Title GEM Vancouver

Author ASB **008071**

Date and Typist February 3, 1971 rm 1

BRITANNIA MINE (No. , Fig.) By A. Sutherland Brown

LOCATION: Lat. 49° 36.6' Long. 123° 08.5' (92G/11E)

The Britannia mine is on the east side of Howe Sound, 40 miles by road from Vancouver.

OWNER: ANACONDA BRITANNIA MINES LTD., Britannia Beach. *Comments by GCW - J.B - D.J.*

METALS: Copper, zinc (see Table 12 for production).

DESCRIPTION:

PROPERTY FILE

Introduction

Sixty-six years of nearly continuous operations have not exhausted the ore reserves of the Britannia mine nor has study over that period revealed with certainty the structure or stratigraphy of the mine. Significant orebodies such as the 040 continue to be found and the potential for finding others is good. The geology of the mine has been carefully studied for much of the period of exploitation, and substantial records kept. Most of the available mine has been remapped and drill core relogged by Anaconda geologists since acquiring the property in 1963. In addition, elaborate geological and geochemical research projects have been conducted. However as [redacted] different interpretations of [redacted] some aspects of the geology are still possible it is obvious that the Britannia orebodies are in a very complex geological situation.

The following description is primarily concerned with the surface geology of an area of the Britannia Shear Zone that is particularly well exposed. It was studied with the hope of rapidly acquiring an acquaintance with the geology of the mine. A total of four weeks in 1969 and 1970 were spent mapping the surface and visiting underground. The Manager and geological staff of the mine extended every help, including extensive

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discussions and joint visits to many of the critical localities. The geology as here described does not necessarily coincide with that of the Anaconda staff. It is hoped that a definitive article on the geology of Britannia will be published by Anaconda geologists. [redacted]

Geological Setting

The Britannia mine occurs in a pendant [redacted] of mainly volcanic rocks intruded [redacted] by several [redacted] plutons (see Fig. and Bostock, 1963). The stratified sequence, probably related to the Gambier Group, [redacted] is dominated by pyroclastic rocks of andesitic to dacitic character which are intercalated near the top and overlain by dark marine shales and siltstones. In a separate but lithologically similar pendant 6 miles south of Britannia, H. W. Tipper of the Geological Survey of Canada has recently collected Albian ammonites. Potassium-argon analysis on the Squamish Batholith that intrudes the Britannia pendant [redacted] on the north gives an apparent age 92 $\pm$ 4 million years (White, 1968). Formation of the ore deposits and intrusion of a dacite dyke swarm predate this pluton [redacted].

The volcanic pile north of the Britannia mine [redacted] is tilted southward about 20 degrees as a monoclinal panel. This monocline is transected to the south [redacted] by a northwesterly trending belt [redacted] of intense deformation one-quarter to one-half mile wide, that has been called the Britannia Shear Zone. The orebodies of the Britannia mine occur within the deformed belt [redacted].

Detailed Geology

The geology of the central portion of the shear zone is shown on Figure .

Except for the Victoria and Empress most of the orebodies that reach the surface do so within this area. Exposure and access are both relatively good. This [redacted] area contains both margins of the shear zone and relatively good correlation can be made with rocks in both walls although some problems of correlation exist with the sequence north of the map on the road to the area from Britannia Creek. On the basis of present work stratigraphic thicknesses are [redacted] approximate.

The intense development of schistosity of rocks within the shear zone makes correlation with those beyond difficult in the field. It is fundamental to the present interpretation that these correlations can be made. The key to the correlations is partly structural in that some units can be traced around a plunging anticlinal nose within the shear zone, and partly stratigraphic in that a [redacted] distinctive marker occurs in similar sequences in both walls and the anticlinal nose. The initial discussion of the stratigraphy assumes the correlations are valid and emphasis is placed on the character of the relatively undeformed rocks. The deformation and alteration are described subsequently.

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Stratigraphy

There are two stratified sequences in the map-area stratigraphically above the mineralized zones: a lower pyroclastic one and an upper shale-siltstone one which are cut by many large dykes. The older stratified sequence is composed of pyroclastic flow rocks of dacitic character called crystal-rich tuff breccia on Figure . These are light grey-green rocks normally lapilli grain size (2 to 20 millimetres) that are charged with chalky plagioclase crystals in matrix and clasts. They are compact rocks with a primary foliation but without bedding planes (see Plate). This [redacted] foliation results from a high percentage of lenticular fragments, the most prominent of which are white or wispy black. These typical rocks grade rarely to somewhat coarser ones in which the primary foliation is not as prominent; or more commonly, to crystal-lithic tuffs with coarse sand-sized clasts. These invariably are well foliated and dominated in appearance by chalky plagioclase. [redacted]. Rocks in this general unit may be regularly bedded, convoluted, or DISAGGREGATED [redacted] by soft rock deformation. Within the pyroclastic sequence there may also be minor intercalations of black or green argillite or volcanic sandstone. Fragments of argillite also form a normal component of the pyroclastic flow rocks. This sequence of crystal tuff breccias [redacted] is one of marker beds which outline the structure.

Overlying this unit [redacted] is a sequence of black argillite and siltstone with thin basal [redacted] beds [redacted] of dark- to light-coloured well bedded argillite [redacted].* The black argillite and siltstone overlying this basal sequence are relatively featureless, poorly bedded, but commonly cleaved. Intercalations of greywacke such as those exposed on the Glory Hole Road immediately north of the Jane Basin may show graded bedding, shale sharpstones, and minor slump structures.

The apparent local stratigraphic section is:

Top

Black argillite, minor siltstone and well bedded basal argillites - - - - - - - - - - 500-550' ±

Coarse, medium and fine dacitic crystal tuff breccias, crystal tuffs and disaggregated crystal tuff fragments in black argillite matrix - - - - - - - - 435-525' ±

Base

in the table. Nevertheless the transition from pyroclastic to sedimentary strata is invariably

* Exposures of this basal sequence are best seen on the crest of the Britannia anticline (to be discussed in next section) where they serve to define the anticlinal structure

indicated by some part of the marker sequence.

ASB Your "pre-min. andesites" are andesitic tuffs with very minor andesitic plugs or flows e.g. in E. Bluff pit DJT

Intruding the stratified sequence are two major dyke sequences, a large dacite dike swarm and a group of small late basic dykes. The early dyke intrusions are composed of dark grey-green rocks that are called andesites. They commonly have a slightly mottled texture that reflects a fragmental nature. They may also contain abundant quartz and chlorite amygdules. These andesites occur in thin dykes and large tapering wedges. They are clearly almost contemporaneous with the pyroclastic flow rocks and may be highly deformed and mineralized.

OMIT

The [redacted] porphyritic dacites [redacted] are massive grey-green rocks with about 15 per cent plagioclase phenocrysts 1 to 2 millimetres long. Some have a flow foliation indicated by fluxion arrangement of phenocrysts and small inclusions, and uneven distribution of phenocrysts. Some are only microporphyritic but in general they have a characteristic appearance and texture. They are either not deformed or only slightly so on their margins. Their emplacement is closely related in time to the [redacted] major mineralization in the shear zone [redacted].

Late dykes are common but volumetrically insignificant and include lamprophyre, basalt, and andesite. The lamprophyre is a dense brownish black rock with lenticular shiny black amygdules. The basalt is fine dense black rock and the andesite a dark grey, [redacted] aphanitic rock.

On the map (Fig.) two other units are shown within the shear zone called chlorite mottled schist and quartz (chlorite) sericite schist. The former is believed to be the schistose equivalent of the dacitic crystal-rich tuff breccia as discussed later. The quartz (chlorite) sericite schist can be shown to have several origins. In general, [redacted] it is produced by isochemical metamorphism of black argillite. Alternatively, it may be formed through intense ductile shear of chlorite mottled [redacted] schist or andesitic tuffs.

[illegible] schist. In particular the westernmost outcrops of andesite were mapped in the field as quartz sericite schist but found on petrographic examination to be andesite. Some of the bands within the chlorite mottled schist are likewise probably part of this same unit. However much of the schist appears to be altered black [illegible] argillite and this is especially true of the [illegible]

Petrography

Petrographic examination of the least deformed and altered representatives of the various rock types reveal the following.

1. Dacitic tuff breccias have the following range of compositions:

	Per Cent
Plagioclase crystals (oscillatory zoned An_{55-30})	10 - 30
Lathy equigranular plagioclase dacite and crowded dacite porphyry	2 - 10
Plagioclase phenocrysts in microcrystalline matrix	30 - 60
Chlorite fragments	10 - 20
Siltstone fragments	0 - 5

The average size of fragments is estimated to be about 4 millimetres. As the average size decreases the percentage of plagioclase clasts increases somewhat but even the finest crystal tuffs have as many lithic fragments as plagioclase clasts. The texture of the various volcanic fragments can be quite variable but all are closely alike in total composition, and are probably dacites. The chlorite fragments are a characteristic element composed of pure, fairly coarse, aligned penninite chlorite, with or without plagioclase crystals. They normally have wispy shapes that are commonly molded to adjacent stronger clasts. They may represent altered pumiceous fragments or possibly even more altered shale fragments.

The texture and composition of undeformed specimens are akin to that of submarine pyroclastic flow rocks (Fiske, 1963). The composition of the bulk of clasts is uniform even though the texture varies. The plagioclase that occurs as clasts or as phenocrysts of lithic clasts are similarly zoned and of the same andesine to oligoclase composition. The foliated flow-molded textures together with wispy chlorite (pumice ?) fragments indicate a probable pyroclastic flow origin just as the intercalation with marine shales also suggests marine origin.

The petrography of the crystal tuffs is similar to that of the tuff breccia but with finer average size and slightly higher concentrations of plagioclase clasts, that in some cases show considerable abrasion. The petrography of the mixed tuff and argillites is identical to that of its component parts.

2. The black shales and siltstones are composed principally of a very fine clay and chlorite paste that commonly has an incipient preferred orientation. In this matrix a variable amount of angular feldspar silt clasts are embedded, together with opaque organic matter, ores, and leucoxene. Most of the shales have at least 5 per cent silt clasts and 5 to 10 per cent combined opaque matter. Greywackes have a similar composition but are coarser with abraded plagioclase laths and angular to rounded quartz dominant in a minor pasty matrix.

3. The grey to greenish grey argillites are similar to the shales with more plagioclase clasts and without significant organic matter. In addition some spheroidal particles of unknown origin occur that are composed of quartz, carbonare, and a zeolite and are about 0.3 millimetre in diameter.

4. All "andesite" specimens were found to be quite highly altered and deformed. They are composed of completely sericitized plagioclase phenocrysts and quartz chlorite amygdules in a finer grained matrix of chlorite and sericite in which are recognizable small sericitized plagioclase laths and minor quartz, leucoxene, and pyrite. Most but not all specimens appear to have a fragmental texture. They are called andesites in contrast to the dacites because of the seemingly more mafic character.

5. Dacite porphyries are composed as follows:

	Range	Average
Phenocrysts		
Plagioclase (oscillatory zoned An_{48-44})	15 - 30	22.3
Augite	1 - 5	2.0
Matrix		
Plagioclase	55 - 65	60.7
Chlorite	2 - 15	9.0
Quartz	1 - 5	2.0
Ilmenite and leucoxene	3 - 4	3.7
		99.7

Somewhat rounded stubby phenocrysts of slightly zoned andesine, 1 to 3 millimetres long with smaller augite phenocrysts occur in a trachytoid to felted matrix dominated by small (0.1 $\pm$ millimetre) plagioclase laths but containing some quartz, ilmenite, or leucoxene, and a trace of potash feldspar.

6. Lamprophyre dykes have a composition as follows:

	Per Cent
Phenocrysts	
Plagioclase (An_{54} $\pm$)	2
Biotite	0.25
Matrix	
Plagioclase (An_{54-30})	40
Potash feldspar	38
Hypersthene	7
Chlorite-biotite	9
Opaques	2
Brown glass	1.75

Fresh stubby, normally zoned plagioclase, with minor biotite phenocrysts, and lenses of altered brown glass occur in a trachytoid matrix of slim plagioclase laths, hypersthene and opaque minerals with interstitial potash feldspar.

Structure

The strata of the Britannia pendant north of the shear zone are tilted southward about 20 degrees in a gently warped monoclinal panel. This uniform dip is abruptly transformed at the Britannia Shear Zone where these rocks are highly deformed in a fault-bounded anticline and subsidiary syncline within the map area (see Figs. and). The anticlinal nose is quite clearly shown on the west slope of the Jane Basin where it plunges westward at 22 degrees. The marker beds of crystal tuff and argillite can be traced around the nose and on either limb beyond the marginal faults. The distorted and highly schistose core is filled principally with intrusive dacite, andesite tuffs, sericite schist and [redacted] chlorite mottled schist that is thought to be metamorphosed crystal-rich tuff breccia. Significant minor folds in green argillites that appear equivalent to those of the marker bed sequence, show that the beds in the southern margin of the schist zone face south and that the anticlinal hinge lies to the north. In the core of the schist zone bedding is rarely identified with certainty and the hinge zone cannot be located. [redacted] Immediately south of [redacted] the footwall fault the indications are that the marker beds face north and are overturned in this direction forming the northern limb of the [redacted] anticline. [redacted] Beyond them the argillites should be folded in a syncline of which there is ~~good~~ little evidence north of the anticlinal nose.

The bounding faults do not appear to be continuous throughgoing faults but rather an en echelon sequence. This is [redacted] suggested underground [redacted] and can be [redacted] inferred *from my mapping* *Faults exposed near the footwall of the shear zone*

[redacted]. The hangingwall fault(s) dip southward at about 70 degrees. [redacted]s dip from 60 degrees to vertical. [redacted]

An additional fault which is judged to be fairly important is exposed on the lowest hairpin turn. Here it strikes north 60 degrees west and dips 25 degrees southward. It is a small thrust that carries the overturned limb with marker beds and crystal tuff and tuff breccia over the argillite sequence with intercalated greywacke. Its continuity and its relation to the footwall fault are not known.

Both dyke sequences seem to be spatially related to the shear zone, being rare at a distance from it but very abundant within and adjacent to it. Intrusion of both predates at least the latest movement. Because of their common fragmental nature, high vesicularity, and similarity to flow rocks in the pendant, the andesites appear to have been most likely intruded at shallow depth during the formation of the volcanic and sedimentary pile. The dacites are in general not schisted even in the core of the anticline [redacted]s [redacted]. Within the shear zone a common feature of the dacites is that they follow the schistosity as narrow dykes until a certain point where they blossom out into a enlarged crescentic body that commonly hoods over *some* orebodies. This is paradoxical for the dacites must have been intruded late in the interrelated folding and faulting process.

MY OBSERVATIONS THAT I WILL STAND BY

Incorrect generalization re: flow banding in dacites

Metamorphism and Alteration

Regional *Metamorphism in Britannia Pendant*

All the rocks except the late basic dykes have been subjected to a *very minor,* low grade [redacted]regional dynamothermal metamorphism *in part equivalent to the lower* [redacted] greenschist facies. Changes due to this metamorphism include incipient (or minor) alteration of plagioclase to clinozoisite, mafic minerals to penninite or other chlorites, glass to very fine stilpnomelane, *(not likely!)* and minor prehnite in amygdules.

Dynamic *Metamorphism in Britannia Shear Zone*

Dynamic metamorphism and hydrothermal alteration have had a more dramatic effect on the character and composition of the rocks than the regional alteration ~~and~~ particularly ~~the~~ *within the* rocks of the shear zone. All rocks within the shear zone have an intense second foliation. Progressive increase in the development of schistosity can be observed in the walls on approach to the shear zone, especially toward the hangingwall. In the latter case a parallel erasure of bedding in crystal-rich tuff breccias can be seen. In much of the shear zone bedding attitudes cannot be observed but intercalations commonly indicate that bedding and schistosity are quite closely parallel. The rocks of the shear zone except for the *late intrusives show varying degrees of schistosity* [redacted] with a marked flattened fabric with *a common* steeply *plunging* [redacted] lineation [redacted]. This is particularly noticeable in the chlorite mottled schist.[redacted].

Microscopically the development of schistosity is first evident as very fine new sericite that grows in the slight matrix of fragmental rocks. It wraps around fragments with an average orientation of that of the developing schistosity. More intense development arises with further growth of sericite, especially along "channels" between fragments accidently oriented in the schistosity. Then new growth of sericite and chlorite in fragments occurs as well with flattening of very fine-grained lithic fragments, molding of weak fragments about strong clasts, and development of some schistose bands through fragments accidentally placed to connect earlier "channels." Increasing intensity involves boudinage and rotation of some strong clasts and further development of micas particularly in a network of bands. Further increase involves not only coarse growth of micas and further flattening but also the breaking down of the feldspars. The latter is accomplished first by disruption of twin patterns, erasure of oscillatory zoning and replacement by albite and quartz. This is followed by complete granulation, flattening, and replacement by mosaic quartz. The rocks immediately south of the hangingwall fault have reached the stage of incipient destruction of feldspar.

It is suggested by [redacted] this study that the crystal-rich tuff breccia and crystal tuff may be [redacted], in fact, the same stratigraphic unit as the chlorite mottled schist. This was suspected in the field but the general lack of plagioclase phenocrysts and clasts in the latter made correlation uncertain.

The alterations of the titanium minerals evident microscopically is also interesting. Traces of ilmenite are found with leucoxene in a few of the freshest specimens of dacites outside the shear zone. All other rocks have leucoxene outside the shear zone but within many have a mixture of very fine porphyroblastic sphene as well as leucoxene. One specimen of quartz sericite schist contained capilliary rutile as well as sphene and leucoxene.

Hydrothermal

Some of the effects of the dynamic metamorphism are difficult to separate from those of hydrothermal metamorphism, involving as they do, growth of similar micas and replacement of feldspars by quartz. However the intense hydrothermal alteration is much more local and appears to be imposed on rocks that already have attained the intense schistose flattened fabric.

Surrounding the sulphide orebodies the host rocks, commonly chlorite mottled schist or andesitic tuff [redacted] ~~in the upper~~ parts of the mine and map-area, are affected by an outward grading alteration. Around and between the massive sulphide lenses remnant rocks are composed almost entirely of quartz, pyrite, [redacted] muscovite and minor chlorite. Not uncommonly textures indicative of the original chlorite mottled schist, etc., are evident but the chlorite mottles are commonly partially replaced by muscovite. Elsewhere, particularly on the fringe areas chlorite mottles are evident. These rocks are cut by pyrite or quartz pyrite veins of several generations. Outward from the sulphide bodies the intensity of the silicification decreases gradationally and its mode changes from complete replacement to ramifying fine veinlets. In a parallel way pyrite also decreases but muscovite-sericite, chlorite, and clinozoisite increase to proportions characteristic of the shear zone remote from [redacted] sulphide bodies. Anhydrite, gypsum, and erratic barite are found in discrete veins and [redacted] disseminations in a zone roughly coincident with that [redacted] of intense silicification.

Thermal

The Squamish Batholith is exposed south of Britannia Creek on the road to the Jane Basin within a mile of Howe Sound (see Fig.). Here argillite and dacite continuous with those of the map-area are visibly thermally metamorphosed.

Sulphide Mineralization

The sulphide orebodies of Britannia are highly heterogeneous mixtures of sulphides, remnant altered host rocks, and discrete veins. The parts that are predominantly sulphides have a characteristic braided appearance that results from the juxtaposition of lenticles of varying mineralogy separated by schistose mica bands and intersected by discrete quartz – sulphide and sulphide veins. Alternatively the braided appearance results from original lenticular quartz-rich and mica-rich bands cut by a variable network of sulphide bands. Not uncommonly within orebodies horses of less replaced rock exist in which the characteristic textures of the chlorite mottled schist or andesite can be recognized.

The main mineralogy of orebodies is simple and fairly constant. Pyrite is by far the most abundant mineral with less chalcopyrite and sphalerite and erratic minor galena, tennantite, or tetrahedrite. The main non-metallic minerals include quartz and muscovite (chlorite), anhydrite [redacted], and siderite. The textures are highly variable and no particular study has been made of them. However a common texture is one in which dense bands 1 to 4 inches wide of granular pyrite averaging about 0.5 millimetre in diameter with some 2- to 3-millimetre grains, and very minor interstitial quartz and chalcopyrite, grade outward through cubic pyrite (0.5 millimetre) with significant interstitial quartz and chalcopyrite to wider quartzose bands with disseminated pyrite and clots of amoeboid chalcopyrite. This may be cut by smaller bands almost discrete enough to be called veins but without much continuity, that consist of sphalerite, lesser chalcopyrite, and quartz, with very minor [redacted] galena and tennantite.

On the fringe of orebodies rather similar pyrite veins exist that in their centre are practically devoid of quartz. The central zone of dense granular pyrite grades outward into the surrounding rock with decreasing quantities of disseminated pyrite. These pyrite veins chiefly follow schistosity but may bifurcate and transect schistosity at any angle for considerable distances.

Some of the grey-green argillites within the shear zone contain significant quantities of pyrite with traces of chalcopyrite. The appearance of these rocks is such that a syngenetic origin of the sulphides is possible (<u>see</u> Plate). Sulphide-rich layers are intercalated with the phyllitic argillites and may occur as laminae that are in effect composed chiefly of lenses of almost solid pyrite that resemble sharpstones, or in some cases worm tubes. The sulphide lenses normally have an ~~imperfect~~ outer rim of quartz. Planes of schistosity and fracture may also be coated with fine pyrite. The sulphide-rich beds are as far as known quite local in the vicinity of the top of the East Bluff and Fairview zinc orebodies. The latter is a sheet-like mass a few feet wide of concentrated pyrite, sphalerite, chalcopyrite, quartz, and barite that 15 [redacted] parallel to metamorphic foliation [redacted] It contains few textures that offer evidence of its origin. The localized distribution as well as some of the features of the sulphide-rich beds are more likely indicative of replacement than syngenetic deposition [redacted].

The main massive orebodies, Bluff, East Bluff, No. 5, No. 8, and 040, all show a marked zonal structure (<u>see</u> Figs. and) in which they have one or more high grade chalcopyrite cores enveloped successively by a lower grade zone and overlapping pyrite and siliceous zones. The plan of the 040 orebody on 4950 level shows this well, although it is less regular than some of the other orebodies. Zinc-rich ore tends to occur in the upper central parts of massive bodies and as almost separate sheet-like masses like the

Fairview zinc vein. In section the main orebodies have a crude lens-like shape, commonly connected to a steeply plunging root which may or may not be of ore grade (see Fig.). The long dimension of the Bluff ore lenses plunge[redacted] about 45 degrees to [redacted] the west [redacted]. The plunge increases in the western and eastern ~~northern~~ orebodies. It is of interest that although the individual orebodies plunge steeper than the crest of the anticlinal structure [redacted], the overall top of the ore zone plunges about the same as the latter and is crudely coincident with the base of the argillite sequence.

The other orebodies such as the Fairview, Empress, and Victoria are stringer lodes and veins composed of thin sheet-like masses of chalcopyrite and pyrite with some quartz that appear generally parallel to the schistosity but actually cut across schistosity in plan at a small angle. The tops of these orebodies [redacted] are eroded so that one cannot guess whether they too might have had an upper limit at the argillites.

Environment of Ore Deposition

Much more study would be necessary to come to firm conclusions regarding the environment of ore deposition. Certain factors that are known are important however in any analysis of the environment. These include the following:

(1) The ore deposits are situated in a volcanic pile of intermediate composition, near the top of a pyroclastic accumulation that is overlain by a marine shale sequence.

(2) The near surface ore deposits are situated within a belt of ductile shear [redacted] associated with a sharp anticlinal flexure to the south of a [redacted] monoclinal panel.

? [redacted].

3 Plutonic rocks thermally metamorphose the dacitic dykes that post-date ore deposition.

4 The orebodies occur in several rock types and have steep westerly plunges. [redacted]

5 The rocks in which the orebodies occur are a rapidly accumulated pyroclastic and sedimentary unit. [redacted]

6 The orebodies are generally concentrically zoned and highly siliceous.

7 [redacted]

The gross and detailed textures of the massive sulphide orebodies are indicative of replacement after the development of schistosity.

From these observations one may conclude that the orebodies are chiefly replacement deposits. They are localized in a sequence of folded and foliated volcanic and sedimentary [redacted] rocks intruded by post and pre-ore dikes [redacted]

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WORK DONE:

TALK PRESENTED TO THE WEST VANCOUVER ROTARY CLUB ON 6 MAY 1970

The Britannia mine, which has been operating for 65 years, is the oldest continuously operated mine in British Columbia and one of the oldest in Canada. At one time it was the largest producer of any copper mine in the Commonwealth. Total production to date has exceeded 50 million tons of 1.25% copper, to produce in excess of one billion pounds of copper.

At no time in the history of the Britannia mine has there been more than a few years of ore reserves in sight. Just when we were about to exhaust all known possibilities for extending present known ore zones we discovered a new ore body in a completely new ore zone, and we are now developing a brand new mine. There is no known geological reason why the Britannia mine should not continue producing for many years to come.

The mine, prior to being acquired by Anaconda in 1963, had been operated for several years on a salvage basis. Anaconda's geologists, engineers and executives recognized an exploration potential in Britannia. A geological research laboratory was established and a relatively large geological staff employed to relog the tens of thousands of feet of diamond drill core and remap thousands of feet of accessible workings in an attempt to solve the complex geological structure and ore controls of the Britannia mine. At the same time a very aggressive exploration programme was conducted. All this has paid off with the discovery of what is called the 040 ore zone, containing an estimated three million tons of better than 1½% copper with a potential for more.

I would like to acknowledge the cooperation and encouragement received from many sources, particularly the Department of Mines and Petroleum Resources, The Honourable Mr. Ray Williston, Minister of Lands, Forests, and Water Resources, and the Mining Association of British Columbia.

B.B. Greenlee
Manager
ANACONDA BRITANNIA MINES.

5 May 1970
rw

HISTORICAL DATES OF THE BRITANNIA MINE

1859	Captain Richards surveying B.C. coast for British Admiralty named Mountain for 100 gun frigate "Britannia".
1888	Mine discovered by Dr. A.A. Forbes, medical doctor, stationed at Hopkins, B.C.
1905	Mill completed and first mine production from the Jane and the East Bluff
1912	Beach store and many houses built on the flats.
1915	Upper, or 1050 Camp at the Jane wiped out by a mudslide - 56 lives lost. Tunnel Camp built (Mount Sheer Camp) No. 2 mill of 2,000 ton capacity completed.
1921	In March the temporarily idle No. 2 mill burned down.
1923	No. 3 mill completed.
1930	Britannia's peak year - reached 7,100 t.p.d. and 44,000,000 pounds of copper produced for the year. Over 1200 employees on payroll during 1930's.
1949	Road connection to Squamish
1952	Road completed to Townsite - later called Mount Sheer
1956	September: The Pacific Great Eastern Railway started regular passenger service to North Vancouver.
1958	March: operations suspended because of low copper prices.
1959	Operations resumed.
1963	The Anaconda Company acquired Britannia property.
1964	Employees went on strike on August 11.
1965	March 2, settlement of strike, with the Assistance of the Minister of Mines, The Honourable Donald Brothers. Resumption of operations on curtailed basis.
1968	Start of the No. 10 Shaft.
1970	October 1 - expected start of production from the new No. 10 Mine.

ANACONDA BRITANNIA MINES LTD.

summary of
1969 Forecast and Plans, Prepared for
Managers' Meeting, March 4, 1969

The Britannia mine is located at Britannia Beach, British Columbia, about thirty-two miles north of Vancouver, near the head of Howe Sound. Access to the property is by paved road, railway and by deep-sea vessels.

The original mineral discovery was made in 1888 and the first mill completed in 1905. After nearly sixty-five years of continuous operations, the old Britannia mine, which has produced in excess of 50 million tons of ore, assaying 1¼% copper, and yielding more than one billion pounds of copper, has given us a new orebody. The mine, prior to being acquired by Anaconda in 1963, had been operated for several years on a salvage basis. Anaconda's geologists, engineers and executives - particularly Jack Knaebel, Vin Perry and Glenn Waterman - recognized an exploration potential in Britannia. A geological research laboratory was established and a relatively large geological staff employed to re-log the tens of thousands of feet of diamond drill core and remap thousands of feet of accessible workings in an attempt to solve the complex geological structure and ore controls of the Britannia mine. At the same time a very aggressive exploration programme was conducted. All this has paid off with the discovery of what is called the 040 ore zone, containing an estimated three million tons of better than 1½% copper and a potential of two to three times that.

The Britannia orebodies discovered to date are found within a sheared zone in a band of steeply-dipping and folded metamorphosed sedimentary and volcanic rocks of varying competency that form a roof pendant two miles wide and seven miles long, surrounded by granite rocks of the coast range intrusive complex. The westerly striking shear zone varies from one to two thousand feet in width for over six miles of strike length before weakening to the east. The Britannia ore zone is known to have a strike length of more than 12,000 feet and a vertical extent of at least 6,500 feet.

The orebodies occur either as steeply-dipping veins five to ten feet wide, particularly near the surface, or as zones of stringer-type mineralization up to 100 feet wide from which

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many of the veins seem to emanate. Individual orebodies are irregular in shape with a strike length up to 200 feet and and a width usually up to thirty or even sixty feet with a dip length of several hundred feet, containing from a few thousand tons to several hundred thousand tons each. The principal minerals are chalcopyrite, pyrite and sphalerite.

These relatively small orebodies are quite elusive; they have not as yet given us a real clue as to how they may be found and usually only fall into a pattern after they have been found. Up until now we have had to rely on just good, common geological judgment. However, geological research here may be on the verge of paying off. It appears that it may be possible to recognize areas of intense mineralization by the alteration and other characteristics of the rocks nearby.

There are indications that certain structural features are present in the 040 ore zone that are similar to those that seem to have geological significance in the control of the Bluff and No. 8 orebodies. This lends encouragement to the thought that there might be much more ore to be found in the 040 zone. Recent drilling from the 4950 level and the 4100 level indicates that there will be considerable ore above the 5100 level and perhaps even above the 4100 level. More encouraging perhaps are the recent drill intercepts below the 5700 level, 300 feet lower than our planned bottom production level. We had an ore intercept of 1.75% copper over 77 feet, and a second intercept of 1.53% over 83 feet, 50 feet above was made by wedging the hole. Rock types and structure divulged by these holes are interpreted that the ground is becoming more favourable for ore deposition as we go down. As a matter of fact, we know of no reason why the No. 8 orebodies should not go down below the 5700 level. We have an intercept of 25 feet of 1½% copper 700 feet below the 4100 level which appears to be the downward continuation of the West Victoria ore zone. The two most attractive exploration targets at Britannia other than the 040, that can be explored from the No. 10 shaft, are a mineralized area several hundred feet in the "footwall" immediately to the west of the 040 below the 5700 level, and the Daisy, 2,000 to 4,000 feet west of the 040.

Difficult as the Britannia orebodies are to find, they are as difficult to mine. We are finding the solutions intriguing. In order to exploit profitably this new orebody it is recognized that an ultra-modern type of mining operation must be conducted which will employ not only the latest mining methods, techniques and equipment, but also Industrial Engineering, modern cost accounting and controls, and a sound personnel programme to improve labour efficiency. Although our feasibility study was based upon our present mining methods we anticipate some major modifications using new techniques and equipment. We will no doubt continue to use longhole blasting but because of the irregular orebodies we will attempt to develop an economical method of driving sublevels with rubber-tired, diesel-powered load-haul-dump equipment, and rubber-tired, diesel-powered two-machine, one-man "parallel hole" jumbos. The Swedes have for some time now developed efficient one-man, two-machine jumbos for blasthole drilling. We will also expect to use larger versions of rubber-tired, diesel-powered load-haul-dump machines for draw point production. These will dump directly into the ore pass system and the muck transported by gravity to the 42 x 48 jaw crusher located below the bottom production level. (We have right now an rental Eimco 912 rubber-tired, diesel-powered LHD machine with which we are driving two short headings on the 4100 level to gain experience in using this type of equipment.)

We are developing an efficient hoisting and haulage system. Currently we are sinking a 15 x 15 square shaft with two skip compartments, a large cage compartment, and a smaller compartment for manway, services and counterweight for service hoist. A 1000 h.p. Canadian General Electric Koepe hoist, hoisting in balance two 7-ton, 140 cu.ft. capacity Sala skips, loaded from measuring cartridges which will be loaded automatically from ore bins. The hoist will be semi-automatic, operated by the skiptender who will be stationed in the vicinity of the shaft loading pockets.

General shaft and hoist specifications will be as follows:

SHAFT

- 4 compartments
- 13' 4½" x 13' 9-3/4"outside timber
- 2 skip compartments
- 1 cage compartment
- a service compartment which will contain manway; cage counterweight; electric cables; air, water, drain and pump lines; ventilation duct

Depth of shaft - planned - 2200 ft.
possible - 3000 ft.
maximum - 4000 ft.

HOIST

Koepe Friction Hoist, Canadian General Electric

Hoist motor - type MCF, 1,000 h.p., 105 r.p.m., 500 volt. D.C.

Main M.G Set - Type CDF, 830 Kw, 500 Volt, D.C. Generator
- Type TS, 1100 h.p., 2300 Volt, 3 Ph, 60 cycle motor

Distance from full dump to bottom of friction wheel - approximately 75 feet.

Hoist - 80" diameter wheel - 4 ropes

Cycle time - at 2200 ft. - 92 secs.
3000 ft. - 114 secs.
4000 ft. - 141 secs.

Production at 85% hoisting efficiency -
at 2200 ft. - 220 t/hr
3000 ft. - 179 t/hr
4000 ft. - 144 t/hr

Hoist capacities, maximum, ore (allowance included for waste hoisting)
Depth - 2200 ft. - 90,000 t/month
3000 ft. - 80,000 t/month
4000 ft. - 70,000 t/month

Drive Rms Loading -
2200 ft. - 969 h.p.
3000 ft. - 980 h.p.
4000 ft. - 990 h.p.

Ropes - 4 x 13/16" full lock hoist ropes
- 2 x 1-3/8" non-rotating tail ropes

Hoisting speed - 2200 ft/min

SKIPS

Make - Sala Machine Works (Swedish, made in Canada)
Type - bottom dump, air activated arc gate
Payload - 7 tons (14,250 lb.)
Deadweight - 16,000 lb.
Length, overall - 23' 6"
Loading Cartridge - weighing type

B.B. Greenlee
Manager.

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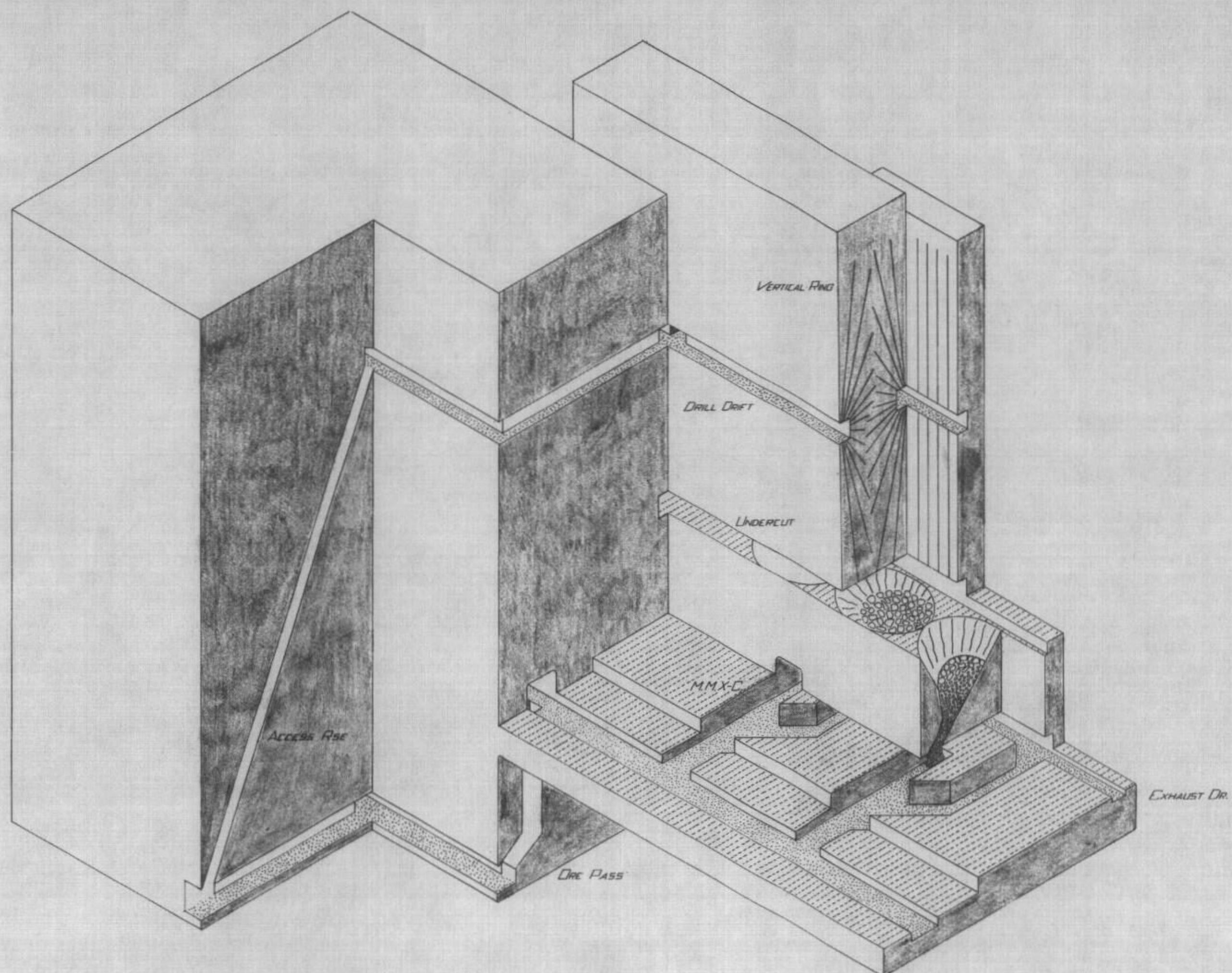
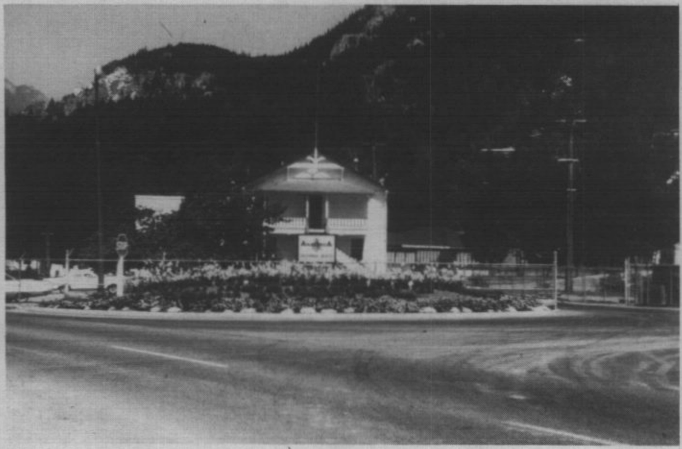
28 February 1969



ISSUED	DATE M D Y	APPROVED	THE ANACONDA COMPANY (CANADA) LIMITED	
1ST ISSUE			TITLE— ISOMETRIC VIEW L.H. STOPING METHOD	
AMENDMENT 1			SCALE— NIL	DATE— M D Y
2			DRAWN—	MINE (OR DRAWING NUMBER)
3			CHECKED—	
4			APPROVED—	



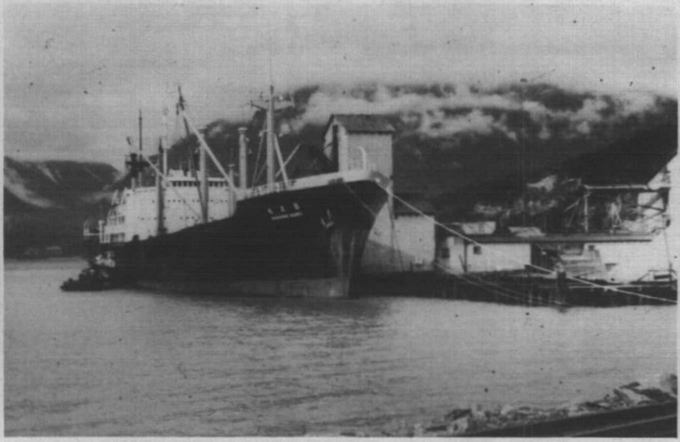
Main entrance and engineering office

General view North, administration and community buildings in the foreground

General view South, over upper townsite. Concentrator and Powerhouse in middle distance

View of lower townsite, looking North-west over Howe Sound. Woodfibre pulp plant on far shore.

General view South-west, Britannia Creek in foreground. Ball-park, apartment buildings



Loading concentrates for overseas shipment

ROUGH DRAFT
18 FEBRUARY

PRESENTATION: THE BRITANNIA MINE

C.I.M. Luncheon,
Thursday, 19 February.1970

Many of you are more familiar than I am with the his tory of Britannia and the mine itself, except for development in recent years. However, to refresh your memories and to acquaint those of you who do not know Britannia, I will briefly run through the historical dates and the production and tell you what we are doing now.

The mine was discovered in 1888 by Dr. A.A. Forbes. First production came in 1905 with the completion of the first mill. The mine has been operating continuously since then with the exception of a four-month strike closure in 1946, a nine-month shutdown in 1958 and a seven-month strike in 1964 - 1965.

DATES IN THE HISTORY OF BRITANNIA BEACH

1888 Mine discovered by Dr. A. A. Forbes

1905 Mill completed and first mine production from the Jane and the EAst Bluff.

1912 Beach store and many houses built on the flats

1915 Tunnel Camp built

Railroad to top of Incline and Incline finished

No. 2 mill of 2,000 ton capacity completed

1923 No. 3 mill completed

1930 Britannia's peak year - reached 7,100 t.p.d. and 44,000,000 pounds copper produced for the year.

Over 1200 employees on payroll during 1930's.

1949 Road connection to Squamish

1952 Road completed to Townsite - later called Mount Sheer

1956 September: The Pacific Great Eastern Railway started regular passenger service to North Vancouver.

1958 March: operations suspended because of low copper prices

August: Seaview highway to VAncouver was opened

1959 Operations resumed

1963 The Anaconda Company acquired Britannia property

1968 Start of the No. 10 Shaft.

Total production to date has exceeded 50 million tons of 1.25% copper, to produce in excess of one billion pounds of copper. This ore came from a mineralized zone of over 13,000 feet strike length extending from the surface to a vertical depth of at least 6,500 feet.

P R O D U C T I O N

1905 - production started from theEast Bluff and the Jane.

1. 1910-1957 Fairview

   20 million tons of 1.3% copper

   500 million pounds of copper produced.

   Mining Methods: Shrinkage
   1930's induced caving....

   Serviced by No. 1 Shaft, started in 1913.

2. 1913-1970 Bluff

   17 million tons of 0.95% copper

   330 million pounds of copper produced

   Mining Methods: Shrinkage in 1930's
   Induced caving and later longhole shrinkage.

   Serviced by No. 7 Shaft, raised in 1942.

3. 1923-1970 Vic toria

   4 million tons of 2.73% copper

   230 million pounds copper produced.

   Mining Methods: Square set, drill and shrink stope.

   Vic toria shaft holed the 4100 level in 1940

PRODUCTION, continued

4.	1937-70	NO. 8
		4-1/2 million tons of 1.41% copper
		125 million pounds of copper produced.
	Mining Methods:	Cut and fill, square sets, longhole shrinkage.

In 1963 The Anaconda Company acquired ownership of the Britannia mine:

(1) to establish an exploration basis in Western Canada;

(2) Jack Knaebel, Glenn Waterman and other executives of Anaconda believed that the Britannia property offered excellent exploration possibilities.

The third of four geological research laboratories was established at Britannia, the first one being at Butte, Montana; the second at El Salvadore, Chile; and a fourth at Salt Lake City, Utah.

A relatively large staff of competent geologists was employed to relog the tens of thousands of feet of core and remap the available mine workings in an attempt to get some clue as to the ore deposition and the structure. Along with this, an aggressive exploration programme was launched and as a result a new ore zone was found nearly one-half mile west of all known ore bodies and approximately 800 feet in the hangingwall. Although the 040 ore zone is quite similar in many ways to that of the No. 8, it has its differences. There is no zinc or gold, although silver is improved. From a standpoint of location and to a certain extent geological features, it is considered a completely new ore zone, requiring a new shaft and development to exploit.

NO. 10 SHAFT DEVELOPMENT

In this day and age square set mining is ordinarily uneconomical, and our recent experience in No. 8 indicates that vertical or horizontal longhole methods were not the answer to mining No. 8 ore bodies because of dilution and high secondary breakage costs. When we were planning the 040 project we knew very little about the 040 ore bodies and assumed that they would be similar to those encountered in the No. 8 Mine. We considered the following alternatives:

(a) Selective mining and conventional level transportation

(b) Relatively large and low-cost mining with ore passes and centralized underground crushing, using a Koepe hoist.

In spite of our poor experience with ore passes at Britannia in the past few years we chose alternative (b) rather than take a chance that the grade or ore would not be as high as earlier drilling indicated and that we would require low-cost mining.

Stoping methods as now planned will in most cases be modified long-blasthole vertical rings developed by foot and hangingwall fringe sub-levels with a modified sub-level caving for the narrower ore bodies. Each stope will be custom designed and our ramp system being driven 125 - 150 feet in the footwall of the ore is designed to allow for maximum flexibility. Sub-levels for stope preparation and haulage can be established at any elevation for any mining method that might be chosen. Rubber-tired, diesel-powered Load-Haul-Dump equipment and jumbos are planned for stope preparation. L.H.D. equipment will be used for production, mucking from draw points and tramming to ore passes.

Anticipated future exploration will be from the No. 10 shaft, both to the west toward and beyond the Daisy mineralization exposed on the surface and probably back to the east to explore the downward possibilities of the No. 8 ore body, or in the hangingwall of the No. 8 ore body.

SHAFT SPECIFICATIONS, KOEPE HOIST, SALA SKIPS, 42 x 48 PIONEER CRUSHER

KOEPE HOIST
- 2200 feet per minute rope speed,
- 140 cu. ft., 7-ton capacity skips.
- Automatic hoisting, no hoistman (service hoistman can operate Koepe hoist manually by swivelling around in his chair to Koepe hoist controls).
- Service hoist - one of our present double-drum hoists, single cage and counterbalance.

RAMP
20% incline
width - 9 - 12 ft.
height- 9 ft.
Haulageways: 9 - 12 ft. wide, 9 ft. high.

EIMCO 912 and SCOOPTRAM L.H.D.
Capacity: 2 yards
Width: 5 feet
Height: 4 ft. 6 ins.
Length: approximately 21 feet.

JUMBO disel-powered, rubber-tired, - manufacturer not yet chosen.

SHAFT SINKING:
- Slashing to pilot raise
- Pilot raise being driven by Alimak raise climber.

ROCKBOLTS: 5/8 x 8 ft. on 4 ft. x 4 ft. pattern.

SCREEN 4" x 4" 4(?) gauge, 5' x 8' pieces.

SPECIFICATIONS, continued

SHOTCRETE Meynadier (Swiss), quite similar to the Italian Aliva.

- minus 5/8" aggregate
- 6 bags to yard mix (up to 10,000 pounds concrete)
- several kinds of accelerators used successfully. sugar sprinkled on shaft muck pile to keep rebound from setting.
- capacity 21 yards per shift (minimum 3" to 5" thick)
- 1 yard per foot of shaft.

We have experienced considerable overbreak in a great part of the shaft, however, with the bolts, screen and the shotcreting, the shaft has settled down and shows no weight or pressure on the timber whatsoever. Shotcrete cracks along screen edges, otherwise looks good.

BEARERS: 12 inch eye beams, just below each station.

It has been a long, hard pull and if it had not been for income from logging, gravel, cement-copper as well as tailings and pyrite, we probably could not have weathered the storm. We have been producing the past couple of years copper ore containing 1% and less of copper. And this is high-cost mining.

In closing I would like to acknowledge the cooperation received from many sources, particularly Bill Peck and his staff, whose understanding and cooperation have been a big help. I would also like to mention the cooperation of The Honourable Mr. Ray Williston, Minister of Lands, Forests and Water Resources, and last but not least my good friend, Charlie Mitchell, whose good advice and sympathy have been invaluable.

B.B. Greenlee
Manager
ANACONDA BRITANNIA MINES LTD.

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