



# Geothermal Energy Potential of Canada



*Stephen Grasby*

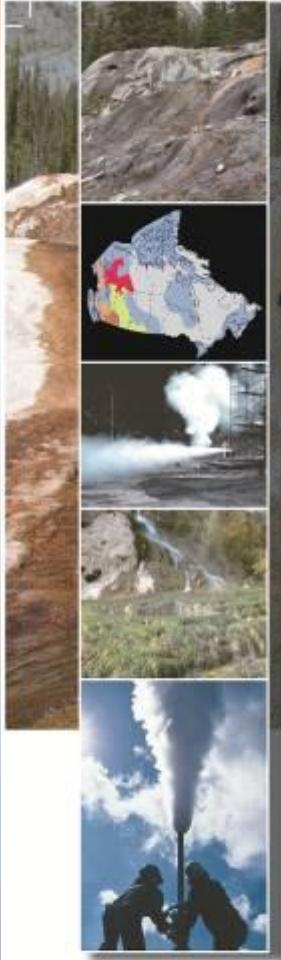


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Canada

Ressources naturelles  
Canada



# Hot of the Press



**Geothermal Energy  
Resource Potential  
of Canada**

Natural Resources Canada / Ressources naturelles Canada



SFU Simon Fraser University  
UNIVERSITÉ SIMON FRASER



L'ALMA  
LAVAL



Canada



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**geopub.nrcan.gc.ca**

**Grasby, S.E. – GSC**

**Allen, D.M. – SFU**

**Bell, S. - Sigma H**

**Chen, Z. – GSC**

**Ferguson, G. – SFX**

**Jessop, A. – GSC**

**Kelman, M. – GSC**

**Ko, M. – GSC**

**Majorowicz, J. – U of A**

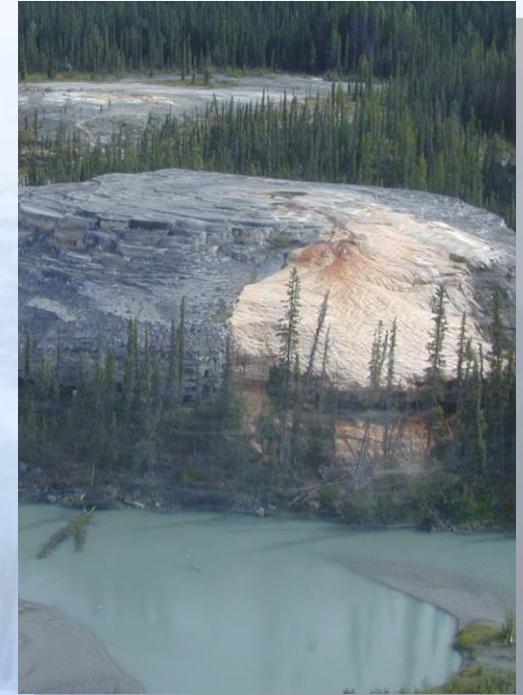
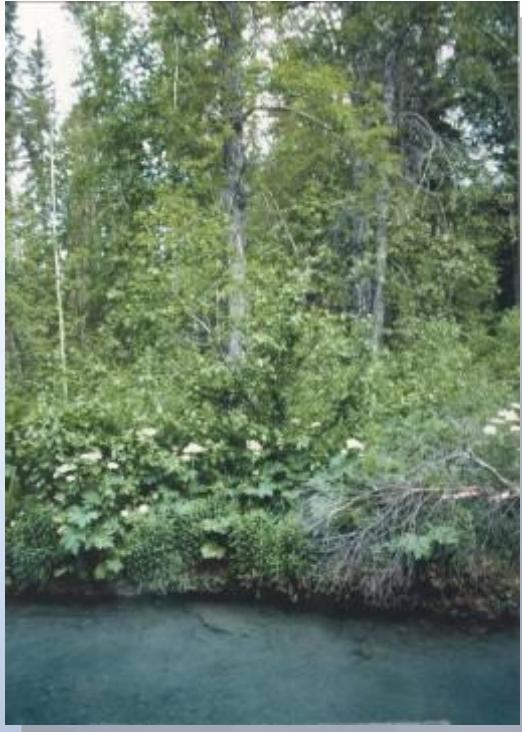
**Moore, M. – U of C**

**Raymond, J. –Laval**

**Therrien, R. –Laval**



# All I wanted was to sample Hot Springs!

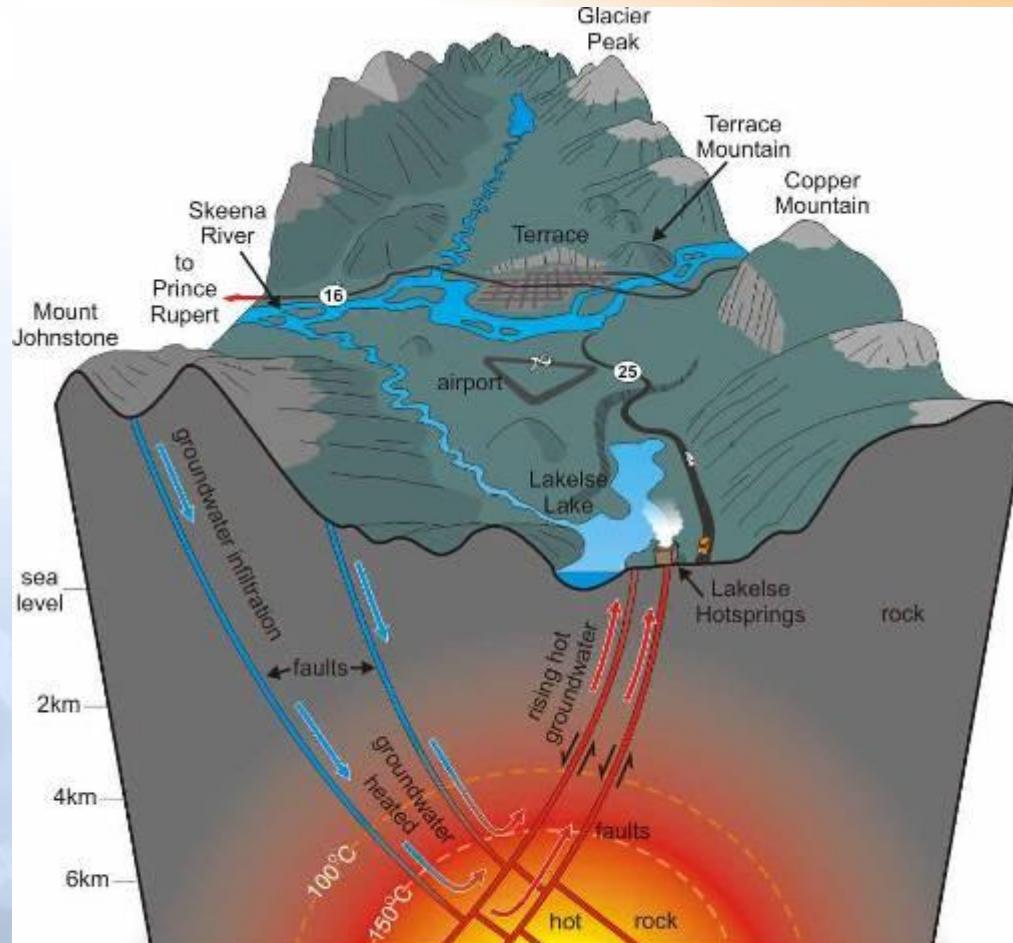


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# Hydrothermal Systems



R. Turner



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# Endangered life



*Adiantum capillus-veneris*



*Argia vivida*



*physella johnsoni*





# Hot Bugs

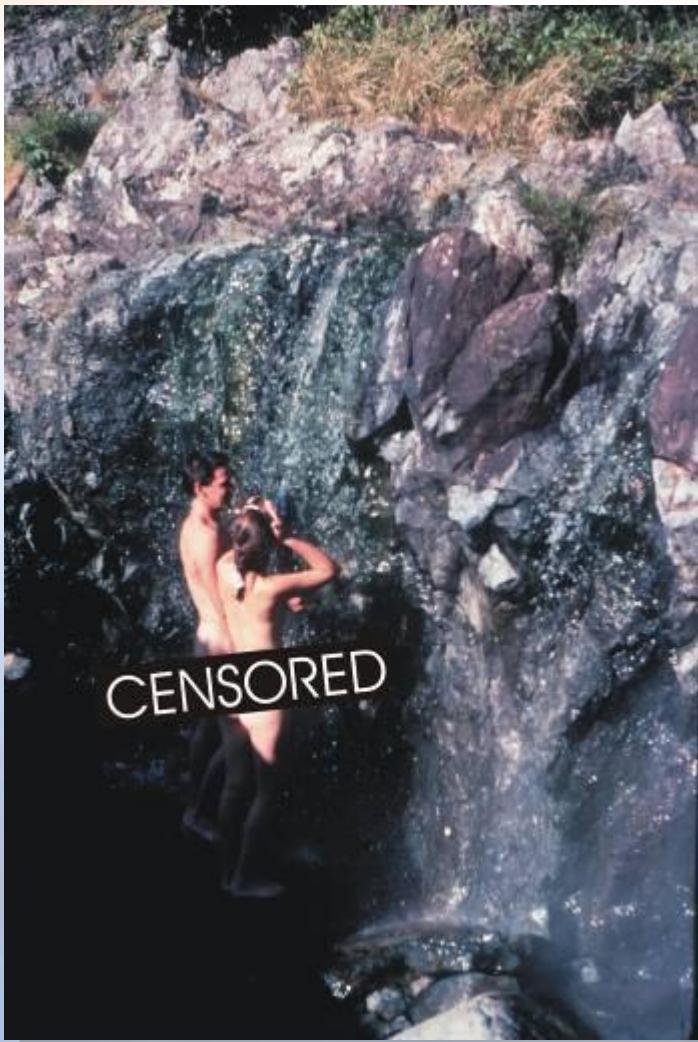


Hottest  
photosynthetic  
life...ever





# Other strange things



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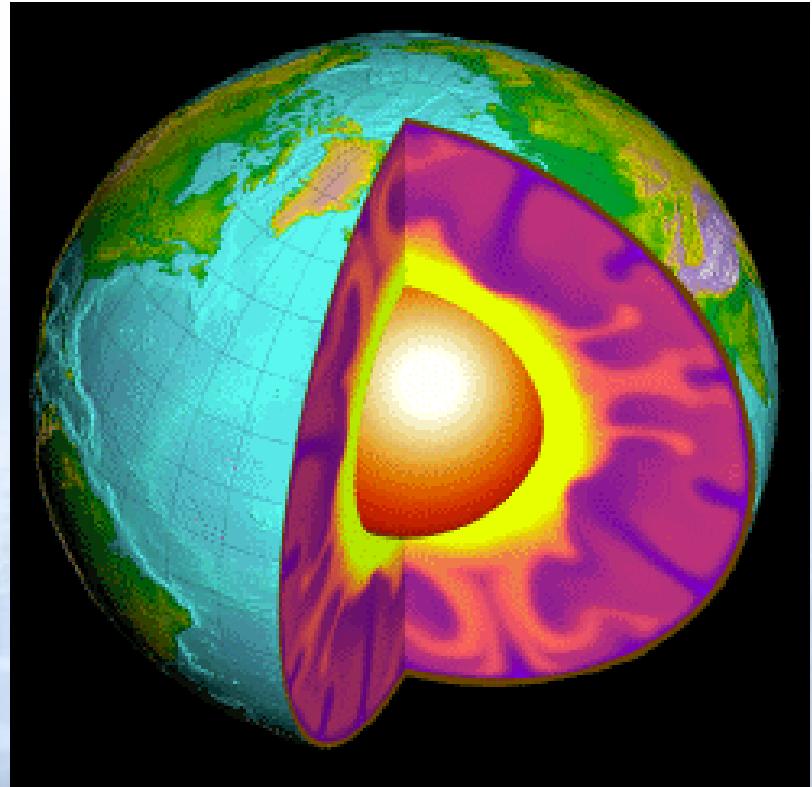
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# What is Geothermal Energy?



- 83% of Earth heat related to radioactive decay of Uranium, Thorium, and Potassium in the crust
- The remainder from mantle cooling

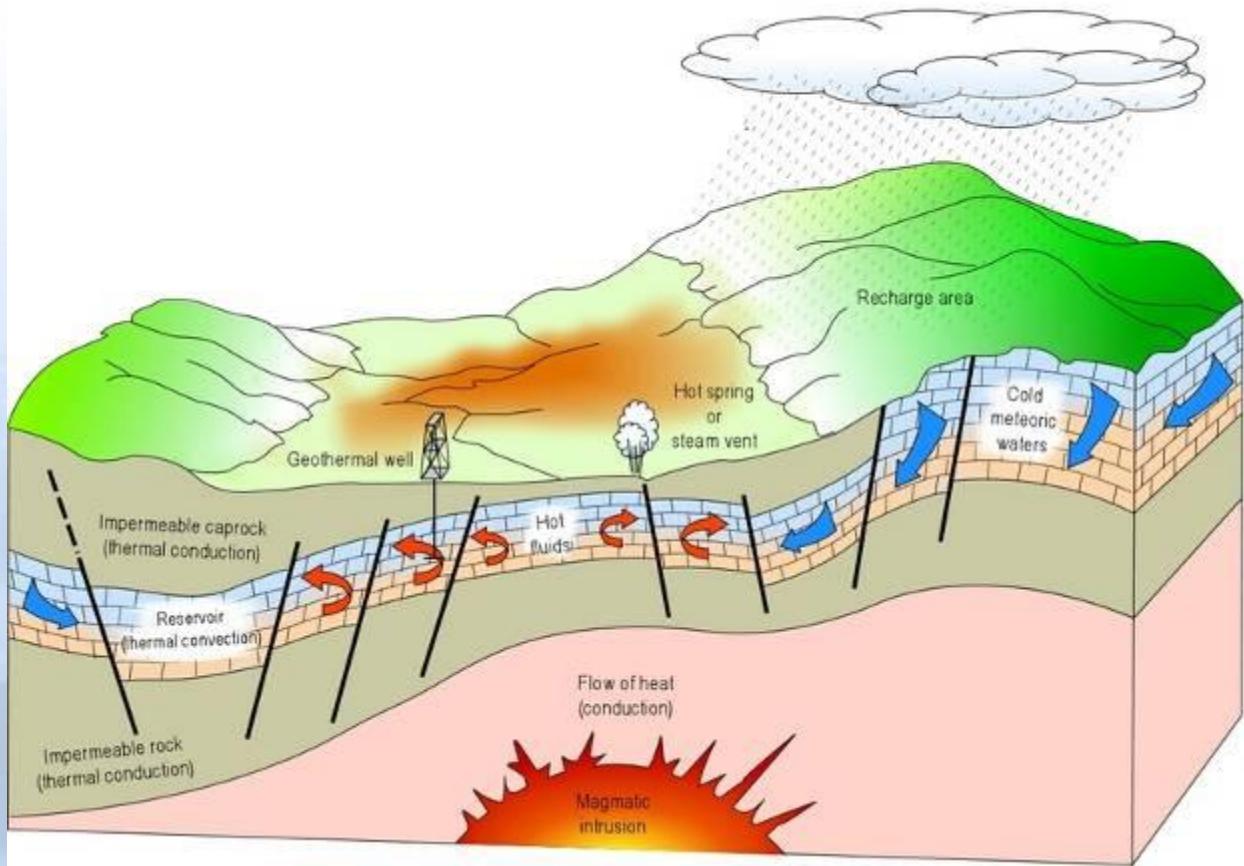




# Resource Play Concept

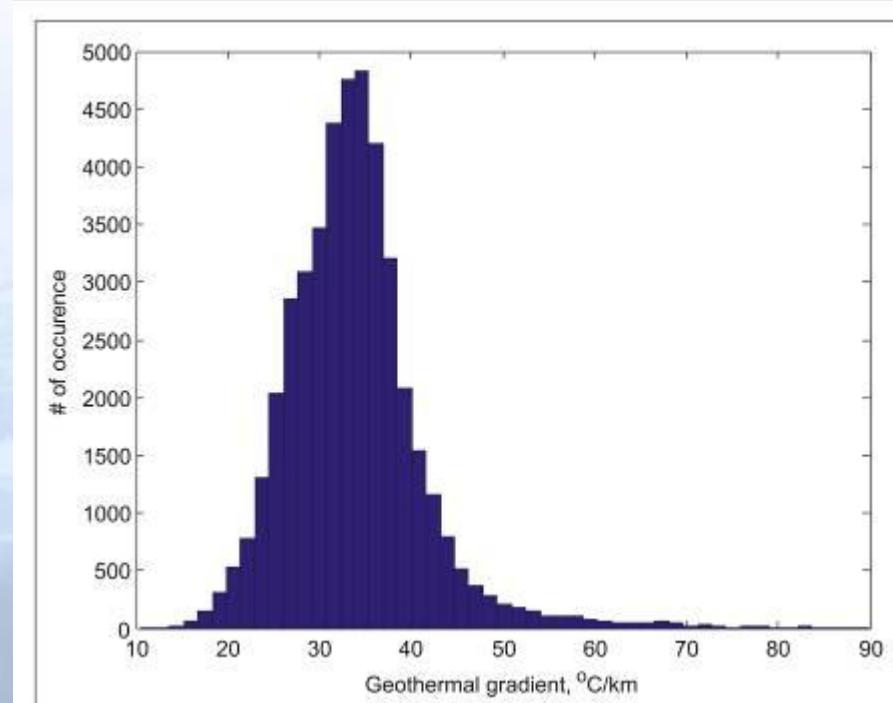
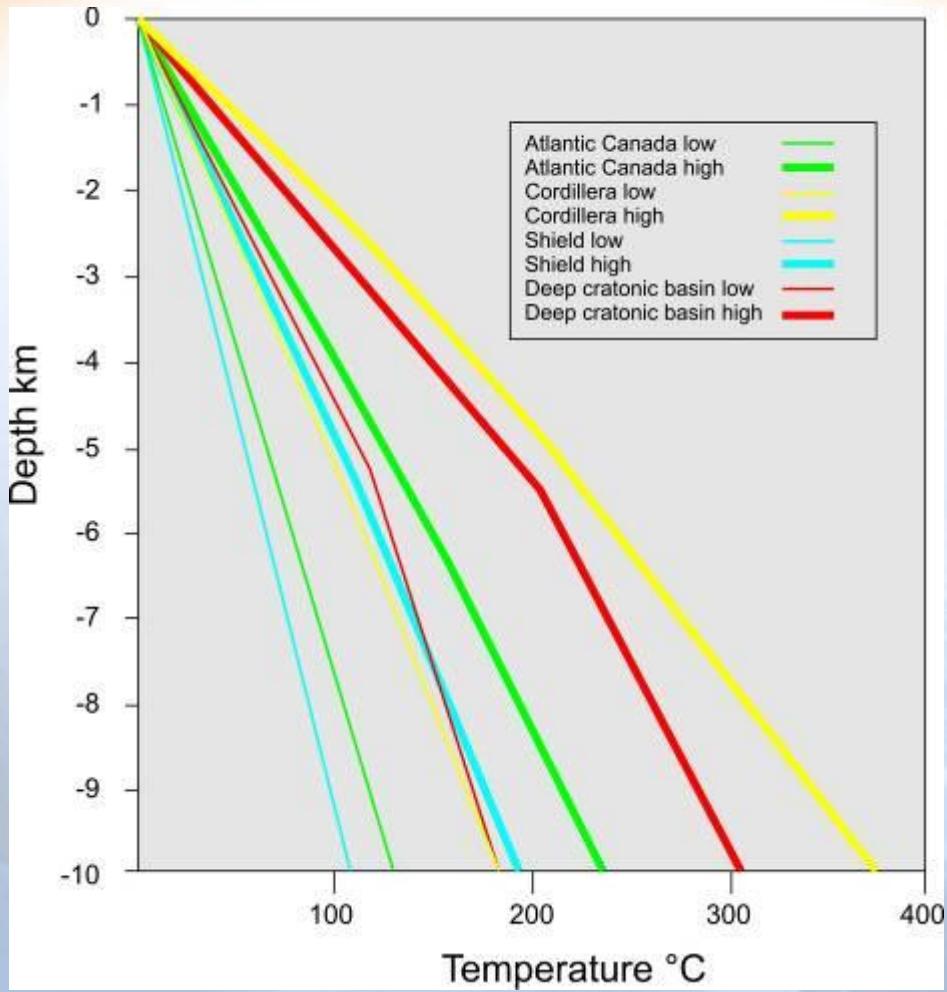


- Heat
- Fluid
- Permeability
- Depth (\$\$\$)





# Geothermal Gradients



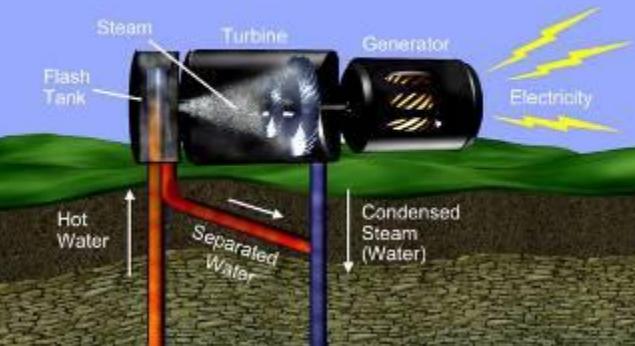


# Resource Production

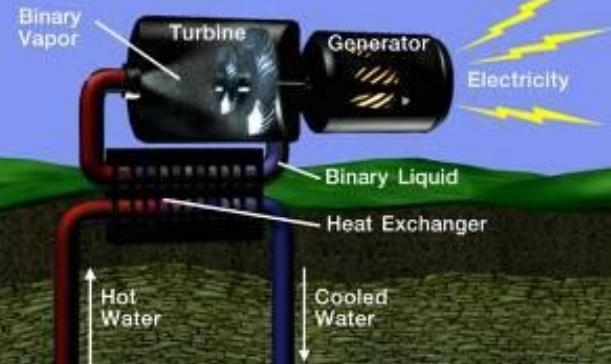


## Electrical Generation

**Steam >180 °C**

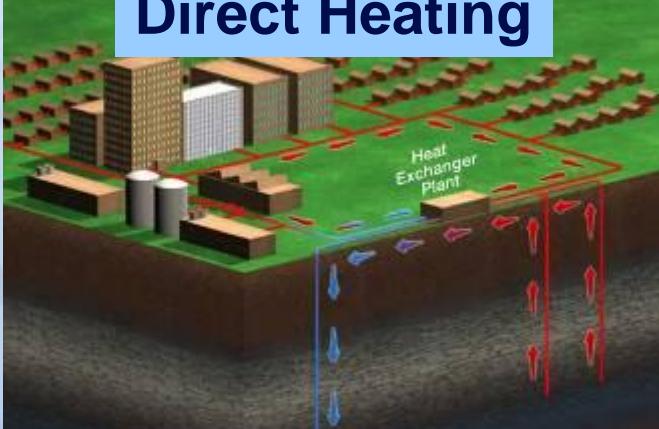


**Binary ~80 to 180 °C**



## Direct use

**Direct Heating**



**Heat exchange**

Heat is collected from the building & transferred to the ground





# Electrical Generation



*Ring of Fire*

IGA data	GWh
United States	17,917
Philippines	9,253
Mexico	6,282
Indonesia	6,085
Italy	5,340
Japan	3,467
New Zealand	2,774
Iceland	1,483
Costa Rica	1,145
Kenya	1,088
Canada	0



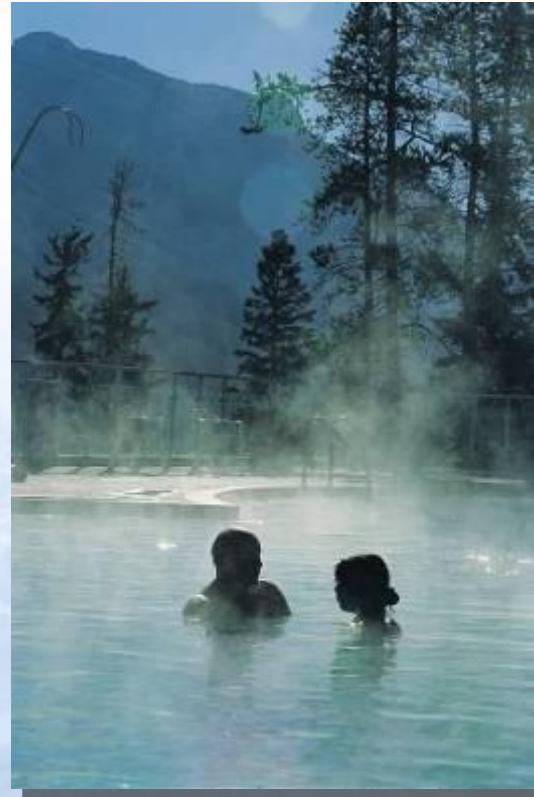


# Direct Use



## IGA data

	GWh
China	12,605
Sweden	10,000
United States	8,678
Turkey	6,900
Iceland	6,806
Japan	2,861
Hungary	2,205
Italy	2,099
New Zealand	1,969
Brazil	1,840
Canada	707



Banff Hot Springs –  
Canada's First National Park





# Cross borderer comparison

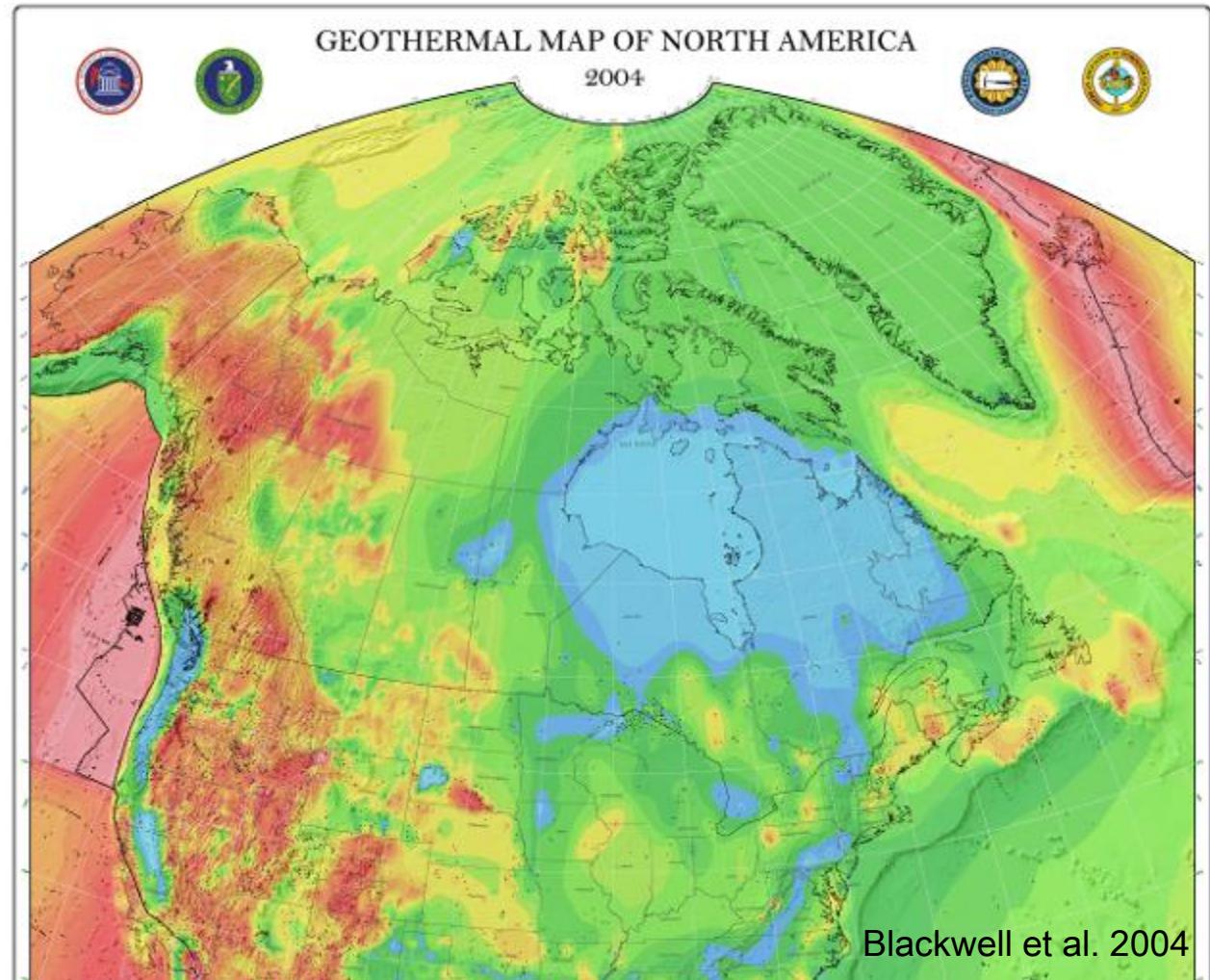


## Canada

- No geothermal power generation
- Niche use as heating source

## US

- World's largest geothermal power generation
- World's 3<sup>rd</sup> largest use as heating source



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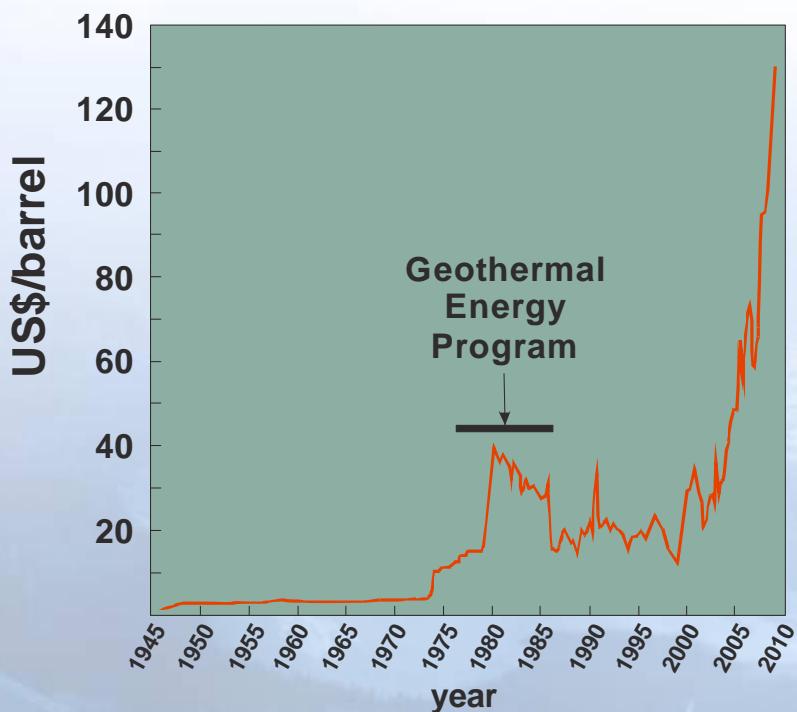
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# Previous work says no potential



## National Geothermal Energy Program

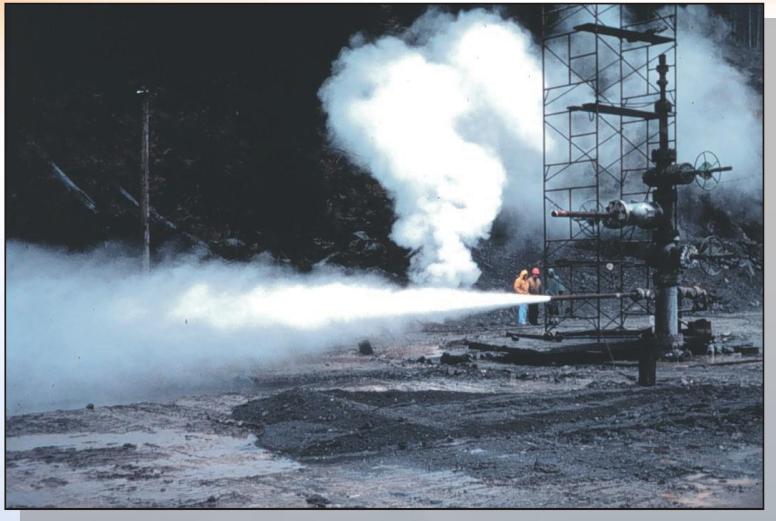


\$6M (80's dollars) over 10 years

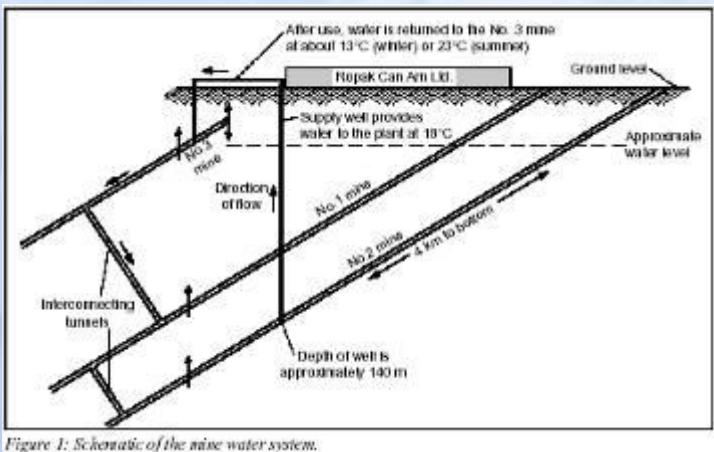
- Primary data collection
- Technology development
- Geothermal labs
- Modelling
- Demonstration projects



# Demonstration Projects



Mt. Meager



Regina

Springhill



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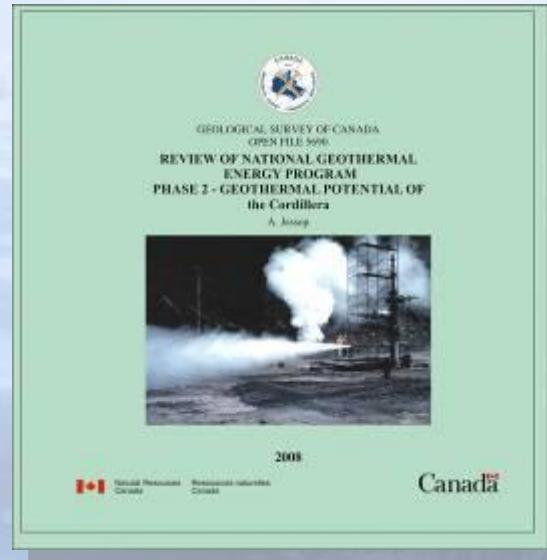
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# Enormous Geothermal Potential



## Sedimentary Basins (2008)



## Cordillera (2009)



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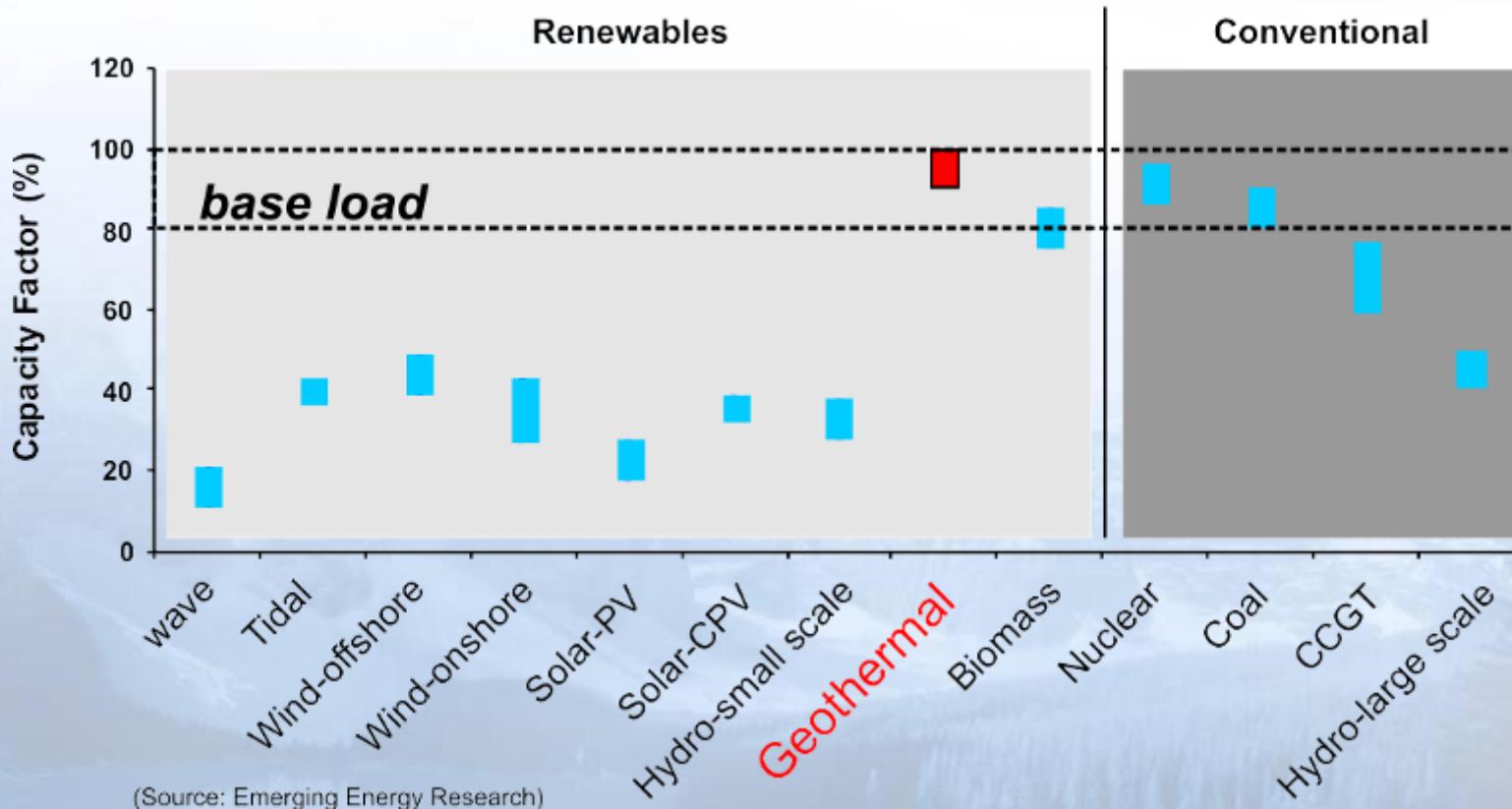
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# Geothermal Haters



## Typical Capacity Factors of Power Generation Technologies

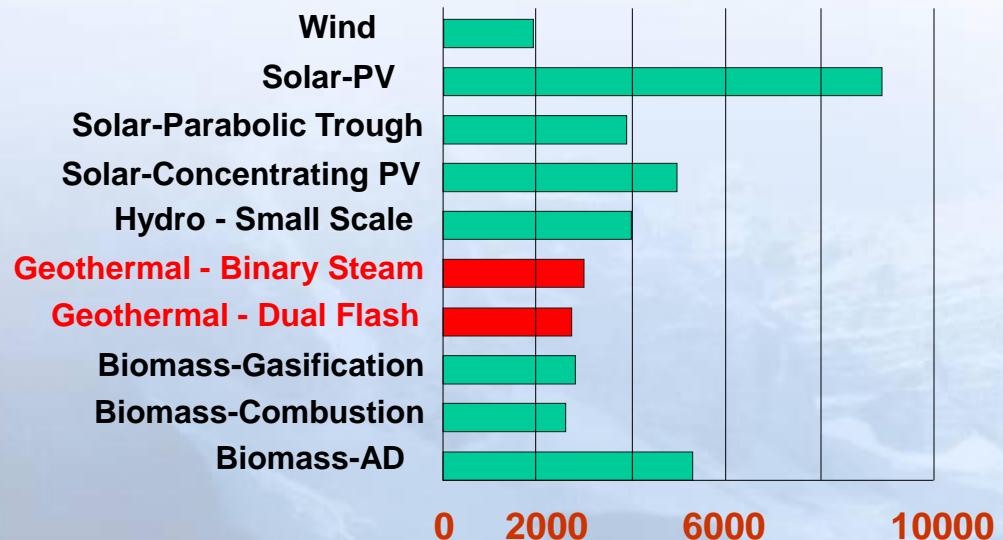




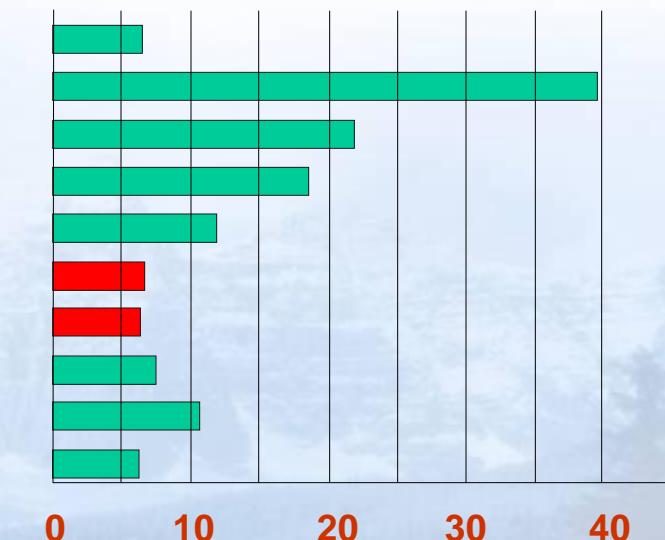
# Low cost renewable



Installed X10<sup>3</sup>\$/MW



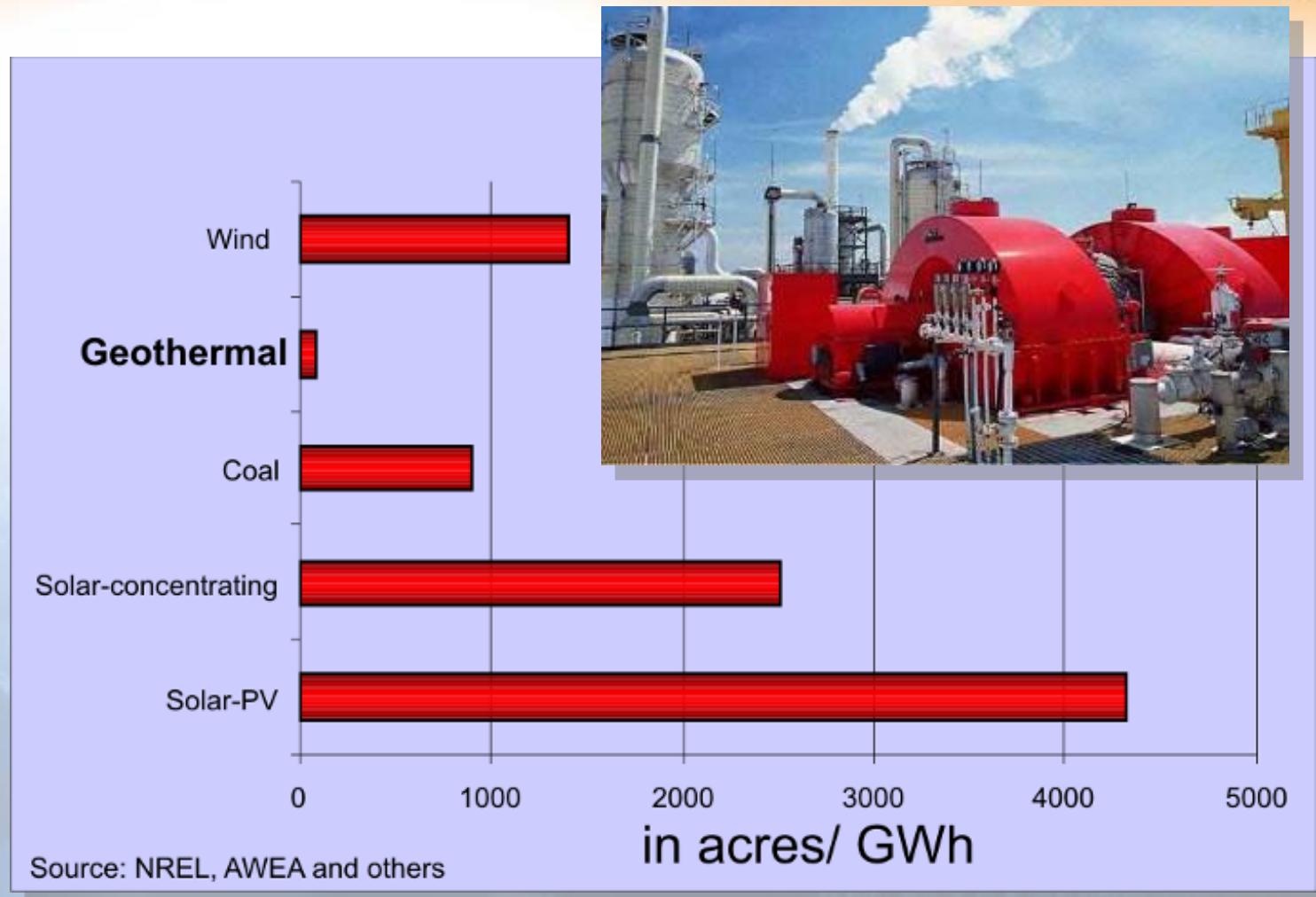
Generation cents kWh



California Energy Commission 2007



# Land Use

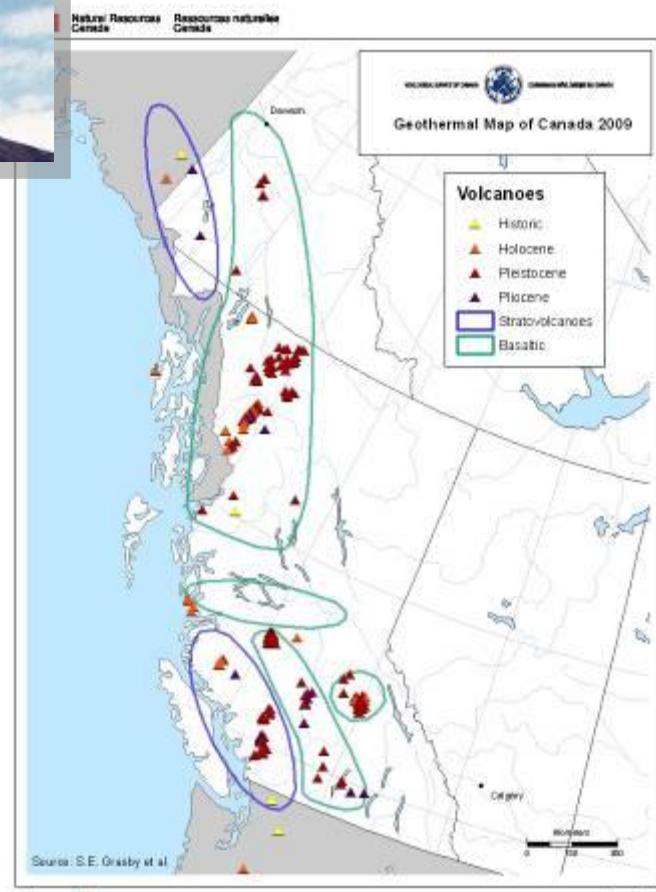




# Only a B.C. Issue



- Anahim
- Chilcotin
- Cascades
- Garibaldi
- Stikine
- Wells Gray-Clearwater
- Wrangell

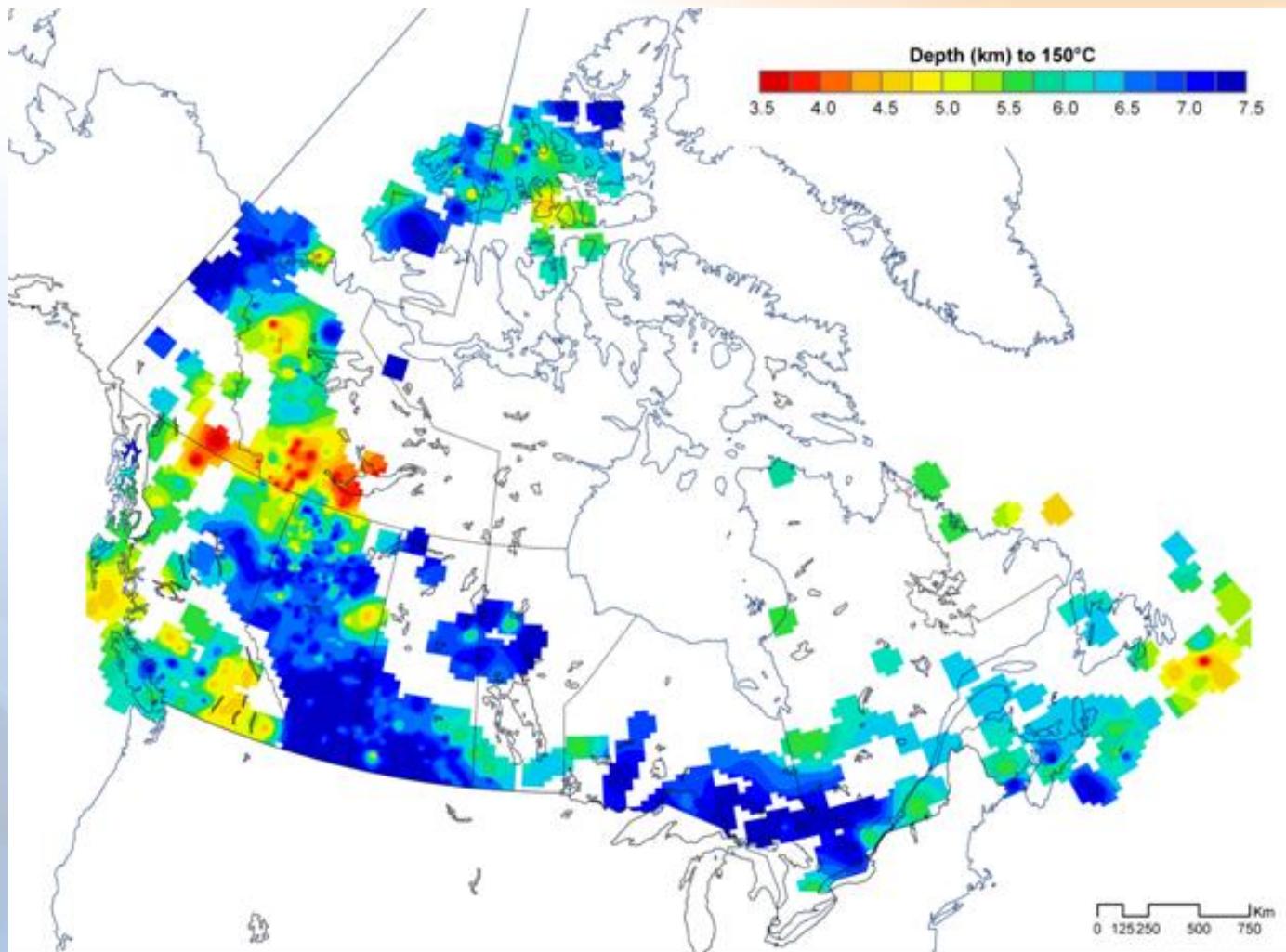


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# Depth to 150 °C



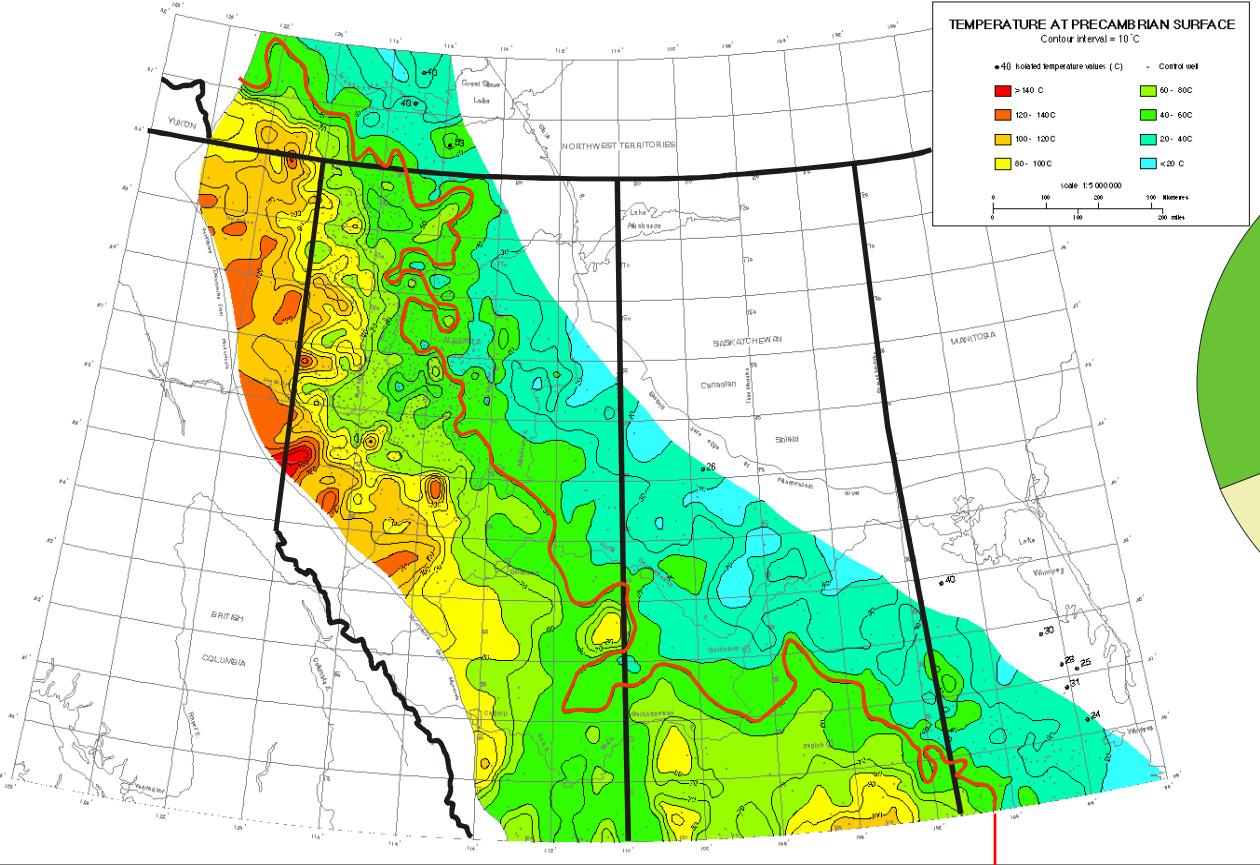
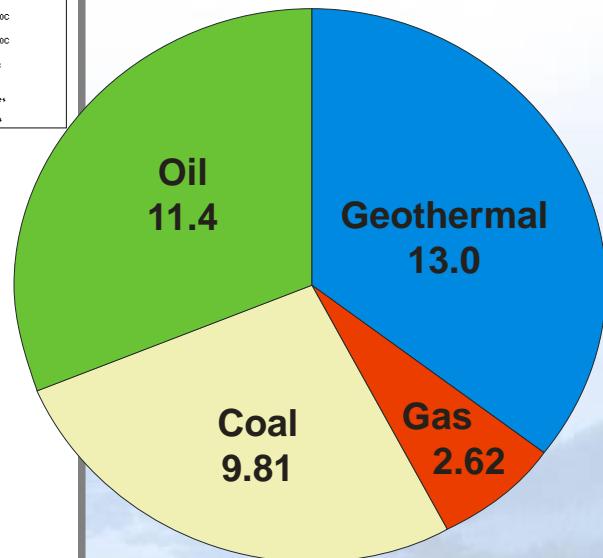


# Hot Sedimentary Basins



## Energy Reserves

$\times 10^{20} \text{ J}$



Bachu and Burwash (1994)

Warm water

Low temperature

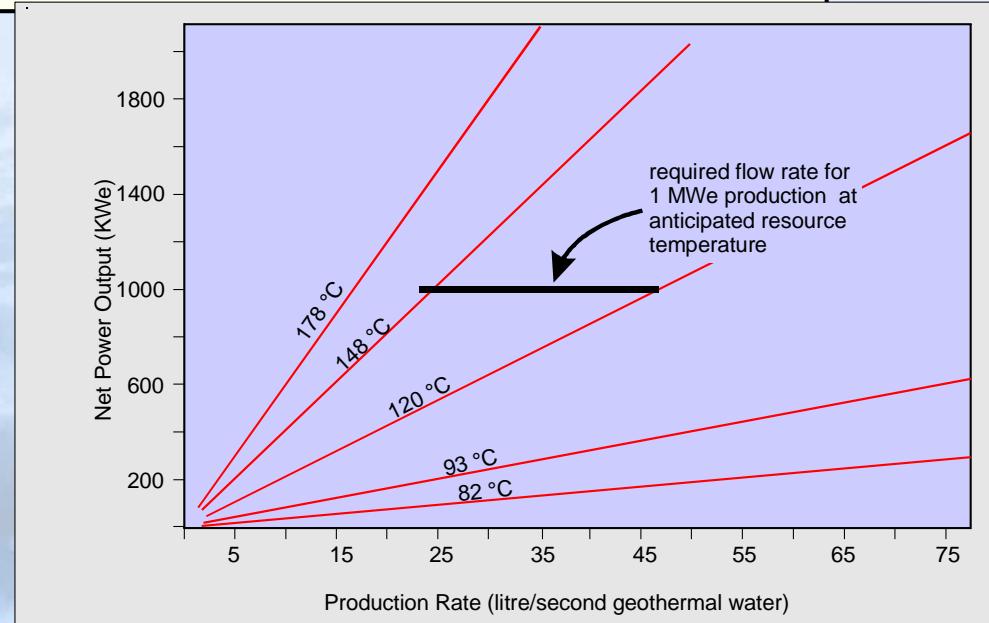
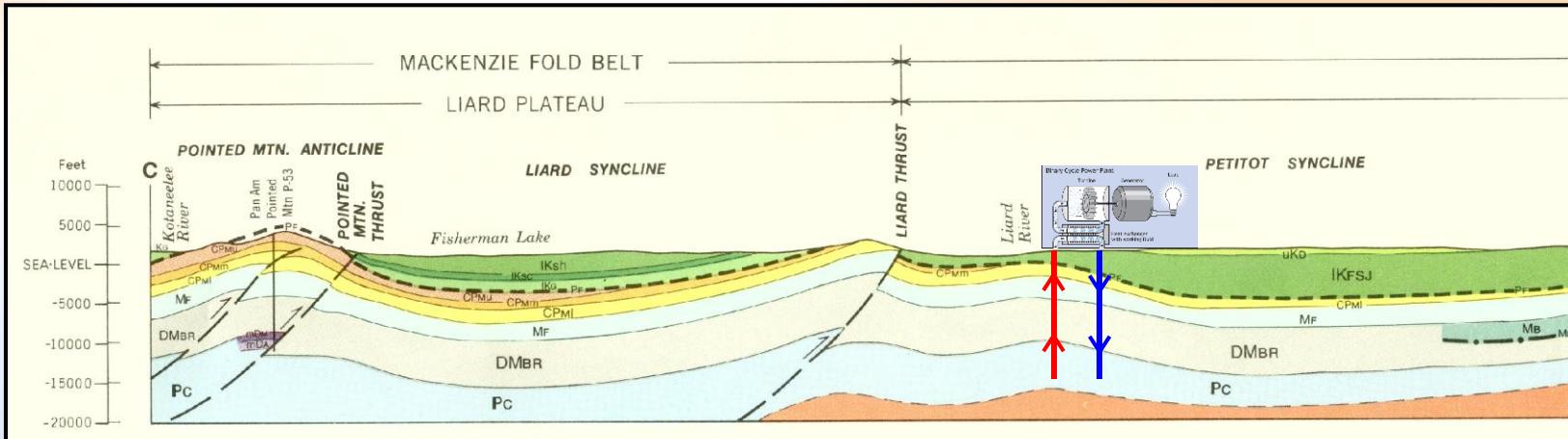


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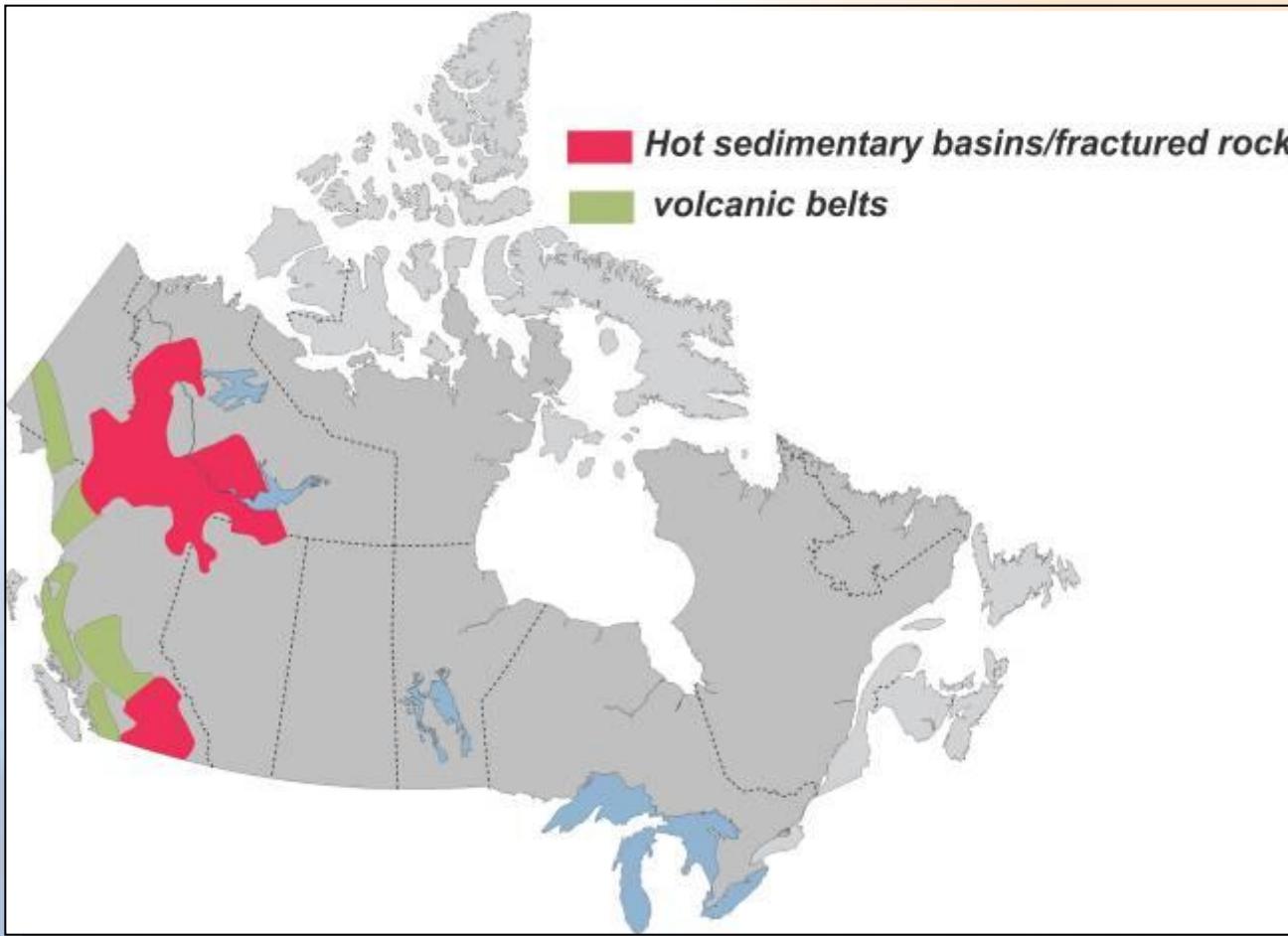


# Fort Liard Project



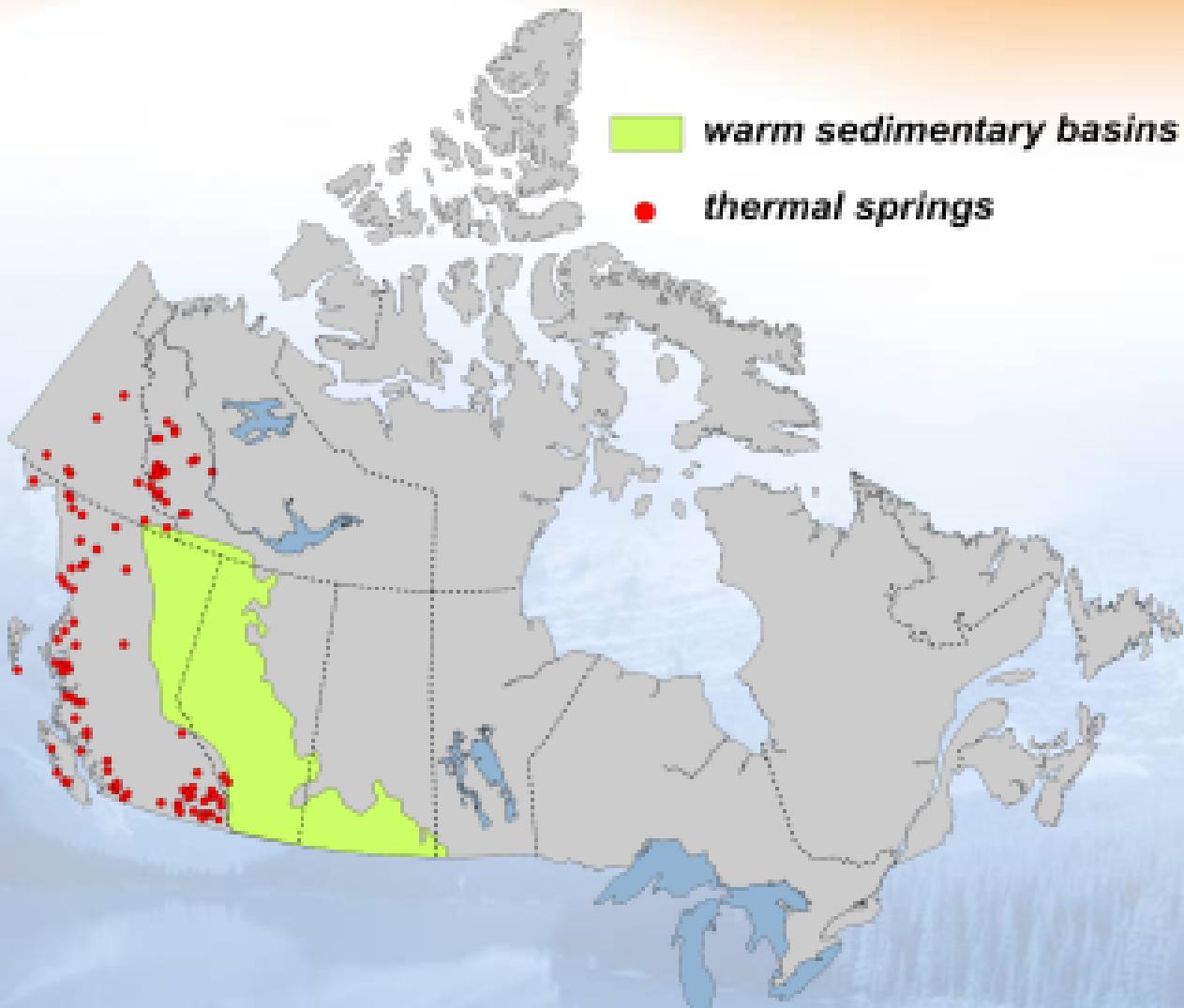


# High Temperature Electrical





# Binary Generation





# Direct Heating

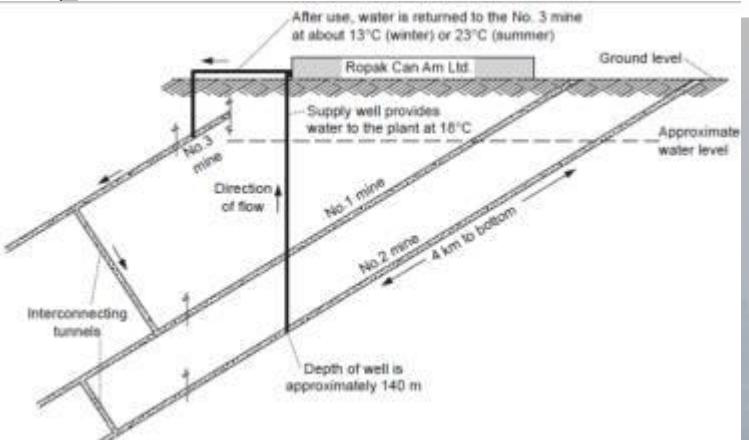
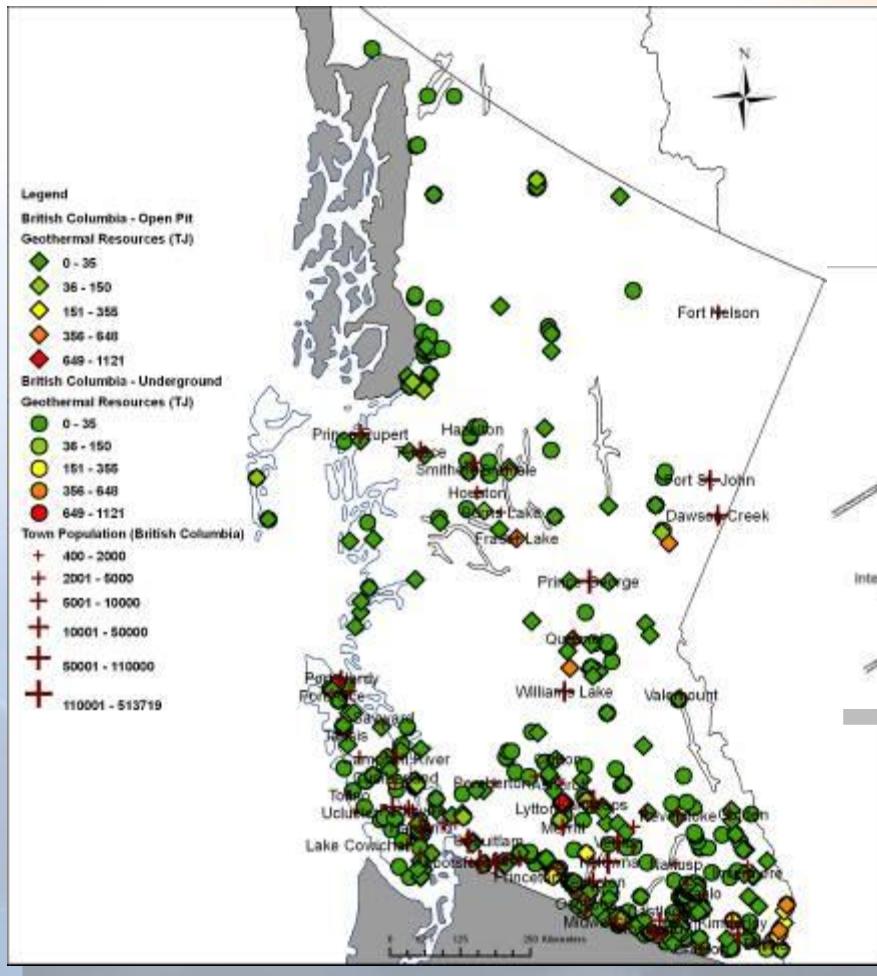


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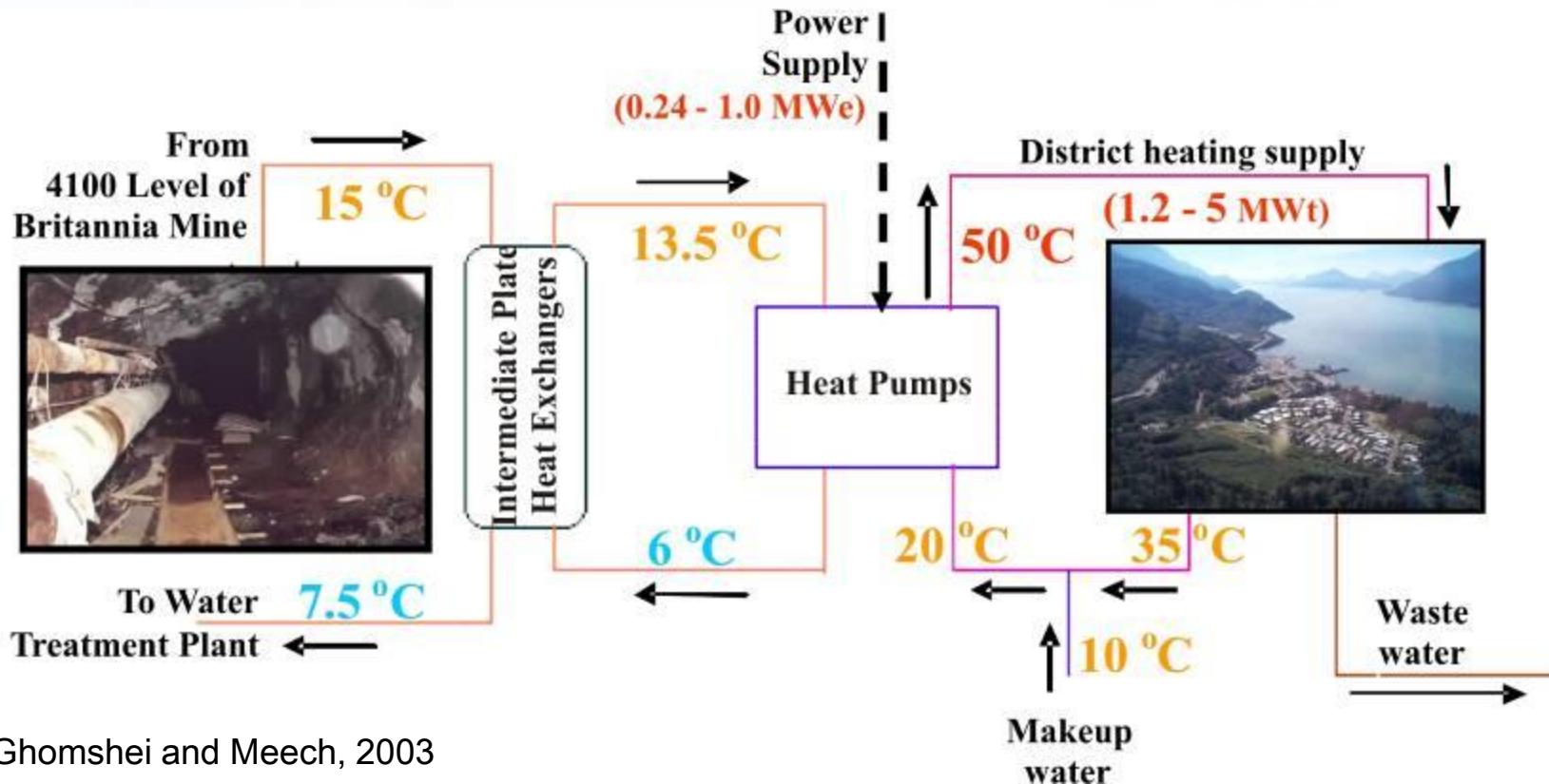


# Abandoned mines





# Britannia Mine, B.C.



Ghomshai and Meech, 2003



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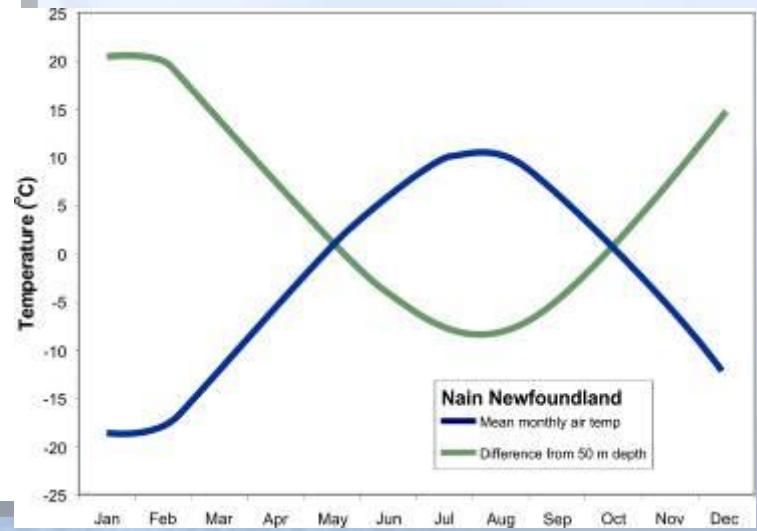
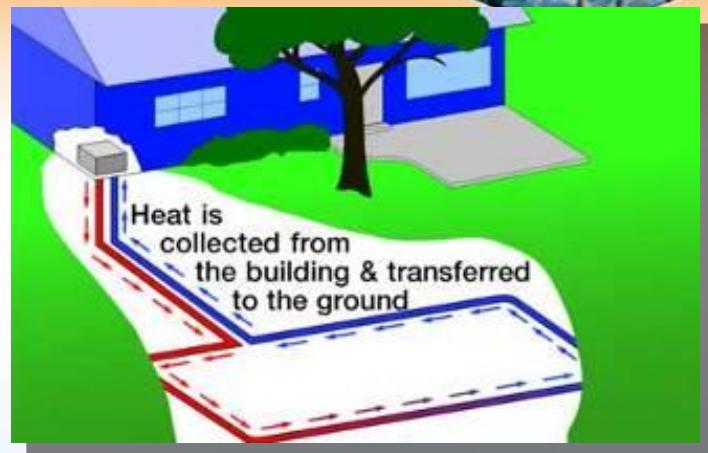
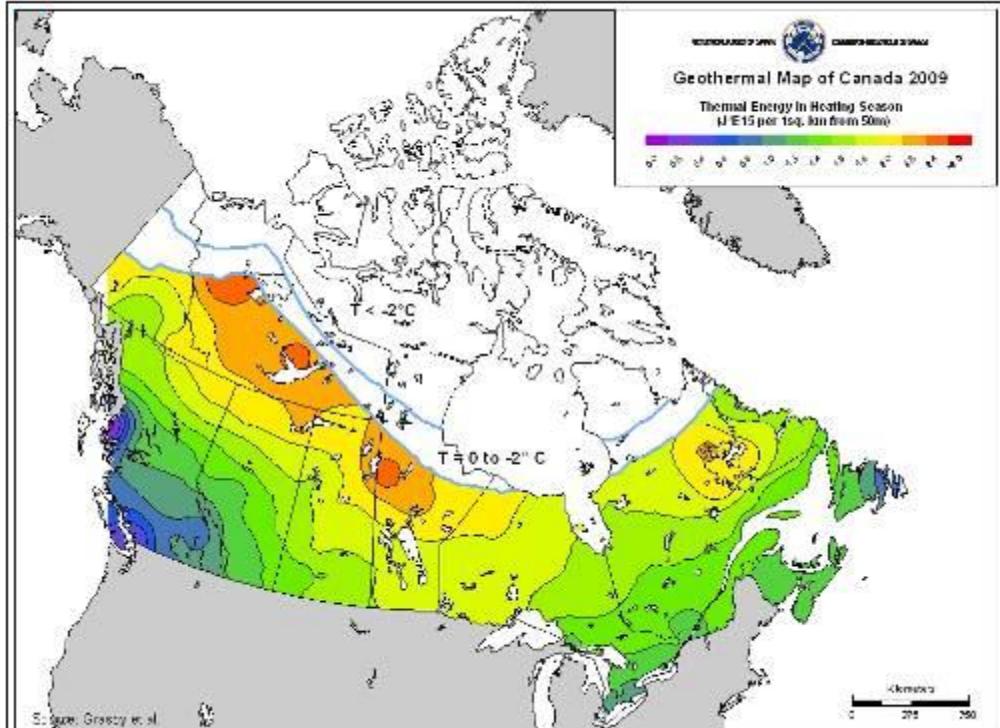
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# Heat Exchange



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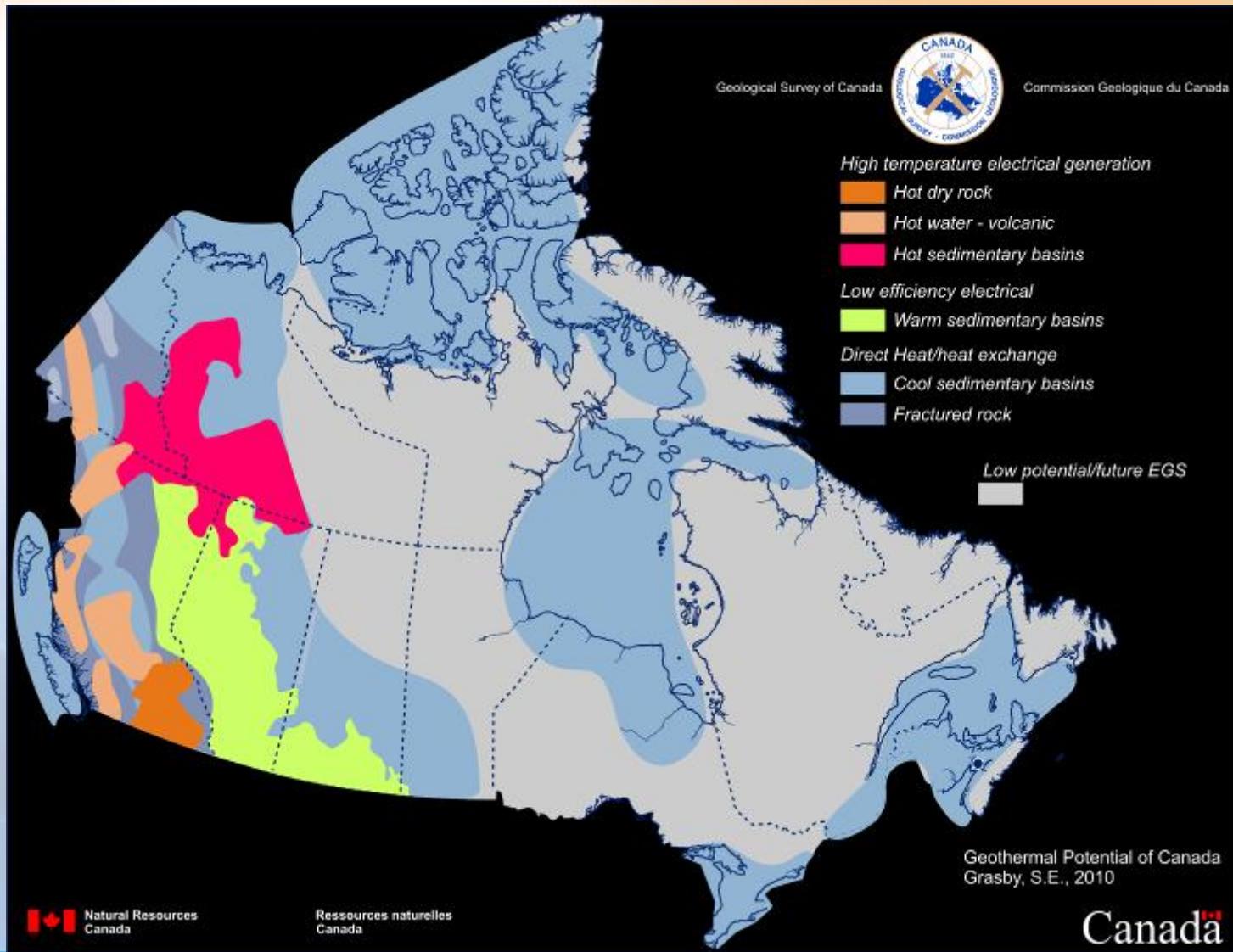


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# Geothermal Energy Potential of Canada

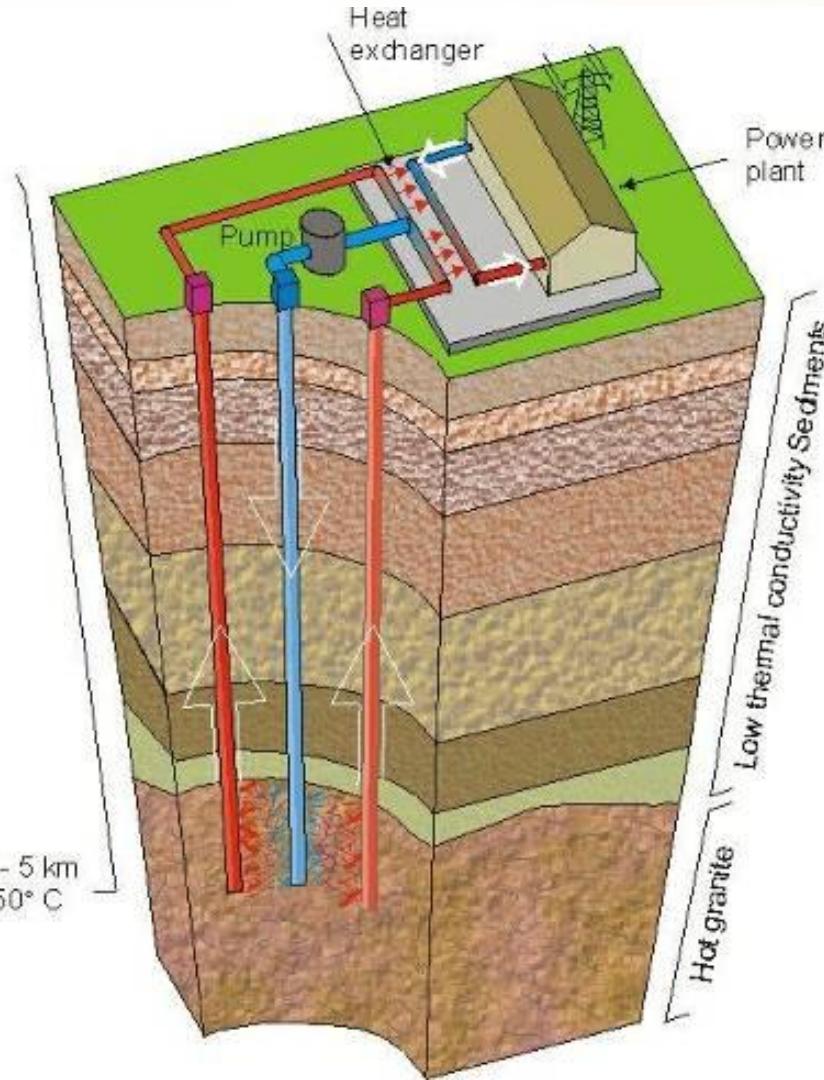




# Enhanced Geothermal Systems



- Heat
- No fluid
- No permeability



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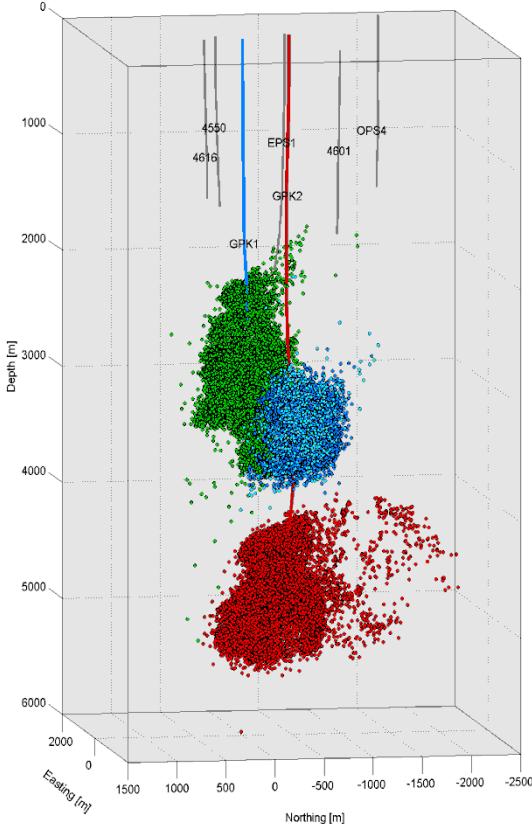
Canada



# EGS Technology Challenges



## Soultz France

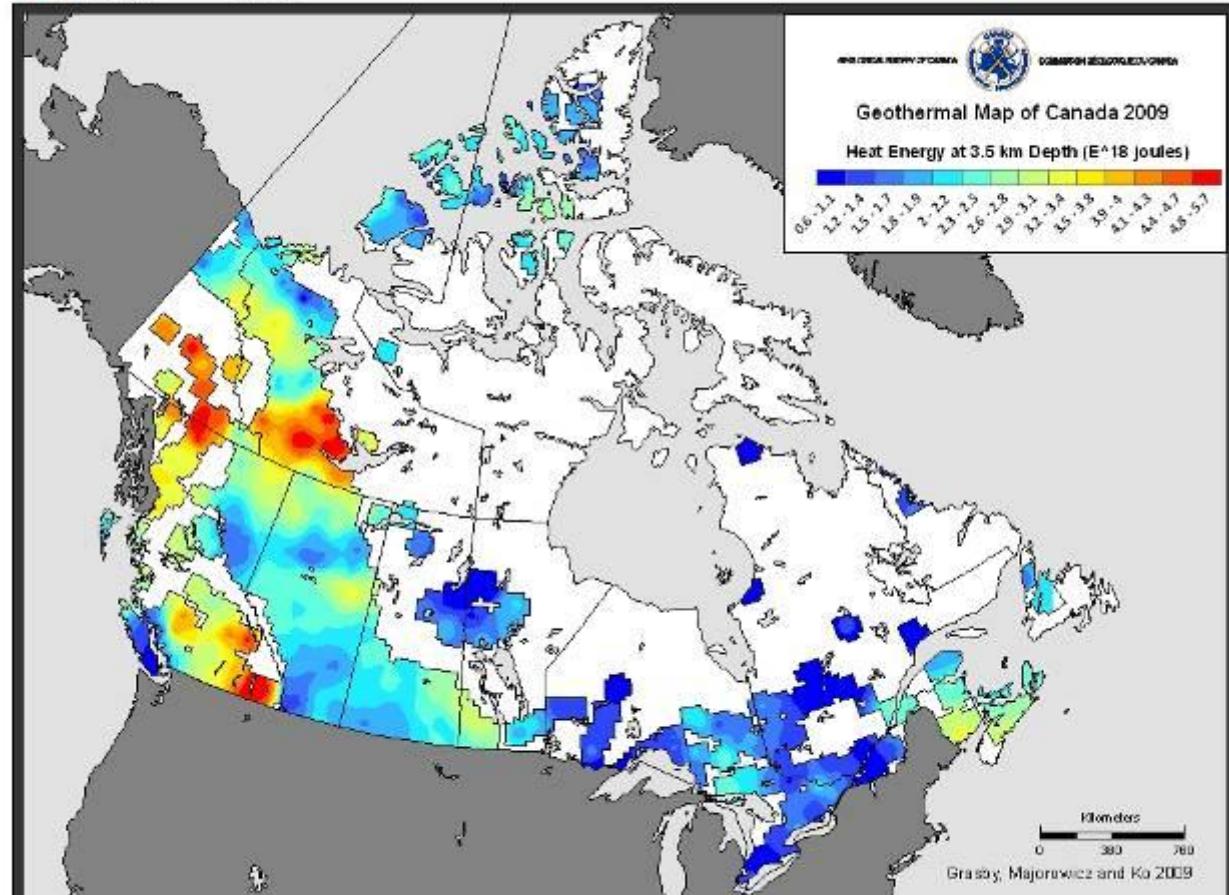


- Directional Drilling (5+ km)
- Fracture stimulation ( $>1\text{km}^3$ )
- Microseismic monitoring and control
- Injection/production well connectivity
- Controlled water loss
- Regional stress fields





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Figure 21

**Estimated in place heat energy at 3.5 km depth is  $3.8 \times 10^{11}$  GWh**

**~1 million times Canada's annual electrical consumption!**



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# Barriers



- **Knowledge:**
  - Resource distribution
  - Geologic favorability
- **Policy considerations:**
  - Market factors – start-up costs and reducing investment risks
  - Energy infrastructure across Canada
  - Abundant and inexpensive hydro in Canada
- **Regulatory framework:**
  - No regulations other than B.C.
  - Land tenure
  - Environmental permitting



# Conclusions



## Geothermal Energy in Canada:

- Enormous potential that is virtually untapped
- Clean source of energy
- Small environmental footprint
- Reliable
- Virtually un-depletable
- Maturity of technologies varies



# Still sampling hot springs



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