CIM - Jubilee Volume 1948 : Gill + Byers

Plotting the internal structures in the stock has shown the structural control of the ore zone by the arch of flow layers. Projection of this arch to depth should be a guide in the further exploration of the deposits. The veins were formerly considered to occupy tension cooling fractures at the roof of the stock and hence were thought to have a very limited vertical range. Reconstruction of the original outline of the stock, using the attitude of the flow layers, indicates that the present surface at Surf Point mine lies about 1,000 feet below the original roof of the stock. If this is correct, one could expect a greater vertical range for the deposits than was to be anticipated under the tension crack hypothesis.

SURF INLET AND PUGSLEY MINES

BY J. E. GILL* AND A. R. BYERS†

The Surf and Pugsley gold-copper mines, owned and operated by Surf Inlet Consolidated Gold Mines, Limited, are about 6 miles inland from the head of Surf inlet, on Princess Royal island, Skeena mining division, British Columbia. Surf inlet is a fiord 360 miles in an air line northwest of Vancouver.

The Surf mine is on the north side of a deep *U*-shaped valley, about ½ mile wide and over 3,000 feet deep. The Pugsley mine is about 4,000 feet to the south, on the south side of the valley.

The original mineral claims are the oldest locations in the Skeena mining division. The discovery was made by tracing white quartz 'float' from the bottom of the valley to where the veins outcropped on surface along its north and south sides.

Production on a large scale commenced in 1917, and from then until the property was closed down in June, 1926, 836,500 tons of ore was mined, yielding 322,297 oz. gold, 176,734 oz. silver, and 5.244,772 pounds of copper, valued at nearly $8,000,000 (gold at $20.67 an oz.). The present Company commenced operations in 1935, and from January, 1936 to November, 1942 produced gold and copper valued at $2,324,013 from 166,546 tons of ore. The following description is based on data collected during examinations made in 1941 and 1942.

*Professor of Geology, McGill University.

†Assistant Professor of Geology, University of Saskatchewan.

GEOLOGY

General

The ore deposits are in quartz-pyrite veins along a complex fault zone with a general north-south strike and a westerly dip averaging 45°. This fault zone is along or near the east side of a roof pendant or screen of meta-sediments and volcanics in the 'Coast Range batholith', which here is composed mainly of quartz diorite and bordering gneisses. The roof rocks are best preserved in the north Surf workings. Farther south they have been recrystallized and injected by material of the batholith to form para-gneiss and injection gneiss.

The fault zone traverses mainly gneissic marginal facies of the batholith. At a few places massive quartz diorite or quartz diorite porphyry is found within the fault zone, but generally the massive facies are at distances up to 500 feet to the east (Fig. 1). A faint lineation is visible even in the massive rocks. It is more noticeable in the hornblende-quartz diorite gneiss nearer the fault zone, where a pronounced preferred orientation of hornblende laths and a streakiness due to segregation of hornblende crystals are striking features. Banding is more prominent in the biotite-quartz diorite gneiss, where contamination from the roof rocks is added to the effects of flowage. Examination of thin sections under the microscope has shown that many of the rocks, for some distance on either side of the 'break', have a marked cataclastic structure. It seems clear, therefore, that movements occurred along this zone during the crystallization of the intrusive rocks traversed by the fault zone, as well as afterward.

Flow layers in the gneissic facies strike on the average north-south, but there are many local deviations of as much as 60°. The lineation measured in all facies plunges on the average northwest at around 45°, but in this, too, there are many departures from the average position.

The Fault Zone

The fault zone has been traced for 14,500 feet horizontally and 3,300 feet vertically. In the part containing the two ore zones it is broadly convex toward the west, striking N.23°E. at the north end, north-south in the central section, and N.18°W. at the south end. Dips range from 30° to 60° W., averaging 45°W. Internally it consists of two or more parallel or sub-parallel shear surfaces or zones from a few inches to 30 feet thick. In places there are two of these, 150 to 200 feet apart. More commonly, however, and particularly along the ore zones, there are several branch shear zones passing obliquely between these, or branching from and rejoining the same one to form loop structures (Figs. 1 and 2).

Individual faults show broad corrugations, grooves, and striæ plunging northward at 30° to 70°, averaging 45°, and there is abundant evidence that during the main movement the west or hanging-wall moved upward along

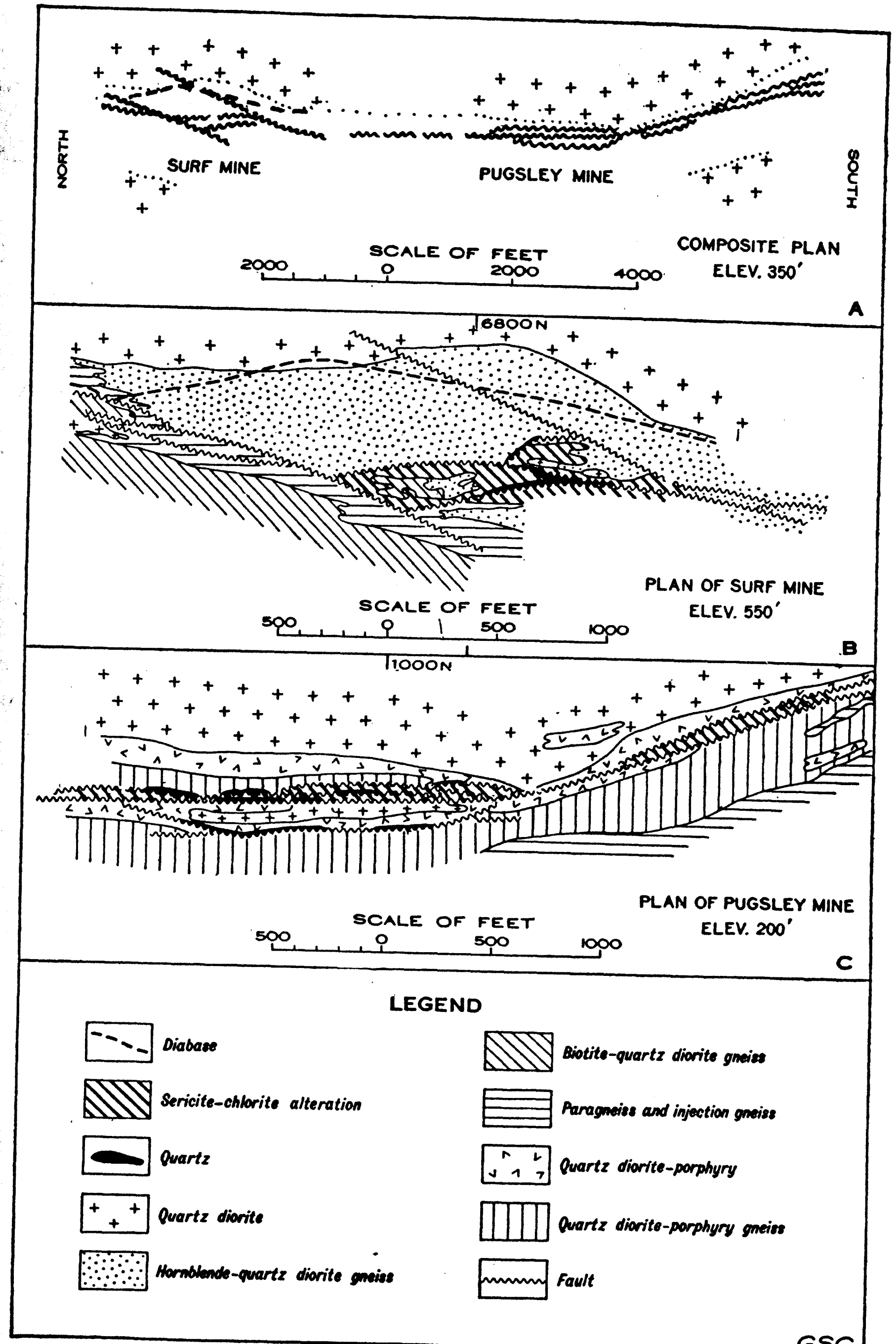

Fig. 1.—Geological plans, Surf Inlet and Pugsley mines.

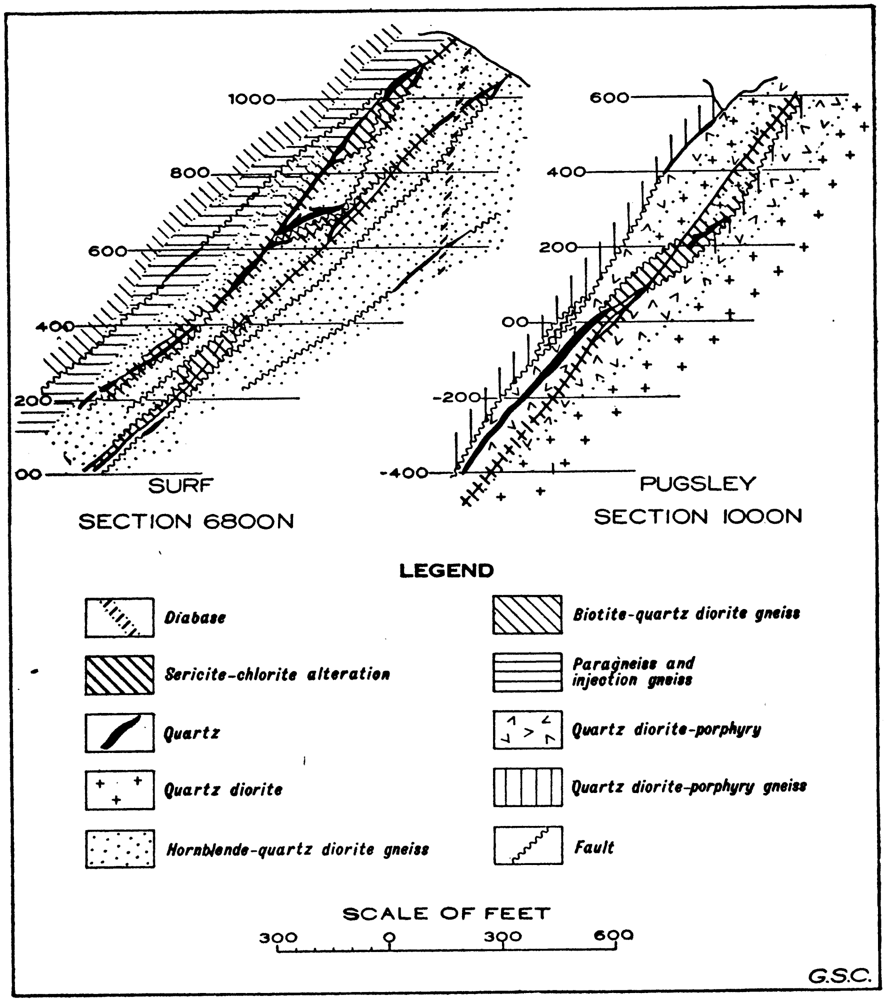

Fig. 2.—Geological cross-sections, Surf and Pugsley mines.

these lines, relative to the footwall. Markings due to later movements are numerous and variously oriented, but two stand out. These are (1) along the dip or inclined steeply toward the southwest, and (2) horizontal. It was not possible to establish the sequence of these late movements, but it is almost certain that the openings for the veins were provided by the small adjustments they record, carrying one wall past the other in directions oblique to the main corrugations.

The Ore Zones

The Surf and Pugsley ore zones occur in complex parts of the fault zone developed at two prominent bends (Fig. *1A*). They are marked by the

presence of numerous veins of milky quartz that have been inserted along slippage surfaces and tension cracks. Vein walls and inclusions show only slight silicification at a few points, so replacement could not have been important in vein formation. Rocks in and near the ore zone have sericite and carbonates derived from alteration of feldspars, and chlorite from hornblende and biotite, but there is no close correlation in distribution between the veins and alteration.

The veins are of various sizes and shapes. Lengths range from less than 100 to 1,000 feet and thicknesses from 2 to 40 feet. Milky quartz is the main constituent, with pyrite forming up to 25 per cent by volume. Two stages of vein formation are evident. The early quartz and pyrite are locally seamed by later pyrite, chalcopyrite, and quartz. Assay tests show that the major part of the gold came in with the late wave of mineralization. Visible gold is extremely rare, but at high magnifications a few particles measuring from 7 to 40 microns have been identified in the fractured pyrite. Ankerite is locally present in quite large amounts, especially in marginal parts of veins. Calcite, dolomite, chlorite, and molybdenite also occur, but always in minor amounts.

Although it is evident that the formation of the two ore zones has resulted from a series of minor adjustments about the two major bends in the fault zone (Fig. 1), it has not been possible to work out the detailed sequence of those adjustments and their correlation with vein and ore formation. This might have been possible if systematic observations had been made in stopes during mining, but unfortunately there were no records for these except the total tonnage removed and the gold recovered.

In the Surf mine some of the veins occupy fissures that, from their positions in relation to the grooves, were tension cracks formed during the main fault movements, but these were no doubt reopened by small, horizontal or oblique, left-hand movements at the time of emplacement of the first quartz. The plunge to the southeast shown in Fig. 2 is in part, at least, due to these, but it is probably only a local feature and ore may be expected to recur at greater depths downward toward the north.

In the Pugsley, the distribution of quartz is most readily explained by small, horizontal or oblique, right-hand movements, opening certain shear surfaces just west of the major bend (see Fig. 1*C*). Not enough work has been done to define a trend for this ore zone as a whole, but because the major flutings plunge north, the best chances for occurrence of ore at depth lie in that direction.

The distribution of ore shoots within the veins depended mainly on still later adjustments during which only the veins along certain shear surfaces and zones were fractured and mineralized. It should be possible now, with a large part of the upper section mined, to establish the positions and trends of these favoured zones and something about their origins, but in the Surf mine especially, quartz was mined wholesale and it is certain that much barren material was taken. The necessary details regarding the distribution of gold and associated later minerals are, therefore, lacking.

Sequence of Events

From the relations observed and briefly described above, the following sequence of events is inferred:

(1) Intrusion of the quartz diorite with flowage upward and toward the south, probably on both sides of the roof pendant. Marginal parts, where contaminated by roof rocks, show banding as well.

(2) Movements continued on the east side of the pendant in the late stages of crystallization of the gneisses, as shown by cataclastic structure.

(3) Failure of the solid rocks under shearing stresses. The west block moved southward and upward, along corrugated surfaces, at around 45° to the horizontal.

(4) Further adjustments, development of some linking shears and tension cracks while solutions rose from a deeper part of the batholith along two main channels near prominent bends and formed large quartz-pyrite veins.

(5) Adjustments oblique to the original corrugations caused fracturing of the quartz and pyrite and provided openings for additional pyrite and quartz plus chalcopyrite, gold, and minor amounts of other minerals.

(6) Intrusion of diabase dykes.

The writers are indebted to Mr. W. H. Hax, President of Surf Inlet Consolidated Gold Mines, Limited, for permission to publish the material contained in this paper.

BRITANNIA MINE*

By W. T. IRVINE†

The Britannia ore deposits are approximately 20 miles north of Vancouver, and occur in a prominent ridge facing Howe sound. A large iron-stained bluff first attracted the serious attention of early prospectors. This, upon investigation, proved to be the outcrop of a large copper orebody. The highest outcrops were 4,300 feet above sea-level.

The original discovery was made in 1888, but no real development took place until 1902. The first mining was done in what came to be known as the Jane orebody, and some production was obtained from this in 1905. Underground exploration led to the discovery of several other orebodies.

The first main adit, the 1,050-foot level, was driven to tap the ore at an elevation of 3,300 feet above sea-level. During succeeding years, however, long adits were driven from points lower down on the mountain side. These, with connecting shafts, followed the ore to horizons well below sea-level. The lowest working has now reached to 880 feet below sea-level.

The property has been in almost continuous operation since its original exploitation in 1905. Until the end of 1944, 732,414,420 pounds of copper and 261,125 ounces of gold had been produced from the mine.

OREBODIES

The Britannia area(1) is underlain by Mesozoic rocks of the Britannia group which form a roof pendant in the Coast Range batholith. The orebodies occur in a sheared part of the pendant, the favourable host rocks being chlorite and sericite schists. The ore is believed to have been deposited by solutions emanating from the batholith.

Eight individual orebodies have been discovered, and these occur either as stringer-lodes, massive replacements, or a combination of the two. Although the principal sulphides are pyrite and chalcopyrite, heavy concentrations of sphalerite occur in some sections. Large amounts of quartz are present, the gangue consisting principally of quartz and schist.

GENERAL STRUCTURE

Steeply dipping rocks of the Britannia formation, which is the lowest part of the Britannia group, are intensely sheared along a zone having a northwest strike and steep dip to the southeast. This shear zone has a

*The writer is indebted to officials of the Britannia Mining and Smelting Company, Limited, or permission to publish this article.

†Geologist, Britannia Mining and Smelting Company, Limited.