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GEOLOGY AND ORE DEPOSITS OF THE ADIT TUNNEL  
AND COLUMBIA MINE, WARD, COLORADO.

C. Richard Murray  
By

not proof read, has been approved for the

C. Richard Murray, B. A.,  
University of Colorado, 1932.

*P. D. George*  
*Ernest E. Muhlstrom*  
Date *Jan 1934*

A Thesis submitted to the Faculty of the Graduate  
School of the University of Colorado in partial fulfill-  
ment of the requirements for the Degree Master of Science

Department of Geology.

1934.

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P. D. George

Ernest E. Wahlstrom

Date June 2, 1934.

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Columbia mine. ----- In back.

Purpose of This Report.

The primary purpose in undertaking this report was to make a detailed study of the ore deposits occurring in the Adit tunnel and Columbia mine, which properties are operated by the Ward-Big Five Gold Mining Company.

Location.

The portal of the Adit tunnel is about a half mile south of the town of Ward which itself is about 15 miles northwest of Boulder, Colorado. The tunnel continues for 4,000 feet in a northwesterly direction. The Columbia mine is considerably closer to Ward, being situated on Nivot Hill a few hundred yards west of the town. The Adit tunnel and Columbia mine are connected underground by the Nivot crosscut which begins 2800 feet from the portal of the Adit and runs slightly east of north for 3000 feet and intersects the Columbia tunnel and Nivot winze.

The area was formerly served by the Denver, Boulder, and Western Railroad, now dismantled, and may be reached either by the Nederland-Ward highway or by Lefthand Canyon highway which intersects the Boulder-Lyons highway 8 miles north of Boulder.

Area Mapped.

The geology of the Adit tunnel was mapped in detail for a distance of 1800 feet from the portal, the re-

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### Area Mapped.

The geology of the Adit tunnel was mapped in detail for a distance of 1800 feet from the portal, the re-

mainder of the tunnel being inaccessible at the time of mapping as a result of cavings of the tunnel roof. The Columbia mine was also mapped in detail as far down as and including the two hundred and fifty foot level wherever access to the workings was possible.

This mapping necessitated a preliminary study of the geology surrounding these deposits, and although the area had been well described and mapped by P. G. Worcester in his report, "The Geology of the Ward Region, Boulder County, Colorado," it was thought advisable to re-map the more limited area covered by this report using a larger mapping scale and a smaller contour interval. An area of about one mile north and south by one and a half miles east and west was mapped (Plate I). Besides the town of Ward, the area also includes the town of Frances, which at present consists of only a few houses and very few inhabitants.

#### Field Methods.

In constructing the topographic and geologic map included in this report, a triangulation net was established using plane table and telescopic alidade. Both topographic and geologic features were then detailed by plane table and stadia rod. The scale used for this work was 300 feet to the inch and the contour interval is 50 feet.

The underground geology of the Adit tunnel and the Columbia shaft was mapped by means of a Brunton compass

and a 100 foot steel tape along with pacing for minor distances, the plotting being done on copies of maps owned by the Big Five Company. Field work was begun in this area in November 1933, and continued until the latter part of May 1934, a rather large proportion of this time being spent on the report.

#### Laboratory and Office Work.

In addition to the field work considerable time was spent in preparing and studying thin and polished sections of the rocks and ores of the area. Fire assays were made on a large number of ore samples from the two mines. The office work consisted largely of preparing the accompanying maps and the writing of the final report.

#### ACKNOWLEDGEMENTS

Appreciation is hereby expressed to members of the Geology Department faculty at the University of Colorado, and to the Ward-Big Five Gold Mining Company for the assistance which they so willingly rendered in the preparation of this report. The writer is especially grateful for the cooperation which he received from Dr. R. D. George, head of the Department of Geology in preparing this report, and to Mr. Stanley M. Walker, General Manager of the Big Five Company, who aided in the field work in many ways. Much valuable and useful information was also obtained from the aforementioned report by Dr. Worcester of the Geology Department.

## HISTORY OF MINING.

The Adit and Columbia Mines with other Big Five properties including the Niwot, Madeline, Dew Drop, High Line, etc. have been the largest gold producers in the Ward district. The Columbia vein was discovered in the very early days of Colorado mining (1862). Included along this vein from west to east are the Niwot, Madeline, Columbia, Sullivan, Baxter, Boston, and Utica mines, all of which have been large producers. (Fig. 1).

The Dew Drop vein was discovered in the early 70's, and this finally led in 1896 to the driving of the Adit tunnel for the advantageous exploitation of the Dew Drop and Columbia veins, ore being trammed through it to the main mill and power plant of the Big Five Company at Frances.

Besides these properties, the area mapped includes the Stoughton, Baltimore, Gold Chief, Cornucopia, Nimbus, and others, at which considerable work has been done. The Stoughton vein which parallels the Columbia has been a large producer.

Complete records of production of the area are not available since many have been destroyed by fires and other means. The records are very incomplete, but it is believed that the combined production of the Big Five properties has been in the neighborhood of \$6,000,000. Of this the Niwot and Columbia produced the most, but in

more recent times, considerable ore has been taken from the Adit tunnel level of the Dew Drop Claim.



Fig. 1. View taken from the Boston dump looking west showing the alignment of dumps along the Columbia vein. The view shows the Baxter, Sullivan, Columbia and Madeline dumps, with the Niwot dump indiscernible due to distance.

more recent times, considerable ore has been taken from the Adit tunnel level of the Dew Drop Claim.

Mining was begun in the area in 1865, when the first mill consisting of 50 stamps was constructed. Operations continued rather steadily until the early 70's, during which time a washer was placed in operation at the Madeline. Activity later became more intermittent and finally ceased.

In 1898 a large number of independent properties were consolidated into the Big Five Company, and a large power plant and mill were established at the portal of the Adit tunnel near Frances, which mill started operations in September 1898. The equipment consisted of crushers, rolls, and jigs, and a recovery of 35-40% was made. At first only the low grade ore was milled, but later all grades were milled.

Becoming discouraged, in 1902 the company ceased mining operations; and, except for a short period in 1921 when there was a poorly managed attempt at rehabilitating the mill by installing a ball mill, electric power, and Wilfley tables, the only work done on the property was by leasees until 1932, when the present Ward-Big Five Company was organized.

## HISTORY OF MILLING.

Milling was begun in the area in 1865, when the Niwot mill consisting of 50 stamps was constructed. Operations continued rather steadily until the early 70's, during which time a smelter was placed in operation at the Madeline. Activity later became more intermittent and finally ceased.

In 1895 a large number of independent properties

PHYSIOGRAPHY.

Pronounced variations in elevation are characteristic of the area mapped; the altitude ranges from slightly below 9,000 feet in the southeast to 10,319 feet near the western boundary. Very few jagged rocky precipices occur, as glaciation has rounded off the hill tops and spurs, many of which are fairly well timbered. Glaciation has left large lateral moraines and ground moraines of unassorted debris in the upper part of California Gulch.

Stream erosion has carved the surface into steep-sided canyons or gulches especially where the streams flow through the glacial debris. (Fig. 2).

Vulcanism has also played an important part in giving the land surface its present configuration. Niwot Hill is formed by a resistant, white, felsite porphyry. Other dikes of which there are a very large number form less conspicuous features, and just south of the main mining buildings of the Big Five at Frances and just outside of the area mapped a large circular boss of quartz monzonite porphyry is a striking topographic feature.

A fault of large displacement has cut off the Columbia vein at the top of Niwot Hill from which there is an abrupt slope to California Gulch.

Fig. 3. A typical outcrop of a felsite dike showing the effect of rapid cooling in producing jointing which results in the formation on weathering of small angular rock fragments as shown.



Fig. 2. View showing California Creek in the center cutting a steep sided ravine through the lateral moraines on either side.



Fig. 3. A typical outcrop of a felsite dike showing the effect of rapid cooling in producing jointing which results in the formation on weathering of small angular rock fragments as shown.

## GENERAL GEOLOGY.

### Areal Geology.

The area mapped is largely underlain by granite and gneissoid granite. Schists and highly metamorphosed gneisses of the Idaho Springs formation although closely adjoining the area in large masses are of minor occurrence in the area mapped. In addition to the granite, believed to be of pre-Cambrian age, a small fraction of the surface is underlain by so-called Tertiary dike rocks, mostly felsites and dellenites. (Fig. 3). These rocks are described in detail in this report. Equivalents of the rocks described as granite, dellenite porphyry, porphyritic dellenite, and rhyolite have been previously described by Dr. P. G. Worcester in his report "The Geology of the Ward District, Boulder County, Colorado".

Finally, a rather large part of the area is covered by glacial debris.

### Glacial Debris.

These deposits are composed of angular boulders in a matrix of finer material. The material is characteristically unassorted. (Fig. 2). The rock fragments are largely gneiss, schist, and granite.

### Pre-Cambrian Rocks

#### Granite

### Megascopic Description.

This rock which underlies practically the whole

area mapped is often highly jointed. It is a pinkish grey, even-grained to porphyritic rock, the even-grained variety being the more common. Where even-grained the crystal grains average  $1/8$  of an inch in diameter, but phenocrysts in the porphyritic variety attain  $1/2$  inch in greatest diameter.

The minerals commonly distinguishable are feldspar, quartz, biotite, muscovite, and pyrite. The feldspar is pink, and Carlsbad twins are indicated by individual reflection of light by each half of these twins.

The rock is typically massive, but in the Adit tunnel it has a distinct gneissoid structure as it has invaded older schists, of which there are remnants, forming an injection gneiss. In the Columbia mine the rock is also gneissic in places, but this appears to be a property of the granite itself.

The rock, where found on the surface, is always considerably weathered, and has a deeper brown color resulting from the formation of iron oxides.

#### Microscopic Description.

Under the microscope the essential minerals observable are plagioclase, orthoclase, microcline, and quartz. The plagioclase is in such small amounts and so badly altered that an absolute determination could not be made, but a maximum extinction angle of  $17^\circ$  measured from the trace of the albite twinning planes indicated sodic andesine. Often times the rock has marked poikilitic texture, minute grains of

quartz being enclosed by plagioclase, orthoclase, microcline, or larger quartz grains. Some of the plagioclase which encloses the quartz is itself enclosed by orthoclase, and this may in turn be completely surrounded by larger quartz grains. This is not in accordance with the usual order of crystallization and suggests replacement of the primary minerals by quartz. Seams of quartz also occur between the grains of the various minerals in what appear to be fractures. However, this replacement may not account wholly for the poikilitic texture since channels which the enclosed quartz could have followed were not always observed.

Accessory minerals are rare in this rock. Biotite from which the iron has been leached and segregated leaving secondary muscovite occurs. Finally, pyrite and black iron ore are sometimes present.

The rock appears to be highly altered wherever found. Kaolin is the chief alteration product and sericite is less important. Calcite grains appear to be secondary after the plagioclase. Limonite stains have resulted from the oxidation of the iron-bearing minerals. Chlorite and sillimanite (?) are found in the gneissoid varieties, but are probably remnants of the injected schist.

Approximate Composition by Volume

## Approximate Composition by Volume (continued)

Average of several slides.

Orthoclase	25%
Biotite	1%
Pyrite and Black iron ore	1%
Andesine (?)	1%

Quartz PyroxeniteMegascopic Description.

This is a nearly black, medium grained rock. It was found only in the Columbia mine where it forms a dike twenty feet wide. The rock is compact and not extensively jointed. It has the appearance of many pre-Cambrian rocks in neighboring areas, and is provisionally assigned to that period.

In the hand specimen short broad prisms of a nearly black mineral are discernable. These are seen in certain cases to have been altered to epidote.

Microscopic Description.

A study of a thin section of the rock showed that it consists almost entirely of augite. The augite is colorless and is biaxially positive. It has excellent intersecting prismatic cleavages at nearly 90°, a maximum extinction angle of 45°, measured from the prismatic cleavage, a birefringence of .022, and a rather high index of refraction. The only other primary mineral is quartz, which occurs in

very small anhedrons between the augite grains. In varying amounts. Chlorite and iron oxide have been derived from the augite, but the amounts of these appearing in the section are not large.

#### Approximate Composition by Volume.

Augite	85%
Quartz	7%
Biotite	3%
Chlorite	3%
Black iron ore	1%

#### Tertiary Rocks

##### Fine Grained Granite (Aplite).

#### Megascopic Description.

This rock occurs in narrow dikes averaging about four feet in width in the Columbia mine. These dikes occur along the veins and are parallel to them. They are nearly always closely jointed and form platy fragments. This rock is provisionally assigned a Tertiary age since it more closely resembles Tertiary rocks than the pre-Cambrian rocks, but its age could not be accurately determined. It is intrusive, as dikes, into the pre-Cambrian granite and is older than the veins.

The rock is grey in color and is rather fine grained. Quartz and feldspar are distinguishable with the unaided

eye. Pyrite from nearby veins occurs within it in varying amounts.

### Microscopic Description.

Microscopic examination shows the rock to consist largely of a highly altered feldspar and quartz. The feldspar is thought to be orthoclase as the grating structure of microcline is absent, and the elongate outline of plagioclase is not apparent. This feldspar encloses anhedrons of quartz in the same manner as the coarse grained granite does. It appears that quartz-bearing solutions invaded the rock at the time when the veins were formed, and quartz partly replaced some of the original minerals. This process also accounts for the high percentage of quartz found in sections of the granite occurring near veins.

As accessories pyrite, needles of apatite, and biotite occur sparingly.

The most important alteration product is kaolin with which some sericite is found.

### Approximate Composition by Volume

Quartz	55%
Orthoclase	45%
Apatite	1%
Pyrite	1%
Biotite	1%

### Microscopic Description.

Under the microscope only one thin section of this

Dellenite Porphyry

The term dellenite porphyry is synonymous with quartz latite porphyry. A dellenite porphyry is characterized by alkali feldspar and soda-lime feldspar in nearly equal amounts, and an appreciable amount of quartz. The plagioclase feldspar is usually andesine, but it may be labradorite. The phenocrysts form less than half of the

rock was examined. The feldspar was determined to be a basic andesine as the maximum extinction angle measured from the trace of the albite twinning was  $26^{\circ}$ . These phenocrysts show little weathering, but considerable fracturing. Zonal banding is a prominent feature in the feldspar phenocrysts. Orthoclase and quartz form a few small phenocrysts. Pale green phenocrysts of a mafic mineral are also rarely present, and they are, with a few exceptions, nearly completely altered to chlorite and calcite. As a result of this alteration absolute identification was impossible, but from their elongate crystal outline and rather low extinction angle, ( $20^{\circ}$ ), their pale green color, and their alteration products, the mineral was thought to be hornblende. It is not appreciably pleochroic.

Small anhedrons of black iron ore and laths of apatite of high refractive index but low birefringence occur as accessories. The black iron ore is the more abundant.

The groundmass is in general microcrystalline, very little glass being observed. Quartz forms about half the groundmass, the remainder being a badly altered feldspar, probably originally orthoclase.

Pale green chlorite, with ultra-blue interference color, and calcite are the most abundant alteration products. In the groundmass the most abundant secondary mineral is kaolin.

Approximate Composition by Volume.

Andesine	27%
Quartz	30%
Orthoclase	30%
Black iron ore	5%
Chlorite	6%
Biotite	2%

Porphyritic Dellenite

Megascopeic Description.

This rock forms a dike averaging about seventy-five feet wide directly west of the town of Frances. It is resistant to weathering and forms the crest of a low ridge. The rock is greyish brown in color and porphyritic in texture. The brown color appears to be largely the result of weathering. Phenocrysts of two kinds of feldspar, one of which is striated as a result of albite twinning, and small though abundant biotite grains form at least one-fifth of the volume of the rock.

Microscopic Description.

Under the microscope crystals of plagioclase and orthoclase are equally abundant. The abundance of the plagioclase afforded an excellent opportunity for its determination by the statistical method of Michel-Levy. It was found to be andesine, as the maximum angle measured between the extinction position and the trace of the albite twinning planes was 25°.

Strongly pleochroic biotite phenocrysts are numerous; they have a greenish black color for light vibrating parallel to the cleavage and a light yellow color for light vibrating at right angles to the cleavage. Quartz crystals of very small diameter are scattered sparsely throughout the slide. Grains of black iron ore and apatite are the only other phenocrysts.

The minerals distinguishable in the groundmass are quartz and orthoclase.

Alteration products are kaolin, iron oxide, and sericite.

#### Approximate Composition by Volume.

Quartz	30%
Orthoclase	40%
Andesine	25%
Biotite	3%
Black Iron Ore	2%

#### Porphyritic Quartz Syenite

##### Megascopic Description.

This rock forms two dikes in the area; they are about fifteen feet wide. They both strike slightly north of west. One of these outcrops east of the Cornucopia mine and the other west of the Dew Drop tunnel. The rock weathers as rapidly as the surrounding granite, and outcrops of this rock are not prominent surface features. The Adit tunnel intersects the dike of this rock occurring west of the Dew

Drop mine. It has a brown color and a porphyritic texture. The phenocrysts are large rectangles of reddish brown feldspar; these attain a maximum length of nearly one-half an inch. Black iron ore, and muscovite are also discernible.

Microscopic Description.

In thin section the large phenocrysts are found to be somewhat kaolinized orthoclase. The groundmass is seen to consist of approximately 70% orthoclase. Quartz occupies the remaining volume, although prominent primary muscovite is frequently present. Black iron ore anhedrons are evenly distributed throughout the rock. Calcite grains are common and may indicate that part of the original feldspar was plagioclase.

Approximate Composition by Volume

Orthoclase	85%
Quartz	10%
Black Iron Ore	3%
Muscovite	2%

Rhyolite Porphyry

Megascopeic Description.

This rock, which forms an important dike in the southwest part of the area, is a typical porphyry. It has a width of seventy-five feet. The phenocrysts are large and prominent; they are quartz, feldspar, and biotite. They weather less easily than the very fine grained groundmass.

Weathering emphasizes the porphyritic texture, pyramidal euhedrons of quartz being most apparent.

### Microscopic Description.

Microscopic examination shows quartz, plagioclase, and orthoclase euhedrons in nearly equal amounts. The plagioclase exhibits a maximum extinction angle of  $27^\circ$  and is therefore basic andesine. Small phenocrysts of muscovite and biotite are present. A few needles of apatite appear, and finally, several grains of garnet (?) are observable. This mineral has a nearly circular outline, a high index of refraction, no cleavage, and a pale reddish color.

### Approximate Composition by Volume

Quartz	40%
Orthoclase	35%
Andesine	15%
Muscovite	7%
Biotite	2%
Garnet (?)	less than 1%
Apatite	less than 1%

### Rhyolite

### Megascope Description.

and fine grained. The rock is, in general, even textured. Biotite phenocrysts are very common, however, in the dike outcropping along the crest of Niwot Hill. Occasionally a few scattered crystals of quartz can be distinguished. The dike rocks can be divided roughly into two varieties: one an extremely fine grained, white variety and the other one a coarser, darker grey rock.

#### Microscopic Description.

Under the microscope the whiter, fine grained variety is found to consist largely of quartz, orthoclase, and secondary kaolin and mica, thus making it a rhyolite.

#### Approximate Composition by Volume

Quartz	45%
Orthoclase	40%
Alteration Products	15%

The darker, coarser grained variety shows more variation in mineral composition. Microlites of plagioclase are abundant. The plagioclase was determined to be andesine as it exhibited a maximum extinction angle of  $26^{\circ}$  measured from the albite twinning lamellae. Biotite is also a common constituent of these rocks.

Needles of apatite and subhedrons of black iron ore are numerous. Chlorite is not uncommon, and the shape of its grains suggests that the mineral from which it was derived was hornblende. An average of the mineral composi-

tion of several sections of this rock gives:

Approximate Composition by Volume.

Quartz	25%
Orthoclase	43%
Andesine	21%
Black Iron Ore	4%
Apatite	2%
Chlorite	3%

This makes the rock a basic rhyolite approaching an acidic dellenite in composition.

STRUCTURAL GEOLOGY.

The area embraced by this report includes two well defined structural entities as noted by Dr. P. G. Worcester, *op. cit.* In California Gulch where the Adit structural features may be considered as typical, the veins and the faults have a northwest trend. Foliation planes in the gneissoid granite in the surrounding area have the same strike. The Columbia and Stoughton veins are characteristic of the immediate vicinity of Ward and have a nearly east and west strike. Here again the strike of the faults and foliation planes parallels the veins.

Dikes in the area show greater variation. The majority strike northwest, but others have east and west, northeast, and north-south strikes. Dips are generally to the north and range from 45° to 90°.

A large amount of faulting has taken place in the area. Layers of fault gouge on one or both vein walls are commonly present. Slickensides are also observable on the vein walls. Fractures crossing the veins are frequently observable, but displacement in these is rarely seen. The major fault of the area, the Niwot, has a strike slightly east of north. *is also found, but not in economic amounts.*

*The primary gold ore, where the topographic conditions were suitable, has been oxidized and enriched leaving free gold in "rotten quartz". These secondary ores were commonly very rich, and they have been largely worked out.*

#### ADIT TUNNEL.

##### General Character of the Deposit. (Plate 2).

The Adit tunnel has a northwest trend and follows along a vein covered by the California, Dew Drop, Helen C., High Line, Gold Bug, Golden Standard, and other claims. The width of the vein ranges in general from one to ten feet. The tunnel follows one remarkably straight and continuous vein. Cross veins and splits though present, are unimportant economically. They show no uniformity of strike and dip. A horse of considerable size is to be seen in the vein. The wall rock is almost universally gneissoid granite, massive granite being found only at the portal and at one place in the tunnel. The tunnel cuts through a porphyritic quartz cyanite dike. The vein is younger than the dike, since the dike is cut by the vein.

-----  
ORE DEPOSITS.

General Discussion.

The ore deposits of the area are principally gold. Silver is almost invariably present, but in too small amounts to be of importance. Lead, copper, and zinc sulphides and tungsten minerals are also found, but not in economic amounts.

The primary gold ore, where the topographic conditions were suitable, has been oxidized and enriched leaving free gold in "rotten quartz". These secondary ores were commonly very rich, and they have been largely worked out.

ADIT TUNNEL.

General Character of the Deposit. (Plate 2).

The Adit tunnel has a northwest trend and follows along a vein covered by the California, Dew Drop, Helen C., High Line, Gold Bug, Golden Standard, and other claims. The width of the vein ranges in general from one to ten feet. The tunnel follows one remarkably straight and continuous vein. Cross veins and splits though present, are unimportant economically. They show no uniformity of strike and dip. A horse of considerable size is to be seen in the vein. The wall rock is almost universally gneissoid granite, massive granite being found only at the portal and at one place in the tunnel. The tunnel cuts through a porphyritic quartz syenite dike. The vein is younger than the dike, since the dike is cut by the vein.

### Character of the Ore.

The ore in the portion of the Adit studied is remarkably homogeneous. It consists of large masses of greasy appearing, grey pyrite in a gangue of milky white, massive quartz. The ore is in general massive, and crystals are rare, only being found in vugs on crystallized quartz. Typical vein banding is rarely present. Chalcopyrite seldom occurs in the mapped portion of the Adit. Calcite and sericite are present but are unimportant.

### Age of the Deposit.

The age of this vein system is thought to be Tertiary. The vein cuts a porphyritic quartz syenite dike similar to those commonly assigned to the Tertiary period of vulcanism. Following this Tertiary period of dike formation, ore-bearing solutions are thought to have been abundant, and these are believed to have been instrumental in forming the ore deposits of the Adit tunnel.

### Ore Deposition.

It appears that the period of mineralization along this vein was relatively of brief duration. At the end of Cretaceous time or early in the Tertiary period, a displacement of large magnitude probably took place in a northwest direction. This movement was, no doubt, instrumental in leaving a weakened zone along the line of the Adit tunnel. The next event of importance was the intrusion of the various surrounding porphyry dikes. Then, after a lapse of time, and

perhaps as a closing feature of the same period of vulcanism, a large amount of quartz filled the major crevice formed during the period of movement, and finally the pyrite with its accompanying gold was deposited within the quartz and on quartz crystals lining vugs in the vein. Still later, movements again occurred in the region, and their position was determined by the strong resistant quartz veins along the borders of which the movement developed gouge seams.

#### Outlook.

It appears that the ore deposits in the portion of the Adit tunnel mapped are destined to remain unexploited for some time as they are of too low grade to be mined and milled profitably. However, it is reported that rich ore shoots occur a short distance farther from the portal in the Dew Drop and High Line claims, and these will, no doubt, be shortly opened by the Big Five Company and may yield excellent profits.

### COLUMBIA MINE.

#### General Character of the Deposit. (Plate 3).

The ore deposits in the Columbia mine form a marked contrast to those in the Adit. Instead of one long, continuous, rarely branching vein, there is a wide zone of mineralization occupied by four more or less parallel veins branching from or closely related to a central or middle vein.

Faults adjacent to and parallel with the veins and marked by wide gouge seams on one or both vein walls are quite common.

### Vein Relationships.

The veins occur in an area of massive pink granite which apparently grades into a gneissoid granite in all directions from the Columbia shaft. The veins frequently parallel dikes of pegmatite and fine grained granite. The pegmatite is similar to the granite in composition, but the amount of quartz is variable and may be practically zero. The areas occupied by the pegmatite, fine grained granite, and coarse, massive granite apparently were conducive to ore deposition, and where the rock becomes more gneissoid the veins are narrow and decrease in value.

### Character of the Ore.

The ore, unlike that in the Adit, consists largely of chalcopyrite. Crystals and masses of pyrite are also frequently present in a matrix of massive chalcopyrite. Quartz is the only important gangue mineral, but subordinate amounts of calcite and feldspar also occur. In addition to the minerals already mentioned, almost negligible amounts of galena, tetrahedrite, chalcocite and bornite occur.

### History and Age of Ore Deposition.

The events leading up to the ore formation are apparently as follows: in pre-Cambrian time the region was

invaded by a very large granite mass. As a final stage of this intrusion, pegmatitic material was injected apparently along a weakened zone. Later still, the fine grained granite was intruded into the cold rocks and was closely jointed due to rapid cooling. At some subsequent time which may have been during the Tertiary period and contemporaneous with the Adit mineralization and the eruption of the nearby, closely parallel felsite porphyry dike forming Niwot Hill, quartz was injected and ribbed the broken zone. Soon after the chalcopyrite formed, and then pyrite was deposited. Following this, the very subordinate galena and tetrahedrite were deposited. One rather brief period of mineralization is indicated, and subsequent vein opening and refilling are not found. The chalcocite and bornite appear to be alteration products forming coatings on the primary minerals as a result of secondary enrichment and weathering processes. The ore is generally confined to the outer portions of the veins, occurring either in the hanging-wall or foot-wall or both. In many places the granite walls are heavily impregnated with the auriferous sulphides. Occasionally the ore streak leaves the quartz entirely and is bounded on both sides by granite walls.

#### MINE WORKINGS.

The various levels of the Columbia will be described only briefly since they are shown in detail on the accompanying map. (Plate 3).

Fifty Foot Level.

The middle vein is the only vein worked on this level. It consists in general of from 2 to 3 feet of white quartz with accompanying pyrite and chalcopyrite. The strike is S. 72° E. which may be considered as about the usual strike of veins in the Columbia. The dip is 65° to the north and also quite typical. The walls are of pink, massive granite. Workings are less extensive on this level than on any other mapped.

One Hundred Foot Level.

Workings on the hundred foot level are confined to the middle and north veins. Pegmatite and fine grained granite occur along and between these two veins. Gneiss occurs at both the eastern and western ends of the middle drift. Where the gneiss occurs the veins are poorly developed, and they were abandoned.

One Hundred and Fifty Foot Level.

Conditions along the one hundred and fifty foot level are very similar to those found on the hundred foot level. Pegmatite and fine grained granite dikes occur along and between the north and middle veins together with massive granite. Gneiss occurs in the west end of the middle drift. The strikes and dips are typical.

Two Hundred Foot Level.

The two hundred foot level is more extensively

worked than any of the others mapped. Drifts follow four veins on this level - the middle, south, north, and north number 2 veins.

The wall rock of the south vein is mainly gneissoid granite with subordinate amounts of massive granite. The vein averages between six inches and a foot in width and appears to be poorly developed, though some assays ran as high as three ounces of gold to the ton. The strike is about the usual S. 70° E., but the dip is exceptional at times being to the south. These dips range from 60° S. at the west end of the south drift to vertical near the east end.

The middle vein is largely in granite with gneissoid granite at each end. Pegmatite occurs sparingly, but no fine grained granite was observed.

The north vein is in a granite area with only a very small showing of pegmatite. The north number 2 vein has pegmatite and fine grained granite paralleling it in its eastern extent. The hanging wall is granite and the foot wall gneissoid granite. This vein passes through a dike of quartz pyroxenite, and farther west the wall rock is granite. The dip varies, being in some places to the south and in others to the north. The vein splits at the east breast into two distinct veins.

In addition to the above veins some minor cross veins occur, the most important is in the cross cut between the middle and south veins, and strikes N. 72° E. and dips 82° N.

about 900 feet from the surface. In addition to this the Columbia dump is being milled with success.

### Two Hundred and Fifty Foot Level.

The two hundred and fifty foot workings are less extensive than those on the two hundred foot level. Gneiss is more abundant. No pegmatite or fine grained granite like that found on the upper levels was seen. A more typical pegmatite, however, consisting of large masses of intermingling quartz and feldspar occurs in the cross cut from the middle to the north vein. Very little work has been done on the south vein where the ore is apparently interspersed through a feldspar matrix. At the west breast of the north drift the vein splits, and one branch of about an inch of chalcopryrite passes into the granite walls without accompanying quartz. The veins have roughly east - west trends with fairly high dips to the north.

### Outlook.

The outlook for the Columbia mine is bright. There is a large amount of ore in the stopes which, under present conditions, can be milled profitably at the Camp Frances mill of the Big Five Company. In addition to this, there yet remains a large block of ore on the two hundred foot level, north number 2 vein, which will run close to half an ounce of gold per ton over a mineable width. No doubt, considerable ore will be found below the two hundred and fifty foot level as old workings continue to be re-opened. The Niwot winze sunk on the Columbia vein has proved ore to a depth of approximately 900 feet from the surface. In addition to this the Columbia dump is being milled with success.

MINING OPERATIONS.



Fig. 4. Big Five dump at the Adit tunnel portal.  
 work. Gasoline engines are employed at the Columbia shaft  
 for driving the compressor, fans, hoist, and generator.  
 (Fig. 5).



Fig. 5. Shaft house and gallows frame at the Columbia shaft.

## MINING OPERATIONS.

In the area mapped the Ward-Big Five Gold Mining Company is practically the only producer. A few other small operations are being carried on intermittently. The present Big Five Company was organized in 1932 and operations began in the early part of 1933. At the present time from two to three shifts are kept busy cleaning out the Adit tunnel for use in tramming ore from both the Adit and Columbia vein systems (Fig. 4).

In the Columbia mine a like number of shifts are engaged in drilling, rock breaking, hoisting, and clean-up work. Gasoline engines are employed at the Columbia shaft for driving the compressor, fans, hoist, and generator. (Fig. 5).

This mill, which began operating only a short time ago (April, 1934), is handling from twenty five to fifty tons of ore daily. This capacity can be increased materially, however, by using more Wilfley tables.

In addition to the mill a completely equipped laboratory is maintained by the Big Five Company in which ores and mill products are assayed, and chemical determinations are carried on. (Fig. 7).

### MILLING OPERATIONS.

The only mill operating in this area is the Camp Frances mill of the Big Five Company. (Fig. 6). A 110 horse power diesel engine supplies power for the mill and drives an electric generator to supply current to the other mine buildings. The ore is first crushed in a Blake jaw crusher and then passed through a ball mill. Classifiers are in closed circuit with this mill, and the material is reground until it passes a 16 mesh screen. The ore pulp then passes over an amalgamation plate; after which it runs over a Wilfley table, and a first concentrate is obtained. The tailings from the first table pass to a lower table, and a second concentrate is obtained, after which the tailings are discharged from the mill to settling ponds. This mill, which began operating only a short time ago (April, 1934), is handling from twenty five to fifty tons of ore daily. This capacity can be increased materially, however, by using more Wilfley tables.

In addition to the mill a completely equipped laboratory is maintained by the Big Five Company in which ores and mill products are assayed, and chemical determinations are carried on. (Fig. 7).

Fig. 7. Big Five laboratory and office at Frances.



Fig. 6. Big Five Mill at Camp Frances.



Fig. 7. Big Five laboratory and office at Frances.

PRESENT OUTLOOK FOR THE WARD AREA.

It is probable that the Ward area will again become a large gold producer. The veins are wide, and though of low grade, they can in general be depended on to retain their values for considerable distances. Unless sufficient capital enters the area, however, progress will undoubtedly be slow as large scale operations are necessary.







