

British Columbia Geological Survey annual program review 2014-2015

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1. Introduction

This annual review highlights the activities of the British Columbia Geological Survey (BCGS) in 2014, providing a summary of projects, events, and accomplishments. In 2015, the BCGS will celebrate 120 years of service to British Columbia and the mineral exploration industry. Throughout this long history, the core role of the Survey has been to link government, the minerals industry, and British Columbians to the Province's geology and mineral resources (see *The British Columbia Geological Survey*, IC2014-7¹). In support of this core role, the Survey is committed to:

- creating, maintaining, and delivering geoscience knowledge to lead informed decision making
- attracting companies and individuals to explore British Columbia for new mineral and coal resources
- acting as the public steward of mineral and coal resources for current and future generations
- guiding public policy by providing assessments on the nature and economic health of mineral exploration and mining activities

The BCGS is responsible for documenting, assessing and archiving the geology and related mineral and coal resources of the Province. The Survey strives to be a leader in public government geoscience, providing data and knowledge to all stakeholders through traditional reports, maps, databases, and resident expertise, but also through innovative web-based delivery. The BCGS is a branch in the Mines and Mineral Resources Division of the Ministry of Energy and Mines. It is headquartered in Victoria, on south Vancouver Island. The Survey is led by Stephen Rowins, the Chief Geologist and Executive Director, and consists of three sections: 1) Cordilleran Geoscience; 2) Resource Information; and 3) the Mineral Development Office (MDO).

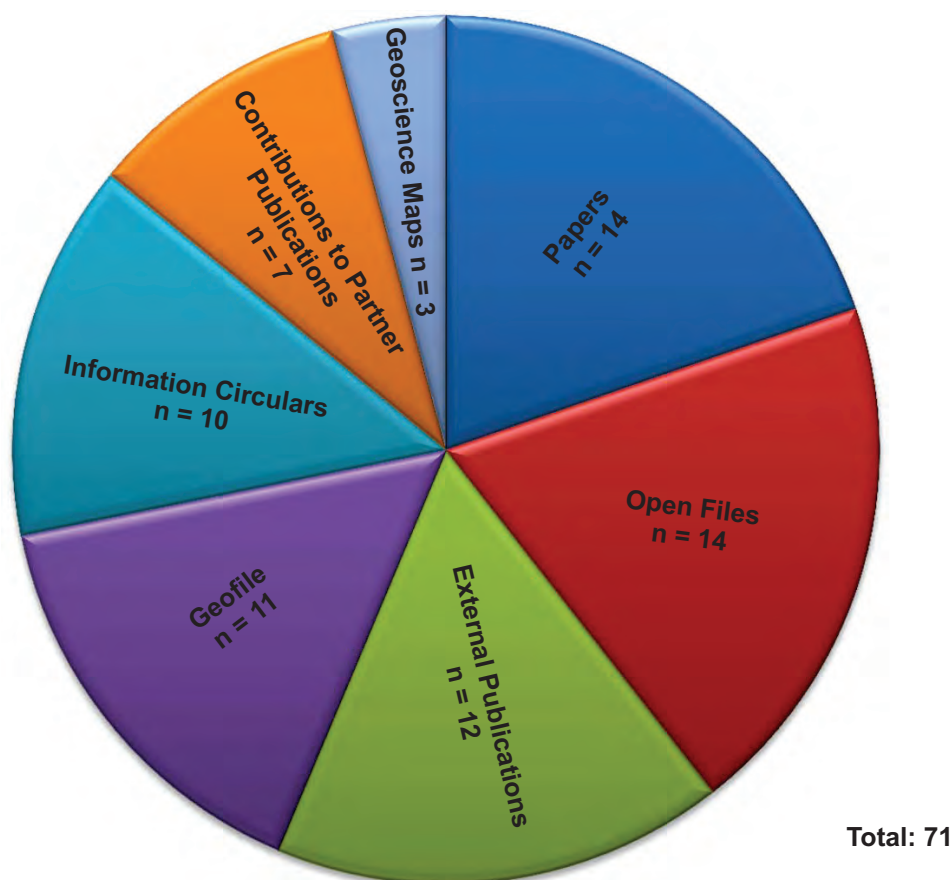
The Cordilleran Geoscience Section, led by Adrian Hickin, is responsible for generating new geoscience knowledge largely

through field-based surveys and targeted mineral deposit studies. Larry Jones directs the Resource Information Section, which is responsible for maintaining and developing the provincial geoscience databases and disseminating geoscience data online. Since 1947, the Resource Information Section has been responsible for evaluating and archiving assessment reports filed by the exploration and mining industry. These reports provide information on geological, geophysical, and geochemical activities related to mineral exploration in BC. Most reports are available online from the ARIS (Assessment Report Indexing System) website. The Mineral Development Office (MDO) is the Survey's Vancouver office and is led by Gordon Clarke. Vancouver is a centre of excellence for global mineral exploration and is the headquarters for more than 800 exploration and mining companies. As the technical marketing arm of the Survey, the MDO is well positioned to connect the exploration community with mineral and coal opportunities, geoscience products of the BCGS, and outputs of the Regional Geologist Program.

The British Columbia Geological Survey provides free web-based access to all of its geoscience outputs. In 2014, the Survey produced 71 new publications (Fig. 1; see Appendix, this volume) the results of which were presented at regional, national, and international scientific meetings and conferences. All publications, data releases, conference presentations, websites, and databases on MapPlace (MINFILE, ARIS, COALFILE, Property File) are profiled annually at the Association for Mineral Exploration in BC (AMEBC) Mineral Exploration Roundup in Vancouver and the Prospectors and Developers Association of Canada (PDAC) meeting in Toronto. Survey products are also distributed at regional geoscience meetings across the province throughout the year.

In January 2015, the Ministry of Energy and Mines and the British Columbia Geological Survey will inaugurate the 'BC Pavilion' at the Vancouver Convention Centre, the new venue for the Mineral Exploration Roundup. Designed as a one-stop venue for Roundup delegates to discuss the business of mineral exploration with government personnel, the Pavilion will be staffed by representatives from the BCGS, Mineral Titles

¹ British Columbia Geological Survey. Information Circular 2014-7, www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/InformationCirculars/Pages/IC2014-7.aspx



Types of Publications by the British Columbia Geological Survey

Papers: This series is reserved for reviews and final thematic or regional works. *Geological Fieldwork, our annual review of field activities and current research, is released as the first Paper of each year.

Geoscience Maps: This series is the BCGS vehicle for publishing final maps.

Open Files: These maps and reports present the interim results of ongoing research, particularly mapping projects.

GeoFiles: These publications enable rapid release of extensive data tables from ongoing geochemical, geochronologic, and geophysical work. As such, they serve the same function as data repositories provided by many journals, providing immediate access to raw data from specific projects.

Information Circulars: These publications provide accessible geoscience information to a broad audience in government, industry, and the general public. Included in the Information Circular series are the annual Provincial Overview of Mining and Exploration, **Exploration and Mining in British Columbia, and the Coal Industry Overview.

Contributions to partner publications: This category included reports, maps, and other products published by another agency such as the Geological Survey of Canada or Geoscience BC, but have received contributions from British Columbia Geological Survey staff.

External publications: These are contributions to the peer reviewed literature and published in a recognized national or international scientific journal.

*The count refers to the total number of article included in Geological Fieldwork.

**Although five articles are included in Exploration and Mining in British Columbia, the volume is counted as a single Information Circular.

Fig. 1. British Columbia Geological Survey publications in 2014.

Branch, Health, Safety and Permitting Branch, FrontCounter BC, and DataBC. The new space will afford the Survey and sister government organizations with the opportunity to present program highlights, geoscience information, and new exploration opportunities, and assist delegates with permitting and tenuring issues.

2. Partnerships

Limited government resources combined with a challenging global investment climate mean that collaborative geoscience partnerships are necessary to maximize the effectiveness of BCGS projects. In 2014, the BCGS collaborated with the Geological Survey of Canada, universities, Geoscience BC, and industry to deliver diverse geoscience projects, some of which are described below. Please contact Adrian Hickin (Director, Cordilleran Geoscience; Adrian.Hickin@gov.bc.ca) for details about partnering with the Survey.

2.1. Geological Survey of Canada

The BCGS and the Geological Survey of Canada (GSC) continue to collaborate closely on both large and small geoscience projects. In 2014, the Province engaged in two main collaborations: the fourth iteration of the Targeted Geoscience Initiative (TGI4) program; and the second iteration of the Geo-mapping for Energy and Minerals (GEM 2) program.

2.1.1. Targeted Geoscience Initiative 4

The TGI4 program provides geoscience knowledge to effectively target buried mineral deposits. The past 30 years have seen a marked decline in proven and probable mineral reserves in Canada (Duke, 2010). As surface discoveries decline, exploration efforts are directed at targets under deep cover. The aims of the program are to: 1) develop robust means of determining if a geological system may contain deeply buried ore (system fertility) and providing a direction to that ore (exploration vectors), thereby reducing investment risk and cost; and 2) develop new and improved geoscience knowledge and techniques to better understand, model, and detect mineral systems. The BCGS has partnered with the GSC on three TGI4 projects: 1) Specialty metals; 2) Orogenic Ni-Cu-PGE; and 3) Porphyry indicator minerals (PIMs) in till. These projects are described in following sections.

2.1.2. Geo-mapping for Energy and Minerals 2

The GSC launched the first phase of a five-year Geo-mapping for Energy and Minerals (GEM) program in 2008. During this phase, the BCGS participated in several initiatives as part of the “EDGES” project (Fig. 2). The goal of EDGES was to outline resource-rich environments in the exotic terranes that accreted to the western flank ancestral North America. BCGS contributions included mapping projects on BC’s north coast, Kutchikan region, central BC (QUEST compilation) and northwest BC (Sutcliffe). The second phase of GEM, a seven-year program (2013-2020), was announced in August 2013. The BCGS is participating in the Cordilleran Regional project (Fig. 2), which

involves the geological surveys of Yukon, Alaska, BC and the Canadian Government. Multidisciplinary field-based studies in poorly understood areas will focus on bedrock geology, crustal architecture, Cordilleran tectonics, and metallogeny to help drive the discovery of new mineral deposits and increase known resources. In addition, surficial geology and glacial history studies will provide vital knowledge for mineral exploration in covered regions. Initial work will be directed at western and southern Yukon and northernmost British Columbia through three themes, or “activities” including: 1) Crustal Blocks, 2) Porphyry Transition, and 3) Cache Creek (Fig. 2). Each activity will begin with a short field reconnaissance to identify priority areas and develop more substantive studies. Surficial geology activities will be integrated with bedrock mapping, facilitating mineral exploration in glaciated and unglaciated drift-covered areas of the Yukon.

2.2. Ministry of Energy and Mines-University of Victoria Partnership (MEM-UVic Partnership)

The goal of this partnership is to support research projects and student training that will benefit UVic, MEM and the energy and mining sectors in BC. Since 2003, the partnership has funded 37 research projects, 25 student projects, and 45 student Co-op positions. Additional funding to the partnership in 2012 supported six new four-month Co-op term positions with the BCGS, three joint research projects, and a project aimed at engaging youth through minerals and mining education.

2.3. Geoscience BC-Targeting Resources for Exploration and Knowledge (TREK)

The Targeting Resources for Exploration and Knowledge (TREK) Project, initiated in 2013, focuses on the northern Interior Plateau. This is an underexplored region with complex and thick sediment and volcanic cover. The first phase of the TREK geochemistry component was a collaboration between the BCGS and Geoscience BC. In 2013 the BCGS completed its contribution to the project through the development, supervision, and production of basal till potential maps. The till potential maps highlight where basal till is most likely to occur, and were used to plan and implement the TREK project till geochemical sampling program. In 2014, ten basal till potential maps of the TREK project area were co-published with Geoscience BC (see Appendix, this volume). In addition, Travis Ferbey, a senior Quaternary geologist with the BCGS, assisted in training Geoscience BC till sampling field crews to use these maps and recognize basal till, which is the ideal media for drift prospecting.

3. Cordilleran Geoscience Section

The Cordilleran Section is responsible for generating new geoscience knowledge through field-based studies, regional mapping, and targeted geoscience projects. The portfolio of projects is developed to balance both short- and long-term needs of the exploration community, thereby stimulating and maintaining a prosperous mineral exploration and investment

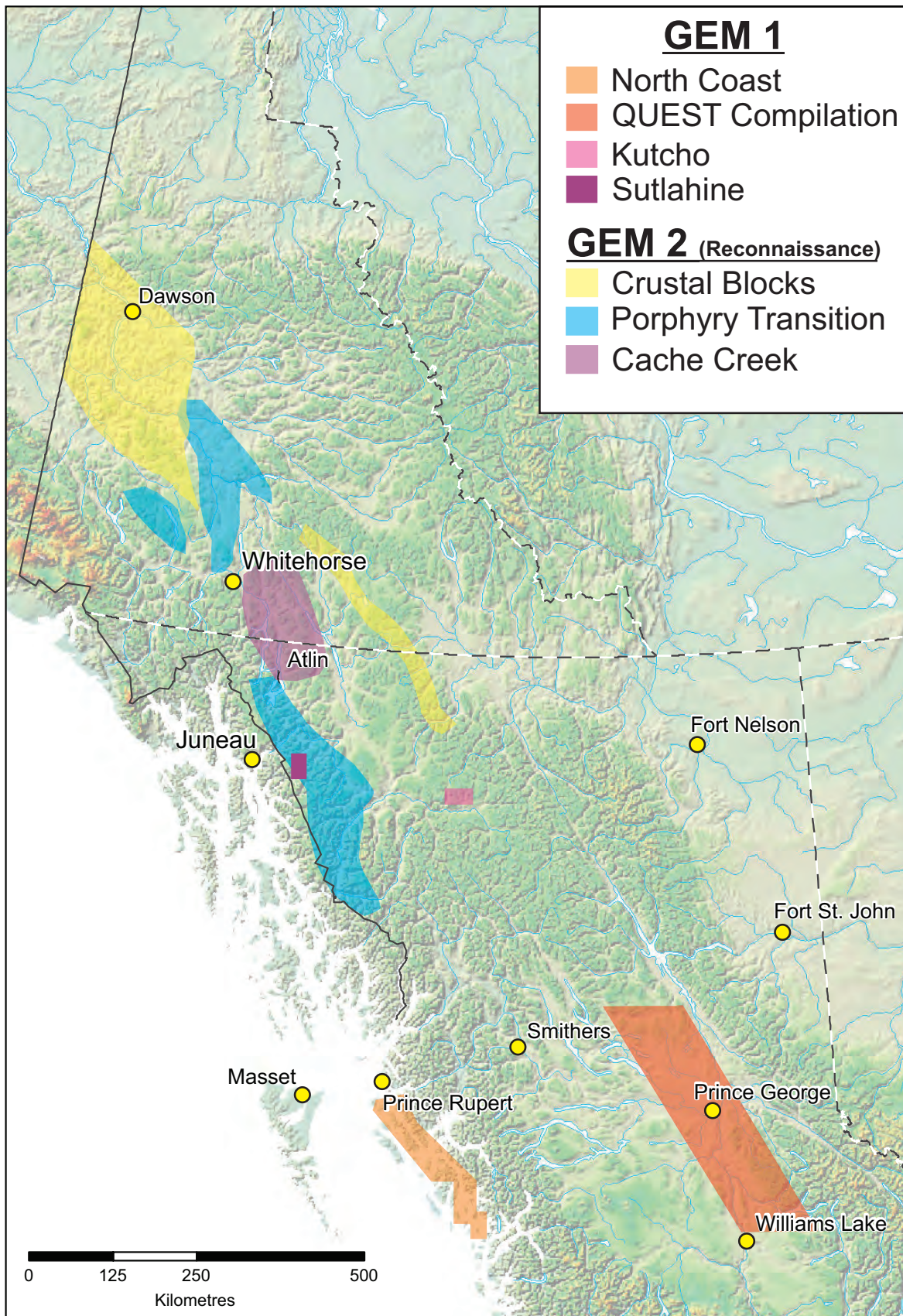


Fig. 2. Location of collaborative projects between the Geological Survey of Canada and the British Columbia Geological Survey through the Geo-mapping for Energy and Minerals (GEM) 1 and 2.

industry in British Columbia. The BCGS continues to have an important role in spurring activity as the exploration industry continues to face financial challenges. BCGS projects yield new geoscience maps, geological models, and exploration targets, thus contributing toward making BC a preferred destination for new investment in minerals and coal resources.

3.1. 2013-2014 Projects

The Cordilleran Section projects cover four general themes: 1) BC Porphyry Initiatives; 2) Exploration Methods; 3) Mineral Deposit Studies; and 4) Regional Synthesis and Map Compilations. Many of these projects are advanced multi-year investigations. The following section highlights 2014 activities (Fig. 3).

3.1.1. BC Porphyry Deposits Initiative

Much of British Columbia's metal endowment occurs in Cu-Mo-Au calc-alkaline and alkalic porphyry deposits genetically related to Late-Triassic to Early Jurassic island arc magmatism (Logan and Mihalynuk, 2014). The BC Porphyry Deposits Initiative, which began in 2012, is directed at: 1) determining the ages and structural controls on arc magmatism and porphyry pluton emplacement; 2) establishing the geological framework of major porphyry trends; and 3) developing new exploration techniques to aid in the discovery of buried or blind deposits. The main project areas (Fig. 4) are in the Intermontane arc complex, focusing on the Nicola Arc in the Quesnel terrane (BC interior plateau) and in Stikine terrane (northwest BC).

3.1.1.1. Nicola Arc

The Nicola Arc consists of three temporally distinct, north-trending plutonic belts that may represent the eastward migration of the Mesozoic arc magmatism (Fig. 5; Logan and Mihalynuk, 2014). This belt of rocks is particularly important to British Columbia's mineral wealth, hosting active mines such as Copper Mountain, Highland Valley, New Afton, and Gibraltar.

3.1.1.1.1. Southern Nicola Arc Project (2013-2015)

Lead by Mitch Mihalynuk and supported by Larry Diakow, the Southern Nicola Arc Project (SNAP) is remapping the geology between Princeton and Merritt (Fig. 6) to refine the stratigraphic, structural, and mineral deposit evolution of the Quesnel terrane. Results of this two-year project are reported by Mihalynuk et al. (2014) and in this volume. New mapping, geochronology, and geochemistry have added detail to the geology between the Allison Lake pluton and the Osprey Lake batholith and identified a number of new mineral occurrences (Fig. 7).

3.1.1.1.2. Gibraltar Mine and the Granite Mountain Batholith (2013-2015)

Gibraltar Mine began production in 1972 targeting Cu-Mo mineralization hosted in the Granite Mountain batholith (Late Triassic). Despite a long production history, the origin of the

deposit has been contentious (Ash and Riveros, 2001), and it has remained unclear if it formed in the Cache Creek terrane or the Quesnel terrane. New mapping, stratigraphic, geochronologic, and paleontologic studies by Paul Schiarizza were directed at resolving the question. Work in 2013 (Schiarizza, 2014) and in 2014 (see Schiarizza, this volume) demonstrates that the Granite Mountain batholith cuts rocks characteristic of Quesnel terrane and is part of a Late Triassic magmatic belt that includes the Guichon Creek batholith, which hosts the Highland Valley Cu deposit.

3.1.1.1.3. Porphyry indicator minerals in till, central British Columbia (TG14; 2010-2015)

Alain Plouffe (GSC) and Travis Ferbey (BCGS) are developing surficial geochemical and mineralogical methods for detecting buried porphyry-style mineralization in drift-covered areas. This project aims to define the key components of till that are enriched with porphyry indicator minerals and retain a porphyry trace element chemistry following a history of erosion from a mineralized outcrop, subglacial transport, and near-surface oxidation. Glacial dispersal of heavy minerals and till matrix are being studied at the Highland Valley, Gibraltar, and Mount Polley mines, and the advanced-stage Woodjam project. A critical part of the study is applying surficial geological mapping and observations of ice-flow indicators to reconstruct the glacial and ice-flow histories at each site. These ice-flow histories will be applied to the interpretation of geochemical and mineralogical dispersal patterns in till.

3.1.1.2. Porphyry Transitions (GEM 2; 2013-2018)

Paired belts of calc-alkaline and alkalic porphyry deposits that are genetically linked to early Mesozoic arc magmatism are documented in the southern Quesnel terrane and, potentially, parts of the more northerly Stikine terrane (Logan and Mihalynuk, 2014). The temporal and geochemical characteristics of the belts are reasonably well constrained in southern Quesnel terrane (Mihalynuk et al. this volume; Schiarizza, this volume), but they remain ambiguous in Stikine terrane (Zagorevski, et al., 2014). The transition from calc-alkaline to alkaline magmatism (e.g., Logan and Mihalynuk 2014) reflects changes in subduction geometry and/or melting regime of lithosphere below the arc. Mitch Mihalynuk (BCGS) and Alex Zagorevski (GSC) are co-leading a project that aims to develop and update the regional geologic framework for magmatism in the Stikine and Yukon-Tanana terrane by characterizing volcanic and intrusive rocks across the BC-Yukon border (Fig. 8). Activities in 2014 were directed at reconnaissance-level work that sets the stage for the larger study and focuses on constraining the age and petrology of Late Triassic to Early Jurassic plutons (Zagorevski, et al., 2014).

3.1.1.3. Structural and stratigraphic control of porphyry mineralization in the Snip-Bronson area (2014)

This project is a continuation of work begun in 2013 in the KSM-Brucejack area near the McTagg anticlinorium

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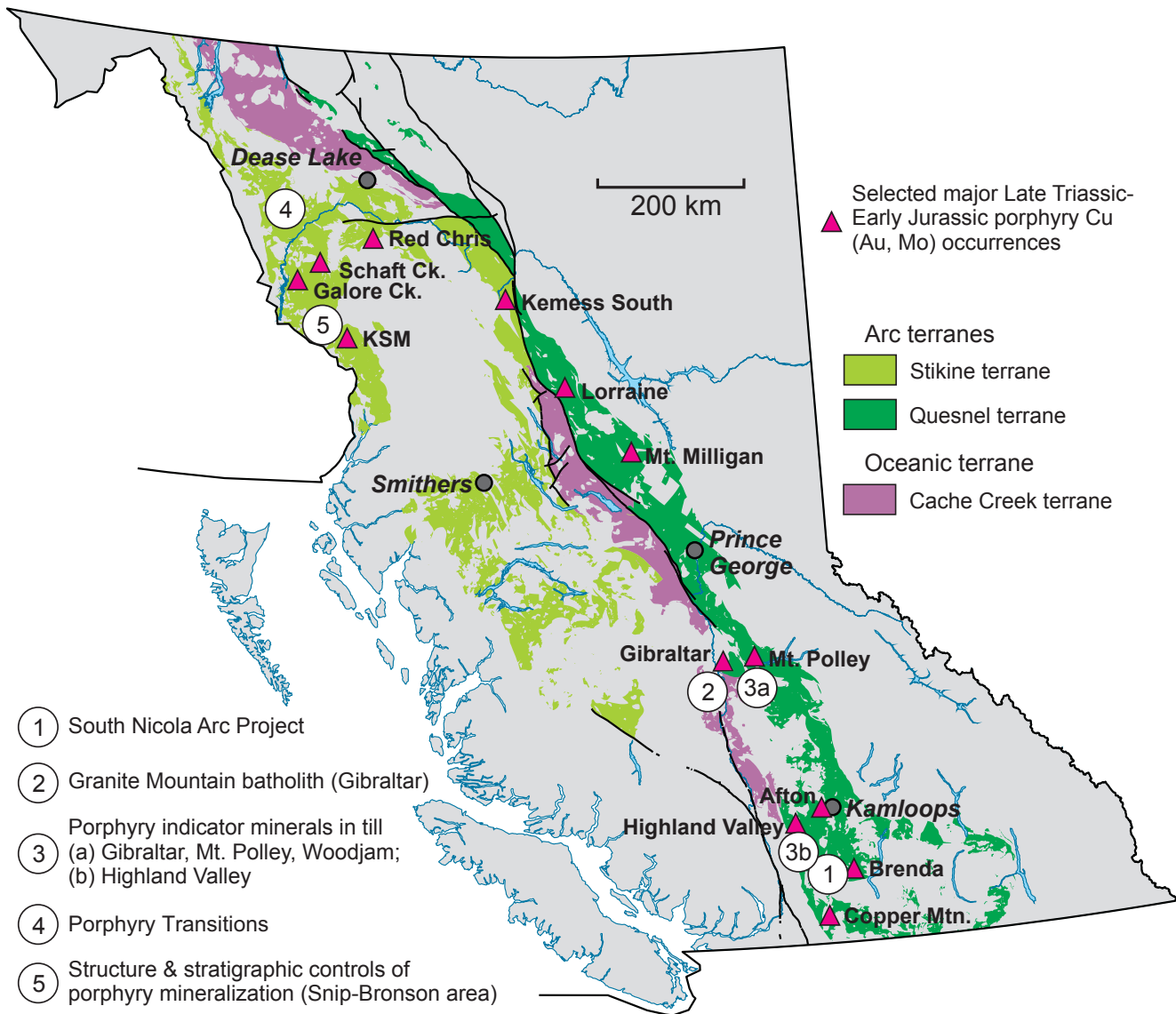


Fig. 4. Location of BC Porphyry Initiative project areas and the main porphyry terranes in British Columbia (i.e. Quesnel and Stikine terranes).

(Nelson and Kyba, 2014). The work is directed at establishing stratigraphic and structural controls on latest Triassic to Early Jurassic porphyry and related mineralisation. A key stratigraphic element, the unconformity between the Stuhini Group (Upper Triassic) and the Hazelton Group (Upper Triassic to Lower Jurassic), represents tectonic interruption and modification of arc magmatism in Stikinia. Also important to orebody location and form are long-lived, multiply-reactivated faults, such as the north-striking Sulphurets fault, which defines the eastern boundary of the McTagg anticlinorium. To the west, south of the lower Iskut River, a set of prominent alteration zones, Early Jurassic intrusions, and porphyry-related epigenetic vein occurrences (the 'Bronson corridor') are associated with the sub-Hazelton Group unconformity. Structural trends here are at a high angle to the generally north-trending grain in the KSM-

Brucejack area. They control the west-northwest-trending mineralized belt, and are thus of pre-mineral origin. JoAnne Nelson and Jeff Kyba aim to extend the understanding of the interaction of synmagmatic structures and Hazelton basins and volcanic centres into the western Iskut River area (Fig. 9; see Kyba and Nelson, this volume).

3.1.2. Exploration Methods

3.1.2.1. Carlin-type Gold in BC (2013)

Led by Alexei Rukhlov, this project uses regional stream-sediment geochemistry to detect Carlin-type gold deposits in northern British Columbia. Statistically robust treatment of multi-element geochemical data successfully demonstrates $\text{Au} \pm \text{As} \pm \text{Hg} \pm \text{Tl} \pm \text{Sb}$ enrichment in stream and lake sediments from the Kechika trough, a long-lived (Neoproterozoic to

Nicola Arc Project

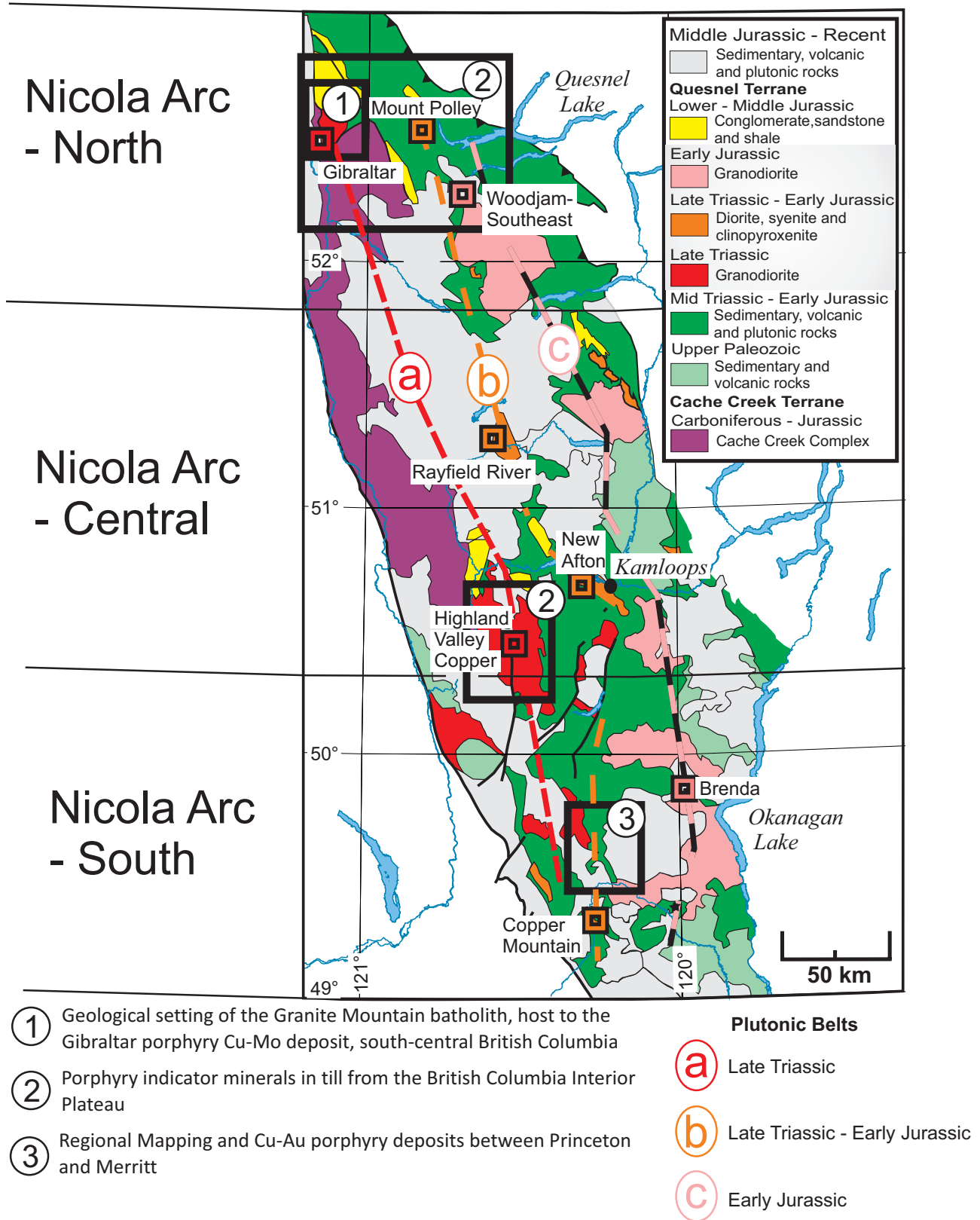


Fig. 5. Location of the Nicola Arc project areas. Generalized geology of southern Quesnellia modified from Logan and Mihalynuk (2013).

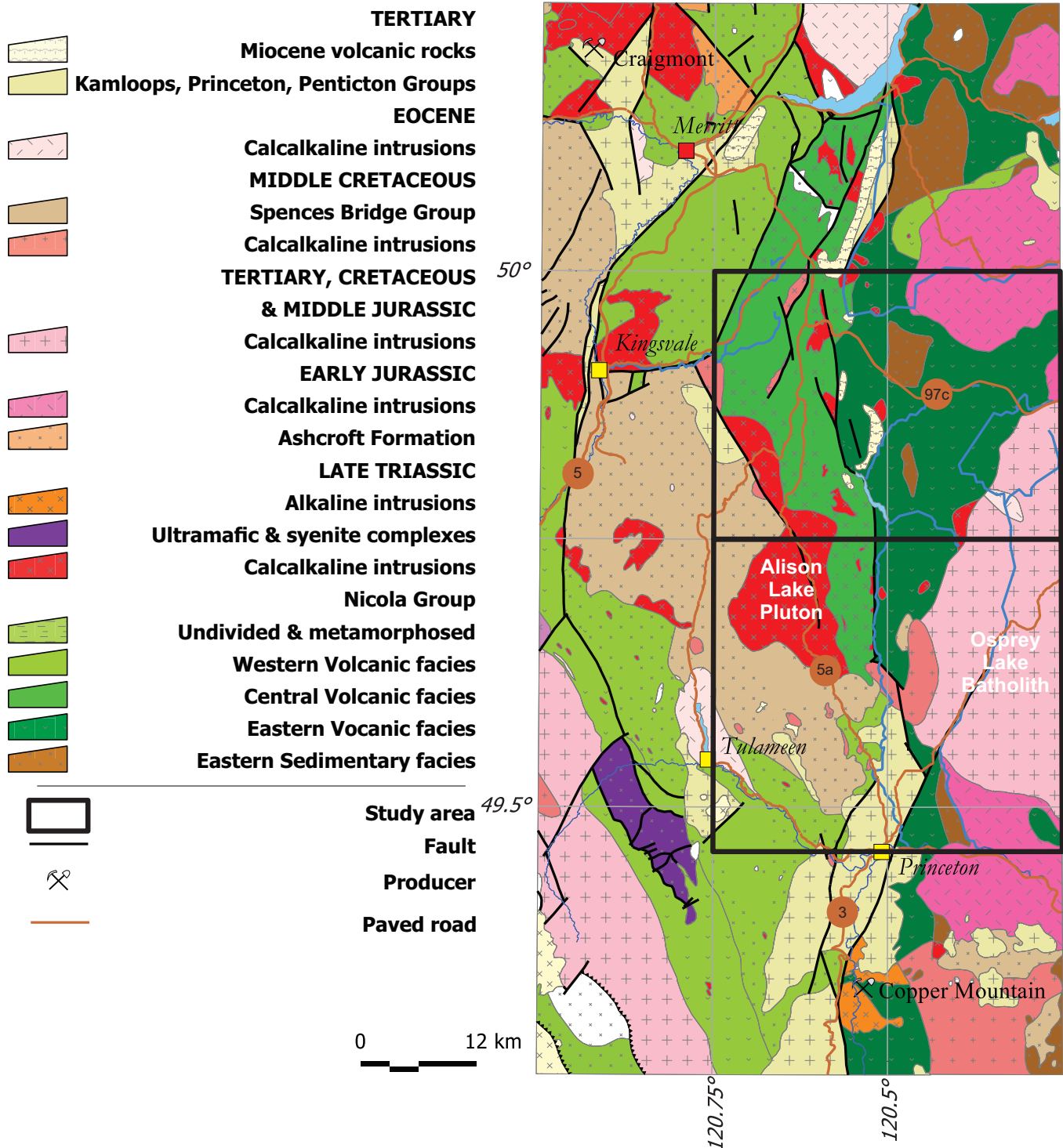


Fig. 6. Generalized geology of the Southern Nicola Arc Project (SNAP) area (from Mihalynuk et al. this volume).



Fig. 7. Geological mapping in the Southern Nicola Arc study area.



Fig. 8. Reconnaissance mapping and geochronological sampling in the northern British Columbia, part of the Porphyry Transitions project under the collaborative GSC-BCGS GEM 2 Cordilleran Regional program.

Paleozoic) deep-water basin in north-central British Columbia. A similar enrichment is found in stream sediments sourced from recently discovered Carlin-type gold and realgar occurrences in Rackla belt in the Selwyn basin of east-central Yukon. The Kechika trough may hold potential for Carlin-type deposits (Rukhlov et al., this volume).

3.1.2.2. Trace Element Systematics of Hydrothermal Apatite in Major Mineral Deposits (MEM-UVic Partnership; 2013-2014)

This project is developing a new exploration tool for concealed deposits using the abundances of trace elements in hydrothermal apatite associated with all the major mineral deposit types. This is a joint research project between the University of Victoria and the BCGS. The project draws on the expertise of Dr. Mao Mao (MEM-UVic Research Scientist),



Fig. 9. Geological mapping and stratigraphic studies on Snippaker Ridge above the Bronson Airstrip, Iskut River area, northern British Columbia.

Dr. Alexei Rukhlov (BCGS), Dr. Stephen Rowins (BCGS), Dr. Laurence Coogan (UVic), and Dr. Jody Spence (UVic) and is funded through the MEM-UVic Partnership. The development of analytical protocols for the measurement of trace element abundances in hydrothermal and magmatic apatites using laser ablation inductively-coupled plasma mass spectrometry (LA-ICPMS) has allowed for the discrimination of hydrothermal apatites from different mineral deposits and different host-rocks. This study will provide a powerful exploration technique in till-covered terrains. Apatite was chosen for this study because it is a common accessory mineral in igneous, metamorphic and sedimentary rocks, and most types of mineral deposits.

3.1.2.3. Lead Isotopes (2013-2014)

Alexei Rukhlov, with support from Travis Ferbey, is testing the application of lead isotopes in till silt and clay fractions to explore for massive sulphide deposits in glaciated terrains where conventional geochemical techniques are inconclusive. Lead isotopic ratios provide a unique way to fingerprint distinct bedrock sources (e.g., mineralization vs background) even in cases where elemental abundances in tills derived from these sources show little contrast. Due to a large difference in Pb isotopic ratios between anomalous and background samples (several %), this technique may not require expensive state-of-the-art precision to highlight a volcanogenic-massive-sulphide (VMS) signal in basal till. Basal till and rock samples, including

the VMS ores from the Seneca deposit (Chehalis River valley; hosted in Middle Jurassic Harrison Lake Formation), were analysed for conventional geochemical and isotopic analyses at three different laboratories to test different extraction and analytical techniques. The project confirmed the method for mineral exploration in northern Cordillera, where most VMS deposits are as young as Mesozoic, and that results from commercial ICP-MS are consistent with those derived from more sophisticated, and expensive, techniques.

3.1.3. Mineral Deposits

3.1.3.1. Specialty Metals (TGI4; 2010-2015)

The BCGS and the GSC continued to collaborate on this five-year Province and nation-wide study of specialty metals and rare earth elements. Specialty metals are uncommon, nonferrous metals used in small quantities (typically < 150,000 tonnes/year or derived from geographically restricted areas). The Specialty Metals Program is led by BCGS Geologist George Simandl and is an important contribution to Natural Resources Canada's TGI4 program. It has two major components: 1) reviewing ore deposits and their mineral economics in Canada; and 2) developing techniques to guide exploration toward ore-grade zones in host deposits. Fieldwork for this project was completed in 2013. In 2014 most efforts were directed at processing stream-sediment samples and developing cost effective, efficient and rapid specialty metal specific (Nb, Ta, and REE) indicator mineral-based vectoring method that involves Quantitative Evaluation of Minerals by SCANNing electron microscopy (QEMSCAN). This technique could be used by industry to follow-up on anomalies detected by regional geochemical surveys. To be effective, new specialty metal specific discrimination diagrams have been developed. Recent work focused on carbon, oxygen, and sulfur stable isotope studies of carbonatite-related mineralization and future work will involve the characterization of carbonatite mineralizing systems. The results of the Specialty Metals project will aid exploration and development of these strategic metal resources.

3.1.3.2. Orogenic Ni-Cu-PGE (TGI4; 2010-2015)

The Ni-Cu-PGE-Cr Ore Systems project is part of the GSC's Intrusion Related Ore Systems Targeted Geoscience Initiative (TGI4) and is in its concluding year. The British Columbia component is a collaborative effort between the BCGS, GSC, and the University of British Columbia. The project is examining the potential for orthomagmatic Ni-Cu-PGE sulphide deposits hosted by mafic-ultramafic intrusions at convergent margins. The aim is to establish mineral deposit models and exploration criteria for poorly understood magmatic sulphide environments in Cordilleran-style orogenic settings: 1) orthopyroxene-rich ultramafic intrusions like Giant Mascot, BC's only past-producing nickel mine (1958-74); and 2) Alaskan-type intrusions such as Turnagain, which has a world-class resource of low-grade nickel. The project is supporting the thesis work of two MSc students at the University of British Columbia.

3.1.4. Regional Synthesis

3.1.4.1. Ice-flow map of Cordilleran Ice Sheet (GEM 2; 2013-2018)

Large areas of northern British Columbia, southern Yukon, and southeast Alaska lack detailed surficial geology maps. Hence glacial transport histories are poorly understood in these areas, hindering effective mineral exploration. Preliminary surficial geoscience studies, including Province-scale compilations of ice-flow features (Ferbey et al., 2013) have revealed glacial-flow history complexities that need to be resolved for drift prospecting programs to be successful. As part of the GEM 2 program, a revised Quaternary ice-flow compilation for the entire Cordilleran Ice Sheet, including Yukon and Alaska, is underway. Once completed, Travis Ferbey and Holly Arnold will fill gaps in current mapping using the BCGS' recently acquired Summit Evolution photogrammetric 3D workstations (Fig. 10), the Provinces inventory of digital stereo models, and newly acquired digital satellite and high-level airphoto stereo models.

3.1.4.2. Coal Field Compilation Maps (2012-2015)

Despite declining coal prices and a reduction in the number of operating coal mines in BC (which dropped from nine to six in 2014), production remained steady, dipped only slightly from 31 million tonnes (in 2013) to a forecasted production of about 29 million tonnes in 2014. Coal remains an important mined commodity in British Columbia and at 46%, coal is the single largest contributor to the total mine production value in British Columbia (IC2015-3²). As a result, demand for information about BC coalfields and the value of the coal industry continues. To address this, BCGS coal geologist



Fig. 10. BCGS geomorphologist mapping surficial geology on the recently acquired Summit Evolution photogrammetric 3D workstations.

² British Columbia coal industry overview 2014, Information Circular 2015-3, www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/InformationCirculars/Pages/IC2015-3.aspx

Janet Riddell has generated coalfield compilation maps that will provide comprehensive information about the geology, production history, and major projects in BC coal-producing regions. The first compilation is for coalfields in the southeast part of the Province. To make the information accessible to a wide range of interested parties, the maps are designed for both technical and lay-person use.

4. Resource Information Section

The BCGS is the custodian of Province-wide geological data, including bedrock geology, surficial geology, mineral occurrences, and multi-element geochemistry from rock, till, stream sediment, and water samples. This information resides in free web-based databases that are integrated with MapPlace, the BCGS online service that allows clients to browse, visualize, and analyze multidisciplinary geoscience data and create custom maps (Table 1). The data and derived products provide baseline geological information for mineral exploration, environmental assessment, and land use planning (see Information Circular IC2014-9³). In particular, they increase exploration effectiveness by enabling users to efficiently gather regional information useful for property-scale evaluation, and help explorers advance projects without duplicating previous work.

4.1. MapPlace and database activities

Since 1995, MapPlace has provided open geoscience data and custom map-making tools to aid in the discovery of deposits and the assessment of mineral potential in British Columbia. MapPlace's unique, interactive applications and tools assist in investment decision making. MapPlace continues to provide clients with efficiencies in research time, data costs, and

analysis. Data themes and applications available on MapPlace include mineral potential, bedrock and surficial geology, publications, mineral and coal tenure, MINFILE, assessment reports, geochemistry, and geophysical surveys. Steven Zhao, Yao Cui, and Pat Desjardins continue to develop the next generation of MapPlace with testing of the new version of MapGuide Open Source. 'MapPlace 20/20' has demonstrated impressive performance, displaying province-wide bedrock geology, geochemistry data and mineral titles within seconds.

MapPlace, database applications, and recent technological advances were presented at several meetings including: Mineral Exploration Roundup in Vancouver, Prospector and Developers Association of Canada (PDAC) in Toronto, Society of Economic Geologists (SEG) in Whistler, Kamloops Exploration Group (KEG) in Kamloops, Free and Open Source Software for Geospatial (FOSS4G) in Portland, Oregon, Geological Society of America (GSA) in Vancouver, and a well-received workshop on the new MapPlace convened by Pat Desjardins, Sarah Meredith-Jones, and Deanna Miller at Minerals South in Nelson.

ARIS is the searchable database of over 34,000 assessment reports submitted to the Ministry of Energy and Mines, in compliance with the Mineral Tenure Act (MTA) Regulations (Fig. 11a). These reports summarized results from exploration programs on mineral claims. After a one-year confidentiality period, the reports become an open resource for planning mineral exploration, investment, research, land use, and resource management. Between 1967 and 2013, about \$2.6 billion of reported work has been captured in ARIS. The Ministry maintains a library of 916 Coal Assessment Reports submitted by exploration companies and dating from 1900 (Fig. 11b). COALFILE contains details of coal exploration reports including data from 11,595 boreholes, 500 bulk samples, 957 maps, 3415 trenches. A search engine leads clients to a summary page for each coal assessment report and links to the complete report. The data are spatially referenced on MapPlace and are available for download as an MS Access database. Ted

³ Online databases at the British Columbia Geological Survey, Information Circular 2014-9, www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/InformationCirculars/Pages/IC2014-9.aspx

Table 1. British Columbia Geological Survey databases.

MapPlace	www.mapplace.ca
ARIS	www.empr.gov.bc.ca/Mining/Geoscience/ARIS
MINFILE	www.empr.gov.bc.ca/MINING/GEOSCIENCE/MINFILE
COALFILE	www.empr.gov.bc.ca/Mining/Geoscience/Coal/CoalBC/Pages/CoalDataReports.aspx
Mineral Titles Online (MTO)	www.empr.gov.bc.ca/TITLES/MINERALTITLES
Publication Catalogue	www.empr.gov.bc.ca/MINING/GEOSCIENCE/PUBLICATIONSCATALOGUE
Regional Stream Sediment Geochemistry ¹	www.empr.gov.bc.ca/Mining/Geoscience/Geochemistry/RegionalGeochemistry
Lithochemical Database ²	www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/GeoFiles/Pages/2005-14.aspx

^{1,2} Currently being updated

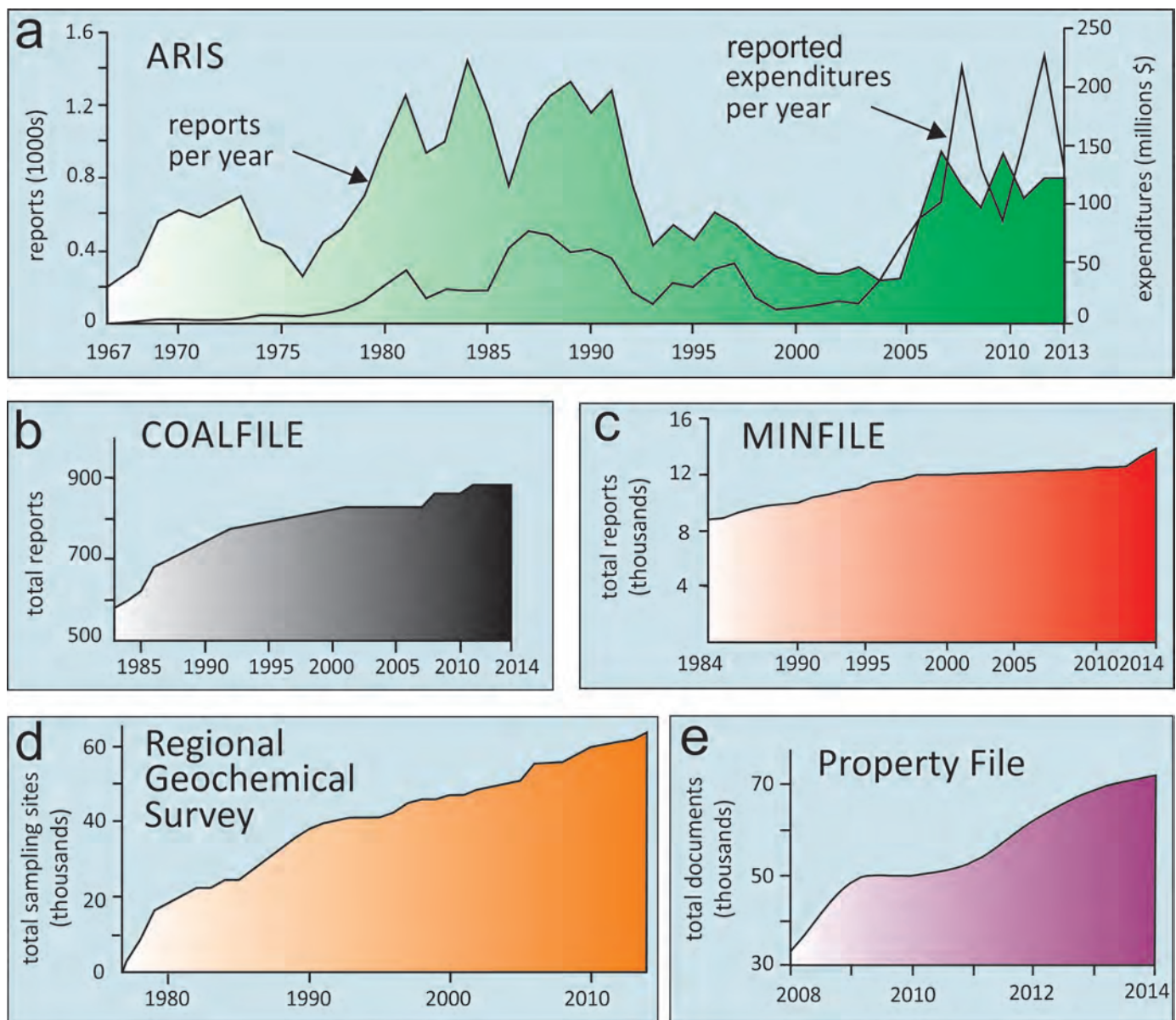


Fig. 11. Growth of some British Columbia Geological Survey databases.

Fuller and Jessica Norris review and manage the ARIS and COALFILE reports and databases.

MINFILE contains geological, location, and economic information on almost 14,000 occurrences and is updated continuously. In the last two and half years, updates to 5900 occurrences included 1700 new entries (Fig. 11c). Using the web-enabled MINFILE search application, users can query by location, identification number, mineralogy, commodity, host rock, deposit type, geological setting age, production, and references. MINFILE links with MapPlace, ARIS and Property File. Sarah Meredith-Jones is the primary contact for MINFILE: Sara.Meredithjones@gov.bc.ca.

The provincial geochemical databases hold field and geochemical data from multi-media surveys conducted by the Geological Survey of Canada (GSC), the British Columbia

Geological Survey, Geoscience BC (GBC), and contractors. The databases are updated regularly and contain results from: 1) the Regional Geochemical Survey program (RGS) including analyses from stream-sediment, lake-sediment, moss, and water samples (Fig. 11d); 2) till surveys; and 3) rock samples collected during the course of mapping projects. The RGS database provides representative geochemical data for catchment basins upstream of sample sites. Samples of fine-grained sediment are typically collected from lakes and streams at an average density of 1 site per 10-13 km². Data catalogued include determinations for up to 63 analytes, field observations, and sample locations. In 2014, Alexei Rukhlov (Provincial Geochemist) and Mustafa Naziri updated and overhauled the RGS database. Currently, the RGS database contains results from 64,828 samples covering over 80 percent of the

province. Previous RGS database versions had inconsistent and conflicting rules for reporting missing values (nulls) and values below the minimum detection limit. These issues severely downgraded the original data quality in the database with potential for misleading interpretations. To address these problems the RGS data were re-compiled from the original published sources using a new standardized data file structure, and are now available for download in a MS Access database.

The provincial lithogeochemical database, last released in 2005, is being retrofitted to improve data quality, enhance data access and retrieval, and update with new data. Tian Han (BCGS Digital Information Scientist) has developed a new simplified data model. Holly Arnold, Mustafa Naziri, and Alexei Rukhlov are updating the database with new analysis produced since 2005 and reviewing archive data to ensure that it has been captured. The team has improved QA/QC, and included links from the data to sources in the BCGS publication catalogue.

Property File is a collection of over 54,000 government, university, personal, and industry documents donated to the British Columbia Geological Survey over the last 150 years (Fig. 11e). Previously available only in hard copy, these documents can now be searched for and downloaded from the Property File database. Property File contains: unpublished reports; theses; field notes; company prospectuses; correspondence; hand-drawn maps; claim maps; mine plans; photographs; and geological, geochemical, geophysical, and drill data. A new Property File layer was posted MapPlace, linking to over 80,000 documents in 7221 sites. The BC Geological Survey accepts donations to Property File and interested parties should contact Kirk Hancock (kirk.hancock@gov.bc.ca).

The BCGS continues to process and integrate geological maps into the province-wide digital geology database, using a 'geologic framework data' (GFD) model (Cui, 2014). In 2014, the GFD model was enhanced and database applications were developed to further automate map integration. Deanna Miller (under the direction of Yao Cui) worked to integrate four maps compiled by Graham Nixon for northern Vancouver Island.

5. Mineral Development Office

The BC Mineral Development Office (MDO) in Vancouver is the technical marketing arm of the British Columbia Geological Survey and the Ministry of Energy and Mines. Its location in downtown Vancouver provides the domestic and international minerals industry with a point of contact for Survey activities, access to government geoscience products, and advice on mineral and coal opportunities in the Province. MDO staff geologists deliver technical presentations at major geoscience meetings, mining conferences, and investment missions. These formal activities are regularly accompanied by informal meetings with individuals and companies that require expert opinion on BC geology, its operating mines, and up-to-date information on the status of exploration projects in the Province.

Primary outputs of the MDO are publications aimed at audiences ranging from large foreign investors through to

independent domestic entrepreneurs. These publications are distributed widely at conferences, business meetings, over the counter, and online. In 2014, an updated version of the 'Opportunities to Explore' document was released in both English and Mandarin. This non-technical publication is designed for new investors who want to learn more about existing and potential exploration and mining opportunities in the Province. Opportunities to Explore is an example of a sector-specific document produced by the MDO that is used by other government agencies (i.e., Ministry of International Trade) to promote trade and investment in BC's mining sector.

The MDO oversees and coordinates the creation of exploration and mining summary documents from the Regional Geologist program, maintaining a legacy that dates back to 1874 with the Annual Reports of the Minister of Mines. The third annual version of the 'Coal Industry Overview' (IC2014- 5⁴) was released in early 2014; publication of this volume will continue on an annual basis (see IC2015-3⁵ for the 2014 review).

After a decade long hiatus, the inventory of gold in the province was updated and released in early 2014 (IC2014- 4⁶) as 'Gold Resources and Production in British Columbia (1890-2013)'. The circular includes a 2,000,000-scale map and spreadsheet. The map shows gold occurrences by deposit type and grade category. The project highlighted a significant increase in gold inventories in the Province over the ten-year period since the last inventory.

6. Regional Geologists Program

The Regional Geologists (formerly District Geologists) program was created in the early 1970s to facilitate economic development in the mineral exploration and mining sector. The British Columbia Regional Geologists represent the provincial government on geological matters at a regional level and capture information on industry activity in their jurisdictions. Within their communities, they provide advice and information on exploration trends, possible investment opportunities, land use processes, First Nation capacity building, public outreach and other key deliverables of government.

7. Staffing announcements

The survey welcomed back Melanie Mitchell, our Branch Coordinator, whose post was ably filled by Janet Hughes, now

⁴ British Columbia coal industry overview 2013, Information Circular 2014-5, www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/InformationCirculars/Pages/IC2014-5.aspx

⁵ British Columbia coal industry overview 2014, Information Circular 2015-3, www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/InformationCirculars/Pages/IC2015-3.aspx

⁶ Northcote, B., Madu, B., Schroeter, T., and Li, G., 2014. Gold production and resources in British Columbia, 1890-2013. resources and production in British Columbia (1890-2013), Information Circular 2014-4, www.empr.gov.bc.ca/Mining/Geoscience/PublicationsCatalogue/InformationCirculars/Pages/IC2014-4.aspx

at the Ministry of Environment. GIS Geoscientist Deanna Miller replaced Fiona Katay who left the BCGS to assume the role of Regional Geologist in Cranbrook. Jessica Norris joined the Resource Information Section as the new coal and mineral assessment geoscientist. The Survey welcomed a new Director to the Mineral Development Office in Vancouver. Gordon Clark replaced outgoing Director Bruce Madu who left the public service to join Geoscience BC, a non-governmental organization that provides grants and contracts to consultants to undertake geoscience projects of direct interest to the minerals industry. Two long-time members of the BCGS team recently retired. Jim Logan, who started with the BCGS in 1989, retired in early 2014 (Fig. 12). Pat Desjardins who joined the Survey in 1986, leaves in early 2015 (Fig. 13).

The Survey is saddened by the passing of Allan Wilcox and alumnus Ward Kilby. Allan joined the Survey in 1981 and was well known throughout the BC exploration industry for his role as compliance officer for mineral assessment reporting. Allan passed away in May. Ward Kilby retired from the Survey in 2000, but remained a very active alumnus and continued to

collaborate with the Resource Information Section on many database projects. Ward passed away in June.

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References

- Ash, C.H. and Riveros, C.P., 2001. Geology of the Gibraltar copper–molybdenite deposit, east-central British Columbia (93B/9). In: Geological Fieldwork 2000, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2001-1, pp. 119-133.
- Cui, Y., 2014. Integration and delivery of British Columbia digital geology. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey GeoFile 2014-9 (poster).
- Duke, J.M., 2010. Government geoscience to support mineral exploration: public policy rationale and impact. Prospectors and Developers Association of Canada, Toronto, Ontario, 64 pages.
- Ferbey, T., Arnold, H. and Hickin, A.S., 2013. Ice-flow indicator compilation, British Columbia. British Columbia Ministry of Energy and Mines, British Columbia Geological Survey, Open File



Fig. 12. Jim Logan at his desk at the BCGS in the late 1980s (top) and in the field in 2012 (bottom).



Fig. 13. Pat Desjardins at Cordilleran Roundup in the late 1980s (top) and at the BCGS open in 2013 (bottom).

- 2013-06, scale 1: 650 000.
- Logan, J.M. and Mihalynuk, M.G., 2013. Bonaparte gold: another 195 Ma porphyry Au-Cu deposit in southern British Columbia? In: Geological Fieldwork 2012, British Columbia Ministry of Energy, Mines, and Natural Gas, British Columbia Geological Survey Paper 20013-1, pp. 71-80.
- Logan, J.M., and Mihalynuk, M.G., 2014. Tectonic controls on Early Mesozoic paired alkaline porphyry deposit belts (Cu-Au ± Ag-Pt-Pd-Mo) within the Canadian Cordillera. *Economic Geology*, 109, 827-858.
- Mihalynuk, M.G., Logan, J.M., Diakow, L.J., Friedman, R.M., and Gabites, J., 2014. Southern Nicola Arc Project (SNAP): Preliminary results. In: Geological Fieldwork 2013, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2014-1, pp. 29-57.
- Nelson, J. and Kyba, J., 2014. Structural and stratigraphic control of porphyry and related mineralization in the Treaty Glacier – KSM – Brucejack – Stewart trend of western Stikinia. In: Geological Fieldwork 2013, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2014-1, pp. 111-140.
- Schiarizza, P., 2014. Geological setting of the Granite Mountain batholith, host to the Gibraltar porphyry Cu-Mo deposit, south-central British Columbia. In: Geological Fieldwork 2013, British Columbia Ministry of Energy and Mines, British Columbia Geological Survey Paper 2014-1, pp. 95-110.
- Zagorevski, A, Mihalynuk, M.G., Joyce, N., and Martin, K., 2014. Characterization of volcanic and intrusive rocks across the British Columbia – Yukon border Gem 2 Cordillera. Geological Survey of Canada, Open File 7697, 10 pages.

In Memoriam

Allan Frederick Wilcox (1947-2014)

Allan graduated from Carleton University in 1971 and worked for Noranda, Manitoba Department of Mines, the Geological Survey of Canada, and Indian and Northern Affairs Canada. He joined the British Columbia Geological Survey in 1981. Allan was instrumental in developing and implementing the first MINFILE, an electronic database of mineral occurrences, and the Assessment Report Indexing System (ARIS). He expertly guided the compliance of mineral assessment reporting by the exploration community. Over the past thirty years, Allan built strong working relationships with clients and was highly respected in the industry. Allan's valuable contribution to Survey geoscience culminated in being part of the MapPlace team that was a 2012 finalist in the Premier Award category for Innovation (MapPlace-World Leader in Geospatial Technology Innovation, Attracting Global Mineral Industry Investment). For many years, Allan volunteered and sat on the board of directors for community theatres and cultural societies and could commonly be seen at a local arena, assisting disabled attendees. Allan passed away peacefully in May 2014.



In Memoriam

Ward E. Kilby (1954-2014)

Ward graduated from the University of Alberta with a M.Sc. in 1978 and worked for several resource companies before joining the BCGS in 1982. Ward held positions of Senior Coal Geologist and Manager of Mineral Potential and GIS until 2000. While at the Survey, Ward began developing MapPlace and brought many of the geoscience databases to the exploration community through visualization and query tools. In large part owing to Ward's efforts, the Province has consistently been ranked in the top ten of the Fraser Institute's Global Ranking of Geological Databases. After leaving the Survey in 2000, Ward consulted with Cal Data Ltd, making great advancements in remote sensing, data management and analysis, web-mapping development, and resource assessments. Ward served on technical advisory committees for Geoscience BC and the BCGS. In 2008, he received the Meritorious Achievement Award from APEGBC and was part of the BCGS team that was a 2012 finalist in the Premier Award category for Innovation (MapPlace-World Leader in Geospatial Technology Innovation, Attracting Global Mineral Industry Investment). Ward passed away on June 30, 2014.

