Characterization of Placer- and Lode-Gold Grains as an Exploration Tool in East-Central British Columbia (NTS 093A, B, G, H)

J.K. Mortensen, Department of Earth and Ocean Sciences, University of British Columbia, Vancouver, BC, jmortensen@eos.ubc.ca

R. Chapman, University of Leeds, United Kingdom

Mortensen, J.K. and Chapman, R. (2010): Characterization of placer- and lode-gold grains as an exploration tool in east-central British Columbia (NTS 093A, B, G, H); *in* Geoscience BC Summary of Activities 2009, Geoscience BC, Report 2010-1, p. 65–76.

Introduction

The famous Cariboo gold rush in east-central British Columbia was triggered by the discovery of rich placer-gold deposits on several creeks in the Likely and Wells–Barkerville areas (Figure 1) between 1859 and 1862. This area has subsequently yielded an estimated 2.5 to 3 million ounces (80–96 tonnes) of placer gold (e.g., Levson and Giles, 1993), which represents roughly half of BC's total historic placer-gold production. Numerous gold-bearing orogenic quartz veins and associated pyritic mantos were discovered in medium-grade metamorphic rocks of the Barkerville Terrane in the Wells–Barkerville area (Figure 1) soon after placer mining began, and have since produced approximately 1.2 million ounces (38.3 tonnes) of gold. Although these lode deposits were probably the source of much of the placer gold in the immediate area (e.g., Johnston and Uglow, 1926), the ultimate bedrock source(s) of much of the placer gold elsewhere in this part of BC has (have) still not been conclusively identified. Other styles of lode gold known to be present in this region include vein-hosted and disseminated gold in low-grade metasedimentary units of the Quesnel Terrane (e.g., Spanish Mountain and Frasergold deposits) and these occurrences, together with those in the Wells–Barkerville area, are referred to as the 'Cariboo gold district' (CGD; Rhys et al., 2009; Figure 1). Farther to the west, volcanic strata and intrusive rocks of the Quesnel Terrane (Figure 1) host porphyry Cu-Au and skarn Au deposits such as Mount Polley and QR, respectively, and potentially other styles of lode-gold mineralization. Active mineral exploration is ongoing in this area and in similar rocks along strike to the north. Airborne geophysical surveys and parallel silt and lake-sediment geochemical studies carried out as part of the QUEST Project by Geoscience BC cover much of the CGD and initial results of the new work have already generated an increased level of exploration activity in this region.

A study by Rhys et al. (2009) of orogenic gold in the CGD, which comprises the Wells–Barkerville mining camp and vicinity in the Barkerville Terrane, and the Spanish Mountain and Frasergold deposit areas in the Quesnel Terrane (Figure 1), has provided an improved understanding of the nature and age of orogenic gold mineralization throughout much of the CGD and, in particular, has shed new light on the structural controls on mineralization in various parts of the CGD and relationships between the various styles of lode-gold mineralization.

Attempting to match the alloy composition of placer-gold grains determined using an electron microprobe with compositions of known lode occurrences in the same vicinity ('geochemical fingerprinting') has previously been used as an exploration tool in many localities, including the Cariboo district (e.g., McTaggart and Knight, 1993; Knight et al., 1999a; Townley et al., 2003; Chapman, 2007). Over the past several years, a much more comprehensive approach for examining the relationships between placer and lode gold has been developed, based on extensive work in the Klondike gold district in western Yukon and in several other localities worldwide (e.g., Chapman and Mortensen, 2006; Mortensen et al., 2006). In this study of relationships between placer and lode gold, a number of different tools were used to determine not only the major-element but also the trace-element compositions of gold from placers and their potential lode sources using both electron microprobe and laser ablation inductively coupled plasma–mass spectrometry (ICP-MS) methods. Other analyses focused on examining and characterizing the mineral-microinclusion suites present within placer and lode gold and carrying out quantitative studies of the evolution of the shapes of placer-gold grains as they are transported in an alluvial-fluvial environment. Use of this much broader array of tools to resolve the problem of relationships between placer and lode gold in a particular region has led to the development of considerably more unique fingerprints for placer gold, which makes it possible to more closely match placer-gold grains with very specific lode sources. In addition, work

Keywords: *Cariboo gold district, gold, placer, lode, composition, exploration*

This publication is also available, free of charge, as colour digital files in Adobe Acrobat® PDF format from the Geoscience BC website: http://www.geosciencebc.com/s/DataReleases.asp.

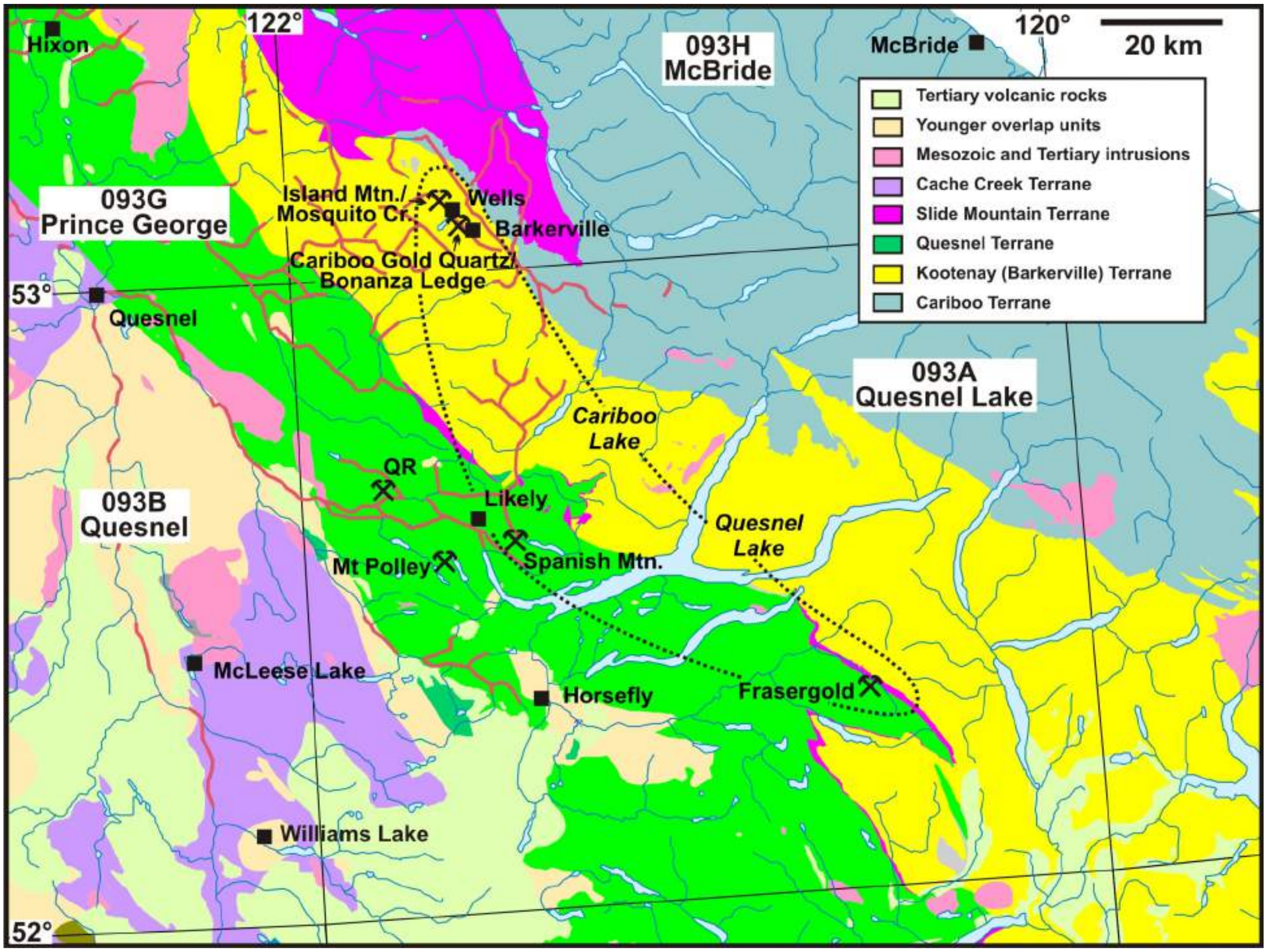

Figure 1. Regional geology of the study area in east-central British Columbia, showing locations of the Cariboo gold district (dotted black line), significant known lode-gold and Cu-Au deposits (mine symbols), and significant placer streams (red lines).

done on the evolution of the shapes of gold grains during transport (Crawford, 2007) shows great promise in producing realistic and relatively precise estimates of the distance a particular set of placer-gold grains has travelled from its lode source. The results of these studies have direct applicability to gold exploration programs. Specific questions that can be addressed using this approach include

How many individual populations of gold (presumed to be derived from different lode sources) are present within a single sample of placer gold based on the sample's alloy composition and/or shape?

What is the most probable style of lode-gold mineralization from which each population was derived, compared to established global compositional fingerprints for gold from different styles of mineralization?

What distance has each compositional population travelled on the basis of average grain shape?

Based on a single sample of placer gold from near the outlet of a drainage basin, one can then evaluate

- what style(s) of lode gold are present within that drainage basin;
- how far down the drainage system each population of gold in the sample has travelled after liberation from its source; and
- whether the alloy compositions and shapes of all of the placer-gold grains can be entirely explained by derivation from known lode sources in the drainage basin or, alternatively, whether other lode sources contributed to the placer.

In the latter case, it is also possible to speculate on the style of mineralization which remains to be discovered in situ. However, numerous complicating factors must be considered in any interpretation, including

Has the area been glaciated or not, and if so, what is the exact nature of the unconsolidated material from which the placer gold was derived (e.g., fluvial, glaciofluvial or till) and what was the direction of glacial transport?

Are the host sediments first-cycle deposits or have they potentially been reworked following drainage reversals or modifications?

Despite these potential complications, characterization of placer gold has been used effectively to guide lode exploration in many parts of the world, including the Klondike district in Yukon (e.g., Knight et al., 1999a, b; Chapman and Mortensen, 2006; Mortensen et al., 2006), Great Britain and Europe (Chapman, 2007; Chapman et. al., 2009), and the Otago Schist belt in New Zealand (Youngson and Craw, 1995). This type of information can be obtained at an early stage in a reconnaissance exploration program, at a relatively low cost.

Research Goals

The current project involves a one-year reconnaissance study of placer- and lode-gold compositions from a large area in east-central BC, including both the CGD and a large region to the west and northwest (Figure 1). This study builds directly on earlier work in the area by McTaggart and Knight (1993; discussed below). A total of approximately 1600 placer-gold grains were collected from 34 separate localities during 2009; together with a large number of additional placer- and lode-gold samples from other sources, these samples will be used to constrain relationships between placer and lode gold in the study area. The main goals of the project are to develop more unique microgeochemical 'fingerprints' for each of the known lode-gold occurrences in the region based on major- and trace-element geochemistry and mineral-microinclusion suites, as well as to evaluate the distribution and likely source(s) of gold with similar signatures in as many placer deposits in the region as possible. It is expected that the work will validate this approach to the study of relationships between placer and lode gold in east-central BC and provide a preliminary assessment of the nature of, and potential for, undiscovered lode sources within the study area. These outcomes will have direct implications for ongoing mineral exploration in this part of BC. Results of this study could later be applied on a regional basis to help with reconnaissance of the less well-explored area to the northwest, which was recently investigated by airborne geophysical and geochemical surveys as part of Geoscience BC's QUEST and QUEST-West projects. Placer-gold deposits are known to be widely distributed throughout this large region; however, few if any significant gold (or gold-bearing) lode sources have been identified thus far. A detailed study of the placer gold in various deposits could provide valuable insights into what style(s) of lode source contributed to each placer deposit, and some indication of their location.

Regional Geological Setting

The study area is underlain by parts of five main terranes (Figure 1). Bedrock in most of the northern and eastern parts of the area comprises metamorphic rocks of the Barkerville Terrane and the structurally overlying Cariboo Terrane. Both the Barkerville and Cariboo terranes in the northern part of the area have been overthrust by mainly mafic volcanic rocks of the Slide Mountain Terrane. The southwestern margin of the Barkerville Terrane is structurally overlain by Middle and Late Triassic volcanic and sedimentary rocks of the Quesnellia Terrane (Figure 1). Still farther to the southwest are mafic volcanic rocks and associated pelagic sedimentary units of the Cache Creek Terrane. A variety of intermediate to felsic intrusions of Mesozoic to Early Tertiary-age plutons occur throughout the area. Parts of the study area are overlain by Tertiary and younger sedimentary and volcanic cover (Figure 1).

Placer-gold deposits in the study area have been described by Levson and Giles (1993). East-central BC was strongly glaciated during the Pleistocene and surficial deposits include a wide range of glacial materials, and alluvial-fluvial deposits from both pre- and postglacial streams. The placer geology in some portions of the study area is further complicated by the fact that several different drainage systems are superimposed on one another and the exact position of the older drainage systems is not well understood. Placer gold in portions of the study area occurs as placer deposits derived directly from relatively local lode sources, but also as deposits that have been reworked from older stream deposits (in some cases still preserved in raised channels, as in the Spanish Mountain area; Figure 1), as deposits dispersed within glacial deposits, and in postglacial streams that may in part be reworking gold from glacially dispersed older placer deposits (e.g., the Hixon area; Figure 1; Levson and Giles, 1993). Interpretation of relationships between placer and lode gold in the study area is therefore not straightforward. Placer gold in major drainages is likely to have a more complex origin than that of placer gold near the headwaters of streams, where there is a greater likelihood that the gold is a primary deposit eroded directly from a local lode source.

Lode- and Placer-Gold Deposits in East-Central BC

The study area covers a variety of known lode-gold occurrences, including both orogenic gold-vein systems in the CGD (comprising the Wells–Barkerville mining camp, together with the Spanish Mountain and Frasergold deposits, and several other areas of gold prospects along and adjacent to placer-gold–bearing creeks in this area), and porphyry Cu-Au deposits, such as Mount Polley, and other intrusion-related deposits, such as the QR skarn Au deposit (Figure 1). Several distinct, but probably related, styles of orogenic gold mineralization have been recognized in the CGD (Rhys et al., 2009). Gold-bearing extensional quartz (±carbonate) veins, in some cases associated with dextral shear zones, hosted by low- to medium-grade phyllite and schist are the most typical style of lode gold within the Barkerville Terrane. This style of mineralization occurs in many localities within the immediate Wells–Barkerville area as well as the Yanks Peak area north of Cariboo Lake (Figure 1), and was the main type of ore mined at the Mosquito Creek, Island Mountain and Cariboo Gold Quartz mines in the Wells area. Gold-bearing pyritic replacement ('manto-style') mineralization also occurs in the Wells area, where it accounted for roughly one third of the lode production. The other two main centres of orogenic gold mineralization in the CGD comprise quartz (±carbonate) veins and vein breccias hosted by Middle to Late Triassic, low-grade, phyllitic metasedimentary rocks that make up the structurally lower portion of the Quesnellia Terrane, which has been thrust northeastward over the Barkerville Terrane. This style of mineralization is currently being explored in the Spanish Mountain deposit southeast of Likely and in the Frasergold deposit, which is approximately 50 km east of Horsefly (Figure 1). Some gold at the Spanish Mountain deposit also occurs with pyrite disseminated within the host phyllite. Published BC MINFILE descriptions of small lode-gold occurrences northeast of Hixon, in the northwestern corner of the study area (Figure 1), indicate that the mineralization may be similar to that at Spanish Mountain.

Historic and current placer-gold workings are present throughout much of the western part of the study area, and the main currently held placer properties are shown on Figure 1. The fact that placer deposits are present in the immediate vicinity of all of the main known lode-gold sources in the region means this area is ideal for evaluating the relationships between placer gold and the various styles of lode gold, and for developing well-characterized microchemical signatures for each type of lode deposit.

Previous Gold Compositional Studies in East-Central BC

A compositional study of placer- and some lode-gold deposits and occurrences in the Cariboo area of east-central BC was carried out by McTaggart and Knight (1993), mainly with funding from the BC Geological Survey. They analyzed gold from a total of 47 placer-gold samples from throughout the region, as well as 18 lode-gold samples (a total of some 3700 individual analyses). Most of the placer samples had been donated from active placer operations set on major placer streams, although a small proportion of samples had been collected in the middle or upper reaches of streams. They also did a limited amount of scanning electron microscope (SEM) work to characterize features such as the presence and nature of high-fineness rims on placer grains (fineness = (Au/[Au + Ag] * 1000)), but the study was based mainly on major- and minor-element concentrations determined using an electron microprobe. Although a very large amount of analytical data was generated by the study, no detailed analysis or interpretation of the data was ever completed and preliminary conclusions were not sufficiently detailed to provide specific constraints for future exploration in the region.

McTaggart and Knight (1993) recognized several distinct compositional populations for placer and lode gold in the region, based mainly on calculated fineness and, to a lesser extent, on measured Hg content of the Au. Their main conclusions about these compositional populations were

- relatively high-fineness (900–950) gold was characteristic of quartz veins in the Wells–Barkerville mining camp and of most of the placers in that area, and farther to the west;
- gold in pyritic replacement-style deposits in the Wells–Barkerville mining camp has considerably lower fineness (850–875), is typically much finer-grained than gold in quartz veins in the same area and has been only rarely seen in placer deposits;
- gold from the Proserpine and Warspite quartz-vein occurrences southeast of Barkerville has a somewhat different composition, with samples from these lodes yielding measured fineness values of 830–890, which indicates that their composition more closely resembles that of the replacement-style mineralization in the main Wells–Barkerville mining camp; and
- lode gold from quartz veins in the Spanish Mountain deposit area and placer gold in streams in the Likely area nearby have distinctly lower fineness values (750–810) than the lode deposits and associated placers farther east in the Barkerville Terrane.

2009 Placer Sampling

A total of 34 new placer-gold samples were collected during the 2009 field season, using gold pans and a portable test sluice. Sampling in 2009 was hampered by relatively high-water conditions during the fieldwork (Figures 2a, b). Placer sampling in east-central BC is also made difficult by the preponderance of low-gradient streams, deep overburden and current paucity of active placer operations allowing ready access to gold-bearing gravel deposits. Despite these obstacles, an excellent suite of placer-gold samples was obtained from sites throughout the CGD and other scattered localities farther to the west and northwest.

Preliminary Results

Samples obtained during the 2009 field season are currently being prepared for analysis. However, analysis of bulk lode-gold samples from the CGD, which were collected during field studies of orogenic gold in the area (Rhys et al., 2009), and gold grains in polished thin sections (K. Ross, unpublished petrographic studies, 2008) has been completed. In addition, the entire dataset generated by the McTaggart and Knight (1993) study has been digitized and this data is currently being re-evaluated and re-interpreted in light of recent re-interpretations (Rhys et al., 2009) of the nature and distribution of orogenic gold in the CGD. The entire suite of gold samples previously studied by

Figure 2. Collecting placer-gold samples in east-central British Columbia, using **A)** panning methods and **B)** a portable test sluice and hand pump.

McTaggart and Knight (1993) has been re-examined using SEM and energy dispersive spectroscopy (EDS) methods to identify and quantify the mineral-microinclusion suites present in each sample.

Figures 3a and b show lode- and placer-gold compositional data from the Wells–Barkerville area of the CGD. Cumulative percentile plots are used to portray the compositional range(s) of the various samples, instead of the simple histograms used by McTaggart and Knight (1993). This method allows straightforward interrogation of data from individual samples; for example, the data for the Burns Mountain lode sample in Figure 3a shows three distinct compositional populations corresponding to 'steps' in the cumulative percentile plot for Ag from this sample at 10, 12 and 15–17% Ag. These relatively subtle variations in composition are nearly impossible to recognize using simple histogram representations of the data. In addition, when using cumulative percentile plots data from a large number of samples can be plotted on the same diagram (e.g., Fig-

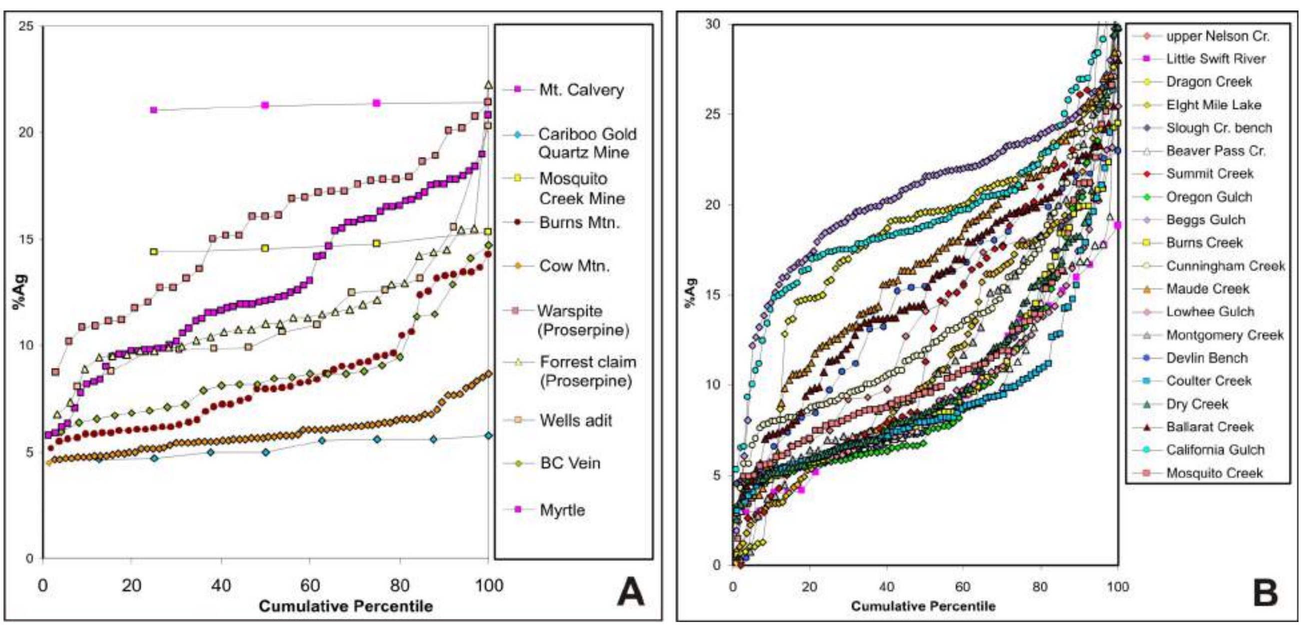

Figure 3. Compositions of **A)** lode gold and **B)** placer gold from the Wells–Barkerville area of the Cariboo gold district, in east-central British Columbia, expressed as cumulative percentile plots of Ag contents. Specific lode occurrences are veins that were sampled by McTaggart and Knight (1993).

ure 3b), which allows direct comparison of the compositional signatures from various sources.

Preliminary results and sampling strategies for specific parts of the study area are discussed in detail below.

Wells–Barkerville Area

Figure 4 presents the simplified geology of the Wells–Barkerville area, showing the locations of the main mines and other significant lode-gold occurrences. Also shown are the locations of placer- and lode-gold samples from the McTaggart and Knight (1993) study, as well as new placer- and lode-gold samples collected during this study. The data for lode gold from various occurrences in the Wells–Barkerville mining camp in Figure 3a clearly shows significant and recognizable differences between the compositions of gold from various lode sources in this area. By comparing the compositions of placer gold in streams in the vicinity of these lode sources, one can immediately begin to evaluate the contribution of gold from the different lode sources into individual placer deposits. Current work focuses on assessing the compositional data from lodes and placers in terms of past drainage patterns in the area, and specifically attempting to determine whether all of the gold in each placer sample could have been derived entirely from known lode occurrences within that drainage system or whether there are other, still undiscovered lode sources to be found. The McTaggart and Knight (1993) dataset is too limited for most of the drainages to be able to make definite conclusions about this; because most of these samples came from active placer operations in main-trunk streams, they are likely to show mixed compositional signatures resulting from the presence of gold from more than one lode source. Placer sampling during 2009 focused on samples from nearer to the heads of streams, where gold is likely to be derived from a single lode occurrence or group of related occurrences.

An example of how the placer and lode compositional data can be used to constrain the source(s) of gold in a specific placer deposit is shown in Figure 5, which compares the compositional range of a sample of placer gold from the middle reaches of Cunningham Creek (in the southeastern part of the area shown in Figure 4) with that of gold from the Hibernia lode occurrence approximately 5 km upstream

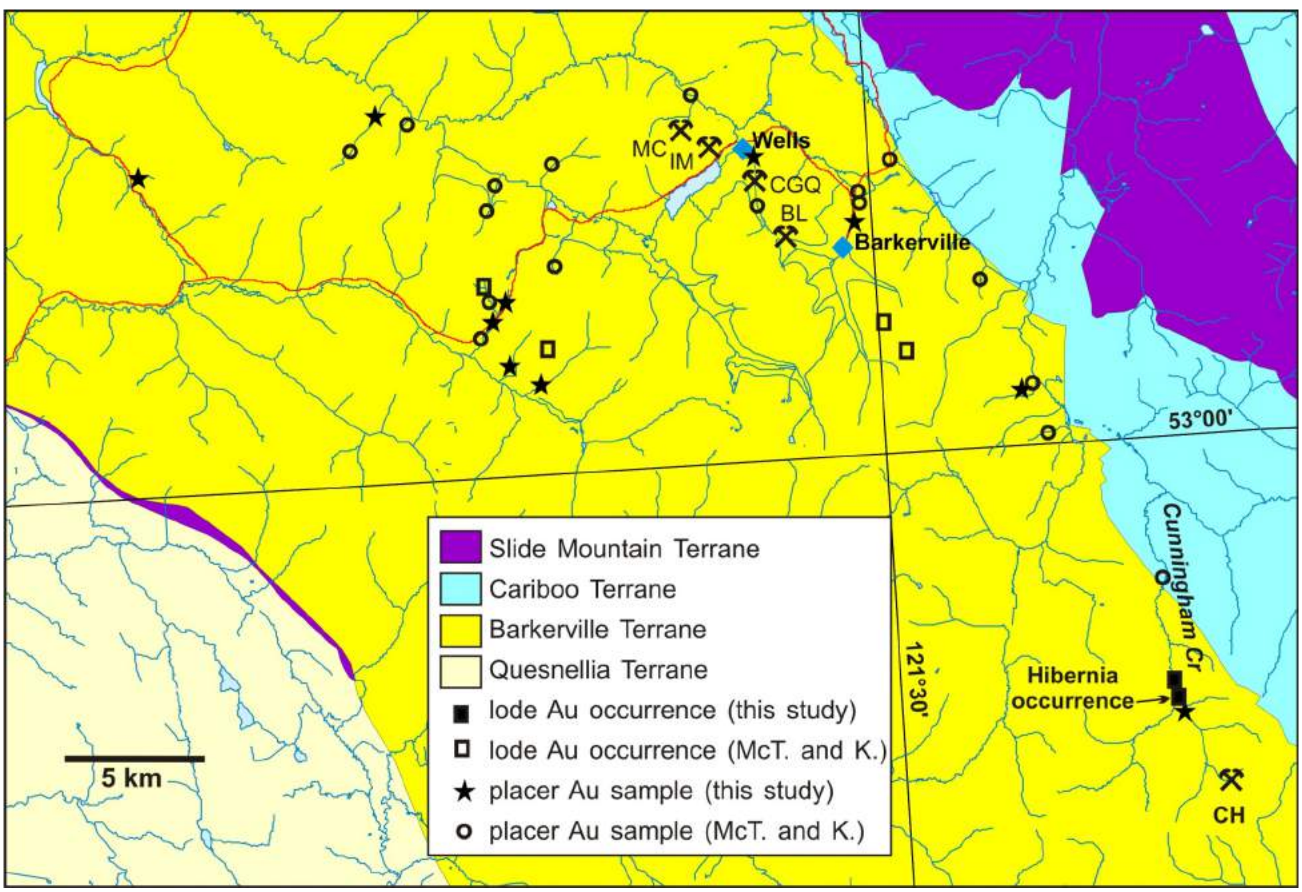

Figure 4. Simplified geology of the Wells–Barkerville and Cunningham Creek areas, east-central British Columbia, showing previous (McTaggart and Knight, 1993) and new (this study) lode- and placer-gold sampling localities. Past-producing gold mines and significant lode occurrences include Mosquito Creek mine (MC), Island Mountain mine (IM), Cariboo gold quartz mine (CGQ), Bonanza Ledge deposit (BL) and Cariboo Hudson mine (CH).

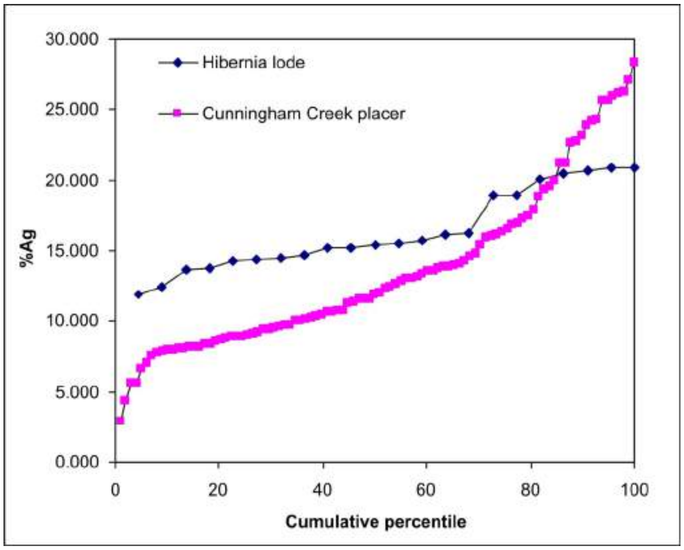

Figure 5. Comparison of compositions of gold from the Hibernia lode on upper Cunningham Creek (this study) with a placer-gold sample from the middle reaches of Cunningham Creek (data from McTaggart and Knight, 1993), east-central British Columbia.

from the placer locality. Gold in the Hibernia lode shows a narrow range of compositions (possibly two separate populations) between 12 and 20% Ag. Although a substantial portion of the gold in the Cunningham Creek placer sample gives compositions that are similar to gold from the Hibernia lode, more than half of the placer sample comprises gold with Ag contents that differ significantly from the Hibernia lode. This indicates either that there is greater compositional diversity in the Hibernia and related vein systems than is indicated by this single sample or that other undiscovered lode sources contributed gold to the placer deposit.

Likely–Cariboo Lake Area

Figure 6 presents the simplified geology map of the Likely–Cariboo Lake area, showing the locations of the Spanish Mountain deposit and the Midas adit in the Yanks Peak area north of Cariboo Lake (lode

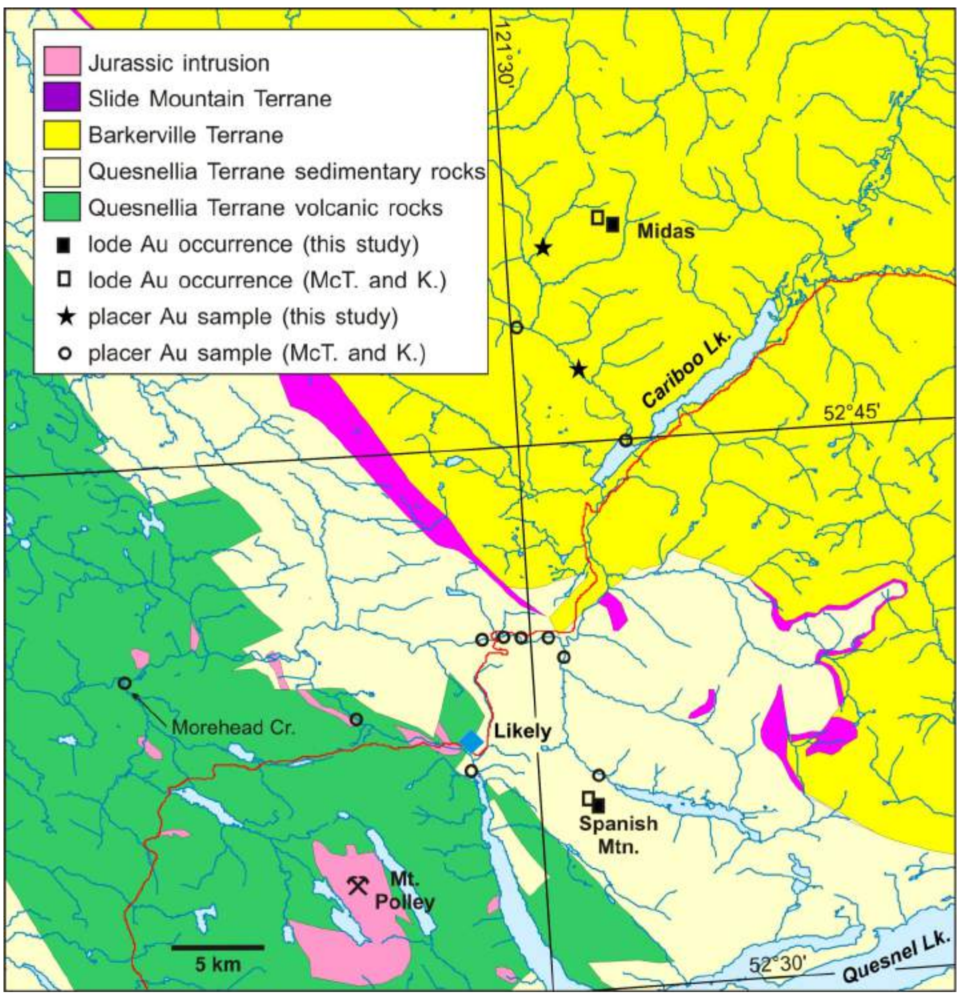

Figure 6. Simplified geology of the Likely–Cariboo Lake area, east-central British Columbia, showing previous (McTaggart and Knight, 1993) and new (this study) placer- and lode-gold occurrences.

samples), as well as previous and new placer sampling localities.

The compositional data for lode occurrences (Figure 7) demonstrates the very limited range of compositions (13–14% Ag) from the Midas vein occurrence in the Barkerville Terrane, as compared to that of veins in the Spanish Mountain deposit (18–27% Ag). Most of the placer-gold grains analyzed in the two Spanish Creek placer samples (data from McTaggart and Knight, 1993) yielded expected compositions, consistent with having been derived from Spanish Mountain veins; however, approximately 30% of the grains yielded much lower Ag contents, which suggests that they are more similar in composition to lode gold from the Cow Mountain area (including the Cariboo Gold Quartz mine; Figure 3a). It appears likely that a component of Barkerville Terrane gold, more specifically a Cow Mountain-Cariboo Gold Quartz–type component, has been incorporated into the Spanish Creek placer, perhaps via an earlier west- or southwest-directed drainage system.

Frasergold Area

A significant lode-gold resource has been established at the Frasergold deposit, approximately 52 km east of Horsefly. The geology of this area is shown in Figure 8.

Gold-bearing veins at the Frasergold deposit are hosted within the same package of Quesnellia Terrane, Middle to Late Triassic, phyllitic sedimentary rocks as that which hosts the Spanish Mountain deposit; however, veins at Frasergold are the product of an earlier veining event than that at Spanish Mountain (Rhys et al., 2009). The composition of lode gold at Frasergold is also distinctly different from that at Spanish Mountain, although this is based on a limited number of analyses (Figure 7). Gold grains at Frasergold have Ag contents of 26–34%, whereas those from several different veins at Spanish Mountain range from 18–27% Ag. This suggests that it may be possible to discriminate between early Frasergold-type vein systems and later Spanish Mountain-type veins on the basis of the alloy composition.

There are no currently active placer leases anywhere in the area shown in Figure 8; however, anecdotal information indicates that some placer deposits are known in the area (the Frasergold deposit was discovered by tracing placer gold up the MacKay River). Of the three placer-gold samples collected from the Frasergold area (Figure 8), two come from small tributaries draining into the MacKay River from the slope on which the Frasergold deposit was located and the third is from the MacKay River itself, at a point approximately 8 km downstream from the deposit. These three samples should provide an excellent representation of the range of gold compositions in the Frasergold deposit and associated occurrences in the area. Rhys et al. (2009) pointed out that two other mineral occurrences in the area (Kusk and Tep 1 [or Forks], MINFILE 093A 061 and 093A 092, respectively; MINFILE, 2009; Figure 8) closely resemble the Frasergold deposit in terms of hostrocks, as well as style of mineralization and alteration. This correlation could be further tested by comparing the composition of gold obtained from veins, local placers or heavy-mineral samples in these two occurrences with that of the gold at the Frasergold deposit.

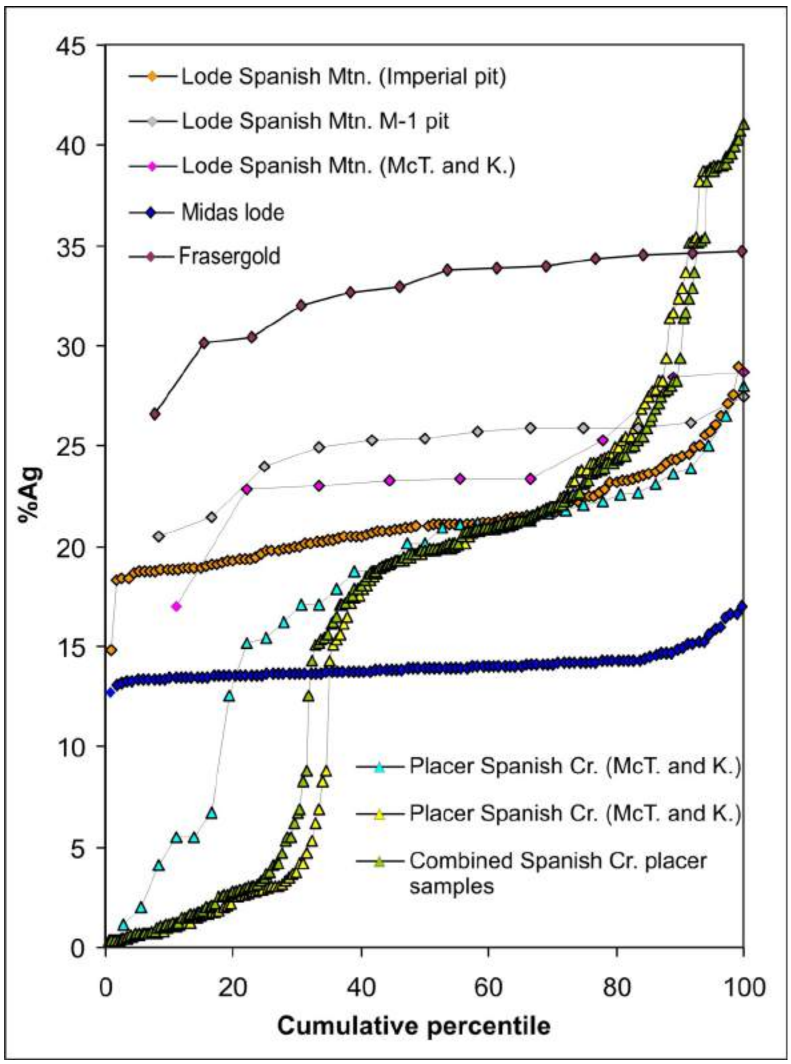

Figure 7. Compositional ranges from gold in veins at the Spanish Mountain deposit, the Midas adit (Yanks Peak area north of Cariboo Lake) and the Frasergold deposit, east-central British Columbia, and two separate placer samples from the Spanish Creek placer immediately downstream from the Spanish Mountain deposit (data from McTaggart and Knight, 1993).

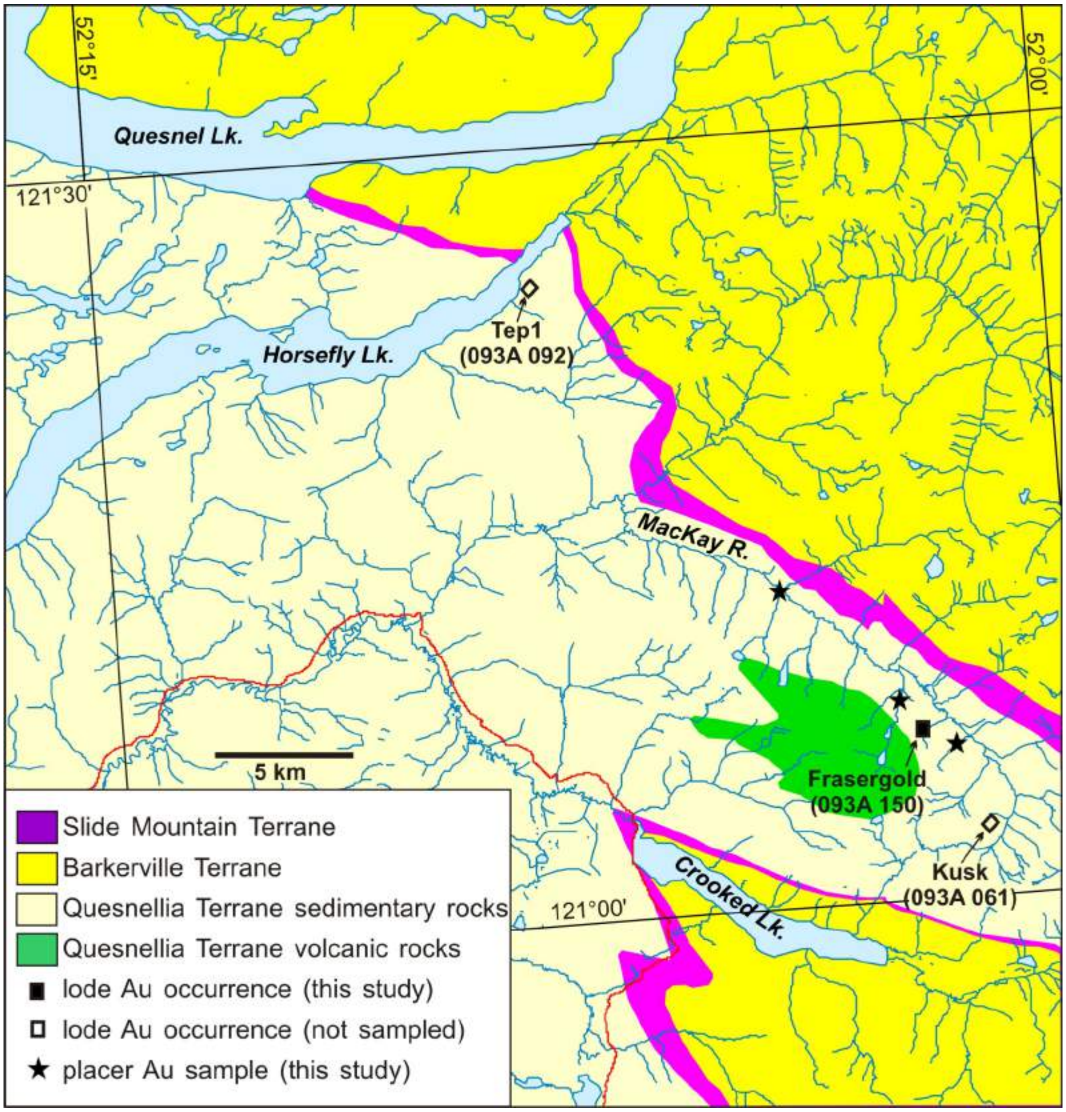

Figure 8. Simplified geology of the Quesnel Lake–Crooked Lake area, east-central British Columbia, showing the location of the Frasergold deposit and two geologically similar occurrences (Kusk and Tep 1), and placer-gold samples collected during 2009.

Hixon Area

Placer deposits have been mined on Hixon Creek and its tributaries in the extreme northwest corner of the study area (Figure 1) for many years. The geology of the Hixon area is shown in Figure 9, together with the locations of placer- and lode-gold occurrences, currently valid placer leases in the area, and the locations of a placer sample previously collected by McTaggart and Knight (1993) and one collected during this study.

The nature of the lode source(s) from which gold in the Hixon Creek placer deposits was derived has not been resolved. Several lode occurrences immediately upstream from the Hixon Creek placer are hosted within the same Middle to Late Triassic black phyllite package that hosts the Spanish Mountain and Frasergold deposits to the southeast, or in greenstones that are interpreted to be part of the Triassic volcanic package of Quesnellia. This includes the Quesnel Quartz occurrence (MINFILE 093G 015), which produced a small amount of gold in the 1930s, and the Cayenne occurrence (MINFILE 093G 014). Both of these occurrences comprise quartz-vein systems in foliated schist and greenstone of the Quesnellia Terrane (Allan, 1984; MINFILE, 2009). The Pioneer occurrence (MINFILE 093G 013), situated on an upstream tributary into Hixon Creek (Figure 9), comprises quartz veins within Triassic black phyllite of Quesnellia. Although it was mined on a very small scale for Pb, Zn and Ag in the 1920s, the veins are also anomalous for gold, which indicates they resemble those at Spanish Mountain. An alternative interpretation of the origin of the placer gold on Hixon Creek might be that it is derived from presently unrecognized epithermal-vein occurrences in the area. This is a possibility because the relatively high Ag contents of most of the gold analyzed from

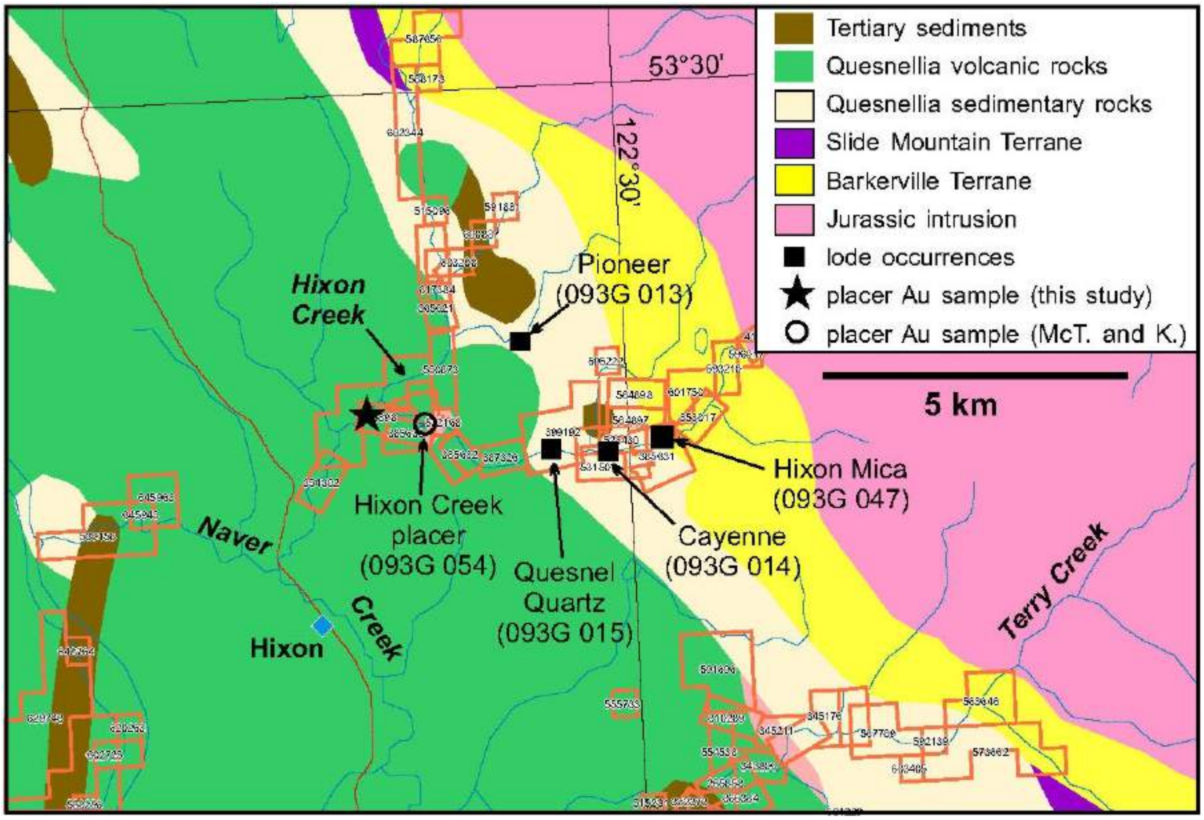

Figure 9. Simplified geology of the Hixon area, east-central British Columbia; currently valid placer leases are shown as red boxes.

Hixon Creek and the range of Ag contents (Figure 10) overall can be suggestive of an epithermal environment (Chapman and Mortensen, 2006). However, the close association of the Hixon Creek placers with Spanish Mountain (or Frasergold)–type gold-bearing veins within phyllite of Quesnellia strongly suggests that mineralization analogous to that at Spanish Mountain or Frasergold is present in the area. The forthcoming examination of the inclusion assemblages present in gold from Hixon Creek may assist in determining the origin of the gold. No inclusions that would be diagnostic of a particular style of mineralization were identified in the sample of fine gold that was collected by McTaggart and Knight (1993). Placer gold is also present on Naver Creek approximately 15 km southeast of Hixon Creek, in an area also underlain by black phyllite of Quesnellia (Figure 9). No lode-gold occurrences are presently known in that area; however, the inference that gold in the Hixon Creek area is likely derived from Spanish Mountain- or Frasergold-type–lode occurrences suggests that exploration for similar mineralization in the Naver Creek area is warranted.

Mineral Microinclusions in Gold

Preliminary results of SEM and EDS examination of the mineral microinclusions present in the placer- and lode-gold samples from the McTaggart and Knight (1993) sample suite show that, although inclusions are relatively rare in many of the grains (especially the finer placer grains), there is a general correlation between the inclusion suites present in the placer gold and the specific mineralogy of the lode sources from which the gold is thought to have been derived (e.g., argentite, sulpharsenide minerals and pyrite in lodes and placers in the Spanish Mountain area, and a strong bismuth signature—including Bi sulphide, sulpharsenide and carbonate minerals—in lodes and placers in the immediate vicinity of Wells). The results of detailed petrographic work on lode-gold occurrences throughout the CGD, now underway as part of the Rhys et al. (2009) study of orogenic gold in the CGD, will assist in providing a more complete evaluation of the micro-inclusion suite.

Discussion

Preliminary results of this study suggest that distinct signatures can be established for various styles of lode gold in the study area based on gold-alloy composition and, to some extent, on the mineral-microinclusion suite present. Significant compositional variations exist, even within individual mining camps (e.g., the Wells–Barkerville mining camp; Figure 3a), and these differences may make it possible to

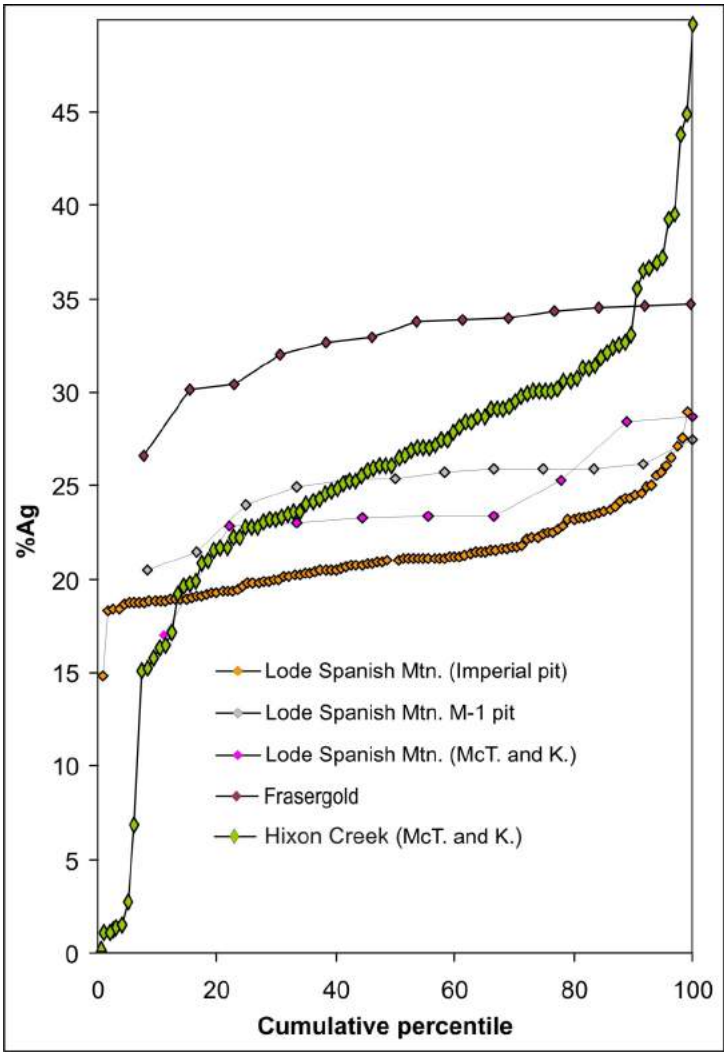

Figure 10. Comparison of compositions of lode gold from the Spanish Mountain and Frasergold deposits with placer gold from Hixon Creek, east-central British Columbia.

constrain the specific vein occurrences from which individual placer deposits were derived. However, this outcome will require that considerably more detailed sampling be undertaken, especially focusing on placer occurrences in the upper reaches of gold-bearing streams. In addition, gold samples must be obtained from more of the lode occurrences in the region to further develop the compositional 'fingerprint' of specific mineral occurrences.

Compositional information for gold from the Mount Polley porphyry Cu-Au deposit or the QR skarn Au deposit (Figure 1) is not yet available. A significant amount of Cu is likely to be present in Au from the Mount Polley deposit and, if so, this may serve to discriminate between Au from porphyry systems and that from orogenic vein systems in the area, which contain no measurable Cu. Work by Stanley (1993) on Cu:Au ratios in many of the alkalic porphyry Cu-Au deposits in the Canadian Cordillera suggested that two separate mineralizing processes commonly occurred in many of these systems, one characterized by a moderate Cu:Au ratio and one by a low Cu:Au ratio. Gold deposits formed during these processes are also expected to show significant compositional differences. The nature of, and relationships between, these two mineralizing processes is not clear. The relatively Au-rich phase has in many instances been interpreted to have formed after the more Cu-rich phase, possibly related to a late, lower temperature hydrothermal event or to local post-mineral remobilization (e.g., Stanley, 1993; Sillitoe, 1993). In any case, two quite different compositions of gold may be present within the Mount Polley and similar deposits. Gold in the Mount Polley and similar deposits is likely to be very fine grained and may tend not to be concentrated in adjacent placer deposits; instead, gold placers such as are found in the vicinity of Mount Polley may be related to associated but more distal styles of mineralization, which contain coarser grained gold.

The Mount Polley deposit occurs in an area of relatively subdued topography with mainly low-gradient drainages. For this reason, placer deposits that might be related to Mount Polley, if present, are extremely difficult to sample using hand methods, and new placer samples from this area could not be obtained. One sample previously analyzed by McTaggart and Knight (1993) from near the mouth of Morehead Creek (Figure 6) could potentially contain gold derived from the Mount Polley area, although Mount Polley lies approximately 16 km to the southeast of the sample locality. In addition, the placer sample was collected near the mouth of Morehead Creek, and may simply be gold that was reworked from raised benches along the Quesnel River. Compositional data for the Morehead Creek sample (not shown) closely resembles that of placer gold in the Wells–Barkerville mining camp, suggesting that it was likely derived from lodes in the Barkerville Terrane to the east rather than from occurrences in the Mount Polley area. However, there are current placer leases farther up Morehead Creek that may contain gold from the Mount Polley area. Gold grains that have been identified in suites of polished thin sections from previous studies of Mount Polley mineralization by personnel from the Mineral Deposit Research Unit at the University of British Columbia will be analyzed to establish the compositional signature of this mineralization; in addition, gold will be separated from samples of gold-bearing ore from the QR skarn Au deposit to determine the signature of this style of mineralization.

Planned Outcomes for the Project

The three main products expected from the study are

a complete characterization of the alloy composition and microinclusion suite for each type of lode gold examined, which will provide a template to identify the source(s) of various placer-gold populations for use in future studies of the region;

an interpretation of the most probable source of gold in each placer sample, together with documentation of the compositional data itself (in digital form) for archiving; and

a discussion of the implications of the new data for future lode exploration in the study area and elsewhere in the QUEST Project area.

Acknowledgments

The authors thank K. Hickey for a critical review of an early draft of the paper.

References

Allan, J.R. (1984): 1983 Summary report: Hixon Creek gold project; BC Ministry of Energy, Mines and Petroleum Resources, Assessment Report 12 129, 35 p.

Chapman, R.J. (2007): An overview of gold mineralization in the Caledonides of Great Britain and Ireland: insights from placer gold geochemistry (abstract); Proceedings of the 9th Biennial SGA Meeting, C.J. Andrew (ed.), Society for Geology Applied to Mineral Deposits, Dublin, p. 943–946.

Chapman, R.J. and Mortensen, J.K. (2006): Application of microchemical characterization of placer gold grains to exploration for epithermal gold mineralization in regions of poor exposure; Journal of Geochemical Exploration, v. 91, p. 1–26.

Chapman, R.J., Leake, R.C., Bond, D.P.G., Stedra, V. and Fairgrieve, B. (2009): Chemical and mineralogical signatures of gold formed in oxidizing chloride hydrothermal systems and their significance within populations of placer gold grains collected during reconnaissance; Economic Geology, v. 104, no. 4, p. 563–585.

Crawford, E. (2007): Klondike placer gold—new tools for examining morphology, composition and crystallinity; M.Sc. thesis, University of British Columbia, 100 p.

Johnston, W.A. and Uglow, W.L. (1926): Placer and vein deposits of Barkerville, Cariboo District, British Columbia; Geological Survey of Canada, Memoir 149, 246 p.

Knight, J.B., Mortensen, J.K. and Morison, S.R. (1999a): Lode and placer gold composition in the Klondike District, Yukon Territory, Canada: implications for the nature and genesis of Klondike placer and lode gold deposits; Economic Geology, v. 94, p. 649–664.

Knight, J.B., Mortensen, J.K. and Morison, S.R. (1999b): The relationship between placer gold particle shape, rimming and distance of fluvial transport as exemplified by gold from the Klondike, Yukon Territory, Canada; Economic Geology, v. 94, p. 635–648.

Levson, V.M. and Giles, T.R. (1993): Geology of Tertiary and Quaternary gold-bearing placers in the Cariboo region, British Columbia (93A, B, G, H); BC Ministry of Energy, Mines and Petroleum Resources, Bulletin 89, 202 p.

McTaggart, K.C. and Knight, J. (1993): Geochemistry of lode and placer gold in the Cariboo District, BC; BC Ministry of Energy, Mines and Petroleum Resources, Open File 1993-30, 25 p.

MINFILE (2009): MINFILE BC mineral deposits database; BC Ministry of Energy, Mines and Petroleum Resources, URL <http://minfile.ca/> [November 2009].

Mortensen, J.K., Chapman, R., LeBarge, W. and Crawford, E. (2006): Compositional studies of placer and lode gold from western Yukon: implications for lode sources; *in* Yukon Exploration and Geology 2005, D.S. Emond, G.D. Bradshaw, L.L. Lewis and L.H. Weston (ed.), Yukon Geological Survey, p. 247–255.

Rhys, D.A., Mortensen, J.K. and Ross, K. (2009): Investigations of orogenic gold deposits in the Cariboo gold district, east-central British Columbia (parts of NTS 093A, H): progress report; *in* Geoscience BC Summary of Activities 2008, Geoscience BC, Report 2009-1, p. 49–74.

Sillitoe, R.H. (1993): Gold-rich porphyry copper deposits: geological model and exploration implications; *in* Mineral Deposit Modelling, R.V. Kirkham, W.D. Sinclair, R.I. Thorpe and J.M. Duke (ed.), Geological Association of Canada, Special Paper 40, p. 465–478.

Stanley, C.R. (1993): A thermodynamic geochemical model for the coprecipitation of gold and chalcopyrite in alkalic copper-gold deposits; Mineral Deposit Research Unit Annual Technical Report, Department of Geological Sciences, University of British Columbia.

Townley, B.K., Herail, G., Maksaev, V., Palacios, C., de Parseval, P., Sepuldeva, F., Orellana, R., Rivas, P. and Ulloa, C. (2003): Gold grain morphology and composition as an exploration tool: application to gold exploration in covered areas; Geochemistry: Exploration, Environment, Analysis, v. 3, p. 29–38.

Youngson, J.H. and Craw, D. (1995): Evolution of placer gold deposits during regional uplift, central Otago, New Zealand; Economic Geology, v. 90, p. 731–745.