Britannia

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BRITANNIA GEOLOGICAL RESEARCH LABORATORY

HISTORY

1963 Jay Hodgson visited mine. Emphasis in geology was placed on examination of structural parameters as a guide to ore control. The model of ore formation was hydrothermal veins emplaced in a deformed rock along structurally favorable zones.

1964 structural studies continued, stratigraphic and petrographic studies were made in selected areas, metamorphism and metasomatism, vein types and metal zoning patterns were studied

1965 surface mapping in the Mill and Winston areas, lab constructed and equipped (cost about $110,000) technicians hired: Jim Vinnell, Fred Falk, John Greenlee

1966 silica healed breccia in No. 8 mine, chemical studies of metasomatism around the Bluff ore body, continued stratigraphic studies looking for marker units, recognition of pyroclastic origin of dacitic tuffs, recognition of Britannia anticline from Burton's surface mapping.

1967 Chris Burton transferred to mine staff, John Payne hired 040 mineralogy studied from drill hole data, heavy metals in pyrite studied, idea of copper zones-mineral traces intersections giving ore bodies, surface mapping on 1"=200' and 1"=1000' by Terry McCullough, Hodgson and Payne.

1968 study of metamorphism and metasomatism in 040 zone dacite study , electron probe work on chlorite, muscovite, epidote, sulfide solution experiments as a model for ore solutions, surface: Furry Creek 1"=400' (McCullough, Ralph Gonzalez), study of outside projects by Hodgson and Payne (Ultramafic rocks)

1969 Hodgson left, summary report of research activities till then, Vinnell transferred to Exploration, Peter Yee hired

1970 Dave Jennings hired, Burton left (summary report), Greenlee left detailed structural studies underground 4950,5250,2200, surface mapping 1"=200' (Jane Basin), 1"=400'(Furry Creek), regional. computer study (Abacus) on 5700 level chemical data.

1971 Jennings left, mapping on surface 1"=400' (West end - Bryan Lynas), problems with X-ray method, lab terminated as such, technicians laid off, Payne transferred to mine staff; visit by Proffett and Gemutz, change of mining method to drifting on ore, recognition of major offset on late E-W faults led to new concept of ore formation as volcanogenic and related to the upper contacts of dacitic tuff units.

1972 surface mapping (West end) completed, numerous old workings and drill logs remapped.

1973 summary report on Britannia (Payne, Jim Bratt, Bart Stone)

SUMMARY OF GEOLOGICAL REPORTS

BRITANNIA GEOLOGICAL RESEARCH LAB

(1963 - 1972)

Oct. 1963

The original studies were focussed on the structural environment, mainly because of the model at the time of hydrothermally introduced sulfides into a deformed host, with the ore control being "favorable structural zones". The problem was to understand the structure in order to determine what were the favorable structural zones.

From early studies Hodgson outlined the following foliations: 1)bedding, 2) a main deformational foliation (schistosity), and 3) a late strain slip cleavage.

A main lineation was mapped; it is steeply plunging roughly parallel to the ore shoots, and is defined by mineral and fragment elongation in the main schistosity.

Some of the variability in schistosity intensity could be correlated with rock type.

Dacite hoods, previously considered a probable structural trap for ore solutions, may not be but may be post-ore.

Jan. 1964 (Mesoscopic Analysis)

More detailed structural studies gave the following nomenclature to foliations, folds, lineations:

Foliations: S - beds, color banding in flows, tuffs

S_I - main schistosity, affects all Britannia mine rocks except late dikes (lamprophyre, andesite, dacite)

S_{II}- strain slip cleavage: includes all foliations cutting S_I

S_{III}- fracture cleavage, generally gently dipping, producing crumbly rocks

S_{IV} - microfaults, irregular cracks, veins: variable orientation, but generally coaxial to L_1.

Folds: F - folds in S for which S_I is not axial planar (pre S_I)

F_1 - folds in S with S_I axial planar

F_2 - microfolds in S_I with S_{II} axial planar

Lineations: L - intersection of S and S_I, defined by color banding on S_I and is parallel to F_1 axes.

L_1 - steeply plunging mineral lineation in S_I, commonly subparallel to the trace of S_{IV}.

L_2 - steeply plunging fragment elongation in S_I, subparallel to L_1, or making an angle of up to 30° to L_1.

L_{2a}- wavy texture on S_1 parallel to long axis of quartz boudins.

Macroscopic Analysis:

The purpose of mesoscopic analysis is to aid in study of macroscopic features, and to determine the distribution of mesoscopic features on a macroscopic (mine-wide) scale.

Macroscopic structures are:

1) Two major folds whose axes plunge steeply west parallel to the plunge of the ore bodies. One fold defines a broad monoclinal warp in rock unit contacts.

2) Based on lineation measurements, F_2 tend not to have a single preferred orentation

3) S_I and L_1 are statistically homogeneous on the scale of the mine, but minor variations may be important regarding ore controls.

4) Post S_I faults are coaxial about L_1 in West Victoria, movement on them might produce the steep plunge of some ore bodies.

Suggestions for mapping

1) Structural measurements taken as part of routine mapping. Start by not mapping every fabric element, but only those which are reasonably established as being significant in the mine as a whole. In detailed studies of more complex areas, all structural elements can be mapped.

2) Structural data to be plotted on special maps.

3) Keep an open mind regarding structural control: don't get preconceived idea on a particular type of structural control which might blind you to other possible important features which might control ore.

July 1964

Petrology

Extrusive rocks: mainly andesite, flow breccias contain one main type of fragment; feldspar phenocrysts commonly singular; amygdules common, and commonly are zoned; they contain qz, ct, ep, chl, with minor feld, ser, and py; groundmass is typically microlitic; alteration and deformation range from weak to strong.

Pyroclastic rocks: andesitic and dacitic (includes green mottled schists) grade texturally to flow breccias in one direction and sedimentary rocks in another; contain a wide variety of size, shape, composition, and texture of fragments; generally well foliated.

Argillites and other sedimentary rocks: very fine dense sericitic groundmass, grading with increasing grain size and chlorite content to fine andesitic tuff; commonly well foliated; S (color banding) is transposed towards S_I with increasing degree of development of S_I, and is best recognized in F_1 hinges.

Intrusive rocks:

Dacite dikes: feldspar phenocrysts commonly clustered in a fine to medium quartz-feldspar groundmass; some types have quartz phenocrysts which show primary resorption texture; some have primary breccia textures; all are metamorphosed to lower greenschist assemblage of qz-ab-Kfeld-chl-ser-ep-leucoxene; weakly deformed by S_I because of original competency (most dacites are post-S_I - 1972)

Lamprophyre dikes consist of unaltered zoned plagioclase and brown hornblende in a fine unaltered matrix (post S_I, post metamorphism)

Anhydritic schists: abundant deformed anhydrite and undeformed veins of anhydrite; suggestion that at least some anhydrite is pre-S_I (all anhydrite is pre-S_I, but some remobilized post-S_I - 1972)

Siliceous rocks: produced by silica metasomatism pre-S_I

No. 8 breccia: irregular fragments of andesitic tuff or flow set in a fine grained "cherty" groundmass; possible origin by base leaching along metasomatic fronts related to an intersecting fracture system, leaving a residuum of quartz and sericite.

Metamorphism:

Tendency towards lower greenschist facies grade of regional metamorphism. S_I and L_1 defined by pods, lenses, and streaks of chlorite and sericite formed during metamorphism. Many veinlets may be products of metamorphic segregation. Variation in foliation intensity depends on degree of formation of sericite and chlorite during metamorphism. In many rocks two preferred orientations of sheet silicates exist, and they may be contemporaneous in development. Epidote alteration spots are developed in many weakly deformed andesitic rocks.

Metasomatism:

Mechanism is base leaching with Ca and Fe replaced by K and H; Al is generally stable but is leached in areas of strong silicification. Quartz veins may be formed in part by segregation of quartz from host rocks under the influence of leaching solutions with high CO_2 and/or SO_3 contents. Pyrite veins with chloritic halos may also have a segregational origin. Most veins are undeformed (most are deformed - 1972). Quartz and chlorite are developed in pressure shadows on pyrite cubes.

Sept. 1964

Stratigraphy (Bluff and No. 8 Mines)

Five units were separated : 1) Jane slate, 2) Bluff tuff, 3) No. 8 sediments (green cherty sediments and dacite "flow"), 4) No. 8 coarse tuff (similar to Bluff tuff, but separated from it by No. 8 sediments), and 5) andesite. An antiform is defined by the distribution of the No. 8 sediments. A description of stratigraphic relations among the units is given: generally an antiform is apparent, but details of relations within the core units are complex.

July 1965

Stratigraphy and Structure

1) The Britannia roof pendant is isoclinally folded on axial planes parallel to S_I, folds plunge gently west.

2) The Britannia shear zone is a distinct geologic entity defined on the basis of development of S_I.

3) Rocks in the shear zone are generally lithologically distinct from those outside the shear zone.

4) Shear zone boundaries coincide generally with distinct lithologic changes.

5) Vertical sections show the shear zone shaped as an inverted funnel. The line of intersection of the flaring bottom and the narrow top plunges about 50°W. Ore bodies are in the top part of the flaring section.

6) Drag folds in the footwall appear to control several ore bodies, and rocks in the folds contain abundant anhydrite.

Detailed Study of No. 5 Ore Body (CCJBurton)

1) Ore host is fault bounded block of coarse dacitic tuff, deformed and strongly silicified.

2) The footwall fault was active over a long geological period and controlled the localization of silicification and ore. (fault post-ore 1972)

3) East-west shearing offset the primary footwall fault and produced a wide zone of intensely deformed rock (part of broad fault zone - 1972).

4) Flatter south and west dipping faults are common, some are healed by quartz.

5) North-south faults post-date the main ore stage.

6) West plunging drag folds occur, their relation to ore are obscure.

7) Sulfides are most abundant along the "damming structure" and adjacent to the bounding faults. The intensity of mineralization is related to the degree of brecciation and silicification.

8) The habit of the sulfides is related to the degree of silicification: massive irregular mineralization is typical of pervasive silicification, while massive sulfide veins occur in areas of moderate to weak silicification (the description suggests a similar distribution of sulfides as in the No. 10 mine - 1972).

Sept. 1965

Surface:

Mapping in two areas: 1) Mill Area above the 4100 portal, and 2)Winston on the hanging wall of the Bluff and Fairview ore bodies. Interesting results are 1) some coarse tuff appears to grade into acid flow rocks (similar to relations above Jane ore body - 1972),

2) mineralization occurs in sediments and tuffs and especially on their contact with dacitic flow(?) rock (cf. No. 10 mine - 1972)

3) mineralization is disseminated and small veins of py, cp, and sl.

Nov. 1965

Surface:

Winston area: S generally parallel to S_1, generally rock contacts are parallel to S_1 except for intrusive andesite. (Note $S_1 = S_I$).

Petrology (Winston area)

Andesite: phenocrysts of plagioclase and clinopyroxene in a matrix of fine laths of plagioclase, clinopyroxene, and fine alteration products of glass. Elongated chlorite blebs probably are amygdules. Metamorphism produced S_1 and alteration of the andesite. Weak alteration includes cracking of plagioclase phenocrysts, alteration of pyroxene to fine fibrous amphibole and then to chlorite. Stronger alteration produces the assemblage chl-ep-ab-carbonate.

Coarse tuff (Jewett, 5b - 1972): fragments of andesite, rhyo-dacite with globular structures (pumaceous or devitrification spherules) and perlitic cracks, and dacite; plagioclase crystals common, some argillite fragments; matrix of very fine grained qz-plag-chl-ser with scattered epidote spots.

Fine grained sediments and tuffs:

Dacite dikes: similar to "mine dikes" (? - 1972)

X-Ray studies show variation in Na/K of sericite based on variable reflections off (002). Chlorite shows variation in even/odd basal reflection intensities showing a higher Fe content in argillite and fine tuffs than in andesite and dacite. Albite contains very little K in solid solution. Many photographs of textures were taken.

Jan. 1966

A study of chlorite around the Bluff ore body gave no good correlation of Fe/Mg of chlorite relative to distance from the ore body.

A study of stratigraphy was begun in detail to attempt to define marker units which would aid in structural interpretation.

A detailed study was begun on silica-healed breccia in the No. 8 mine.

Silica Healed Breccia

Angular fragments of andesitic sediments in a dense white cherty matrix. Sediments in part show gently dipping S, in part are transposed parallel to S_1. Silica healing is vein-like layers parallel to S_1 and concentrated in zones of strong S_1. In places silica healing bulges out and cuts S_1 and S. The matrix is very fine grained qz with lesser ser, chl, leucoxene; sericite and chlorite are aligned parallel to S_1. Chlorite in the matrix of the breccia is light green and has a lower Fe/Mg ratio than darker green chlorite in the andesitic sediments. Al/Si ratios of each are similar. Tiny quartz veins and patches of anhedral quartz with minor pyrite cut the silica healing, and may represent recrystallized breccia matrix. Quartz-pyrite veins which cut silica healing contain strained quartz grains with unstrained fine mosaic quartz along the edges of some grains. In the tuffs some plagioclase crystals are replaced by mosaic quartz.

The suggested geological history would have formation of S_1, then formation of silica healing and quartz-pyrite veins, then late deformation producing recrystallization of silica healing and strain in quartz of veins.

March 1966

2700 Level Chemistry Study

A study was begun on the 2700 level in and around the Bluff ore body to test for possible chemical halos around that ore body, especially in the Bluff coarse tuff. Results showed a halo of high Si, qz, and S and low K and Ti up to 300 ft from the ore body. A similar pattern for Si and S occurs in Bluff coarse tuff just above the No. 8 ore body (but here K is also high). Differences in composition between rocks are much greater than differences within rock units, thus one needs to know the original rock type to know whether or not an analysis is anomalous. Chemical analysis may aid in rock nomenclature for stratigraphy.

April 1966

Stratigraphy

Several stratigraphic units were recognized on the basis of chemical composition, and these help to outline the overall stratigraphy.

1) Unit B - formerly called dacite flow-indurated sediments, is called a sediment (dacite flow - 1972). It is rich in SiO_2, contains 5 to 20% plagioclase phenocrysts, is mottled and locally layered from alternation of quartz-rich and mica-rich domains.

2) Shale ? : contains three facies, normal, pyritic, and anhydritic; occurs on footwall of No. 8 and Bluff ore and at the west end of both.

3) Crystal tuff: host of No. 8 ore body and silica healed breccia.

Numerous difficulties arise in attempts to correlate units over much distance. (partly because of late major faulting at that time not recognized - 1972) volc strat local not extensive.

June 1966

Recognition that the rocks called green mottled schist were pyroclastic in origin, and had been extremely metasomatized in places to give the quartz-sericite-chlorite assemblage.

Factors indicating a pyroclastic origin are

1) lack of sorting of fragments
2) locally preserved vitrophyric groundmass texture
3) primary stretching of vitric fragments
4) moulding of vitric fragments on lithic fragments and crystals
5) perlitic cracks in groundmass

Coarse tuff units included Bluff, No.8 and No. 10 coarse tuffs as well as the hangingwall and footwall porphyritic units (Jewett - 1972)

Green fragments are mainly sericite with minor chlorite and quartz, and have hour-glass shapes with frayed ends; they commonly are moulded around lithic fragments and crystals. Siliceous fragments are dusty aggregates of quartz, locally porphyritic with feldspar commonly pseudomorphed by a mosaic of quartz. They probably originally were a glassy vent filling which was broked during explosive ejection of the source magma for the pyroclastic rocks.

Unit B is reinterpreted as a welded, recrystallized volcanic pyroclastic rock or flow. It contains alternating siliceous and mica rich domains with gradational boundaries, and contains scattered fragments similar to those in the coarse tuff units. Perlitic cracks occur locally. G'w?

Andesitic coarse pyroclastic rocks contain mainly chloritic fragments with small amounts of anhydrite, calcite, and pyrite; and lithic fragments which are commonly microlitic andesite

July 1966

Surface: Mapping in Jane Basin (1"=200') by CCJBurton was begun.

Chemistry: The 040 coarse tuff (No. 10) shows a high Si, low K around the 040 ore zone.

Petrology: Detailed study of GMS (green mottled schist), GFBx(green fragment breccia) and Unit B. Many photos.

anticline on basis of stratigraphy.

Sept 1966

On surface, recognition of Jewett-like rocks on the hanging wall and footwall, and general similarities between hangingwall and footwall sequences suggests a fold closure at the west end of Jane Basin.Except for some structural complexities, the Jewett formation can be traced around the nose of such a fold, since then described as the Britannia anticline.

Jan. 1967

040 Detailed Mineralogy from Drill Holes

Three stages of mineralization were described

1) main stage quartz(strained) veins with py-cp-chl and minor ct, sl,gal,po, ep, and Kfeld. (correspond to main ore period - 1972)

2) late stage quartz (unstrained) veins with mica, carbonate, and various sulfides (correspond to late NE quartz veins - 1972)

3) late bleached zones in which chlorite is altered to a fine mixture of kaolinite, siderite, ankerite, calcite, and po is altered to py and sid. (These zones correspond to late NE carbonate faults - 1972)

Surface: presence of anticlinal fold confirmed with the mineralization mainly restricted to the core zone. In the west end of 4100 and on surface a large scale zoning of iron sulfide, with py rougly coincident with rocks with strong S_1, and po outside the strongly deformed zone. These zones cut across stratigraphic units and dacite dikes (? - 1972). Biotitic alteration in the far west end of 4100 level is caused by contact metamorphism about the Squamish pluton just to the north.

Chemistry: A high Si, S, low K zone was outlined on the 3500 and 5700 levels; some of the high values are not centered around known ore bodies, thus giving possible exploration targets. The anomalous zones are generally subplanar parallel to S_1. A preliminary study on trace metal contents of pyrite showed Cu to be higher both in pyrite and in rock near ore, but no other patterns were seen. Elements examined were Cu, Zn, Pb, Ag, and Ni.

April 1967

Mineralogy and Chemistry of 040 Zone

Hydrothermal mica and chlorite occur in quartz veins and on their borders and in pressure shadows of disseminated coarse pyrite. They are distinguished from corresponding metamorphic minerals by higher d_{002} of mica and higher Fe/Mg of chlorite in the hydrothermal occurrences. K feldspar is common in ore veins as a discontinuous selvage on vein walls with epidote. Inclusions in pyrite are common; they are sulfides and silicates similar to those in the surrounding rock and suggest equilibrium crystallization. Chalcopyrite is anisotropic and twinned, probably the products of deformational recrystallization. The type of metasomatic processes which occur (silicification, sulfidization, and formation of anhydrite) could explain much or all of the chemical variability in the rocks.

A model of ore forming solutions would be as follows:

In low grade zones, base-base and base-H^+ reactions with Al relatively inert. In high grade zones, solution of all primary metals and the gain of quartz is the primary metasomatic process.

Anomalous trace metal (Cu,Pb,Zn,Ag,Ni) zones envelop the No. 10 ore body and the root of the No. 8 ore body on the 5700 level. Such zones when found away from ore bodies would be considered exploration targets.

The Cu-Zn distributions were studied in the No. 8B ore zone using sections spaced on 50 foot centers. Results show higher grades towards the top of the ore body, with zones high in Zn cross cutting zones high in Cu.

Problems in interpretation of chemical analysis occur because of the large number of factors controlling the distribution of elements. Thus only obvious differences can be considered when looking for ore controls and exploration tools.

A study of details of mineralogy of ore was started in the 040 ore zone in holes 1-57-60 and 1-57-61. The significance of the results may not be well appreciated because of the small volume of rock available.

July 1967

Structural Control

The No. 10-No. 8-Bluff copper zone was defined by the linear trend of these ore bodies on plan, bearing 079°. Mineral traces defined by the direction of elongation of ore zones and mineralized tails of ore bodies strikes 098°, roughly parallel to S_1. It is postulated that ore bodies occur at the intersection of these features, and that projection of these features might lead to exploration targets in this and other zones. This relationship is purely empirical, but at the time gave as good a direction to exploration as any other tool.

No. 8 Ore Body 52-040 region

Two types of silica healed breccia were mapped, one with a rock flour matrix (A) in part with a pyritic matrix (A1) and the other with an igneous matrix (B). Quartz-pyrite segregations occur in the matrix and may be gradational recrystallization products of the finer grained matrix.

Veins include 1) pyrite (partly pre-brecciation), 2) small qz-cp-py, and 3) large cp-py-sl-(minor qz). All breccias and veins are deformed; veins at a high angle to S_1 appear more strongly deformed than those more parallel to S_1. Pyrite veins in andesite have bleached halos high in K and Si and low in Fe, Ca, and S, suggesting possible leaching of pyrite in rock to form vein.

Surface: mapping on the scale of 1" = 1000' showed:

1) gently dipping rocks north of the shear zone and steeply dipping rocks to the south define a large monoclinal structure; the Britannia shear zone occurs at the juncture of the two limbs. All rocks south of the juncture are more or less schistose.

2) Granodiorite on the north limb intrudes the sequence and is undeformed. Granodiorite and quartz diorite on the south contact of the volcanic sequence is strongly deformed along the contact.

3) Most dacite is extrusive or sub-volcanic intrusive of the same age as the volcanic sequence. Late dikes cut the sequence in the mine area parallel to S_1.

4) Volcanic and sedimentary rocks are intimately intermixed, and large scale correlations were mostly unsuccessful because of the absence of reliable marker units.

5) The north limb of the fold is weakly metamorphosed to zeolite facies (?), while the south limb is strongly recrystallized in the lower greenschist facies.

Dec. 1967 - Feb. 1968

040 Zone

The 040 zone consists of two main ore lenses (called 5700 and 5200) and several smaller low grade lenses. These were faulted by E-W faults parallel to S_1 with a left lateral displacement of less than 200 feet. Vertical displacement is less than 50 feet with the north side displaced downwards. Dacite dikes were intruded into the fault zones during a period of dilatentcy. Some dikes are continuous, others are markedly discontinuous; dikes do not extend above the 5000 level. Post-dacite dikes are vuggy quartz-carbonate with minor sulfides and/or chlorite. (The 5200 lens may be a down-faulted block of the 5700 lens, displaced along a rather nebulous fault zone - 1972 (RASutherland).) Or 5200 lens is a northwest faulted block off the east end of the 5700 lens, displaced up to the west at about 45° for about 250 ft. (Stone, 1973

Dacites:

A study was begun in the 2700 level tunnel to attempt to distinguish subunits in rocks which had been grouped as dacite. This project was extended to cover much of the mine area on the basis of samples collected in previous studies. Several types of dacite were distinguished on the basis of texture and cross cutting relations (in thin section), but the distinction in the field was more difficult. (Later work has shown that only detailed field mapping of different units plus some follow up lab work will provide a good classification and distribution of different dacite units. - 1972). The types of dacite outlined in this study include 1) mottled dacite porphyry, gradational into porphyritic coarse dacitic tuff (Jewett), 2) fine dacitic tuff, possibly gradational into coarse dacitic tuff (Bluff), 3) mine dacite dikes, 4) quartz-plagioclase porphyry dikes and intrusions, 5) microlitic andesitic dacite, and 6) hornfelsic recrystallized dacite along the contact with younger plutonic rocks.

Mineralogy of 040 Ore Zone

Results of detailed point counting in several drill holes in the zone show: 1) po occurs only in the central part of the 5700 body

2) dark green chlorite is abundant in parts of the 5200 body, but is minor in the 5700 body.

3) the cp/py ratio is high in ore zones.

4) sl and gal are rare

5) po occurs mainly as irregular patches and as scattered veinlets (of exsolution origin) in cp. Po is commonly altered along its borders to marcasite-pyrite.

6) a silver mineral (argentite?) (native Ag ?) occurs in high-grade cp zones as rods in cp and as intimate intergrowths with chlorite

Deformation textures are common in the main stage veins; these are as follows:

1) py is fractured while other minerals are not, coarser grains are more strongly fractured than finer grains, and grains surrounded by chalcopyrite are more strongly fractured than those surrounded by quartz. Many

fractures in pyrite are subparallel throughout the area of a polished block. Fractures commonly are filled with cp, qz, and chl.

2) Quartz grains are strained and commonly have fine mosaics of unstrained quartz grains along their borders, suggesting recrystallization of strained quartz into unstrained quartz.

3) Some pyrite grains in chalcopyrite are rounded

4) some intergrowths of chalcopyrite and chlorite are aligned parallel to S_1.

5) po exsolution(?) veinlets in chalcopyrite are bent and folded.

6) the degree of deformation of surrounding rocks is similar to the degree of fracturing of pyrite

7) the shape of pyrite grains depends on the degree of deformation of the rock: more euhedral pyrite occurs in less deformed rocks.

Late veins consist of coarse grained, unstrained quartz and carbonate, with lesser chlorite and sulfides. They are commonly vuggy, and are most abundant in dacite and andesite dikes. Pyrite is unfractured and strongly embayed by sphalerite. Epidote and K feldspar are common in veins in andesite.

Metasomatism

Based on electron microprobe analysis of typical Britannia minerals, an hypothesis of metasomatism was developed to explain chemical variation in Britannia rocks. The model involves H^+- cation and cation-cation exchange reactions, with increases in Si, K, and H and decreases in Fe, Ca, and to a lesser extent Na. Progressive alteration of andesitic basalt gives the following sequence of mineral assemblages:

1) original rock - pyroxene, calcic plagioclase
2) weak alteration - chl-act-ep-Kfeld-qz-intermediate plag
3) strong alt'n - chl-musc-ab-qz
4) very strong alt'n - chl-musc-qz

Metamorphic chlorite and muscovite are similar in composition to those minerals in the greenschist facies rocks elsewhere in the world. Hydrothermal chlorite has a higher Fe/Mg ratio than metamorphic chlorite, but variation within samples is large. The distribution of Fe_{II} and Fe_{III} in chlorite and muscovite is strongly dependent on oxygen fugacity.

Experimental Sulfide Reactions:

The approach taken was to work with complex systems attempting to simulate actual conditions rather than treating ideal simple systems and trying to combine them theoretically to predict actual results in nature. Results showed 1) cp and sl about equally soluble at 400-500°C.

2) cp shows incongruent solubility in presence of Zn with Fe entering solution leaving a Cu rich residual (bn)

3) some oxidation occurs in the above reaction, presumably by H diffusion thru the tube walls.

4)orders of stability in solution are Fe>Zn>Cu and Pb > Zn.

5) in 4N KCl sol'n with musc and Kfeld, orders of stability in solution are Zn> Cu and Zn>Fe(?).

August 1969

Hodgson Summary Report

Hodgson emphasized that the major ore control at Britannia is structure. In more detail, factors he considered important are:

1) En echelon patterns of ore bodies related to a series of mineral traces controlled by a deep seated system of regularly spaced fundamental structures which were part of a large scale strain system which was active over a long period of time.

2) The structural uniqueness of ore body sites existed long before and long after ore formation. Thus all ages of structures can be used to explore for new ore zones.

3) Total mineralization patterns including quartz, pyrite, and anhydrite are important because all appear to be spatially related at least in a broad sense to ore bodies.

4) Trace element analysis or exploration core might show weak mineral zones which when followed along strike might give ore bodies.

The summary report contains compilations of much data on the main mine levels, including structural, mineralization, and stratigraphic data.

Dec. 1969

Upper Furry Creek

Geological mapping showed that the units in the mine area extended to the east along most of the upper part of Furry Creek, although thick overburden in the valley bottom prevented mapping there. Geophysical surveys showed two anomalies trending roughly parallel to the valley, one through the Fairwest workings and the other to the north through Cyrtina Creek. Further detailed geophysical work and diamond drilling were recommended on this exploration target.

Chemical Analysis

A continuing program of analysis of diamond drill core on the 4100, 4950, and 5700 levels of the No. 10 mine is being carried out using X-Ray and AA methods. Results have shown that rock types can be distinguished on chemical compositions, despite subsequent alteration, and has shown varying degrees and types of alteration. Further work is contemplated.

March 1970

Structure

Detailed studies by Jennings (and Payne) on 4950 and 5250 levels between the No.8 and No.10 mines have produced the following nomenclature:

Planar elements: S - bedding
S_1- early major schistosity, folds S
S_2- later weaker schistosity, folds S_1

Linear elements: L - intersection of S and S_1 (parallel to F_1 axes)

L_1- streaky mineral lineation in S_1; intersection of S_1 and S_2; transport direction as inferred from parallelism to principal elongation direction of deformed lithic fragments and subnormal attitude to boudin lines.

L_2- intersection of strain slip cleavage on S_1

Folds: F - as yet unrecognized, open concentric folds in S which predate development of S_1.

F_1 - folds in S produced by active transport of S by S_1, S_1 is axial planar, axes parallel L, plunge 0-25° E or W in No. 10 mine.

F_2 - folds in S_1 produced by active transport of S_1 by S_2, S_2 is axial planar, F_2 axes parallel L_1.

F_3 - imprecisely defined open late warps in S_1

Technicians: developed method for making of polished thin sections, wrote out procedures for such and for X-ray analysis, starting to develop method of X-ray analysis using fusion technique which should eliminate problems of high Si and Al for samples with abundant sheet silicates, and cut down problems of different matrices.

Apr. 1970

Underground: Mapping near (but not in) the main 040 ore bodies showed that metamorphism producing S_1 was earlier than formation of ore veins.

Regional: Mapping of the Gambier group along Hwy. 99 south of Britannia showed

1) broad open folds with no axial plane cleavage gently deform the rocks whose lithology is similar to that at Britannia.
2) a volcanic neck at Brunswick Point has abundant py and po related to it both in the volcanic rocks and in surrounding hornfelsic argillite. Large inclusions of quartz diorite to granodiorite occur in the volcanic neck and indicate that the Gambier group rocks were deposited on a plutonic basement.

Mapping west of Howe Sound shows the Britannia shear zone in the same structural position as to the east. The shear zone makes a sharp swing to the north and links up with a band of high grade gneisses and schists along the axis of the Tantalus range.

July 1970

Underground: Mapping on the 2200 level crosscut has shown a megascopic syncline in the footwall argillite north of the main Britannia anticline. This fold has not been recognized on surface.

September 1970

Surface: The Jane Basin area and Upper Furry Creek area have been mapped and a report is being prepared.

Oct. 1970

Burton's summary report

The report gives a good summary of the geology of most of the ore bodies at Britannia. Interesting points brought out by Burton are:

1) ore is mostly of replacement origin

2) primary structural controls dictate the location of feeder zones for quartz and sulfides: these may be large scale flexures in the shear zone, deep seated structures, buried plutons.

3) secondary controls are responsible for localizing sulfides in dilatent areas in the shear zone: these may be shear faults, brecciated zones, junctions of two shearing systems.

4) agrees with idea of Hodgson of structural uniqueness of ore body sites over a long period of time.

5) ore bodies are bounded by zones of strongly schistose rock which probably acted as an impermeable barrier to ore solutions.

6) andesitic rocks in the No. 10 mine are mainly intrusive; their contact with coarse tuff provided a favorable structural zone for formation of dilatent zones into which ore could migrate. (much of these andesitic rocks are now considered to be fine tuffs, the contact zone is an original stratigraphic zone at which ore was formed - 1972).

Feb. 1971

Chemical Study

A computer-based study of the 5700 level rocks was made by John Burns of Abacus. The study was to determine patterns in chemical components which might show halos about ore bodies. Because of the complexities of stratigraphy near the 040 ore body, results of the study were not too useful in this regard. However several factors were determined which account for almost all the variability in chemical composition of the rocks. Further work based on these factors might be useful to outline chemical halos.

Problems continue in attempts to adapt our X-Ray equipment to the new fusion method of analysis.

Summer 1971

The surface was mapped from Jane Basin west to Howe Sound on a reconnaissance basis, and two survey lines were put in to aid further mapping

Summer 1972, Winter 1971

Numerous old drill cores were relogged, and old workings remapped to outline major patterns of late faults and stratigraphy. Detailed mapping in the No. 10 mine by mine geologists showed that the ore was related to the upper contact of dacitic pyroclastic rocks and overlying fine andesitic tuffs. Late faults appear to have offset ore bodies, and different ore bodies may be fragments of original larger more continuous zones. Mapping of west end of the area completed.

Winter 1972

Final report made based on volcanogenic origin of sulfides

72-73 drilling Furry Creek

BRITANNIA PROJECTS

Project Identification	Title of Study	Undertaken by	Start of Project	Report Completed
AA	Dacite Chemistry	JGP		
AB	Chemistry of the 040	JGP		
AC	Sulphide Mineralogy of the 040	JGP		May 1968
AD	Sulphide Mineralogy of the Bluff	JGP		
AE	Metamorphism and Metasomatism	CJH		May 1968
AF	Electron Microprobe Analysis	CJH		May 1968
AG	Experimental Study of Sulphide Zoning	CJH		May 1968
AH	Trace Element Patterns Below 4100 on the West Victoria	DMcG		July 1968
AI	Victoria Surface Mapping	TMcC & RG		
AJ	Southern Furry Creek Pluton	SMcC		
AK	2700 Level Mapping	JP		
AL	4100 Trace and Major Element Study	RAS & JP	June 1969	
AM	4950 Trace and Major Element Study	RAC & JP	June 1969	
AN	5700 Trace and Major Element Study	DDM & JP	June 1969	
AO				
AP				
AQ				
AR				
AS				
AT				

29 July 1969
C.C.J. Burton