

# SOCIETY OF MINING ENGINEERS of AIME

345 EAST 47TH STREET, NEW YORK, N. Y. 10017

PREPRINT  
NUMBER

68-AG-346



118

## A MINE FLOOD, VANCOUVER ISLAND

R. L. Loofbourow  
Consulting Engineer

Ernest K. Lehmann  
Consulting Geologist

Minneapolis, Minnesota

Permission is hereby given to publish with appropriate acknowledgments, excerpts or summaries not to exceed one-fourth of the entire text of the paper. Permission to print in more extended form subsequent to publication by the Institute must be obtained from the Secretary of the Society of Mining Engineers of AIME.

If and when this paper is published by the Institute, it may embody certain changes made by agreement between the Technical Publications Committee and the author, so that the form in which it appears here is not necessarily that in which it may be published later.

These preprints are available only on a coupon basis. The coupon books may be obtained from SME headquarters for \$5.00 a book (10 coupons) for Members or \$10.00 a book for nonmembers. Each coupon entitles the purchaser to one preprint. Mail completed coupons to PREPRINTS, Society of Mining Engineers, 345 East 47th Street, New York, N. Y. 10017.

PREPRINT AVAILABILITY LIST IS PUBLISHED PERIODICALLY IN  
MINING ENGINEERING.

A MINE FLOOD, VANCOUVER ISLAND  
R. L. Loofbourow Ernest K. Lehmann\*

ABSTRACT

The Sunro Copper Mine is near the south coast of Vancouver Island about 35 miles west of Victoria. Failure of the roof of a large open stope let a good sized mountain stream into the mine. Broken ore, boulders and sand were washed into the underground mill and out through a 7 800-foot adit. The adit became plugged; water burst out on a ridge above the adit, washing out the portal and a trestle by which it was reached,

Rock and ore are strong but several systems of steep, pronounced but generally tight fractures are found on and parallel to the walls of the orebody.

The stope was started from a slusher drift 390 feet below the bed of the River and brought up to an elevation 155 feet below the River by blasting vertical and horizontal rings of longholes in the nearly vertical orebody. Mining was stopped there and five months were given to grouting and bolting the pillar under the bed of the River. During this time and for several months thereafter sloughing increased the width, length and height of the stope. At the last known observation the stope was 77 to 96 feet wide, 185 feet long and the highest point of the domed back was only 55 feet below the River.

The flooding took no lives. In other respects, however, it might be difficult to find in mining lore a more savage example of the application of "Murphy's Laws".

INTRODUCTION

The authors visited the property during the rehabilitation period on behalf of Associated Metals and Minerals Corporation. Permission to present this paper is gratefully acknowledged. Cooperation and courtesies of Cowichan Copper Company, particularly on the part of Mr. O. G. MacDonald, President, are thoroughly appreciated.

Topography of the mine site is rugged. The canyon of the Jordan River, where it crosses the mineralized area is about 500 feet deep. Except in and near the bottom of the canyon, bedrock outcrops are scarce. At high elevations bedrock is generally covered by thick unconsolidated material.

Annual rainfall is reported to be in the neighborhood of 100 inches concentrated in the autumn and winter. During heavy rains the River can rise five feet in a few hours. On the ridge above the adit through which the mine is entered, the British Columbia Hydro and Power Authority has a reservoir into which it diverts much of the River flow during the drier summer months. See Figure 1.

The Sunro copper deposits are steep, rather irregular masses tending to be tabular. Width and intensity of mineralization increase where controlling structures approach or cross. The orebody into which the River water broke is on the section of three steep fracture systems which appear to localize mineralization

\* Consulting Engineer and Consulting Geologist, Minneapolis, Minnesota

and reduce the normally high competence of the ground. These three systems strike about N-S, N20W and N45E. Stevenson (1951) suggested that this reach of the Jordan River, which is very nearly N45E for two miles, follows a fault zone.\* Failure which flooded the mine was precisely in the area where these three structures meet below the bed of the Jordan River.

Country rock of the orebody on which the failure occurred is a strong black Tertiary basalt. With sill-like intrusions of gabbro and granitic plugs and dikes, this strong basalt underlies a strip five to ten miles wide along the south shore of Vancouver Island. The basalt flows strike 60 to 70 degrees west of North and dip 60 to 70 degrees to the northeast.

We saw no physical description of the rock cut by holes drilled through the ground which failed. Holes which cut the N45E fracture system several hundred feet below the adit level were reported to have found some open fractures, broken ground and mud. In the stopes and development headings which were accessible after the flood, evidence of tight ground was strong. This evidence included puddles of water on drift floors near open raises, water marks indicating that air had been trapped in raises as the pressure rose, and the almost complete absence of leakage from the North Stope when full of water to nearby workings. See Figures 2 and 3.

## HISTORY

The property was staked in 1915. Control passed through various hands, including those of several of the larger Canadian mining firms. Gradually the copper-bearing outcrops were explored by adits and by drilling from the surface and underground. Several orebodies of modest size and moderate grade were discovered and a number of mineralized zones indicated.

In the fall of 1960 a small mining company leased the property and began to work toward production under a plan well calculated to utilize a long existing adit to develop two stopes on the more accessible as well as the richer portion of the most completely known orebody. Because these stopes were 7 800 feet from the portal of the adit and ore would have had to be hauled a good deal farther to reach a convenient millsite, the mill was placed underground at the adit level where this orebody narrowed. A coarse ore storage was cut in rock above the primary crusher. Slusher drifts were driven north and south on the main orebody from the top of this "bin" and two stopes were undercut through drawpoints. Meanwhile a service-ventilation raise and a rock-pass were driven to the surface through rock which was to become a pillar between the two stopes.

Because there was no convenient place to stack ore for later retrieval, an initial section of the concentrator was pushed to completion to accept ore broken in stope preparation. Meanwhile a winze was sunk to a point 500 feet below the adit and four levels were opened.

\* Stevenson, J.S. (1951) Sunlock and Gabbro, in the Annual Report for the year ending December 31, 1950, of the British Columbia Minister of Mines, pp A180-A194.

The first concentrate was produced on May 1, 1962, and the concentrator was in full operation by November of that year. Drilling from the winze was outlining the lower part of the orebody and plans were being made to explore some of the other mineralized zones. The operation appeared to be satisfactorily entering a stage of profitable production.

### MINING

Except for a little development ore, the mill was supplied from two long-hole stopes, mostly from the larger north stope. The best ore was near the junction of the north and northwest trending fracture zones and the northeast cross structure. This junction was near the north end of the north stope and under the Jordan River as indicated in Figure 1.

These stopes were worked by blasting horizontal rings of longholes. Mine sections examined after the flood indicate that by February 1963 the back of the North Stope had been advanced to an elevation about 235 feet above the slusher drift and 155 feet below the River. The stope was 50 to 93 feet wide and about 160 feet long, the narrower end being under the River.

Although plans had been announced to carry this stope to an elevation 100 feet below that of the River, it is probable that these plans were given up in the spring or summer of 1963. In retrospect it appears likely that control of the stope back had been lost by this time and was never regained.

Mine records indicate that on March 8, 1963 a contractor was engaged to bolt and grout the ground below the bed of the River. During the next five months he reported drilling 315 holes having a total length of 24,792 feet and pumping 728 sacks of cement.

Although blasting in the North Stope appears to have been discontinued in the summer of 1963, sloughing continued gradually. The mine stope sections show that width and length of the stope increased to 77 to 96 feet and 185 feet respectively. On the central and northern sections the peak of the domed back was only 55 feet below the River.

### FLOODING

On December 5, 1963 River water began to pour into the stope. This immediately ended production by washing broken ore through the drawpoints to the scam drift to the coarse ore bin and thence into the crusher room and out the adit. For the first ten days water is reported to have flowed two feet deep in the adit. Then the adit flowed full for another ten days, throwing out pipe and timber. It may be inferred that during this 20-day period much of the North Stope was filled with boulders and sand, and that a large volume of these materials was swept into the mill and excavations and out the adit.

More was to come. At distances of 1 680 to 1 820 and 1 860 to 1 900 feet from the portal, the adit crosses zones of broken rock. These weak intervals had been timbered and backlagged. As the timber was cut out by the fast water and rock

moved by it, the back of the adit apparently began to cave. At the end of the month flow at the portal stopped, and virtually the full tunnel flow burst out on the ridge at an elevation about 250 feet above the adit. At this point there is at least 100 feet of unconsolidated material. The flow of water ground-slucied a deluge of water, trees, sand and boulders toward the River. In passing it took out the timber at the portal and a trestle connecting the portal with shops, warehouse and office, threatening these buildings. As the weak ground in the adit caved, it seems probable that a large chunk of rock fell into the fast moving current and was slammed into or against the outlet toward the portal, quickly plugging this outlet. No one knows just how suddenly this may have happened, but imagine the water-hammer which could be generated by a column of water about 9 x 9 feet in section, 6 000 feet long, moving under a head which approached 470 feet! A crater about 200 feet wide and 60 to 100 feet deep was formed at the surface and a gash of varying dimensions was cut from it through the portal to the River. See Figure 5.

#### INFERRED CAUSES OF FAILURE

Although seeing the action only in retrospect, the authors feel that the prime cause of failure was the intersection of strong fracture systems in and near the back of the sizable stope. One may have been a fault on which there were small openings or pockets of broken rock and mud. Even though the canyon is steep and erosion must be assumed to be comparatively rapid, it is likely that fractures were more open near the surface and horizontal stresses were less than at greater depth. Fractures were both within and outside the orebody.

The large extent of horizontal stope-back was a factor, of course. However, the authors believe that at the elevation where mining is reported to have stopped and where sloughing took over, the stope as mined would not have broken through if the basalt had been intact. They think sloughing to fracture planes in stope walls widened the stope importantly and this probably preceded large-scale failure of the back.

A number of other conditions may have contributed probably to a minor degree. On the N45E fracture system there may have been openings from which the first flows of water washed rock chips or mud. Pressure of water acting hydrostatically on fracture walls may have helped sloughing. Vibrations from blasting in the stope itself and later from nearby work may have been another minor cause. With the River at a high stage the vibrations set up by large boulders slammed together under water may have been a factor.

05-AD-246  
WATER ENTERED  
N. SLOPE

BASALT

GABBRO

RESERVOIR

RIVER

JORDAN

BASALT

ADIT

GRAVEL

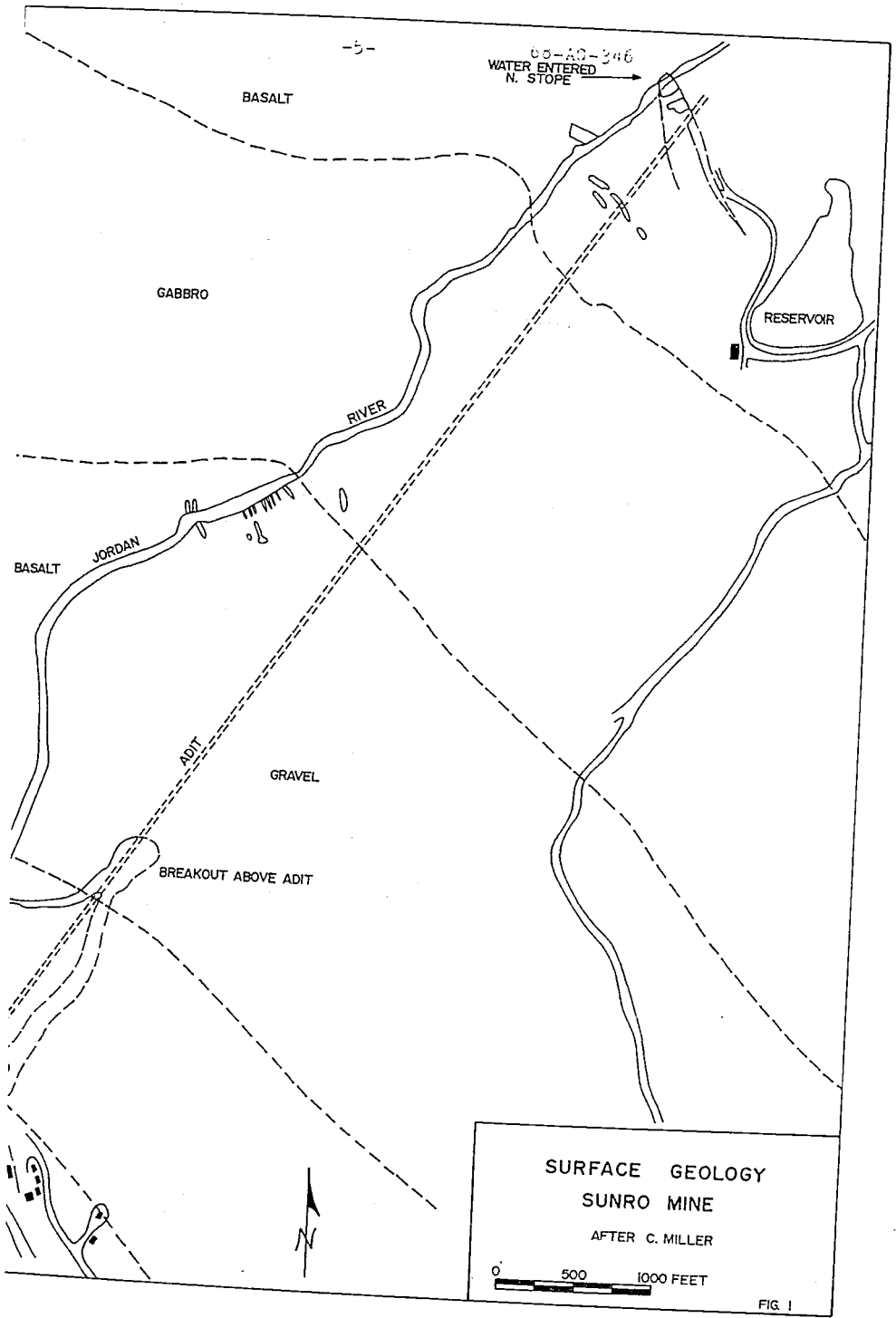
BREAKOUT ABOVE ADIT

### SURFACE GEOLOGY SUNRO MINE

AFTER C. MILLER

0 500 1000 FEET

FIG. 1



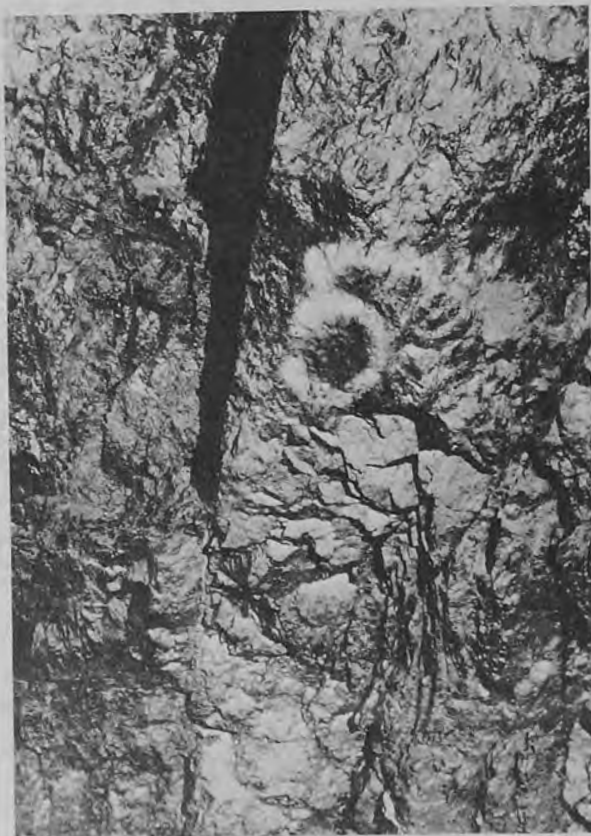


Figure 2

A "B" Fracture (approx. N20W) in the 5210 Slusher Drift. The right-hand edge of heavy shadow is on the fracture plane. Platy material below the numeral is basalt. Elsewhere there is disseminated chalcocopyrite.

Dec. 9, 1964

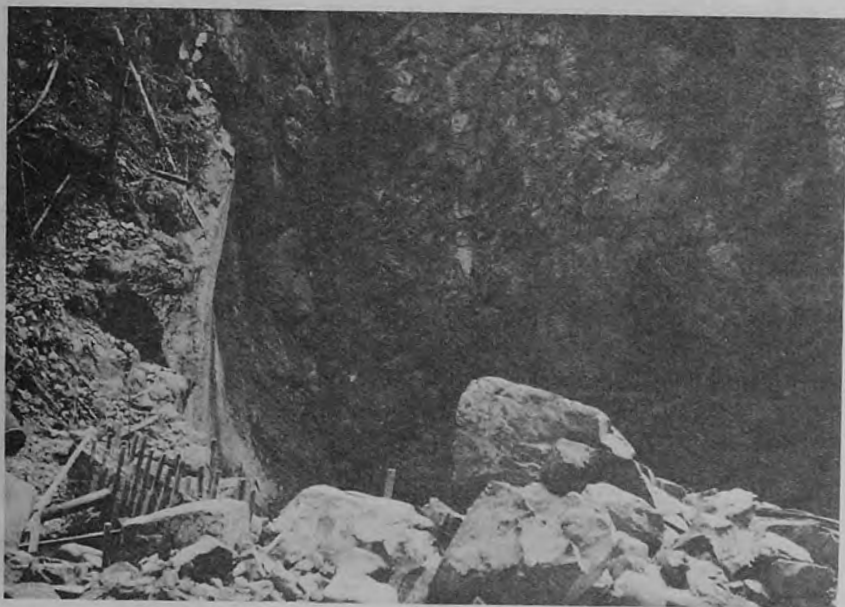


Figure 3

Strong N20W Fractures on left-hand (upstream) side of the caved stope, looking southeast from pile of boulders between the stope and the diverted River. Low diversion dam at lower left. Photograph taken May 4, 1964 just after the mine and the flooded stope had been dewatered. The River was low.



Figure 4

Looking upstream across the flooded slope. Low diversion dam is seen at far edge of water. Trees on the upper third of the photograph are on the far (NW) side of the Jordan River. The photograph was taken December 4, 1964 at time of high water. After the mine was dewatered, bulkheads were built to confine water in the slope and it was allowed to refill.



Figure 5

Part of the Blow-Out above the Adit, May 4, 1964. Note the swath cut through the timber above the center of the photograph.



Figure 6

Flotation Section of the Concentrator

December 9, 1964

Cells have been cleaned out and motors removed for cleaning but rock in foreground could not be moved until the adit was opened.