PennState
College of Earth
and Mineral Sciences

John and Willie Leone Family
Department of Energy and
Mineral Engineering

Analysis of Injectivity and Storage Capacity in Pennsylvania's Oriskany Formation

Vincent Bucciarelli

EME Summer Research Internship Program 2021

INTRODUCTION

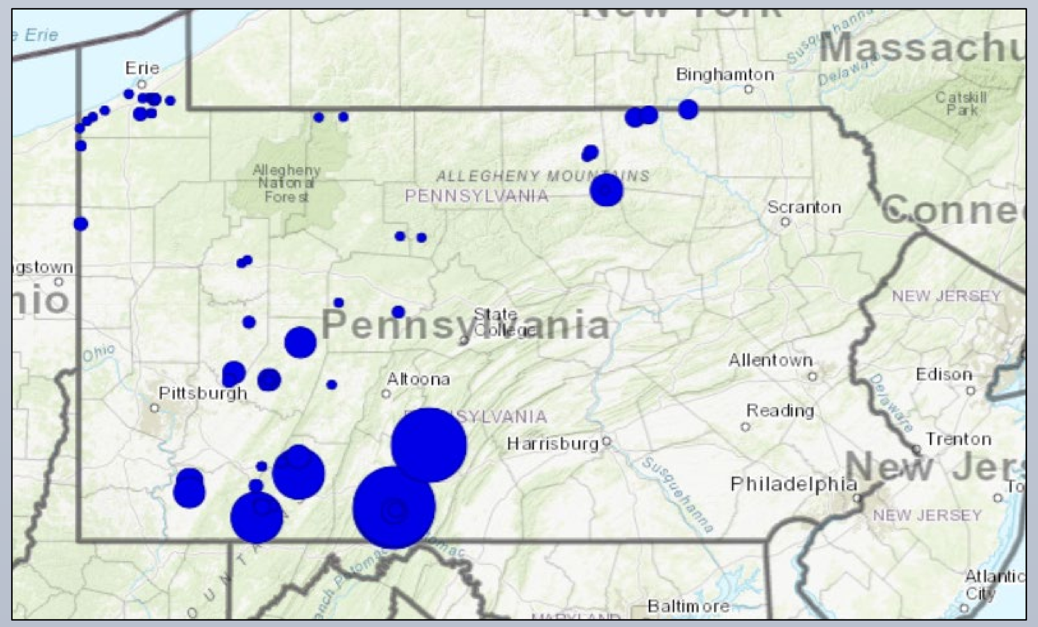
When considering topics of growing importance in the energy industry, mitigating climate change with carbon sequestration or the underground storage of hydrogen and methane may come to mind. Of the underground options for gas storage, depleted reservoirs are sometimes favored for their existing production data and widespread availability. Of these existing reservoirs, the Oriskany shows promise as a proven and prolific producer and unit of storage of natural gas for 80 years. In this study, the injectivity and storage capacity of 64 Oriskany wells in Pennsylvania are analyzed. Attention is given to the importance of gas storage in the supercritical phase as well as how the varying underground temperature and pressure conditions are conducive to the phase requirements.

OBJECTIVE

This study aims to investigate the storage capacity and injectivity of wells in Pennsylvania that targeted or target an Oriskany formation. Utilizing the chemical properties of methane, carbon dioxide, and dihydrogen, the temperature and pressure conditions of the Oriskany, and the existing production data, an illustration of optimal Oriskany storage and injectivity emerges.

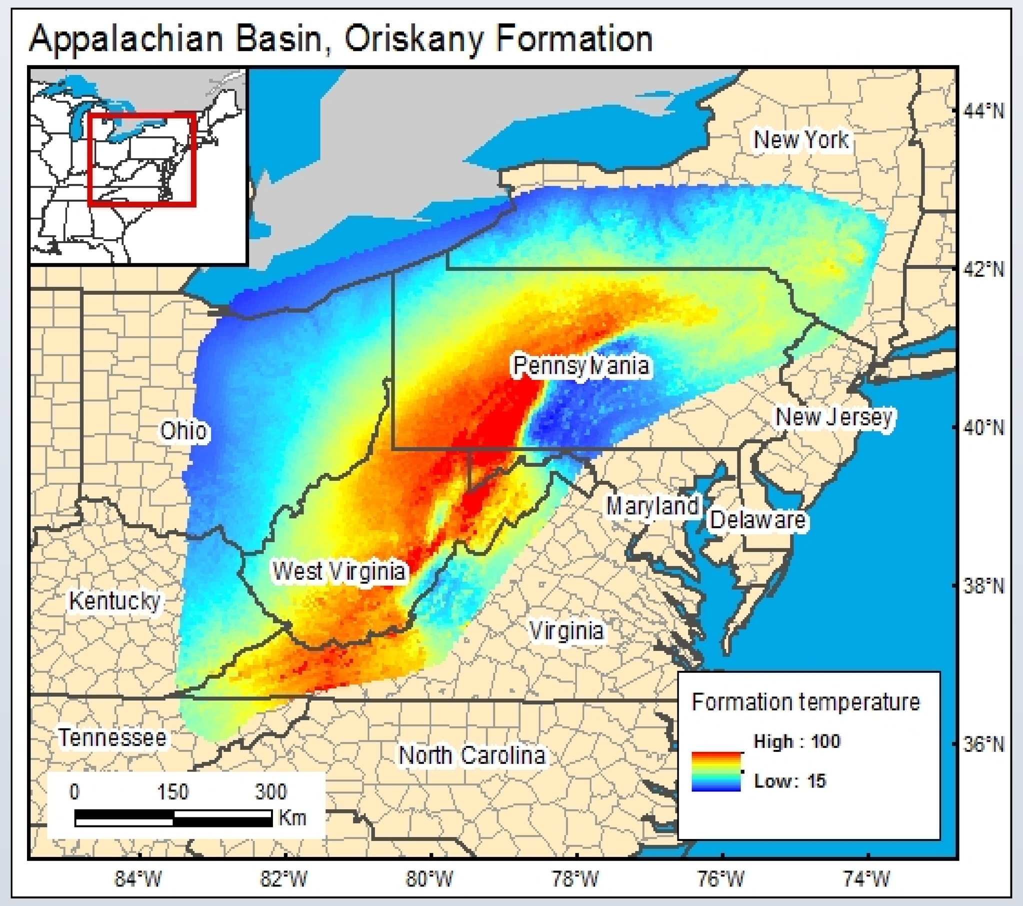
MATERIALS & METHODS

To conduct research, Enverus was used to collect data on 64 wells matching the description of an Oriskany reservoir in Pennsylvania. The reservoirs included in this study are the Blair Oriskany (2), Oriskany (3), Oriskany sandstone (52), unconventional Oriskany sandstone (1), and Roaring Run Oriskany (6). Below is a map of Pennsylvania with blue dots of varying sizes representing the wells and their cumulative gas production. The largest dot represents 5,660 Bcf while the smallest dot approaches 1 Mcf.



MATERIALS & METHODS

Below is a map showing the temperature range in degrees Fahrenheit of the Oriskany. This map is significant as it illustrates in red and orange a zone conducive to supercritical phase storage of all three gases listed earlier. The limiting factor of this type of storage is with carbon dioxide's temperature requirement of 88°F, thus confining the zone to the colors correlating to near 100 °F.

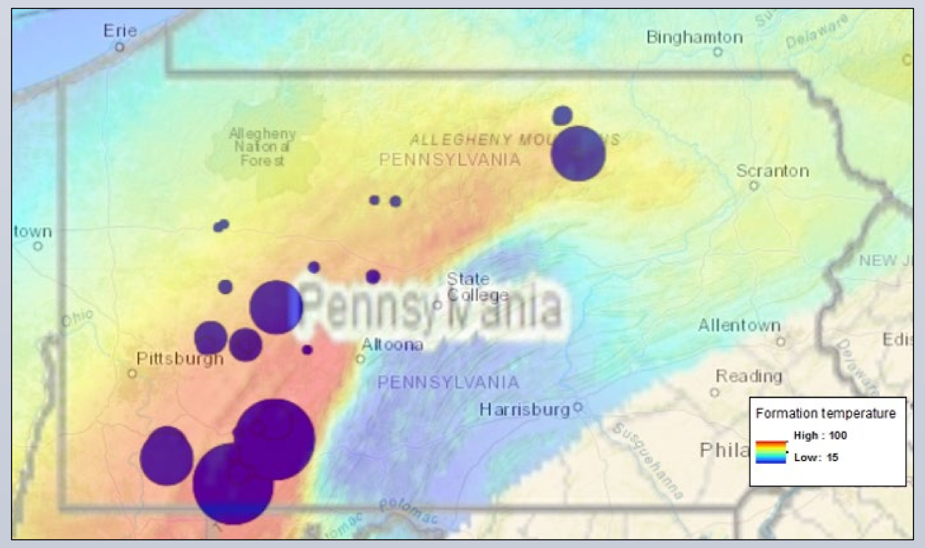


The temperature map and cumulative gas map are overlaid, and 37 of the 64 wells are selected as conducive to supercritical storage of the three gases. Although the gas produced is a good estimate for the storage capacity of methane, the storage capacity of carbon dioxide and dihydrogen must be calculated.

As the reported cum. gas values are standardized volumes, all three gas volumes are assumed equal at standard conditions. Multiplying by each gas's respective density at standard conditions will yield a storage capacity for a well in a unit of weight; final weight values for the reservoirs are reported in tons.

The energy value for dihydrogen is calculated using the gross heating value for the gas; one pound is approximately 61,084 BTU. Dihydrogen's value is calculated by assuming one kilogram of the gas is a dollar in value. This estimate comes from the DOE's plan to reduce the cost of clean hydrogen in the next decade.

The storage value of carbon dioxide is calculated using an industry estimate of one ton of the gas being stored for $60.



The graph above shows the wells conducive to supercritical phase gas storage. It is observed that the lower left of Pennsylvania yields many viable targets for injection as supported by high formation temperatures and large storage capacities. This trend continues diagonally through the state and closes with a few wells near the border that contain billions of cubic feet of storage capacity between them. Not only does this map reveal where viable storage sites already exist, but it implies the existence of and allows interpolation on where potential storage sites are in-between the dots.

RESULTS

The table below illustrates the ten wells with the most potential as storers of gas. Peak gas is highlighted in orange as a rate and illustrates the injectivity potential of the wells. Weights and volumes remain green and outline the storage capacity of different gases in the wells. Currency values in gold show the value of the reservoir with maximum hydrogen stored and the value of the reservoir when storing maximum amounts of carbon dioxide. This injectivity and storage data can help determine the viability of injecting into these wells when compared to the costs and amounts associated with the cases being considered.

Well	Peak Gas (Mcf/day)	Cum. Gas (Bcf)	H2 Weight (Ton)	CO2 Weight (Ton)	CO2 Storage Value ($)	GWh of H2	H2 Value ($)
1	3,010	1,947	5,462	120,329	7,219,730	196	4,955,224
2	2,158	1,932	5,420	119,404	7,164,211	194	4,917,119
3	1,203	1,140	3,198	70,455	4,227,317	115	2,901,397
4	625	1,119	3,140	69,170	4,150,172	112	2,848,449
5	799	1,097	3,077	67,780	4,066,796	110	2,791,224
6	1,047	881	2,472	54,456	3,267,337	89	2,242,520
7	163	727	2,041	44,961	2,697,683	73	1,851,541
8	393	662	1,857	40,917	2,455,039	67	1,685,004
9	638	641	1,798	39,612	2,376,744	64	1,631,266
10	558	456	1,279	28,184	1,691,057	46	1,160,648

CONCLUSIONS

The Oriskany is a proven and prolific producer and unit of storage in Pennsylvania, and the depleted reservoirs of this formation are ready to serve as vessels for mitigating climate change and adding infrastructure to the storage and movement of gases. The most efficient way to store gases such as carbon dioxide is in the supercritical state, but this requires certain temperature and pressure conditions. The Oriskany's conditions are checked with the supercritical phase requirements of three gases to determine areas that are optimal for storage. This area is overlaid with relevant production data of Oriskany wells to yield a map that illustrates the zones in Pennsylvania with the most potential for storing gas in the Oriskany

Calculations using the production data supplement this graph and provide a strong foundation for understanding the quantities and prices associated with storing gases in Pennsylvania's Oriskany formation.

REFERENCES

- Henderson, F.D. "Producing the Oriskany in Southwestern Pennsylvania." Paper presented at the SPE Eastern Regional Meeting, Lexington, Kentucky, October 1991. doi: https://doi.org/10.2118/23430-MS
- "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *The Basics of Underground Natural Gas Storage - U.S. Energy Information Administration*, EIA, 16 Nov. 2015, www.eia.gov/naturalgas/storage/basics/.
- Azretovna Abukova, Leyla , Nabievich Zakirov, Sumbat , Pavlovich Anikeev, Daniil , and Ernest Sumbatovich Zakirov. "Formation of an Effective Hydrogen Storage in an Aquifer and Control of its Parameters." Paper presented at the SPE Russian Petroleum Technology Conference, Virtual, October 2020. doi: https://doi-org.ezaccess.libraries.psu.edu/10.2118/201999-MS
- Schmelz William J., Hochman Gal and Miller Kenneth G. 2020Total cost of carbon capture and storage implemented at a regional scale: northeastern and midwestern United StatesInterface Focus.1020190065 20190065 http://doi.org/10.1098/rsfs.2019.0065
- Ciampoli, Paul. "Department of Energy Seeks to Cut Cost of Hydrogen by 80%." *Department of Energy Seeks to Cut Cost of Hydrogen by 80% | American Public Power Association*, APPA, 8 June 2021, www.publicpower.org/periodical/article/department-energy-seeks-cut-cost-hydrogen-80.
- Engineering ToolBox, (2005). *Fuel Gases Heating Values*. [online] Available at: https://www.engineeringtoolbox.com/heating-values-fuel-gases-d_823.html.
- "Oriskany Formation, Appalachian Basin (01)." *Bureau of Economic Geology*, GCCC, 2021, www.beg.utexas.edu/gccc/co2-data/oriskany-01.

ACKNOWLEDGEMENTS

Dr. Wang, Dr. Alexis, and Dr. Kleit assisted continuously in the process of doing research and