Investigations of Orogenic Gold Deposits in the Cariboo Gold District, East-Central British Columbia: Progress Report

David A. Rhys[1], James K. Mortensen[2] and Katherina Ross[1]
([1] Panterra Geoservices Inc., <panterra@shaw.ca>; [2] University of British Columbia, <jmortensen@eos.ubc.ca>)

INTRODUCTION

The famous Cariboo Gold Rush in east-central BC was triggered by the discovery of rich placer gold deposits on several creeks in the Likely and Wells-Barkerville areas between 1859 and 1862. This area has subsequently yielded an estimated 2.5 to 3 million ounces (80 to 96 tonnes) of placer gold, roughly half of BC's total historic placer gold production. Gold-bearing orogenic gold-quartz veins and associated pyritic replacement deposits in metamorphic rocks of the Barkerville Terrane were discovered soon after placer mining began and have produced approximately 1.2 million ounces (38.3 tonnes) of gold since that time. Lode gold exploration continues both in the Wells-Barkerville area and in structurally higher rock units of the Quesnel Terrane farther to the south and west, where the Spanish Mountain and Frasergold deposits occur. Together with the Wells/Barkerville camp, the Spanish Mountain and Frasergold deposits, and several other areas of gold prospects along and adjacent to placer-bearing creeks in both the Barkerville and Quesnel Terranes define the Cariboo Gold District (CGD).

In August 2008 a one-year, reconnaissance scale project was initiated in the CGD, funded by three companies (International Wayside Gold Mines, Skygold Ventures and Hawthorne Gold Corp.) with matching funds from Geoscience BC. The goal of the project is to better understand the nature and origin of orogenic gold vein systems in the main mineralized portions of the CGD, and builds on extensive structural, mineralogical and textural work that has been carried out previously by Rhys and Ross (2001), as well as a large number of mainly thematic studies in the area by other previous workers. The new study includes additional surface mapping and structural work (especially in the Spanish Mountain area), coupled with petrologic studies, Ar-Ar and U-Pb geochronology and Pb isotopic analysis. When completed, the results of the new work will provide a detailed framework for the timing of gold mineralization in different parts of the CGD and the structural and possible lithological controls on mineralization. This poster summarizes some of the field and petrographic observations that have come out of the study thus far, along with new geochronological and Pb isotopic results. A full report on the preliminary results of the study will be published in Geoscience BC Summary of Activities 2008 (Report 2009-1; release date Jan 28, 2009).

WELLS-BARKERVILLE CAMP

The Wells-Barkerville camp is by far the most important gold producing camp within the CGD, having been the source of virtually all historical lode gold production and much of the placer production from the district. Lode gold production in the camp has come from the Cariboo Gold Quartz, Island Mountain and Mosquito Creek mines, which collectively define a single, shallow northwest plunging mineralizing system that is developed over a 4.5 km strike length, from which 1.23 million ounces of gold have been produced. Gold mineralization exhibits both strong structural and stratigraphic control, and is developed mainly within 150 m of the northeast-dipping contact between interbedded quartzite, sericite phyllite and limestone of the Downey Succession to the northeast ("Baker" unit in mine terminology), and carbonaceous metaturbiditic rocks of the Hardscrabble Succession to the southwest ("Rainbow" unit). Showings and deposits continue for a further 10 km to the southeast from the Cariboo Gold Quartz Mine in the same stratigraphic position (e.g., Warspite, Hard Cash, Antler Mountain; Fig. 1). Mineralization is of two varieties, replacement and vein mineralization, which occur together within a broad zone of diffuse Fe-carbonate-sericite alteration and high D2 strain.

REPLACEMENT MINERALIZATION IN THE WELLS-BARKERVILLE CAMP

Replacement mineralization occurs within limestone at the Mosuito Creek and Island Mountain mines in the northwestern portion of the camp, where it comprises multiple small (500-40,000 tonnes), manto-like, folded, northwest plunging, rod-shaped bodies of massive, fine-grained py > Fe-carbonate + qtz that replace limestone bands within 25 m of the structural base of the Downey (Baker unit) Succession. Approximately 32% of lode production from the camp was from this mineralization type. Ore shoots plunge parallel to axes of, and are spatially associated with hinge zones of, mesoscopic D2 folds. Highest Au grades are associated with fine grained pyrite within which Au occurs as grains along crystal boundaries and fractures.

Replacement mineralization of similar character at the Bonanza Ledge Zone SE of the Cariboo Gold Quartz-Mosquito system. However, the Bonanza Ledge Zone is hosted by, and replaces thinly bedded metaturbidites of the Hardscrabble Succession that are approximately 500m structurally lower than the Rainbow-Baker contact area which hosts replacement mineralization in the Mosquito and Island Mountain mines. Mineralization in the Bonanza Ledge Zone occurs in discrete areas of massive, banded and veinlet pyrite within a 20-100 m wide zone of intense sericite-Fe Mg-carbonate-pyrite alteration. High grade mineralization (5-80 g/t Au) occurs in areas locally more than 30 m thick comprising 10-70% pyrite in a gangue of muscovite, dolomite-ankerite and quartz, forming at least two crudely shallow plunging zones. Au occurs as 2.5-60 mm native grains on fractures or grain boundaries in pyrite with galena and chalcopyrite, or encapsulated in pyrite.

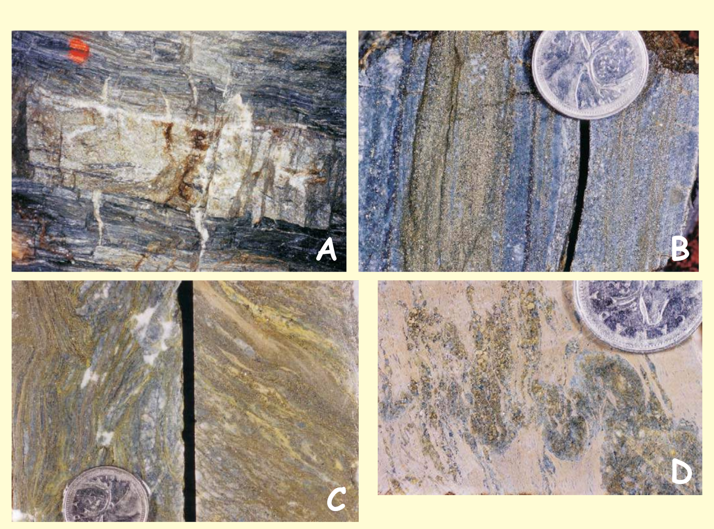

Figure 2: Style of replacement mineralization in the Wells-Barkerville camp. A: Band of pyrite replacement mineralization in the foliated limestone of the Baker unit, Mosquito Creek mine. Field of view 2 m. B: Detail of fine-grained banded pyritic replacement mineralization in blue-grey dolomitized limestone from the Mosquito mine. C: Typical replacement style pyritic mineralization from the Bonanza Ledge Zone, showing fine grained pervasively disseminated pyrite lamina and bands which alternate with dolomitic (left) and tan sericite altered (right) matrix. Protolith was calcareous siltstone (left) and mudstone (right). D: Mauve colored purple-grey peripheral sericite alteration to the Bonanza Ledge Zone containing ptygmatically folded pyrite-pyrrhotite veinlets.

Figure 3. Folded early quartz-carbonate vein with muscovite envelopes, Mosquito Mine, 4400 level. Vein is within lower portions of the Baker limestone. Field of view is 1.2 m, view southwest of drift wall.

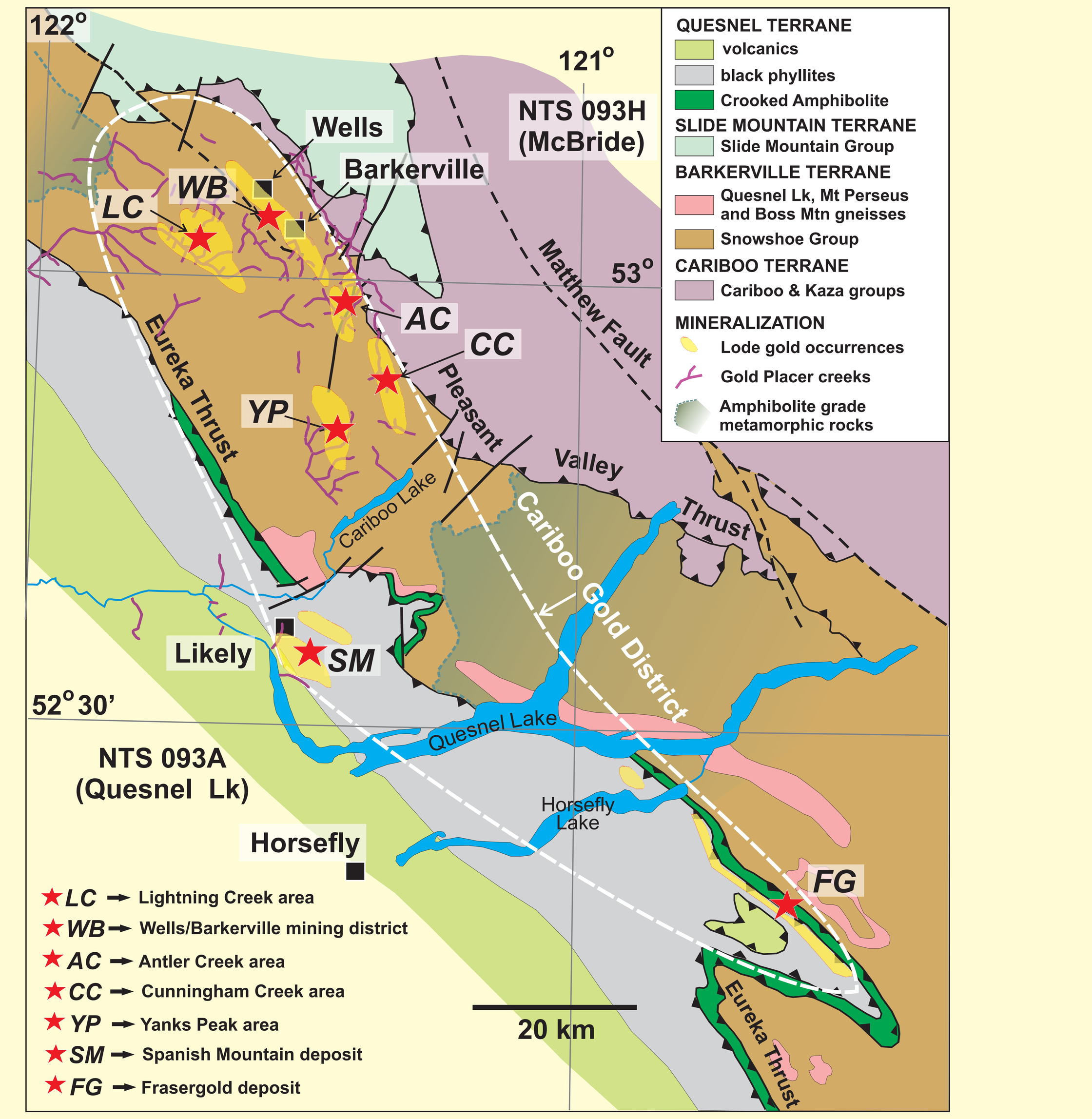

Figure 1. Regional geological setting of the Cariboo Gold District, showing principal terranes and major lithologic packages. Areas of known lode gold occurrences are shaded in yellow, and placer gold producing creeks are indicated by thick purple lines. Principal known gold-producing areas in the Barkerville Terrane are in areas of greenschist grade metamorphism, and do not extend into amphibolite grade domains

QUARTZ VEIN MINERALIZATION IN THE WELLS-BARKERVILLE CAMP

At least two stages of quartz veining occur in the Wells-Barkerville camp, comprising an early poorly mineralized and deformed set of veins which are cut by auriferous, late tectonic quartz-carbonate-pyrite veins. The early veins (Fig. 3) are moderately NE-dipping, variably deformed qtz +/- Fe-carbonate +/- musc veins. The veins range up to 1 m thick, are boudinaged and folded, and laterally discontinuous along strike and affected by most or all D2 strain. These veins contain only background or low (<2 g/t) gold concentrations. In contrast, main stage quartz veins associated with gold mineralization (Fig. 4) are structurally late and post-date all D1 and much or all D2 strain in the region. They have been the source of approximately 68% of the lode gold production in the Wells-Barkerville Camp. Although individual veins are discordant to stratigraphy, the vein systems as a whole are stratabound and generally confined to 150-250 m of stratigraphy within grey pelitic to psammitic phyllite of the Rainbow unit over the entire >4 km length of the system. The favorable portions of the Rainbow unit lie immediately adjacent to, and southwest of the Rainbow-Baker contact area where replacement mineralization is developed, and veins frequently extend up to or into the same horizons as the replacement mineralization.

The auriferous veins comprise E-W trending, steeply dipping, low displacement sinistral shear veins ("diagonal veins") with strike lengths of 20-150 m and coeval, sheeted sets of northeast trending extension veins ("orthogonal" or "transverse" veins) that together form complex vein arrays. Veins consist of white qtz + py with Fe-carbonate +/- musc selvages and pyritic cores. Native gold occurs in association with pyrite, and locally cosalite and bismuthinite. Adjacent to replacement mineralization, the veins typically cut across it, although in some locations extension veins may emanate off the margins of pyrite replacement zones. The structural style of veins is dominantly brittle, but local stylolitic pressure solution seams, sinistral shear bands, and sigmoidal shapes to extension veins support local semi-brittle behavior during vein formation. The veins postdate most D2 strain and cut across F2 fold closures; however, they are kinematically consistent with formation in response to NE-SW directed D2 shortening, collectively suggesting a late D2 timing.

A third type of auriferous quartz vein is the "strike" or "A" vein type, which are more continuous, fault hosted, NW-trending and steep NE dipping shear veins to the SE of the Cariboo Gold Quartz mine near the Bonanza Ledge Zone. The largest vein of this type is the BC vein (Fig. 5), which has been traced in outcrop and drilling for 800 meters, is locally >30 m thick, and is localized in carbonaceous phyllite termed the BC unit, that lies approximately 500 m southwest of the Rainbow-Baker contact. The Bonanza Ledge Zone occurs between immediately within, and for up to 50 m into, its footwall.

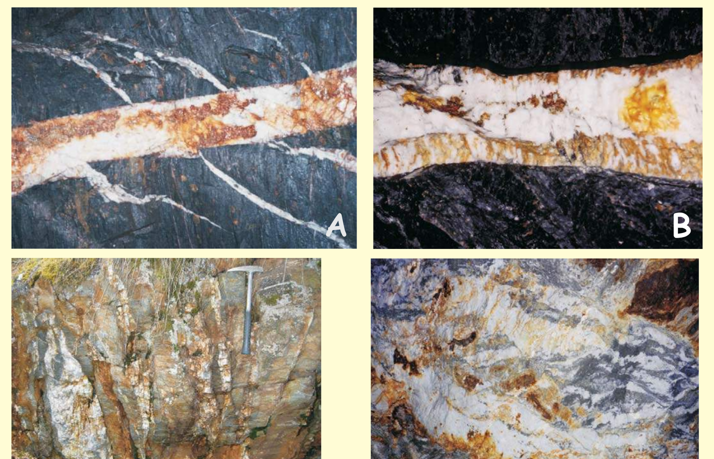

Figure 4: Main stage auriferous quartz vein systems in the Wells-Barkerville area. A: ENE-trending quartz vein in contains clots of coarse, partially oxidized pyrite, and is obliquely joined by north-northeast trending extensional veins. Field of view = 2 m, Cariboo Gold Quartz mine. B: Mineralized quartz-pyrite fault-fill, east-west trending diagonal vein, Mosquito Creek Mine. Vein is approximately 0.8 m thick. Grey banding in the vein is pyrite. C: Sheeted NE-trending qtz > py + Fe-carbonate extension veins on the SE side of Williams Creek at the Blackjack prospect near Barkerville. View is to the NE. D: NE-trending extensional ("transverse") vein in the Cariboo Gold Quartz mine. Vein is 0.3 m thick.

Figure 5: Surface exposure of the BC vein, a major "strike" vein, looking southeast. This thick, northwest-trending fault-fill vein hosts several oreshoots and lies directly adjacent to the Bonanza Ledge zone. Note person for scale (right).

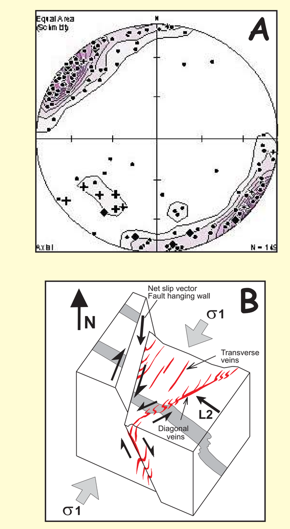

Figure 6: Geometries of auriferous veins in the Wells-Barkerville area. A: Equal area projection of poles to quartz veins in the central Wells-Barkerville gold system. Data is from underground workings and surface exposures in the Cariboo Gold Quartz and Mosquito Creek mines, and at surface along Lowhee Creek. Symbols are as follows: small dots = extension veins; diamonds = diagonal veins, large crosses = BC vein. Note the dominant steep northeast trends to extensional veins. Data is from Rhys and Ross (2001) with additional data collected in 2008. B: Block model illustrating interpreted relationships between the principal auriferous vein sets and north-trending dextral > east side down faults in response to inclined northeast-southwest directed shortening.

Sample No.	Rock Type and Location	Interpreted $^{40}Ar/^{39}Ar$ Age
BL-073	Baker unit, sericitic quartzite, Lowhee Creek	Rising spectrum to ~153 Ma (re-run rising spectrum to ~150 Ma)
BL-135	Rainbow 2 unit (upper) 1500 Level Cariboo Gold Quartz Mine; muscovite-quartz-carbonate phyllite	146.6 ± 1.1 Ma (poor plateau)
BL-122A	Deformed pre-mineral vein, 1200 Level Cariboo Gold Quartz Mine; muscovite coating fractures and in vein envelopes	153.7 ± 0.9 Ma (good plateau)
BL-130	Deformed pre-mineral vein, from Myrtle Prospect trenches	155.2 ± 1.0 Ma (excellent plateau)
BL-086	Baker unit, north Lowhee Creek, muscovite-quartz phyllite in hanging wall of Bonanza Ledge zone	151.5 ± 0.8 Ma (good plateau)
BL-043	Fuchsite bearing Fe-carbonate, muscovite alteration of calcareous mudstone along Lowhee Creek	151.5 ± 0.8 Ma (excellent plateau)
BL-133-4	4400 Level Mosquito Creek Mine; banded fine grained ankerite-pyrite replacement ore	148.5 ± 1.0 Ma (excellent plateau)
2K-31, 211-1	Replacement ore, Bonanza Ledge Zone; banded muscovite-pyrite phyllite with coarse pyrite-Fe-carbonate bands	138.2 ± 0.8 Ma (good plateau)
BL-134-1	Replacement ore, Bonanza Ledge zone; muscovite phyllite with disseminated pyrite	Rising spectra to ~142 Ma (re-run 135.5 ± 0.8 Ma; partial plateau)
BL-002	Muscovite phyllite with oxidized pyrite porphyroblasts in hangingwall of Bonanza Ledge Zone	142.8 ± 0.8 Ma (good plateau)
BL-125-1	Diagonal quartz vein, 1200 Level Cariboo Gold Quartz Mine; clots of coarse randomly oriented muscovite within vein	147.6 ± 0.8 Ma (good plateau)
BL-129-1	Extensional quartz vein, 4400 Level NW of Mosquito Creek Mine; coarse muscovite on envelope to vein	141.4 ± 0.8 Ma (excellent plateau)
BL-128-1	Extensional quartz vein, 4400 Level SW of Mosquito Creek Mine; randomly oriented coarse muscovite	142.6 ± 0.8 Ma (excellent plateau)

Table 1. Summary of 40Ar/39Ar ages for muscovite from early and late quartz veins and host schists from the Wells-Barkerville camp. Muscovite in host rock schist and associated with early, deformed quartz veins tend to give slightly older ages (>146.6 Ma), whereas muscovites from within replacement style and extensional vein style gold ore give largely overlapping ages in the range of 138.5-147.6 Ma. We suggest that the 40Ar/39Ar muscovite ages are probably close to the age of formation, and do not reflect slow cooling of the Barkerville Terrane as a whole, which would suggest that the last significant metamorphic event that affected the region associated with the D2 event occurred in Late Jurassic to earliest Cretaceous time, and most or all of the gold mineralization in the Wells-Barkerville area formed at roughly the same time or very slightly later.

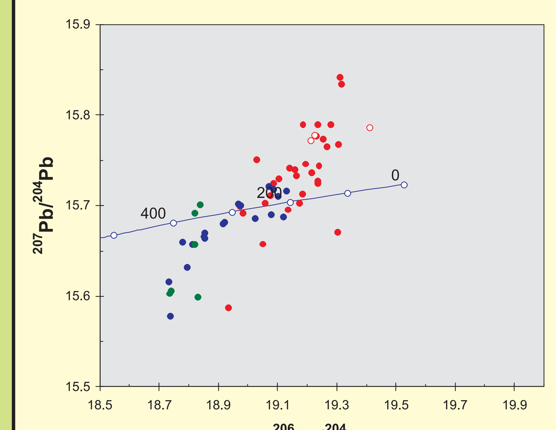

Figure 7. Lead isotopic compositions of sulphides from gold-bearing veins (solid red circles) and replacements (open red circles) in the Wells-Barkerville camp, veins in the Spanish Mountain area (solid blue circles) and veins in the Frasergold deposit (solid green circles). The "shale curve" of Godwin and Sinclair (1982) is shown for reference. The data are consistent with our interpretation that all presently recognized styles of mineralization in these three areas are roughly similar in age. The data also indicates that the metals in styles of gold mineralization in the CGD are dominantly crustally derived.

SPANISH MOUNTAIN DEPOSIT

The Spanish Mountain deposit occurs within the black phyllite package of the Quesnel Terrane, approximately 3 km east of its probable thrust contact with overlying mafic volcanic rocks of the Nicola Group to the southwest (Spanish Thrust, Fig. 1). The deposit is hosted by interbedded slaty to phyllitic, dark grey to black siltstone, carbonaceous mudstone, greywacke, and minor conglomerate. The sedimentary units are locally intruded by plagioclase +/- quartz-phyric dykes and sills; these occur commonly in the Lower Argillite at the structural base of the carbonaceous phyllite sequence (Fig. 8). These sills are affected by all phases of folding, alteration, and quartz vein mineralization (Fig. 8). Locally irregular outlines to the contacts of these sills, and brecciation on their finer-grained margins that may represent peperitic textures suggest that they may have been intruded into unconsolidated sediments. Five separate samples of the intrusions have yielded U-Pb zircon ages of 185.6 +/-1.5 to 187 +/- 0.8 Ma.

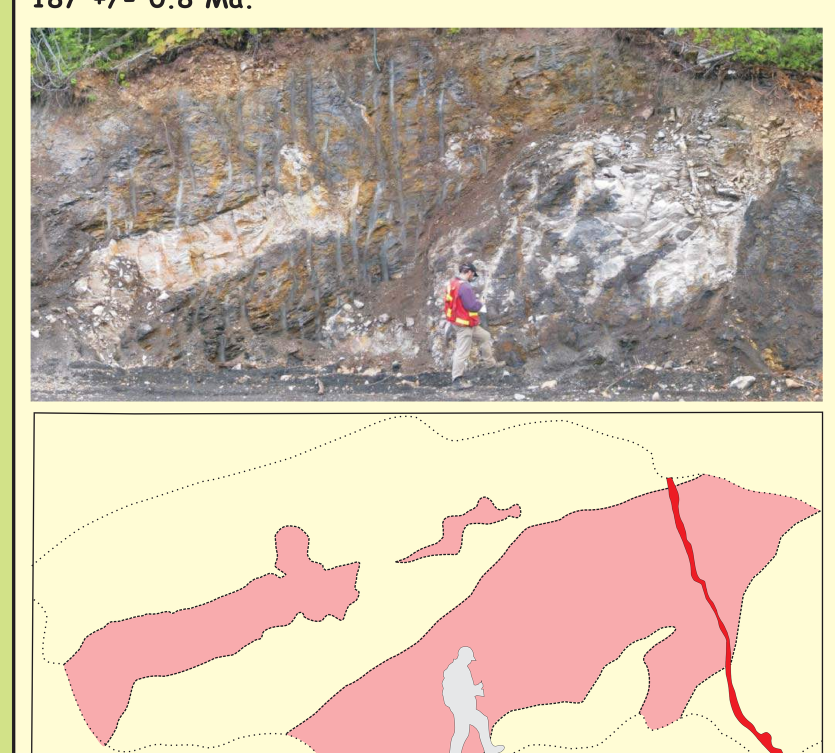

Figure 89: View to the southwest of a drill cut out in lower portions of the carbonaceous phyllite sequence on Spanish Mountain. The photo illustrates two concordant, deformed, and S1 parallel porphyritic sills (in pink in the inset), which are cut by northwest trending, steep northwest dipping quartz extension veins (shown in red).

MINERALIZATION AT SPANISH MOUNTAIN

The Spanish Mountain deposit is a bulk tonnage gold system that also includes local higher grade gold-bearing quartz veins. The most economically significant gold mineralization (>1 g/t Au) occurs in wide zones (10-135 m) hosted dominantly within the black argillite/ siltstone, and to a lesser extent in greywacke, often straddling the contact. These zones may occur as a set of stacked, roughly lensoidal zones which at a local scale are stratabound and spread most widely along carbonaceous phyllite ("argillite") units, but at a deposit scale are stacked and linked, defining a overall northerly elongate mineralizing system which is developed discordantly across several stratigraphic horizons. The largest zone identified to date is the "Main Zone", which has been traced by drilling over a strike length of approximately 1.3 km, and width of 500 m. The "Lower Zone" occurs beneath the Main Zone, in the structurally lower, carbonaceous argillite unit of the same name. The smaller, less well defined North Zone occurs in the structurally highest carbonaceous unit.

The second mineralizing event is associated with tectonically late quartz veins and faults that share similarities with the dominant, late vein-related gold mineralization episode in the Barkerville Terrane. They cut the folded early quartz-pyrite veins described above and are most often manifested by sets of sheeted, northeast trending and steep northwest dipping qtz ± Fe-carbonate extension veins <5 cm thick that may contain minor pyrite, galena, sphalerite and tetrahedrite. In surface exposures, base metals were noted most abundantly in veins within the North Zone. Sheeted extension veins are typically spaced from a meter to several meters apart in mineralized carbonaceous phyllite. Vein densities are commonly much higher in sandstone and in feldspar or quartz phyric sills.

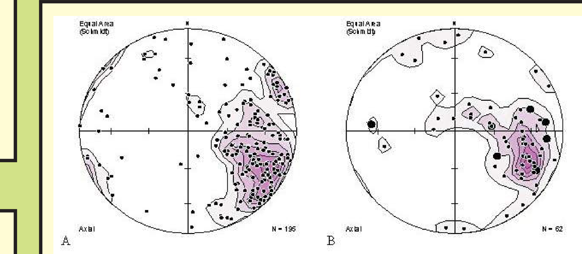

Figure 9: Equal area projections of poles to orientations of quartz veins in the Spanish Mountain deposit. A: Quartz veins less than 5 cm thick. B: Quartz veins >5 cm thick, including fault hosted and shear veins. Large dots = ribboned shear veins, mainly from the North Zone.

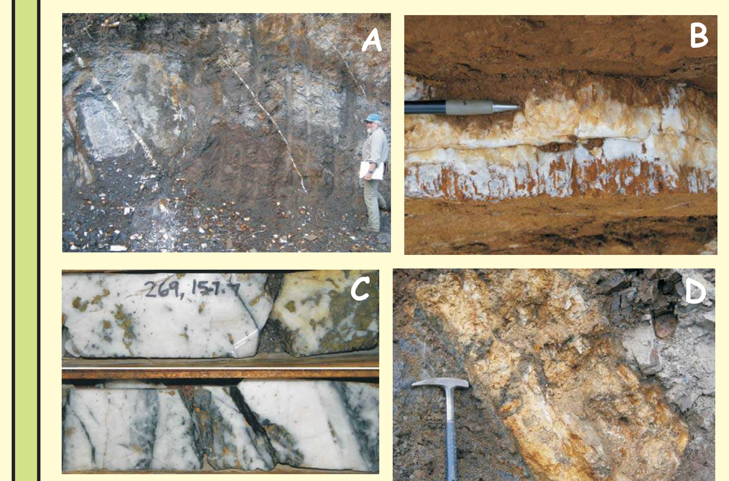

Figure 10: Spanish Mountain auriferous quartz veins. A: Sheeted northwest dipping quartz extension veins hosted by carbonaceous phyllite in the Main zone surface exposures, view southwest. B: Extension vein in sill hosted by the southern siltstone sequence shows paragenesis from early massive quartz-pyrite in core. C: Brecciated, friable rusty quartz vein in northerly trending, west dipping fault. View south, Main zone exposures. D: High grade (23.9 g/t Au) ribboned quartz shear vein with pyrite clots (above) and carbonaceous-pyritic black slip surfaces and breccia bands (below) in a fault zone.

FRASERGOLD DEPOSIT

The Frasergold property, located approximately 60 km SE of Spanish Mountain, covers an ~10 km long, northwest-trending area of mineralized prospects along the northeast limb of the Eureka Peak syncline (Fig. 1). Mineralization at Frasergold is hosted by the same general sequence of Triassic metasedimentary rocks and contain the same distinctive coarse Fe-carbonate porphyroblasts that occur at Spanish Mountain. Gold mineralization at Frasergold occurs within, or is spatially associated with stratabound sets of white quartz >> Fe-carbonate + muscovite + pyrite veins that are developed in the "knotted" Fe-carbonate porphyroblastic carbonaceous phyllite unit. The veins form complex sets that are developed in concentrated zones several meters to tens of meters wide which collectively dip to the southwest (Fig. 11) and which form a bulk tonnage low grade gold deposit. Quartz veins within mineralized zones at Frasergold comprise mainly subparallel, approximately S0/S1 parallel (concordant) quartz veins and veinlets. These veins are affected by both D1 and D2 strain, and are commonly transposed and boudinaged in the plane of S1, locally with the development of internal S1-parallel stylolites. The veins are affected by F2 folds, and vary in orientation across F2 fold limbs, although generally are within or close to parallel to S0/S1. Larger, 15-50 cm thick quartz-carbonate veins that are developed at moderate to high angles to S0/S1 are also associated with the concordant veins. Highest gold grades (>3 g/t Au) commonly occur associated with the larger veins where they contain abundant Fe-carbonate + pyrite. Gold occurs both as relatively coarse, free grains associated with masses of Fe-carbonate, pyrite and/or pyrrhotite within the veins, and also as fine grains within quartz near vein margins.

Figure 11: Style of deformed vein systems in the Frasergold deposit. A: Stratabound deformed quartz veins in outcrop near Grouse Creek. S2 foliation is parallel to the rock hammer, and axial planar to folds of the veins. View NW. B: Folded, concordant extension veins; view SE in underground workings; field of view 2 m. C: A banded, southwest dipping discordant vein, at lower right, is joined in its hangingwall by folded, narrower semi-concordant quartz extension veins. Although folded by F2 folds, the veins in the hangingwall of the larger vein display geometries compatible with development as sigmoidal extension vein arrays in the hangingwall of a larger shear vein. View northwest in underground workings. D: Larger, steeply dipping 0.5 m wide white quartz veins with auriferous orange-brown Fe-carbonate >> pyrite bands. View SE in underground workings.

ACKNOWLEDGMENTS

This project is funded by Geoscience British Columbia with the matching support of Hawthorne Gold Corporation, Skygold Ventures Ltd. and International Wayside Gold Mines. The authors are extremely grateful to the hospitality, logistical support and access provided by all three of these companies during the 2008 fieldwork.