Prospective Areas for Intrusion-Related Gold-Quartz Veins in Southern British Columbia

By James M. Logan

INTRODUCTION

Cretaceous granitic rocks can be traced the length of the northern Cordillera and are known for their association with tungsten and tin mineralization. In Alaska and Yukon the mid-Cretaceous Tombstone Suite intrusions are also associated with base metal-poor, gold-bismuth mineralization, including the Fort Knox (127.5 x 10^6 g Au), Dublin Gulch (35.7 x 10^6 g Au) and Brewery Creek deposits (28.7 x 10^6 g Au) (Figure 1). Similar, smaller intrusion-related gold-quartz vein occurrences (*i.e.* Valparaiso and Cam-Gloria) are located in southern British Columbia associated with the mid-Cretaceous Bayonne Suite (Logan, 2000). In contrast with the metaluminous, subalkalic, reduced I-type Tombstone Suite, the Bayonne suite consists of mostly peraluminous, subalkalic hornblende-biotite granodiorite and highly fractionated 2-mica granites, aplites and pegmatites. These, like there northern counterparts, are emplaced into miogeoclinal rocks of ancestral North America and the Shuswap and Kootenay terrane pericratonic rocks.

The first year's field studies focused on two intrusion-hosted gold-quartz systems in southern BC, the Cam-Gloria and Valparaiso. The former is now known to be hosted in a Middle Jurassic intrusion located 7.5 km from (peripheral to) the causative Cretaceous intrusion/mineralizing system. This summer, fieldwork continued mapping and deposit studies in the southern Omineca belt and attempted to assess gold-bismuth±tungsten±copper systems hosted in mid to high-grade metamorphic rocks located peripheral or proximal to mid-Cretaceous intrusions. Fieldwork was carried out east of the Columbia River Fault in the Selkirk Mountains and north of Shuswap Lake between Baldy Batholith and the Monashee décollement. These two areas were selected for follow-up from a subset of prospective areas recognized as favorable to host intrusion-related gold-tungsten-bismuth veins by Lefebure *et al.* (1999).

In the Selkirk Mountains, Au-W quartz veins (Orphan Boy, Stanmack mineral occurrences) located on the southern flank of the northwest-trending Windy Range metamorphic culmination (Read and Brown, 1981) were visited and sampled. Tungsten-skarn, tin and molybdenum mineral occurrences in and around the Battle Range Batholith, were examined, in our ongoing effort to characterize and assess the intrusion-related gold potential of Cretaceous plutons. This multi-phase batholith, located southeast of Revelstoke, occurs at the centre of the arcuate magmatic belt of Cretaceous rocks. It links those bodies which intrude ancestral North American strata at the southeastern end (Bayonne, Mount Skelly Pluton) with

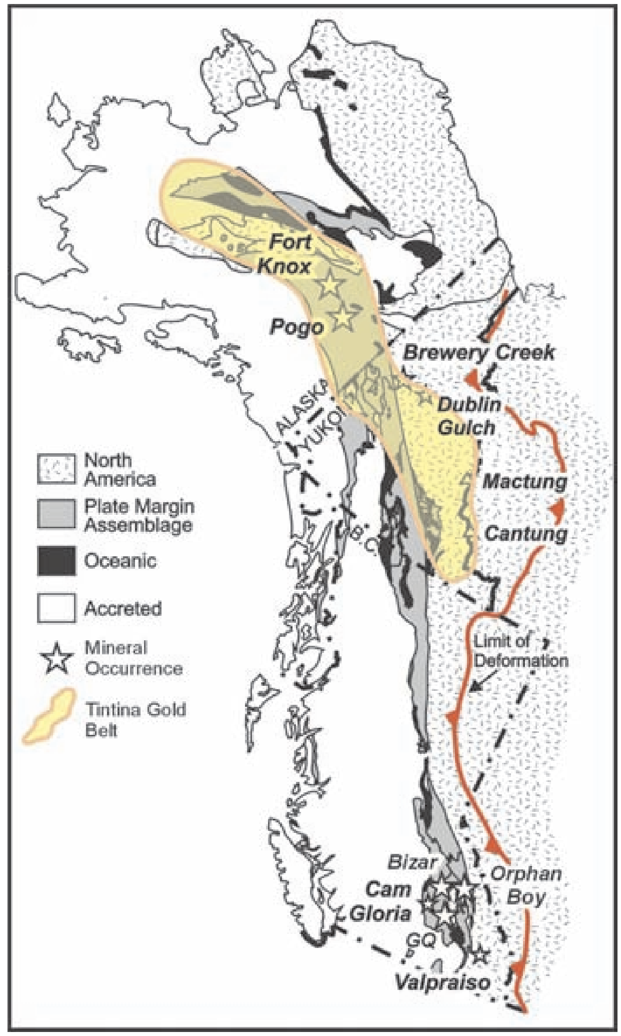

Figure 1. Tectonic assemblage map, after Wheeler and McFeely (1991) showing the distribution of North American, plate margin, oceanic and accreted rocks of the Canadian and Alaskan Cordillera, the location of the Tintina Gold belt and select gold occurrences.

those plutons intruding Kootenay terrane strata at the northwestern termination (Baldy/Shuswap area).

The Shuswap component comprised follow-up of anomalous samples from last years work in the Baldy Batholith area (Logan and Mann, 2000) and continues sampling and lithogeochemical characterization of plutonic rocks in the area east of Adams Lake. In addition, the high grade metamorphic "Pogo-like" setting of the Shuswap complex-hosted Bizar-Goldstrike and GQ mineral prospects (Cathro and Lefebure, 2000) were mapped and sampled.

INTRUSION-RELATED MODEL

The principal features of intrusion-related deposits are reviewed in recent publications, by McCoy *et al.* (1997), Poulsen *et al.* (1997) and Thompson *et al.* (1999). The major deposits in the Yukon and Alaska comprise diverse styles of gold mineralization that can be describe with respect to their spatial relationship to the causative intrusion (Figure 2):

- the intrusion-hosted low grade, large tonnage sheeted and stockwork low sulphide vein systems at Fort Knox (Bakke, 1995; Bakke *et al.*,1998), Dublin Gulch and Clear Creek,
- and the skarn, replacement and vein systems that occur in country rocks proximal, peripheral and distal - to the granitoid intrusions, such as on the Dublin Gulch property, at Brewery Creek and True North.

SELKIRK REGION

Battle Range Batholith

The Battle Range Batholith (BRB) is an elliptical, northwest-trending, mid- to Late Cretaceous post accretionary intrusive, and one of a group of intrusions

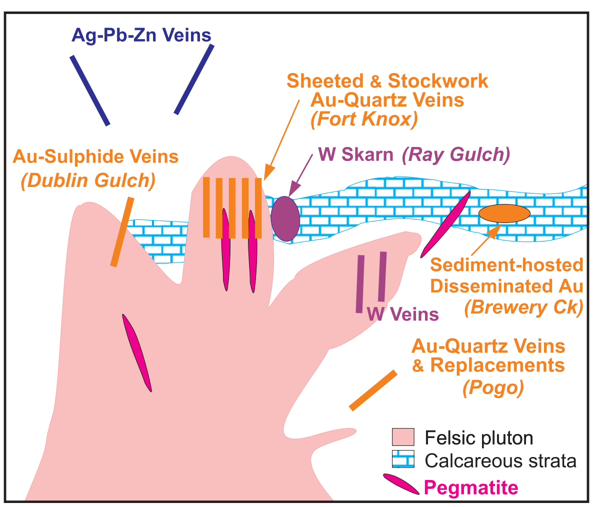

Figure 2. Schematic model of plutonic-related mineral deposits, showing different styles and zonation of intermediate to felsic "reduced"plutons intruded into a continental margin setting.

which comprise the Bayonne Granitic Suite. It extends from Duncan River west to the head of Albert Creek and covers an area of approximately 800 km^2 (Figure 3).

GEOLOGY

The BRB discordantly intrudes Late Proterozoic to Early Paleozoic metasedimentary and metavolcanic rocks of the Hamill to Lardeau Groups. Northwest-trending, southwest-verging regional fold and faults structures control the distribution of these units and characterize the southwestern Illecillewaet Synclinorium. Late northwest-trending subvertical crenulation cleavage is superposed on an early north-striking, compositional layering parallel schistosity. The early structures dip east, and plunge north. The southwest-verging deformation accompanied peak regional metamorphism which occurred at metamorphic conditions of 6-7 kbar in the Middle Jurassic (Colpron, 1996). Chlorite, biotite and garnet mineral zones of regional metamorphism are overprinted by chlorite, biotite, andalusite, sillimanite and sillimanite-orthoclase zones of contact metamorphism in the aureole around the Albert Stock and Battle Range Batholith (Sears, 1979). The contact metamorphic assemblage sillimanite-andalusite-staurolite-garnet-biotite-muscovite-quartz constrains the pressure between bathozone 2 and 3, approximately 3.5 kbar (Sears, 1979).

The batholith is a composite body consisting of three subalkalic, weakly peraluminous intrusive phases differentiated on mineralogy, texture, grain size and magnetic signature (Read and Wheeler, 1976). From oldest to youngest, these include a biotite-hornblende quartz monzonite (sodic andesine), a muscovite-biotite granodiorite (calcic oligoclase), and pyritiferous alaskite (Read and Wheeler, 1976). Hamill, Badshot and Lardeau Group metasedimentary strata comprise re-entrants in the north and south parts of the batholith. North of the northern re-entrant, the intrusion is comprised mostly of porphyritic biotite granite and equigranular biotite-muscovite granite. These phases are gradational from one to the other. The porphyritic variety is coarser grained and characterized by up to 2.5 cm phenocrysts of potassium feldspar. Dikes of pyritic aplite, muscovite pegmatite and sheeted quartz-sulphide veins are common features in the area north of Freeze Creek. Mean magnetic susceptibility measurements are low (0.34, n=10). The main body of the intrusion south of the metasedimentary screen comprises a potassium feldspar porphyritic biotite granite to granodiorite (Figure 4). Mean magnetic susceptibility measurements are also low (0.31, n=9). South of the headwaters of Houston Creek and encircled on its western end by metasedimentary rocks of the southern re-entrant is a biotite-hornblende granodiorite phase of the batholith (Figure 3). In contrast to the calcic oligoclase of the two-mica granite, this phase is characterized by sodic andesine (Read and Wheeler, 1976). As anticipated for the more mafic hornblende-bearing phase, the mean magnetic susceptibility measurements are higher (6.87, n=12).

Read and Wheeler (1976) recognized a third and youngest phase of the Batholith. It consists of a small (3 km^2) pyritiferous aplite centered on Pequod Glacier, approximately just east of the center of the Batholith (Figure 3). In addition, fine to medium-grained, quartz-feldspar-garnet aplite dikes, quartz veins and less commonly coarse-grained pegmatite dikes occur primarily near the margins of all the intrusive phases.

Recalculated K-Ar dates for two of three samples collected from Freeze Creek cirque (Figure 3), in the northern part of the Battle Range Batholith give uniform mid-Cretaceous cooling ages. The ages on a biotite-muscovite pair from a fine-grained monzogranite (GSC 62-21 and -20), yield 93.4 Ma and 94.2 Ma respectively and a biotite separate from coarse quartz monzonite with potassium feldspar megacrysts, yield an age of 96.5 Ma (Leech *et al.*, 1963). The third sample, a combined aplite and pegmatite vein which crosscuts the former two rock types gave an unexpected older age of 122.6 Ma (Leech *et al.*, 1963). Late Cretaceous to Paleocene mica cooling ages in the Clachnacudainn complex suggest a protracted thermal evolution at lower structural levels, and anatextic generation of leucogranite and pegmatite along its western margin (Colpron *et al.*, 1999).

Sampling in the Freeze Creek cirque area and south of Houston Creek has been completed for Ar-Ar and U-Pb, zircon dating to establish the crystallization ages of these separate phases of BRB.

MINERALIZATION

A number of magmatic-hydrothermal styles of mineralization occur associated with the Battle Range Batholith. These include those hosted within (molybdenum greisen veins, tin pegmatites and tungsten veins) and those located adjacent to the batholith in metasedimentary and metavolcanic rocks (Au quartz veins, W ± Mo skarns and polymetallic base metal ± Au veins). The only record of gold mineralization for the area is located 8 to 15 kilometres east of the eastern margin of the batholith. Past production of gold, with scheelite values is recorded from mainly silver-rich base metal workings at McMurdo Creek and the Ruth-Vermont deposit (Figure 3).

Mad

The Mad (82K-167) showing is a porphyry Mo occurrence located below Pequod Glacier in the headwaters of Butters Creek. Molybdenite occurs as disseminations

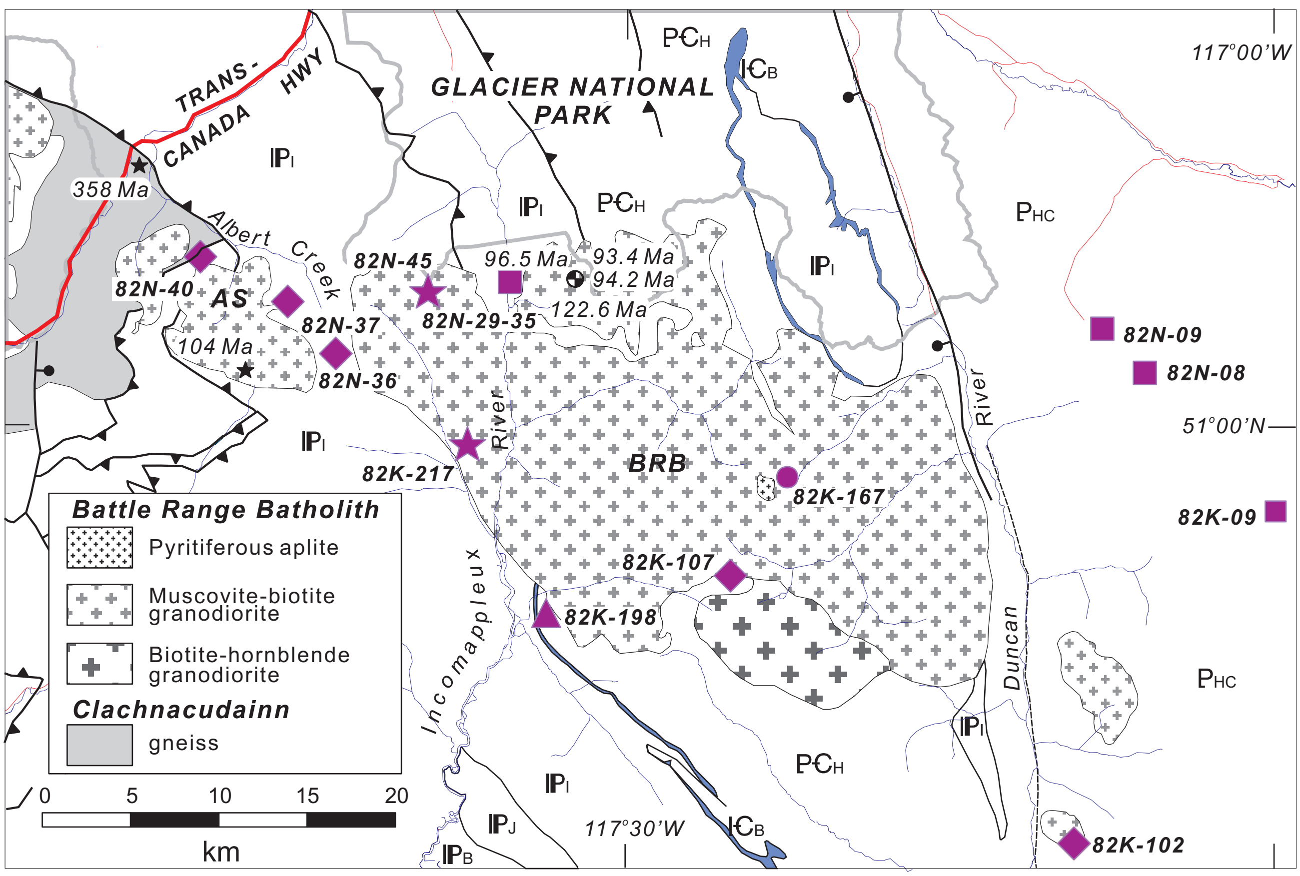

Figure 3. Regional Geology of Battle Range Batholith showing three magmatic phases; biotite hornblende granodiorite, muscovite-biotite granite and pyritiferous aplite phases, modified after Read and Wheeler (1976). In addition are location and ages of K-Ar analyses (Leech *et al.*, 1963), zircon dates for Albert stock (AS) (Crowley and Brown, 1994) and Clachnacudainn gneiss (Parrish, 1992). MINFILE occurrence symbols include tin (star), molybdenum (circle), tungsten-molybdenum (diamond) and lead-siver-zinc±gold veins (square).

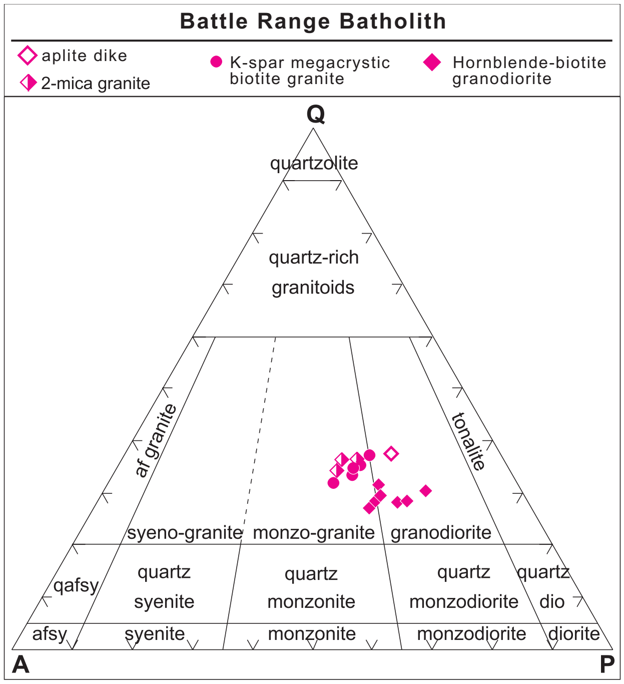

Figure 4. Modal quartz-alkali feldspar-plagioclase feldspar plot for Battle Range Batholith. Fields from LeMaitre (1989).

and quartz-sericite greisen veins within a pyritiferous alaskite porphyry stock which intrudes the coarse grained potassium feldspar megacrystic biotite granite of the main phase of the Battle Range Batholith.

Wrong Glacier

A series of narrow, en echelon, north-striking quartz-filled fractures and joint planes forms the Wrong Glacier occurrence. It is located 1.5 km southeast of Oasis Lake in biotite-hornblende granodiorite near the southern end of the batholith. The 1-3cm wide veinlets contain quartz, muscovite, pyrite and acicular tourmaline needles. The veins are enveloped by a bleached alteration zone comprised of sericite, pyrite and dolomite extending 1-5 cm into the potassium-feldspar megacrystic, granodiorite host. Grab samples from two sulphide and tourmaline bearing quartz veinlets returned below detection values for gold with slightly elevated tungsten values (Table 1).

McBean

North of Freeze Creek near the northern margin of the batholith, the biotite-muscovite granite is cut by pink weathering aplite dikes and numerous sheeted, sulphide-bearing quartz veins (Figure 3). The veins are commonly 6 to 10 cm wide and spaced 2 or 3 per metre. The predominant sulphide is pyrite. Alteration is restricted to narrow greisen-style envelopes of sericite and quartz (Photo 1). Two grab samples of the vein material returned below detection values for gold, although one (JLO31-271-2) contained anomalous values of bismuth and tungsten and elevated lead values (Table 1).

Ice, Ex90

The Ice (82N-36) and Ex90 (82N-37) occurrences are located at the head of Albert Creek. Mineralization was first discovered and assessed by the Union Carbide Exploration Company in 1971. The Ice claims (Westervelt, 1972) were staked to cover anomalous tungsten stream geochemical values located in the Albert Creek valley. Follow-up work located a stratabound horizon of disseminated scheelite mineralization and discordant tungsten-bearing quartz veins. In addition, a 10 to 15m wide, north-trending sulphidized-breccia zone was recognized. The north-trending zone of stratabound scheelite was defined by night lamping to be 425 m long and between 3-12 m in width (Westervelt, 1972). C. Graf (1986) spent a day prospecting and sampling the head of Albert Creek to evaluate the extent of the stratabound tungsten mineralization. Rock sampling (n=9) indicated ranges of WO3 values from .03% WO3 to 0.64% WO3 and anomalous values for fluorine, bismuth and copper (Graf, 1986).

The mineral occurrences occupy a narrow belt of Early Paleozoic Lardeau, Index Formation metasedimentary rocks (Sears, 1979) that separate the mid-Cretaceous Albert Stock in the west from the Battle

Photo 1. Sheeted sulphide-bearing quartz veins (10 cm wide) and greisen alteration in biotite-muscovite granite, south of Mount McBean.

TABLE 1
SELECTED GEOCHEMICAL ANALYSES, SELKIRK MOUNTAINS AREA, BATTLE RANGE BATHOLITH AND GROUNDHOG BASIN

Field Number	Au	Ag	As	Bi	Cu	Mo	Pb	Sb	W	Zn	DESCRIPTION
Battle Range-Wrong Glacier											
00JLO-30-270	-2	-5	<1	0.24	1	1.2	9	-0.1	74.3	26	Qtz-tourmaline veinlets
00MZA-30-165	-2	-5	1	0.09	8	1.2	14	0.5	28.1	24	Qtz-tourmaline veinlets
Battle Range-Ice, EX90											
00JLO-24-212	-2	-5	4	0.17	45	1.2	18.5	-0.1	1.7	72	grab hornfels metapelite, pyrrhotite
00JLO-24-215	-2	-5	1	0.2	25	0.6	15.5	0.3	0.6	82	grab pyrrhotitic hornfels quartzite
00JLO-24-220	-2	-5	<1	0.16	74	3.6	7.5	-0.1	2.3	132	grab calcsilicate, diss pyrrhotite
00JLO-24-220-2	-2	-5	1	0.15	137	7.8	24.5	-0.1	1.7	140	grab pyrrhotitic hornfels quartzite
00JLO-25-224	-2	-5	**46**	0.75	64	1	4	0.3	3.1	6	Sulphidized, silicified breccia, float
00JLO-25-225	-2	-5	**63**	1.8	56	1	6.5	0.2	5.9	6	Sulphidized, silicified breccia, grab
00JLO-25-226	17	-5	**208**	**45.5**	8	2.8	45.5	1.7	5.9	16	2 m chip pyrite+silica fault zone
00JLO-25-228	6	-5	<1	**26.6**	8	1	3	0.1	2	4	30 cm chip qtz vein, x-cutting
00JLO-25-231	-2	-5	<1	**32.1**	4	3.8	13	0.3	2.6	4	grab of 75 cm qtz vein, x-cutting
00JLO-25-232	-2	-5	<1	0.89	2	0.8	1	-0.1	2.3	2	grab of 3 qtz veins, x-cutting
00JLO-26-235	-2	-5	3	0.12	22	1.2	13	-0.1	61.6	8	aplite dike
00JLO-27-244	-2	-5	<1	**22.8**	4	1	2	0.2	**410**	<2	grab of qtz vein, x-cutting
00JLO-27-245	3	-5	7	**35.8**	15	5	2.5	-0.1	14.8	6	1.25 m chip qtz vein, x-cutting
00JLO-27-247	-2	-5	17	0.74	10	1.2	26	0.2	7.1	12	grab tourmaline-pegmatite
Battle Range-Escalade											
00JLO-28-253	-2	-5	7	6.91	114	**431**	12.5	0.2	**144**	246	pyrrhotite-Mo skarn
00JLO-28-253	-2	-5	14	7.67	98	**667**	15	0.4	**137.5**	254	pyrrhotite-Mo skarn
00JLO-28-254	-2	-5	2	0.34	104	33	19	2.2	4.5	278	grab hornfels metapelite, pyrrhotite
00JLO-29-261-2	-2	-5	6	0.1	21	1.6	20	0.2	2	16	aplite dike
00JLO-29-262	-2	-5	7	0.15	<1	1	4.5	-0.1	1.8	102	calcsilicate
Battle Range-McBean											
00JLO-31-271-2	-2	-5	2	**62.5**	65	7.8	111.5	0.1	**798**	98	pyritic sheeted qtz veins
00JLO-31-271-4	-2	-5	13	1.41	137	15.6	11.5	-0.1	26.9	52	pyritic sheeted qtz veins
Battle Range-McMurdo											
00JLO-32-285	**1250**	48	**955**	**30**	85	1	**>2.43%**	91.9	<10.0	524	grab 30 cm qtz-carbonate vein
00JLO-32-285-2	**835**	7	**3200**	3.93	74	1.8	3290	13	**802**	3900	grab 20 cm qtz vein, Sn//
00JLO-32-286	-2	-5	7	0.07	10	1.6	16	0.3	22.5	44	grab, 1.0 m qtz vein (axial planar)
00JLO-32-287	**5130**	-5	**3360**	0.26	3	1.6	10.5	-0.3	10.8	6	1 m chip qtz vein + pyritic Hw zone
00JLO-32-287-2	**32500**	-5	**1410**	3.72	3	4.4	9.5	-0.2	4.8	2	1 m chip qtz vein + pyritic Fw zone
00JLO-32-287-3	**16200**	-5	**>10000**	1.94	3	1.8	20.5	2.1	5.4	<2	grab, pyrite-rich Fw+Hw zones
Battle Range-Ruth/Vermont											
00JLO-33-288	**4060**	**381**	**>10000**	2	**4630**	<1.0	**19.40%**	**4160**	<10.0	5.49%	dump sample mineralized vein
00JLO-33-288-3	-2	7	**95**	0.18	19	1.8	2620	53.3	**1130**	472	50 cm chip,So // qtz vein
00JLO-33-288-4	**1800**	34	**>10000**	0.41	380	1.6	404	**308**	1.9	486	grab, 20 cm qtz vein (axial planar)
Groundhog basin-Ole Bull											
00JLO-20-183	-2	-5	9	0.39	3	0.6	8.5	-0.1	**209**	<2	30 cm chip qtz vein, NE-trending
00JLO-20-183-2	4	-5	4	0.11	5	0.6	5.5	-0.1	3.4	2	48 cm chip qtz vein, NE-trending
00JLO-20-184	**25**	-5	9	**4.17**	10	1	105.5	-0.1	5.4	6	1 m chip, qtz vein + pyritic phyllite
00JLO-22-195	8	-5	10	0.04	3	0.4	2.5	0.1	0.3	2	50 cm chip qtz vein, NE-trending
00JLO-22-195-2	**5950**	-5	12	0.05	96	0.6	5.5	0.2	0.7	2	grab, sulphide-rich vein material
Groundhog basin-Aurun											
00JLO-20-185	**38**	-5	12	**5.27**	3	0.6	390	-0.1	0.7	2	40 cm chip qtz vein, NE-trending
Groundhog basin-Lund											
00JLO-20-186	**85**	-5	6	0.52	15	0.6	70.5	0.9	0.7	30	25 cm grab, qtz+pyrrhotite zone
Groundhog basin-Orphan Boy											
00JLO-20-187	7	5	6	**11.4**	10	0.6	303	-0.1	0.9	2	60 cm chip qtz vein, NE-trending
Groundhog basin-regional											
00JLO-21-189	-2	-5	5	0.04	5	0.6	6	-0.1	0.3	22	qtz vein float
00JLO-21-191	-2	-5	21	0.37	34	1	19	-0.1	0.5	12	grab, 5 cm qtz vein, N-trending
00JLO-21-193	-2	-5	7	<0.01	3	0.6	1.5	-0.1	0.3	2	grab, 25-10 cm qtz vein, Sn //
00JLO-22-196	**85**	-5	11	0.1	7	0.6	9.5	-0.1	0.5	2	grab, pyrrhotite-rich qtz vein float
00JLO-22-197	14	-5	9	0.1	10	0.4	11	-0.1	0.3	40	grab 25cm qtz-CO_3 vein, NE-trending
00JLO-22-199	-2	-5	<1	0.06	1	0.6	4	-0.1	0.5	2	grab, 18 cm qtz vein, NW-trending
00JLO-22-200	-2	-5	6	0.76	25	1.2	6	0.2	0.4	4	grab, 20 cm qtz vein, Sn //
00JLO-22-201	2	-5	7	0.29	130	0.6	20.5	-0.1	0.8	54	grab, pyrrhotitic graphitic lmsn
00JLO-22-202	-2	-5	2	0.02	2	0.6	1	-0.1	0.2	<2	grab 35cm qtz vein, NE-trending
00JLO-22-203	-2	-5	18	0.03	6	0.6	2.5	-0.1	0.3	6	grab, 50cm qtz-CO_3 vein, S_{n+1} //

Au, As and Sb by INA; other elements by total digestion-ICP

Au in ppb, rest in ppm

Sample locations *see* Figures 3 and 6.

Range Batholith to the east (Figure 3). In this area, the Index Formation consists of a mixed and interbedded package of grey and dark green phyllite, micaceous quartzites and phyllitic grits. The strata trend-northerly, dip-easterly and are folded into southwesterly overturned folds that characterize the western flank of the Selkirk Fan. The contact metamorphic aureole from the two mid-Cretaceous magmatic bodies, overprints syntectonic, lower greenschist facies regional metamorphism. Semi-pelite and micaceous quartzite units are characterized by large andalusite porphyroblasts retrograded to muscovite, chlorite and quartz assemblages. A narrow, less than 1 km wide sillimanite zone, with sillimanite-biotite-muscovite-andalusite-garnet-quartz-plagioclase metamorphic mineral assemblage occurs adjacent to Albert Stock and western contact of the BRB.

Prospecting and sampling along the eastern contact zone of the Albert Stock, in the area of the Ex90 tungsten-molybdenum skarn, did not locate any anomalous precious or base metal mineralization. Four grab-samples (2-pyritic semipelite, 1-micaceous quartzite and 1-calcsilicate, Table 1) all returned low metal values.

Mapping and sampling on the east side of Albert Creek was directed to test the gold potential of known mineralization at the Ice prospect. Scheelite occupies north-trending fractures as coarse 1-1.5cm masses, and as fine disseminations with minor wolframite distributed through the quartzite host-rock. For the most part the fracture density in the quartzite averages 1 per 0.5 m. Orthogonal to the stratabound mineralization, are narrow, 30cm rarely up to 100 cm wide, east-trending quartz-pyrite-muscovite veins that contain disseminated scheelite. The east-trending (260-300°Azimuth) quartz veins contain an envelope of coarse intergrown muscovite and vuggy quartz, with a narrow, sericite alteration selvage that extends several centimeters into the country rock. Five samples of this type of quartz vein show consistently elevated Bi, and erratic but elevated Au and W values (Table 1). The north-trending, sulphidized-breccia zone can be traced for approximately 800m. It is a 10 to 15m wide steep west-dipping zone, comprised of separate metre-scale silicified and sulphidized breccia zones. Pyrite forms the matrix to breccia clasts, fine disseminations and coarse cubes in open-space fillings and variably replaces clasts. Pyrrhotite occupies tight, cross cutting fractures. The zone was sampled at three locations. Grab samples contain anomalous arsenic and elevated bismuth and gold values (Table 1).

Escalade

A small tungsten mineralized skarn zone, the Escalade occurrence (82K-107) is developed in a belt of interbedded limestone and rusty pelite which forms a reentrant of Lower Cambrian metasediments near the southern margin of the batholith. The area straddles the headwaters of Houston and Kellie creeks. Read and Wheeler (1976) show the re-entrant to be comprised of quartzite, phyllitic quartzite and black phyllite of the Marsh Adams Formation and limestone with green and grey calcareous phyllite of the Mohican Formation. Strata is folded into a northeast plunging antiformal syncline with younger thin layered Mohican Formation limestone and rusty phyllite occupying the core of the fold (Read and Wheeler, 1976). The Escalade showing includes a number of small tungsten and molybdenum mineralized, skarned-carbonate and rusty pelite developed adjacent to the northerly-trending contact of potassium feldspar megacrystic, biotite±hornblende granite of the BRB. Grab samples from the divide between Houston and Kellie creeks returned elevated molybdenum and tungsten and minor bismuth, but like other sulphidic-phyllite and calcsilicate samples from east of Stygian Lake, no gold values (Table 1).

McMurdo and Ruth Vermont

The Crown Point (MINFILE 82N-09) property is located at the head of McMurdo Creek, about 10 km northeast of the Battle Range Batholith and the Ruth Vermont (MINFILE 82K-09) about 17 km east of the batholith. Both are past producers. The Ruth-Vermont operated sporadically between 1892 and 1970. The majority of the production of 17,248 kg of Ag, 9.4 kg of Au, 23,137 kg of Cd, 55,693 kg of Cu, 3,253,956 kg of Pb and 5,947,422 kg of Zn occurred between 1970 and 1981. The Crown Point produced 8,211 g of Ag and 3,808 kg of Pb from 5 tonnes mined prior to 1930. Mineralization is chiefly silver-rich, Pb-Zn vein and replacement deposits hosted in Late Proterozoic Horsethief Creek Group phyllite, argillaceous limestone, quartzite, grit and pebble conglomerate. The units are folded into regional northwest-trending, westerly-verging folds with mineralized veins occupying oblique, transverse and bedding parallel fracture sets related to fold geometries. The quartz-carbonate veins consist of pyrite, galena, sphalerite, arsenopyrite and silver-rich copper-antimony sulphosalts. Gold is generally associated with arsenopyrite and pyrite and scheelite occurs in late stage quartz veins. Where the density of veins crosscutting limestone beds is high, silicification and fine-grained sulphide replacement has taken place.

Several narrow, less than one metre wide axial planer auriferous quartz veins comprise the “Gold showing” at the Crown Point past producer. The veins are north to northwest-striking and dip steeply northeast. They cut micaceous quartzites and quartz grits in the hinge-zone of a NW-trending anticline. The veins are mainly quartz and carbonate, locally vuggy with euhedral quartz crystals and contain pyrite, minor galena, sphalerite and trace chalcopyrite. Three samples (JLO32-287, -2, -3) across a 2 metre wide quartz vein from this area returned anomalous Au and As (Table 1). The 20 to 25 cm wide hangingwall and footwall zones to the vein contain approximately 30 % coarsely crystalline cubic pyrite. A number of other 20 to 30 cm wide bedding parallel and orthogonal quartz-carbonate veins occur in the immediate area. These contain minor pyrite, galena and sphalerite and anomalous Au, As and locally tungsten values (Table 1).

GOLD POTENTIAL OF BATTLE RANGE BATHOLITH

Field studies of the Battle Range Batholith confirmed the presence of several styles of mineralization commonly found associated with mid-Cretaceous intrusion-related gold mineralization in Alaska and the Yukon. Unfortunately, the limited number of samples didn't turn up any new gold mineralization and there are no RGS data to show the prospective nature of the region for gold. The results of these studies suggest the northwestern end of the batholith was emplaced at about 10 km depth in the upper crust. This is deeper than most of the Yukon and Alaska intrusion-related deposits. The Au-As-Sb association with PB-Zn-Ag veins at the Crown Point and Ruth Vermont has some analogies with distal intrusion-related deposits in Alaska (Dolphin?, True North).

Groundhog Basin

The Orphan Boy (82M-167) and Stanmack (82M-80) showings standout as potential intrusion-related gold systems in the Lefebure *et al.* (1999) province-wide evaluation of MINFILE occurrences. The showings are drained by creeks with placer gold production and the auriferous quartz veins contain low (1-2%) total sulphide content, consisting of pyrite, pyrrhotite, tungsten, minor galena and chalcopyrite. The showings occupy the Groundhog basin, which lies in the Goldstream River area, east of the Columbia River and approximately 90 km north of Revelstoke (Figure 5).

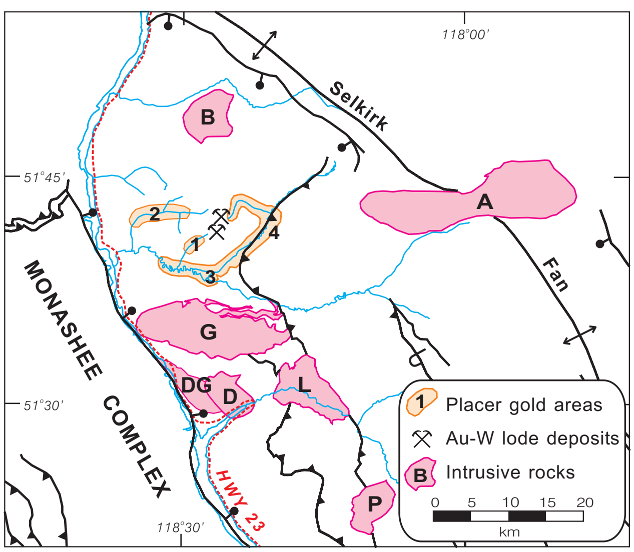

Figure 5. Location of the Orphan Boy and Stanmack Au-quartz vein occurrences on the western flank of the Selkirk fan structure, within the Columbia River Fault hangingwall rocks of the Selkirk allochthon. Shows placer gold creeks; McCulloch (1), Old Camp (2), Goldstream (3) and French (4) and the distribution of granitic rocks; Early Mississippian Downie gneiss (DG), Middle Jurassic Pass Creek (P) and Adamant (A), Late Jurassic Bigmouth (B), mid-Cretaceous Goldstream (G) and Long Creek (L) and Late Cretaceous Downie (D).

HISTORY

Placer gold was first discovered on Goldstream, French and McCulloch creeks as early as 1865. Although large amounts of gold are know to have been recovered from them during those early years, there is no record of production until 1886. In 1906, H. Carmichael, the Provincial Assayer, referred to some $3,000,000 of gold taken during the 1865-6 season, this included a $375 nugget from French Creek. The total recorded production of 6240 ounces or 194,064 grams (Holland, 1980) was derived primarily from French Creek (86.6%). Lode gold was discovered in the late 1890's in the Groundhog Basin and by 1896 development was underway on the Ole Bull and Orphan Boy claims (Gunning, 1929; Wheeler, 1965).

The majority of the exploration work to date has concentrated on the Crown Grants that contain the known quartz vein structures. A number of exploration programs consisting of reconnaissance geological mapping, soil, silt and rock sampling and geophysical surveys were completed in the early 1980's (Chapman *et al.*, 1982; Schindler, 1984). More recently two programs of diamond drilling were completed to test the known showings (Figure 6). The 1995 program tested the Orphan Boy and Ole Bull zones with 1347m of diamond drilling in 12 holes (Cooke, 1996). The following year (1996), the Orphan Boy, Aurun, Lund, Ole Bull and James zones were tested with 929 m of drilling in seventeen holes (Henneberry, 1997). Vein intersections from both programs returned spotty gold values and inconclusive results.

GEOLOGY

The Northern Selkirk Mountains comprises polydeformed Late Proterozoic to early Paleozoic metasediments and metavolcanic rocks of the Selkirk allochthon. These rocks accumulated along the western margin of ancestral North America and were deformed, metamorphosed and later displaced eastward during the Late Jurassic to Eocene (Brown *et al.*, 1986). In this area the Selkirk allochthon is intruded by two main suites of granitic rocks (Figure 5); the Middle Jurassic (ca. 180-165 Ma) Nelson Suite of granodiorite and quartz monzonite (*i.e.* Adamant and Pass Creek plutons) and the mid-Cretaceous (ca. 110-90 Ma) Bayonne Suite of quartz monzonite, diorite and two-mica granite (*i.e.* Goldstream and Long Creek). In addition, a less voluminous Late Cretaceous (ca. 70 Ma) suite of leucogranites, and an Early Mississippian (ca. 360 Ma) suite of orthogneiss have been recognized in the Clachnacudainn complex (Parrish, 1992) and the Downie Creek area (Logan and Friedman, 1997). The late Jurassic to Early Cretaceous zircon (149±11 Ma), and titanite (141±7 Ma) ages for the Bigmouth pluton (Marchildon *et al.*, 1998) are not common in southeastern British Columbia.

The strata north of the Goldstream River in the Groundhog basin is correlated with the Index Formation of the Lardeau Group (Logan and Colpron, 1995). It consists of a lower carbonaceous and calcareous dark

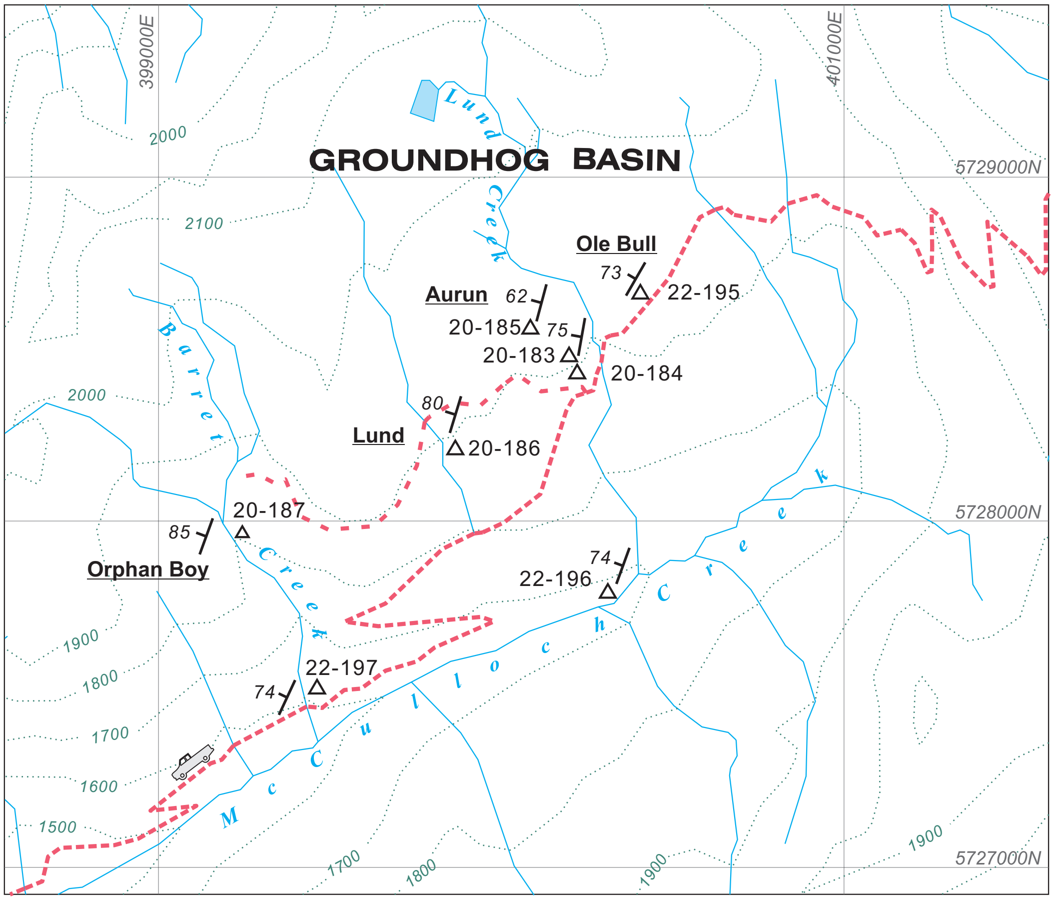

Figure 6. Location and vein orientation of auriferous quartz lode zones comprising Orphan Boy and Stanmack MINFILE showings in the Groundhog Basin. Sample locations correspond with Table 1. Small scale placer gold extraction is ongoing in McCulloch Creek.

phyllite and schist, a middle green member of chlorite schist, greenstone and phyllite and an upper member of micaceous quartzite and coarse quartz grits.

The Groundhog basin occupies the western flank of the Selkirk fan structure, an area dominated by southwest-verging folds and thrust faults (Wheeler, 1963,1965; Brown *et al.*, 1978; Price, 1986). Two generations of structures are recognized throughout the Goldstream area (Hoy, 1979; Logan and Colpron, 1995; Colpron *et al.*, 1995). The earlier generation of structures corresponds to northwest-trending, southwest-verging folds and thrust faults that define the map pattern. Regional relationships indicate a Middle Jurassic age for this generation of structures (Parrish and Wheeler, 1983; Brown *et al.*, 1992). The southwest-trending structures are deformed by younger, easterly-trending, gently plunging folds. These structures predate the emplacement of the mid-Cretaceous intrusive suite. North-trending fractures, normal faults and open warps are the youngest structures and are interpreted to be associated with Eocene crustal extension along the Columbia River fault.

Rocks of the Groundhog basin area contain mineral assemblages characteristic of greenschist facies metamorphism. This low-grade zone is bound to the south by contact metamorphic assemblages related to the Goldstream, Long Creek and Downie intrusive bodies. Assemblages of biotite-garnet±andalusite define this metamorphic culmination. Northeast of the Groundhog basin is a segment of the northwest-trending Windy Range metamorphic culmination. It extends for over 90 km between Mica Dam and Rogers Pass (Wheeler, 1965; Greenwood *et al.*, 1991; Read *et al.*, 1991). Regionally, the Windy Range culmination grades from biotite zone in the southwest, to sillimanite - potassium feldspar in the core of the culmination (Leatherbarrow, 1981). To the northeast, metamorphic grade decreases to kyanite-staurolite zone along the southwest flank of the Rocky Mountain Trench. These amphibolite facies rocks and migmatites follow the axis of the west-northwest-trending Selkirk fan, approximately 25 kilometres to the north (Figure 5).

The Groundhog basin rocks contain carbonate, chlorite, quartz, plagioclase assemblages characteristic of the chlorite zone of greenschist facies metamorphism and chlorite grade mineral assemblages define the dominant foliation. The west-northwest trend of the isograds is discordant with the more northerly trend of the regional structures north of the Goldstream River (Logan and Colpron, 1995). Porphyroblast growth in the Windy Range culmination appears to post-date the development of the dominant regional fabric. Synkinematic biotite-grade assemblages are present in the northern part of the basin and have been interpreted as contemporaneous with emplacement of the late Jurassic to Early Cretaceous Bigmouth granodiorite (Marchildon *et al.*, 1998).

GOLD-QUARTZ VEINS

Three separate quartz veining events are recognized for the area: a syn-metamorphic, likely Mid-Jurassic; a pre-mid-Cretaceous; and a young, gold- tungsten-mineralizing episode of either Late Cretaceous or Tertiary age. The first two events are widespread in the area while the latter is restricted to northeast-trending structures in the Groundhog Basin (Figure 7).

Synmetamorphic quartz veins parallel, and are folded by, the dominant foliation. The veins are bull quartz, grey to vitreous and rarely contain minor coarse cubic pyrite. Recrystallization during metamorphism exsolved the fluid inclusions to grain boundaries, and changed the milky white to grey coloured vein-quartz to a vitreous blue-grey colour (Figure 7a). East-trending, massive, white quartz and locally rusty-weathering quartz-iron carbonate veins (up to 0.5 m wide) parallel the attitude of late crenulation cleavage (Figure 7c). A third stage of auriferous ± galena and scheelite quartz veining corresponds with a period of northwest-southeast extension. These quartz and quartz-carbonate veins crosscut the early structures and are restricted to parallel northeast-trending structures (Figure 7b & d). The vein structures occur in parallel sets. At the Lund Creek showing three quartz veins are known and further north in area of the Orphan Boy Shaft, 5 parallel vein structures are contained within a 70 m wide zone. Weak alteration extends from 1 to 5 centimeters beyond the veins and includes, sulphidized, carbonatized and sericitized wallrock envelopes.

Analytical results for these various types of quartz veins from the Groundhog basin and surrounding areas are tabulated in Table 1. Gold, lead, tungsten and minor bismuth enrichment is present in quartz veins. A weak association of gold, lead and bismuth is apparent for samples of the Ole Bull-shaft, Lund, Aurun and Orphan Boy showings (Figure 6), but not from the two veins sampled north of the Ole Bull shaft (00JLO-22-195, 195-2). Mineralization consists of pyrite and lesser pyrrhotite, with minor galena and scheelite. In thin-section the east-trending veins exhibit substantial grain size reduction, variably strained quartz, and sericite filled fractures. The younger, northeast-trending auriferous veins consist of larger, weakly strained, interlocking quartz grains cut by narrow fractures filled with cubic pyrite, euhedral quartz and zoned dolomite crystals. A single grain of native gold associated with pyrite was recognized in one polished thin-section sample (JLO-22-195-2). Extending from the vein wall into the host rock is a zone of sericite alteration, which bleaches and overprints the chlorite-bearing greenschist-grade, micaceous quartzite and carbonaceous schists. Later-stage fracture-controlled carbonate (dolomite?) alteration is most prevalent in hanging-and footwall to the vein contacts. Southeast and structurally below the Groundhog veins in the French Creek area, another northeast-trending vein (JLO-22-202) is characterized by large strained quartz grains with numerous euhedral tourmaline crystals, no opaque minerals and low geochemical analyses (Table 1). An east-trending quartz-carbonate vein from this same general location (Figure 7c) also returned low geochemical analyses.

PROSPECTIVE AREAS - GROUNDHOG BASIN

There is a strong structural and paragenetic control to the different types of quartz veins in the Groundhog basin. The auriferous veins are restricted to northeast-striking, steep-dipping structures, commonly as sets of parallel veins ranging from 20 to 100 cm in width. These gold veins are not classical orogenic-gold deposits, generally associated in space and time with collisional tectonic regimes. Orogenic-gold deposits are characterised by their association with regional high-angle faults, vertical continuity, extensively developed wallrock alteration, and hydrothermal fluids sourced from metamorphic devolatillization at depth. The Groundhog basin veins post-date the Middle Jurassic syntectonic greenschist metamorphism, and probably any metamorphic fluids generated during development of the Cretaceous(?) Windy Range metamorphic culmination. The veins crosscut mid-Cretaceous or older structures and therefore any relation to magmatism is limited to mid-Cretaceous or younger intrusive suites.

The characteristics of the gold-quartz ± tungsten mineraliation in the Groundhog Basin are permissive for an intrusion-related gold-quartz system. The absence of any causative intrusive body would suggest that the veins are peripheral or distal-types of mineralization, and perhaps explains the weak correlation between Au:Bi and Au:Pb.

The restriction of gold mineralization to northeast-trending structures indicates a discrete strain and coincident hydrothermal event which to date is only recognized in the Groundhog Basin area. Therefore, this drainage basin with its significant gold placer production warrants further exploration for gold-rich veins. In the region mid- to Late Cretaceous intrusive bodies, such as the Goldstream Pluton, Long Creek or younger leucogranite are also likely the most prospective in the Groundhog area. Regional fault structures and reactive sulphidized, carbonaceous rocks are potential hosts for low-grade disseminated replacement gold mineralization.

Shuswap Region

In the area north of Shuswap Lake the Kootenay terrane is comprised of Neoproterozoic and younger amphibolite-grade sillimanite-bearing metamorphic rocks (Campbell, 1963; Okulitch, 1979; Read *et al.*, 1991) intruded by composite, deformed and plutonic rocks. Devono-Mississippian, Middle Jurassic, mid-Creta-

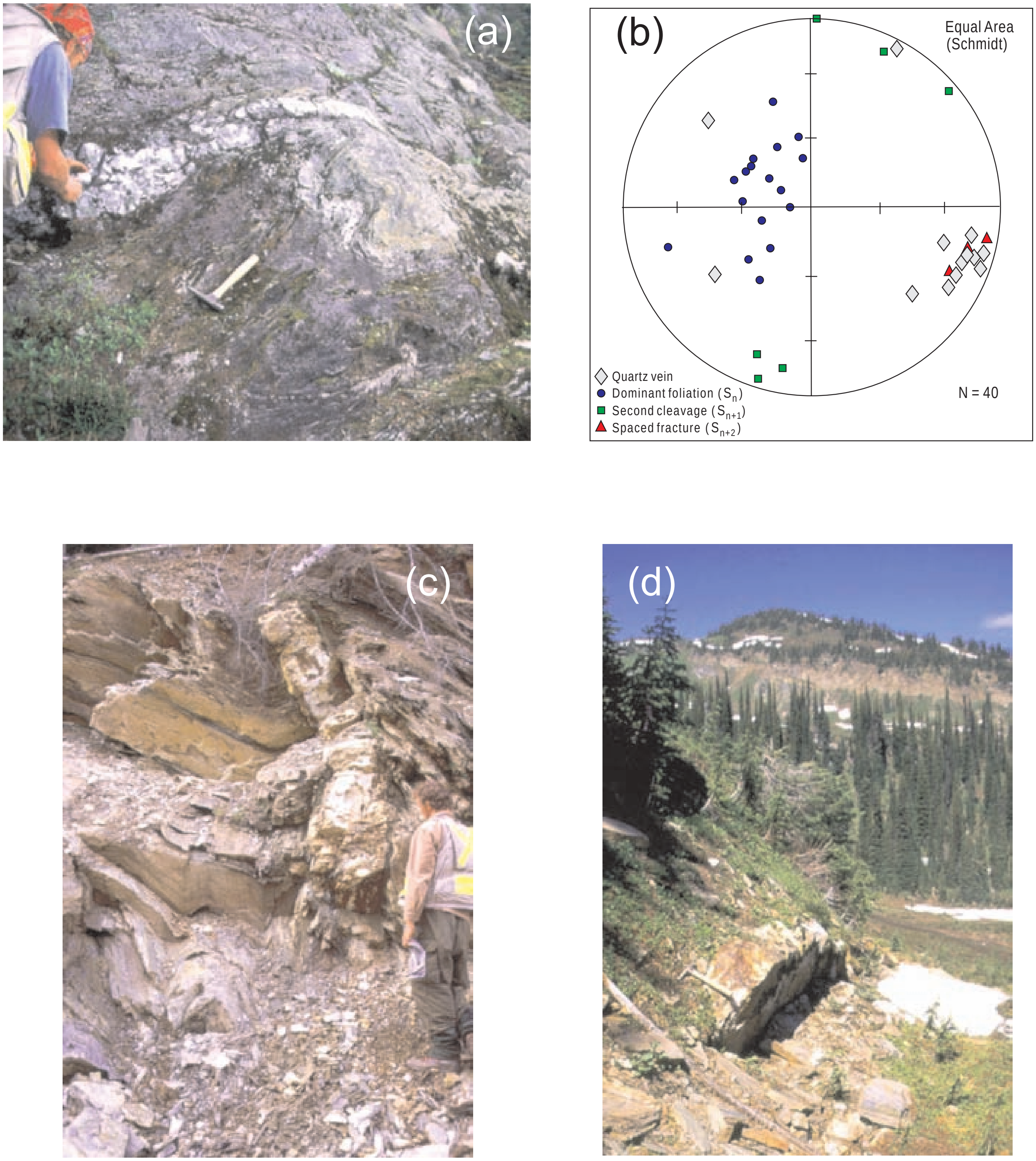

Figure 7. Three main quartz vein styles and morphologies found in the Groundhog Basin. Equal area plot of poles to; veins, dominant foliation (Sn), second cleavage (Sn+1) and late spaced fracture planes (Sn+2). Photos correspond to early synmetamorphic Sn parallel quartz veins (a), pre or syn mid-Cretaceous Sn+1 parallel veins (c) and northeast-trending late auriferous quartz veins (d).

ceous, late Cretaceous and Paleocene suites of magmatism are known from detailed studies elsewhere (Armstrong, 1988; Sevigny *et al.*, 1990; Scammell, 1993; Parrish, 1995), but isotopic dating and chemical classification of intrusions remains unresolved, and poses fundamental problems to the study of intrusive-related gold mineralizing systems in this high-grade terrane.

Baldy Batholith

GEOLOGY

Follow-up work from the 1999 season focused primarily in the northeast corner of the Baldy Batholith and the area south of the batholith between Adams and East Barriere lakes (Figure 8). The Baldy Batholith is a west-trending, mid- to Late Cretaceous post accretionary

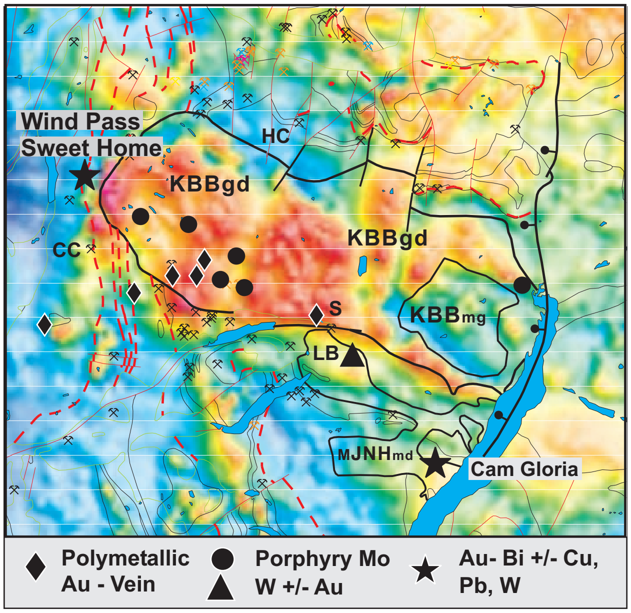

Figure 8. Aeromagnetic intensity survey map showing distribution and various styles of mineralization related to Cretaceous Baldy magmatism. The hornblende-biotite granite phase in the western 2/3rds of the batholith is distinct from the biotite-muscovite granite in the east and the hornblende quartz monzodiorite of the Honeymoon stock.

intrusive (Schiarizza and Preto, 1987; Calderwood *et al.*, 1990). It intrudes Proterozoic to mid-Paleozoic Kootenay terrane metasedimentary and metavolcanic rocks and postdates most of the penetrative deformation in the area. A variety of mineral deposits are related to its intrusion (Schiarizza and Preto, 1987, Logan, 2000). The intrusion is multiphase consisting (from oldest to youngest) of a K-spar megacrystic hornblende-biotite quartz monzonite, biotite monzogranite to granite and a biotite-muscovite granite (Logan, 2000). Molybdenum ± gold mineralized quartz veins, aplite and pegmatite bodies are concentrated in the northeastern corner of the batholith spatially associated with the youngest 2-mica granite phase.

Moss mat, traditional silt and heavy mineral separate-samples returned elevated to anomalous values of Au, Bi, W, and sulphate (in stream waters) from streams draining the northeast end of the Baldy Batholith (Lett, Jackaman and Englund, 2000). Follow-up mapping and sampling this year along logging roads in the area of Fisher and Gollen creeks recognized narrow, north and northeast-trending sulphide-bearing quartz veins and pegmatites. Three grab samples from two of these zones returned below detection gold values and very low Ag, As, Bi, Cu, Mo, Pb, Sb W, and Zn values (Table 2).

Last summer sampling in the Bendelin Creek area returned anomalous gold (6430 ppb), bismuth (562 ppm), and copper (900 ppm) values from grab sample 99JLO-2-18-2 (Logan and Mann, 2000). The pegmatitic segregation is hosted in leucocratic biotite, muscovite monzogranite of the Baldy Batholith. The irregular 2 to 2.5 m wide, northerly-trending pegmatite comprises coarsely intergrown muscovite, biotite, potassium feldspar, quartz and small pink garnets and a central core (1.8 m) of bullish grey quartz. Sericite alteration and molybdenum mineralization are concentrated along the margins of the pegmatite, adjacent to the central quartz core and monzogranite country rock. Chip sampling of the footwall (0.5 m), quartz core (1.8m) and hangingwall (1.2m) pegmatite zones returned slightly elevated molybdenum values in the latter and below detection gold values for all three samples (Table 2).

Similar molybdenum-only mineralization was located along the Adams Lake road at the eastern margin of the batholith where locally it is intruded by numerous aplite and pegmatite dikes. At this location, the potassium-feldspar megacrystic, biotite granite is silicified, weakly sericite-altered and cut by north-trending brittle faults.

Honeymoon Stock

South of the Baldy Batholith, between East Barriere and Adams lakes an irregular, east-trending granite body interfingers with Devono-Mississippian orthogneiss and Neoproterozoic to Paleozoic micaceous quartzites (Figure 8). Intrusive rocks include hornblende porphyry monzodiorite, biotite-hornblende-epidote quartz monzodiorite and biotite granodiorite. The southeastern-most apophysis (Honeymoon stock), hosts the gold-quartz Cam-Gloria vein and has an U-Pb titanite age of 161±7.8 Ma (personal communication J. Mortensen, 2000). The quartz monzodiorite is typically coarsely crystalline and equigranular with rare potassium feldspar megacrysts forming up to 5% of the rock. Dominant mineralogy includes andesine plagioclase, potassium feldspar, hornblende, biotite, quartz and epidote.

Continued mapping of the western and northern parts of this intrusive body indicate the majority are biotite-hornblende-epidote quartz monzodiorite, suggesting they be correlated with the Honeymoon stock and assigned a Middle Jurassic age. Coarse-grained gneissic units containing sillimanite-staurolite-biotite-hornblende assemblages, calcsilicate gneisses (Schriaizza and Preto, 1987) and rusty-weathering migmatites with felsic leucosomes, pegmatites and sugary-textured aplite dikes host the intrusions in this area. It is not known whether these metamorphic mineral assemblages represent contact or burial metamorphism.

An analogous structural and metamorphic setting is the Kootenay Arc south of Kootenay Lake (Archibald *et al.*, 1983), where late synkinematic Nelson suite rocks and their contact metamorphic aureoles are intruded and reset by mid-Cretaceous and younger metamorphism and plutonism.

MINERALIZATION

Cam-Gloria

The Cam-Gloria gold prospect (MINFILE 82M 266) is located three kilometres west of Honeymoon Bay, Adams Lake (Figure 8). The property was staked by Camille

TABLE 2
SELECTED GEOCHEMICAL ANALYSES, SHUSWAP AREA, BALDY, GOLDSTRIKE-BIZAR, AND GQ MINERAL OCCURRENCES

FIELD NUMBER	Au	Ag	As	Bi	Cu	Mo	Pb	Sb	W	Zn	DESCRIPTION
Baldy-Bendelin/Fisher Ck											
00JLO-1-3	7	-5	56	2.31	103	0.6	13	-0.1	0.4	84	garnet-diopside skarn
00JLO-3-14	-2	-5	23	0.29	<1	1.6	12.5	0.2	1.3	6	1.2 m chip FW-pegmatite
00JLO-3-14-2	-2	-5	8	0.34	1	0.6	1	-0.1	0.2	<2	1.5 m chip qtz core
00JLO-3-14-3	-2	-5	6	0.64	<1	**559**	18	0.3	1.8	8	0.5 m chip HW-pegmatite
00JLO-4-16-2	-2	-5	5	0.36	15	8.4	34.5	0.3	1.5	16	oxidized 5-10mm qtz veinlets
00JLO-4-21	-2	-5	1	0.18	3	3.8	26	-0.1	0.8	2	grab of pegmatite
00JLO-4-22	-2	-5	2	0.22	4	7	31.5	0.3	1.1	20	clay-altered leucogranite
00JLO-4-22-2	-2	-5	4	0.44	7	2	26	-0.1	1.3	20	pyritic quartz pegmatite
00JLO-4-27	-2	-5	3	5.47	<1	1.6	22	-0.1	1.8	12	grab of pegmatite
00JLO-5-47	-2	-5	<1	13.1	13	**1180**	22	-0.1	3.2	18	quartz vein w/ Mo
Windpass*											
GW-1	**2020**	1	10	58	532	3	2	<2	<10	48	Grab from dump
GW-2	**88590**	8	2	**1450**	1715	5	4	2	10	36	Grab from dump
GW-3	**30890**	16	40	**492**	4720	3	234	<2	10	44	1m channel, Compressor zone
GW-4	**2900**	0	<2	**86**	709	1	<2	<2	<10	16	grab, Fire Station trench
GW-5	**79410**	6	34	**2550**	3420	12	<2	<2	<10	52	chip, #3 Main adit
GW-6	**5900**	11	<2	**528**	6800	<1	<2	16	<10	64	grab, high grade dump
GW-7	**33870**	1	8	**992**	366	4	<2	<2	<10	10	Sweet Home dump
GW-8	**2180**	33	4	*	>10000	1	<2	<2	<10	502	7.5 m chip, #1 adit
GW-9	**13170**	1	<2	**508**	1275	1	<2	<2	10	10	3.5 m chip, #3 adit
Shuswap-GQ											
00JLO-15-144	-2	-5	7	0.05	18	0.6	3	-0.1	1.1	38	calcsilicate marble
00JLO-15-144-2	**115**	-5	7	7.73	**1445**	2.8	8	0.3	101	78	pyrrhotite-scapolite skarn
00JLO-16-151	-2	-5	<1	2.69	579	5	6	-0.1	**160.5**	108	pyrrhotite-scapolite skarn
00JLO-16-153	**854**	-5	5	**79.8**	**1005**	2	8	-0.1	**222**	102	pyrrhotite-scapolite skarn
00JLO-16-156	5	-5	4	1.17	7	0.2	9	0.2	2.9	88	carbonatite
00JLO-17-166	5	-5	5	0.12	2	0.4	60.5	-0.1	0.7	2	pegmatite, leucosome
Shuswap-Bizar											
00JLO-9-93	-2	-5	5	1.64	25	5.8	2.5	-0.1	0.2	4	grab 15 cm pyritic qtz vein
00JLO-10-95	2	-5	6	0.55	16	2	4	-0.1	0.3	6	qtz+muscovite vein, Sn //
00JLO-10-95-2	-2	-5	<1	0.29	11	0.8	7.5	-0.1	0.5	8	qtz+andalusite vein, X-cutting
00JLO-10-98	-2	-5	14	0.81	219	3.2	6	-0.1	0.9	8	grab 5 cm pyritic qtz vein
00JLO-10-99	-2	-5	5	0.05	3	1.4	3	-0.1	0.3	6	pegmatitc leucosome
00JLO-11-111	-2	-5	9	0.3	4	1	4	-0.1	0.3	<2	lensoidal bull quartz body
00JLO-13-133	-2	-5	10	0.82	<1	0.8	22.5	0.1	0.9	44	clay-altered leucogranite

Au, As and Sb by INA; other elements by total digestion-ICP
Au in ppb, rest in ppm
Sample locations *see* Figures 8, 9 and 10.
* Windpass samples from Jenks (1997)

Berubé in 1997 and optioned to Teck Corporation in early 1999. Teck carried out surface mapping, geophysical surveys and excavator trenching and drill tested the main vein. Seven holes totaling 835.9 metres were drilled, logged and sampled (Evans, 1999). No further work was undertaken and the property was returned to the owner.

The property was mapped and the vein and alteration system sampled in 1999 as part of our ongoing study to characterize intrusion-related gold deposits in British Columbia. For the results of this work the reader is referred to Logan (2000), Logan and Mann (2000) and references therein. In conjunction with the 1999 mapping, the stream sediment geochemical signature of the deposit was evaluated using multiple sampling media (Lett, Jackaman and Englund, 2000).

Gold mineralization at Cam Gloria occupies quartz veins, up to 7 meters thick, within multiple fault and shear zone structures hosted in potassium feldspar megacrystic quartz monzodiorite. The veins are enclosed by wide zones, in places up to 30 m of pervasive sericite alteration, which also contain elevated gold values. The wide alteration zone accompanying quartz veins and mineralization is not a well developed characteristic of intrusion-hosted deposits. Gold values are erratic in samples from trenches and diamond drill hole intersections of the vein and alteration, but do show good correlation with Bi, Pb and Ag (Evans, 1999). A weaker correlation with As, Cu, Zn, Te and W is evident. These correlation characteristics are similar to other intrusion-related deposits in Alaska and the Yukon (McCoy *et al.*, 1997).

U-Pb geochronology of quartz monzodiorite from the Honeymoon stock gives a preliminary Middle Jurassic date of 161.0±7.8 Ma from 2 concordant titanite fractions (personal communication, J. Mortensen, 1999). Pb-isotope analyses of vein sulphides give 207/206 and 208/206 ratios (personal communication, J. Gabites, 1999) which plot within a cluster of Cretaceous vein deposits from the Baldy and Revelstoke area (Logan, unpublished data), indicating the lead in the Cam-Gloria vein has a Cretaceous model age. Ar-Ar analysis on the sericite alteration envelope is ongoing (D. Archibald, Queens University) to help constrain the age and relationship of mineralization to the Jurassic and Cretaceous magmatic events in the Adams Lake area. Preliminary results indicate that mineralization is younger than the Middle Jurassic host stock and probably associated with the Mid-Cretaceous Baldy Batholith. Since the auriferous mineralization at Cam-Gloria is not related to the Honeymoon stock, it is interpreted as a peripheral (to the causative Baldy Batholith) intrusion-related, gold-quartz vein hosted in an older intrusion.

Windpass and Sweet Home

Other candidate "proximal/peripheral" intrusion-related gold-quartz veins related to the Baldy Batholith are the Windpass (MINFILE 82P-39) and Sweet Home (MINFILE 82P-40) mines (Figure 8). Both were important producers of gold prior to 1940 (Taylor, 1989). Total production between 1916 (discovery) and 1944 was 1071.7 kg of gold, 78 906 kg of copper and 53.5 kg of silver from 73 319 tonnes milled. Operating data indicate a millhead grade of 24 g/t gold (Smith, 1936).

Both the Windpass and Sweet Home are west-trending, north-dipping, shear-hosted quartz veins which cut a hornblende, pyroxene diorite sill and adjacent bedded cherts of the lower Fennell Formation approximately 1.5 km west of the Baldy Batholith (Schiarizza and Preto, 1987). Mineralization is restricted to that part of the shear zone hosted in the diorite and consists of, in apparent paragenetic sequence; magnetite, pyrrhotite, pyrite, cobaltite, chalcopyrite, gold, bismuthinite, bismuth and supergene native copper (Uglow and Osborne, 1926). Four grab samples from the Windpass dump, two from surface trenches and three chip samples, 2 from the #3 main adit and 1 from the # 1 Windpass adit (Table 2; Jenks, 1997) are plotted on Figure 11. Analyses show a strong Bi and Au correlation for mineralized samples. The presence of magnetite and chalcopyrite within the mineralizing system is not a common feature of deposits associated with reduced intrusions.

PROSPECTIVE AREAS - BALDY BATHOLITH

The area surrounding the mid-Cretaceous Baldy Batholith is prospective for intrusive-related peripheral deposits like the Windpass-Sweet Home (located approximately 1.5 km west) and the Cam-Gloria gold-quartz vein (located approximately 7.5 km south) of the main intrusive body. The former are hosted in west-striking moderately north-dipping fissure veins in Fennell Formation diorite, the latter in northeast-trending, steeply northwest-dipping fissure structures cutting Middle Jurassic monzodiorite. Copper, copper-molybdenum porphyry and base metal polymetallic vein showings are associated with the hornblende-biotite granite phase of the intrusion which comprises the western two-thirds of the batholith. This area may represent the upper?/mid-level of the intrusion, whereas the areas proximal to the margins or carapace (presently eroded) are more prospective to host late stage evolved fluids ± metals. The muscovite-biotite granite in the eastern one-third of the batholith is associated with abundant pegmatites, aplites and porphyry molybdenum mineralization. This style of mineralization characterizes the interior of the highly fractionated youngest phase of the batholith. The eastern end of the batholith is faulted off by the Adams Lake-North Thompson Fault, a west-side down listric normal post-Paleocene fault structure. Areas encompassing the known intrusive-related deposits extend from the mainly steeply-dipping contacts of the Baldy batholith at least as far as 7.5 km. This is a substantial amount of prospective ground remaining to be fully tested.

GQ

Several Au- Cu-W-Bi skarn occurrences were discovered northeast of Shuswap Lake in 1999 by Warner Gruenwald. The prospective nature of the area was recognized through silt sampling and the discoveries resulted from following up anomalous gold values. The showings (SW, SE and NE showings, Gruenwald, 1999) outcrop on new logging roads in Second Creek drainage (82M/02), a northwest-flowing tributary of the Anstey River. The GQ claims were staked in the fall to cover the area. The property was visited in 1999, and described by Cathro (Cathro and Lefebure, 2000). In July the author, together with M. Cathro, D. Lefebure and D. Marshal revisited the showings and spent 2 days sampling and mapping the sulphide occurrences.

GEOLOGY

The GQ property straddles the Monashee décollement, a major west-dipping contractional fault (Read and Brown, 1981), with large Late Cretaceous to Paleocene east-directed displacement (Parrish, 1995). West of the fault, in the hangingwall are Windermere-equivalent, amphibolite facies metamorphic rocks of the Selkirk allochthon (Figure 9). The Selkirk allochthon corresponds to the "paragneiss and pegmatite" map unit "E" of Wheeler (1965), which includes pelite and semi-pelite schist, quartzofeldspathic gneiss, impure marble, garnet-hornblende amphibolite and minor micaceous quartzite, at the GQ property. These metasedimentary rocks have been extensively intruded by numerous narrow lenses of granite and pegmatite. The mineralized showings are hosted in and adjacent to buff and rusty weathering impure marbles and calcsilicate horizons within a thick sequence of interlayered micaceous quartzites, pelite and semi-pelite and minor amphibolite.

The east side of the property is underlain by footwall rocks of the Monashee décollement, an Early Proterozoic crystalline basement of orthogneisses and an unconformably overlying sequence of paragneisses of uncertain age, termed the cover sequence (McMillan, 1973, Journeay, 1986). The rocks at GQ show wide zones of strong deformation related to shear strain within the Monashee décollement zone.

The western half of the property is underlain by a north-trending subalkalic, weakly peraluminous, biotite monzogranite intrusion. This is part of the large, 35 km^2 composite Anstey Pluton, which at its northern exposure, is a strongly sheared and metamorphosed tabular body, with a 92-94 Ma, crystallization age (U-Pb zircon and monazite age, Parrish, 1995). On the GQ property, the eastern contact is a 2-3 km wide zone of interlayered paragneiss and foliation parallel sills or crosscutting dikes of biotite monzonite, tourmaline ± garnet pegmatite and aplite bodies. The pegmatite and aplite show various relationships to the paragneiss and exhibit a variety of igneous textures including; coarse equigranular, crowded-potassium feldspar megacrystic, pegmatitic and gneissic varieties, all which can occur together at the outcrop scale. The relationships between textural phases are often gradational but crosscutting fine-grained dikes with chilled margins are present. Crosscutting, syn-tectonic foliated biotite-muscovite potassium feldspar pegmatite, coarse-grained tourmaline-bearing biotite leucogranite and aplite are the most common dikes located in the western part of the property. These vary from several centimetres up to ten's of metres wide and for the most part lie parallel with foliation of the gneisses. Where they cut the granite the contact is gradational and not always planar. Often there is no chilled margin, alteration envelope or any indication of non-equilibrium. Fine-grained, muscovite, garnet-bearing aplite dikes crosscut both the dominant foliation of the paragneisses and sills of biotite monzogranite. The youngest intrusive rocks are narrow 1 to 5m wide, dark green, aphanitic olivine basalt dikes. The dikes strike northerly and dip-steeply and probably occupy Tertiary or younger extensional structures.

The paragneiss and schist contain a north-northwest-trending moderate southwest-dipping bedding parallel foliation. Below the décollement, in Monashee complex rocks, a southwest-plunging crenulation cleavage is superposed on the dominant north-trending foliation. There are two areas in Third Creek where the paragneiss and pegmatite contain discrete ductile shear zones. Mylonite zones in monzogranite, shear bands in paragneiss, and leucosome-tails on rotated garnet-hornblende amphibolite boudins all show a tops to the northeast sense of shear related to strain within the Monashee décollement zone.

Pelitic rocks contain sillimanite-orthoclase±muscovite without kyanite suggests sillimanite-muscovite zone of amphibolite facies for the rocks hosting mineralization. The calcsilicate schist and marble contain calcite-diopside-quartz-tremolite and/or actinolite.

East of the décollement are interlayered semi-pelite, calcsilicate marble, stratabound carbonatite tuff, amphibolite augen and rare pegmatitic leucosomes. The pelite contain kyanite-muscovite-garnet-biotite ± sillimanite assemblages indicate upper amphibolite facies metamorphism (Journeay, 1986). Pods of coarse grained sillimanite and feldspar-quartz-biotite augen define a southwest-plunging stretching lineation. Carbonatite (pyroclastic-type) horizons were noted, and one was sampled east of the GQ showings, in footwall rocks within cover sequence rocks of the Monashee complex. The sample returned anomalous values for the rare earth elements: barium, cesium, lanthanum and niobium, which compare extremely well with the range of values for the Mount Grace carbonatite (Höy, 1987). The Cottonbelt and other Pb-Zn-Ag stratabound, Shuswap type deposits overlie bedded carbonatites in the Mount Grace area (Höy, 1987), suggesting that the eastern portion of the GQ property may share an equally high prospective nature to host these stratabound occurrences.

Mineralization

Mineralization in the Selkirk allochthon consists of narrow (10-40cm), auriferous sulphide skarns developed along the contact zones between leucocratic, siliceous aplitic to pegmatitic granite sills and calcsilicate marble or rusty pelitic schist. Sulphides of mainly pyrrhotite, minor pyrite and traces of chalcopyrite occur as disseminations and fracture-fillings of several percent to semi-massive pods comprising up to 20-30 percent of the rock. In the massive pods, sulphides are interstitial, forming a 'net-texture' to the subhedral and euhedral calcsilicate skarn assemblage of diopside, scapolite, garnet and quartz grains. The scapolite is approximately 25% marialite (Na end member) and 75% meionite (Ca end member) (personal communication, D. Marshall, 2000). In the majority of showings the sulphides are found in the intrusion or between it and the calcsilicate assemblage of the country rock, indicative of an endoskarn. A 3 m section across the 'middle sulphide occurrence' on the north side of Second Creek, consists of the following succession. Beginning at the hangingwall side of the sill and progressing westward is 7 cm of semi-massive net-textured pyrrhotite, scapolite, diopside skarn (sample JLO-16-151), gradational into 15 cm of garnet-diopside±pyrrhotite-skarned rusty schist. Beyond this is 1.5 meters of calcsilicate rock and then interlayered biotite schists and calcsilicate marbles. Pyrrhotite occupies high-angle, late stage crosscutting structures within the skarn zone. Cathro and Lefebure (2000) report anomalous values for Bi, Cu, Te , and W from grab samples from the SW showings.

Samples of the pegmatite, mineralization and calcsilicate marble show that enrichment of Au is limited to the narrow sulphide endoskarn. The only gold value from pegmatite is low (5 ppb Au). A sample of the calcsilicate located 4 m from the mineralization at the SW showing contains below detection Au values (Table 2). The enrichment of Au, Bi, and Cu, Au:Bi correlation and ratios, morphology and calcsilicate assemblage are similar to proximal tungsten-gold skarns developed adjacent to Tombstone intrusions at the Marn (Brown and Nesbitt, 1987) and Horn (Hart *et al.*, 2000) and in general to reduced gold-skarn mineralization (Meinert, 1998). Neither the timing of mineralization, nor the age or relationship of the causative pegmatites are known. If the pegmatites are related to the 'dated phase' of the Anstey Pluton, they are mid-Cretaceous, and predate the high-grade metamorphism and shearing (Scammell, 1993; Johnson, 1994) that occur between Late Cretaceous and Paleocene, at this structural level in the Selkirk allochthon (Parrish, 1995). Alternatively, the pegmatites may be anatectic leucosomes related to this younger period of crustal thickening and high heat flow. The mineralization indicated to date is limited to narrow and isolated gold-sulphide skarn zones which do not extend far into the calcsilicate or schist host.

Goldstrike-Bizar

The Goldstrike (Bizar) property (MINFILE 82M 267) is located 16 kilometres northeast of the village of Avola (Figure 10). Mineralization was discovered and staked by Leo Lindinger in 1998. The property was briefly visited in 1999 (Logan, 2000; Cathro and Lefebure, 2000). Five short holes drilled in October, 1999 by Cassidy Gold Corp, intersected narrow zones of quartz sulphide mineralization (Greunwald, 1999).

Mineralization at the Bizar showing consists of semi-concordant, and sheeted quartz-sulphide veinlets hosted by amphibolite grade micaceous quartzite and quartz-muscovite-biotite-garnet schist of the Shuswap complex. The style and characteristics of mineralization are similar to other intrusive-related proximal deposits in Alaska and the Yukon, in particular the high-grade Pogo deposit. Specifically these include; its structural morphology (shallow dipping, quartz sulphide layer), metamorphic grade of host rock, and high-grade gold assays correlative with high bismuth values. To assess the likelihood of these correlations the property was revisited in 2000 and four days were spent mapping the area surrounding the Bizar showing.

GEOLOGY

Mapping indicates the property is underlain by garnetiferous biotite-muscovite schist and micaceous quartzite with minor amphibolite and calcsilicate units. West of Tumtum Lake the metasediments consist of micaceous quartzite with interlayered biotite-muscovite-quartz schists and rusty, sericite-quartz-pyrite schist. Rare, thin amphibolite and orthoquartzite beds occur 2 km northwest of the lake. The pelitic rocks contain

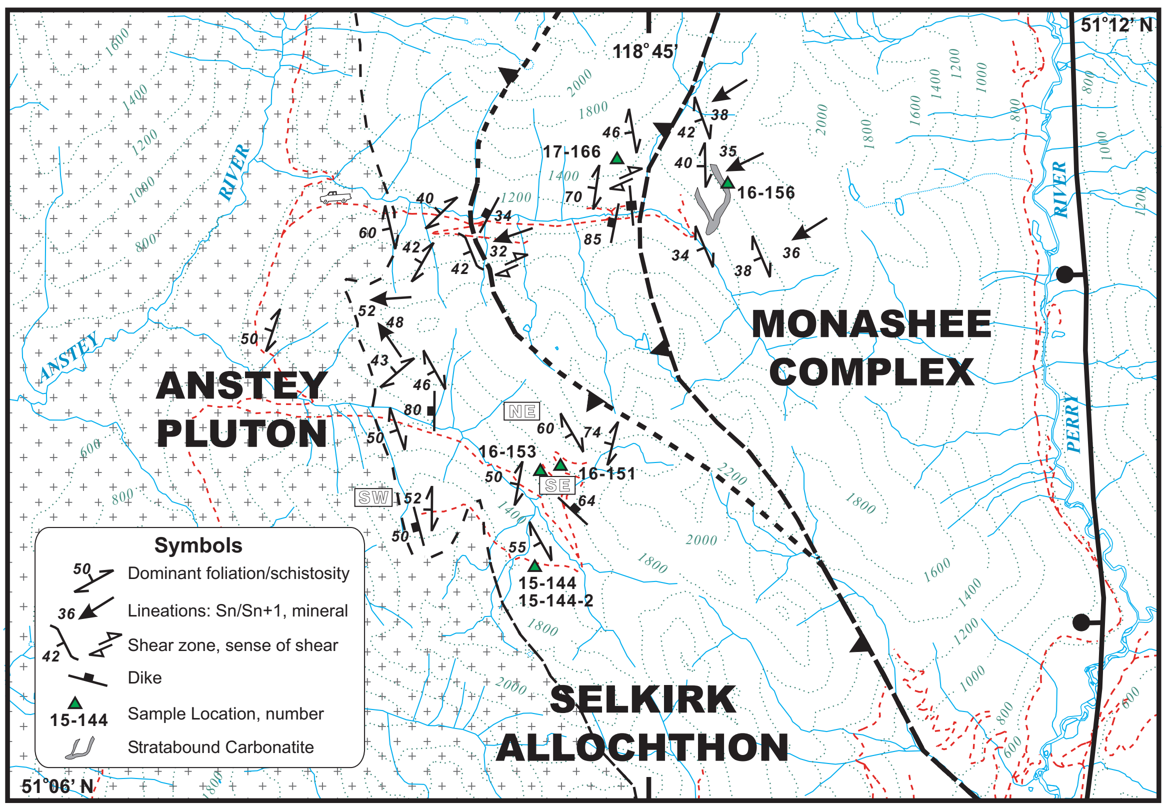

Figure 9. Geology of the Selkirk allochthon (SA) and the western edge of the Monashee Complex in the area between the Perry and Anstey rivers, modified from Höy and Brown (1981). A three-fold subdivision of the GQ property includes; leucogranites of the Anstey Pluton, a gneiss and pegmatite unit of the SA and paragneiss of the Monashee Complex. Shown are locations of the SW, SE and NE mineral showings, geochemical samples and the stratabound carbonatite locality.

biotite, muscovite, plagioclase and quartz ± garnet assemblages characteristic of the garnet zone of greenschist facies metamorphism. West from the lake, and up to the top of Groundhog Mountain the pelitic rocks contain staurolite, andalusite and chlorite, and the calcareous rocks contain garnet and hornblende in addition to the garnet zone assemblage minerals, indicating amphibolite facies metamorphism. Andalusite pseudomorphs up to 2 cm in length, commonly retrogressed to muscovite are developed along the foliation planes in pelitic layers close to the granodiorite contact on Groundhog Mountain. Thin sections show static garnet, biotite and amphibole porphyroblast overgrowth of an early dominant foliation. The contact assemblage minerals for the most part are retrograded; garnets have biotite and chlorite rims, andalusite is rimmed by sericite. The garnet-biotite-staurolite-andalusite assemblages most likely represent a contact aureole related to the large composite granitoid body which envelopes the western side of the property. The contact aureole and therefore the intrusion postdate the syntectonic development of the dominant regional fabric. Sparse mineral lineations within the aureole are similar to the younger, southeast-trending structures. This may constrain the second phase of folding to the time of pluton emplacement.

The metasedimentary rocks are intruded to the north, west and south by variably deformed, composite, hornblende, biotite and biotite-muscovite granitic bodies. Narrow leucosomes and peraluminous (andalusite-bearing) pegmatitic sills occur throughout the sequence, but are much more abundant farther north. Northwest of Tumtum Lake the intrusive body is a leucocratic, equigranular to sparse potassium feldspar megacrystic, biotite granodiorite. Marginal phases are foliated, lineated and contain more mafic minerals than the interior. The granodiorite contains abundant biotite-muscovite-quartz-potassium feldspar and garnet pegmatite dikes, sheeted quartz veins and aplite dikes. A second composite intrusive body consists of: an older foliated hornblende, biotite, epidote granodiorite; a potassium feldspar megacrystic, biotite granodiorite; and a younger equigranular biotite, muscovite granite phase. This body crops out west of Groundhog Mountain in fault contact with amphibolite facies micaceous quartzites. As much as 10 m from the fault the granodiorite is thoroughly fractured and pervasively chlorite altered. An isolated, small exposure of metamorphosed, gneissic feldspar metacrystic quartz monzodiorite is interlayered with micaceous quartzite and rusty metapelite 3 kilometres west of the south end of Tumtum Lake. On the modal quartz-alkali feldspar-plagioclase feldspar plot (LeMaitre, 1989), the few samples collected from all of these intrusion scatter across the granodiorite field. In addition they have major and trace element abundances similar to Devonian-Mississippian granodiorite orthogneisses and middle Jurassic quartz monzodiorite bodies in the Adams Lake area. In thin-section the foliated granodiorite samples contain plagioclase, potassium feldspar, biotite, hornblende, quartz and epidote with trace amounts of sphene, apatite and tourmaline. No isotopic age constraints are known for any of these intrusions.

The schists and quartzites contain a dominant north-northwest-trending dominant foliation defined by synmetamorphic biotite and muscovite. A younger phase of southeast-trending, steeply dipping crenulation cleavage and open folds deforms the north-trending structures. At the Bizar showing the stratabound massive sulphide horizon is tightly folded about these younger structures axis plunging 30° towards 140°Azimuth.

MINERALIZATION

Two main types of quartz bodies are present in the area. Bedding/foliation parallel, shallow-dipping quartz-biotite-feldspar ± sulphide layers and aplitic leucosomes; and steeper, north and northwest-trending quartz-muscovite-andalusite ± sulphide veins that crosscut bedding/foliation and generally parallel crenulation cleavage. The relatively younger, andalusite-bearing quartz veins vary in width from 1 to 20 cm depending primarily on the competency of the host. Where hosted in quartzite and micaceous quartzite the veins are narrow, but well defined and where the structure crosses into tightly crenulated mica schists they often pinch out. These veins tend to parallel southeast-trending structures. Andalusite indicates peraluminous magmatism, related to crustal thickening and anatectic melting which postdates the development of early structures and dominant foliation.

Lithogeochemical sampling of quartz veins, alteration and intrusive rocks was carried out in conjunction with mapping. Four individual veins ranging from 2-20 cm in width and containing minor pyrite and/or pyrrhotite were sampled across the property. All were steeply dipping, crosscut the dominant foliation and located distal from the main discovery zone (Logan, 2000; Cathro and Lefebure, 2000). A foliation parallel, 15 cm rusty weathering aplitic leucosome and a composite of sheeted quartz veinlets hosted in granite southwest of the Bizar showing were also sampled. Gold values for all samples were below detection and all of the other intrusion-related geochemical signature elements returned low values (Table 2).

The stratabound mineralization at the Bizar showing is concordant with dominant synmetamorphic foliation and has been deformed and metamorphosed together with the schists into southeasterly plunging folds (Logan, 2000). Conclusions from the 1999 drilling project indicate that mineralization is "stratigraphically controlled with quartz veins, veinlets and siliceous zones concordant with bedrock foliation" (Greunwald, 1999). The setting of the Bizar is similar to other Shuswap-type stratabound deposits of Pb-Zn-Ag±Cu (*i.e.* Cottonbelt, River Jordan, Ruddock Creek; Höy, 1996). With the exception of low silver values the enrichments of Au, Cu, Bi, As, Sb and Zn present at Bizar closely match the geochemical signature of the Shuswap-type deposits. Further prospecting and exploration is warranted on this property but a stratabound model, similar to the Broken

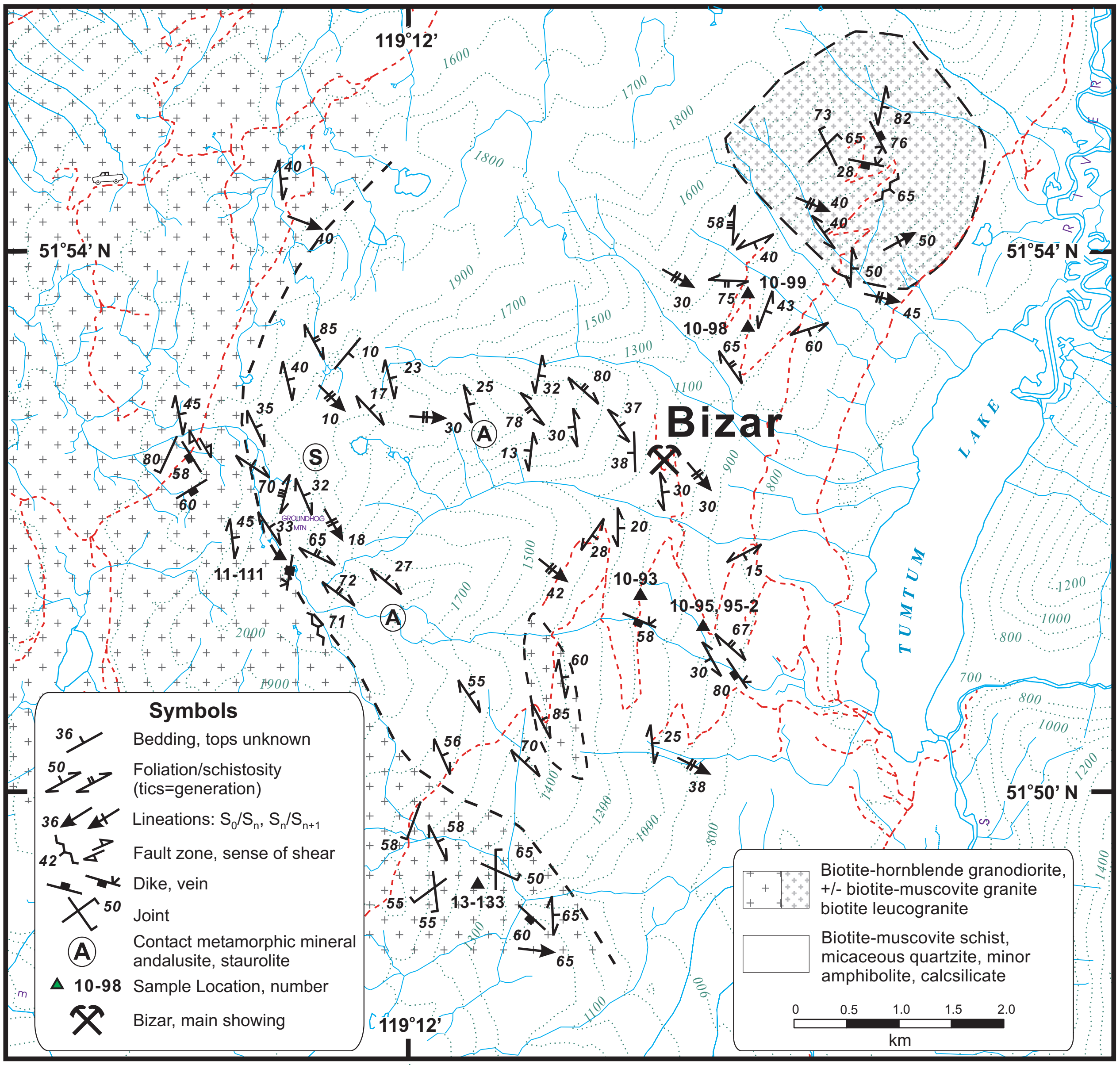

Figure 10. Geology of Tumtum Lake area showing the location of stratabound mineralization at the Bizar zone and the location of sampled quartz veins.

Hill/Shuswap-type is more applicable for evaluation of this area than an intrusion-related model.

DISCUSSION

One of the challenges for exploration for intrusive-related gold quartz veins, hosted by country rock is distinguishing them from other types of mesothermal quartz veins. In some cases there are diagnostic characteristics, such as direct association of gold mineralization and quartz veins with pegmatites or aplites, to show the genetic relationship to an intrusion. Otherwise, detailed studies of the fluids, paragenesis of mineral phases and/or dating of various geological events is required to prove the magmatic parentage of the fluids.

Since this data is frequently not available for mineral occurrences, it is more difficult to establish the genesis of auriferous quartz veins hosted by sedimentary, volcanic or unrelated intrusive rocks, or their metamorphic equivalents. As shown by the gold quartz veins in the Groundhog Basin, it is possible to use field characteristics to infer whether they are intrusive-related or belong to orogenic gold deposits. These characteristics include; vein structures that postdate the main (Middle Jurassic) orogenic event, narrow alteration envelopes, association of bismuth minerals with gold, and presence of tungsten minerals in the veins.

One area of research that may provide the exploration geologist with a quick and fairly reliable tool for distinguishing intrusion-related gold quartz veins is trace metal contents and ratios, particularly for gold and bismuth. In a recent paper Flanigan *et al.* (2000) show that bismuth, gold and arsenic values from intrusion-related deposits of Alaska and Yukon change systematically with respect to depth of emplacement or distance from the causative pluton. Average Bi:Au ratios range from 31:1 for deeper and more proximal deposits to 0.36:1 for shallower and more distal deposits. Bi vs Au correlations range from r=0.89 for deeper and/or more proximal deposits to r=0.12 for shallower and/or more distal deposits. The changes for As:Au are much less predictable that Bi:Au ratios. In addition, they suggest that correlation and ratios may be used predictively in less well known intrusive environments to direct exploration.

In British Columbia early results show some deposits exhibit very strong Bi to Au correlations. Statistical correlation values for Au and Bi from the highest to lowest are; .96 for Valparaiso (intrusion-hosted), .89 for the Windpass (proximal-peripheral vein) and .53 for Cam Gloria (peripheral vein). The higher correlation of Au and Bi has been linked to intrusion-hosted deposits and/or deeply emplaced deposits and to the initial precipitation of madonite (Au2Bi) Flanigan *et al.* (2000). Positive correlation of Bi and Au is also a well-known characteristic of reduced gold skarns. In particular, at the Crown Jewel gold skarn deposit in Washington, the presence of coarse-grained bismuthinite can be used to indicate ore-grade gold material (Meinert, 1998). The British Columbia deposits also indicate similar relationships between Bi:Au ratios from a limited data set of intrusion-related mineral occurrences (Figure 11). The majority of the data points fall above Bi:Au ratio of 10:1 (*i.e.* Bi concentrations are typical higher than gold by an order of magnitude). Average Bi:Au ratios are 36:1 for the Valparaiso samples, 32:1 for samples from the Windpass. The samples from Cam Gloria show a wide variability, with an average Bi:Au ratio of 269:1. The veins in the Groundhog Basin Basin and at the Ruth/Vermont and McMurdo past producers cannot be easily linked to specific intrusions. Vein samples from these areas have a negative correlation of Bi and Au and erratic Bi:Au ratios. The samples from Groundhog Basin show generally lower concentrations and a wide variability of Bi and Au values, possibly reflecting characteristics of a more distal intrusion-related system. If the values with below detection Au, and samples JLO22-195-2 (Au>Bi) and JLO22-187 (Au<Bi) are excluded from the calculation, the average Bi:Au ratio is 30:1.

The average Bi:Au ratio is 12:1 for the quartz-carbonate vein and replacement samples taken from the Ruth/Vermont and McMurdo base metal and gold past producers. Statistical correlation values for Au and Bi are -.11 for the Ruth/Vermont-McMurdo samples.

Low Rb and Nb abundances have been cited by McCoy (1999) as characteristics of gold mineralizing-intrusives of the plutonic-related deposit type. These are also characteristics of granites formed in volcanic arc settings Pearce *et al.* (1984). Bayonne suite intrusions from the southern Canadian Cordillera (Brandon and

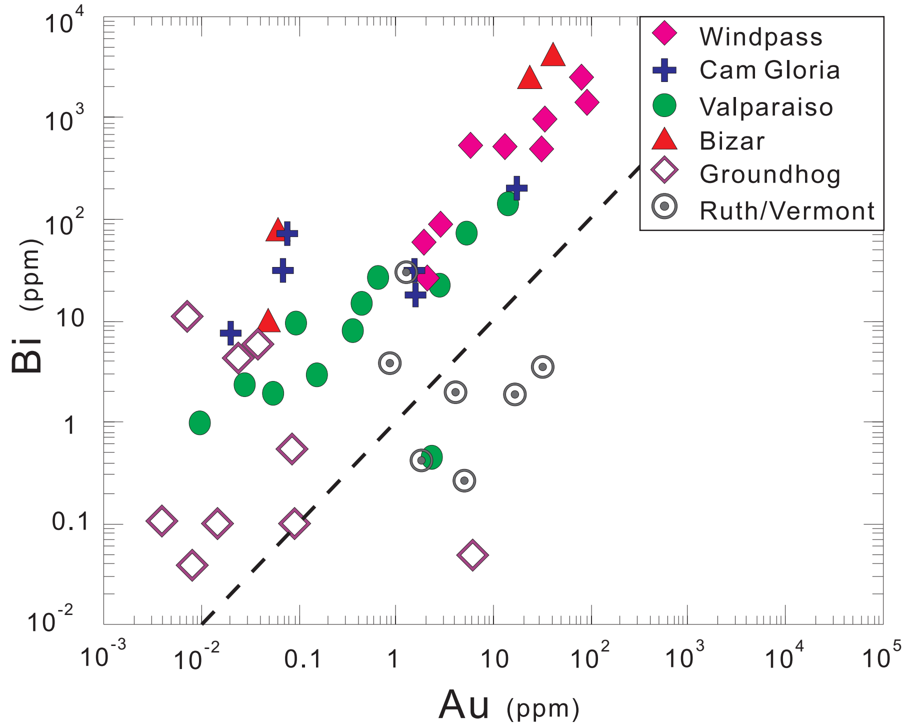

Figure 11. Bi vs. Au values for mineralized samples of intrusion-related quartz veins. Windpass samples from Jenks (1997); Bizar, Valparaiso and Cam Gloria samples from Logan (2000), Groundhog and Ruth/Vermont samples this study.

Lambert, 1993; this study) are shown in Figure 12 along with the field for mid-Cretaceous Tombstone suite intrusives (Murphy, 1997). The Bayonne suite intrusions overlap the volcanic-arc, syncollisional and within-plate fields, a non-diagnostic position shared by the Tombstone-Tungsten suite of Alaska and the Yukon (Lange *et al.*, 2000). The Middle Jurassic Honeymoon Bay stock plots in the volcanic-arc field, whereas the phases of the Baldy Batholith straddle the triple junction between VAG - syn-COLG and WPG (Logan *et al.*, 2000). Undated composite, deformed intrusive phases from the GQ and Bizar mineral occurrences (Figure 12b) plot in the volcanic-arc field but the relationships to gold-bismuth mineralization is equivocal. Unpublished data from the Goldstream pluton show the biotite granite phase overlaps the Tombstone field and hornblende quartzdiorites which plot in the WPG field (Figure 12a), while data for the Battle Range Batholith (Figure 12c), similar to the Bugaboo, Fry Creek and Horsethief Creek plutons from Brandon and Lambert (1993) have substantially higher Nb values and plot in the WPG field.

CONCLUSIONS

A key exploration approach for intrusion-related gold deposits is to explore in, and around, highly differentiated granitic intrusions, specifically those intruded in continental margin settings. In contrast with the metaluminous, subalkalic, reduced I-type Tombstone Suite, the Bayonne suite consists of mostly peraluminous, subalkalic hornblende-biotite granodiorite and highly fractionated 2-mica granites, aplites and pegmatites. These are emplaced into miogeoclinal rocks of ancestral North America and Kootenay terrane pericratonic rocks. This ancestral continental margin setting and mid-Cretaceous magmatic belt defines a W-Sn±Mo province which follows the Omineca belt south from Alaska to the Canadian-US border.

Intrusion-related gold-quartz vein occurrences are located in southern British Columbia associated with the Bayonne suite (ie. Valparaiso; intrusion-hosted mineralization, Sanca stock and at Cam-Gloria and Windpass, fissure veins peripheral to the Baldy Batholith). These occurrences have similar Au-W-Bi signatures and physical characteristics to the larger Alaska and Yukon deposits. More research is required to establish if the Bayonne suite plutons contain the metal and sulphur budget necessary to form economic intrusion-related mineralization.

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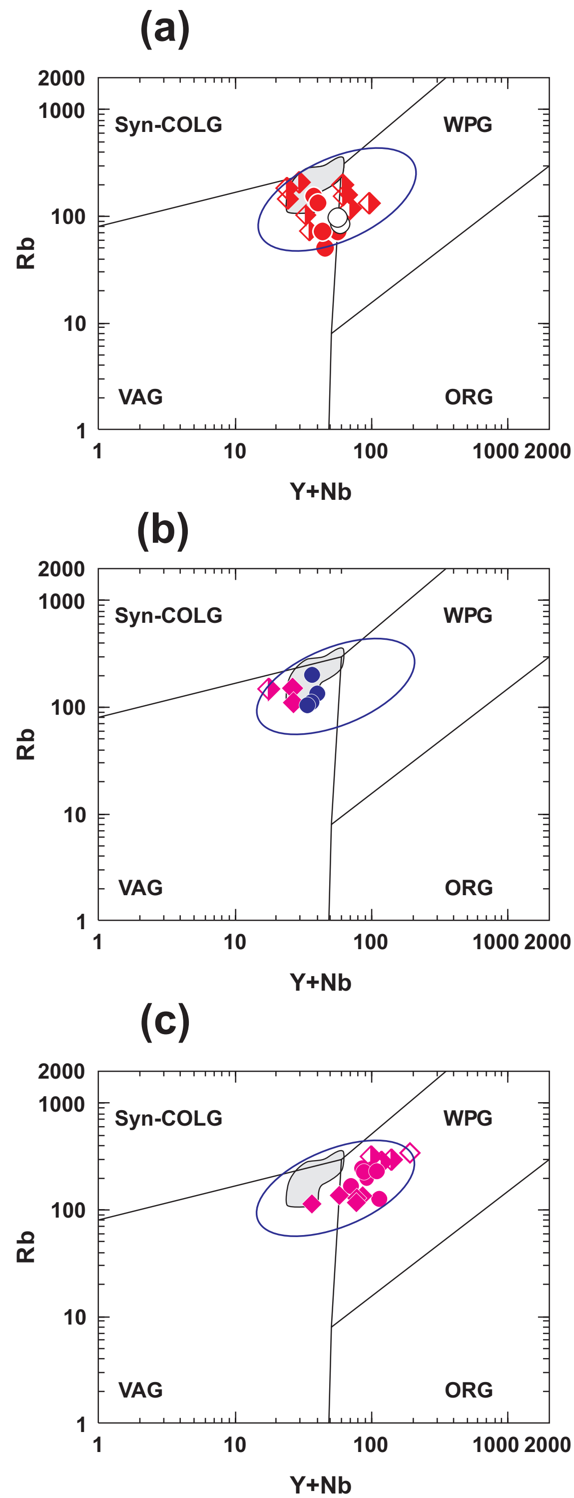

Figure 12. Rubidium vs. Yittrium + Niobium values for unaltered Cretaceous plutonic rocks of Southern British Columbia. Tectonic setting boundaries are from Pearce *et al.* (1984). The field for metaluminous Tombstone-tungsten suite plutons and dikes is shown (Murphy, 1997). 12a) Goldstream and Bigmouth samples, 12b) Anstey and unnamed Shuswap bodies in the vicinity of the Bizar-Goldstrike mineral occurrence, 12c) Battle Range Batholith samples, with symbols as in Figure 4 . Symbols for Goldstream Pluton are solid circle = hornblende diorite, diamonds = biotite granite; open circle = Bigmouth Pluton.

Dave Lefebure improved an earlier version of this manuscript and Verna Vilkos's help with the Figures is muchly appreciated. This study is part of a larger program investigating the potential for plutonic-related gold deposit in British Columbia.

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