Mineralogical Characteristics of Porphyry-Fertile Plutons: Guichon Creek, Takomkane and Granite Mountain Batholiths, South-Central British Columbia

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Introduction

Distinguishing metal-fertile from barren plutons continues to be a significant challenge for geologists exploring for porphyry Cu (Au, Mo) deposits. Information that contributes such a priori knowledge provides guidance early in the exploration process to make decisions more effectively and efficiently on focussing exploration resources on more prospective targets.

The characterization of fertility features is of particular importance for BC porphyry exploration. In BC, many porphyry systems occur within or around the edges of large batholiths. These combined features make BC an exceptional locality to test and utilize such porphyry fertility indicators.

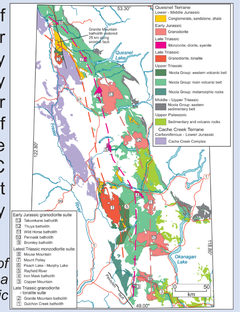

***Figure 1**: Simplified geology map of south-central British Columbia showing location of major plutonic bodies (from Schiarriza, 2014)*

Objectives

This project identifies field, mineralogical and geochemical characteristics of known porphyry-fertile plutons and develops exploration tools for the subsequent identification of new fertile plutonic terrains of British Columbia. Physical and chemical features in common accessory minerals, e.g., apatite, titanite, zircon, that show evidence of magmatic processes such as high oxidation state, evidence of fluid saturation, magma fertilization by mafic melt injection, and sulfate saturation and depletion will be characterized:

- Determine the mineralogical features of accessory minerals that characterize and distinguish porphyry fertile intrusions.
- Assess geochemical features of common accessory minerals that indicate fertility.
- Document fertility evidence over time and space in an evolving composite zoned pluton.
- Assess the utilization of rapid mineralogical characterization tools.
- Construct a toolkit to provide a predictive decision-making framework to assess fertility in rocks, stream sediment and till heavy mineral concentrates.

Mineral Recorders of Fertility

Porphyry fertility of a crystallizing magma is influenced by features or processes such as oxidation state, fractionation, magma mixing, and the amount and saturation of water, metal, chlorine and sulphur. These features are variably recorded in crystallizing accessory minerals of the parent pluton commonly as characteristics such as zoning or chemical composition.

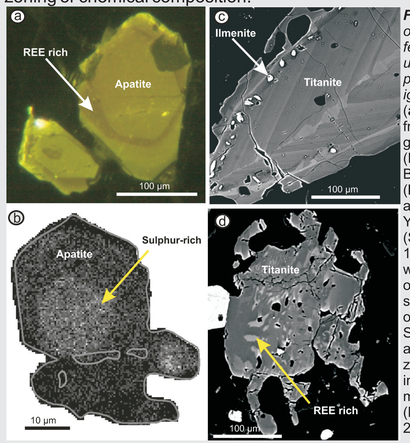

***Figure 2**: Examples of mineralogical features that can be used to characterize porphyry fertility of igneous bodies:* (**a**) Apatite grain from Bethlehem granodiorite (Highland Valley; Bouzari et al., 2011). (**b**) X-ray intensity of apatite from Yerington batholith (Streck and Dilles, 1998). (**c**) Titanite with concentric oscillatory and sector zoning (Russ of Mull granite, Scotland; McLeod et al., 2011). (**d**) Patchy zoning in titanite with interstitial and marginal growth (McLeod et al., 2011).

- **Apatite** crystals from fertile systems can be zoned with sulfur-rich cores and sulfur-poor rims, indicating early sulfate saturation and the crystallization of anhydrite (Figure 2a & b: Streck and Dilles, 1998).
- Apatite trace element compositions can record the degree of fractionation and oxidation state of the magma (Belousova et al., 2002).
- **Zircons** from porphyry fertile intrusions in northern Chile have Ce and Eu compositions with significantly higher oxidation states than barren intrusions (Ballard et al., 2002).
- Co-existing hornblende and **magnetite** is a diagnostic feature of mineralized silica-undersaturated igneous complexes in BC (Lueck and Russell, 1994).
- **Titanite** displays concentric oscillatory zoning and REE-rich patches that represent changes in melt composition from magma mixing and late sub-solidus modification by fluids (Figure 2 c & d; McLeod et al., 2011).

Guichon Creek Batholith

The Late Triassic Guichon Creek (65 × 20 km) is a composite batholith that ranges from diorite and quartz diorite compositions at the border to younger granodiorite in the centre (Casselman et al., 1995) which hosts most of the several Highland Valley porphyry Cu-Mo deposits (Valley, Lornex, Highmont, Alwin, Bethlehem and JA).

The Border and Highland Valley phases are the oldest phases, forming the outer part of a pluton emplaced into the Nicola – Cache Creek groups. The young Bethlehem phase intruded the Highland Valley and Border phases. The Bethsaida phase intruded the Bethlehem phase and forms dikes and small plugs in them (McMillan, 1976)

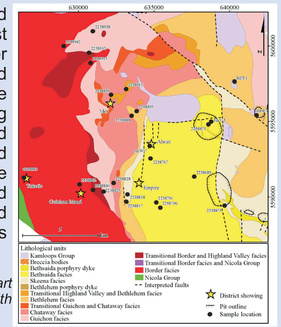

***Figure 3**: Geology map of central part of the Guichon Creek batholith showing location of samples.*

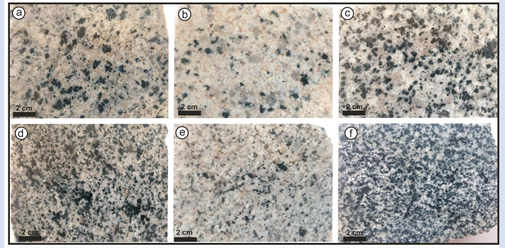

***Figure 4**: Examples of various Guichon Creek intrusive units*: (a) Bethlehem phase (b) Bethsaida phase (c) Chataway variety (d) Guichon variety (e) Skeena variety (f) Border phase.

Granite Mountain Batholith

The Late Triassic Granite Mountain batholith (18 × 10 km) hosts the Gibraltar porphyry Cu-Mo mine and is subdivided into three main units: Border phase diorite to quartz diorite; Mine phase tonalite; and Granite Mountain phase leucocratic tonalite. It was originally thought that the Granite Mountain batholith have intruded Cache Creek terrane but a recent study (Schiarizza, 2014) recognized Nicola Group strata occurring on the northeastern margin of the batholith and suggested that it is a part of the Quesnel terrane and correlative with the Guichon Creek batholith.

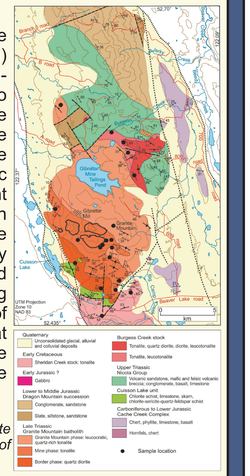

***Figure 5**: Geology map of the Granite Mountain batholith showing location of samples (Schiarizza, 2015).*

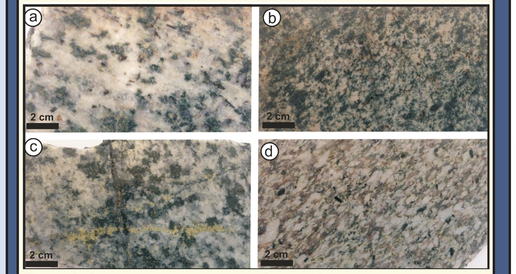

***Figure 6**: Granite Mountain rocks*: (a) Granite Mountain leucocratic tonalite (b) GMB diorite (c) Mine phase diorite (d) Sheridon Creek tonalite.

Takomkane Batholith

The Takomkane batholith is a large (40 x 50 km) Late Triassic-Early Jurassic composite intrusive body that hosts several mineralized centers including the Woodjam porphyry camp (Megabuck, Takom, Southeast Zone and Deerhorn).

The Takomkane batholith records an 11 million year-long magmatic evolution with three separate mineralizing events at Woodjam property (Schiarizza et al., 2009; Bouzari et al., 2011). Moreover, the presence of Cu-Au and Cu-Mo deposits together with the regional NW tilting of geological units provides an insight into different levels of exposure and potentially subtle geochemical variations of intrusive bodies.

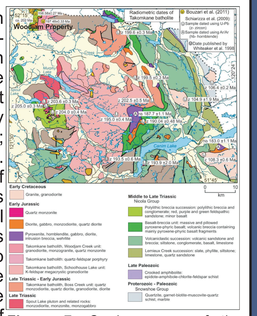

***Figure 7**: Geology map of the Takomkane batholite (Schiarizza et al., 2009).*

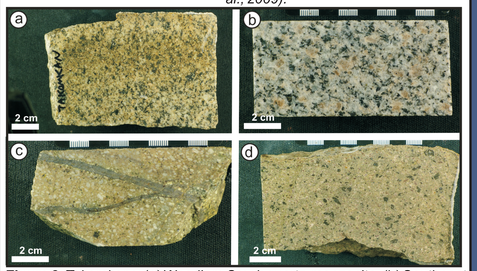

***Figure 8**: Takomkane*: (a) Woodjam Creek quartz-monzonite (b) Southeast Zone quartz-monzonite (c) Deerhorn monzonite (e) Corner Lake syenite

Methods

Field and laboratory work are focused on various intrusive bodies of three well-documented batholiths, the Guichon Creek, Takomkane, and the Granite Mountain batholith, located in BC. Rock samples are examined to characterize the physical and chemical features of accessory minerals such as apatite, titanite, zircon, magnetite or garnet.

Laboratory techniques include binocular microscopy, petrography, cathodoluminescence, infrared/ultraviolet light, SEM, ICP-MS, and MLA (mineral liberation analysis).

Current Work

Sample material in MDRU's rock collection as well as mapping projects in Granite Mountain batholith by BCGS is utilized to compliment this year's fieldwork. Rocks are documented and processed to obtain thin-sections and mineral separates that will be evaluated in a range of observable techniques including binocular and petrographic microscopes, SEM and by cathodoluminescence. Selected samples will be evaluated for mineral chemistry using the electron microprobe and laser ablation ICP-MS to characterize previously observed features.

Acknowledgements

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