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Geological Survey of Canada
Scientific Presentation 104

Public presentations of May 21st, 2019: Environmental Geoscience Program, current status of research projects (phase 2014-2019)

N. Jacob, M. Parsons, C. Rivard, M.M. Savard, S. Larmagnat,
P.M. Outridge, D. White, H. Kao, and G. Lintern

2019

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Public presentations of May 21st, 2019: Environmental Geoscience Program, current status of research projects (phase 2014-2019)

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Publications in this series have not been edited; they are released as submitted by the author.

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Environmental Geoscience Program (EGP)
Public Presentations from coast to coast

To increase the program visibility and to promote outreach, a public science presentation has been offered to NRCan and key partners via Tandberg and NRCan live web over the last four years. All videos can be access here: http://nrtube.nrcan.gc.ca/group/egp (previous years) and this year here (https://gcdocs.gc.ca/nrcan-rncan/llisapi.dll/link/41982658)

All the Power Point presentations (8) presented on May 21st, 2019 for the 2014-2019 phase are included in this report.

Key words: Critical metal deposits, geoscience tools, shale gas and groundwater, oil sands, fluid in carbonates, mercury, geological storage of carbon, induced seismicity, dredge disposal

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Environmental Geoscience Program (EGP) – Phase 2014-2019
Public presentations of May 21st, 2019

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Geoenvironmental characteristics of gold and critical metal deposits

Caractéristiques géo-environnementales de l'activité aurifère et des dépôts de métaux critiques

Michael Parsons (GSC-Atlantic, Dartmouth, NS)

21 mai 2019 – May 21, 2019

Canada

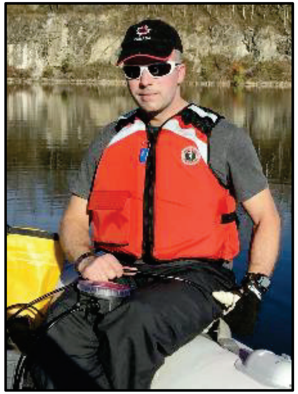
Metal Mining Project : Abstract

The **Critical Metals** Activity used detailed geochemical, mineralogical, and limnological methods to characterize processes controlling the mobility of trace elements and radionuclides in mine wastes and waters at the abandoned St. Lawrence Columbium (SLC) Mine in Oka, Quebec. This mine operated from 1961 to 1976 and at the time was one of the largest niobium (Nb) producers in the world. Geologically, the SLC Mine is very similar to several other carbonatite-hosted mineral deposits across Canada that are being considered for mining of elements used in green energy and high-tech applications, including Nb and rare earth elements (REE). These studies have generated new geoscience knowledge on the potential environmental impacts of mining critical metals and have been used by the Québec Ministère de l'Energie et des Ressources Naturelles (MERN) to help guide remediation decisions for the SLC Mine site. The results will also help industry and regulators to improve environmental predictions for future Nb- and REE-mining projects and to support the development of new environmental guidelines.

The **Northern Baselines** (Geoscience Tools for Environmental Assessment of Metal Mining) Activity used a multidisciplinary geochemical, paleolimnological, micropaleontological, and traditional knowledge approach to produce new geoscience knowledge on baseline geochemistry and cumulative impacts of geogenic and anthropogenic processes, particularly climate variability, on the transport and fate of metal(loid)s in mineralized regions of northern Canada. New geoscience knowledge on the role of climate variability on speciation of arsenic in porewater and sediments, and the seasonal cycling of metalloids between surface waters and sediments has implications for Environmental Assessment, remediation of contaminated sites, including Crown lands, and new development. The activity also generated new knowledge on the impacts of 21st century climate change on long-term carbon dynamics in permafrost wetlands, important for understanding feedback mechanisms and global carbon cycling.

Critical Metals Project Team

Michael Parsons (GSC-A)
Surface waters, mine wastes



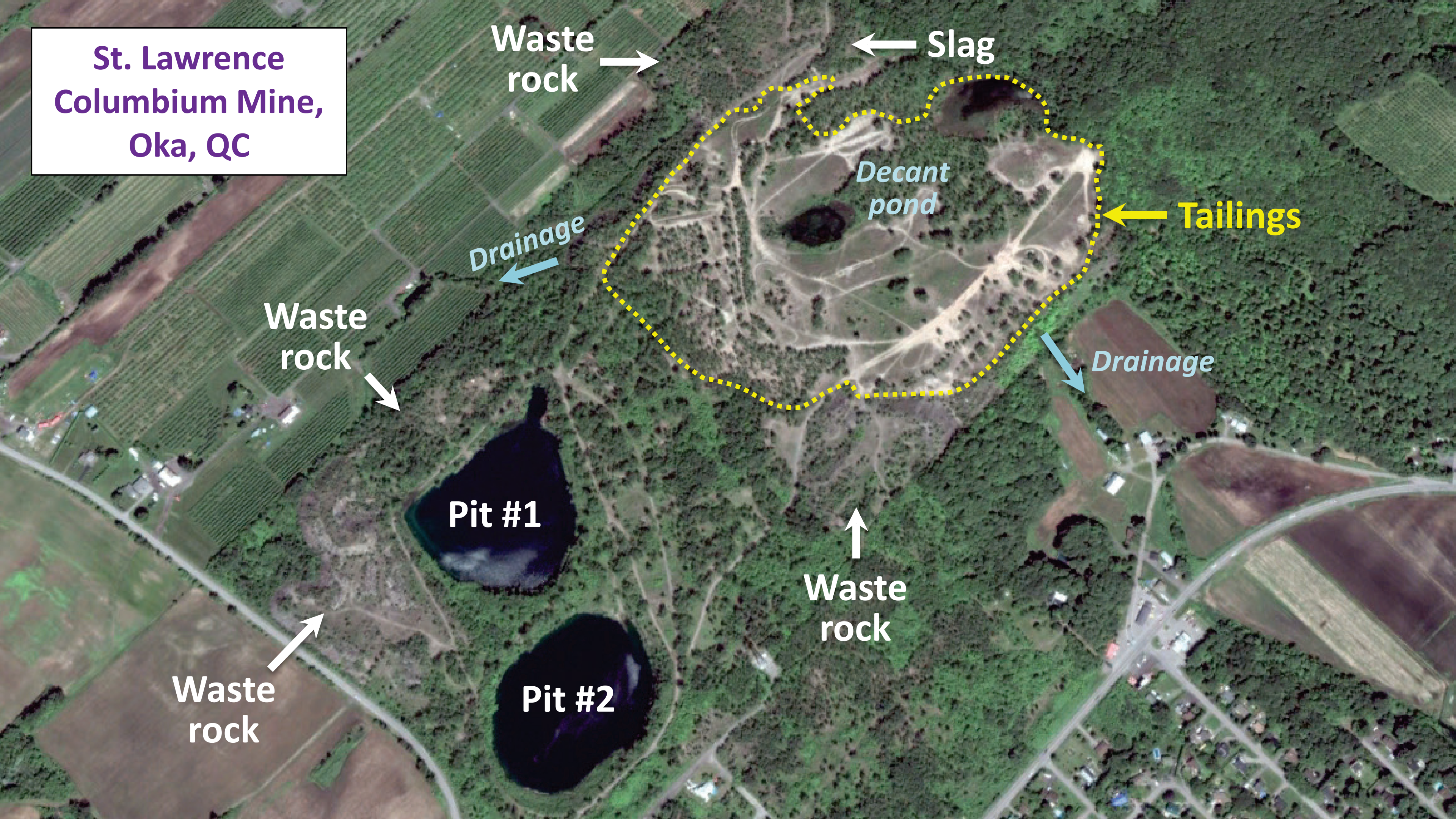
Alexandre Desbarats (GSC-NC)
Groundwaters, mine wastes

Jeanne Percival (GSC-CC)
Mineralogy

Katherine Venance (GSC-CC)
Mineralogy

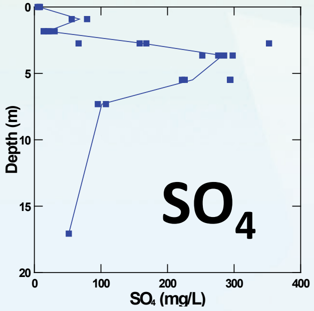
Heather Jamieson & Sean Des Roches (Queen's Univ.)
Geochemistry and mineralogy of mine wastes

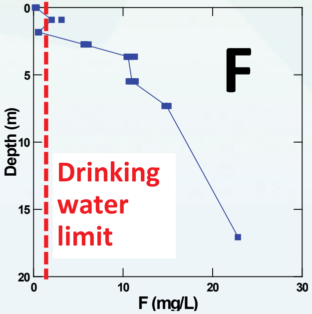
Tom Al & Hannah Balkwill Tweedie (Univ. of Ottawa)
Geochemistry and mineralogy of smelter slag


St. Lawrence Columbium Mine, Oka, QC
Waste rock
Slag
Decant pond
Tailings
Drainage
Waste rock
Drainage
Pit #1
Waste rock
Waste rock
Pit #2

Critical Metals S&T Success Story:
Geochemistry of tailings seepage

Goal: Characterize groundwater-tailings reactions that control the mobility of trace elements (F, Nb, REE, U, Th, Ra-226) in seepage from infiltrating precipitation to discharge points





Key results and achievements:

- Installed 6 drive-point piezometers at depths from 3 to 24 feet in tailings, near the decant pond – sampled seasonally from 2016-2018
- Drilled and sampled monitoring well through entire thickness (~25 m) of the central tailings impoundment
- In the tailings drainage, average fluoride (F) concentrations are ~9 mg/L, which is 75 times the guideline value for the protection of aquatic fauna. In contrast, uranium (U) concentrations in interstitial and drainage waters are low (<4 µg/L).
- MERN requested GSC data on tailings pore-water chemistry to help them plan remediation of the SLC mine site

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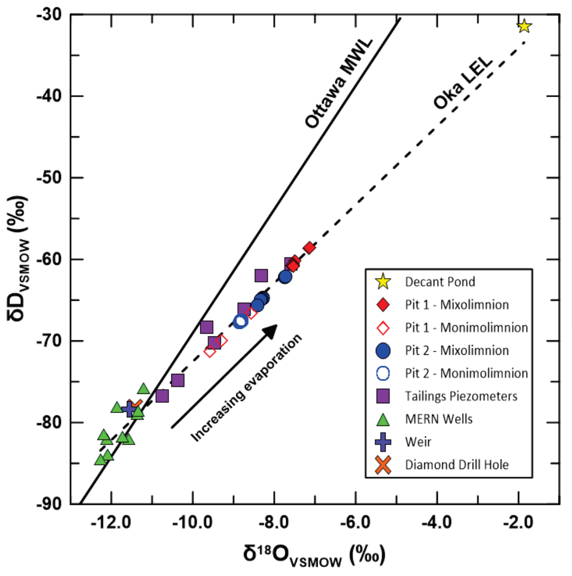
Critical Metals S&T Success Story: Limnology and geochemistry of mine pit lakes

Goal: investigate the key controls on metal (e.g. U, Th, REEs) and radionuclide (e.g. 226-Ra, 210-Pb) concentrations in the pit lake water



Stable isotopes of water in SLC pit lakes, surface water, and groundwater

Key results and achievements:

- Water sampling and water column profiling was conducted in two flooded open pits at the SLC Mine in July 2016, October 2016, February 2017, May 2017, October 2017, and September 2018 to document seasonal variations in the chemistry of the pit lake waters.
- Results show that metals and radionuclides in the local bedrock and mine waste are relatively immobile in well-oxygenated surface water but may be transported in deeper, low-oxygen groundwater.
- On April 16, 2018, results from this research were provided upon request to the MERN to help guide mine site remediation decisions.
- Successfully measured Nb, Th, and REEs down to low part-per-trillion levels using GSC's new Element XR High-Resolution ICP-MS

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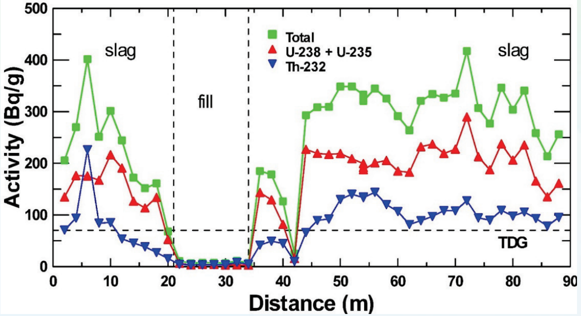
Critical Metals S&T Success Story:
Geochemistry and mineralogy of waste rock, tailings, and slag

Goal: Characterize mineralogy and weathering reactions that lead to mobilization of Th, U and REEs from waste rock, tailings and slag materials



Radiometric survey of slag disposal area

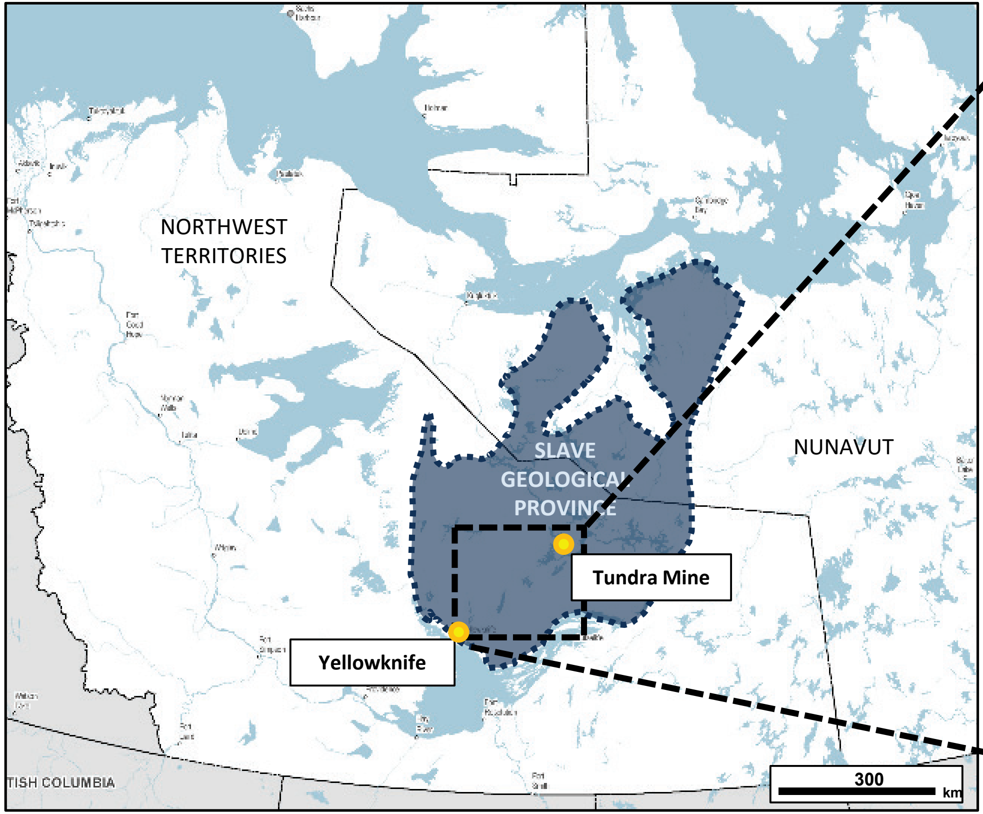
Key results and achievements:

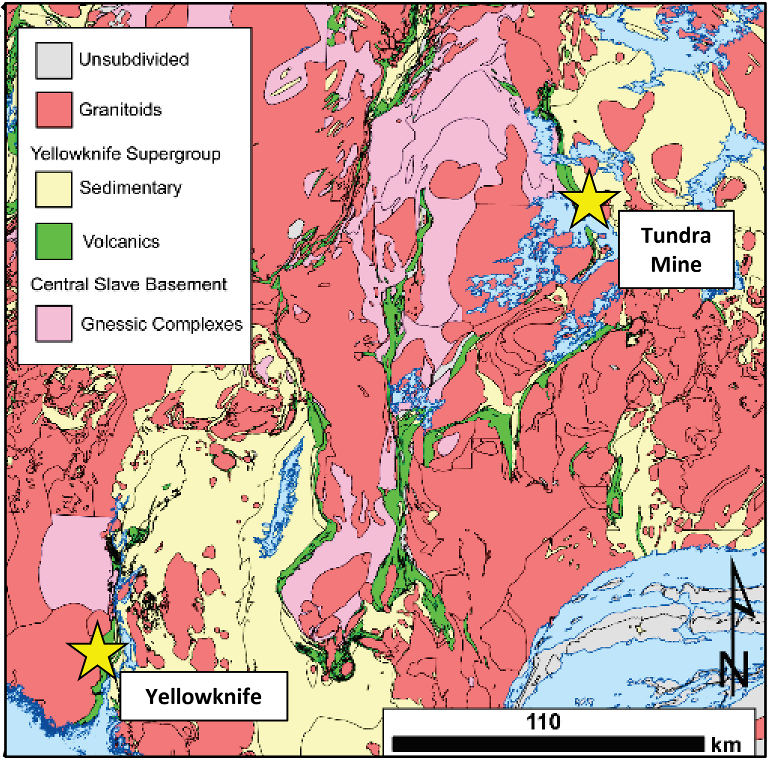
- **Tailings** are dominated by calcite with variable amounts of mica, quartz, plagioclase and K-feldspar, pyroxene, amphibole, zeolite (analcime), apatite (fluorapatite), oxides, minor niocalite and trace perovskite.
- **Slag** is dominated by hibonite, perovskite, Ca-zirconate, F-Na-bearing Ca-aluminate glass ± vesuvianite, grossite, gibbsite, cristobalite, moganite, jarosite, siderite, uraninite, augelite, thorite, bredigite.
- Ferroniobium slag at the SLC Mine contains concentrations of U, Th and radionuclides that exceed Canadian guidelines for the disposal of radioactive waste. Tailings have relatively low levels of U and Th.
- Leaching of elements from waste rock and slag being studied in detail by M.Sc. students Sean Des Roches (Queen's) and Hannah Balkwill-Tweedie (Univ. of Ottawa), respectively (both finishing in 2019).

Northern Baselines Project Team

- Jen Galloway (GSC-C)
- Mike Parsons (GSC-A)
- Omid Ardakani (GSC-C)
- Thomas Hadlari (GSC-C)
- Peter Morse (GSC-NC)
- Steve Wolfe (GSC-NC)
- Tim Patterson (Carleton)
- Heather Jamieson (Queen's)
- Mike Palmer (CIMP/Carleton)
- Hendrik Falck (NTGS)
- Graeme Swindles (Leeds)
- Chris Spence (ECCC)
- Bill Shotyk (U Alberta)
- Anthony Chappez (Central Michigan Univ.)
- Yellowknives Dene FN
- North Slave Métis Alliance
- Tłı̨chǫ Government

Northern Baselines Activity: Study Sites





Geology of the Southern Slave Geological Province

Maps from Clare Miller (Queen's Univ.)

Northern Baselines S&T Success Story: Traditional Knowledge and Inuit Qaujimajatuqangit

Past Knowledge of Climate and Environment held by the Métis of Great Slave Lake

"Everything Seems to Have Changed"

A TK Study on Tłı̨chǫ and Climate Change
for Natural Resources Canada's Project:
Geoscience Tools for Supporting Environmental Risk Assessment of Metal Mining

We have to live with it: Cultural Knowledge of Contamination and Environmental Change

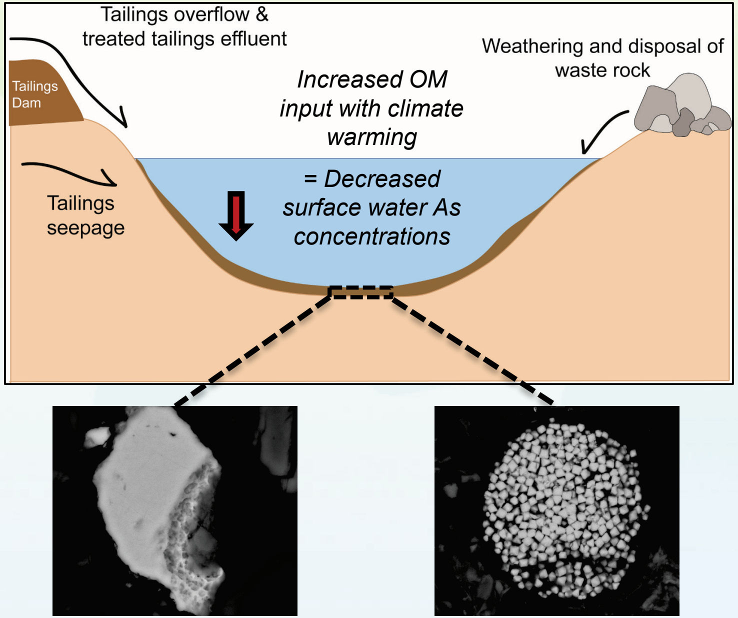
March 31, 2017

- Funded 3 TK and 1 IQ studies
- Organized on-the-land IQ camp in August 2017
- Key observations:
  - Seasonality ~2 weeks delayed freeze-up
  - Early winter season rain, delayed ground freeze up has impact on spring freshet volumes
  - Longer duration of ice freeze-up with implications for fish habitat and ice quality
  - Impact of climate change and past land-use on culture
  - HQP: How to formulate research questions WITH communities (partnership)
  - Listening & Different ways of knowing
- Published paper in Polar Knowledge Canada's *Aqhaliat Report* providing guidance for working with Traditional Knowledge (TK) during environmental studies of metal mining in Northern Canada:
  - **Galloway, J.M.** and Patterson, R.T. (2018) Introduction to traditional knowledge studies in support of geoscience tools for assessment of metal mining in northern Canada. *Polar Knowledge: Aqhaliat 2018*, Polar Knowledge Canada.

Northern Baselines S&T Success Story: Controls on Arsenic Mobility in a Changing Climate

- The influence of regional climate change on long-term arsenic (As) stability in northern lakes is poorly understood. This creates uncertainty for environmental assessments for mining projects, environmental monitoring, and establishing realistic targets for contaminated site remediation.
- We collected sediments and surface waters around legacy mine sites near Yellowknife, and at the abandoned Tundra Mine, NWT to study the controls on As mobility and to determine how modern day climate warming influences As.
- Results show that the effect of climate warming on the mobility of As in lakes largely depends on the source of As to the lake systems, the mineral form of As in the sediment, and the composition of organic matter.
- Focus of Ph.D. student Clare Miller (Queen's Univ.) – co-supervised by Heather Jamieson and Michael Parsons.

Lakes close to Tundra Mine (mainly sulphide-hosted As)



Arsenopyrite *As-bearing framboidal pyrite*

Northern Baselines S&T Success Story: Wetlands

Improved understanding of the complex ways in which climate change is affecting ecosystems. Effects of climate warming vary depending on wetland type, and this has implications for carbon storage and release. Climate change has altered ecology across the Arctic wetlands, but whether that will result in a transition to productive peatlands will be strongly influenced by the complex dynamics that govern the wetlands. Permafrost wetlands in mineralized regions are reservoirs for organic matter as well as elements of potential concern, including arsenic.

Dr. Peter Morse (GSC-O) collects a permafrost peat core from the TerraX property near Yellowknife for detailed plant macrofossil, palynological, and geochemical study

Findings recently published in new study by University of Leeds Ph.D. student (co-supervised by Jen Galloway; NERC-funded project focused on Canadian wetlands) in *Geophysical Research Letters*:

Sim, T.G. Swindles, G.T., Morris, P.J., Gałka, M., Mullan, D., **Galloway, J.M.** (2019) Pathways for Ecological Change in Canadian High Arctic Wetlands Under Rapid Twentieth Century Warming. *Geophysical Research Letters*, https://doi.org/10.1029/2019GL082611.

Northern Baselines Activity Summary

- New conceptual models of the role of climate change and organic matter in biogeochemical cycling and speciation of As
- Collaboration with Indigenous organizations resulted in four TK/IQ studies. Two are published in peer reviewed journals
- Stakeholder workshops held in Yellowknife prior to Geoscience Forum with participation from OGDs (ECCC, CIRNAC, GNWT), Indigenous organizations, universities (incl. HQP), industry, and other researchers (2015, 2016, 2018)
- 4 PhD and 2 MSc candidates, northern-based training
- External grants ($1 million cash Polar Knowledge Canada, CIMP, NSERC, NERC + $2.5 million in-kind support from OGDs, industry, Indigenous organizations)
- Over 30 publications in peer-reviewed journals, including *Science of the Total Environment, PLoS One, Quaternary International, Global Change Biology, Journal of Global and Planetary Change, Journal of Ecology, Nature Scientific Reports, Nature Geoscience, Geophysical Research Letters*
- Field programs in subarctic and Arctic Canada, including on-the-land Inuit Quajimajatuqanit camp
- Multidisciplinary team that included Indigenous organizations, OGDs (CIRNAC, ECC), GNWT, industry (TerraX, Seabridge Gold), and national and international universities
- Successes include GNWT Public Health advisory for As in surface waters of the Yellowknife region

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Assessing groundwater vulnerability to shale gas activities in the Sussex area, southern New Brunswick

Évaluation de la vulnérabilité des aquifères à l’exploitation du gaz de shale dans la région de Sussex, dans le sud du Nouveau-Brunswick

Christine Rivard

May 21st, 2019

Canada

ABSTRACT

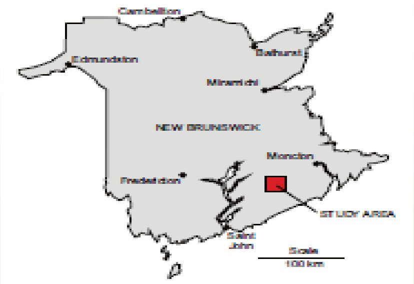
A project studying potential hydrocarbon migration through natural pathways or fracking-induced fractures from deep (~2 km) Carboniferous shale or tight sand units to shallow aquifers was initiated in 2015 in the Sussex area, southern New Brunswick. The study area includes the McCully gas field that has been in production since 2001 and the Elgin field that is investigated for its condensate potential. Because the intermediate zone (IZ) located between shallow aquifers and units targeted for hydrocarbon production is poorly characterized, this project relies on the integration of data from different earth science disciplines, including geology, geophysics, geomechanics, hydrogeology and water and rock geochemistry. Fieldwork in 2018-2019 included the drilling of two observation wells, borehole geophysics, and groundwater monitoring.

Data collected during this 4-year project and their interpretation provided no evidence for the presence of large-scale connections between gas reservoirs and shallow aquifers in this study area. On the contrary, the IZ seems to provide an efficient barrier protecting the shallow aquifer from the potential upward migration of fluids originating from deep hydrocarbon reservoirs. This conclusion integrates the interpretations derived from the geomechanical study, from the geophysical and geological analyses of the structural context and from the geochemical baseline study. Although large-scale upward fluid migration is considered very unlikely, evidence of some upward migration over a few hundred meters was found based on old, evolved groundwater observed in two of the shallow (50 m) observation wells. This water indicated a contribution from evaporites from a relatively shallow salt structure (~250-300 m), whose chemical components are assumed to have been transferred to the active groundwater flow zone by diffusion. Also, regular monitoring of several shallow wells helped ascertain the source of methane in groundwater when individual samples provided ambiguous results.

PROJECT MEMBERS

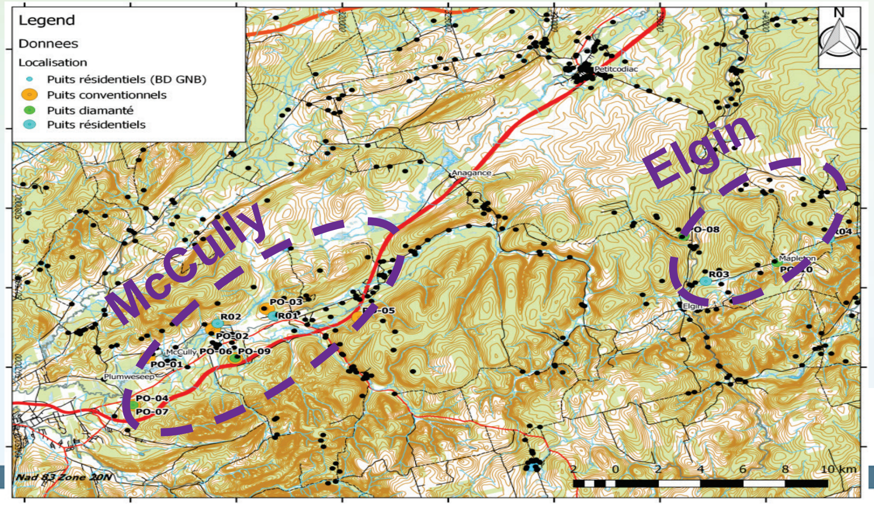
Christine Rivard, research scientist in hydrogeology
Denis Lavoie, research scientist in geology
Geneviève Bordeleau, research scientist in geochemistry
Xavier Malet, technician and database manager
Mathieu Duchesne, research scientist in seismic reflection
Gilles Bellefleur, research scientist in seismic reflection (GSC-Ottawa)
Nicolas Pinet, research scientist in structural geology – seismic reflection
Virginia Brake, geophysicist
Heather Crow, borehole geophysicist (GSC-Ottawa)
Dennis Jiang, research scientist in rock geochemistry (GSC-Calgary)
René Lefebvre, professor in hydrogeology at INRS
Stephan Séjourné, structural geologist and geomechanics (Consultant)
Tom Al, professor in hydrogeochemistry at U of Ottawa
Pierre Ladevèze, research scientist in geology ; Vincent Tremblay, technician
François Huchet (INRS) and David Barton (U Ottawa), M.Sc. students
Darryl Pupek and Mallory Gillis, hydrogeologists (NBDELG) ; Steve Hinds, geologist (NBDEM)
Tom Martel and John Comeau (Corridor Resources)

Introduction



The study area comprises two sub-regions

- McCully gas field: in production since 2001
- Elgin area (prospect): condensates (ethane, propane and butane)
- Duration: 2015-2019



Objective : To investigate potential natural migration pathways, which could be enhanced by hydraulic fracturing, to assess aquifer vulnerability.

≈ 40 gas wells

Introduction

Potential links between deep geological units targeted by the industry and surficial aquifers are not well documented.

A natural connection is presumed possible only if permeable discontinuities are present (e.g., fault zones) providing a preferential migration pathway.

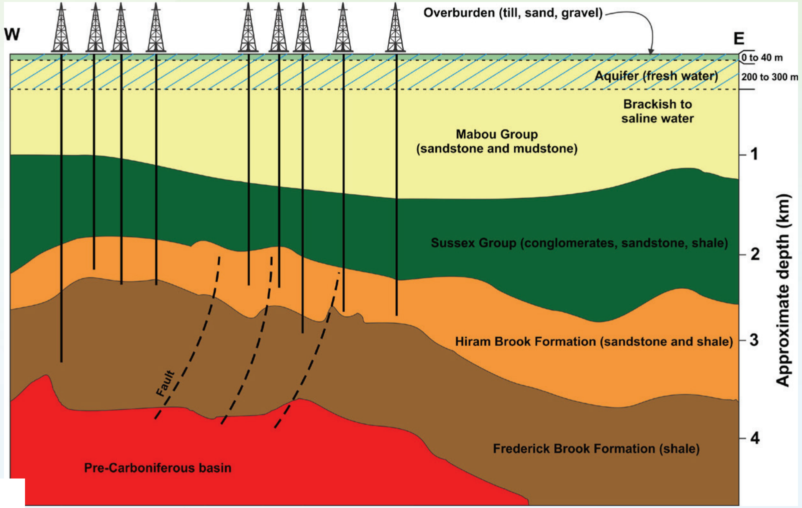
Surficial aquifers

Few data available ← Intermediate zone

Zone targeted by the industry

Use of indirect data

geophysical, geomechanical, hydrogeological and geochemical



Fieldwork for 2018-2019

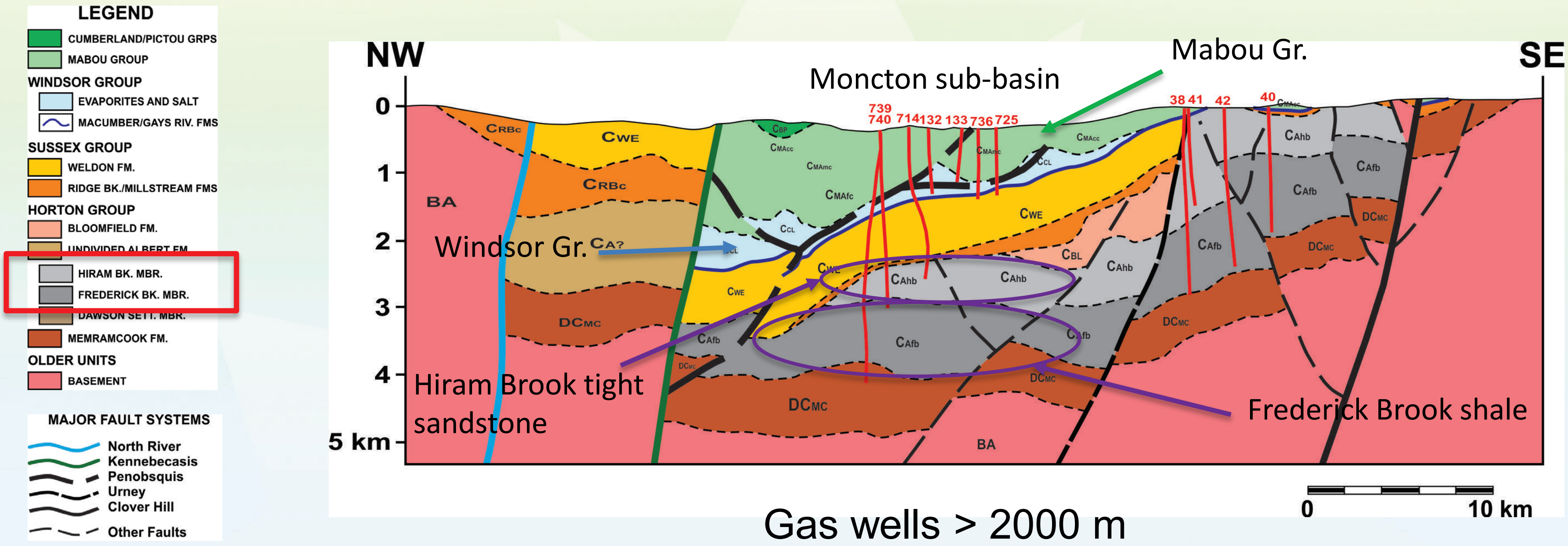
- Completion of 2 additional diamond-drilled wells to compare results of borehole geophysical logging with those from hammer-drilled wells.

- GW monitoring every 4 months of 5 observation wells and 4 residential wells

- Decommissioning of all the observation wells

Geological context

The study area is located in the Maritimes Carboniferous Basin



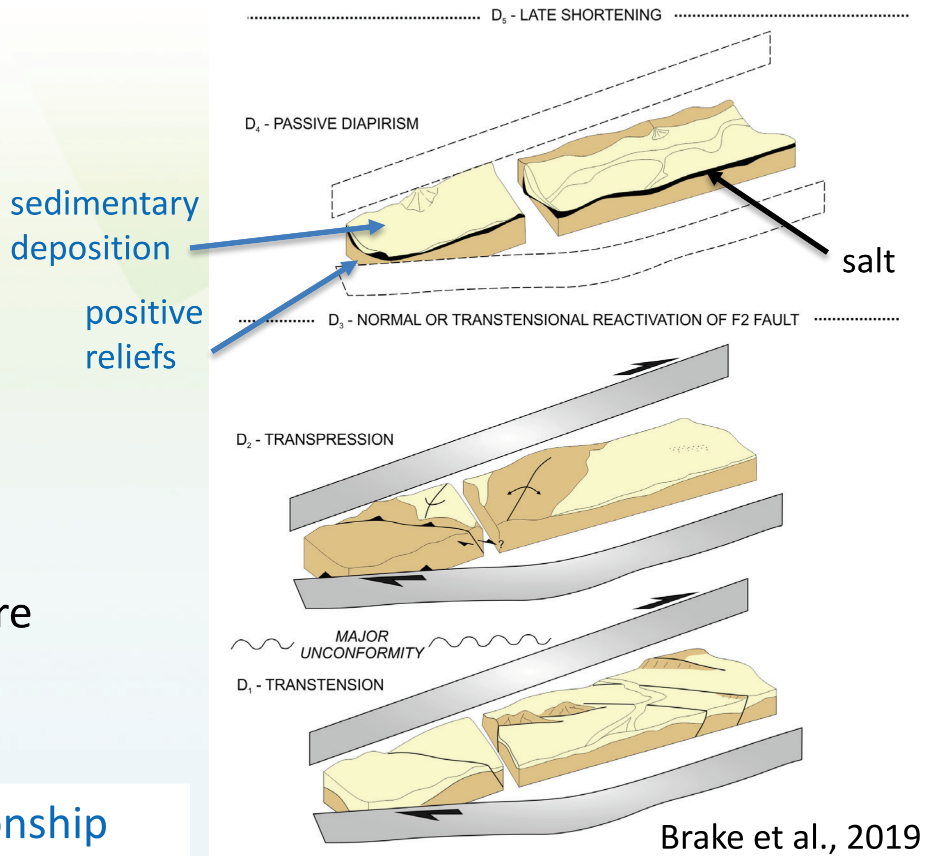
Hinds and Parks, 2017

Geological interpretation

The two first stages of basin evolution took place in a strike-slip setting

- net extension along fault nearly perpendicular to the basin axis during the first stage
- net shortening during the second stage.

Late stage: influence of the main faults is more subtle and deformation is mainly associated with salt motion.

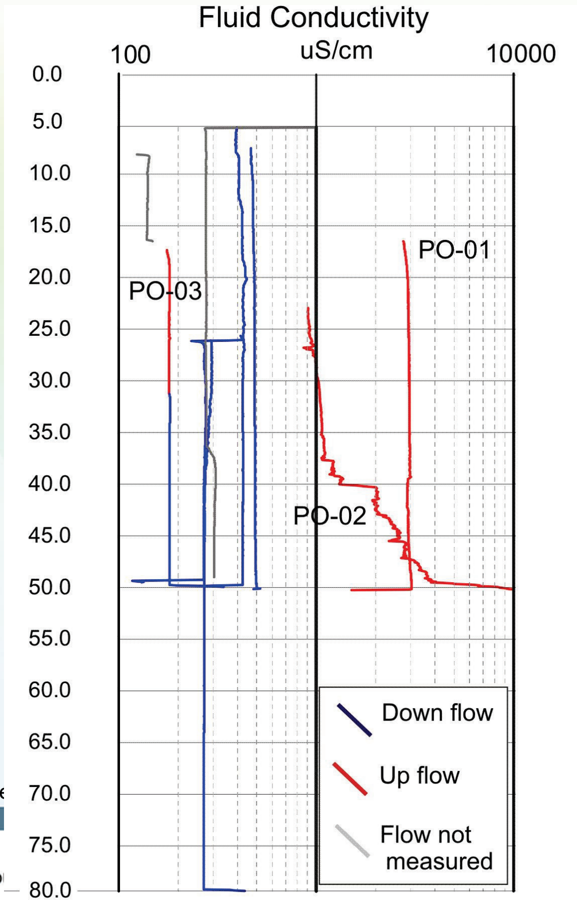


Brake et al., 2019

This new model enhances the close relationship between tectonics and sedimentation.

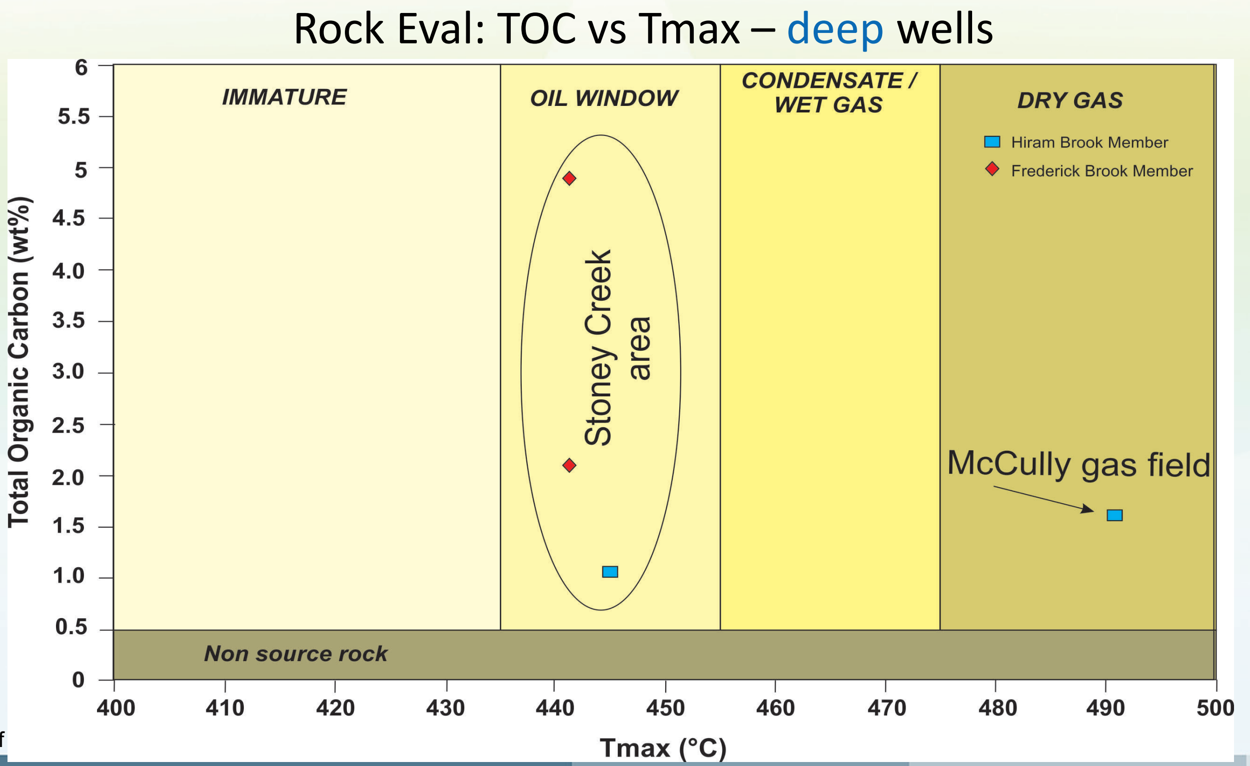
Borehole geophysical logging

Groundwater conductivity logs



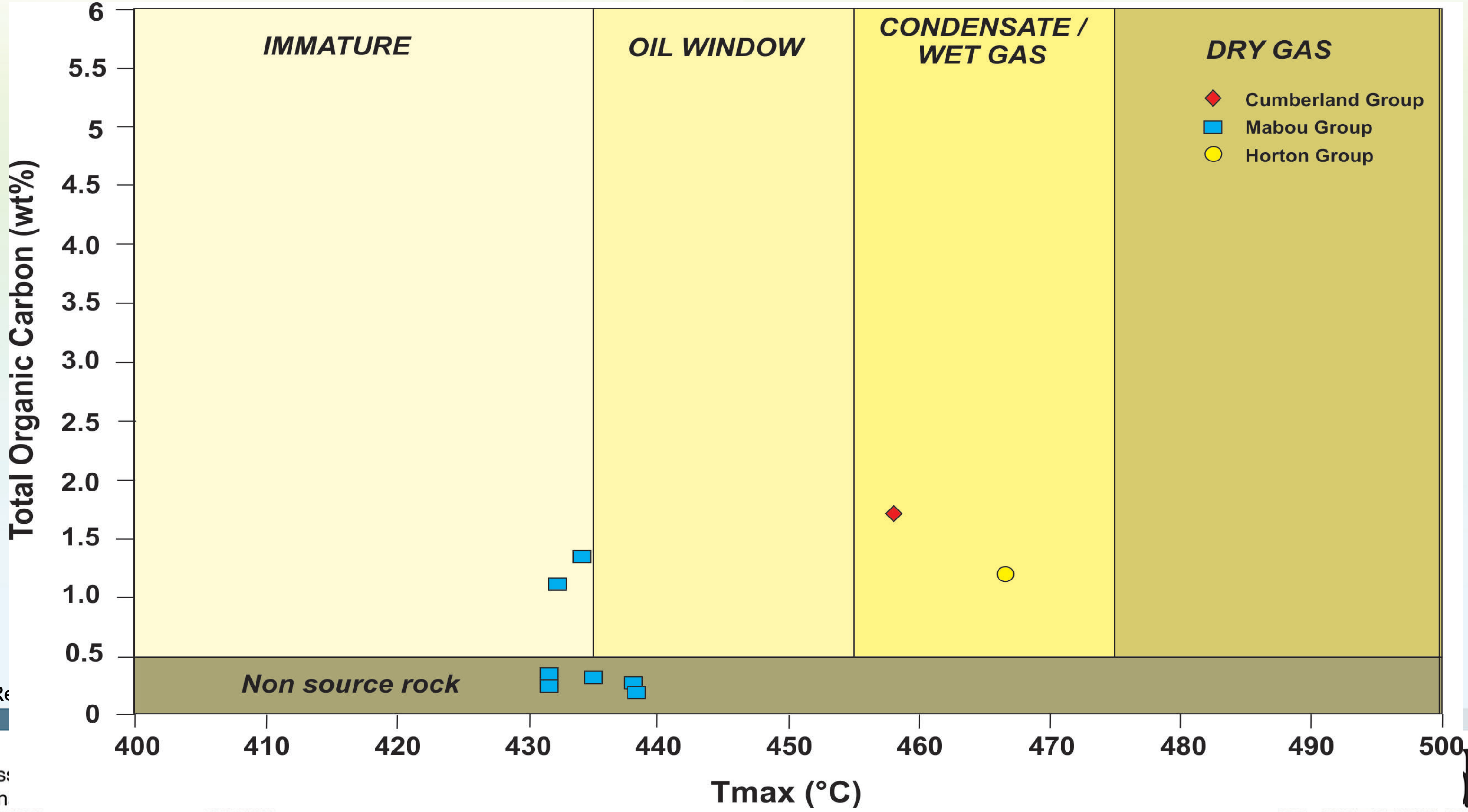
- Site-wide differences in fluid properties highlighted varying groundwater dynamics (recharge, discharge)
- Guided sampling depths
- Supported resulting analyses of groundwater geochemistry data

Rock organic geochemistry



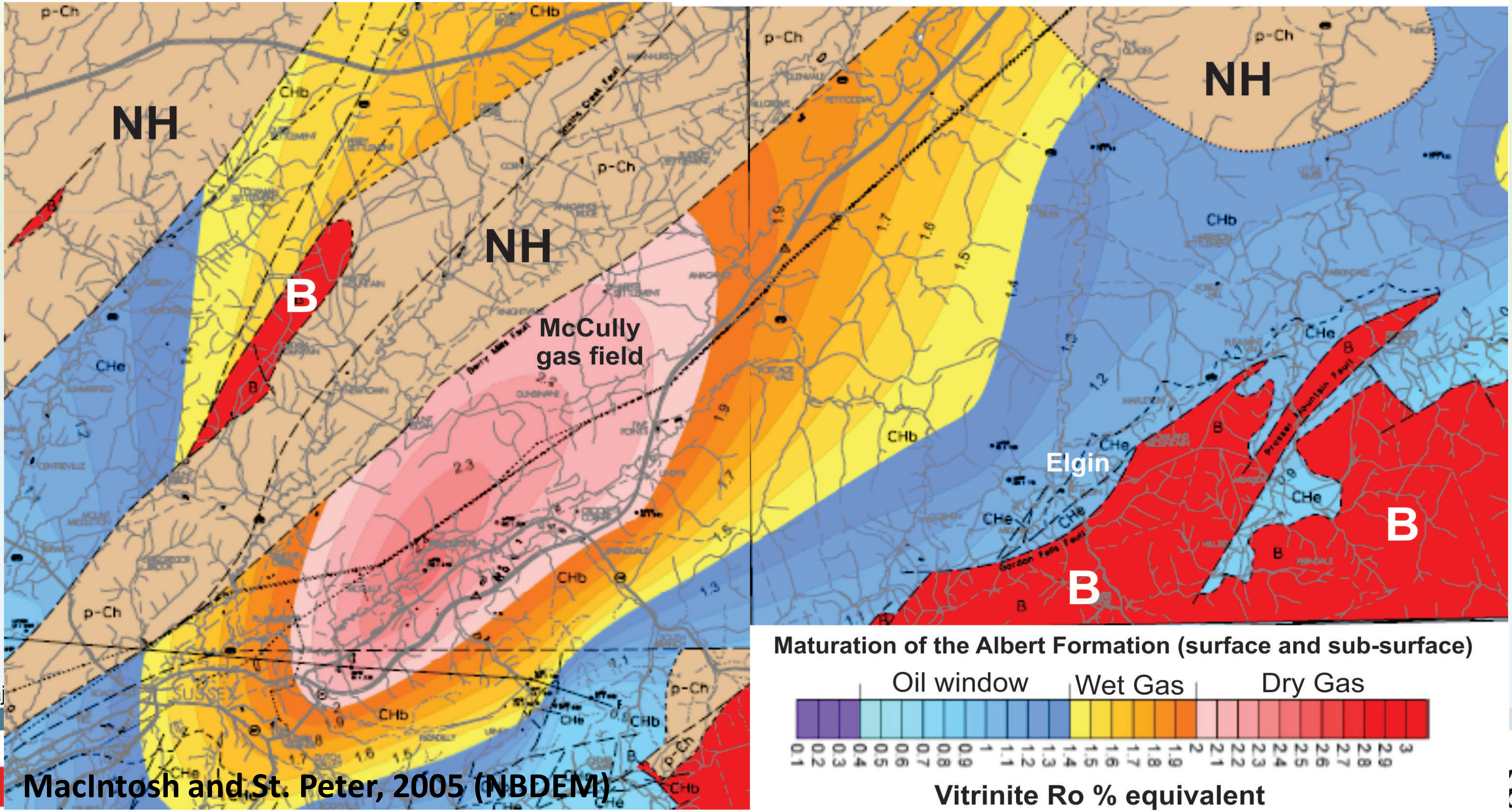
Rock organic geochemistry

Rock Eval: TOC vs Tmax - shallow observation wells



Rock organic geochemistry

Thermal maturation map from OM reflectance



GW geochemistry

Legend

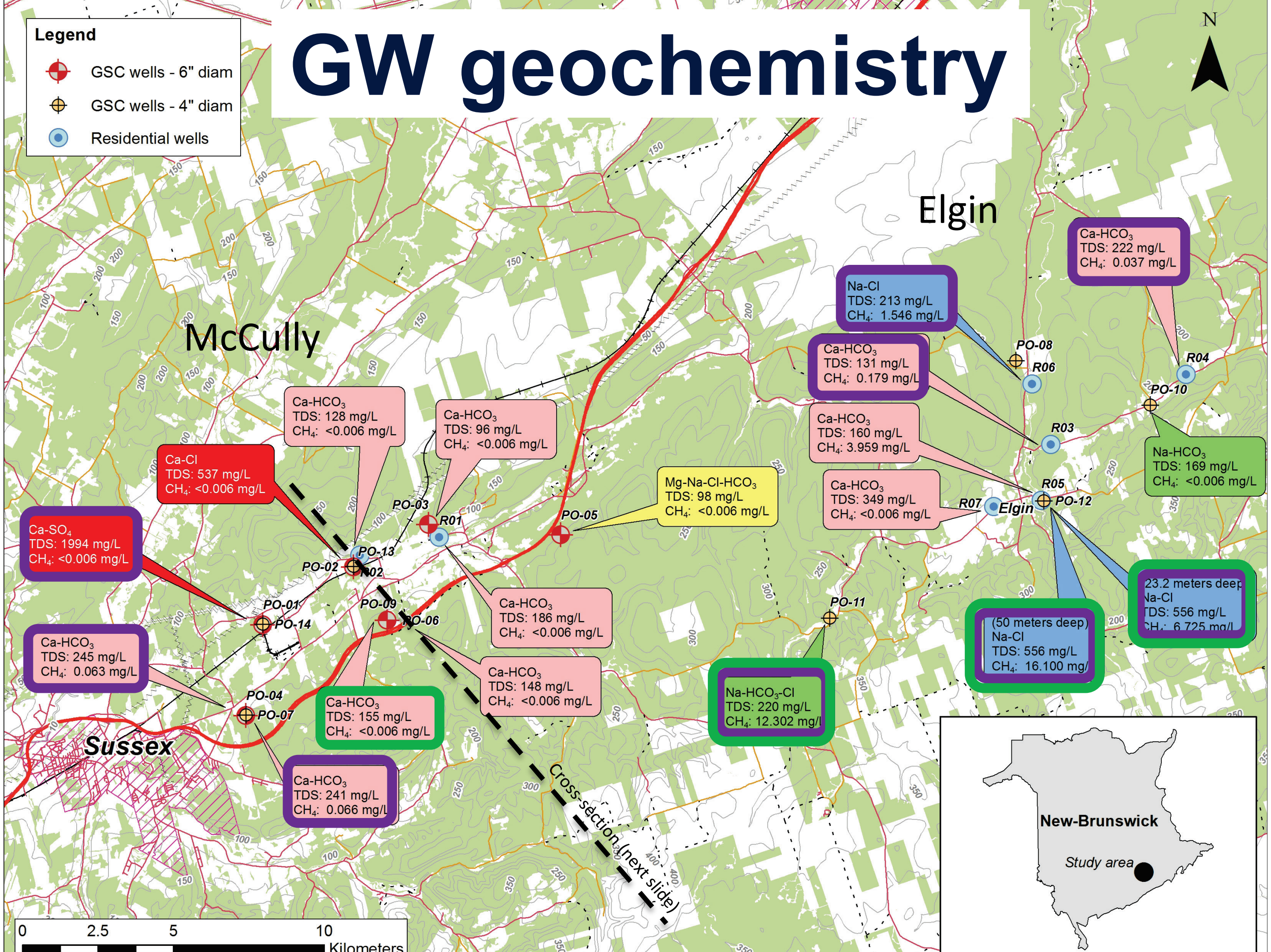
- Mixed (Mg-Na-HCO_3-Cl)
- Ca-HCO_3
- Na-HCO_3, Na-HCO_3-Cl
- Ca-SO_4, Ca-Cl
- Na-Cl

- Methane
- Ethane

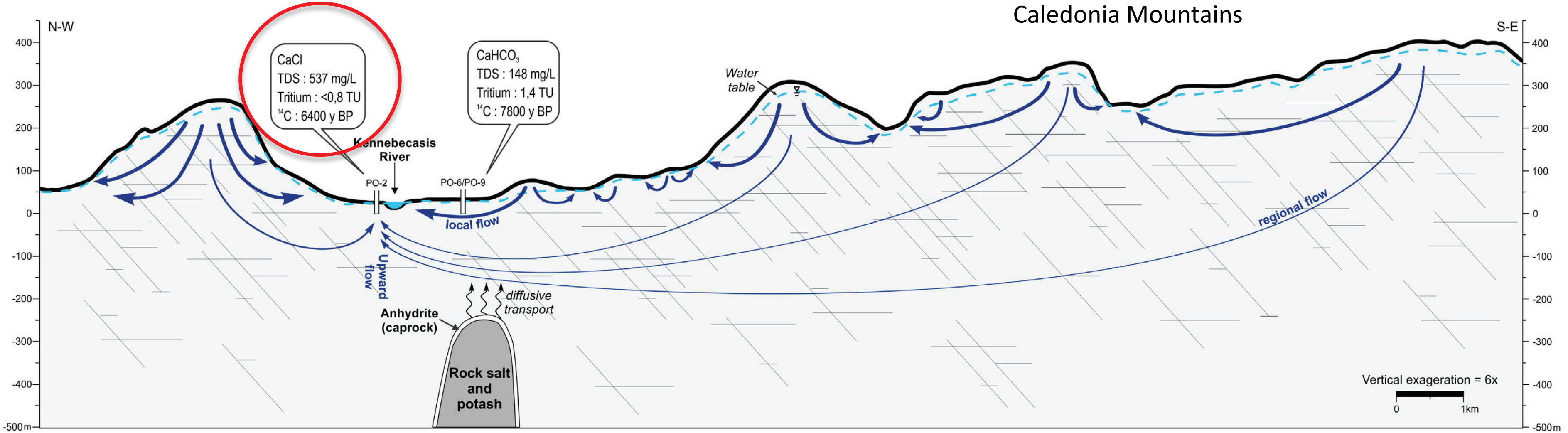
Low methane concentrations:

McCully: < 1 mg/L

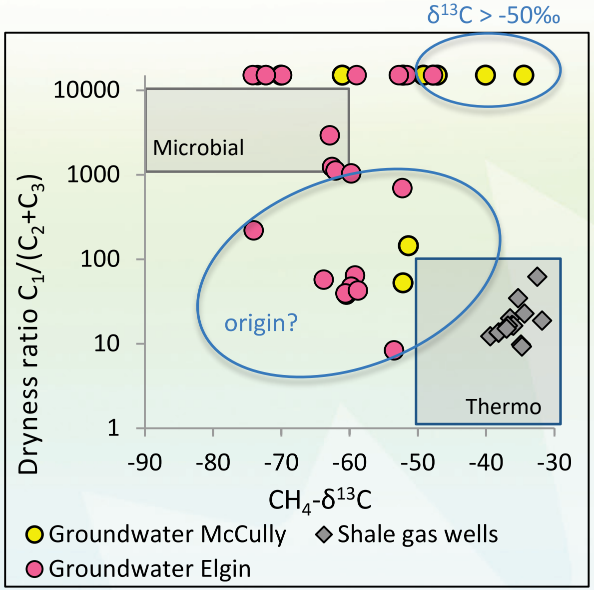
Elgin: < 5 mg/L

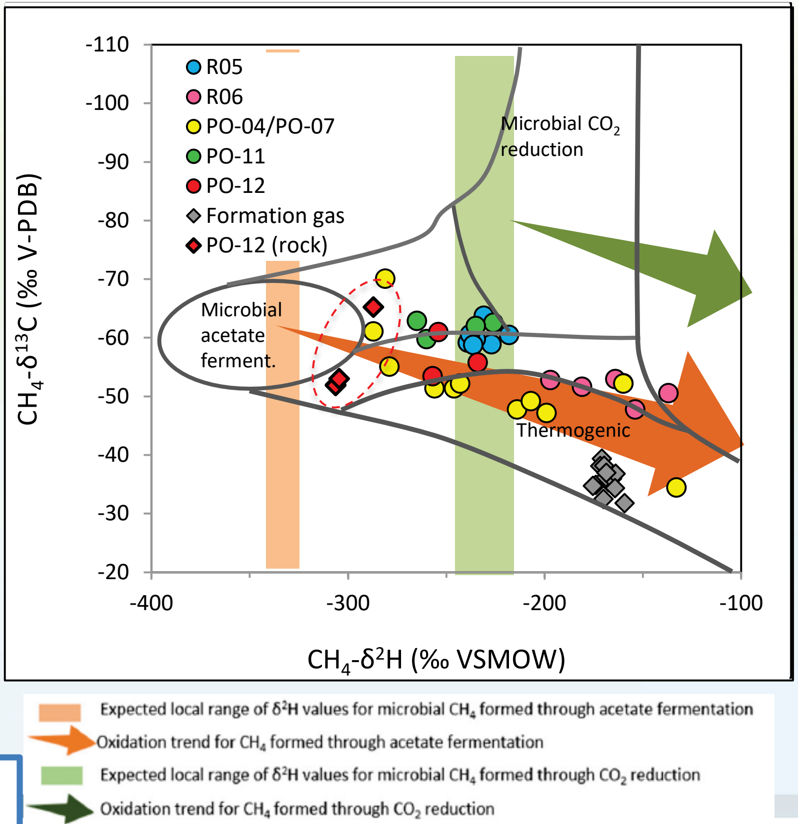


Groundwater flow conceptual model



Groundwater geochemistry





Monitoring: allowed the correct intepretation of methane origin

Comparison with results from core samples:
both types of gas likely come from shallow aquifer

Bordeleau, 2019

Canada

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SOURCES

Développer des indicateurs et comprendre les impacts environnementaux dans la région des sables bitumineux

Developing indicators and understanding environmental impacts in the Oils Sands region

Martine M. Savard

21 mai / May 21st, 2019




Canada

ABSTRACT

All research activities of SOURCES relate to developing new methodologies to allow distinguishing contaminants that are naturally released to water and terrestrial ecosystems from those produced by oil sands (OS) extraction activities. Main objectives : (1) assessing how new indicators and approaches for waterborne and airborne contaminants can help identify OS extraction-related changes to the natural regimes; and (2) understanding processes controlling the distribution of contaminants in the broad region of the OS open-mining developments.

Waterborne Contamination

The current research is a direct follow up of NRCan previous test study (OF 7195) as there is a need to specifically continue characterizing the various natural sources of contaminants (numerous lithostratigraphic units and groundwater systems); better constrain the anthropogenic signals of the contaminants, and identify, quantify and model the flux of OS-related chemicals into the groundwater near open-mining OS extraction activities, at the regional scale.

Metals - This activity explores lithium (δ^7Li) isotopes of groundwater as an indicator to strengthen the discrimination between natural and OS-derived contaminants, and the chemistry and reactive transport of metals to understand their distribution and fate.

AEOs – This study specifically evaluates the potential of hydrogen (δ^2H), and stable ($\delta^{13}C$) and radioactive ($\Delta^{14}C$) carbon isotopes for characterizing Acid Extractible Organics (AEOs), and investigates the biogeochemical processes controlling their distribution in groundwater.

Airborne Contamination

Forest N Cycle - This research involves characterizing airborne nitrogen (N) contaminants in air wet and dry samples from outside the OS region using new isotopic methods (on-line simultaneous $\delta^{15}N$, $\delta^{18}O$ and $\delta^{17}O$ values); to distinguish their ranges from OS air results. It further investigates the possible impacts of these airborne N contaminants on processes controlling the long-term tree-ring $\delta^{15}N$ trends, by determining $\delta^{15}N$ values in the complete suite of the soil-fungi-root-stem-leave continuum. This research also addresses the question as to how the nutritive regimes of pine and spruce stands and the forest N cycle are modified by OS operations (coll. with ECCC, CFS-Q, CFS-Ed).

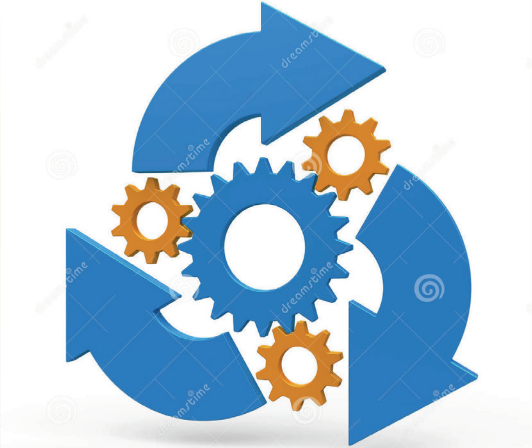
PAHs –The key issue here is quantifying natural polycyclic aromatic hydrocarbons (PAHs) related to forest fires and bitumen-containing rocks from anthropogenic sources. Naturally present in bitumen, PAHs are also released into the environment through the incomplete combustion of organic matter, whether from modern biomass or fossil fuels, and via diagenetic processes. The current activities focus on applying compound-specific $\delta^{13}C$, δ^2H and radiocarbon analysis (^{14}C) to sediment cores and snow of lakes in the OS region in which PAHs from forest fires can perhaps be distinguished from those that are OS mining-related and hence contain no detectable ^{14}C.

LMS/GSC - TEAM MEMBERS

Jason Ahad (Que)
Christian Bégin (Que)
Jade Bergeron (Que)
Cindy Bourgault (Que)
Danielle Brown
Lauriane Dinis (Que)
Paul Gammon (Ott)
Isabel Girard (Ott)
Larissa Goh (Que)
Thamara Guzman (Que)
Marc Luzincourt (Que)

Joëlle Marion (Que)
Sam Morton (Ott)
Hooshang Pakdel (Que)
Pierre Pelchat (Ott)
Stéphanie Roussel (Ott)
Hamed Sanei (Cal)
Martine M. Savard (Que)
Anna Smirnoff (Que)
Guillaume Tétrault (Que)
Patrick Watt (Que)
Zhaoping Yang (Ott)
James Zheng (Ott)

SOURCES - Outline

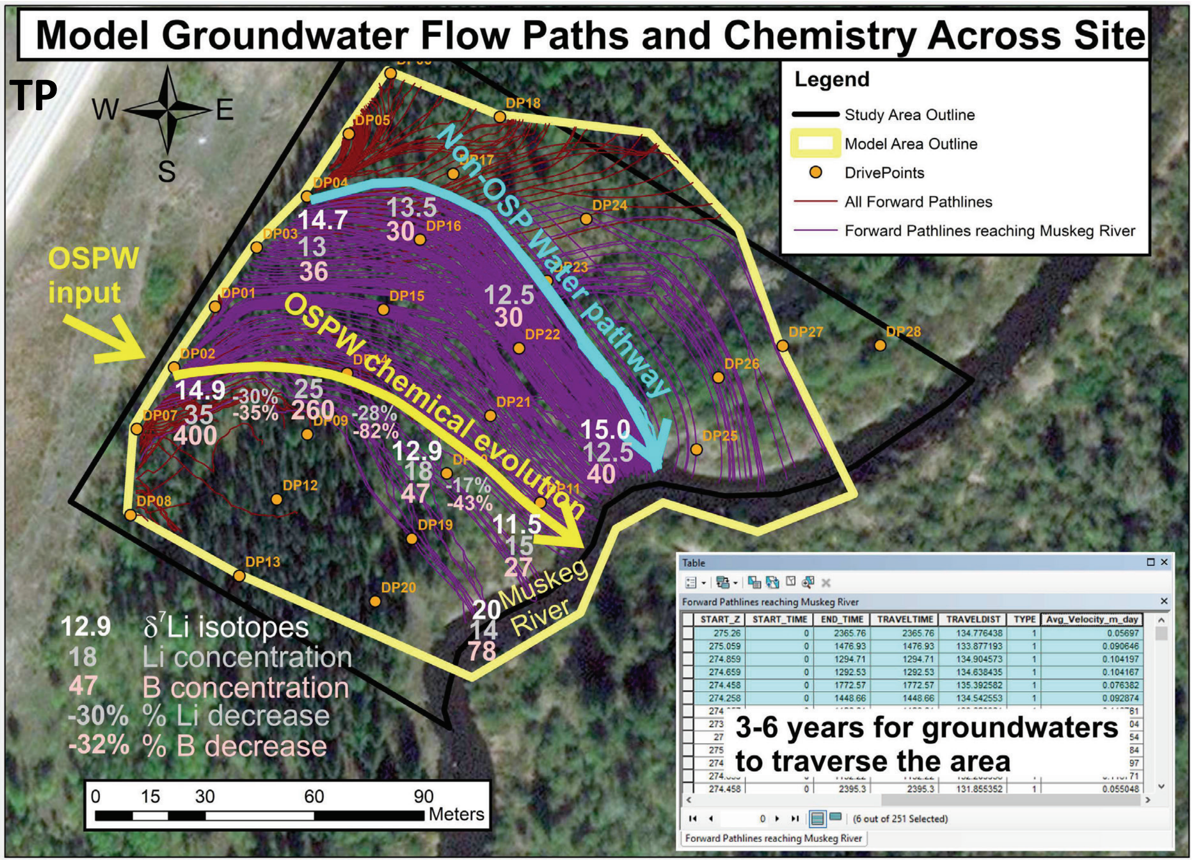


Developing indicators (fingerprints)

Understanding processes behind the distribution of contaminants

In Waterborne Metals & Naphthenic Acids (AEOs), and Airborne PAHs & N-species (Forest N cycle) of the Lower Athabasca, open-mining, OS region

Waterborne Contamination - Metals



Reactive Transport Model

First detailed RTM for the chemical evolution of an OSPW plume (Morton et al in prep.)

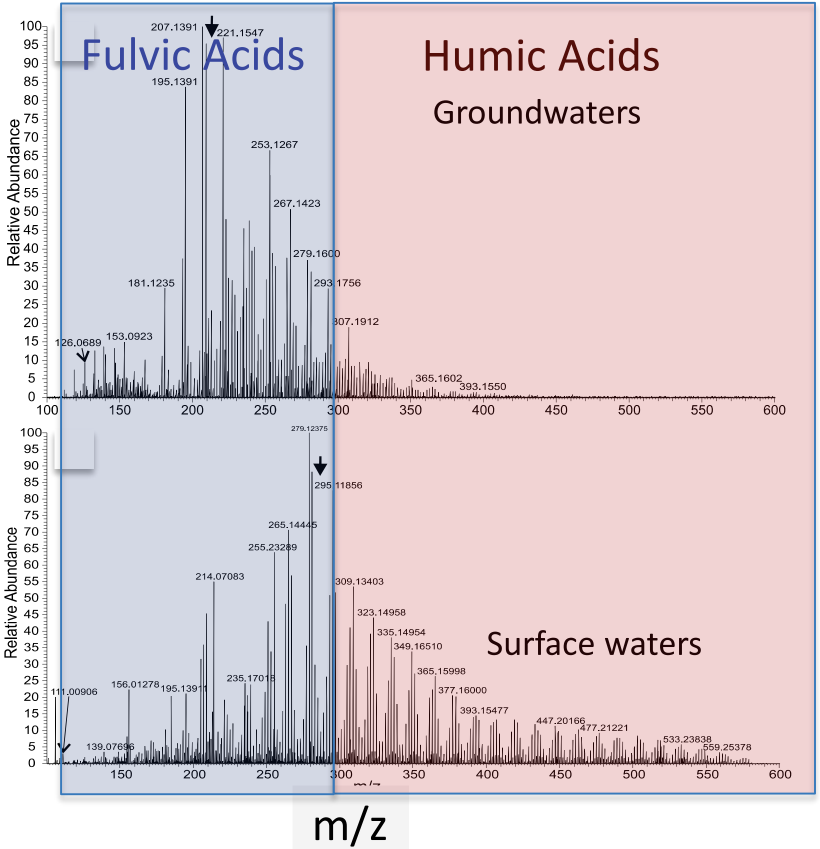
First inorganic fingerprints for recognizing an OSPW plume in natural environments

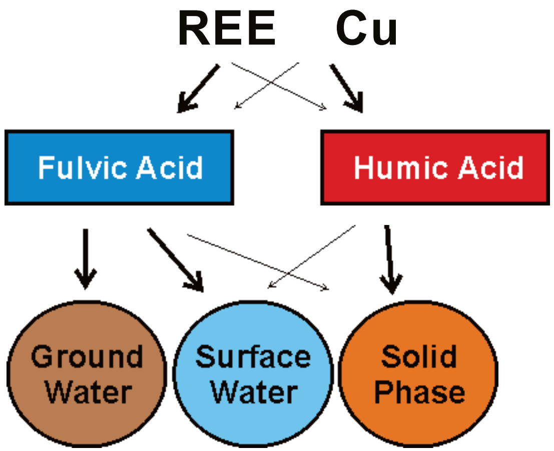
OSPW flux at this site insignificant to Muskeg River chemistry

Waterborne Contamination - Metals

Organic molecular spectra environmentally controlled

Organic molecule (sorption) controls metal chemistry in Oil Sands Region





Organic-rich OS environments control the metal chemistry and distribution in GW and SW (Roussel et al., in prep.)

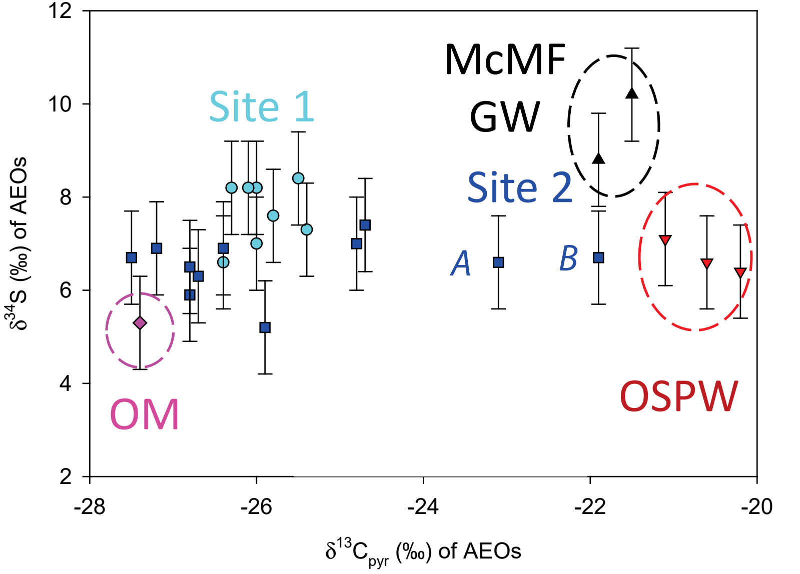
<u>OM sorption</u> explains metal distribution patterns around OS operations *and probably in boreal environments in general*

Waterborne Contamination – Naphthenic acids (AEOs)

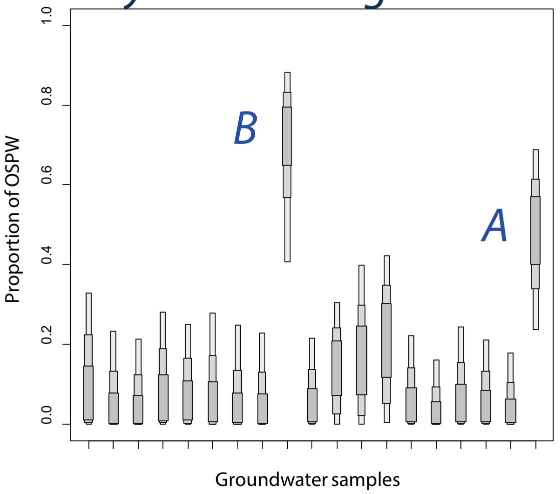
Apportionment of sources for 'naphthenic acids' (acid extractable organics - AEOs) in groundwater near OS tailings ponds

Dual isotope approach using intramolecular carbon isotope analysis (δ^{13}Cpyr) and new **sulphur isotope analysis (δ^{34}S)** (Ahad et al., in prep.)

Distinct isotopic values of 3 main end-members



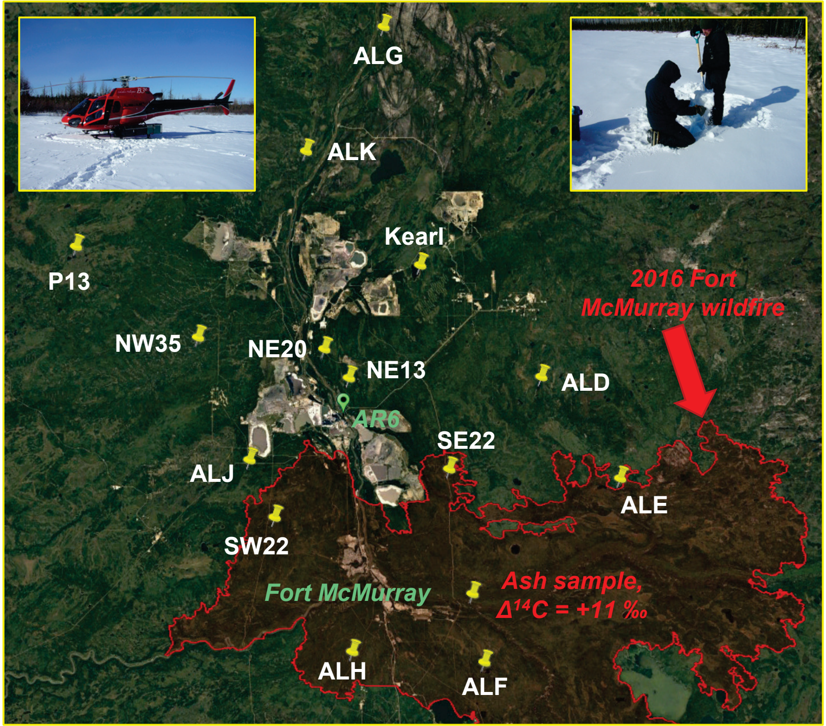
Quantification of OSPW inputs in samples of site 2 - Bayesian mixing model

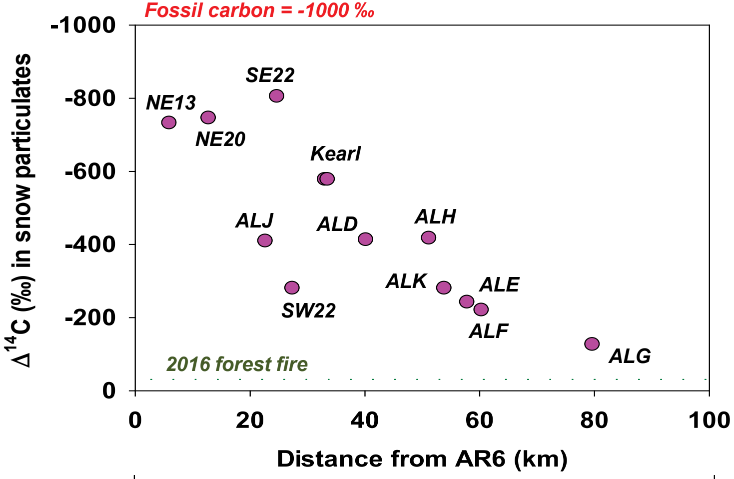


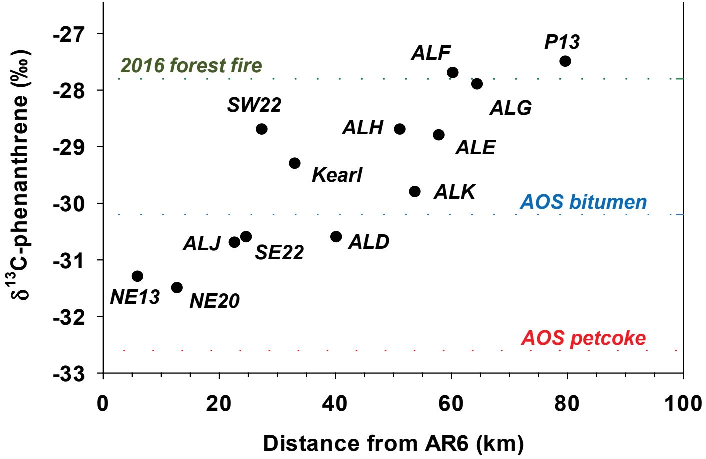
Airborne Contamination – PAH emissions

PAHs in snow deposited on Athabasca OS region lakes

$\delta^{13}C$ and $\Delta^{14}C$ results used to quantify petrogenic C in snow particulates (Ahad et al., in prep.)

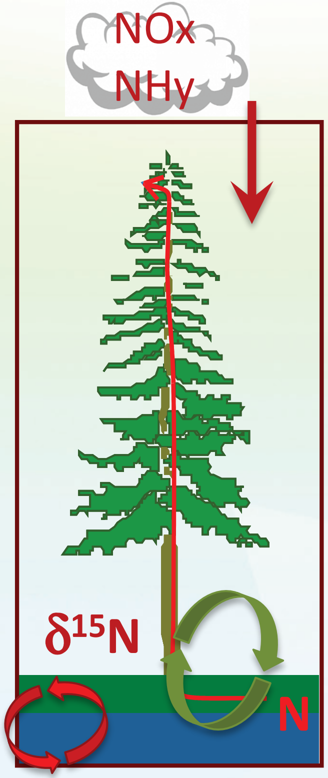






Airborne Contamination – Forest N Cycle

Can Tree-Ring $\delta^{15}N$ series record changes in Forest N Cycle ?



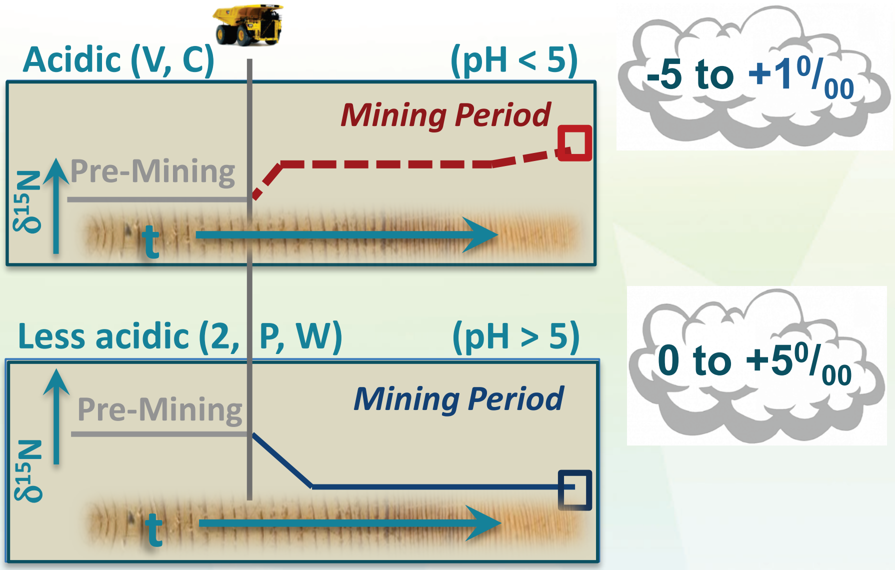
Ring $\delta^{13}C$ series for separating CC from changes in air quality (Savard et al 2014)
Development of methodologies for air isotopic characterization
Air anthropogenic N emissions (Savard et al 2017, Savard et al 2018)

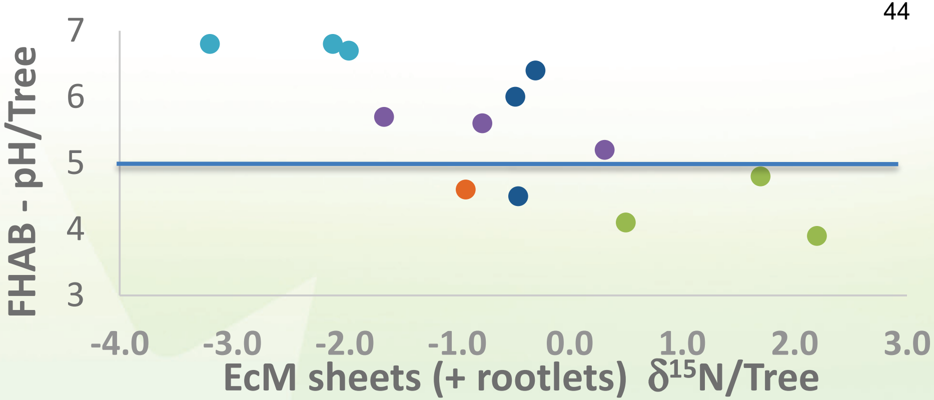
Development of methodologies for soil isotopic characterization
Soil pH and $\delta^{15}N$ of soil NH_4, NO_3, DON
$\delta^{15}N$ of Fungi (EcM), Rootlets, Leaves, Tree-Rings

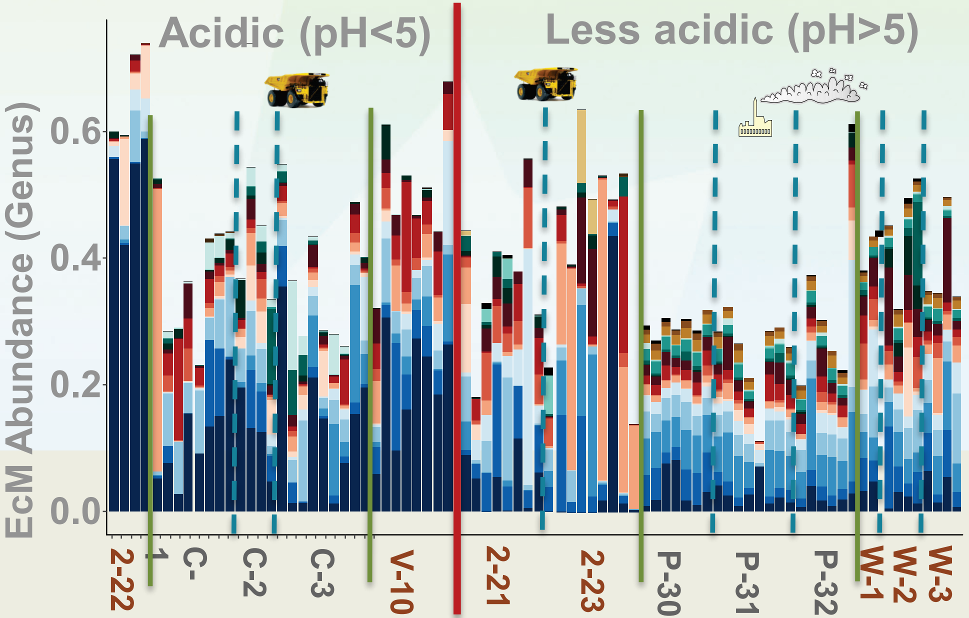
Characterization of Soil Chemistry
Incubation Tests (CFS) – Soil N transformation rates in FHAB horizons
DNA sequencing (OTUs at CFS) of Fungi (EcM) – Diversity and abundance
DNA sequencing (OTUs at CFS) of Bacteria – Diversity and abundance

Integration of data (Savard et al 2019 in *proceeding WRI-16+AIG-13*, Savard et al in preparation)

Airborne Contamination – Forest N Cycle







OS-mining N emissions enhance the pre-operations, local, underground N dynamics, and affect the Tree-ring $\delta^{15}N$ responses, regardless of the OS N signals

Data integration best explained by soil conditions and specific microbial communities controlling the isotopic N transferred to trees


SOURCES
SOurce determination Using isotope
Ratios Characterization of Environmental Samples
Merci boréal !
Martine M. Savard
418 654-2634
martinem.savard@canada.ca

Ressources naturelles Canada
Natural Resources Canada

Fluid storage and circulation in carbonates

Stockage et circulation au sein de carbonates

Stéphanie Larmagnat

May 21st, 2019

Canada

ABSTRACT

- **Title:** Fluid storage and circulation in carbonates
- **Project duration:** 2 years
- **PROJECT leader:** Denis Lavoie (GSC-QC)

Abstract: Conventional methods applied to oil and gas reservoir are revisited to address fluid flow and fluid storage capacity in carbonates in a Silurian succession in the Lower St. Lawrence area. With this case study, research activities compile key geological attributes (porosity, permeability, thermal conductivity) data and reconstruct the timing of diagenetic fluids circulation (creating or occluding porosity). The main goal is to understand how a conventional reservoir characterization would applied to geothermal development in a low temperature context.

PROJECT MEMBERS

- Stéphanie Larmagnat, GSC, Research scientist in Sedimentology
- Denis Lavoie, GSC, Research scientist in Sedimentology
- Jasmin Raymond, INRS, Professor in Geothermal Energy
- Michel Malo, INRS, Professor in Structural Geology
- Pierre Francus, INRS, Professor in Sedimentology
- Mathieu Des Roches, INRS, Research officer
- Louis-Frederic Daigle, INRS, Research technician
- Alexandre Aubiès-Trouilh, Squatex Ressources et Énergie Inc., Geologist

Introduction

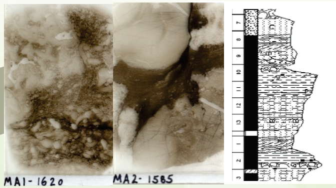
Naturally (macro)porous intervals – St. Cléophas outcrop

Fractured and vug-bearing intervals -Massé No.1 well

- Silurian carbonate Formation, with naturally (macro)porous intervals
- At the outcrop, this interval was interpreted as hydrothermal dolomites (HTD)
- Potential to be a reservoir analog of Albion-Scipio and Stony Point fields (Ordovician, Michigan basin, USA) or the Ladyfern gas field (Devonian, British Columbia)

Integrated approach

FACIES ANALYSIS



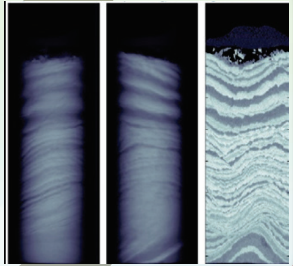
#2

GEOTHERMAL PROPERTIES

High precision thermal conductivity and diffusivity scanner

#1

CT-SCAN



STRATIGRAPHY, MAPPING

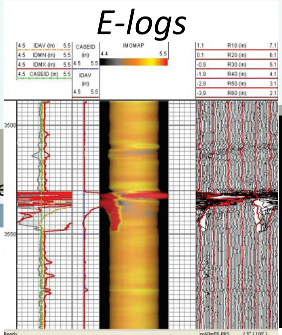
Understanding reservoir heterogeneity and how it transfers to geothermal properties

MICROANALYSES & GEOCHEMISTRY

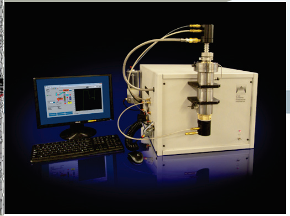
MEB, microprobe, stable isotopes

PETROPHYSICS

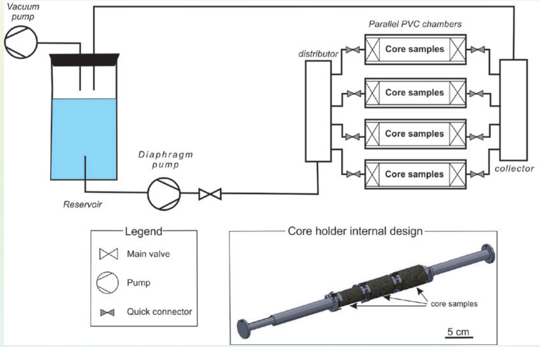
E-logs



Conventional petrophysics



#1 - Porosity using medical CT development



New core holder and flooding Set-up

Marine and Petroleum Geology
Available online 13 May 2019
In Press, Accepted Manuscript

Research paper

Continuous porosity characterization: Metric-scale intervals in heterogeneous sedimentary rocks using medical CT-scanner

Stéphanie Larmagnat [a], Mathieu Des Roches [b], Louis-Fréderic Daigle [b], Pierre Francus [b], Denis Lavoie [a], Jasmin Raymond [b], Michel Malo [b], Alexandre Aubiès-Trouilh [c]

Show more

https://doi.org/10.1016/j.marpetgeo.2019.04.039

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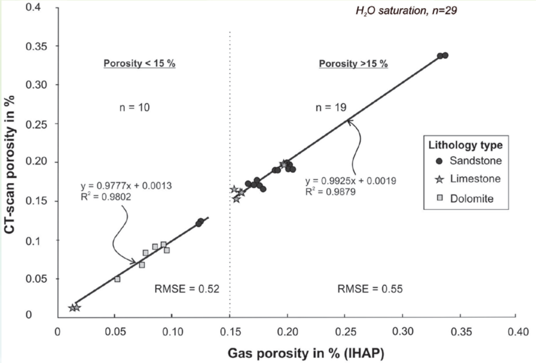
Methodology tested on 32 reference samples and 8 different lithologies



100% water

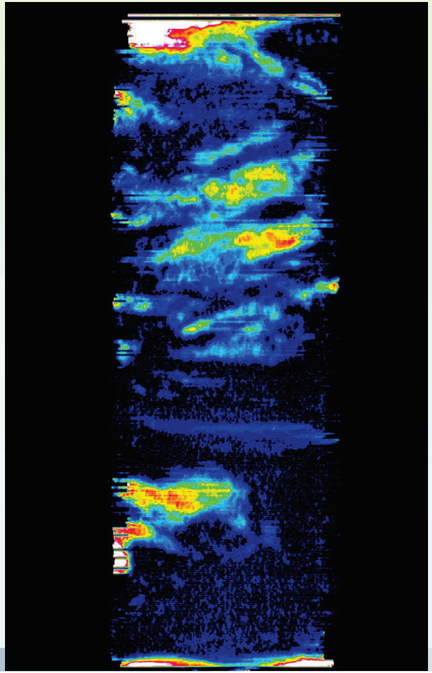
0% water

Rapid and improved visualization. First view of 3D distribution, critical for reservoir management

3D porosity matrix

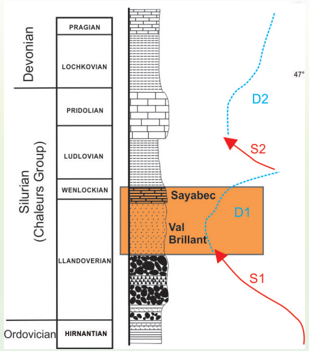
CT-scan porosity = 2,76 %

Helium porosity = 4,2 %

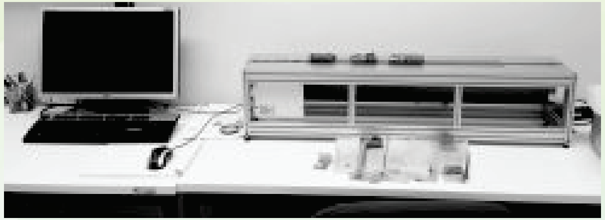


Canada

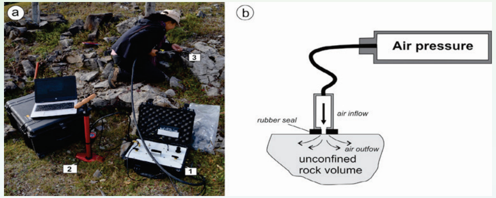
#2 - Permeability and thermal conductivity



Infrared scanner: thermal conductivity



Probe permeameter measurements (air permeability)



Statistics	St-Léon Siltstone	Sayabec limestone Fine-grained	Sayabec limestone Nodular	Sayabec limestone Bioclastic	Sayabec limestone Reefal	Sayabec Massively bedded HTD*	Sayabec HTD* breccia	Val-Brillant sandstone
Permeability (mD)								
Mean	**0.95**	**10.54**	**11.16**	**1.24**	**10.31**	**10.60**	**3.95**	**20.17**
Min	*0.38*	*0.92*	*5.76*	*0.57*	*8.41*	*1.43*	*0.77*	*0.19*
Max	*1.52*	*15.80*	*19.48*	*1.94*	*12.70*	*22.10*	*7.84*	*40.24*
Permeability (m^2)	**9.5E-17**	**1.054E-15**	**1.116E-15**	**1.24E-16**	**1.031E-15**	**1.06E-15**	**3.95E-16**	**2.0165E-15**
Porosity (vol. %)	**0.5**	**0.45**	**3.7**	**1.3**	**0.6**	**-**	**7.15**	**10.7**

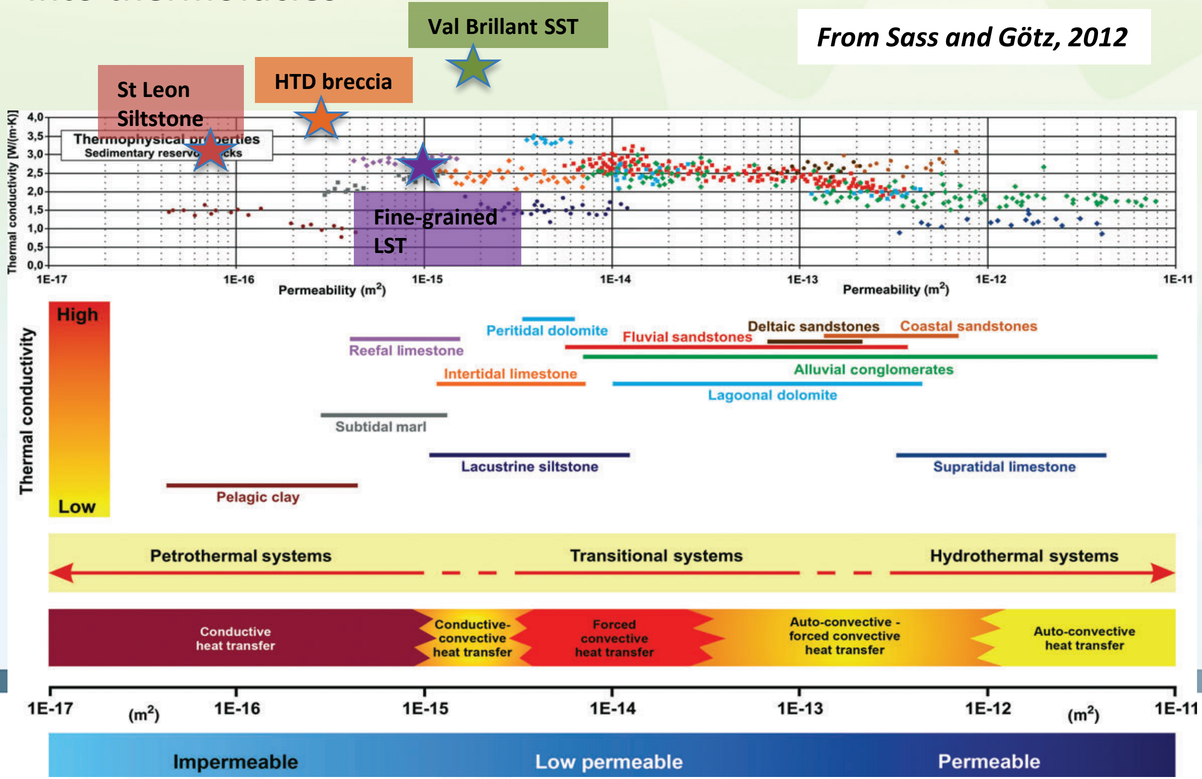
TC mean	TC min	TC max	Lithology/Lithofacies
5.31	4.34	5.88	Val Brillant SST (1)
4.35	4.10	5.88	Massively bedded HTD
3.93	3.16	4.36	HTD breccia (2)
3.25	3.11	3.39	St Leon Siltstone
3.08	2.86	3.29	Sayabec Bioclastic LST (3)
2.98	2.66	3.20	Sayabec Bioturbated LST
3.14	2.86	3.33	Sayabec Reefal LST
2.66	2.28	2.95	Fine-grained LST

SST = Sandstone
LST = Limestone
HTD = Hydrothermal Dolomite

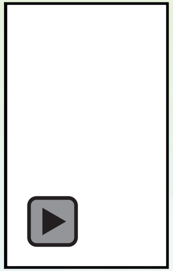
TC = Thermal conductivity, expressed in W/m/K

Integration into thermofacies concept

Coupling petrophysic and geothermal properties into thermofacies



➢ **Perspective : coupling 3D CT-scan outputs with high resolution infrared scanning**



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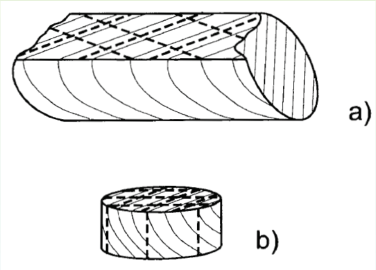


High resolution properties distribution in 3D as an input for upscaling

Canada

PUBLICATIONS

Papers and Open files (published or accepted)

1. Larmagnat, S., Des Roches, M; Daigle, L -F; Francus, P; Lavoie, D., Raymond, J; Malo, M; Aubiès-Trouilh, A., *2019*. Continuous sub-millimetric porosity characterization: metric-scale intervals in heterogeneous sedimentary rocks using medical CT-scanner, ***accepted in Marine Petroleum Geology journal***.
2. Larmagnat, S., Aubiès-Trouilh, A., Malo, M., Raymond, J.,2019. Detailed lithologic log of the lower Silurian Sayabec Formation in the Ressources et Énergie Squatex Massé No 2 well in eastern Québec, Geological Survey of Canada, Open File 8527, 2019, 22 pages, https://doi.org/10.4095/313530
3. Larmagnat, S., Francus, P; Des Roches, M; Daigle, L -F; Raymond, J; Malo, M; Aubiès-Trouilh, A. Tomodensitometry applied to characterize rock properties of a conventional heterogeneous carbonate reservoir in Quebec; Geological Survey of Canada, Open File 8386, 2018, 1 sheet, https://doi.org/10.4095/308112

Papers and Open files (in preparation)

1. Larmagnat, S; A. Aubiès-Trouilh; Malo, M. ; Raymond, J. From outcrop to subsurface fine-scale stratigraphy – the Silurian Sayabec Formation in the Lower St. Lawrence area, eastern Quebec. In preparation for *Journal of Sedimentary Research*.
2. Larmagnat, S; Lavoie, D., Rajaobelison, M. M. ; Raymond, J; Geothermal assessment of a conventional hydrocarbon reservoir in eastern Québec: Preliminary field and petrophysical data, in preparation for Geological Survey of Canada Open file

CONTACT INFORMATION

- Project leader’s name: Denis Lavoie
- Phone number: 418-654-1463
- Email address: Stephanie.Larmagnat@canada.ca

THANK YOU!

Ressources naturelles Canada
Natural Resources Canada

Mercury in the Environment
Le mercure dans l'environnement

Global Mercury Assessment 2018 (United Nations Environment Programme - UNEP)
Arctic mercury biogeochemical processes

P.M. Outridge

May 21st, 2019

ABSTRACT

- Leadership & writing contribution to Global Mercury Assessment 2018 (Arctic Monitoring and Assessment Programme (AMAP) / United Nation Environment Programme (UNEP)
- Aquatic Geochemistry team - two chapters
- GMA 2018 in press
- Several individual legacy publs. on Arctic Hg

PROJECT MEMBERS

- PI: Peter Outridge (GSC Ottawa)
- Key collaborators: Gary Stern & Fei Wang (U. Manitoba), Paul Hamilton (Cdn Museum of Nature), **Canada**); Rob Mason (U. Connecticut, **USA**); Xinbin Feng, Chinese Academy of Sciences, **China**); Hamed Sanei & Rune Dietz, Aarhus U., **Denmark**); Saul Guerrero (Universidad Metropolitana, **Venezuela**); Arctic Monitoring & Assessment Programme (Simon Wilson, AMAP, **Norway**), Lars-Eric Heimbürger (CNRS, **France**)

Output from GMA 2018, Chapter 2, Global Budget and Cycle

Environmental Science & Technology

Critical Review

Cite This: *Environ. Sci. Technol.* 2018, 52, 11466−11477

pubs.acs.org/est

Updated Global and Oceanic Mercury Budgets for the United Nations Global Mercury Assessment 2018

P. M. Outridge,[*,†,‡] R. P. Mason,[§] F. Wang,[‡] S. Guerrero,[‖] and L. E. Heimbürger-Boavida[⊥]

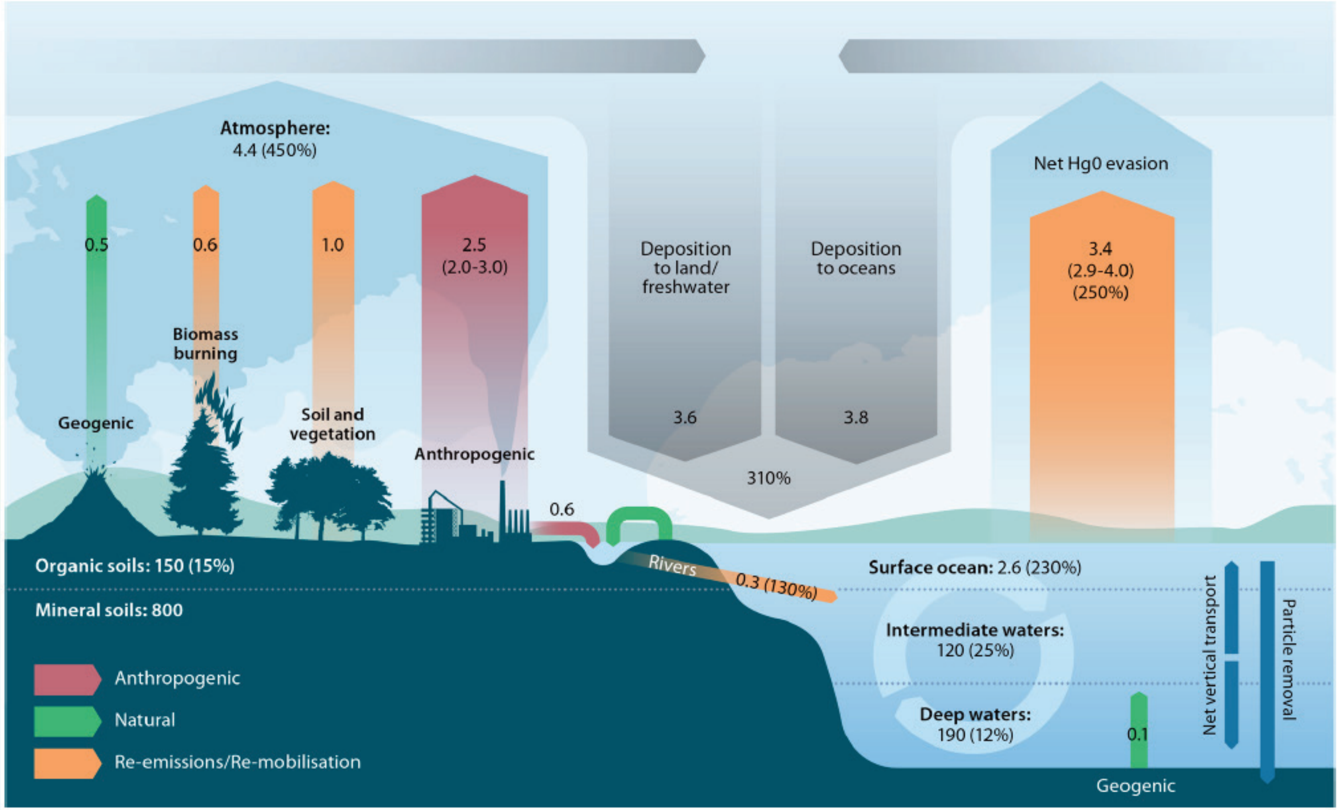
[†]Geological Survey of Canada, Natural Resources Canada, 601 Booth St., Ottawa, Ontario K1A 0E8, Canada

[‡]Center for Earth Observation Science and Department of Environment and Geography, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada

[§]Department of Marine Sciences, University of Connecticut, 1080 Shennecossett Road, Groton, Connecticut 06340, United States

[‖]Universidad Metropolitana, Autopista Caracas Guarenas, Caracas 1073, Venezuela

[⊥]Aix Marseille Université, CNRS/INSU, Université de Toulon, IRD, Mediterranean Institute of Oceanography (MIO) UM 110, 13288, Marseille, France


Atmosphere:
4.4 (450%)
0.5
0.6
1.0
2.5
(2.0-3.0)
Biomass burning
Geogenic
Soil and vegetation
Anthropogenic
Deposition to land/ freshwater
3.6
Deposition to oceans
3.8
310%
Net Hg0 evasion
3.4
(2.9-4.0)
(250%)
0.6
Rivers
0.3 (130%)
Organic soils: 150 (15%)
Mineral soils: 800
Surface ocean: 2.6 (230%)
Intermediate waters:
120 (25%)
Deep waters:
190 (12%)
0.1
Geogenic
Net vertical transport
Particle removal
Anthropogenic
Natural
Re-emissions/Re-mobilisation

Output from GMA 2018, Chapter 9, Monitoring the Convention

Science of the Total Environment 674 (2019) 58–70

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

ELSEVIER

Review

How closely do mercury trends in fish and other aquatic wildlife track those in the atmosphere? – Implications for evaluating the effectiveness of the Minamata Convention

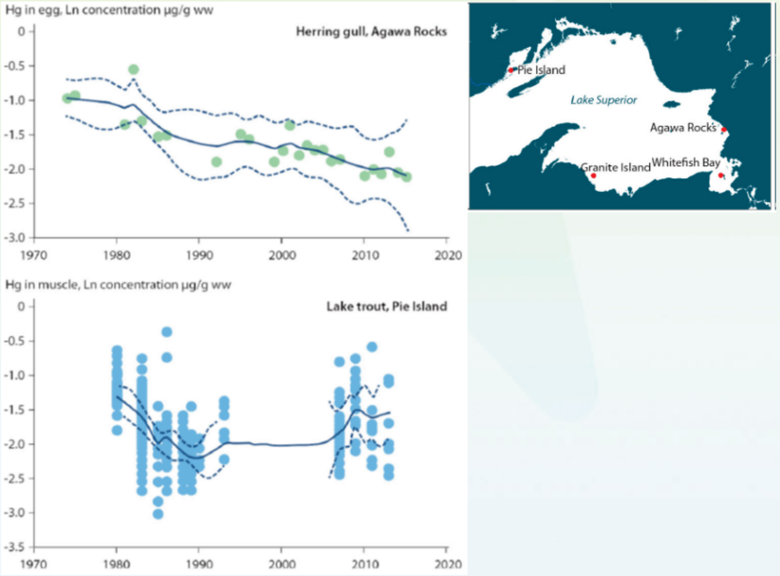
Check for updates

Feiyue Wang [a,*], Peter M. Outridge [a,b], Xinbin Feng [c], Bo Meng [c],
Lars-Eric Heimbürger-Boavida [d], Robert P. Mason [e]

[a] *Centre for Earth Observation Science, and Department of Environment and Geography, University of Manitoba, Winnipeg, MB R3T 2N2, Canada*
[b] *Geological Survey of Canada, Natural Resources Canada, 601 Booth St., Ottawa, ON K1A 0E8, Canada*
[c] *State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, 46 Guanshui Road, Guiyang 550002, China*
[d] *Aix Marseille Université, CNRS/INSU, Université de Toulon, IRD, Mediterranean Institute of Oceanography (MIO) UM 110, 13288 Marseille, France*
[e] *Department of Marine Sciences, University of Connecticut, 1080 Shennecossett Road, Groton, CT 06340, USA*

Past:

- Biotic trends and air trends often unrelated
- Environmental & biogeochemical processes intervening
- Climate change a common overarching factor



Future:

- Effectively unpredictable
- A range of outcomes
- Not always related to air trends

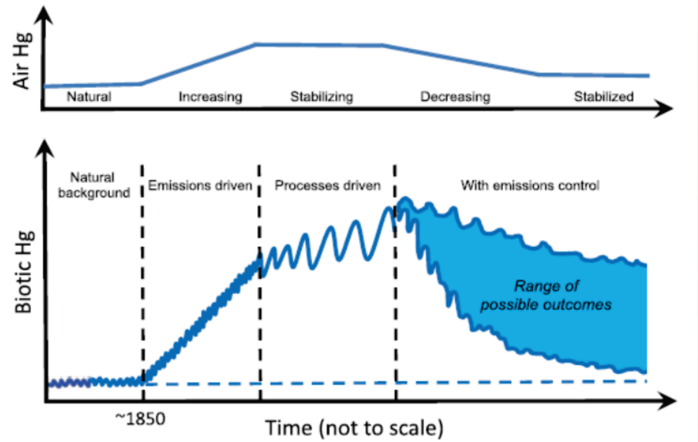


Fig. 7. A schematic representation of evolution in the Hg concentrations in air (top) and aquatic biota (bottom), showing changes over time in the principal drivers of Hg bioaccumulation. The figure is updated from Wang et al. (2010). See the text for details.

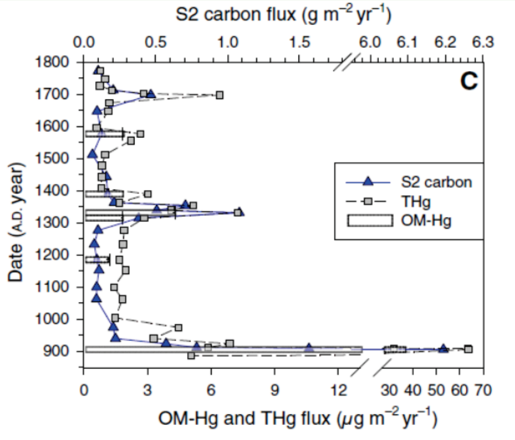
LIMNOLOGY and OCEANOGRAPHY

ASLO

Limnol. Oceanogr. 9999, 2019, 1–14
© 2019 Association for the Sciences of Limnology and Oceanography
doi: 10.1002/lno.11135

Algal scavenging of mercury in preindustrial Arctic lakes

P. M. Outridge,[1,2*] G. A. Stern,[2] P. B. Hamilton,[3] H. Sanei[4,†]
[1]Geological Survey of Canada, Natural Resources Canada, Ottawa, Ontario, Canada
[2]Centre for Earth Observation Science, University of Manitoba, Winnipeg, Manitoba, Canada
[3]Canadian Museum of Nature, Ottawa, Ontario, Canada
[4]Geological Survey of Canada, Natural Resources Canada, Calgary, Alberta, Canada



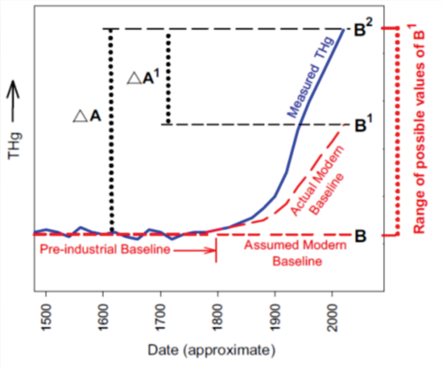


Fig. 6. Schematic of a stylized lake sediment THg profile, showing the impact of algal scavenging on the calculation of anthropogenic Hg inputs.

Take-home messages

1. Climate-related changes in algal productivity affect natural baseline mercury concentrations and fluxes in sediments.

2. Implications for calculation of anthropogenic mercury fluxes in 20th C, because the natural baseline is still changing (an unrecognized process)

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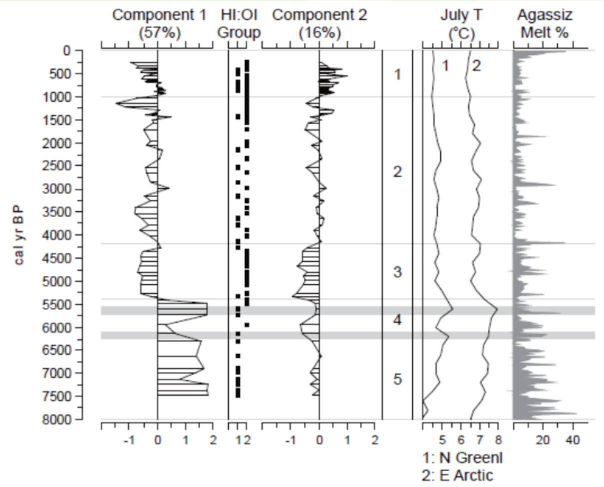
ELSEVIER

Holocene climate change influences on trace metal and organic matter geochemistry in the sediments of an Arctic lake over 7,000 years

P.M. Outridge [a, b, *], H. Sanei [c], C.J. Courtney Mustaphi [d, 1], K. Gajewski [d]



6. Comparison of the sediment geochemistry changes over time with reconstructed July air temperature data, and Agassiz Ice Cap melt data for the past 8000 years. The principal ponents (see Fig. 2) of sediment chemistry are compared to group membership of the HI/OI ratio plot (see Fig. 4). Eastern Canadian Arctic and North Greenland July temperatures

Take-home message

Changing climate (air temp) during Holocene altered trace metal geochemistry in sediments by impact on erosion rates (carbonate terrain)

CONTACT INFORMATION

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Ressources naturelles Canada | Natural Resources Canada

Measuring, monitoring and verification of geological carbon storage

Mesure, surveillance et vérification de la séquestration géologique du carbone

Don White

May 21st, 2019

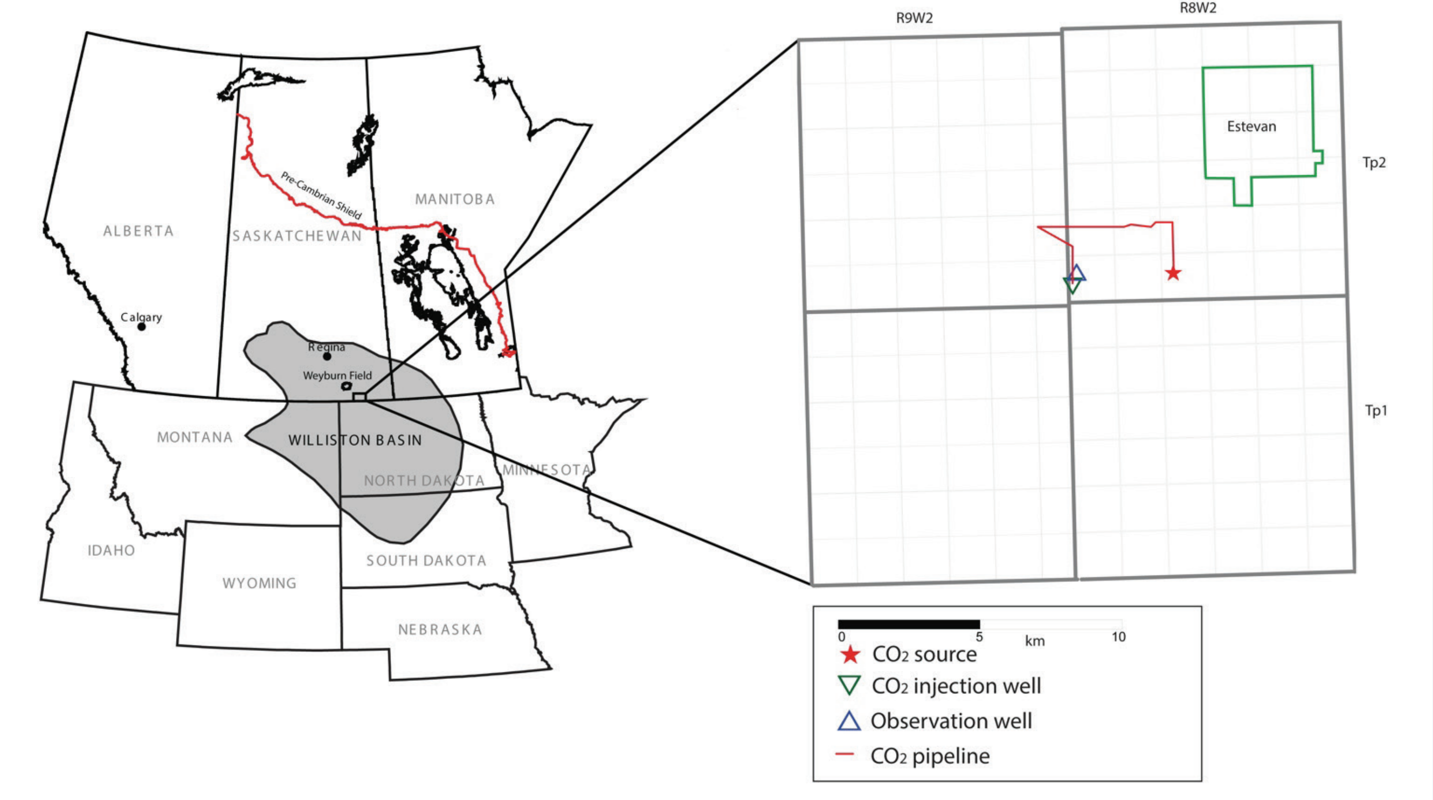
ABSTRACT

- Carbon capture and storage (CCS) has been identified as a priority issue within the context of the North American Climate Change and Energy Collaboration and Mission Innovation. An important aspect of CCS is the need to improve public confidence in long-term geological storage of CO_2. A key to developing confidence for the longer term is a demonstration of safe and expected storage behaviour in the short term. Two primary concerns of the public and government regulatory bodies are the potential for induced seismicity and for CO_2 leakage. To alleviate these concerns, storage monitoring is critical in demonstrating that the subsurface CO_2 plume is behaving as expected, and that induced microseismic or seismic activity is being closely monitored. The Aquistore CO_2 Storage Project is a multi-year research and monitoring project to demonstrate that storing CO_2 deep underground is a safe and workable solution to help reduce greenhouse gas emissions to the atmosphere. The Geological Survey of Canada's studies within the project are focused on the development of improved monitoring methodologies and a better understanding of the relationship between CO_2 injection and induced seismicity.
- A total of ~200 ktonnes of CO_2 were injected at the Aquistore site from April-2015 to May-2019. Injection is occurring within a saline formation at a depth of 3150-3350 m. Passive seismic monitoring at the site which began in 2012 has not identified any seismicity associated with the injection process. The first time-lapse 3D seismic surveys were conducted in February and November of 2016 when the cumulative injected quantity of CO_2 was 36 ktonnes and 102 ktonnes, respectively. The latest 3D survey occurred in March-2018 with 141 ktonnes injected. The resultant time-lapse seismic images show how the CO_2 plume is partitioned vertically within the reservoir and how it is spreading laterally. The seismic observations indicate that the initial geological model used for CO_2 flow simulations will have to be modified.

PROJECT MEMBERS

- Don White, Kyle Harris, Brian Roberts, Jim Craven (**GSC**)
- Mike Craymer, Jason Silliker (**CGS**)
- Sergey Samsonov (**CCRS**)
- Lisa Roach (**LAN Geophysics**)
- Darcy Holderness (**SaskPower**)
- Erik Nickel, Ivan Marsden, Zeinab Movahedzadeh (**Petroleum Technology Research Centre**)
- Chris Nixon, Doug Schmitt, Ben Rostron (**University of Alberta**)
- Chris Hawkes (**University of Saskatchewan**)
- Anna Stork (**Bristol University**)
- Tom Daley, Michelle Robertson (**Lawrence Berkeley National Lab**)
- Masashi Nakatsukasa, Mamoru Takanashi (**Japan Oil, Gas Metal NC**)

Aquistore CO_2 Storage Project




2013
CO_2 Capture Plant
SaskPower
Boundary Dam
2,573,685 TONNES
captured since operational start-up
2017: 506,848 t
2018: 625,996 t
2019: 108,352 t
SaskPower
Powering the future®

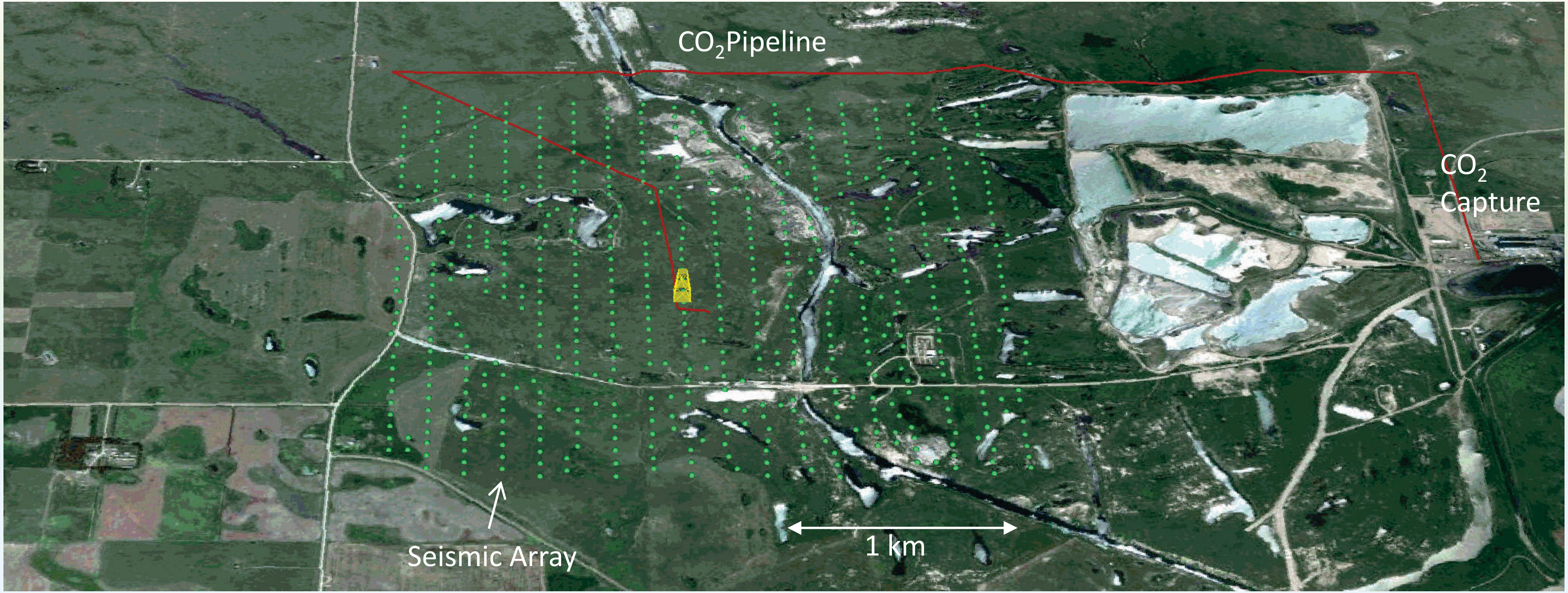
GSC Research Objectives

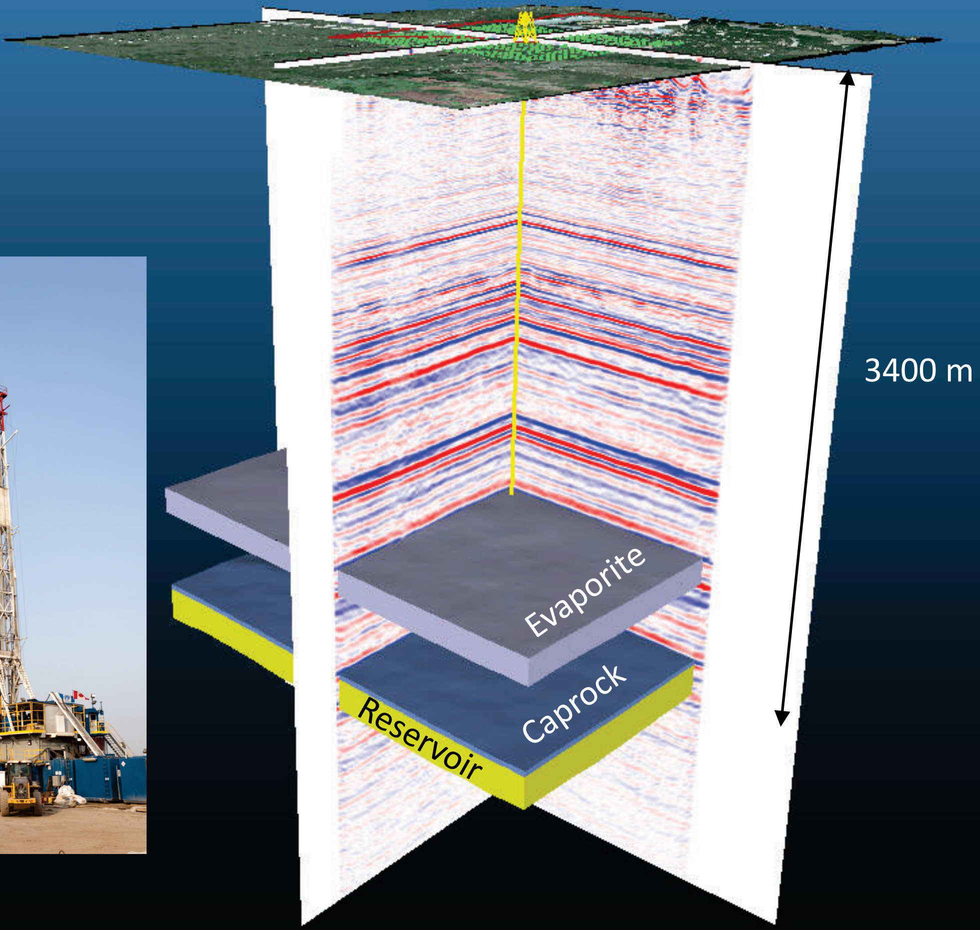
- Methods for monitoring CO_2 containment
- Induced seismicity

Outcomes

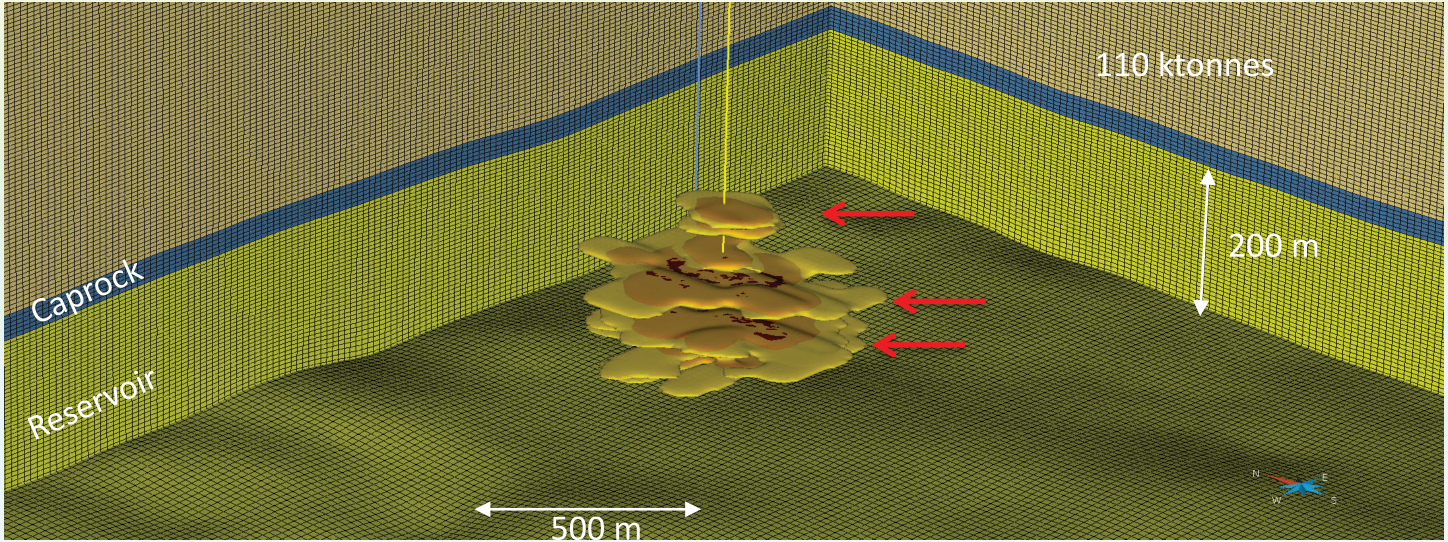
- Informs regulations and international standards under development
- Effective but efficient CO_2 monitoring

Aquistore CO_2 Storage Project



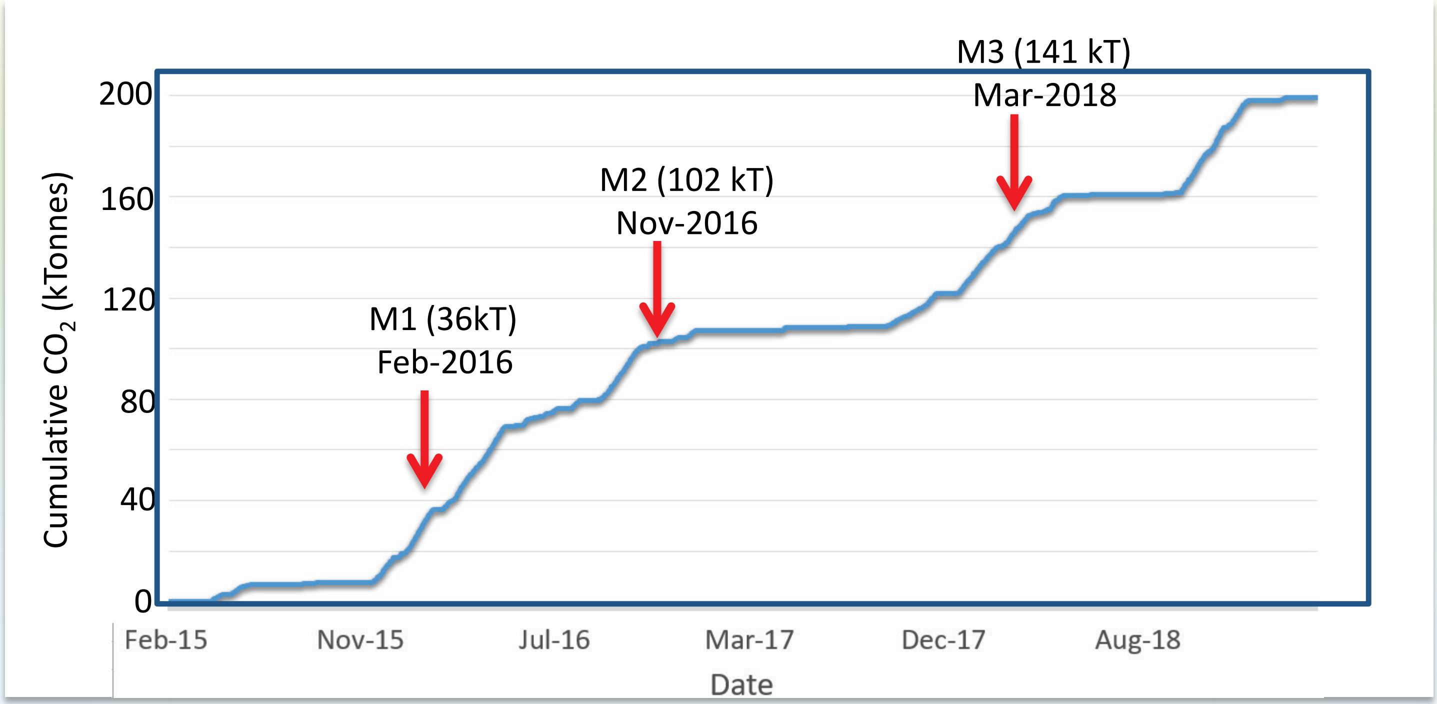

3400 m
Evaporite
Caprock
Reservoir

Model: 110 kT CO_2

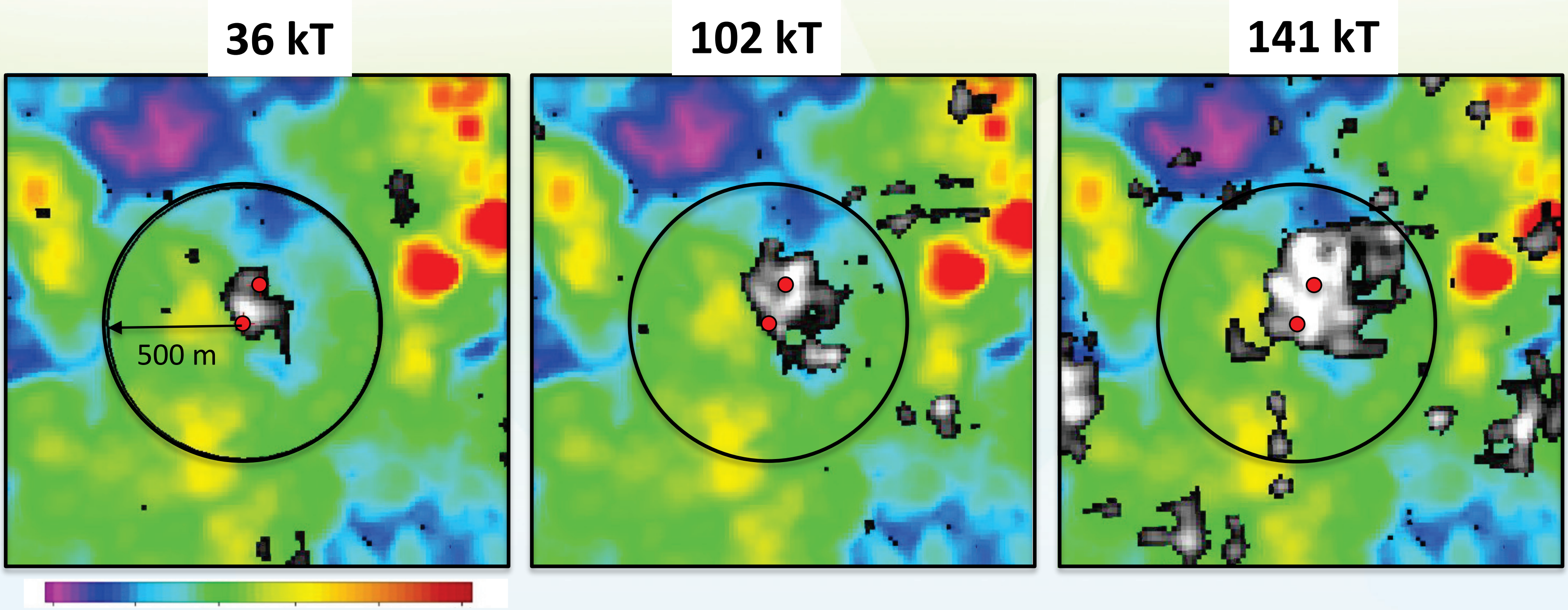


3400 m Depth

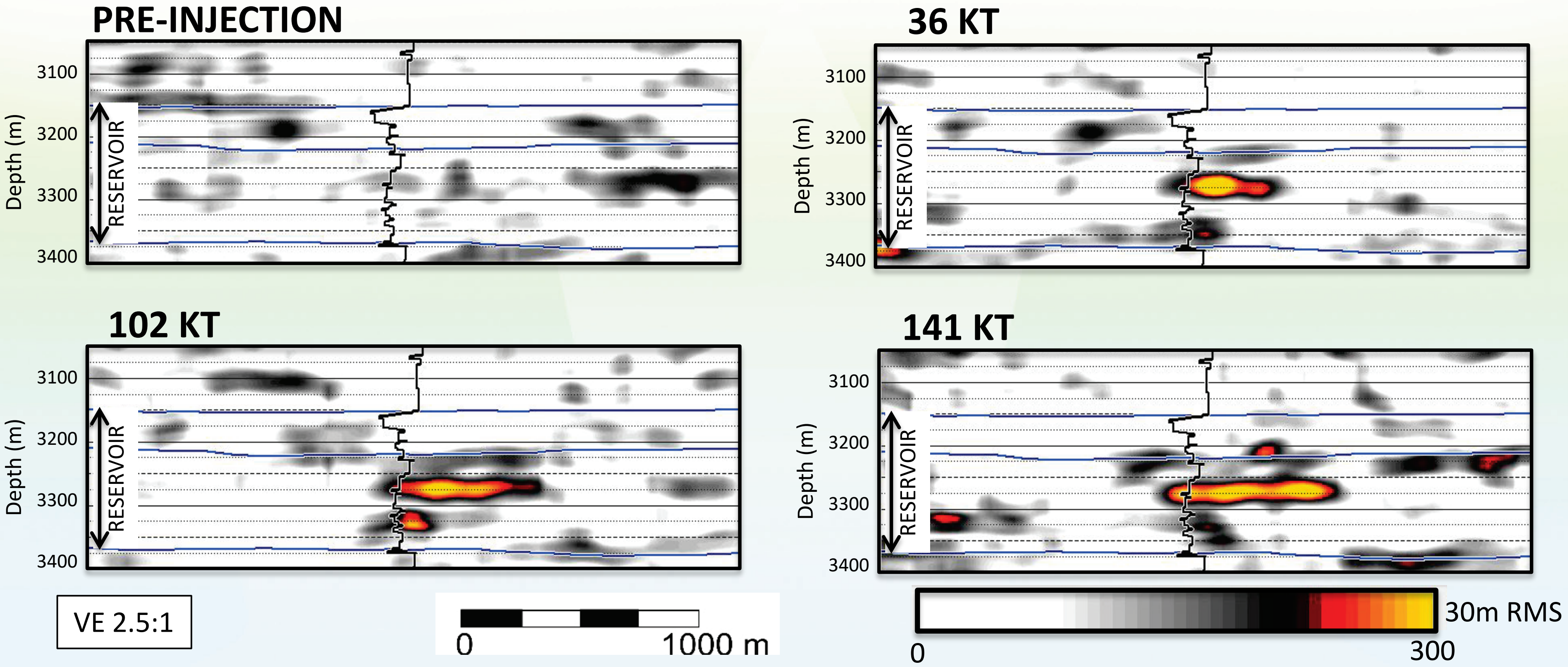
CO_2 Injection



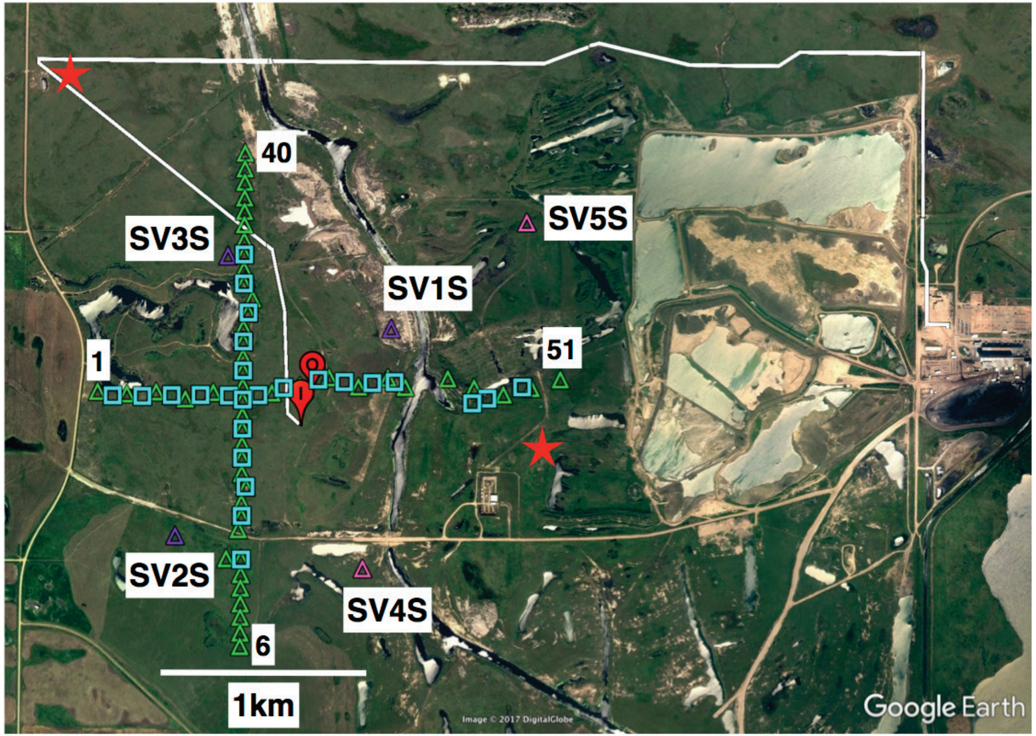
Reservoir Structure



4D RMS AMPLITUDE DIFFERENCE: S-N SECTIONS

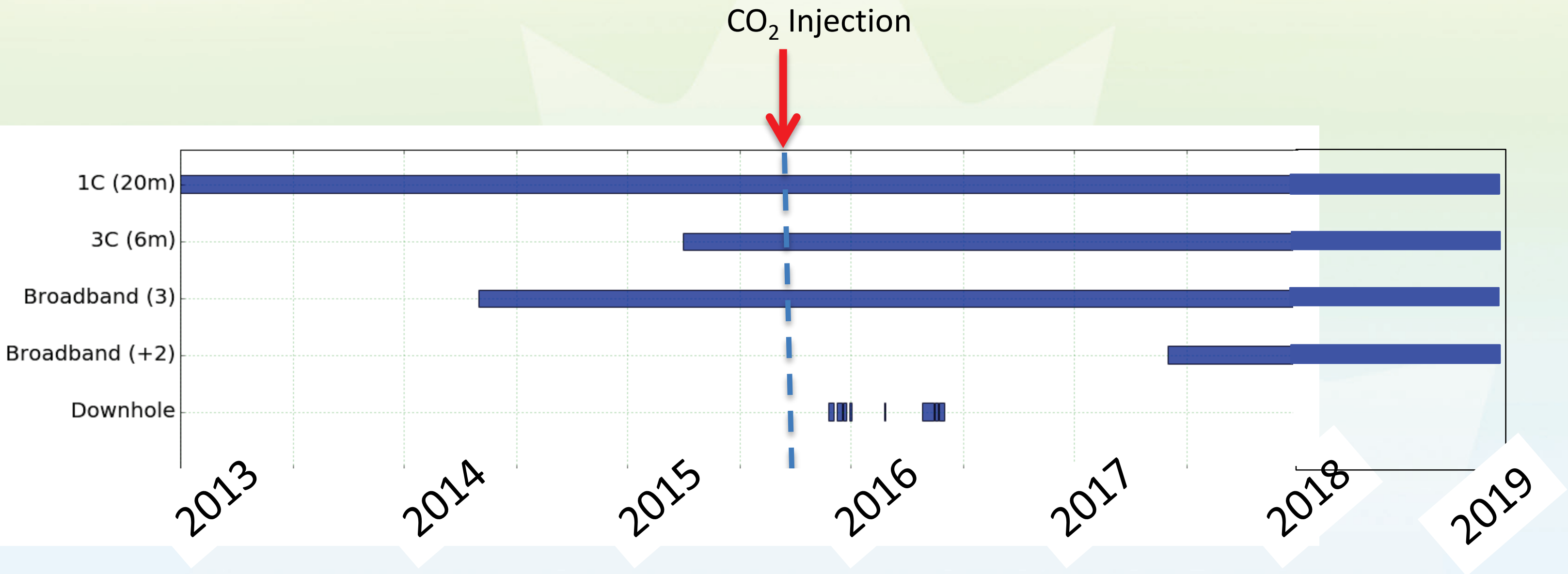


Microseismic Monitoring



(Stork et al., 2018)

Monitoring Period



(Stork et al., 2018)

Induced Seismicity

- No induced seismicity during 4 years of injection
- Minimum detectable magnitude for 3.2 km depth:
  - BB: M_L= -0.8
  - Array: M_L= -1.6 to -0.6
- Magnitude of completeness (STA/LTA):
  - BB: M_W = 1.3
  - Array: M_W = 0.6

(Stork et al., 2018)

Conclusions

- Demonstrated efficient 3D time-lapse monitoring using a sparse permanent seismic array.
- CO_2 plume is contained within the reservoir.
- Continuous passive monitoring shows no detectable induced seismicity

CONTACT INFORMATION

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Induced Seismicity Research Project: Summary of Accomplishments 2014 – 2019

Projet de recherche en sismicité induite : Résumé des accomplissements 2014-2019

Honn Kao

May 21st, 2019 (presented by Ramin Dokht)




Canada

ABSTRACT

The Induced Seismicity Research (ISR) project has a national scope with team members from NRCan offices in Sidney, Vancouver, Ottawa, and Quebec City. The Project established close collaborators with both public and private sectors, including provincial and local governments, crown corporations, professional organizations, and research universities, to address critical knowledge gaps in induced seismicity and to provide observation-based science to improve regulations on the development of unconventional hydrocarbon resources. The ISR Project has accomplished numerous achievements during the past 5 years. Five most representative examples are presented. They are:

- Enhanced regional seismicity monitoring in major shale gas basins in east, west, and north Canada;
- Establish scientific evidence for the link between hydraulic fracturing and induced earthquakes in Canada;
- Explore factors that control the seismogenesis of induced earthquakes;
- Improved methodology/algorithm in detecting/locating small injection-induced earthquakes;
- Contribute to improved regulations on the development of unconventional hydrocarbons.

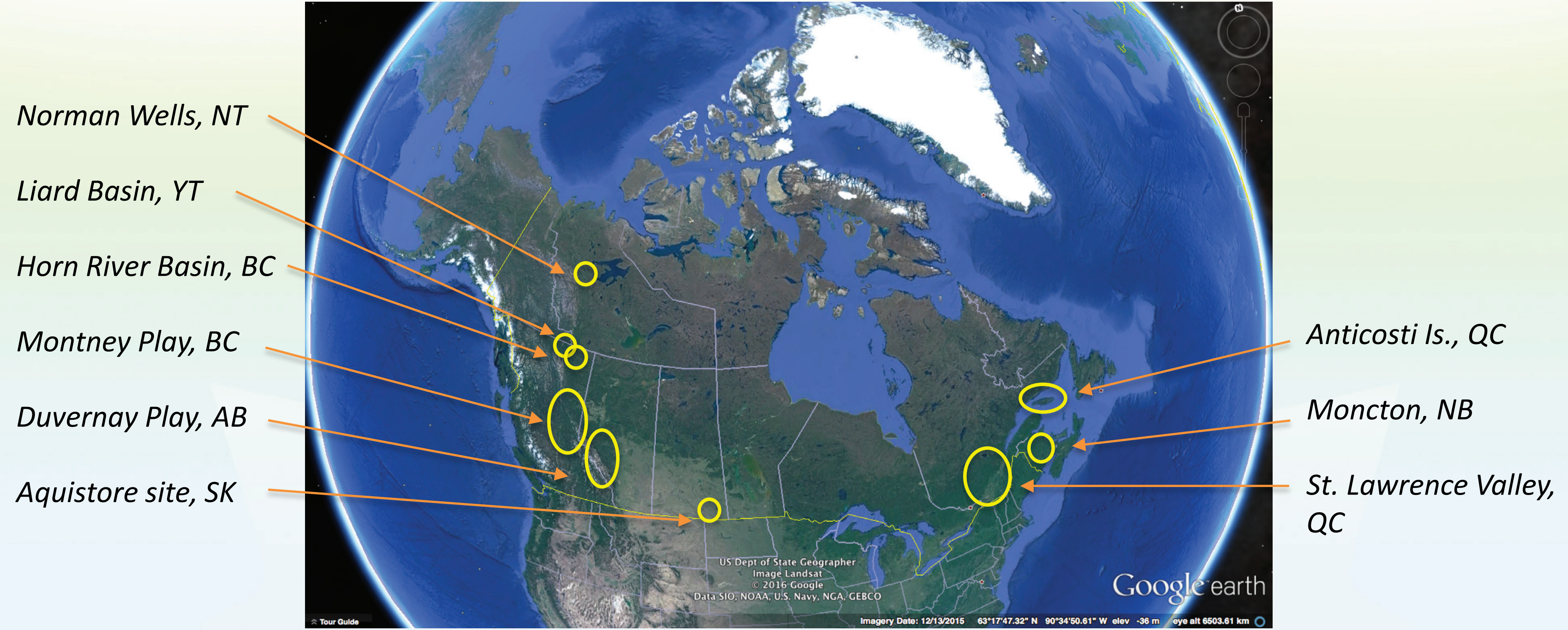
KEY PROJECT MEMBERS

- GSC Research Scientists
  - Pacific: Honn Kao (Project Leader), John Cassidy, Ramin Dokht, Adebayo Ojo (NRCan PRP, since 2019)
  - Ottawa: Maurice Lamontagne, Don White, David Snyder (2014-2017)
  - Quebec: Denis Lavoie
- GSC Research Associates
  - Amir Farahbod (NSERC PDF, 2012-2016)
  - Alireza Babaie Mahani (PDF funded by Geoscience BC)
  - Ryan Visser (PC-2), Dino Hwang (contractor), Shutien Ma (contractor)
  - Dawei Gao, Ayodeji Kuponiyi, Jesse Hutchinson, Fengzhou Tan (UVic graduate students)
  - John McKay, Brindley Smith, Jayden Rowley, Jeremiah Wilbur, Byron Kontou, Connor Gaudreau, Metea Marr, and Chet Goerzen (co-op terms)
- CCMEO
  - Sergey Samsonov, Khalid Omari (2014-2016)

MAJOR COLLABORATORS

- Governments/Crown Corporations
  - BC Oil and Gas Commission
  - BC Hydro
  - Alberta Energy Regulator
  - Yukon Geological Survey
  - Northwest Territories Geoscience Office
  - New Brunswick Department of Energy and Mines
  - Ministère des Ressources Naturelles du Québec
  - Hydro Québec
- Professional Organizations
  - Geoscience BC
  - New Brunswick Energy Institute
  - Canadian Association of Petroleum Producers
- Academia
  - McGill Univ., Univ. of Ottawa, Western Univ., Univ. of Calgary, Univ. of Alberta (Canada)
  - Univ. of Bristol (UK)

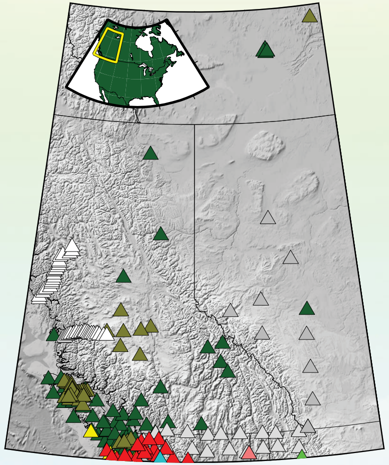
National Scope of NRCan's ISR Project

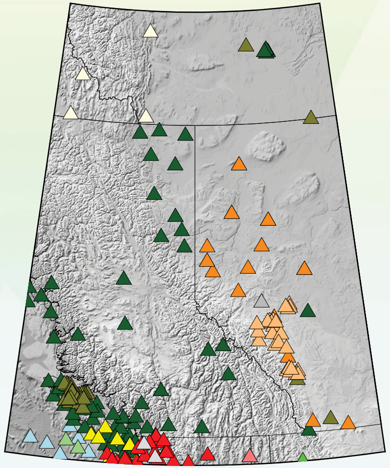


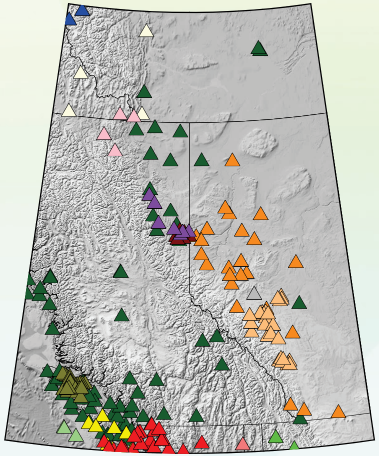
MAJOR ACHIEVEMENTS

- Enhanced regional seismicity monitoring for major shale gas basins in Canada

Western Canada (BC, AB, YT, NT)







Networks active during 2006

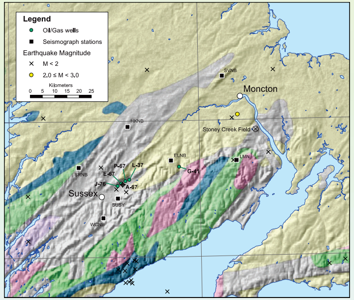
CN	MB	PB	PO
TA	US	UW	XU
XY	Y5	Political boundaries	

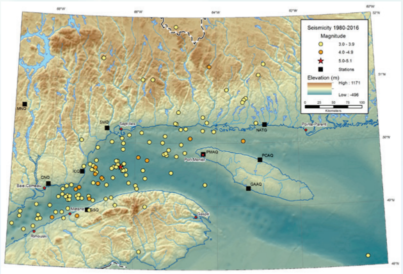
7D	CN	MB	NV
NY	PB	PO	RV
TA	TD	US	UW
Y5	Political boundaries		

tive during 2018

1E	7C	CN	MB
NV	NY	PB	PO
RV	TD	US	UW
XL	Y5	YO	
Political boundaries			

Eastern Canada (NB, QC)

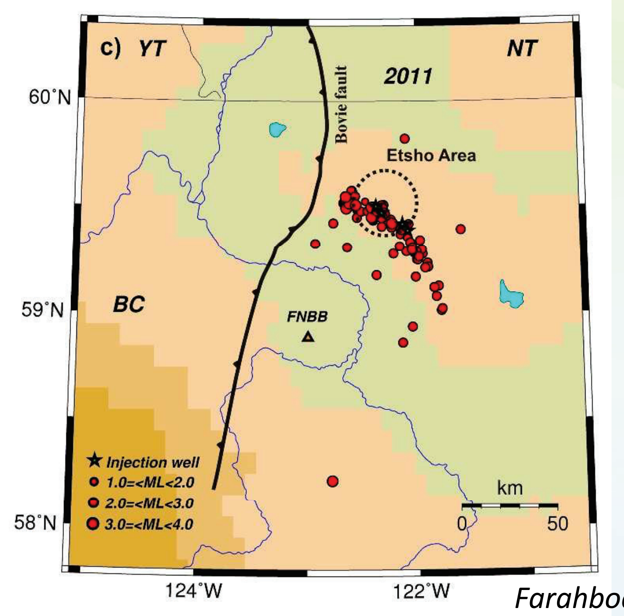




MAJOR ACHIEVEMENTS

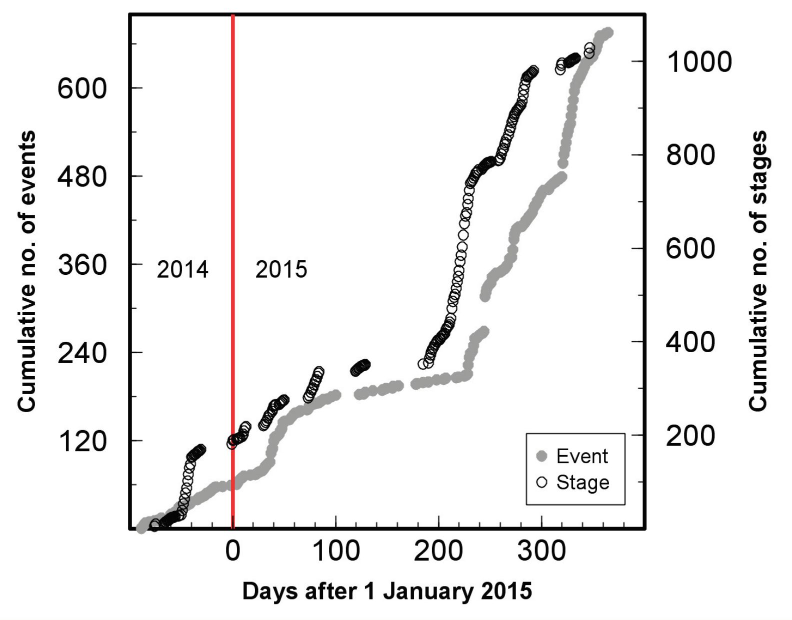
Establish scientific evidence for the link between hydraulic fracturing and induced earthquakes in Canada

Horn River Basin, NE BC



Farahbod et al. (2015a)

Montney Play, NE BC

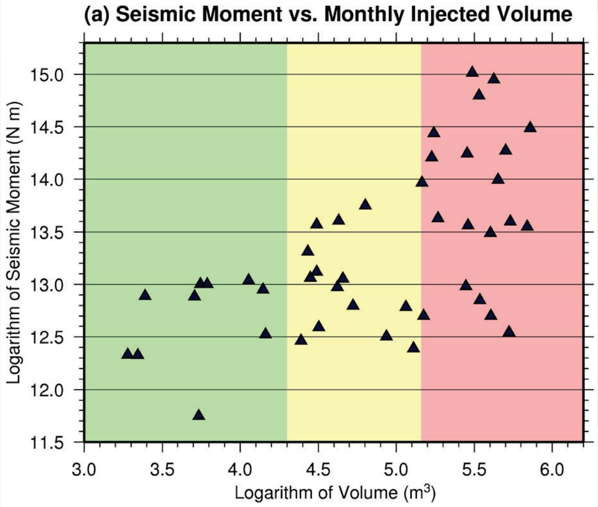


Mahani et al. (2017)

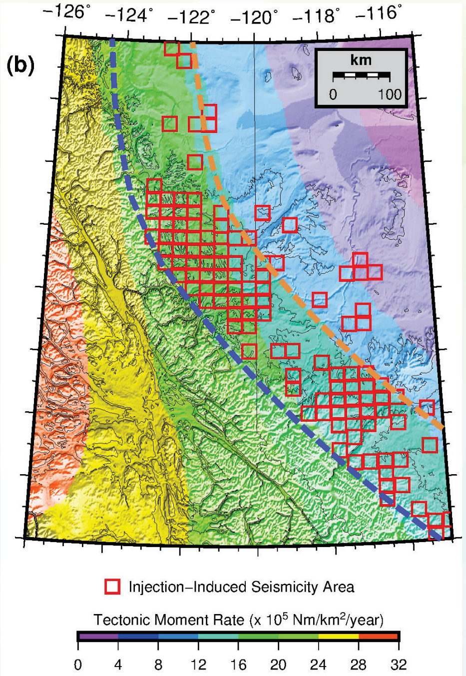
MAJOR ACHIEVEMENTS

Explore factors that control the seismogenesis of induced earthquakes

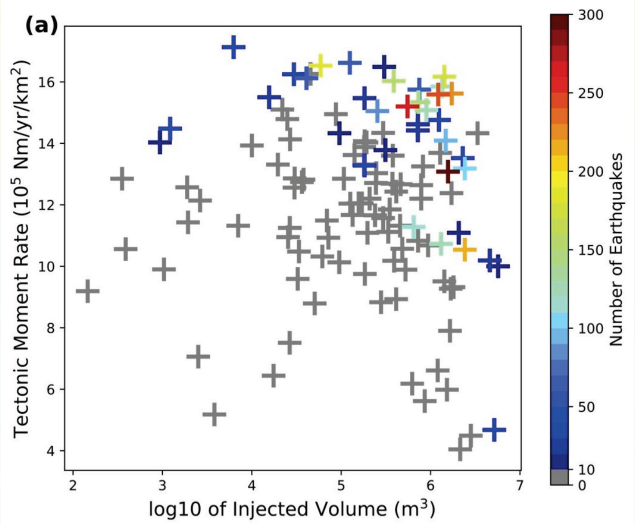
Injection Volume



Farahbod et al. (2015b)



Tectonic Strain Rate

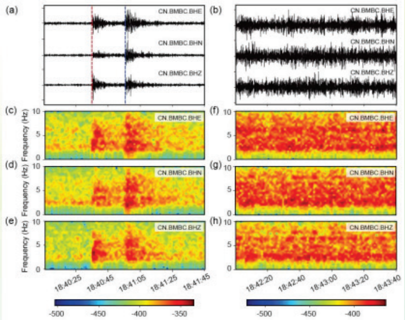


Kao et al. (2018)

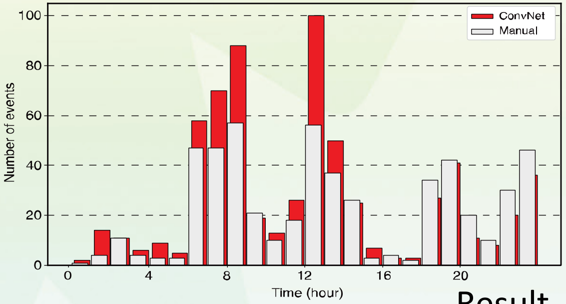
MAJOR ACHIEVEMENTS

Improved methodology/algorithm in detecting/locating small IIEs

Deep Convolutional Neural Network (ConvNet)



Input

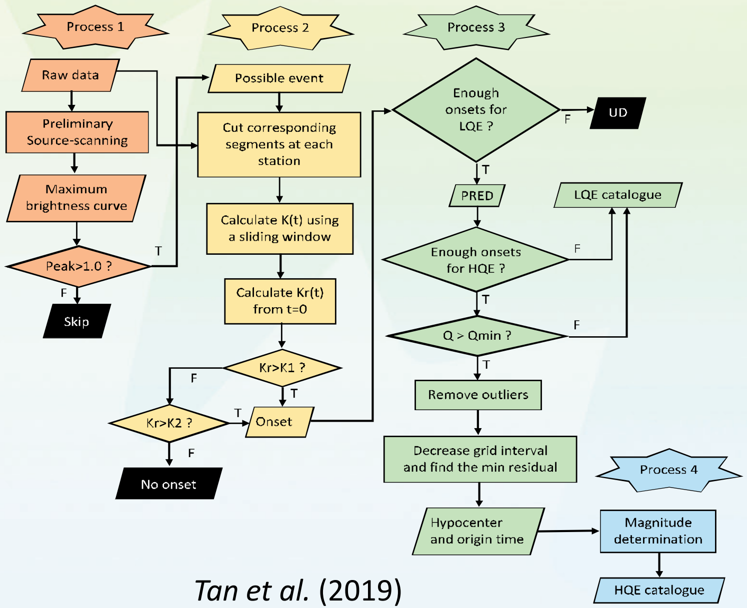


Result

Layer	Type	Kernel Size	Stride	Output
1	Input data	—	—	3 maps of 33 × 99 neurons
2	ConvReLU	5 × 7	—	16 maps of 29 × 93 neurons
3	Maxpool	1 × 2	(1, 2)	16 maps of 29 × 47 neurons
4	ConvReLU	5 × 5	—	16 maps of 25 × 43 neurons
5	Maxpool	1 × 2	(1, 2)	16 maps of 25 × 22 neurons
6	ConvReLU	3 × 3	—	16 maps of 23 × 20 neurons
7	Maxpool	2 × 2	(2, 2)	16 maps of 12 × 10 neurons
8	ConvReLU	3 × 3	—	16 maps of 10 × 8 neurons
9	Maxpool	2 × 2	(2, 2)	16 maps of 5 × 4 neurons
10	FC	—	—	320 neurons
11	FC	—	—	2 neurons

Dohkt et al. (2019)

Seismicity-Scanning Based on Navigated Automatic Phase-Picking (S-SNAP)



Tan et al. (2019)

MAJOR ACHIEVEMENTS

Contributions to improved regulations on the development of unconventional hydrocarbons

- 2014: New permit conditions for drilling and production operations in the Horn River Basin (BC Oil and Gas Commission).
- 2015: New regulation on induced seismicity in BC (Section 21.1, Drilling and Production Regulation, Oil and Gas Activities Act)
- 2015: Induced Seismicity Traffic Light Protocol (IS-TLP), Subsurface Order No. 2 (Alberta Energy Regulator)
- 2016: New permit conditions requiring ground motion monitoring within specified areas (BCOGC Industry Bulletin 2016-19).
- 2017: Amendments to the Drilling and Production Regulation (BCOGC Industry Bulletin 2017-10).
- 2017: Consulted by BC Auditor General's office on issues of induced seismicity in BC.
- 2018: New order on monitoring, mitigation and reporting requirements for permit holders in the Kiskatinaw area (BCOGC Special Project Order 18-19-001).
- 2018: Participate BC Scientific Hydraulic Fracturing Review Panel proceedings.

CONTACT INFORMATION

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Science-based dredge disposal guidelines for port expansion

Directives fondées sur la science afin de disposer des dragages lors d’expansion portuaire




Gwyn Lintern

May 21st, 2019

Canada

ABSTRACT

Coastal energy infrastructure and other port projects require dredging to make the sites suitable for construction. On the west coast of Canada, dredging has been required at many recently proposed port sites. Environment and Climate Change Canada (ECCC) licences disposal of material at several large disposal-at-sea (DoS) sites on the coast. Proponents may also propose a new or temporary DoS site nearer to their development to save enormous shipping time and costs. Depending on the level of contamination of the sediment to be disposed, and the methods used, the regulation may require sediment to be disposed at either a dispersive or non-dispersive site. In the past several years, "guidelines for determining dispersivity" have been proposed by NRCan (Lintern)/EC scientists and stipulated to two proponents. The validity of the methodology is being tested. NRCan is part of a triparty Regional Ocean Disposal Advisory Committee that will investigate several aspects of dredge disposal on the coast, one of which is dispersivity of existing sites. NRCan is tasked with determining dispersivity at existing sites and with conducting sensitivity analysis of the variables used in the existing guidelines. This requires oceanographic mooring instrumentation, data analysis and modeling.

PROJECT MEMBERS

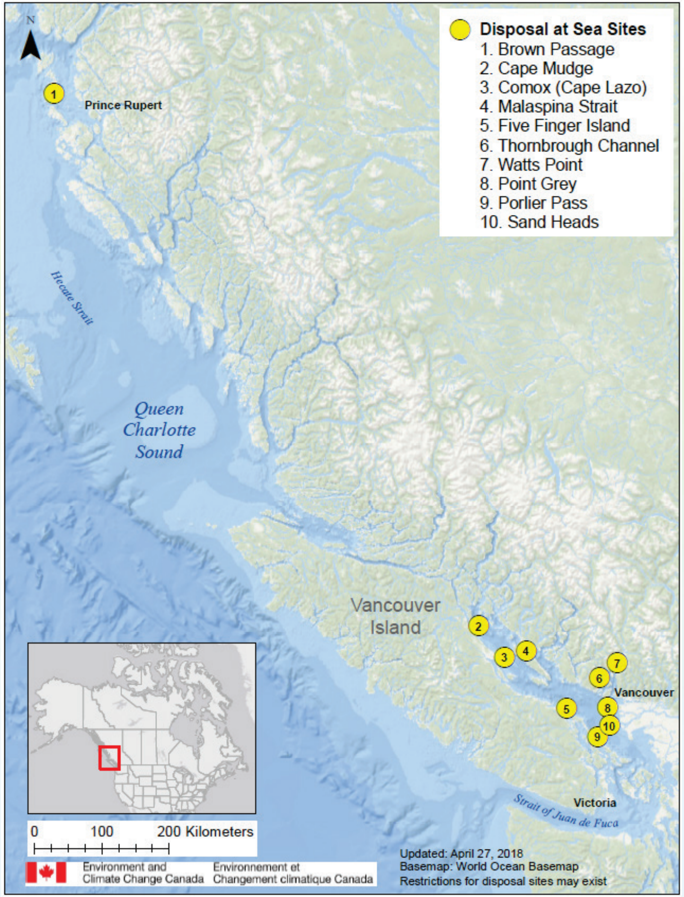
- Gwyn Lintern (GSC),
- Roanna Leung (ECCC)

Background

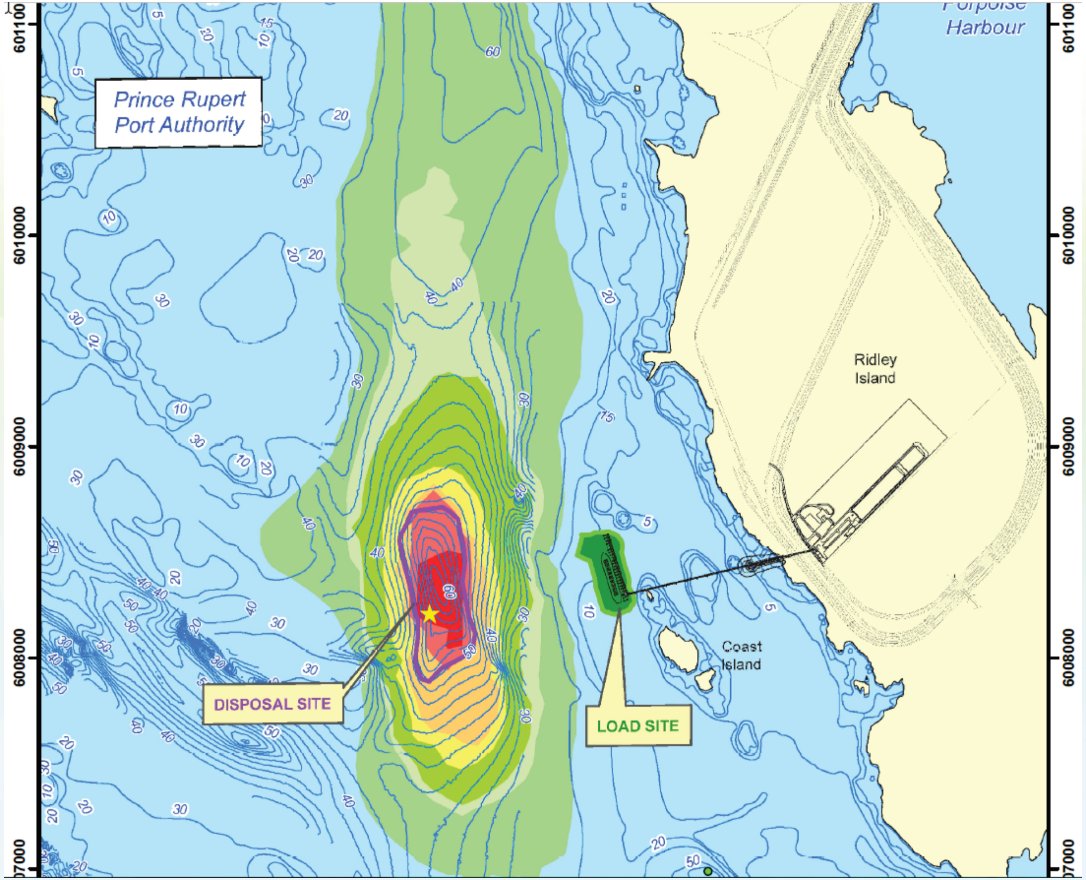
- Canada regulates Disposal at Sea (DAS) through a permit system under the *Canadian Environmental Protection Act 1999* (CEPA, 1999) and is required to conduct regular monitoring of DAS sites through *Schedule 6* of *CEPA*.
- Canada publishes results of monitoring activities in an annual compendium to fulfill its international obligation under the 1972 London Convention and its 1996 Protocol.
- A permit should require sites characteristics to be determined quantitatively, which would then set the criteria for what types of material can be dumped
- determine whether the proposed disposal site can be considered non-dispersive (use peak 1% bottom current speed <25 cm/s or other methods)

Issue

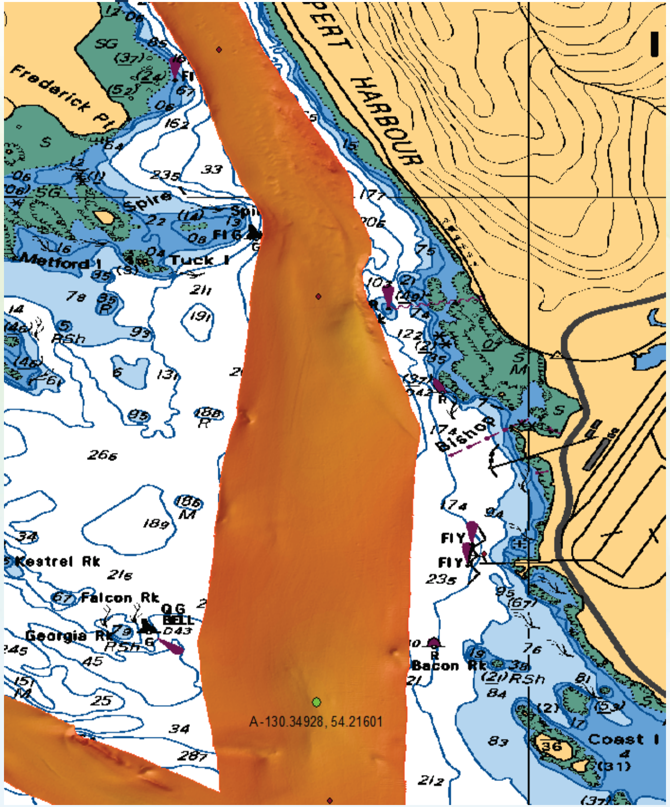
- Disposal sites few and far
- Transport is expensive
- Proponents are requesting new disposal sites.
- License requests (in EA's) vary in quality
- Guidelines are required



Example


Prince Rupert
Port Authority
Porpoise
Harbour
Ridley
Island
Coast
Island
DISPOSAL SITE
LOAD SITE

Dispersive or non-dispersive?



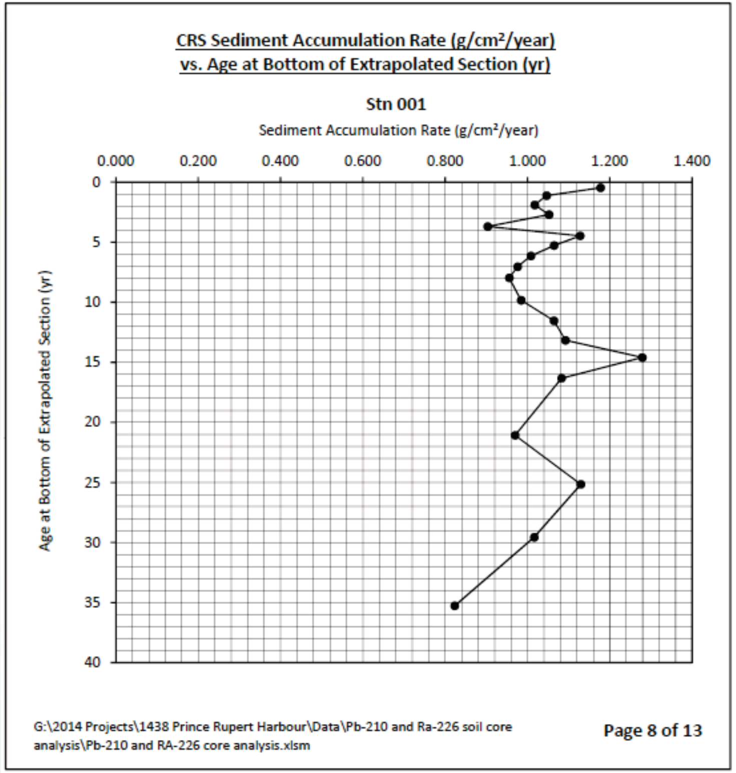
← Bathymetry

Backscatter →

Darker = finer grained

Dispersive vs non-dispersive?

Coring and Pb210 and Ra226 isotope analysis



Dispersive or non-dispersive?

Hydrodynamic modeling

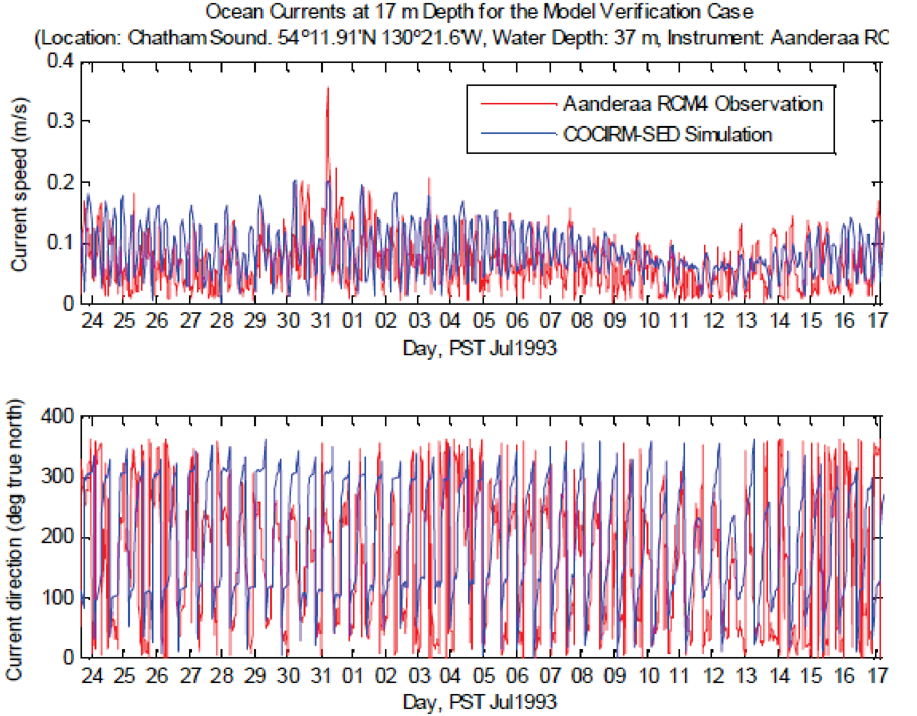


Figure 5: Verification modeled and measured ocean currents at 17 m depth near disposal site 1.

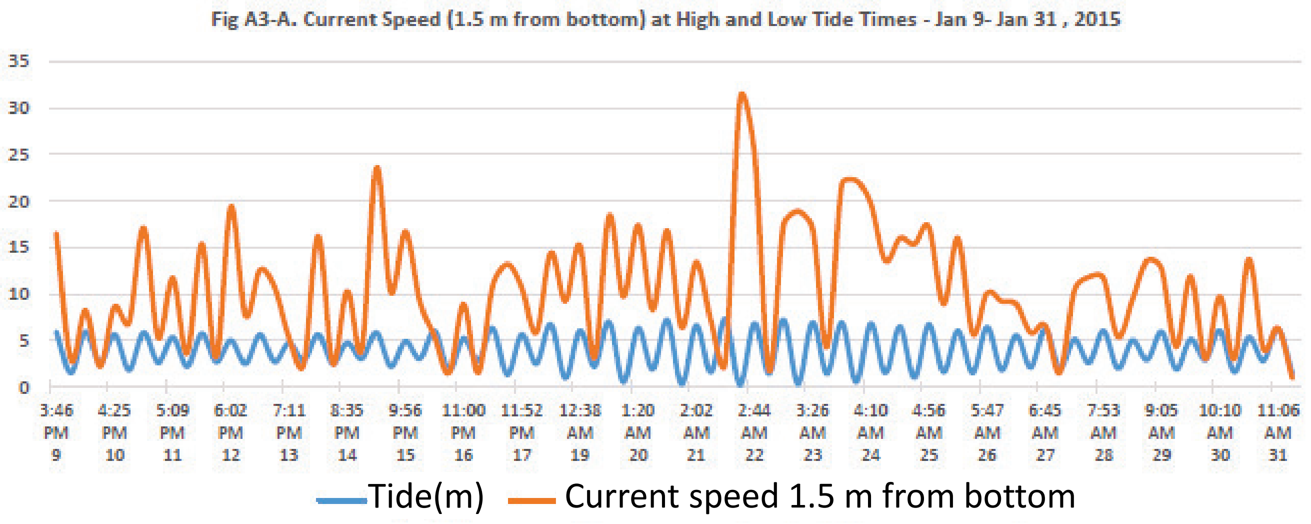
Dispersive or non-dispersive?

Actual measurements of currents and sediment

Dispersive or non-dispersive?

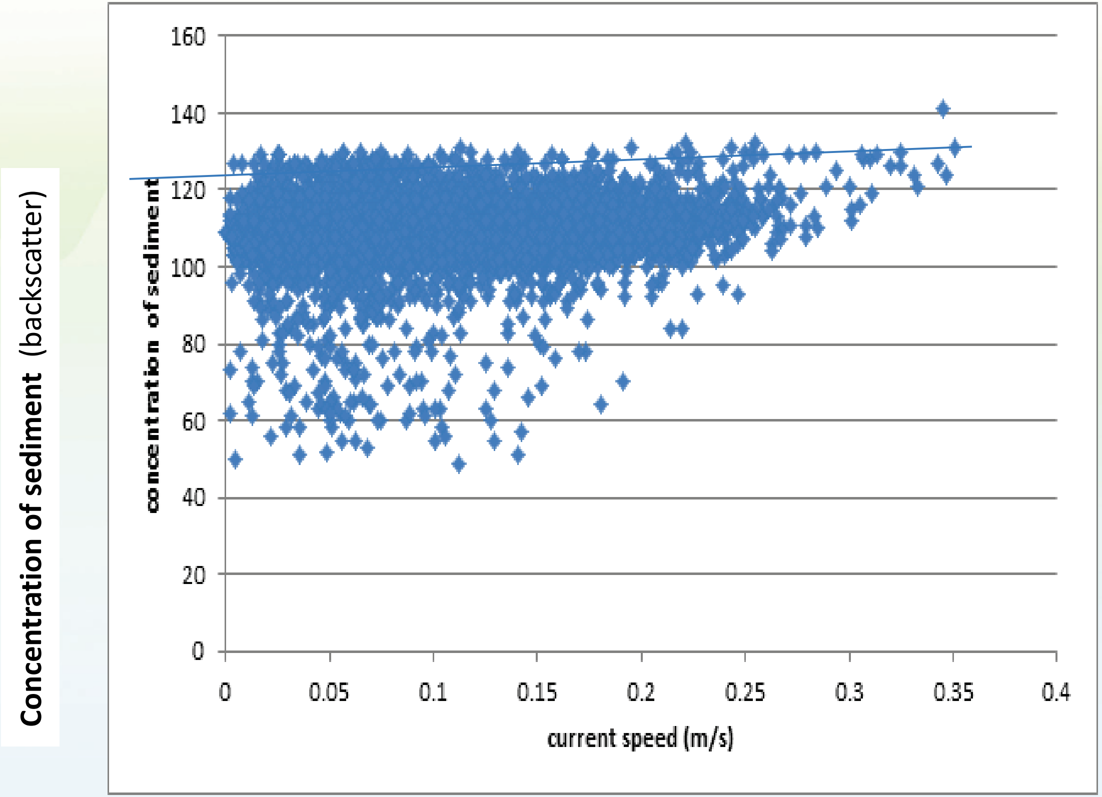
Testing:

Peak 1% bottom current speed <25 cm/s



Dispersive or non-dispersive?

Optical or acoustic backscatter of sediment in water



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Acting Program manager: Eric.Boisvert@Canada.ca
Geoscience Planning Officer: Nathalie.Jacob@Canada.ca

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Shale Gas – Groundwater project leader: Christine.Rivard@Canada.ca
SOURCES project leader: MartineM.Savard@Canada.ca
Fluid Storage and Circulation in Carbonates project leader: Denis.Lavoie@Canada.ca
Mercury in the environment project leader: Peter.Outridge@Canada.ca
Carbone Capture and Storage project leader: Donald.White@Canada.ca
Shale Gas –Induced Seismicity project leader: Honn.Kao@Canada.ca
Dredge disposal at sea project leader: Gwyn.Lintern@Canada.ca




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