Gold, Granites, and the Geochronology of Bralorne and Bendor

Developing Better Exploration Models for the Bridge River-Bralorne Gold Camp

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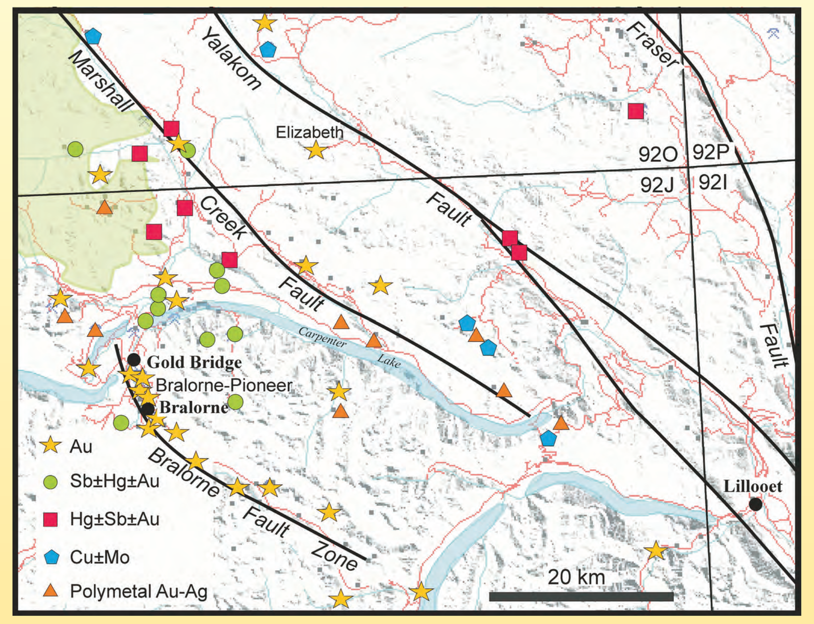
INTRODUCTION

The Problem

Much of the existing age dating of mineralization at Bralorne, and for all of this important district, is imprecise, inaccurate, and difficult to relate to either magmatic, structural, thermal or tectonic events with confidence. It is therefore difficult to generate a district scale ore deposit model upon which to confidently base aggressive exploration efforts.

This project will provide numerous accurate and precise age determinations of several styles of mineralization and of several magmatic phases, in order to construct a robust exploration model that can be related to the magmatic, structural and thermal events that have been previously identified by mapping and past research.



Regional scale map of the broader Bralorne-Bridge River mineral district which contains more than 60 mineral occurrences. Mineral occurrences are broadly zoned with gold-dominated veins in the west, stibnite-dominated veins in the central region, and mercury associated mineralization further east.

Questions Worth Asking

- Was there just one district wide mineralizing event?
- Were there different events for veins of different ore minerals?
- What about this progressive easterly younging of mineralizing events away from the Coast Plutonic Complex?
- Do any of the mineral occurrences have a direct relationship to a specific granite or magmatic event?
- Some (or more) magmatic phase or event(s)?
- What are the vein's relationship to metamorphism from the CPC?
- Are the veins associated with a particular structural event?
- What role does uplift play?
- Is there gold deeper in the stibnite veins? If so, how deep?

PROJECT RATIONALE

The Bralorne-Bridge River mineral district in southwestern British Columbia hosts a large range of epigenetic mineral deposit types, but the region is dominated by the Bralorne-Pioneer orogenic vein system that generated more than 4.1 million ounces of gold from high-grade ores (0.58 opt) between 1897 and 1971 (Church 1996). However, although orogenic gold deposits typically form district scale camps with numerous producers, only a small amount of gold was produced from three other small deposits (Wayside, Congress, Minto). In addition, much of the broader district is dominated by ores that are characterized by gold-poor antimony or mercury mineralization. Many of these small occurrences are recognized as being small, high-level, potentially epithermal occurrences. Most of the suggested deposit models for this region support significant differences between the gold-rich and gold-poor occurrences. This has discouraged aggressive exploration in much of the area except for those veins immediately adjacent to Bralorne-Pioneer system.

An alternative interpretation may be that the stibnite and mercury systems are simply the upper (epizonal) portions of orogenic gold systems (such as Donlin Creek) and that the entire district representative of one large hydrothermal event that should be explored more aggressively for gold resources.

Geochronology is one method to determine if such a model is possible, and is the line of research herein pursued.

REGIONAL EVENTS

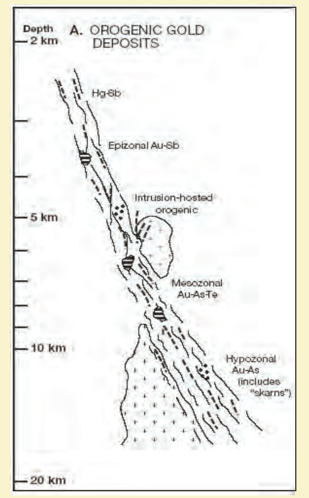
Where do the Bralone-Pioneer gold veins fit? Are all the Bridge River veins part of the same event or related to different events?

45 Ma	Intrusion of lamprophyric dykes
65 Ma	Intrusion of Bendor batholiths
70 Ma	End of hydrothermal effects of CPC
85-75 Ma	Peak CPC magmatic activity & meta'm
91-86 Ma	Movement on Eldorado Fault system
91 Ma	Intrusion of albitite dykes
105-92 Ma	Emplacement of "Bralorne ophiolite"
130-105 Ma	Pre- Albian deformation
230-160 Ma	Subduction-related deformation
230 Ma	Blueschist metamorphism
250 Ma	Metamorphism of oceanic crust
288-271 Ma	Formation of oceanic crust

Can the timing of mineralization confirm the timing of motion on the structures?

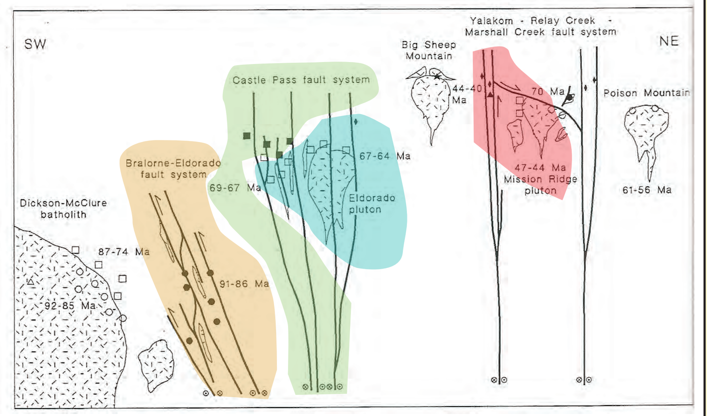
EXPLORATION MODELS

Orogenic gold deposits are among the most lucrative of the deposit types, and the best understood of the gold deposit models. They are lucrative because they represent focused accumulations of structurally controlled, generally coarse-grained gold that is easy to mine and has a simple metallurgy. Considerable research on these deposits, mainly in the Yilgarn and Superior cratons has resulted in a very high-level of understanding about the characteristics and controls of formation of this deposit type. In particular, these deposits are recognized to form from the focusing of crustal scale fluids into structural regimes that transcend much of the brittle crust. As such, there is a continuum of orogenic gold deposit types with features specific to their level of formation (Groves 1993, 1998).



The ":crustal continuum" model for orogenic gold deposits (Colvine1987, ; Groves et al.,1998, graphic from Groves et al., 2003).

STRUCTURAL EVENT MODEL



The result of considerable regional mapping and research in the area led Schiarizza et al. (1997) to integrate their structural and tectonic observations and data with the mineral occurrences to develop a model in which the different metallogenic belts are related to different structural belts with the mineralization forming in response to different structural events.

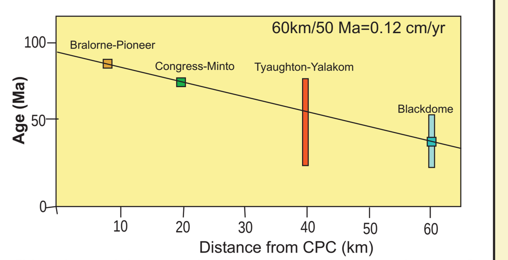
MAGMATIC MODEL

Several authors have attributed the formation of mineralization to specific magmatic rocks or events. For example, the close association of albitite dykes, which locally occupy the same structures as the veins, and are often intensely altered, are therefore considered to be closely, and genetically related to mineralization (Cairnes 1938; Leitch et al. 1991).

OPHOLITE MODEL

Original models emphasized a strong genetic association with the Bralorne ophiolitic assemblage, particularly the plagiogranite intrusions, but these have been determined to be Permian in age (Leitch et al. 1990). More recently Ash (2001) has emphasized the association of mesothermal gold mineralization with ophiolitic assemblages, and at Bralorne has related mineralization to movement on the ophiolite's bounding faults.

COAST PLUTONIC COMPLEX MODEL



District-wide variations in the styles of mineralization, and their progressive easterly younging trend, can be accounted for with increasing distance from the progressive flux of heat and fluids from the Coast Plutonic Complex (Woodsworth et al. 1977).

GEOCHRONOLOGY

The proximity of the Bendor Batholith to the Bralorne Pioneer gold mines requires that the timing relationships between magmatism and mineralization be firmly established. Here, we see remnants of the old Bralorne mill with the granodioritic peaks of the Bendor Batholith in the background.

AGE of BENDOR BATHOLITH

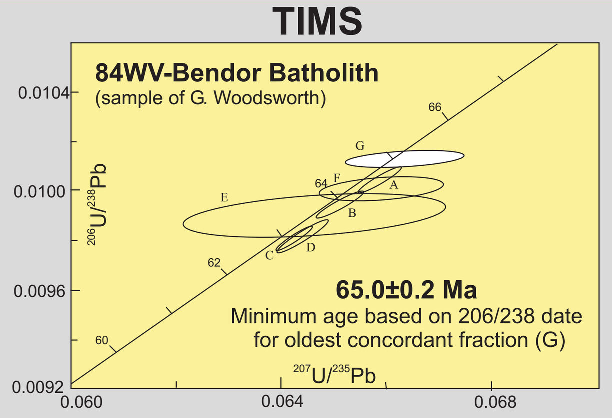
The Bendor suite of batholiths are among the most significant plutonic and thermal features of the region. A precise age of magmatism is required in order to interpret other ages of the region in terms of direct association or as having been effected by the pluton's thermal effects. Some have even suggested that the Bendor batholith is a potential mineralizer, so this hypothesis must be tested.

PREVIOUS EFFORTS

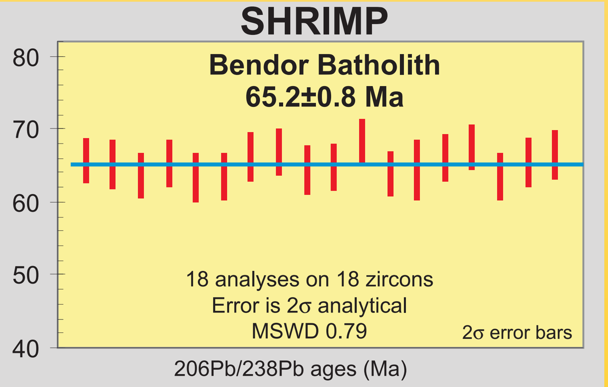
Numerous existing K-Ar dates for the Bendor batholith and associated plutons range from 64 to 57 Ma, and indicate a Late Cretaceous age. In addition, a 3-4 m.y. difference between the hornblende and the biotite dates indicated that the pluton may have cooled slowly.

A U-Pb TIMS date from Friedman and Armstrong (1990) confirmed a date of 63±2 Ma, but several of the zircon phases showed evidence of Pb-loss and ancient inheritance making a precise interpretation of the data difficult.

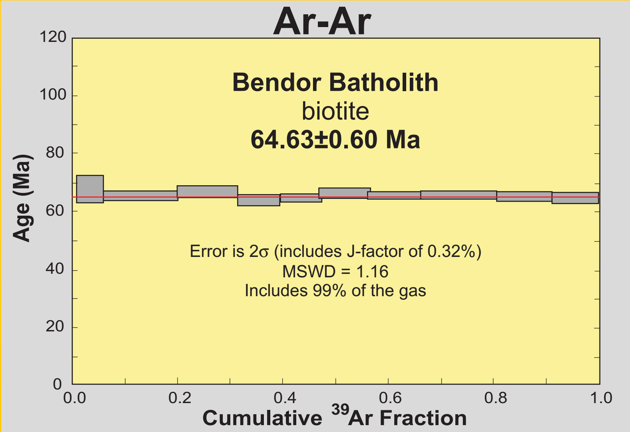
TIMS



SHRIMP



Ar-Ar



OUR RESULTS

TIMS

Re-analysis of zircon fractions using improved methods yields a concordant and more precise age of 65.0±0.2 Ma.

SHRIMP

Small spot analysis(20 microns) of clean zones from 18 different zirons from the same sample yielded a precise date of 65.2±0.8 Ma.

Ar-Ar

A laser Ar-Ar date of very good looking biotite, also from the same sample, gives an excellent plateau age of 64.6±0.6 Ma.

CONCLUSION

The Bendor batholith is 65 Ma and biotite shows no effects of slow cooling or thermal perturbations.

AGE OF ORES

PREVIOUS DATES ON ORES AND ALTERATION

Several previous K-Ar dates on gangue and alteration minerals, and altered dykes adjacent to veins, range from 69 to 45 Ma, potentially suggesting a wide range in the ages of mineralization. None of these dates however, are from the Bralorne-Pioneer ores.

CROSS-CUTTING CONSTRAINTS 91 to 44 Ma

At Bralorne, mineralization is well constrained to younger than the 91.4 Ma (U-Pb zircon) altered and mineralized albitite dykes, and older than the 44 Ma (K-Ar biotite) cross-cutting lamprophyre dykes (Leitch et al. 1990). A date of 85.7 Ma (K-Ar hb) on intra- to post-mineral green hornblende porphyry dykes was considered a possible syn to post age for mineralization, potentially providing a narrow bracketing the timing of mineralization to between 91 and

RECENT Ar-Ar DATES OF BRALORNE ORES

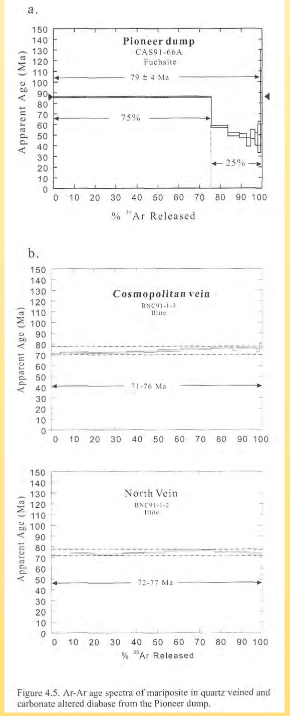


Figure 4.5. Ar-Ar age spectra of mariposite in quartz veined and carbonate altered diabase from the Pioneer dump.

Three Ar-Ar dates have been recently obtained from veins in the Bralorne district (Ash 2001) and yield data that are difficult to interpret. One determination is a mix of 87 Ma and 60-50 Ma ages that when combined, give a total gas age of 79±4 Ma (essentially the same as a K-Ar determination). The other two samples that were analysed yield a series of increasing steps from approx. 70 to 80 Ma. The analyses were considered to indicate resetting of older dates by a ca. 70 Ma structural and hydrothermal event. Unfortunately these analyses are ambiguous and cannot be used

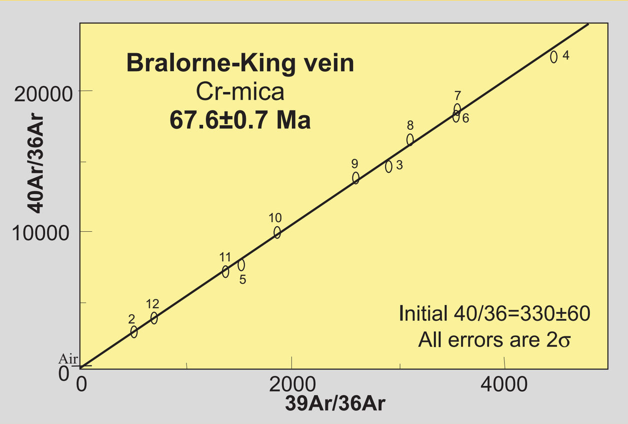
NEW Ar-Ar AGES

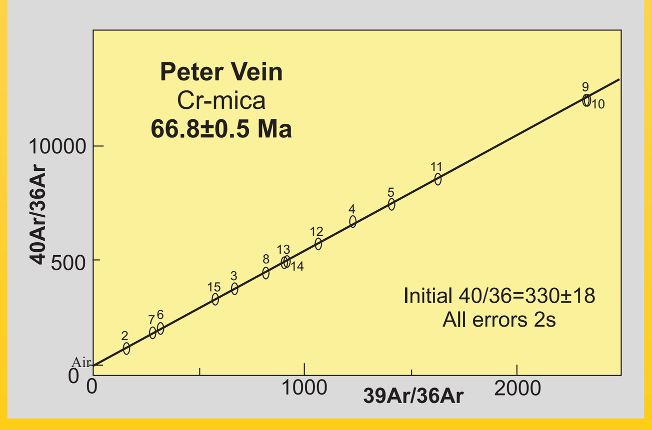
We present two new age determinations on fuchsite from altered wallrock inclusions contained within mineralized vein material from the two deposits within the Bralorne-Pioneer camp. One determination is from the King vein at Bralorne and the other is from the recently discovered Peter vein.

Both determinations indicate the presence of excess Ar making interpretations of apparent age spectra suspect.

Removal of phases with excess Ar yield well defined isochron ages of 67.6±0.7 Ma for the King vein, and 66.8±0.5 Ma for the Peter vein.

Based on these analyses, the age of mineralization of the Bralorne-Pioneer gold veins is therefore approximately 67 Ma.





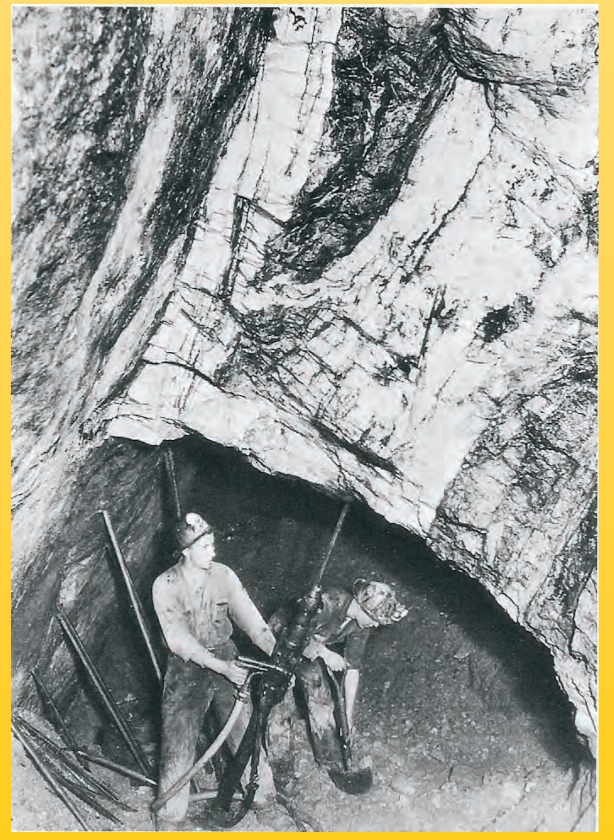
CONCLUSIONS

Fifteen excellent gold specimens and a fine collection of photographs that document the Bralorne-Pioneer mine's history are available at the Royal Alberta Museum. Ron Mussieux, photo.

- Our geochronological data confidently indicate that the Bendor batholiths are 65 Ma. This resolves uncertainty in previous K-Ar and U-Pb ages that ranged from 73 to 61 Ma.
- Two analyses from two different veins located approximately 15 km apart yield nearly identical ages for mineralization within the Bralorne-Pioneer system to approximately 67 Ma.
- Therefore, the Bralorne ores are apparently slightly older than the Bendor Batholiths. Additionally, the dating is precise enough that the errors of the Bendor and Bralorne do not overlap. Because the Bralorne ores are older than the pluton, they cannot be genetically related.
- However, it is possible that the thermal flux from the Bendor batholith has reset the Ar systematics to give approximately coeval timing.
- The presence of excess Ar in the minerals also adds another complicating feature that makes the use of Apparent Age specta from previous analyses suspect.

BEYOND GEOCHRON

Ore geochemistry is an effective method of indicating the nature of the ore forming fluids, their chemistry, origin and the processes involved in generating ore deposits. Most deposits from the region have a reasonable amount of existing geochemical data, such as fluid chemistry and microthermometry, stable and lead isotope data. However, except for Bralorne (Leitch et al. 1991), much of the data remains unpublished. We intend to compile the salient published and unpublished data, collect new data, which will be assessed and interpreted. From this we will provide a modern interpretation of the regional metallogeny upon which to base exploration models. Preliminary work indicates that quartz from the lower temperature stibnite veins have oxygen isotopic values similar to those higher temperature gold-only veins at Bralorne-Pioneer (Fig. 2). This observation alone is critical, as it means that the low temperature veins are likely the upper portions of orogenic lodes and that they were not formed from shallow meteoric fluids associated with epithermal deposit types.



Bralorne drillers prepare the 7D stope for blasting.
Leonard Frank, photo, Vancouver Public Library, VPL 14847

FUTURE WORK

We currently have approximately 10 additional samples from other veins in the district submitted for Ar-Ar geochronology.

We also have several samples of various magmatic phases that will undergo SHRIMP U-Pb and Ar dating in order to provide constraints on the region's magmatic and thermal history.

In order to test the validity of our Ar dates, particularly to see if they have been reset by the Bendor Batholith, we will be utilizing the innovative Re-Os dating technique on arsenopyrite from a few of the deposits.

We are compiling existing data on fluid chemistry and isotopic results for the region in order to compare Bralorne to the rest of the district.

ACKNOWLEDGMENTS

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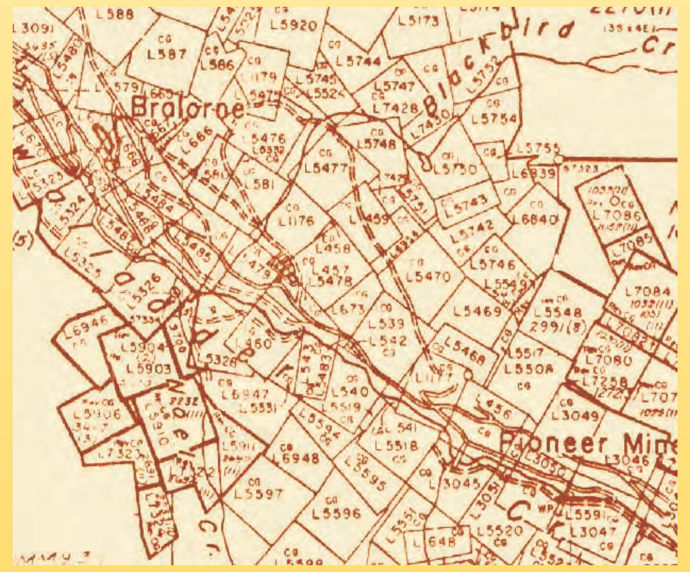

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