



Natural Resources  
Canada

Ressources naturelles  
Canada



**Geological Survey of Canada  
Scientific Presentation 92**

**Looking back at a decade of large and innovative  
geological survey programs in Canada, 2008–2018**

**D. Lebel**

**2018**

## Presented at: Resources for Future Generations, Vancouver, British Columbia

Date presented: June 20, 2018

For information regarding reproduction rights, contact Natural Resources Canada at [nrcan.copyrightdroitdauteur.nrcan@canada.ca](mailto:nrcan.copyrightdroitdauteur.nrcan@canada.ca).

Permanent link: <https://doi.org/10.4095/311189>

This publication is available for free download through GEOSCAN (<http://geoscan.nrcan.gc.ca/>).

### Recommended citation

Lebel, D., 2018. Looking back at a decade of large and innovative geological survey programs in Canada, 2008–2018; Geological Survey of Canada, Scientific Presentation 92, 28 p. <https://doi.org/10.4095/311189>

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



# Challenge: What should be next?

- What are the lessons to be learned from the Geological Survey of Canada’s experience with large, policy-driven **public geoscience** programs?
- What public geoscience is needed **to maximise national impact** through a rapidly changing social-economic and policy landscape?
- Where do we invest to **balance the needs** of the **present** with the needs of **future generations**?



Transborder relationships



Regional concerns



Participatory democracy



Earth: Economically Productive and Healthy



Clear, focused international policy

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018

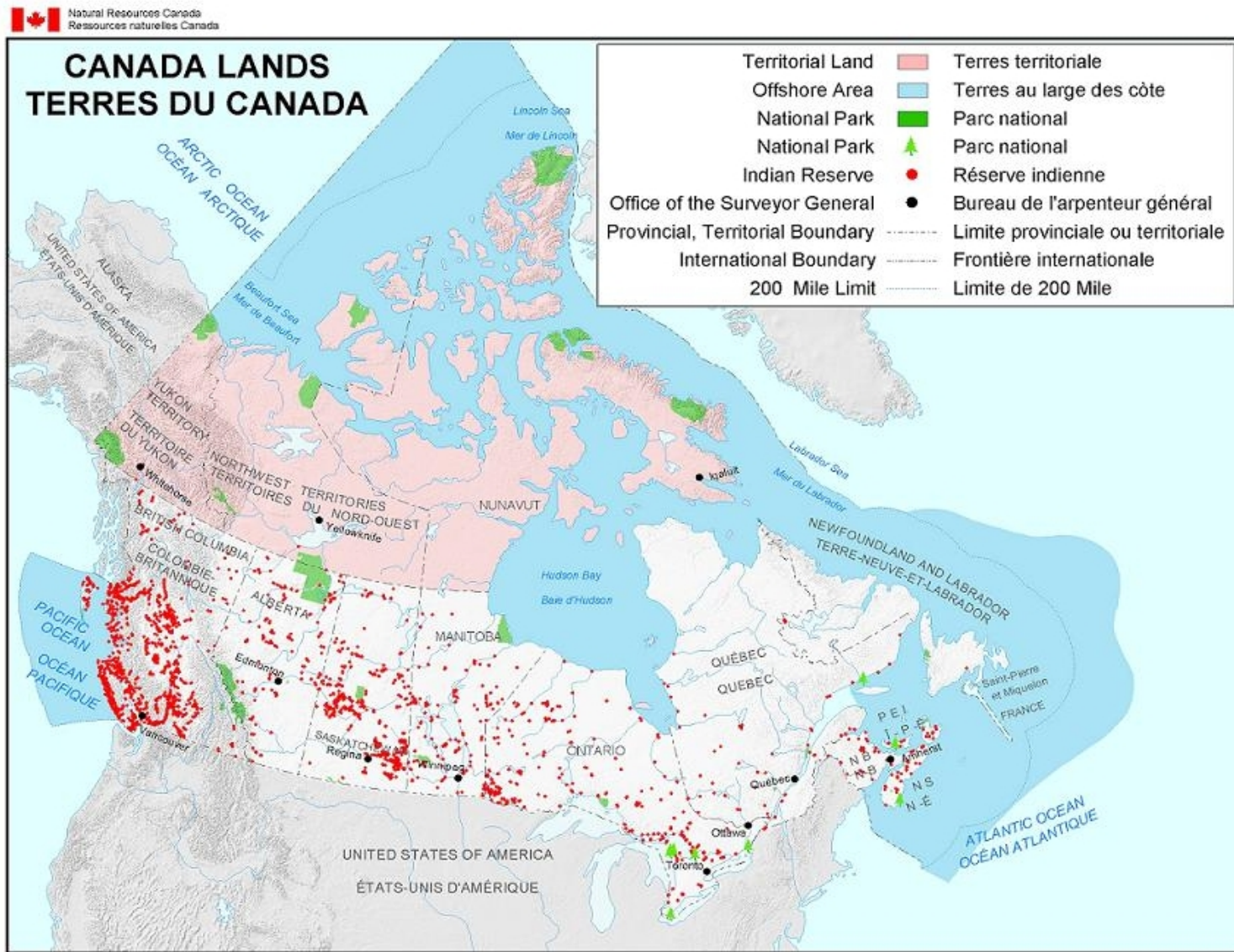


Natural Resources  
Canada

Ressources naturelles  
Canada



# Canada's challenges: ~17 million km<sup>2</sup> of geography <sup>4</sup>



## Governance

- A diverse geography and land regime:
  - Federal lands, 10 Provinces, three territories
  - Since 1970's, >800,000 km<sup>2</sup> of land have come under the direct control of Aboriginal groups through the comprehensive claims process

## Ocean estate landmass

- ~7 million km<sup>2</sup>
- >1.5 million km<sup>2</sup> claimable extended continental shelf under UNCLOS ~0.9 million km<sup>2</sup> of fresh water

*NRCan is currently delivering on the largest land reform period in the history of Canada since the settlement of the west - through contribution to Aboriginal Land Claims, First Nation Self-Government/Land Management and territorial devolution Initiatives*

Canada



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

# Canada: True North

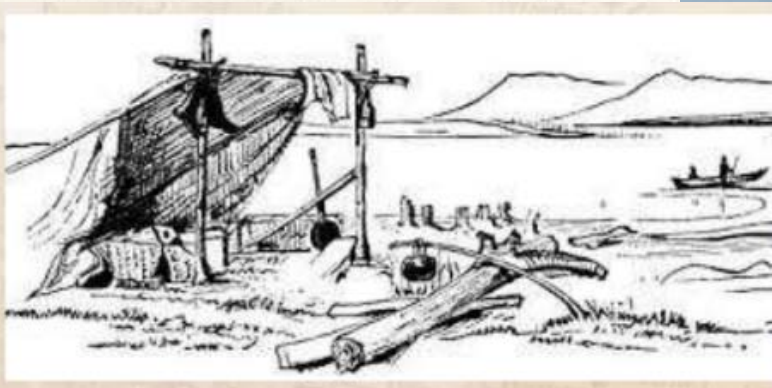


# Canada's geology is one of the pillars of its prosperity...

...but understanding the geology of ~17 million km<sup>2</sup> of territory is a never ending task.  
In less than 200 years Canada has evolved from...

**from....**

**to...**



William Logan, 1843 expedition to Gaspé, looking for coal to propel Canada's industrial revolution...

...the thriving economy and cities of 21<sup>st</sup> Century Canada, and second best mining exploration destination in the world, with majority (57%) of the global mining financings done on Toronto and Vancouver Stock Exchanges in 2016



Today Canada ranks in the top five countries in the global production of 13 major minerals and metals:

- First in potash
- Second in uranium, nickel and niobium
- Third in cobalt, aluminum and platinum group metals
- Fourth in salt, sulphur and tungsten
- Fifth in diamonds, graphite and gold

And is the sixth largest producer of oil at 4Mbl/d, third largest reserves in the world

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources  
Canada

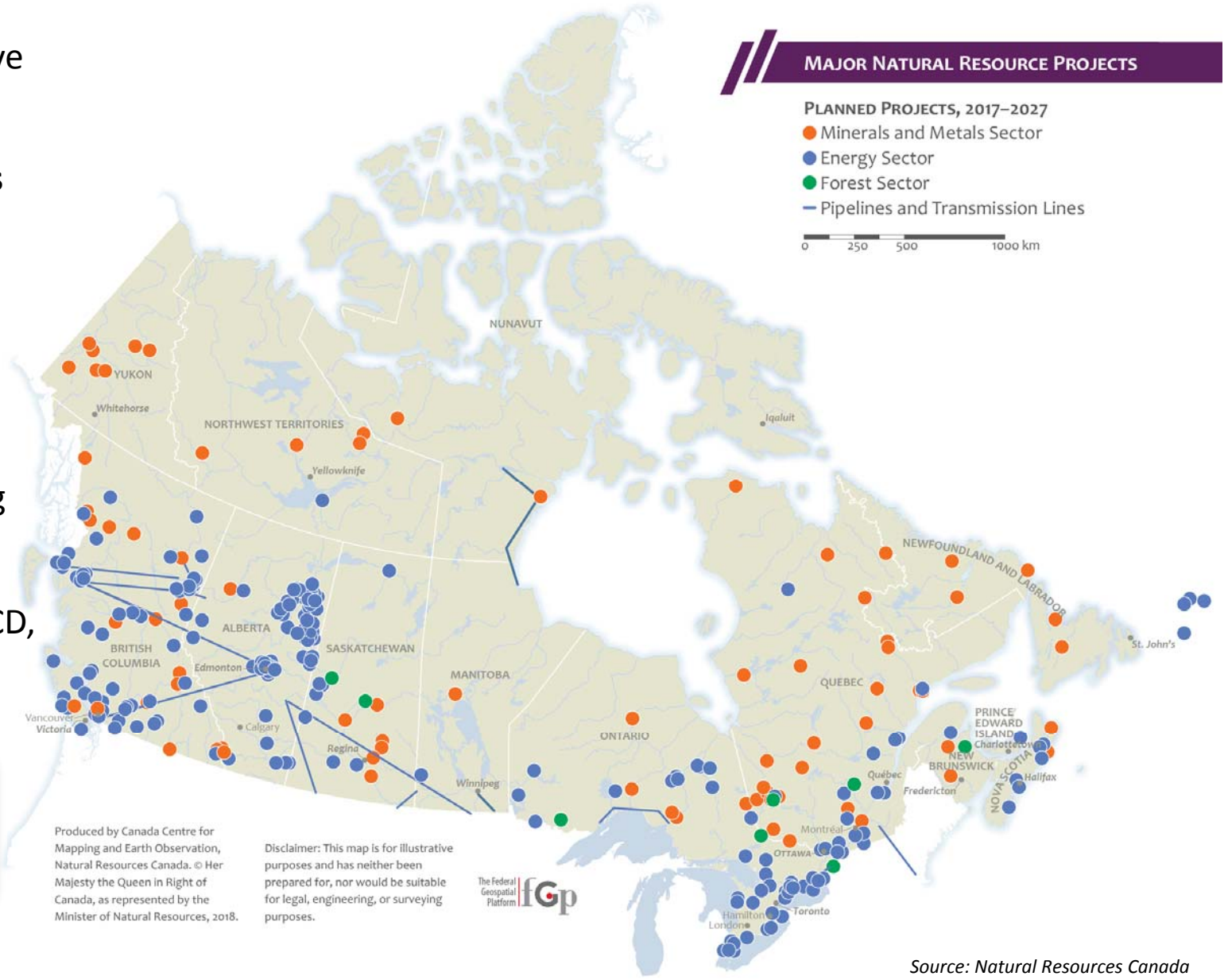
Ressources naturelles  
Canada

Canada

# Canada has world class natural resource assets...

-  **3<sup>rd</sup> largest oil reserves** globally, with extensive infrastructure in place
-  Some of the world's **richest natural gas wells**
-  **Highest-grade uranium** deposits globally
-  **Rich polymetallic deposits** (e.g., nickel, platinum group metals, and gold)
-  **9% of the world's forests**, with world-leading sustainable management certification
-  **7th lowest industrial electricity prices** in OECD, driven primarily by large hydro capacity

 **470 major projects under construction or planned over next 10 years: \$648B in potential investment**



# The Geological Survey of Canada and its Provincial and Territorial Partners

As an integral part of the Department of Natural Resources' Lands and Minerals Sector, the GSC is Canada's national geoscience research organization.

Canada has a highly successful and complementary system of Federal/Provincial/Territorial Geological survey organisations

Its mission is to provide authoritative geoscience knowledge to:

- inform the stewardship of Canada's onshore and offshore lands;
- sustain responsible resource development for future generations; and,
- keep Canadians safe from natural hazards and related risks.



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



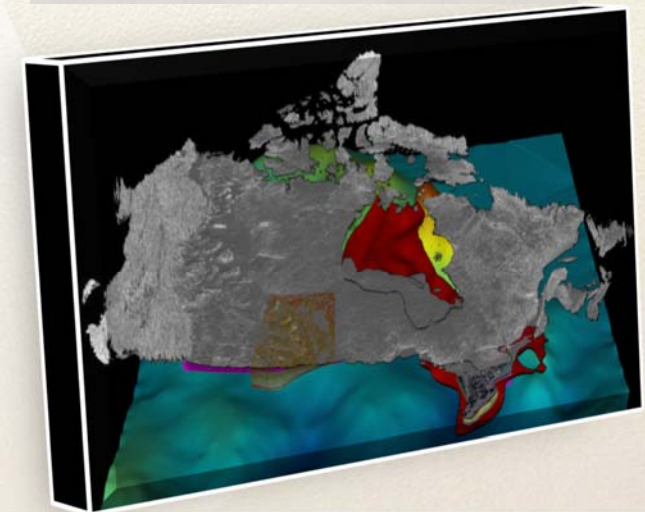
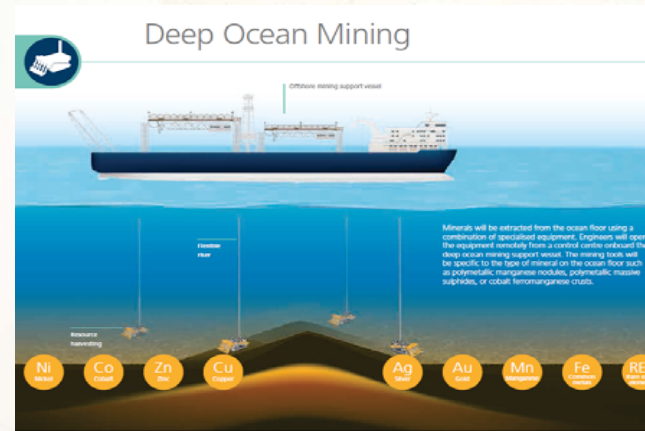
# The GSC has undergone many changes; however, its primary role has remained unchanged...

“**Make a full and scientific examination and survey of the geological structure and mineralogy of Canada**”

Changing societal needs and technologies transform how we understand and interact with the world.

These changes enable the GSC to continually reinvent itself and remain relevant to successive generations of Canadians.

*From boots on the ground, to eyes in the sky, to big data and algorithms on the web, to enabling the national geoscience ecosystem, to developing cutting edge expertise to advise decision makers...*



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

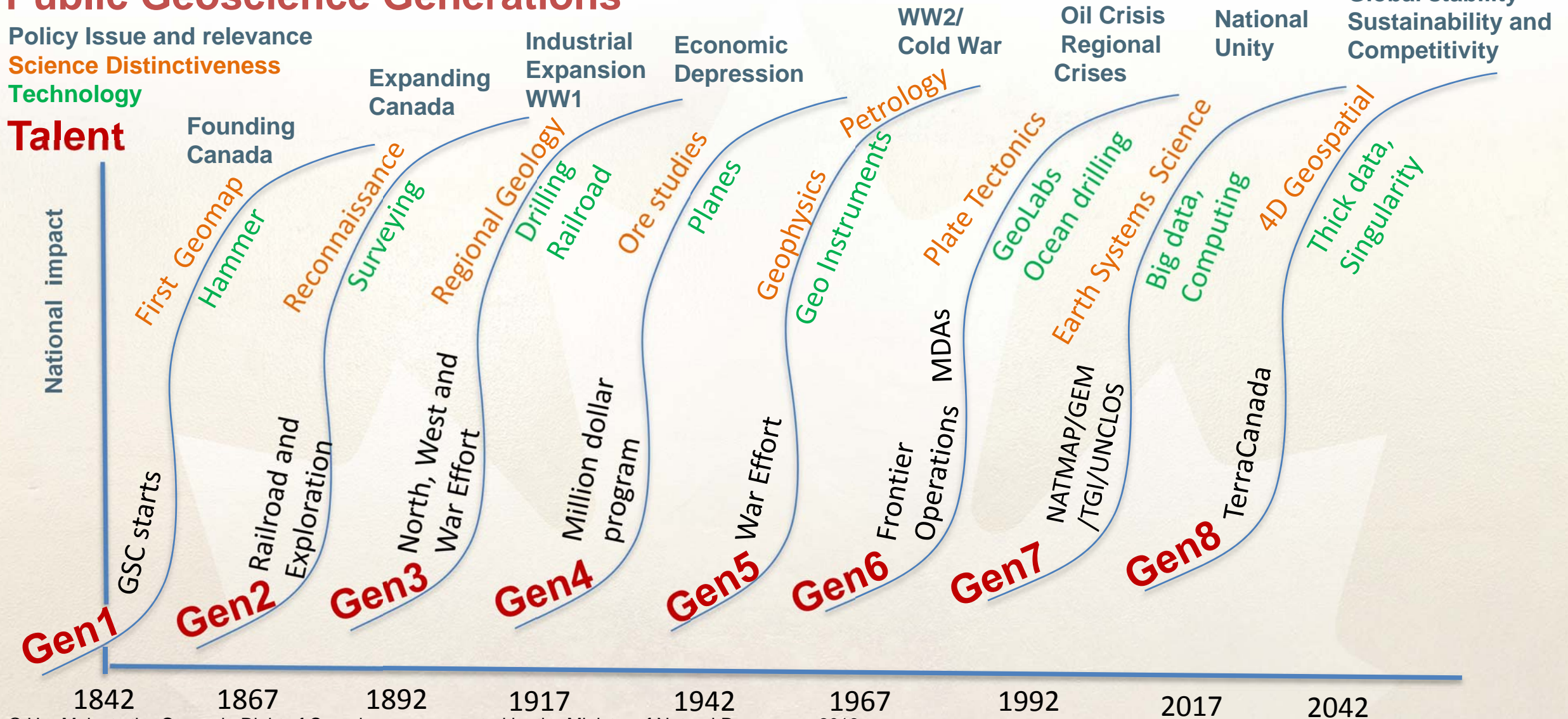
# Public Geoscience Generations

Policy Issue and relevance

Science Distinctiveness

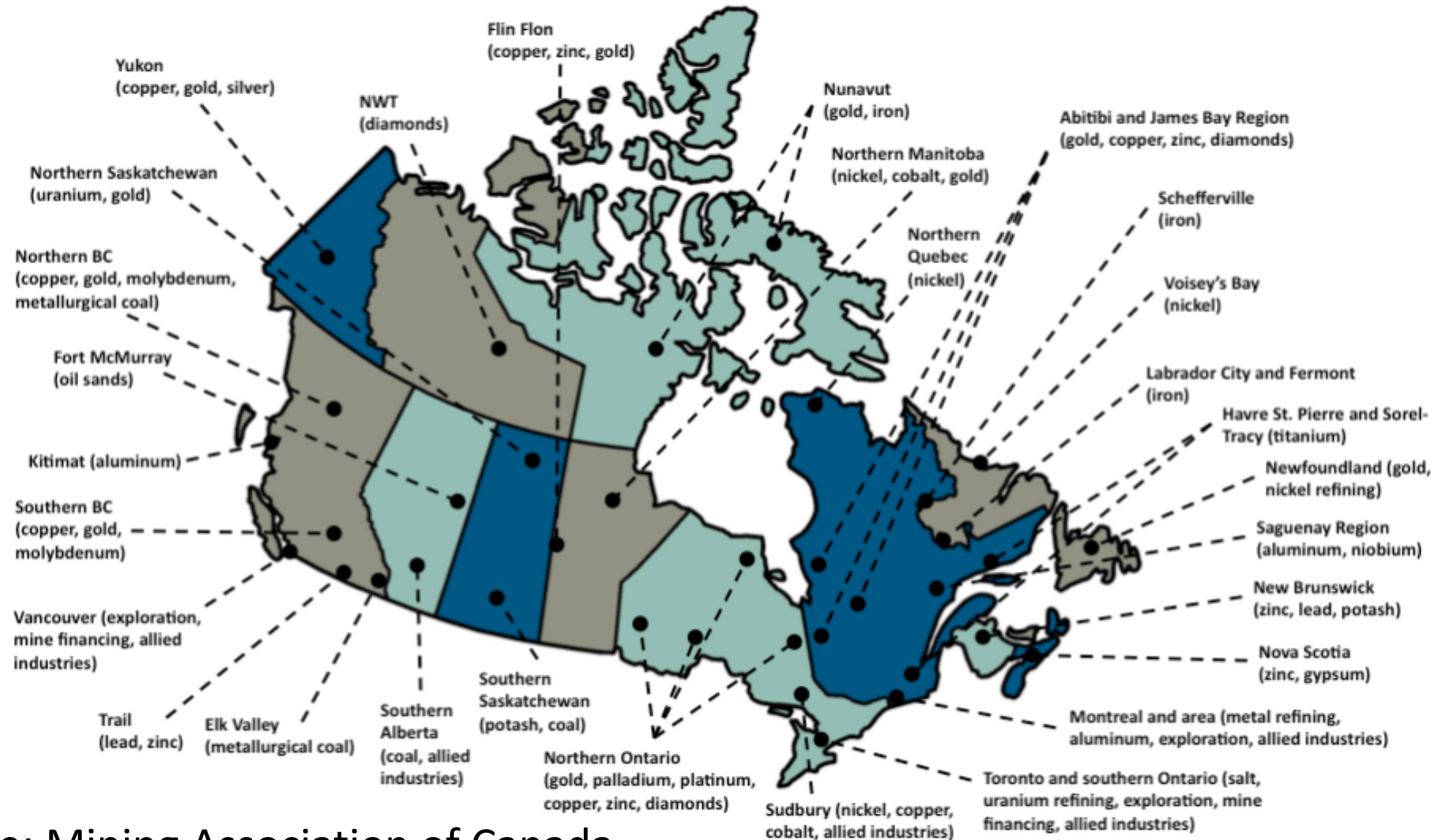
Technology

Talent



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018

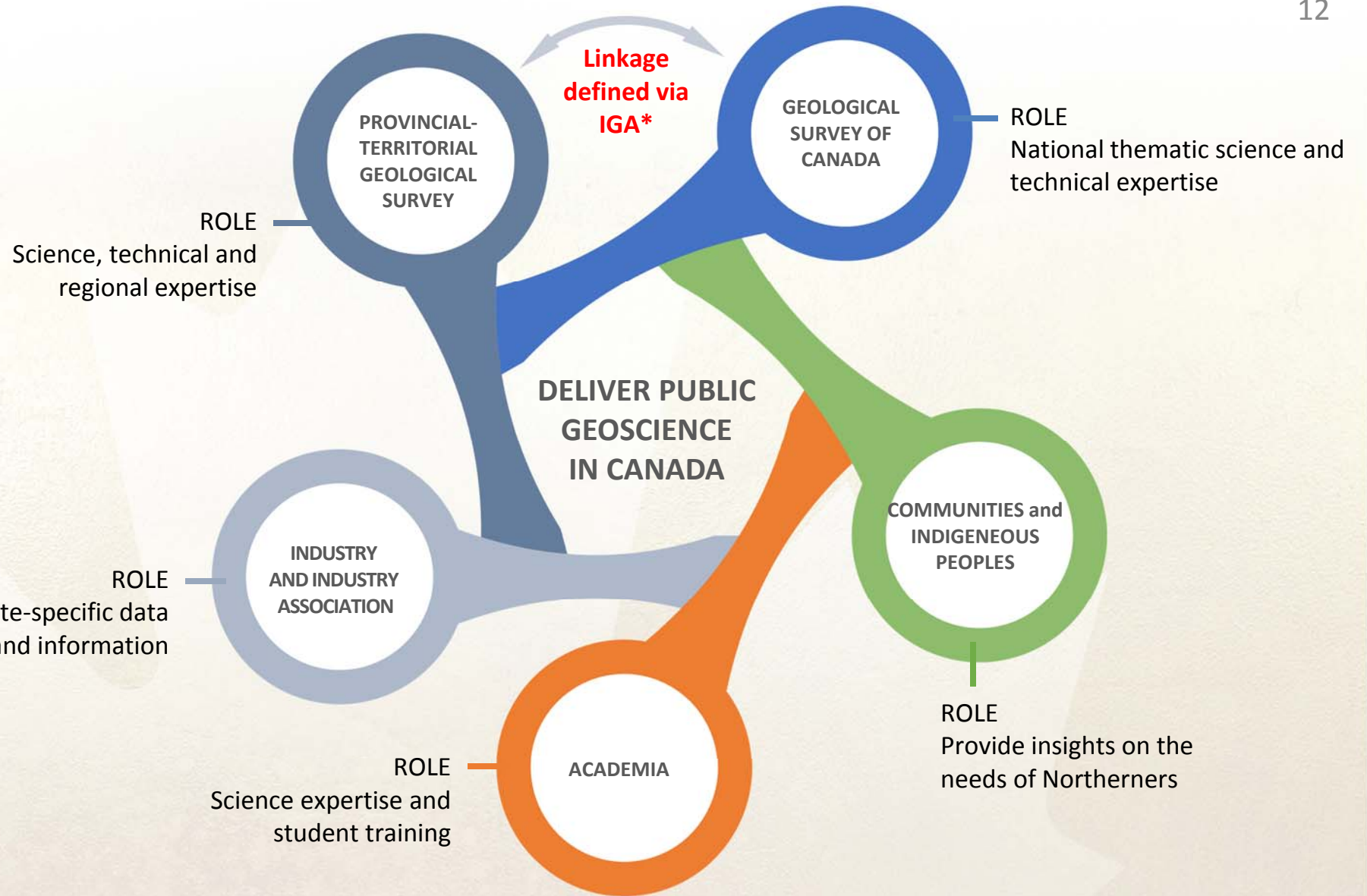
# Canada's mineral potential requires continued public geoscience to be unlocked through generations



Reference: Mining Association of Canada

# Geoscience Ecosystem in Canada

\*The **Intergovernmental Geoscience Accord (IGA)** defines the complementary roles of Canada's geological surveys, as well as mechanisms for cooperation and collaboration



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources Canada

Ressources naturelles Canada



# 2001 to 2018: Public Geoscience Gen7 priorities

**Mission:** “Provide public geoscience knowledge to sustain the exploration effectiveness and international competitiveness of the mineral and energy sectors, inform the stewardship of its onshore and offshore lands, and increase the safety and security of Canadians”

*Geological Survey of Canada  
Strategic Plan 2013-2018*

## PRIORITY 1. Unlocking Canada's Resource Potential Through Geoscience

Geo-mapping for Energy and Minerals (GEM-2)

Targeted Geoscience Initiative (TGI-5)

Geoscience for New Energy Supply (GNES)

Canada's Extended Continental Shelf Program (UNCLOS)

## PRIORITY 2. Environmental Geoscience for Responsible Resource Development

Environmental Geoscience Studies & Assessments

Climate Change Geoscience Program

Groundwater Geoscience Program

## PRIORITY 3. Geoscience for Public Safety and Risk Reduction

Public Safety Geoscience

Canadian Hazard Information Service (CHIS)

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018

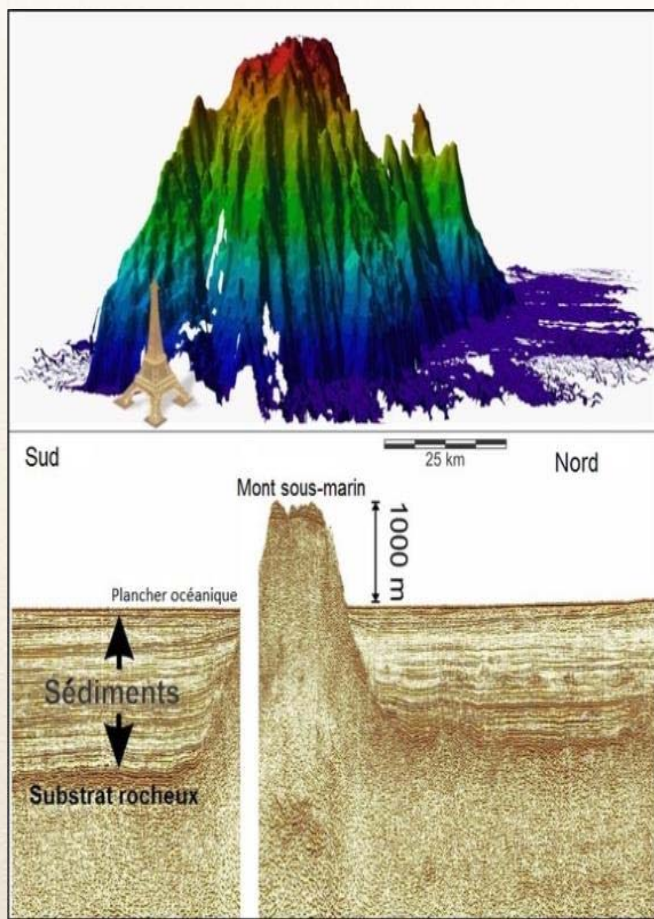


Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

# Public Geoscience is fundamental for Sovereignty United Nations Convention on the Law of the Sea (UNCLOS)



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources  
Canada

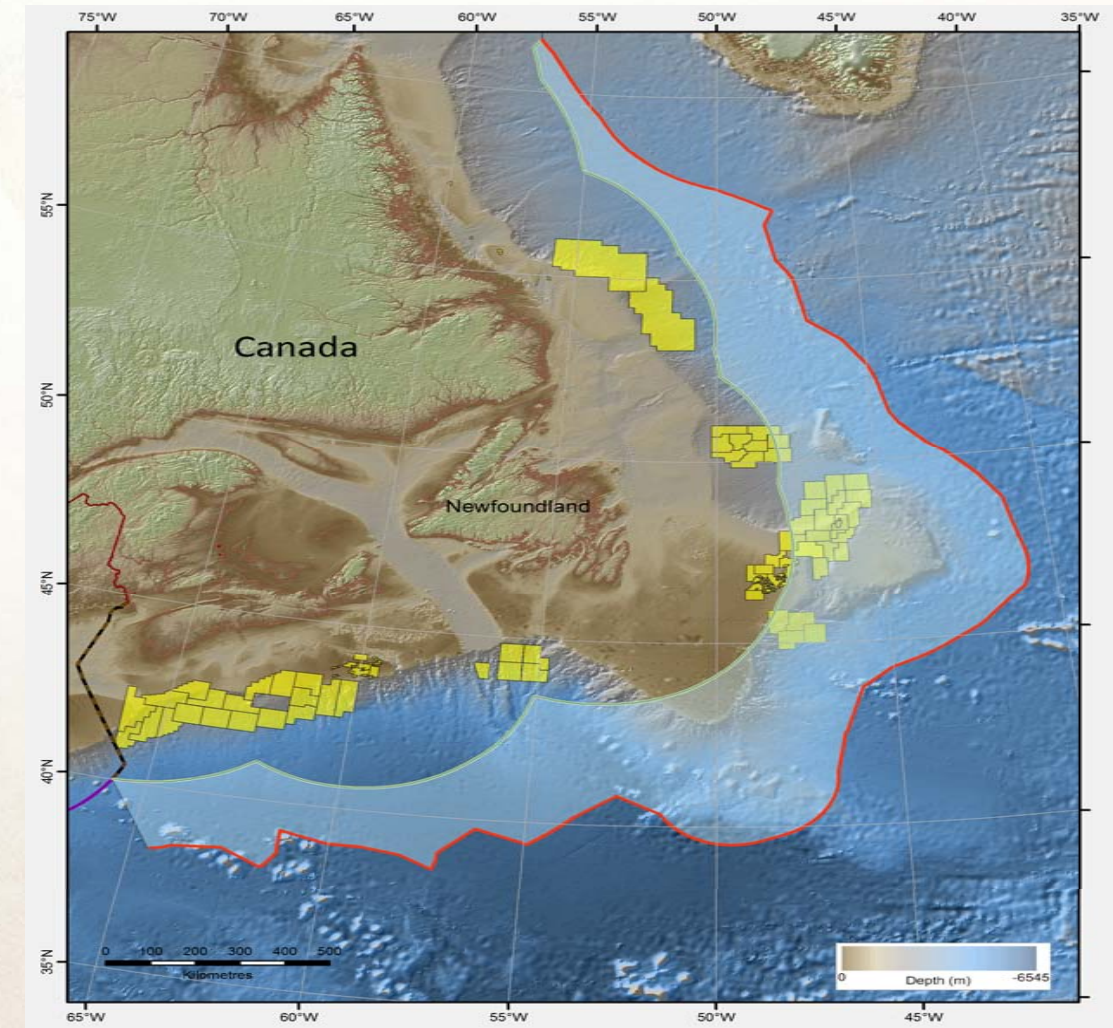
Ressources naturelles  
Canada

Canada

# Atlantic Offshore:

## Public Geoscience multiplies investment returns

- **2013:** Submission filed with the United Nations
- **2018:** Detailed legal and technical presentation to the UN Commission on the Limits of the Continental Shelf
- Adds **1.2 million square kilometers** to Canada's offshore landmass on the Scotian Shelf, Grand Banks and Labrador Sea
- Offshore investments driven by Public Geoscience: Oil/gas lease blocks (yellow) inside and outside 200 nM limit, within Extended shelf
- Statoil Flemish Cap discovery
- 1:100 return investment on Geology Play Fairway analysis in Nova Scotia offshore (2B investment)



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

# Arctic Ocean Submission

- Data acquisition with **icebreakers, ice camps and Autonomous Underwater Vehicles (AUVs)**
- **Surveys** with icebreakers conducted from **2007-2011** and **2014-2016**
- **International scientific collaboration.** Ten of 15 expeditions with **Denmark, Sweden or the United States**
- The program is on track to file Canada's submission with the UN **no later than 2019, defining Canada's last international boundary**
- Canada's extended continental shelf is expected to **exceed 1 million square kilometres of seafloor**



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada



# Public Geoscience for Land and Minerals

## REMOTE AND EXPANSIVE

In the “North”

Opportunity for **new** economic development

Need foundational knowledge of the land for communities to **make informed land-use decisions**

Possibility of significant near-surface deposits

Primary interest of “**Juniors**”

No infrastructure

In areas of **inadequate geoscience knowledge**

## Geo-Mapping for Energy and Minerals

## ACTIVE MINERAL REGIONS

National, but concentration in “**South**”

Need economic **sustainability** for mining-dependent communities

Land-use frameworks in place from current mining activities **leverage existing land-use decisions**

Near-surface deposits likely exploited

Primary interest to “**Miners**”

Well developed infrastructure

In **data-rich, well studied** mining camps

## Targeted Geoscience Initiative

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018

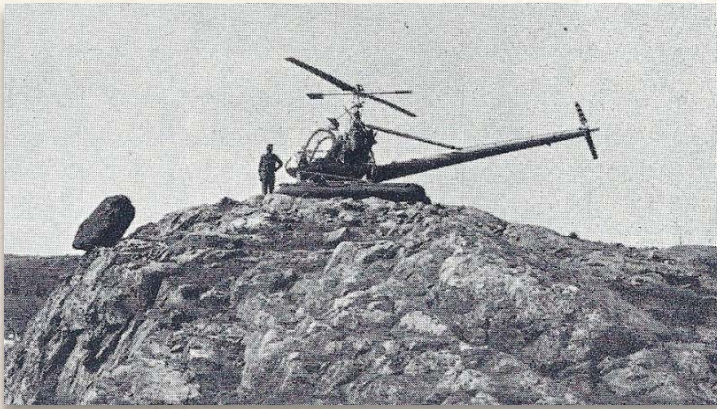
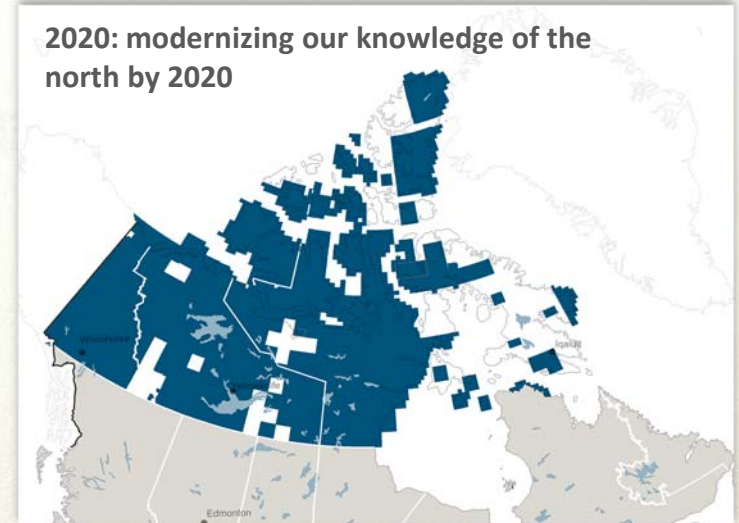
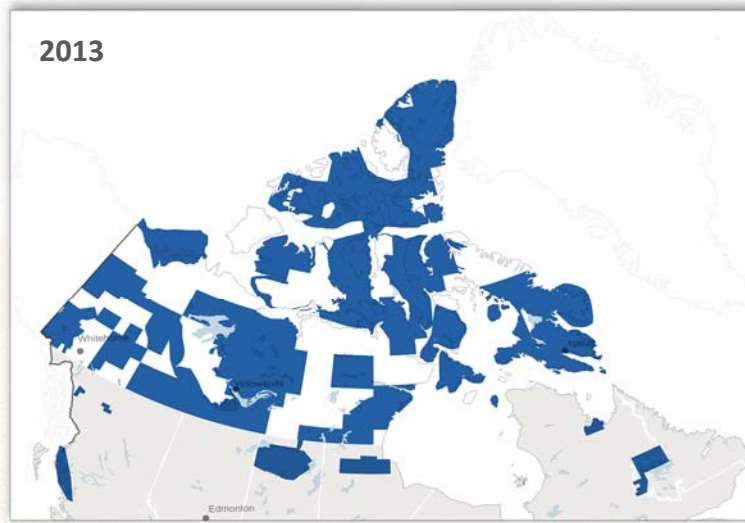
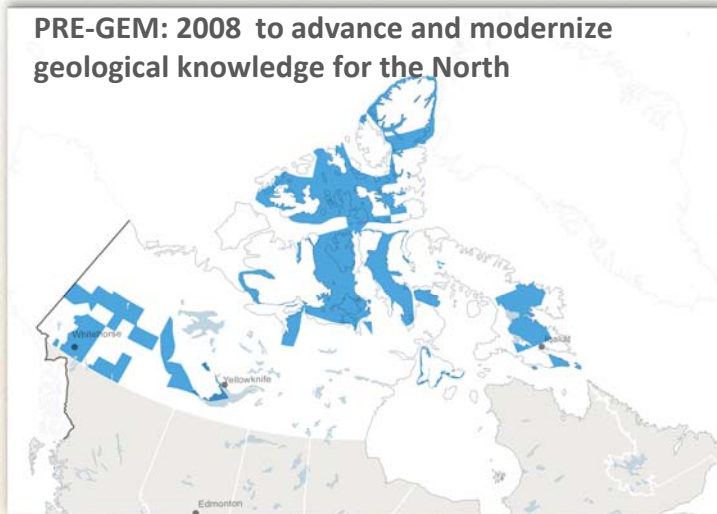


Natural Resources  
Canada

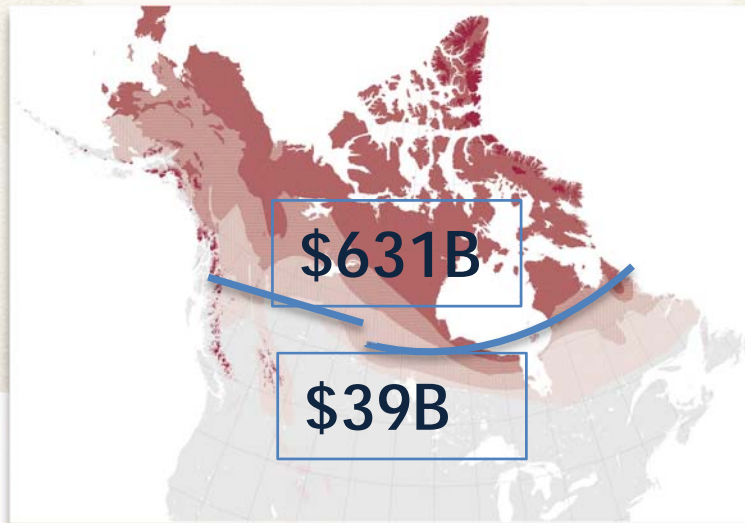
Ressources naturelles  
Canada

Canada

# Northern Geoscience Results and Potential<sup>18</sup>



Canada Geology in the North pre-2008  
 ...old data + old models = outdated conclusions



A significant driver for Territories and Canada's economy

- Mining is currently the primary private-sector driver for the territorial economies, accounting directly for 18 to 25% of their GDP.
- Mining accounts for approximately 15% of overall employment in the Territories, making a difference in the lives of Northerners.

*Analysis of data from Statistics Canada & Government of NWT*



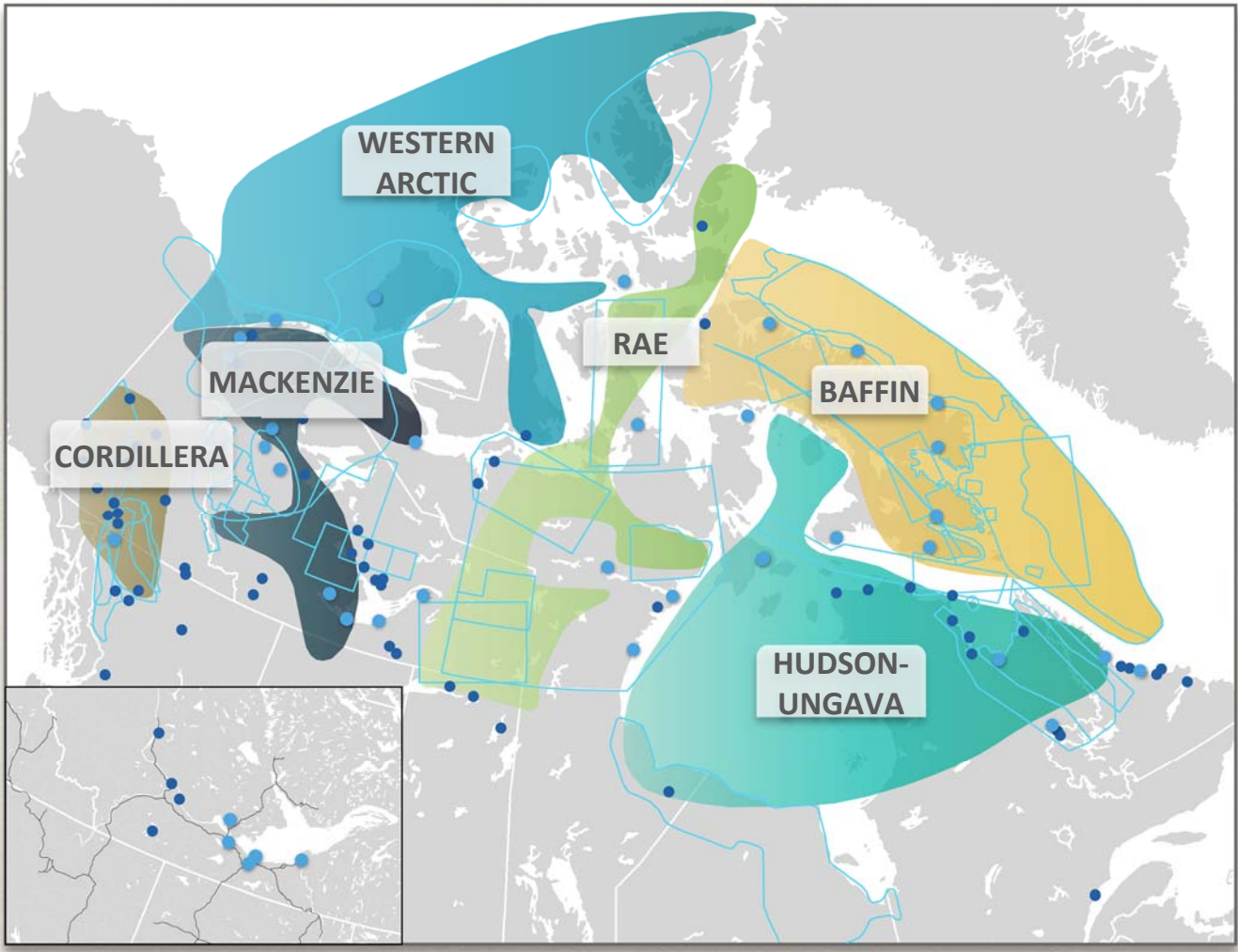
Natural Resources  
Canada

Ressources naturelles  
Canada

**12 years to map the north**

Canada

# Northern Geoscience for Northerners



Engage and plan field work



Culturally significant areas



Updating and filling knowledge gap



Local businesses and training opportunities



School visits



Northern perspectives are valued in all stages

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources Canada

Ressources naturelles Canada



# Northern Geoscience for Northern development 20

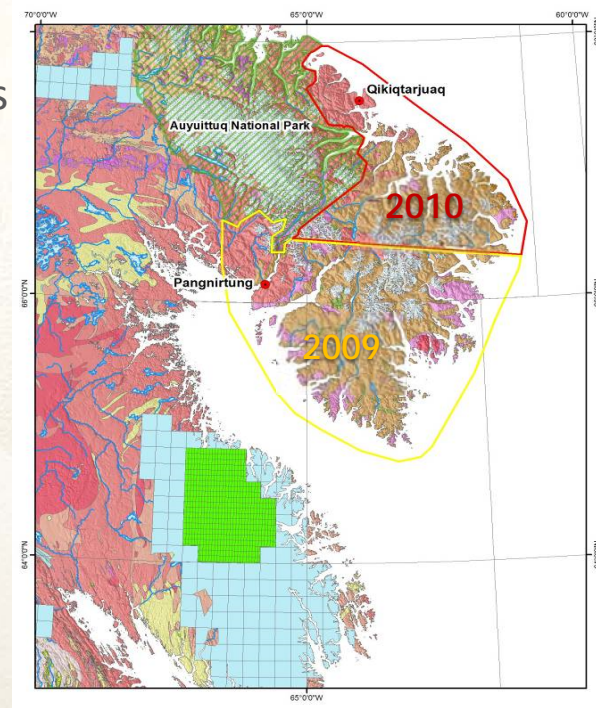
## DIAMONDS ARE FOREVER... IN CANADA

### RESEARCH

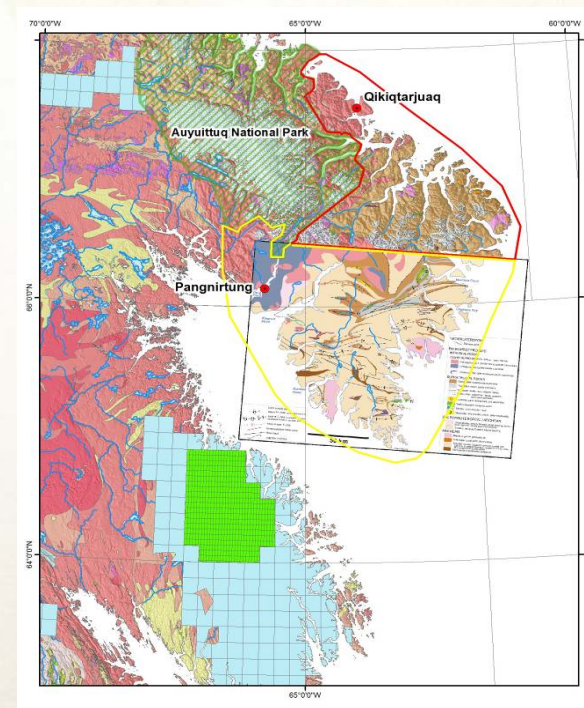
- GEM-2 early research activities focused on providing new scientific knowledge in the Cumberland Peninsula.

### RESULTS

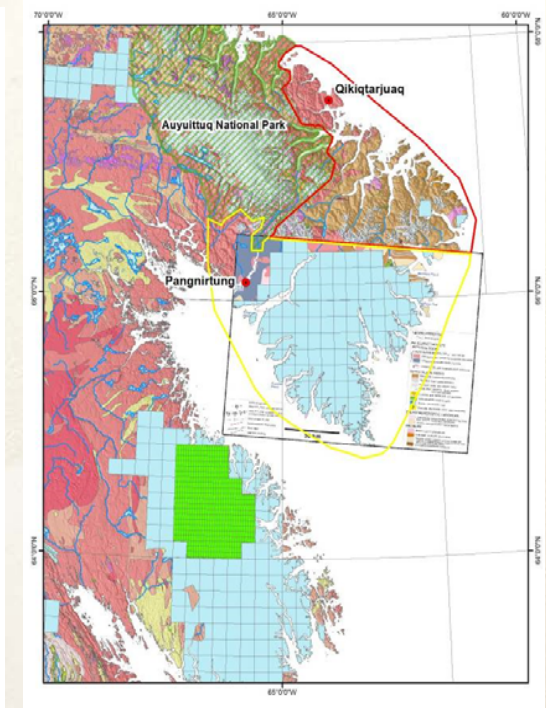
- Public Geoscience knowledge leads to new diamond exploration in that area.
- Reduced risk to industry.



Pre-GEM: 2008



New geoscience maps  
Fall '09



Prospecting permit  
coverage: Feb. '10

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018




Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

# Targeted Mineral Geoscience



 Natural Resources Canada  
Ressources naturelles Canada

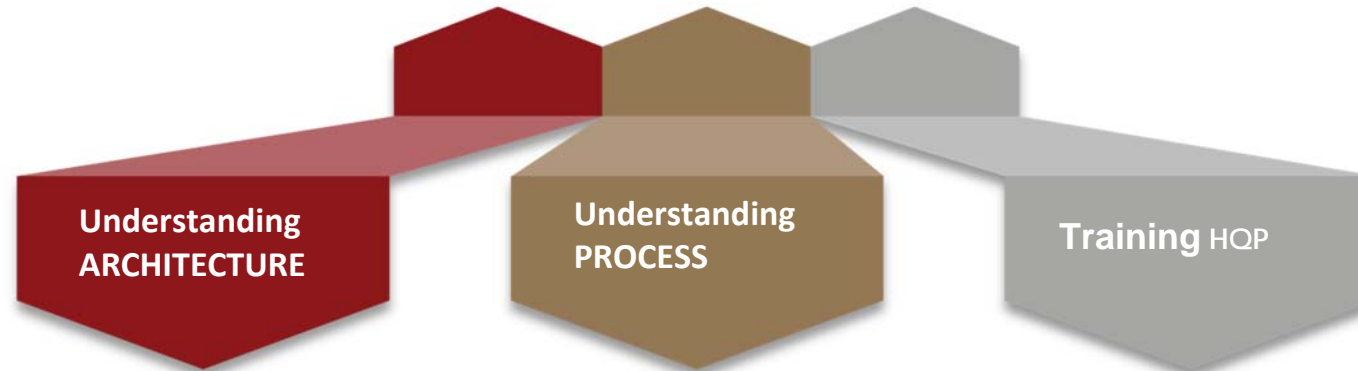
Reducing industry risk: new geoscience knowledge and tools to enable industry to adopt innovative exploration approaches.

Enhancing the efficiencies of discovery at depth in and around existing mining camps.

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018

# TGI generates geoscience knowledge to enhance effectiveness of deep exploration for Canada's key economic minerals

## KEY ELEMENTS OF THE TGI PROGRAM

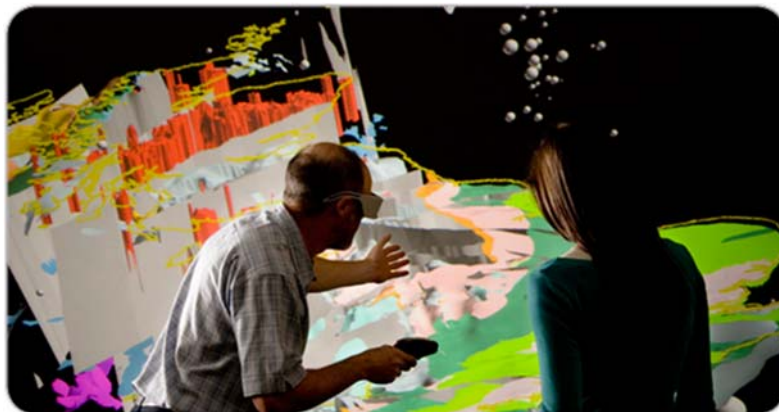


Develop new knowledge, methodologies and models that will enhance the exploration industry's ability to detect buried ore deposits

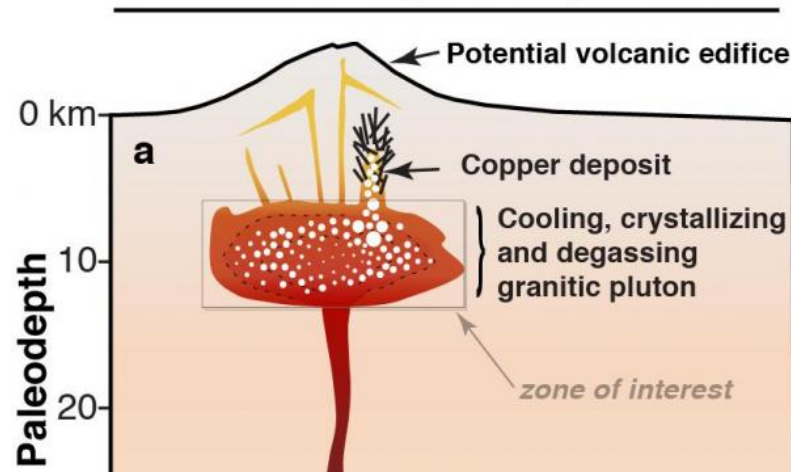
Integrate multi-scale scientific knowledge of sources of metals and the pathways they take to become an ore deposit that can be used by industry to innovate their exploration approaches

Participate in the training and mentoring of students to increase the number of HQP available to the mineral industry

### 3D Modelling of Ore Systems



### Ore Forming Mechanisms Active magmatic system



### HQP Development



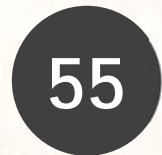
# TGI by the numbers

2010

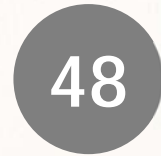
2017



public geoscience knowledge PUBLICATIONS



distinct INNOVATIVE RESULTS being used by industry



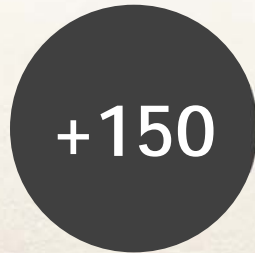
GRANTS



public and stakeholder science PRESENTATIONS



COLLABORATING COMPANIES



STUDENTS TRAINED



Projects focused on Canada's key economic minerals

- GOLD
- NICKEL-COPPER-PGE
- URANIUM
- VOLCANIC AND SEDIMENTARY
- PORPHYRY
- SPECIALTY METAL

S  
Y  
S  
T  
E  
M  
S

**Example of Impact: Agnico Eagle (2017):**  
 "...initiatives such as TGI-4, TGI-5, GEM-1 and GEM-2 programs provided (and are still providing) priceless knowledge and tools to aid in various aspects of mineral exploration..."

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



Natural Resources Canada

Ressources naturelles Canada

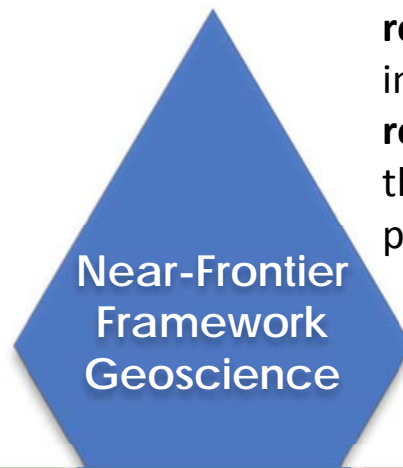


# Concepts that Support the Junior Mining Sector

The future for industry success leads through three intersecting themes

Promoting a more innovative and **competitive Canadian** exploration service industry by creating **novel, cutting-edge tools** and methods to better detect new mineral deposits

**Geoscience for Innovative Detection Tools**



**Near-Frontier Framework Geoscience**

focusing on the **near-surface regions** within reach of infrastructure to **improve regional geology** and help the junior industry target high potential

**TGI**

**Expanding the Search Space at Depth**

responding to the need to search **deeper for new deposits** near known deposits

# The Canadian Minerals and Metals Plan<sup>24</sup>

A plan that helps position Canada as the leading mining nation and lay the foundation for lasting success at home and abroad





PERMAFROST AND GROUND ICE

-  GLACIERS
-  CONTINUOUS
-  EXTENSIVE DISCONTINUOUS
-  SPORADIC DISCONTINUOUS
-  ISOLATED PATCHES
-  NO PERMAFROST



**MINERALS**  
Competitiveness

**INFRASTRUCTURE**

Required for development. How and where to build



**CLIMATE CHANGE**  
Economic development in a changing climate and changing land

**COMMUNITIES**

Insufficient data for Informing Decisions and regulatory process



**ECOSYSTEM APPROACH**  
Arctic Science and Traditional knowledge  
Conserve vs Develop

**CLEAN ENERGY**

e.g. Geothermal  
Reduce dependence on diesel



# NGEN: Northern Geoscience for Northerners 2020-2034



Natural Resources  
Canada

Ressources naturelles  
Canada

Canada 

# Terra-Canada Vision



## Transdisciplinary science

Chemical, mechanical, physical, biological, radiological & engineering



## Earth System Science

Rock, soil, water, air, natural hazards, earth observation, climate adaptation



## Zero Footprint Mining R&D

Zero tailings, Zero emission, Zero water contamination,



## Low Carbon Future

Building and transportation efficiency, Efficient batteries, Renewable Energy



## Big data and Artificial Intelligence

Environmental change, mineral exploration, natural hazard mitigation



## Social Science and Indigenous Knowledge

Engaging society and communities



## Human and Environmental Protection

Therapeutics, radiation standards, air quality, regulatory science



## Develop and Deploy Human Capital

Developing a talent pipeline for competency, leadership and outreach



© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



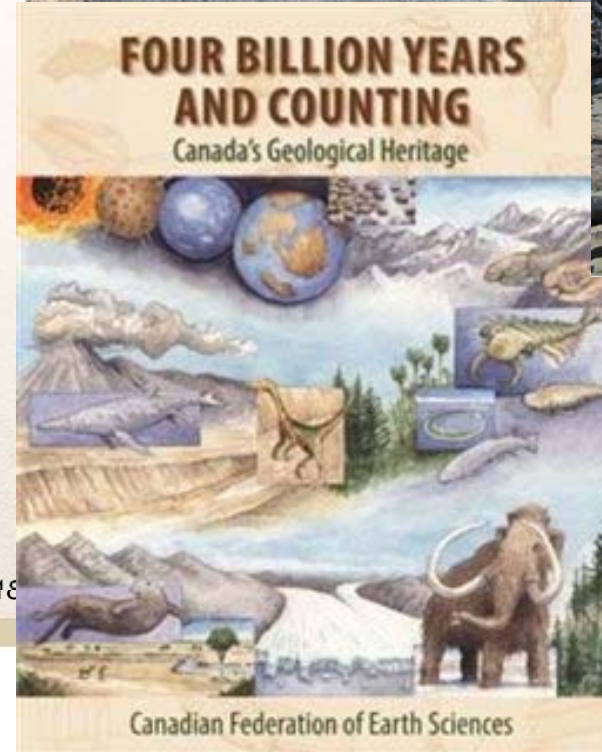
Natural Resources  
Canada

Ressources naturelles  
Canada

Canada

# Takeaways on Public Geoscience

- There are many lessons learned to share from policy-driven, high technology, leading edge geoscience programs
- Canada's Public Geoscience changed and stays relevant through nearly two centuries of rapidly changing social-economic and policy landscape
- We need new investments to balance the needs of the present with the needs of future generations



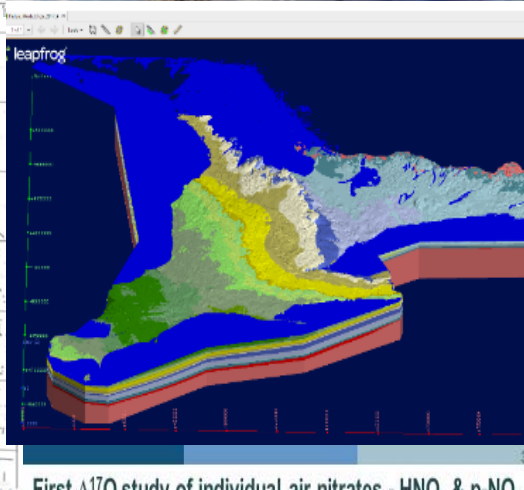
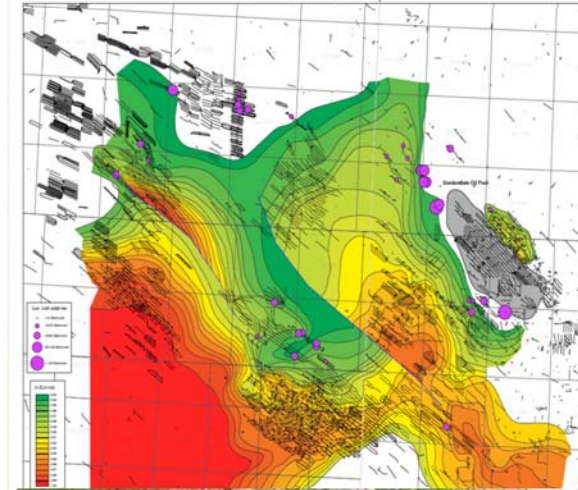
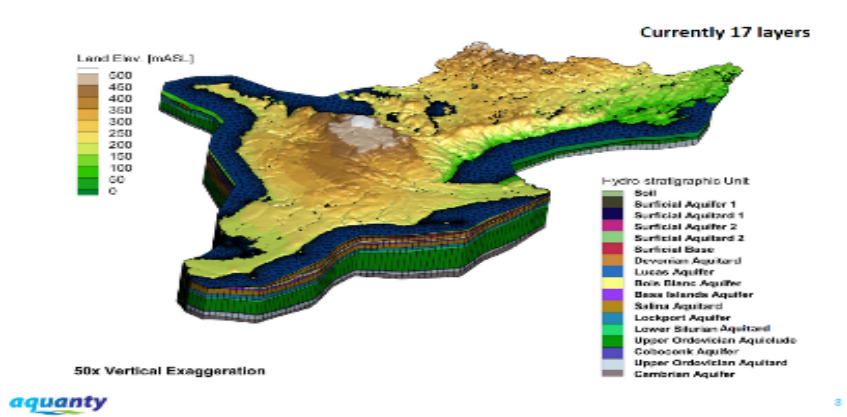
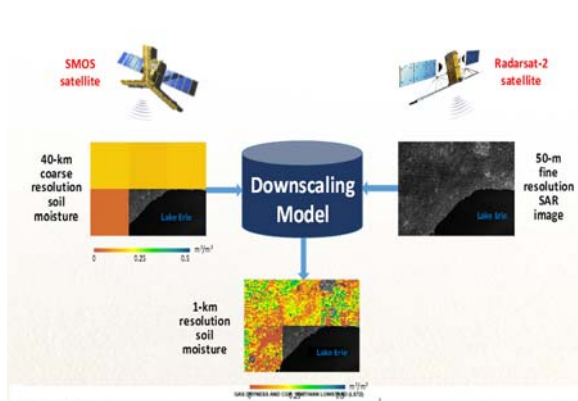
© Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2018



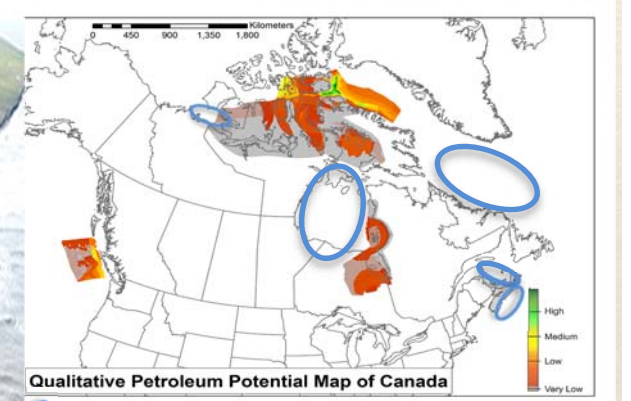
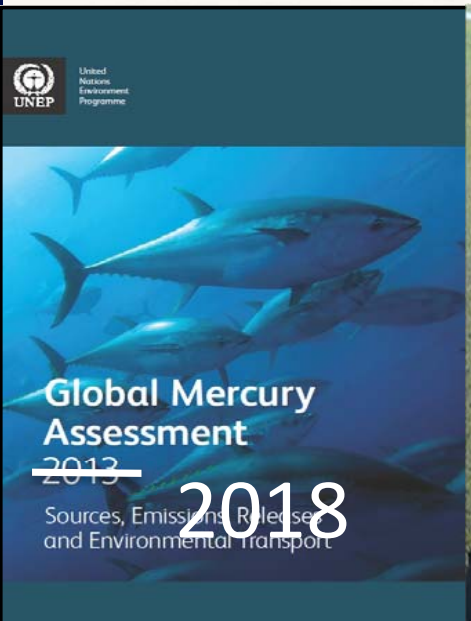
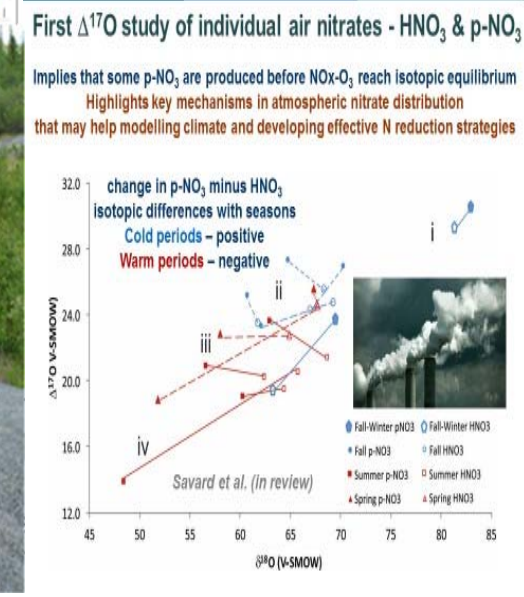
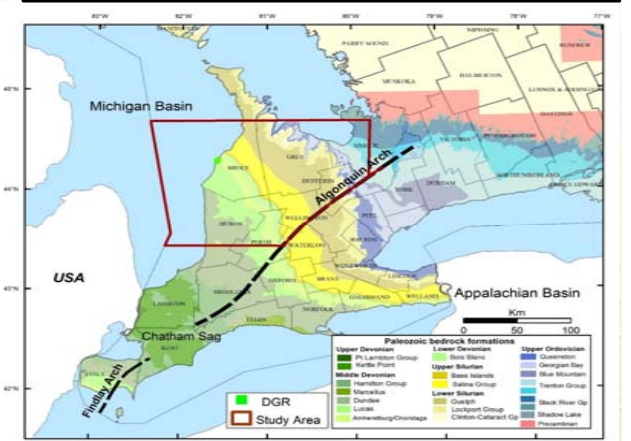
Natural Resources  
Canada

Ressources naturelles  
Canada

Canada



*Thank You*



Ongoing MCT project work, March 2018

**Canada**