Natural Resources Canada | Ressources naturelles Canada

National dialogue on groundwater (NDGW)

Dialogue national sur les eaux souterraines (DNES)

November 3, 2021

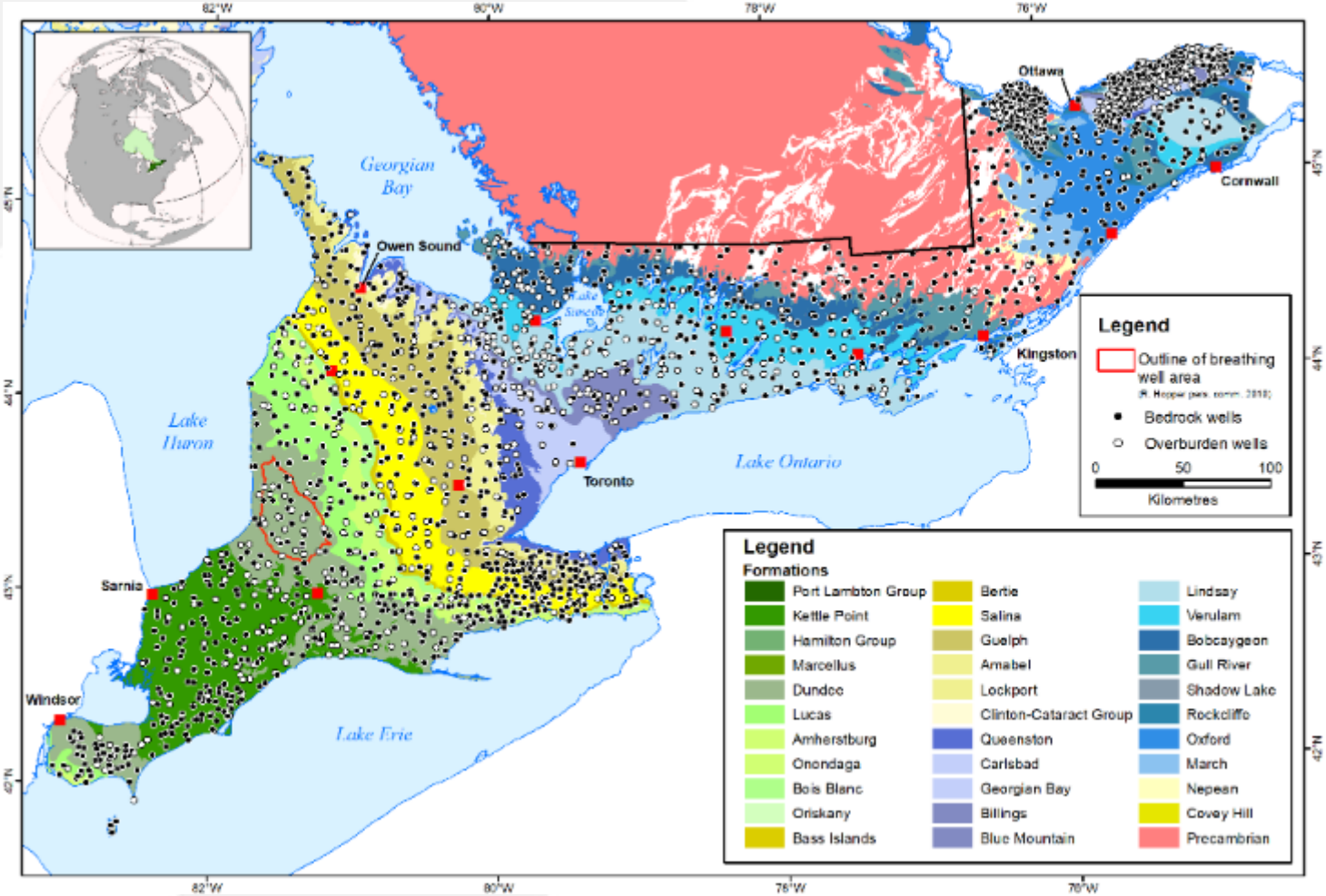
Canada

Overview

1. Greetings (Éric Boisvert) – 5 minutes
2. Breaking News or New development (all) – 5 minutes
3. Presentation – 30 minutes (15 minutes each)
   - **Stew Hamilton** - "OGS groundwater geochemical data release 2021 – 60% more data and hundreds of new reasons to download and dig through it."
   - **Sarah Hirschorn and Alexander Blyth** - Innovative Techniques to Characterize Groundwater and Porewater in Deep, Stable Geological Environments
4. Questions (all) – 10 minutes
5. Wrap-up and next meeting on January 19, 2022, from 1 to 2 p.m.(ET)

OGS Groundwater Geochemical Data Release 2021

60% more data and hundreds of new reasons to download and dig through it



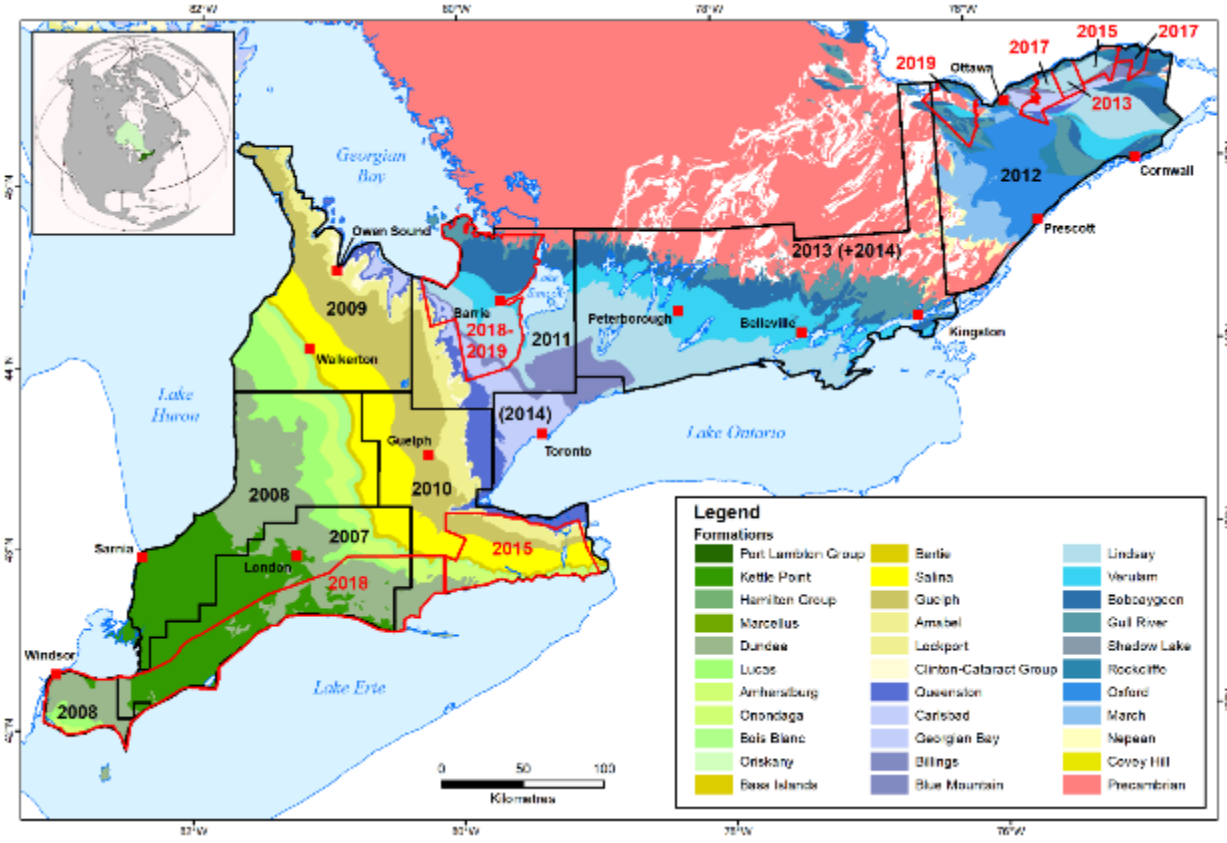
Stew Hamilton

Ontario Geological Survey

Ambient Groundwater Geochemistry Program

- Primary sampling done between 2007 and 2014, published in 2015
- Add-on projects mostly between 2015 and 2019, data are *in press*

- 1 bedrock & 1 overburden well per 10x10 km cell
- 96,000 km^2
- 2892 stations
- 3616 samples
- 90% drilled wells
- 134 DB fields
  - 27 station attributes
  - 107 sample attributes
- Northern Ontario data to follow…



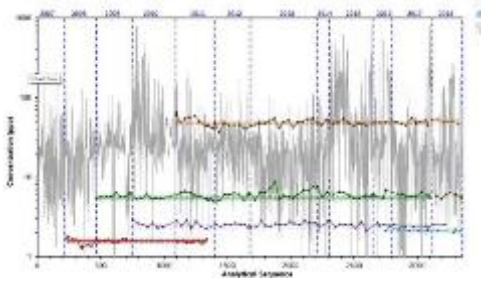
Ontario

MINISTRY OF
NORTHERN DEVELOPMENT, MINES,
NATURAL RESOURCES AND FORESTRY

Ambient Groundwater Geochemistry Mapping: Methods and Products

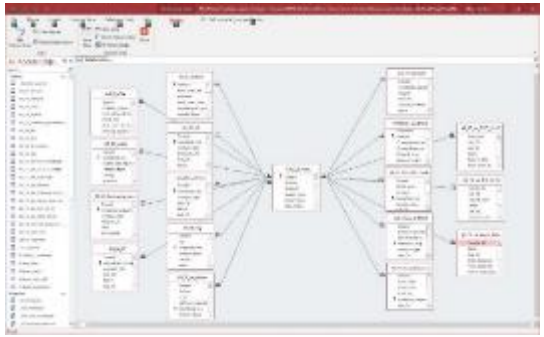
Data acquisition

Quality Assurance Program



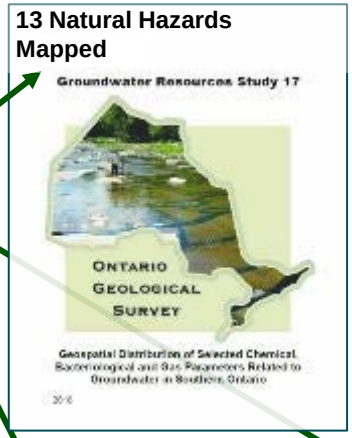
Products

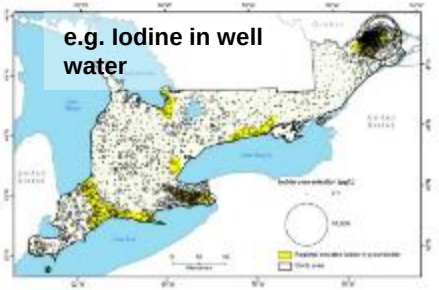
AGGP Database

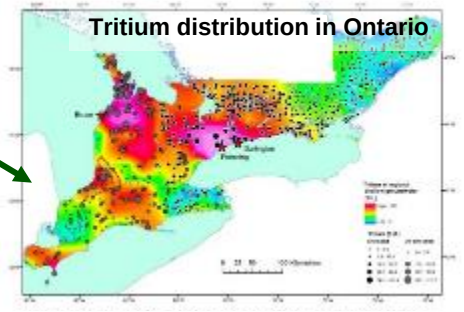


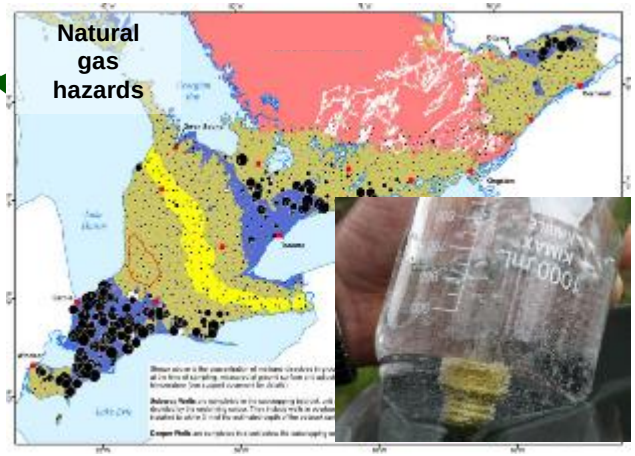
Value added studies & societal benefits

13 Natural Hazards Mapped

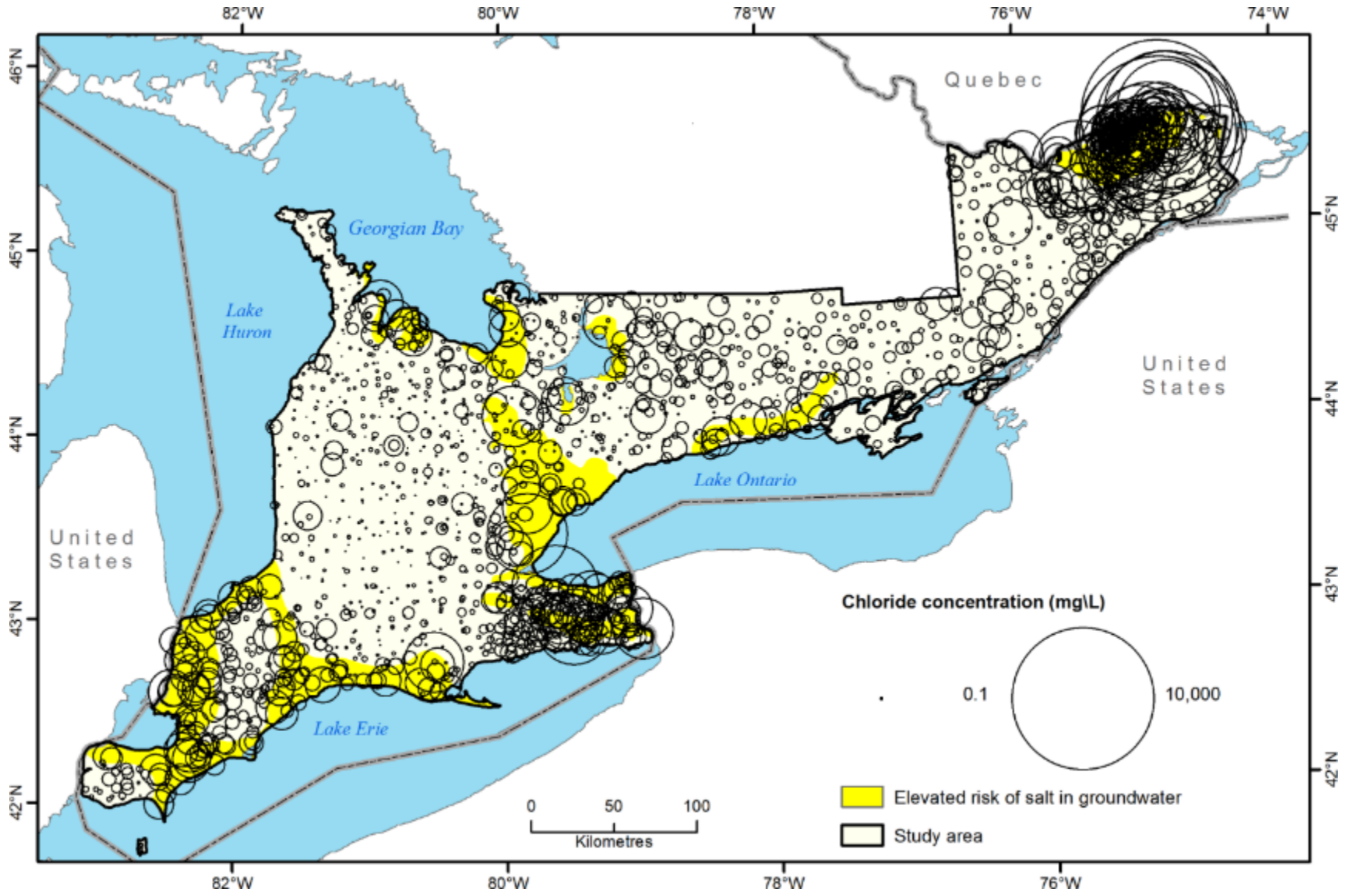




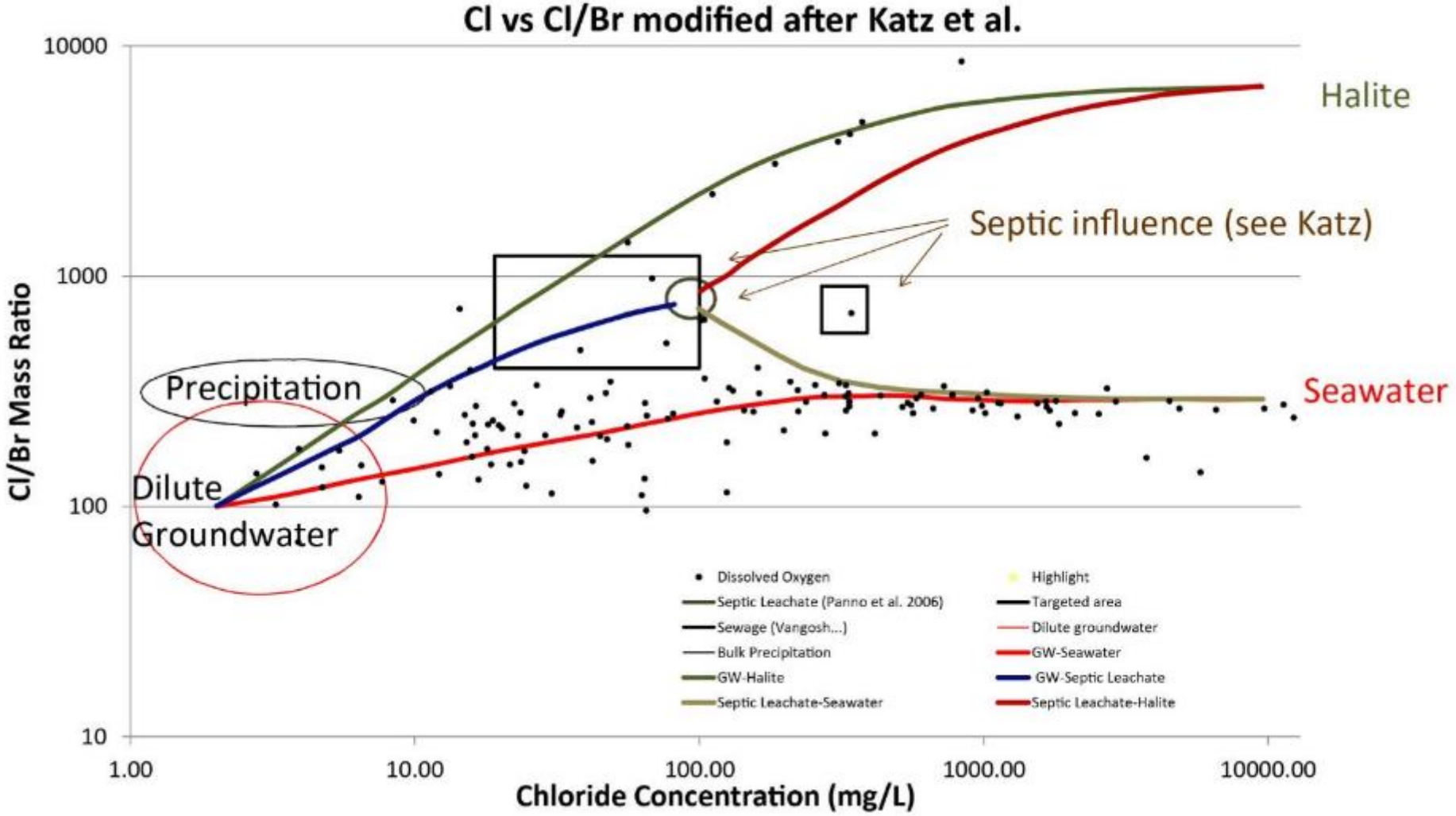




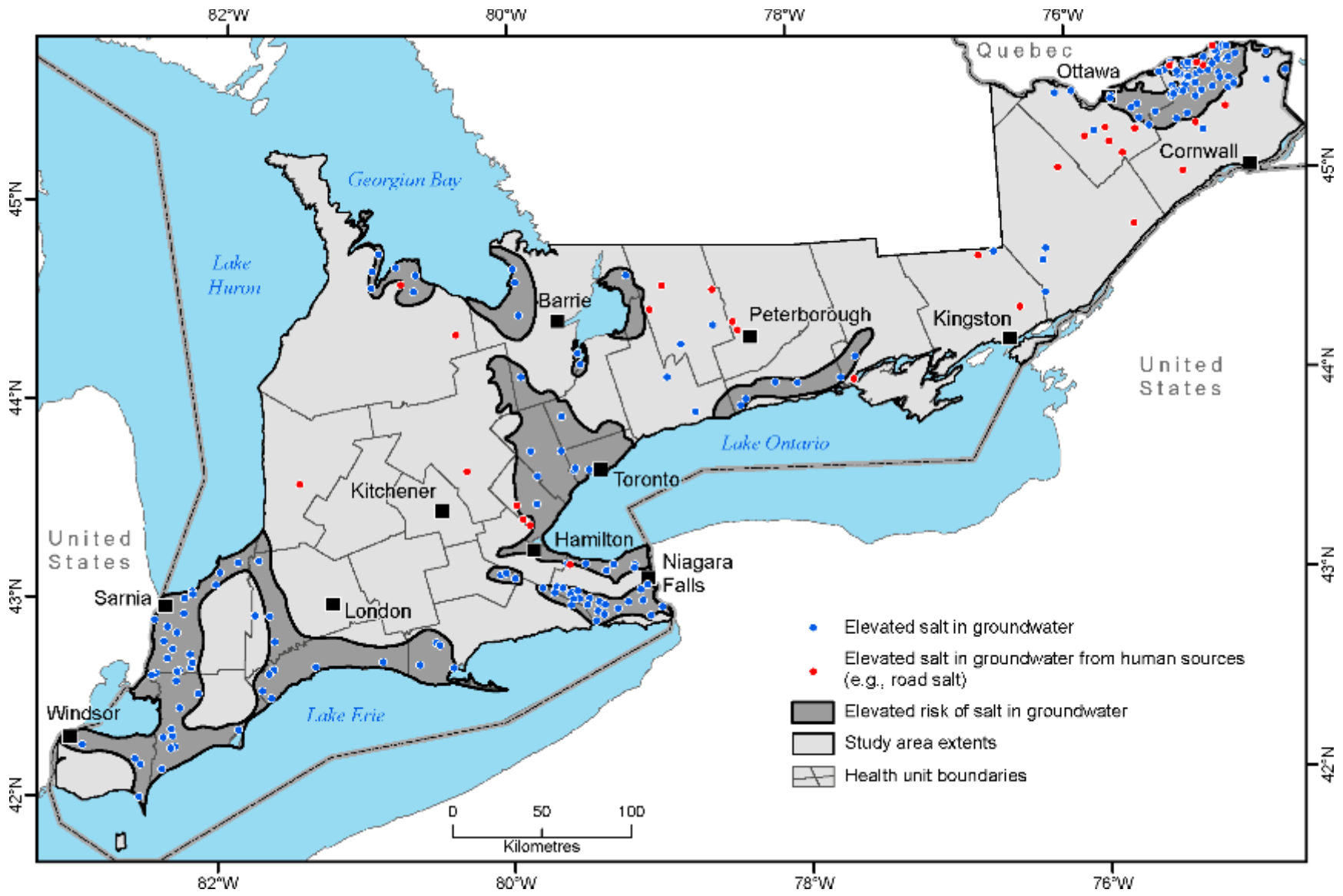
Hazard mapping – chloride



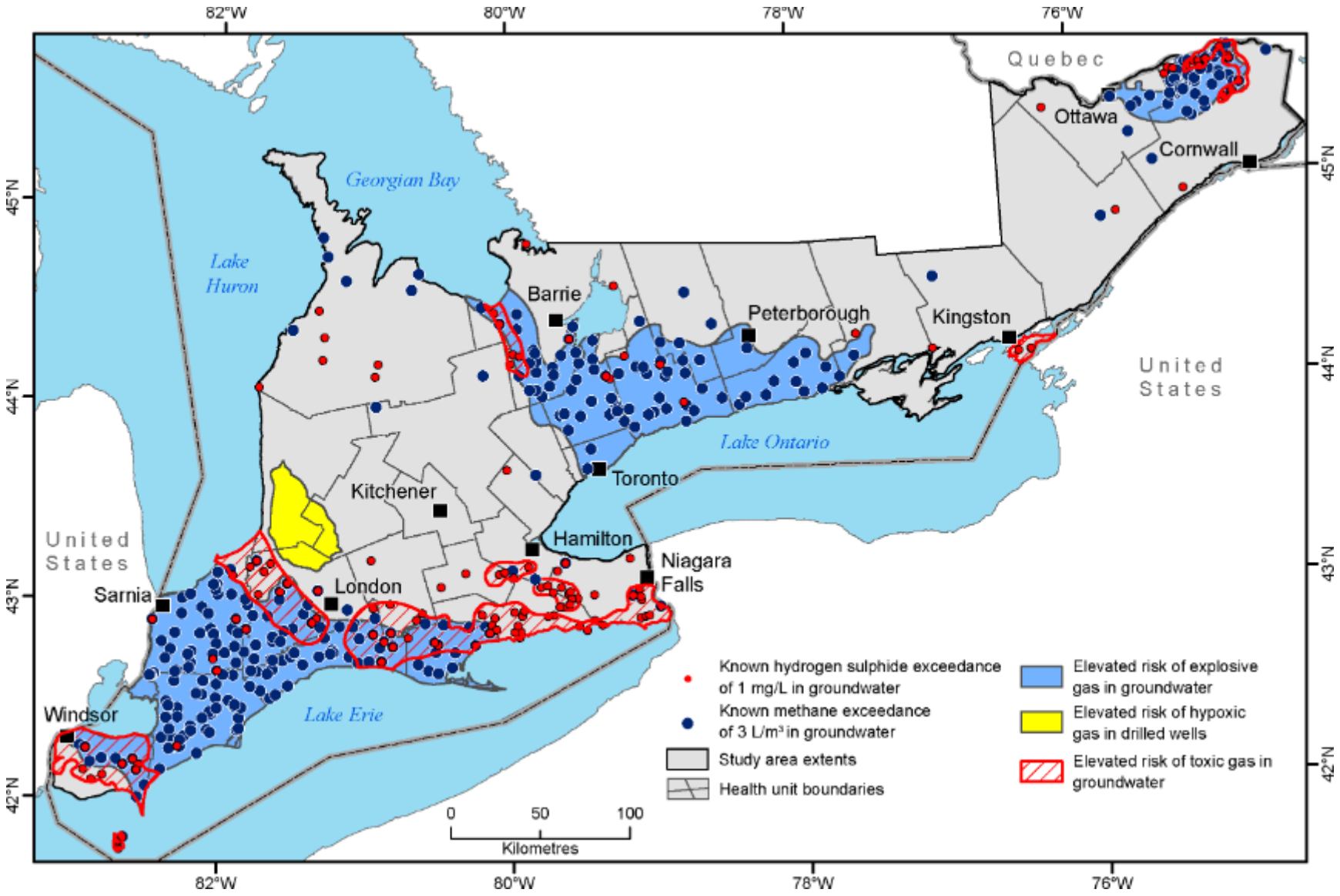
Drilled water supply wells



Hazard mapping – chloride



Groundwater-related gases



Dissolved H_2S Bedrock Wells

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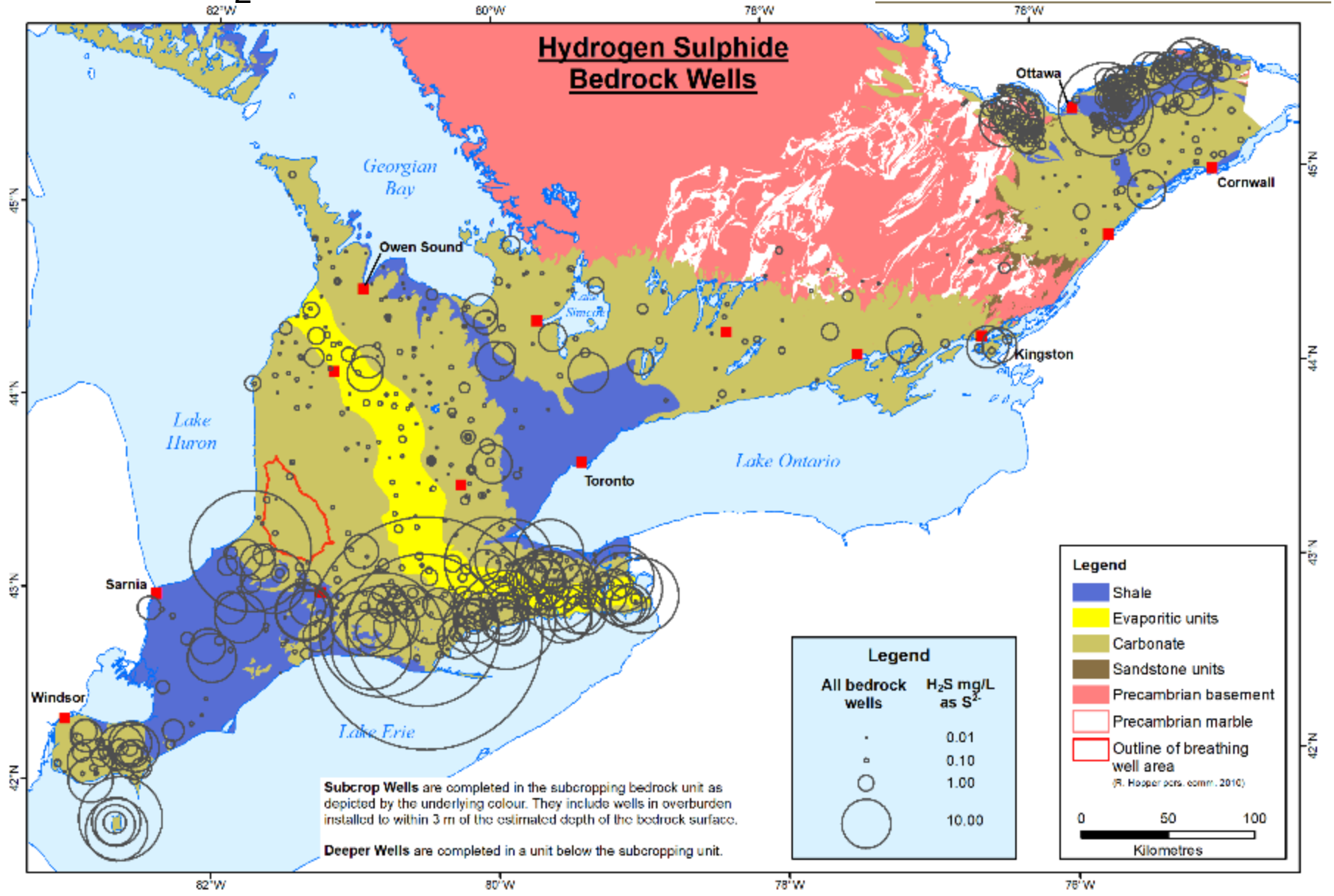

Sulphur Isotopes, Bedrock Wells

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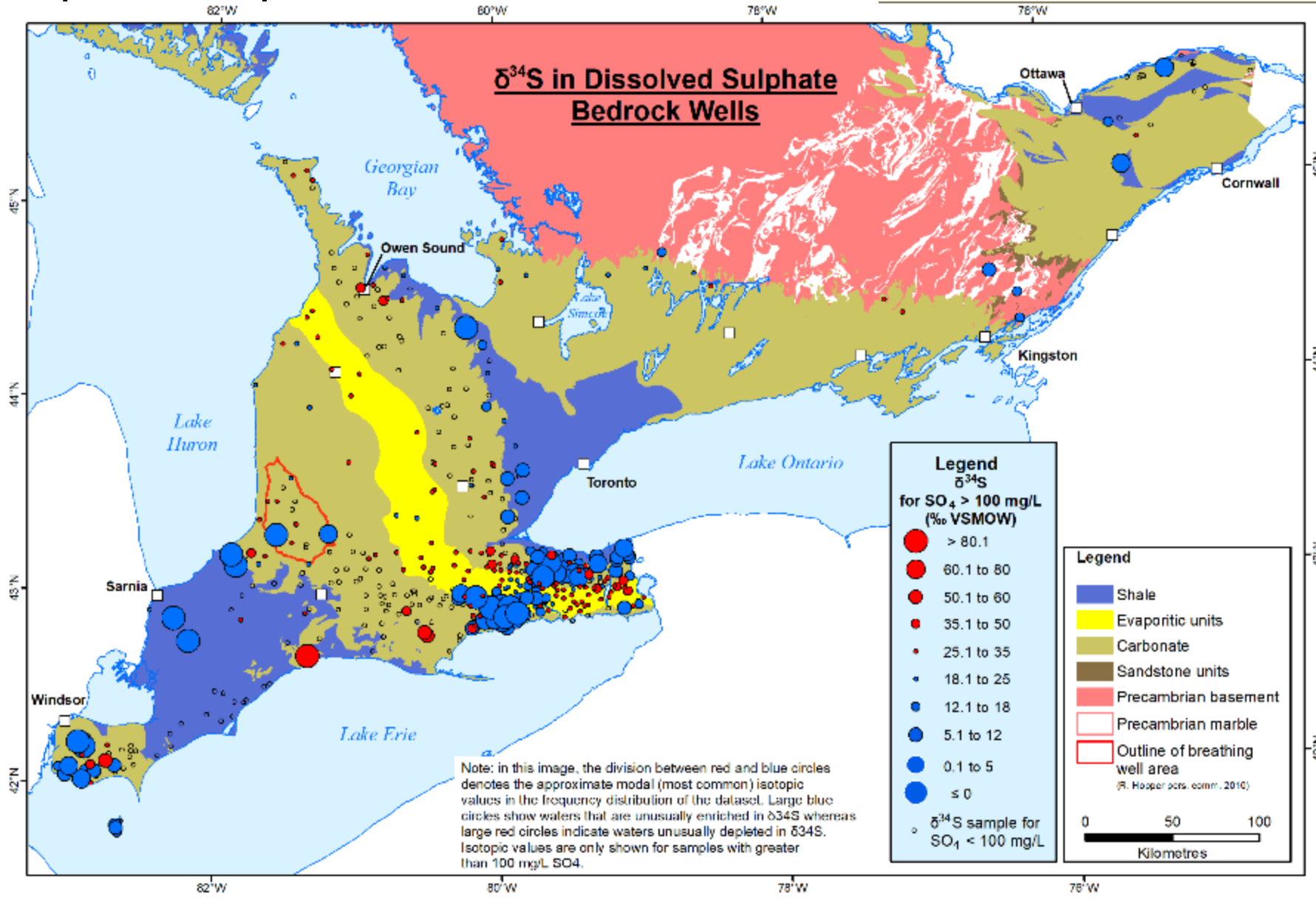

Dissolved Methane, Bedrock Wells

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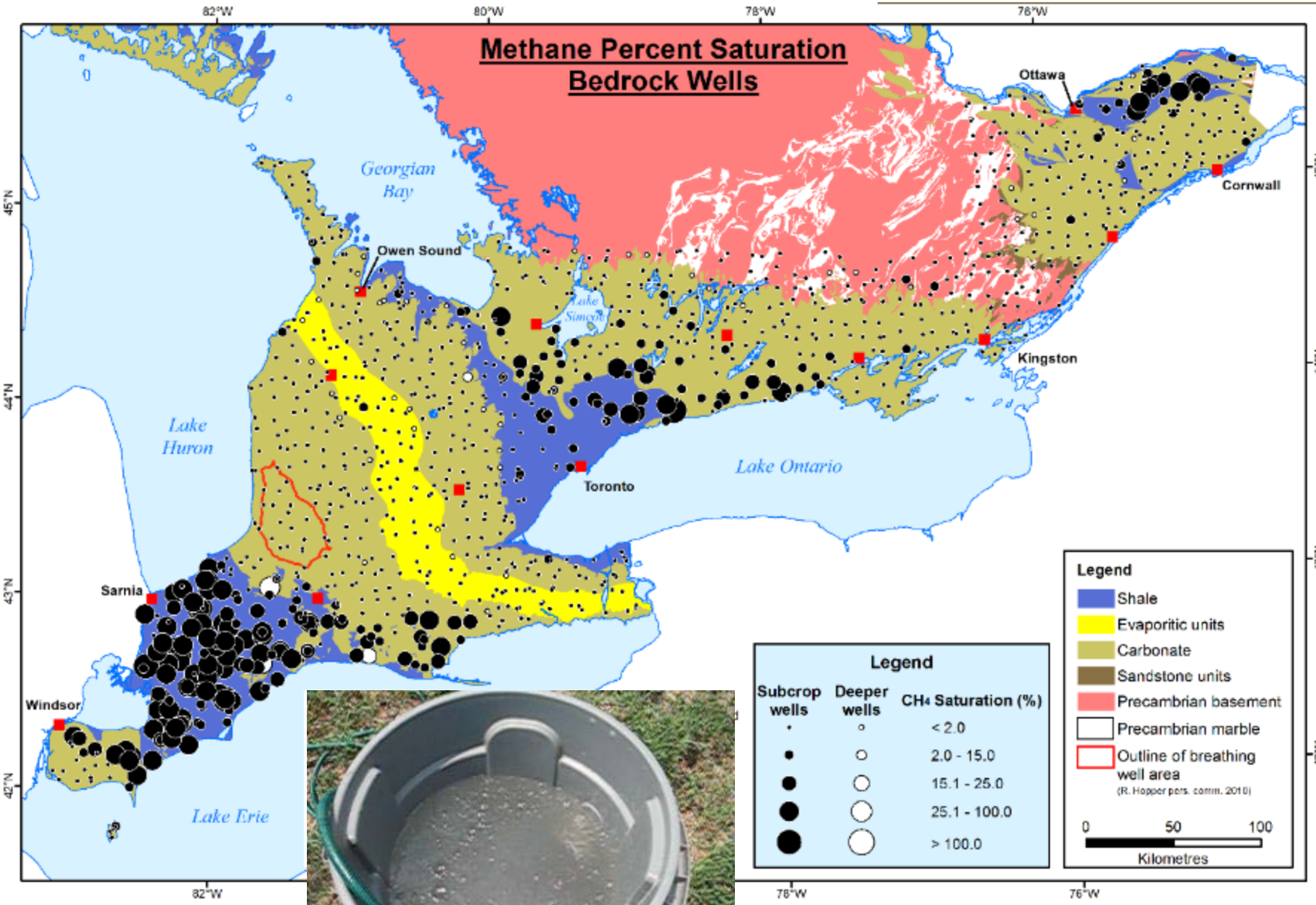

$\delta^{13}C_{CH4}$, Isotopes in Natural Gas (bedrock)

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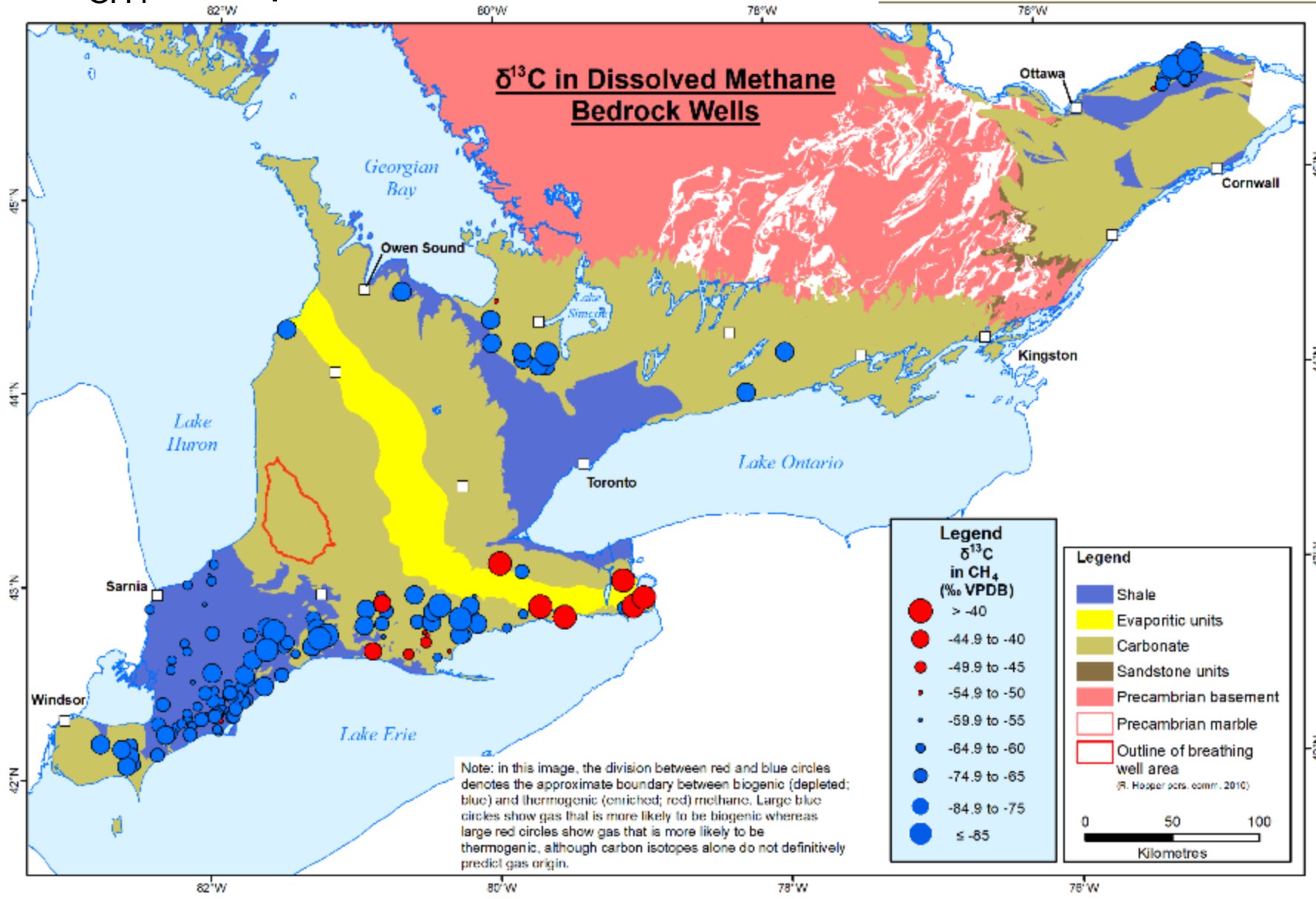
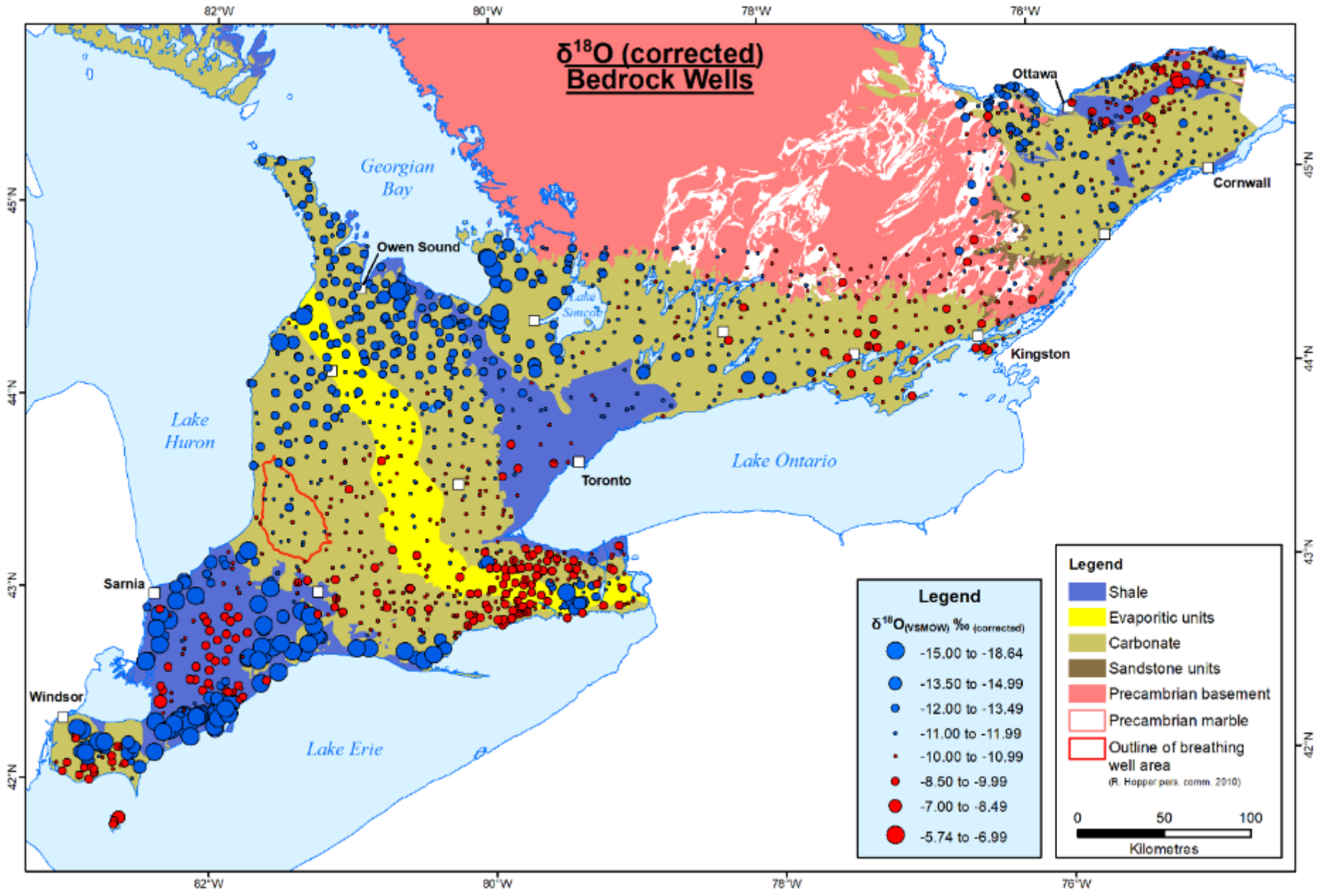
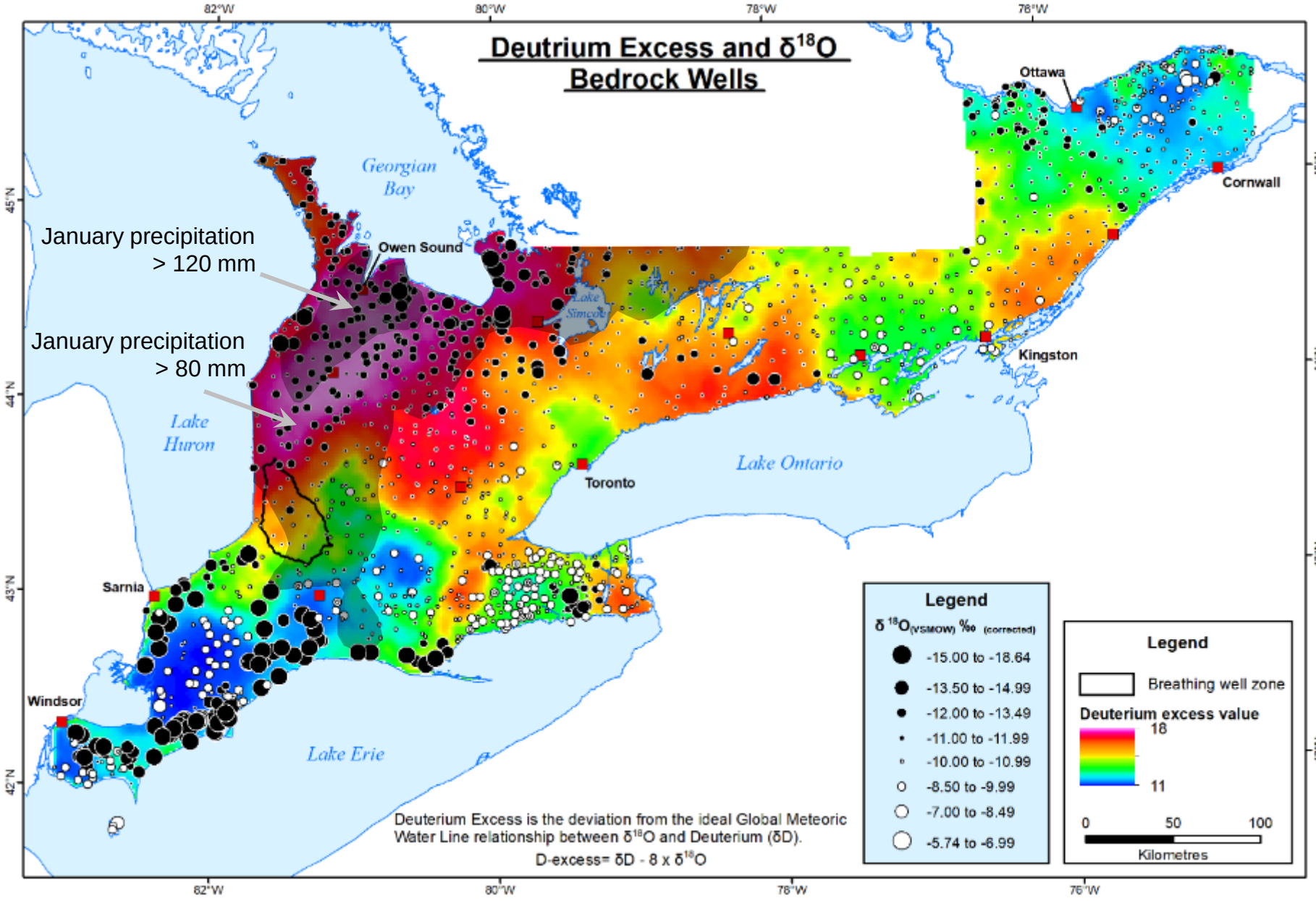
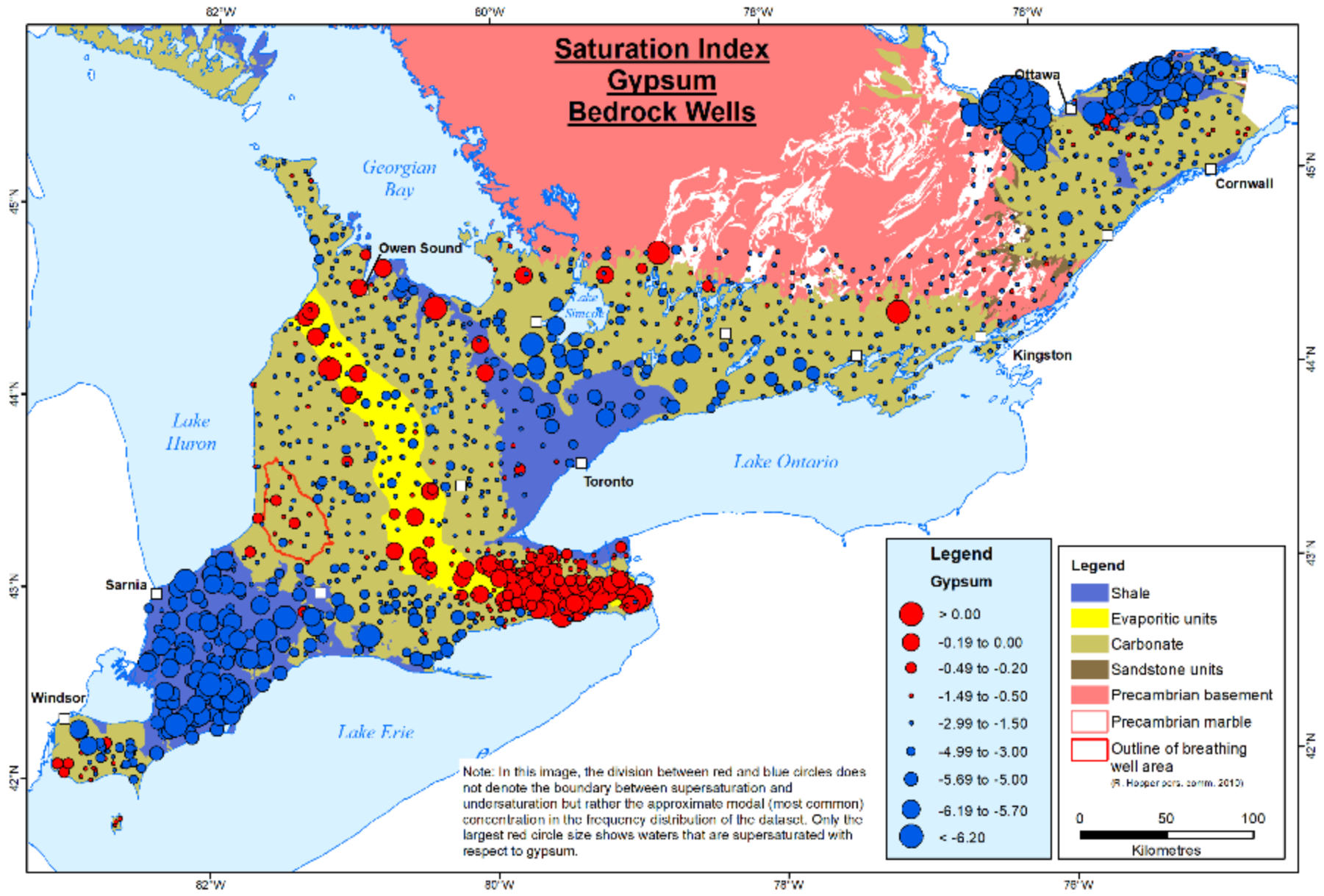



δ18O (corrected)
Bedrock Wells
82°W
80°W
78°W
76°W
45°N
44°N
43°N
42°N
Georgian Bay
Lake Huron
Lake Simcoe
Lake Ontario
Lake Erie
Owen Sound
Ottawa
Cornwall
Kingston
Toronto
Sarnia
Windsor
Legend
δ18O(VSMOW) ‰ (corrected)
-15.00 to -18.64
-13.50 to -14.99
-12.00 to -13.49
-11.00 to -11.99
-10.00 to -10.99
-8.50 to -9.99
-7.00 to -8.49
-5.74 to -6.99
Legend
Shale
Evaporitic units
Carbonate
Sandstone units
Precambrian basement
Precambrian marble
Outline of breathing well area
(R. Hopper pers. comm. 2010)
0
50
100
Kilometres

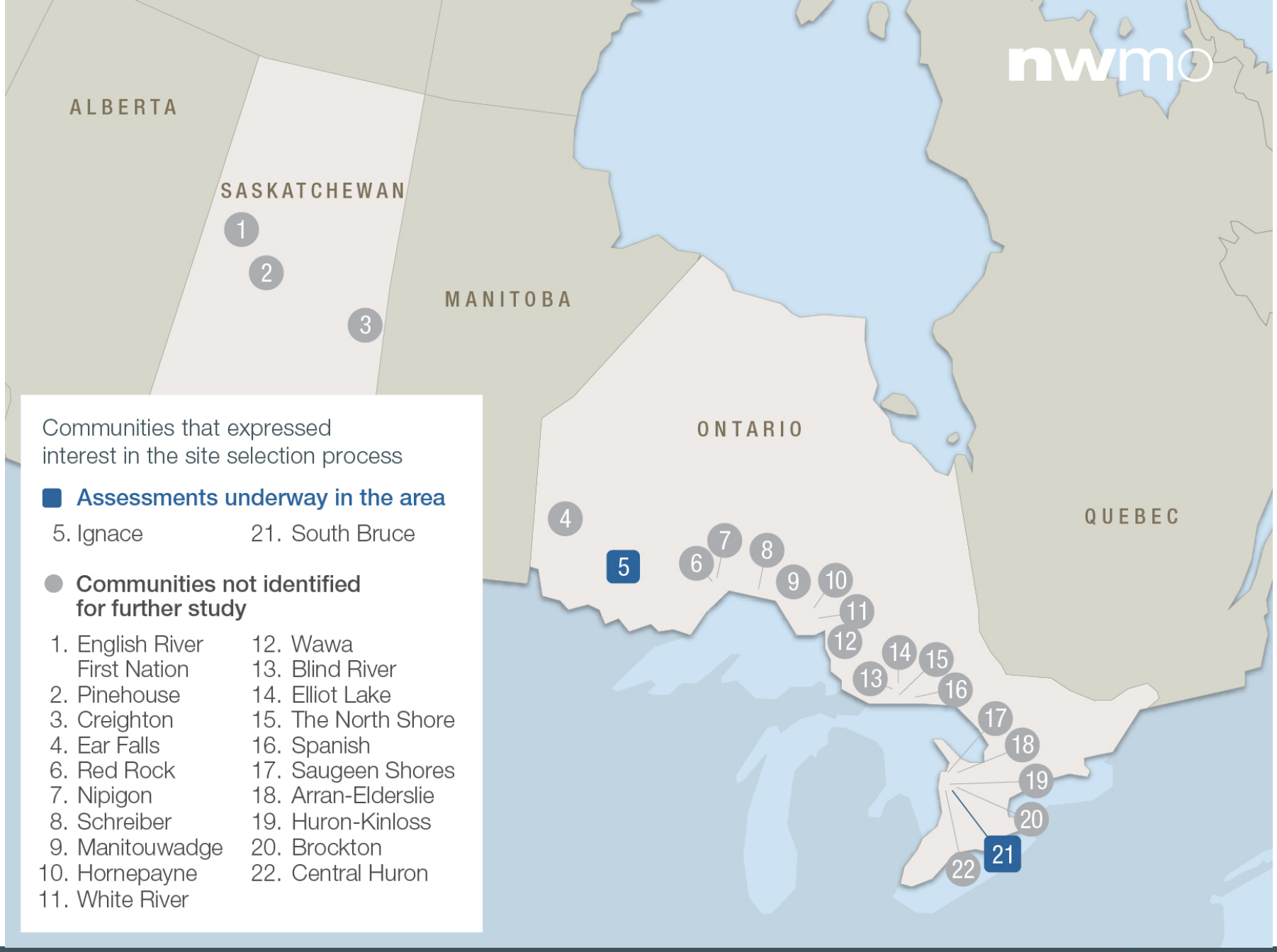

Deutrium Excess and δ18O
Bedrock Wells
January precipitation
> 120 mm
January precipitation
> 80 mm
Georgian Bay
Lake Huron
Lake Simcoe
Lake Ontario
Lake Erie
Owen Sound
Ottawa
Cornwall
Kingston
Toronto
Sarnia
Windsor
82°W
80°W
78°W
76°W
45°N
44°N
43°N
42°N
Legend
δ 18O(VSMOW) ‰ (corrected)
-15.00 to -18.64
-13.50 to -14.99
-12.00 to -13.49
-11.00 to -11.99
-10.00 to -10.99
-8.50 to -9.99
-7.00 to -8.49
-5.74 to -6.99
Legend
Breathing well zone
Deuterium excess value
18
11
0
50
100
Kilometres
Deuterium Excess is the deviation from the ideal Global Meteoric Water Line relationship between δ18O and Deuterium (δD).
D-excess= δD - 8 x δ18O


Saturation Index
Gypsum
Bedrock Wells
82°W
80°W
78°W
76°W
45°N
44°N
43°N
42°N
Georgian Bay
Lake Huron
Lake Simcoe
Lake Ontario
Lake Erie
Owen Sound
Ottawa
Cornwall
Kingston
Toronto
Sarnia
Windsor
Legend
Gypsum
> 0.00
-0.19 to 0.00
-0.49 to -0.20
-1.49 to -0.50
-2.99 to -1.50
-4.99 to -3.00
-5.69 to -5.00
-6.19 to -5.70
< -6.20
Note: In this image, the division between red and blue circles does not denote the boundary between supersaturation and undersaturation but rather the approximate modal (most common) concentration in the frequency distribution of the dataset. Only the largest red circle size shows waters that are supersaturated with respect to gypsum.
Legend
Shale
Evaporitic units
Carbonate
Sandstone units
Precambrian basement
Precambrian marble
Outline of breathing well area
(R. Hopper pers. comm. 2010)
0
50
100
Kilometres

Conclusions

- The Ambient Groundwater Geochemical database is a unique high quality, high density regional characterization of groundwater geochemistry in southern Ontario
- Although there have already been more than a dozen graduate theses and numerous journal papers published so far, there are potentially many more similar studies that could be done and we urge academics and students to use the data to its fullest extent
- The new release, with 60% more data and chemical modelling outputs has hundreds of potential uses as a regional geochemical database and almost limitless potential uses for local-scale hydrogeological studies in Ontario.
- The new release is in press and will be available this Fall, with a pan-southern Ontario "**OGS-Earth**" version available online… and the Northern Ontario release by Kayla Dell will follow.

Innovative Techniques to Characterize Groundwater and Porewater in Deep, Stable Geological Environments


ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
nwmo
Communities that expressed interest in the site selection process
Assessments underway in the area
5. Ignace
21. South Bruce
Communities not identified for further study
1. English River First Nation
2. Pinehouse
3. Creighton
4. Ear Falls
6. Red Rock
7. Nipigon
8. Schreiber
9. Manitouwadge
10. Hornepayne
11. White River
12. Wawa
13. Blind River
14. Elliot Lake
15. The North Shore
16. Spanish
17. Saugeen Shores
18. Arran-Elderslie
19. Huron-Kinloss
20. Brockton
22. Central Huron

Site Evaluation Process

Site evaluation process is driven by community's interest to participate.

Initial Screening
(Few months)

Desktop studies to evaluate the potential suitability of the community against a list of initial screening criteria

Preliminary Assessment
(Multiple years, 2 phases)

Technical and Social, economic and cultural assessments to determine whether a site in the community has the potential to meet the detailed requirements for the project:

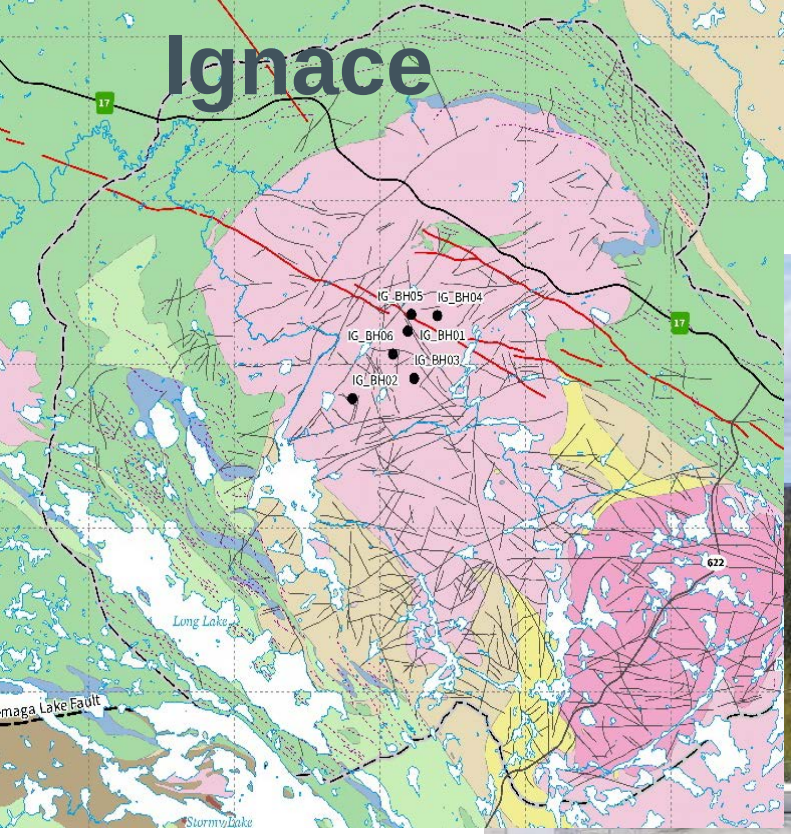
- **PHASE 1:** Desktop for all communities
- **PHASE 2:** Field Work for a subset of communities

Detailed Site Characterization
(~potentially 3-5 years)

Detailed field investigations at one site to confirm suitability of the site based on detailed site evaluation criteria:

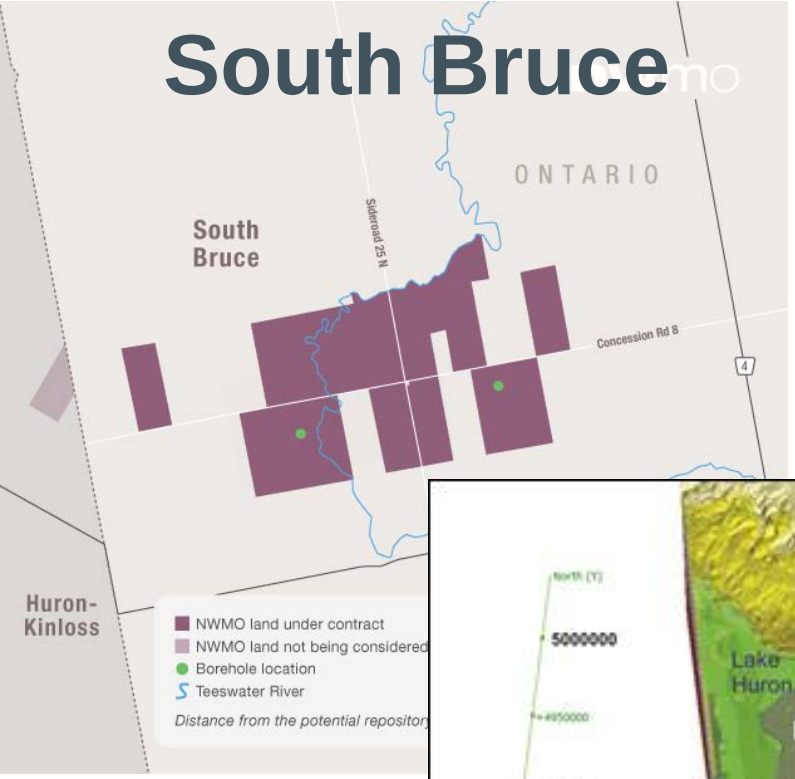
- Technical evaluation (detailed field investigations)
- Continue social, economic and cultural assessment

Ignace

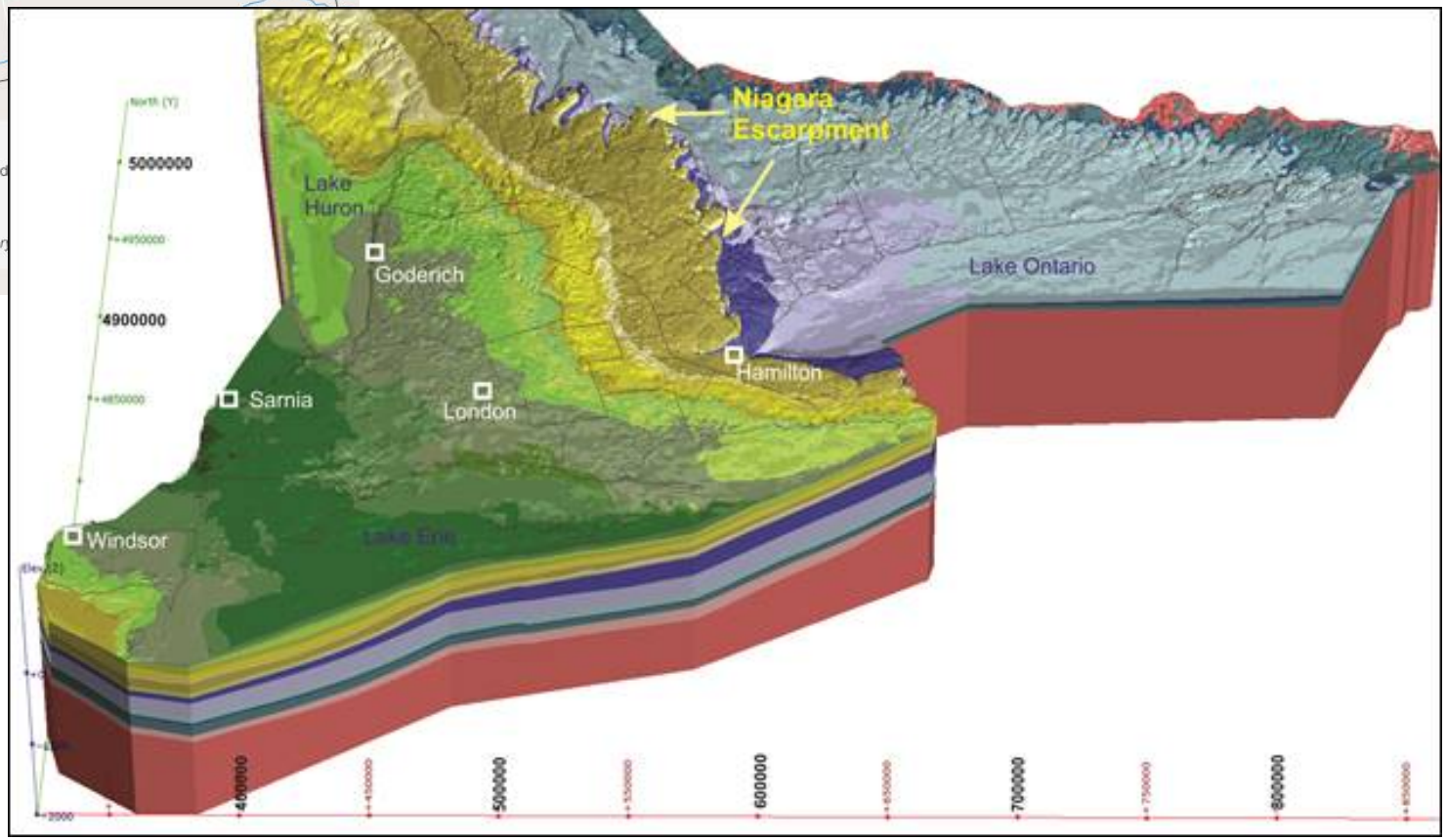

17
IG_BH05
IG_BH04
IG_BH06
IG_BH01
IG_BH03
IG_BH02
17
622
Long Lake
maga Lake Fault
Stormy Lake


RODREN

South Bruce



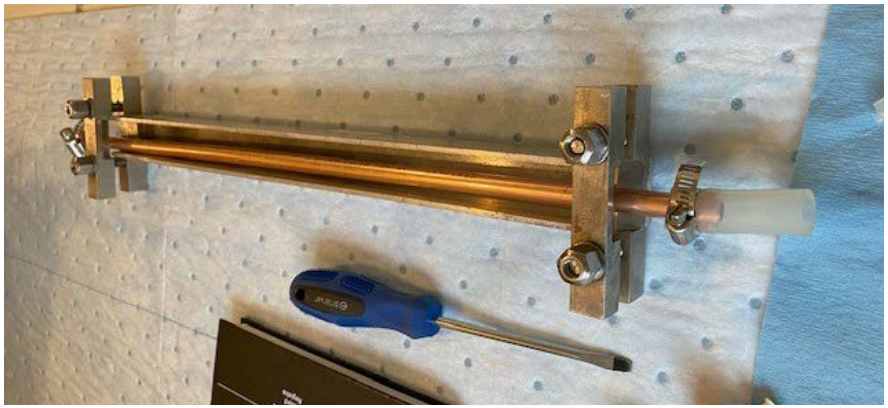
Three-Dimensional Geological Model of the Paleozoic Bedrock of Southern Ontario (Geological Survey of Canada, 2021)



Sample Collection Methods

1) Opportunistic Groundwater Samples

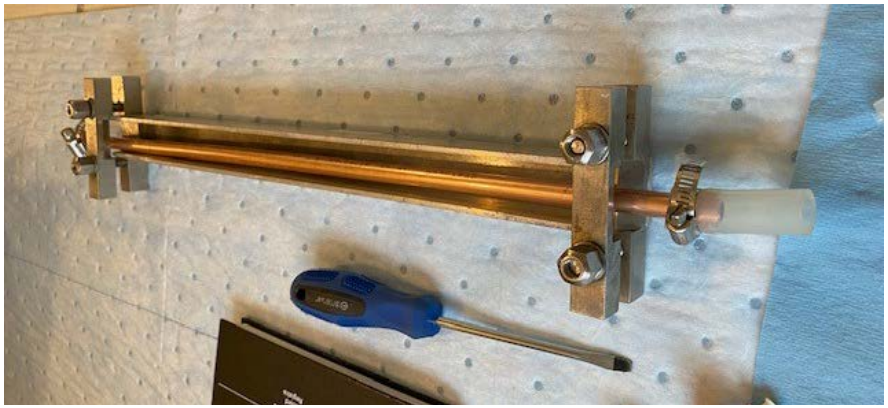
- “First-strike” samples minimizes mixing.
- Taken during drilling when a trigger indicates a sample is possible.
- Purged for up to 72 hours or more.
- Fluorescein tracer.
- Flow-through cells
- Downhole sampler (Mount Sopris or Westbay)
- Sealed copper tubes (Noble gases).



Sample Collection Methods

2) Long-term Monitoring Groundwater Samples

- Westbay monitoring well installations with 20 monitoring zones.
- Purge intervals for up to 1 year using pumping ports.
- Fluorescein tracer.
- Downhole Westbay sampler
- Sealed copper tubes (Noble gases).



Sample Collection Methods

3) Porewater Samples

- Retrieved and preserved within <30 minutes.
- Preserved using reagent grade nitrogen and double bagged in sealed polyethylene bags.
- Preserved in steel canisters for noble gases.

In-Field Analysis

Multi-metre

- pH, Cond, Temp, DO, ORP and Turbidity

HACH Kits

- Performed for analytes that degrade with atmospheric contact.
- Alkalinity, DO, Sulphide and Ferrous Iron.

Standard Laboratory Ion and Isotope Analysis

Parameter Group	Parameter List
Field Parameters and In-Field Analysis	pH, Temp, ORP, EC, DO, Density, Fluorescein Alkalinity, DO, S^{2-},Fe^{2+}
Physical-Chemical	pH, Total Alkalinity, TIC
Major Elements & Metals	Na, K, Ca, Mg, Sr, Li, Si, B, Fe_{Total}
Anions, Trace Elements and Nutrients	Br, F, I, SiO_2, Cl, NO_3, SO_4, PO_4, HCO_3, NO_2, S_{Total}, S^{2-} Cu, Ni, Zn, Pb, Cd, Al, As, Se, Bi, U, Cs, Rb, Ba, Cr, Co, Th, Zr NH_4, NH_3 + NH_4, N_{Total}, P_{Total}, TOC, DOC
Rare Earth Elements	Ce to Y
Stable Isotopes	δ^{13}C-DIC, δ^{18}O, δ^{2}H, $^{87}Sr/^{86}Sr$, δ^{37}Cl
Radioisotopes	^{3}H, $^{14}C_{DIC}$, ^{129}I, ^{36}Cl, ^{40}K, ^{238}U, ^{234}U, ^{222}Rn, *^{223}Ra, ^{224}Ra, ^{226}Ra, ^{228}Ra, ^{227}Th, ^{232}Th, ^{230}Th, ^{210}Po, ^{210}Pb, Gross Alpha & Beta*

Innovative and Non-Standard Laboratory Analysis - Water

Age Dating Techniques

- $\delta^{18}O$-$\delta^{2}H$ – indication of age (modern, glacial, magmatic equilibrated)
- ^{3}H - ~70 years
- ^{14}C - 50,000 years
- ^{36}Cl – 100,000 to 1 million years
- Noble Gas Isotope Ratios (He, Ne, Ar) - billions of years

Innovative and Non-Standard Laboratory Analysis - Core

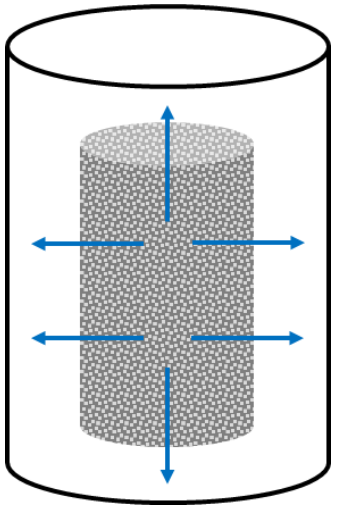
Isotope Diffusive Exchange

- Used to determine the stable water isotopic composition ($\delta^{18}O$ and $\delta^{2}H$) and mass of porewater.
- Naturally saturated rock material is placed into two vapour-tight containers along with test waters of known and distinct isotopic composition.
- Porewater and test water are allowed to isotopically equilibrate over the vapour phase, without any direct contact between the core and test water.
- The porewater isotope composition and the water content of the rock sample can be derived by isotope mass balance relationships.

Innovative and Non-Standard Laboratory Analysis - Core

Out-Diffusion

- Conducted to derive porewater chemical concentrations of naturally-saturated crystalline rocks
- Determine the Cl and Br concentrations and the δ37Cl isotopic signature of porewater, as well as the major ion compositions and $^{87}Sr/^{86}Sr$ isotope ratios of test solutions
- Performed on intact core samples (~19 cm length)
- immersed in ultrapure water, within vapour-tight containers
- Porewater is allowed to equilibrate with surrounding solution over several months (up to one year)
- For Cl and Br, the concentrations of the experimental solution can be converted to porewater concentrations by applying mass balance calculations after equilibrium is achieved
- The $^{37}Cl/^{35}Cl$ isotopic ratio and the $^{87}Sr/^{86}Sr$ isotopic ratio also are measured



Innovative and Non-Standard Laboratory Analysis - Core

Noble Gas Concentration and Isotopes

- Determine noble gas concentrations dissolved in porewater and their isotopic composition.
- Assess diffusive properties of low-permeability rock and the evolution of porewater (diffusion profiles – concentration and isotopic signature).
- Crystalline samples are sealed in evacuated steel containers.
- Over time, dissolved gases in the porewater diffuse out of the sample and are released into the container void space.
- Gas mixtures are extracted and are separated and purified.
- Concentration in the container void volume is measured and concentration in the porewater is calculated using the gravimetrically-determined water content of the rock sample.
- Isotopic composition is determined.

Questions?

Thank you and see you all at the next meeting:
January 19, 2022 from 1 to 2 p.m. (ET)