3260 0105

MOUNTAIN CITY COPPER MINE

ELKO COUNTY, NEVADA

by

R.R. COATS and E. C. STEPHENS

TABLE OF CONTENTS

Page

ABSTRACT
INTRODUCTION
1. HISTORICAL INFORMATION
   A. Mining Operation in the Area
   B. Statistics of Mine Production
2. PHYSIOGRAPHIC HISTORY AND PRESENT TOPOGRAPHY
3. GEOLOGIC HISTORY
   A. Stratigraphic Column
   B. General Structure of Area
   C. Place of Mineralization in Geologic History
4 ECONOMIC GEOLOGY - PRIMARY ORE
   A. Forms of the Ore Body
   B. Stratigraphic Relations of the Ore Body
   C. Mineralogy of the Deposit
   D. Factors Controlling Form and Location of Ore Bodies
   E. Effects of Metamorphism on the Ores and their Environment
   F. Summary of Sequence of Geologic Events Required for Formation of Primary Ores
5. ECONOMIC GEOLOGY - SECONDARY ORE
   A. Supergene Sulfide Enrichment
   B. Oxide Enrichment or Residual Concentration
   C. Paragenesis of Secondary Ore and Gangue Minerals
   D. Physical and Chemical Controls Affecting Formation of Secondary Ores
6. ORE GENESIS

E. C. Stephens,
Senior Geologist,
The Anaconda Company,
25 Broadway,
NEW YORK. N.Y.10004.

R. R. Coats,
Research Geologist,
U.S. Dept. of Interior,
345 Middlefield Road,
MENLO PARK. CALIFORNIA. 94025.

ABSTRACT

High grade copper ore was discovered in 1932 in the long dormant Mountain City (Cope) Mining district, Elko County Nevada. From 1932 to 1947 the one producing mine in the district, the Mountain City copper mine produced 1,109,878 short dry tons of ore averaging 9.745 per cent copper, .274 ounces silver and .0057 ounces gold per ton.

The primary ore bodies are lenticular in shape and are composed largely of quartz, pyrite and chalcopyrite. The ore lenses in general strike north westerly and dip northerly. They occur in the Rio Tinto formation within a definite stratigraphic sequence composed largely of shales with associated minor quartzite lenses.

The principal ore body, the '200' was completely leached to the 200 level. Abruptly beneath the barren gossan is supergene copper sulfide ore much of which assayed 50 per cent copper. The secondary copper minerals are sooty and massive chalcocite, bornite and covellite.

The ore bodies occur in sedimentary rocks and are epigenetic.

INTRODUCTION

The discovery of 50 per cent copper ore at the Mountain City Copper Mine, Elko County, Nevada, in 1932 focused geologic attention on this relatively isolated part of northern Nevada. Other than a United States Geological Survey report on S. F. Emmon's visit to the old silver mines in the Mountain City (Cope) mining district in 1908, little was known of the geology of the area. Detailed geological mine mapping and reconnaissance work by the geologists of the Mountain City Copper Company staff, from 1932 to 1947, resulted in a generalized idea of the geological setting of the mine. Also, in 1932, T. B. Nolan visited the district and prepared a report which was not published. Later a comprehensive study of the geology of the Mountain City and adjoining Owyhee quadrangles was undertaken by R. P. Coats, who is co-author of this paper, and other members of the United States Geological Survey. The objective of the paper is to present a brief description of the mine and district geology. Although the work of many geologists was freely used in obtaining the information presented here, the authors accept full responsibility for their own statements. The writers wish to thank particularly Mr. V. D. Perry, Vice President and Chief Geologist of The Anaconda Company (the parent company of the Mountain City Copper Company) for allowing publication of the Company's maps and information,

and to Dr. T. B. Nolan, Director of the United States Geological Survey for allowing publication of its information.

1. HISTORICAL INFORMATION

A. Mining Operations in the Area

Silver veins were first discovered in the Mountain City (Cope) mining district, Elko County, Nevada in 1869. Up to 1908, when S. F. Emmons of the United States Geological Survey visited the district, it is reported to have had a production worth approximately one million dollars. The district then was dormant until 1913 when the adjoining Duck Valley (Western Shoshone) Indian Reservation was opened for mineral location. Prospectors again rushed to the district but no silver mines of importance were found. One of the prospectors, Samuel F. Hunt located a copper gossan. It took his partners and him until 1932 to sink an inclined shaft to a depth of 242 feet through barren gossan at which point the gossan abruptly ended and supergene copper ore assaying 50 per cent was found. The ore body at the discovery point was 72 feet in width.

B. Statistics of Mine Production

The Mountain City Copper mine from 1932 until operations ceased in 1947, produced 1,109,877.712 dry short tons of ore averaging 9.745 per cent copper, 0.274 ounces of silver and 0.0057 ounces of gold per ton. Of this, around 177,042.752 tons averaging 26.11 per cent copper were shipped directly to the smelter in Utah and the remaining ore was concentrated at the mine. Table I shows the production of the Mountain City mine by years.

4. ECONOMIC GEOLOGY - PRIMARY ORE

A. Forms of the Ore Body

The primary ore bodies of the Mountain City copper mine are disc-shaped lenses which occur in a definite sequence of dark shales having a few minor quartzite lenses of the Rio Tinto formation. The longest continuous horizontal dimension of the largest lens (the '200' ore body) is 1,100 feet in strike and its maximum width is 92 feet. The lenses strike N.65° west to N.85° west and dip north commonly parallel to bedding from 65° to 85°.

B. Stratigraphic Relations of the Ore Body

The primary ore bodies occur in a definite shaly sequence locally known as the 'ore horizon'. This occurs approximately two thirds of the way stratigraphically above the Rio Tinto formation - Black Rock quartzite contact.

The two principal ore bodies, the '200' and the '600' appear to be faulted segments of the same lens. Other, but smaller, lenses occur both laterally and below the principal ore bodies.

The 'ore horizon' which attains a maximum thickness of 200 feet consists largely of dark, thin layered carbonaceous shales. The primary ore lenses, which are restricted to the 'ore horizon' commonly parallel but also cut across bedding.

C. Mineralogy of the Deposit

1. Minerals present, ore and gangue, with changes laterally and in depth

The two principal hypogene sulfide minerals are pyrite and chalcopyrite. A little sphalerite is associated with the 'massive' ore types (quartz-pyrite-chalcopyrite massive mixture) and one minor occurence of galena was found close to one of the principal ore lenses. There are local variations in the ratio of the various sulfides to one another in each ore type. Each ore type, however, is remarkably constant within itself. There are no significant changes of the hypogene sulfide mineralization laterally or vertically within an individual ore type. The relationship of the various ore types have been plotted in great detail.

The supergene copper ore minerals, chalcocite, bornite and covellite, which largely replace primary sulfides, are the most abundant in the 50 feet immediately beneath the present top of the ground water table in the '200' ore body. As a generality the supergene minerals become less abundant in direct proportion to the depth beneath the ground water table. There are, however, deep prongs of secondary mineralization, which extend more than 200 feet below the top of the ground water table and which follow down along loosely consolidated permeable zones in the primary ore.

The shales in the footwall of the '200' ore body in the east end of the mine have secondary copper mineralization. Here the secondary minerals replace pyrite and a large proportion of the chalcocite appears to have filled in openings in carbonaceous shales and in tubular rods of dark grey quartz which are a common feature of these particular dark shales.

The oxide copper minerals, cuprite, native copper, malachite and azurite which resulted essentially from the oxidation of supergene copper minerals are found along with chalcocite in 'footwall shales' (the shales underlying the 'ore horizon'). These extend to a depth of more than 200 feet below the'200' level, and have a lateral spread of more than 600 feet south of the primary '200' ore body from which the copper originated. The secondary copper minerals in the 'footwall shales' occur where the impervious 'footwall' clayey alteration did not exist in the extreme eastern part of the '200' ore body, or where transverse faults broke the seal and allowed the secondary solutions access to the shales in the footwall of the '200' ore body.

Oxide copper minerals also developed in a few restricted local areas directly above the supergene ore in the '200' ore body. In most instances the oxide and secondary copper sulfide minerals constituted a 'mixed' ore type that was shipped directly to the smelter.

2. Changes in mineral composition of wall rock in all directions from ore wall rock alteration

The intensity of wall rock alteration surrounding the hypogene ore bodies varies over broad limits. The most intense alteration in the '200' ore body lies in the shales immediately in the footwall of the hypogene sulfide lens. The chloritic and clayey alteration, however, does not exist in the extreme east end of the '200' ore body. Other than the highly altered shale mentioned above, which attains a thickness of more than 25 feet, the greater proportion of the carbonaceous shales of the 'ore horizon' have a black greasy appearance. They are described as being 'woody' or 'schisty'. The shales in the hanging wall commonly but not always are less altered than those in the footwall. The alteration of the 'ore horizon' rocks is more intense near the sulfide lenses but it persists for hundreds of feet laterally (strikewise) beyond the ore lenses.

3. Mineral Textures

Each rock type has its characteristic textures. The 'massive' hypogene ore type is a hard rock which consists of an intimate mixture of quartz, pyrite, chalcopyrite and rarely sphalerite. The 'dark grey quartzite' ore type is erratically silicified and the sulfides, of which chalcopyrite is more abundant than pyrite, cut the quartzite in random directions. The 'dark quartz' ore type is the result of complete silicification and is coarsely banded. The sulfides occur as streaks and blobs and only rarely are accompanied by later surge glassy white quartz except near the gradational contact with the 'banded white quartz' type. The 'banded white quartz' ore type bands are distinct and range from one quarter to one inch in thickness. The strike of the banding seldom is parallel to the strike and dip of the ore lenses. It has been suggested that the bands represent bedding planes but this is debateable. The initial silicification of the 'banded white quartz' ore type is completely pervasive and no sulfides accompanied the initial silicification. The banded quartz was crackled followed by the introduction of glassy quartz, pyrite and chalcopyrite in that order. This later surge is represented by a myriad of tiny criss-cross veinlets in which any one or combination of minerals may be present.

In the massive secondary ore, which occurs from the top of water table for a depth of approximately 50 feet, the original hypogene ore textures have been largely obliterated by the replacement of sooty and massive chalcocite.

4. Mineral Paragenesis

The banded white quartz ore type demonstrates the mineral paragenetic sequence well. First, the initial pervasive silicification stage followed by crackling of the rock; then the distinct orderly sequence of the mineralizing stage consisting of quartz, pyrite and chalcopyrite (in this order).

5. Grade of Ores in valuable metals

The average silver and gold content of the ores which is relatively low is given in Table I. The silver and gold content of the ores apparently varies only with respect to the ore types. There is no appreciable vertical or lateral variation of gold or silver content within individual ore types. The grades for the direct shipping and milling ores are shown in Table I.

D. Factors Controlling Form and Location of Ore Bodies

The known hypogene copper ore bodies have a definite stratigraphic control. They lie within a particular sequence of sediments consisting of largely black and grey shales containing minor quartzite lenses. There are many tight 'Z' folds in the area of the ore bodies and the 'ore horizon' sequence appears to be relatively more disturbed than other units of the Rio Tinto formation. Suggestions of why this particular sequence is favourable for ore deposition while adjoining shales are not, range from a structural explanation of greater distortion of the 'ore horizon' to the possibility of the mineralization being controlled along an unconformity. No evidence of an unconformity, however, was recognised in the mine area. The principal feature of the ore deposition is that it was restricted to a specific definite stratigraphic unit.

Replacement of the shales and quartzites first by silica and later by a quartz-sulfide surge left no recognizable evidence of paths of ore movement.

E. <u>Effects of Metamorphism (regional or dynamic) on the Ores and their Immediate Environment</u>

Metamorphism in the mine area appears to be entirely pre-ore.

F. <u>Summary of the Sequence of Geologic Events Required for the Formation of the Primary Ores</u>

The geologic events began with the accumulation of the sediments, structural deformation resulting in their being folded into a north-dipping homoclinal structure, the intrusion of andesitic and dioritic rocks (and possibly the extrusion of some andesitic rocks) which are now represented as amphibolites, the emplacement of the Mountain City granodiorite and related rocks north of the mine area, intrusion of porphyry dikes in the mine area, first stage silicification and alteration and introduction of second stage mineralizing surge consisting of glassy quartz, pyrite and chalcopyrite.

5. ECONOMIC GEOLOGY - SECONDARY ORE

A. Supergene Sulfide Enrichment

Following the deposition of the primary ore there were Tertiary volcanic extrusions. This was either preceded or followed by a post-mineral faulting. The present drainage system developed and supergene sulfide enrichment took place during this time.

The conditions of fundamental importance that stand out conspicuously in the supergene enrichment of the Mountain City copper ore body are that the wall rocks of the ore body were argillaceous rocks and quartzites; the primary ore body consisted of quartz and abundant sulfides but no carbonates; there was an impervious clayey layer developed during the alteration stages along the greater part of the footwall of the '200' ore body, thus confining the greater part of the copper rich supergene solutions to the ore body itself. The abundant yearly precipitation allowed for complete flushing of the copper bearing solutions to the water table. The abundant sulfides in the ore body readily furnished sulfate solutions. The level of the nearest drainage channel to the mine, Mill Creek, represents the deepest to which downcutting had progressed since the hypogene ore body was deposited. These conditions resulted in a complete leaching of the ore body in the oxide zone and consequently the gossan assayed no copper.

B. Oxide Enrichment or Residual Concentration

There were no residual oxide copper minerals left in the gossan other than in a few isolated locations immediately overlying the chalcocite ore. There are, however, oxide copper minerals overlying the secondary ore body which occurs in the 'footwall shales' south of the east end of the ore body. Some of these oxide copper minerals are found in surface excavations.

C. Paragenesis of the Secondary Ore and Gangue Minerals

Sooty and massive chalcocite apparently shows a preference for replacing chalcopyrite before pyrite. The chalcopyrite commonly was replaced by bornite and covellite before chalcocite was developed particularly in the deeper parts of the supergene zone.

Bornite and covellite also occur with chalcocite immediately beneath the top of the water table and the relationship here of one to the other is not definite.

D. Physical and Chemical Controls Affecting the Formation of Secondary Ores

1. a quartz-sulfide primary ore enclosed in argillaceous rocks.

2. an abundance of sulfides

3. a relatively consistent and abundant annual precipitation

4. complete leaching of the copper minerals in the oxide zone and abrupt change of environment at water table.

5. loose permeable zones in the hypogene ore which allowed the secondary solutions to penetrate and be deposited as supergene minerals more than 200 feet beneath the top of the water table.

6. ORE GENESIS

The ore deposits of the Mountain City copper mine occur in black and grey shales and with associated minor quartzite lenses of the Rio Tinto formation. There is a definite stratigraphic control. The ore deposits have a broad alteration envelope. Ore lenses cut across as well as being parallel to bedding even though being restricted to a specific stratigraphic unit. There are altered porphyry dikes in the mine although none is in contact with the hypogene ore. The deposits are epigenetic. The primary ore is estimated to have averaged between 6 per cent and 7 per cent copper before being enriched by supergene processes. The siliceous high-sulfide ore deposits and argillaceous wall rocks, the abundant precipitation in the Mountain City area, the confining impermeable altered shale on the footwall of the greater part of the '200' ore body which restricted most of the enriching solutions to the ore body itself all combined to make a textbook example of a completely leached gossan and the development of an extremely rich supergene ore.

GENERAL REFERENCES

EMMONS, W. H.,	A Reconnaissance 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, Elko County, Nevada; 1932.
GILBERT, D. C., and POLLOCK, C. P.,	Reconnaissance of the Centennial Range from Mountain City to Bull Run Mountain, Elko County, Nevada. 1932. Unpublished.
KILDALE, M. B., and STEPHENS, E. C.,	Map of Surface of Mountain City Copper Mine, 1932. Unpublished.
BEECHEL, GRAYDON, and SMITTEN, ROGER	Stratigraphic Correlation Chart, Mountain City Copper Mine, 1938. Unpublished.

STEPHENS, E. C., and DROUBAY, S. K., Reconnaissance of the Mountain City Quadrangle, 1937. Unpublished.

11

Production

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	% H_2O	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	2.201	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	18,938.24	.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	85.926
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	260,445,600	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	30,435.63	.0054	653.733
1941	** 241,081,400	4.319	230,669,600	6.204	14,311,368	.240	27,727.20	.005	581.012
1942	** 226,936,400	4.527	216,663,000	5.205	11,277,550	.214	23,155.68	.005	539.881
1943	** 215,377,600	5.169	204,244,600	4.692	9,583,331	.194	19,857.34	.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	148.035
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.

32600105