Tom Schroeter
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CONCENTRATOR OVERVIEW
AT
SIMILCO MINES LTD.

(MEMBER OF THE PRINCETON MINING CORPORATION GROUP OF COMPANIES)

JANUARY 1991

by

T. G. Smith
Concentrator General Superintendent

and

D. McLaren
Operations Metallurgist

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SUMMARY

Location: Situated on the Similkameen River, 10 miles south of Princeton, British Columbia, Canada.

Type: A 25,000 sdtpd, low-grade, open-pit copper mine producing approximately 320 sdtpd of copper concentrate with an average grade of 28%.

Operation: Primary crushing through a 54 inch gyratory crusher, primary grinding in three 32 foot semiautogenous mills, secondary grinding in two ball mills, and concentration of chalcopyrite by froth flotation.

HISTORY

In December, 1967, Newmont Mining Corporation purchased all of the Grandby Mine holdings in the Copper Mountain area, and in 1968, they acquired the main claims in the Ingerbelle area west of the Similkameen river. Concentrator operation at Newmont's Similkameen property commenced in March 1972 using only autogenous milling. Within several weeks the mills had been converted to semiautogenous operation. By February 1976, plant capacity had been expanded with the addition of two secondary ball mills and scavenger flotation cells.

As part of a more recent strategic thrust to consolidate as a gold mining company, Newmont chose to sell the Similkameen Mine. In June 1988, Cassiar Mining Corporation reached an agreement to take control of the operation and the name was changed to Similco Mines Ltd. Since assuming operating responsibility, Cassiar (now Princeton Mining Corporation) has embarked on a major campaign to increase reserves, improve plant performance and restore the equipment to a reasonable operating condition.

ORE

The host rock is mainly composed of altered tuffs and agglomerates, with the most prominent being a pale greenish bleaching of the dark volcanics. A conversion of andesine plagioclaise to albite, together with the formation of considerable epidote, has converted the host into a hard, tough rock.

Based on the current estimated reserves and production rates, the expected life time of the Similco Mine is approximately five years. However, an active in-pit and near-pit exploration program has recently delineated some more potential ore in the Virginia Zone and identified further drilling targets in the Alabama, Lost Horse Gulch West, Honeysuckle, and Oriolle Zones.

The mill head grade is approximately 0.50% copper. The copper occurs mainly in the form of chalcopyrite primarily as fine disseminations with lesser amounts present as discontinuous fracture-filling and coarse blebs. Other copper minerals include bornite and some oxides. The major gangue mineral is pyrite having an average head grade of 3.0%.

CRUSHING AND GRINDING

Flow Sheet Description

The ore is dumped from a fleet of 100-ton and 150-ton haulage trucks into a 54 inch x 74 inch Allis-Chalmers gyratory crusher which is located about two miles from the mill. The ore is crushed to minus 9 inch and stockpiled. Coarse ore is reclaimed from this stockpile through draw points equipped with apron feeders. A one mile cable belt conveyor transports the ore over a deep valley to a 65,000 ton live capacity coarse ore stockpile near the mill.

A general flow sheet of the grinding circuit is presented in Figure 1.

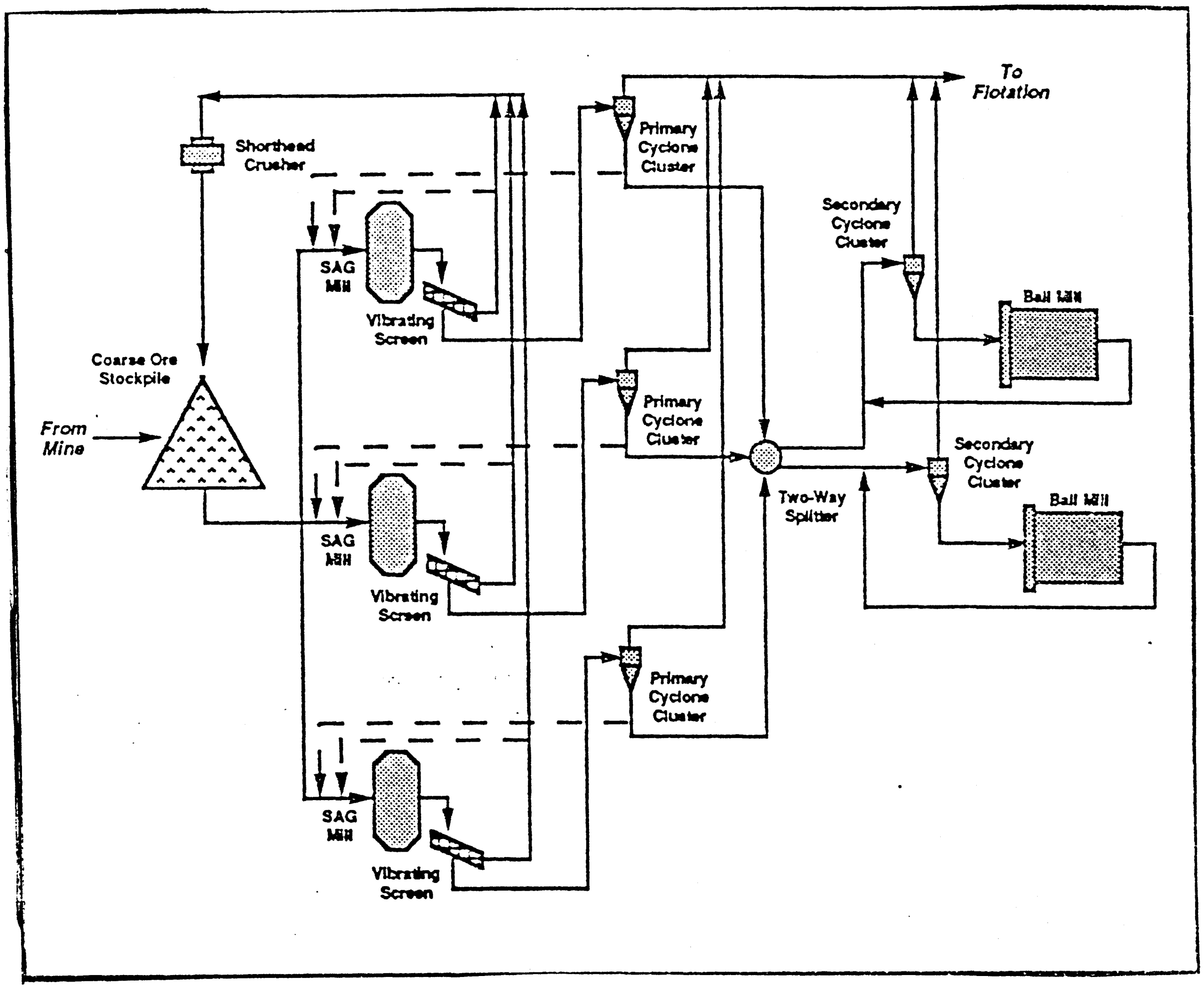

Figure 1: Flow Sheet of the Similco Grinding Circuit

There are six draw points from the coarse ore pile, each equipped with a Hydrastroke feeder. Ore is reclaimed from two draw points to feed one of the three 32 foot diameter by 14 foot long, 8000 hp Hardinge semiautogenous primary mills. The mills are equipped with 1 inch -opening grates and discharge onto Tyler vibrating screens. The screens cut at 1/2 inch. Screen oversize is normally combined with the oversize streams from the other two circuits and crushed in a 5 1/2 foot Nordberg short head crusher set at 1/4 inch. Crusher discharge is returned to the coarse ore stockpile. If necessary, screen oversize material can be recycled to the SAG mill feed. The screen undersize for each circuit is pumped to a cluster of 20 inch diameter Krebs primary cyclones. The primary cyclone overflow (35% solids, 70% -200 mesh) reports to flotation. The primary cyclone underflow will normally report to the secondary milling circuit. However, in cases where there are capacity limitations in the secondary milling circuit, it is possible to recycle the primary underflow to the SAG mill feed.

The three primary cyclone underflow streams are combined and then split to feed the two parallel secondary grinding lines. Each secondary grinding line consists of a 16.5 foot diameter by 28 foot long, 5000 hp Dominion ball mill operating in reversed closed circuit with four 30 inch diameter Wemco cyclones. The two secondary cyclone overflow streams (45% solids, 50% -200 mesh) are diluted to 40% solids and pumped to flotation.

Mechanical/Operational

The SAG mills employ a liner/lifter combination with alternating rows of flat liners, and flat liners with a lifter insert. Currently two of the three mills have been lined with Skega's Polymet rubber liners and lifters on an experimental basis. The current ball loading is 150 tons per primary mill. The SAG mills are charged with 5 inch balls according to a daily schedule. The average power draft per SAG mill is 8500 hp. The availability of the SAG mill circuit is approximately 90% and this is the limiting operating time factor in the concentrator. A preventive maintenance program is currently being implemented with a view to increasing this figure to 92%.

The ball mills employ a wave type NiHard liner arrangement. combination. The current ball loading is 190 tons per mill. The ball mills are charged with a combination of one third each 2.5 inch, 3 inch and 4 inch balls according to the power demand of the mill. The average power draft of a ball mill is 5000 hp. Ball mill circuit availability is approximately 98%.

The current total grinding steel consumption is 1.4 lb/ton and the operating work index is 30 kwh/t.

Controls

The control objective in the milling circuit is to maximize production with the secondary objective of minimizing product particle size. Typically, this strategy leads to a form of constraint control where the secondary ball mill capacity is most often the rate limiting factor.

The SAG mill power draft is automatically controlled to set point by manipulation of the Hydrastroke feeders. (The feed rate is measured by a weigh scale but this signal is not used in control.) The water addition to the SAG mill feed is ratioed to the fresh ore feed rate. A SAG mill bearing pressure signal is available for inferring mill load but is seldom used.

All of the cyclone feed pump boxes are equipped with variable speed pumps. The speed is manually set by the operator to maintain a constant cyclone feed pressure. The pump box level is automatically controlled to set point using a pressure sensor and pump box water as the manipulated variable.

A power signal is available from each of the secondary mills and this value and its recent trend are used by the operator to make decisions regarding circuit operation. For example, low and decreasing power can be countered by reducing the secondary circuit loading. This is accomplished by diverting the primary cyclone underflow on one or more circuits back to the SAG mill feed. In turn, this may increase the SAG mill load and power draft resulting in a reduction in the production rate. The control practice becomes one of balancing the loading between the SAG and ball mills.

An Autometrics PSM is installed on the secondary rougher flotation feed stream. The particle size and percent solids signals provide a blended measure of grinding circuit performance. As a consequence, these signals are used by the operator study for diagnostic purposes.

CONCENTRATION

Flow Sheet

A general flow sheet of the existing flotation circuit is shown in Figure 2.

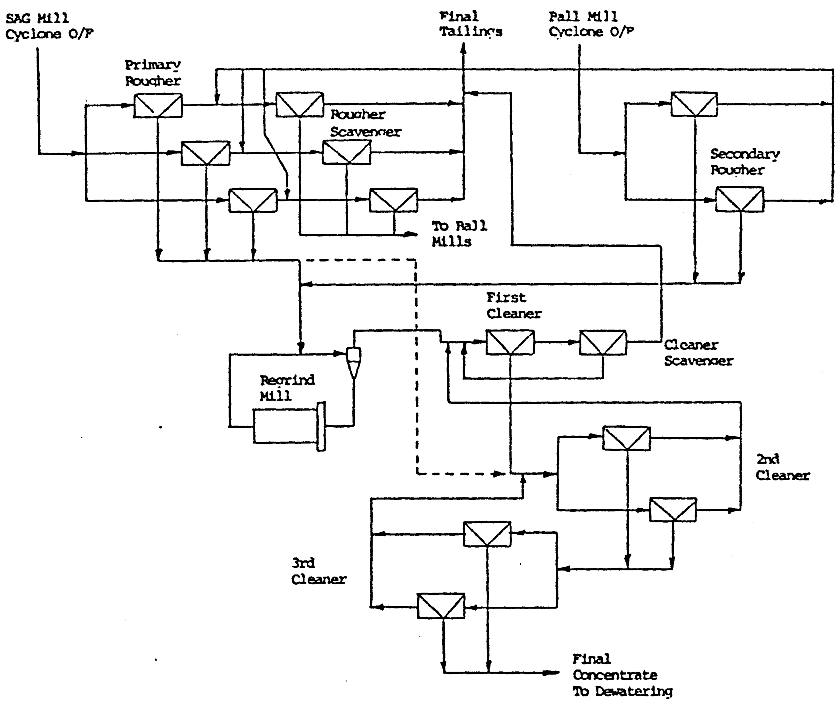

Figure 2: Flow Sheet of the Existing Similco Flotation Circuit

The primary cyclone overflow streams from the SAG mill circuit gravity feed a distribution tower located in the flotation circuit. The feed is split into three parallel primary rougher banks of 6 x 400 $ft.^3$ Agitair flotation cells. Primary rougher concentrate is pumped to the regrind circuit or, when desired, to second cleaner feed.

Secondary cyclone overflow, which constitutes 70% of total flotation feed, is pumped to two parallel secondary rougher banks of 4 x $38m^3$ (1350 $ft.^3$) Outukumpu flotation cells. Secondary rougher concentrate feeds the regrind circuit.

Primary and secondary rougher tailings streams are combined to feed three parallel rougher scavenger banks of 10 x 400 $ft.^3$ Agitair cells. Scavenger concentrate is low grade and reports to the ball mill cyclone feed pumps. Rougher scavenger tailings reports to final tails.

Combined rougher concentrates feed the regrind circuit consisting of a 12 foot diameter, 18 foot long, 3000 HP Dominion ball mill in closed circuit with a cluster of 10 inch diameter Krebs cyclones. Regrind circuit product (95% -325 mesh) feeds a cleaner circuit featuring three cleaning stages and a cleaner scavenger. The first cleaners consist of 5 x 400 $ft.^3$ Agitair cells. Second and third cleaners respectively consist of two parallel banks of 8 and 3 x 100 $ft.^3$ Denver cleaner scavenger cells. Cleaner scavenger concentrate feeds back to the first cleaner while scavenger tailings report to final tails.

Mechanical/Operational

Similco recently modified both the rougher and cleaner flotation circuits in an effort to improve copper recovery. The commissioning of six Denver 300 $ft.^3$ cleaner scavenger cells in October 1989 and eight Outukumpu OK 38 secondary rougher cells in October 1990 has served to increase copper recovery by 3.5% Cu or an estimated 2.1 million pounds of copper per year.

Flotation reagents used are potassium amyl xanthate (PAX - 0.035 lb/ton), MIBC (0.10 lb/ton), lime (0.75 lb/ton) and sodium sulphide (Na_2S - 0.005 lb/ton). Initial PAX and MIBC additions are made in the grinding circuit pump boxes which feed the primary cyclones. Further, staged additions of PAX and MIBC are made in the primary and secondary rougher and rougher-scavenger cell banks. Na_2S is added to the rougher scavenger. To depress the pyrite gangue, slurried lime is added to the grinding circuit pump boxes to maintain the rougher flotation pulp pH of 10.4. Lime is also stage added in the cleaner circuit to maintain a pH of 12.0.

The regrind ball mill is charged with 1.5" balls according to a daily schedule.

With the existing flotation circuit the copper concentrate stream typically assays 28% Cu, 0.15 oz/ton Au and 2.5 oz/ton Ag. Copper recovery averages about 80%. Coarse particle losses play a significant role in limiting copper recovery.

Controls

The control objective of the flotation circuit is to maximize the net smelter return.

Controls in the flotation circuit are regulatory in nature, with a fair degree of manual control. The major PAX and MIBC additions are controlled to an operator imposed set point using Prominent metering pumps and solenoid timing respectively. Manually controlled Clarkson feeders are used to make stage additions of sodium sulphide. Pulp level in the flotation cell banks is controlled by a localized loop based on a bubble tube sensor and a motorized dart valve as the final control element. Air control on all cells is manually adjusted. Lime addition uses solenoid timing to control pH to set point based on an operator's measured value.

A Bondar-Clegg On-Stream Analyser is employed for diagnostic purposes in the flotation circuit. Eight streams are monitored for % Cu, % Fe and % solids, with assays available on a 10 minute interval.

DEWATERING

The copper flotation concentrate reports to a 70 foot Eimco thickener, thickened to about 60% solids, filtered with an 8 foot 10 inch x 8-disc filter, and dried in a 5 foot x 50 foot Lockhead-Haggerty dryer to about 8% moisture.

Percol E10 flocculant (0.02 lb/T) and Drew M-89-22 filter aid (0.15 lb/T) are used to aid the dewatering process. Fuel oil consumption averages about 1.8 gallons per ton of concentrate for the dryer.

From the dryer, the concentrate is conveyed to a storage shed where it is loaded into trucks and delivered to port facilities in Vancouver.

EFFLUENT DISPOSAL AND WATER SUPPLY

The plant tailing flows by gravity about 900 feet downhill across the Similkameen canyon, via a suspension bridge and then 3,500 feet to a cyclone station. From the four 30 inch diameter Krebs cyclones the overflow goes into Smelter Lake, an ecologically dead lake, and the underflow is used to build up the dams at each end of the lake. Seepage pumps are set up at both ends of the tailing impoundment to ensure that no effluent is discharged into the environment.

Two pump barges on the tailing pond recycle the water back to the concentrator, to make up about 75% of the total consumed water. The other 25%, used for cooling water and gland water, comes from a pumping station at the Similkameen River, 700 feet below the concentrator site.

POWER

Power for the mine and concentrator is supplied by B.C. Hydro and Power Authority, with a sub-station located at the concentrator site. About 95% of the power is consumed by the concentrator, mainly in the grinding stage, with the other 5% consumed by the mine. Concentrator power usage is about 34 kwh/ton of ore milled.

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