Geothermal resources for energy transition: Past, present and future of IGCP 636 group

Jasmin Raymond, Daniela Blessent, Mar Alcaraz, Michel Malo, Linda Daniele, Renato Somma

GAC-MAC-IAH-CNC-CSPG Joint Meeting May 15-18

SY-04 MON 1:40 PM IUGS, Geoparks, and IGCP

HALIFAX 2022

Riding the waves of change
Surfer sur la vague du changement

UNESCO PROJECT IGCP - 636:

Geothermal resources for energy transition:
Direct uses and renewable base-load power around the globe

Universidad de Medellín
Ciencia y Libertad

CYTED

INVOLVED INSTITUTIONS FROM AROUND THE WORLD:

THE AMERICAS

WING

CONICET

CEGA

INEEL

INRS

Université LAVAL

EUROPE

Université de RENNES

brgm

INGV

UMONS

GeoZS

Iceland School of Energy

KTH

ICGC

EOS

RSE
Ricerca sul Sistema Energetico

ASIA

Institute of Rock and Soil Mechanics, Chinese Academy of Sciences

OCEANIA

The University of Auckland
School of Environment

URGE

AFRICA

Ecole Nationale Polytechnique de Constantine

Centre de Développement des Energies Renouvelables

UNESCO PROJECT IGCP - 636

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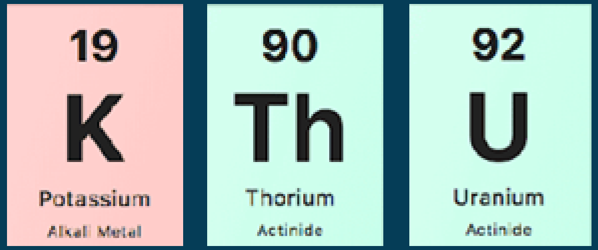
Content

- ✓ Introduction
- ✓ Geothermal Energy
- ✓ History of the group
- ✓ Collective goals
  - ✓ Education and outreach
  - ✓ Deep geothermal resources
  - ✓ Shallow geothermal installations
- ✓ Contributions of project leaders
- ✓ Conclusions

Geothermal Energy

- Low emissions
- Local resource
- 24/7
- Small footprint

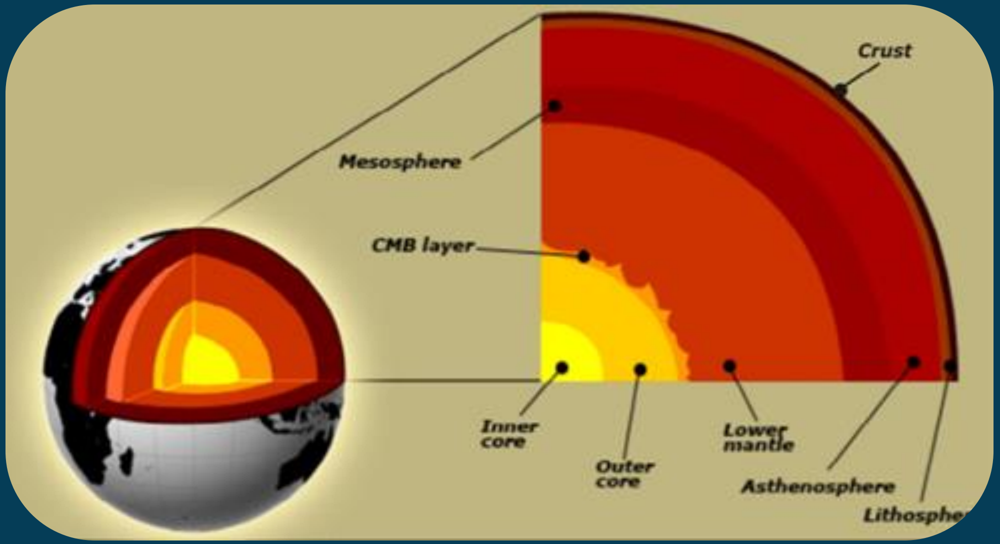
- Heat Source:
  - Earth's formation
  - Radiogenic decay



SUSTAINABLE DEVELOPMENT GOALS

7 AFFORDABLE AND CLEAN ENERGY

11 SUSTAINABLE CITIES AND COMMUNITIES



History of the group

Beginnings - 2014

CENTRE DE LA
FRANCOPHONIE
DES AMÉRIQUES

Young scientist project 2016-2019

International mobility under the young scientist program

Colombia in 2016

Chile in 2017

France in 2018

- Annual meetings in 2016, 2017, and 2018
- Global participation of students

Present days

Daniela Blessent
Project leader

Linda Daniele
Project co-leader

Mar Alcaraz
Project co-leader

Jasmin Raymond
Project co-leader

Renato Somma
Project secretary

“Our main objective is to advance methodologies and techniques to characterize and model geothermal systems, ensuring sustainable exploitation and social acceptability of this form of renewable energy.”

Collective goals

- Educate and reachout to communities
- Beter understand deep geothermal reservoirs
- Support the installation of geothermal heat pumps

Education and outreach

Survey to evaluate the public perception on geothermal energy


Geothermal Energy

Science – Society – Technology

About | Articles | Submission Guidelines

Research | Open Access | Published: 02 March 2021

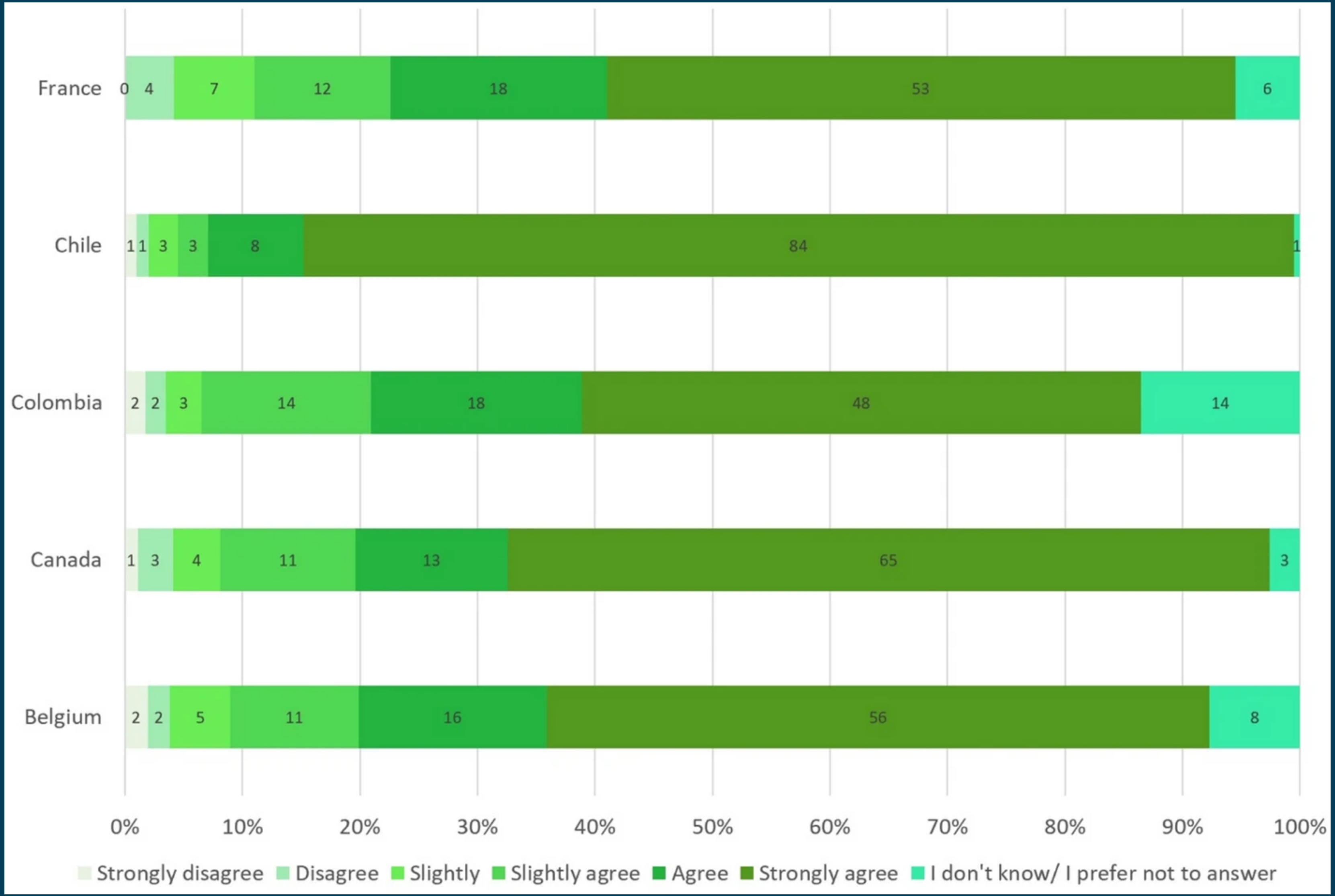
An online survey to explore the awareness and acceptance of geothermal energy among an educated segment of the population in five European and American countries

D. Balzan-Alzate, J. López-Sánchez, D. Blessent, J. Raymond, C. Dezayes, J. P. Portela, E. Ramírez Restrepo, D. Moreno Rendón, M. Malo, P. Goderniaux, L. Daniele & T. Le Borgne

Geothermal Energy **9**, Article number: 9 (2021) | Cite this article

1577 Accesses | **5** Altmetric | Metrics

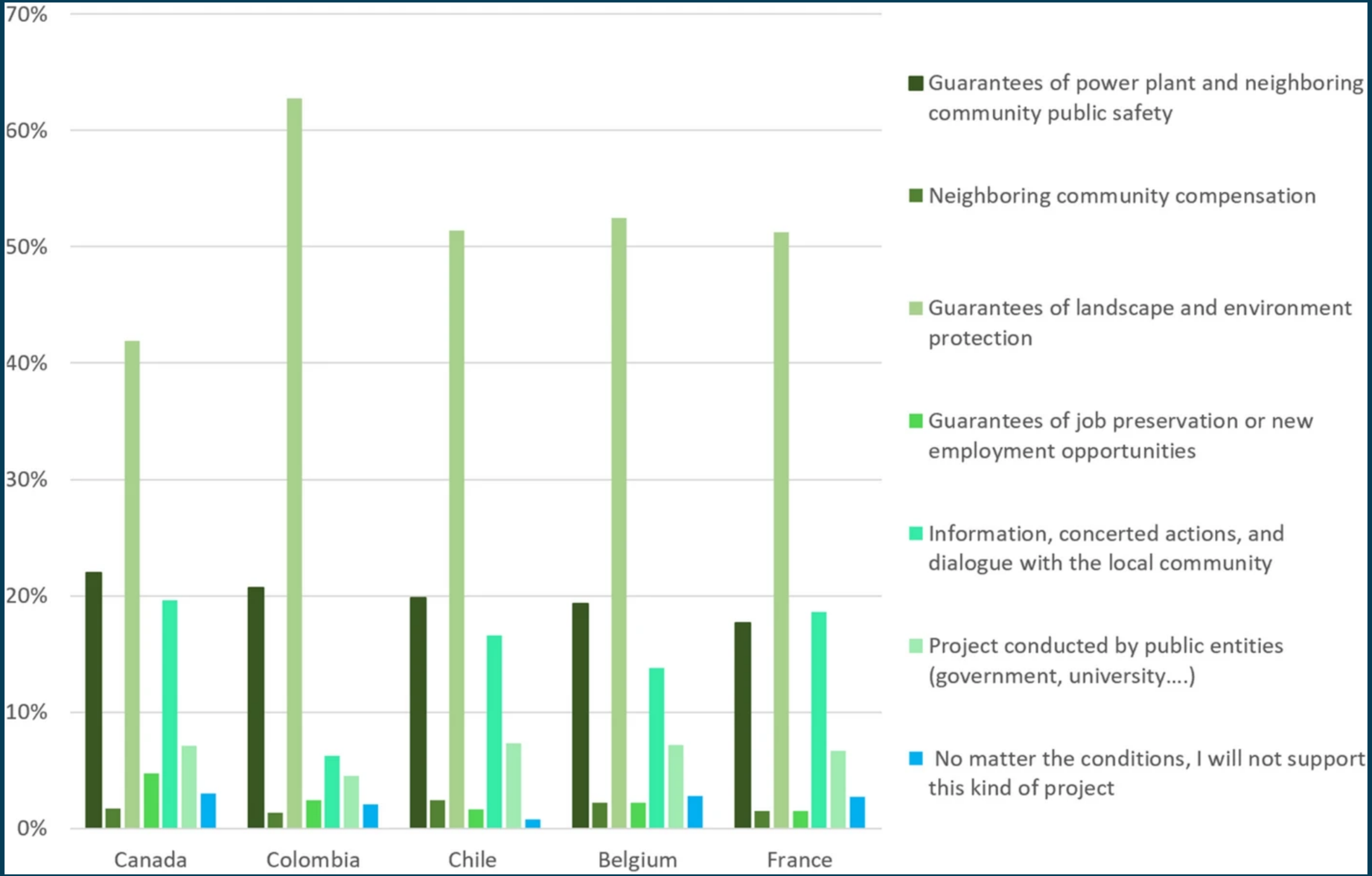
Acceptance to produce geothermal energy



Decreased by 8 to 18 % when explaining that hydraulic stimulation may be required

Balzan-Alzate, 2021 (Geothermal Energy)

Conditions that should be satisfied to support a pilot geothermal project



Balzan-Alzate, 2021 (Geothermal Energy)

Education and outreach
Geotheroom

Virtual learning platform about geothermal energy where students and professionals around the world can interact

Launched - *January 2022*

Education and outreach

Review of ongoing exploration for unconventional geothermal resources

Open Access | Review

Review of Recent Drilling Projects in Unconventional Geothermal Resources at Campi Flegrei Caldera, Cornubian Batholith, and Williston Sedimentary Basin

by Renato Somma [1,2,*], Daniela Blessent [3], Jasmin Raymond [4], Madeline Constance [5], Lucy Cotton [5], Giuseppe De Natale [1], Alessandro Fedele [1], Maria Jose Jurado [6], Kirsten Marcia [7], Mafalda Miranda [4], Claudia Troise [1] and Thomas Wiersberg [8]

1 Osservatorio Vesuviano, INGV, 80124 Naples, Italy
2 IRISS, CNR, 80134 Naples, Italy
3 Programa Ingeniería Ambiental, Universidad de Medellin, 050026 Medellin, Antioquia, Colombia
4 Institut National de la Recherche Scientifique, 490 Couronne St., Quebec City, QC G1K 9A9, Canada
5 GeoScience Limited Unit 1Falmouth Business Park, Bickland Water Road, Falmouth TR11 4SZ, UK
6 Geosciences Barcelona CSIC, 08028 Barcelona, Spain
7 DEEP Earth Energy Production Corp. Box 6 Site 515 RR5, Saskatoon, SK S7K 3J8, Canada
8 Helmholtz-Zentrum Potsdam—Deutsches GeoForschungsZentrum GFZ, 14473 Potsdam, Germany
* Author to whom correspondence should be addressed.

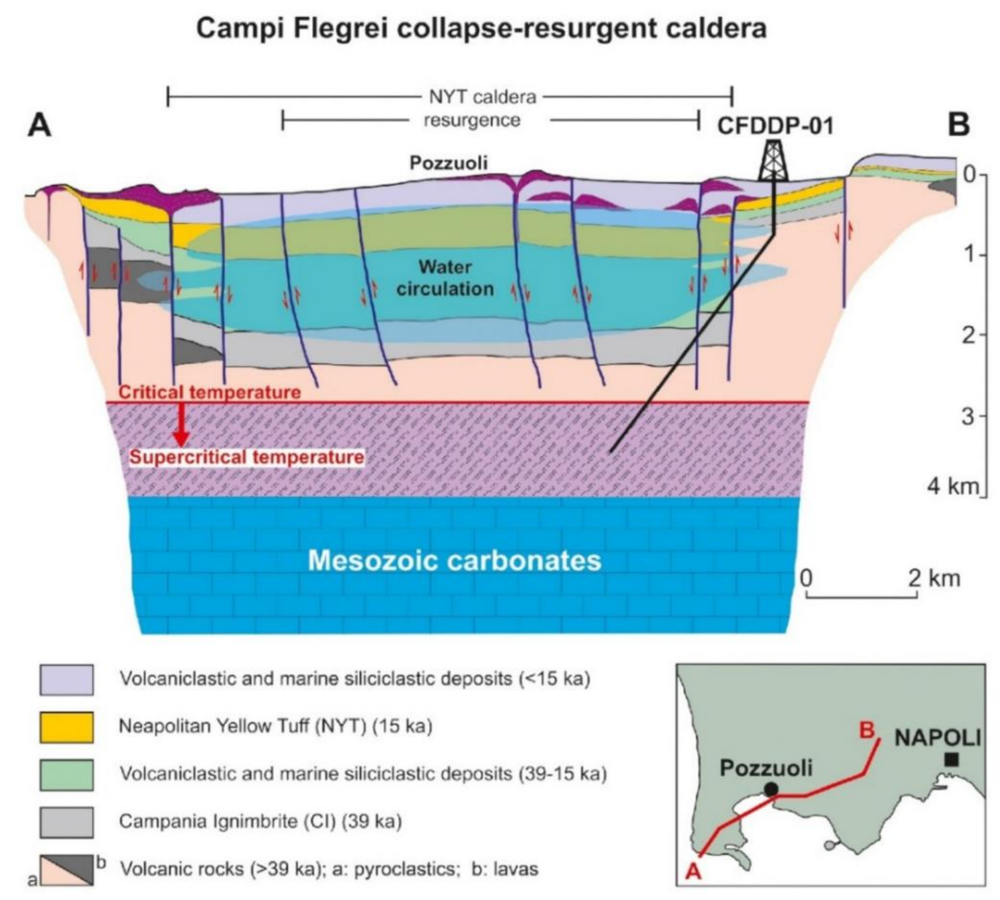
Academic Editor: Paul Christodoulides

Energies 2021, *14*(11), 3306; https://doi.org/10.3390/en14113306

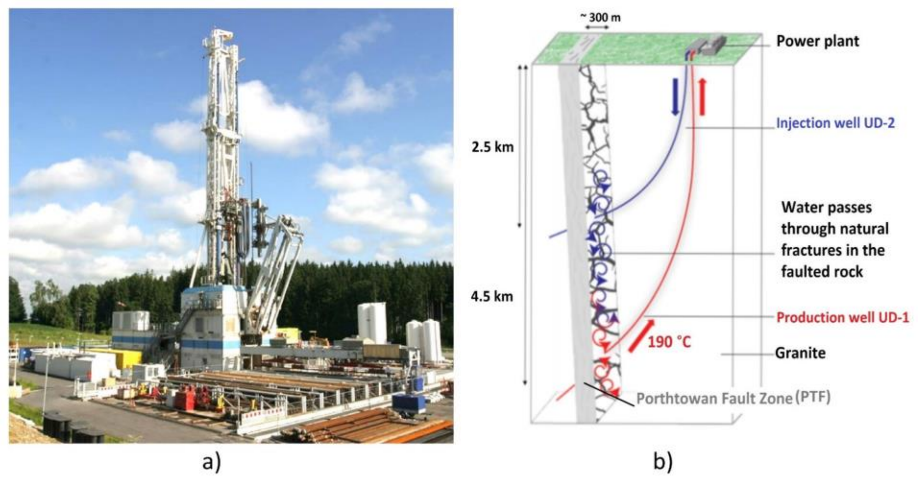
energies

Ongoing exploration for unconventional resources

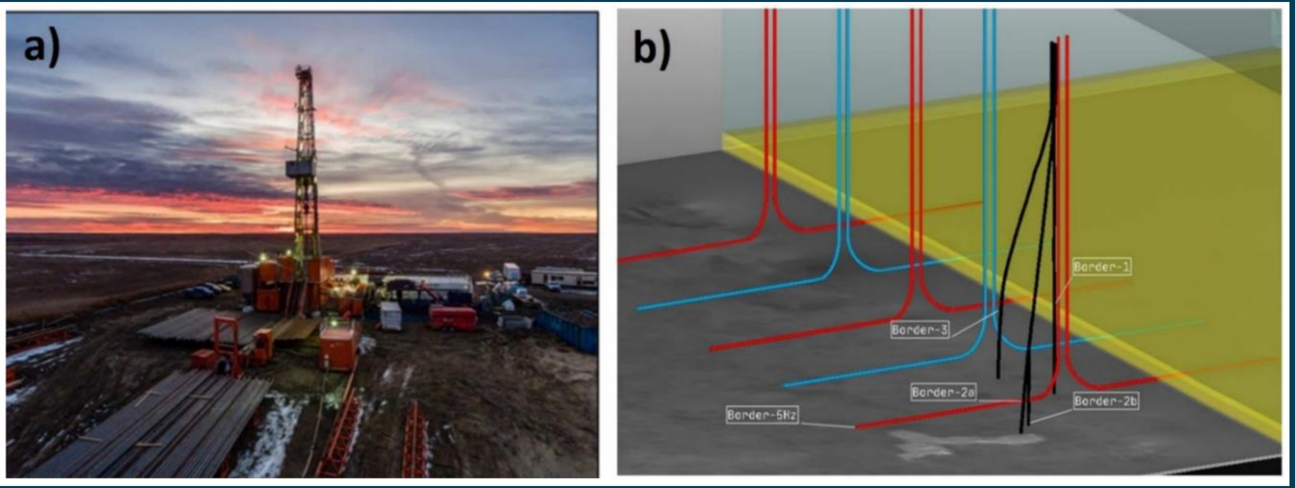
Campi Flegrei caldera, It – Supercritical fluids



Cornubian Batholith, UK – EGS



Williston Basin, Can – Hot sedimentary aquifer



Ongoing exploration for unconventional resources

Table 2. Summary of the main characteristic of the three geothermal drilling projects considered.

Project Acronym	Country	Maximum Drilled Depth TVD	Bottom/Hole Temperature (°C)	Geothermal Gradient (°C/km)	Period of Drilling Activities	Number of Wells Drilled to Date in Each Project
CFDDP	Italy	500	~110	220	2012	1
UDDGP	United Kingdom	5057	187	37.2	2019	2
DEEP	Canada	3450	127	36.8	2019–2020	6

Table 3. Population density in the regions of the three geothermal projects reviewed.

Country	Site	Population Density Residents/km^2	Year	Source
Italy	City of Naples	8091	2020	ISTAT [62]
United Kingdom	Cornwall county	161	2018	Office for National Statistics [63]
Canada	Southern Saskatchewan province	<2	2020	Statistics Canada [64]

Somma, 2021 (Energies)

INRS contributions to IGCP 636 - Canada

log laboratoire ouvert de géothermie

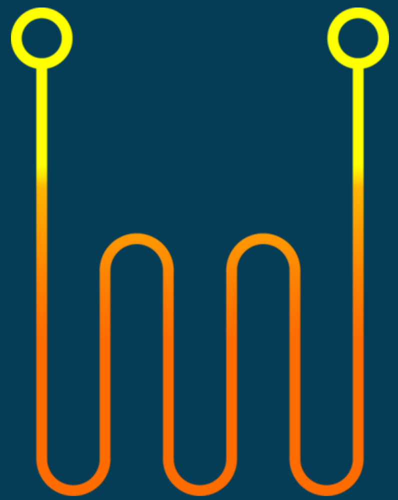
INRS Institut national de la recherche scientifique

unesco International Geoscience Programme

The LOG (Laboratoire ouvert de géothermie)

Open access in exchange of contributions to a shared database

- Users can do its own thermo-hydraulic analysis for free
- Results are compiled in a common database (thermal conductivity, thermal diffusivity, porosity, permeability)
- Sample location and geological description have to be supplied



15 active/recent projects

Canada:

Québec and Nunavik – 9

Nunavut – 1

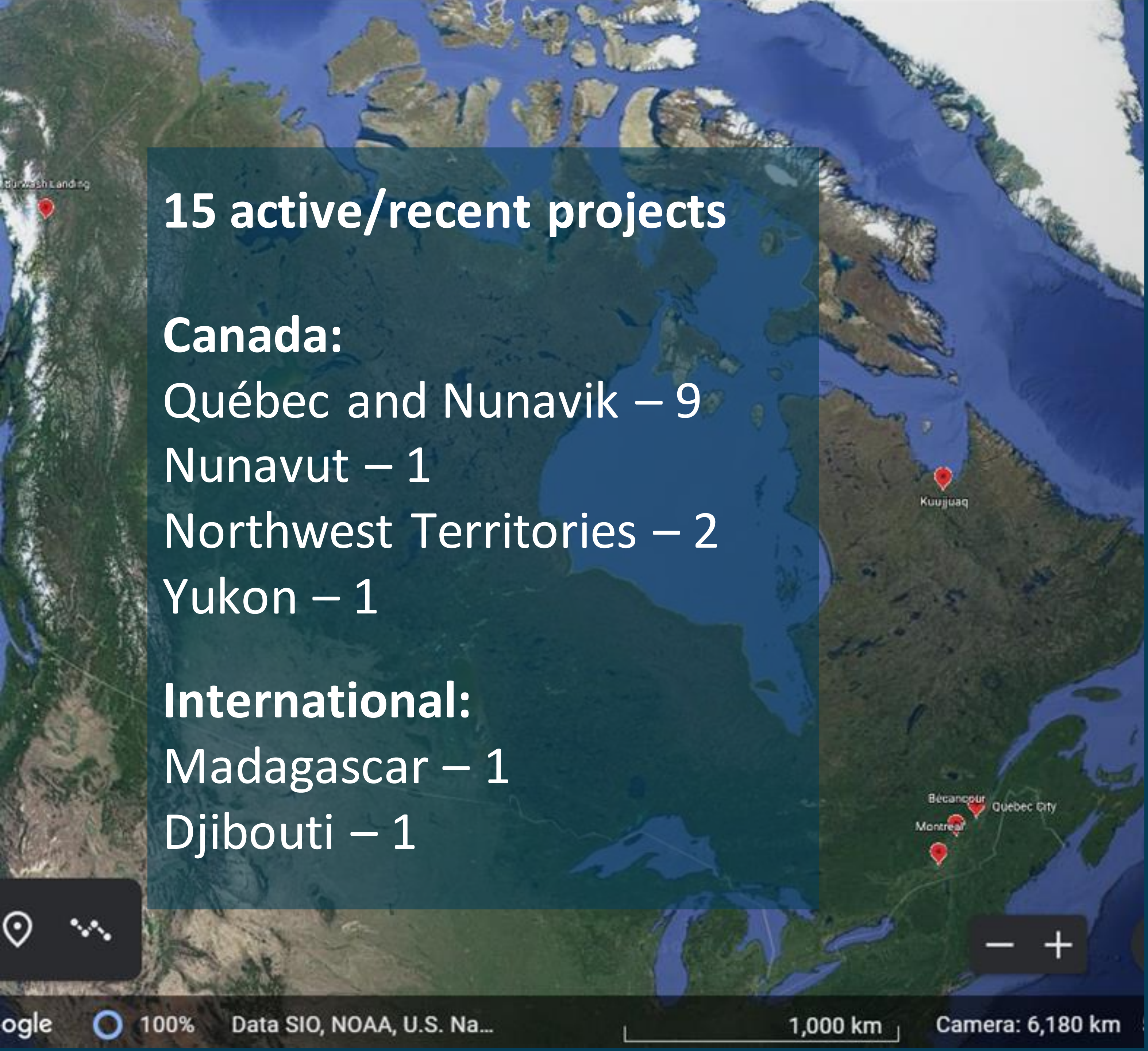
Northwest Territories – 2

Yukon – 1

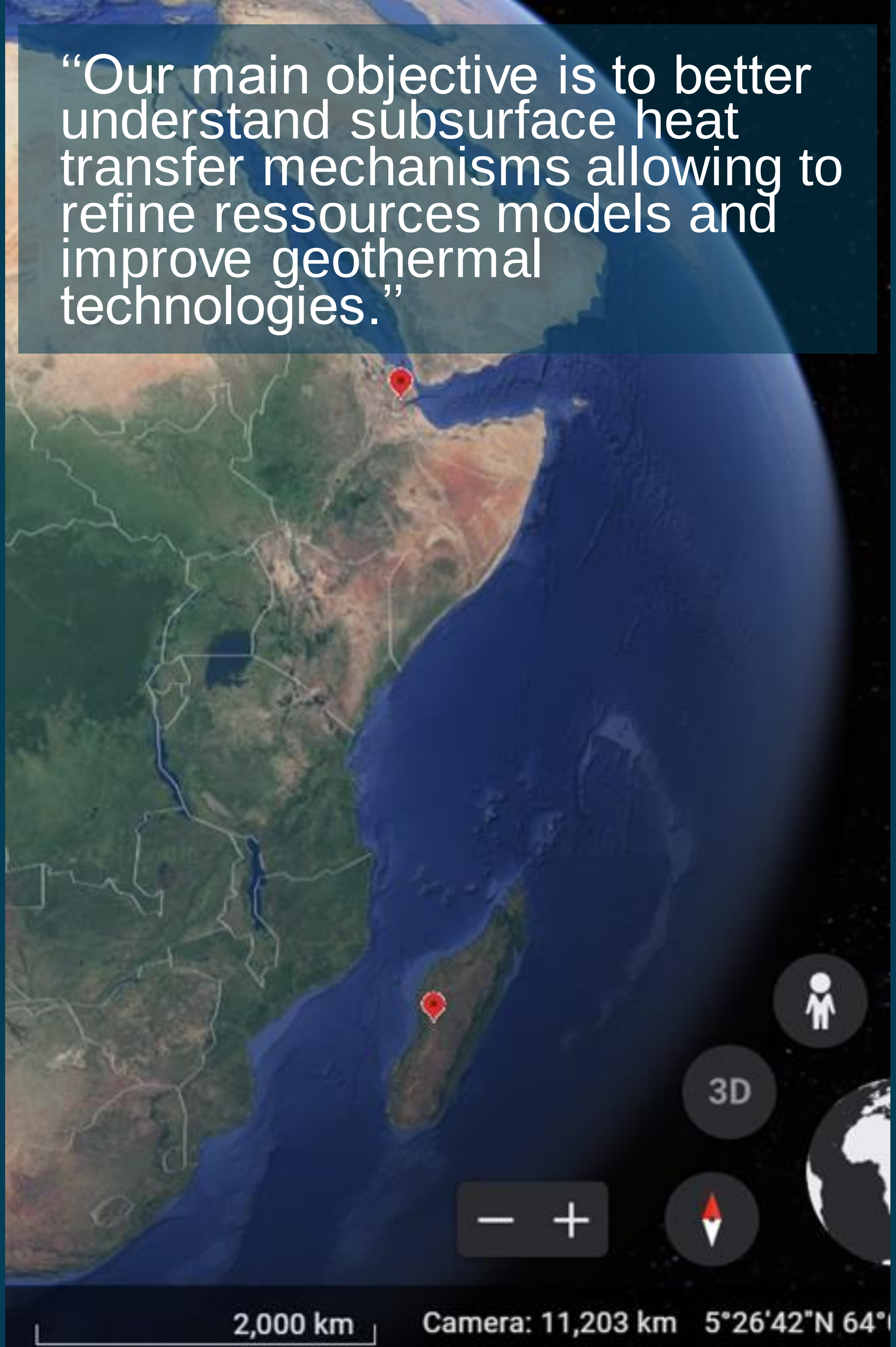
International:

Madagascar – 1

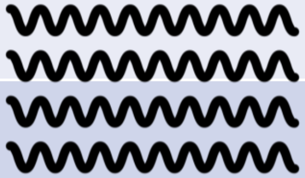
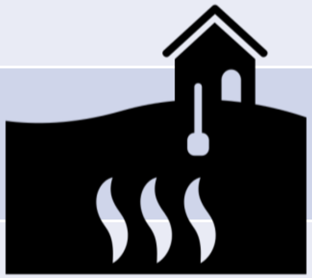
Djibouti – 1



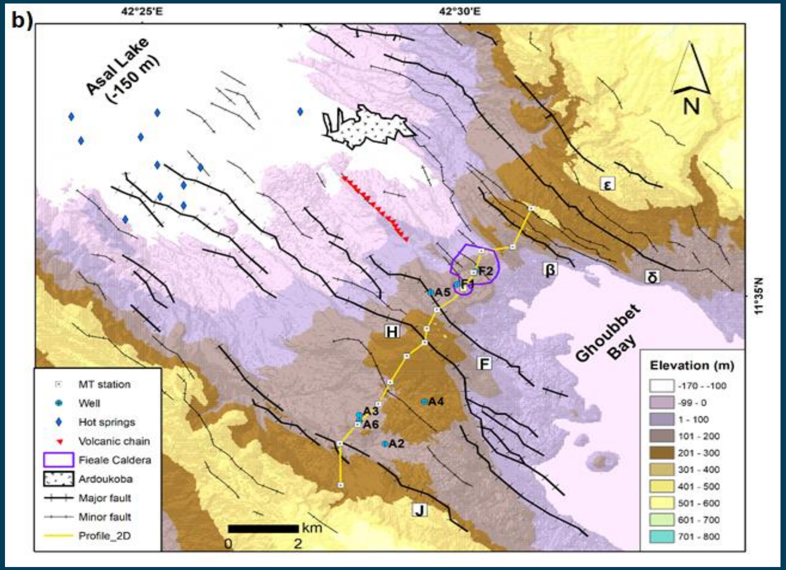
"Our main objective is to better understand subsurface heat transfer mechanisms allowing to refine ressources models and improve geothermal technologies."

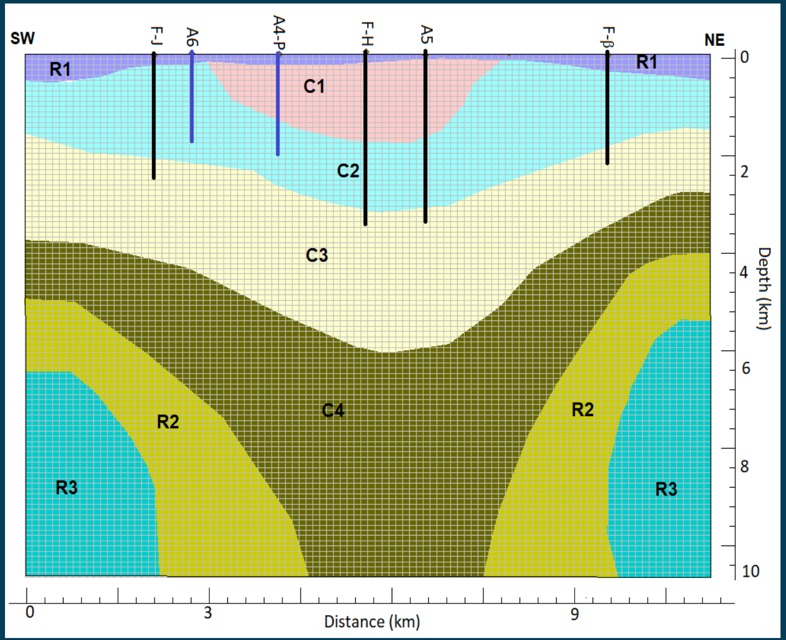


Deep geothermal resource projects

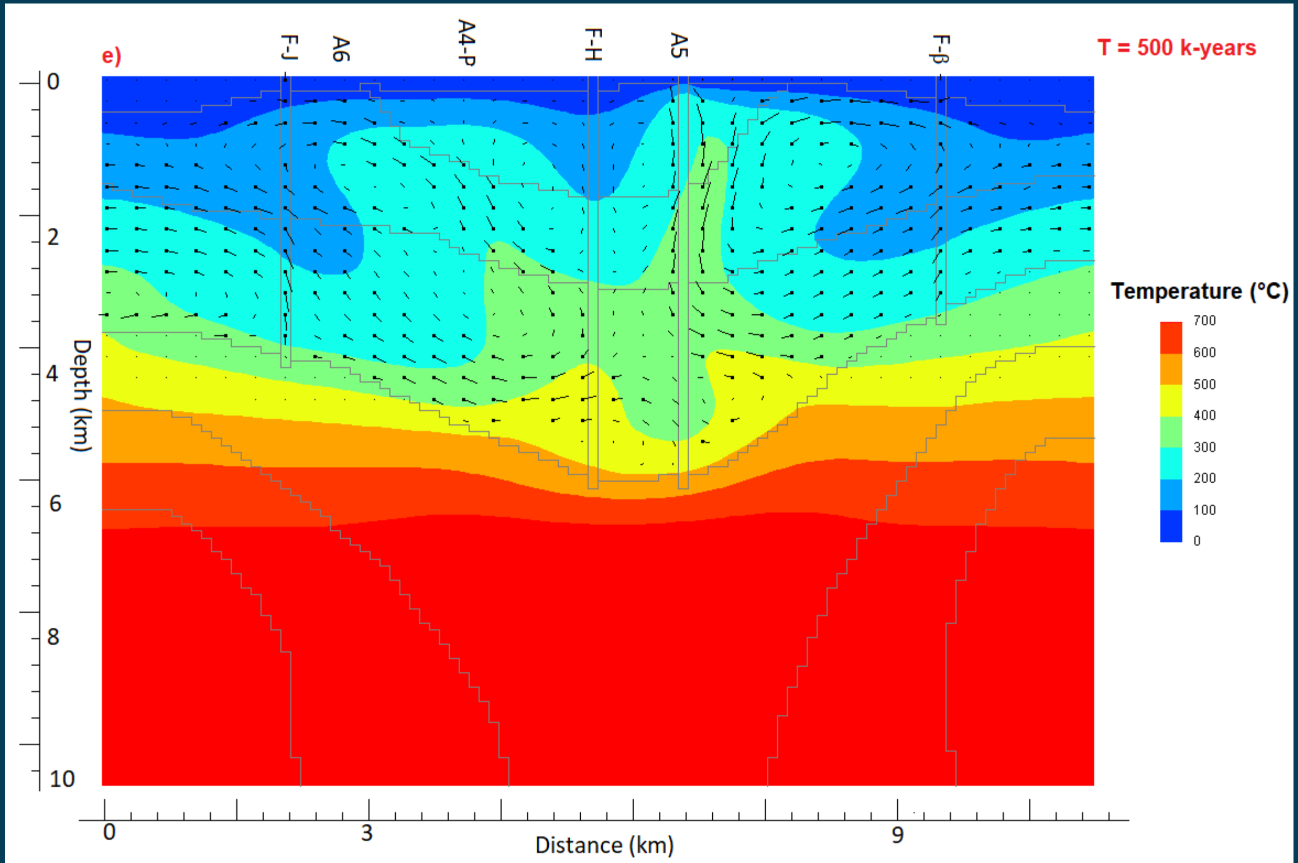
Location	Ressource type	Use	Geological setting	Heat transfer (resource)	
Asal Rift, Djibouti	High temperature hydrothermal	Electricity generation	Active rift and volcanism	Free convection	
Ambilobe and Ambanja, Madagascar	Moderate temperature hydrothermal	Electricity generation	Graben and fossil magmatic	Forced convection	
Burwash Landing, Yukon	Moderate to low temperature hydrothermal	Direct heat production	Active faults of an orogenic blet	Forced convection	
South Slave Region, Northwest Territories	Moderate to low temperature unconventional	Direct heat production	Hot sedimentary basin and basement rocks	Conduction	
La Prairie, Québec	Low temperature unconventional	Direct heat production and heat pumps	Sedimentary basin	Conduction	
Bécancour, Québec	Low temperature unconventional	Direct heat production and heat pumps	Sedimentary basin	Conduction	
Kuujjuaq, Nunavik	Low temperature unconventional	Direct heat production and heat pumps	Basement rocks	Conduction	

Asal Rift - Djibouti





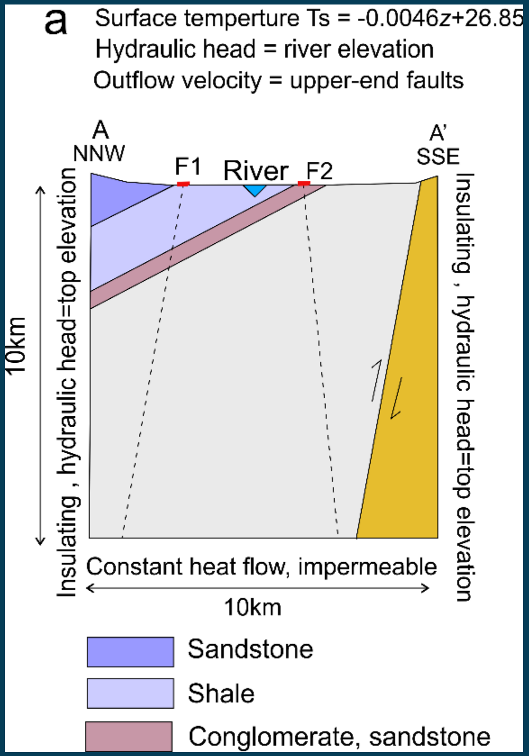
- Electricity imports are 94% from Ethiopia
- Electrification rate of 51.8% only
- Electricity cost of 0.42 $CAD/kWh



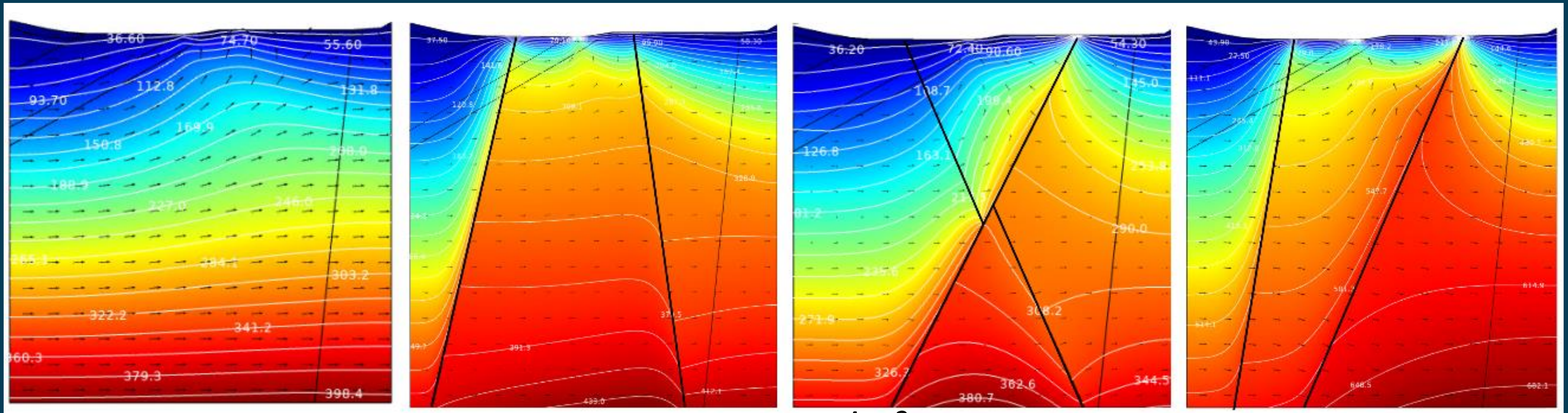
Aden (PhD Thesis)

North Madagascar - Ambilobe

- 74% of electricity produced from fossil fuels
- Electrification rate of 39% only
- Wood is often used to extract vanilla, creating deforestation

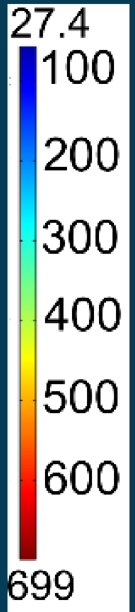


Rajaobelison 2021 (PhD Thesis)



99 mW/m^2

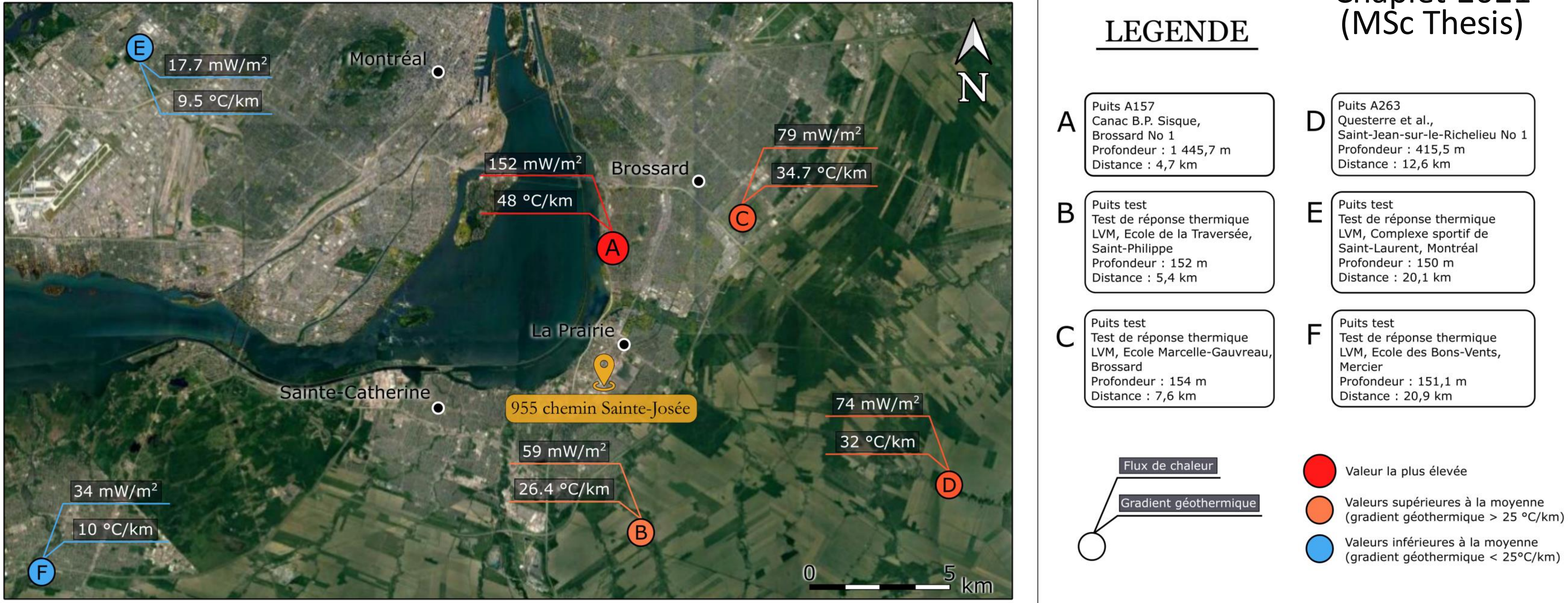
T(°C)



La Prairie, Québec

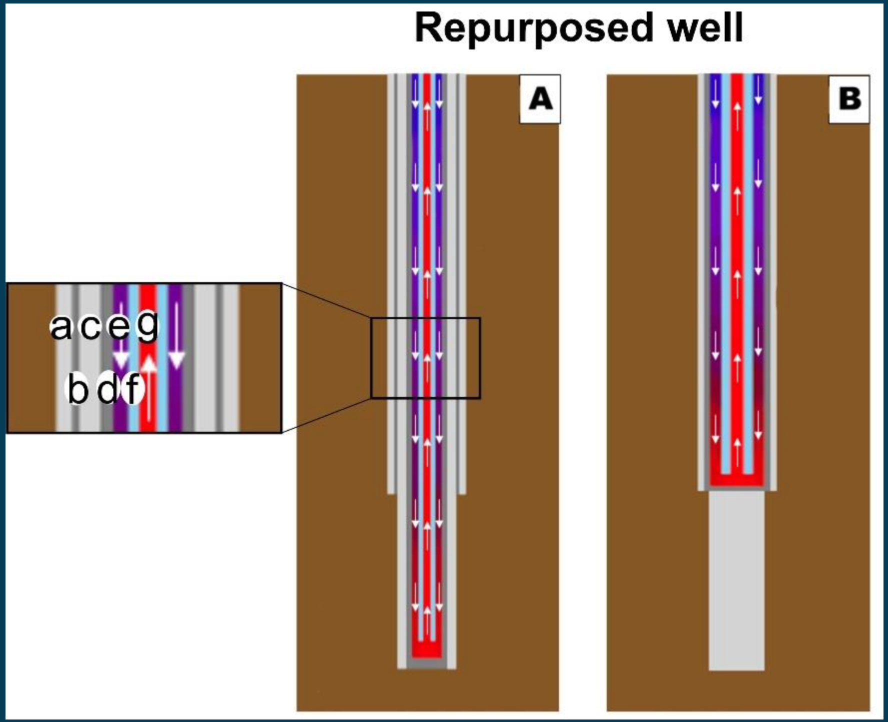
- Important real estate development on the south shore of Montreal

Chaplet 2021
(MSc Thesis)

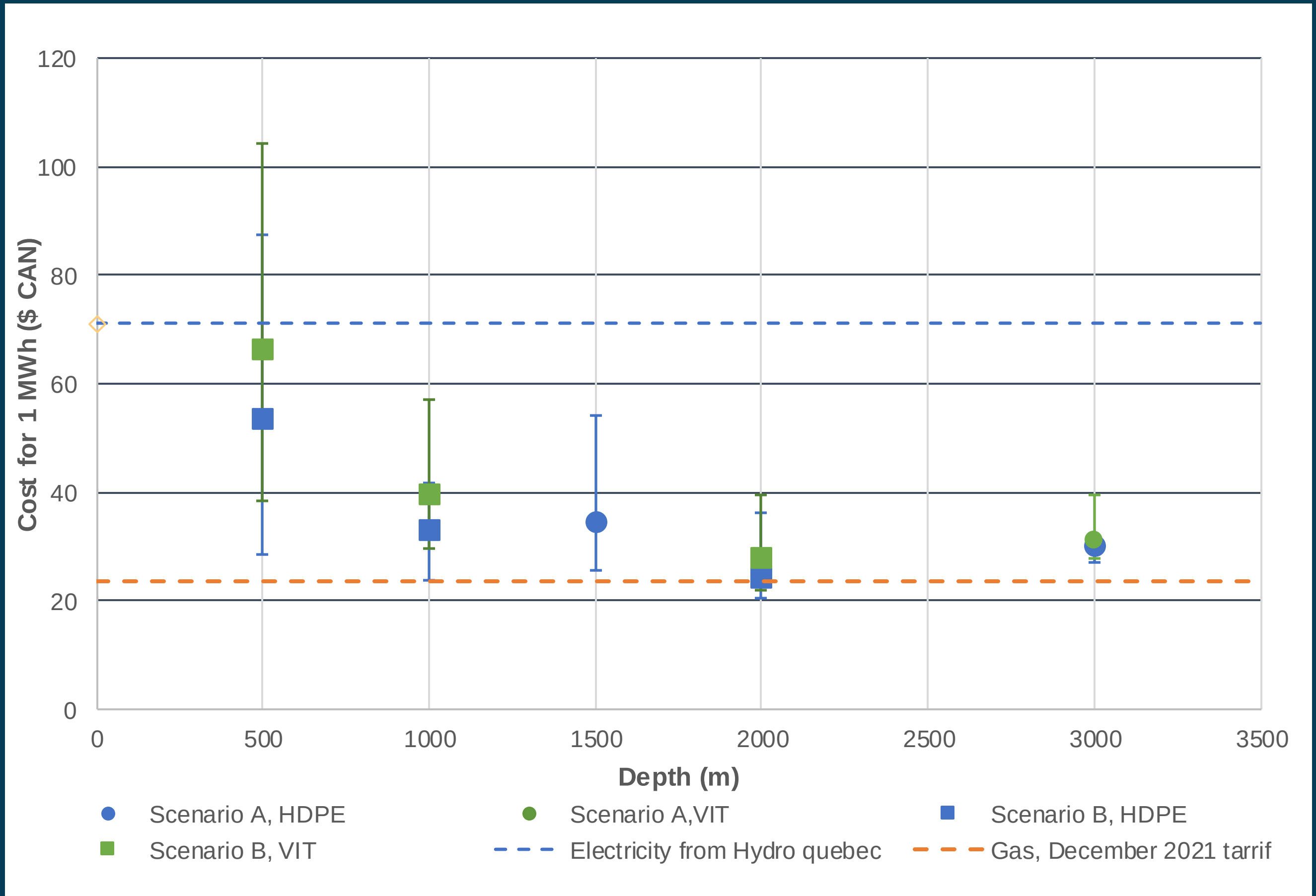


Bécancour (Québec)

- Québec government recently adopted a new bill (21) to stop oil and gas exploration
- Possibility to convert oil and gas wells in something greener



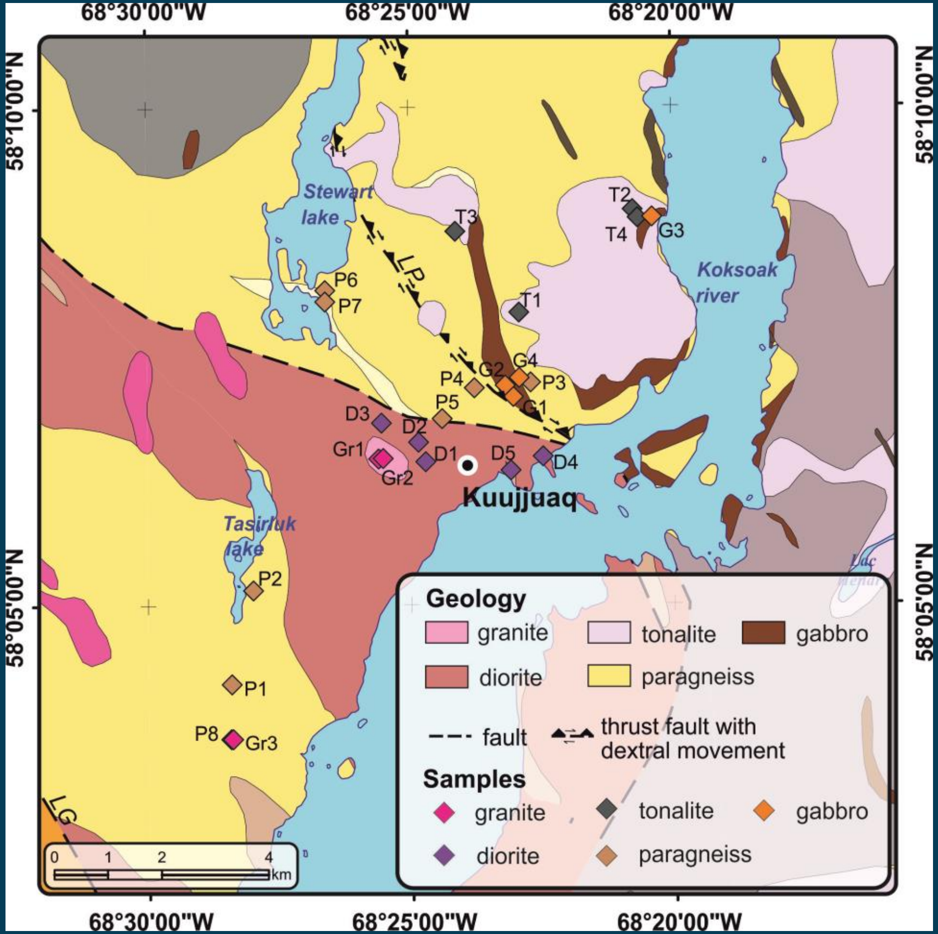
a: Pre-Existing grout, b: Pre-existing casing, c: New grout, d: Steel outer pipe, e: Annulus space, f: Inner pipe, g: inner space.

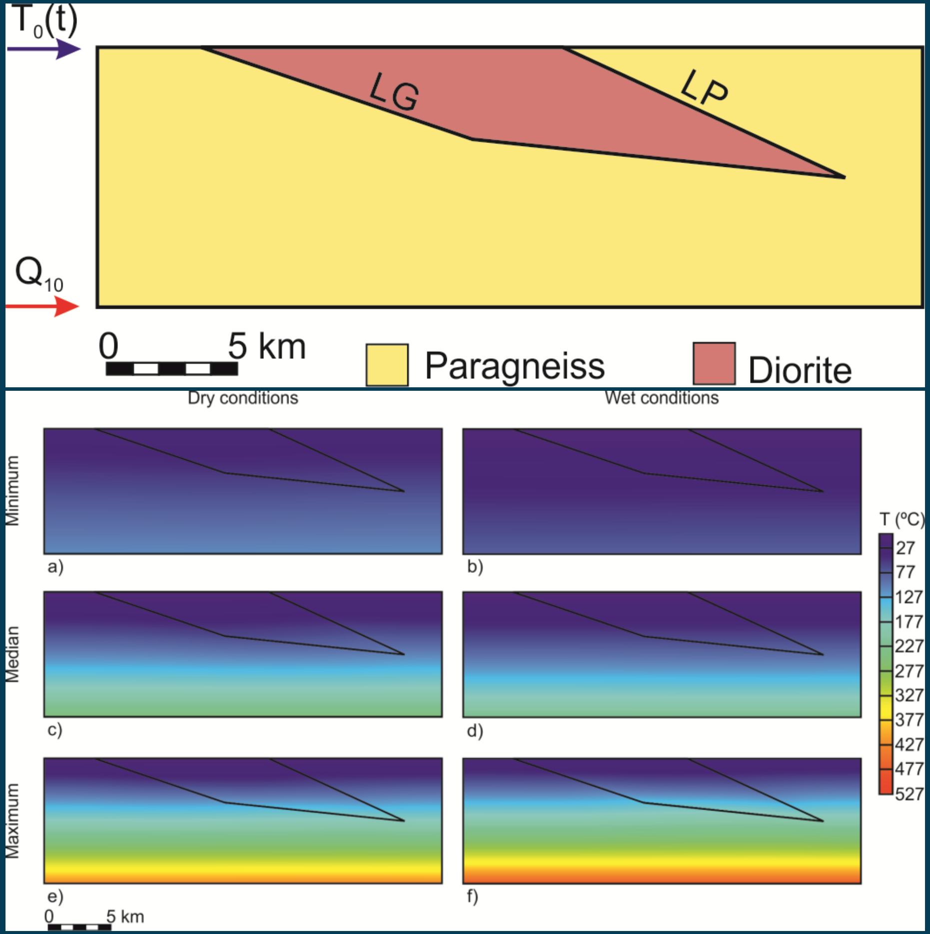


Gascuel, Pre-print (Geothermics)

Kuujjuaq, Nunavik (Northern Québec)

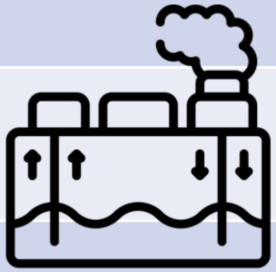
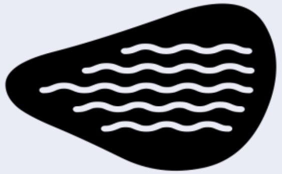
- 14 k people living in 14 remote communities
- Strictly dependent on diesel for electricity and space heating
- Energy is cost (with subsidies) is 2 to 10 more than in the south



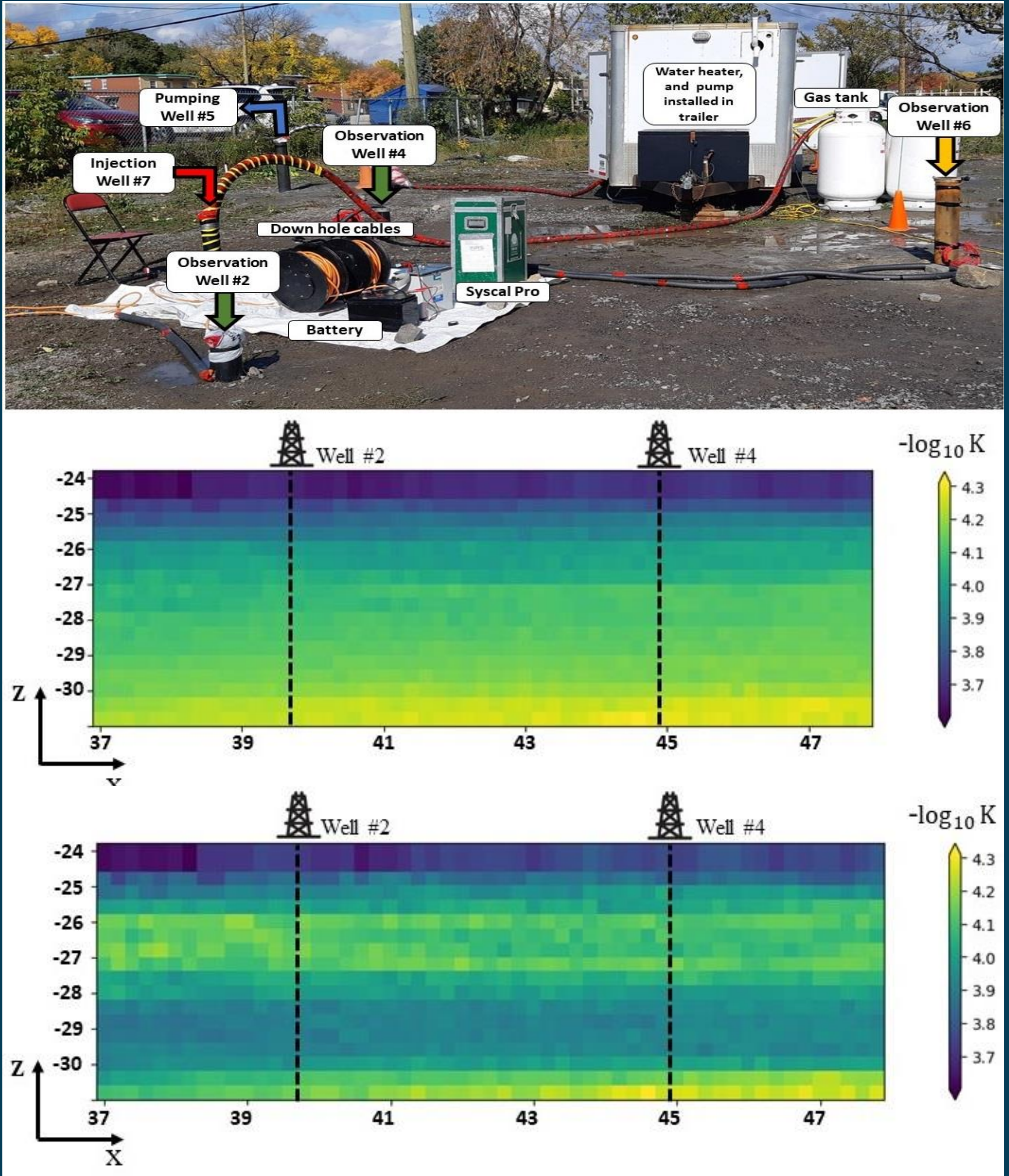


Miranda 2021 (PhD Thesis)

Geothermal heat pump projects

Location	System type	Use	Geological setting	Heat transfer (system)	
D’Estimauville, Québec (QC)	Groundwater (open loop)	Heating and Cooling	Unconfined gravel aquifer	Forced convection	
Éleonore Mine, Eeyou Istchee (James Bay, QC)	Groundwater (open loop)	Heating	Active mine	Forced convection	
Con Mine, Yellowknife (NWT)	Groundwater (open loop)	Heat production and storage	Flooded underground mine	Forced convection	
Carey and King Beaver Mines, Thetford Mines (QC)	Surface water (open loop)	Cooling	Flooded open pit	Forced convection	
Kuujjuaq, Nunavik (QC)	Ground-coupled (closed loop)	Heat production and storage	Permafrost	Conduction	
Whapmagoustui-Kuujjarapik, Nunavik (QC)	Ground-coupled (closed loop)	Heat production and storage	Permafrost	Conduction	
Umiujuaq, Nunavik (QC)	Ground-coupled (closed loop)	Heat production and storage	Permafrost	Conduction	
Montréal (QC)	Ground-coupled (closed loop)	Heating and cooling	Vadose zone	Conduction	

D’Estimauville, Québec (QC)

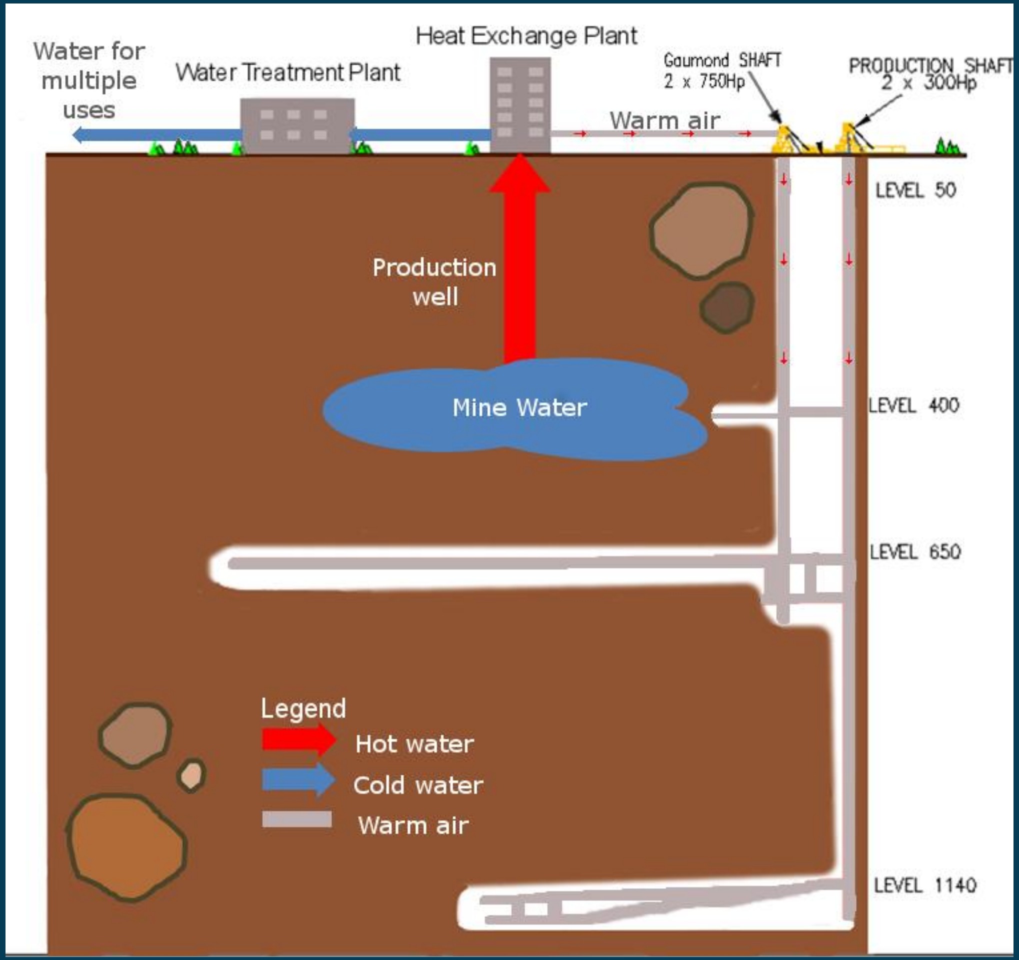


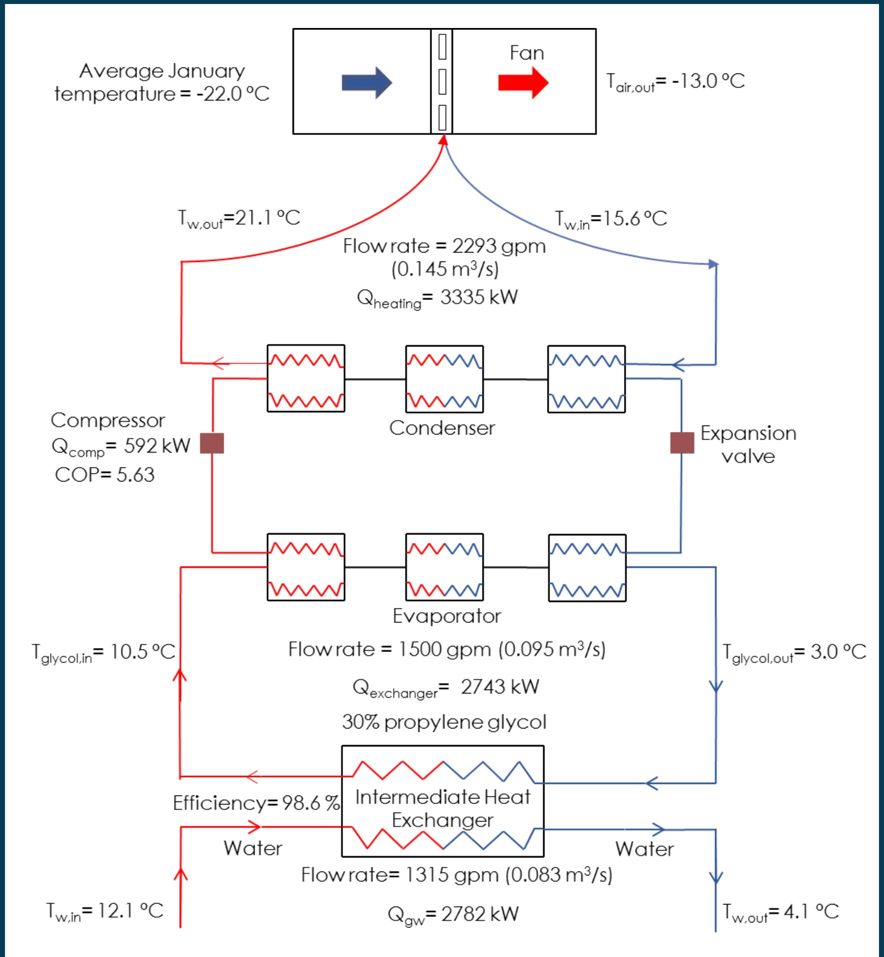
Shariatinik (PhD Thesis)

- Heat waves and urban heat islands are severely affecting the quality of life in dense cities
- Buildings require smart cooling solutions, but convention air conditioning systems can make it worst
- Aquifers can play a role to provide cooling

Éleonore Mine, Eeyou Istchee (James Bay, QC)

- Underground workings are heated with propane
- Annual heating bill near 1.5 M$/yr



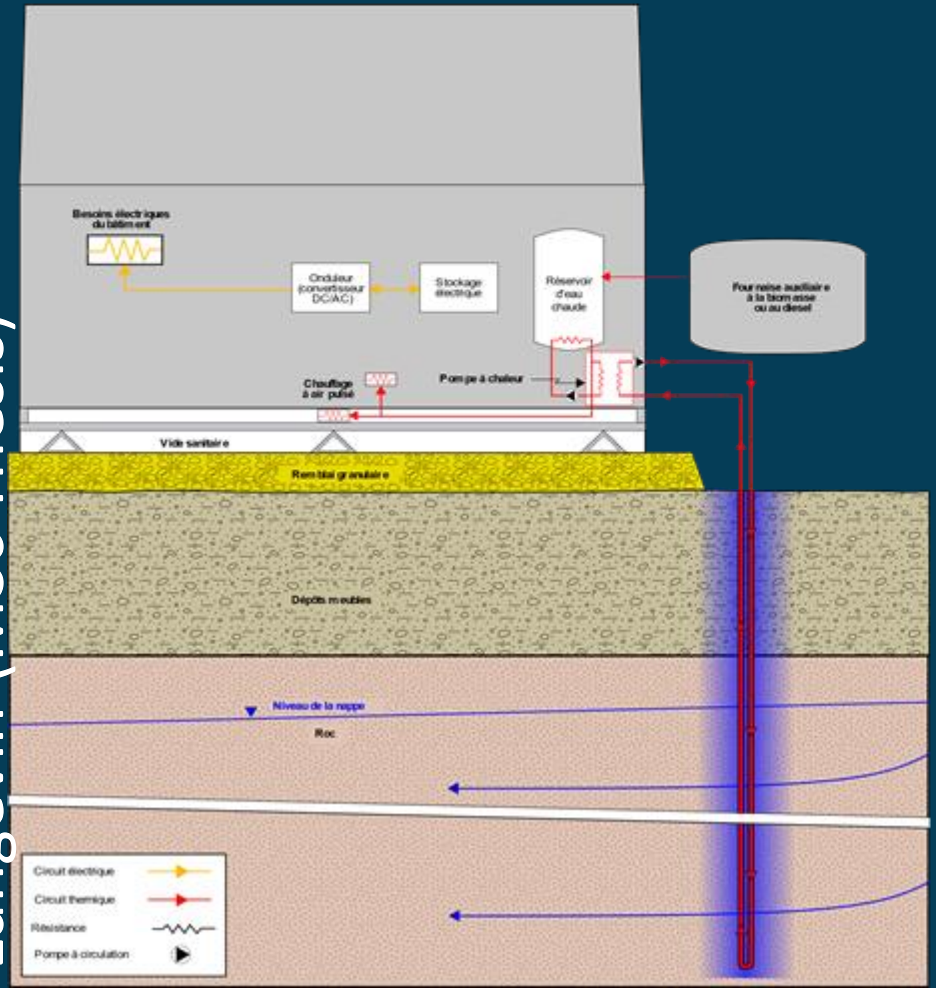


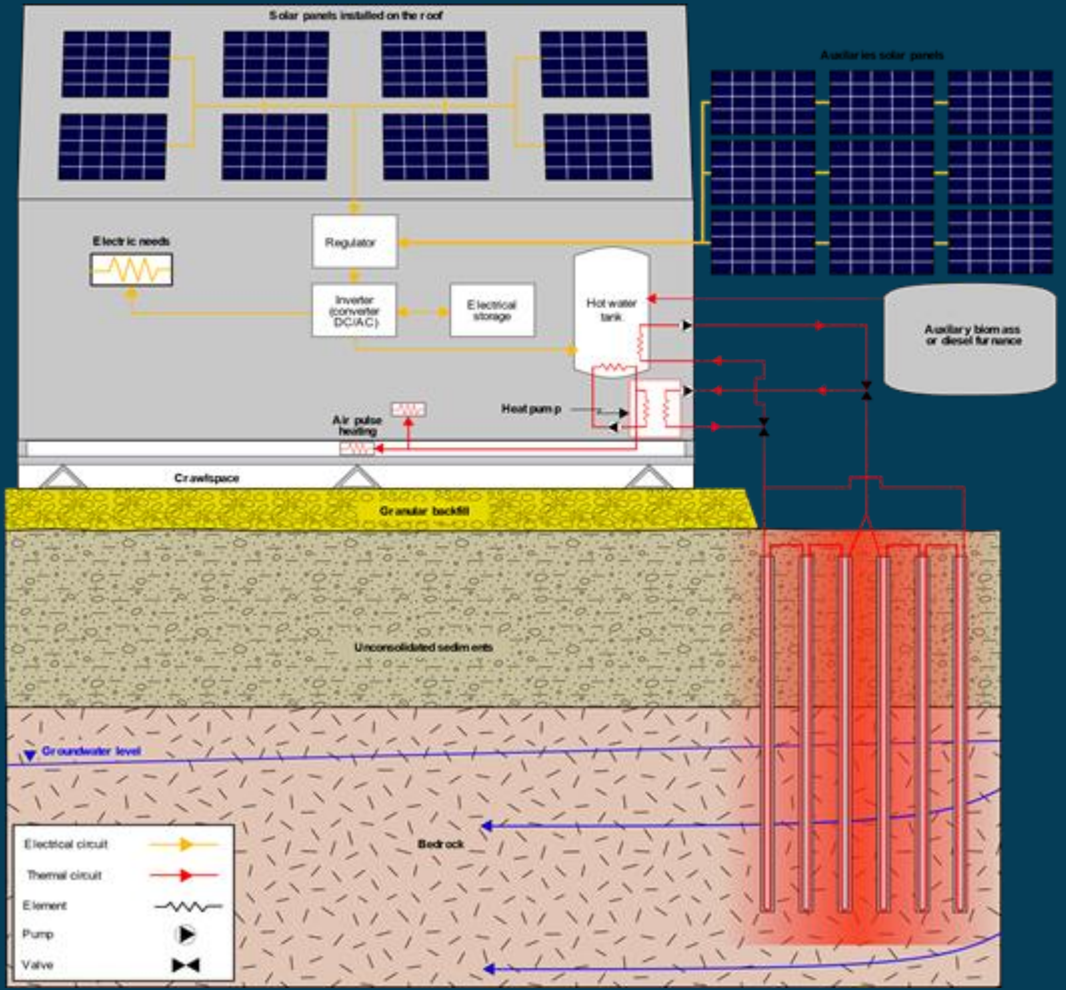
Alvarado 2020 (MSc Thesis)

Kuujjuaq, W.-K., Umiujuaq - Nunavik(QC)

- 50 % of energy consumed is for space heating
- Achieved with oil furnaces
- Oil sales are an important revenue for Inuits

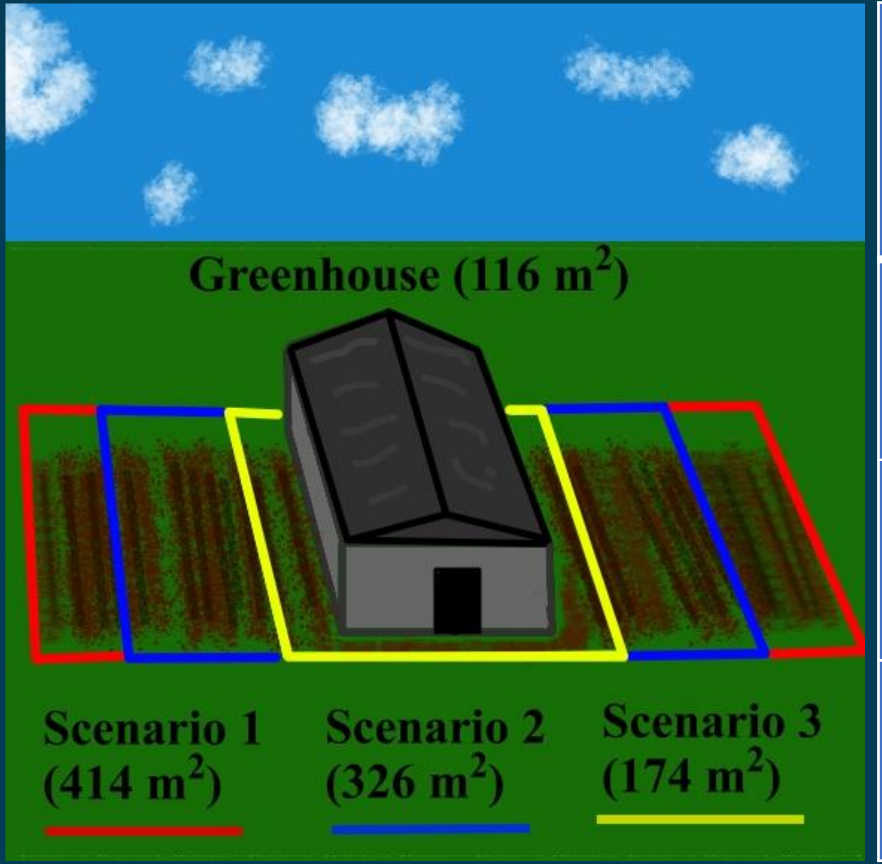
Langevin (MSc Thesis)





Community greenhouses in Montreal (QC)

- The pandemic has highlighted the need for local food
- Community greenhouse can help underprivileged districts
- Affordable technologies are needed to heat greenhouses



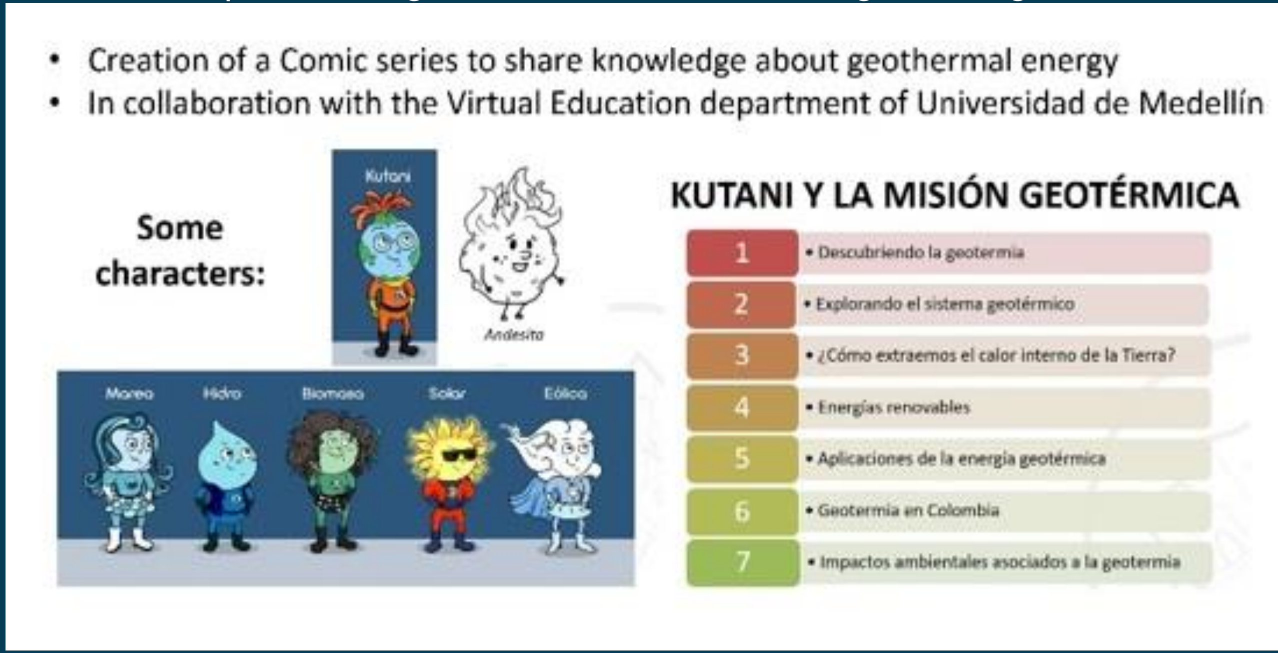
Scenario	Peak loads covered	System	Required space (m)	Comparison with greenhouse size of 116 m^2 (%)
1	100%	Heating	40.8 x 8 (326.4 m^2)	281%
	100%	Cooling	51.8 x 8 (414.4 m^2)	357%
2	100%	Heating	40.8 x 8 (326.4 m^2)	281%
	60%	Cooling	34.8 x 8 (278.4 m^2)	240%
3	40%	Heating	21.8 x 8 (174.4 m^2)	150%
	30%	Cooling	18.8 x 8 (148.8 m^2)	128%

Léveillée-Dallaire (MSc Thesis)

UdeM contributions to IGCP 636 - Colombia

1. Analyzing the feasibility shallow geothermal installations to provide the required cooling load for a flower storage room or similar space conditioning needs (greenhouses, university computer rooms...)

2. Development of digital tools to share knowledge about geothermal



3. Fieldwork in the Nevado del Ruiz volcano area: geothermal potential assessment and geochemistry characterization

CEGA contributions to IGCP 636 - Chile

2017 – Invernadero geotérmico en CET Valle Verde, Puerto Aysén.

2018 – Climatización geotérmica Liceo Altos de Mackay, Coyhaique.

2019 – Invernadero geotérmico para el cultivo de tomates, Panguipulli

2019 – Invernadero y secador de productos agrícolas geotermal, Liquiñe

2020 – Cámara plantinera para la reactivación económica, Mafil

2021 – Climatización geotermia Escuela Luis Cruz Martínez, Curacautín

2022 – Climatización geotérmica Liceo Arturo Prat, Puerto Cisnes.

2023 – Climatización geotérmica posta de Salud Rural, Illahuapi.

2023 – Calor y frío para edificación de uso público, Antofagasta.

RIGS contributions to IGCP 636 - Argentina

Analytical solution for shallow geothermal energy management at city scale considering subsurface heat island effects in shallow aquifers

Regional evaluation of shallow geothermal energy in Latin American cities with GIS technics

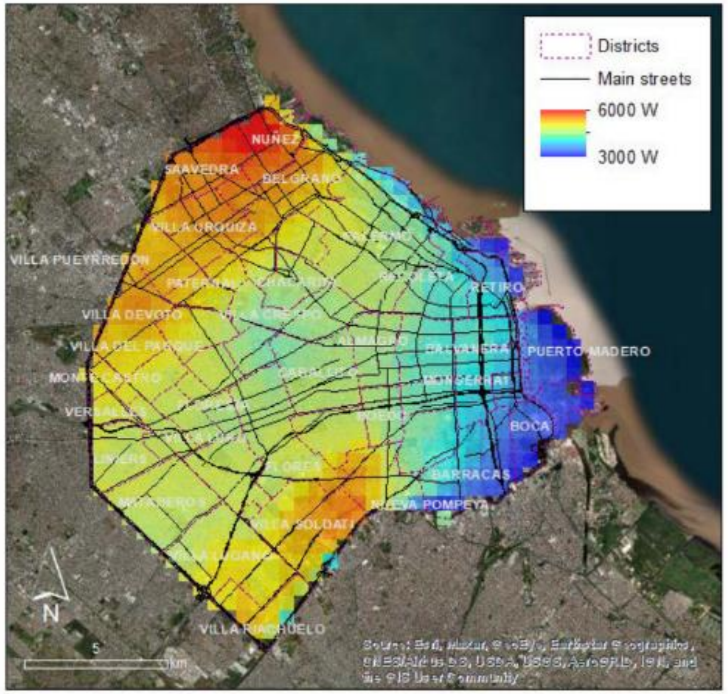
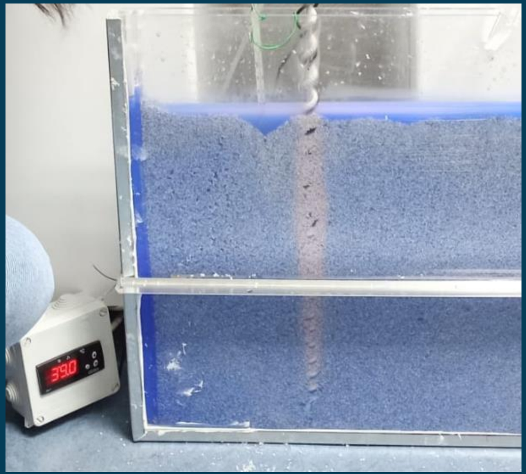


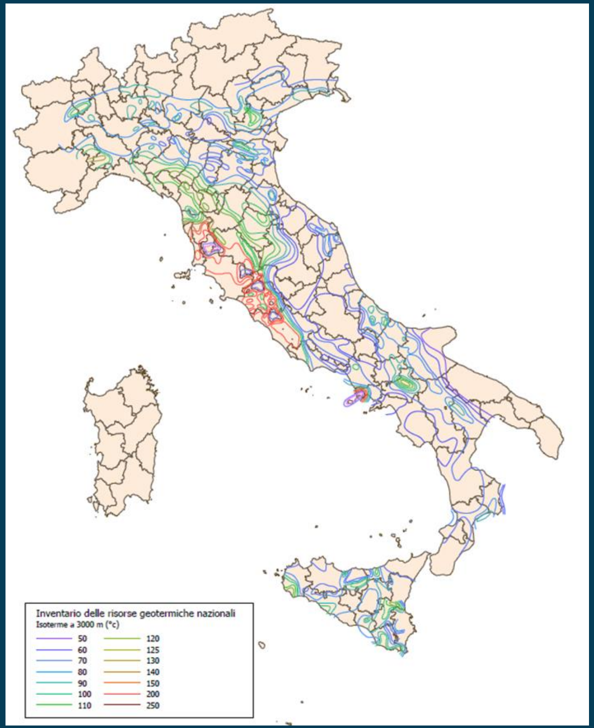
Fig. 1. Map of gross shallow geothermal energy potential of Buenos Aires for a heat exchanger.



Promotion of shallow geothermal energy with an installation model reproducing the thermal behavior of aquifers

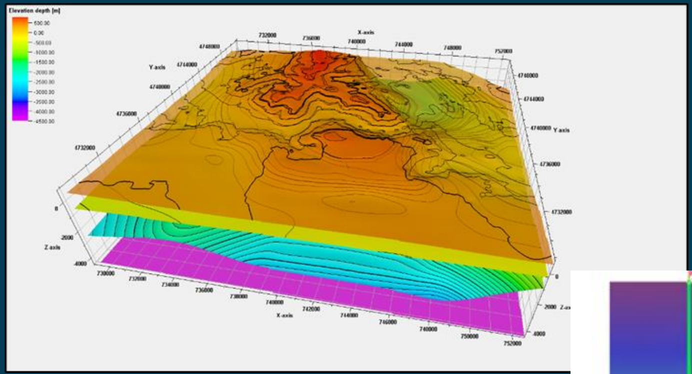
RSE* contributions to IGCP 636 - Italy

Research on Energy System –RSE Spa
Italian Research Center
Contact: Dr. Nunzia Bernardo
nunzia.bernardo@rse-web.it

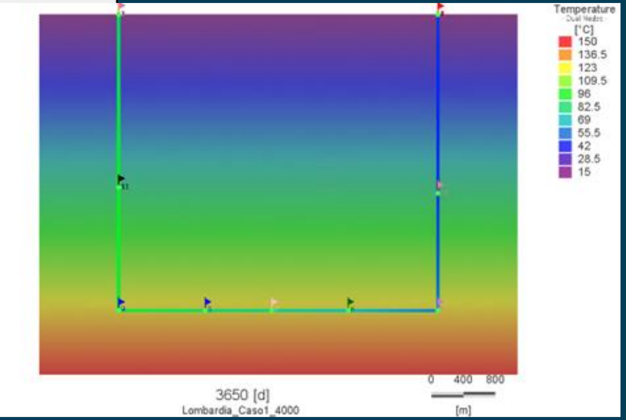


Research projects among **Ricerca di Sistema** public funding

Mapping geothermal potential for high, medium and low enthalpy;



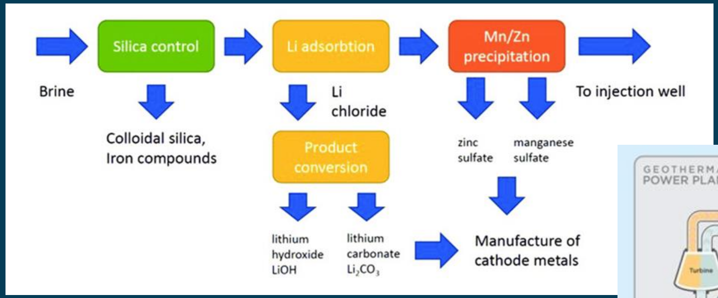
Numerical modeling to evaluate geological feasibility of innovative close loop geothermal plants;



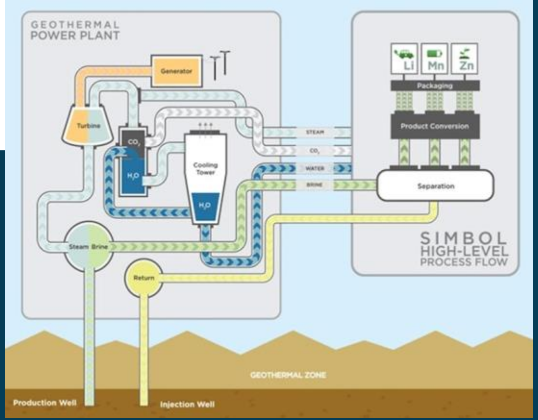
RSE* contributions to IGCP 636 - Italy

Research on Electro-energetic System
Italian Research Center
Contact: Dr. Nunzia Bernardo
nunzia.bernardo@rse-web.it

- Geological and territorial evaluation of possible integration of geothermal in the energetic mix for the constitution for **Energy Community**;
- Support local and government institution to **develop strategic energetic plans** at different scales;



Scheme for extracting lithium and other valuable chemicals from geothermal brines.



Process of mining lithium and other metals from geothermal brine (source: Simbol Materials)

- Geological and geochemical evaluation of strategic raw materials content in geothermal brine (**geothermal brine mining**)*.

*part of this activity will be supported by the collaboration with two Italian research centers INGV and CNR

PROJECT 636

Geothermal Resources for Energy Transition

IUGS UNESCO IGCP

UNESCO INTERNATIONAL GEOSCIENCE PROGRAMME

Conclusions

1. Education & outreach
2. Deep geothermal reservoirs
3. Geothermal heat pumps

SUSTAINABLE DEVELOPMENT GOALS

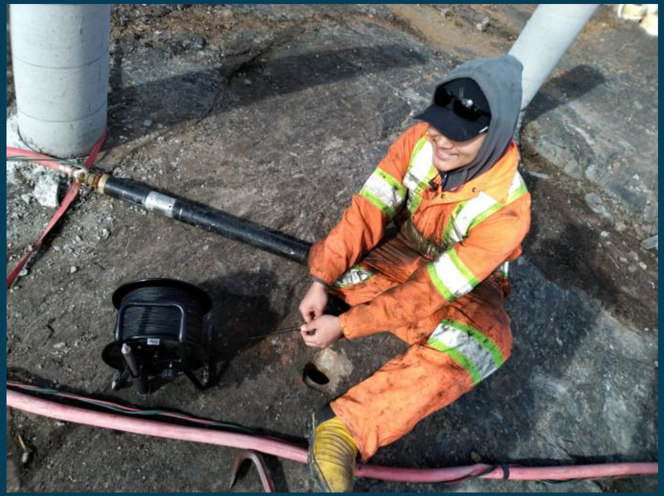
7 AFFORDABLE AND CLEAN ENERGY

11 SUSTAINABLE CITIES AND COMMUNITIES

Conclusions

IGCP 636 Group to provide expertise for geothermal drilling projects

- 234 m borehole drilled in Kuujjuaq
- Exploration borehole to be drilled in La Prarie (fall 2022)
- International Continental Drilling Program – Interest in Colombia



UNESCO IGCP 636

Geothermal Resources for Energy Transition

www.igcp636.com
www.log.ete.inrs.ca
jasmin.raymond@inrs.ca