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The Mountain City Copper Mine

Elko County, Nevada

E. C. Stephens

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Summary
~~Abstract:~~

Ore averaging more than 50 percent copper was discovered at the Mountain City Copper Mine in northern Elko County, Nevada on February 27, 1932. The mine then was known as the Rio Tinto Mine or the Nevada Rio Tinto. The first shipments of ore were made during the summer of 1932. From then until the mine was closed in 1947 the production amounted to 1,162,176 tons of ore averaging 9.745 percent copper, 0.274 ounces silver and .0057 ounces gold per ton. Of the total ore produced, 182,340 tons averaging 26.1 percent copper were shipped directly and the remainder was concentrated at the property. The concentrates were shipped to the International Smelter at Tooele, Utah.

The two principal orebodies were known as the "200" or "main" orebody and the "600" orebody. These appear to be the faulted parts of the same orebody. The main orebody is a lens more than a quarter of which is composed of massive iron and copper sulphides. The ore replaces schist and other shaly rocks, and to a minor extent, quartzite, of the Rio Tinto formation. No fossils were found in the Rio Tinto formation in the mine area. The formation underlies the Banner formation which is considered to be of Mississippian age. Other uneconomic smaller lenses of hypogene sulphide ore were found in the Rio Tinto mine when underground exploration was done easterly, westerly and downward from the main orebody.

The average strike of the main orebody is North 78° West and its average dip is 65° North. Footwall dips range from a few to 90 degrees. The hanging wall has less irregularity than the footwall, but locally it dips vertically and is even overturned.

The ore deposits are cut by post-mineral faults. In one of the principal fault systems the strikes of individual faults range from North 12° West to North 70° East and dips range from 5° to 65° westerly or northwesterly. The prevailing strikes are northeasterly. The dips of the faults tend to flatten with depth. The traces of the faults on plan are sinuous, particularly those having low dips.

No. 6 fault occurs in the western part of the mine. It strikes from North 55° to 70° West and dips from 51° to 68° Northeast. No. 6 fault has a right hand horizontal displacement of the beds from 400 to 800 feet.

An east-west striking fault system, of which No. 4 fault is typical, dips north from 30° to 50°. The faults of this system apparently have relatively small displacements.

The main orebody has a strike length of 1,100 feet on the 200 level and a maximum width of 90 feet.

The ore deposit has a relatively inconspicuous leached outcrop in Copper Gulch. The gossan, which assays no copper, consists largely of sandy quartz fragments cemented with brown, yellow, and, to a lessor extent, red and maroon iron oxides.

The original discovery shaft is a 63° incline. It was started in gossan and remained in it for 242 feet before abruptly entering ~~the~~ high-grade chalcocite ore. The transition from gossan having no copper to chalcocite ore having plus 50 percent copper ore was less than 1 foot in thickness in this location. Throughout most of the main orebody the contact between the gossan and the supergene ore is sharp and less than a few inches in thickness. It is from 12 feet above to 10 feet below the 200 level track elevation, although in one part of the mine, along the hanging wall side of the No. 1 fault, the top of the sulphides is 50 feet below the 200 level. In one restricted area there is a 20 foot thickness of oxidized ore containing malachite, a little azurite, cupriet and native copper along with residual sulphides. This oxidized ore was shipped directly to the smelter.

The bottom of the zone of secondary enrichment extends from 50 feet to as much as 210 feet below the 200 level. The deeper prongs of secondarily enriched ore were the result of loose, permeable zones which allowed the supergene solutions access to replaceable primary sulphides.

The hypogene sulphides are largely pyrite and chalcopyrite. A small amount of sphalerite occurs in the massive type primary ore. A few specks of galena were found in a quartz veinlet just a few feet from the orebody. The principal supergene minerals are chalcocite, the greater part of which is the sooty variety, bornite and covellite. Pyrite also is a supergene mineral.

Native copper, cuprite, malachite and azurite are common minerals of the oxide zone. The richness of the supergene copper ores at Mountain City was the result of many contributing factors:

The hypogene ores averaged 6.5 per cent copper or more.

There is a large proportion of pyrite and chalcopyrite in the hypogene ores which furnished excess amounts of sulphate solutions during the leaching and enriching process.

The wall rocks contain very little to no lime, the presence of which could have precipitated the copper from solution at this point, and thus prevented almost all of the oxide zone from being devoid of copper minerals.

With one conspicuous exception, there is a layer of chloritic, clayey alteration on the footwall of the main ore deposit. This impervious layer restricted the copper bearing solutions to the orebody itself during the enriching process. Where the confining impervious layer was absent on the footwall in the east end of the orebody, there was a leakage of the supergene solutions and secondary chalcocite was deposited for more than 600 feet horizontally (South) from the footwall of the hypogene orebody. Other, but minor, leakages of the enriching solutions occured where transverse faults broke the clayey seal on the footwall, resulting in chalcocite being ~~Chalcocite was~~ deposited in footwall shaly rocks.

The Mountain City Copper Mine is located in a mountanious region where there is abundant precipitation. The top of the water table in the mine area coincides with the top of the chalcocite ore. It is approximately 10 feet above the level of Mill Creek, the nearest major drainage channel which is a half a mile north of the mine.

The hypogene ores at Mountain City are restricted stratigraphically to what is know locally as the "ore horizon." This consists of a series of shaly beds as much as 220 feet in thickness which lie stratigraphically almost two thirds above the base of the Rio Tinto formation. The rocks on both sides of the "ore horizon" are largely well bedded shales, some black and some alternating black and light gray. The term shale as used here by the ~~miners~~ writer includes slates, phyllites and schists.

The Rio Tinto formation in the mine area may be described as being essentially a series of dark shaly rocks having quartzite lenses, a few massive argillaceous and calcareous beds and substantial units of siliceous shales and cherts. ~~No fossils were found in the Rio Tinto formation. It underlies the Banner formation which, on fossil evidence, is considered to be Mississippian~~. The altered rock on the footwall of the orebody, and which was mentioned above, contains pyrite and a little chalcopyrite. Chalcocite and other supergene copper minerals commonly replace the pyrite and chalcopyrite in this formation.

The "ore horizon" occupies a definite position in the stratigraphic column, but the distinguishing characteristics of the rocks in this zone also are the result ~~of a combination~~ of alteration ~~processes~~ and movement. Many of the rocks have slick, dark shiney faces and the terms "black carbonaceous" and "woody" describe them well. Alongside of individual sulphide deposits the "ore horizon" beds are quite distinctive. Away from sulphide bodies, the alteration effects commonly are weak and the "ore horizon" rocks are not easily distinguished from adjoining sediments.

The rocks of the "ore horizon" are darker, have more fissility and are more broken than adjoining members of the Rio Tinto formation.

The ores and wall rocks at Mountain City presented an interesting mining problem in loose rock. Square sets were used entirely for the mining because of the looseness of the ore and walls and ~~also~~ because a high recovery of ore was desired. Seldom could stope backs of more than 25 or 36 square feet be left open for more than a few hours without caving. Most of the workings were kept timbered close to the working faces. Detailed geologic notes and samples were taken daily of every working face in all drifts, cross cuts, shafts, winzes, raises and stopes. Assay results were available to the next shift after the samples were taken. This information was used daily in the operations and it allowed for accurate and efficient ore control.

Most of the ore consisted of loose rock and very little powder was required to break it. In certain sections of the mine, particularly in the primary ore zone, the massive sulphides were ~~very~~ hard ~~both~~ to drill and to break. The mining was carefully planned and executed and more than 99 percent of the total sulphide orebody was extracted.

History of the Discovery:

The history of the discovery of the Mountain City Copper mine is essentially that of its discoverer, Samuel Frank Hunt, from the years 1919 to 1932. Hunt, a prospector-geologist, first was attracted to Cope (Mountain City) district in 1919 when the adjoining Duck Valley Indian Reservation was opened to the public for mineral locations. A small rush took place and Hunt arrived too late to locate any claims. The entire ~~southwestern~~ southeastern part of the Indian Reservation had been covered with new locations.

After spending approximately a week on the reservation, Hunt satisfied himself of its lack of ore possibilities. Before leaving the district, however, he investigated the Copper Gulch area which lies a mile and a half south of the Reservation. He was informed that the gulch received its name from a boulder of copper ore and that he could go to Copper Gulch and see it for himself. He found the boulder which contained a tiny amount of malachite, some cuprite and a little native copper.

He walked up the gulch for a few hundred feet above the boulder where he found the dump of an old adit on which was brown and yellow barren gossan. The adit had been driven during the 1890 decade by the McGinnis brothers, local ranchers who at that time were prospecting for gold. They had diverted the creek with a small flume and sluiced a few scars of the east side of the gulch. The McGinnis brothers failed to find gold either on the surface or in the adit and abandoned the claims.

Hunt told the writer that his uncle, who was a geology professor in Texas, had once shown him specimens of gossan from the Rio Tinto copper deposits in Spain. The rocks found in ~~the~~ Copper Gulch ~~dump~~ bore a marked resemblance to the Rio Tinto rocks so Hunt called his claim the Nevada Rio Tinto.

After locating the property, Hunt interested Mr. Vivian P. Strange, a Salt Lake City, Utah contractor, in supplying the capital to develop the prospect. For this, Strange received a three quarters interest. Hunt returned to Mountain City yearly and performed the annual assessment work. He once built a churn drill rig and drilled one hole 135 feet in depth, and with the help of local rachers sank a shaft 73 feet in barren gossan. Strange then hired a reputable geologist from Salt Lake City to examine the property. The geologist, who made a cursory visit to the property, recommended that Strange abandon the venture as it was nothing but a worthless prospect. Subsequently, Strange severed his partnership with Hunt. Hunt then sought to interst most of the larger mining companies in the Salt Lake mining region in his property but failed. During this time he sent specimens of the gossan to mining men and geologists in the southwest and in San Francisco who were experts on gossans. He received a reply from San Francisco stating that the specimens did not represent a capping of a ~~the~~ copper orebody although it ~~it~~ did have some indications of zinc minerals. The letter also contained the usual statement that the location of the property was too remote to warrant an examination. Hunt informed the writer that only one geologist, Reno H. Sales, offered him encouragement. Sales, who happened to be in Salt Lake City one winter when Hunt was making the rounds of the mining offices with his little sack of gossan specimens, advised Hunt to keep digging until he determined what the underlying sulphides were. Hunt did not forget this interview with Sales. It was this circumstance that later allowed the Anaconda Copper Mining Company to make the entering purchase of stock in the Rio Tinto Copper Company from Hunt. Failure to get action from any of the established mining companies led Hunt to seek help for financing his prospect from Ogden C. Chase, a stock promotor in Salt Lake City, who dealt in penny mining stocks. Chase formed the Rio Tinto Mining Company and mailed stock certificates to a list of prospective buyers along with a prospectus. If the prospective buyor wished to purchase the stock, he was to pay five assessments of one cent per share as called for by the Rio Tinto Copper Company. This stock was transferred, share for share, for Mountain City Copper Company stock after Anaconda obtained control of the property ~~. The stock later~~ and subsequently sold for more than $17.00 a share. The original prospectus contained a prediction by Hunt that a large body of 20 percent copper ore would be found in the shaft at a depth of 225 feet below the surface. As a matter of record, ore assaying 50 per cent copper ~~over~~ having a width of ~~70~~ 72 feet at that location was discovered ~~was encountered at~~ at 242 feet. ~~(215 vertical distance)~~.

The total amount of money spent on the property from the time Hunt located it in 1919 until ore was found on February 27, 1932 amounted to less than $7000.

Many people, besides Hunt, had an important part in finding the ore. Ogden C. Chase, the promotor, his brother George, and his brother-in-law, Percy Christopherson, actually performed the manual labor to sink the prospect shaft from the depth of 73 feet to 242 feet, where ore was ~~found~~ discovered. Jack and Walter Davidson, who operated the general store at Mountain City, put all of their money into the property and supplied the prospectors at the mine with food and materials so that they could keep working. Other local people including George Nelson, George Irland and Pat Maloney helped do the work and gave encouragement to the miners. Mrs. George Nelson provided Mr. Hunt with board and room during the years Hunt performed the annual assessment work.

Production

~~The following chart shows the total production of the Mountain City Copper Mine.~~

Geologic Work

The earliest recorded geological work in the Mountain City district was done by W. H. Emmons* According to Emmons "---------no geologic mapping was undertaken except that incidental to examination of the ore deposits."

In the early summer of 1932, D. C. Gilbert assisted by Clem Pollock then of the International Smelting Company, a subsidiary of the Anaconda Copper Mining Company, made a reconnaisance map (not published) of the Centennial Range from Mountain City to Bull Run Mountain.

Later, in the summer of 1932, M. B. Kildale and the writer mapped the surface adjacent to the Mountain City Copper mine. This map was not published.

In August 1932 Crawford and Frobes ** published a description of some polished sections of the ore from the Rio Tinto (Mountain City) Copper mine.

T. B. Nolan, through a joint arrangement between the Nevada Bureau of Mines and the U. S. Geological Survey visited the district in 1932 and prepared a report *** and unfortunately this, too, was never published.

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* Emmons, W.H., A Reconnaisance of Some Mining Camps in Elko, Lander and Eureka Counties, Nevada, U. S. Geological Survey Bulletin 408, 1908.

** Crawford, A. L. and Frobes, D. C., Microscopic characteristics of the Rio Tinto, Nevada Copper deposits. The Mines Magazine (Colorado School of Mines Alumni Association) Vol. 22, pp 7-9; August 1932

*** Nolan, T. B., The Mountain City Mining District, ~~1932~~ Elko County, Nevada; 1932.

S. K. Droubay and the writer mapped the Mountain City Quadrangle in 1938 but this work was not published. Mapping emphasis was placed on locating and examining the Rio Tinto Formation to the east and northeast of the mine and determining the extent and relationship of the granitic rocks to the Paleozoic sedimentary rocks in the quadrangle. The volcanics were grouped as a single unit and no attempt was made to determine structure in the volcanic areas.

Many sources of geologic information are included here. The geologic notes of Reno H. Sales, made during the original examination of the mine, the surface maps of D. C. Gilbert, the maps and stratigraphic correlation charts made by Graydon R. Beechel and Roger Smitten, observations of M. B. Kildale and Tom Lyon and other officials of the Anaconda Copper Mining Company together with underground notes and maps made by W. T. Swensen, James Wilson, Earl Whitney, John Baker, Charles Michaels, Earl Stevenson and other members of the Mountain City Geological department all were used freely. Responsibility for any statements made here, however, is solely the writer's. Permission to publish this paper was given by Mr. Clyde E. Weed, Chairman of the Board of Directors and Mr. Vincent D. Perry, Vice President and Chief Geologist of the Anaconda Company.

General Geologic Setting of Mine

The Mountain City Copper Mine lies in the northern part of the Centennial Mountain range at an elevation of approximately 6000 feet. The copper orebodies occur in the Rio Tinto formation, which underlies the Banner formation of Mississippian age. The Paleozoic rocks become progressively older to the Southwest in the Centennial range and 12 miles from the Mountain City Copper Mine is the Cambrian quartzite which forms the bulk of Bull Run Mountain. The greater part of the beds in this 12 mile stretch of the Centennial range strike generally easterly and northeasterly and dip northerly. The Rio Tinto formation has a northerly dip. Approximately a mile north of the mine is the Mountain City granodiorite. The sedimentary rocks overlying the Rio Tinto formation also dip northerly toward the intrusive. The Mountain City granodiorite is one of a series of easterly elongated intrusives that occupy an east-west trending mountainous belt which is joined to the Centennial range in the Mountain City and adjoining Owyhee quadrangles. The Mountain City granodiorite mass is exposed for 7 miles in the Mountain City quadrangle and extends westerly into the adjoining Owyhee quadrangle. Its maximum North-South dimension is 4 miles. The south contact of the granodiorite is generally steep and its north contact dips gently to moderately north. The invaded rocks north of the intrusive exhibit a higher degree of metamorphism over a broader area than those to the south of the intrusive. North of the mine and largely within the Banner formation are amphibolites consisting of small intrusive plugs, sills, dikes and possibly some extrusives. The amphibolites are believed to have been derived from andesites or diorites. There are a few igneous dikes in the mine area but their original texture is ~~completely~~ obliterated by alteration. The least altered of the dikes appear to have a porphyritic texture. None of the dikes are in contact with the hypogene orebody. They are generally light gray in color and possibly are andesitic in composition.

Remnants of extrusive volcanic rocks are found in the higher elevations in the mine area. One patch lies 1600 feet south and another 3200 feet northeasterly of the mine.

To Summarize: The Mountain City Copper orebodies occur in north-dipping shaly sedimentary rocks of the Rio Tinto formation a mile south of the Mountain City granodiorite. A few altered igneous dikes are found in the mine area. These do not intersect the hypogene orebodies and their relationship to the ore is not clear. The amphibolites which occur largely in the Banner formation north of the mine area and south of the granodiorite commonly contain oxide copper minerals but this copper mineralization apparently is unrelated to the hypogene copper mineralization of the Mountain City Copper mine.

Exploration emphasis in the mine area was placed on developing the stratigraphic unit of the Rio Tinto formation known as the "ore horizon." All of the lenses of hypogene sulphides found during the mine exploration occur in this "ore horizon." The rocks of the "ore horizon" are intensely sheared and crumpled and contrast with the less deformed adjoining units of the Rio Tinto formation.

The Rio Tinto Formation

The Mountain City Copper orebodies occur in the Rio Tinto formation. The thickness of this formation has been estimated from as little as 1100 feet to as much as 2100 feet in the mine area. The lower figure seems more likely. ~~reasonable~~. There is no complete undisturbed section that can be measured, ~~completely~~. Tight folds and faults break the continuity of the section. Many of the units vary in thickness and lithology within short distances both vertically and laterally in the mine area.

The Banner formation unconformably overlies the Rio Tinto formation. In the Rio Grande mine workings a fault separates the two formations. The lowermost unit of the Banner formation in this area is a conglomerate largely composed of angular to subangular fragments of limestone and bluish grey limy shale. ~~and~~ This rock contains an occasional 4" to 10" rounded boulder of white quartzite. Overlying the conglomerate is a medium grained sandstone, the lower part of which is cemented with loose fine limy particles. Amphibolite is either intrusive into the sandstone as a sill or possibly it could be an extrusive. The amphibolite contains porphyroblasts of calcite, native copper, cuprite and malachite. Most of these are 1/4" to 3/8" in diameter. The sandstone grades upward into a bluish limestone.

Underlying the Rio Tinto formation is the Black Rock quartzite - a dark, coarse textured and often cross bedded quartzite. Near the north contact of the quartzite, it is commonly brecciated and cemented with white quartz. This breccia in some places contains pyrite. The quartzite contains shale partings.

G. R. Beechel and R. Smitten compiled the mine stratigraphic information of the Rio Tinto formation and made a set of 1"=50' maps for the Mountain City Copper Company in 1938. Their description of the units, beginning with the oldest of the series, is as follows:

Gray to black chert with gray shale partings. ~~Measured thickness in mine area is 15 feet.~~

delete this line

Schisty and siliceous shale. Black schisty and carbonaceous shale and gray to black siliceous or silicified shale in irregular layers. Schistocity well developed. Some white banded quartz. The thickness ranges from 225 to 254 feet in mine area.

Footwall well-bedded shale. Light gray to black well-bedded shale. Bedding distinct. Some tight folding and cross-bedding. Striped in layers of light to dark gray in upper levels of mine. Locally the shale is loose and gritty. Small tubular lenses of gray quartz - these being 1" by 3" or 4" in cross section and up to 10' or 12' in length, are common. The shale grades into a medium to dark gray limy shale on lower levels of mine. The thickness ranges from 448 feet to 531 feet in mine area and is as much as 772 feet in the east end of mine workings.

Black carbonaceous shale. This is the so-called "ore horizon." It is a generally loose and fissile black carbonaceous shale. Contains areas of siliceous shales and hard, blocky massive argillites. Much of the rock is schistose and is intensely crumpled.

The hanging wall, well-bedded, black to dark gray shale has distinct bedding. On the upper levels of the mine the shale is alternately light and dark gray with irregular schistose black units. Becomes more massive in lower levels of mine with less distinct bedding.

<u>Limy shale,</u> generally gray but partly brownish gray and black. Texture slaty to massive. Contains small stringers of calcite, layers of acicular metamorphics and erratic areas of silicification.

From the black carbonaceous shale unit up are lenses of dark gray quartzite.

Pyrite is indigenous to the most of the shales of the Rio Tinto formation, particularly the black and dark gray shales.

A brownish gray volcanic tuff possibly could be one of the upper units of ~~part of the uppermost part of~~ the Rio Tinto formation although ~~its~~ this relationship is not clear.

Gossan

There is much soil cover in the mine area and the leached outcrop in Copper Gulch is relatively inconspicuous. On the east side of the canyon is a small outcrop of silicified schist containing some red iron oxides. A cut on the west side of the gulch exposed 6 feet of gossan composed of loose, sandy fragments of quartz cemented with yellow and brown iron oxides. A very small amount of the gossan had brick red and maroon coloration. The 190 foot adit into the west side of the gulch, although it angles across the strike, showed the gossan to have a substantial width at this point. Farther south are some silicified breccia outcrops having iron oxides. In the bottom of the Gulch was a small cut having a few malachite stains. Other than this, there were no copper minerals exposed on the surface. When excavations later were made for the surface plant of No. 2 shaft, some oxide copper minerals were found in the footwall shales. This represented the outcrop of the supergene mineralized area on 300 level.

The No. 1 shaft was collared ~~in the~~ in gossan and continued in it 242 feet to the water table. At the water table the shaft entered 50 percent plus chalcocite ore.

~~The greater~~ A large part of the 200 level is in gossan. In the west end of the mine the leached banded quartz type ore produced a ~~vuggy~~ vuggy quartz having no iron minerals. Most of the leached capping, however, consists of yellow and brown iron oxide minerals and quartz. ~~This~~ It is characterized by a large proportion of quartz.

Hypogene Mineralization

The hypogene sulphide minerals of the Mountain City

Copper mine are pyrite, chalcopyrite and sphalerite. Supergene sulphide minerals are chalcocite, bornite covellite and pyrite. Oxide minerals are malachite, azurite, cuprite and native copper.

Mineralizing activity was initiated with a silicification of shales and quartzites of the "ore horizon." The silicified rock was then crackled and this was followed later by the introduction of quartz, pyrite and chalcopyrite.

The distribution of the 5 hypogene and 2 supergene ore types is shown on the accompaning 1"=50' plan maps and sections. The normal distribution of the hypogene ore types proceeding from the hanging wall to the footwall of the "200" ore lens is 1) Massive 2) Quartzite 3) Dark quartz with some quartzite 4) Banded white quartz and 5) Altered shale.

The "massive" hypogene ore is composed largely of an intimate mixture of fine grained pyrite, chalcopyrite and quartz with minor sphalerite. The rock is very hard and dense. Pyrite is most abundant, chalcopyrite usually comprises from 6 to 30 percent and white quartz from 5 to 25 percent of the rock. The massive type ore occurs principally on the hanging wall side and ~~hear~~ near the edges of the ore lenses. Its contacts with the hanging wall shales and with other hypogene ore types are sharp.

The replaced "dark gray quartzite" ore retains the quartzite texture although the rock has been silicified erratically. Chalcopyrite is commonly more abundant than pyrite and forms 25 to 40 percent of the rock. Bedding is rarely discernable.

The "dark quartz" ore type often includes some quartzite. The rock has been completely silicified and, in most places, a coarse but distinct banding is developed parallel to the strike of the walls of the ore lens. Chalcopyrite commonly is more abundant than pyrite. The sulphide minerals occur as irregular streaks and blobs and are seldom accompanied by later surge glassy quartz except near the contact with the "banded white quartz" ore type. The contact of the "dark quartz" with the "banded white quartz" ore types usually is sharp but in the lower western part of the "200" orebody and in the "600" orebody it is gradational. Typical assays of this type hypogene ore range from 3 to 12 percent copper.

The "banded white quartz" type ore usually underlies the "dark quartz" ore. The bands are from a quarter of an inch to an inch in width. The banding seldom is parallel to the strike and dip of the ore lens. The bands could represent the original bedding planes. The initial silicification is complete and the banded quartz is dense and white. No sulphides accompanied the early silicification. The banded quartz was crackled and this was followed by the ore mineralizing surge consisting of an introduction of glassy quartz, pyrite and chalcopyrite. The banded quartz is cut by a myriad of tiny criss-cross veinlets of glassy quartz, pyrite and chalcopyrite. One or any combination of these three minerals may occur in any one veinlet. The veinlets commonly range from 1/32" to 1/4" in width. The paragenetic sequence is definite; quartz being followed by pyrite then chalcopyrite.

Far removed from the ore lenses of the "ore horizon", and in rocks much lower stratigraphically, exploration to the east and southeast of the mine disclosed areas of white banded silicified shale that is similiar to the "banded white quartz" ore type. This rock, however, ~~contained~~ contains only first stage silicification. It had not been crackled and does not contain the all important later veinlets of the quartz, pyrite, chalcopyrite surge. The attitude of the banding in these silicified zones does not conform either to bedding or schistocity.

The "chloritic altered shale" which forms the footwall of the greater part of the "200" orebody contains streaks of pyrite and chalcopyrite most of which lie close to adjacent ore types. This soft mass of clayey and chloritic altered shale is in sharp contrast with the adjacent ore types, and fault gouges are developed largely within 5 feet of the contact. Most of the ore that occurs in the chloritic altered shale lies close to this 5-foot gouge zone. Where chloritic altered shale on the footwall of the orebody was present, it acted as a dam and restricted the copper rich supergene solutions to the orebody itself. In the eastern part of the orebody this altered shale is absent and the supergene solutions migrated southwards into the footwall shales as much as 600 feet from the hypogene orebody.

Supergene Mineralization

The supergene sulphide minerals are chalcocite, which is largely of the sooty variety, bernite, covellite and pyrite.

The deposition of the supergene copper sulphides was so complete over a large proportion of the hypogene orebody that the original ore textures were largely obliterated. Where this occurred the rock was given the name "massive high-grade type ore." There are some residual hypogene sulphides and quartz left in this ore type.

The footwall shales that contain supergene copper minerals, and their oxidation products, are considered to be a second supergene ore type. The difference between the two supergene ore types is that the massive high-grade type originally was a hypogene ore whereas the footwall shales originally were not hypogene ore - just shales.

The supergene zone in the "200" orebody is generally characterized by a sharp upper contact with the gossan and a gradational lower contact. The bottom of the enrichment extends from 50 feet to as much as 210 feet below the 200 level. The deeper prongs of secondarily enriched ore were the results of loose permeable zones which allowed the supergene solutions access to replaceable primary sulphides.

Chalcocite, bornite and covellites replace chalcopyrite and pyrite. In many places chalcocite fills in open cracks and vugs. Undoubtedly, as the water table was progressively being lowered, there was a reworking ~~leaching~~ of the upper part of the supergene zone and the copper redeposited in the water table zone.

In the eastern part of the orebody an erratic layer of very loose tiny pyrite crystals containing no copper, lies on top of the supergene copper ore and under the rusty gossan. This layer is as much as 12 feet in thickness.

Through the greater part of the "200" orebody, the altered shale layer on the footwall of the orebody acted as a dam and restricted the supergene copper-bearing solutions to the orebody itself. In the eastern end of the orebody, where the altered shale does not occur on the footwall of the hypogene orebody, there was a leakage of the supergene copper-bearing solutions and secondary chalcocite was deposited for more than 600 feet horizontally (south) of the footwall of the hypogene orebody. This secondary orebody is richest nearest the hypogene orebody and a few areas contain as much as 10 percent copper. Most of the 300 level "secondary shale ore" assays range from 1 percent to 5 percent copper with the greater part averaging 2 percent or less depending how the assays are grouped and where ore limits are drawn. The top of the sulphide zone is from 40 to 85 feet above the 300 level. The mineralized zone extends to and slightly below the 400 level. The principal ore mineral is chalcocite although cuprite and native copper have a wide distribution. Malachite is the principal oxide copper mineral on the 200 level. Chalcocite replaced the indigenous pyrite of the footwall shales. Possibly the carbon of the black shales also could have precipitated the chalcocite. An attempt was made to mine and mill the secondary "footwall shale orebody" but only the better mineralized areas were economic.

Rich spots of chalcocite in the shale are associated with tubular rods of dark gray quartz which are widely distributed in the footwall shales. These rods have oval cross section of 1" by 2" or 3" and have length as great as 10 feet or more.

The footwall shales also were mineralized with secondary copper minerals where transverse faults cut the hypogene orebody and broke the clayey seal of the altered shale on the footwall of the orebody.

Structure

The stratigraphic unit known as the "ore horizon" occurs approximately two thirds of the way up above the base of the Rio Tinto formation. It has been intensely deformed and contrasts sharply with the less deformed adjoining shales. The intense crumpling and movement in the "ore horizon" provided the important pre-ore control for the mineralization.

Post mineral faults are abundant in the mine area. The most prominent is a set of N. 12° E. to N. 70° W. striking and westerly dipping faults that displace the ore to the left om plan. In the western part of the mine this predominantly northeasterly striking system is terminated by the No. 6 fault, also post-mineral, which strikes from N. 55° - 70° W. and dips from 51° to 68° northeasterly. The No. 6 fault has a right hand displacement on plan. Most of the post-mineral faults in the mine are are normal or gravity type structures. No. 1 fault, however, originally was considered to be a thrust fault although this interpretation has been questioned.

Where a northeasterly striking fault cuts sharply across the "200" orebody, much of the fault movement is transferred and taken up in the altered shale along the footwall of the orebody.

MOUNTAIN CITY COPPER COMPANY

STATEMENT OF ORE PRODUCED TO DECEMBER 31, 1947 COMPILED FROM SHIPMENTS OF ORE TO SMELTERS AND FROM ORE MILLED AS SHOWN BY "STATEMENT OF TREATMENT, PRODUCTION AND LOSSES AT CONCENTRATOR"

Year	Wet Weight Pounds	% H20	Dry Weight Pounds	COPPER Per Cent	COPPER Pounds	SILVER Ounces Per Ton	SILVER Ounces	GOLD Ounces Per Ton	GOLD Ounces
SHIPMENTS * SHIPPING ORE									
1932	* 1,470,621	2.281	1,437,076	37.259	535,442	.348	250.19	.005	3.593
1935	* 31,951,522	2.564	31,132,285	26.312	8,191,666	.422	6,566.77	.0025	39.310
1936	* 89,688,440	2.895	87,091,822	25.989	22,633,846	.435	18,932.24	.0052	226.680
1937	* 54,037,810	3.222	52,296,742	27.242	14,246,869	.446	11,651.96	.0060	146.224
1938	* 13,583,980	3.968	13,044,937	25.795	3,364,912	.628	4,096.62	.0068	44.518
1939	* 44,263,560	3.375	42,769,843	28.319	12,111,996	.515	11,023.53	.0082	175.370
1940	* 44,458,220	2.775	43,224,520	27.356	11,824,340	.498	10,764.32	.0091	197.706
1941	* 34,425,580	2.435	33,587,271	26.847	9,017,229	.438	7,357.03	.0096	161.149
1942	* 17,177,360	2.282	16,785,381	27.695	4,648,739	.348	2,918.70	.0100	83.926
1943	* 8,788,896	2.515	8,567,872	25.331	2,170,064	.428	1,833.42	.0095	40.825
1944	* 12,077,576	2.743	11,746,264	17.138	2,013,036	.489	2,873.18	.0101	59.252
1945	* 6,770,160	2.770	6,582,595	12.673	834,226	.445	1,465.15	.0115	37.953
1946	* 3,665,840	3.216	3,547,954	17.226	611,153	.416	737.52	.0153	27.103
1947	* 2,320,960	2.239	2,270,942	11.305	256,720	.370	419.56	.0116	13.171
Total Shipments:-	*364,680,525	2.905	354,085,504	26.112	92,460,238	.457	80,890.19	.0071	1,256.780
On Hand 12-31-47	000		000						
Total Production to December 31,1947:-	*364,680,525	2.905	354,085,504	26.112	92,460,238	.457	80,890.19	.0071	1,256.780
ORE MILLED - MILLING ORE									
1936	** 54,234,040	2.141	53,072,960	8.531	4,527,464	.2827	7,503.43	.005	132.682
1937	**271,716,400	4.149	260,443,600	8.264	21,524,346	.266	34,650.05	.0058	757.689
1938	** 125,925,400	4.655	120,064,000	8.428	10,119,435	.215	12,919.25	.0054	326.429
1939	** 234,586,200	4.439	224,173,800	8.071	18,092,495	.261	29,215.67	.0054	607.414
1940	** 253,410,200	4.340	242,411,600	7.188	17,424,908	.251	30,433.63	.0054	653.733
1941	** 241,081,400	4.319	230,669,600	6.204	14,311,368	.240	27,717.20	.005	581.012
1942	** 226,936,400	4.527	216,663,000	5.205	11,277,550	.214	23,155.68	.005	537.881
1943	** 215,377,600	5.169	204,244,600	4.692	9,583,331	.194	19,857.14	.0049	500.485
1944	** 148,204,600	5.576	139,941,360	5.386	7,536,799	.261	18,286.08	.0053	372.961
1945	** 72,770,000	6.731	67,871,600	5.723	3,918,441	.279	9,464.14	.0074	249.447
1946	** 65,715,600	8.593	60,068,400	5.672	3,407,170	.208	6,234.38	.0068	203.162
1947	** 49,714,200	7.380	46,045,400	4.653	2,142,515	.173	3,971.93	.0064	148.033
Total Milled:-	**1,959,672,040	4.797	1,865,669,920	6.639	123,865,822	.239	223,408.58	.0054	5,070.928
On Hand 12-31-47	000		000						
Total Production to December 31,1947:-**	1,959,672,040	4.797	1,865,669,920	6.639	123,865,822	.239	223,408.58	.0054	5,070.928
GRAND TOTAL PRODUCTION TO DECEMBER 31, 1947:-	2,324,352,565	4.500	2,219,755,424	9.745	216,326,060	.274	304,298.77	.0057	6,327.708

* These figures are actual smelter weights and assays.

** Figures calculated by the mine office from operations of "Poidometer" installed in mill.

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