GTX Geothermal Datathon 2021

Team Name: GeoStars

Team Members:

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Project Overview

Quantitative

Problems

Underestimation

Limited True temperature measurements

Approaches

ML model for True Temperature Predictions

DST data and well log information

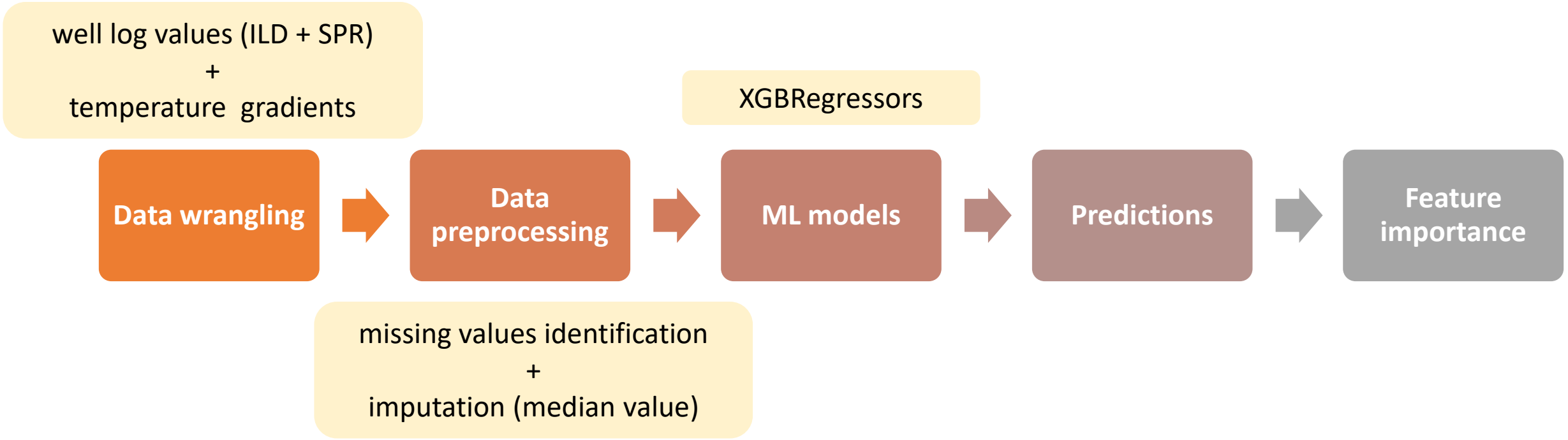
Qualitative

Estimate geothermal potential

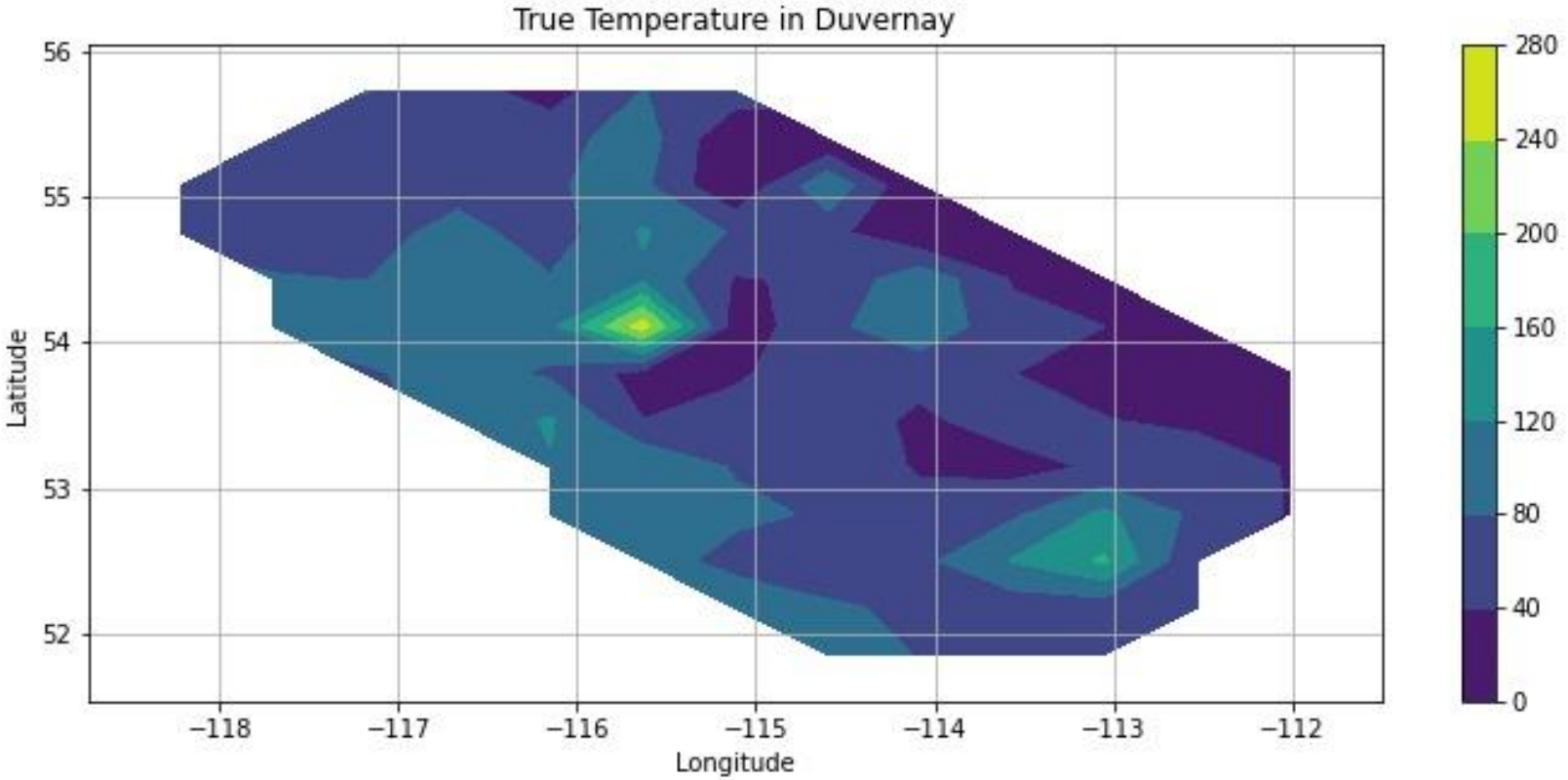
Identify high permeability/productive areas

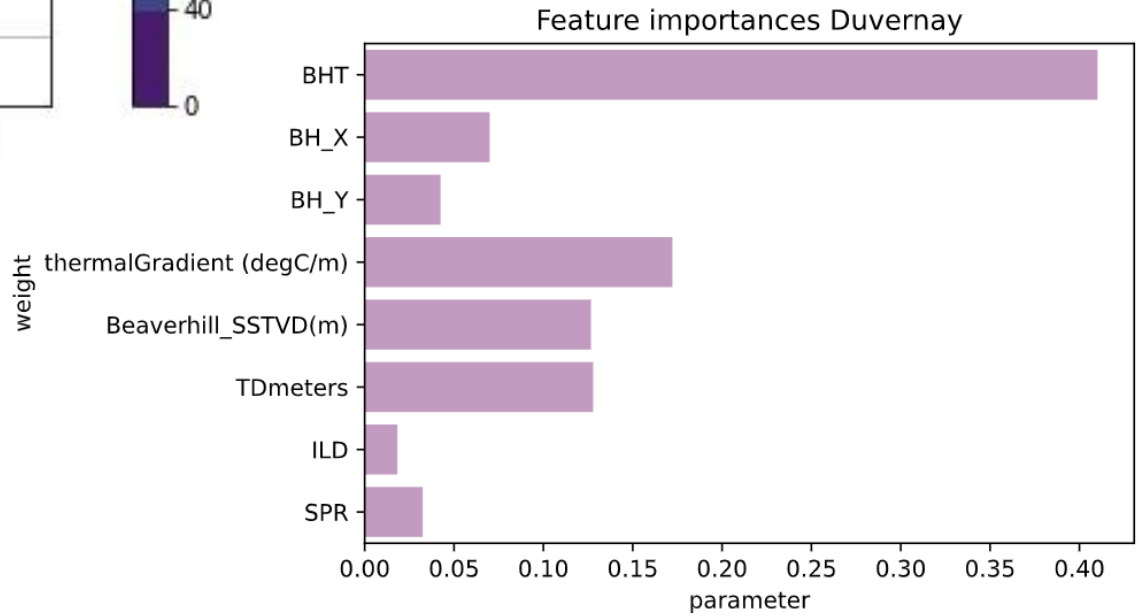
Simplified economic evaluation

Machine Learning Model

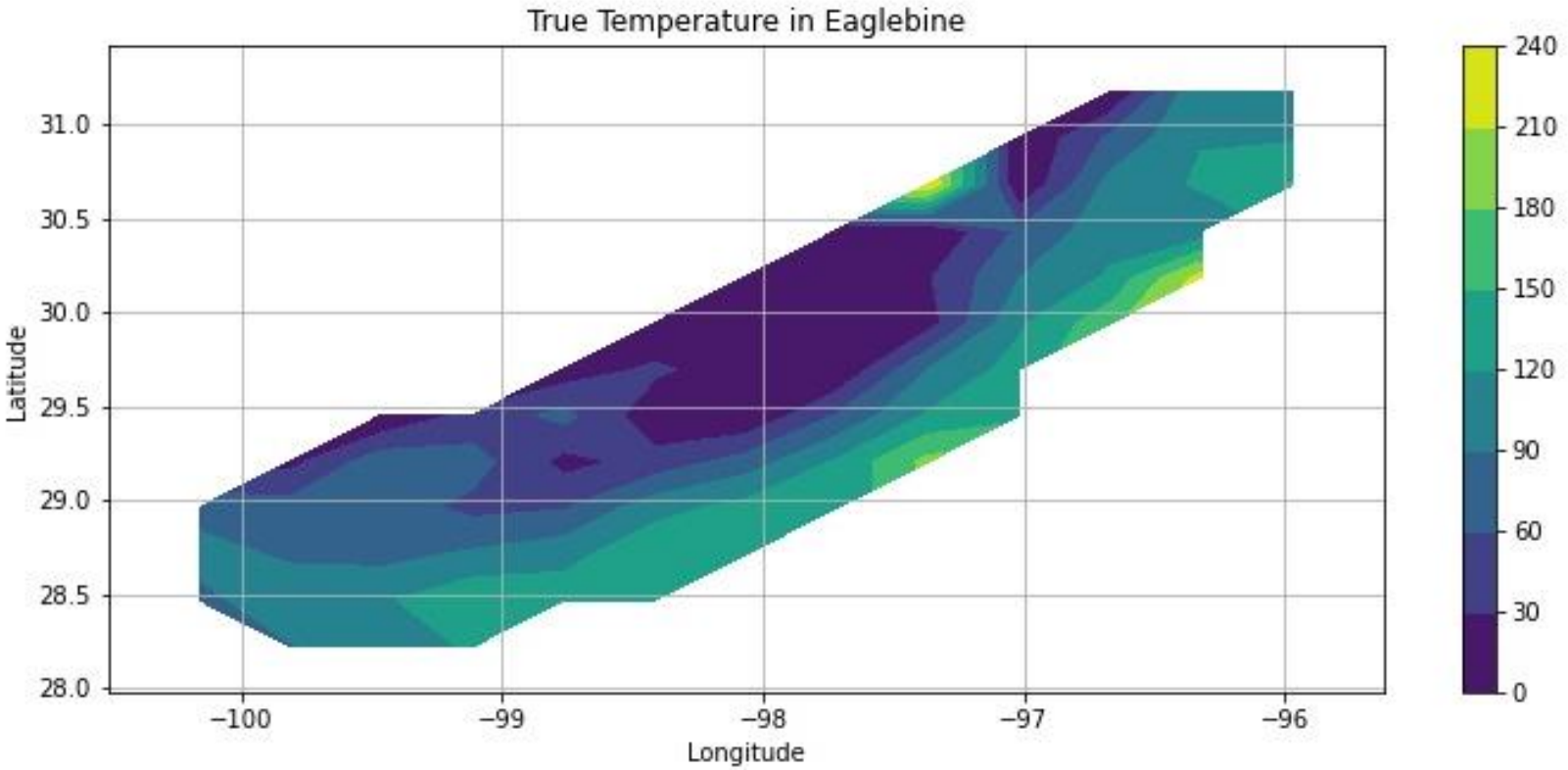


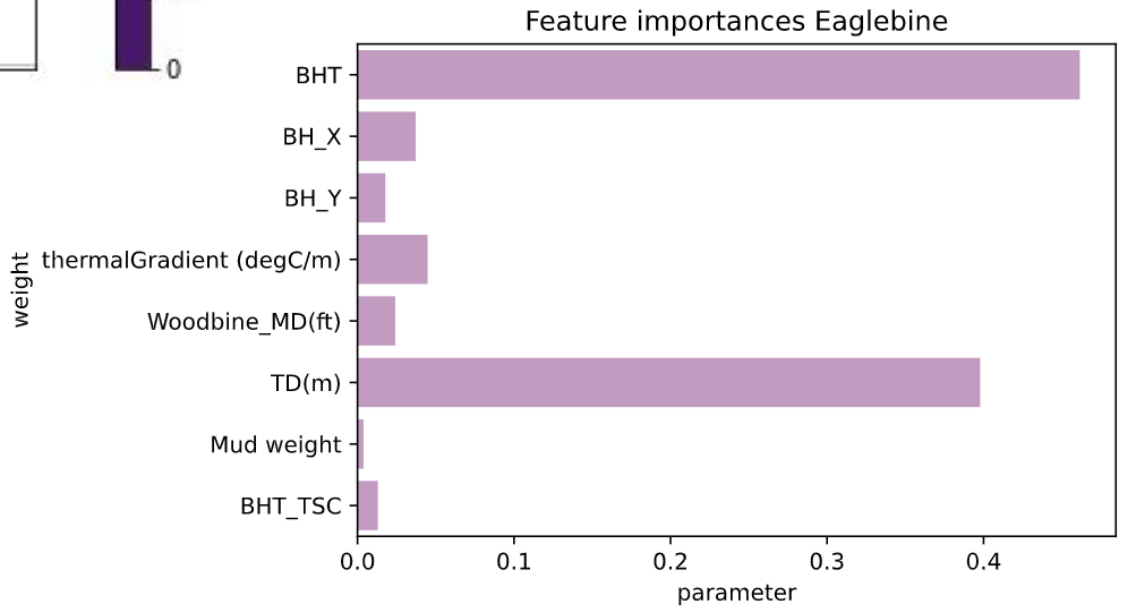
Predictions & Feature Importance – Duvernay





Predictions & Feature Importance – Eaglebine



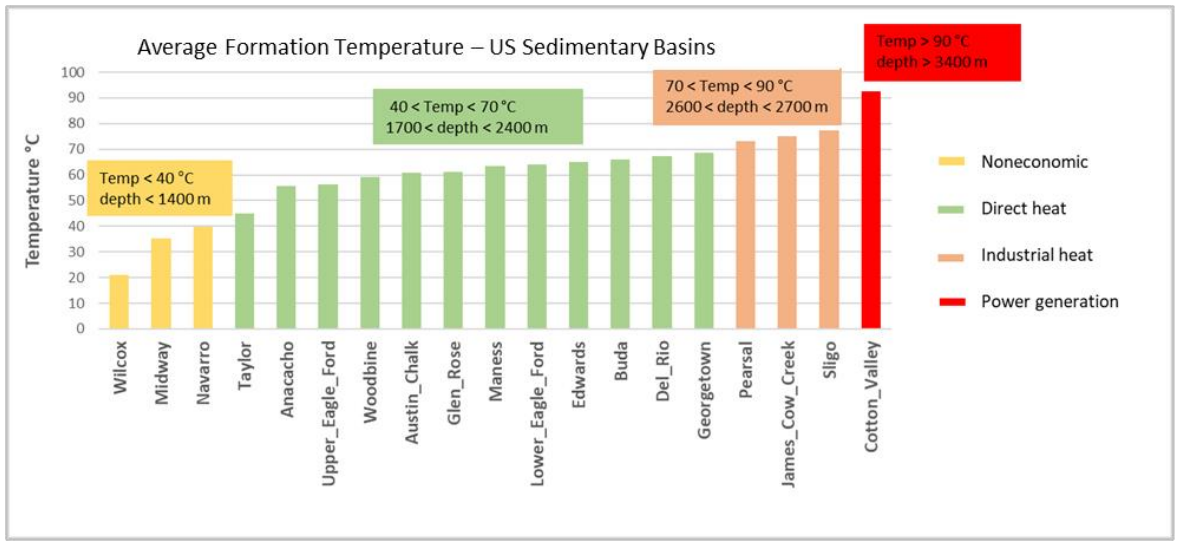


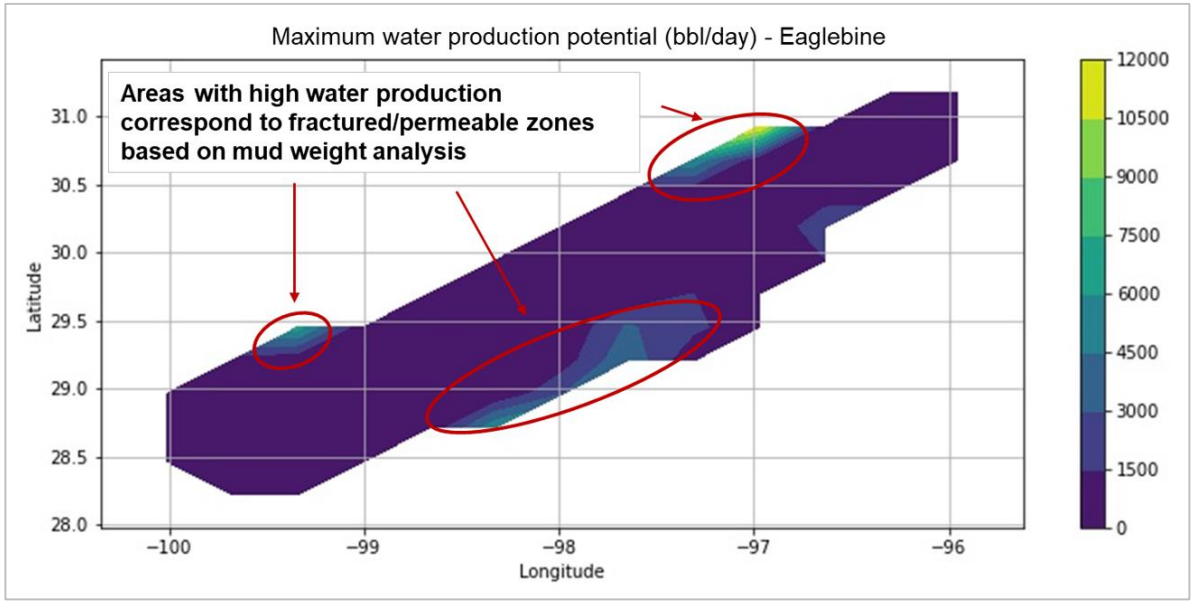
Geothermal Considerations

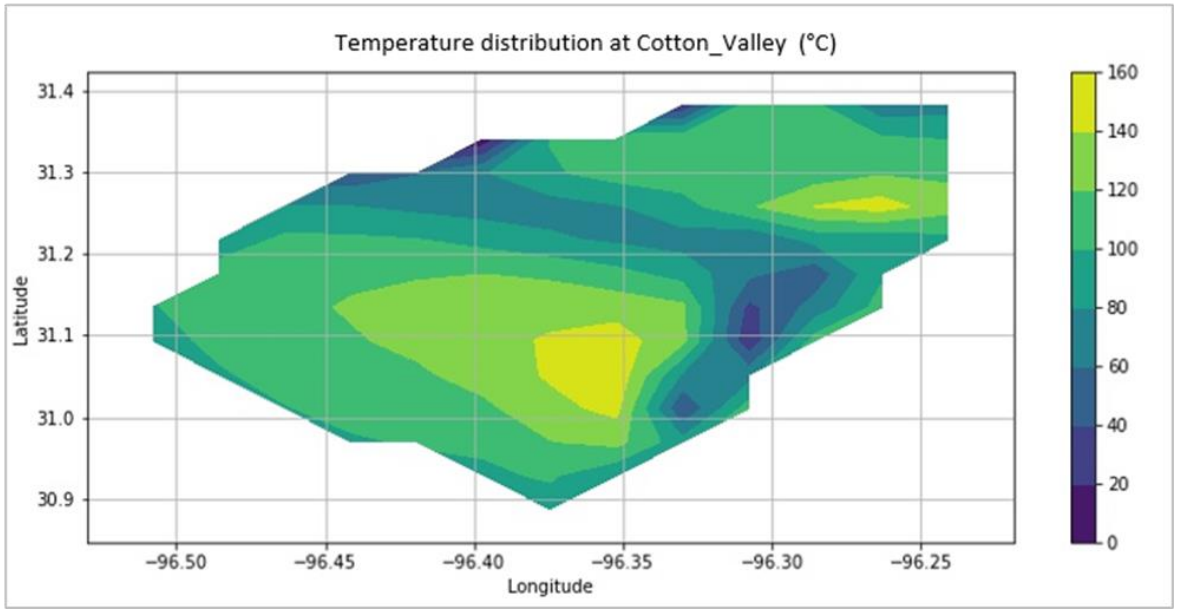
- Major areas suitable for geothermal developments are shown based on water production and fracture analysis, for both Eaglebine and Duvernay
- Using the modeled true temperature and the resulting geothermal gradient, the average temperature was derived for different formations
- According to the available dataset, US sedimentary formations (Eaglebine) seem to have higher temperature compared to the Canadian sedimentary basins (Duvernay)
- The Cotton Valley formation in the US, is considered to be the hottest sedimentary rock, and its temperature distribution map is provided separately

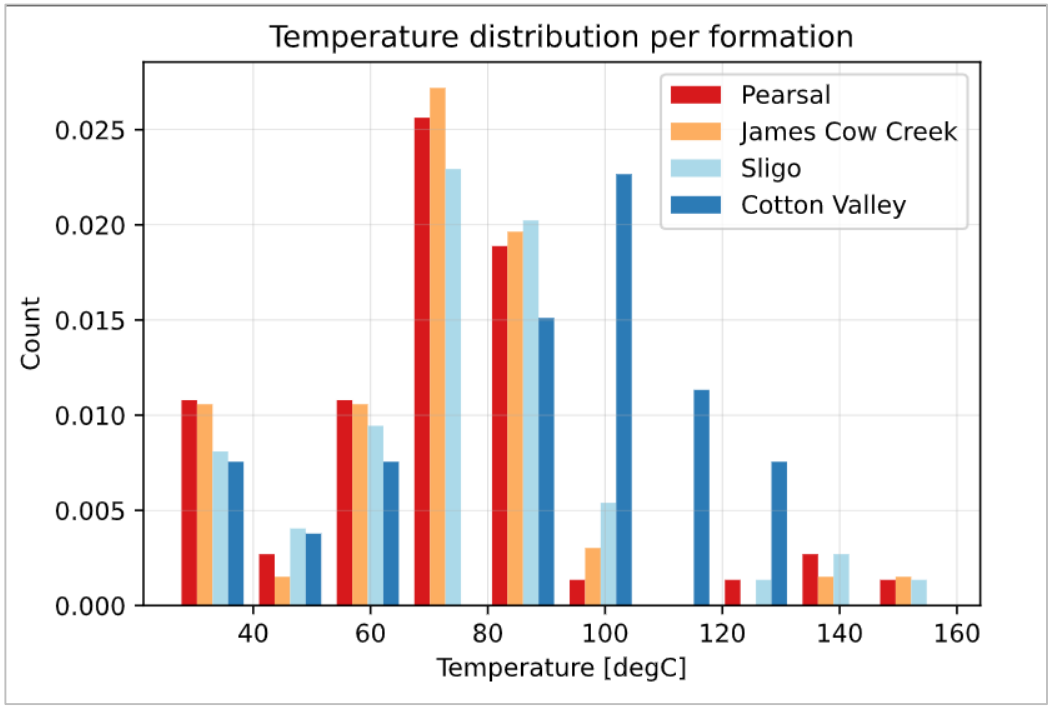
- Formation temperature
  - 40-70 °C: direct heat use
  - 70-90 °C: industrial heat applications
  - > 90 °C: power generation

Eaglebine

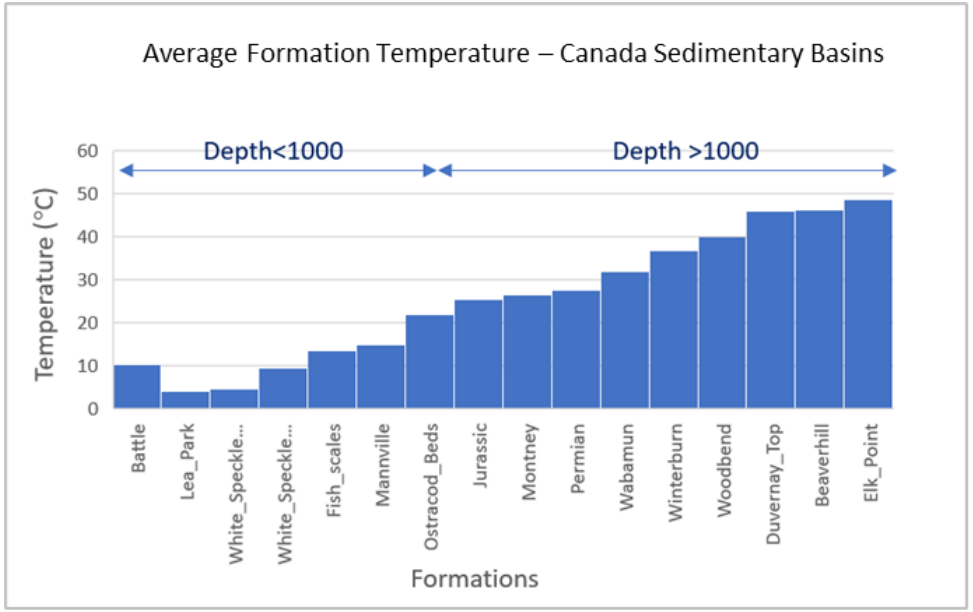

Average Formation Temperature – US Sedimentary Basins
Temperature °C
Temp < 40 °C
depth < 1400 m
40 < Temp < 70 °C
1700 < depth < 2400 m
70 < Temp < 90 °C
2600 < depth < 2700 m
Temp > 90 °C
depth > 3400 m
Noneconomic
Direct heat
Industrial heat
Power generation
Wilcox
Midway
Navarro
Taylor
Anacacho
Upper_Eagle_Ford
Woodbine
Austin_Chalk
Glen_Rose
Maness
Lower_Eagle_Ford
Edwards
Buda
Del_Rio
Georgetown
Pearsal
James_Cow_Creek
Sligo
Cotton_Valley

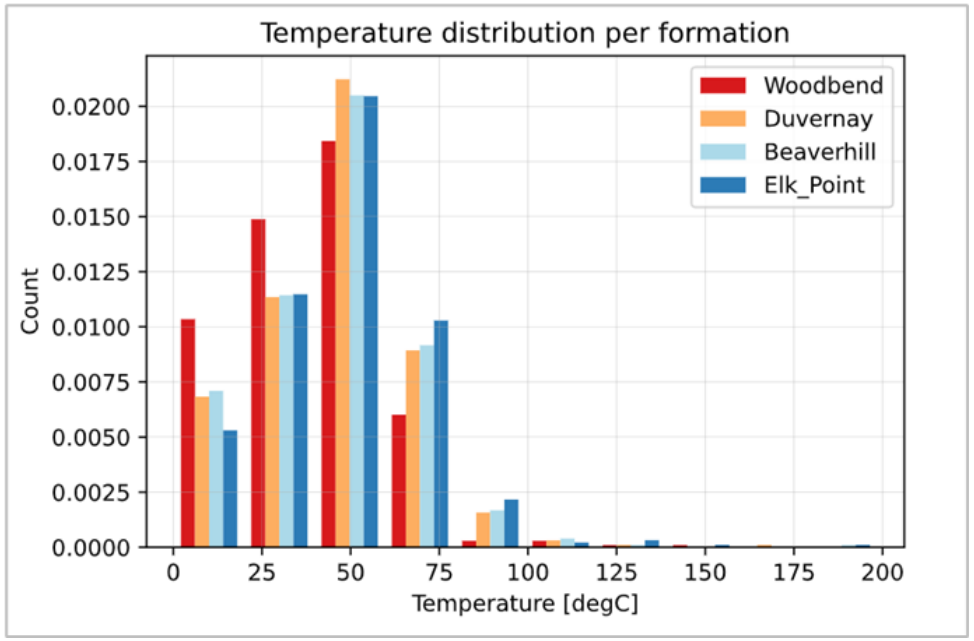

Maximum water production potential (bbl/day) - Eaglebine
Areas with high water production correspond to fractured/permeable zones based on mud weight analysis
Latitude
Longitude

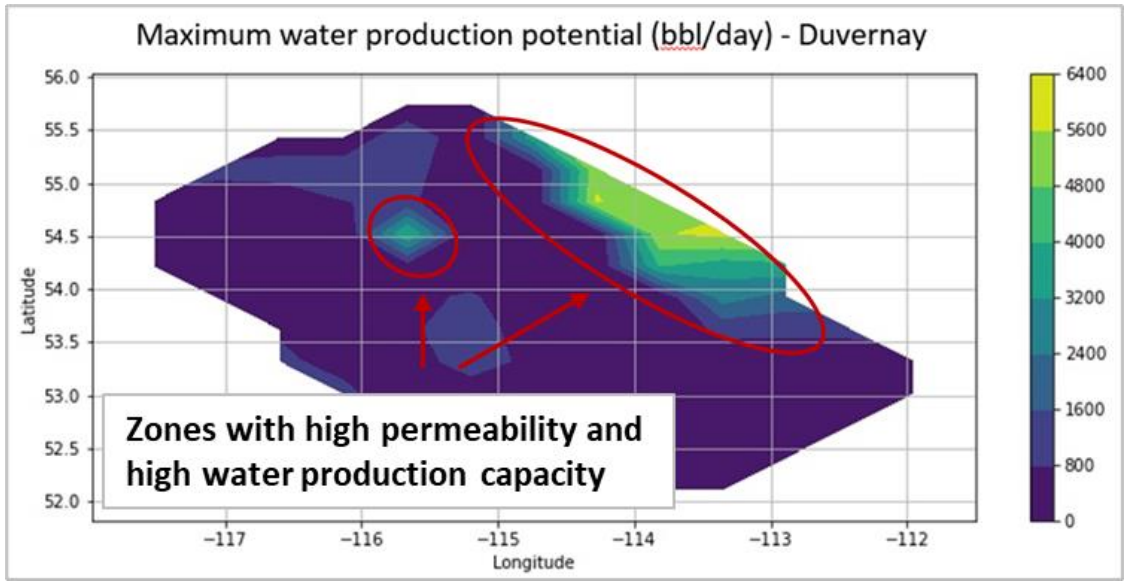

Temperature distribution at Cotton_Valley (°C)
Latitude
Longitude


Temperature distribution per formation
Pearsal
James Cow Creek
Sligo
Cotton Valley
Count
Temperature [degC]

Duvernay


Average Formation Temperature – Canada Sedimentary Basins
Depth<1000
Depth >1000
Temperature (°C)
60
50
40
30
20
10
0
Battle
Lea_Park
White_Speckle...
White_Speckle...
Fish_scales
Mannville
Ostracod_Beds
Jurassic
Montney
Permian
Wabamun
Winterburn
Woodbend
Duvernay_Top
Beaverhill
Elk_Point
Formations


Temperature distribution per formation
Woodbend
Duvernay
Beaverhill
Elk_Point
Count
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
0
25
50
75
100
125
150
175
200
Temperature [degC]


Maximum water production potential (bbl/day) - Duvernay
Zones with high permeability and high water production capacity
Latitude
56.0
55.5
55.0
54.5
54.0
53.5
53.0
52.5
52.0
−117
−116
−115
−114
−113
−112
Longitude
6400
5600
4800
4000
3200
2400
1600
800
0

Important Factors Affecting The Development Costs And Plans

- Temperature
- Depth
- Geological structural
- Permeability
- Water production potential
- Proximity to towns, electrical grid networks, or existing facilities

Recommendations

- Drill Stem Test (DST) is the most reliable source of reservoir parameters. Due to the lack of DST data for Eaglebine, and missing DST parameters in the Duvernay dataset, it was not possible to predict the exact production rate and permeability. DST data analysis is strongly recommended for further geothermal resource characterization.
- Water produced from deep sedimentary aquifers has a high concentration of dissolved solids. Precipitation of the solids in production wells and surface infrastructures can reduce or inhibit the flow. Detailed fluid geochemistry analysis helps to overcome these challenges and design mitigation strategies.

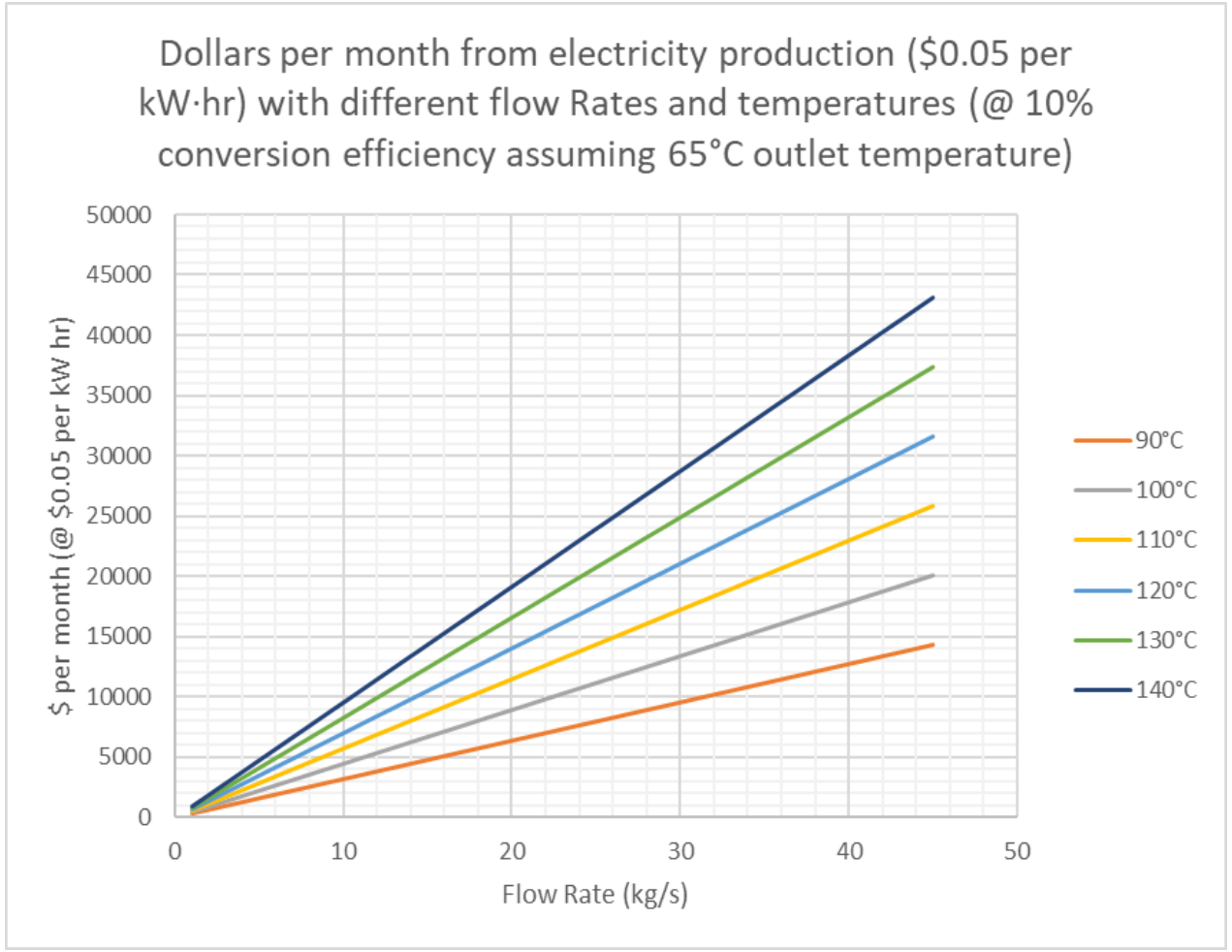
Geothermal Economics

Energetic productivity

Energy produced = Heat Capacity x Flow Rate x Temperature Change x Conversion Efficiency

Economic Factors

- **Flow rate**
- **Temperature**
- Surface infrastructure
- Pump and heat exchanger maintenance
- Well integrity (age)
- Purpose

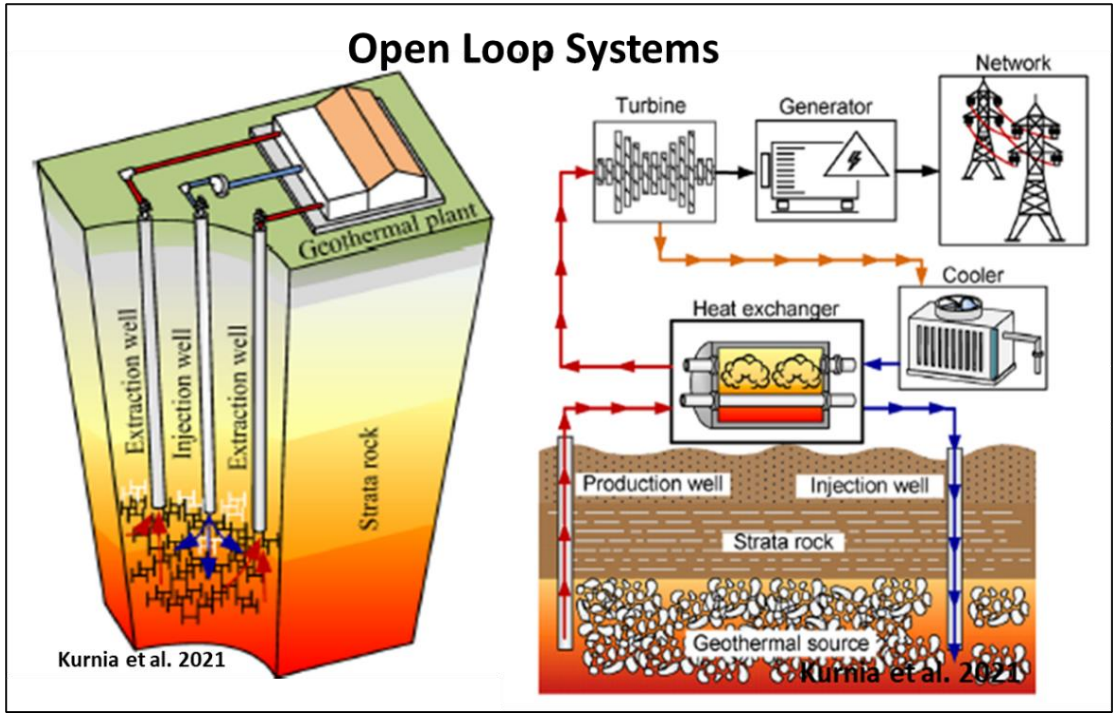


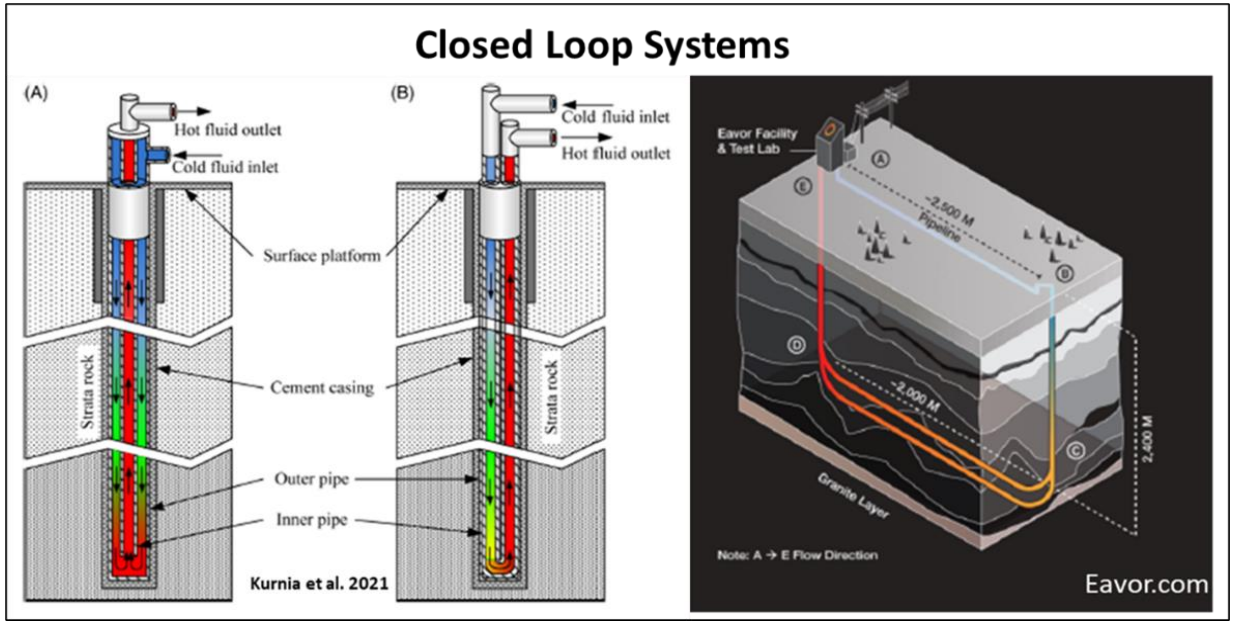
Technology

Perceived Value

utilization of hot, currently producing wells with high water cuts for combined heat, power, and oil production

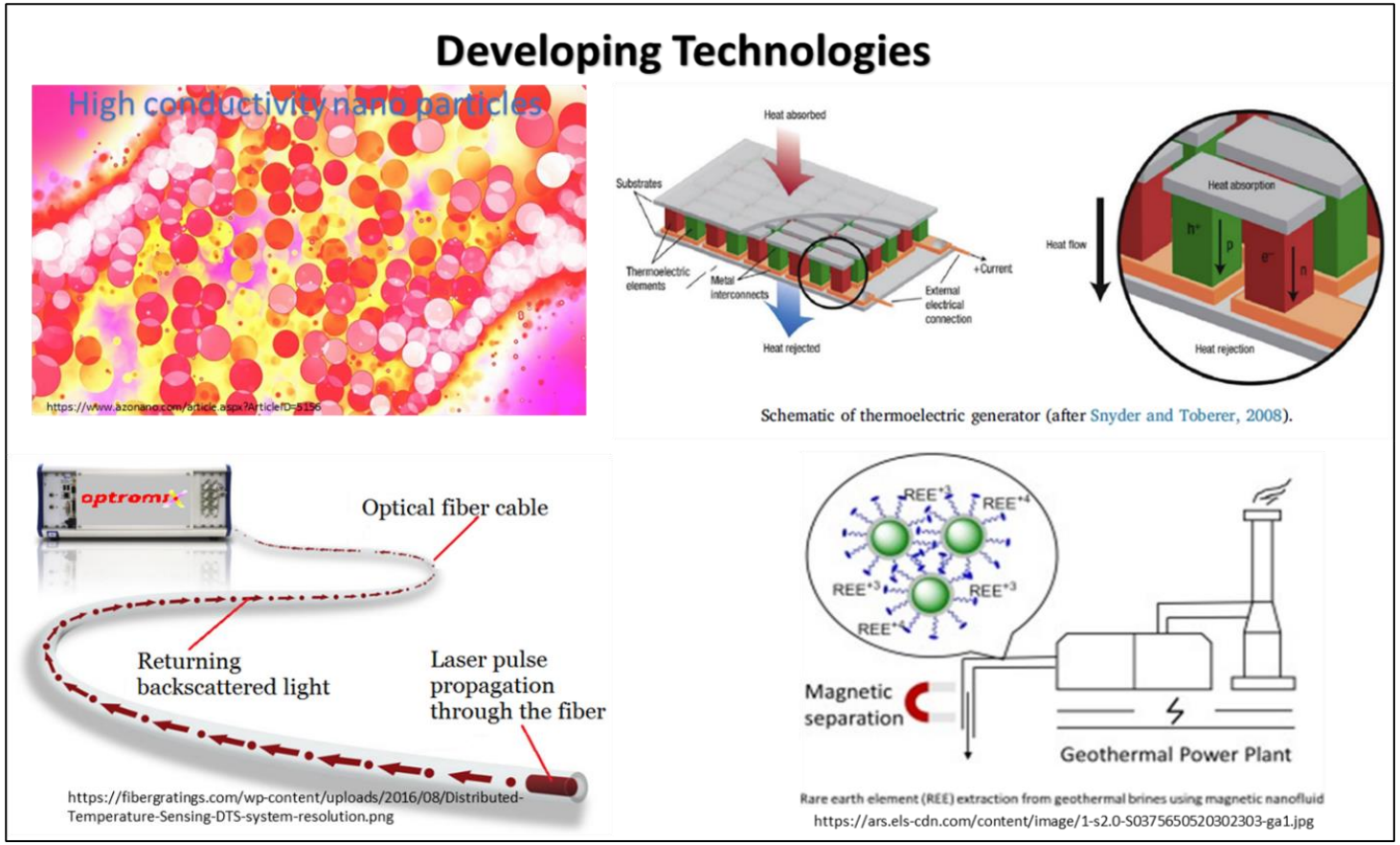
- Longer lifespan of producing wells
- Low carbon energy
- Future operations can consider two resources
- Heat and power can be used locally to reduce carbon intensity of oil and gas operations
- Initiates geothermal operations in prospective area
- Abundant wells for reinjection or monitoring





Future Development

- Fluid engineering for binary systems
- Nano particles in closed loop fluids
- Thermoelectric generators (near 100% efficiency)
- Element extraction from brine (not just lithium)
- Real time monitoring using DAS fiber optics
- Accurate BHT temperature method



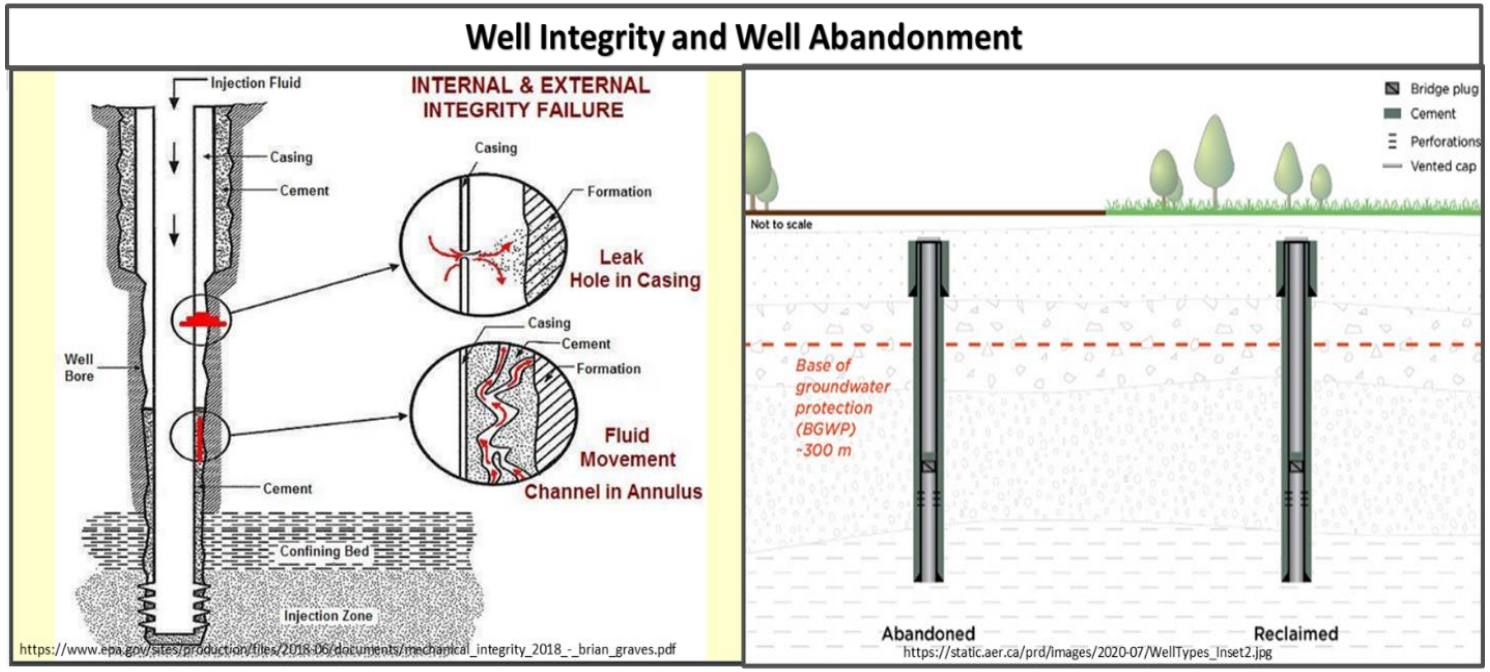
Using existing/developed wells and basins

Advantages

- Subsurface disturbance already exists
- Data is abundant
- Infrastructure of some sort already exists
- Opportunity to reassess safety of suspended and abandoned wells
- Abundant wells for various purposes

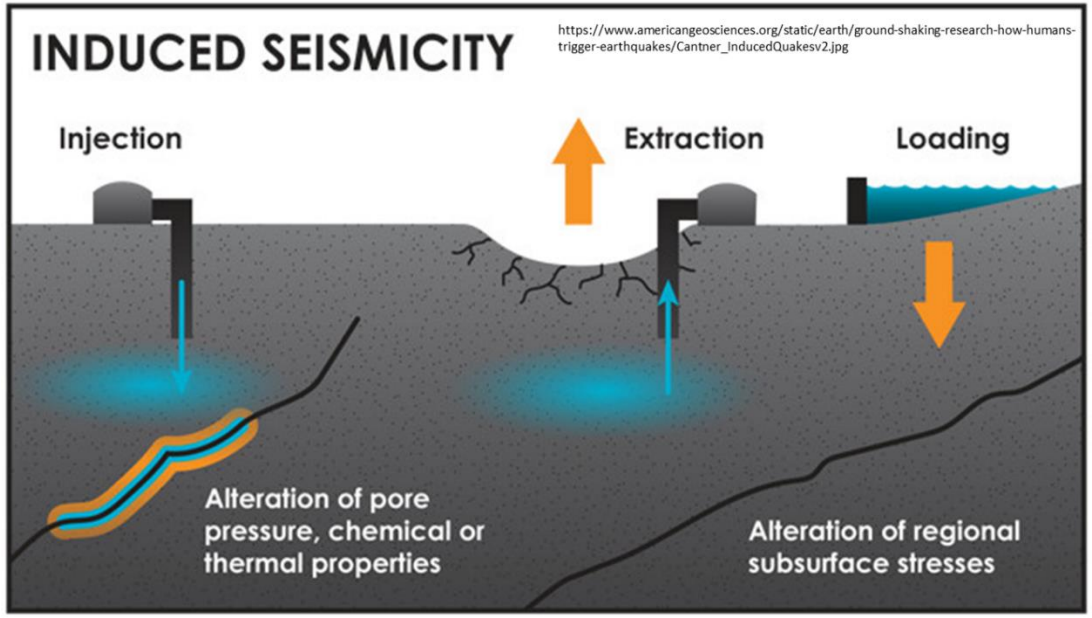
Problems

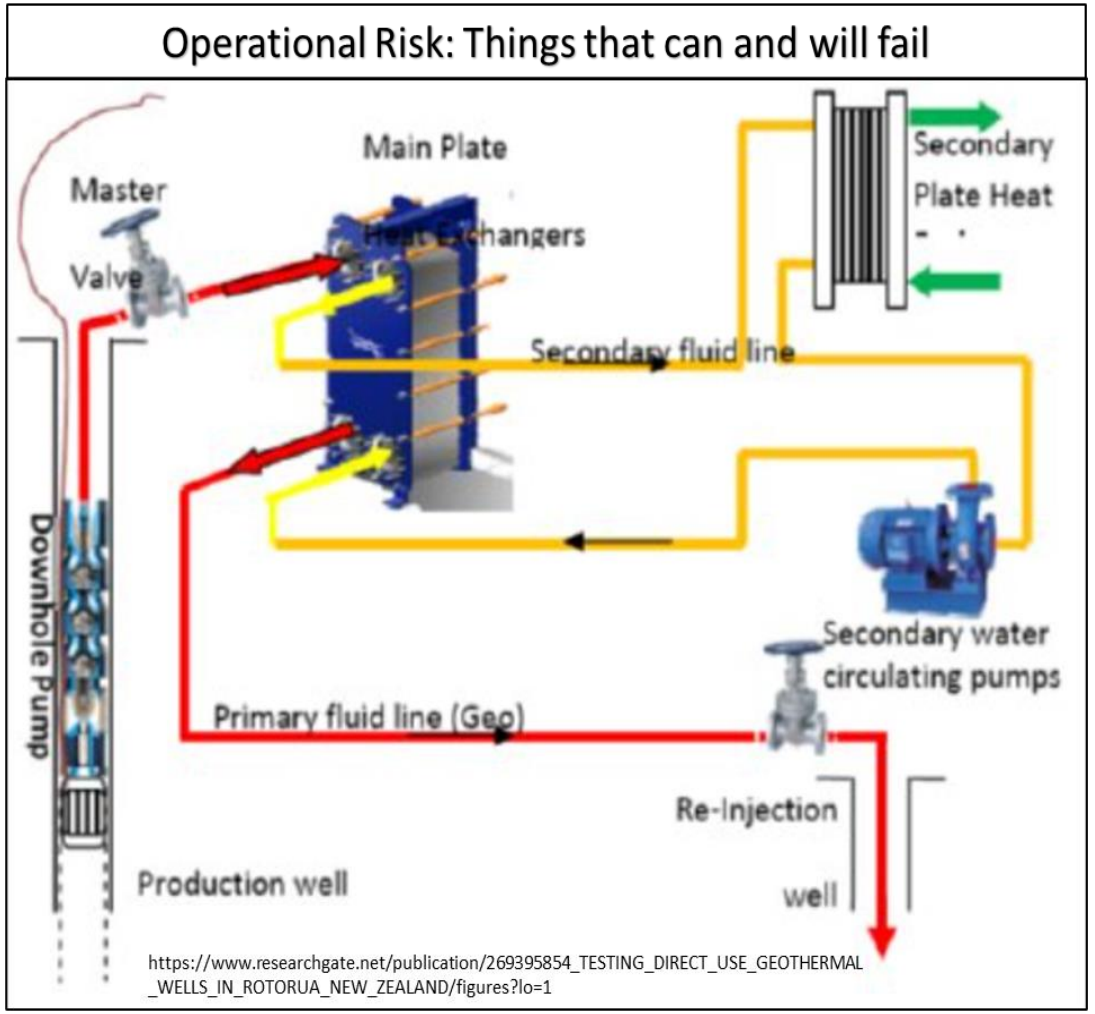
- Well integrity
- Abandonment costs
- Pressure issues
- Environmental responsibility
- Long payback times
- Casing size and flow rates



Operational Risks

- Pump failure
- Formation damage
- Heat exchanger scaling
- Well integrity
- Induced seismicity





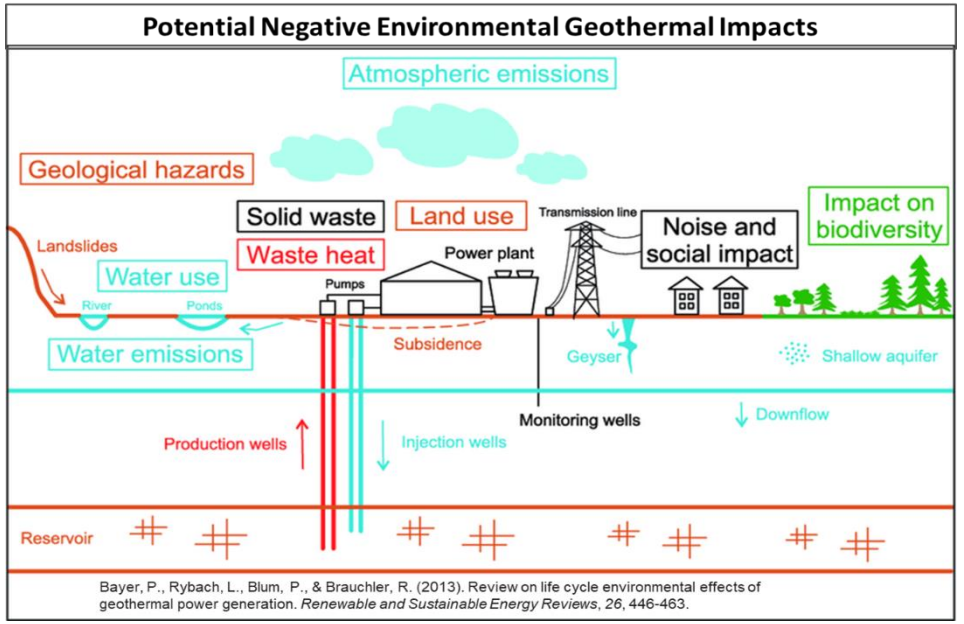
Environmental Impacts

Negative

- Well casing failure/well integrity (older is typically worse)
- Induced seismicity and formation fracturing
- Re-disturbing surface
- Brine spills
- Large withdrawal of geothermal fluids
- Waste production and disposal
- Noise
- Impact on sensitive living organisms
- Released gases

Positive

- Non carbon intensive electrical energy
- Low emission base load power
- Low impact and low cost thermal energy
- Re assessment of old wells in previously developed basins
- Drive for reworking poorly abandoned wells
- Monitoring of heavily drilled “mature” oil and gas basins



Barriers And Opportunities

- Oil and gas companies see a challenging regulatory, operational and financial situation in geothermal
  - Needs to be changed with regulations and incentives
- Commercial viability
  - Needs to be demonstrated and incentivized
- Societal and financial recognition of baseload power
  - Needs societal baseload power understanding
  - Needs appropriate baseload power regulation and valuation
- Recognition of emissions from current baseload power production
  - Geothermal impact on emissions needs to be quantified and shared

- Consistent long term plan for carbon tax, carbon credits, or carbon trading
  - Increase value and create a potential carbon economy
- Long term energy policy with substantial incentives
  - Derisk and provide value
- Effectively regulate and recognize heat as a resource
- Exploration/Research & development government tax breaks
- Faster and more consistent geothermal permits and exploration licenses
- Drilling insurance for failed wells

Thank you!