Surficial Geochemical Map Packages for British Columbia Porphyry Systems

C.J.R. Hart, Mineral Deposit Research Unit (MDRU), The University of British Columbia, Vancouver, BC, chart@eos.ubc.ca

S. Jenkins, Mineral Deposit Research Unit (MDRU), The University of British Columbia, Vancouver, BC

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Introduction

The application of geochemical methods to surficial materials for the exploration and discovery of British Columbia (BC) porphyry deposits has resulted in many successes, but is fraught with challenges that contribute toward decreasing success in areas of cover. Porphyry systems themselves are invariably diverse, large and zoned; their geochemical signatures can vary considerably over large areas, depending on sample and survey location within the system. Post-mineralization dispersion of surficial materials by glacial, alluvial and mass-wasting processes further diffuses the signal. Additionally, the pedogenic processes involved in soil formation, such as oxidation, bio- and cryoturbation, leaching and hydromorphic dispersion, further contribute to modifying the geochemical signal and patterns.

Savvy explorers are well aware of these challenges, and tools have been developed to assist in their recognition. Geochemical-exploration models, for example, were first developed and presented by Bradshaw (1975) for deposits in the Canadian Cordillera and Canadian Shield. General, conceptual geochemical-exploration models (GEMs) were created for ore deposits in BC based on fundamental scientific principles and a limited number of case histories. These preliminary models summarized the potential controls on geochemical dispersal, and the expected results of the modified geochemical distributions. Subsequent efforts emphasized GEMs in volcanogenic massive-sulphide and shale-hosted Pb-Zn-Ag deposits in the Canadian Cordillera (Lett and Jackman, 2000; Lett, 2001; Lett and Bradshaw, 2003). Although it was recognized by Lett and Bradshaw (2003) that greater development and refinement of GEMs related to Cordilleran porphyry deposits was required, little progress was made and advances in the scientific literature were few.

Keywords: *British Columbia, geochemical exploration model, surficial geochemistry, ARIS, geochemical survey, porphyry deposit, soil*

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This Geoscience BC–sponsored MDRU research project aims to create a framework to considerably expand on the conceptual models presented by Bradshaw (1975), by providing an abundance of spatially enabled data that can contribute toward the development of real and constrained, empirically defined geochemical-exploration models for BC porphyry deposits in various surficial environments. The largest step toward improving GEMs comprises the compilation and updating of information relevant to evaluating such models, which can be sourced from the accumulated historical exploration data from both industry and government sources.

The purpose of this project and these results is to provide the mineral-exploration community with easy access to surficial geochemistry data and related information that facilitates exploration and discovery of BC porphyry deposits. For a selected group of porphyry deposits, geochemical information available in print form has been compiled, digitized and updated to meet modern geospatial standards, and paired with spatial datasets related to the physiographic setting, glacial history, surficial materials and other geological factors that may influence geochemical distributions. Examples of how such data can be utilized to understand the importance of surficial process, terrain and climate in modifying the geochemical signals are provided in Blaine and Hart (2012).

Location Selection

Initially, 44 BC porphyry deposits were evaluated for this project according to a range of features related to their geographic and physiographic settings. These included pedogenic and geomorphic factors potentially affecting geochemical dispersions, such as the glacial history, the thickness and type of glacially derived cover, topography and climate. From these, 15 porphyry deposits and/or groups of deposits were selected as localities deserving of greater attention due to availability of Assessment Report Indexing System (ARIS) data (Table 1). These deposits are Brenda, Getty, Iron Mask region (contains Afton, Ajax and Galaxy deposits), Mount Polley, Primer, Mouse Mountain, Davidson, Louise Lake, Pitman, Hearne Hill and Morrison, Takla-Rainbow, Mount Milligan, Shaft Creek North, Alwin and Red Chris (Figure 1).

Table 1: Classification of three major types of British Columbia porphyry deposits based on factors affecting surficial geochemical expression. Climatic factors include temperature (classed by the length of the frost-free period [ffp]), and precipitation (classed by the annual amount of non-snow precipitation [nsp]). Topographic factors include a general expression of relief (steep, moderate or slight). Deposits selected for delivery as geochemical-data compilations for this project are shown in bold text.

Climate		**Calc-Alkalic**			**Alkalic**			**Molybdenum**		
	Topography:	Steep	Moderate	Slight	Steep	Moderate	Slight	Steep	Moderate	Slight
Warm (ffp >50 days)	**Wet** (nsp >500 mm)	Ok North, Hushamu	**Louise Lake**	Gambier Island	Kena Gold, Kena (Gold Mountain)	-	-	**Pitman**	-	-
Warm (ffp >50 days)	**Dry** (nsp <500 mm)	**Hearne Hill,** Indata, May, **Morrison, Schaft Creek**	**Brenda,** HED, Poplar, **Highmont, Alwin**	**Getty South,** Jean	**Mt. Polley, Mt. Milligan,** Col	**Getty, Mouse Mtn., Primer**	**Ajax, Galaxy,** Woodjam	Carmi Mo, **Davidson,** Stewart	Mineral Hill	-
Cool (ffp <50 days)	**Wet** (nsp >500 mm)	Taseko, Huckleberry, New Nanik, Whiting Creek	-	-	-	-	-	-	-	-
Cool (ffp <50 days)	**Dry** (nsp <500 mm)	**Takla-Rainbow,** Kemess, **Red Chris**	Gnat Pass, Eaglehead	-	Chuchi Lake	-	-	Storie	-	-

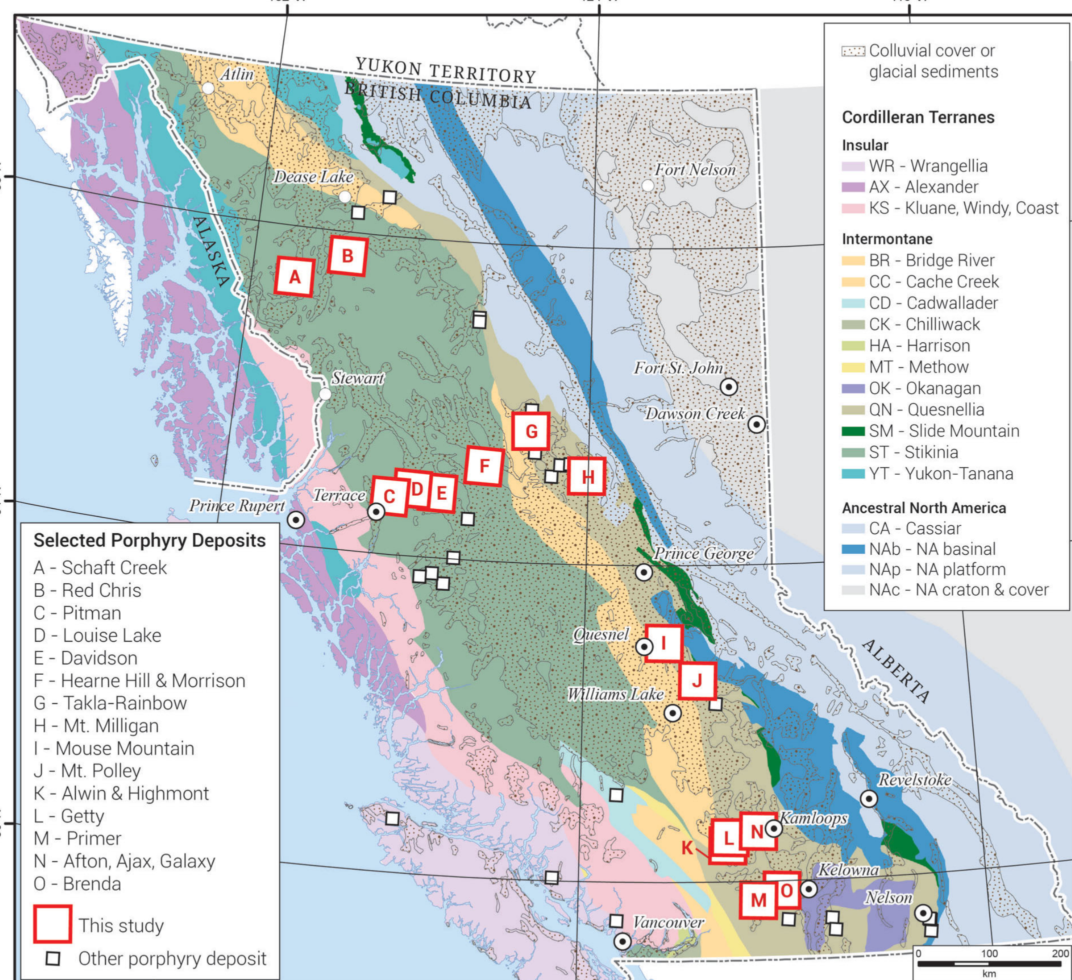

Figure 1: British Columbia porphyry deposits evaluated for this project (white squares with black or red borders) and those selected for geochemical-data compilations (white squares with red border), shown in reference to the distribution of Quaternary glacial deposits and older cover, as well as major terrane boundaries (Colpron and Nelson, 2011). Label refers to the legend key and to the name of the geochemical-data compilation associated with this project (e.g., Schaft Creek is package 2016-15-A).

Capturing Archival Data

Geochemical-sample data have been captured from many industry and government sources, including regional geochemical surveys carried out by the Geological Survey of Canada (Lett, 2011) and the BC Geological Survey (BCGS); the results of updated sampling and archival-sample analysis available from Geoscience BC; deposit- and area-specific studies carried out by the BCGS and Geoscience BC; and historical geochemical data generated through exploration by industry.

The primary source for the geochemical data compiled in this study is the ARIS archives, maintained by the BC Ministry of Energy and Mines. The ARIS documents are generally stored as scanned-to-PDF documents and vary widely in scan quality. Data of good quality for the selected deposits were retrieved through optical character recognition (OCR) of the scanned PDF documents and manually reviewed for errors, or entered into tables manually. Where text quality of the scanned document was too poor to determine the values, they were entered as null values.

This process resulted in the creation of approximately 50 000 spatial data points pertaining to individual geochemical samples for the 15 selected porphyry deposits shown in Figure 1. Compiled geochemical data were then re-projected into either geographic (latitude and longitude) or UTM co-ordinate systems for ease of use and to provide internal spatial confidence. The breakdown of these data by sample type is given in Table 2.

Products

Following geochemical-data compilation, additional relevant datasets were integrated with the geochemical data and packaged as self-extracting ArcGIS® map packages

Table 2: Distribution of sample type within the Assessment File Indexing System (ARIS) datasets digitized for each porphyry deposit in the GIS map packages. Abbreviation: BLEG, bulk leach extractable gold.

Compilation	Porphyry	Data source	Sample type										
			Soil	Silt	Stream sediment	Moss mat	Lake sediment	Till or outwash	Rock	Grab	Vegetation	BLEG	Unclear
A	**Schaft Creek**	ARIS	183						17				
		RGS (Lett, 2011)			278								
B	**Red Chris**	ARIS	2463										
		RGS (Lett, 2011)			425								
C	**Pitman**	ARIS	872										
		RGS (Lett, 2011)			790								
D	**Louise Lake**	ARIS	1101	534									
		RGS (Lett, 2011)			438		22						
E	**Davidson**	ARIS	446										
		RGS (Lett, 2011)			331		50						
F	**Hearne Hill & Morrison**	ARIS	807					1228					
		RGS (Lett, 2011)			714		803						
G	**Takla-Rainbow**	ARIS	19701		1978	165		1275	1751				8
		RGS (Lett, 2011)			841								
H	**Mt. Milligan**	ARIS	2519	32	59							33	
		RGS (Lett, 2011)			394		606						
		Other sources						121			133		
I	**Mouse Mtn**	ARIS	3403						1	15	2		2
		RGS (Lett, 2011)			692		31						
J	**Mt Polley**	ARIS	5625					85					
		RGS (Lett, 2011)			829								
		Other sources	105								100		
K	**Alwin & Highmont**	ARIS	712										
		RGS (Lett, 2011)			266								
L	**Getty**	ARIS	4298										
		RGS (Lett, 2011)			212								
		Other sources											318
M	**Primer**	ARIS	1151										
		RGS (Lett, 2011)			377								
N	**Afton, Ajax & Galaxy**	ARIS	2403		27		3	341					
		RGS (Lett, 2011)			186								
O	**Brenda**	ARIS	3788										
		RGS (Lett, 2011)			533								

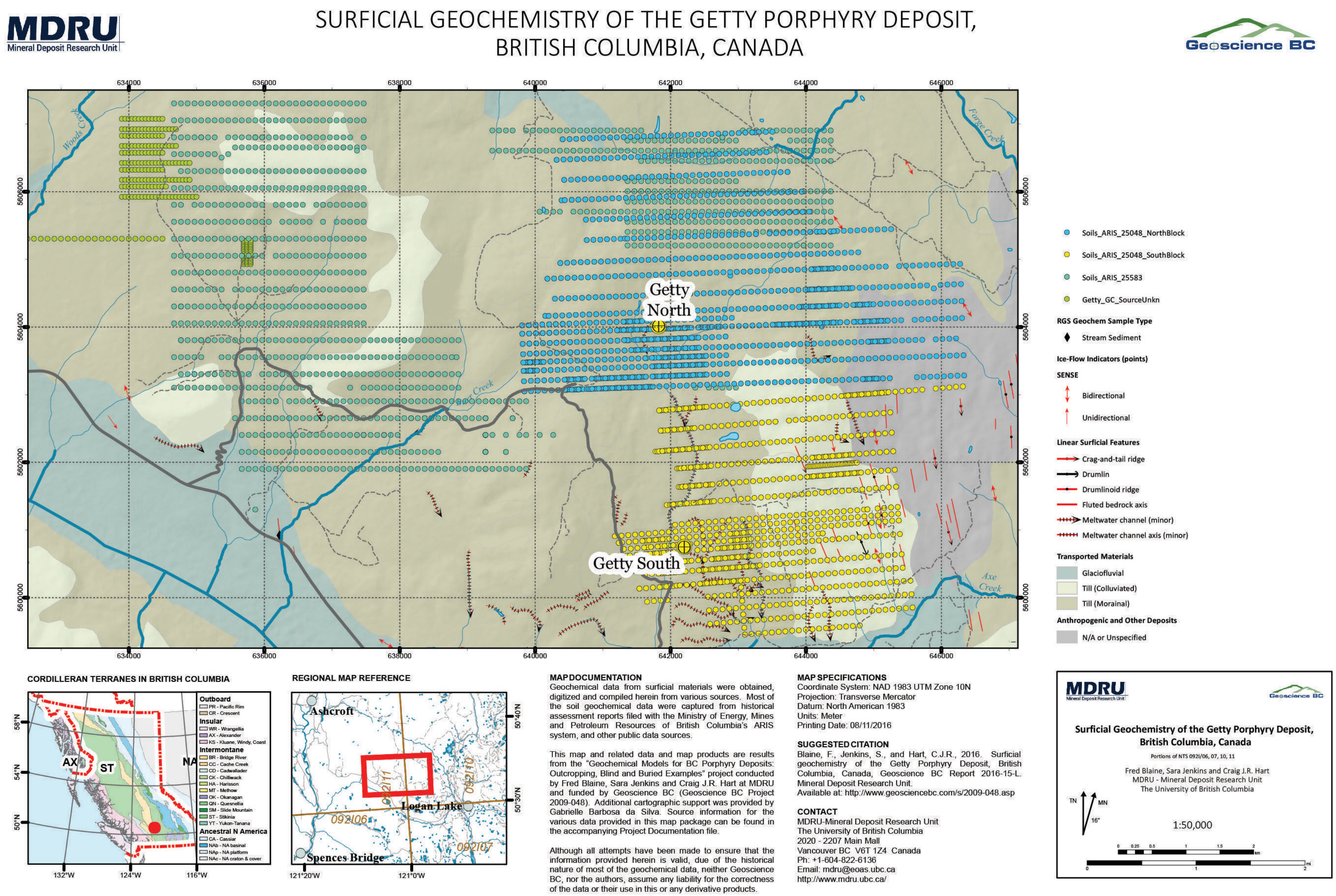

Figure 2: Surficial geochemistry of the Getty porphyry deposit, as an example of a self-extracting map package that is designed to be displayed or printed in 11 x 17 inch format. Features and text displayed here are representative and not intended to be utilized.

(.mpk) to allow users to undertake their own interpretations of geochemical signatures based on interrelated influences of physiography, geology, mineralization, surficial materials and glacial history at each porphyry deposit (Figure 2). For these packages, all GIS layers have been clipped to an area of 50 by 50 km around the deposit or group of deposits, but the maps are best displayed at the scale that incorporates the range of compiled soil-geochemical data. Users ultimately have the flexibility to view at whatever scale they wish.

Additional layers for each map package vary depending on availability of data at the highest level of detail, and may include

- digital elevation data and rendered hillshade images built from 30 m images resampled to 12 m resolution (Alaska Satellite Facility, 2015);
- National Topographic System (NTS) 1:50 000 scale gridlines and UTM zones;
- bedrock geology and faults (Colpron and Nelson, 2011; Cui et al., 2015);
- surficial geology (Fulton, 1995; Hashmi et al., 2015; Plouffe and Ferbey, 2015);
- glacial indicators (Ferbey et al., 2013);
- soils (BC Ministry of Environment, 2015);
- hydrological features (BC Ministry of Forests, Lands and Natural Resource Operations, 2016);
- geophysical imagery from various sources;
- scanned geological maps from assessment reports; and
- cultural and transportation information sourced from OpenStreetMap contributors (2016).

The packages open as a fully symbolized ArcGIS map project at a fixed scale (between 1:24 000 and 1:75 000), and display in a format suitable for printing on ledger/tabloid (11 by 17 inch) paper. Metadata for each layer are populated according to the ISO 19139 Metadata Implementation Specification.

Packages are accompanied by tabulated files (.xlsx) of geochemical data with map co-ordinates for manipulation outside ArcGIS; Geological Survey of Canada (GSC) fonts and layer files for third-party reproduction of symbologies in map packages; and a report summarizing the work conducted on the project, with a full list of ARIS reports and references for each map package. The project will also deliver georeferenced TIFF and PDF exports of the maps to ensure broad usability within the exploration sector. These files are available for download from the Project 2009-048: Geochemical Models for BC Porphyry Deposits: Outcropping, Blind and Buried Examples page of the Geoscience BC website.

Please note that, although reasonable efforts have been made to ensure that the data presented are of the highest quality, there may be errors due to the historical nature of the data, transcription and OCR errors, and spatial re-projections necessary to provide the data in modern GIS formats. Neither Geoscience BC, MDRU nor the authors assume any liability for the correctness of the data or decisions based upon its use.

Conclusion

The success or failure of a geochemical exploration program designed to discover a porphyry Cu system can depend on the practitioner's ability to interpret the data and effectively drill targets. Understanding how geochemical signatures respond and are modified according to various physiographic, glacial, pedogenic, climatic and related features is essential to effective exploration decision-making. Datasets provided as part of this project offer the ultimate, made-in-BC opportunity for geologists to discover and understand the various controlling features related to surficial geochemical responses and patterns.

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