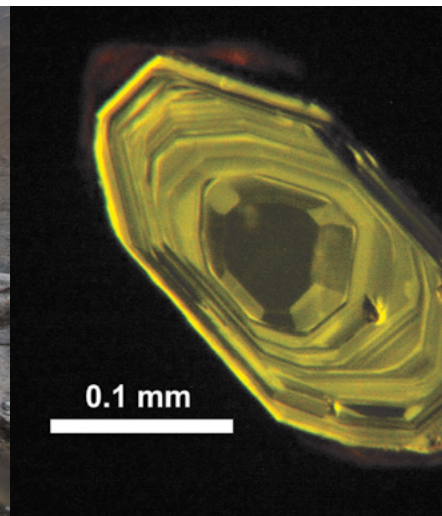




Annual Report 2020–21





Front cover photo: Theron Finley. This page photos **Top row:** Tim Van Dijk, Steve Grasby, MDRU; **Middle row:** Theron Finley, Max Goetz; **Bottom row:** Bianca P. Iulianella Phillips, Dawn Stenzel.

Chair & CEO Message

Highlighting the Need for Science, Technology, Innovation and Collaboration

The COVID-19 pandemic made 2020 and early 2021 a period of significant change, challenge and adaptation for society globally. As we look to economic recovery there is an opportunity to build on British Columbia's successes and leverage our existing competitive advantages, with an important role for organizations like Geoscience BC.

Investments today in science and technology will attract investment, create jobs, promote collaborative innovation, reduce emissions and support Indigenous reconciliation throughout the province.

Geoscience BC's previous annual reports have covered calendar years. This year, we have changed this to bring reporting in line with our fiscal year, which starts on April 1. As a result, this annual report covers a 15 month period, from January 1, 2020 to March 31, 2021.

During the reporting period Geoscience BC completed 13 research projects, had 32 ongoing projects and started one new project, for a total of 33 current projects at fiscal year end. This annual report provides highlights on many of our innovative projects that are contributing to BC's economic recovery and lower emission future.

Leveraging Core Funding and Attracting Investment

Geoscience BC minerals, energy and water research is made possible by core funding received from the Province of British Columbia. The most recent core funding received was \$5 million in one-year bridge funding announced in May 2019 by then-Minister of Energy, Mines and Petroleum Resources Michelle Mungall. We are grateful for this continued support and, at the time of writing, are in ongoing discussions with the provincial government about continued funding and a long-term funding mechanism. Letters from more than 35 industry and business organizations, universities, communities and Indigenous groups support our requests. The all-party Select Standing Committee on Finance and Government Services unanimously recommended continued funding for Geoscience BC.

Geoscience BC has leveraged core provincial funding by a multiplier of more than 1.7 times through direct and indirect partner funding. The return on investment of minerals-related geoscience research is estimated to be at least five times. The demand for and relevance of Geoscience BC's independent earth science research continues to increase. This aligns with the forecast demand in growth for BC's lower emission intensity minerals and natural gas and emerging zero-emission geothermal and hydrogen energy.



Stephanie Killam
CHAIR OF THE BOARD



Gavin C. Dirom
PRESIDENT & CEO

Building Partnerships

The COVID-19 pandemic has highlighted the need for collaboration and strong partnerships. This has continued to be a focus for Geoscience BC and is underlined by newly formalized partnerships with organizations such as the BC Oil and Gas Commission, the British Columbia Geological Survey, the Canadian Gas Association's Natural Gas Innovation Fund and Petroleum Technology Alliance Canada.

On behalf of the Board, we wish to thank the Geoscience BC staff and the many dedicated volunteers from industry, governments, communities, Indigenous groups and academia for their flexibility, understanding and enthusiasm through a particularly challenging period. Over the coming years we believe that the made-in-BC collaborative approach to public geoscience will be essential in reducing emissions and increasing innovation, provincial competitiveness, investment, jobs and Indigenous participation right across the province.

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Chair & CEO Message



Investments today in science and technology will attract investment, create jobs, promote collaborative innovation, reduce emissions and support Indigenous reconciliation throughout the province.

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Meet the Geoscience BC Staff



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MINERALS

Advancing Science & Innovative Geoscience Technologies

Highlight: Extracting important public geoscience and mineral deposit data from National Instrument 43-101 technical reports to make them more readily accessible, searchable, and locatable.



8

Advancing Science & Innovative Geoscience Technologies

Highlight: Our research partners are developing and testing a range of innovative methods designed to help discover mineral deposits in BC. Methods developed in BC can be shared across the country and around the world.



10

Advancing Science & Innovative Geoscience Technologies

Highlight: A report that examined the potential for ultramafic rocks in BC to capture and store carbon dioxide through a process known as carbon mineralization highlights that, with additional research into applications, this could be an important tool in reducing emissions.

11

Identifying New Natural Resource Opportunities

Highlight: In 2020–21, researchers made progress with our ongoing *Central Interior Copper-Gold Research* series by examining the prospective Quesnel terrane and the extensive till cover that obscures it in BC's North Central Region.



12 OIL & GAS

Advancing Science & Innovative Geoscience Technologies

Highlight: A new wastewater disposal project aims to identify and characterize disposal zones for the waste fluids used and recovered during natural gas operations, primarily from the Montney Play.

14 Facilitating Responsible Natural Resource Development

Highlight: Results from ongoing targeted research into the relationship between earthquakes and natural gas development – known as induced seismicity – in BC’s Northeast Region.



16 GEOTHERMAL

Enabling Clean Energy

Highlight: Results published from ongoing *Garibaldi Geothermal Volcanic Belt Assessment Project*, examining the geothermal potential of the Mount Meager volcano in BC’s Southwest Region, one of Canada’s highest potential geothermal areas.

17 WATER

Understanding Water

Highlight: Launch of the *Collaborative Water Monitoring Program* for the Peace region in BC’s Northeast Region.



18 GOVERNANCE, MANAGEMENT & FINANCE

Highlight: From January 1, 2020 to March 31, 2021 Geoscience BC completed 13 minerals, energy and water research projects and had 33 new or ongoing projects.

19 THANK YOU, VOLUNTEERS!

Thank you to our Board of Directors, Technical Advisory Committees and other volunteers.

Over 50 volunteers contribute more than 1,500 hours annually to Geoscience BC.

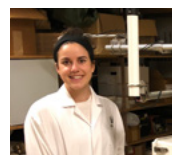
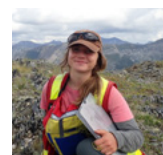
20 PUBLIC ACCESS & DATA MANAGEMENT

All project reports and data deliverables are on the Geoscience BC website, which also hosts our Earth Science Viewer online mapping application.

22 In 2020, Geoscience BC funded 10 students to advance geoscience research related to BC’s minerals, energy and water resources.

21 EXTERNAL RELATIONS & COMMUNICATIONS

Highlight: Geoscience BC formalized several relationships by signing partnership and memorandum of understanding agreements.



Geoscience BC Staff



Gavin C. Dirom
M.Sc., P.Ag.
PRESIDENT & CEO



Carlos Salas
M.Sc., P.Geo.
EXECUTIVE VICE PRESIDENT
& CHIEF SCIENTIFIC OFFICER



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COORDINATOR &
OFFICE MANAGER



Rhonda Schultz
BFA
ACCOUNTANT &
CORPORATE SECRETARY

Minerals

Minerals in BC

Mining is one of British Columbia's "big economic drivers", according to the Business Council of BC. The province hosts significant deposits of important metals such as copper, gold, molybdenum, silver and zinc as well as metallurgical (steelmaking) coal and industrial minerals. In 2020, BC mining generated gross revenue of \$9.28 billion.

Although the COVID-19 pandemic impacted the economy in 2020, mineral exploration and mining activities were declared essential and continued with strict safety measures in place. Mineral exploration spending in BC hit \$422 million in 2020, the highest since 2013.

HOW WE CONTRIBUTE Return on Investment

Geoscience BC's collaborative minerals research projects attract investment and stimulate innovation in BC: a review of Assessment Report Indexing System (ARIS) from 2005 to 2018 suggests that every \$1 invested by Geoscience BC in minerals research leads to approximately \$6.60 of mineral exploration investment. In 2020 and beyond, our projects are supporting economic stimulus as we look to a post-COVID-19 economic recovery.

Our minerals research goals align with provincial initiatives such as CleanBC, the Economic Recovery Task Force, the Mining Jobs Task Force, the Climate Solutions Council and Indigenous reconciliation goals. Our innovative public minerals research increases investment, innovation, competitiveness and jobs in every corner of the province, and helps to reduce emissions and environmental impacts.

This section highlights our completed and ongoing minerals research from January 1, 2020 to March 31, 2021.

2020-21 MINERALS PROJECTS

The *Summary of Activities 2020: Minerals* volume contains 15 technical papers on our minerals research during 2020. View and download your copy at www.geosciencebc.com

Completed Projects

11

Ongoing Projects

16

New Projects

0

BC COPPER

Copper plays a key role in a net-zero emission future because it is needed in applications such as electronics, infrastructure, clean energy and transport. It is included on Canada's new critical minerals list. Copper is BC's largest metal export: in 2019, BC copper mines produced more than 6.5 billion pounds of copper, over half Canada's total production for the year. Geoscience BC is generating public earth science research that can help find the next generation of copper deposits that will support BC jobs and our economy, and supply the global transition to a renewable energy future.

Advancing Science & Innovative Geoscience Technologies

Putting NI 43-101 Technical Reports on the Map

In January 2021, Geoscience BC released the results of the *Phase 2: Georeferencing and Data Capture of National Instrument 43-101 Reports in British Columbia* project that made it easier for mineral explorers and others to access and locate information contained in technical reports. The team at Purple Rock Inc. extracted public geoscience and mineral deposit location data from National Instrument 43-101 (NI 43-101) technical reports: documents that contain geologic assessments submitted to the Canadian Securities Administrators. This location information is now available for hundreds of 43-101 reports for BC projects through Geoscience BC and the British Columbia Geological Survey, making the data more accessible, searchable and locatable.



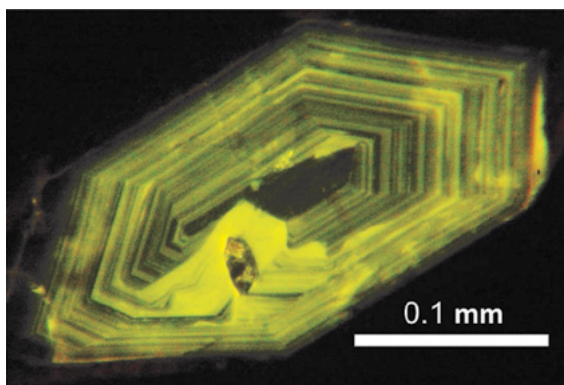
Engaging with communities answers questions, builds understanding and highlights new and potential opportunities. Photo: Veronique Jones.

STRATEGIC MINERALS RESEARCH OBJECTIVES

- ▶ Identifying New Natural Resource Opportunities
- ▶ Advancing Science & Innovative Geoscience Technologies
- ▶ Facilitating Responsible Natural Resource Development

Geoscience BC supports the development and application of innovative exploration techniques and technologies. Our goal is to provide new data analysis, evaluation and modelling tools that improve economic and environmental performance. BC is a hub for innovation and a testing ground for new tools and methods to locate and better understand mineral deposits. Methods developed in BC can be shared across the country and around the world.

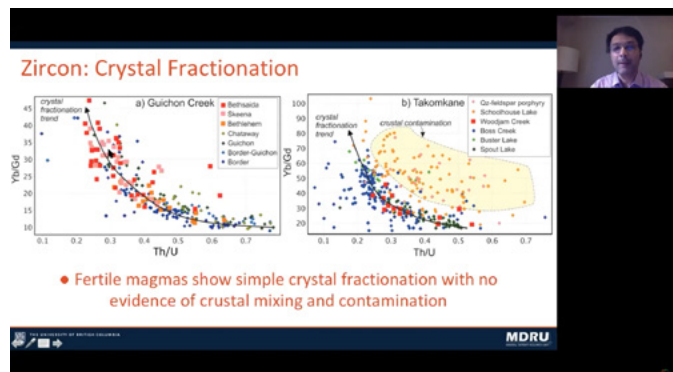
In 2020–21, our research partners developed or tested a range of innovative methods that can help detect mineralization in BC.



Zircons can be used to assess if a granitoid rock formed under 'copper-friendly' conditions. Photo: MDRU.

Zircons for Copper Exploration

A Geoscience BC report released in September 2020 wraps up the latest research from a series of Porphyry Indicator Minerals (PIMS) projects conducted by the University of British Columbia's Mineral Deposit Research Unit (MDRU). The final report for the *Assessing BC Porphyry Fertility using Zircons* project describes the unique chemical and textural characteristics within zircon mineral grains from granitoid rocks that can help mineral explorers identify whether they are formed under 'copper-friendly' conditions.



Lead researcher, Farhad Bouzari, presented a summary of PIMS research carried out in recent years at a webinar co-hosted by Geoscience BC and MDRU in October 2020, and again at the Association for Mineral Exploration Remote Roundup conference in January 2021.

Supercharging Stream Sediments

The *Geochemical and Indicator Mineral Data from a Regional Bulk Stream-Sediment Survey, Boundary District, South-Central British Columbia* project tested a more efficient bulk sampling and analysis strategy for collecting stream sediments in BC. Geologist and project lead Wayne Jackaman collected bulk stream and sediment samples over the Penticton map sheet (NTS 082E) in southern BC and derived mineralogical information and geochemical data to achieve new insight into the upstream mineral potential of each drainage basin. Jackaman describes the strategy and presents new data in a final report published in January 2021.

Real-Time Soil-Gas Sampling

Geoscience BC published a final report in June 2020 that details testing of a portable device designed to identify anomalous soil gas concentrations that could indicate geological faults and mineralization buried below glacial sediment deposits in central BC. The *Soil-Gas Detection of Bedrock Mineralization and Geological Faults Beneath Glacial Deposits using Economic Electronic Gas Sensors* project built a portable device that consists of a carbon dioxide and oxygen sensor connected to a simple soil gas sampling mechanism and connected to a laptop for real time measurements.

In 2019, project lead Dave Sacco and colleagues tested the technique at Mouse Mountain near Quesnel and Shiko Lake near Horsefly, where faults and copper-gold showings are known to exist. The change in concentration of carbon dioxide and oxygen detected in the soil at the test sites was spatially coincident with inferred structures or mineralization beneath glacial deposits.



A 2020 Geoscience BC report details testing of a device to measure soil gas concentrations that can be used to help detect buried geological faults and mineralization. Photo: Dave Sacco.

Biogeochemical Sampling

In the region southwest of Vanderhoof near the Blackwater mine in North Central BC, an innovative halogen analysis method for vegetation samples collected from the tops of spruce trees is showing promise to focus the search for buried mineralization.

Commonly, halogen elements fluorine, chlorine, bromine and iodine are strongly enriched in alteration and gangue minerals associated with mineral deposits. Over time the halogen elements can move out of these minerals and migrate into soils, water and vegetation at the surface.

In April 2020, Geoscience BC released a final project report for the *Halogens in Spruce Treetops and Integration with Existing Multi-Element Data – Blackwater and TREK Regions (NTS 083C,F)* project.

The report examined how concentrations of halogen elements in spruce treetop needles can signal mineral deposits or changes in geology below the surface. Mapping the distribution of halogen elements in these biological surface materials may help detect buried ore deposits.

Using DNA to Locate Mineralization

Thousands of microbial species live within a soil sample and interact with the soil and the surrounding environment constantly. A Geoscience BC final project report released in August 2020 shows how analyzing soil microbial DNA could be used to locate mineralization buried beneath glacial overburden, a particular challenge for mineral exploration in large parts of BC.

The report summarizes the work of the *Application of Genomics to Mineral Potential* project by the researchers at the University of British Columbia's MDRU.

Comparing the quantity and species of microbes found in soil samples collected over ore deposits with soils from other areas can help to zero in on buried mineral deposits.

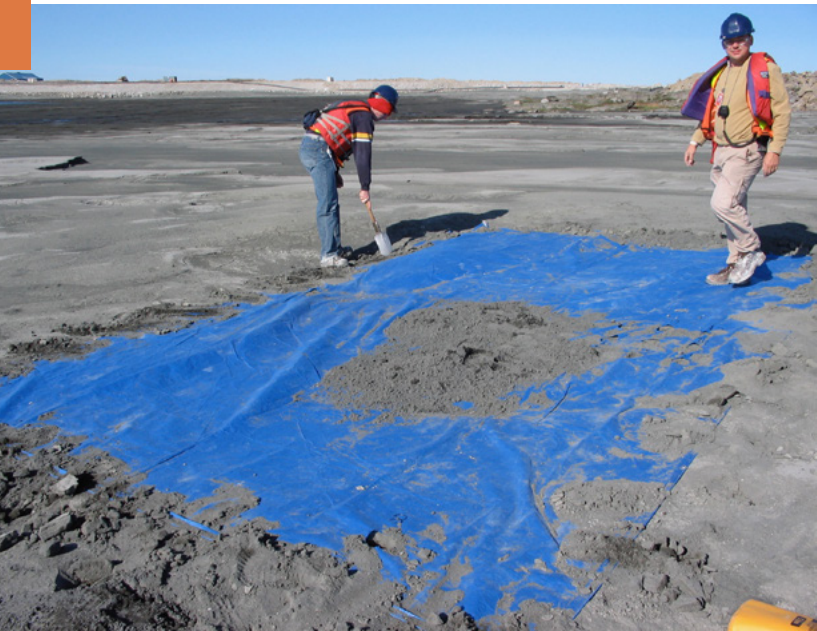
 **University of British Columbia professor and project co-lead Dr. Sean Crowe**



Analysis of microbial DNA from soils can be used to locate potential mineralization. Photos: Bianca P. Iulianella Phillips.

Locking Away Atmospheric Carbon in Minerals

In November 2020, Geoscience BC released an initial report that assessed the potential for ultramafic rocks in BC that can capture and store the greenhouse gas carbon dioxide (CO₂), through a process known as carbon mineralization. The *Carbon Mineralization Potential for BC* project is assessing the potential for certain magnesium-rich minerals found in ultramafic rocks that can also host nickel deposits to naturally bind with CO₂ in the atmosphere. The result is a solid carbonate mineral form where the CO₂ remains in a stable state for thousands of years.



Sampling carbonated tailings at Diavik diamond mine. Photo: Siobhan Wilson.

The *Carbon Mineralization Potential of Ultramafic Rocks in British Columbia: A Preliminary Assessment* report highlights that, with additional research into applications, this could be an important tool in reducing CO₂ emissions.

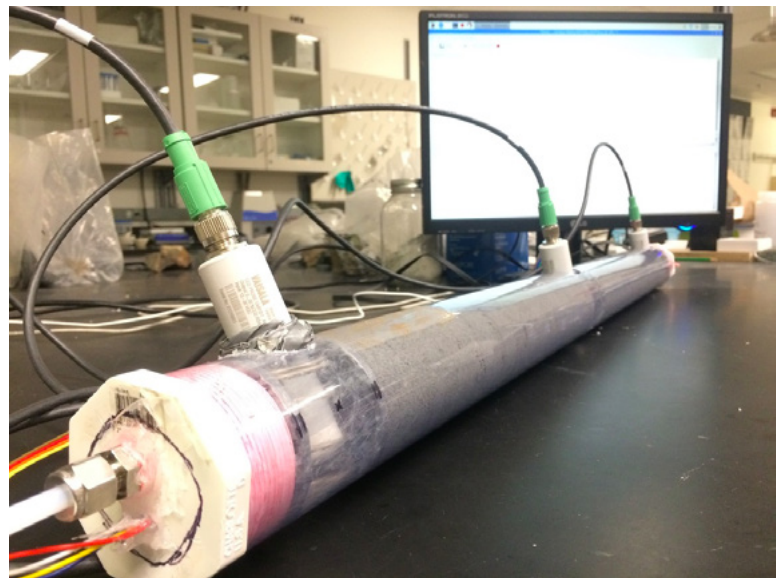
The research is part of a wider initiative led by Dr. Gregory Dipple at the University of British Columbia that involves industry partners, geoscience agencies and universities across Canada and Natural Resource Canada's Clean Growth Program.

WASHING STEELMAKING COAL FOR ASSESSMENT

At the exploration stage, coal samples from BC's steelmaking coal deposits must be 'washed' to remove mineral and ash particles before their coal and coking quality can be accurately assessed. The *Producing Clean Coal from Western Canadian Coalfields using the Water-Based 'Roben Jig' Process – Application to an Industrial Setting* project tested an innovative and safer way of assessing the economic viability of steelmaking coal samples using a new, water-based Roben Jig method: a simple water-based shaking technique to wash coal samples as effectively as traditional processes, without the use of carcinogenic organic liquids. A Geoscience BC report released in August 2020 demonstrates the final stage in a series of projects by researchers at the Canadian Carbonization Research Association.



Mineralized atmospheric carbon in tailings, Clinton Creek Mine, Yukon. Photo: UBC.



Simulated mineralization of powerplant exhaust CO₂ in laboratory experiments. Photo: Eric Wynands (UBC).

Identifying New Natural Resource Opportunities

Central Interior Copper-Gold Research Project Progress

The *Central Interior Copper-Gold Research (CICGR)* program covers an area of approximately 50,000 square kilometres in BC's North Central Region between the Mount Milligan Mine near Mackenzie, and the Gibraltar Mine near Williams Lake. This region, known to geologists as the central Quesnel terrane, has significant mineral potential but extensive Quaternary glacial sediments, including till, obscure the bedrock in the region and hinder mineral exploration. Geoscience BC is committed to spending \$2.9 million in the region to support a series of targeted research projects under the CICGR umbrella.

Tracing Till

The ongoing *CICGR: Surficial Exploration Project* is combining analysis of new and existing till samples with high-resolution satellite imagery to trace till samples and geochemical anomalies back to their source, which may help to identify areas of potential mineral exploration interest. The project is integrating surficial mapping, results of new surface sediment sample analyses, reanalysis of archived till samples and compilation of historical data to create an updated, higher quality dataset.

The 2020 field program focused mainly on till sample collection and some field verification of the surficial geology mapping. By the end of 2020, 456 new till samples had been collected and 960 historic samples were reanalyzed using modern laboratory techniques.

Porphyry Potential Under Cover

Publicly available geophysical data holds great potential to provide insight into the geology of the till covered central Quesnel terrane. The ongoing *Identification of New Porphyry Potential Under Cover in Central British Columbia* project is using existing Geoscience BC and other publicly available geophysical data to model the overburden thickness through the most heavily covered portions of the Quesnel terrane and characterize geophysical anomalies related to porphyry deposits.

With this data, the MDRU research team is attempting to characterize and resolve a suite of geophysical anomalies that are consistent with porphyry deposits, helping mineral explorers know where to focus efforts and gain insight for future geophysical and geochemical surveys.



Anomalies found at the surface may help to identify mineral deposits buried beneath layers of till in BC's North Central Region. Photo: Haj Bains.

Got Data? New Golden Triangle Regional Project

Geoscience BC launched the new *Golden Triangle Geophysics Data Compilation Project* in July 2020 to collect high-quality privately held geophysical data for the booming Golden Triangle area in BC's Northwest Region. Following initial discussions with industry, communities and Indigenous groups in the area in 2020 and early 2021, Geoscience BC reviewed, bought and consolidated existing airborne magnetic data that was not currently available publicly for the area. The data will be used to update the public dataset for the area in 2021.

Mineral Probability Maps

The *Advanced Analysis of the QUEST-South Stream Sediment Geochemical Data, British Columbia* project used machine learning and multivariate statistical methods to produce a series of new mineral deposit probability maps. In a final report released in June 2020, Telemark Geosciences generated a series of predictive maps based on probability estimates for various mineral deposit types in BC's South Central Region.



Brady Clift, Manager, Minerals discusses CICGR project at an open house in Prince George in December 2019. Photo: Lorne Clarke.

Oil & Gas

Oil and Gas in BC

British Columbia's oil and gas sector produces some of the cleanest and lowest emission intensity natural gas in the world and supports thousands of jobs throughout the province.

Upstream oil and gas investment for 2021 is forecast to grow by 29 per cent from an estimated \$3 billion in 2020 to \$3.9 billion in 2021.

HOW WE CONTRIBUTE

Collecting, interpreting and sharing new scientific data about BC's oil and gas sector helps to build the province's reputation as a producer of choice by reducing greenhouse gas emissions, minimizing impacts on the land and addressing specific environmental and social concerns.

Our oil and gas research aligns with goals and recommendations of provincial initiatives such as CleanBC, the Economic Recovery Task Force, the Scientific Hydraulic Fracturing Review Panel and the Climate Solutions Council.

This section highlights completed, ongoing and new oil and gas research from January 1, 2020 to March 31, 2021.

Advancing Science & Innovative Geoscience Technologies

Helping to Identify Wastewater Disposal Zones

In January 2020, Geoscience BC launched the new *Wastewater Disposal in the Maturing Montney Play Fairway of NEBC* project. The project aims to identify and characterize disposal zones for the waste fluids used and recovered during natural gas operations, primarily from the Montney Play.

The results will help natural gas operators efficiently target where to drill necessary disposal wells and reduce the need to transport wastewater by truck to the nearest well.

Throughout 2020, the Petrel Robertson Consulting Ltd. team consulted with 17 operators and wastewater disposal firms and the BC Oil and Gas Commission to identify the challenges of fluid disposal.

They also mapped and characterized 176 active, suspended and abandoned wastewater disposal wells in the study area.

THE MONTNEY PLAY

Approximately 87 per cent of BC's natural gas production is from the Montney Play in the Northeast Region of the province. The Montney Play is a gas-prone area within the Western Canadian Sedimentary Basin that contains some of North America's most significant natural gas resources. Public research to enable responsible development of natural gas from this zone is critical to BC.

2020-21 OIL & GAS PROJECTS

The *Summary of Activities 2020: Energy and Water* volume contains 11 technical papers on our oil and gas research during 2020. View and download your copy at www.geosciencebc.com

Completed Projects

1

Ongoing Projects

10

New Projects

1

STRATEGIC ENERGY: OIL & GAS RESEARCH OBJECTIVES

- ▶ Identifying New Natural Resource Opportunities
- ▶ Advancing Science & Innovative Geoscience Technologies
- ▶ Facilitating Responsible Natural Resource Development
- ▶ Enabling Clean Energy

Sour Gas Distribution Research to Reduce Cost and Risk

Sour gas is natural gas that contains measurable amounts of hydrogen sulphide (H₂S). Even in small amounts, H₂S can turn ‘sweet’ natural gas into ‘sour gas’ – a colourless, flammable gas that smells like rotten eggs, damages infrastructure and can be deadly if inhaled. Understanding the distribution of sour gas in the subsurface helps to improve planning, reduce development costs and reduce risk.

Geoscience BC research is further developing understanding of the complex distribution of sour gas in BC’s important natural gas development areas, namely the Western Canadian Sedimentary Basin’s Montney, Doig and Duvernay formations.

In 2020, the ongoing *Distribution, Origin, and Implications of Hydrogen Sulphide in Unconventional Reservoir Rocks in Western Canada with Insights into the Stratigraphic Zonation and Lateral Variability of Producing Hydrocarbon Liquids* project improved understanding of the source and distribution of sour gas and hydrocarbon liquids in unconventional reservoirs in BC’s Northeast Region.

One study analyzed the mineralogy and geochemistry of core samples from the Triassic Charlie Lake, Halfway, Doig, Montney and Belloy formations and used isotopic ratios (“fingerprints”) to determine the source of the sulphur. Results show that the sulphur source is not restricted to the Devonian, as is commonly believed by some Montney Play operators.

Another study generated an H₂S distribution map using approximately 700 gas analyses of a public database of drill-stem tests and production tests from over 300 wells distributed throughout the entire extension of the Doig Formation subcrop in BC and Alberta.

Canada’s oil and natural gas industry supports the studies by Geoscience BC. We’re confident they will add to the existing body of reliable science and data, which industry and the regulator can use to further improve performance, grow our understanding and helping us to continuously improve the ongoing responsible development of British Columbia’s resources.



Geoff Morrison, Manager, British Columbia, Canadian Association of Petroleum Producers

Enabling Clean Energy

TARGETING VALUE AND REDUCING EMISSIONS

Geoscience BC’s Natural Gas Atlas is an open-access geochemical database containing analyses of publicly available samples of natural gas types found in the Northeast Region of BC. It improves understanding of where natural gas liquids are located, enabling natural gas producers to target higher-value gas streams. It can also be used to aid remediation and reduce greenhouse gas emissions by helping to pinpoint potential sources of fugitive natural gas emissions.

In December 2020, we announced the addition of new gas chemistry data and a new processing script to the database and extended the project to add data from over 100 producing Canadian Natural Resources Limited gas wells from formations throughout BC’s Northeast Region. The Natural Gas Atlas information and database can be viewed at www.bcnga.ca.

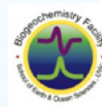
BCNGA

[Goals](#)[Background](#)[Database](#)[Plots & Maps](#)[About](#)

BC Natural Gas Atlas

An independent geochemical catalogue and mapping of natural gas occurrences in British Columbia, Canada

Developing an accessible and viewable geochemical database for a broad range of users, e.g., public, First Nations, industry, government, environmental, and non-governmental groups.



The www.bcnga.ca website hosts the Natural Gas Atlas database.

Facilitating Responsible Natural Resource Development

ONGOING INDUCED SEISMICITY RESEARCH

A set of targeted Geoscience BC research projects are generating new public geoscience about the relationship between earthquakes and natural gas development – known as induced seismicity – in BC's Northeast Region. Geoscience BC has been funding induced seismicity research in the region since 2012, and a recommendation for further research into induced seismicity was included in the 2019 *Scientific Review of Hydraulic Fracturing in British Columbia* report.

Seismicity and Machine Learning

The *Statistical Assessment of Operational Risks for Induced Seismicity from Hydraulic Fracturing in the Montney, Northeast BC* project used a novel multivariate statistical approach to determine if induced seismicity events are caused by geological factors (related to the rock formations that host the natural gas resources) or completion practices (the process of hydraulically fracturing a drilled well to produce natural gas from zones that would otherwise be uneconomic to produce), or a combination.

The report, released in November 2020, concludes that no single factor was identified as being responsible for induced seismicity and that understanding induced events is highly dependent upon the specific datasets used and the features selected for use in statistical models.

RESEARCHING WHAT TRIGGERS INDUCED SEISMICITY

Understanding the relationships between all the factors that trigger induced seismicity is an important step in the creation of best practices for induced seismicity mitigation techniques from hydraulic fracturing operations. Our goal is that through continued research, these lessons will help companies develop best practices to mitigate those risks and lead to prevention of these events.

Mapping Susceptibility

The ongoing *Development of an Induced Seismicity Susceptibility Framework and Map for NEBC Using an Integrated Machine Learning and Mechanistic Validation Approach* project is developing an induced seismicity susceptibility map for the Montney Play. Researchers at University of British Columbia are combining multiple datasets in a machine learning setting, together with laboratory experiments and numerical simulations. In 2020–21, the first phase of the project was completed. This involved testing different machine-learning algorithms to determine the relative importance of several geological and operational parameters in relation to the triggering of induced seismicity.



Geoscience BC seismicity research is valued by industry, local communities and Indigenous groups because it mitigates risk and answers questions about the relationship between ground motion and natural gas development in northeastern BC.

Photos: Darcy Shawchek.



Expanded Monitoring Network

The ongoing *Comprehensive Investigation of Injection-Induced Earthquakes in Northeastern British Columbia* project manages a network of nine seismographs to monitor ground motion in BC's Northeast Region and studies the source characteristics of significant seismic events.

In 2020-21, University of Victoria researchers completed a study that investigated the seismic characteristics of the largest hydraulic-fracturing-induced earthquake in Canada – a 4.6 moment magnitude (M_w) earthquake that occurred in August 2015 within the southern Montney Play northwest of Fort St. John – and the different seismic response times at three nearby hydraulic fracturing well sites. The study developed 3D poroelastic models using detailed numerical simulations of the geomechanical evolution caused by fluid injection. The results suggest that a conduit-like structure can efficiently facilitate the migration of fluid pressure from the injection well to the receiver fault.

Shear-Wave Velocity Studies

Ongoing research is categorizing and mapping surface sediments to understand their effect on ground-motion amplification. In the *Amplification of Seismic Ground Motion Hazard Mapping for the Fort St. John – Dawson Creek Area* project, Dr. Pat Monahan and Petrel Robertson Consulting Ltd. are collecting new shear-wave velocity data acquired from shallow sediments at 28 sites in the Fort St. John and Dawson Creek area. Studies in 2020 found that depth to bedrock is a better predictor of shear-wave velocity than whether till or glaciolacustrine deposits occur at surface.



In early 2020, 13 new broadband seismometers and two accelerometers were installed in the Kiskatinaw region.

Photo: Nanometrics.



A new network of monitoring stations makes it possible to more accurately locate the epicentre of ground motion events.

Photo: Nanometrics.

Additional Real-Time Public Monitoring Stations for Kiskatinaw

The *Understanding and Mitigating Induced Seismicity Risk in the Kiskatinaw Area, BC* project installed and is monitoring a closely spaced network of seismographs in the Kiskatinaw Seismic Monitoring and Mitigation Area (KSMMA) area in the Northeast Region to generate new public data about ground movement and induced seismicity.

In early 2020, 13 new broadband seismometers and two accelerometers were installed. These will enhance the monitoring capabilities of ongoing operations, improve risk assessments and help inform mitigation strategies. The new network has made it possible to locate the epicentre of events more accurately, resulting in a more complete picture of ongoing seismicity in the KSMMA.

Geothermal

Geothermal Energy in BC

As we transition to net-zero emission and alternative sources for electricity and heat, geothermal energy can play an important role in British Columbia's future energy mix.

HOW WE CONTRIBUTE

Geoscience BC's public geothermal energy research is being used by geothermal explorers and developers, communities, Indigenous groups and governments to make decisions about potential development projects. It helps to assess viability and reduces investment risk at high-potential sites in BC and encourages geothermal exploration and development in the province. Stable, renewable energy sources, such as geothermal, have the potential to help Canada meet its target of net-zero greenhouse gas emissions by 2050. Our geothermal energy research aligns with provincial initiatives such as CleanBC and the Climate Solutions Council.

In March 2021, Fort Nelson First Nation's Deh Tai LP secured \$40.5 million in funding for its Clarke Lake Geothermal Project. Geoscience BC research was instrumental in the development of this project.

This section highlights our ongoing geothermal research from January 1, 2020 to March 31, 2021.

If geothermal energy resources are to play a significant role for British Columbia's economy, we need not only to assess the resource potential near high-demand, high-potential centres, such as the Garibaldi Volcanic Belt, but also to expound the virtues of direct-use and geo-exchange to help communities offset their energy needs.

Geoscience BC Executive Vice President & Chief Scientific Officer Carlos Salas

2020-21 GEOTHERMAL PROJECTS

The *Summary of Activities 2020: Energy and Water* volume contains one technical paper on our geothermal research during 2020. View and download your copy at www.geosciencebc.com

Completed Projects 0

Ongoing Projects 1

New Projects 0

Enabling Clean Energy

In April 2020, Geoscience BC published the results from the first year of field work on the ongoing *Garibaldi Geothermal Volcanic Belt Assessment Project*. The Mount Meager volcano in the Garibaldi Volcanic Belt in BC's Southwest Region is one of the highest potential geothermal areas in Canada.

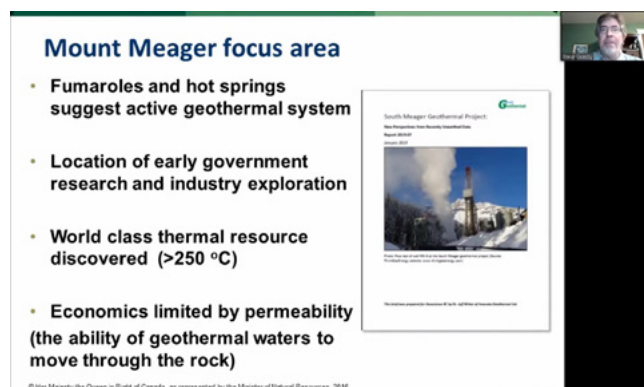
We are collecting the vital baseline geoscience information about the depth, temperature and permeability of potential aquifers – and their suitability to generate geothermal heat and power.



Project Lead and Geological Survey of Canada Research Scientist Dr. Steve Grasby

This multi-partner collaborative project led by Geological Survey of Canada Research Scientist Dr. Steve Grasby is generating new data to create a comprehensive three-dimensional model of the rocks, faults and aquifers below the Mount Meager volcano. In summer 2020, the research team retrieved instruments deployed in 2019 and filled in data gaps along the north flank of Mount Meager.

Final results will be integrated into a new three-dimensional model of the heat and reservoir plumbing of the Mount Meager complex, providing a better understanding of the geothermal resource potential and reducing exploration and financial risk for geothermal exploration and development companies. It will also help to better understand other volcanic belts in BC.



In May 2020, Geoscience BC and the Geological Survey of Canada co-hosted an online open house to provide an update on the project for the 130 interested locals, industry, researchers and politicians who registered. The presentations from the open house can be downloaded from www.geosciencebc.com.

STRATEGIC GEOTHERMAL RESEARCH OBJECTIVES

► Enabling Clean Energy

Water

Water Research in BC

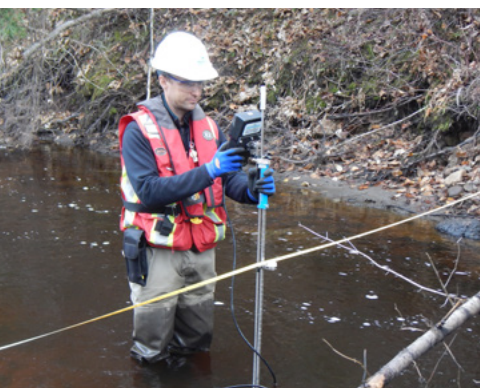
Much of Geoscience BC's water research is focused on British Columbia's Northeast Region, where there is significant demand for surface water and groundwater for agriculture, natural gas production, households and other uses.

HOW WE CONTRIBUTE

Since 2008, Geoscience BC has been funding research into water resources related to oil and gas and mineral development. In 2018, water became a separate Geoscience BC strategic focus area. In 2019, following recommendations of our Strategic Task Force on Water, an addendum was added to Geoscience BC's Strategic Plan 2018-2022 to include four new water research goals.

In 2019, the Ministry of Energy, Mines and Petroleum Resources released its *Scientific Review of Hydraulic Fracturing in British Columbia*. Further research into natural gas development and water withdrawals, the availability of baseline water quality and quantity data and fugitive gas were recommended in the report.

This section highlights our completed and ongoing water research from January 1, 2020 to March 31, 2021.



The *Pilot Collaborative Water Monitoring Program* will collect water quality, quantity and climate data, and incorporate Indigenous knowledge of water.

Photo: Matrix Solutions.

2020-21 WATER PROJECTS

The *Summary of Activities 2020: Energy and Water* volume contains four technical papers on our water research during 2020. View and download your copy at www.geosciencebc.com

Completed Projects	1
Ongoing Projects	5
New Projects	0

Unrestricted the budget for one project that will not be initiated.

STRATEGIC WATER RESEARCH OBJECTIVES

► Understanding Water

Understanding Water

New Collaborative Water Monitoring Program

Throughout 2020-21, Geoscience BC built the *Pilot Collaborative Water Monitoring Program, Northeast BC*. Consisting of three interrelated projects, the program will install co-located surface water monitoring stations, groundwater wells and climate monitoring stations at multiple sites in the Peace region. Baseline water quantity, quality and climate data will be collected at the monitoring sites and assessed for watershed water balances, surface water flows and groundwater-surface water interactions. The program team will work with Treaty 8 First Nations to study Indigenous Traditional Knowledge and Western scientific findings from the four sites.

The projects are led by researchers from the BC Oil and Gas Commission (BC OGC), Matrix Solutions Inc., the Ministry of Energy, Mines and Low Carbon Innovation and Shell Canada Ltd. Teams from Blueberry River First Nations, Doig River First Nation, Halfway River First Nation, McLeod Lake Indian Band, Saulteau First Nations and West Moberly First Nations have committed to participate in the study. Participating First Nations will receive data collection, sampling and station maintenance training.

Gas Migration in Groundwater

Two ongoing projects are providing the baseline research needed to support the responsible development of BC's natural gas resources. Both projects are helping to determine and mitigate the risks associated with this development, to improve monitoring and guide future remediation work. The ongoing *Peace Region Scientific Groundwater Monitoring Network Installation Study* is a collaborative project led by the University of British Columbia's Energy and Environment Research Initiative that installed 29 monitoring wells in BC's Northeast Region.

Groundwater and sediment samples collected from the wells will illustrate background groundwater conditions and determine the distribution of natural gas in the top 100 metres of the subsurface. In 2019 and 2020, monitoring wells were sampled for inorganic and gas geochemical analysis and isotopic analysis. After the project is complete, the monitoring wells will remain and can be used to provide long-term datasets to systematically characterize groundwater conditions.

The ongoing *Assessment of Fugitive Natural Gas on Near-Surface Groundwater Quality* study is examining how unintentional gas leaks from natural gas development ('fugitive emissions') can move into shallow aquifers and the physical and biogeochemical processes that control subsurface gas migration. In 2018, a small measured amount of gas was injected into a monitoring well at the Hudson's Hope Field Research Station and ongoing measurements are documenting how gas can migrate through a contained aquifer, the overlying unsaturated zone and the atmosphere. The project is testing a variety of fugitive gas monitoring and detection methodologies to quantify the amount of natural gas that remains, degrades or leaves the subsurface. The most recent sampling event occurred on July 17, 2020.

Governance, Management & Finance

Geoscience BC employs nine staff and is supported by over 50 volunteers who contribute more than 1,500 hours annually. Our volunteer Board of Directors is responsible for overall governance and strategic direction, including research project budget decisions based on recommendations from the Board's Minerals, Oil & Gas and Geothermal Technical Advisory Committees (TACs). Our organizational structure maximizes applied research investment and minimizes administrative expenditures.

Ensuring Transparency, Accountability & Responsibility

From March 2020, Geoscience BC adapted day-to-day work and project planning and management within a changing environment as the COVID-19 pandemic situation developed. This included staff working from home and implementing a flexible approach to remotely connecting with project partners, consultants, committee members and the Board of Directors.

In September 2020 we held our 15th Annual General Meeting online. There were no changes to the Board and terms were renewed for Jeff Christian, Christine Ogryzlo, Donna Phillips and Robert Quartermain. Through the Board's Nominating Committee, work is underway to further improve internal Board governance tools and methods to identify and assess needs, including diversity.

All interim and annual Geoscience BC Society financial statements are reviewed by the Board's Finance Committee and are available to download at www.geosciencebc.com/updates/financial-statements

Geoscience BC wishes to thank the departed volunteers who contributed their time and expertise to the TACs for their invaluable contributions guiding our earth science research. We welcome the new members who have joined our Minerals and Oil & Gas TACs via an improved, open and transparent recruitment process and look forward to welcoming new members to our Geothermal TAC in the first half of 2021. We also said farewell to Laura Wytrykush and welcomed Randy Hughes to the role of Geoscience BC's Manager, Energy & Water.

Strategic Review

We completed our Strategic Plan Midterm Review in September 2020 following outreach to key partners and interest groups. In response to Strategic Plan Midterm Review feedback, messaging used in our communications materials has been updated, and improvements have been made to the Geoscience BC website to better reflect our open and transparent processes. An internal, multi-phase assessment of our five-year Scientific Project Plan was completed in March 2021.

Strategic Research Area	Completed Research Projects	Current Research Projects
Minerals	140	16
Energy: Oil & Gas	25	11
Energy: Geothermal	11	1
Water	26	5
TOTAL	202	33

Building Future Opportunities

In February 2020, Geoscience BC submitted a request for \$6.5 million in year-end funding to the government of BC. A decision was deferred by Minister Ralston in April due to the COVID-19 pandemic and we reiterated our request in a June submission to the BC Budget 2021 consultation as well as the COVID-19 economic recovery consultation process in July 2020.

In August 2020, the all-party Standing Committee on Finance and Government Services unanimously recommended to the Legislative Assembly that the provincial government continue funding Geoscience BC and the British Columbia Geological Survey (BCGS).

A revised request was submitted to the government of BC in February 2021 that asked for continued support for a made-in-BC coordinated and adequately resourced provincial approach to public geoscience, including:

- Funding Geoscience BC \$6.5 million for fiscal year 2021/22;
- Establishing a sustainable long-term funding mechanism for Geoscience BC, with an annual investment of \$5.5 million for fiscal years 2022/23 and 2023/24; and
- Providing a sustainable level of base funding for the British Columbia Geological Survey so that it can continue to collaborate with partners to deliver its complementary mandate and work with Geoscience BC to leverage further federal government support.

BC's new *Lobbyists Transparency Act* came into effect in May 2020. Geoscience BC files monthly reports in compliance with the Act.

STRATEGIC GOVERNANCE, MANAGEMENT & FINANCE OBJECTIVES

- Ensuring Transparency, Accountability & Responsibility
- Building Future Opportunities

Geoscience BC Board of Directors

Stephanie Killam, Chair * ** ***
District of Mackenzie (retired Mayor)

Donna Phillips, Vice Chair * **
Executive Vice President, Corporate
Development, Pacific Canbriam Energy

John Milne, Treasurer *
Audit Partner, KPMG LLP

Jeff Christian *
Partner, Lawson Lundell LLP

Gavin C. Dirom *
President & CEO, Geoscience BC

Lana Eagle **
Senior Advisor & Consultant,
Lana Eagle Consulting

Michael Gatens ***
Unconventional Gas Resources Canada
(former CEO, retired)

Doug Konkin **
Adjunct Professor,
University of British Columbia

Nalaine Morin
Principal, ArrowBlade Consulting Services

Christine Ogryzlo **
Communications Manager,
Smithers Exploration Group

Dr. Robert Quartermain
Consultant

Carlos Salas
Executive Vice President &
Chief Scientific Officer,
Geoscience BC

Dr. Alan Winter ***
Former Innovation Commissioner,
Province of British Columbia

* Finance Committee

** **Nominating Committee** - Jim Gray,
Non-Board Member, and past Geoscience BC
Treasurer and Director sits as an independent
member of the Nominating Committee

*** Compensation Committee

MINERALS Technical Advisory Committee

Dr. Shaun Barker † Mineral Deposit Research
Unit, University of British Columbia

James Barr SilverCrest Metals Inc.

Dr. Peter Bradshaw FPX Nickel Corp.

Dr. Greg Dipple
University of British Columbia

Dr. Craig Hart ‡ Mineral Deposit Research Unit,
University of British Columbia

Alf Hills Consultant

Jacques Houle Consultant

Dr. Julie Hunt ‡ Mineral Deposit Research
Unit, University of British Columbia

Steve Irwin ‡ Geological Survey of Canada,
Natural Resources Canada

Fiona Katay ‡ BC Ministry of Energy, Mines
and Low Carbon Innovation

Dr. Jules Lajoie Comtek Enterprises Ltd.

Dr. Jim Lang Hunter Dickinson Inc.

Nalaine Morin Arrowblade Consulting

Dr. Robert Quartermain
Consultant

Diana Sollner Consultant

Alastair Still GoldMining Inc.

Dr. Pim van Geffen CSA Global

Neil Wildgust BC Geological Survey,
Cordilleran Geoscience

Brady Clift Geoscience BC (Staff Support)

Gavin C. Dirom Geoscience BC

Christa Pellett Geoscience BC

Carlos Salas Geoscience BC

† Joined TAC during reporting period

‡ Departed TAC during reporting period

OIL & GAS Technical Advisory Committee

Dan Allan Technical Advisory Committee
Chair, Canadian Society for Unconventional
Resources

Deanna Cottrell Shell Canada Ltd.

Colin Frostad † Tourmaline Oil Corp.

Dr. Brendan Galloway † PETRONAS Canada

Tannis Gibson Saguaro Resources Ltd.

Bruce Hancock ‡ Encana

Dr. Brad Hayes Petrel Robertson Consulting Ltd.

Elizabeth Johnson BC Ministry of Energy,
Mines and Low Carbon Innovation

Jeff Johnson BC Oil and Gas Commission

Clint Tippet Consultant

Chris Wilcox † Ovintiv Services Inc.

Gavin C. Dirom Geoscience BC

Randy Hughes Geoscience BC
(Staff Support)

Carlos Salas Geoscience BC

GEOTHERMAL Technical Advisory Committee

Dr. David Chapman ‡ University of Utah
(Professor Emeritus)

Dr. Grant Ferguson University of
Saskatchewan

Dr. Stephen Grasby Geological Survey of
Canada, Natural Resources Canada

Dr. Cathie Hickson Technical Advisory
Committee Chair, Geothermal Canada

Sarah Kimball ‡ BGC Engineering Inc.

Dr. Jasmin Raymond Institut National
de la Recherche Scientifique – Eau Terre
Environnement

Tim Sadlier-Brown
Sadlier-Brown Consulting Ltd.

Alex Tu BC Hydro

Dr. Nathalie Vigouroux-Caillibot
Douglas College / Simon Fraser
University (adjunct)

Warren Walsh BC Ministry of Energy,
Mines and Low Carbon Innovation

Dr. Jeff Witter Innovate Geothermal Ltd.

Gavin C. Dirom Geoscience BC

Randy Hughes Geoscience BC
(Staff Support)

Carlos Salas Geoscience BC

Public Access & Data Management

For British Columbia to compete and thrive in the long-term, there is an ongoing need for new, unbiased public geoscience data, relevant information and innovative research that solves challenges, attracts investment, informs decisions and supports the responsible development of our natural resources.

Geoscience BC's Public Access & Data Management focus area supports our data management system and public access to research. All project reports and data deliverables are on the Geoscience BC website, which also hosts our Earth Science Viewer (ESV) online mapping application.

Geoscience BC project information is also available through the British Columbia Geological Survey and the Ministry of Jobs, Economic Recovery and Innovation's *BC Economic Atlas*.

Providing Public Access to Data

In 2020, our GIS Specialist, Ron Prasad, reorganized the data layers in the ESV to reflect the three Geoscience BC strategic focus areas: minerals, energy (oil and gas; geothermal) and water. He continued to provide GIS support to technical and senior staff and work on restructuring internal GIS and public facing website database tables.

In 2020, we began collecting additional website metrics to track report and data downloads for the first time. This is a valuable new way to measure the impact of Geoscience BC projects. Other website metrics will allow us to better plan website upgrades and social media by tracking where traffic is coming from and monitoring the terms that are used on the website's search function.

Maintaining Secure Digital Data

We continued to work towards our goal to maintain safe and secure databases, digital data project libraries, information technology infrastructure and management controls to professional standards and practices in 2020-21. This involved evaluating Geoscience BC server upgrade options to address flexibility in remote working applications as a result of the COVID-19 pandemic, upgrading Network Attached Storage capacity to five terabytes for large project datasets in advance of future server upgrades, and undertaking a comprehensive review and update of publicly available datasets.

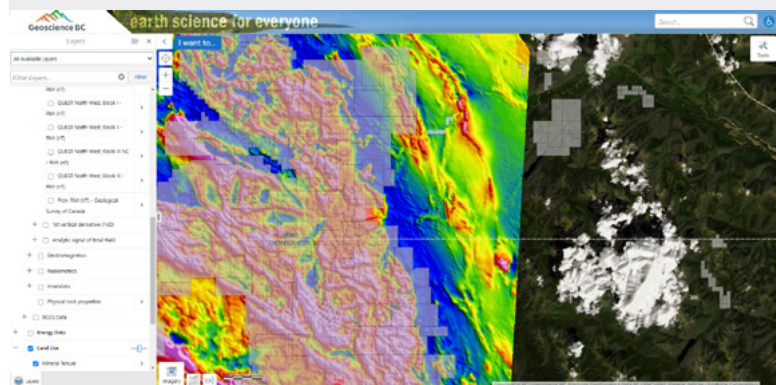
BENEFITS OF PUBLIC GEOSCIENCE DATA

Our research is publicly accessible and has been welcomed by diverse groups including the natural resource sectors, academia, communities, Indigenous groups and governments. By making the research and data we generate open and accessible to all, we are encouraging economic growth, research and innovation in BC and supporting education, awareness and inclusion in decision-making for all British Columbians.

WHAT IS THE EARTH SCIENCE VIEWER?

The ESV is Geoscience BC's custom, web-based map and data discovery service. It is a single access point to view all of our research projects, reports and data.

Using ESRI's ArcGIS platform and accessed via www.geosciencebc.com, the ESV is an easy way to view information spatially and add context with extra geographic information system (GIS) data layers.



The Earth Science Viewer is an easy way to view data, with the option of adding additional GIS layers.

STRATEGIC PUBLIC ACCESS AND DATA MANAGEMENT RESEARCH OBJECTIVES

- Providing Public Access to Data
- Maintaining Secure Digital Data

External Relations & Communications

Geoscience BC's External Relations & Communications focus area supports our relationships with the natural resource sector, community leaders, Indigenous groups, academia and governments. It ensures we operate and communicate in a transparent manner; make our research easy to understand and share; that we are responsive to needs of our partners and interest groups; and that we attract funding for Geoscience BC's in-demand research projects.

Increasing Awareness & Expanding Collaborative Network of Partners

STRATEGIC PARTNERSHIPS SIGNED



In 2020, Geoscience BC formalized several relationships by signing partnership and memorandum of understanding agreements with the BC Geological Survey, the BC Oil and Gas Commission, the Canadian Gas Association's Natural Gas Innovation Fund and the Petroleum Technology Alliance of Canada.

Meetings Move Online

Although many events, such as local government association conferences, were cancelled in 2020 due to COVID-19, we transitioned to online meetings and continued to engage with provincial staff, regional districts and government advisory groups. In addition, we hosted and participated in meetings to update industry, community and Indigenous leaders on research projects throughout the province.

Improved Online Presence

Following the launch of our new website in 2019, we made further refinements in 2020-21, including moving old report page content into the new format and improving the site's Google Analytics functionality. For the first time, downloads and use of the website's search function can be effectively measured, helping Geoscience BC to more effectively assess project success.

Serving Technical & Academic Partners

Technical summaries for the majority of Geoscience BC's active minerals, energy and water projects in 2020 have been published in our *Summary of Activities 2020: Minerals and Energy and Water* volumes.

To increase use of past Geoscience BC data and reports, we started a #ThrowbackThursday social media campaign in 2020. As a result, there has been an increase in views and downloads of Geoscience BC's completed projects that provide high-quality and useful data.

In July 2020, we launched the monthly Digging Deep blog. This provides an opportunity to look at past research themes and connected projects in a new light, emphasizing the value of completed projects. The blog posts are some of the most popular pages on the Geoscience BC website, and have contributed to an increase in downloads of past project data.



Geoscience BC published data from the *Vancouver Island North Regional Project* at the AME Roundup conference in January 2020. Posters from 13 Geoscience BC researchers were also displayed at the conference. In January 2021, seven posters were available at the online AME Remote Roundup online conference. Photo: Dawn Stenzel.

SHARING PUBLIC INFORMATION DURING THE COVID-19 PANDEMIC

Since the COVID-19 pandemic began in March 2020, the way Geoscience BC engages with all groups has had to change, with activities such as open houses and presentations moving online. This has some advantages such as making attendance easier for a wider group of people, and making recordings and presentations available online after the event. For example, nearly 500 people have watched live and recorded versions of a May 2020 open house discussion on the *Garibaldi Geothermal Volcanic Belt Assessment Project* – far more than normally would have attended an in-person meeting.

STRATEGIC EXTERNAL RELATIONS & COMMUNICATIONS OBJECTIVES

- Increasing Awareness & Expanding Collaborative Network of Partners
- Demonstrating Research Value & Building Broader Support
- Serving Technical & Academic Partners

Scholarships

Increasing Geoscience Literacy & Capacity

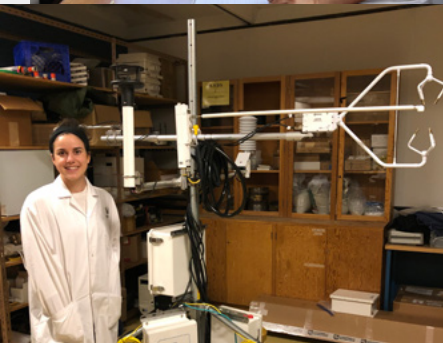
The Geoscience BC scholarship program is designed to inspire the next generation of earth scientists by supporting graduate students working on British Columbia-based projects. In 2020, we funded 10 students working on geoscience research related to BC's minerals, energy or water resources. These projects covered subjects ranging from carbon capture in mine tailings, to developing tools for copper exploration, to modeling gas, groundwater and hydrocarbon fluids.



Modelling Induced Seismicity

Ph.D. candidate **Ali Mehrabifard** is investigating the factors that influence the likelihood of induced seismicity related to natural gas development causing a seismic event of a given magnitude. He is using state-of-the-art laboratory experiments and numerical modelling, with further constraints being provided by empirical field data.

SUPERVISORS: Dr. Erik Eberhardt and Dr. Doug Stead, University of British Columbia



Carbon Mineralization in Mine Tailings

M.Sc. student **Anne-Martine Doucet** is comparing two environmental monitoring techniques to quantify how long it takes for surficial carbon dioxide (CO₂) to be taken up by weathered minerals in ultramafic rocks. Two methods for measuring the changes in CO₂ within dynamic closed chambers compared and used to cross-validate the results.

SUPERVISOR: Dr. Greg Dipple, University of British Columbia



Prescribed Burns for Mine Reclamation

M.Sc. student **Brandon Williams** is testing the effects of prescribed burning in a closed tailings storage facility as a means of shifting an agronomic community to a native grassland. His objectives are to test the effects of burning and provide insight into the use of traditional Indigenous knowledge to accelerate ecosystem recovery on disturbed mine lands.

SUPERVISOR: Dr. Lauchlan Fraser, Thompson Rivers University



Tools for Copper Discovery

M.Sc. student **Gabrielle Jones** is working to constrain the geochronology and petrogenesis of the Hogen batholith using in situ accessory mineral isotope and trace element data. Gabrielle will use the data to estimate emplacement ages and provide insight to the nature and antiquity of the batholith. Her goal is to provide a petrogenetic model for this complex porphyry-forming environment.

SUPERVISOR: Dr. Graham Pearson, University of Alberta



Fluid Injection and Earthquakes

Ph.D. candidate **Marco Roth** is creating a catalogue of earthquakes that have occurred in the Dawson-Septimus area in the Northeast Region to examine the relationships between fluid injection and earthquakes. He is investigating the characteristics of induced earthquakes and the rocks they occur in to better understand how operation parameters affect earthquakes.

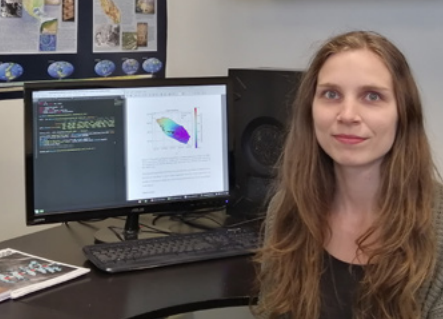
SUPERVISORS: Dr. Rebecca Harrington, Ruhr University Bochum, and Dr. Yajing Liu, McGill University



Tracking Gas in Groundwater

M.Sc. student **Max Goetz** is examining the distribution, concentration and origin of dissolved methane in groundwater in BC's Northeast Region. Using data from newly installed monitoring wells, he will construct a regional-scale 3-D numerical groundwater model to identify key recharge pathways and residence times of buried valley and fractured bedrock aquifers.

SUPERVISOR: Dr. Roger Beckie, University of British Columbia



Induced Seismicity in the Montney Formation

Ph.D. candidate **Paulina Wozniakowska** is using machine learning to determine factors that control seismicity in northeast BC's Montney Formation. The project puts emphasis on the determination of seismogenic potential and the discrepancy between the seismicity rates in particular oil and gas fields.

SUPERVISOR: Dr. David Eaton, University of Calgary



Skarn Mineralization on Vancouver Island

Ph.D. candidate **Rebecca Morris** is examining skarn deposits that were historically mined for copper, gold and other metals. Her research will examine the characteristics of the skarn mineralization at pluton-carbonate contacts in two contrasting magma systems and generate 3D models.

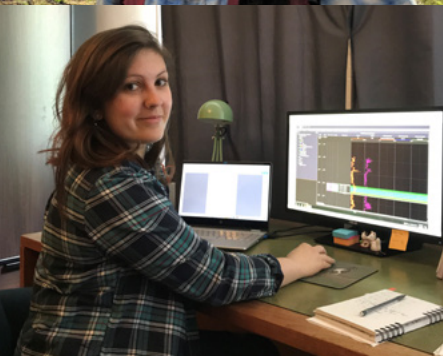
SUPERVISOR: Dr. Dante Canil, University of Victoria



Comparing Copper Deposits

M.Sc. student **Taylor Ledoux** is examining zircons extracted from rocks, stream and till samples from BC's South Central Region and comparing them with samples collected from similar rocks in Arizona and central Chile. He is looking for features that distinguish 'copper-friendly' porphyry fertile arc magmas from those that formed barren intrusions.

SUPERVISOR: Dr. Craig Hart, University of British Columbia



Fluid Modeling in the Montney

Ph.D. candidate **Victoria Chevrot** is modelling the migration and distribution of hydrocarbon fluids in the Montney Formation in BC's Northeast Region. Using field data from the Septimus field, she is developing new models for hydrocarbon migration and distribution in unconventional reservoirs.

SUPERVISOR: Dr. Nicholas Harris, University of Alberta

This project allows me to gain the project management experience which is required for any geologist and is an extremely transferable interdisciplinary skill.



M.Sc. student **Gabrielle Jones**



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