QUÉBEC GEOSCIENCE CENTRE

ANNUAL REPORT
2020-2021

Resources and the Environment: Bridging two worlds
Annual report from May 1, 2020 to April 30, 2021
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MESSAGE FROM THE DIRECTORS

A year of adaptation and resilience

The year 2020-2021, marked by the COVID-19 pandemic, has forced us to rethink our practices and reinvent ourselves. The impact of the pandemic on our lives and our work is unprecedented. Starting with our workplace. To address the issues associated with COVID-19 and minimize the impacts, the Joint Health and Safety Committee has been hard at work. Several key individuals coordinated access to the building and the delivery of protective equipment, completed numerous documents required for return to the workplace and trained employees. This collaborative effort put in place the tools and sanitary rules to reduce the risk of spreading the virus within the community, even though many people were telecommuting for most of the year.

Distance and virtual mode have not prevented the members of the Québec Geoscience Centre (QGC) from standing out and continuing their quest for excellence. It is a valuable asset for a federal research agency, such as the Geological Survey of Canada (GSC), and a university, such as the Institut national de la recherche scientifique (INRS) to be able to work in collaboration. An asset that must be preserved and developed in order to respond to the current challenges of our society while being at the forefront of geoscience research.

With more than 20 years of experience at the GSC, Réjean Couture becomes the new Director of the GSC-Quebec (GSC-Q) in August 2020, succeeding Andrée Bolduc who had headed the office for 8 years. Last April, Louise Hénault-Ethier became the new Director of the Eau Terre Environnement Research Centre (ETE) of INRS. André St-Hilaire returned to his full-time teaching position after having served as interim director of the Centre for 12 months.
A pivotal year for science programs as well. At the GSC, the Geo-mapping for Energy and Minerals program, renamed GEM-GeoNorth (2020-2027), and the Targeted Geoscience Initiative (TGI; ongoing) were renewed, bringing new perspectives to the partnership. The TerraCanada initiative has also been launched and will expand the geoinformatics and geoenvironmental teams and infrastructure. The ETE Centre of INRS presented its new five-year scientific program to reflect the evolution of research activities for the coming years.

Thanks to all and congratulations!

Réjean Couture  
Director of the Geological Survey of Canada in Quebec

André St-Hilaire  
Interim Director of the Eau Terre Environnement Research Center of INRS
QUÉBEC GEOSCIENCE CENTRE

Who are we?

- A unique partnership between a university centre (Eau Terre Environnement Research Centre - ETE of the Institut national de la recherche scientifique - INRS) and a government agency (Quebec Division of the Geological Survey of Canada - GSC-Q of Natural Resources Canada - NRCan)

Our mission

- Respond to relevant socio-economic issues by developing knowledge of regional geology, georesources and environmental geosciences

Our vision

- Collaborate to be a focal point of excellence in geoscience, open to all, while ensuring the cooperation and participation of Canadian governments, agencies and universities

Our objectives

- Foster scientific collaboration between the ETE Centre and the GSC-Q
- Raise awareness of the general public to the Earth Sciences and to contribute to arouse the interest of the youngest
- Publish outreach materials and organize special events to engage and support youth interest in science
- Train the next generation of scientists through the inter-university graduate program in Earth Sciences offered jointly by INRS and the Department of Geology and Geological Engineering of Laval University

One of Canada’s largest multi-disciplinary earth science research clusters
THE QGC IN A FEW FIGURES

Our members

Country of origin of our students

3 Research Chairs
30 Awards
19 Joint Projects
HIGHLIGHTS

Reinventing the QGC

Over the past year, consultations were held within our two organizations to discuss the future of the QGC. Several ideas were put forward to increase member involvement, sense of belonging and visibility. To this end, a joint committee of professors/researchers, research assistants/professionals, technicians and students will be formed in the fall of 2021 to reinvent the QGC and maximize its potential.

TerraCanada

TerraCanada is one of several "science clusters" in Phase 1 of the Laboratories Canada strategy led by Public Services and Procurement Canada. This initiative brings together more than 1,600 scientists from five federal departments, including NRCan, to strengthen federal science and renew laboratory infrastructure. It has a direct impact on the QGC through the expansion of geoinformatics and geoenvironmental teams and infrastructure. Its goals include (1) leveraging expertise in artificial intelligence to develop technologies and management systems to support geoscience, and (2) better monitor environmental contaminants throughout the resource development cycle.
# GEOSCIENCES AT THE SERVICE OF ECONOMIC DEVELOPMENT AND THE ENVIRONMENT

<table>
<thead>
<tr>
<th>GSC Team</th>
<th>INRS Team</th>
<th>Expertises</th>
<th>For more information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patrick Mercier-Langevin, Kathleen Lauzière, Valérie Bécu</td>
<td>Pierre-Simon Ross, Simon Tremblay-Hébert (M.Sc.)</td>
<td>Metallogeny Volcanology</td>
<td>Project: Géologie des indices aurifères de la zone Caniapiscau-Koksoak de l’Orogène du Nouveau Québec (Fosse du Labrador) (3)</td>
</tr>
</tbody>
</table>

Support the development of sustainable energy solutions

| Stéphanie Larmagnat | Jasmin Raymond, Maria José Oviedo Valencia (M.Sc.) | Geothermal energy Petrophysics Tomodensitometry | Project: Testing artificial fracture effects on rock properties (porosity, permeability, thermal conductivity) (5) |
| Daniel Paradis | Erwan Gloaguen, Jasmin Raymond, Benyamin Shariatini (Ph.D.) | Geothermal energy Hydrogeology Geophysics Data assimilation | Project: Optimisation des systèmes de géothermie (6) |
**Understand the impact of human activities on the environment**

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jason Ahad, Jade Bergeron, Hooshang Pakdel, Anna Smirnoff, Leah Mindorff</strong></td>
<td>Environmental sedimentology Geochemistry of metals Organic geochemistry</td>
</tr>
<tr>
<td><strong>Mathieu J. Duchesne</strong></td>
<td>Applied geophysics Environmental sedimentology</td>
</tr>
<tr>
<td><strong>Mathieu J. Duchesne</strong></td>
<td>Applied geophysics Geothermal energy</td>
</tr>
<tr>
<td><strong>Daniel Paradis</strong></td>
<td>Hydrogeology Hydrology Heat transfer Numerical modelling Digital inversion</td>
</tr>
<tr>
<td><strong>Christine Rivard, Vincent Tremblay</strong></td>
<td>Hydrogeology Geology Geochemistry Geophysics</td>
</tr>
</tbody>
</table>

**Characterize water resources**

<table>
<thead>
<tr>
<th>Project</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Daniel Paradis</strong></td>
<td>Hydrogeology Hydrology Data assimilation</td>
</tr>
<tr>
<td><strong>Daniel Paradis</strong></td>
<td>Hydrogeology Geochemistry Numerical modelling</td>
</tr>
<tr>
<td><strong>Daniel Paradis</strong></td>
<td>Hydrogeology</td>
</tr>
<tr>
<td>Name</td>
<td>Role Details</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Daniel Paradis</td>
<td>René Lefebvre, Aymen Nefzi (Ph.D.)</td>
</tr>
<tr>
<td>Michel Parent</td>
<td>Richard Martel, Thomas Robert, Luc Trépanier, Marco Boutin, Karine Bédard, Jean-Sébastien Gosselin, Marc-Alexandre Fillon (Ph.D.), Jean-Philippe Drolet (Postdoc)</td>
</tr>
<tr>
<td>Didier Perret</td>
<td>Damien Pham Van Bang, Marc Richer-Lafêche, Jacob Stolle</td>
</tr>
</tbody>
</table>

In bold: project leader(s)
(*): Project location number on the map

Location of our projects for the year 2020-2021

Supporting mineral resource exploration while helping environmental protection
KNOWLEDGE DISSEMINATION

Characterize water resources

Publication of the synthesis report ARCHIVES

The ARCHIVES project, which ran from 2008 to 2014, was a collaboration between GSC-Quebec (Christian Bégin and Martine Savard) and INRS (Yves Bégin and Pierre Francus). It involved several universities in Quebec (UQAR, UQAM, Laval University) and Europe as well as Hydro-Québec and OURANOS as partners. This project’s goal was to develop and use climate-sensitive indicators to reconstruct the long-term natural variability of hydro-climatic parameters determining water supply in basins of interest for hydroelectric production in northeastern North America. These indicators are natural archives derived from dendrochronology, dendroisotopy and lake sedimentology. At the end of the project, managers of hydroelectric resources as well as authorities concerned with climate change benefit from a better knowledge of the spatio-temporal evolution of hydro-climatic conditions. This knowledge will facilitate the development of future hydrological scenarios appropriate for this region, which is sensitive in many ways to climate change.

The most important findings of this colossal work carried out by the ARCHIVES team of researchers has just been published by the GSC in the form of an open access synthesis report (Bégin, C. et al., 2021). The 21 chapters of this impressive 211-page document will certainly constitute a reference in the field of paleoclimatology. In addition, Christian Bégin, Martine Savard and Joëlle Marion received the Logan Award from the GSC Director for their work in dendrogeochemistry over the past 25 years.
Understand the impact of human activities on the environment

Understand the environmental impact of diluted bitumen

Context
Alberta oil sands are one of the largest bitumen reserves in the world. Unlike conventional crude oil, bitumen is a highly degraded viscous oil. To transport it by pipeline, it must be mixed with lighter hydrocarbon fractions, resulting in a less viscous diluted bitumen (called 'dilbit'). Although pipelines are considered safer than other means of transportation, major spills have occurred. As a result, approvals for new pipelines have raised public concern about the environmental impacts of potential dilbit spills.

Objectives
Although a growing number of studies address the behaviour and toxicity of dilbit in fresh and salt water environments, few detail the fate and transport of dilbit in the vadose zone and groundwater. To address this knowledge gap, GSC (Jason Ahad) and INRS (Valérie Langlois, Richard Martel) teams are collaborating to better understand the degradation and toxicity of dilbit in shallow groundwater systems. The results of this research will be used to better inform the public as to whether spilled dilbit poses a greater, equal or lesser threat to aquifers than conventional crude oil spills.

Method
To this end, Ph.D. candidate Scott Hepditch is conducting separate controlled spill experiments with dilbit and a comparative sample of a conventional crude oil blend with similar physical and chemical properties. These spills were conducted in large unsaturated soil columns. Column leachate and soil core samples have been collected to determine a range of toxicological, geochemical, and microbial parameters. The next steps will involve working with saturated soil tanks.
Adapt to natural hazards

Approaches to sustainable management of the Baie-Saint-Paul’s coastline

**Context**
The Baie-Saint-Paul’s area is located in a steep transition zone between the mountain and the sea. The area is known to be subject to several natural hazards such as landslides, high tides and ice jams.

**Objectives**
As part of the INÉDINE project, teams from INRS (Damien Pham Van Bang, Marc Richer-Laflèche and Jacob Stolle) and the GSC (Didier Perret) are analyzing the geological and hydrological risks to which Baie-Saint-Paul and the Upper St. Lawrence Estuary are exposed. The main objective is to develop sustainable approaches to coastal management to help counteract erosion caused by climate change and to address the vulnerability of this coastal area and its community.

**Method**
Field work was conducted during the summers of 2020 and 2021 to collect sediment samples, measure current velocity and wave amplitude, and document the beach profile. This data will be used for numerical and physical modelling in the wave flume Environmental Hydraulics Laboratory. This 120 m long flume enables the simulation of waves, tides and high flow currents. A replica of the Baie-Saint-Paul beach profile has been reconstructed to study how and at what speed the beach erodes. The next steps will be to see if vegetation is able to slow the erosion. In September 2021, high-resolution seismic reflection surveys will be conducted in Baie-Saint-Paul to estimate the temporal recurrence of massive sedimentary inputs associated with large earthquake-induced movements in the Gouffre Valley. These surveys should also help to clarify the activity of the St. Lawrence Fault during the Holocene.
## RESEARCH FACILITIES

### A diversified range of first-class geoscience laboratories

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Contact(s)</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta-Lab</td>
<td>Jason Ahad</td>
<td>Analysis of stable isotopes (H, C, N and O) applied to hydrogeological, environmental and mineral studies.</td>
</tr>
<tr>
<td>Dendrochronology and Dendrogeochemistry</td>
<td>Christian Bégin</td>
<td>Analysis of the physical and geochemical parameters of tree ring sequences.</td>
</tr>
<tr>
<td>Geochemistry, Imagery and Radiography of Sediments (GIRAS)</td>
<td>Pierre Francus</td>
<td>Non-destructive radiography analyses coupled with micro-x-ray fluorescence chemical analysis of rocks, soil and sediment.</td>
</tr>
<tr>
<td>Contaminant Hydrogeology</td>
<td>Richard Martel</td>
<td>Study of soil and groundwater contaminants and development of <em>in situ</em> treatment processes at the intermediary level between the laboratory and the field.</td>
</tr>
<tr>
<td>Hydrogeology and Environmental Characterization</td>
<td>Daniel Paradis</td>
<td>Field equipment for groundwater characterization and numerical modelling equipment.</td>
</tr>
<tr>
<td>INRS-GSC joint laboratory</td>
<td>Stéfane Prémont and Kathleen Lauzière</td>
<td>Geochemical characterization of rocks, sediments, soil horizons and tree rings.</td>
</tr>
<tr>
<td>Digital Cartography and Photogrammetry (LCNP)</td>
<td>Kathleen Lauzière</td>
<td>Acquisition, management, analysis and dissemination of geoscientific data.</td>
</tr>
<tr>
<td>Applied Geoscience (LGA)</td>
<td>Marc Richer-Lafièche</td>
<td>Geophysical studies applied to mineral, gas and oil exploration, geotechnics and archaeology.</td>
</tr>
<tr>
<td>Environmental Hydraulics (LHE)</td>
<td>Damien Pham Van Bang</td>
<td>Large-scale flume simulations of waves, tides and strong river currents for the development of sustainable approaches to coastal management.</td>
</tr>
<tr>
<td>Geophysical Imaging and Erwan Gloaguenn Measurements (LIAMG)</td>
<td>Erwan Gloaguen</td>
<td>Applied work mainly for the characterization of reservoirs for CO₂ sequestration, hydrogeology and oil.</td>
</tr>
<tr>
<td>Geothermal Energy (LOG)</td>
<td>Jasmin Raymond</td>
<td>Open laboratory for measuring the thermal and hydraulic properties of geological materials.</td>
</tr>
<tr>
<td>Physical, Numerical and Geophysical Simulation</td>
<td>Lyal Harris</td>
<td>Numerical analyses combining CT-assisted analog simulation methods with geophysical, remote sensing and field data interpretations.</td>
</tr>
<tr>
<td>Multidisciplinary CT-Scan</td>
<td>Pierre Francus and Damien Pham Van Bang</td>
<td>Non-destructive dynamic 4D measurements of internal density variations on static bodies (internal structure, porosity, etc.) or of dynamic phenomena, mainly in hydrology.</td>
</tr>
</tbody>
</table>

For more information: cgq-qgc.ca/en/facilities
COMMUNICATION AND ANIMATION

Joint participation in geoscience conferences (virtual)

October 19-23: XPLOR 2020
November 16-18: Québec Mines + Énergie 2020

Joint participation in internal and external activities (virtual)

November 5-6: INRS Student conference Eau Terre Environnement
January 27: Career Day in Science and Engineering at Laval University
February 6: INRS Open House
March 8: International Women’s Day: presentation of the film Picture a scientist
April 22: Earth Day: presentation of the film River’s End

MANAGEMENT, KNOWLEDGE DISSEMINATION AND PUBLICATIONS

INRS Eau Terre Environnement Research Centre
INRS Specialized Documentation and Information Service (SDIS - link)
Reports and theses (link)
Scientific articles (professor profiles - link)

Geological Survey of Canada
Federal Science Libraries Network (link)
Geoscan database (link)
Natural Resources Canada publications and reports (link)
Directory of scientists and professionals (link)

STUDENT PORTAL

Inter-university programs in Earth Sciences
Master and PhD programs at the ETE Centre (link)
Master and PhD projects available at INRS (link)

University internships
INRS Undergraduate Summer Research Internships (link)
INRS Research internships (link)
Federal Student Work Experience Program (link)
Federal Research Affiliate Program (link)

Postdoctoral internships
INRS Postdoctoral Fellowships (link)
Federal Postdoctoral Research Program (link)

INRS-GSC Graduates 2020-2021 codirection
Master
Ronan Abhervé (René Lefebvre, Daniel Paradis)
PhD
Guillaume Légaré-Couture (Michel Parent, René Lefebvre)
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