



# Geothermal: geoscientific and engineering challenges

# **Roman Shor**

**CREWES Annual Meeting 2021** 







#### Flow of thermal energy

**Geothermal Systems** 

Gaps in Technology

**Opportunities** 





Réunion Plume Seismic tomography uncovered a vast tree-like plume of hot material in Earth's mantle.

# If only it was that *simple*

1

Source: Quanta magazine, A Massive Subterranean 'Tree' Is Moving Magma to Earth's Surface https://www.quantamagazine.org/a-massive-subterranean-tree-is-moving-magma-to-earths-surface-20210915/

## Geothermal Potential



S.E. Grasby, D.M. Allen, S. Bell, Z. Chen, G. Ferguson, A. Jessop, M. Kelman, M. Ko, J. Majorowicz, M. Moore, J. Raymond, R. Therrien. Geothermal Energy Resource Potential of Canada. NRCan. 2012

R.M. Prol-Ledesma and D.J. Morán-Zenteno, Heat flow and geothermal provinces in Mexico, Geothermics, Volume 78, 2019















- What is needed?
  - A thermal reservoir
    - Thermal conductivity & working fluid permeability
  - Conduction / convection for recharge
  - Subsurface access (wells)
  - Conversion of heat to power
  - Use of waste / latent heat



Source: Wikipedia, *Enhanced geothermal* system

## Types of Geothermal Systems

#### **Traditional Geothermal**

Sufficient formation fluid, pressure & temperature to drive steam turbines

#### **Enhanced Geothermal Systems**

Sufficient formation permeability for injection and production from hydraulically fractured vertical and horizontal wells

#### **Advanced Geothermal Systems**

Low to zero formation permeability for closed-loop well-based heat exchangers



Source: Herald and News, Geothermal energy poised for a comeback

https://www.heraldandnews.com/news/geothermal-energy-poised-for-a-comeback/article\_36993e3c-5b10-11e4-a18a-33f257637255.html

## Design Considerations



#### Thermal Reservoir Characterization and Mapping

Heat flow & fluid flow in the reservoir

Thermal conduction & convection

Thermal reservoir recharge



Open-loop vs closed-loop designs

Heat exchanger design





Source: https://harvesttotable.com/





Source: http://itccca.com/

What is needed

Source: https://harvesttotable.com/

#### Geothermal reservoirs

Characterization and mapping

Sustainable reservoir management

#### **Drilling technologies**

Efficient hard rock drilling (> 50m / hr)

High temperature electronics for borehole placement

#### **Production equipment**

Inexpensive scaling and corrosion inhibitors

Parasitic loads (pumps)

Energy conversion

Higher efficiency electricity production

#### Geothermal Reservoir Characterization



#### **Open Challenges**

Thermal Conductivity

Thermal Resistivity Seals

Fault & Fracture Mapping

Seismic Monitoring (DTS and DAS)

**Deep Structural Mapping** 

Jenkins et al., Safe storage and effective monitoring of  $CO_2$  in depleted gas fields. Proceedings of the National Academy of Science. 2012. 109(2)



Potential to provide **high-capacity factor**, **baseload**, zerocarbon, electricity generation.

Wind and solar require energy storage or back-up power generation (thus overbuilding the grid)

Opportunity to **pivot** expertise from the oil & gas sector Reservoir engineering (including understanding of thermal flows) Significant improvements in drilling technology Completion designs and understanding of scaling & corrosion



#### What has been done

# Unconventional oil & gas: reduced drilling costs and increased gas reservoir contact

#### What needs to be done

Geothermal: reduced drilling costs, improved thermal reservoir contact and improved thermal energy use



#### What has been done

# Unconventional oil & gas: reduced drilling costs and increased gas reservoir contact

#### What needs to be done

Geothermal: reduced drilling costs, improved thermal reservoir contact and improved thermal energy use

#### **Questions?**