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


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

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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.

Utilization Temperature Range (°C)

- Residential
- Commercial
- Industrial (Except Process Steam)
- Primary Metals
- Chemicals
- Petroleum and Coal Prod.
- Food Industry
- Paper and Pulp
- Other Manufacturing

Fox et al., 2011
Temperatures at 3.5 km

United States map showing temperature ranges at 3.5 km depth.
Deep Geothermal for Direct-Use

Basic needs in the system:
1. Heat in rock
2. Permeability in rock
3. Demand on surface

Field ≈ Pool ≈ Reservoir
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

- Temperature at depth for all TBR reservoirs
- Select one reservoir as proxy
- Recoverable energy
- Permeability estimate
- Stimulation potential
- Induced Seismicity Risk
Single Reservoir Analysis:

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

- Temperature at depth for all fields
- Select one field as proxy
- Recoverable energy
- Permeability estimate
- Stimulation potential
- Induced Seismicity
- Risk
Single Reservoir Analysis:

- Temperature at depth for all fields
- Select one field as proxy
- Recoverable energy
- Stimulation potential
- Induced Seismicity
- Single Reservoir Analysis:
Reservoir length: 13,000 m
Reservoir width: V
Reservoir thickness: 160 – 175 m
Heat capacity of limestone: $C_p$
Density of limestone: $\rho$
Reservoir Temp: 81 ºC
Reinjection Temp: 25 ºC
Efficiency factor: $\eta$
Recovery factor: $R$
Time: $t$

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

- Temperature at depth for all fields
- Select one field as proxy
- Permeability estimate
$y = 1.8715e^{0.4967x}$

$x =$ porosity ($\%$)

$y =$ permeability (mD)
Calculated Permeability Estimates:

- Log Average: 3.3 mD
- Log Standard Deviation: 7.2 mD
- Log Maximum: 5500 mD

Measured Core Average: 65 mD

\[ y = 1.8715e^{0.4967x} \]
Single Reservoir Analysis:

- Temperature at depth for all fields
- Select one field as proxy
- Stimulation potential
- Induced Seismicity Risk
### Stress Data

<table>
<thead>
<tr>
<th></th>
<th>Stress at 3 km depth</th>
<th>Orientation at Quackenbush Hill</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{H,\text{max}} (\sigma_1)$</td>
<td>85 ± 4 MPa</td>
<td>N71°E ±15°</td>
</tr>
<tr>
<td>$S_{H,\text{min}} (\sigma_3)$</td>
<td>55 ± 3 MPa</td>
<td>N161°E ±15°</td>
</tr>
<tr>
<td>$S_V (\sigma_2)$</td>
<td>65 MPa</td>
<td>vertical</td>
</tr>
</tbody>
</table>
First hydrosheared fractures oriented oblique to trend of grabens
\[
\frac{\tau}{\sigma_n} = 0.08
\]

\[
\mu = 0.85
\]

0.08 \ll 0.85

Low Risk
Basin-Scale Analysis
Methods

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

\[
\frac{Q}{\Delta P} = \frac{2\pi kH f_a}{\mu} \left(\frac{L}{MPa\ s}\right)
\]

\( k \) = permeability

\( H \) = reservoir thickness

\( f_a \) = area factor

\( \mu \) = water viscosity

**Porous media approximation**
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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