 80.
has been partly replaced with pyrite; 25% quartz; 15% pyrite; and small amounts of calcite, apatite, and zircon.

**Structure.**—The Duffy vein has been exposed by a drift for a length of about 400 feet. In this drift (Plate V) the vein dips 47° NE.; however, about twenty feet above the drift the vein splits and one shoot continues on this dip, while the other dips 80° NE. Both shoots are strong and continuous.

As shown on Plate V a cross fracture occurs in the vein. Mineralization has increased on the south side of this fault and two rather strong stringers go into the footwall. The vein here is about ten feet wide. On the north side of the fault the vein continues, but is much narrower. No mineralization occurs along the fault and it is assumed that faulting is later than mineralization.

**The Hidden Treasure Vein**

Only a few samples were taken from this vein, and those from the surface. It was not possible to enter any of the crosscuts to this vein.

Megascopically the vein looks much the same as the Duffy vein. The pyrite is very coarse, and the crystals are much larger than those in the Duffy vein. Not as much fixed limonite appears in the capping of this vein.
as that observed in the Duffy vein. This would lead to the conclusion that the Hidden Treasure vein bore less copper.

Plate IX a, and b, photomicrographs of polished sections from the outcrops of the Hidden Treasure vein and the Duffy vein, show the difference in the structure of the pyrite in the two veins.

Plate IX c shows a thin section of the vein matter in the Hidden Treasure vein. The rock contains 85% quartz, which is very fine grained, about 1% pyrite, and the remainder an alteration product, white mica.

The Hidden Treasure vein and the Duffy vein are only 600 feet apart. Why the mineralization is slightly different is a matter of speculation, and further study of the problem is necessary. It is a prime purpose of this paper to try to establish some means of telling which of the various veins in the district are likely to carry economic values and which do not. The answer to this question seems to be in the amount of fixed limonite in the cappings of these veins.

Other Veins

The other veins were not studied in detail by the writer, but some information was obtained from other reports and from observations noted during reconnaissance in the district.
Plate IX

a. Pyrite in the outcrop of the Hidden Treasure vein.

b. Pyrite in the outcrop of the Duffy vein.

Figure 6 shows a polished section of galena picked up on the extension of one of the Independence veins. Other galena was found in the district in the area away from the center. This would suggest a zoning of mineralization. Other observers have noted this zoning, and John M. Conrow suggested that the intersection of the Duffy vein and the Deadman vein be taken as the center of mineralization, and that the greatest intensity of mineralization is within a radius of 1000 feet of this center.

Alteration and Enrichment

As has been already stated, erosion in the district is rapid, and the water table is shallow due to the ruggedness of the country. However, some alteration has
taken place below the oxidized zone. The ore 125 feet below the outcrop of the Duffy vein (which is the deepest in the district) shows very small particles or specks of malachite deposited in the openings between the pyrite crystals. Azurite was observed in the drift between the vein and the foot wall.

Plate X shows a few polished sections of the ore taken below the outcrop. The pyrite does not seem to be replaced, but the chalcopyrite has been altered to covellite along solution cracks. Limonite also occurs between the pyrite and the chalcopyrite, neither of which show signs of having been attacked by the solutions which carried this limonite into the fissures.

No gold believed to be secondary or supergene has been found in the specimens examined, but then no residual gold has been found in the capping. All the gold is associated with the pyrite and seems to have come in with the solutions that carried the pyrite into the fissures.

No enrichment of the primary minerals is of importance, the only enrichment being the alteration of chalcopyrite to covellite.

GENESIS

The fissures in which mineralization has taken place have doubt formed during cooling of the Haystack stock.
Plate X

a. Showing alteration of chalcopyrite (c) to covellite (cv), and the replacement of pyrite (p) with quartz (q). Sample from outcrop.

b. Showing alteration of chalcopyrite (c) to covellite (cv), and development of quartz (q).

c. Showing alteration of chalcopyrite (c) to covellite (cv) and limonite (li).

d. Showing alteration of chalcopyrite (c) to covellite (cv) and development of quartz (q).
Later movement along these planes caused openings into which the ore minerals were deposited. Two waves of solutions occurred. The first carried in the pyrite and gold, and the pyrite was deposited as course crystals on the walls of the openings. This wave was hydrothermal. The sericitation of the vein matter and horses support this conclusion. A second wave of solutions which carried in the chalcopyrite filled up the spaces left between the pyrite crystals, and in some places filled up the space left between the two walls of the cracks not completely filled by pyrite.

Another possible explanation is that mineralization was continuous and that the temperature of the country rock dropped during mineralization. The pyrite formed at the higher temperature, while chalcopyrite was deposited at the lower temperature.

According to Lindgren's classification of fissure veins these veins would fall in the intermediate temperature zone (150°C–300°C).
DESCRIPTION OF THE VARIOUS PROPERTIES

There are three groups of claims in the district which deserve mention. These are, (1) the Independence group, (2) the Duffy #4 claim, and (3) the Hidden Treasure group. There are other claims which have been prospected; and some on which ore has been mined and milled. These later will be discussed briefly, with some comments on the placers in the district. The information was gathered from reports previously mentioned and from the author's observation while working on the Duffy #4 claim in the summers of 1938 and 1939. Some information was obtained by the author from various people connected with the properties while these were operating.

PLACERS

Three placer claims are located in the district. One is on Basin Creek just where the upper road crosses this creek. An estimated 4000 tons of gravel has been worked here. The remains of an old crane and cable for moving the large boulders can still be seen. It is believed that this work was done by Ethan H. Cowles in 1906. The author has panned this gravel and estimated the value to be about $8 per ton.

Another placer is about 500 feet below the above mentioned workings. Here an estimated 10,000 to 12,000
tons of material has been worked. The most successful of the various methods tried was hydraulic mining, but operations were handicapped by the large boulders. The work ceased when 25 feet of valueless capping gravel caved in on the machinery. This work was done in about 1930. Since that time several prospectors have worked the gravels by hand methods when the water was plentiful and all have made at least wages. No records or estimates of values are procurable or have ever been attempted on this property.

The third placer is also on Basin Creek about 200 feet above where it flows into the Boulder River. This property has only been worked by hand methods in recent years. Here again no data is available as to the value of the gravels, but each summer someone is working on the property.

THE INDEPENDENCE GROUP

The Independence group consists of three claims on the Independence veins. Three adit tunnels or drifts were driven as shown on Plate V. The work was done between 1892 and 1894. At present the two upper tunnels are filled with solid ice. The lower adit was opened in the summer of 1933, but has again caved.

In October of 1894 one report shows that the mill, which was situated on the Boulder River, treated 72 tons
of ore from adits No. 1 and No. 2 and recovered 16,566 oz. of gold and 9.33 oz. of silver. The tails were assayed from this run and the mill recovery was 54% of the values. From this it can be calculated that the ore averaged about 0.45 oz. of gold per ton. No data is included in the report to show where the ore came from in the two tunnels. The ore mined out is shown on Plate V.

The author entered the No. 3 adit in 1938. A small seam was followed in driving this tunnel. From surface indications this adit seems to have been driven between the two Independence veins with the idea of developing both veins from this one drift. At the adit crosscuts were started in both directions toward the veins but these were never completed. On the surface the outcrops of the veins are only 40 feet apart, but the crosscuts in the drift are only 18 feet in one direction and 9 feet in the other direction. Probably just as these crosscuts were being driven all work stopped on the property and they were abandoned for this reason.

The ore occurs in these two veins in shoots, which is typical of the district. One man, H. C. Freeman, sampled No. 1 adit. He carefully removed the tract and took samples from the ore in place every 10 feet, his records showing that in the drift a shoot starts 47 feet from the portal and extends for 90 feet. Another shoot starts 20
feet farther on and extends for 30 feet. The remainder of the vein averages only 6 inches in width. An average of the twenty-three samples taken shows 1.31 oz. of gold per ton. The shoot which is 90 feet long averages 0.57 oz. per ton, with an average of two feet in width.

THE DUFFY #4 CLAIM

This claim is on the Duffy #4 vein and has its south endline about where the Deadman vein and the Duffy #4 vein intersect.

The development on this property consists of an adit which intersects the vein 205 feet from the portal. This work was done in 1895-1896. About 1000 tons of ore was stope cut at this time. A five stamp mill was built at the portal of the adit and the ore was amalgamated and concentrated. The mill was powered by an electric motor. Concentration was attempted in the mill, but none were shipped to a smelter.

In 1933 interest was aroused in this property and another adit was started 125 feet lower and directly below the upper adit. This tunnel was driven for 430 feet and then the work ceased.

In the summer of 1938 the author's interest was aroused in the possibilities in the district and as the upper adit of the Duffy #4 claim was the only open tunnel,
investigation started here. 240 feet of drift exposed the vein for this distance, with five raises driven into the ore. This work was done in 1896. The author sampled all exposures of the vein with 10 feet intervals.

Figure 7. This view shows the dumps of the upper and lower adits of the Duffy vein.

between each sample. The assays on these samples were very irregular. One sample would assay 3 to 4 oz. of gold per ton, while the one next to it would show only a trace of gold. For this reason two samples were cut between the previous samples, which made a sample cut every 40 inches along the vein. It was found, however, that these samples were just as irregular. An average
of all samples taken (68) was 0.38 oz. of gold per ton, 2 oz. of silver, and 0.9% copper. This average was checked by taking a composite of all samples.

In the late summer of 1938 the upper adit, raises, and stopes were repaired. In the early spring development work proceeded, and a 50 ton mill was erected. At present this mill is ready to run, and development work in the mine has advanced so that stoping of the ore can also proceed.

THE HIDDEN TREASURE GROUP

The Hidden Treasure group consists of one patented claim and other claims along the Hidden Treasure vein. Three adits were driven to intersect this vein by Ethan H. Cowles in 1906. No records of tonnage or production are available, and all adits are caved. A 10 stamp mill was built on the property in 1907 and ore was brought to the mill by a 400 foot tramway. Concentration was attempted here also. These concentrates were assayed and showed 0.33 oz. of gold per ton, with a trace of silver and copper. Unless most of the gold was recovered by the amalgamation plates, this would indicate that the ore was not very high grade. Work ceased here in 1908 and the property has never been operated since.
OTHER PROPERTIES

As can be seen from the accompanying map (Plate III), other veins exist in the district. Oral reports indicate that the Poorman vein was a producer in the early days of the camp, but no evidence now exists to substantiate such rumors.

The district is marked by numerous short adits and shafts. In fact one can trace the veins by simply lining up the prospect holes on any one of them.

In the southern-most end of the district and on the extension of the Independence veins quite a deep shaft has been sunk, which is now caved. Remains of a mill exist here, and much ore must have mined and milled in the early days. Here again no records are available.

Undoubtedly some shoots of rich ore were encountered in these various prospects. Because the values were mined out, or else because none were found, the prospects were abandoned and other shoots were looked for. One assay from the North Star vein, which is just east of the Independence vein, is reported to show 800 oz. of gold per ton, but this was probably a hand-picked specimen.
The work done in the district in the past has been done with little capital and no systematised development or investigation of the geologic setting.

The Independence veins, the Duffy vein, and the Hidden Treasure vein, all carry economic values of gold, silver, and copper. Other veins give indications of being of economic importance.

It is the belief of the writer that an intelligent investigation of the structure and mineralogy of the district will result in finding veins which can be mined at a profit. Diamond drilling in the district would be a cheap and quick method of determining structure and of finding the shoots in the veins.

The metallurgical problem of concentrating the gold-bearing pyrite is a simple one to solve, and gravity concentration of this ore is very cheap and successful. Transporting sulphide concentrates to the railroad at Big Timber is rather expensive, but not excessive if a high grade concentrate is made.

The future of the Independence Mining District depends on intelligent prospecting, cheap milling costs, and good management.
PLATE III

GENERAL GEOLOGIC
MAP
OF THE
INDEPENDENCE
MINING DISTRICT.

SCALE 3"=1 mile

LEGEND

- HAYSTACK STOCK
- ACID ANDESITE BRECCIA AND FLOWS
- BASIC ANDESITE BRECCIA AND FLOWS
- CAMBRIAN QUARTZITES AND LIMESTONES
- ANDESITES AND DACITES Dikes and Sills
- SCHISTS AND GNEISSES
- MINERALIZED VEINS
- ROAD
CROSSECTION OF VEIN IN DRIFT

WORKINGS on the DUFFY #4 VEIN
SCALE 1" = 20'

PROFILE of WORKINGS on the INDEPENDENCE VEINS