DESCRIPTION AND RELATIONSHIPS OF
THE OPHIR VALLEY, COLORADO, ORE DEPOSITS

A
THESIS
SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE
OF GEOLOGICAL ENGINEER AT
THE COLORADO SCHOOL OF MINES

[Signature]
COLORADO SCHOOL OF MINES
GOLDEN, COLORADO
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Ophir valley is just 14 miles, by road, south of Telluride, in San Miguel county, Colorado. It is in the heart of the San Juan Mountains. Mining operations have been carried on here since 1876. The area saw a boom at the turn of the century. Gold and Silver have been the most important products. There are two general types of veins represented in the area, indicating two distinct periods of mineralization. The base-metal veins are the more prominent, and are the main producers of lead and silver. The Alta, Silver Bell, Badger, Favorite, Carbonero, and New Dominion mines all work this type of vein. The other type of vein is the gold-quartz-pyrite vein, represented by the Silver Tip mines, and the Crown Point mine.
ACKNOWLEDGEMENTS

I am indebted to the United States Geological Survey for permission to use for study as a thesis problem ore samples, mine maps, statistics, and other data collected while in the employ of that organization.

I am also grateful to Dr. Vhay, Mr. Varnes, Dr. Broughton, and Mr. Odell, members of the field party, who were responsible for a large part of the field work, and to Dr. Parker and Dr. Waldschmidt of the Colorado School of Mines who supervised the laboratory work and preparation of the paper.

J.W.G.
The purpose of this paper is to present a general description of the ore deposits, and the structural conditions of Ophir Valley, Colorado.

The subject was chosen because it presented the possibility of accomplishing field work which was done while systematically mapping the geology of the area under the direction of Dr. J. S. Vhas, for the preparation of his professional paper on the area.

This paper does not present a complete coverage of the subject because there are several excellent, separate research problems included within the scope of this report that are only touched upon lightly. Because of the great amount of time that would be required to completely cover all of the mines investigated, only two type mines were chosen for complete coverage including a microscopic examination of the ore specimens. The other mines are described in a general way.

By doing this many small and unimportant mines were investigated, while some large and more important ones remained untouched; but the general feature were obtained of the deposits of the whole valley including rich and poor veins alike.

All of the mine maps except plate I are copies of those drawn for the United States Geological Survey. These maps have not yet been published.

A word should be inserted about the accuracy of the surveying and mapping done in relation to the subject matter of this paper. The areal mapping done by the Geological Survey was very accurate, but the study of fissuring in relation to igneous intrusions and ore deposits was only approximate. First, in order to study the subject completely, all of the fractures, joints,
veins, and fissures, mineralized and barren, should be mapped. Although the location of the veins may be accurate within 10 to 50 feet the strikes and dips must be very accurate, and this in some cases is beyond the scope of a Brunton compass. Sometimes a transit should be used. However, since it is not the purpose of this paper to draw any important conclusions, the accuracy of the work is sufficient.
Ophir Valley is in the San Juan Mountains in Southwest Colorado, just
14 miles by road South of Telluride. It contains the Howard Fork of the San
Miguel River. It trends East-West, and is very deep, showing numerous effects
of alpine glaciation. The outcropping rocks are distinctly striated parallel
to the course of the valley. Elevations range from 9,000 feet on the
valley floor to over 13,000 feet on the peaks that border it. The slopes
are everywhere extremely steep, grading into vertical cliffs at places. The
south slope is heavily forested, whereas the north slope has only scattered
patches of aspens. The heaviest timber has been burned off of the north side.

The valley is U-shaped and in many places is very swampy. Timber line
is between 11,000 and 12,000 feet.

At the present time there are not many people in the valley. A few families
live at Ophir Loop, a station on the Rio Grande railroad at the mouth of the
valley. Old Ophir, the original mining town, 3 miles above Ophir Loop, has
a permanent population of two people, but shepherders and itinerant families move in during the summer. Both towns once boasted large populations.

The climate is typically that found in mountains. The winters are long and severe but the summers are short and mild. Snow covers the valley floor from October until May, and it is always present on the peaks bordering the valley. Rain is frequent in summer, and there is always enough moisture to support luxuriant growths of plants. In some places it is even rank.

The only great development this valley ever had was in connection with the mining industry. Although there is now no mining activity, old mill sites and destroyed tram lines can be seen from one end of the valley to the other. The primary phase of it was gold mining, but it is now a ghost area with only one or two mines being worked. At the present time the area is used extensively for sheep grazing.
Physiographically the valley is very interesting. It is surrounded on three sides by a ring of ridges and peaks all between 13,550 and 14,000 feet. The highest and most prominent are Mount Silverton on the north side, Yellow Mountain on the south side, and Lookout Peak at the head of the valley. High rugged cliffs mark the mouth of the valley, the Howard Fork dropping to the San Miguel River thru a narrow canyon. Above this narrow entrance, the valley widens and its bottom becomes flat. The river flows more gently thru a series of swamps. All the tributary valleys enter from the south, those on the north being nothing more than deep "V"-shaped gullies conforming to the steep valley slope. On the south, two tributary valleys, Waterfall Canyon and Swamp Canyon, have cut back considerably more than a mile into the range. They have been glaciated and head in cirques. The whole system is a series of hanging valleys. Swamp and Waterfall canyons hang over the Howard Fork and it in turn hangs over the San Miguel. Moraines and other deposits of glacial till are numerous.

The slopes of the valley are extremely steep because of the hardness of the rock. At the higher parts, and at the head of the valley high cliffs are present instead of slopes. Extensive talus slopes are common and in the vicinity of Lookout Peak and Ophir Pass talus covers the entire slope from the ridges to the floor of the valley. The rocks are of all sizes and in every stage of weathering.

The stratigraphy of the area is closely related to the structure. The San Juan Mountains present one of the most complicated geological areas in Colorado. Continental sediments have been uplifted, peneplained, and covered with thousands of feet of volcanic tuff and lava flows. These in turn have been intruded by stocks and dikes which have metamorphosed the sediments surrounding them.

For the purpose of this paper two sections of the sediments were observed.
One below Telluride on the San Miguel River, and the other on Mount Silver overlooking Ophir Valley and the Alta basin.

<table>
<thead>
<tr>
<th>Age</th>
<th>Formation</th>
<th>Depth</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jurassic</td>
<td>Dakota</td>
<td>125-175</td>
<td>Brown to buff sandstone</td>
</tr>
<tr>
<td></td>
<td>Old</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morrison</td>
<td>Morrison</td>
<td>600</td>
<td>Shale and sandstone</td>
</tr>
<tr>
<td></td>
<td>Wanahka</td>
<td>900</td>
<td>First strong sandstone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Strong shales, weak sandstone</td>
</tr>
<tr>
<td>Triassic</td>
<td>Entrada</td>
<td>100</td>
<td>Pony Express, black limestone, brecciated, thin.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>175</td>
<td>Massive bedded, yellow ss.</td>
</tr>
<tr>
<td></td>
<td>Wingate</td>
<td></td>
<td>Gray shale</td>
</tr>
<tr>
<td>Dolores</td>
<td></td>
<td></td>
<td>Bright red, calcareous ss.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Brick-red mudstone, shale, calcarious, sandy shales, some clastic limestones.</td>
</tr>
<tr>
<td>Cutler</td>
<td></td>
<td>1550</td>
<td>Maroon, gray, coarse, ss. interbedded, and cross-bedded, some micaceous shale</td>
</tr>
</tbody>
</table>

This section of the pre-Telluride, Mesozoic sediments. Excellent outcrops of the sedimentary rocks can be seen throughout the whole of the San Miguel canyon below Telluride. These sediments have been tilted slightly, dipping them to the northwest, and truncated by erosion. On this erosion surface the Telluride conglomerate was deposited unconformably. This is the most noticeable and significant unconformity in the whole section, and is the division between two entirely different environments in past geologic time. They are all continental deposits, or were deposited under fluctuating shore conditions.
<table>
<thead>
<tr>
<th>Age</th>
<th>Depth</th>
<th>Name</th>
<th>Character</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neocene</td>
<td>30</td>
<td>Potosi Latites</td>
<td>Red breccia and flows</td>
</tr>
<tr>
<td></td>
<td>200-400</td>
<td></td>
<td>Red, glassy, banded rhyolite</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td></td>
<td>Cannonball - Dove-colored latite</td>
</tr>
<tr>
<td></td>
<td>90-400</td>
<td></td>
<td>Potosi pink latite</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td></td>
<td>Potosi white latite</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td></td>
<td>Red brecciated flow, vesicles</td>
</tr>
<tr>
<td>Eocene</td>
<td>1500</td>
<td>San Juan tuff</td>
<td>Breccia and tuff</td>
</tr>
<tr>
<td></td>
<td>100-200</td>
<td>Lower San Juan</td>
<td>Water-laid tuff - in a lake</td>
</tr>
<tr>
<td></td>
<td>200-300</td>
<td>Telluride Cong.</td>
<td>Conglomerate</td>
</tr>
<tr>
<td>Mesozoic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This section, of the sediments and volcanics on Mount Silver shows the attitude of the lower beds in relation to the Telluride Conglomerate and the higher volcanics. The unconformity (see section) is very evident at many places. The lower part of the San Juan tuff is characteristically water deposited. The general belief is that a huge inland lake existed in this area at the time of deposition of the San Juan tuff. The source of the tuff was the well known Silverton caldera to the east. The tuff not only filled the lake, but formed a bed over it 1,500 feet thick. Above this, successive lava flows with intermittent beds of tuff were deposited. There was evidently considerable igneous activity at that time. The extrusive igneous rocks of
the area range from rhyolite through andesite. The andesite is the highest
flow, and it was observed only in the uppermost twenty feet of Lookout Peak.

At a later time the volcanics and underlying beds were faulted and in-
truded by monzonite igneous masses. Ophir valley seems to have been a local
center for igneous activity. Several different types of rock are represented
as intrusions of all sizes and shapes in different parts of the valley. The
ones having any possible connection with the ore deposits in the valley are
shown on Plate I. The largest and most important is the intrusion in the lower
part of the valley. It forms the Ophir Needles and the narrow gap at Ophir
Loop. The intrusion is essentially monzonite on the north side of the valley,
but grades into a diorite on the southern side. This igneous body persists
in depth both in volume and character as indicated by workings at the Carri-
beau mine which extend to a depth of 1200 feet. No change of character was
noticed in this distance. Numerous dikes cut the sediments and are evidently
emanations from the large intrusive masses.

The sediments below the Telluride conglomerate in the valley itself have
all been metamorphosed by the intrusions. They are all part of the Dolores
formation, according to C. W. Cross, but some Cutler and Entrada may be in-
cluded. Most of them are not recognizable near the intrusions, but at the
head of Waterfall canyon, some distance from the intrusion, the sediments have
the same pink color as the Dolores elsewhere. On the west side of the large
intrusion the sediments dip steeply to the west, pushed up on end by its dy-
namic action. In the Ophir Needles the Telluride conglomerates and Hancock
shale are literally plastered against the igneous rocks. Fossil imprints
were found in the Hancock shale only a few feet from the igneous-metamorphic
contact. On the east side of the intrusion the beds are almost flat, but dip
slightly to the northwest and west. They are of the same metamorphic character.

There are two interesting topographic reflections of structure in the
valley. One is the narrow gorge at Ophir Loop, which flattens and widens out immediately to the east and west. The canyon part has been eroded in resistant igneous rock, while the smooth parts of the valley are eroded in softer sediments. The other feature is the deep "gut"-like character of the vein outcrops. The mineralizing solutions have weakened the country rock so much that the outcrops have been eroded into deep trenches. These trenches, or "guts," can be followed for miles across the country.
The ore deposits of Ophir valley, within the scope of this investigation, are divided into 3 classes: fissure veins, replaced beds, and pegmatitic pipes. The latter two are relatively unimportant as the examples of them are few and small in size. All the ore deposits that have been worked are fissure veins.

Development of the mines is almost entirely by tunnels driven into the steep mountainsides. The veins are worked by overhand stoping.

Five systems of fissures have been noted in the Telluride-Ophir area.

They Are:

1. N 87°W- This set is well developed in the Mount Wilson, Sunshine Mountain and Yellow Mountain area. It has rare representation on Silver Mountain.

2. N 36°E- This set is not well developed in Ophir valley.

3. N 53°-55°E- These veins are prominent in Mount Wilson area.

4. N 17°W-N 2°E- These fissures are found on Silver Mountain and adjoining spurs.

5. N 25°-31°W- This set is fairly well distributed. Most all of the veins have a S-W dip.

The veins are grouped into zones of widely and narrowly spaced fissures. The spaces between fissures vary from several hundred feet to an inch. There is a peculiar rhythmical recurrence of alternate wide and narrow zones. This is true especially in the Caribenero mine where the E-W trending base-metal vein alternately pinches and widens out.

The veins penetrate all rocks in the area, and are later than the lava flows and monzonitic stocks. They were probably caused by dynamic action in
some adjacent area.

The veins themselves are narrow zones of closely spaced fissures that have been filled with ore. These generally consist of alternating bands and lenses of ore and country rock. The ore almost never completely fills the space between the two walls. The metallic ores usually follow the footwall and the rest of the vein is easily worked gouge.

Local ore chambers are common where the country rock has been brecciated and ore is the cementing material. Some very large "horses" have been known. Microscopic study shows that the parallel fissuring has not reached minute dimensions. The smallest distance between such fissures is one inch while smaller more irregular fissures are noted in between them. Open vugs are common.

The veins pass from one formation to another, without any apparent change in character. An example is the Smuggler vein which extends through the San Juan tuff into the rhyolites above. The only character changed is that there is less space-filled with ore than below. The veins are of the same width and strike, but sometimes change dip, steeping as they pass into the more dense formation. Veins in the Mancos shale and Morrison formation are narrow, while those in the Cutler and Dolores are wide.

The veins are unusually long along their strike. Where systems of veins intersect, the ore sometimes switches from one vein to another of different strike. Intersections usually provide richer ore, but cases have been known where impoverishment is the result because of the extensive open space and the small amount of ore.

Rolling of the veins is common and indicates normal faulting. However faulting of the veins themselves is not extensive.

On yellow mountain the veins almost all strike east-west, and are silver bearing base-metal veins. The silver occurs in galena and freibergite (argentiferous grey-copper). Also, on Yellow Mountain there are examples of brecci
cemented by ore, and two colors of quartz gangue.

The gold-quartz-pyrite veins near Ophir contain saccharoidal quartz with disseminated fine grains of pyrite and gold. The veins are filled solidly instead of just having ore along the footwall. These veins, of entirely different character than the base-metal veins, may be very close to the base-metal veins and still be independent of them. This is a good indication of two periods of mineralization.

Near the veins there has been extensive replacement of the wall rock with pyrite and sericite. On the north side of the valley the rocks have been highly mineralized with pyrite by impregnating ore solutions, not only in the vicinity of the veins, but everywhere. Hydrothermal decomposition of the pyrite has accompanied this. The leaching of the pyrite has caused the vivid colors seen on the peaks and talus slopes around Ophir. Some of the iron oxide has been redeposited in the iron spring on the floor of the valley in the form of bog iron ore.
Prospectors first entered this region in 1875, when locations were made on the Smuggler vein just east of Telluride. One ton of ore worth 2,000 dollars was shipped to the smelter at Alamosa. In 1878 shipments were first made from Ophir valley. The ores were exceedingly rich in silver. In the early days ore was carried out on mules, and had to be very rich to be profitable. Yet 50,000 dollars worth of ore was packed out during the first four years of Ophir's existence.

Two Spanish arrastres were built at Ophir in 1879, and some of the ore was milled there.

The Alta and Palmyra were located and worked in 1881. These veins, now operated by one mining company, are the only ones in the vicinity of Ophir still working. Burchard, in his report for 1881 mentions the Alta and Palmyra as two of the most productive mines. He also says of the veins in the Iron Springs District, (those on Silver and Yellow Mountains), "The ore is high grade, although the veins are narrow, the widest being that of the Osceola Mine." In his report for 1882, Burchard mentions locations on the Gold King and Minnie Myrtle veins in Gold King Basin. The map presented with this report, Plate I, shows the position and limited extent of this network of veins in Gold King Basin.

The principle Ophir mines in operation in 1882 were the Summit, Tip Top, Lookout, Nevada, Carribean, Butler, Vulcan, Silver Bell, Tidal Wave, Magnolia, Mohawk, San Juan, Globe (Suffolk), and Osceola.

The production figures for that year were:
<table>
<thead>
<tr>
<th>Mine</th>
<th>Ore (short tons)</th>
<th>Silver (oz)</th>
<th>Gold value</th>
<th>Lead (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nevada</td>
<td>32,650</td>
<td>155,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silver Bell</td>
<td>16,800</td>
<td>67,300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carribeau</td>
<td>10,000</td>
<td>200,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summit</td>
<td>18,480</td>
<td>140,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lookout &amp; Tip Top</td>
<td>9,600</td>
<td>160,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mohawk</td>
<td>232</td>
<td>960</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Globe &amp; Suffolk</td>
<td>$910</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand View</td>
<td>3,600</td>
<td>2,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winnifred</td>
<td>300</td>
<td>2,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>2,800</td>
<td>$36</td>
<td>21,000</td>
<td></td>
</tr>
<tr>
<td>Tidal Wave</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pitkin</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butler</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sparrow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deadwood</td>
<td>2,100</td>
<td>12,600</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>716</strong></td>
<td><strong>96,562</strong></td>
<td><strong>$964</strong></td>
<td><strong>761,260</strong></td>
</tr>
</tbody>
</table>

In 1887 there were in Ophir three mills operating 60 stamps and an 80-stamp mill in the course of erection.

In his report for 1899, Hodges mentions that the Carribeau mine changed its operation from manual labor to machinery owned by a London company. At that time the mine was the chief producer of the valley, employing 100 men. It had a milling plant with 20 stamps. The net value of the ore was $30.75 per ton.

During 1890 an electric plant had been set up at the junction of the Howard Fork and San Miguel Rivers at the mouth of Ophir valley. Water power was used. For many years this plant supplied electricity to towns and mines as far away as Telluride and Ouray. In 1881 a railway had been built to Silverton from Durango, and ore from Ophir was packed on mules over Ophir Pass and shipped to Durango from Silverton. However in 1890 the Rio Grande Southern Railway
completed its line from Durango north through Ophir Loop, and from then on, ore was shipped from this station. This greatly stimulated development.

In his report for 1900, Hodges mentions conditions of several of the mines. The Globe-Suffolk Mining Company's property was one of the most developed and best equipped, but was in litigation at the time. At the time it had a 40 stamp mill with amalgamating appliances, and two Frue smelters. The Butterfly-Terrible group was progressing rapidly, and had a 30 stamp mill with Frue smelters.

The year 1901 saw increased development on the southwest side of the valley where the Terrible-Butterfly, Butterly, Silver Bell and Caribea were located.

In 1911 the two chief mines on the south side of the valley were the Carribean and the Silver Bell, both having mills. The Silver Bell mill had a capacity of 150 tons daily. It had 50 stamps, 20 Frue smelters, three winflays, one jig, and the necessary crushers. The Carribean mill had 50 stamps. Both operated on electric power from the Telluride Power Company. On Silver Mountain the most important mines were the Alta, Carbonero and the Calumet Telluride.

These early years saw the most extensive development in Ophir valley. Production was increasing and the mines brought public interest to the district. Ophir and the surrounding towns were thriving and overcrowded with miners.

During later years however, activity quieted down and mining continued without general notice. More mines were opened up. The Carbonero, Crown Point, Favorite, Lower Silver Tip, New Dominion were all brought subsequent to 1900, but most of the mines that exist in the valley today, whether caved or accessible were started in that first period before 1900. At one time even the Iron Spring was worked and the iron oxide shipped to the Alamosa smelter for use as a flux.

The mines were closed down for long periods only to open again. On the whole the most worked properties of the whole valley are the Alta System, the Suffolk, Carribean, Butterfly, Silver Bell and Carbenero. Today the only one
working is the Alta. The Butterfly worked up until 1941 when its mill burned down. Until recent years there were several large mills with aerial trams to the mines, but the Alta mill is the only one working now. The destroyed mills and the cables of the tram lines of the Carribean, Suffolk, Favorite, Silver Bell, and Schumaker may still be seen.
EXPLANATION OF PLATE I

The large map accompanying this report shows only the generalized areal geology and the economic geology treated in this paper. Topographic maps of the United States Geological Survey should be consulted for the geography and topography of Ophir valley.

The igneous geology, shown in green, was taken from the Geologic Atlas of the area published in 1902. The work was done by C.W. Cross and C.W. Furrington. The igneous-sedimentary contacts were mapped by them to a scale of 1:62,500, and are only approximate. Wherever their work does not check with the geology as observed by our field party, I have indicated the doubtful contacts with dotted lines. Dotted igneous contacts intersecting and surrounding mine workings are those that were observed underground. The classification of the igneous rocks, and the geology of the metamorphosed sediments was also taken from C.W. Cross.

The mine shown on the map are those that were mapped. Many of the larger and older ones were inaccessible, and only their portals and elevations are shown. The red lines indicate veins, and where these lines are solid the veins have been drifted or stope on.
DESCRIPTIONS OF THE ORE DEPOSITS

Because of the lack of time to cover the subject completely, only four mines have been studied thoroughly. These are the Alta, the Silver Bell, and the upper and lower Silver Tip mines. The others are only mentioned briefly, and are shown on Plate I.

There are three types of ore deposits in Ophir valley: lode veins, replaced beds, and pegmatitic pipes. The lode veins are most important and include most all of the mines in the area. Replaced beds have been found at three places each a great distance from the other. These will be discussed only in connection with the Crown Point mine, but all are shown on Plate I and all are of the same character. One pegmatitic pipe was investigated, but it is not discussed at all. It is a pipe of massive and crystallized quartz and molybdenite. The molybdenite occurs as large flakes and crystals on and in the quartz. Inclusions of molybdenite in quartz crystals are common.

The pipes and replaced beds will not be discussed independently because they are the least important, and only four examples of the lode veins are discussed.

BASE METAL VEINS

THE ALTA MINE

LOCATION

The Alta mine, and mining camp are on the west side of Silver Mountain, at the western extremity of the ridge that separates the Gold King Basin from the Alta Basin. Most of the mine workings, however, are under the more central points of the mountain, and the vein outcrops are high on the same mountain, and
the vein outcrops are high on the same mountain. The altitude of the Alta camp is just 11,000 feet. The mine is approached by a road from Ophir Loop. An aerial tram transports the concentrated ore from the mine to this shipping point. In previous days tram lines connected the mill at Alta with higher workings in each of the two basins, but these are now destroyed.

History

Mining operations have carried on in these basins since before 1880. Then, there were many mines operating under separate management. Those mentioned in early reports are the Alta, Palmyra, Gold King, and Minnie Myrtle, Tip Top, and Saint Louis.

In his report for 1882, Burchard describes some of these properties.

"The Gold King vein has a 4 feet pay streak of ore averaging $60 per ton in gold after milling.

"The Minnie Myrtle has 250 feet of development. Ores carry both gold and silver. In 1880 owners erected a 10 stamp mill with runners. Ore is trammed to the mill, 2,600 feet away. Mines are high on the Mountain." Doubtless these workings were much above the present 8th level of the Alta Mine.

"The Alta belongs to the Silver Mountain Mining Company which has been developing it since 1881. The present work consists of three levels aggregating 700 feet. The ore is gray copper and sulphuret which is found in streaks and pockets."

These properties have since become consolidated under the Alta Mining Company.

Both basins are literally filled with old workings, but most of these are now abandoned and caved. All the veins being worked are reached by a long tunnel from the Alto camp and mill. The company maintains an employment
of from 50 to 80 men in normal times

DEVELOPMENT

As can be seen on Plate I, the Gold King Basin contains a great many veins which branch and interlock. The eighth level of the mine which connects with the mill and mining camp, is the lowest and main haulage level. It starts in landslide well below the basin and extends for over a mile to the present workings. Ores are trammed along this level to the mill, and after being concentrated are carried by aerial tram down the mountain to Ophir Loop where they are loaded into cars and shipped. This tramway is the only one operating in the valley at the present time.

Only two veins are being worked now, the Alta and Palmyra. They are both approached by means of the 8th level tunnel, which splits a little less than half way in one branch going to each vein. Both of these veins are parallel in strike and dip, and are mineralogically similar.

The Alta vein has been worked for more than 1,500 feet along the strike of the 8th level, and stopes have been extended up beyond the 4th level. These levels are more than 100 feet apart vertically.

The Palmyra vein has seen the least development having been driven less than 1,000 feet along its strike and 100 feet along its dip.

The ore is blocked out by raises and drifts, and mined by underhand and overhand staving. It is dropped down chutes and loaded into cars on the 8th level.

No map of the mine accompanies this paper, and cross sections were taken at only a few places. The information present is by no means complete, and only a very general idea can be drawn of the vein structure and texture. However, on Plate I the network of Alta veins is shown without the corresponding workings. These veins are only the largest and most productive. There are many smaller seams and fractures.
GENERAL GEOLOGY OF THE WORKINGS

The part of the mine investigated was driven into only two formations. The landslide that covers the whole lower part of Silver Mountain on the west of the San Juan tuff. Approximately ½ mile from the portal, and just beyond the place where the tunnel splits, one going to Palmyra and one to the Alta, is the contact between the landslips and the San Juan breccia. The San Juan tuff is very thick at this point as the total vertical extent of the present workings, some 800 feet, is driven only in the tuff. The veins, however, extend on up through the volcanics, and their outcrops are found high on the mountain. The tuff has been indurated, and metamorphosed by subsequent intrusions. In the workings the tuff is a dark green color, and has been extensively silicified and pyritized by the ore forming solutions. At most places along the walls of the drifts it is recognized only with difficulty, unless one can see the particles of breccia.

The pyrite is well distributed throughout both the dike and tuff. The particles are small and generally anhedral. The pyritization has extended for great distances from the intrusions, and can be found miles away.

The silicification was most intense closest to the veins. The country rock has been indurated and bleached white by this action. Late quartz is in the vein.

Also in the veins are streaks and wide zones of kaolin, presumably having altered from the feldspar in the tuff and dike.

The tuff has been faulted and intruded by dike. Although displacements are very difficult to discern because of the homogeneity of the breccia. The veins themselves follow fault planes and shear zones. At one place on the 8th level a lateral displacement was made noticeable by the presence of a dip that was displaced about 20 feet.

The veins also seem to follow almost vertical dikes in places. This is
especially true of the Alta vein where three separate green dikes generally follow the vein zone along its strike. It might be suggested that in places the veins have followed planes of weakness along the dike-breccia contacts where displacement or faulting was altogether absent. It might also be true that some faulting took place along these dike contacts merely because there were weak places present. However, there is no evidence presented in this paper to prove anything conclusively. It is very difficult, in places, to tell the difference between the tuff and the dike rocks, as they have both been attached by altering solutions. The dikes range in texture from aphanitic to phaneritic porphyritic.

DESCRIPTION OF DEPOSITS

Fissure Systems

Following the map it can be seen that there are two general sets of veins in the Gold King and Palmyra Basins. The ore minerals found in these veins are galena, sphalerite, tetrahedrite, chalcocite, chalcopyrite. The gangue minerals are quartz, clay, barite, siderite, dolomite, manganosiderite, and calcite.

One set, having only three well defined representatives, strikes roughly N 45° E with variations. The veins are the Minnie Myrtle, Crown Jewel, and Tip Top. Each one curves along its strike. The tip top curves to the east, while the other two curve to the north. There is no horse tail structure, and no series of closely-spaced parallel veins. Each vein being separated from the other by about 1000 feet.

The other set varies in strike from N 30° W to N 80° W and is decidedly different from the other. Here is a well developed horsetail structure on the southeast end of the veins. The veins split into a number of parallel, closely spaced fissures. The faulting was evidently more severe in this set because of the greater number of veins. It would seem to be more of a shattering effect because of the horsetail structure and the veins that intersect and join.
The Palmyra and Saint Louis veins are about 150 feet apart. The Saint Louis has two splits off of it that join together and run into the Palmyra. The Hancock has two smaller splits off of it, and itself joins with several veins at one place. The Missouri Girl is one of these splits, and itself has three other veins splitting off of it. The Alta consists of two parallel veins, both having several splits. The Statesburg is one of these.

Although there is not much conclusive evidence it would seem from looking at the map that the N W - S E set was the earlier. The other set seems to have displaced some of the veins; the Tip Top cutting the Alta is a good example.

Vein junctions are present here to a great degree and should contain ore shoots but I know of none that been explored by mining. At one place the Saint Louis, Arlington, Hancock, Tip Top, and one other vein intersect at one point. Such an intersection would form an excellent passage for ore bearing solutions. The intersection or junction of two veins is a very common thing in this network, and at many places, three or more join.

Another feature to note is the great lateral and vertical extent of the veins. Where they intersect the surface they form deep "guts" in the volcanics. These guts are easily picked out and may be followed for miles across the country. A vertical extent of over 2,000 feet is known to exist, and it is probably even greater. The outcrop of the Crown Jewel crosses Silver Mountain, almost at its top, above 13,000 feet, and the eighth level of the mine is only 11,000 feet. The veins show no signs of bottoming with depth.

If the veins change in width as they go from one type of rock to another, it is not too evident in the mine. Most of the workings are in the San Juan tuff, and the veins follow the dikes instead of crossing them.

Vein Structure (cross sections)

Cross sections of the Alta vein.

X-A This cross section was taken on the eighth level of the Alta vein, in
the vicinity of station 67. Here the vein is following a bleached, altered dike. The dike itself has been fissured and brecciated. This is not just one clear cut vein. There are a whole series of parallel smaller fractures, the innermost ones carrying the greater mineralization. Quartz and clay are prevalent in the outside ones. The Alta vein at this point is a banded zone of small fissures.

I-B This section is 40 feet breastward of station 65 on the eighth level of the Alta vein.

Here the vein is a single, well defined, filled fissure with sharp contacts. The small quartz fissure on the south is the only trace of any braiding of veins. Station 65 is only a few hundred feet from station 67, so this shows the amount of vein variation possible in a short distance.

I-C This section is 23 feet breastward of station 65 on the eighth level of the Alta vein. Here the vein follows the contact between the dike and San Juan tuff. It has been lagged so it could not be studied in detail, but the branching of the fissures on the north wall is indicative of the character of the rest of the vein. I can offer no explanation for entirely different character of fissures immediately adjacent to each other, other than the possibility that the least mineralized fissures were more choked with clay and breccia when the ore solutions entered.

I-D This section is at station A-1 on the 1943 United States Geological Survey map of the sixth level of the Alta vein.

Here again the vein is in dike, and may be following the dike-tuff contact as before. Although it is not too well developed, this section shows a tendency toward a banded zone of parallel veins. Also the innermost vein shows the most mineralization probably because it was more open than the others. This situation is typical of the larger veins in this area. They are all a series
of closely spaced fissures both parallel and braided. Usually they are termed "gash veins." The dip of the main fissure, or zone, is abnormally flat here.

I-E This section is breastwork of sixth level. Although no section is offered here a statement can be made as to the character of the vein. Again there is a whole zone of smaller fissures parallel and branching. As the breast is approached a series of short, parallel fissures is encountered. As one dies out, another takes up almost immediately to the south, or footwall side of the drift. This may be either an unusual condition in the gash vein or may be caused by tension fissuring. However at the breast everything dies out, and

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It is well to mention here that the dip of the vein on the whole sixth level of this vein is considerably flatter than that on the eighth level.

I-F Section at the 1943 breast of eighth level of the Alta vein.

Here, the vein is in or following the dikes, and is a single vein rather than a zone of smaller ones. The richest mineralization is in the middle while the outside is thick with clay and breccia.

Cross sections on the Palmyra vein.

II-A Section at breast of eighth level of Palmyra vein.

The vein is following the dike-breccia contact, and appears to be a large brecciated zone rather than a single well defined fissure. The dike on either side of the main part of the vein is bleached and silicified to an extreme extent. Here is a remarkable similarity between this vein and some parts of the Alta. Both veins follow dikes of the same character. The situation of the two parallel clay streaks on each side of the drift, and the diagonal main veins may be evidence of tension fissuring on a large scale.
II-B  This is the section at station B-61 + 150 on the United States Geological Survey map of eighth level of Palmyra vein. The vein is still following the breccia-dike contact, and the richest base metal zone is right up against the tuff. The two to three feet of clay possibly came from the alteration of the dike. This would indicate that the dike altered more readily that the tuff. The three inch streak in the footwall should be noticed. This once joined with the one in the hanging wall, and may be more evidence of tension fissuring.

II-D  This is a section of part of the vein in the stope above the eighth level of the Palmyra vein. The vein dips to the north, and is entirely in the dike. The vein is banded, and in two bands are base metal sulfides deposited simultaneously with the barite. The quartz is possibly late quartz deposited after everything else in the center of the vein.

It is well to mention here that although the Alta and Palmyra veins are very similar structurally, they differ in their degree of mineralization. The Alta vein is much richer in concentrated base metal sulfides. It contains little clay and gangue, while in the Palmyra, clay and gangue are most common. Also in the Palmyra, there is a greater amount of siderite and manganosiderite in the gangue. There are very few sulfides in the Palmyra. The principal gangue minerals in both veins are quartz, siderite, barite, and clay.

Tension Fissuring.

This situation was first noticed on a small scale stope above the eighth level of the Palmyra vein. (see drawing) As can be seen from the section the mineralization jumps from one fissure to another. In the cross-section, vein "a" which has carried most of the mineralization up to this point suddenly pinches out, the mineralization being revived in fissure "b" which is just taking up. "a" and "b" are parallel. Smaller quartz and barite fissures can be seen, diagonally connecting the two larger fissures. The mineralizing solutions could have migrated along these smaller cracks.
In this instance the most logical explanation for this phenomenon is a shear movement which produced consequent tension fissures, (see drawing). As the movement was diagonal rather than strictly strike or dip, because evidences of the same thing have been noted in several places, and leads one to believe that there were a whole series of compound movements along many small planes, this would explain a wave movement along faults as it has been doing, the Saint Louis vein my be intersected. (see drawing)

The Saint Louis vein was lost, the dip of the Saint Louis vein is not apparent. The Saint Louis vein is not apparent. The Saint Louis vein is not apparent. The Saint Louis vein is not apparent. The Saint Louis vein is not apparent. The Saint Louis vein is not apparent. The Saint Louis vein is not apparent.

Boiling of Veins

It is also believed that if the necessary follows the trend of the mineralization along tension fissures as it has been done, the Saint Louis vein my be intersected. (see drawing)

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Boiling of Veins

In the St. Louis vein especially, it is noticed that the dip of the vein changes by related.

Rolling of Veins

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Boiling of Veins

In the St. Louis vein especially, it is noticed that the dip of the vein changes by related.
considerably, and that this change in dip is closely related to the richness of mineralization. Along the eighth level the dip is steep, from 60 to 65°, and the vein is very rich. On the sixth level it varies from 40 to 50°, and the vein is very poor. As one climbs the raises from the eighth level up, it is noticed that the vein rolls, flattening and steepening at a constant rate. The flat places are from 100 to 200 feet apart.

Sweetser 5/ in his article on the mines of Ophir mentions this as an indication of normal faulting, and W.H. Emmons 6/ in his paper on such vein behavior says it is the result of movement in only one direction along a fault plane in which several or many directions are represented. (see drawing) This differential movement results in certain very tight places followed by abnormally wide open spaces along both the strike and dip of veins. In normal faulting, as the vein rolls, the flat dips will be tight and the steep dips very wide. In reverse, or thrust faulting, the opposite would be the case. Emmons also states that a change of only 3° of dip with a corresponding displacement of only 20 feet will produce an opening 1.74 feet wide. This is evidently the situation existing in the Alta vein.

Although the drifts are sinuous passages, changing constantly in strike, changes of mineralization in relation to strike rolls are not so evident. Rolls have also been noticed in the Palmyra, but with no noticeable corresponding mineralogical changes.

Large Scale Faulting

From the foregoing data on the structure of veins it would seem that the faulting was not great. Of course displacements are difficult to find because of the homogeneous character of the wallrock. I would conclude that the faulting was
in a diagonal direction rather than along strike or dip because evidences of both have been found. The amount of movement was not great, and consisted of many differential movements along compound, shattered zones rather than ore well defined displacement. Thus the present veins are a conglomeration of small parallel and interlocking fissures.

Structural Control of Ore Deposition

As is the case with all the large mines in the valley, there is a definite zoned grouping of minerals related to the temperature and pressure of deposition and replacement. Although I do not have specimens from a wide vertical extent of the mine, the temperature-depth range can be shown by the presence of chalocite in the sixth level and its absence in the eighth level. Considerable calcsphalerite has been found in the higher levels while practically none is found in the lower levels. That there was zoned deposition indicates that the ore was deposited a considerable distance beneath the surface. It is an epithermal deposit, and much of the ore is hypogene, as indicated by the isometric character of the chalocite.

The nearest intrusion to the Alta mine is the monzonite-diorite batholith found on Mt. Ophir to the south. It is my opinion that these veins are related to it as it is the probable source of the ore-bearing solutions.
THE SILVER BELL MINE

LOCATION AND HISTORY

The Silver Bell Mine is on the south side of Ophir valley at its mouth. On this south side Yellow Mountain, followed to the west, grades into Hogback Ridge. This ridge ends rather abruptly at the San Miguel River. The mine is almost at the end of this ridge. The mill is in Ophir Loop, and the higher levels of the mine overlook the town.

Although the exact date of location is unknown, the mine was being worked as early as 1882. In these early years it is mentioned in statistics as being one of Ophir's leading producers of silver. Sweetser, in 1911 mentioned this mine in his short article on Ophir. At that time it had a mill of 150 tons daily capacity. The mill consisted of 50 stamps, 20 Freer wackers, three Wilfleys, one jig, and the necessary crushers. This mine has always used electric power generated by the Telluride Power Company. The Silver Bell was, without a doubt, one of the leading producers in the whole area, but at the present time it is abandoned and in very poor condition.

The survey and investigation of this mine was not complete because of the inaccessibility of the workings. In order to study the subsurface geology completely a single map should be had covering, in addition to the Silver Bell, the Terrible and Butterfly. Such a map does exist of the workings, but it was impossible to log all of them because of their caved conditions. The map that accompanies this report is of only the mill level of the Silver Bell. Great parts of it are caved, and the amount of workings shown is in no way commensurate with the total distance of workings in that end of Yellow Mountain. The information obtained can only furnish a vague indication of the conditions that really exist. Samples were taken only at a few places through-
out the mine, and on the dump. Most of these represent poor values because
the richer areas have been mined out. The samples give a general idea of
what minerals are present and their paragenesis.

DESCRIPTION OF THE WORKINGS

Mill Level

This is the general haulage level for the mine, and is driven at the
same elevation as the mill in the bottom of the valley. It consists of the
Whitehead tunnel, 2865 feet long, and drifts on the Butler and Ida veins
which have been intersected. Both veins have been worked extensively.
Plate III shows the present extent of this level. It is undoubtedly much
larger than shown, but numerous cave-ins make part of it inaccessible.
The tunnel strikes generally S 17° E throughout its whole length. At
1,401 feet it intersects an east-west striking vein, and drifts have been
extended for 35 feet on each side.

At 1,720 feet it intersects the Butler vein, which strikes roughly
N 70° W. This was the principle vein worked, and both east and west drifts
are extensive. The west drift is saved 180 feet from the tunnel, but the
east drift is in good condition, and goes for 302 feet before it splits into
two workings and stops. All of the west drift and 50 feet of the east drift have
been stoped. Because of unsafe conditions no attempt was made to investigate
the stopes. The west drift, as far as investigated, and the first 150 feet
of the east drift are very straight, and have a well defined vein system.
The greater part of the east drift is very sinuous. It weaves back and forth,
almost constantly changing strike, with branching and rejoining passages.
Evidently it was driven for exploration purposes.

At 2,345 feet the Ida vein is intersected. There is a manway on the west
side of the tunnel. A drift and raise are seen to begin on the east side,
but the ground is soft and everything is caved. The tunnel ends in solid, very sound, rock at 2990 feet.

Sixth Level

The relation of the sixth level portal to the mill and Whitehead tunnel can be seen on Plate I. Although this is probably the most extensive level in the mine, it was not investigated because it is caved 132 feet from the portal. At the portal there are abandoned living quarters and an old aerial tram by which ores were transported to the mill 800 feet below. The slope of Hogback Ridge is very steep here, and the dump extends over half way down the mountain. The portal is in an unweathered, solid cliff. The tunnel trends south-southwest in a straight line for 732 feet, until it intersects the Butler vein. The ground at the vein is extremely soft, and everything is caved.

Fifth Level

The portal of the fifth level is 200 to 300 feet above that of the sixth level, and slightly to the west. This level is probably the oldest of the mine. Hardly any dump is noticeable. The tunnel extends generally south for 150 feet, until it intersects the Butler vein and is completely caved. The ore found on the dump is greatly oxidized.

GEOLaOY OF THE MINE

Hogback Ridge

The west end of Hogback Ridge is a continuation of the same monzonitic intrusion found in the Ophir Needles. Metamorphosed sediments of the Dolores formation are found at the bottom of the valley, turned up against the intrusion in the same manner as those across the valley. Also there is a sedimentary pendant surrounded on all sides by intrusion. The greater part
of the mountain, however, is made up of igneous rocks of two types. One is a coarse grained diorite-monzonite, and the other is a fine grained gabbro-diorite. Contacts between the two are sharp. Either two different intrusions or two different cooling stages of the same intrusion are represented. These same two types of rock are found on the north side of the valley. There is some argument as to which is the older; since the fine seems to intrude the coarse in the Silver Bell, and on the other side of the valley evidence is found of the coarse intruding the fine. These igneous rocks are also found in the Terrible and Butterfly properties.

The Sediments

The sediments present are believed to be those of the Dolores formation, although they are so metamorphosed it is hard to recognize them. They consist of quartzites and hard marbles that dip steeply to the west. They have been roughly correlated with the sediments contacting the west side of the Ophir Needles to the north.

All the rocks have been silicified to some extent. Some marbles have been affected to such a degree that it is impossible to scratch them with a steel instrument. Such rocks were found at many places in the valley, and were termed "calc-silicates." Much of the rock has been bleached by these processes. The greater part of the sediments have also been pyritized, and well developed pyrite crystals are common. The quartzites seem to be affected more than the marbles.

The sedimentary pendant, previously mentioned is interesting, but complicated. Its structure seems to be that of a wedge pinching out with depth, and completely surrounded by intrusion. Its general outline can be seen on Plate I, and a tentative block diagram is included in the report.
(see diagram). It is noticed that the contacts on both sides of the pendent dip toward each other, thus the amount of sediment decreases with depth. In the Whiteshead tunnel the pendent with the dipping contacts is found near the portal. The portal itself is in coarse intrusion. The coarse intrusion-sedimentary contact is found 115 feet in, and the fine intrusion-sedimentary contact is found 539 feet in. This 524 feet of tunnel is the only place in the whole mine where sedimentary rocks are found.

The Intrusions

Both kinds of igneous rocks have been altered in about the same way, and with the same results. When not in the vicinity of the veins or small fissures it is very hard and fresh, but in and near the veins it is extremely weak and soft. It would seem that when once altering solutions found access to the rock it altered very rapidly. The weathered product is mostly clay, and is indicative of the high feldspar content of the rock. For great distances from the veins the wallrock has been heavily pyritized. The grains of pyrite are very small, and are apparently anhedral.

The igneous-sedimentary relations in the early portion of the tunnel have already been mentioned. The fine intrusion is first found 659 feet from the portal, and persists for 1,216 feet where, at station 16+55 there is a contact with the coarse intrusion. At this point there seems to be an irregularity or wave in the contact. It is found three times in the east wall, and only once in the west wall. This same contact is also found at station 22+53 in the east drift of the Butler vein. From this station to the breast of the east drift, coarse intrusion persists. Also in the main tunnel coarse intrusion persists from station 16+55 to the breast at station 28+65. Thus, as shown on the map, the fine intrusion is surrounded by the coarse, and this relation tends to indicate that the coarse was intruded by the fine. The fine-coarse contact has been found in the Butterfly mine, and its general trend there supports this view. The fine intrusion forms a small, oval
shaped body surrounded almost completely by the coarse. Wherever noticed, the contact dips away from the center of this oval. However, the opposite case could be possible, and is supported by evidence of coarse intruding fine in the Ophir Needles. The explanation for this would be that the coarse intruded along the lines of weakness at the previously existing sedimentary-fine intrusion contact. Stepping of the sediments would furnish the space now occupied by the coarse intrusion. This would also explain the presence of the huge sedimentary wedge found between the coarse and fine intrusion. At this particular point the sediments were either too strong, or the intrusion followed an already existing fracture in the sediments themselves.

The behavior of fractures in the two kinds of igneous rocks bears on the richness of the veins. As a general rule, the veins are wider and richer in the fine intrusion. Evidence of this is very prevalent. The greater part of the Butler vein is in the fine intrusion, and from the size and extent of the workings the ore was very good. Even the small stringers, still to be seen, are rich in sulfide minerals. However, the veins immediately tighten up and become poor as they enter the coarse rock. The Ida vein is in the coarse rock, and where investigated it contained almost no sulfide minerals.

Faulting

As in the Alta mine, faulting here is difficult to follow because of the homogenous character of the rock. Undoubtedly there was faulting, which caused the open fractures and eventually the veins. The Whitehead tunnel is driven along the most noticeable fault in the mine. The tunnel follows a clay and gouge zone with sharp contacts from the portal to station 14401, where it runs out in the east wall. Displacements of about two feet horizontally were observed on two small veins crossing the tunnel. The fault seems to die out before the Butler vein is reached because no displacement is noticed on that vein. This fault is certainly younger than both intrusions, and is probably older than the fault producing the Butler vein.
DESCRIPTION OF THE DEPOSITS

The Mill Level

Fissure Systems

The most prominent fissure system has many components which strike generally a very few degrees north of west. This system carries the best mineral values. Because of the length of the tunnel and drifts, and the large number of fissures belonging to this system, they will not be discussed individually. They occur in definite zones, the center of each zone being a large vein such as the Butler or the Ida.

The first of these zones is found between stations 11-59 and 14-53. In this area there are four fissures about evenly spaced, and varying in thickness from two inches to one foot. None are parallel, and the strike of one is even southeast instead of west-northwest. The outer veins both dip to the south; while one inner vein is vertical, and the other dips to the north. These fissures are spaced from 50 to 100 feet apart. The two outer veins carry only clay and pyrite with some quartz, but the two inner fissures carry considerable amounts of carbonate and sulfide minerals.

The second zone of west-northwest fissures has the Butler vein for its center, and ranges from station 15-68 to station 17-40. All of the fissures here are heavily mineralized. They have an average spacing of 35 feet, the maximum being 50 feet. The strike in nearly the same for all except the northernmost which strikes southeast-northwest. There are four small veins on the north side of the Butler, and only one on the south side, so that the Butler itself is not in the center of the zone. On the north side all dip to the north except one which is vertical. The Butler and the fissure to the south of it both dip to the south. Dips vary from 45 to 90 degrees.

The mineralization is about the same in every case, and consists of quartz,
pyrite, and barite principally, but with smaller amounts of galena, chalcocite, tetrahedrite, chalcopyrite, and sphalerite. The northernmost fissure carries small amounts of hubnerite.

The third zone is found in the coarse intrusion between stations 21+63 and 23+45, with the Ida vein as its main fissure. Here also, all the smaller fissures are concentrated on the north side of the Ida vein. The Ida is the last fissure south. A prominent set of fissures around station 21+63 dips from 63 to 80 degrees to the south, but the Ida and surrounding fissures are all vertical or dip slightly to the north.

A fourth zone of small veins is found at the extreme end of the tunnel between station 26+91 and the breast. In this area the coarse intrusion is very fresh, and water pours in streams from open holes in the fissures. Five fissures are prominent, dipping at various angles to both the north and south. Their average spacing is about 50 feet. All are similar, and contain quartz, pyrite, and clay. It is possible that these fissures indicate another large vein, similar to the Butler and Ida, that is still ahead along the tunnel line.

The Butler Vein

The general location of this vein has already been described. Its trend and character can be observed on the map.

The character of the vein changes noticeably within the range of our observation. As can be seen on Plate III, west of station 18+70 the drift is straight, and the vein is a concise group of closely spaced, parallel fissures separated by small bands of altered intrusion. Undoubtedly the best mineral values came from farther west in the drift and stopes, where the vein is probably a single, large, and completely mineralized fissure. It cannot be a very great distance west of the tunnel that the vein begins to split into a horsetail structure, and it crosses the tunnel in a zone of seven individual fissures. It keeps it straight course for 150 feet, and
then the fissures begin to break-up more, changing constantly in dip and strike. This character can be seen from the twisting of the drift. Evidently none of the small fissures were good enough to permit stoping, and the drift was driven for exploration purposes. The fissures are practically never parallel, but join, part, intersect, and weave about very irregularly. At station 22-53 in the drift the vein leaves the fine monzonite and enters the coarse. From here on the breaking-up effect is greater than before. The vein is evidently dying out.

Where the dip of the vein is constant enough to mean anything, it is about 60° to the south. However, it immediately steepens in the stopes, indicating a roll.

The minerals found in the vein are the base metal sulfides typical of this area: galena, sphalerite, chalcopyrite, chalcocite, tetrahedrite, silver, some gold, pyrite, and many others. The gangue minerals are: pyrite, kaolin, manganosiderite, quartz, barite, calcite, dolomite, and others. Only in the west drift and in the vicinity of the tunnel are the base metal minerals found in any abundance. After the vein has broken up the fissures contain mostly quartz, clay, pyrite, and manganosiderite.

Cross Sections of the Butler Vein

X-I Section in the east wall of the Whitehead tunnel at the Butler vein. The actual vein width is exaggerated to show more detail, and is really only four feet wide. The parallel, individual fissures are shown, with the heaviest mineralization in the center. (see section)

X-II Section at breast of Butler vein in south split of east drift. Notice how the mineralization follows the footwall. The section shows the great extent of small-scale fissuring, and the general poor mineral occurrences. At this point the vein has lost considerable value. Also significant is the way the small fissures pinch out in very short distances.
Section at the breast of the north split of the east drift on the Butler

Although the headings of these two splits are not far apart, their
characters and dips are entirely different, this one being essentially ver-
tical. Notice the zone of altered intrusion on each side of the main, but
poorly mineralized, central fissure. The clay lenses may be "horses", or frag-
ments of intrusion confined in the vein, that have altered completely to
kaolin.

The Ida Vein

The Ida vein can be seen only in the tunnel itself because all of the
side workings are completely caved.

The character of the vein here is similar to that in the east drift of
the Butler. It is a large zone of many both regular and irregular fissures,
and all have poor mineralization. The center of the vein is a three-foot,
vertical fissure containing clay, quartz, and carbonates. The smaller fissures
on each side of it all dip toward the center.

It is possible that one of the greatest contributing factors to the
poor mineralization is that the country rock is coarse intrusion. Most of
the definite fissures are very tight.

On the east side of the tunnel at this point is the caved Ida raise.
The higher levels of this vein were worked extensively, and the ore was
dropped down this raise, loaded, and tramed to the mill. A caved manway is
found on the west side of the tunnel. The Ida raise is inaccessible from
any point at the present time.

Cross Sections of the Ida Vein

X-C Section of the west wall and part of back in the tunnel at the Ida vein.
(see drawing)

The Vein at Station 21+ 89

At station 21+ 89 is a ten-inch vein that strikes parallel to the Butler
vein, and dips 60 degrees to the south. It is banded in layers of different
minerals or rocks.

A cross section of this vein can be found at the back of this report. The drawing on the right shows the character of the whole vein in relation to the tunnel. Notice how the mineralization follows the footwall. The drawing on the left shows the finer relationships of the minerals and the banding of the vein. Very evident here is the occurrence of galena and sphalerite as islands in the barite. This is common in the mine, though well-shown here. The banding is very prominent and regular, though no evidence was found to explain the offset of the two quartz fissures at the right. This vein has been reopened several times after being filled, and new bands have been deposited. This reopening affect is probably the cause of much of the banding in the veins of this mine. The barite-base metal sulfide streak has been opened, and a band of late quartz has been deposited in its center.

The Sixth Level

Although the sixth level, from preexisting maps, is the most extensive, it was impossible to investigate it because of the caved portion in the vicinity of the Butler vein 752 feet from the portal. However, in this open distance the same zoned character of the fissures as found in the mill level was observed. I have assumed that the cavi-in is the approximate position of the main vein. As one progresses south toward the cavi-in the frequency and size of the clay and quartz streaks increases. Thus there would be a whole zone of fissures constituting a mineralized fault, with the Butler vein as its center or main component. There evidently has been some movement on the fault, but it is difficult to pick up because of the homogeneity of the rock.

The occurrence of hubnerite in the sixth level is one of the things commonly known about the Silver Bell mine. This is because tungsten is not common in the valley. It is said to occur in the upper part of the Ida raise, and what there is of it is fairly high grade. During the first World War a party paid between $1600.00 and $1800.00 for privileges to work this tungsten
area. Another lease recently worked the deposit, but with unknown results. The deposit is evidently a limited and unusual occurrence. It is considered a high temperature mineral in this case.

RELATION OF THE SILVER BELL TO OTHER MINES

Other Workings in the Silver Bell

Although parts of the mine are inaccessible there are generalized maps of these parts. The west drift on the mill level of the Butler extends a great distance, and may connect with the Butterfly workings on the same vein. On the sixth level there are drifts on both the Ida and Butler veins, which also may connect with the Butterfly.

The Butterfly Mine

The positions of the portals of this mine, and the trend of the veins is shown on Plate I. The mine is on the very end of Hogback Ridge. The mine was only entered twice, and just a few of the workings were investigated. There are four levels to the mine, but two, the mill level and the third level, are most important. The Ida and Butler, and several other veins have been worked. The contact between the fine and coarse intrusion was found in the third and mill levels, trending in an east-west direction. The mine is driven entirely into intrusive rock. The mineralization is similar to that of the Silver Bell.

The Terrible Mine

The Terrible mine is on the north side of Hogback Ridge, just west of the Silver Bell workings. Its only connection with the surface is a short tunnel at approximately the same elevation as the outcrop of the Butler vein on the surface. The mine has been abandoned for years, and the dump, deposited on a 70 degree slope, has long since broken away and rolled down the mountain. The tunnel is driven 40 feet into the mountain where it opens into a large
room with a double shaft in its center. The shaft has been sunk on the
Butler vein to a depth of 400 or 500 feet, but it is inaccessible. The
vein can be clearly seen on the sides of the shaft, and is a composite, two-
foot, banded vein of oxidized ore. It dips about 75 degrees to the south.
No specimens were taken. It was seen on an old map that the Butterfly and Terri
Terrible workings overlap, but whether they connect or not is unknown.

The Butler Outcrop

At a position and elevation indicated on Plate I, the Butler outcrop has
been trenched for some distance along its strike. Oxidized ore is prevalent.

STRUCTURAL CONTROL OF ORE DEPOSITION

The Butler has been followed from its outcrop, almost on top of the ridge,
to the floor of the valley, some 2,000 feet. In this distance several varia-
tions were noted. The ore is clearly oxidized on the surface, the copper
carbonates being plentiful. Lower, in the upper workings of the Silver Bell,
it is passing from the oxidized to the enriched supergene zone. This is where
the most extensive mining has taken place. In the mill level there are
signs of it passing into the hypogene zone, as noted by the presence of
specular hematite.

It is evident that the vein rolls several times in this distance, and
it is never constant in either dip or strike. There has evidently been
some movement along the fault plane, but the amount or direction is not known.

A significant fact, noted in the Butler vein but also true of most of the
other base metal veins in the area, is that the mineralization follows the
footwall.

The ore deposits of Hogback Ridge are considered to be epithermal. The
presence of high temperature minerals such as hubnerite and specular hem-
atite are probably due to local conditions and the nearness to the intrusion,
rather than to the depth of deposition.
THE BADGER MINE

LOCATION AND HISTORY

The Badger mine is on the floor of the valley, about 300 yards west of Ophir. Its exact location is shown on Plate I.

The property was worked in the early part of the 20th century, and was mentioned in several of the early reports. In 1911, Sweetser mentioned the Badger vein on Silver Mountain as being a gold-quartz vein, though the vein may have been worked higher on the mountain at the time.

The tunnel was started at the foot of Mount Silver with the intention of intersecting all of the veins found at higher elevations, for exploration purposes. This would not only prove the ore deposits, but would make mining operations much simpler. The tunnel was still being driven as late as two years ago, but the prohibitive cost of $31.00 per foot caused a shutdown. The mine is in better condition than any other idle property in the valley, and all parts are accessible. The investigation carried out was complete, though not extensive. No ore specimens were collected.

DESCRIPTION OF THE WORKINGS

Plate II is a map of the Badger tunnel and its respective drifts.

GEOLoGY OF THE MINE

The first 150 feet of the tunnel is driven into the coarse monzonitic intrusion previously mentioned. The vertical contact can be seen on Plate II. The position of the contact in the mine throws light on the nature of the whole eastern end of the intrusion, and helps prove that the north side of the valley is right on the edge of it. Therefore, the veins related to this intrusion are concentrated in the edges and around the outside of it. The middle part is somewhat barren.
The rest of the tunnel is driven into metamorphosed sediments, consisting of silicified marbles and quartzites. All of the sediments are pyritized. The sediments strike to the north, and dip about 18 degrees to the west. The sedimentary-igneous contact is chilled, and the sediments have not been upturned or deformed in any way by the intrusion. This suggests a stoping action by the magma. The metamorphosed sediments are rather thinly bedded, and individual members only one or two feet thick can be seen. In the back of the stopes, 65 feet above the level of the tunnel, is a bed of metamorphosed conglomeratic sandstone. All the sediments have been silicified and pyritized, and where not fresh considerable amounts of limonite and clay are found.

DESCRIPTION OF THE DEPOSITS

Both base metal and gold-quartz veins were intersected and worked in the tunnel. The gold veins outnumber the lead-zinc veins. Four sets of fissures of the same general strike are found in the mine, with a total of 13 veins in a distance of 2119 feet.

The first set, striking east-west, and having three examples, is found in the first 845 feet of the tunnel. Two occur within 25 feet of each other. The dip of each is different, and all are gold-quartz-pyrite veins.

The second set strikes a few degrees west of north, and all members consist of quartz-pyrite fissures. There are three good examples, and each tends to fissure and split up into smaller veins. They all dip to the west. One joins into an east-west trending vein.

Another set strikes N 60° W, with dips both to the north and south. All are small quartz-pyrite veins. There are three good examples.

The last set strikes N 60° E, and dips to the south. There is only one example of this type; but it is the largest vein in the mine, and is the only base metal vein. At the east end of the vein it is a quartz vein only one inch wide, but at the western end it is a whole zone of small parallel fissures filled with quartz, pyrite, and base metal sulfides.


EVALUATIONS

The one important observation seems to be that the gold veins do not maintain their richness with depth. Of course, no sampling or assaying was done to actually determine values, but the amount and kind of work done in a mine is a good indication of what was in it. In this case the base metal vein was the only one stopeed. At other intersections either small amounts, or no work was done. It was the prohibitive cost of operation that caused mining to stop, and if good gold values had been present the cost of operation might have been reduced enough to continue tunneling.
NEW DOMINION MINE

This mine was inaccessible at the time of investigation because of bad air, so only a few words can be said about it.

Plate IV is a map of the mine workings, which shows the trend of the two veins drifted on. Both are base metal veins having an east-west trend.

All the information about the mine contained in this report was obtained on the dump of the mine. It is evidently driven almost entirely into a bleached silicified, and pyritized quartzite. However, one member of the party found a contact with a coarse monzonite in the tunnel just before the air became too bad.

Very good specimens and crystals of pyrite, chalcopyrite, quartz, and sphalerite can be found at the dump. The pyrite occurs in large, perfect cubes and pyritahedrons in the quartzite, as a result of a selective replacement of the wall rock. The sphalerite, quartz, and chalcopyrite, comprise the ore. Sphalerite is found in vugs in the quartz, in very good isometric crystals. Very little galena is present. Molybdenite in very small seems occurs sparingly on the dump.
FAVORITE MINE

This mine was not entered, and there is no map available of its workings, but at the time of investigation it was being worked by a local resident of the valley.

The Favorite is one of the oldest mines in the valley, and is mentioned in several early reports. It produced enough to warrant the construction of a mill in the town of Ophir, and an aerial tram from the mill to the mine. Both are now in ruins.

One specimen of supposedly high-grade ore, was obtained from the man working the property. From this ore sample of solid steel galena, it seems that the deposit is a base metal vein.
SILVER TIP MINE

The lower Silver Tip mine, sometimes referred to as the Yellow Jacket, is one of the most recent mines in Ophir valley. Although it was driven on a vein that has been long known, It is a small gold property owned and operated by a private individual. It is in the upper part of the valley on its north side.

The mine is not being worked at the present time, but operations were only recently stopped. No production figures are available.

The portal of the mine is almost on the floor of the valley. Its tunnel is driven north-northeast for 400 feet in the north side of the valley. At this point it intersects a vein that strikes north-northeast. This vein has been drifted on for 300 feet.

The mine is interesting from the viewpoint of vein dip and structure. The upper Silver Tip mine is only a few hundred feet northeast of the mine in mention, and the two should really be considered together. The upper Silver Tip, higher on the slope, was driven before the turn of the century, and proved to have very good gold values. The northeast striking vein was stoped to some extent. The lower Silver Tip mine was driven with the intention of intersecting the same vein worked on in the upper Silver Tip. The veins on both mines have the same strike and dip, but have a slightly different character, there being more base metal sulfides in the lower one. The upper vein seems to have little sulfide, although this is not positive because the stopes in the upper mine were not investigated. From the dip and position of the veins on the mine map it is very possible that the two veins are the same. This conclusion is based on a Brunton compass survey.

The mine is driven almost completely in a white quartzite that may be a part of the Dolores formation. The tunnel intersects a green porphyritic dike.
striking northeast, at 305 feet. An intrusion is found in the drift, extending along it for 45 feet from station 6+53. The intrusion strikes northeast, and may be a large dike or a small boss. This intrusion is also green and slightly porphyritic, but of a different texture than the dike found in the tunnel. The quartzite and intrusives throughout the mine have been heavily silicified and pyritized, and near the veins the rocks have been weakened by alteration and leaching. The pyrite occurs generally in small grains, sometimes crystals, scattered evenly throughout the rock. There is a heavy flow of water in the mine, which seeps in from the higher parts of the hill. This circulating ground water has leached much of the pyrite, and deposited limonite on the walls of the drift. Limonite encrustations on the walls are as much as a foot thick. Much of it is carried out of both the upper and lower Silver Tip mines and deposited in the noted Iron Spring on the floor of the valley. These two mines are the principle source of water and material entering the Spring at the present time.

Much of the quartzite is difficult to recognize because of silicification.

There seems to be a definite distribution of minerals in the mine. Minerals found on the dump, where they are best seen, are molybdenite, molybdate, hubnerite, pyrite, galena, chalcocite, chalcopyrite, malachite, and azurite.

The molybdenite, as seen on the dump, and in the mine, occurs in thin seams and veinlets, and as very thin layers on joint faces. The hubnerite occurs in the same way, but is not as abundant. There are only small amounts of both, and no concentrated amount occurs in any one place.

DESCRIPTION OF VEINS

Fissure Systems

There seems to be two general fissure systems shown in this mine. They vary both in strike and mineralization.
The most prominent set of fissures strikes generally northeast, having minor variations. The best example of this is the Silver Tip vein itself, striking generally N 61° E, and dipping 74° to the north. It is a quartz pyrite vein containing scattered base metal sulfides. Quartz and pyrite are most abundant. The quartz is both massive and vuggy. Pyrite is very common both in the veins and in the country rock which has been pyritized for some distance on either side of the vein. Small amounts of galena and sphalerite occur more as irregular islands in the gangue, and not so much in filled fissures. They are found in quartz and calcite. The Silver Tip vein averages two inches to one foot in width in the quartzite, but pinches to one-half in the intrusion in the drift. Much of the sulfides in the vein have been stained by chalcedony. Neither the dip or the strike of the vein are constant; they weave and roll.

Other representatives of this fissure system are found in the tunnel. It must be remembered, however, that only the fractures and veins carrying some mineralization were mapped. To make the data complete all joint planes and barren fissures should have been recorded. One hundred feet from the portal a small veinlet strikes N 80° E, dipping 73 degrees north. It is one-half inch wide and carries concentrated pyrite, molybdenite, and enargite. Two hundred and three feet from the portal a second veinlet strikes N 80° E, and is almost vertical. It is one-fourth inch wide and carries principally molybdenite. The third veinlet is 290 feet from the portal, striking N 42° E, and is vertical. It contains one-half inch of pyrite coated with supergene chalcosite.

The small size of these veinlets and their limited degree of mineralization suggests that they might be components of a joint system rather than fractures along which there has been considerable movement.

The second fissure system strikes generally west-north. These fissures are also very small, are widely spaced, and carry much less mineralization than the other set. There are only two good examples of this set in the mine, and
and both are found in the tunnel.

The first is 335 feet from the portal and is a breccia or crush zone rather than a single fissure. It strikes N76°W, and is practically vertical. It is 6 feet wide and consists of an mass of interlacing fissures, large and small. The filling material is all clay, pyrite, late quartz, and some molybdenite. No displacement was noted in the quartzite, and the possibility of faulting is vague, although it may have taken place. If there is a fault there, its displacement is not large.

The other northwest fissure is 370 feet from the portal, and also in the tunnel. Its exact strike is N67°W, and it is vertical. The fissure is two to four inches wide, and consists of clay and small amounts of molybdenite.

Although locally they may seem the same, generally this set of fissures is much less mineralized than the other set. Realizing the incompleteness of the mapping with regard to unmineralized joints and fissures, few conclusions can be drawn, and of the few, none are positive. However, the northeast fissures are narrower, more numerous, and carry more mineralization than the others. The northwest are wider, and carry mostly clay. It would seem that the widest fissures, apporing the best passageway for solutions, would be the richer, but the evidence is contrary to this. Of course, it must be remembered that the Silver Tip vein belongs to the northeast system and is wider than any other single fissure in the mine.

Mineralization in Fissures

This mineralization may be considered as a joint plane or tight fissure mineralization because of its variability. The minerals found were pyrite, chalcocite, hubnerite, molybdenite, molybrite, azurite, and malachite. (this is exclusive of the Silver Tip vein) The pyrite is most abundant, no doubt related to the regional pyritization and the chalcocite occurs as a stain coating on the pyrite. Malachite and azurite are probably alteration products of
the chalcopyrite. These occurrences are common, however, it is the hubnerite and molybdenite that are interesting. Only three specimens showing traces of hubnerite were found in the entire mine. Each time it was in the form of small blue-black crystals deposited on joint faces. The largest specimen came from the dump, while the other two were found in the tunnel. The piece found on the dump came from a part of the dump that probably was taken from the drift instead of the tunnel. Thus, not enough information is present to deduce any kind of control or restriction for the occurrence of this mineral.

On the other hand, the molybdenite seems to come only from very tight fissures and joint planes in the tunnel. None has been found in the drift, although it may be present, and obscured by the heavy coating of limonite on the walls. Also no fissure wider than one-half inch has been found to carry molybdenite. The molybdenite present is the result of the oxidation of the molybdenite. The thin layers of molybdenite are not flattened or slickensided, indicating there was no movement. Molybdenite is so soft it would certainly show it.

The most peculiar occurrence of any mineral in this mine is that of pyrite in lodes. Lodes of this type have been found at two places in the mine; are on the north side of the Silver Tip drift; and in the west wall of the tunnel just 152 feet from the portal. The ore in the drift is of an irregular shape and is as much as a foot across in the widest place. As far as investigated it contained nothing but pyrite. The pyrite was brittle and seemed to be already broken into small angular fragments. The fragments were fresh and not coated with anything. The only crystalized piece found was half of a pentagonal dodecahedral modified by an octahedron, one inch in diameter. The fragment was not broken, because of the presence of smaller crystals. On the uncrystallized side, and evidently it had much room to grow in. This lode occurred in the quartzite where it was heavily silicified, and no clay was present.

The other lode in the tunnel, also in quartzite, was present only on on
side of the working. As shown in the accompanying cross section it pinches out behind the lagging and is found neither in the roof, floor, or other side. The pyrite on the right side of the lode was heavily fractured in place, and so weak that it was impossible to get a large piece for a specimen. It was all coated with chalcosite giving it a deep blue color. No crystallized pieces were found. All the fractures in the pyrite were filled places containing the white clay, seen on the left, and in places the clay seems to have impregnated the pyrite. This is the reason the pyrite breaks so easily. The 10 inches of clay on the left is a pure white except where locally stained with limonite. When dry it is either as hard and compact as chalcedony or soft and powdery. It is very slippery when wet.

It is possible that these lodes were large open holes in the country rock, that were filled with pyrite during the intense pyritization of the region. The holes may have been a result of the fracturing caused by the intrusion. The peculiar thing is that they are not continuous, but occur as isolated masses. A description of this clay is included within this report.

Possible Relation of Intrusion

The peculiar type of mineralization in the mine combined with the small irregular areas of intrusion in both Silver Tip properties, are reason to believe there is a larger intrusion nearby. It would seem that both mines are driven into the metamorphosed sediments just roofing the larger coarse-grained body. The surface of the intrusion would be irregular as shown by the small dikes and bosses in both mines. In fact, I go so far as to believe that all the sediments present are merely roof pendants. This would account for the mineralization. Hot juices emanating from the intrusion would penetrate all the joints, cracks, and small spaces in the roof, depositing thin layers of minerals in them. The

However, if this were to be the case, we should find molybdenum and hubnerite in the drift as well as the tunnel. As was said before the longest tungsten specimen is believed to have come from the drift from its position on
the dump. Then in the upper Silver Tip mine, molybdenum was found on the extreme west end of the drift. Since these two drifts are considered to be on the same vein, we may consider the molybdenum as also being on the Silver Tip vein, although not found in the lower drift. It must be remembered, however, that the walls of the drift are thickly covered with limonite, and if molybdenite were present it would be difficult to find.

The minerals found in the mine are conflicting as to temperature of deposition, and hence in relation to their depth of formation.

Tourmaline is definitely a high temperature mineral, and is considered to be hypothermal. Molybdenite is a high temperature mineral, and although tungsten sometimes occurs at many temperatures it is generally considered most often to be a high temperature mineral. Gold and pyrite can occur at any temperature.

However galena, sphalerite, chalcopyrite, and the other base metal sulfides are generally low temperature minerals, and in the San Juan Mountains are considered epithermal.

Thus we have both high and low temperature minerals in a mixed up conglomerate.
OLD SILVER TIP MINE

LOCATION AND HISTORY

The portal of the upper Silver Tip mine is 550 feet northeast of the lower mine, and 90 feet vertically above it.

This mine is primarily a gold property, and was worked before 1900. It must have lain idle for some time, but recently was taken over by the same person who owns the lower mine. It is worked intermittently.

The mine was surveyed with a Brunton compass and the workings logged. The stope indicated on the map was not investigated, and the extreme east end of the drift was looked at hurriedly because of the extremely wet conditions, and coating of limonite on the walls.

DESCRIPTION OF THE WORKINGS

The accompanying map shows the extent and position of the workings consisting of a tunnel, drift and stope. The tunnel is driven N 12°E for 260 feet into the mountain. It has one bend in it. At 165 feet the Silver Tip vein was intersected. A drift follows the strike of the vein east for 340 feet until it branches, the southeast branch extending for 40 feet more. The drift is stopped for 160 feet east of the tunnel. The drift extends 60 feet west of this intersection. A small crosscut extends for 50 feet southwest of the intersection.

The mine is very dry except for the tunnel north of the intersection and the extreme east end of the drift. These are the places most recently worked and are extremely wet.

GEOLOGY OF THE MINE

The same intrusion present in the lower mine is found in irregular masses throughout the tunnel and drift. The tunnel is driven into overburden for 85 feet, until it strikes bedrock, which is the intrusion. Intrusion persists
for five feet, then a wedge shaped block of sediment 16 feet thick is found, with more intrusion on the other side. The sedimentary-igneous contacts converge to the east and it was assumed that they met out in the east wall. The intrusion persists for 55 feet. The sedimentary-igneous contact, found 16 feet from the drift, swings to the north and east, cutting the cross cut and west drift and the tunnel again 53 feet from the drift. The contact can be seen on the map. The entire east drift is in sediment. The whole picture gives the impression of the roof of the intrusive body, very irregular and with odd shaped roof pendants of sediments interspersed. The mine is driven so as to intersect both bodies and gives a confusing pattern.

The sedimentary-intrusive contact must dip somewhat steeply to the west from the upper mine, because igneous occurrences are not nearly so frequent in the lower. The lower mine gives the impression of having been driven considerably above the intrusion roof because only two small igneous areas have been found.

The igneous rock closely resembles that found in the lower mine. It is green and coarse grained. In the innermost part of the tunnel there are numerous small inclusions in the rock. Specimen XII-E-1 shows one of these inclusions surrounded by the coarse intrusion. The inclusion itself seems to be a fragment of a similar green, coarse grained igneous rock, and it has a well developed reaction rim around its periphery.

**SEDIMENTARY FORMATIONS**

The mine is driven into a white altered quartzite when not in the intrusion. It is extensively pyritized, silicified and altered so that it places it is confused with marble. It is a fairly large grained rock, with a well developed joint system. The original sandstone may be considered completely metamorphosed. It has lost its original red color, assuming it is the Dolores formation, and has been bleached white. Also, except where extremely altered, it is very hard.
All of the quartzite has been pyritized for some distance away from the intrusion and veins. The pyrite occurs both in very thin fissures, as replacement crystals of all sizes as anhedral grains in the quartzite. It is genetically related to the intrusion.

The quartzite has also been extensively silicified. Except where altered it is extremely hard. This alteration is most extreme in a zone which closely follows the sediment intrusion contact, on the sediment side.

Along the Silver Tip vein, and the larger fissures there is a great deal of kaolin resulting from the alteration of feldspars in the igneous rock.

Minerals and ore structure may be seen much better on the dump than in the mine. Molybdenite was found outside, occurring the same way as in the lower mine. Green and blue chalcedony was found in crustified bands in vugs and open vein fragments. It was evidently the last thing deposited, being on top of even the late quartz. Good crystals of pyrite in pentagonal dodecahedrons and cubes are present. The ore and rock has been oxidized to a much greater extent than on the lower dump.

Fissure System

The number of mineralized fissures is very few, and since joints and open fractures were not mapped, only one fissure system can be discussed. All the veinlets strike northeast and dip either vertically or to the north.

The first example is 135 feet from the portal. It strikes N 75° E and is almost vertical. It consists of two inches of galena and sphalerite. Strangely it is found only in the east wall, and pinches out in the back.

The second veinlet, 138 feet from the portal, strikes N 54° E, and is practically vertical. It is found only in the west wall, running into the sedimentary-intrusión contact and pinching out. It contains one-eighth inch of molybdenite and pyrite. The molybdenite underlies the pyrite and, as proved microscopically, is younger than the pyrite.
The main Silver Tip vein in this mine strikes N 15° E and dips about 55° N. It has been stoped to some extent and evidently carries some gold. It is thinner here than in the lower mine and is subject to minor variations. In the west drift, where it enters the intrusion, it pinches to a very thin veinlet containing quartz, molybdenum and galena. Here also it is very kaolinized. In the extreme east drift it is just a quartz streak and finally ends up in a broken zone.

Odd Occurrences.

Odd occurrences of minerals in this mine also indicate the irregular overlap of high and fairly low temperature minerals.

At locality K in the east drift, as indicated on the map, are found small amounts of hubnerite occurring on very tight joint faces in the quartzite. It is well crystallized, but the crystals are small. Hubnerite is a high temperature mineral.

Chalcedony

This mineral was found mostly on the dump, but it was also noticed on parts of the Silver Tip vein. It is the last mineral deposited in many open fissures and vugs, almost completely filling them. It forms in crustified bands over layers of the earlier minerals. It is either green or blue.

This is a low temperature mineral if it is hypogene, and it may possibly even be supergene. Because the chalcedony was not found in the lower mine and the ore is more oxidized above, it is very possible that the chalcedony is supergene rather than primary. It could have been derived from the silicified quartzite and monzonite.

Molybdenite

Molybdenite occurs here the same as in the lower mine. It is found on the dump, and at two places in the mine. The second fissure mentioned carried
same molybdenite under the pyrite present. At the west end of the drift it is found with galena, on very thin seams and joint faces. The fact that it is on the Silver Tip vein, and in close association with the galena means that it was probably deposited at the same time as the other minerals. This destroys the possibility of two primary mineralization periods in the same mine.

GENERAL RELATIONS

Considering both mines together, and assuming that both mines have drifted on the same vein, the Silver Tip properties are fairly complete as a small geologic problem. The same type of intrusion has been found in both mines, and the sediments and mineralization are the same.

As previously mentioned, the mines are driven into the irregular roof of a batholithic intrusion. There is a definite mixing of high and low temperature minerals instead of the usual temperature zoning. Many of these minerals do not occur in large definite veins, but as extremely thin layers and traces on tight joint planes. It is my belief that these minerals were deposited from hot juices that emanated from the intrusion, penetrating even the smallest of openings. Such conditions of circulation would exist only very close to the inter intrusion, which actually is the case.

The rock and ore in the lower mine is very fresh, being relatively unaltered and unaffected by supergene enrichment. However, the rocks and minerals of the upper mine have been oxidized noticeably. Supergene enrichment has also taken place, although chalcedony is the only possible evidence.

Most difficult to explain is the intermingling of high and low temperature minerals.

EXPLANATION OF HIKU SHIN

Telescope Veins

A logical explanation would be that the surface of the ground was relative
close to the upper limit of the intrusion when the mineralization took place.

In the case of an intrusion ideally located at a great distance below the surface, there would be a normal sequence of deposition. The minerals would be found in zones whose relation to each other depends on the temperature and pressure of deposition. However, in the case of an intrusion near the surface the heat and pressure of rising solutions would be dissipated more rapidly because of the greater number of fractures and open spaces in the rock. The minerals would be found together in the same depth zone as is the case with these mines. 10/

According to Lindgren this phenomenon has been noticed elsewhere in the

10/ Lindgren, W., Mineral Deposites, p. 121, 1933

San Juan mountains, the area where it seems to be best developed. He refers to such veins as "telescoped veins."
CROWN POINT MINE

The Crown Point mine is on the north side of Ophir valley at an elevation of 10,240 feet. Its exact location can be seen on Plate I. The workings look old, but are not of great extent. Most of the mine was driven with hand steel.

The mine was mapped with a Brunton compass and 50 foot tape, and the workings logged. No previously existing maps were consulted. Therefore, there is no way of knowing the value of the mine as to what has been taken out of it.

Although the portal is caved all the other parts of the property are accessible. The stope was considered unsafe. It has been five to ten years since the mine was last operated.

GEOLOGY OF MINE

The mine is driven entirely into metamorphosed, sandy limestones and limestones. The beds strike from 12 to 20 degrees southwest and dip slightly to the northwest. The mazonite intrusion is only several hundred feet to the west, and because of its proximity the sediments have been affected by altering solutions to a great extent. All of the rocks have been silicified, and pyritization is extreme in some places. This is notable in the tunnel on either side of the Crown vein where, though confined to certain beds, the replacement was intense. In the vicinity of the sump in the west drift on the Crown vein, large parts of one bed have been altered completely to clay. All of the veins and fissures also have a high clay content.

Faulting in the mine was noticed at only one place. This small fault is in the tunnel north of the Crown vein, and has a displacement of less than a foot. It is a zone about six inches wide filled with clay and gouge.

DESCRIPTION OF DEPOSITS

Fissure Systems

The irregularity and number of workings on the Crown vein can be seen from
the mine map. Gold values were evidently high because considerable stoping was done. Even though the actual fissures can be seen only in a few places, it is evident that the vein is a zone of very small quartz, pyrite fissures that are irregular in both dip and strike. It is even doubtful whether this is a fault zone or not, as there is no apparent displacement of the beds. All the fissures are almost vertical, but dip slightly to the north.

Residents in the valley stated that the sump at the intersection of the westernmost small crosscut with the south drift of the Crown, produced all high grade ore. The sump is from eight to ten feet deep, and probably works an ore shoot of some kind.

The short drift at the very end of the tunnel is driven on a one and a half inch quartz, pyrite, base-metal vein. Its strike is east-west, and it is vertical. It is also a zone of small fissures that are irregular and short. No displacement of the beds was noticed on any of these fissures.

From the strike of this vein it seems that it would intersect the Crown vein at the small cut out in the north wall of the north drift on that vein. There is a small fissure filled with clay and pyrolusite going into the wall at that point, that may connect with the base-metal vein. The question arises as to why the miners did not drift on this vein directly from the Crown drift. The answer lies in the extent of mineralization, which is evidently not great at the cutout. The base metal vein evidently dies out.

On the map three fissures can be seen in the tunnel between the Crown vein and the portal. They all have the same northwest strike and are nearly vertical. The northern one carries better mineral values than the other two, and was drifted on for a few feet. The others are zones of clay, pyrite, and calcite.

SPECIAL OCCURRENCES

Replaced Bed
In the tunnel, just south of the base metal vein, a sedimentary bed has been first altered to, or replaced by ankerite and dolomite, and then replaced by tetrabedrite. The section shows the position of this bed in the mine. (see section)

The bed itself is a dense, white silicified marble, and is very hard. In a zone immediately surrounding the tetrabedrite, the bed is composed largely of ankerite and dolomite, and has a brown color. The tetrabedrite itself is in a flat lying zone that varies from a few inches to over a foot in thickness. The contact are fairly sharp, but irregular. The tetrabedrite is concentrated and constitutes a high grade ore of copper. It is cut by the previously mentioned fault.

The gray copper zone dies out within short distances along the tunnel and only traces of it were found in the opposite wall of the tunnel. It was however, followed around the corner, and into the drift on the base-metal vein. The deposit is local and of small extent.

Three replaced beds, either the same one mentioned or another stratigraphically close to it, can be seen on the surface just above the entrance to the mine. These beds were not only replaced and altered, but large portions have been removed leaving the rock porous and vuggy. They are a red color, and are now partially oxidized. The vugs and pores in the rock are full of small honey-colored garnet crystals. The presence of these garnets is characteristic of the replaced beds in Ophir valley. They have been found in beds at two other localities, and in the future it may be possible to use them for the correlation of metamorphosed beds.

The walls of the workings in this mine are covered to a great extent with malachite, (copper carbonate). It was present only in traces or small amounts in all the other mines entered. Because of the poor mineralization and small amounts of copper sulfides in the fissures, I believe that the malachite comes
from the leaching of other replaced beds containing gray copper. The number
and location of such beds already mentioned is a good indication that there
may be others.

Paragenesis Of The Tetrahedrite Bed

Since no specimens were collected from the fissures in the mine, discus-
sion will be limited to the paragenesis of the minerals in the replaced beds.
This must be done without a microscopic examination, and is therefore only a-
proximate.

1. Metamorphism of bed.

2. Silicification.

3. Dolomitization or Ankeritization.

THE ALTA MINE

I-A-1-(1) Specimen taken from the Alta vein, at station 67 on the 8th level. The ore minerals present are: galena (10%), sphalerite (2%), pyrite (1%), and chalcopyrite (stain). The gangue consists of; quartz (40%), and an altered green dike-rock (40%). There are small amounts of kaolin and limonite.

Galena is present as irregular islands in the quartz. It is fresh, has good cleavage, and no crystals. The islands range from 0 to ½ inches in diameter. Sphalerite is also present as islands in the quartz. It is yellow, and the islands are larger than the galena islands. There are no crystals. The pyrite occurs as fine, disseminated grains, and is confined to the dike-rock. There are some crystallized grains present as striated pentagonal dodecahedrons. The galena and sphalerite generally occur independently, but in some places the galena surrounds the sphalerite, and is probably younger.

The quartz is confined to filled fissures in a brecciated mass of dike rock. The dike is altered. Pyrite is confined to the igneous rock, but the limonite is found only in the quartz. Well developed quartz crystals are found in several vugs.

The dike was fractured by some sort of fault movement, and brecciated. There was an early deposition of quartz followed by a replacement sequence of sulfide minerals. The pyrite was deposited independently of the rest of the sulfides, probably at the early stages of ore-solution activity. Specimen I-A-1-(2) is the same as (1).

Microscopic Description.

P.S. 707, and 708, 703, 704 See picture No. 8

Pyrite occurs in small, both euhedral and anhedral grains scattered
throughout the quartz and gangue. It never occurs with the ore minerals unless they are replacing it, which is seldom. There are almost no linear areas of pyrite, indicating there was not much fissure filling.

There are many regular to irregular fragments of sphalerite, as cavity fillings, surrounded entirely by quartz. Sphalerite seems to be the only mineral primarily deposited in open fissures. There is no evidence of sphalerite replacing anything else. It occurs in typical islands.

Galena is replacing both pyrite and sphalerite. The contacts are smooth. Galena is not as abundant as sphalerite, and show no strain effects.

Chalcopyrite is not abundant, and is found only in small areas contacting the galena and sphalerite. It is replacing both. The contacts are smooth.

Tetrahedrite is not common, but is found in one place in P.S. 706, in the center of a sphalerite area. It is evidently replacing the sphalerite.

Small linear fractures are present, but they are generally not mineralized. These run into larger areas of ore. It would seem that the solutions did not deposit until the fractures widened out into good sized cavities, or the fractures are the result of, and occurred after, the formation of the larger sized openings.

I-O-1 This specimen came from the hanging wall of the 8th level of the Alta vein at station 95 25.

Galena (5%) — Galena (5%) occurs as uniformly sized and distributed that grade up to \( \frac{1}{16} \) inch in size. It is found in a matrix of barite and quartz. It has good cleavage; but no crystals although some grains show a cubic outline.

Sphalerite, (3%), occurs as irregularly distributed and sized grains in a matrix of barite and quartz. Cleavage is well developed, but there are no crystals. It is somewhat weathered.

Pyrite occurs in several ways and is of several ages. Is (4%). It is found in the San Juan tuff as an introduced product, and is finely disseminated,
fresh, and is not evenly distributed. There are not many crystals. It occurs as an early vein deposition, in and near the other sulfides and quartz. It is fresh. It is in small, uniformly distributed particles, and there are no crystals. It contacts both quartz and barite in the vugs.

Chalcopyrite (1%) is found in the vein with the other sulfides. There are only small amounts, and it is fresh.

The gangue consists of quartz, barite and San Juan tuff. The quartz is both massive and vuggy, and is intermingled with the barite. The barite is cream colored, and also massive and vuggy. It is fresh. The tuff is green to red and occurs in pyritized bands.

The specimen was taken from the edge of a larger banded vein. It shows nice banded structure. The quartz and barite seem to be contemporaneous. There was some brecciation before the ore deposition.

Microscopic Description

P.S. 705 and 706

The ore minerals are pyrite and chalcopyrite, and the gangue is barite.

The pyrite occurs both in isolated equi-dimensional masses, and in linear fissures. It is the most abundant mineral in the section. Chalcopyrite is replacing the pyrite. In 706 only galena is found in isolated masses in the barite. Section 705 shows the contact between the barite and tuff. It is sharp to gradational, and more pyritized than either the tuff or barite above.

I-D-1- This specimen shows excellent banded structure. One half of the specimen is all tuff, while the other half is banded vein. The minerals occur in distinct bands, although in some places islands of sulfide are found in the gangue. The minerals present are quartz, barite, galena, sphalerite, chalcopyrite, chalcocite, kaolin, and pyrite. There are islands of galena and sphalerite in the quartz, and islands of barite in the galena.

The order of deposition was as follows: quartz in a thin irregular band
next to the tuff, a thin band of sphalerite with some galena, then a thick layer of quartz with some galena islands. Lastly the galena band with some contemporaneous barite.

The galena has no crystals, but has well developed cleavage faces. The sphalerite is yellow to brown, and has good cleavage faces but no crystals. The pyrite, as before is the result of a general pyritization. The chalcopyrite covers the galena in one place.

The tuff is massive and very much altered. Pyrite is disseminated in five grains throughout it. The quartz is massive and is a dirty gray-white. It gets grayer around the islands or bands of sulfide. The barite is found in the galena.

Microscopic Description

P.S. 699 and 700 —— see picture 7.

Pyrite (4%) is found in the wall-rock, but not much in the vein. There are no fissures of pyrite; it occurs only as small disseminated grains. There are no crystals.

Galena (5%) occurs almost entirely within the sphalerite, but some is found isolated in the gangue. The contacts are smooth replacement contacts. It shows almost no strain effects.

The sphalerite (3%) has a fabricated pattern. It seems to fill fractures and holes rather than replace anything. The contacts are, with the gangue, angular and irregular.

Chalcocite (0.5%) is in contact with the galena, pyrite, and chalcopyrite. It has smooth replacement contacts. It seems to have replaced the chalcopyrite. In P.S. 700 it occurs as a zone around a chalcopyrite grain.

Chalcopyrite is found around the edges of the galena, replacing it. The contacts are smooth. It is also found in thin fissures in the sphalerite and gangue.
Tetrahedrite is found in relation to the galena and sphalerite in two ways. It is found as smooth circular islands in the galena, and also around the edges of both galena and chalcopyrite. This is an indication of two stages of gray-copper replacement. One before the galena, and another after the chalcopyrite and chalcocite.

The structure of section 699 is interesting. The section was taken from the edge of a vein, and half of it is in gangue.

The gangue side consists of fractured tuff or dike. Spaces have been filled with galena and sphalerite. Because of the proximity to the vein itself it can be assumed that the galena and sphalerite are the result of vein solutions slightly penetrating the wall-rock. The pyrite is due to a regional pyritization, and the same can be said of the silica. Barite and calcite are confined to the wall-rock and only quartz is found in the vein.

There is no sharp boundary between the vein and wall-rock. They grade into each other. The vein consists of a number of areas of ore in an almost solid matrix of quartz. The sphalerite seems to have been deposited in fractures, vugs, and holes in the quartz. This is supported by its discontinuous, spotty appearance. The sphalerite was replaced by galena which occurs around the edges of the sphalerite. Chalcopyrite, gray-copper, and chalcocite are replacing the galena. Whether the tetrahedrite is before or after the chalcopyrite is not known.

I-D-2 The only sulfide mineral present in this specimen is pyrite in the form of small disseminated particles, and striated cubes and pyritohedrons. It is fresh. The gangue is either an altered dike or part of the San Juan tuff. For convenience this type of rock was called a "mineralized brecciated rock", while mapping the mine. There are two small stringers of barite or hard clay running through the specimen. One side looks somewhat slicker sided.
I-3-1  No well defined structure is apparent on this specimen. It came from the central part of the vein, and is mostly a massive intermingling of sulfides and gangue. The thin seams and stringers of quartz and barite are the only structure present. These are parallel.

Galena is found as bands, and isolated islands. The islands are irregular in size and shape. It is in contact with everything else. Both steel and ordinary galena are present, although there are no crystals.

Pyrite occurs in the same way as the galena. Massive, irregular in size, shape, and distribution; fresh, and with a few small crystals. It contacts everything.

Chalcopyrite is found as isolated grains and thin bands. It is fresh, and irregular in size, shape, and distribution.

Bornite (?) is a reddish gray to deep blue color and is massive. It occurs as a coating.

Sphalerite is found the same way as the galena. It is yellow to brown, shows good cleavage, and is massive in large areas.

Quartz forms 60% of the specimen, and is the matrix. It is found also in thin, white, parallel, fissures. There are no vugs and it is very dense.

Barite is found also in thin stringers, but is cream-colored. Clay and pyrophyllite occurs as an encrustation.

The ore was deposited in fractures, and as replacements, in a pre-existing gangue. The ore and gangue were later fractured, and a late period of gangue deposition took place.

Microscopic Description

P.S. 701 and 702 (see pictures 9 and 14)

Pyrite (50%) is very prevalent, and in this specimen was deposited simultaneously with the quartz. The structure shown is that of a perfect eutectic between these two minerals.

Galena occurs both as a replacement area, and as a primary deposition. It
is most common around the edges of the pyrite and is replacing it. All the contacts are smooth. In P.S. 702 it is found replacing sphalerite and pyrite. The galena shows some strain effects, and this is indicative of a late brecciation of the ore.

Chalcopyrite is in small amounts found replacing the galena. However, it is also found replacing the pyrite and sphalerite directly. It has smooth contacts.

Sphalerite is present mostly as a cavity filling. Although in some places it replaces the pyrite, it seems to have its own separate stage of deposition. This is possible because the pyrite is acutectic.

The paragenesis for this specimen was as follows:

pyrite  ---------------
sphalerite  ---------------
galena  ---------------
chalcopyrite  ---------------

I  II-4-1  This specimen shows a good banded structure, both in different colors of quartz and in zones of pyrite crystals.

Pyrite (10%) is present in fairly large pyritohedrons that are uniformly distributed in the quartz. The pyrite is fresh.

The quartz (90%) is large grained and massive. It is pink to white, fresh, and vuggy. Small crystals of quartz are found in the vugs. Limonite stains the quartz.

The pyrite is probably the result of a selective replacement of the wallrock.

II-4-2  This specimen shows good banding in layers of tuff and quartz. The ore also shows some banding in bands of pyrite and galena. The only well defined band is a band of quartz that has sharp contacts with the tuff. The
contacts are marked with vugs filled with quartz crystals. One band of tuff seems to have been completely brecciated and silicified. It contains considerable galena.

Galena (15%) occurs in streaks and isolated islands in a quartz matrix. The centers of the grains are fresh, but the edges are weathered and altered. They are surrounded by zones of malachite and limonite.

Pyrite (10%) occurs in both the brecciated tuff and the quartz, as isolated, irregularly distributed islands and bands. Some pyritohedrons have formed. The edges have altered extensively to limonite.

Sphalerite is present only in small amounts.

The quartz (60%) is vein quartz, but the tuff has been silicified. It is stained with limonite and clay.

The tuff (on dike) is green. It has been extensively brecciated, silicified. The angular breccia particles have been surrounded by quartz. Everything has been pyritized.

Microscopic Examination

P.S. 697 (see picture 6)

The galena present shows definite signs of strain and pressure, indicating movement after deposition.

Sphalerite is found in great amounts, with its typical discontinuous structure and jagged contacts.

Chalcopyrite occurs as islands in the gangue, and replacing sphalerite and galena.

Pyrite is found as disseminated small grains, the result of an extensive pyritization.

Tetrahedrite is found in association with the galena.

II-B-1 Bein structure is very evident on this specimen. The one inch veinlet is banded by country rock on both sides. The veinlet itself consists
of scattered sulfide areas in a matrix of barite. Zones of concentrated sulfides occur at the contacts. Small amounts of megascopic gold were observed in those zones. Vugs are common.

Galena (10%) occurs in isolated islands in the barite. It is fresh in places, but weathered and decomposed in others. There are no crystals. These islands are irregular in size, shape and distribution.

Pyrite (8%) occurs in isolated zones and islands in the barite. There are no cry stals. The grains are uneven in size, and shape. The centers are fresh but the edges are altered to limonite.

One very minute grain of gold was observed in a vug, lying on top of some quartz and galena. The particle seems to conform closely to the surface.

Barite (35%) forms the matrix of the vein. It is white to gray, and stained with limonite. In several vugs, are welldeveloped, monoclinic crystals. The barite is unaltered.

The dike or tuff (45%) is highly silicified and pyritized, and is hard to recognize. It is massive, gray, and aphanitic.

Malachite, limonite, clay, and mangaciderite stains are found in the vugs on the sulfides.

After silicification and pyritization the country rock was probably fractured, and the barite and sulfides subsequently deposited.

II-B-1 This specimen represents a portion of a barite filled fissure. Galena and other sulfides are found in the matrix of barite. The vein-wallrock contact is marked by a color change.

Galena (5%) occurs as irregularly shaped islands of various sized and distribution. It is weathered and altered. There are no crystals.

Pyrite occurs in very small amounts associated with both the barite and galena.

Barite (95%) forms the mass of the specimen. It is massive and vuggy, and
varies from grey to yellow in color. Fairly large crystals of barite occur in the vugs.

Clay and limonite (2%) cover barite in the vugs.

II-C-1. This specimen is a typical example of a hardened and dehydrated gouge. The brecciated country rock has been altered, and the spaces filled with clay and gouge. The rock has been stained by the alteration of the pyrite.

Galena is found in extremely small particles scattered irregularly throughout the semi-vein mass. It is found in the quartz.

Pyrite occurs as five disseminated particles in the country rock only. It has altered to some extent.

White, soft clay is found next to the vugs, and on one whole side of the specimen. It is probably the result of wallrock alteration.

The country rock is altered to a great degree. It has been brecciated and bleached. It is covered with clay and limonite.

Calcite has formed as well-shaped dog tooth crystals in the vugs. It is clear and white, but in places is coated with black manganese oxide. This calcite was the mineral deposited.

II-C-2. This specimen represents the cross-section of a vein from its edge to the middle. At the edge is green dike filled with disseminated pyrite grains. Angular fragments of this dike are found out in the vein. Vugs and galena in the quartz are found close to the contact. There is a one-half to one inch zone of quartz and barite at the edge. This is filled with patches of ore.

Then there is a two to two and a half inch zone of solid sulfide ore, with small stringers of quartz running through it. Then after a very thin band of quartz, is a zone of steel galena one-eighth to one-fourth inches wide. A band of late quartz follows this. Two periods of quartz deposition are shown.

Galena (40%) is evenly distributed. It is in contact with everything else.
Sphalerite (5%) is found in medium to large grains of yellow color. Found mostly in contact with the galena.

Chalcopyrite (5%) is massive, and unevenly distributed. It is mostly in contact with the galena, but some with the gangue.

Pyrite (2%) is found in anhedral and anhedral grains in the dike. Cubes are well developed.

Stein galena is found in the center of the vein, and is black and fine grained.

Quartz (20%) is found in two stages of deposition. There are vugs lined with small quartz crystals.

The barite is cream-colored, fresh, and unevenly distributed in grains and stringers.

The dike occurs in angular, brecciated fragments in the vein. On the end of the specimen it is massive.

Microscopic Examination

P.S. 697 and 698 (see picture 5)

Sphalerite occurs in the same manner as in the previous sections.

The galena (60%) is replacing the sphalerite, and shows definite strain effects. It also occurs to some degree as islands in the gangue alone.

Pyrite and chalcopyrite occur as before. The pyrite is the result of a regional pyritization, and the chalcopyrite is replacing both galena and sphalerite.

This rock has been affected by a post-mineral brecciation.

II-C-5 This specimen shows two thin, parallel veinlets cutting the matrix of dike. One is barren, containing only quartz, while the other is filled with tetrahedrite and quartz. The tetrahedrite seems to cover the quartz.

The tetrahedrite (5%) is massive, lead gray, and fresh.
Pyrite (one-half %) is found, as before, disseminated in the dike.
The quartz (4%) is massive, fresh, and pink colored. It fills the vein.
The dike (90%) is green, aphanitic, fresh, and pyritized.

THE SILVER BELL MINE

X-A-13 This specimen, consisting of manganosiderite and quartz is inter-
esting because of the structure shown. The pre-existing large barite crystals
in a matrix of manganosiderite has been replaced with late quartz. In many places
the replacement has been incomplete resulting in the formation of vugs having
the shape of the barite crystals. Occasionally there are well developed chal-
copryrite and pyrite crystals supported by the quartz crystals in the vugs.
More extensive are more siderite and manganosiderite crystals also supported by
quartz crystals. The specimen is evidently supergene.

X-A-14 This specimen consists of bands of pyrite, specularite, quartz,
and dolomite. The quartz is evidently late quartz filling a seam in the pyrite.
Also in the center of a pyrite band is the irregular zone of specularite, about
one inch thick. It is dark grey, has curved cleavage faces, and a ruby red
internal reflection. Several well developed pyrite crystals are imbedded in the
hematite. The irregular stope of the band may mean a replacement of either
pyrite or specularite has taken place. Specularite is mentioned by Lindgren as
a hypothermal mineral. The pyrite is vuggy in places, and the vugs are filled
with dolomite, or late quartz.

Description of Hubnerite In Silicified Rock. (binocular microscope)

The rock is a breccia of a green rock. The whole has been indurated and
silicified. Fragments of the green rock (marble?) or metamorphosed fine grained
sediment) are soft, and can be easily scratched with a needle. Between and around these angular, soft fragments are light pink fragments (very hard), and other silicified clays. It could very well be a brecciated igneous rock, because some grains similar to orthoclase can be seen. The rock was extremely brecciated, leaving many open spaces.

The breccia was extensively silicified, the quartz filling most all of the smaller cavities, and lining the sides of the larger ones. Small, well developed quartz crystals can be seen in the larger vugs. The silica consolidated and hardened the breccia.

The rock (mostly in the areas between breccia fragments) contains both euhedral and anhedral grains of pyrite. The euhedral grains are well developed cubes striated by cubes. They are found mostly in a matrix of quartz, indicating the pyrite to be almost contemporaneously deposited with it.

Well developed, monoclinic crystals of hubnerite are found in all the vugs, almost completely filling them. The crystals are interlocking, tabular, striated lengthwise, and show a ruby-red internal reflection. This mineral also occurs in small veinlets (somewhat massive) filling the remaining small fissures. The crystals are clearly intergrown with each other.

Aggregates of clear quartz crystals can be seen in numerous places growing out of, or on top of the well developed hubnerite crystals. This indicates a period of late quartz deposition.

Epidote is seen to fill spaces between hubnerite crystals, and is evidently later than the hubnerite. It occurs most often as a vug filling, and well developed epidote crystals can be seen in completely filled vugs. This mineral could have come from the alteration of ferro-magnesium minerals in an igneous rock.

X-I-3 This specimen was taken from the stope on the Butler vein in the Whiteside tunnel. Quartz forms the mass of the specimen. It appears that the quartz filled some cavity because it is banded. One outer surface of the
specimen is covered with small, vuggy quartz crystals. The quartz probably filled some fissure, was fractured, and the space filled with ore. The tetrahedrite and galena appear to have filled vugs rather than fractures.

The minerals present are: quartz (90%), tetrahedrite (3%), galena (2%).

Quartz forms the mass of the specimen. It is fractured into veinlets and small cavities. These have been filled with galena, and the galena has been replaced by tetrahedrite. P.S. 693 and 694, See picture No. 2.

X-L-4 This specimen, from the dump of the mine, is made up of mostly galena. There are bands of steel and cubic galena. The galena has been strained, and the steel galena looks almost schistose. The minerals present are: steel galena (65%), cubic galena (30%), clay and gangue (3%), chalcopyrite (2%).

The galena is in small, discontinuous stringers with no definite orientation. There is evidence of distortion.

The chalcopyrite is present only in one or two places. It is mostly confined to the gangue, but in several places it has replaced the galena.

The gangue (calcite) was fractured, and the spaces filled with ore. Later there was subsequent pressure and movement. P.S. 695.

THE FAVORITE MINE

XXXII-A-1 This specimen is nothing but galena, except for small holes filled with clay. Both steel and cubic galena are present.

P.S. No. 692. See picture No. 1.

Galena forms the matrix of the specimen. It shows strain effects, and late quartz has been deposited in fractures that cut it. It forms 85% of the section.

Tetrahedrite (13%) is replacing the galena, and has smooth contacts with it.

Chalcopyrite (3%) appears to be replacing both the galena and tetrahedrite.

Small amounts of sphalerite are being replaced by all the other sulfides.
SUMMARY AND CONCLUSIONS

The following is the paragenesis of the base-metal ores:

Gangue

Pyrite

Sphalerite

Galena

Chalcopyrite

Chalcocite

Tetrahedrite

Late quartz

There are two stages of tetrahedrite, one before the galena, and one after.

Gold, silver, and the ruby silvers are present in these ores, but the grains are so small that they cannot be seen with a microscope. The presence of silver was proved by microchemical tests. Because of this difficulty, their position in the paragenesis is unknown.

THE SILVER TIP MINE

VII-1-1 This is a specimen of the clay from the pyrite lode in the tunnel of the lower mine. It was studied by means of a petrographic microscope.

Macroscopically it is white, chalky, and very dense. Microscopically it is isotropic, and its index of refraction is between 1.521 and 1.537. These two properties did not check with any clay known, and it is still unidentified.

VII-1-3 Samples A-1, 2, 3, all came from the same pyrite lode.

The pyrite (95%) is massive, and extensively fractured, the fractures being filled with the clay just mentioned. It is heavily coated with chalcocite. Limonite and malachite are also found as stains on the pyrite.
VII-B-1 This sample came from the Silver Tip vein.

Galena occurs as a vein mineral in a matrix of quartz. It is coated with chalocite. Pyrite is found exclusively in the pyritized country rock. Chalocite is found staining almost all the sulfides. Malachite also stains minerals, probably resulting from the alteration of the chalocite. The mass of the specimen is quartzite, the country rock. It is bleached and altered. Typical vein structure is shown. Two separate veins are present, running at right angles to each other. One contains only pyrite and limonite, and the other contains galena, pyrite, chalocite, malachite, kaolin, and quartz.

Microscopic Description.

P.S. 713. See pictures No. 12 and 13

Pyrite is the result of an extensive wallrock pyritization. It is both a cavity filling and a replacement product. The section is filled with small, anhedral grains, with only a few crystals.

Sphalerite occurs as a cavity filling and as a replacement of some of the pyrite. It has mostly irregular contacts.

Galena is replacing the sphalerite.

Molybdenite occurs only as a cavity filling, and is found between the pyrite and the quartzite. It is also being replaced by chalocite.

Chalocite is the last mineral deposited, and is entirely a replacement product. It replaces all the sulfides in the section.

Gold is visible with the high-power objective, occurring only in very small grains isolated in the quartz.

VII-D-5 This specimen was taken from the tunnel. It consists mostly of quartzite which is hard, and from fine to medium grained. It has been extensively pyritized. Some of this pyrite has altered to limonite, and most all of it is coated with some chalocite. The specimen is also heavily coated with malachite.
Microscopic Description

P.S. 714

Pyrite occurs in euhedral and anhedral grains of all sizes and shapes. It is the result of the extensive pyritization.

Molybdenite is found in very small cavities and fissures in the quartz, and in contact with the pyrite. It is evidently later than the pyrite, and in some places is found in fractures in the pyrite.

VII-D-7 This specimen was also taken from the tunnel. The mass of it is white quartzite, heavily stained. It has a bluish-gray color that may be due to disseminated molybdenite. One face of the specimen is covered with flattened, smeared pyrite, evidently caused by movement. Several vugs are present along this fissure. The pyrite is covered with chalocite, malachite, and azurite. A coating of molybdenite is found between the pyrite and the quartzite. Small amounts of hubnerite are also seen. Small quartz crystals cover the molybdenite in places.

Microscopic Description.

P.S. 709. See pictures No. 10 and 15

Pyrite occurs as fine disseminated grains, as before.

Sphalerite occurs in filled fissures, and as a replacement of the pyrite. It was probably deposited shortly after the pyrite.

Chalcopyrite is found in only one place in contact with chalcoite.

Galena is found in the same manner as usual, replacing sphalerite.

Chalcoite is seen to replace all the other sulfides in beautiful replacement examples. It occurs as concentric zones around galena, sphalerite, and chalcopyrite. It is even seen to replace molybdenite (see picture). The paragenesis for this specimen is the same as for the base-metal veins.

VII-E-8 The main mass of the specimen is white, coarse grained quartzite. A thin seam of pyrite runs through the specimen; it is ½ inch wide and has sharp contacts. There is some muscovite, quartz present. Some of the quartz has
that blue color that may be due to disseminated molybdenite.

Microscopic Description.

P.S. 710 and 711

Disseminated pyrite was the only mineral found upon examination.

VII-2-3 This specimen, taken from the tunnel, contains pyrite and molybdenite. Small amounts of chalcopyrite are also found. All the sulfides are stained with chalocite. Pyrite is the result of the pyritization. One side of the specimen borders on a vein which contains, in addition to the minerals mentioned, some vuggy late quartz.

Microscopic Examination.

P.S. 712 See picture 11.

The pyrite seems to have been deposited in an open fissure rather than having replaced the quartzite. It has also filled many small fissures.

Molybdenite occurs as before in small fissures and cavities between the quartz and pyrite, and in fractures in the pyrite itself. It is definitely later than the pyrite, and there is no evidence that it has replaced the pyrite.

DESCRIPTION OF TOURMALINE OCCURRENCE.

Megascopically, it is found only on small joint faces, and in very thin seams. It has a fibrous, radiating structure, and a silky luster. It is gray to light green in color.

Microscopically, it is green, pleochroic, and has parallel extinction.

Pleochroically, it has the maximum absorption perpendicular to the polarizer, which is a positive test for tourmaline. It is length fast, and has a low birefringence. The index of refraction is very high.

SUMMARY AND CONCLUSIONS

The paragenesis of the minerals in the gold-quartz-pyrite veins is more difficult to determine. The only positive conclusion that can be reached is
that the pyrite was deposited first, and that the molybdenite was brought in at
some later date. Chalcocite is also later than the pyrite. The relative age
of the gold is not known.
CONCLUSIONS

From the foregoing information it seems possible that there could have been two periods of mineralization in the ore deposits of Ophir valley. This view is supported by Lindgren and Ermons. The best evidence is that two distinct types of veins occur in the same area, the base-metal veins, and the gold-quartz-pyrite veins. I have made the assumption that these veins change character with depth, and that generally all the veins are alike. Their present difference is the result of different depth zones being exposed by the present erosional surface. The earliest set of veins could have been emplaced when the ground surface was much higher. The higher parts of these veins could have also been gold-quartz-pyrite veins, but as the ground surface eroded down the deeper base-metal portions were brought to the surface. I have assumed that the present gold-quartz-pyrite veins are of such recent date that we still see only their upper portions. Give erosion enough time to lower the ground surface several hundred feet, and a slight change might be noticed.

From this conclusion, it follows that the intrusions producing the base-metal veins are older than those producing the gold veins. So far no evidence has been found to support this theory.
Section I-A
a fine green dike
b 3 in country rock
c 4 in green dike
d 2 in qtz
e 4 in sulfide
f 4 in country rock
g 2 in sulfide
h 2 in dike
i 8 in sulfide
j 1 ft M.B.R.
k 3 in soft, white clay
l green dike

Section I-B
a green dike
b 1\frac{1}{2} ft sulfide
c green dike
d 1\frac{1}{2} in qtz vein
e green dike

Section I-C
a S.J. tuff
b 5 in S.J. tuff
c 1 \frac{1}{2} in sulfide
d 2 in S.J. tuff
e 3 in M.B.R.
f 4 in S.J. tuff
g 4 in M.B.R.
h green dike

Section I-D
a green dike
b 3 in clay
c green dike
d 5 in clay, M.B.R.
e green dike
f 2-5 in sulfide
g M.B.R. pyritized zone
h green dike
Diagram illustrating a rolling vein.

Section I-F
a. green dike  
b. 1-2 inches clay & gouge  
c. 3-3½ in. white gouge  
d. 1 ft. sulfide vein  
e. 1-2 ft. altered C.R.  
f. 3-4 in. clay, gouge, pyrite  
g. green dike

Section II-A
a. S.J. tuff  
b. heavy clay  
c. R.B.B.  
d. pyritized clay  
e. vuggy qtz & sulfide  
f. barren barite  
g. bleached dike  
h. M.B.R.  
i. bleached dike  
j. heavy sulfide  
k. white bleached dike  
l. fine green dike  
m. fine green dike

Section II-B
a. S.J. tuff  
b. 3-4 in. barite, galena  
c. R.B.B.  
d1 fine green dike  
e. 3 in. barite, sulfide  
f. fine green dike
Section II-C

a. green dike
b. pinching out vein
c. diagonal connecting fissure
d. vein starting up
e. green dike

Diagram showing how tension fissures can be produced.

Section II-D

This section shows the vein bending very closely. Taken from the Palmyra stopes.
Diagram from January, 1945 Mining Technology, showing origin of extremely rich portions of veins as they roll.

Block diagram showing position of sedimentary pendant in relation to the two types of intrusion in the Silver Bell mine. Green is the coarse intrusion, and blue is the fine.
Section X-G

a coarse intrusion
b clay
c 0.5 in. pyrite
d clay with manganese siderite
e 6 in. clay
f 4 in. qtz
g 0.5 in. pyrite
h altered intrusion
i coarse intrusion
j 4 in. qtz, and pyrite
k qtz, and pyrite

Section X-II

a coarse intrusion
b 1 in. pyrite
c 0.25 in. calcite, barite
d intrusion
e intrusion
f 5 in. pyrite, barite, siderite
g altered C.R.
h Barite stringer
i 0.5 in. clay
j 6 in. qtz, calcite, barite
k splits of calcite, barite
l pyrite, barite streak

Section X-I

a fine intrusion
b 1 ft reaction zone
c 3/4 in. barite
d 3/4 in. altered C.R.
e 1/3 in. barite
f 2 in. intrusion
g 0.5 in. barite streaks
h altered C.R.
i 4 in. barite, qtz
j 7 in. intrusion
k Country rock

l 10 in. barite
m 1 ft intrusion
n 4 in. barite, qtz
c 1/3 in. pyrite
p 1/3 in. barite
q unaltered intrusion
r 4 in. barite and pyrite
s 3 in. base metal sulfide

Entrance to Butler east drift

This is a four foot zone, exaggerated
This shows position of vein in relation to drift.

Looking at east wall

Section X-F

a coarse diorite
b 3/4 in. altered C.R.
c 1 in. barite, pyrite, sulfide
d 1/2 in late qtz
e 1 in. barite, sulfide
f 1 in. clay
g 1 in. qtz, manganosiderite
h altered diorite
i 3 in. clay

Section X-G

n 2 in. clay in roof
o qtz, siderite, pyrite
p intrusion
q clay streaks
r intrusion

a coarse intrusion
b 6 in. altered intrusion
c 1 in. qtz.
d 1/2 in. siderite
e 4 in. altered intrusion
f 2 in. siderite
g 2 ft. altered C.R.
h 1 in. qtz
i 4 in. altered C.R.
j 1 in. barite
k altered C.R.
l horizontal slickensides
m qtz, siderite
Galena, sphalerite, and chalcopyrite. Galena is replacing the sphalerite, and chalcopyrite is replacing the galena.

Tetrahedrite replacing galena—notice the smooth contacts, indicating replacement.
Galena, sphalerite, and chalcocpyrite. Galena is replacing sphalerite, and chalcocpyrite is replacing both.

Chalcocpyrite, galena, and pyrite. Galena is replacing pyrite, and chalcocpyrite is replacing galena.
Galena, sphalerite, and tetrahedrite. Galena is replacing sphalerite, and tetrahedrite is replacing both.

Galena, chalcopyrite, and pyrite. Chalcopyrite is replacing both galena and pyrite.
Galena, sphalerite, and chalcocite. The galena is replacing the sphalerite, and chalcocite is replacing both.

Pyrite and molybdenite. The molybdenite is later than the pyrite, but does not replace it.
Pyrite and chalcocite.
The chalcocite is replacing the pyrite.

Molybdenite and chalcocite.
The chalcocite is replacing the molybdenite.
The detail is poor, but the minerals can be seen as sinuous ridges, and irregular areas.
Pyrite and galena.
The galena is replacing the pyrite. Also shows the eutectic of pyrite with quartz. The galena can be picked out by its high color and lack of relief.

Galena and chalcocite.
The chalcocite is replacing the galena.
Silver Tip Mines

Scale: 1" equals 100'

Section of clay-pyrite lode in west wall of lower mine
CROWN POINT MINE

Scale: 1" equals 100'

Section of replaced tetrahedrite bed in west wall of tunnel.


