The Geology of the Blackwater Epithermal Au-Ag Deposit

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Introduction

The Blackwater Au-Ag deposit of central British Columbia has a combined measured and indicated resource of 306 million tonnes with 8.62 M oz Au averaging 0.88 g/t, and 57.52 M oz Ag averaging 5.8 g/t (New Gold, April, 2013). The deposit falls within the general epithermal class, sharing characteristics of low and intermediate sulfidation systems. Nonetheless several of its traits are somewhat atypical, making it stand apart from the average epithermal system.

This project aims to characterize the Blackwater deposit in order to assess its timing and nature, and compare its characteristics to other epithermal deposits. Results of detailed core logging, petrographic work, X-ray diffraction (XRD), Scanning Electron Microscope (SEM) analysis as well as stable isotope analyses are presented here.

Objectives	Methods
-To determine the source of the sulfur which comprises sulfides.	-Sulfur stable isotope analysis
-Relate high Au and Ag grade zones to lithologies and alteration assemblages.	-Detailed core logging and petrography -XRD and SEM work

Geological Setting

The Blackwater Au-Ag deposit (star, images 1&2) is situated in the Stikine terrane of the Intermontane Belt of central BC (green, image 1). Local stratigraphy, from oldest to youngest, consists of Jurassic Hazelton group island arc volcanics and sediments (purple, image 2), and Bowser Lake basinal sediments and volcanics (red, image 2). These rocks are overlain by Late Cretaceous, felsic to intermediate volcanics of the Kasalka group (green, image 2). The above rocks are in turn overlain by Eocene to Neogene volcanics (blue, grey, image 2). The Area has been intruded by several plutons including the Late Jurassic Laidman batholith (red, image 2) (Poznikoff et al., 2000), the Capoose pluton (green, image 2) dated at 67.1 ± 2.3 Ma (Andrew, 1988) and the Paleogene Ch pluton dated at 51.8 ± 1 Ma (blue, image 2) (Diakow and Levson, 1997). A fourth un-named pluton is suspected to lie beneath shallow surface cover a few kilometers south of the Blackwater deposit (Diakow and Levson, 1997, Friedman et al., 2001). Much of the project area is mantled by glacially derived quaternary sediments (tan, image 2) ranging from a few to several tens of meters in thickness, making geologic field mapping and exploration a challenge. The greater project area is bounded by northwest and northeast trending faults of unknown displacement (image 2).

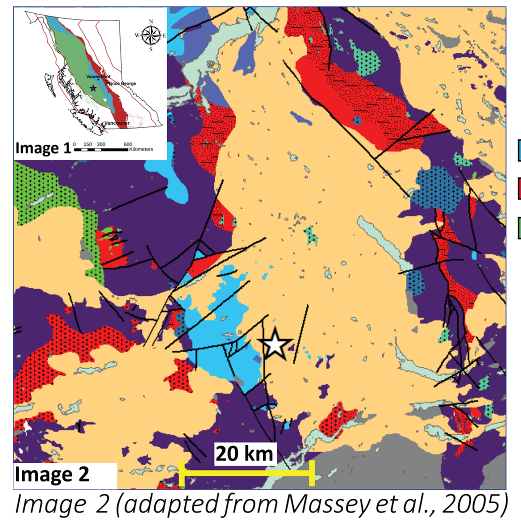


Image 2 (adapted from Massey et al., 2005) shows the geology of the Blackwater region.

Explanation:Image 1

Terranes of the Intermontane Belt
- Cache Creek Terrane
- Quesnel Terrane
- Stikine Terrane
- Outlines of superterranes

Symbols
- Blackwater deposit location
- Mapped Faults
- Lakes

Explanation:Image 2

Quaternary
- Quaternary cover

Eocene
- Endako Group volcanic rocks
- Ootsa Lake Group volcanic rocks
- Plutonic rocks

Late Cretaceous to Paleocene
- Plutonic rocks

Late Cretaceous
- Kasalka Group volcanic rocks
- Capoose Pluton

Jurassic
- Bowser Lake Group volcanics
- Laidman Batholith
- Bowser Lake Group sediments

Paleozoic and Early Mesozoic
- Hazelton Group rocks

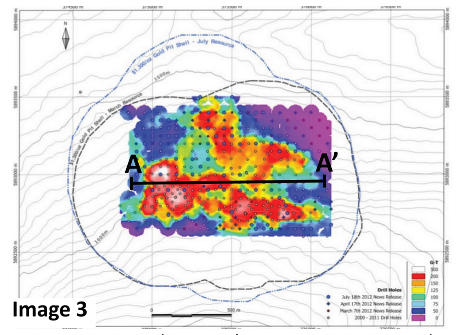
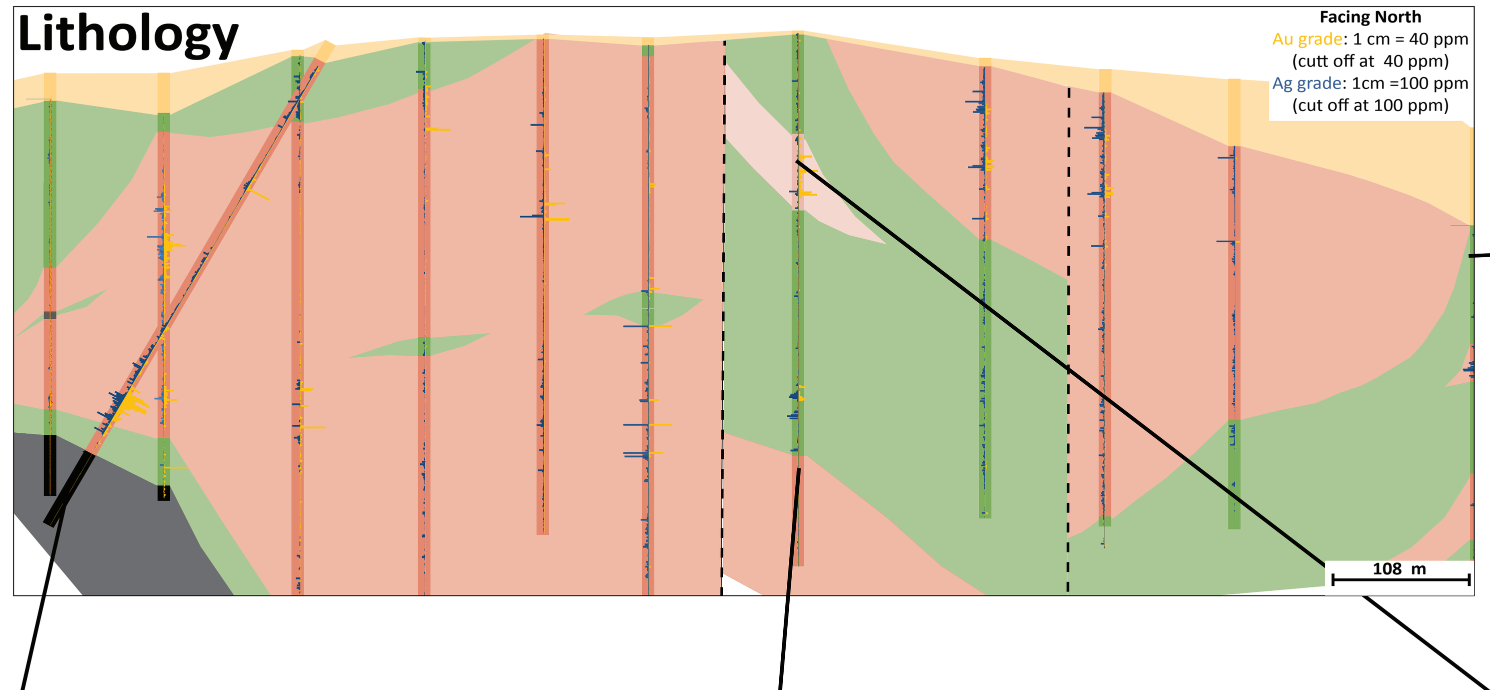


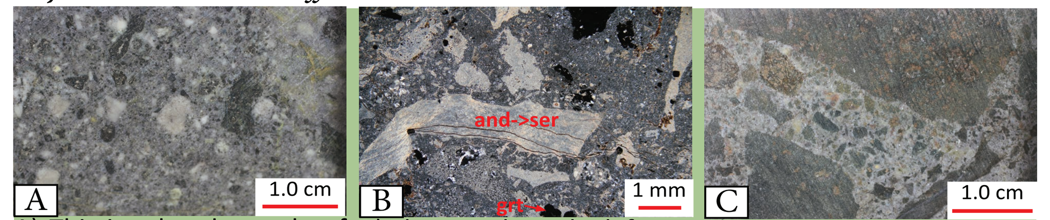
Image 3 above shows a Au grade-thickness plan view of the Blackwater gold resource from the 2012 technical report (Simpson, 2012). The A-A' line shows the location of the lithology and alteration cross sections presented in this poster.

Lithology



The Blackwater deposit is hosted predominantly within a sequence of interlayered lithic rich lapilli tuff and flow banded to massive rhyolitic tuff. Both of these rock types lie in depositional and faulted contact with each other and overlie andesitic flows and autobreccias. All of these rock units are underlain by basinal mudstones, sandstones and conglomerates (not on cross section). The andesites and sediments are intersected in drill holes primarily at the deposit's periphery. Exploration drilling to date indicates that the majority of high grade Au and Ag mineralization occur preferentially within the felsic volcanics.

Polymictic, Lithic Rich Tuff

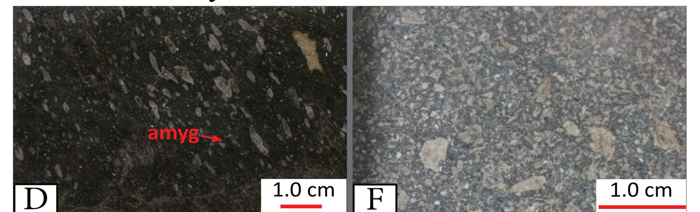


A) This is a hand sample of matrix supported lithic rich tuff. Clasts are andesitic lapilli with curviplanar clast boundaries, and rounded, white siliceous lapilli.

B) The sample to the left in thin section (XPL) shows lapilli clasts with whispy to curviplanar clast boundaries altered to sericite (and->ser) and garnet (grt).

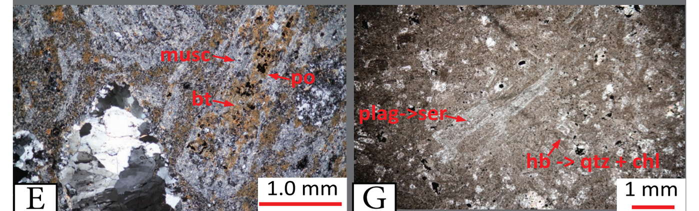
C) Lithic rich tuffs vary in their clast componentry and percent of matrix. Here a tuff is monomictic with primarily andesitic lapilli clasts.

Andesitic lava flows and autobreccias



D) A hand sample of relatively unaltered andesite with silica amygdules (amyg) exhibits flow allignment.

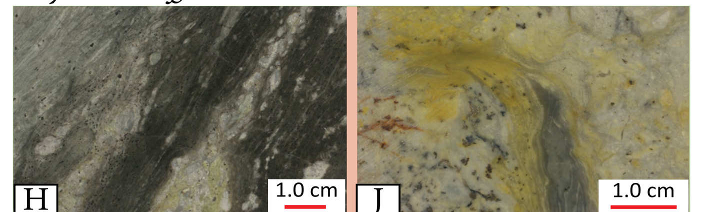
F) A hand sample of plagioclase porphyritic andesite.



E) A microphotograph of (D) (XPL) shows 40% euhedral plagioclase crystals altered to muscovite (msc), biotite (bt) and pyrrhotite (po).

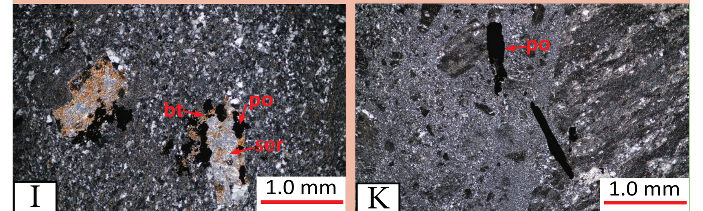
G) A thin section of sample F) shows plagioclase (plag) being altered to sericite (ser), and primary hornblende (hb) altered to chlorite (chl) and quartz. (qtz).

Rhyolite Tuff



H) A hand sample of relatively unaltered, 3% phenocryst bearing, vitreous ash tuff, with silica and sericite alteration exploiting flow banding.

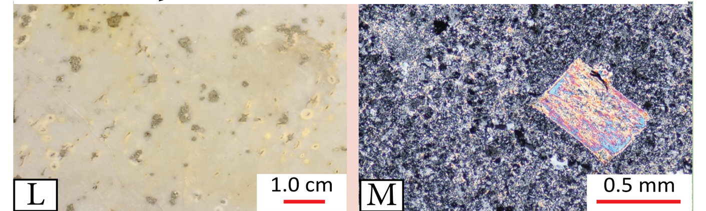
J) An autobrecciated ash tuff is altered to sericite and silica.



I) In thin section (XPL), H) shows feldspar phenocrysts altered to sericite (ser) and biotite (bt) which form with pyrrhotite (po). The fine grained groundmass consists of quartz and k-feldspar partly altered to sericite.

K) A thin section (XPL) of an autobrecciated rhyolite with disseminated, acicular pyrrhotite.

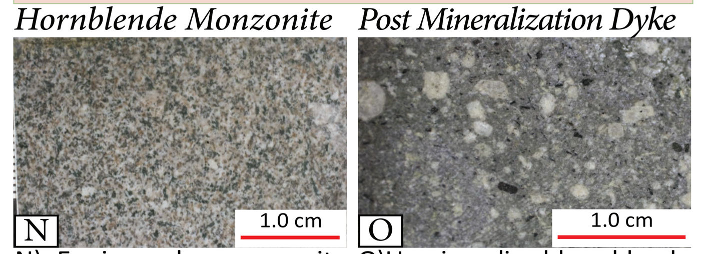
Massive rhyolite



L) In hand sample this rock is aphanitic, bleached white, and massive.

M) In thin section, this rock is compositionally similar to the laminated rhyolitic volcanics (dark pink unit), with most of its original feldspar altered to muscovite.

Hornblende Monzonite *Post Mineralization Dyke*



N) Equigranular monzonite has 30% primary mafics altered to actinolite.

O) Unmineralized, hornblende and biotite bearing, plagioclase porphyritic, dioritic dykes intrude sediments and lithic rich tuffs in the south.

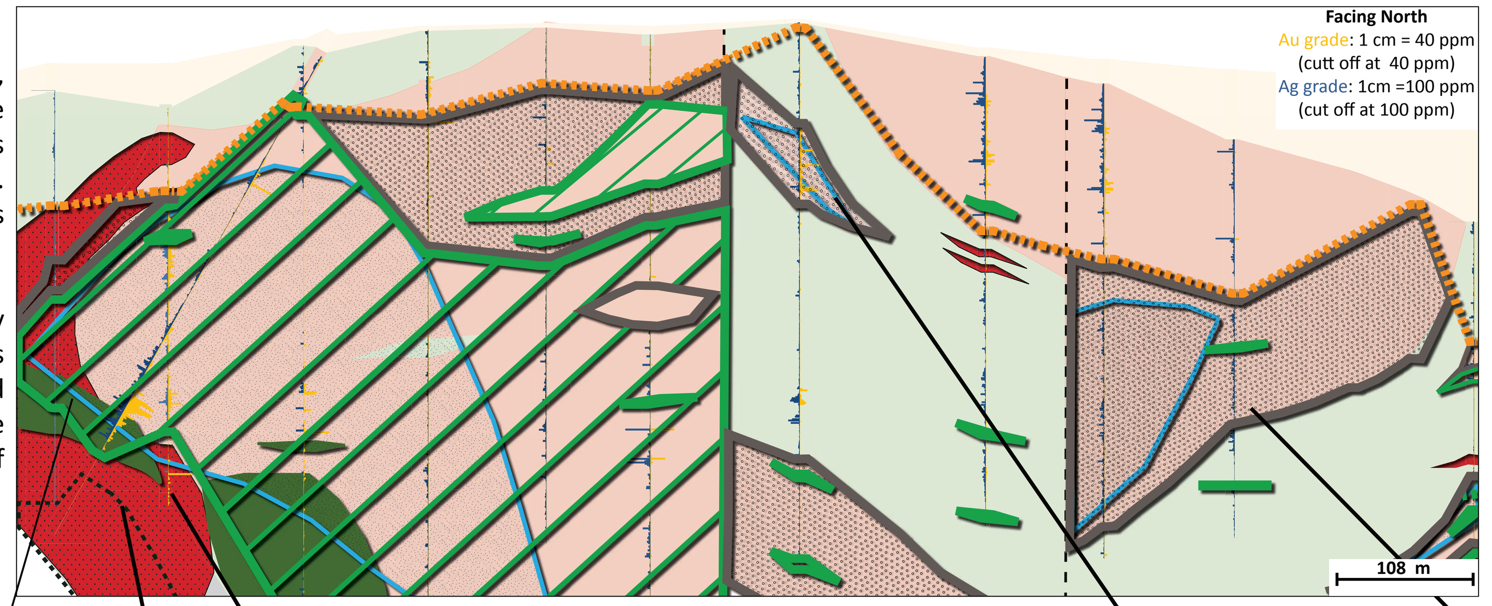
Explanation

- Fault, sense of displacement unknown
- Quaternary surficial deposits
- Polymictic, lithic rich tuff
- Rhyolitic, laminated tuff
- Massive rhyolite
- Andesitic lava flows and autobreccias

Alteration

On the western portion of the cross section, garnet (images A-C) is present in veins, alters mafic minerals in andesitic lavas flows, and andesitic clasts which comprise volcaniclastic rocks. Biotite (Images D-I) is fine grained and present in veinlets with chlorite, sericite, quartz and sulfides and alters mafic minerals in plagioclase porphyritic andesite. Actinolite, pyrrhotite and chalcopyrite appear in veins with silica envelopes (images J-L). These veins are only present in plagioclase porphyritic andesite.

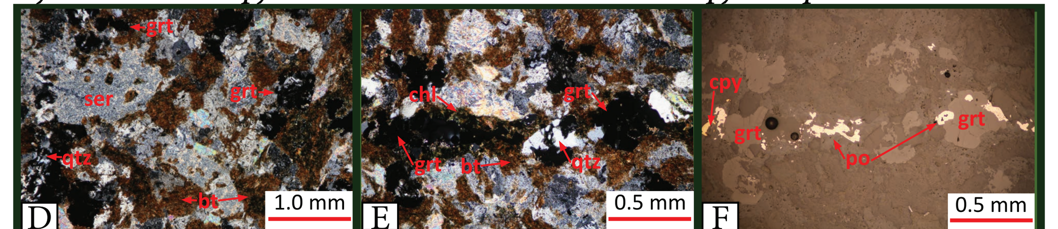
On the eastern portion of the cross section, silica and sericite alteration are grey (image M) instead of dark green (image G). These areas of alteration host veins with green muscovite, silica and pyrite +/- sphalerite, chalcopyrite, garnet and tourmaline (images M-O). Rhyolites, especially those on the western part of the cross section, demonstrate a SWIR spectral signature (images P & Q) indicative of tobelite, an NH_4 bearing muscovite.



Explanation

- *Weathering horizon : Fe-oxides, white illite, muscovite and silica.*
- *Minimal to no alteration*
- *NH_4 bearing muscovite SWIR spectral signature*
- *Grey silica and sericite alteration.*
- *Green silica and sericite alteration.*
- *Pyrrhotite-Chalcopyrite-Biotite-Green Sericite ± Arsenopyrite-sphalerite-galena*
- *Spessartine Garnet and Quartz Alteration*
- *Pyrrhotite-Chalcopyrite-Actinolite-Silica*

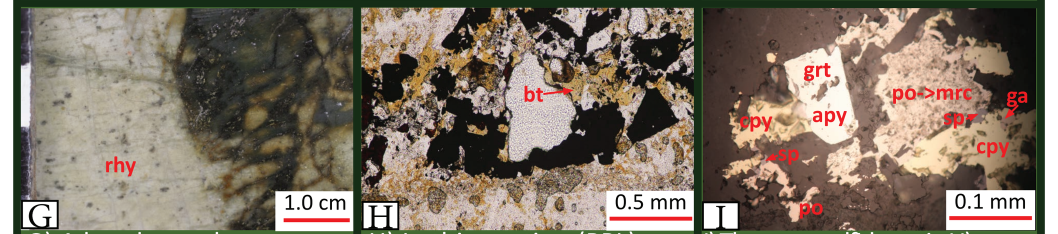
Pyrrhotite-Chalcopyrite-Biotite-Green Sericite ± Arsenopyrite-Sphalerite-Galena



D) In thin section (XPL) garnet (grt) and biotite (bt) replace primary euhedral hornblende phenocrysts, while quartz (qtz) and sericite (ser) alter primary plagioclase.

E) A microphotograph (XPL) of biotite (bt), chlorite (chl) and quartz (qtz) in a vein with sulfides. Garnet (grt) is either part of or crosscut by the vein.

F) The same view as in E) but in reflected light (PPL) shows sulfides are pyrrhotite (po) with lesser chalcopyrite (cpy).

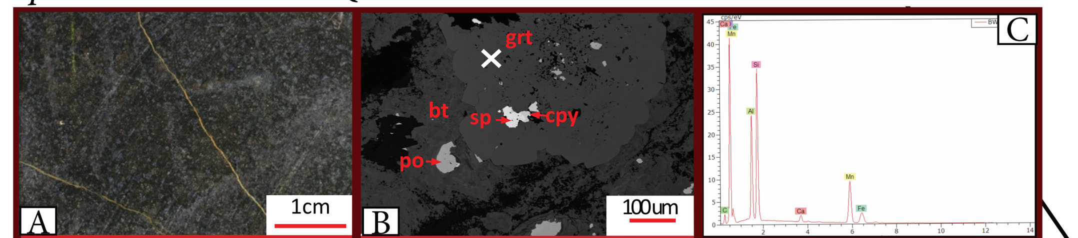


G) A hand sample showing alteration pseudo brecciating a laminated rhyolitic (rhy) ash tuff.

H) In thin section (PPL), biotite (bt) is present with green sericite and sulfides.

I) The same sulfides as in H), but in reflected light and higher magnification, shows that sulfides are pyrrhotite (po), chalcopyrite (cpy), arsenopyrite (apy), sphalerite (sp) and galena (ga).

Spessartine Garnet and Quartz Alteration

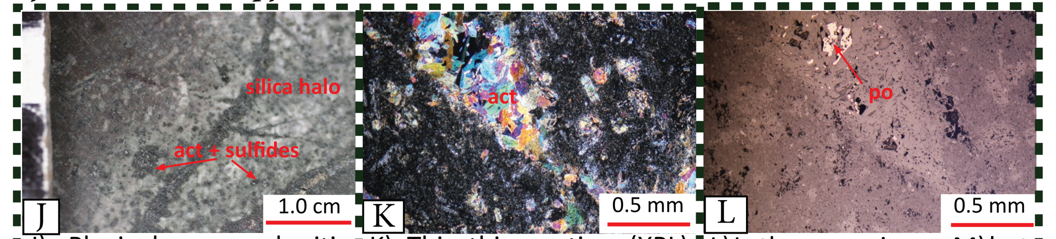


A) A hand sample of autobrecciated andesite is altered to fine grained biotite and garnet. Images D-F show microphotographs of this rock.

B) A back scatter electron image of garnet (grt) with biotite (bt), sphalerite (sp), pyrrhotite (po) and chalcopyrite (cpy). The X denotes EDX spot analysis

C) EDX results show that garnets are manganese (yellow labels) rich with lesser calcium (pink) and iron (blue).

Pyrrhotite-Chalcopyrite-Actinolite-Silica

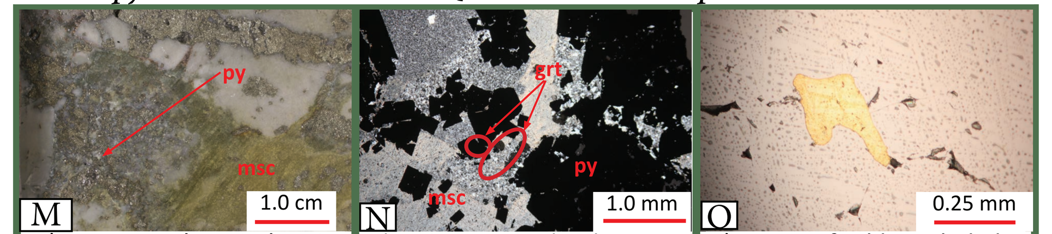


J) Plagioclase porphyritic andesite is intruded by an actinolite(act) & sulfide vein with a silica halo.

K) This thin section (XPL) shows actinolite (act) with sulfides in a vein.

L) In the same view as M) but in reflected light, actinolite is present with pyrrhotite (po).

Veined pyrite-Green Muscovite-Quartz ± Garnet, Sphalerite & Tourmaline

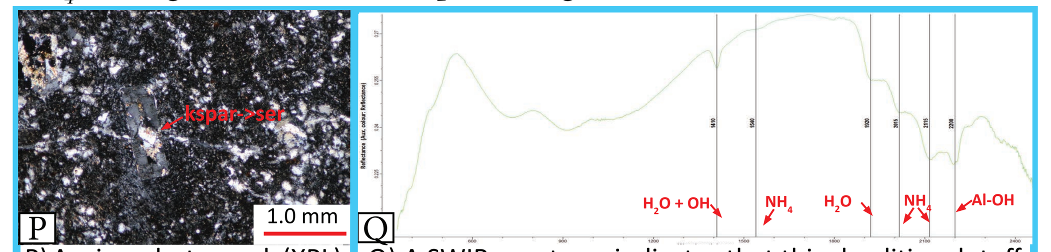


M) A wavy, subvertical pyrite (py), green muscovite (msc) & quartz vein hosts gold grains. Subhedral garnet is vein controlled as seen in image P) to the right.

N) In thin section (XPL) garnets (grt)envelope veined pyrite (py) and muscovite (msc).

O) A grain of gold is included in a veined pyrite crystal.

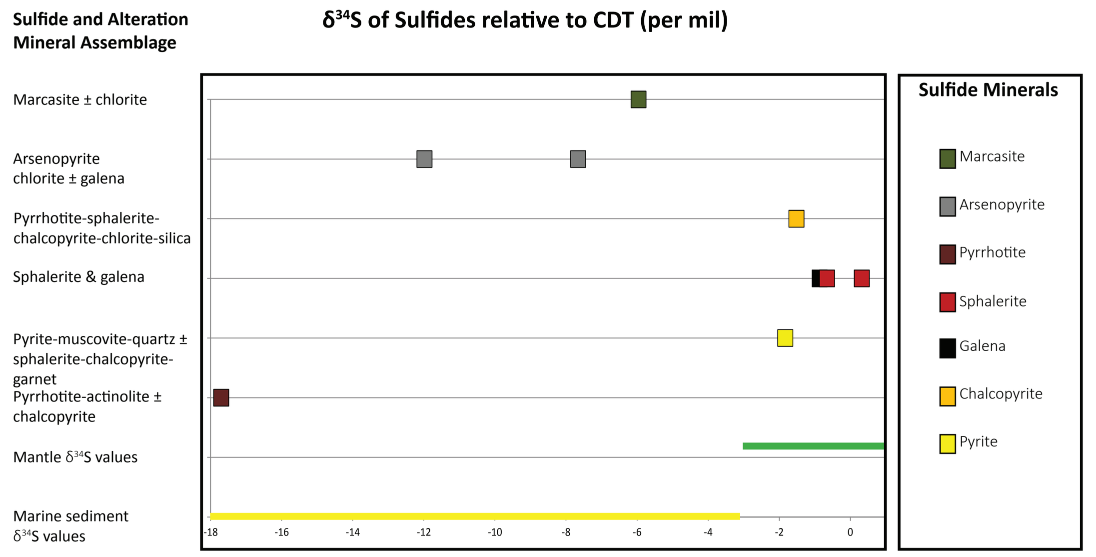
NH_4 Bearing Muscovite SWIR Spectral Signature



P) A microphotograph (XPL) of laminated tuff shows remnant primary k-feldspar (kspar) partially altered to sericite (ser).

Q) A SWIR spectrum indicates that this rhyolitic ash tuff has been altered to ammonium (NH_4) bearing muscovite. Vertical lines show the location of distinguishing troughs in the spectrum.

The Source of Sulfur



Sulfur Isotope Results

-The nine sulfide samples provided $\delta^{34}S$ values ranging from 0.3 to -17.7 per mil. Each alteration and sulfide mineral assemblage has a distinct sulfur isotopic composition

-$\delta^{34}S$ values for sulfides can be divided into a minimum of two groups

-Sulfides from three different assemblages yield values close to zero, indicating sulfur originated from an igneous source.

-The remaining samples have light sulfur isotope compositions (low $^{34}S/^{32}S$), with $\delta^{34}S$ values that span from -6.0 to -17.7 ‰, indicating that sulfur has been leached from a sedimentary source.

Conclusions

-High Ag and Au grades show a spatial correlation with each other and preferentially occur in rhyolite.

-Au and Ag are present in areas with pyrite-green muscovite-quartz +/- sphalerite veins and disseminations. At depth, on the western portion of the cross section, high Au and Ag grades are also spatially associated with chalcopyrite, pyrrhotite, biotite and dark green sericite which is present in veins and alter the host rock.

-Sulfur isotope data and the potential presence of NH_4 bearing muscovite are indications that hydrothermal fluids interacted with basinal sediments during their ascent.

- Blackwater has characteristics of low and intermediate sulfidation epithermal systems, (chart 1). However, certain features can not be explained by the typical epithermal deposit model.

	Low	Intermediate	High	Blackwater
Tectonic Setting	Intra-, near-, and back-arc, as well as post collisional rifts	**Continental margin arc**	**Continental margin arc**	**Continental margin arc?**
Stress Regime	Extensional	Extensional to neutral	Near neutral or mild extension	**Regional north east directed transpression, local stress state unknown**
Deposit Style	Banded veins of quartz, chalcedony, and adularia plus subordinate calcite	**Veins,** stockwork, breccias & pipes	Disseminated in leached silicic rock	**Veined and disseminated sulfides (pyrite, pyrrhotite & sphalerite> chalcopyrite, galena and arsenopyrite).**
Metal Signature	Au ± Ag	**Ag-Au, Zn,** Pb, Cu	Au-Ag, Cu, As-Sb	**Au-Ag, Zn**
Minor metals	Zn, **Pb, Cu, As,** Mo, Sb, Hg	Mo, **As,** Sb	Zn, **Pb,** Bi, W, Mo, Sn, Hg	**Cu, As, Pb**
Genetically Related Igneous Rocks	Bimodal volcanism	**Andesitic-dacitic arcs, some rhyolitic rocks**	Calc-alkaline andesites to dacites	**Rhyolitic to andesitic rocks**
Connection to porphyry	None with the exception for alkaline magma related systems	Moderate	Many	**Undetermined**
Sulfides	-**Pyrite with lesser arsenopyrite** in quartz veins - **minor chalcopyrite**, tetrahedrite or tennantite	-Chalcopyrite - Tetrahedrite-tennantite, -Fe poor sphalerite -**minimal arsenopyrite** and pyrrhotite	-Pyrite + enargite, luzonite, famatinite or covellite	**Pyrrhotite, pyrite, sphalerite>arsenopyrite, chalcopyrite>galena**
Silicate Gangue	Veined quartz, chalcedony, adularia plus subordinate calcite	Vein filling, crustiform and comb quartz	Massive fine grained silicification and vuggy quartz	**Pervasive sericite and silica alteration of host rocks.**
Carbonate Gangue	**Minor and late calcite**	Common, typically including manganiferous types	None	**Late calcite**
Fluid pH	**Neutral**	**Neutral**	Acidic fluids	**Neutral**
Key Proximal Alteration Minerals	Illite/smectite, adularia	**Sericite**, adularia uncommon	Vuggy quartz, alunite, pyrophillite and dickite	**Sericite, quartz, silica, biotite, garnet, chlorite, actinolite**

Chart 1, adapted from Sillitoe and Hedenquist, 2003, compares characteristics of Blackwater to those of a typical epithermal system.

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Acknowledgements

This project is a collaborative research effort between New Gold Inc. and the Mineral Deposit Research Unit. New Gold is acknowledged for their generous financial support of this project. Geoscience BC is also thanked for their financial support. The author's, especially E. Looby, extend their gratitude to the geologists and techs of New Gold for their field support and helpful geological discussions.