Porphyry Integration Project: Combining British Columbia's Wealth of Datasets with Modern Exploration Geoscience at the District Scale to Provide New Insight into Porphyry-Deposit Exploration Strategies

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Introduction

British Columbia is home to one of the world's major alkalic porphyry districts and also hosts numerous calc-alkalic porphyry deposits. The majority of copper production in the province since the 1960s has come from porphyry deposits and six of the top ten producing or past-producing copper mines in BC are porphyry deposits (BC Ministry of Forests, Mines and Lands, 2010). These deposits also contain other metals as the primary or secondary commodity, including molybdenum, gold and silver. The discovery record has proven Stikine and Quesnel arc terranes to be two of the most prospective geological terranes in BC for porphyry deposits. Over 2000 porphyry-related showings, prospects, developed prospects and deposits have been reported in BC (BC Geological Survey, 2010; Figure 1).

The geological diversity of porphyry deposits within the province has proven intriguing to researchers, and has provided challenging complexity to explorers. Porphyry Cu-Mo-Au, Cu-Au, Cu-Mo, Mo deposits, and transitional variations thereof, occur with varying igneous associations as well as within limited, but variable, geological hostrocks. Moreover, the geological processes at work in the different physiographic regions of the province effectively alter their surficial signatures. With the variety in type, age and geology of BC's porphyry deposits, exploration for this deposit type can be a challenge, but decades of exploration history, combined with new geoscience data, can provide direction and subtle indicators, which may be used as guides to locating deposits. Understanding the geological characteristics of BC porphyry deposits and developing new exploration criteria are fundamental to making new discoveries and developing these prospects into the mines of the future.

Keywords: *porphyry deposits, data compilation, integration, exploration targeting*

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Recent Developments in the Understanding of BC Porphyry Deposits

Over the past several decades, there has been significant advancement in the understanding of BC's porphyry systems. In the 1990s a major porphyry-deposit research project was undertaken by the Mineral Deposit Research Unit (MDRU) of the University of British Columbia, which led to advancements in the understanding of the characteristics and regional tectonic associations of several BC porphyry Cu-Au deposits. The widely known special volume published by the Canadian Institute of Mining, Metallurgy and Petroleum included 69 papers containing descriptions of porphyry and porphyry-related deposits in Western Canada and the United States (Schroeter, 1995). Several recent studies by the BC Geological Survey have further examined the setting of certain porphyry deposits and regional geological mapping projects have continued to define the regional tectonic setting of porphyry systems in BC (e.g., Nixon and Peatfield, 2003; Logan et al., 2007). Furthermore, recent research on alkalic deposits in BC carried out under the alkalic research project jointly run by MDRU and the Centre for Ore Deposit Research of the University of Tasmania (Chamberlain et al., 2007) has led to the development of deposits models for several key deposits, including Mount Polley, Mount Milligan and Galore Creek.

In addition to scientific advancements, exploration datasets and in-house company knowledge of porphyry deposits have been growing as the result of over 50 years of porphyry-focused exploration. Industry has conducted detailed geophysical and geochemical surveys, as well as geological mapping and drilling on numerous properties. Some of this data has been filed in the BC assessment report system (ARIS), which hosts a wealth of data from over 60 decades of exploration. Even more data is stored within company databases that are not currently available to the public.

Building on QUEST

The availability and use of high-quality, regional datasets has vastly expanded since the advent of digital-files data collection, distribution and storage. Geoscience BC's

QUEST, QUEST-South and QUEST-West projects have generated a significant volume of new data covering key parts of the Stikine and Quesnel terranes, including airborne-gravity and electromagnetic (EM) surveys, as well as geochemical analyses of new, and reanalyzed, stream- and lake-sediment samples. Geoscience BC has also recently funded many stand-alone projects focused on developing porphyry-deposit exploration techniques (e.g., Cook and Dunn, 2007; Dunn et al., 2007; Bouzari et al., 2010; Heberlein, 2010; Heberlein and Samson, 2010; Mitchinson and Bissig, 2010; Heberlein and Dunn, 2011; Mitchinson and Enkin, 2011).

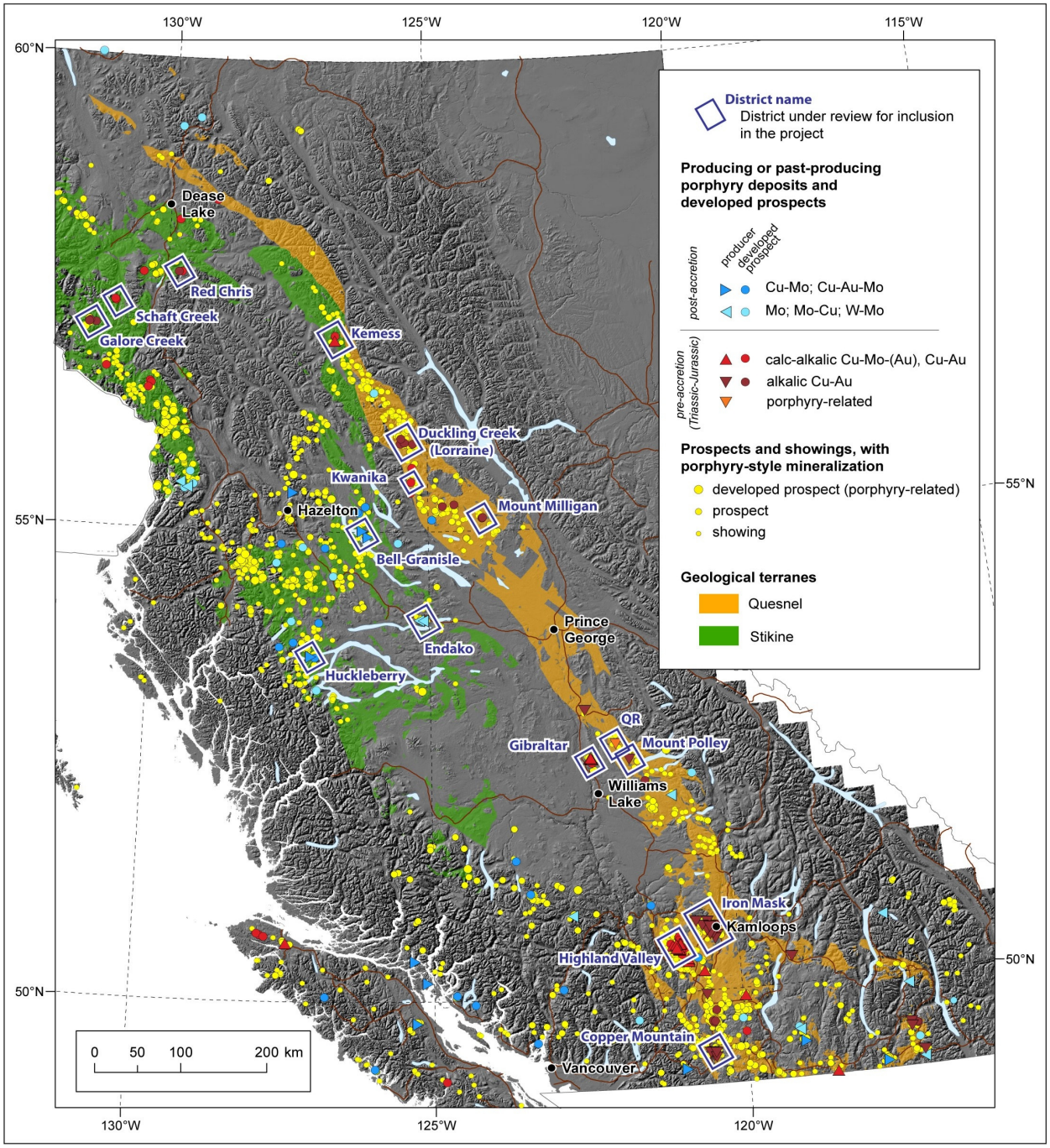

Figure 1. Digital elevation model of British Columbia showing the location of producing porphyry deposits and 'porphyry-style' mineralization (Canadian Council on Geomatics, 2004; BC Geological Survey, 2010). Classification of occurrences follows the tectonic-related divisions highlighted by McMillan et al. (1995). Although found elsewhere within BC, porphyry mineralization is most commonly associated with the Stikine (green) and Quesnel (orange) terranes, highlighting the prospectivity of these terranes for additional discoveries. Blue outlines correspond to the porphyry districts of interest that are currently under consideration by the project team. Ultimately, districts will be chosen to represent the spectrum of BC porphyry-deposit types (not all districts outlined in Figure 1 will be included in the final project).

The history of porphyry research and exploration in BC, combined with improved understanding of porphyry systems and significant new regional datasets, as well as detailed studies of deposits and assessment of suitable exploration techniques, creates an opportunity to integrate these new datasets and knowledge into a comprehensive BC porphyry-deposit exploration framework.

Project Approach

The Porphyry Integration Project is based on a 'porphyry signature' concept. The intention is to identify geological characteristics at the district scale that will help lead to the identification of contained deposits. By studying several relatively mature districts, some of which have producing mines, the project team will benefit from knowing where the porphyry deposits lie within those districts and have access to historical exploration data collected within the district, both adjacent to and remote from the known deposit(s). The goals of the project are to compile, integrate and interpret district-scale information in the context of the regional-scale data contained in industry, academic and public geoscience datasets; it further aims to provide exploration guidelines directly useful to exploration companies in vectoring to porphyry deposits in comparably unknown districts as they follow up on regional-scale targeting programs.

The district-scale focus is key to the project model. The project will not attempt to conduct detailed research on individual deposits; it will instead concentrate on the intermediate scale, in between the detailed deposit or property scale, which is the focus of industry, and the more expansive regional scale, which is the focus of public geoscience agencies. The district scale is familiar to explorers working on mineral properties and the products generated through this project will be directly comparable to those produced at the mineral-exploration project scale, thereby being of immediate use to explorers.

Datasets for compilation and integration include, but are not limited to

- geological mapping (BC Geological Survey and Geological Survey of Canada regional mapping; property-scale mapping);
- BC MINFILE mineral occurrences;
- remote-sensing data;
- regional geophysical surveys, including recent regional Geoscience BC and Natural Resources Canada airborne-gravity and magnetic surveys;
- property-scale geophysical surveys, including induced-polarization, EM and magnetic datasets;
- regional geochemical surveys;
- soil surveys using various extraction techniques;
- stream-sediment surveys;
- whole-rock geochemistry; and
- detailed deposit research, including isotope- and mineral-chemistry studies.

Layering and manipulation of digital data will enable an evaluation of any trends and features visible in the datasets, and assist the project team with accessing their ability to effectively recognize the location of deposits in a given district. Based on this evaluation, the project team will endeavour to develop a set of geological, geophysical and geochemical tools and techniques, which can be applied to porphyry exploration in other districts.

Porphyry Districts of Interest

Sixteen districts of interest have been identified (see Figure 1) and compilation is underway to evaluate the public datasets and potential company datasets that exist in each of these areas. A limited list of districts will be chosen to be the focus of this project, selection of which will depend on the availability, quality and breadth of data.

Project Deliverables

Planned products of the project include a hard-copy atlas of maps for each district selected and guides to deposit characteristics, as well as recommendations on exploration tools and techniques. The scale of maps between districts will be held constant to maximize the ability to compare and contrast data between map sets. As porphyry deposits of different classes and age (e.g., alkalic Cu-Au, Cu-Mo, Mo; Triassic–Jurassic versus Cretaceous) will be integrated, some of which occur in different physiographic regions, the ability to compare between deposits is important to the effectiveness and usefulness of the final product.

Project Team

The project is a collaborative effort between Geoscience BC and the MDRU at the University of British Columbia. The three branches (geology, geophysics and geochemistry) of the project all contribute to the complete integration of data on each district and will rely on the expertise provided by Geoscience BC consultants and MDRU researchers. D. Heberlein (Heberlein Geoconsulting and Geoscience BC project team) and F. Blaine (MDRU) will be responsible for the geochemical components of the project. D. Heberlein, an expert in geochemistry-driven exploration targeting, recently completed two Geoscience BC-funded projects focused on testing the effectiveness of geochemical methods in identifying buried porphyry deposits in central Quesnellia (Heberlein, 2010; Heberlein and Samson, 2010). F. Blaine is currently working on a Geoscience BC-sponsored project entitled "Geochemical Models for BC Porphyry Deposits: Outcropping, Blind and Buried Examples" (http://www.geosciencebc.com/s/2009-048.asp). P. Kowalczyk (Mira Geoscience and Geoscience BC project team) and D. Mitchinson (MDRU) will be responsible

for the geophysical components. P. Kowalczyk, a leading authority on geophysical techniques applied to mineral exploration, has over 40 years of experience in BC mineral exploration. D. Mitchinson is nearing completion on a Geoscience BC-supported post-doctoral research project entitled "Integrated Geological and Geophysical Porphyry Models: Adding Value to Geoscience BC Geophysical Data" (see Mitchinson and Bissig, 2010; Mitchinson and Enkin, 2011; http://www.geosciencebc.com/s/2009-001.asp). F. Devine (Merlin Geosciences Inc. and Geoscience BC project team) and T. Bissig (joint MDRU-Geoscience BC researcher) will be responsible for the geological components. F. Devine has expertise in regional- to property-scale geology evaluation and experience in recent porphyry Cu-Au exploration and research in BC. T. Bissig is leading the MDRU porphyry Cu-Au- and epithermal Au-deposit projects and brings global experience in porphyry-deposit research, including expertise on BC's alkalic porphyry Cu-Au deposits.

Summary

This project will be among the first to develop a comprehensive and comparative view of new multidisciplinary datasets on key BC porphyry deposits, specifically focused on exploration strategy. Data compilation is underway with districts chosen for compilation and integration by the end of 2010. District dataset development will continue through 2011, with all products to be available in early 2012. New information on this project will be available through the Geoscience BC website (www.geoscience bc.com).

Acknowledgments

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