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GEOLOGY OF THE MAGGIE PROPERTY, INDIAN RIVER AREA, SOUTHWESTERN BRITISH COLUMBIA* (92G/11E)

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INTRODUCTION

The Indian River project is a continuation of mapping by the senior author on the Maggie property (formerly known as the Hopkins property) centred at approximately latitude 49°38′ north, longitude 123°02′ west (Figure 2-3-1) around the headwaters of the Indian and Stawamus rivers. Access from Squamish is by 10 kilometres of logging road that parallels the Stawamus River.

The property consists of 84 units in 11 claims, staked in 1976 by H. Hopkins after finding copper-lead-zinc mineralization (Clendenan and Pentland, 1979). Since 1977, work by International Maggie Mines Ltd. and Placer Development Limited (now Placer Dome Inc.) has included mapping, trenching, 78 drill holes totalling 8005 metres, and two short adits with drifts following mineralization (Drummond and Howard, 1985). A detailed history of the property is given in Reddy *et al.* (1987). Minnova Inc. has recently optioned the property and has completed grid mapping and geochemical studies concentrated on the Mar and War Eagle claims.

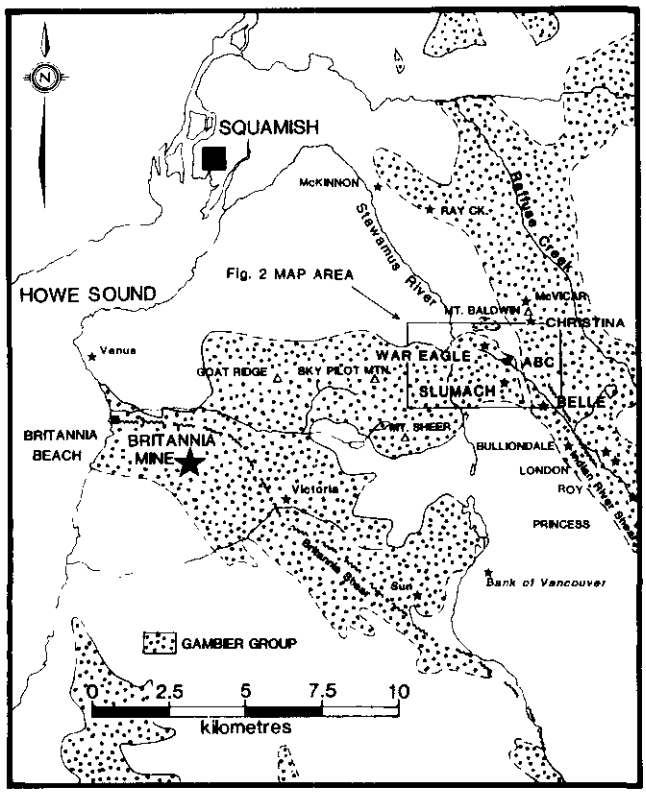

Figure 2-3-1. Location of the map area and mineral prospects in the Britannia–Indian River pendant, southwestern British Columbia.

The Maggie property is on the eastern edge of the Britannia–Indian River pendant that hosts the volcanogenic deposits of the abandoned Britannia camp and several prospects along the Indian River valley (Figure 2-3-1). This study is directed toward gaining an understanding of the relative structural and stratigraphic location of the Indian River prospects with respect to the Britannia orebodies.

The Slumach gold zone on the Mar claim of the Maggie property (south-central part of the map area, Figure 2-3-2) consists of two parallel quartz-chlorite veins carrying sulphides and anomalous gold and silver values. These veins cut an intensely hornfelsed zone characterized by pervasive biotitization, local silicification and development of chlorite and cordierite.

REGIONAL GEOLOGY

The Britannia–Indian River pendant is mainly a calc-alkaline, subaqueous volcanic and sedimentary sequence of felsic to intermediate pyroclastics, flows, cherts, argillites and greywackes. Schofield (1926) named the strata of Goat Ridge, adjacent and west of the project area, the Goat Mountain formation. He described it as a monoclinal succession dipping moderately to the southwest with the Britannia formation being stratigraphically higher. The Indian River area was described as Lower and Middle Goat Mountain formation by James (1929). He felt that the Britannia formation, host to the Britannia orebodies, was older than the Goat Mountain formation, and therefore had been thrust over it.

More recently the entire pendant has been classified as the Gambier Group of Late Jurassic to Early Cretaceous age (Armstrong, 1953). Correlations between Gambier Group and the Britannia and Goat Mountain formations suggest that the Lower Goat Mountain formation is equivalent to lower Gambier Group, and that the Britannia formation has not been thrust over the Goat Mountain formation (*compare*

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British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1987, Paper 1988-1.

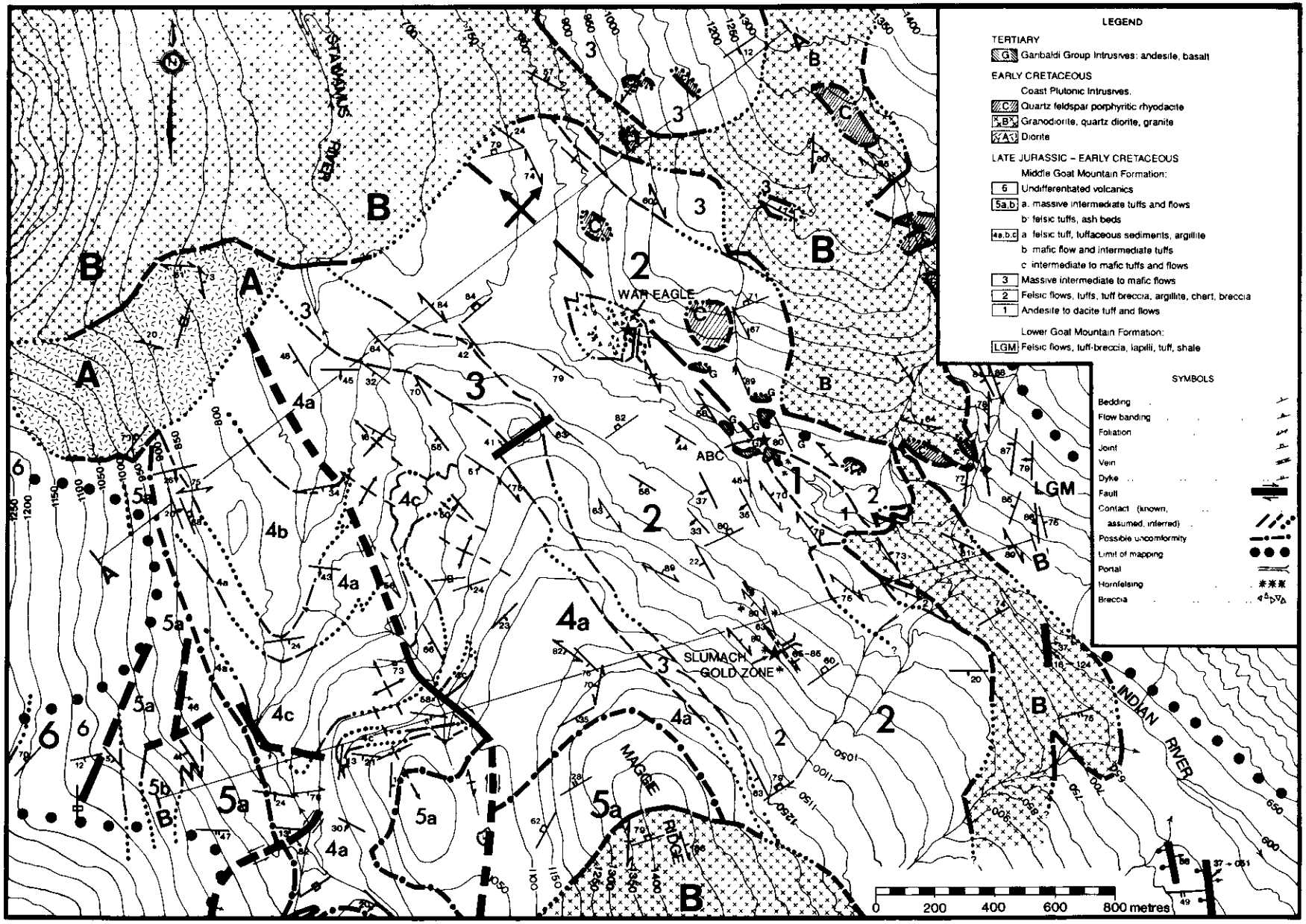

Figure 2-3-2. Geology map of the Maggie property at the headwaters of the Indian and Stawamus rivers, Britannia–Indian River pendant, southwestern British Columbia.

McColl, 1987). Therefore the project area is probably within the Lower and Middle Goat Mountain formation or lower Gambier Group.

Pelecypods (as yet of undetermined age) found in the northeast corner of the map area may help constrain the age of the Goat Mountain formation.

The Coast plutonic intrusives surround portions of the stratified rocks creating screens or pendants. These bodies are oriented northwesterly throughout the Coast Complex. Late Garibaldi Group basaltic dykes and sills intrude both the pendant and the plutonic rocks.

LOCAL GEOLOGY

James (1929) used the granodiorite apophysis that cuts across the Indian River valley to partition the Lower from the Middle Goat Mountain formation (Figure 2-3-2). Units on both sides of the intrusion are characterized by abundant felsic volcanics and appear similar. However, the structural orientations are different on opposite sides of the intrusion, and flows dominate over pyroclastic rocks to the east. Lower and Middle Goat Mountain formation, the surrounding Coast plutonic intrusives and dykes and sills of the Garibaldi Group are described in the following sections.

LOWER GOAT MOUNTAIN FORMATION

This north-striking succession of felsic flows, interbedded with shale, fragmental tuff-breccia and lapilli tuff, is at least 350 metres thick. Dips are steeply west and east, with tops to the west. The bottom of the formation is not exposed here and exposures continue to the southeastern part of the map area. The upper part of the formation is truncated by granodiorite.

MIDDLE GOAT MOUNTAIN FORMATION

Six major units form a continuous stratigraphic succession from the Indian River valley to the lower slopes of Sky Pilot Mountain. The section, at least 2.5 kilometres thick within the map area, continues to Goat Ridge to the west. It dips moderately south-southwest. The six units are described below, from oldest to youngest (Figures 2-3-2 and 2-3-3).

Lower intermediate tuffs and flows (Unit 1) comprise dark green, massive andesitic to dacitic tuffs with minor intermediate flows. This unit crops out in the bottom of the Indian River valley and has a minimum thickness of 25 metres. The tuffs vary from fine-grained ash and crystal tuffs to lapilli tuffs with a few large fragments up to 15 centimetres across. Flows are feldspar porphyritic and sometimes contain chloritic amygdules. The flows are also marked by ubiquitous development of chlorite and epidote; local hornfelsing by contact metamorphism destroys many textures and makes the upper contact of this unit indistinct.

Felsic tuffs, flows and sedimentary interbeds (Unit 2), lying conformably above Unit 1, consist of a 750-metre-thick felsic tuffaceous succession with numerous argillite and chert beds. (This unit includes packages II, III and IV of Reddy *et al.*, 1987). Numerous cycles of explosive volcanism are indicated by the repeated layers of coarse tuff-breccia with fragments up to tens of centimetres across. The middle of this unit is dominated by numerous shale and tuffaceous chert horizons. Individual beds are commonly 1 centimetre thick; massive cherty beds up to 2 metres thick occur locally. Bedding is well developed and faces upwards. The breccia at War Eagle adit (Figure 2-3-2) is at the stratigraphic top of the sediments and probably represents the start of a new eruptive cycle.

The hornfelsed upper part of Unit 2 hosts the Slumach gold zone. Lithologies that host the veins are probably felsic

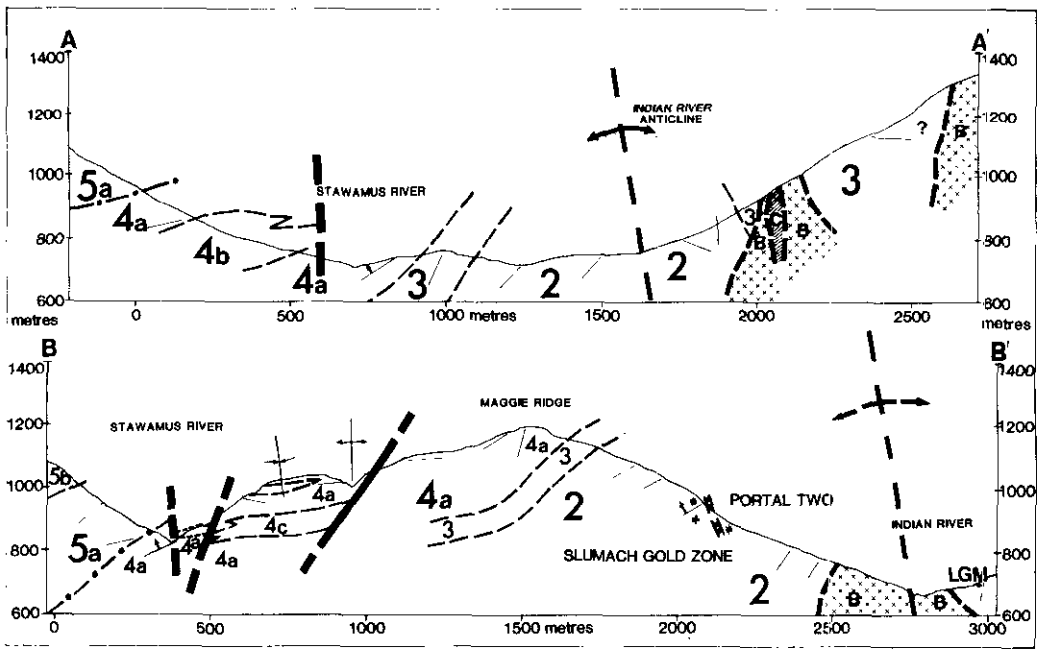

Figure 2-3-3. Cross sections A-A′ and B-B′ of the Maggie property. The section lines are shown in Figure 2-3-2.

lapilli tuffs, as suggested by rocks on strike with the hornfelsed mineralized zone. Near the upper contact, good shale marker beds show that Unit 2 is conformable with Unit 3.

Massive intermediate to mafic flows (Unit 3) form resistant bluffs at the north end and east side of Maggie Ridge. They are massive, dark green intermediate flows that total about 150 metres in thickness. Locally layers of epidotized fragments give an orientation suggesting flow parallel to bounding units. Whole rock analyses indicate intermediate to mafic compositions (C. Burge, personal communication, 1987).

Felsic tuffs, sediments and intermediate interbeds (Unit 4) conformably overlie the massive flows of Unit 3. Unit 4a consists of a thick felsic tuffaceous sediment series with several intermediate interbeds. The total thickness varies from 150 metres minimum at the top of Maggie Ridge to over 650 metres in the Stawamus River valley (Figure 2-3-2). The lithology consists generally of thin to massive beds of ash to lapilli tuff, and rarely tuff-breccia, interlayered with thin shale or greywacke beds. Beds always face up.

Units 4b and 4c are extensive intermediate to mafic volcanic units that interfinger with the felsic sediments of Unit 4a. Most of Unit 4b appears to be a thick hornblende and pyroxene porphyritic mafic flow with numerous epidote-rich layers. Unit 4c is poorly stratified in part, but resembles 4b in the more massive parts of the outcrop.

Massive intermediate volcanics (Unit 5) form a set of bluffs rimming the west side of the Stawamus River valley. It consists of intermediate tuffs and flows (5a) and interbedded felsic tuffs and fine ash beds (5b) that are characterized by accretionary lapilli. Several faults disrupt the outcrop patterns on the west side of the Stawamus River valley. The drastic thinning of Unit 4, and irregular contacts with Unit 5, possibly reflect a paleotopographic surface developed on Unit 4.

Upper felsic tuffs and overlying undifferentiated units (Unit 6) conformably overlie Unit 5. The unit was not mapped in detail, but a continuous bimodal succession of felsic and intermediate to mafic rocks continues off the map area (*see* Heah *et al.*, 1986).

COAST PLUTONIC INTRUSIVES

Three major types of intrusive bodies are found in the map area: a diorite pluton (Unit A), granitoid plutons (Unit B) and several small quartz feldspar porphyritic rhyodacite bodies (Unit C). Heah *et al.* (1986) used a two-point rubidium-strontium isochron to date the Squamish granodiorite pluton in the northwest corner of the map as Early Cretaceous (114 ± 40 Ma). Mid-Cretaceous metamorphism is associated with the emplacement of the Squamish granodiorite (Heah *et al.*, 1986; *see* "Metamorphism" below).

Diorite (Unit A) in the northwest corner of the map, has distinctively white-weathering coarse-grained feldspar phenocrysts (up to 60 per cent) in a strongly chloritized green groundmass (30 to 60 per cent). Magnetite and bright red hematite blebs (5 per cent) are interstitial to the coarse feldspars. Locally the diorite is strongly foliated and metamorphism up to the lower amphibolite facies is observed near the contact with the granodiorite.

Granodiorite (Unit B) often has faulted contacts where the Squamish pluton intrudes the earlier diorite and sediments. Composition varies from granite to diorite with granodiorite being most common. The pale grey, coarse-grained bodies are made up of quartz (35 per cent), plagioclase (45 per cent), potassic feldspar (10 per cent) and mafic minerals (10 per cent). On the east and west sides of the map, plutons are granodiorite to quartz diorite with biotite as the major mafic mineral. In the Indian River intrusion the lithology is granite with obvious potassic feldspars, quartz and biotite. On Maggie Ridge the mafic minerals are biotite and hornblende up to 25 per cent and this latter body has a chilled margin 75 metres wide along its northern contact. A myrmekitic texture of quartz and plagioclase is observed in thin sections from this chilled zone.

Quartz feldspar porphyritic rhyodacite (Unit C) intrusives are small massive dykes and bodies that intrude the sediments and plutons. They are found only on the eastern side of the Indian River valley and are sporadically distributed for several kilometres southeast of the map area. The intrusives are plagiophyric with crystals 5 millimetres long that average up to 10 per cent of the rock. Quartz eyes are usually 3 millimetres long and comprise 8 per cent of the rock.

Garibaldi Group intrusives (Unit G) intrude the stratified units and plutonic bodies throughout the map area. Light brown or dark green dykes (up to 3 metres in thickness) often exhibit columnar jointing. Phenocrysts are plagioclase and/or euhedral hornblende. Many dykes are vesicular and locally have calcite amygdules. Vesicles in a large basalt dyke in the east-central part of the map area contain chabazite in radiating groups of acicular rhombs up to 3 centimetres across. These intrusives are fresh-looking andesite and basalt dykes of probable Tertiary age.

STRUCTURE

The project area has three main structural elements: (1) east of the Indian River and the granodiorite apophysis; (2) between the Indian River and Stawamus River; and (3) along the Stawamus River.

East of the Indian River bedding, S_0, strikes north and dips steeply west or east (Figure 2-3-2). This series of felsic flows and interbedded sediments appears structurally different from felsic units to the west. Tops show the sequence faces consistently west and is therefore overturned.

Between the Indian River and Stawamus River beds generally strike northwest and dip moderately to the southwest. Excellent tops indicate that the sequence is upright. A major anticlinal structure, with its axial trace parallel to the Indian River, is indicated by predominantly northwest-striking, nearly vertical axial-planar cleavage, S_1 (Figures 2-3-2 and 2-3-3). The gradual change in attitude from moderately southwest-dipping beds near Portal Two, through shallow dips east of Portal Two, to vertical beds east of the War Eagle adit indicates that the asymmetrical antiform might be overturned to the northeast. A few minor fold axes indicate a shallow fold axis that plunges northwest, north of the Indian River–Stawamus River pass, and southeast to the south. James (1929) and Roddick (1965) recognized this antiform

and drilling results support their interpretation (Drummond and Howard, 1985).

East of Maggie Ridge, a second locally developed cleavage (S_2), strikes north and dips moderately to the west. S_2 is axial planar to minor folds with steep northwesterly plunging axes.

Along the Stawamus River beds strike easterly and dip moderately to the south. The change in bedding orientation and the rapid thinning of intermediate dome-like interbeds of Units 4b and 4c are possibly indicative of a low-angle unconformity with an irregular paleotopography between Units 4 and 5. Higher up, in the Sky Pilot bowl, thick-bedded sequences dip shallowly to the southwest (Heah *et al.*, 1986).

Poorly expressed broad, open anticline-syncline pairs are evident in changes of bedding attitude just east of the Stawamus River. The folds have a consistent moderate northwest plunge and steep southwest-dipping axial planes. The fold axis of one very open syncline appears to plunge gently southeast.

Numerous late north to northwest-striking faults are subparallel to the S_1 cleavage. Several northeast-striking faults were noted near Portal Two and parallel to creeks east of the Indian River.

METAMORPHISM

The entire pendant exhibits lower greenschist facies regional metamorphism that has little affect on the felsic units, but renders the units of intermediate composition massive and difficult to distinguish as tuffs or flows. A common alteration mineral assemblage includes chlorite-epidote-quartz-sericite ± zeolites. Potassium-argon dates obtained by McColl (1987) in the Britannia Ridge area were Late Cretaceous (90.5 ± 3.2 Ma and 81.4 ± 3 Ma). Lower amphibolite grade metamorphism within the diorite pluton (Unit A), peripheral to the Squamish granodiorite (Unit B), has been dated by potassium-argon as Late Cretaceous (101 ± 4 Ma and 95.1 ± 3.3 Ma) by Heah *et al.* (1986).

Contact metamorphic hornfels is widespread in mineralized areas peripheral to the plutons. Pervasive purplish brown secondary biotite development is often accompanied by silicification and chloritization. The hornfels is easily distinguished in hand specimen by pale brown, ovoid, 5 to 10-millimetre porphyroblasts (cordierite with quartz) within a dark brown biotitic groundmass.

MINERALIZATION

The Maggie property has five main mineralized zones that have been explored since the early 1900s. The five prospects are: (1) Belle, (2) ABC, (3) Christina, (4) War Eagle and (5) Slumach. Other properties along the Indian River valley include the Roy, London, Bulliondale and McVicar (Figures 2-3-1 and 2-3-2). These prospects are all on or close to the Indian River shear zone, a discontinuous zone of shearing that trends northwest along the Indian River valley.

Camsell (1917) and Brewer (1918) describe the Belle (Irish Molly or W.C., MINFILE 092G/NW-014) prospect just south of the southeast corner of the map on the Bob claim. Pyrite and chalcopyrite occur in a 3.1-metre-wide zone of "schistose gangue" trending northwest and dipping about 65 degrees to the southwest (Brewer, 1918). Mineralization is localized along the contacts of a granodiorite porphyry dyke and associated with biotitization and later silicification. Brewer (1918) sampled a 25-foot-wide (7.6-metre) zone that assayed trace gold, 68.6 grams per tonne silver and 5.3 per cent copper. Three other possibly related exposures upslope from this zone are probably along strike. A 31-metre adit was driven prior to 1917 to intersect the lower zone, but reportedly did not reach it.

The ABC prospect (MINFILE 092G/NW-028), described by Brewer in 1918, is located on the most northerly tributary of the Indian River, on the War Eagle claim. The workings probably lie within the area of disseminated pyrite, chalcopyrite and sphalerite mineralization (up to 4 per cent sulphides) associated with the intensely hornfelsed and silicified zone in the centre of the map area. Numerous faults and a pervasive S_1 cleavage were also noted in this area. An adit driven 9.1 metres into the banks of the creek has since caved (H. Hopkins, personal communication, 1986).

The Christina prospect (MINFILE 092G/NW-041) is a scattered series of outcrops of pyrite and sphalerite in sheared felsic volcanic rocks just covered by the legend of Figure 2-3-2 in the northeastern corner of the map area (Seraphim, 1977). This is probably a southern extension of widespread pyrite-chalcopyrite-sphalerite-galena mineralization exposed on the McVicar claims on Mount Baldwin.

Exploration on the War Eagle claim (MINFILE 092G/NW-042) has been concentrated around Portal One. The close proximity of a breccia and vent zone (Clendenan and Pentland, 1979) suggests a volcanogenic style of mineralization. An adit has been driven along quartz-sulphide "stringer" mineralization in a sheared zone (Archibald, 1981). The stringer sulphides are possibly remobilized from two flat-lying volcaniclastic horizons hosting subeconomic mineralization encountered at depth (Archibald, 1981). Although high-grade zones of anastomosing veins are reported locally underground, the sampling returned an average grade of 0.50 per cent copper, 0.35 per cent zinc and 0.20 per cent lead (Clendenan and Pentland, 1979). The portal is now buried, but examination of the dump material shows that the dominant sulphides are pyrite, chalcopyrite, sphalerite, pyrrhotite and minor galena, in a silicified, rebrecciated, intensely altered and biotitized gangue.

Work on the Slumach gold zone has been focused on two quartz veins near Portal Two on the Mar claim. The Main and East veins trend northwest and dip steeply northeast. They carry up to 15 per cent sulphides, primarily pyrite, sphalerite, chalcopyrite and traces of galena in a brecciated and silicified wallrock gangue. The sulphides appear to have been rebrecciated and cemented by quartz. Fragments of wallrock within the vein are totally biotitized or chloritized and have cockscomb quartz envelopes. Both veins consist of a higher grade (gold-silver) vein approximately 1 metre wide, with lower grade, altered hanging and footwalls (Drummond and Howard, 1985). The wallrocks are intensely hornfelsed tuffaceous sediments of Unit 2. Numerous late, dark green andesitic dykes cut the zone at varying angles.

The Main vein varies from 30 to 70 centimetres wide over its 70 metres known length and averages 65.5 grams per tonne gold over a 31-centimetre width (Drummond and How-

ard, 1985, based on nine channel samples from the Portal Two subdrift, the range is 19.7 to 109.4 grams per tonne). Free gold has been reported (H. Hopkins, personal communication, 1987; Blundell, 1984) and an association of gold within pyrite has been determined (Blundell, 1984). The East vein, 9 metres east of the Main vein, is at least 20 metres long and varies from 30 to 200 centimetres in width (Drummond and Howard, 1985).

A second zone of quartz with galena, sphalerite, pyrite and coarse euhedral barite lies above the Slumach zone, but its extent is not known.

CONCLUSIONS

The Maggie property in the Britannia–Indian River pendant is underlain by dominantly subaqueous, calcalkaline intermediate and felsic volcanic rocks with minor sediments that are probably part of the Late Jurassic or Early Cretaceous Lower and Middle Goat Mountain formation of the lower Gambier Group. Northwest-striking units in the Indian River area are folded into a broad northwesterly trending anticline. Westerly trending orientations in the Stawamus River valley suggest that an unconformity or structural break exists above or within a thick felsic tuffaceous unit (Unit 4). Late Cretaceous lower greenschist facies metamorphism is related to emplacement of Coast plutonic intrusives. Mineralization is associated with contact metamorphism in the Slumach gold zone, a quartz-chlorite vein with anomalous gold values. Other mineralization such as that on the War Eagle claim, represents a low-grade volcanogenic sulphide system with remobilized sulphides in higher grade "stringer" zones.

ACKNOWLEDGMENTS

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REFERENCES

Archibald, G.F. (1981): Summary Report on 1980-81 Diamond Drill Program, War Eagle Claim, Vancouver Mining Division, *Maggie Mines Limited*, Unpublished Report, 11 pages.

Armstrong, J.E. (1953): Preliminary Map, Vancouver North, British Columbia (Descriptive Notes), *Geological Survey of Canada*, Paper 53-28, 7 pages.

Blundell, R.G. (1984): Preliminary Test Data on Maggie Mines Ore, Kamloops Research and Assay Laboratory Ltd., *Maggie Mines Limited*, Unpublished Report, 11 pages.

Brewer, W.M. (1919): Indian River District, Western District (No. 6), *Minister of Mines, B.C.*, Annual Report, 1918, pages F275-F278.

Camsell, C. (1917): Indian River Copper Deposits, Vancouver Mining Division, *Geological Survey of Canada*, Summary Report 1917-B, pages 23B-25B.

Clendenan, A.D. and Pentland, W.S. (1979): Report on the 1978 Exploration Program on the Hopkins Property, Maggie Mines Limited, Squamish, British Columbia, *Placer Development Ltd.*, Unpublished Report, 22 pages.

Drummond, A.D. and Howard, D.A. (1985): Report on Exploration Potential Using a Massive Sulphide Volcanogenic Model (with Reference to the Slumach Gold Zone) at the Indian River Deposit, near Squamish, British Columbia, *International Maggie Mines Ltd.*, Unpublished Report, 45 pages.

Heah, T.S.T., Armstrong, R.L. and Woodsworth, G.J. (1986): The Gambier Group in the Sky Pilot Area, Southwestern Coast Mountains, British Columbia, *Geological Survey of Canada*, Paper 86-1B, pages 685-692.

James, H.T. (1929): Britannia Beach Map-area, British Columbia, *Geological Survey of Canada*, Memoir 128, 139 pages.

McColl, K.M. (1987): Geology of the Britannia Ridge, East Section, Southwest British Columbia, Unpublished M.Sc. Thesis, *The University of British Columbia*, 207 pages.

Reddy, D.G., Ross, J.V. and Godwin, C.I. (1987): Geology of the Hopkins Property, Indian River Area, Southwestern British Columbia, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 43-45.

Roddick, J.A. (1965): Vancouver North, Coquitlam and Pitt Lake Map-areas, British Columbia, *Geological Survey of Canada*, Memoir 335, 276 pages.

Schofield, S.J. (1926): The Britannia Mines, British Columbia, *Economic Geology*, Volume 21, pages 271-284.

Seraphim, R.H. (1977): Report on the Clarke Claim, Indian River, Vancouver Mining Division, *Maggie Mines Limited*, Prospectus of May 19, 1978, pages 34-43.