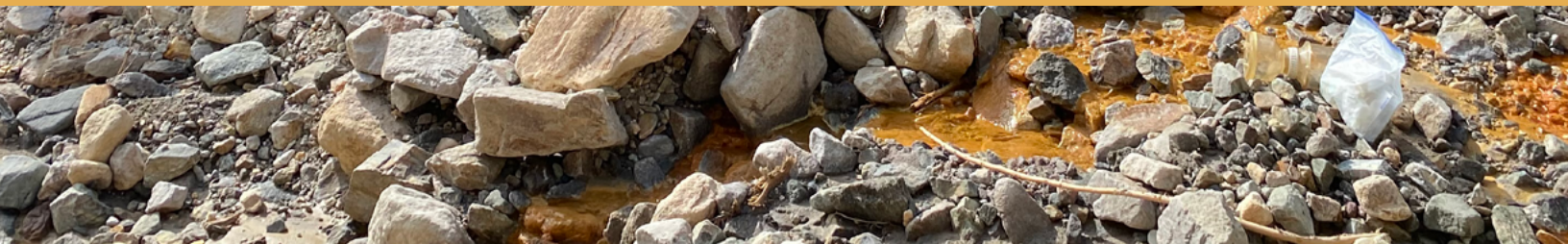
Geoscience BC

ANNUAL REPORT 2022 / 23



Cover image: A Natural Resources Canada research scientist at the Turbid Creek thermal spring on the south flank of the Mount Cayley volcano. *Photo credit: Steve Grasby*

This page: Natural Resources Canada research scientist Wanju Yuan at Pebble Creek thermal spring collecting water samples. *Photo credit: Steve Grasby*

CHAIR & CEO MESSAGE

We are meeting a growing need for a made-in-Canada collaborative approach to independent public geoscience that enables a transition to a net-zero emissions economy.

Donna Phillips
CHAIR OF THE BOARD

Gavin C. Dirom
PRESIDENT & CEO

Geoscience BC critical minerals and metals, clean energy and geological carbon capture and storage (CCS) research is at the very beginning of the secure supply chain needed to develop a net-zero emissions economy. We are meeting a growing need for a made-in-Canada collaborative approach to independent public geoscience that attracts investment, makes innovation possible and supports reconciliation with Indigenous Peoples.

Cash and in-kind contributions from industry and other partners are essential to demonstrating support for our approach, and can be used to attract additional financial support from provincial and federal governments. Our agreements with agencies such as the BC Energy Regulator, BC Geological Survey and Geological Survey of Canada ensure that our research supports, complements and adds value to their work. Thank you to the organizations that have committed to supporting our future research projects.

Funding Support

A significant focus for Geoscience BC during the reporting period (April 1, 2022 to March 31, 2023) has been further developing this collaborative funding model to ensure we can continue to meet evolving needs for independent public geoscience.

We are proud that our new Corporate, Individual, Student and Associate membership opportunities, which were activated on April 1, 2022, have created a new mechanism for industry, governments, academia, communities and Indigenous groups to contribute to future critical minerals and metals, cleaner energy, geological CCS and water research that is needed to make evidence-based decisions. Thank you to the 163 new members that had joined by March 31, 2023! We look forward to welcoming more in the coming year.

Valuable Research

An example of valuable Geoscience BC research in 2022/23 includes the *Georeferencing and Data Capture of 2019-2021 NI 43-101 Reports* project.

This makes finding mineral exploration data by location easy. National Instrument 43-101 Technical Reports contain comprehensive geoscience information on prospective mineral properties and are available from the Canadian Securities Administrators' SEDAR website.

This project makes it possible to search for location data for hundreds more mineral exploration and development reports in British Columbia. It's just one example of many Geoscience BC minerals projects that collectively attract over $7 in mineral exploration investment for every $1 put into research.

Another example is the *Northeast BC Geological Carbon Capture and Storage Atlas* project, which is an Energy Resources project made possible by support from the Province of British Columbia's Hydrogen Office and the BC Centre for Innovation and Clean Energy. Published in January 2023, this project's report and data bring a game-changing level of detail to understanding the potential for geological CCS.

We are now working with partners to identify priorities and opportunities to fund similar geological CCS studies in other parts of the province. Some of these are Project Concepts: new research ideas in development for which we are seeking input and investment from Geoscience BC members, industry, government, academia, communities and Indigenous groups. You can find more detail about our current minerals, energy resources and geothermal Project Concepts on pages 9 to 15 of this report.

The potential role of Geoscience BC's research was highlighted by our participation in the launch of the Canadian Minerals Strategy in December 2022. Here, Chief Sharleen Gale of the First Nations Major Projects Coalition and Fort Nelson First Nation said: "A good example is the approach taken by organizations like Geoscience BC to engage with Nations on public, open earth science research that can help us to be involved and make our own decisions at the very beginning of the critical minerals development process."

Indigenous Input

In 2022/23 we also added a new tool to our governance to bring further Indigenous input to our research and everyday work. In March 2023, our Board of Directors approved members of an Indigenous Relations and Reconciliation Advisory Council. The Council will begin its important work in early 2023/24.

On behalf of the Board, we would like to thank our staff, volunteers and many supporters for their passion, input and tireless support during an important year for Geoscience BC.

We gratefully acknowledge the financial support of our partners, including the Province of British Columbia through the Ministry of Energy, Mines and Low Carbon Innovation.

CONTENTS & YEAR IN REVIEW 2022/23

17 GOVERNANCE, MANAGEMENT & FINANCE

To attract member and industry investment in Geoscience BC, we announced a series of Project Concepts in July 2022 at a special webinar. Project Concepts are research ideas that are being refined through discussion with members and other interested groups.

18 MEMBERSHIP & SPONSORSHIP

Geoscience BC non-voting Corporate, Individual, Student and Associate membership categories were launched in January 2022 for the 2022/23 year. Geoscience BC had a total of 172 members, by March 31, 2023.

It is easy to join Geoscience BC and our collaborative network developing valuable independent public geoscience at:
geosciencebc.com/membership

19 PUBLIC ACCESS & DATA MANAGEMENT

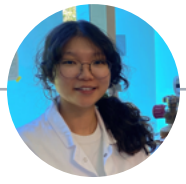
Ensuring equitable and easy access to our public research adds significant value to Geoscience BC projects. Making research and data open and accessible enhances economic growth, research and innovation in BC, and supports education, awareness and inclusion in decision-making.

20–21 EXTERNAL RELATIONS & COMMUNICATIONS

We continued to expand our collaborative network of partners in 2022/23, including with organizations such as the First Nations Climate Initiative, the Battery Metals Association of Canada and the Clean Resource Innovation Network.

22–23 GEOSCIENCE BC SCHOLARSHIP PROGRAM

The Geoscience BC Scholarship Program has supported 144 students with $720,000 in funding since 2007. In 2022, we awarded scholarships to ten students working on research related to BC's minerals, energy and water resources.



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▶ **Jim Gray** and **Stephanie Killam** are non-Director members of the Nominating Committee

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Ministry of Forests

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Sadlier-Brown Consulting Ltd.

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BC Hydro

Dr. Nathalie Vigouroux-Caillibot
Douglas College/SFU (adjunct)

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

Dr. Jeff Witter
Innovate Geothermal Ltd.

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MINERALS

Independent public geoscience that helps identify potential sources of critical minerals and metals is vital to developing secure supply chains needed to power the global net-zero emissions economy. This is reflected in both provincial and federal priorities and in the fact that demand for BC's minerals and metals is increasing: mineral exploration spending in the province rose from $660 million in 2021 to $740 million in 2022, driven by an 84% increase in spending on copper exploration[1].

How we Contribute

Geoscience BC's collaborative approach and peer-reviewed public minerals geoscience is a valuable tool used by industry, government, academia, communities and Indigenous groups to understand new mineral exploration opportunities. Every $1 invested in public minerals geoscience research attracts an estimated $7 in new mineral exploration investment in BC. To date, Geoscience BC has invested $40 million in minerals research, resulting in approximately $365 million in corresponding investment reported in the BC Assessment Reporting Indexing System to December 2021.

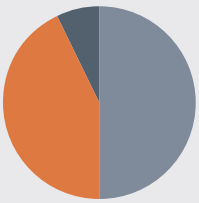
This section highlights our completed, ongoing and new minerals research from April 1, 2022, to March 31, 2023.

2022/23 Minerals Projects

The *Summary of Activities 2022: Minerals* volume contains eight technical papers on minerals research conducted through Geoscience BC projects, or by our 2022 Scholarship Program recipients. View and download your copy at **geosciencebc.com**

Minerals Research Strategic Objectives

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



Completed Projects	7
Ongoing Projects	6
New Projects	1

1. *https://www.ey.com/en_ca/news/2023/03/british-columbia-exploration-sector-hits-10-year-expenditure-high*

PROJECT CONCEPTS

Geoscience BC Project Concepts are new research ideas in development for which we are seeking input and investment from Geoscience BC members, industry, government, academia, communities and Indigenous groups. If you have suggestions, input or are interested in contributing to a project, contact us at info@geosciencebc.com.

Critical Minerals in Tailings & Waste Rock

As Canada encourages increased mineral exploration for critical minerals and metals as part of the transition to a net-zero emissions economy, innovative solutions are being sought in addition to traditional bedrock-hosted mineral deposits. Geoscience BC's *Critical Minerals and Metals in BC Mine Tailings and Waste Rock* Project Concept proposes to assess the physical, mineralogical and geochemical properties of tailings and waste rock at former and current mine sites for economic concentrations of critical minerals and metals. This new data could support updated interpretations of the resource and also support the improvement of their environmental and social legacies.

Fieldwork in southeastern BC. *Photo Credit: Dr. D. Pattison*

Piloting Carbon Storage in Ultramafic Rocks

Innovation in carbon sequestration in BC is a growing and a necessary area of research as Canada strives to meet its net-zero targets and as emitters seek to store or offset their carbon emissions. The *Pilot-scale Carbon Capture and Storage in Ultramafic Rocks* Project Concept would capitalize on previous and ongoing Geoscience BC research into the potential for carbon storage in ultramafic rocks through the conversion of CO_2 into stable carbonate minerals. This Project Concept aims to permit and develop a pilot-scale facility to test the sequestration of CO_2 in ultramafic rocks. The quality technical data and information generated would allow for evidence-based decisions to be made by those looking to attract investment, de-risk emerging opportunities and position BC at the forefront of carbon management.

Identifying New Natural Resource Opportunities

Quesnel Terrane Opportunities

The Quesnel terrane was the focus of several Geoscience BC minerals research projects in 2022/23. It is a distinct package of rocks that runs roughly northwest-southeast across the province and hosts significant copper-gold deposits, but in many areas is buried under thick glacial deposits.

Our research in the Quesnel terrane can be used by industry, communities, Indigenous groups and academia to better understand the bedrock geology, make science-based decisions and attract mineral exploration investment.

New Maps and Data Support Surficial Exploration

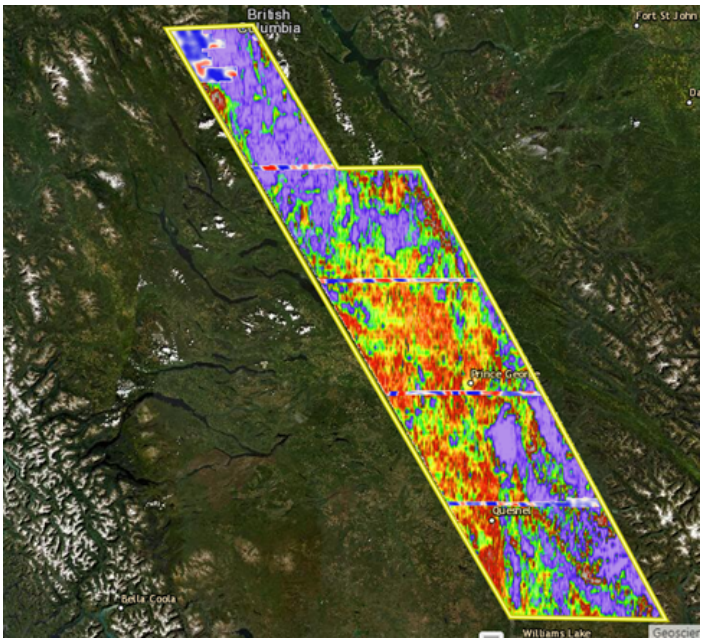
Central Interior Copper-Gold Research (CICGR) is a major multi-year Geoscience BC program of collaborative minerals earth science projects in British Columbia between the Mount Polley (Quesnel) and Gibraltar (Williams Lake) mines in the south, and the Mount Milligan (Mackenzie) mine in the north.

Since 2019, the *Central Interior Copper-Gold Research: Surficial Exploration Project* has generated new surficial geology maps for the area and analyzed over 3,200 new and archived till samples for their geochemical and mineralogical data to be able to develop a glacial framework to identify anomalies in till and trace them back to their bedrock source areas.

New surficial geology, drift thickness and till sampling suitability maps were published in April, followed by new infill till geochemical and mineralogical data from traditional and drill-supported till sampling programs in January. These results allow users to identify mineral exploration opportunities or place their property scale results within a regional context. This project will be completed in 2023/24.

Revealing Quesnel Terrane's Deep Geology

The *Undercover and Deep Geology from QUEST Electromagnetic and Gravity Data* project is using existing regional versatile time-domain electromagnetic (VTEM) and gravity data from Geoscience BC's QUEST project to derive new information about bedrock geology in the central Quesnel terrane, located between Williams Lake and Mackenzie. The QUEST datasets show promise for distinguishing between volcanic units within the Quesnel terrane and identifying magnetic or nonmagnetic intrusive rocks and structure. Geophysical data and models will be compiled in 3-dimensional Geographic Information System (GIS) platforms along with geological maps and bedrock observation data. This exploratory data analysis allowed for the preliminary identification of spatial correlations between gravity data and geological models and for distinguishing massive volcanic and intrusive domains from more permeable and porous sedimentary-rock-dominated domains. This project will be completed in 2023/24.



Undercover and Deep Geology from QUEST Electromagnetic and Gravity Data

Soil-Gas Detection Tool Advancements

The *Soil-Gas Detection of Bedrock Mineralization and Geological Faults Beneath Glacial Deposits Using Economic Electronic Gas Sensors* project advanced an innovative and cost-effective tool for mineral exploration. It developed and tested a real-time, portable soil gas survey technology to assist in the detection of mineral deposits beneath glacial sediments. The prototype was first tested on Vancouver Island before development of a more advanced prototype. Modifications included improved functionality from simplified components. Field testing took place at the Mount Milligan Mine where trenching, completed by Centerra Gold Inc., allowed for direct observations to corroborate the soil gas survey results. Results showed a spatial correlation between CO_2 and O_2 anomalies and mapped bedrock fracturing exposed in the trench. The modified system shows potential for detecting bedrock structures and associated mineralization beneath areas covered by glacial sediments.

Geo-Exploration Atlas of Mount Milligan Porphyry

A geo-exploration atlas of the Mount Milligan porphyry copper-gold district in North Central BC was completed as the final installment of the *Porphyry Integration Project*. This project examined the geochemical, geological and geophysical signatures for select porphyry districts in BC through analysis of existing public data and presented the findings at common district and deposit scales. Public data incorporated in the Mount Milligan atlas includes bedrock and surficial geology maps, gravity, aeromagnetic, radiometric, electromagnetic, induced polarization, stream sediment/till/soil geochemistry and biogeochemistry datasets. The Mount Milligan atlas joins existing editions for the Mount Polley porphyry copper-gold district and the Endako porphyry molybdenum district.

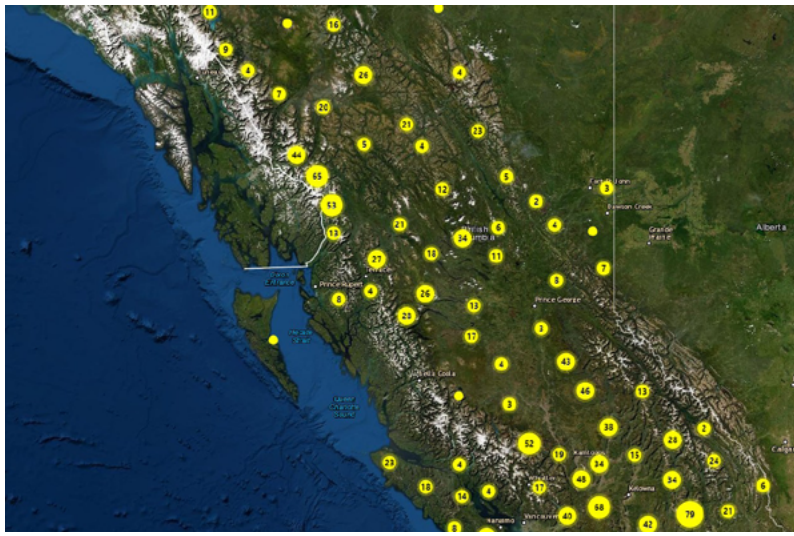
Skeena Arch Mapping Supports Exploration

The Skeena Arch near Smithers in BC's Northwest Region is known to be highly prospective for mineral deposits and hosts several past-producing mines. Enhanced mapping and understanding of the structure can allow for the discovery of potential new deposits and mineral exploration. Through field mapping which followed on from Geoscience BC's *Search Phase I: Airborne Magnetic Survey* project, the *Extracting Geological Value from Search Airborne Magnetic Data, West Central British Columbia* project shows that structural deformation within the Skeena Arch formed conduits for magmatic activity which contributed to widespread porphyry formation and related mineralization. The project also identified previously unknown Middle Jurassic volcanogenic massive sulphide (VMS) deposits, with the northern area in particular noted for its potential copper, silver and molybdenum deposits. The results are recorded on a 1:50,000 geology map of NTS 093L/13.

The open pit at Mt. Milligan Mine. *Photo Credit: Centerra Gold*

Georeferencing NI 43-101 Reports to 2021

National Instrument 43-101 Technical Reports (NI 43-101) contain comprehensive scientific and technical overviews of mineral projects, but were not searchable by location or geological information. The *Georeferencing and Data Capture of 2019-2021 NI 43-101 Reports* project continued the highly valuable work conducted in earlier years to map and georeference BC-related NI 43-101 reports, providing an easily searchable format. While the earlier phase included reports from 2004 to 2019, this project included reports to September 2021. The project also used the NI 43-101 reports to add or update mineral occurrence data in the BC Geological Survey MINFILE database.



National Instrument 43-101 Technical Reports can now be searched by location.

Penticton Map Sheet Upgraded

Furthering knowledge of the Kootenay Boundary area of BC's South Central Region, the *Geochronology, Deposit Studies and Geological Mapping, Penticton Map Sheet, East-half (NTS 082E, east half), Southern British Columbia* project has generated new information about rock types and ages in the east half of the Penticton map sheet. The area has a rich history of mining for critical minerals and metals such as molybdenum and zinc as well as gold, lead and silver. Geological mapping and geochronological dating have now more clearly defined the emplacement of the early Penticton Group volcanic rocks that host epithermal metal deposits. The data differentiates numerous small, high-level stocks that may host porphyry and vein deposits in what was previously mapped as undifferentiated batholith, providing fresh insight into areas worthy of new mineral exploration.

> **Geoscience BC plays an important role in identification of mineral deposits... A case in point is the discovery of a new, low sulphidation epithermal occurrence in the Greenwood area of southern BC by Goldcliff Resource Corporation.**
>
> Warner Gruenwald, P.Geo
> Geological Consultant to Goldcliff Resource Corporation

ENERGY RESOURCES

Geoscience BC's independent energy resources research supports BC and Canada's clean economy by providing data and reports essential to understanding nascent carbon management opportunities, as well as guiding the growing natural gas sector in BC.

As liquefied natural gas export terminals come online, demand for BC's low-carbon intensity natural gas is set to continue to grow, and with it the need for independent research to guide and regulate the sector.

The high level of interest in the *Northeast BC Geological Carbon Capture and Storage Atlas* demonstrated the significant demand for independent data on this new sector for BC in 2022/23.

How We Contribute

Geoscience BC energy resources research helps governments, communities, Indigenous groups and industry to make more informed decisions on their path to a net-zero emissions economy.

To support this, there has been a significant increase in the need for public geoscience to guide the development of carbon management in recent years. In 2022, this culminated in support from the Ministry of Energy, Mines and Low Carbon Innovation's BC Hydrogen Office and the BC Centre for Innovation and Clean Energy (CICE) to develop the *Northeast BC Geological Carbon Capture and Storage Atlas*, which was published in early 2023. We expect to continue developing similar projects for other BC regions soon.

Meanwhile, research that brings low carbon innovation to the natural gas sector continues, including research into new produced water treatment techniques, and sampling brines from natural gas sites to map the potential for the extraction of critical metals such as lithium.

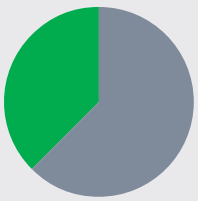
This section highlights completed and ongoing research projects from April 1, 2022, to March 31, 2023.

2022/23 Energy Resources Projects

The *Summary of Activities 2022: Energy & Water* volume contains six technical papers on Energy-Resources research conducted through Geoscience BC projects or by our 2022 Scholarship Program recipients. View and download your copy at **geosciencebc.com**

Energy Resources Research Strategic Objectives

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



Completed Projects	5
Ongoing Projects	3
New Projects	0

PROJECT CONCEPTS

Geoscience BC Project Concepts are new research ideas in development for which we are seeking input and investment from Geoscience BC members, industry, government, academia, communities and Indigenous groups. If you have suggestions, input or are interested in contributing to a project, contact us at info@geosciencebc.com.

Carbon Storage Potential in BC's Lower Mainland

The option to sequester carbon close to emission sources can provide logistical and financial advantages. With the Lower Mainland region in Southwest BC being the province's largest urban area, a suitable carbon storage reservoir in that region could greatly contribute to the Province's *CleanBC* targets. The area is host to thick, deep, sandstone formations that may have potential for carbon sequestration, however, research is needed to understand this potential. The *Southwest BC Geological Carbon Capture and Storage Atlas* Project Concept will be a first step in providing publicly available information, specific to the area, to support decision-making by government, communities, Indigenous groups and industry.

Carbon Sequestration Potential in Central Interior BC

The large Nechako Basin in BC's Central Interior Region has sedimentary rocks over 4,000 metres thick, which may offer saline aquifers for carbon capture and sequestration. In addition, carbon mineralization into surface volcanic mafics in the region may be possible. The *Central Interior BC Geological Carbon Capture and Storage Atlas* Project Concept aims to compile all existing technical data for the basin, provide an estimate of carbon storage potential, and identify areas for further research.

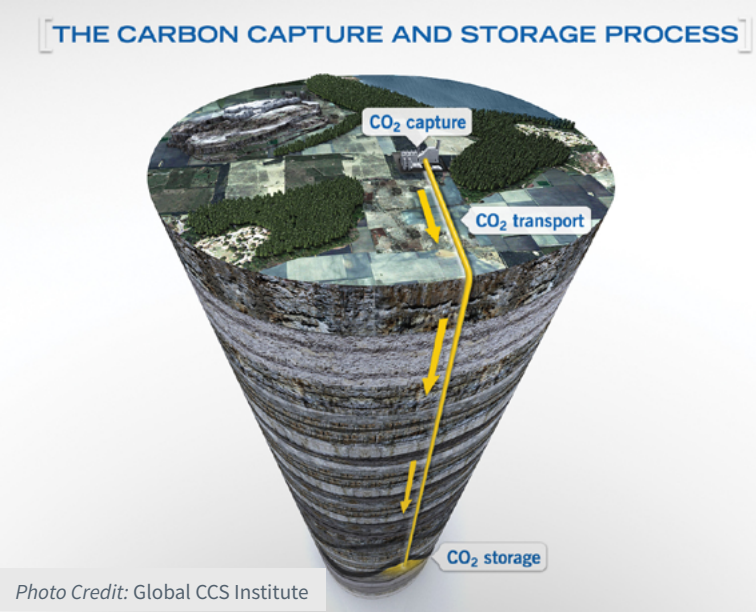


Photo Credit: Global CCS Institute

Carbon Storage Potential in BC's Southeast Fernie Basin Area

With the Fernie Basin in BC's Southeast Region host to over six kilometres of sedimentary strata, including potentially unmineable coal seams, there is potential for saline aquifer and coal carbon sequestration with the latter being undertaken in conjunction with a surface hydrogen project. Research is needed to understand this potential. The *Southeast BC Geological Carbon Capture and Storage Atlas* Project Concept is a first step in providing publicly available information, specific to the area, to support decision-making by government, communities, Indigenous groups and industry.

Northeast BC Geological Carbon Capture and Storage Atlas – Phase 2

Geoscience BC's first-phase report of geological carbon capture and storage potential, the *Northeast BC Geological Carbon Capture and Storage Atlas* released January 2023, identified 1.2 Gt and 3.0 Gt of CO_2 storage potential in depleted natural gas pools and deep saline aquifers, respectively, for total storage potential of 4.2 Gt (see page 14). The next phase of research is required to address knowledge gaps and to qualify and advance sites towards Storage Capacity designation. The proposed research would include further evaluation of site-specific storage, seals and risks, as well as transportation and carbon hub initial assessments.

Montney Formation Water Treatment Innovation

Supported by Geoscience BC and the Natural Gas Innovation Fund, Saltworks Technologies Inc.'s *Saltworks AirBreather Pilot* project was completed with the release of the final report in 2022. The project aimed to develop and test humidification-dehumidification technology for treating Montney Formation water co-produced with natural gas. Results showed that the water produced after treatment met all BC aquatic life water quality guidelines. The research identified that water with lower sulphate levels could precipitate industrial-quality salt as a by-product. At this time, the technology can produce a concentrated brine without onerous intervention, but solid salt production currently requires considerable operator intervention. As a result, further research and testing are required to advance the technology or research the effects of disposing of concentrated brines in water disposal wells.

Photo Credit: Saltworks Technologies

Formation Water as a Lithium Source

The *NEBC Lithium – Formation Water Database* project is collecting, assessing, and characterizing subsurface brines for dissolved metal concentrations, with the goal to establish the potential for extracting critical minerals and metals from subsurface brines in BC's Northeast Region. The project builds on the knowledge of the presence of elevated metal concentrations, including lithium, in Alberta and Saskatchewan. The project addresses the current data gap of the limited publicly available datasets for brine metal chemistries in BC. It is generating an initial brine database of lithium and other dissolved minerals and metals through a large-scale sampling program within active oil and gas fields. The release of the 2022 field sampling program update indicates that lithium concentrations range from low values of 0.1 mg/L to approximately 100 mg/L. The higher concentrations are within the range of technical limits for direct lithium extraction technologies and as such are interpreted to warrant further investigations. This project is a partnership between Geoscience BC, LithiumBank, Natural Resource Canada's Geological Survey of Canada and Northern Development.

> **"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

Northeast BC Carbon Storage Atlas

The *Northeast BC Geological Carbon Capture and Storage Atlas* project produced a report, data and a series of maps summarizing CO_2 sequestration potential target candidates in BC's Northeast Region. Researchers identified saline aquifers sites and depleted or nearly depleted natural gas pools as potential carbon storage reservoirs in twelve formations. A database for depleted pools and aquifers, that provides reservoir metrics and storage calculations, is also provided. The research identifies that more than 66 years' worth of BC's GHG emissions (4,230 Mt of CO_2) could potentially be stored in formations in northeastern BC, with significant potential in depleted pools north and northeast of Fort St. John and in deep saline aquifers in the Dawson Creek and Fort St. John area, and south of Fort Nelson. The project was a partnership between Geoscience BC, the Ministry of Energy, Mines and Low Carbon Innovation's Hydrogen Office and CICE.

From left to right: Christa Williams and Robert Pockar from Canadian Discovery, and Randy Hughes from Geoscience BC.

> **Carbon capture and storage could be a new industry in British Columbia on the lands of Treaty 8 First Nations. By informing Indigenous communities and sharing the research at an early stage, we can make more informed decisions about our involvement in this sector and about our future.**
>
> Chief Justin Napoleon, Saulteau First Nations

Geothermal heat and energy have significant potential to contribute to Canada's net-zero emissions economy. This includes playing a role in green hydrogen production.

How We Contribute

Geoscience BC's collaborative approach to geothermal research, including a significant partnership with Natural Resources Canada for the *Garibaldi Geothermal Volcanic Belt Assessment Project,* is being used by geothermal explorers and developers, communities, Indigenous groups and governments to make decisions about potential projects. It also aligns with provincial and federal hydrogen strategies by aiding the development of potential green hydrogen production facilities.

For example, Geoscience BC research has informed investment decisions valued at more than $40 million at Fort Nelson First Nation's Tu Deh-Kah Geothermal project in BC's Northeast Region, as well as at Meager Creek Development Corporation's geothermal and green hydrogen project in BC's Southwest Region.

This section highlights completed, ongoing and new geothermal research from April 1, 2022, to March 31, 2023.

2022/23 Geothermal Projects

The *Summary of Activities 2022: Energy & Water* volume contains two technical papers on geothermal research conducted through Geoscience BC projects or by our 2022 Scholarship Program recipients. View and download your copy at geosciencebc.com

Geothermal Research Strategic Objective

- Enabling Clean Energy

Completed Projects	1
Ongoing Projects	1
New Projects	1

PROJECT CONCEPTS

Geoscience BC Project Concepts are new research ideas in development for which we are seeking input and investment from Geoscience BC members, industry, government, academia, communities and Indigenous groups. If you have suggestions, input or are interested in contributing to a project, contact us at info@geosciencebc.com.

Enhancing Geothermal Systems Understanding

The potential for geothermal energy to be a clean energy resource, including for low carbon intensity hydrogen production, is largely untapped in BC. Geothermal energy can generate baseload power and heat and can be particularly beneficial for remote communities. However, characterizing the potential in individual geothermal systems can be expensive. Two Project Concepts aim to provide publicly available research and data that would help assess the geothermal resource potential in areas determined to be the most prospective in two regions, enabling industry, communities, Indigenous groups, government and the regulator to make evidence-based decisions. The *Southeast BC Geothermal Energy Potential Assessment* Project Concept plans to assess the hot fluid flow systems associated with crustal faults in BC's Southeast Region, and the *Northwest BC Geothermal Energy Potential Assessment* Project Concept aims to assess this area as it hosts numerous volcanoes and hot springs.

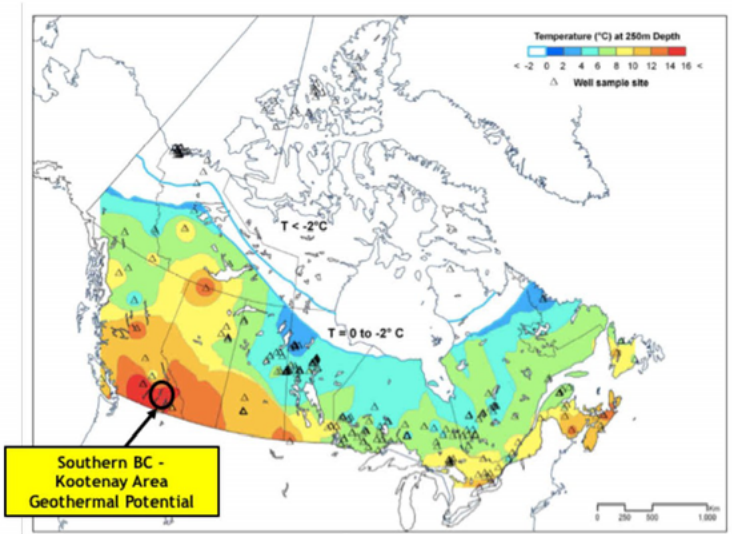
Garibaldi Geothermal Research Update

The summer 2022 field season of the *Garibaldi Geothermal Volcanic Belt Assessment Project* focused on the Mount Cayley Volcanic Complex, approximately 25 kilometres southwest of Whistler. Continued collection of magnetotelluric data is allowing for enhanced data to generate a resistivity model and gravity surveys were conducted to add to existing data to provide better coverage for analysis. Additional geophysical and geological surveys were also undertaken, including bedrock mapping and paleomagnetic sampling around both the Mount Meager and Mount Cayley complexes to better assess eruptive histories. With this final field season now complete, work is underway to analyze all data and generate a final report, anticipated to be released in mid-2023.

Natural Resources Canada research scientists laying out equipment for magnetotelluric measurements. *Photo Credit: Steve Grasby*

Kootenay Lake Geothermal

The Kootenay Lake area in BC's Southeast Region is geothermically active, with hot springs recording notably high water temperatures, thanks to the presence of deep-seated Eocene faults. Research into the potential for the east shore of the lake to be a geothermal resource was advanced in summer 2022 with the *Kootenay Lake Geothermal Project — Phase Two* fieldwork to conduct geological, geochemical and geospatial analyses. Water sampling and field testing from sites across the study area led to the selection of twenty sites for geochemistry analysis, funded by Geoscience BC. Study results identified several sites worthy of further research, focusing on the Crawford Creek and Orebin Creek area. This site lies adjacent to the Orebin Creek Fault which may act as a conduit for geothermal fluid movement from depth. A plan for additional research (Phase 3) is being developed by the research team.



Kootenay Lake Geothermal Project geothermal in context. Adapted from Geological Survey of Canada 2012.

WATER

The sustainable use and management of water resources in northeastern BC protects these resources for communities to be healthy and for the economy to thrive[1]. Our projects are contributing to this strategy by facilitating research that provides the necessary data for informed decision-making, while also incorporating Traditional Knowledge.

How We Contribute

Geoscience BC aligns with federal agencies and provincial policies such as the Canada Water Agency and Clean BC through water research programs relating to energy and mineral development. Current collaborative research ensures that Indigenous perspectives are incorporated to ensure that any decision-making regarding water resources or development that impacts such resources can more meaningfully consider impacts to First Nations.

This section highlights our ongoing water research from April 1, 2022, to March 31, 2023.

> **Water has a spiritual nature to our people. Some waters are home to our myth Spirits and channel our voices as echoes, memories and more. This program is a helpful step because it gathers Traditional Knowledge and explores how it can be considered alongside Western science in decision making.**
>
> Nathan Paul Prince, Traditional Land Use Coordinator, McLeod Lake Indian Band

2022/23 Water Projects

The *Summary of Activities 2022: Energy & Water* volume contains one technical paper on water research conducted through Geoscience BC projects. View and download your copy at **geosciencebc.com**

Water Research Strategic Objective

- Understanding Water

Completed Projects	0
Ongoing Projects	5
New Projects	0

Collaborative Water Monitoring in Northeast BC

The *Pilot Collaborative Water Monitoring Program, Northeastern British Columbia* is a collaboration of three projects aimed at further gathering and understanding river, groundwater, and climate data and interactions in BC's Northeast Region while also incorporating Traditional Knowledge into this understanding. In the last year, ongoing recording of data from hydrometric stations occurred as part of the *Northeast BC Hydrometric Monitoring Network Improvements* project. This data captured spring freshet and summer discharge.

Sampling to assess groundwater quality was conducted as part of the *Coordinated Groundwater, Surface Water and Climate Monitoring Program, Northeast BC* project. In addition, data was collected from newly installed climate stations and groundwater wells and will be used to support the assessment of the water balance at the sampling sites.

The *Traditional Knowledge and Scientific Data Education, Comparison and Collaboration in Northeast BC Surface Water Use* project saw the agreement to participate by McLeod Lake Indian Band and Halfway River First Nation. Field visits and meetings engaged Elders and community members on the uses and importance of water to the Nations, with much discussion on concerns of land use and development on water quality. First Nations community members were also trained in sampling and monitoring to facilitate ongoing participation in the program.

A comprehensive report of the program data and interpretations of the program's co-located monitoring equipment is expected at the end of 2023.

Hydrometric monitoring at Hulcross Creek. *Photo Credit: Ryan Rolick, BC ER*

1. *https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-planning-strategies/northeast-water-strategy*

GOVERNANCE, MANAGEMENT & FINANCE

Geoscience BC's governance model is successful because of the estimated 1,500 hours contributed annually by more than 50 volunteers. This includes our Board of Directors, which is responsible for overall governance and strategic direction, including research project budget decisions based on recommendations from the Board's Minerals, Energy Resources and Geothermal Technical Advisory Committees (TACs). To add Indigenous input to our governance, in January 2023 we announced the creation of a new Indigenous Relations and Reconciliation Advisory Council. Council members were appointed by the Board on March 16, 2023.

Ensuring Transparency, Accountability & Responsibility

On September 22, 2022, we held our 17th Annual General Meeting. At the meeting we welcomed former BC cabinet minister Doug Donaldson to the Board of Directors. Board Chair Stephanie Killam stepped down from her position after four three-year terms as a Director, and Donna Phillips became Chair of the Board, having previously served as Vice Chair of the Board. Director Lana Eagle is now Vice Chair of the Board.

Nalaine Morin, Alan Winter and former Chief Scientific Officer Carlos Salas also stepped down from the Board as Directors. Also, Geoscience BC President & CEO Gavin C. Dirom, Vice President Minerals Christa Pellett, Vice President External Relations Richard Truman and Accountant and Corporate Secretary Rhonda Schultz were reappointed as officers of the Society.

In October we announced six new members of our TACs. Dr. Mary Ann Middleton (EDI Environmental Dynamics Inc.), Dr. Shawn Hood (GoldSpot Discoveries), and Dr. Anelda Van Staden (Teck Metals Ltd.) joined the Minerals TAC. Sara McPhail (BC Ministry of Energy, Mines and Low Carbon Innovation), Dr. Steve Rogers (WSP-Golder), and Ron Stefik (BC Energy Regulator) have joined the Energy Resources TAC.

We thank all new and parting Directors and TAC members for their dedication to Geoscience BC.

Following the announcement of the Indigenous Relations and Reconciliation Advisory Council January 2023, our board approved the Council's volunteer Indigenous members at our March 2023 Board Meeting. They are:

- Bill Adsit, Tahltan
- Maynard Angus, Consultant, Nisga'a
- Maxine Bruce, Lil'wat
- Jordan Dickie, Stkemlupsemc te Secwepemc Nation (SSN), Fort Nelson First Nation
- Maxime Lepine, Consultant, Metis and Huron
- Lisa Mueller, Nation2Nation, Tsilhqot'in
- Jeff Skopyk, Teck Resources, English River First Nation Cree and Dene, Saskatchewan

The Council is chaired by board volunteer and Vice Chair Lana Eagle.

Building Future Opportunities

Following the launch of new classes of Geoscience BC membership in January 2022, we were pleased to finish the 2022/23 year with 163 Corporate, Individual, Student and Associate members representing diverse groups including industry, government, academia, communities, Indigenous groups and more. This is in addition to collaboration agreements in place with groups such as the BC Geological Survey, Natural Resources Canada (Geological Survey of Canada), the BC Energy Regulator and industry groups. These are all essential to building a funding model with contributions from governments, industry and other partners. We continued to further develop relationships with the federal government, including participating in Natural Resources Canada's Critical Minerals Strategy launch in December 2022.

In its August 2022 Report on the Budget 2023 Consultation, the BC Select Standing Committee on Finance and Government Services recommended that the provincial government "ensure that Geoscience BC is well-resourced to attract exploration investment and maintain competitiveness". The report stated: "Regarding public geoscience, the Committee highlighted the value of Geoscience BC and new research… It supported further resourcing in this area."

BC communities continued to advocate for Geoscience BC. For example in September 2022, the Union of BC Municipalities passed a resolution recommending that "the Province of British Columbia work with Geoscience BC and the Government of Canada to continue funding for Geoscience BC to undertake critical earth science research that helps achieve net-zero emission targets, builds partnerships, creates jobs and attracts investment by investing $5 million annually in Geoscience BC; and assisting Geoscience BC to establish a sustainable long-term funding model".

Geoscience BC Completed & Current Projects since 2005

Strategic Research Area	Completed Research Projects	Current Research Projects
MINERALS	150	7
ENERGY RESOURCES	35	3
GEOTHERMAL	12	1
WATER	26	5
TOTAL	**223**	**16**

Municipal leaders passed a resolution supporting provincial and federal government funding for Geoscience BC at the 2022 UBCM Convention.

MEMBERSHIP & SPONSORSHIP

Geoscience BC non-voting Corporate, Individual, Student and Associate membership categories were launched in January 2022 for the 2022/23 year. Geoscience BC had 163 non-voting members and nine voting members (the Directors), for a combined total of 172 members, by March 31, 2023.

Geoscience BC membership opportunities make it easy for a wide range of partners to support, provide input, network and stay up to date on Geoscience BC minerals, energy and water research. We are proud to welcome industry, academia, communities, Indigenous groups and governments as Corporate, Individual, Student and Associate members as we work towards shared goals.

Geoscience BC membership is an essential part of our evolving collaborative funding model because it provides a space to discuss and refine future research needs. It has led to several organizations expressing an interest in contributing cash and in-kind funding support for research projects.

In July 2022 Geoscience BC announced a series of Project Concepts at a webinar for members and partners. Project Concepts are new research ideas in development for which we are seeking input and investment. Details of current Project Concepts can be found in the Minerals, Energy Resources and Geothermal sections of this annual report (*see pages 9-15*).

In addition, key regular Geoscience BC activities are now also available to sponsor. For example, sponsorship opportunities have been developed for our annual Scholarship Program in 2023/24.

Geoscience BC membership and sponsorship activities are supported by our Membership & Sponsorship Committee, which is a committee of the Geoscience BC Board of Directors.

Joining Geoscience BC

It is easy to join Geoscience BC and our collaborative network developing valuable independent public geoscience at geosciencebc.com/membership

MEMBERSHIP & SPONSORSHIP

MEMBERSHIP LEVELS AND BENEFITS	$10,000 CORPORATE LARGE (300+ employees)	$5,000 CORPORATE MEDIUM (25-299 employees)	$2,500 CORPORATE SMALL (1-24 employees)	$100 INDIVIDUAL	$25 STUDENT	$0 ASSOCIATE
Public demonstration of support for shared public geoscience goals	●	●	●	●	●	●
Updates on research project planning, progress, completion and results	●	●	●	●	●	●
Career development and networking opportunities					●	
Input into developing research themes and program focus	●	●	●	●		
Advance notice of research project co-funding opportunities	●	●	●	●		●
Eligible to sponsor and partner on research programs and projects	●	●	●	●		
Complimentary Individual memberships	5	3	2			

PUBLIC ACCESS & DATA MANAGEMENT

Ensuring easy access for all to Geoscience BC critical mineral, energy and carbon capture storage research is essential to solving challenges, attracting investment, informing decisions, and supporting the path to a net-zero emissions 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 Development 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 through a Steering Committee and Memorandum of Understanding (signed in 2020).

Maintaining Secure Digital Data

Throughout 2022/23, we continued to progress work 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.

As we continue to evolve our work practices with many of the team working remotely part- or full-time, we continue to develop our remote access systems, including transitioning project work to a cloud-based system.

The ESV is our custom web-based map and data service. Outlines for all projects since 2005, as well as data from many projects and reports, are available along with other valuable layers such as mineral tenures, DLS grid and orthoimagery. The ESV can be accessed via **geosciencebc.com** and is an easy way to view information spatially without the need for specialized software.

ADDING VALUE TO PUBLIC GEOSCIENCE

Ensuring equitable and easy access to our public research adds significant value to Geoscience BC projects. Making research and data open and accessible enhances economic growth, research and innovation in BC, and supports education, awareness and inclusion in decision-making.

Geoscience BC research 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.

EXTERNAL RELATIONS & COMMUNICATIONS

Geoscience BC's External Relations & Communications focus area adds value to our independent public geoscience by developing and maintaining relationships with the natural resource sectors, community leaders, Indigenous groups, academia and governments. This has evolved as we adapt to an updated collaborative funding model and as research interest grows in areas such as critical minerals and metals and carbon capture and storage.

Our External Relations & Communications function 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

Throughout 2022/23 Geoscience BC continued to share project information with interested parties. This included, for example, meeting with municipal leaders to provide updates on the *Garibaldi Geothermal Volcanic Belt Assessment Project*.

Discussion about how to define Geoscience BC's role in reconciliation with Indigenous peoples continued. Saulteau First Nations Chief Justin Napoleon accepted a role on the Steering Committee for the *Northeast BC Geological Carbon Capture and Storage Atlas*, ensuring Indigenous involvement in research designed to guide the development of a new sector in BC. We began seeking volunteers to join an Indigenous Relations and Reconciliation Advisory Council in January 2023. Following review new members were confirmed by the Board of Directors in March 2023 (*see page 17*).

To understand and explain the value of Geoscience BC research, we have worked with Victoria-based Purple Rock Inc. to assess reports in the Assessment Report Indexing System, known as ARIS. This has highlighted that every $1 invested by Geoscience BC in minerals research attracts a minimum of $7 in corresponding mineral exploration. The analysis has also provided useful information showing which minerals projects are most valuable, and which organizations are using and referencing Geoscience BC projects in their reports.

We continued to expand our collaborative network of partners in 2022/23, including with organizations such as the First Nations Climate Initiative, the Battery Metals Association of Canada and the Clean Resource Innovation Network.

Changes made to the Geoscience BC website in 2022/23 included updating the homepage to focus on research themes and to make information about new Project Concepts (*see pages 9-15*) easy to find.

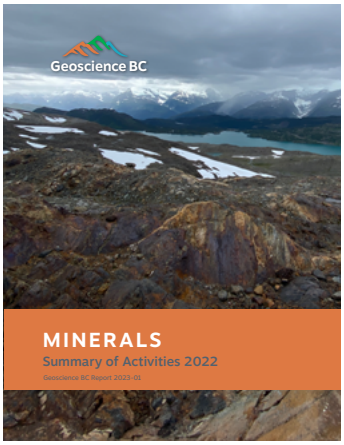
Demonstrating Research Value & Building Broader Support

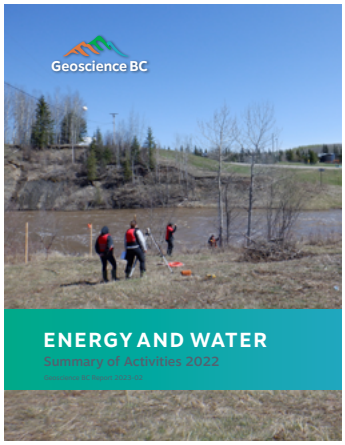
Geoscience BC further built on previous support for funding our research, including a new resolution passed by both the North Central Local Government Association and Union of BC Municipalities (UBCM) in September 2022. In addition, the Standing Committee on Finance and Government Services recommended further provincial funding.

Following the launch of Geoscience BC membership in January 2022, updating members became a new focus for 2022/23. This included a webinar to introduce Project Concepts to members and potential members in July 2022.

Serving Technical & Academic Partners

Minerals and Energy & Water volumes of our Summary of Activities 2022 were published in January 2023, providing updates on many ongoing Geoscience BC projects. Summary of Activity papers were also featured in our regular Digging Deep blogs. Digging Deep brings together several projects into a concise blog and is also a valuable tool to demonstrate the continued relevance of past research projects.





A HYBRID ENGAGEMENT MODEL

As COVID-19 restrictions relaxed through 2022/23, we began adopting a hybrid in-person and online model for engaging with groups interested in Geoscience BC research. For example, for the Northeast BC Geological Carbon Capture and Storage Atlas, an in-person open house was held in Fort St. John early on in the project with partners from the BC Centre for Innovation and Clean Energy and Canadian Discovery. We adopted an online model to present project results in February 2023, attracting around 150 delegates.

Geoscience BC Website: Top 10 Projects by Page Views (Apr. 1, 2022 – Mar. 31, 2023)

1	Northeast BC Geological Carbon Capture and Storage Atlas	2,063
2	Central Interior Copper-Gold Research: Surficial Exploration Project	1,347
3	Garibaldi Geothermal Volcanic Belt Assessment Project	819
4	Extracting Geological Value from Search Airborne Magnetic Data, West Central BC	637
5	Kootenay Lake Geothermal Project (Phase Two)	484
6	Identification of New Porphyry Potential Under Cover in Central BC	476
7	Georeferencing and Data Capture of 2019-2021 NI 43-101 Reports	467
8	Undercover and Deep Geology from QUEST Electromagnetic and Gravity Data	401
9	NEBC Lithium - Formation Water Database	390
10	Carbon Mineralization Potential Assessment for BC	372

Geoscience BC Social Media Summary

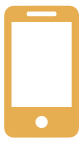
	Apr. 1, 2021 – Mar. 31, 2022	Apr. 1, 2022 – Mar. 31, 2023	% increase
LinkedIn	4,166 followers	**4,826 followers**	15.8
Twitter	2,412 followers	**2,478 followers**	2.8
Facebook	945 followers	**1,033 followers**	9.3
Instagram	994 followers	**1,142 followers**	14.9

Geoscience BC Website Visitor Summary

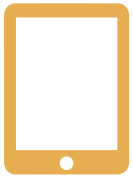
New Visitors	21,061
Returning Visitors	3,592
Users	21,362
Page Views	66,494
Files Downloaded	12,621
Reports Downloaded	5,455

Geoscience BC Website Visitors by Device Type

15,093
COMPUTER



6,069
MOBILE



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TABLET

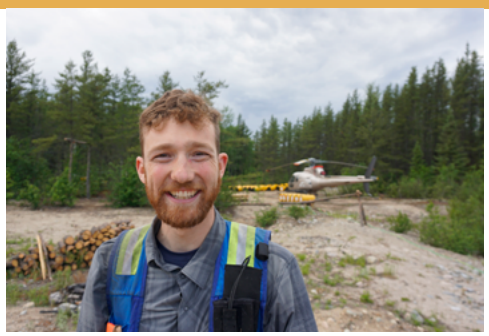
Increasing Geoscience Literacy & Capacity

The Geoscience BC Scholarship Program supports graduate students working on BC-based geoscience projects. In 2022, we awarded scholarships to ten students working on research related to BC's minerals, energy and water resources. The Program has supported 144 students with $720,000 in funding since 2007.

Gold Mineralization in the Stikine Terrane

M.Sc. student **Alex Hutchinson** is researching the structural and lithologic controls on gold mineralization in the Blueberry Zone of the Scottie Gold deposit located in the Stewart-Iskut mineral belt, part of the Golden Triangle in BC's Northwest Region. Through field mapping and laboratory analysis, she is building an ore deposit model for this epithermal-porphyry gold deposit.

SAINT MARY'S UNIVERSITY



Magnetotelluric Studies in Geothermal Systems

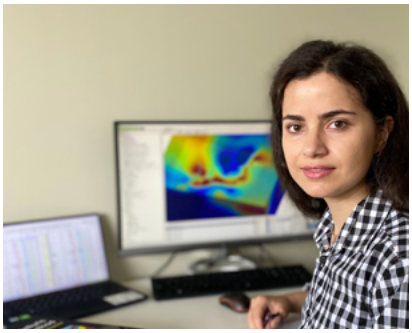
M.Sc. student **Ben Eaton** is contributing to innovations in the search for critical minerals through his research on new copper-porphyry indicator mineral methods by testing glacial deposit samples from the Northwest Copper East Niv Cu-Au-porphyry property in BC's North Central Region. His study will utilize machine learning and algorithms to identify indicator minerals by optical microscopy, micro-X-ray fluorescence, and scanning electron microscopy.

UNIVERSITY OF BRITISH COLUMBIA

Biosensors of Concealed Mineralization

A repeat scholarship recipient, Ph.D. candidate **Bianca Iulianella Phillips** is applying molecular tools to explore for mineral deposits concealed by soil cover. Her aim is to utilize inexpensive and rapid fingerprinting of soil communities to detect ore mineralization through the recognition that soil microorganisms can change depending on physical and chemical changes in the soil, a result of changing bedrock beneath.

UNIVERSITY OF BRITISH COLUMBIA



Fracture and Fault Systems in the Garibaldi Volcanic Belt

Ph.D. candidate **Fateme Hormozzade's** research focuses on the use of audio-magnetotelluric data to explore for shallow geothermal resources in the Garibaldi Volcanic Belt in BC's Southwest Region. Combining this data with legacy magnetotelluric data and 3D inversion techniques, this project will generate a new electrical resistivity model which can enhance understanding of the hydrothermal system and subsurface fluid flows.

CARLETON UNIVERSITY

Fluid Evolution of Ore-bearing Veins in Brucejack Epithermal Deposit

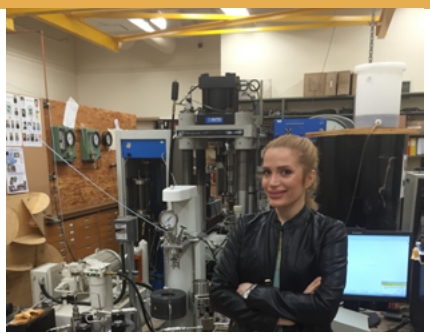
M.Sc. student **Kevin Ng** is researching the physico-chemical conditions that occurred in hydrothermal fluids in the Bonanza Grade Epithermal Gold-Silver Deposit in Brucejack, in BC's Northwest Region. His project utilizes various analytical laboratory techniques to identify the geological processes that led to deposit formation and to determine whether ore formation was part of the evolution of a single fluid or otherwise.

MCGILL UNIVERSITY

Reconstructing the Georgia Basin for Carbon Sequestration Potential

Ph.D. candidate **Maziyar Nazemi** is building an integrated 3D geological model for the Georgia Basin, which underlies the Lower Mainland region (BC's largest GHG-emitting urban centre). This model and data will be used to evaluate carbon sequestration reservoir potential and construct a 3D static model of sedimentary strata, helping to assess the feasibility of underground CO_2 storage in this region.

SIMON FRASER UNIVERSITY



Fibre Optics Application for Underground Monitoring and Mine Surveillance

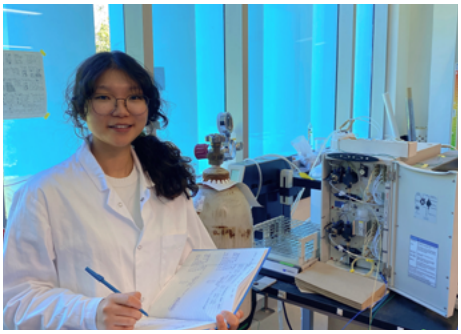
Ph.D. candidate **Sepide Hendi** is developing a new, non-destructive, in-situ stress measurement technique utilizing fibre optic sensors integrated with borehole geophysical techniques to measure in-situ stresses. Such a technique would assist operational decision-making in rock engineering design in geothermal and unconventional gas development.

UNIVERSITY OF BRITISH COLUMBIA

Geomechanical Interactions Between Open Pit and Cave Mining

M.A.Sc student **Tia Shapka-Fels** completed her examination of geomechanical interactions between open pit and cave mining through the application of numerical modelling. She studied the influence of different scenarios and methods on open pit stability, cave propagation and their connection behaviour. Her results provide context and guidance in modelling large-scale pit-to-cave transition scenarios.

UNIVERSITY OF BRITISH COLUMBIA



Capacity of Carbon Capture Reactivity in Mine Tailings

Ph.D. candidate **Xueya Lu** is researching the dissolution of the solid waste produced during hard-rock mining to determine its capacity to capture and store atmospheric CO_2 via subsequent precipitation of carbonate minerals. Her research aims to establish a characterization toolbox to enable the estimation of mineral carbonation potential using low-cost geochemical and numerical modelling strategies.

UNIVERSITY OF BRITISH COLUMBIA

Fault Stability Analysis in the Septimus Field

Ph.D. candidate **Zahra Esmaeilzadeh's** research focuses on hydraulic fracturing and fault reactivation in the presence of a pressure barrier, relevant to induced seismicity in BC's Northeast Region. She is reviewing available data with the objective of reappraising pressure terrane boundaries and evaluating the relationship between fault structures, pressure terranes and induced seismicity.

UNIVERSITY OF CALGARY

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