



ANNUAL REPORT **2021 – 2022**

CHAIR & CEO MESSAGE

Geoscience BC is adapting and will emerge from the COVID-19 pandemic prepared to meet the needs of a rapidly changing world. Commitments to a lower carbon economy are manifesting in increased demand for critical minerals and metals, for cleaner energy and for developing geological carbon capture and storage. All of these require new public geoscience that can be accessed and used by industry, governments, academia, communities and Indigenous groups to make evidence-based decisions.

During the reporting period (April 1, 2021 to March 31, 2022), Geoscience BC completed eight research projects, had 25 ongoing projects and started three new projects, for a total of 36 projects during the 2021-2022 fiscal year.

Deeper Collaboration

A collaboration agreement with the Canadian Hydrogen and Fuel Cell Association and a memorandum of understanding with the Geological Survey of Canada serve as examples of our work to develop new relationships and deepen collaboration with our partners.

These new agreements are just a small part of our exciting and necessary transformation, which includes diversifying funding sources. Geoscience BC received \$5 million in funding from the Province of British Columbia in 2019 and continues to seek additional funding to enable future research. Targeted, but limited, provincial funding was secured in 2021 – 2022 for projects such as the *Traditional Knowledge and Scientific Data Education, Comparison and Collaboration in Northeast BC Surface Water Use* project, which is part of the *Pilot Collaborative Water Monitoring Program, Northeast BC*, and the forthcoming *Northeast BC Geological Carbon Capture and Storage Atlas* project. This is a partnership between Geoscience BC, provincial government and the new BC Centre for Innovation and Clean Energy.

Strong Alignment

Our research projects and direction have strong alignment with industry and government priorities, and we believe we have the structure and track record to leverage resources and deliver vital research quickly, efficiently and effectively. With that in mind, we have worked to build our profile within the federal government and submitted a funding request to the 2022-2023 budget consultation process with the goal of establishing a funding model with contributions from provincial and federal governments and third parties.

In January 2022, we launched new non-voting membership classes. These are already proving valuable as a mechanism to develop stronger relationships, receive more input and improve communication with a wide variety of groups. Thank you to the 44 members that joined between January 31 and March 31. We look forward to welcoming many more members.

Significant Progress

We have also made significant progress using sponsorship to leverage funds. In January 2022 we announced the *NEBC Lithium – Formation Water Database* project which is leveraging funding from Geoscience BC with funds from LithiumBank and Northern Development – as well as in-kind support from the Geological Survey of Canada. In March 2022, we also opened our Scholarship Program to sponsorship for the first time.

On behalf of the Board, we would like to thank our staff and many volunteers for their input and tireless commitment to Geoscience BC during a transformational year. It has positioned us well to meet the growing need for a made-in-BC collaborative approach to public geoscience that helps us transition to a net-zero emission economy, attract investment and spark innovation.



Stephanie Killam
CHAIR OF THE BOARD



Gavin C. Dirom
PRESIDENT & CEO

Cover photo: Haj Bains

MEMBERSHIP & SPONSORSHIP

In early 2022, Geoscience BC launched two initiatives: new classes of membership and sponsorship.

New, non-voting classes of membership were announced on January 31, 2022 and are designed to boost research collaboration opportunities. This makes it easier for a wider range of partners to provide more input on, and benefit from, Geoscience BC research priorities and project ideas.

Corporate, Individual, Student and Associate memberships bring together industry, academia, communities, Indigenous groups and governments to achieve shared goals and increase the value of Geoscience BC research.

Enhancing Independence

The new membership structure will also help to leverage investments in Geoscience BC's public earth science research and provide more flexible yet stable long-term funding mechanisms that enhance our independence. Already, it is demonstrating and further building support for Geoscience BC's independent, public earth science research.

Sponsorship Opportunities

The *NEBC Lithium – Formation Water Database* project is an initial example of the opportunities presented by research sponsorship. Announced in January 2022, this project is funded and supported by Geoscience BC, LithiumBank, Northern Development and the Geological Survey of Canada. More detail on this project can be found on page 13.

In March 2022, we opened applications for the 2022 Scholarship Program and, at the same time, opportunities to sponsor the 2022 Program. This creates a new and unique way to support the next generation of geoscientists working in British Columbia. More information on the Scholarship Program can be found on page 22.

Scan this QR code to visit Geoscience BC's Membership page →



44

new 2022/23 Corporate, Individual, Student and Associate members joined Geoscience BC since the launch on January 31, 2022.



↑ The next generation of geoscientists: Richard Truman welcomes Geoscience BC's first Student member — UBC geology student John Tofflemire.

The transition to a lower carbon economy increases demand for BC's natural resources.

New Geoscience BC membership opportunities are increasing collaboration and help ensure we deliver the research that is needed to inform evidence-based decisions, including those relating to critical minerals and metals, cleaner energy generation, emissions reduction and geological carbon capture and storage.

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CHAIR & CEO MESSAGE

“Our research projects and direction have strong alignment with industry and government priorities, and we believe we have the structure and track record to leverage resources and deliver vital research quickly, efficiently and effectively.”

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MEMBERSHIPS & SPONSORSHIPS

Highlight: New Geoscience BC membership opportunities boost collaboration and make it easier for partners to provide more input on, and benefit from, our research projects.

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Meet the Geoscience BC Board

Meet the Geoscience BC Technical Advisory Committees

Meet the Geoscience BC Staff

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MINERALS

Highlight: We share upcoming research project updates, including a project developing a portable soil-gas measurement system to detect bedrock mineralization buried beneath glacial deposits.



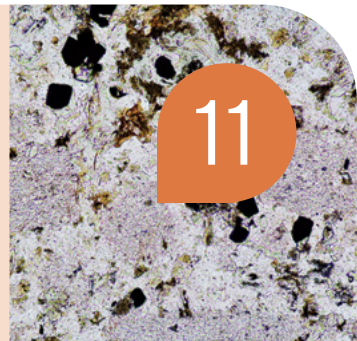
Identifying New Natural Resource Opportunities

Highlight: As part of the Central Interior Copper-Gold Research program in 2021-2022, new mineral exploration targets were identified and understanding of glacial sediments was significantly enhanced.

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Advancing Science & Innovative Technologies

Highlight: Carbon capture and storage research is assessing the potential for ultramafic rocks to bind with atmospheric carbon dioxide.



NATURAL GAS Enabling Clean Energy

Highlight: Research to help bring drone-mounted GHG emissions surveys closer to accreditation was completed as part of the goal to map aerial measurements of emissions in BC.

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Identifying New Natural Resource Opportunities

Highlight: A new collaboration in BC's Northeast Region was launched to map lithium concentration in brines and assess potential for future extraction of this critical metal.





Facilitating Responsible Natural Resource Development

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Highlight: Several research teams completed projects studying the relationship between earthquakes and natural gas development – known as induced seismicity – in BC’s Northeast Region.

**GEOTHERMAL
Enabling Clean Energy**

16

In 2021-2022, fieldwork at the Mount Cayley volcanic complex continued as part of the ongoing *Garibaldi Geothermal Volcanic Belt Assessment Project* to understand geothermal potential in part of BC’s Southwest Region.

**WATER
Understanding Water**

17

Highlight: The Collaborative Water Monitoring Program in BC’s Northeast Region progressed, including studies incorporating Traditional Knowledge into the research.

GOVERNANCE, MANAGEMENT & FINANCE

19

From April 1, 2021 to March 31, 2022 Geoscience BC completed eight minerals, energy and water research projects and had 28 new or ongoing projects.

PUBLIC ACCESS & DATA MANAGEMENT

20

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

EXTERNAL RELATIONS & COMMUNICATIONS

21

Highlight: In 2021-2022 Geoscience BC built stronger relationships with groups such as the First Nations Major Project Coalition and the Indigenous Resource Network.

SCHOLARSHIPS

22

In 2021, Geoscience BC funded ten post-graduate students working on projects related to BC’s minerals, energy and water resources.



BOARD OF DIRECTORS



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District of Mackenzie
(retired Mayor)



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Executive Vice
President, Corporate
Development, Pacific
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Audit Partner,
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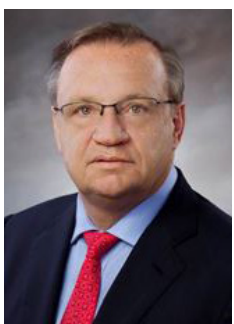
Gavin C. Dirom *

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



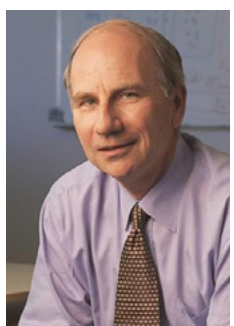
Dr. Robert Quartermain

Consultant



Carlos Salas

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

**** Departed during
reporting period

TECHNICAL ADVISORY COMMITTEES

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

Gavin C. Dirom Geoscience BC

Alf Hills Consultant

Jacques Houle Consultant

Dr. Jules Lajoie Comtek Enterprises Ltd.

Dr. Jim Lang Hunter Dickinson Inc.

Nalaine Morin Arrowblade Consulting

Christa Pellett Geoscience BC

Dr. Robert Quartermain Consultant

Carlos Salas ‡ Geoscience BC

Diana Sollner Technical Advisory Committee Chair, Consultant

Alastair Still GoldMining Inc.

Dr. Pim van Geffen CSA Global

Neil Wildgust BC Geological Survey, Cordilleran Geoscience

Brady Clift Geoscience BC (Staff Support)

OIL & GAS

Technical Advisory Committee

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

Deanna Cottrell Shell Canada Ltd.

Gavin C. Dirom Geoscience BC

Colin Frostad Tourmaline Oil Corp.

Dr. Brendan Galloway PETRONAS Canada

Tannis Gibson Saguaro Resources Ltd.

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

Carlos Salas ‡ Geoscience BC

Clint Tippett Consultant

Chris Wilcox † Ovintiv Services Inc.

Randy Hughes Geoscience BC (Staff Support)

Brian Abraham † Dentons Canada LLP

Gavin C. Dirom Geoscience BC

Brian Fairbank † Consultant

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

Peter Nilsen † Ministry of Forests, Lands, Natural Resource Operations and Rural Development

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

Tim Sadlier-Brown Sadlier-Brown Consulting Ltd.

Carlos Salas ‡ Geoscience BC

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.

Randy Hughes Geoscience BC (Staff Support)

† Joined TAC during reporting period

‡ Departed TAC during reporting period

GEOSCIENCE BC STAFF



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



Carlos Salas
M.Sc., P.Geo.
CHIEF SCIENTIFIC OFFICER



Christa Pellett
M.Sc.
VICE PRESIDENT, MINERALS



Richard Truman
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EXTERNAL RELATIONS



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Brady Clift
B.Sc., P.Geo.
MANAGER, MINERALS



Ron Prasad ‡
B.Sc., Adv. Dip. GIS
GIS SPECIALIST



Candice Appleby ‡
COMMUNICATIONS
COORDINATOR &
OFFICE MANAGER



Rhonda Schultz
BFA
ACCOUNTANT &
CORPORATE SECRETARY

‡ Departed during reporting period

MINERALS

Critical metals and minerals are essential in the manufacture of products needed for the transition to a low carbon economy. Diverse mineral deposits and a wealth of exploration and mining talent position BC well to become a global leader. With exploration spending at a near record \$660 million in the province in 2021¹, and with the demand for critical minerals expected to increase significantly, BC is well-placed to advance its mineral exploration and mining activities to help meet the global need for these resources².

HOW WE CONTRIBUTE

Geoscience BC's collaborative research projects often occur in regions with known mineral deposits or mining, and that have the potential for the discovery of new deposits. This includes the North Central Region between Mackenzie and Williams Lake where research is helping to 'see through' glacial sediments that may hide mineral deposits beneath. Another example is the completed Vancouver Island North Regional Project where 98% of the \$1.1 million investment was spent in BC and resulted in eighty-three new claims and a potential industry investment of \$3–4 million on mineral exploration within a year of release.

2021–22 MINERALS PROJECTS

The *Summary of Activities 2021: Minerals* volume contains nine technical papers on minerals research during the fiscal year 2021–2022. View and download your copy at www.geosciencebc.com

Completed Projects

3

Ongoing Projects

13

New Projects

1

STRATEGIC MINERALS RESEARCH OBJECTIVES

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

Our minerals research also aligns with Indigenous reconciliation goals and provincial and federal initiatives working towards Canada's net-zero emissions targets.

This section highlights completed and ongoing minerals research from April 1, 2021 to March 31, 2022.

Upcoming Mineral Highlights

As 2022 progresses, Geoscience BC expects the release of reports on the following projects.

The *Extracting Geological Value from Search Airborne Magnetic Data, West Central British Columbia* project has already produced a new bedrock geology map for the Skeena Arch area near Smithers. The final project report will summarize field activities and mineral occurrences within the map area.

The *Characterization of Gold Compositions in British Columbia* project is identifying potential new mineral development opportunities by building an open-source database on the composition of gold grains from streams and mineral deposits around the province.

The *Soil-Gas Detection of Bedrock Mineralization and Geological Faults Beneath Glacial Deposits using Economic Electronic Gas Sensors* project issued an initial report in 2020 highlighting the development of a portable soil-gas measurement system to detect bedrock mineralization and geological faults buried beneath glacial sediment deposits. The project was then extended to conduct further testing at the Mount Milligan Mine in partnership with Centerra Gold Inc., the results of which are expected to be published in spring 2022.



↑ Changing our understanding: Fieldwork for the Central Interior Copper-Gold Research program has resulted in new surficial mapping for the region. Photo: Wayne Jackaman.

1 http://cmscontent.nrs.gov.bc.ca/geoscience/PublicationCatalogue/InformationCircular/BCGS_IC2022-01.pdf

2 <https://www.worldbank.org/en/topic/extractiveindustries/brief/climate-smart-mining-minerals-for-climate-action>

Identifying New Natural Resource Opportunities

CENTRAL INTERIOR COPPER-GOLD RESEARCH PROGRAM

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 is underlain by rocks that geologists refer to as the Quesnel terrane. It has significant mineral potential but extensive Quaternary glacial sediments, including till, that obscure the bedrock in the region and hinder mineral exploration. Research from the 2021-2022 year saw new mineral exploration targets identified and significantly enhanced understanding of the glacial sediments. To date, \$1.4 million has been spent on the CICGR program.

Buried Porphyry Potential

Part of the CICGR program, the *Identification of New Porphyry Potential Under Cover in Central British Columbia* project was completed in January 2022. The goal was to identify areas with the potential for copper-gold porphyry deposits that may currently be underexplored due to glacially deposited sediments at surface. An updated overburden thickness model was published to identify where bedrock may be more accessible under the sediments and drilling less expensive. The research also created geophysical models that 'see through' the sediments, allowing for a suite of possible porphyry deposit hosts or sources of intrusive rocks to be identified. These mineral exploration targets were selected based on geophysical patterns associated with known copper-gold porphyry deposits hosted in similar rocks to the north and south. This project was conducted in collaboration with the Mineral Deposit Research Unit at the University of British Columbia.

Surficial Geology Analysis Revival

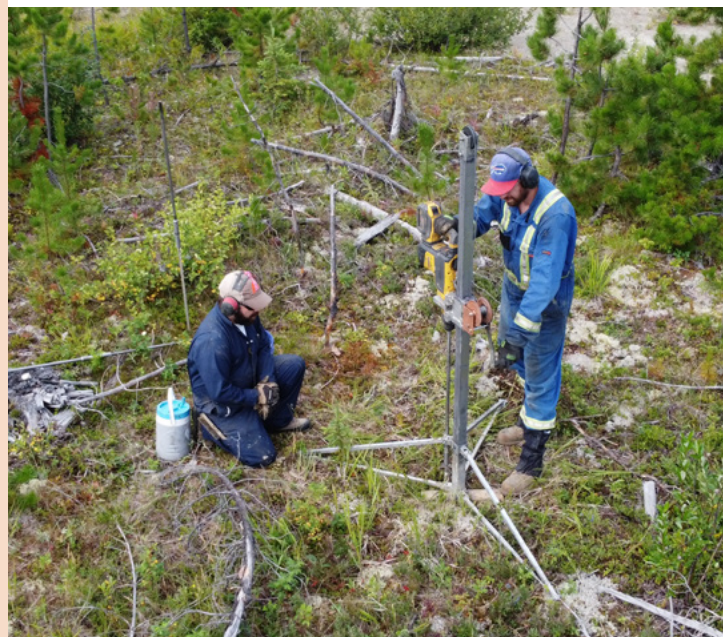
The ongoing *Central Interior Copper-Gold Research: Surficial Exploration Project* is generating new maps and data to provide the glacial framework necessary to interpret geochemical and mineralogical anomalies in the sediments and trace them back to their bedrock source. The research has generated surficial geology map suites, collected and analyzed new till samples, and tested a portable drill. The first set of maps, which were published in June 2021, identify the distribution and characteristics of surficial sediments and associated sediment transport directions in the northern portion of the CICGR project area. The researchers are also re-analyzing over 1,000 till samples collected in the 1990s and 2000s to bring them to current standards and allow for direct comparison to newly collected till samples and data.

Geophysical Data for the Golden Triangle

In September 2021, Geoscience BC published the geophysical data acquired for the *Golden Triangle Geophysics Data Compilation Project*. This collaboration between Geoscience BC and the mineral exploration and development sector has created valuable new public data which can be used to support economic development and guide decisions about exploration for critical minerals in northwest BC's Golden Triangle for years to come. Ten companies took part by contributing private geophysical data covering over 1,000 square kilometres. The data was reviewed, purchased and consolidated into data sets that are now publicly available.

Rare Earth Elements in Coal Deposits

The ongoing *Characterization and Extraction of Rare Earth Elements from East Kootenay Coalfields – REE BC Coal Project* is creating a database of rare earth elements (REEs) in East Kootenay coal deposits and testing extraction of REEs from promising samples. More than one hundred samples were collected, with REE concentrations on ash basis varying from 91 to 686 parts per million. Cerium, lanthanum, neodymium, yttrium and scandium accounted for more than 77% of the total REEs. Results to date show that the coal is enriched in REEs and that BC coals may become a viable source of REEs if extraction processes are further refined.



↑ A small, portable drill was tested as part of the *Central Interior Copper-Gold Research: Surficial Exploration Project*. Photo: Wayne Jackaman.

Advancing Science & Innovative Technologies

New Tools for Copper-Gold Exploration

New tools to give a boost to copper-gold porphyry deposit exploration were identified in the *Porphyry Vectoring Techniques in Advanced Argillic Altered Rocks in British Columbia* project, which was completed in January 2022. The project, which took place in three areas across BC's Northwest and North Central Regions, studied the zones of advanced argillic alteration that can form a blanket of clay and aluminous-rich minerals above and around an economic copper-gold porphyry deposit. Traditionally, this alteration zone makes exploration for the deposit more difficult. Rock samples were analyzed by a range of techniques, with the observations providing a toolset that can support rapid and cost-effective mineral exploration of porphyry copper and related epithermal mineralization.

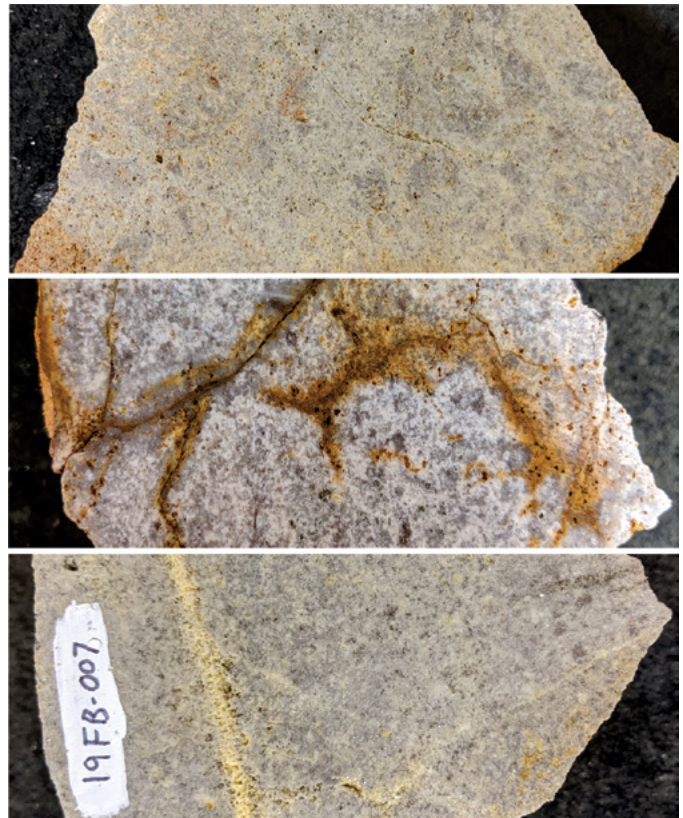
Advancing Geological Carbon Capture and Storage

Carbon capture and storage has been identified as a priority emissions reduction and mitigation tool by federal and provincial governments, industry and others. Geoscience BC is supporting research that identifies favourable geological carbon capture and storage options. One project already underway is the *Carbon Mineralization Potential Assessment for BC* that is assessing the potential for certain magnesium-rich minerals in ultramafic rocks to bind with carbon dioxide (CO₂) from the atmosphere. The result is a solid carbonate mineral form, where the CO₂ remains stable for thousands of years. A suite of research projects is being led by researchers at the University of British Columbia. Geoscience BC is contributing by funding a BC carbon mineralization prospectivity report and atlas. Working with the BC Geological Survey (BCGS), final results are expected to be published in 2022.



Putting NI 43-101 Technical Reports on the Map

In early 2021, Geoscience BC released the results of the *Georeferencing and Data Capture of National Instrument 43-101 Reports in BC* project. This project georeferenced NI 43-101 technical reports up to 2019 for the first time, making existing data significantly easier to find and use. Geoscience BC's Earth Science Viewer and the BCGS' MapPlace 2 platform now host this information, and the BCGS' MINFILE database was updated with the information found in the reports. In October 2021, an extension to the project was started to georeference technical reports from 2019 to 2021. Pairing the reports with location information makes it easier for mineral explorers and others to access and locate information contained in technical reports hosted in SEDAR (System for Electronic Document Analysis and Retrieval).



↑ The *Porphyry Vectoring Techniques in Advanced Argillic Altered Rocks in British Columbia* project generated new tools to help pinpoint potential copper-gold porphyry deposits within zones of advanced argillic alteration. Photo: Farhad Bouzari.

← The *Carbon Mineralization Potential Assessment for BC* project is indexing and mapping the potential for rocks like these to absorb carbon dioxide. Photo: BRIMM.

NATURAL GAS

BC's natural gas sector produces some of the cleanest and lowest emission intensity natural gas in the world. The expected growth in capital spending in the natural gas sector for 2022 would mark the second straight year of significant increases in investment as producers look to capitalize on stronger commodity prices due to rapidly growing global demand for natural gas³.

HOW WE CONTRIBUTE

Aligning with federal and provincial strategies to continue in the transition to net-zero emissions by 2050, Geoscience BC's research provides data that allows for more informed decision-making by governments, communities, Indigenous groups, and the natural gas industry. This research includes the monitoring of greenhouse gas (GHG) emissions to provide baseline data on natural and industrial emissions, or the potential migration and release of methane into groundwater or the air.

In 2021–2022 Geoscience BC completed its most recent projects studying the relationship between earthquakes and natural gas development in BC's Northeast Region, giving a better understanding of this seismic activity to industry as well as local governments, communities and Indigenous groups.

This section highlights completed, ongoing and new natural gas research projects from April 1, 2021 to March 31, 2022.

2021–22 NATURAL GAS PROJECTS

The *Summary of Activities 2021: Energy & Water* volume contains seven technical papers on natural gas research during the fiscal year 2021–2022. View and download your copy at www.geosciencebc.com

Completed Projects 5

Ongoing Projects 6

New Projects 2

STRATEGIC OIL & GAS RESEARCH OBJECTIVES

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

Enabling Clean Energy

TARGETING VALUE AND REDUCING EMISSIONS

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

In 2021, key samples from Canadian Natural Resources Limited producing gas wells were added to the project, along with a new quality control and assurance script to improve reliability and provide quality assessment to the data. New data mapping functions were also added.

The *BC Natural Gas Atlas* information and database can be viewed at www.bcnga.ca.

The *GHGMap: Aerial Measurements of Greenhouse Gas Emissions, British Columbia* project will complete in 2022. Researchers developed and tested state-of-the-art drone-mounted sensors to measure background GHG emissions, while also locating and measuring emissions at specific GHG emitting sites. Two drones, one with a laser spectrometer (OPLS) for detecting and quantifying GHG emissions, and a second with a downward looking micro methane laser (LIDAR) for rapid aerial emissions detection surveys, were developed for the project. The research helps bring drone-mounted emissions surveys closer to accreditation and use by industry and government.

Advancing Science and Innovative Technologies

Tracing Sour Gas in the Montney

The *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 is now complete. The project maps and predicts the provenance and distribution of 'sour gas' and hydrocarbon liquids in important unconventional reservoirs in parts of the Western Canadian Sedimentary Basin in BC's Northeast Region. The research suggests that sulphate-rich fluids migrated from the Triassic Charlie Lake Formation into the Montney and Doig formations via conduits of fracture and fault systems. Anhydrite, precipitated in discrete zones in the Montney, in contact with hydrocarbons, generated hydrogen sulphide (H₂S) gas. Structural elements, burial history, changes in total organic carbon, and other factors have created a complex hydrocarbon system in the Montney and Doig formations.



↑ The GHGMap project uses drone-mounted sensors developed from NASA technology to detect greenhouse gas emissions. Photo: Dawn Stenzel

Identifying Wastewater Disposal Zones

In November 2021, Geoscience BC completed the *Wastewater Disposal in the Maturing Montney Play Fairway of NEBC* project. The research provides new knowledge about potentially suitable locations for disposal of wastewater from natural gas operations in northeast BC's Montney Play. Deciding where to place a disposal well can be a complex process, especially in northeast BC where suitable disposal zones are increasingly difficult to find. The research integrated hydrogeology, geomechanics, reservoir characterization and structural geology to evaluate suitable wastewater disposal zones below the base of usable groundwater. Of 13 formations assessed, seven are potentially suitable for wastewater disposal, and disposal favourability maps were generated for each of these zones.

Montney Produced Water Treatment

The *Saltworks AirBreather Pilot* project began in 2021, with Geoscience BC and the Natural Gas Innovation Fund supporting Saltworks Technologies Inc. to develop and test humidification-dehumidification technology (the AirBreather) for suitability in treating Montney Formation water co-produced with natural gas. The intent of this technology is to treat produced saline water on natural gas sites by using excess heat from gas production. The project tested its innovative evaporation system on saline, produced water samples, collected from natural gas operations in the Montney Play. The AirBreather units turn the saline water into clean water for reuse (or into water vapour for safe release into the atmosphere), and clean, re-usable salt. Although targets for zero-liquid-discharge and clean salt were met, the pilot findings suggest that evaporative crystallizer technology may be a better alternative. Saltworks has estimated that the natural gas sector spends approximately \$180 million per year managing ponds and transporting saline water from production sites in northeastern BC. Finding the right water treatment technology, at suitable costs can reduce the need for transporting water for disposal and maintaining local water balances, while reducing operating costs.

Identifying New Natural Resource Opportunities

A POTENTIAL NEW LITHIUM SOURCE

In January 2022, Geoscience BC announced a partnership with LithiumBank, the Geological Survey of Canada and Northern Development to collaborate on the *NEBC Lithium – Formation Water Database* project. This new research collaboration could pave the way to diversifying the economy in northeastern BC and to providing a new source of lithium, a metal critical for clean technologies. The project will assess concentrations of lithium and other important elements in the brines of the region's formations by sampling existing natural gas wells. The researchers plan to collect hundreds of samples from up to twelve different subsurface formations. The samples will be analyzed before producing a database and suite of maps for the sampled formations, including lithium concentration maps. The Geological Survey of Canada is providing in-kind support for this project.

“Lithium is critical for the battery supply chain and electric vehicle revolution, and plays a key role in our fight against climate change. This project is the type of innovative research that pushes the envelope to create a pathway to net-zero that will create jobs and economic opportunity.”

**Honourable Jonathan Wilkinson,
Minister of Natural Resources Canada**



↑ The *Saltworks AirBreather Pilot* project has been testing a process that harnesses waste heat from natural gas production to treat saline wastewater. Photo: Saltworks Technologies

Facilitating Responsible Natural Resource Development

INDUCED SEISMICITY RESEARCH

Since 2012, Geoscience BC has been funding research projects that study the relationship between earthquakes and natural gas development – known as induced seismicity – in BC's Northeast Region. While still participating in the BC Seismic Monitoring Research Consortium, the 2021-2022 period saw the completion of its four most recent induced seismicity research projects. To date, Geoscience BC has distributed \$2.9 million for induced seismicity research.

The Seismic Monitoring Research Consortium includes Geoscience BC, the BC Oil & Gas Research and Innovation Society, the BC Oil & Gas Commission, and the Canadian Association of Petroleum Producers, with Natural Resources Canada as a research partner. Since its inception in 2012, the Consortium has increased monitoring stations from two to 37 across various networks. They capture essential seismic data, which is disseminated freely into the public domain.

Open-Access Seismic Data for Kiskatinaw

The *Understanding and Mitigating Induced Seismicity Risk in the Kiskatinaw Area, BC* project was completed in 2021, with the raw data released publicly. This project established a dense network of fifteen seismographs in the Kiskatinaw area of BC's Northeast Region, to better understand the circumstances of earthquakes caused by hydraulic fracturing and wastewater disposal. The project monitored the seismographs over 14 months, with over 9,000 events detected and located.

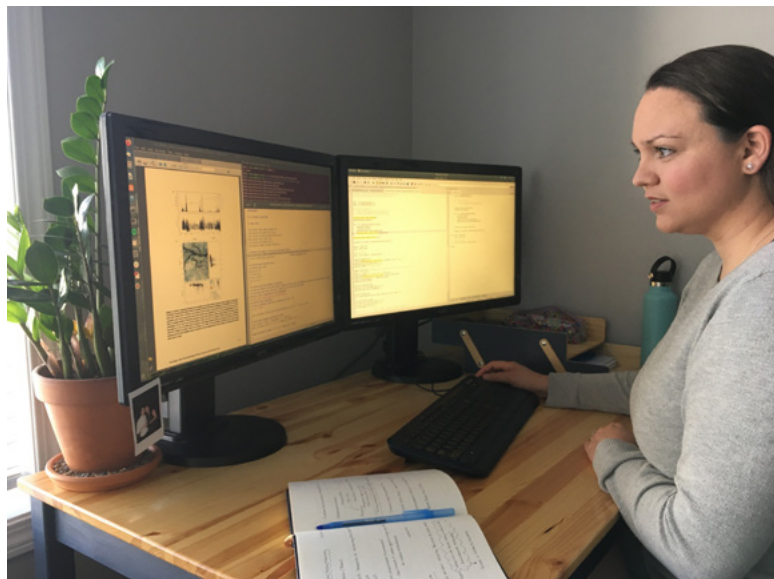
The researchers concluded that this real-time continuous data could aid the generation of shakemaps that can help understand local and seasonal variations in ground motion. The researchers also found that the data can help identify and map subsurface structures, which helps to improve analysis of geological susceptibility to induced seismicity. This data adds to an existing wider-spaced network to form a more detailed understanding of seismicity in the Kiskatinaw region.

Sustaining Seismic Monitoring

In 2020, the *Comprehensive Investigation of Injection-Induced Earthquakes in Northeastern British Columbia* project took over the operation of eight seismographs in the Fort St. John and Dawson Creek area known as the McGill Array. This allowed enhanced seismic monitoring and research in the Kiskatinaw Seismic Monitoring and Mitigation Area (KSMMA). In doing so, Geoscience BC is supporting the maintenance and operation of the seismographs to provide real-time seismicity data to operators, regulators and the public. The researchers have now established the most comprehensive and accurate earthquake catalogue for BC's Northeast Region. The final report includes research on source characteristics, and factors that control seismogenesis.

Mapping Seismic Susceptibility

The *Development of an Induced Seismicity Susceptibility Framework and Map for NEBC using an Integrated Machine Learning and Mechanistic Validation Approach* project was completed in 2021. The report and data can help improve models that predict induced seismicity through the use of machine learning techniques applied to the Northeast BC Region's Montney Play. The project conducted a machine learning and advanced numerical analysis review to model the relationship between natural gas well hydraulic completions, geology and seismic activity. A key finding was that, in general, local geological conditions are more important than the operational features when predicting induced seismicity. Also published are maps showing the areas more likely to be susceptible to induced seismicity.



↑ Monitoring seismic activity in the northeast BC's Kiskatinaw area is helping to mitigate effects of natural gas development. Photo: Thomas Swinscoe

Shear-Wave Velocity Studies

The *Amplification of Seismic Ground Motion Hazard in the Fort St. John – Dawson Creek Area* project was completed in February 2022. This project assessed the potential amplification of ground motion in specific shallow geological conditions, such as those found in the area around Fort St. John and Dawson Creek. The researchers collected data from over 4,800 wells and boreholes. A new depth to bedrock contour map was prepared and digital topographic mapping was used to revise existing surficial geological maps. The project concluded that, within the project area, susceptibility to amplification of seismic waves is widespread, but particularly where sediment depth to bedrock is between five and 15 metres. The results will be useful for managing energy industry activity to identify areas that may have an increased likelihood of felt events due to local surface conditions.

Better Understanding Seismicity

The *Monitoring and Risk Assessment of Anomalous Induced Seismicity due to Hydraulic Fracturing in the Montney, Northeast British Columbia* project aimed to provide a better understanding of the nature of such seismic events in that region. Researchers designed, built and tested a dense array of 15 monitoring stations of accelerographs paired with geophones to monitor hydraulic fractures and fluid disposal operations. The research also demonstrated that a dense array of accelerographs is required to map asymmetrical attenuation observed for seismic events over magnitude 1.5, and can be used to help understand whether an event will be felt or potentially cause damage at the surface. The report demonstrates that 3D hydro-geomechanical modelling can be used to better understand the processes and parameters that control induced seismicity in the Montney Play.



↑↑ A closely spaced network of seismographs in the Kiskatinaw area enabled significantly enhanced seismicity and ground motion monitoring. Photos: University of Calgary

← The Northeast BC Seismic Research Consortium has significantly expanded the region's seismic monitoring network. Photo: Nanometrics



GEOHERMAL

As Canada transitions to net-zero emissions and alternative sources of energy, including advancing federal and provincial hydrogen strategies, geothermal energy can play an important role in BC'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 also aids the development of the hydrogen sector in BC, which aligns with federal and provincial hydrogen strategies.

The research helps assess viability, reduces investment risk and encourages responsible geothermal exploration and development in the province. Stable, renewable energy sources, such as geothermal or hydrogen, have the potential to help Canada meet its target of net-zero GHG gas emissions by 2050.

This section highlights ongoing geothermal research from April 1, 2021 to March 31, 2022.



2021-22 GEOTHERMAL PROJECTS

The *Summary of Activities 2021: Energy & Water* volume contains two technical papers on geothermal research during the fiscal year 2021-2022. View and download your copy at www.geosciencebc.com

Completed Projects

0

Ongoing Projects

1

New Projects

0

STRATEGIC GEOTHERMAL RESEARCH OBJECTIVE

► Enabling Clean Energy

Advancing Garibaldi Geothermal Knowledge

The *Garibaldi Geothermal Volcanic Belt Assessment Project* is giving a boost to BC's clean energy transition. 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 and Mount Cayley volcanoes in BC's Southwest Region.

In July 2021, Geoscience BC published the first major report of the project with the release of mapping, data and a final report from the Mount Meager Complex, widely regarded as BC's most promising geothermal 'hot spot'.

This report provides the most detailed understanding to date of the potential for geothermal energy at this location. It contains a comprehensive set of studies that gathered geological, geochemical, geophysical, paleomagnetic and physical rock property data to help predict the presence of hot, permeable aquifers that could potentially be developed to generate geothermal energy. It marks the completion of the first phase of the collaboration between Geoscience BC, the Geological Survey of Canada and seven colleges and universities, and includes analyses and fieldwork completed in 2019 and 2020.

The second phase of the project is underway. Two seasons of fieldwork around Mount Cayley, approximately 20 kilometres west of Whistler, in 2021 and 2022 will lead to the release of the final report in 2023. The interim report for the summer 2021 fieldwork season will be published in spring 2022, and the project team is working with the Squamish Nation (Skwxwú7mesh) in the planning and implementation of research.

← Gravity meters are just one of the many tools and techniques used as part of the *Garibaldi Geothermal Volcanic Belt Assessment Project*, which is attracting new interest to BC's Southwest Region.

“ We have relied heavily on work done by Geoscience BC in our decision to participate in the purchase of the Meager Creek Development Corporation, and are continuing to rely upon it as we arrange financing for the development of the geothermal energy potential.

Richard Hawker, President,
Remedy Energy Services Inc.

WATER

With increased pressures facing water resources, there is a growing need to understand them. Geoscience BC-funded water research is leading to more informed decision-making that protects water resources, including incorporating Traditional Knowledge in research.

HOW WE CONTRIBUTE

Geoscience BC funds research into water resources related to energy and mineral development. It aligns with federal and provincial initiatives such as the Canada Water Agency and CleanBC. Research currently includes a series of projects in northeast BC where collaborative research is leading to a better understanding of water quality and quantity as recommended in the provincial government's 2019 *Scientific Review of Hydraulic Fracturing in British Columbia*.

This section highlights completed and ongoing water research from April 1, 2021 to March 31, 2022.

Gas Migration in Groundwater

The *Assessment of Fugitive Natural Gas on Near-Surface Groundwater Quality* project has given valuable insights into the movement and measurement of natural gas in the shallow subsurface, as well as assessments of impacts to groundwater, using a custom-built field station at Hudson's Hope in BC's Northeast Region.

The project examined the processes that impact gas migration, and the results provide baseline research needed to make informed decisions regarding the production and development of BC's natural gas resources.

A gas mixture mimicking Montney natural gas was released under controlled conditions into the subsurface. Various monitoring methods traced its movement and quantified its environmental effects. By measuring attributes before, during and for two years after injection, researchers found that the majority of the gas remained in the subsurface. The findings suggest that gas migration in the early time after release of natural gas did not lead to degradation of groundwater quality. Based on data from the first two years, the impact on groundwater geochemistry included no significant changes in major or trace elements.

Monitoring Network

The *Peace Region Scientific Groundwater Monitoring Network Installation Study* focused on the distribution, concentration and origin of dissolved hydrocarbons, principally methane in groundwater.

The research installed a network of monitoring wells throughout the Peace Region, spaced both close to and distant from natural gas wells, and close to the communities of Chetwynd, Dawson Creek, Fort St. John and Hudson's Hope. Samples were taken from the wells over four campaigns to understand the chemistry and dissolved gas content of groundwater. Domestic water wells in the area were also sampled.

Researchers found that naturally occurring methane is common in Peace Region groundwater, mostly at very low concentrations, and that there was no correlation between the amount of dissolved methane in the groundwater and proximity to natural gas wells.

The research was funded by the BC Oil and Gas Commission, Geoscience BC, the Ministry of Energy, Mines and Low Carbon Innovation and Mitacs.

Fort Nelson Area Water Monitoring

In 2017, Geoscience BC and Fort Nelson First Nation (FNFN) signed an agreement for FNFN to manage four hydrometric monitoring stations. The agreement was renewed in 2021. The monitoring stations at D'Easum Creek, Dilly Creek, Kiwigana River and Sahtaneh Creek have been monitoring water flow as part of the FNFN's *Liard River Basin Monitoring Initiative* project.

They are important in understanding any effect natural gas development has on water flow. The agreement gives FNFN data to make decisions and ensure water is being used in a safe and sustainable manner, with data also available publicly.

2021-22 WATER PROJECTS

The *Summary of Activities 2021: Energy & Water* volume contains two technical papers on water research during the fiscal year 2021-2022. View and download your copy at www.geosciencebc.com

Completed Projects

0

Ongoing Projects

5

New Projects

0

STRATEGIC WATER RESEARCH OBJECTIVE

► Understanding Water

Collaborative Water Monitoring Program

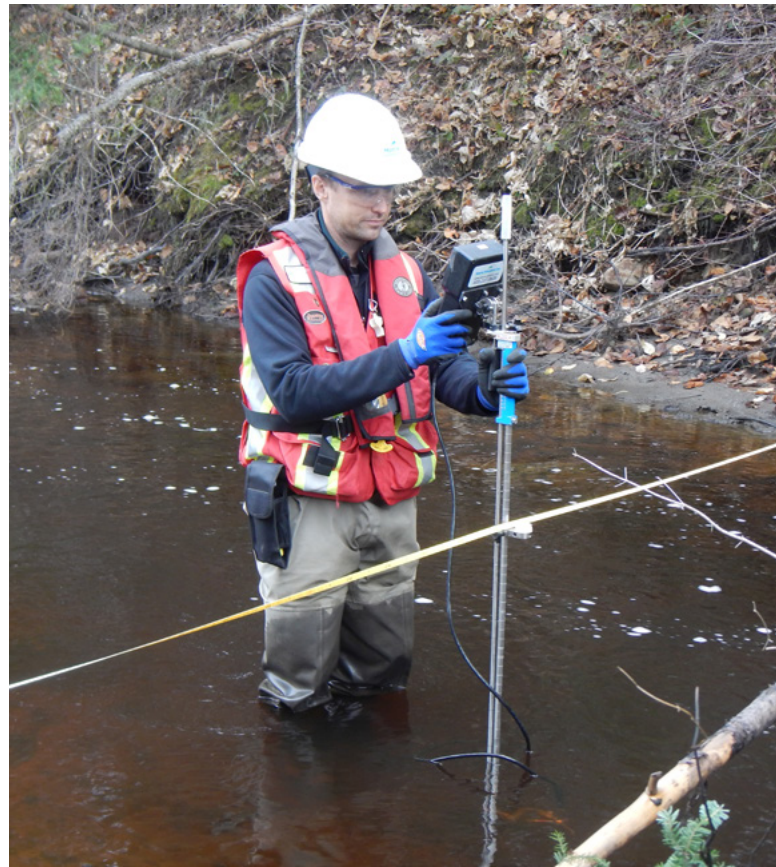
The three studies in the *Pilot Collaborative Water Monitoring Program*, *Northeast British Columbia* project were ongoing through 2021 and will continue in 2022. Specifically, the projects are: *Northeast BC Hydrometric Monitoring Network Improvements*; *Traditional Knowledge and Scientific Data Education, Comparison and Collaboration in Northeast BC Surface Water Use*; and *Coordinated Groundwater, Surface Water and Climate Monitoring Program, Northeast BC*. The projects rely on installing co-located surface water monitoring stations, groundwater wells and climate monitoring stations at multiple sites in the Peace Region. Installation began in 2021 and is continuing in 2022.

Baseline water quantity, quality and climate data from the monitoring sites will be assessed for watershed water balances, surface water flows and groundwater-surface water interactions.

The program team is working with Treaty 8 First Nations to integrate Indigenous Traditional Knowledge and Western scientific findings from five sites identified to date.

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 are participating in the study and will receive data collection, sampling and station maintenance training.

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 are participating in the study.



↑↑ Baseline water quantity, quality and climate data from monitoring sites are being assessed in the *Pilot Collaborative Water Monitoring Program*.
Photo: Matrix Solutions

GOVERNANCE, MANAGEMENT & FINANCE

Geoscience BC staff are 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). In January 2022, we announced new non-voting membership sub-classes: Corporate, Individual, Student and Associate. Our structure maximizes applied research investment and minimizes administrative expenditures.

Ensuring Transparency, Accountability & Responsibility

Through 2021 and into 2022, Geoscience BC continued to adapt through the COVID-19 pandemic. 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 early 2022, local staff began working from the Geoscience BC office more regularly.

On September 23, 2021, we held our 16th Annual General Meeting online. Nalaine Morin and Michael Gatens were re-appointed for three-year terms. Also at this time, Doug Konkin stepped down from the Geoscience BC Board. We thank Doug for his enthusiasm and effort during his time as a Board Director.

We also thank departing TAC members for their invaluable contributions guiding our earth science research. In June 2021, we were pleased to welcome Diana Sollner as Chair of our Minerals TAC. Diana has been a member of the committee since 2017.

In July 2021, we welcomed Brian Abraham (Dentons Canada LLP), Brian Fairbank and Peter Nilsen (Ministry of Forests, Lands, Natural Resource Operations and Rural Development) to our Geothermal TAC.

Building Future Opportunities

In spring 2021, the Geoscience BC Board formed a Funding Options Task Force to review and provide input on funding options in addition to the provincial government, which has provided approximately 80% of our funding since inception in 2005. It focused on seeking federal government funding to match provincial funding, setting up research sponsorship opportunities and creating new non-voting membership sub-classes.

This led to further developing our relationship with federal government, including multiple meetings with federal staff and submissions to the 2022-2023 budget consultation process in August 2021 and February 2022.

Geoscience BC Completed & Current Projects since 2005

Strategic Research Area	Completed Research Projects	Current Research Projects
Minerals	143	14
Energy: Oil & Gas	30	8
Energy: Geothermal	11	1
Water	26	5
TOTAL	210	28

Geoscience BC also continued to pursue provincial government funding, including providing submissions to the budget consultation process. In its November 2021 *Report on the Budget 2022 Consultation*, the BC Select Standing Committee on Finance and Government Services recommended that provincial government "increase funding for Geoscience BC".

Building on our existing Memorandum of Understanding (MOU) with the BC Geological Survey, Geoscience BC signed a five-year MOU with the Geological Survey of Canada in early 2022 to enhance collaboration efforts between organizations and deliver the best value from geoscience research. These agreements are important to the made-in-BC coordinated approach to public geoscience to attract investment and enable responsible natural resource development.

Geoscience BC is building support for a funding model that would include contributions from both the federal and provincial governments and industry sponsors to enable proposed research that identifies critical minerals and metals, advances carbon capture utilization and storage, and catalyzes cleaner energy.

In January 2022, Geoscience BC Society's Bylaws were amended to include and define new non-voting members. Subsequently, the Board established four membership classes. As of March 31, 2022 Geoscience BC had already signed up 44 Corporate, Individual, Student and Associate members representing multiple sectors, industry associations, academia, governments and communities. More information on membership and sponsorship opportunities can be found on page 3.

All interim and annual Geoscience BC Society financial statements are available to download at www.geosciencebc.com/updates/financial-statements

PUBLIC ACCESS & DATA MANAGEMENT

For BC to compete and thrive in the long-term, there is an evolving need for new, unbiased public geoscience data, relevant information and innovative research that solves challenges, attracts investment, informs decisions and supports the path to a net-zero economy.

Geoscience BC's Public Access & Data Management focus area supports our data management system and public access to research. All research project reports and data are available through the Geoscience BC website, which also hosts our Earth Science Viewer (ESV) online mapping application. Geoscience BC research project information is also available through the BC Geological Survey and the Ministry of Jobs, Economic Recovery and Innovation's *BC Economic Atlas*.

Providing Access to Public Data

Geoscience BC's website and ESV are driven by internal project and report databases, which also ensure that project outlines and links to projects are available on the Data BC tool. In addition, we collaborate with the BC Geological Survey to ensure that data and project results are shared as part of a Memorandum of Understanding, signed in 2020.

Work in 2021 included planning for geographical information system (GIS) hardware and software upgrades, which are expected to be completed in 2022.

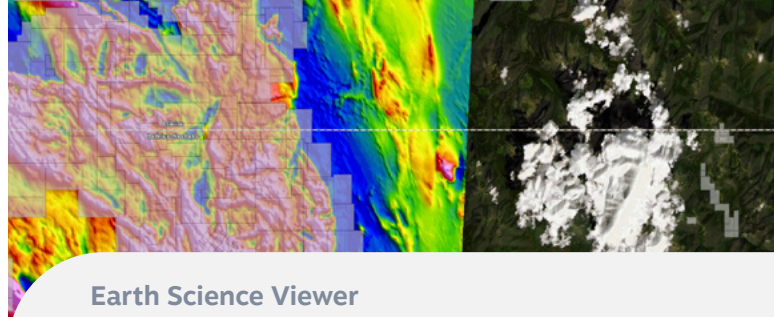
Maintaining Secure Digital Data

Throughout the year, 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.

With data storage needs expected to grow in the future, additional storage was added to our servers in 2021 and backup systems were upgraded. With our team increasingly working remotely through the COVID-19 pandemic and work practices evolving, we improved support for remote access to our systems.

Adding Value to Public Geoscience

Geoscience BC's research is available to everyone. It is used by a diverse range of groups including the critical minerals and metals, clean energy and environmental sectors, as well as academia, communities, Indigenous groups and governments. Making research and data open and accessible enhances economic growth, research and innovation in BC, and supports education, awareness and inclusion in decision-making in BC.



Earth Science Viewer

The ESV is Geoscience BC's custom web-based map and data service. All project outlines, as well as data from many projects, are available along with other useful geographic information system (GIS) layers such as mineral title information. The ESV can be accessed via www.geosciencebc.com and is an easy way to view information spatially without the need for specialist software.

Use of the ESV is expected to grow further in the coming years as new research relating to critical minerals and metals, cleaner energy and carbon storage is published.

Popular Projects

The Geoscience BC website continued to attract more visitors in 2021-2022. The most popular projects were:

Project	Page views
Garibaldi Geothermal Volcanic Belt Assessment Project	1,308
Identification of New Porphyry Potential Under Cover in Central British Columbia	790
Golden Triangle Geophysics Data Compilation Project	712
Central Interior Copper-Gold Research: Surficial Exploration Project	637
Carbon Mineralization Potential Assessment for BC	624
Wastewater Disposal in the Maturing Montney Play Fairway of NEBC	616
Clarke Lake Demonstration Project Development Engineering Pre-Feasibility of a Pilot Geothermal Power/Direct Use Facility at Clarke Lake	441
Porphyry Vectoring Techniques in Advanced Argillic Altered Rocks in British Columbia	432
Mount Meager Data	363
Vancouver Island North Regional Project	350

EXTERNAL RELATIONS & COMMUNICATIONS

Geoscience BC's External Relations & Communications focus area supports our relationships with the natural resource sectors, community leaders, Indigenous groups, academia and governments. This is evolving to include the nascent carbon capture and storage community, and includes a focus on membership and sponsorship opportunities.

It ensures we operate and communicate in a transparent manner; make our research easy to understand and share; that we are responsive to the 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

In addition to discussing individual projects with Indigenous groups, work began in 2021-2022 on discussing a process to define Geoscience BC's role in reconciliation with Indigenous peoples. This is expected to continue as Geoscience BC prepares its next strategic plan (April 2023 onwards). Discussions with Tsilhqot'in communities about a collaboration agreement are expected to continue through 2022.

In 2021-2022 Geoscience BC also built stronger relationships with the First Nations Major Project Coalition and with the Indigenous Resource Network. The aim of this is to provide opportunities for FNMPC members and IRN partners to be involved in research planning and implementation and to ensure they are aware of free access to research results.

Several changes were made to the Geoscience BC website in 2021-2022 to assist openness and transparency. This included redevelopment of the projects and data search function to make research projects easier to find and adding a tool to submit outline proposals to Geoscience BC.

Demonstrating Research Value & Building Broader Support

Expressions of support from federal and provincial governments (see page 19) were also the sentiment of a BC Chamber of Commerce resolution prepared by Terrace, Fort St. John and Campbell River Chambers supporting increased provincial funding for public geoscience. The resolution was passed at the BC Chamber of Commerce Annual General Meeting in May 2021. In early 2022 similar work with municipalities started, and it is hoped that a supportive resolution will be presented at the Union of BC Municipalities convention in September 2022.

Serving Technical & Academic Partners

Minerals and Energy & Water volumes of our *Summary of Activities 2021* were published in January 2022, providing updates on many ongoing Geoscience BC projects. *Summary of Activity* volumes were also featured at webinars co-hosted with the Association for Mineral Exploration (2021) and the Canadian Society for Unconventional Resources (2022).

Many events in 2021-2022 were online, including open houses for the *Central Interior Copper-Gold Research* program and the *Garibaldi Geothermal Volcanic Belt Assessment Project* and presentations to Kamloops and Smithers Exploration Group sessions. Geoscience BC also attended the in-person AME Roundup 2022 conference.

A ROBUST ENGAGEMENT MODEL

Our robust engagement model is designed to ensure that partners, industry, government, communities, Indigenous groups and academia are aware of and have input on our research projects. Our CRM (Customer Relationship Management) system includes more than 3,000 contacts and is an essential tool used to engage during project planning, launch, implementation and completion.

DIGGING DEEP WITH THE GEOSCIENCE BC BLOG

Digging Deep brings together several projects into a concise blog. It is a great way to get up to speed on projects. It is emailed monthly to our email update list and to members – or watch out for it on our Facebook, Instagram, LinkedIn and Twitter accounts @GeoscienceBC.

SCHOLARSHIPS Increasing Geoscience Literacy & Capacity

The Geoscience BC Scholarship Program supports graduate students working on BC-based projects. In 2021, we awarded scholarships to ten students working on geoscience research related to BC's minerals, energy and water resources. The Program has supported 134 students with \$670,000 in funding since 2007.



Modelling Induced Seismicity

Ph.D. candidate **Ali Mehrabifard** received his second Geoscience BC scholarship researching induced seismicity related to natural gas development. With state-of-the-art laboratory experiments and numerical modelling, he has conducted a sensitivity analysis of Montney Formation stiffness and its effects on induced seismicity behaviour and frequency-magnitude distribution.

University of British Columbia



Machine Learning in Rock Engineering Design

M.Sc. student **Beverly Yang** is studying the feasibility of integrating machine learning techniques in geotechnical engineering design, with an emphasis on the rock mass characterization and classification systems. She is also examining the readiness of the technical community to adopt a paradigm shift in the data collection process.

University of British Columbia



Biosensors of Concealed Mineralization

Ph.D. candidate **Bianca Iulianella Phillips** is developing the application of molecular tools for through-cover mineral exploration through research on soil microbial community biosensors. Her research is studying shifts in microbial community profiles, induced by chemical or physical differences related to geology, that are detectable in the surficial environment.

University of British Columbia



Magnetotelluric Studies in Geothermal Systems

Ph.D. candidate **Cedar Hanneson's** research uses electromagnetic geophysics, specifically magnetotellurics, to study the rocks of southern BC for the application of searching for geothermal resources. His study areas are the Southern Rocky Mountain Trench and Columbia Mountains in southeastern BC and the Garibaldi Volcanic Belt in southwestern BC.

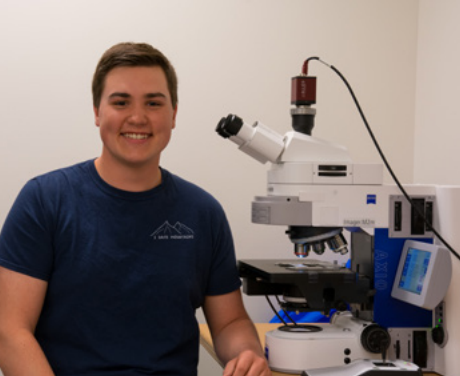
University of Alberta



Dam Breach Parameters and Runout Events

M.Sc. student **Daniel Adria** is back-analyzing and modelling the breach process and runout for up to sixty case histories of tailings dam failure. Using trends from the modelled results, forward analysis can be refined to address the greatest uncertainty for tailings facilities and the environment.

University of British Columbia



Crustal Cooling History of the Intermontane Belt

M.Sc. student **Kade Damant's** thesis uses apatite and zircon low-temperature thermochronology to quantify the upper crustal cooling history of the Intermontane terrane and constrain its burial and erosional history. This information will improve the understanding of Cordilleran evolution and aid mineral exploration efforts.

University of Calgary



Geochemistry and Mineralogy in the Toodoggone District

M.Sc. student **Pascal Voegeli** is studying the Silver Pond area within the Toodoggone district of north-central BC. With an argillic alteration lithocap resembling that found in a high sulphidation system, his research aims to apply SWIR, petrography and geochemical analysis to generate an applied exploration strategy.

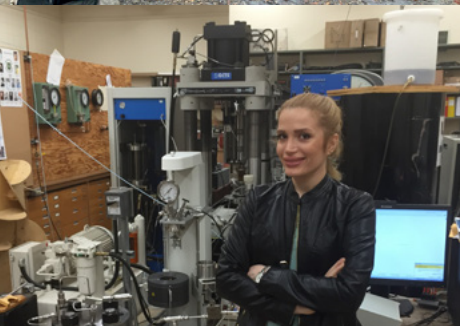
University of Alberta



Structure and Stratigraphy of the Montney Formation

M.Sc. student **Samantha Mackie** is integrating previous Montney studies to map the structures/fracture systems and understand stratigraphic permeability distributions as it relates to sulphate-rich fluids sourced from underlying Devonian evaporites. The goal is to better predict elevated hydrogen sulphide levels and support the development of a formation-wide hydrogen sulphide map.

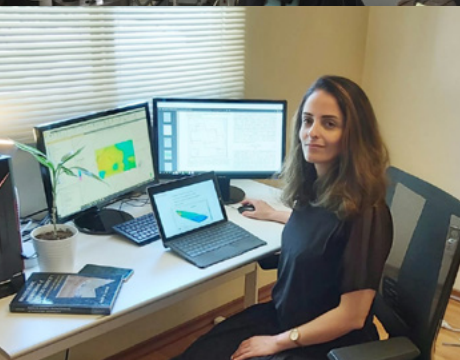
University of Calgary



Fibre Optics Application for Mine Surveillance

Ph.D. candidate **Sepide Hendi** is developing a new non-destructive in-situ stress measurement technique utilizing directionally sensitive fiber optic sensors integrated with borehole geophysical techniques. The application of this research could assist decision-making for geothermal and unconventional gas development, as well as safety in underground mining.

University of British Columbia



Fault Stability Analysis in the Septimus Field

Ph.D. candidate **Zahra Esmaeilzadeh** is researching the Septimus Field in the Kiskatinaw Seismic Monitoring and Mitigation Area to investigate the effects of pressure partitioning and stress barriers on induced seismicity, fracture propagation and production. Integrated reservoir modeling, geomechanical modeling, and fault-slip-potential analysis will be applied to quantify the effects of pressure barriers.

University of Calgary



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