Repurposing Trenton-Black River Gas Fields as Low-Temperature Geothermal Reservoirs in New York State*

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Abstract

Geothermal resources have the potential to meet a significant portion of the low-temperature (30–100°C) thermal energy needs in the United States, in applications such as space heating, warming greenhouses, desalinization, food drying, and refrigeration. Harnessing heat from sedimentary basins may be one option for fulfilling those low enthalpy needs. For a region with a known thermal resource, a major contributor to investment risk is locating a reservoir capable of heat extraction. An approach to reduce that risk is to target specific structural and/or stratigraphic settings that have been proven as commercial oil and gas reservoirs. This study focused on the Appalachian Basin of New York, for which there are abundant geophysical and borehole data. Known oil and gas fields in New York were evaluated for potential repurposing as geothermal reservoirs using a Monte Carlo Simulation of an innovative productivity index equation tailored to low-temperature geothermal systems, measured in liters per megapascal (L/MPa). Reservoir parameters included in the productivity index were formation depth, thickness, pressure, area, porosity, permeability, fluid viscosity, and distance between wells. Results were incorporated into a geographical information system to determine the extent to which the best performing reservoirs coincide with the highest thermal gradient in the region. The Trenton-Black River hydrothermal dolomite gas fields of New York showed the most promising opportunity for conversion to low-temperature geothermal reservoirs. First, the calculated productivity index for these fields is the highest in the state, ranging from 19–33 L/MPa. Second, the reservoirs are located at 2500–3200 meters depth, coinciding with New York's highest

thermal gradient, resulting in temperatures at depth ranging from 65 to 85°C. The fields are conveniently located near the Elmira-Corning townships, where heat can be provided for a variety of end-uses. This study confirms the potential to produce geothermal heat in southern New York, specifically using the Trenton-Black River gas fields, and suggests that a similar analysis could be done for Trenton-Black River trends in Indiana, Ohio, Michigan, and West Virginia.

References Cited

Fox, D.B., D. Sutter, and J.W. Tester, 2011, The Thermal Spectrum of Low-Temperature Energy Use in the United States: Proceedings, Thirty-Sixth Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California, SGP-TR-191, p. 1-15.

Patchen, D.G., J.B. Hickman, D.C. Harris, J.A. Drahovzal, P.D. Lake, L.B. Smith, R. Nyahay, R. Schulze, R.A. Riley, M.T. Baranoski, L.H. Wickstrom, C.D. Laughrey, J. Kostelnik, J.A. Harper, K.L. Avary, J. Bocan, M.E. Hohn, and R. McDowell, 2006, A Geologic Play Book for Trenton-Black River Appalachian Basin Exploration: Final Report Prepared for U.S. Department of Energy, DOE Award DE-FC26-03NT41856, p. 231–240.

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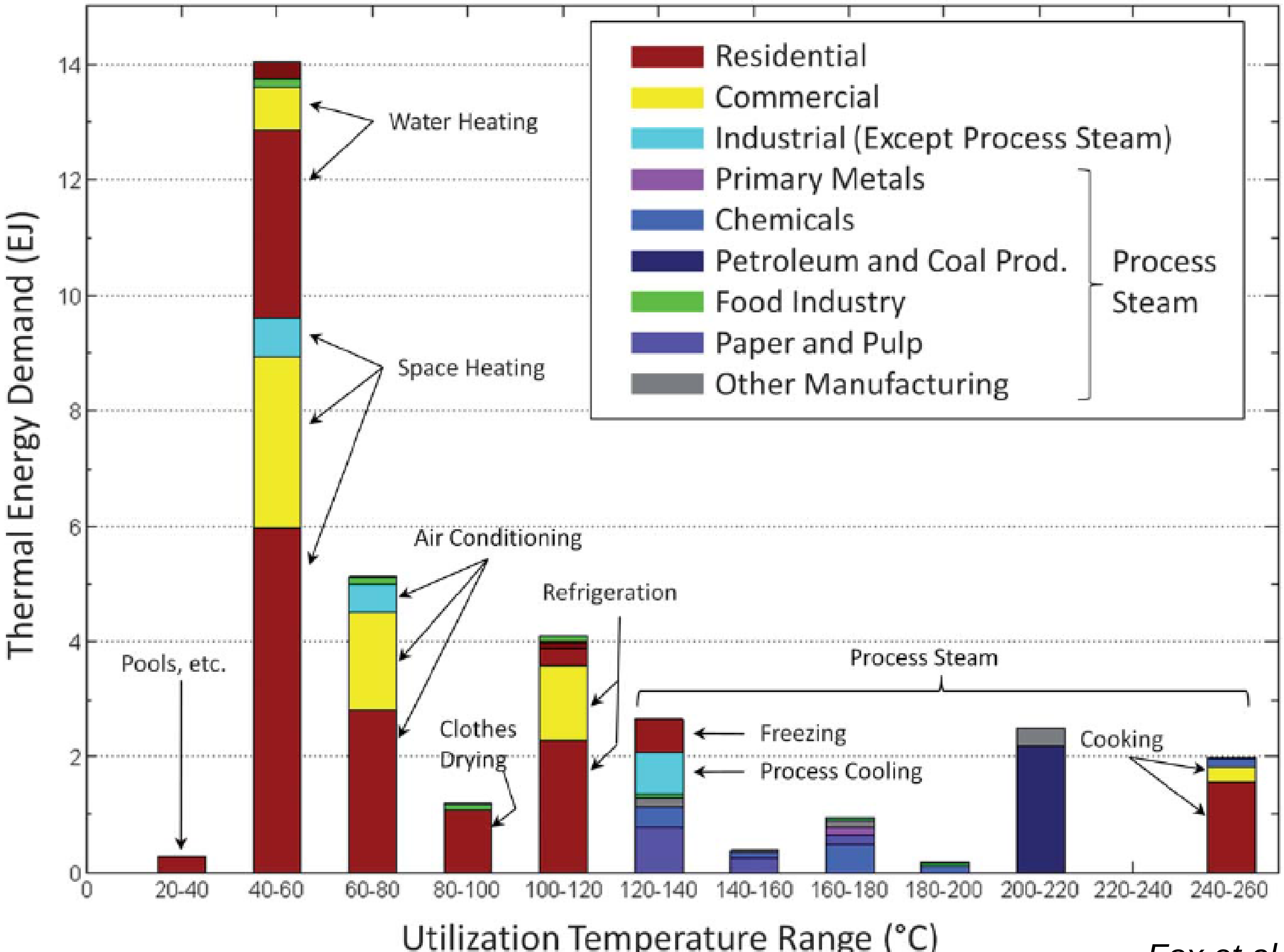
Outline

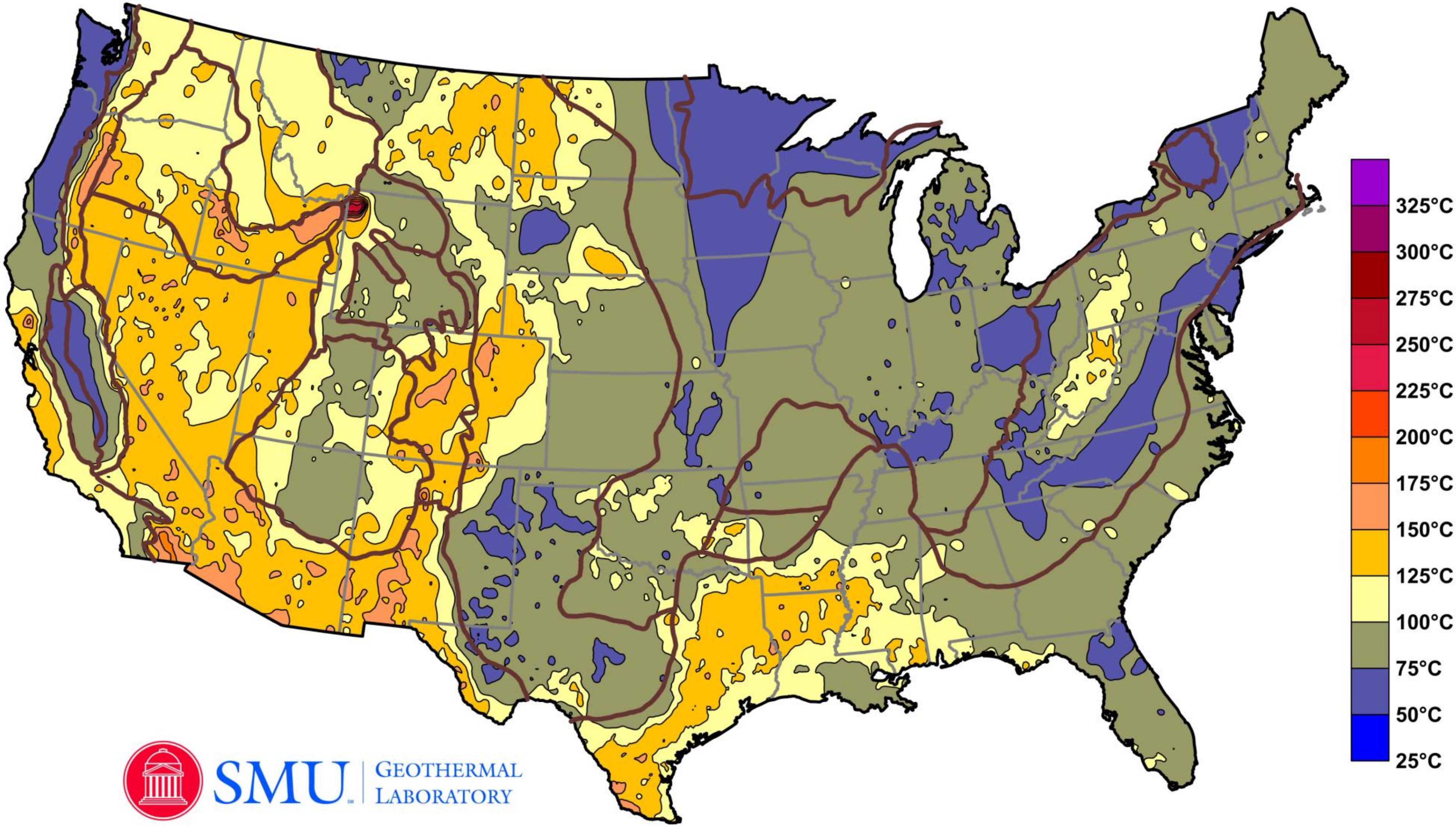
1. Motivation
2. Geothermal basics
3. Trenton-Black River play in New York
4. Single reservoir analysis
5. Basin-scale reservoir analysis

Thermal Energy Usage in U.S.



Fox et al., 2011

Temperatures at 3.5 km



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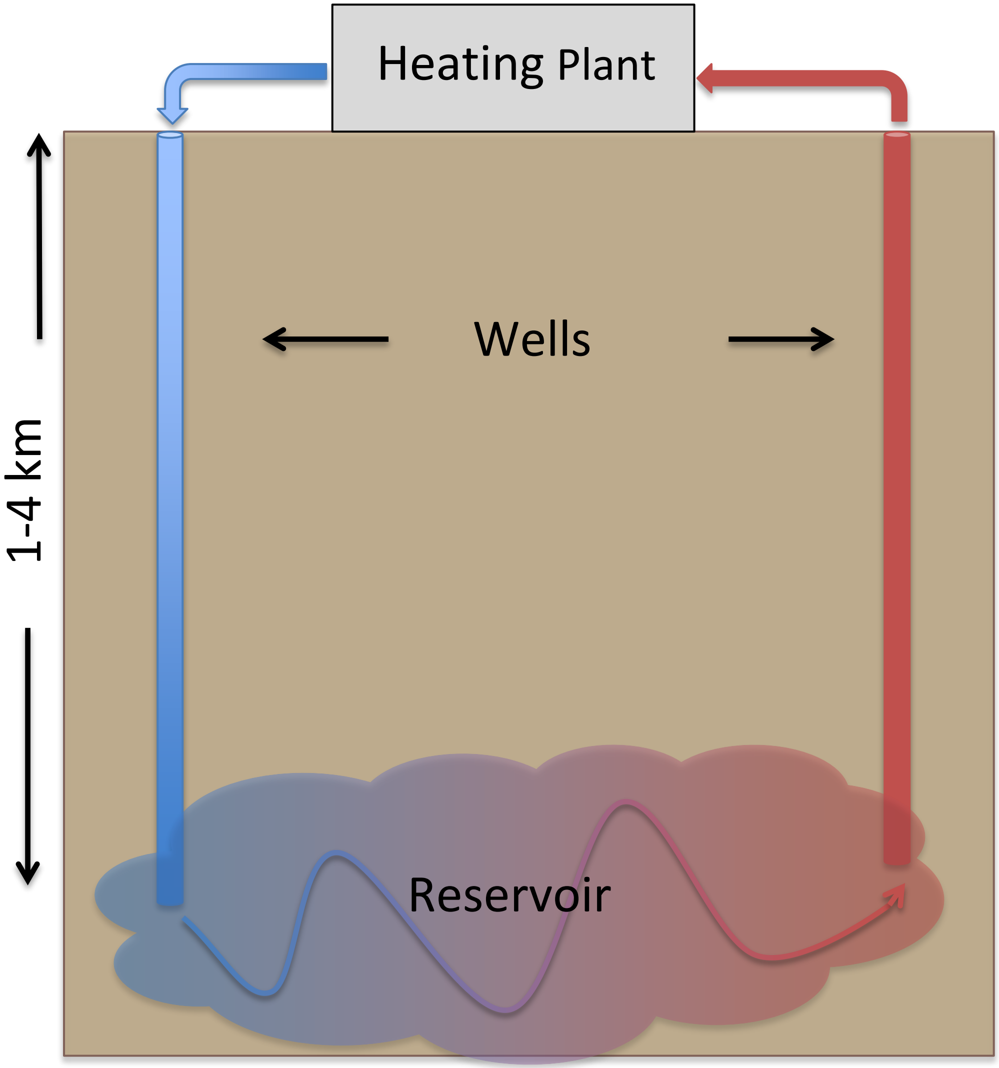
Deep Geothermal for Direct-Use



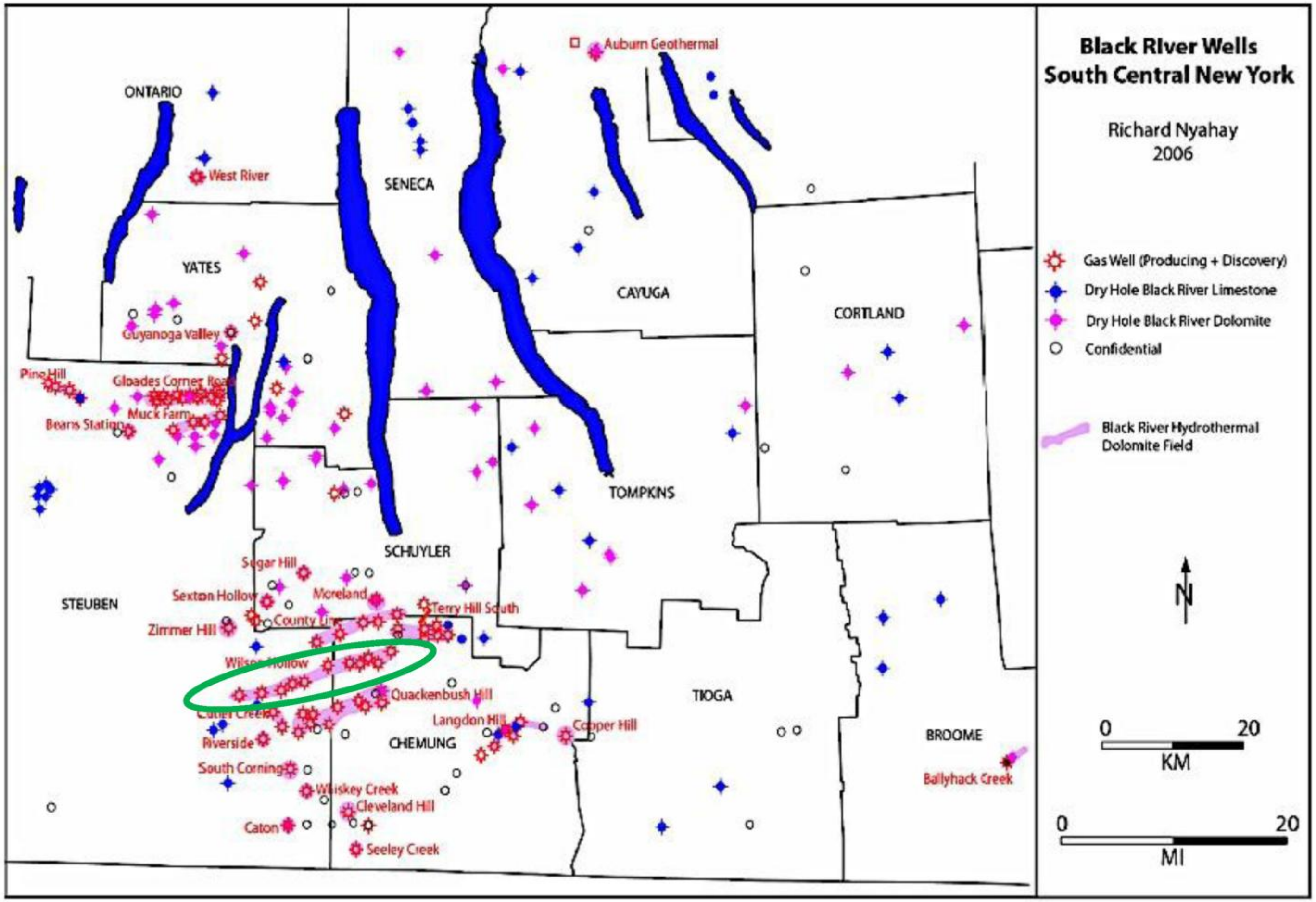
(Not to scale)

Basic needs in the system:

1. Heat in rock
2. Permeability in rock
3. Demand on surface

Field ≈ Pool ≈ Reservoir

Trenton-Black River in New York

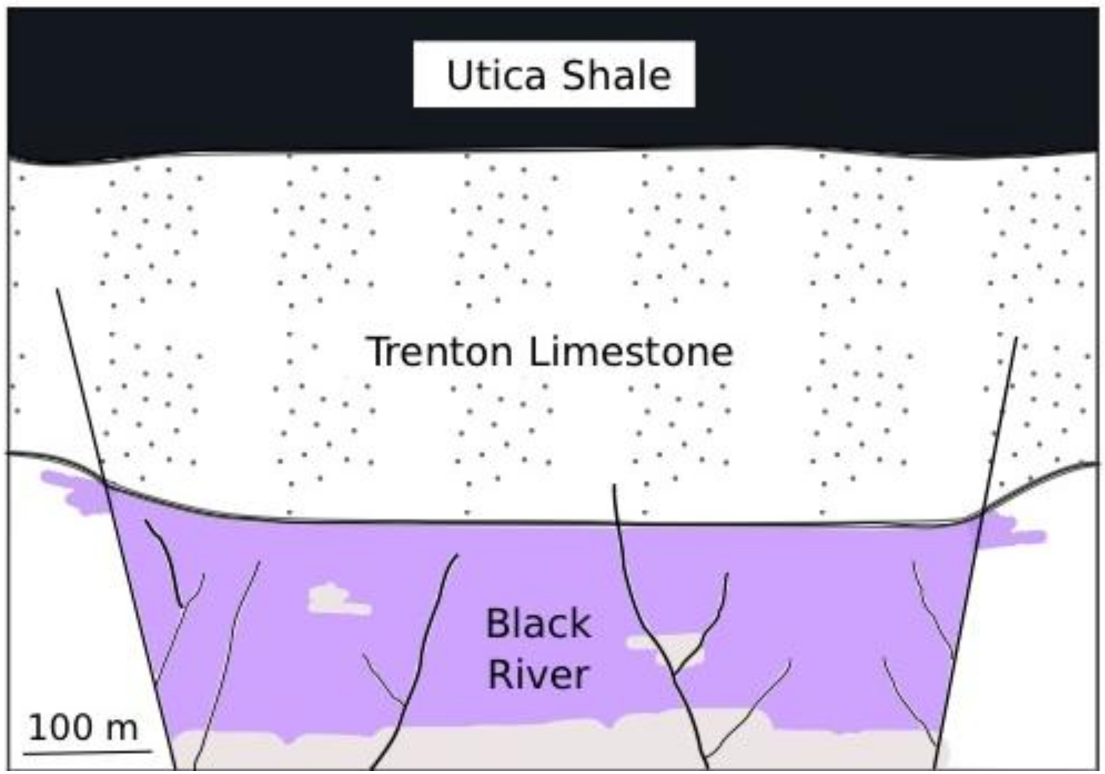


Source: Patchen et al., 2006

Presenter’s notes: Best gas producers in NY since 2000, still producing. Were of great interest to the carbon sequestration community due to their “deep, large, container-like” qualities. Were primary target for geothermal analysis.

Trenton-Black River in New York

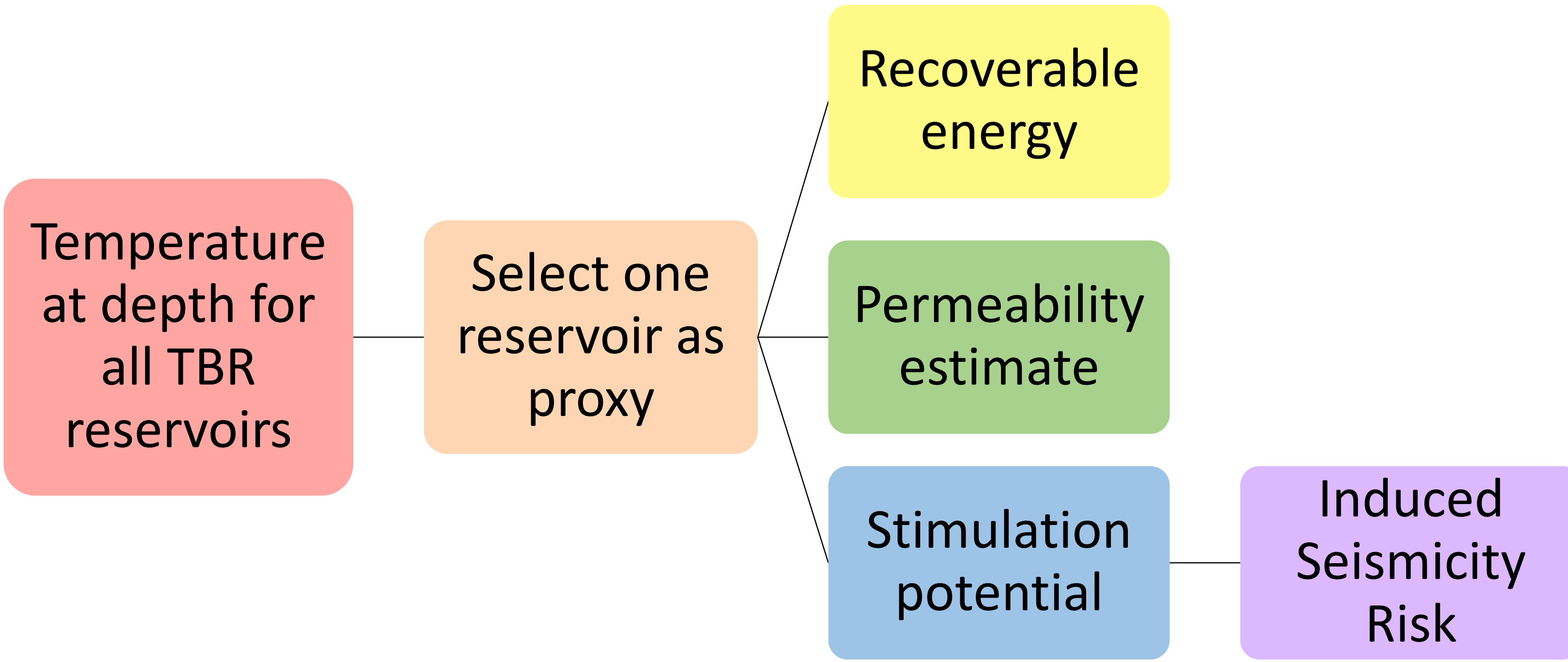
Cross-section at ~2-3 km depth



- Negative flower structures
  - Long, narrow grabens
  - Transtensional
  - Bounded by subvertical faults
- Hydrothermal alteration in the late Ordovician
- Dolomite localized around faults and fractures
- Higher porosity and gas associated with dolomite
- Limited permeability data

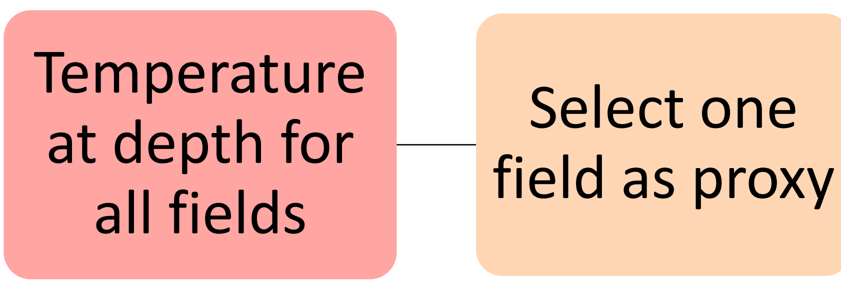
Single Reservoir Analysis:

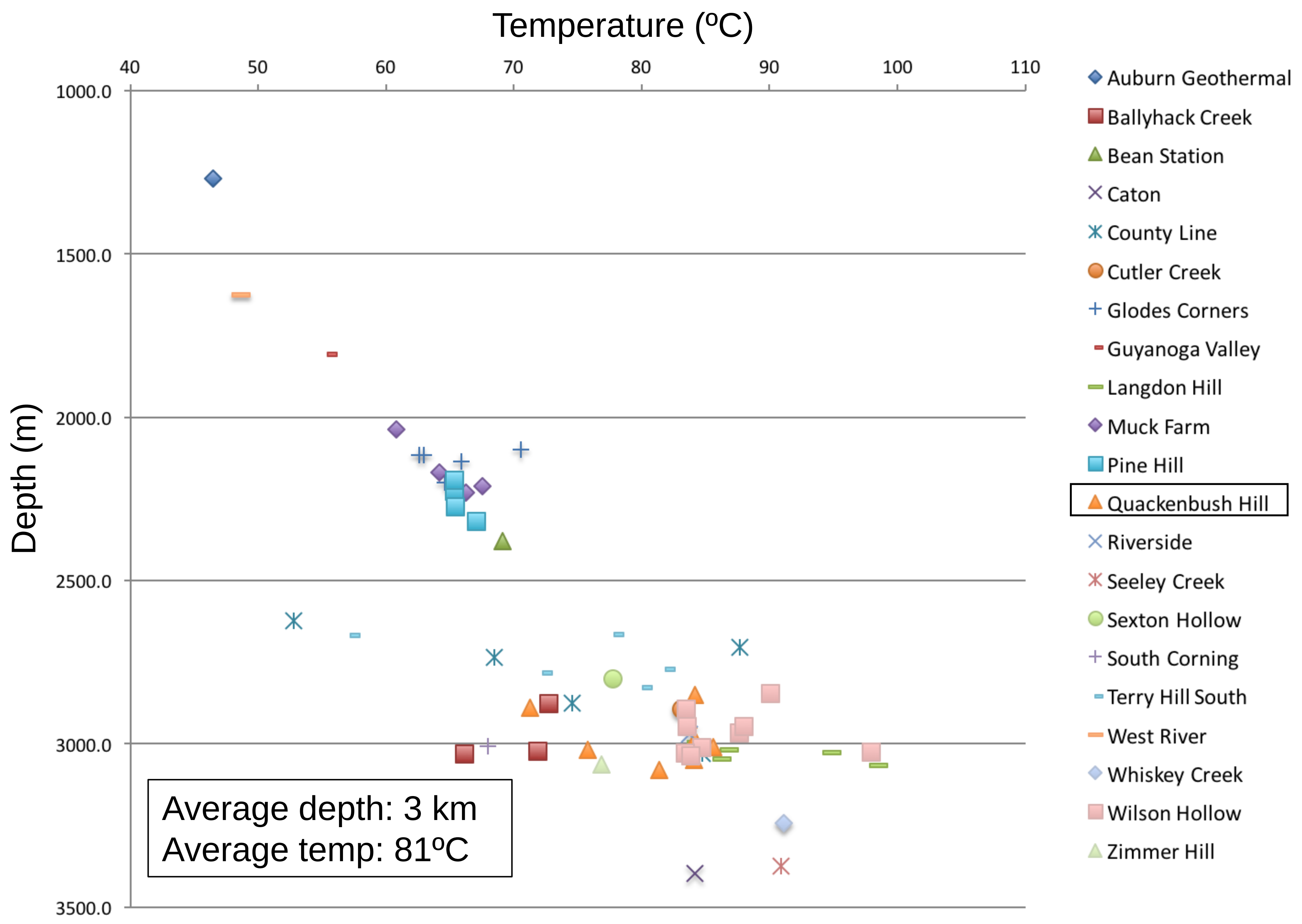
Analyze the prospect of the T-BR gas fields for geothermal energy production



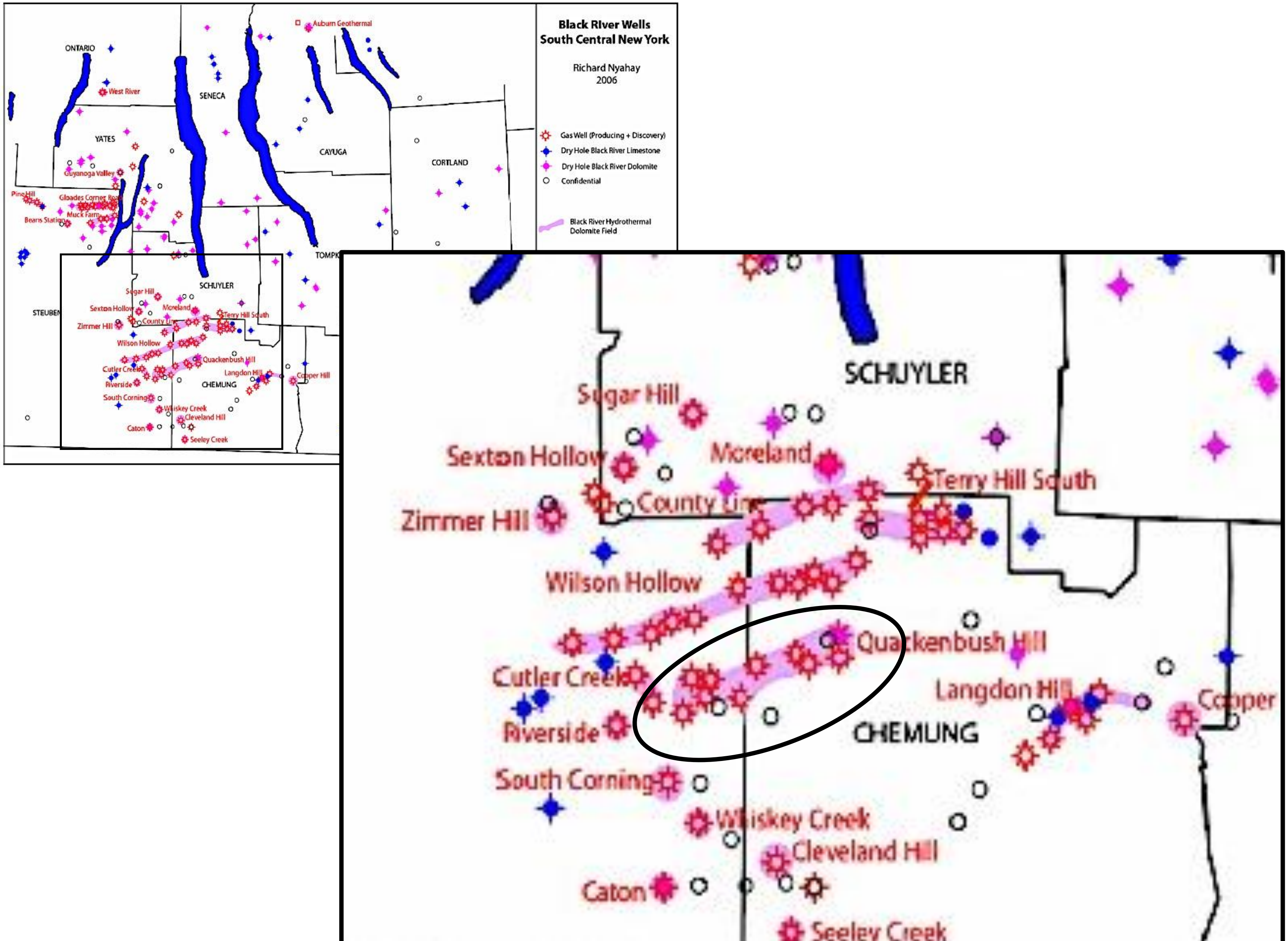
Single Reservoir Analysis:

Analyze the prospect of the T-BR play for geothermal energy production

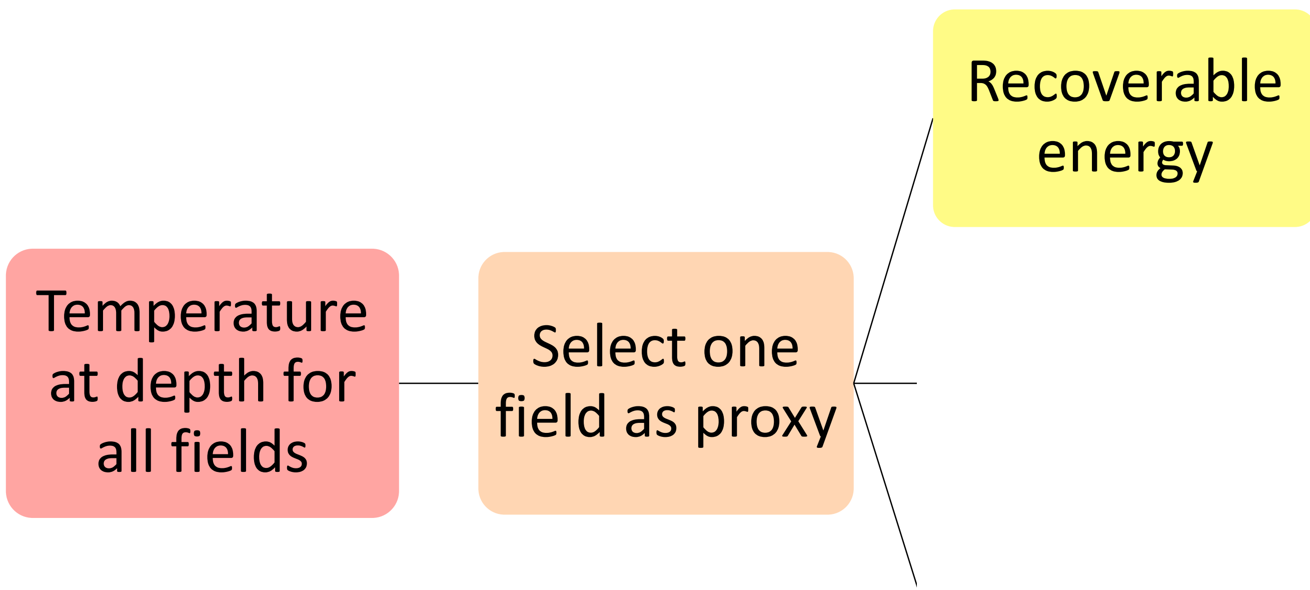




Temperature (ºC)
40
50
60
70
80
90
100
110
Depth (m)
1000.0
1500.0
2000.0
2500.0
3000.0
3500.0
Auburn Geothermal
Ballyhack Creek
Bean Station
Caton
County Line
Cutler Creek
Glodes Corners
Guyanoga Valley
Langdon Hill
Muck Farm
Pine Hill
Quackenbush Hill
Riverside
Seeley Creek
Sexton Hollow
South Corning
Terry Hill South
West River
Whiskey Creek
Wilson Hollow
Zimmer Hill
Average depth: 3 km
Average temp: 81ºC


Black River Wells
South Central New York
Richard Nyahay
2006
Gas Well (Producing + Discovery)
Dry Hole Black River Limestone
Dry Hole Black River Dolomite
Confidential
Black River Hydrothermal Dolomite Field
ONTARIO
SENECA
YATES
CAYUGA
CORTLAND
SCHUYLER
STEUBEN
CHEMUNG
Auburn Geothermal
West River
Guyanoga Valley
Pine Hill
Glodes Corner Road
Muck Farm
Beans Station
Sugar Hill
Sexton Hollow
Moreland
County Line
Terry Hill South
Zimmer Hill
Wilson Hollow
Quackenbush Hill
Cutler Creek
Langdon Hill
Cooper Hill
Riverside
South Corning
Whiskey Creek
Cleveland Hill
Caton
Seeley Creek

Single Reservoir Analysis:



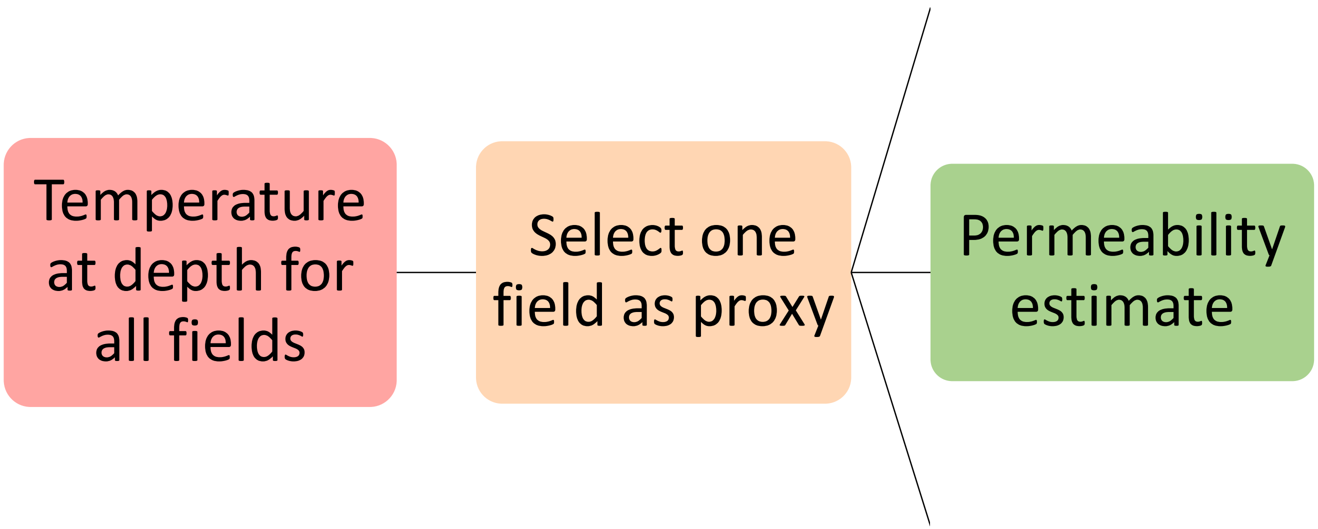
$$\text{Recoverable Thermal Energy} = \frac{\rho V C_p \Delta T \eta R}{t}$$

Reservoir length	V
Reservoir width	
Reservoir thickness	
Heat capacity of limestone	C_p
Density of limestone	ρ
Reservoir Temp	ΔT
Reinjection Temp	
Efficiency factor	η
Recovery factor	R
Time	t

$$\text{Recoverable Thermal Energy} = \frac{\rho V C_p \Delta T \eta R}{t}$$

1.26-5.05 MW$_{th}$
660-3600 homes in NY state

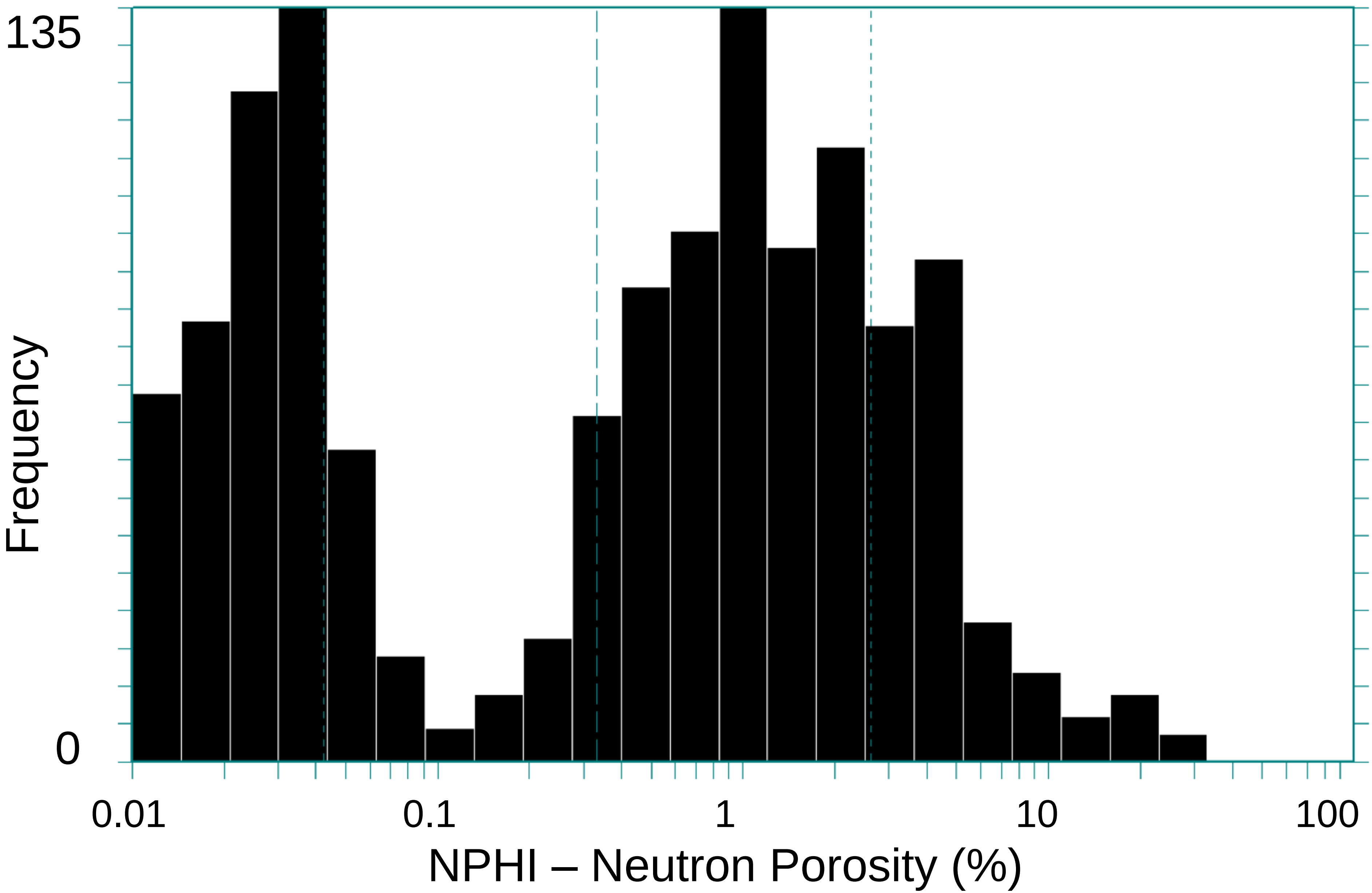
Single Reservoir Analysis:



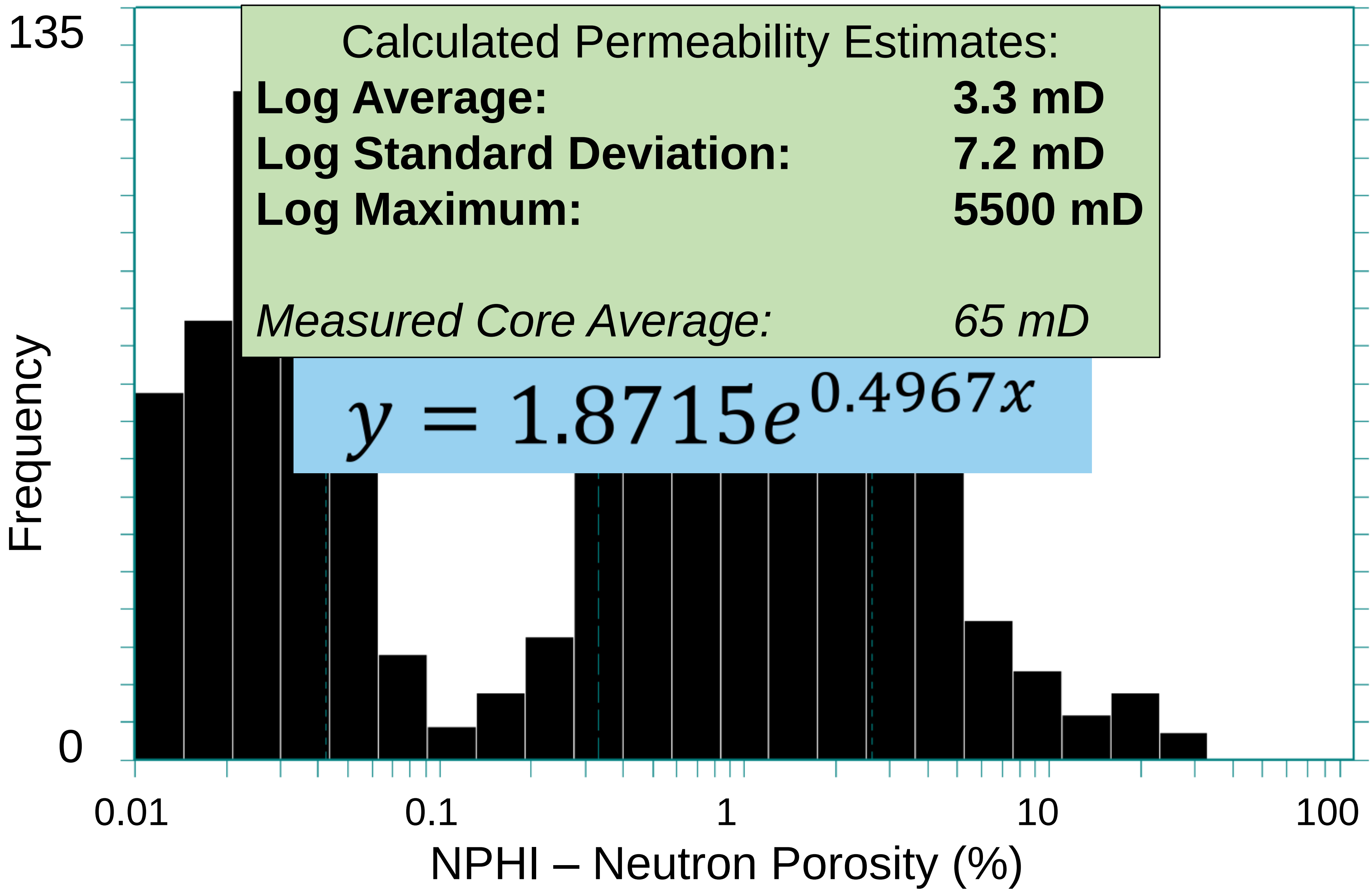
$$y = 1.8715e^{0.4967x}$$

x = porosity (%)

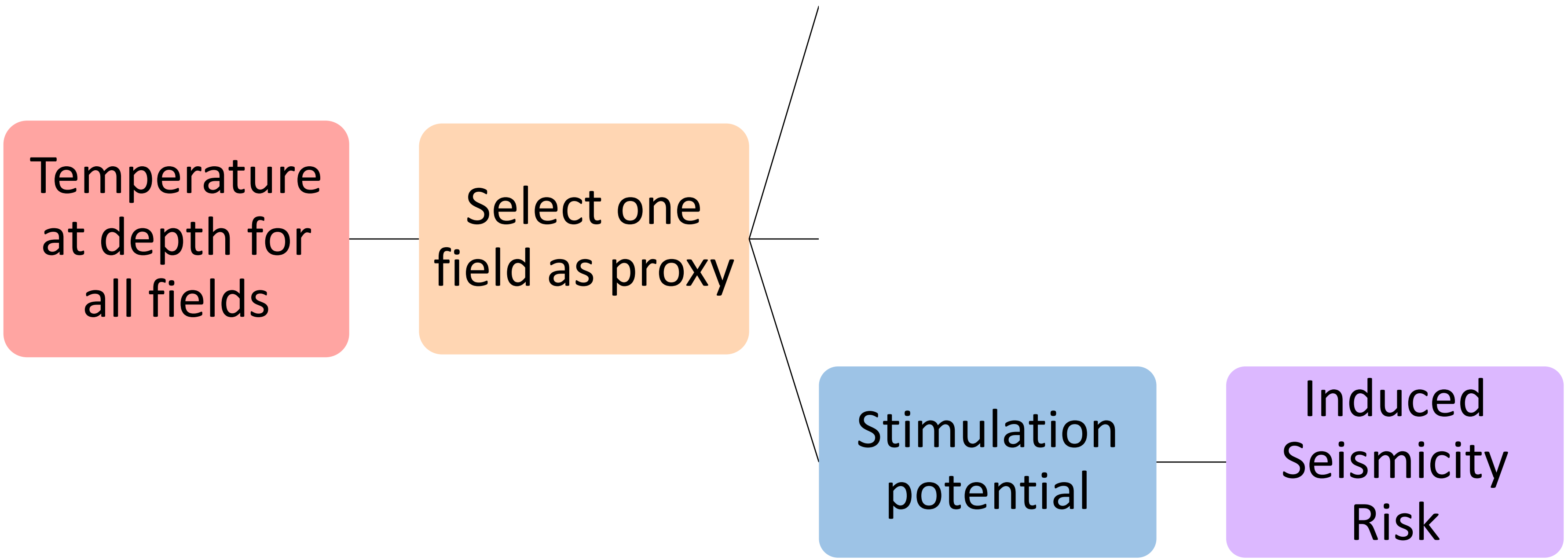
y = permeability (mD)



135
0
Frequency
0.01
0.1
1
10
100
NPHI – Neutron Porosity (%)


Calculated Permeability Estimates:
Log Average: 3.3 mD
Log Standard Deviation: 7.2 mD
Log Maximum: 5500 mD
Measured Core Average: 65 mD
$y = 1.8715e^{0.4967x}$
135
0
Frequency
0.01
0.1
1
10
100
NPHI – Neutron Porosity (%)

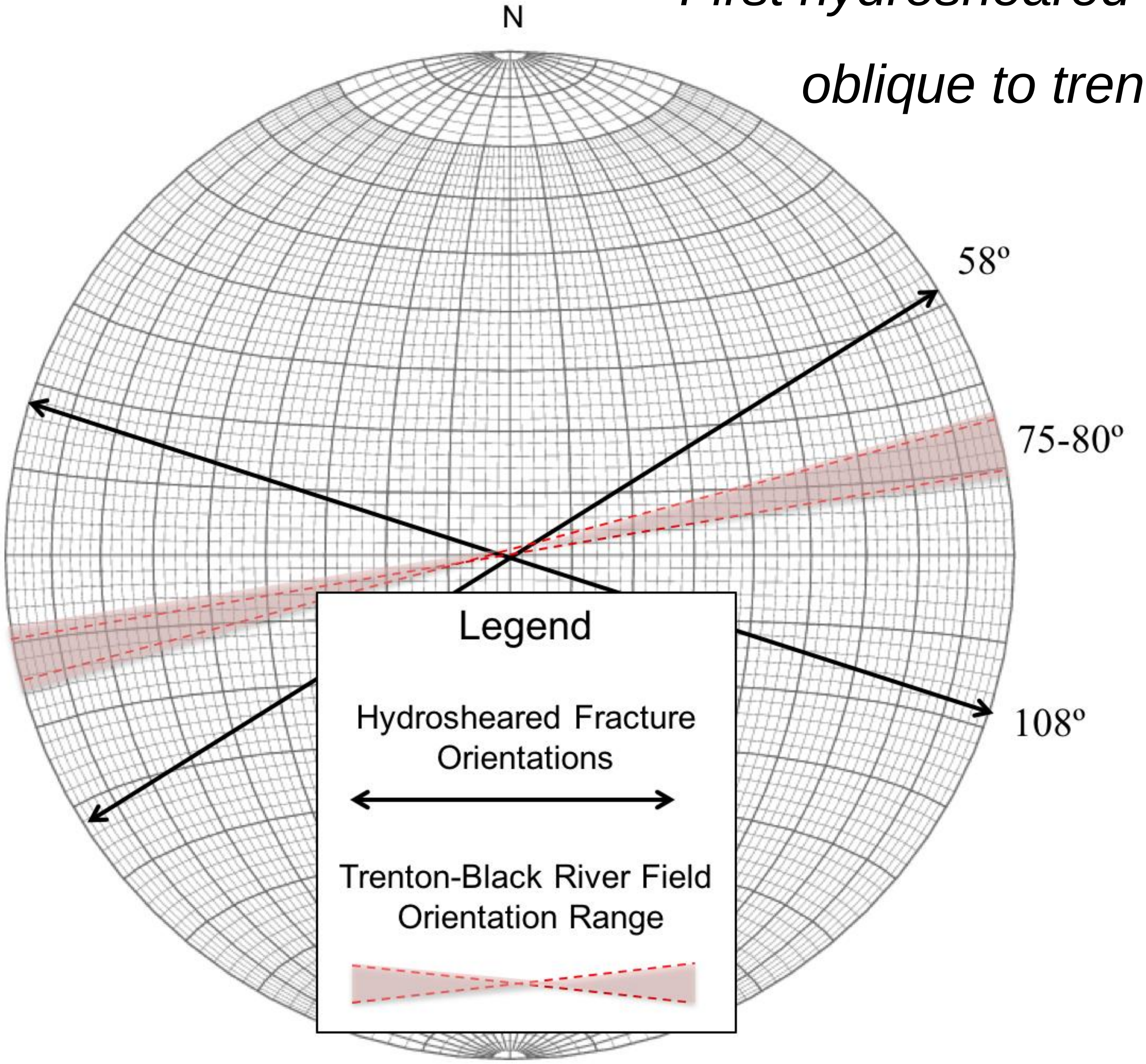
Single Reservoir Analysis:

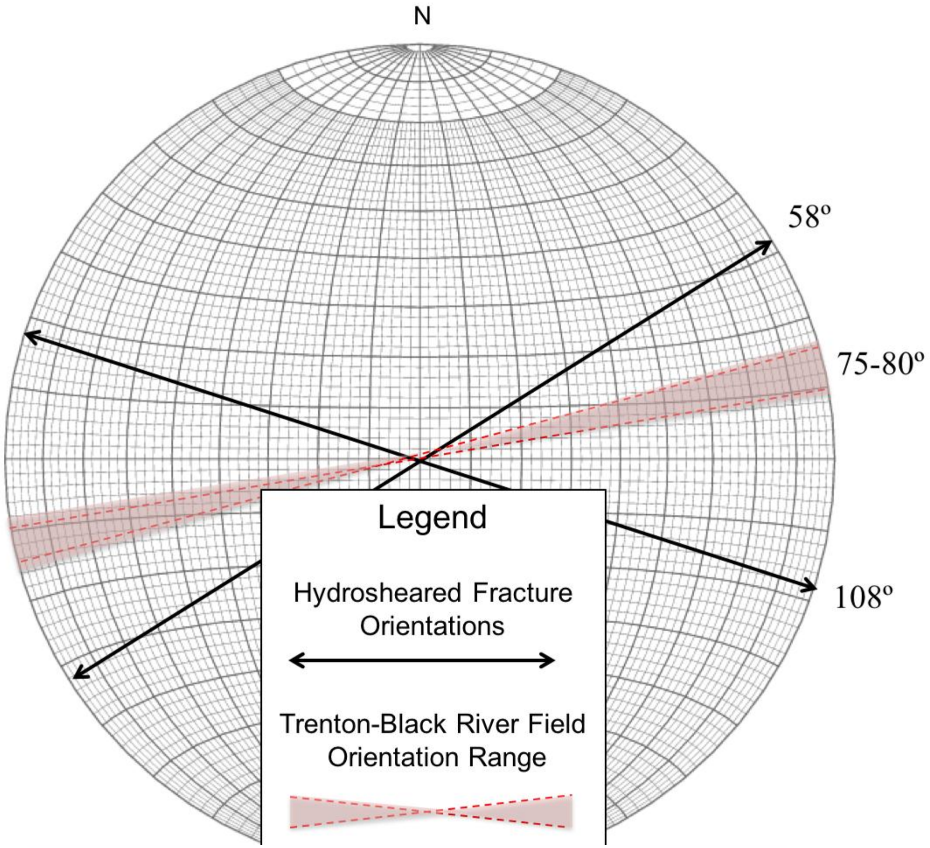


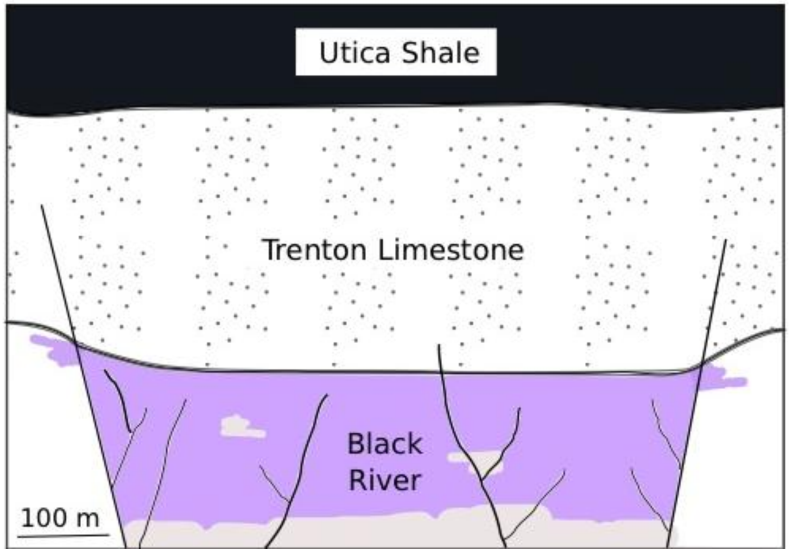
Stress Data

	Stress at 3 km depth	**Orientation at Quackenbush Hill**
$\mathbf{S_{H,max}}$ $(\boldsymbol{\sigma_1})$	85 ± 4 MPa	N71ºE ±15º
$\mathbf{S_{H,min}}$ $(\boldsymbol{\sigma_3})$	55 ± 3 MPa	N161ºE ±15º
$\mathbf{S_V}$ $(\boldsymbol{\sigma_2})$	65 MPa	*vertical*

First hydrosheared fractures oriented oblique to trend of grabens





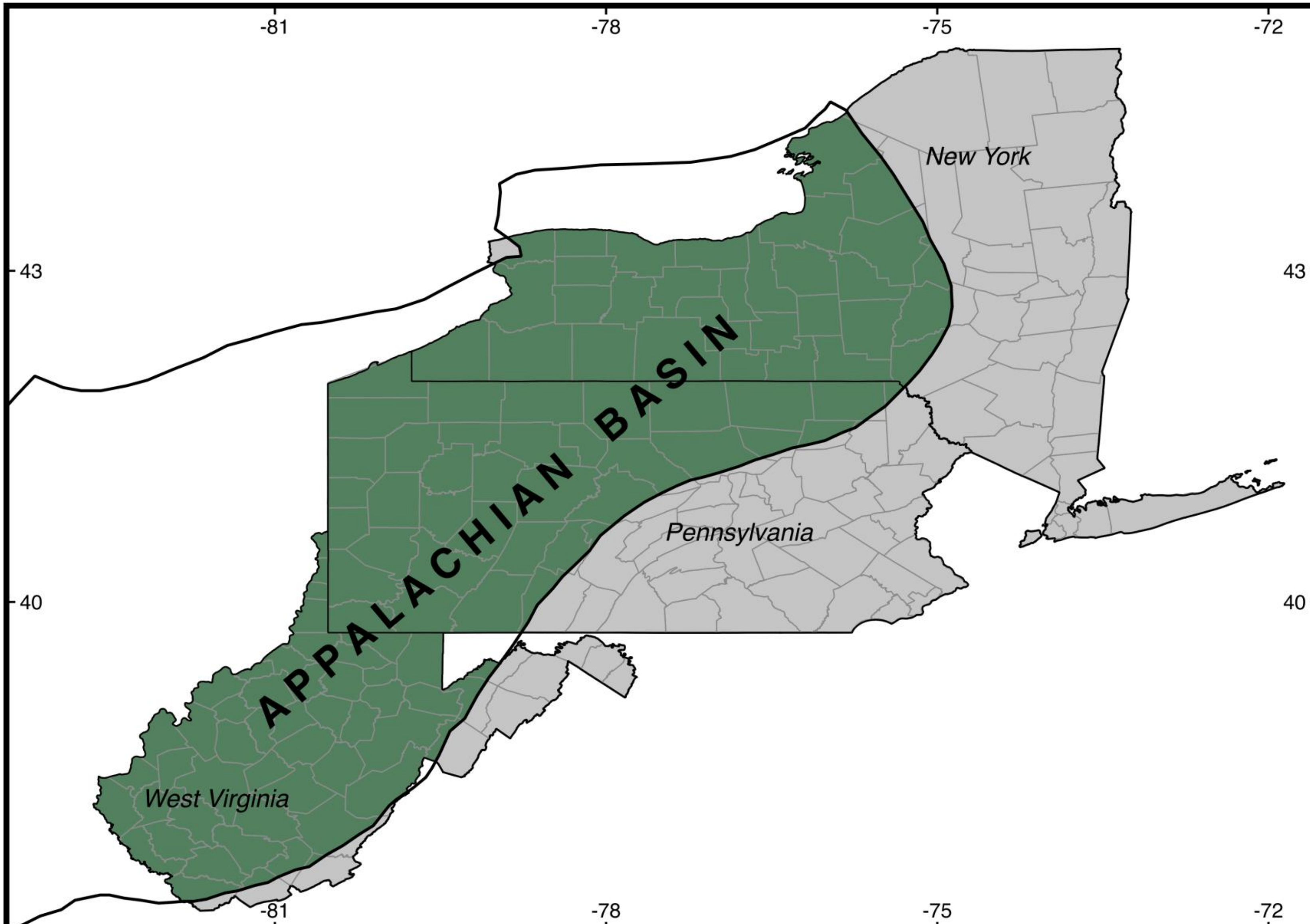


$$\frac{\tau}{\sigma_n} = 0.08$$

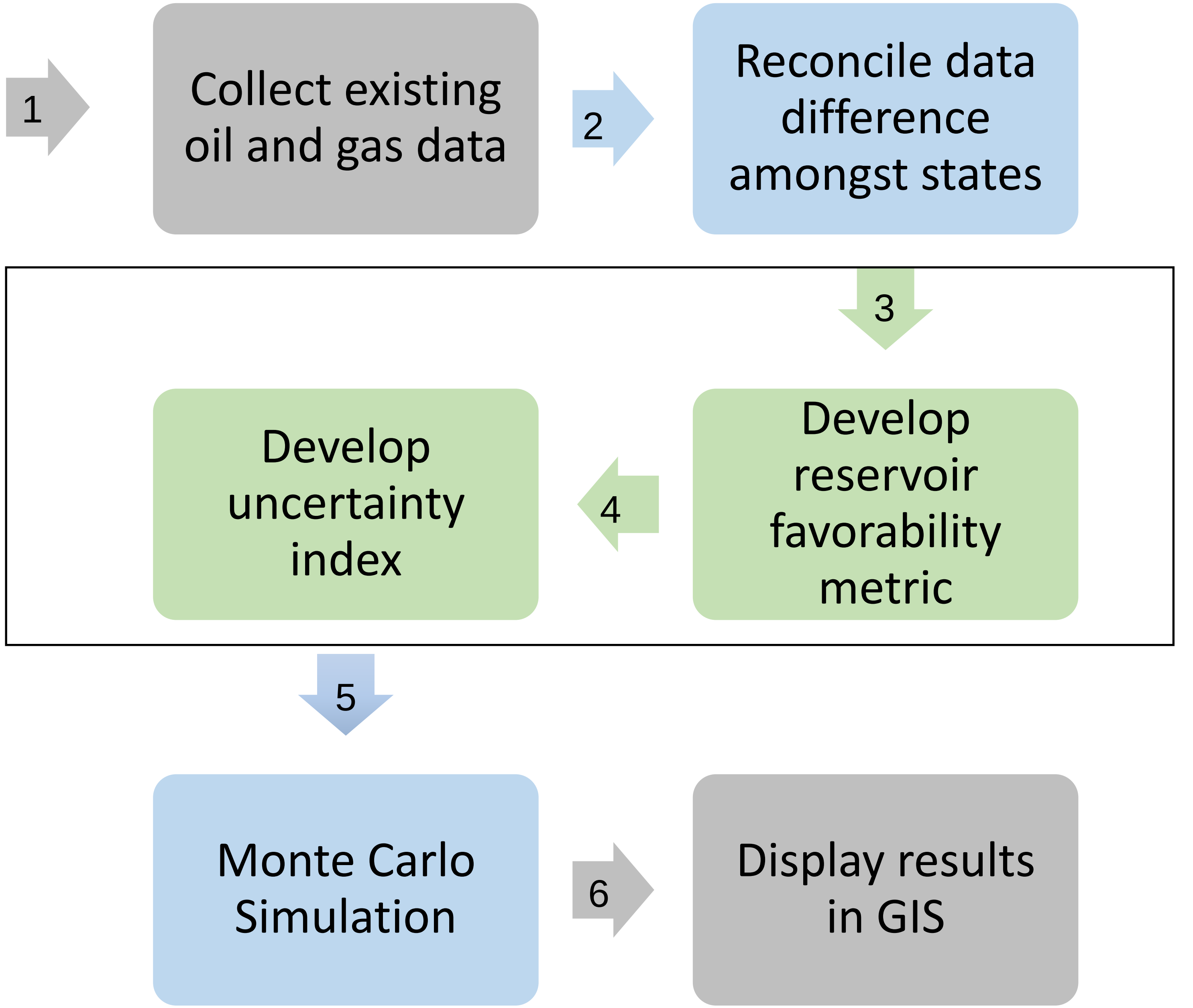
$$\mu = 0.85$$

0.08 << 0.85
Low Risk

Basin-Scale Analysis



Methods

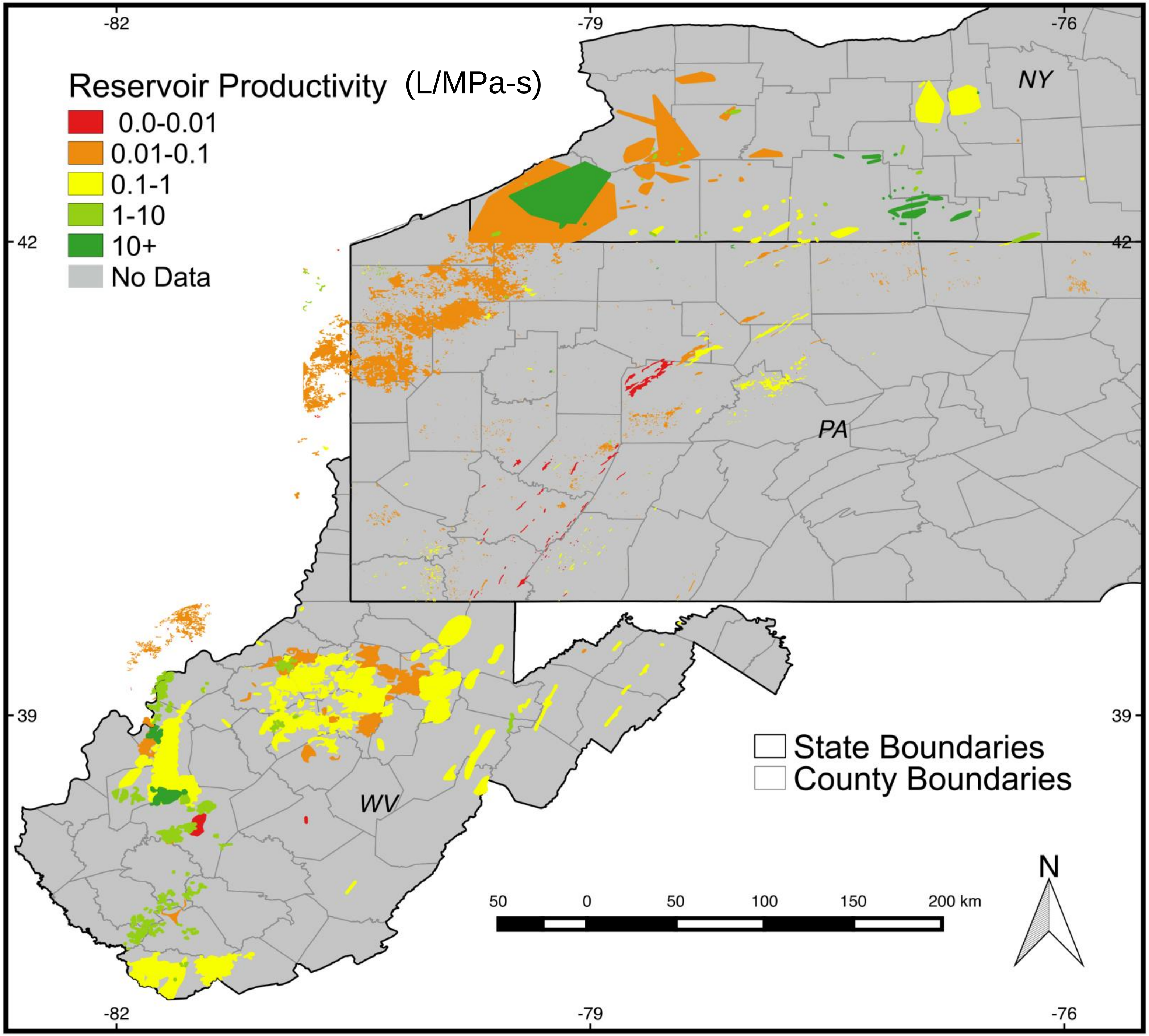

1
Collect existing oil and gas data
2
Reconcile data difference amongst states
3
Develop reservoir favorability metric
4
Develop uncertainty index
5
Monte Carlo Simulation
6
Display results in GIS

Reservoir Productivity Index =

$$\frac{Q}{\Delta P} = \frac{2\pi k H f_a}{\mu} \qquad \left(\frac{L}{MPa\ s}\right)$$

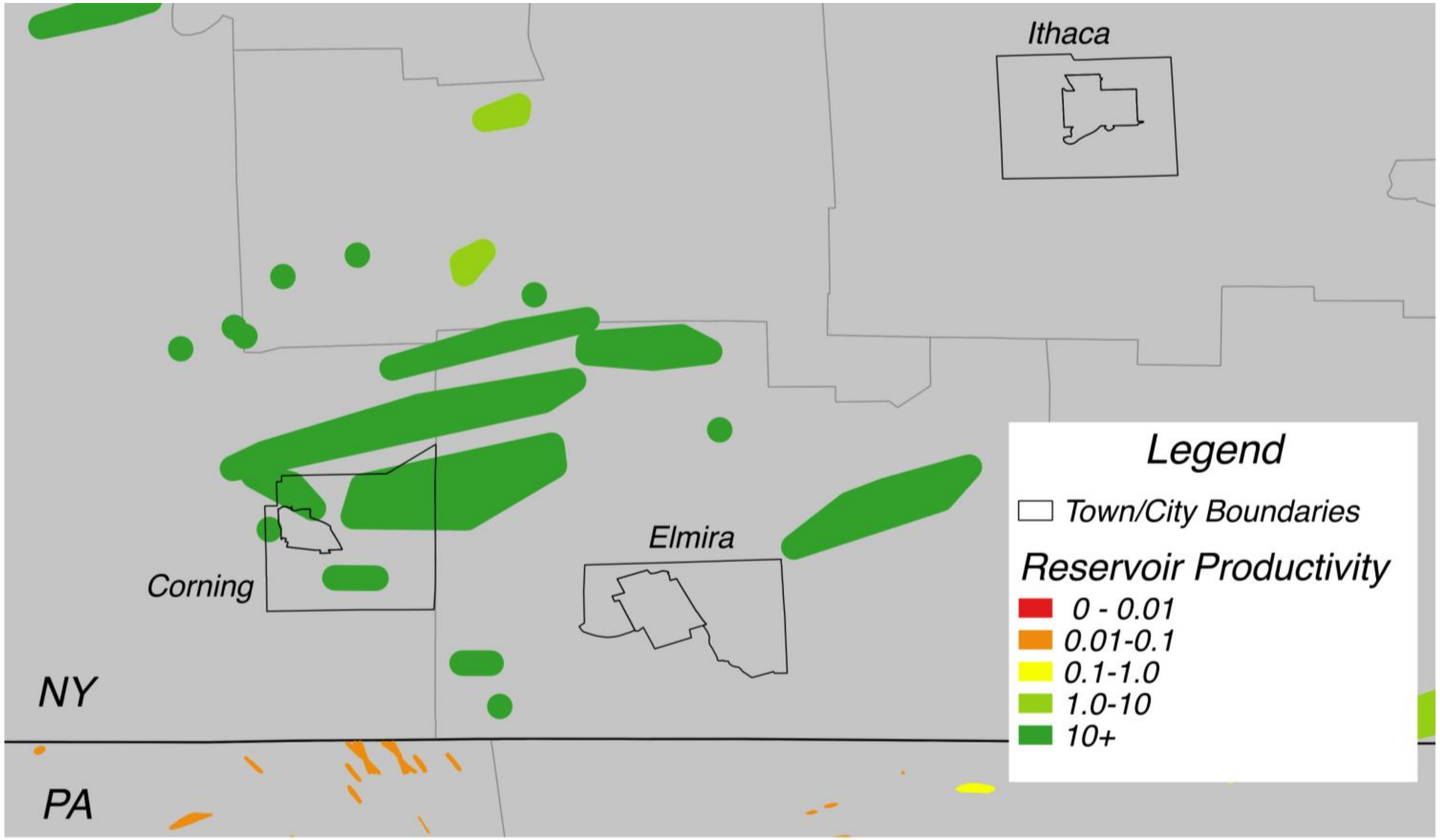
k = permeability
H = reservoir thickness
f_a = area factor
μ = water viscosity

*** Porous media approximation***



Reservoir Productivity (L/MPa-s)
0.0-0.01
0.01-0.1
0.1-1
1-10
10+
No Data
-82
-79
-76
42
39
NY
PA
WV
State Boundaries
County Boundaries
50
0
50
100
150
200 km
N

Conclusions



- T-BR play is promising in basin and play contexts.
  - Lacking enough permeability data
- Located near Corning, Elmira

Future Work

Fracture intensity analysis of T-BR outcrop

Looking for future collaboration with companies to allow us to understand the reservoir properties and potential flow rates

Flow tests? Reservoir modeling?

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Thank you! Questions?

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