Defining CO_2 Storage Options in the Upper Ohio River Valley: Advanced Characterization of Geologic Reservoirs and Caprocks

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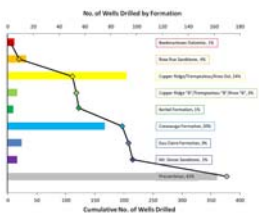
INTRODUCTION

As part of a collaborative effort to assess potential CO_2 storage targets in the Midwestern U.S., reservoir analysis and regional-scale CO_2 storage resource estimation has been conducted in the eastern Ohio sub-basin of the Appalachian Basin region to facilitate identification, mapping, and resource quantification of the potential reservoir and caprocks in the Cambrian-Ordovician sequence. A comprehensive geologic database has been built using existing well logs and other petrophysical core and formation top data. This database is updated as needed and is used concurrently with injection well test and operational data (2008-2015) available for more than 50 wells in the sub-basin. Geologic data have been analyzed using petrophysical and statistical techniques to help build a regional geologic model study area in eastern Ohio. Log, core, seismic line, and injection operational data indicate a stacked Cambrian-Ordovician storage complex in the eastern Ohio sub-basin may be a viable option for long-term, commercial-scale CO_2 storage in the region.

METHODOLOGY

Data Collection and Database Assembly

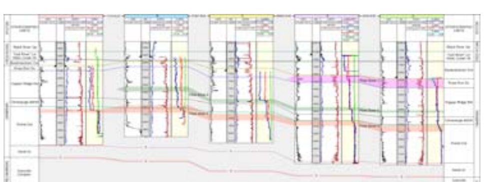
- In-house compilation and evaluation of well data, including log and core data
- Assessment of previous research: Appalachian Basin depositional setting and geologic evolution
- Review of previous seismic work and existing seismic data available



Above: Wells Drilled, by Formation, in Publicly available Databases with Study Area

Above: Seismic data coverage in eastern Ohio used in regional geologic assessment. Blue and Green lines highlight purchased lines (>350 mi.)

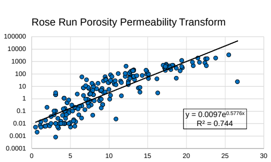
- Additional data collection facilitated by collaboration with local well operators, including; basic and advanced logs, production/injection logging, injection tests, and operational data
- Comprehensive dataset enhances understanding of regional geologic setting, and can help provide key constraints on local-scale assessments



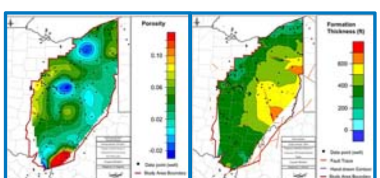
Above: West-to-east log cross-section showing three major brine intake zones identified from spinner test data.

Regional Mapping of Geologic Reservoir and Caprock

- Maps of key petrophysical properties such as porosity and thickness were generated from well log data



Above: Plot of core-measured porosity and permeability data for the Rose Run sandstone.



Porosity Map Rome Formation | Thickness Map Rome Formation

Above: Rome porosity map without faults (left) and isopach map with faults (right). Wells data points shown as black dots, fault traces are shown as bright orange lines, and study area is outlined in red.

- Porosity-Permeability transforms were calculated from core data for modeling input

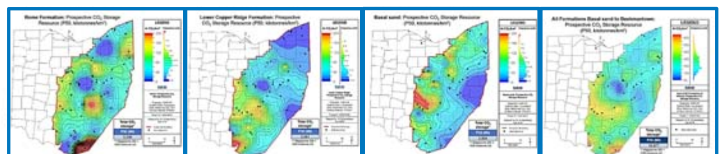
RESULTS

Reservoir Feasibility Assessment

- Static volumetric storage resource estimation from NETL/DOE CO2-SCREEN calculation tool for the potential storage formations of interest
- Key inputs: reservoir thickness, porosity, temperature, pressure

Formation	Total Area (km^2)	Avg. Thickness (m)	Avg. Porosity (%)	Avg. Depth (m)	Avg. CO_2 Density (kg/m^3)	Avg. T (°C)	Avg. P (MPa)
Beekmantown	32,470	92	4	2,194	799	53	23
Rose Run	41,031	34	3	2,122	804	52	23
Upper Copper Ridge	61,236	63	2	1,910	796	48	20
Copper Ridge B	61,236	27	2	1,974	800	49	21
Lower Copper Ridge	61,236	72	5	2,000	800	49	21
Kerbel Sandstone	37,781	10	6	1,665	799	43	18
Conasauga	61,236	27	2	2,079	799	51	22
Rome	61,236	130	4	2,106	799	51	22
Basal Sandstone	61,236	40	7	2,236	804	54	24

Above: Average formation properties calculated from the heterogeneous dataset imported into CO2- SCREEN.



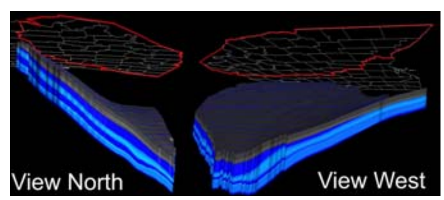
Rome Formation P50 Prospective Resource (5,556 Mt) | Lower Copper Ridge Formation P50 Prospective Resource (3,561 Mt) | Basal sand Formation P50 Prospective Resource (3,904 Mt) | All Reservoirs in Study P50 Prospective Resource (19,877 Mt)

Above: CO_2 Storage Resource maps for selected formations and compilation of formations. Regional trends for both sandstones and dolomites show the highest resource estimates are in central and southern central Ohio.

Formation	Mt CO2 /km3 Pore Volume			Total Prospective CO2 Storage Resource (Mt)					ESaline Depositional Environment (CO2-SCREEN; IEAGHG, 2009)
	P10	P50	P90	P10	P50	P90	Theoretical Max.	Esaline P50 (avg.)	
Beekmantown	5	18	43	652	2,137	5,227	97,207	2.20%	Dolomite: Unspecified
Rose Run	5	20	61	188	757	2,305	30,320	2.50%	Clastics: Peritidal
Upper Copper Ridge	5	18	42	436	1,462	3,498	66,236	2.21%	Dolomite: Unspecified
Copper Ridge B	5	18	42	205	674	1,634	30,776	2.19%	Dolomite: Unspecified
Lower Copper Ridge	5	17	42	1,090	3,561	8,637	163,846	2.17%	Dolomite: Unspecified
Kerbel Sandstone	6	22	63	134	505	1,464	18,610	2.71%	Clastics: Delta
Conasauga	5	17	42	393	1,321	3,194	29,480	4.48%	Dolomite: Unspecified
Rome	5	18	42	1,639	5,556	13,281	250,824	2.22%	Dolomite: Unspecified
Basal Sandstone	6	24	70	990	3,904	11,348	130,915	2.98%	Clastics: Shallow Shelf

Left: Results of heterogeneous CO_2 resource estimation simulations. Formations with highest resource estimates are Rome, Basal sand, and Lower Copper Ridge. The total resource estimate for the study area is 19,877 Mt.

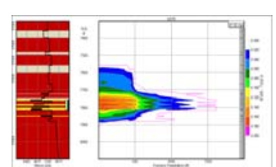
- Regional structural model based on geologic data, regional maps, and available seismic data
- Local scale assessments at sites of interest
- Dynamic modeling of CO_2 scenarios at local scale



Above: Static Earth Model (SEM) structural framework in Eastern Ohio showing laterally extensive caprocks (gray) and reservoirs (blue).

Caprock Feasibility Assessment

- Analysis of image and acoustic log data concurrently with core data for determination of mechanical properties
- Static and dynamic modeling of geo-mechanical caprock behavior
- Fracture analysis and modeling of behavior



Above: STIMPLAN 2-D Model Example for Fracture Mapping Model

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