CO_2 Geologic Storage Opportunities in the MRCI Region

Mark Kelley, Stuart Skopec, Sanjay Mawalkar, Priya Ravi Ganesh, Amber Conner, Derrick James, John Hershberger, Aubrey Collie, Neeraj Gupta (Battelle); MRCI Geoteam[a]

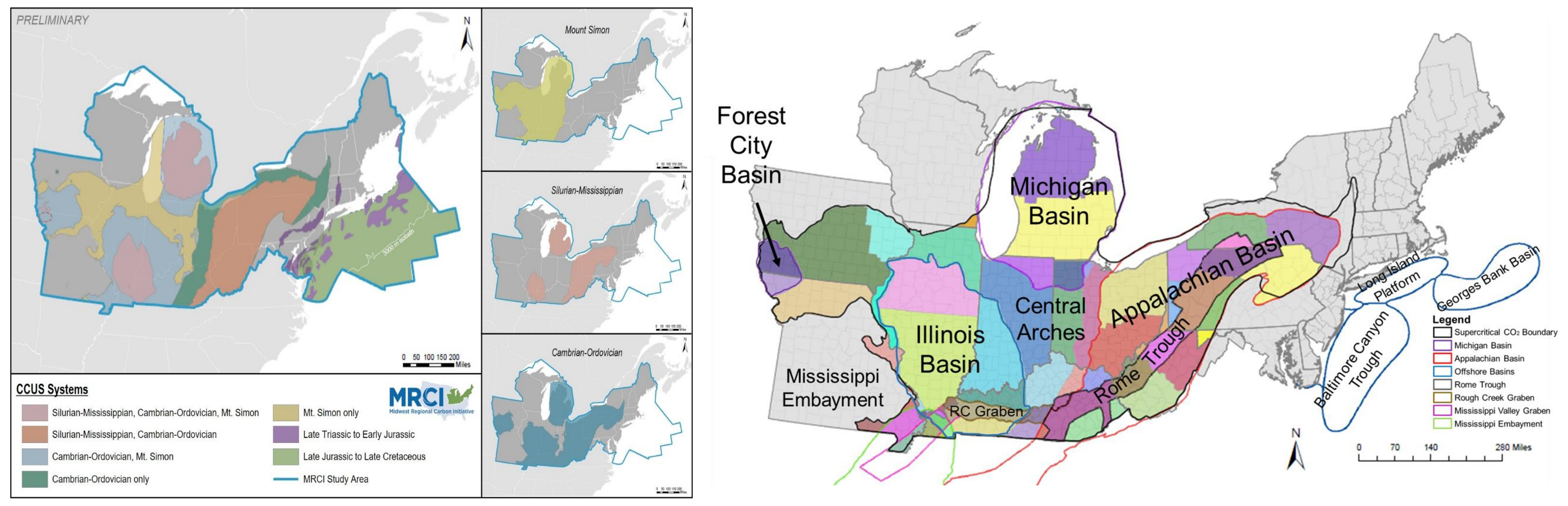
a. MRCI Geoteam: Jessica Moore, Sue Pool, Eric Lewis, Phil Dinterman (West Va. Geol. Survey); Steve Greb, Tom Sparks, Seth Carpenter (Kentucky Geological Survey); Jim McDonald, Michael Solis (Ohio Geol. Survey); William Harrison, Autumn Haagsma (Michigan Geological Repository for Research and Education); Ken Miller, John Schmelz (Rutgers Univ.); Kristin Carter, Robyn Anthony, Katherine Schmid, Michele Cooney (Pennsylvania Geol. Survey); Ashley Douds, Valerie Beckham-Feller (Indiana Geol. Survey); Ryan Clark (Iowa Geo. Survey); Charles Bopp (Illinois State Geol. Survey)

Abstract

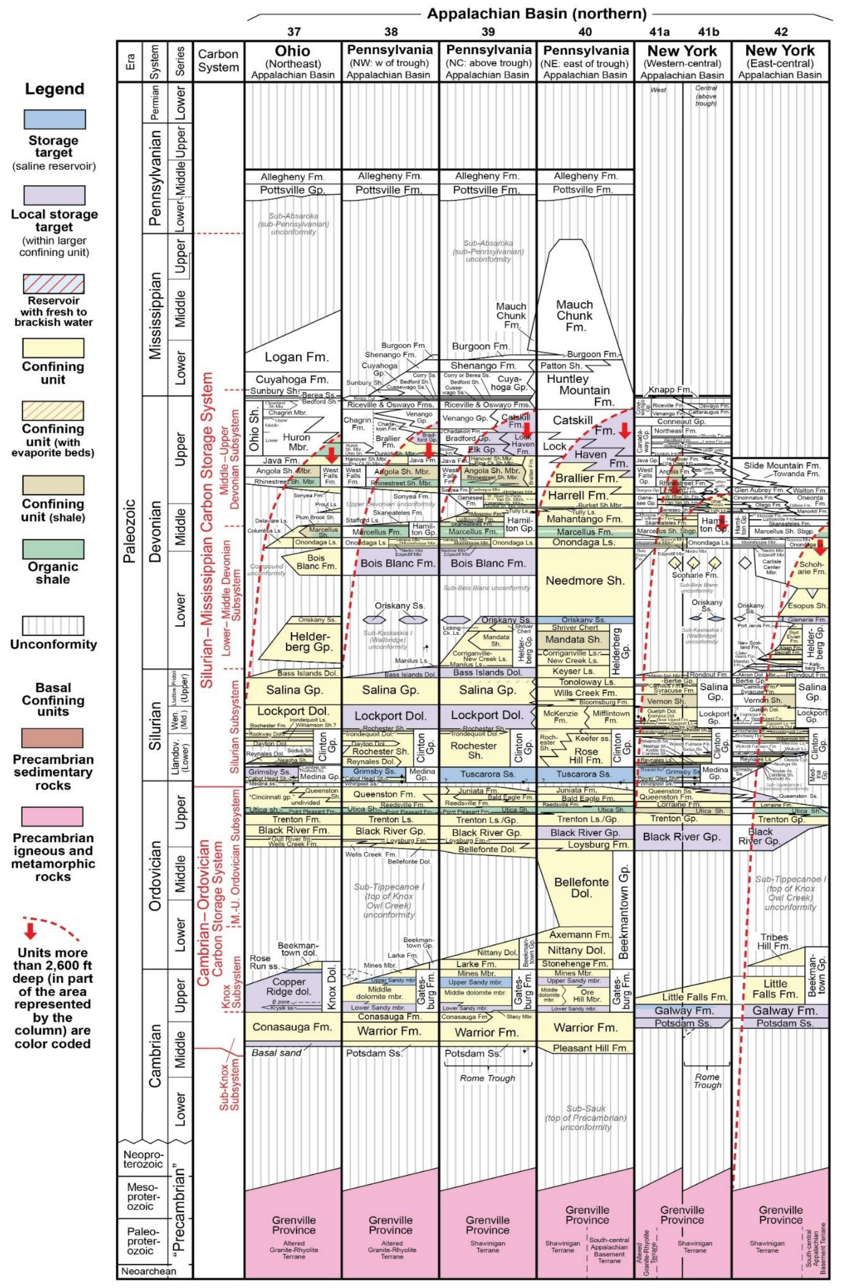
One of the key objectives of the Midwest Regional Carbon Initiative (MRCI) is to develop tools and information to accelerate the deployment of carbon capture, utilization, and storage (CCUS) in the Midwest-Northeast United States, a 20-state region with much of the country's carbon dioxide (CO_2) emissions. One of the major needs of project developers is easily accessible geologic information to efficiently identify, evaluate, select, and permit a CO_2 storage site. This project is conducting multiple activities to help address this need, including:

- Identifying distinct geologic sub-regions within the MRCI Region and inventorying and labeling potential reservoirs and seals within each sub-region; and grouping sub-regions into carbon storage (CS) systems;
- Compiling previously made and generating new geologic maps that define the depth, structure, and thickness of reservoirs in each CS system in an ARC GIS;
- Conducting numerical CO_2 injection modeling for selected CS systems to evaluate their viability for hosting a commercial-sale ($\geq$1 MMT/yr for 30 yrs), including estimating the number of injection wells, Area of Review (CO_2 plume area and pressure-impacted area), and pressure requirements to achieve the target injection rate.

Defining Carbon Storage Systems



The interior basins and arches part of the MRCI region (in which the Precambrian surface is > 2,600 ft below ground surface), is divided into 48 subregions (colored areas on the map on the right based on geologic structures and geography; there are 4 additional subregions in the Mid-Atlantic offshore area.

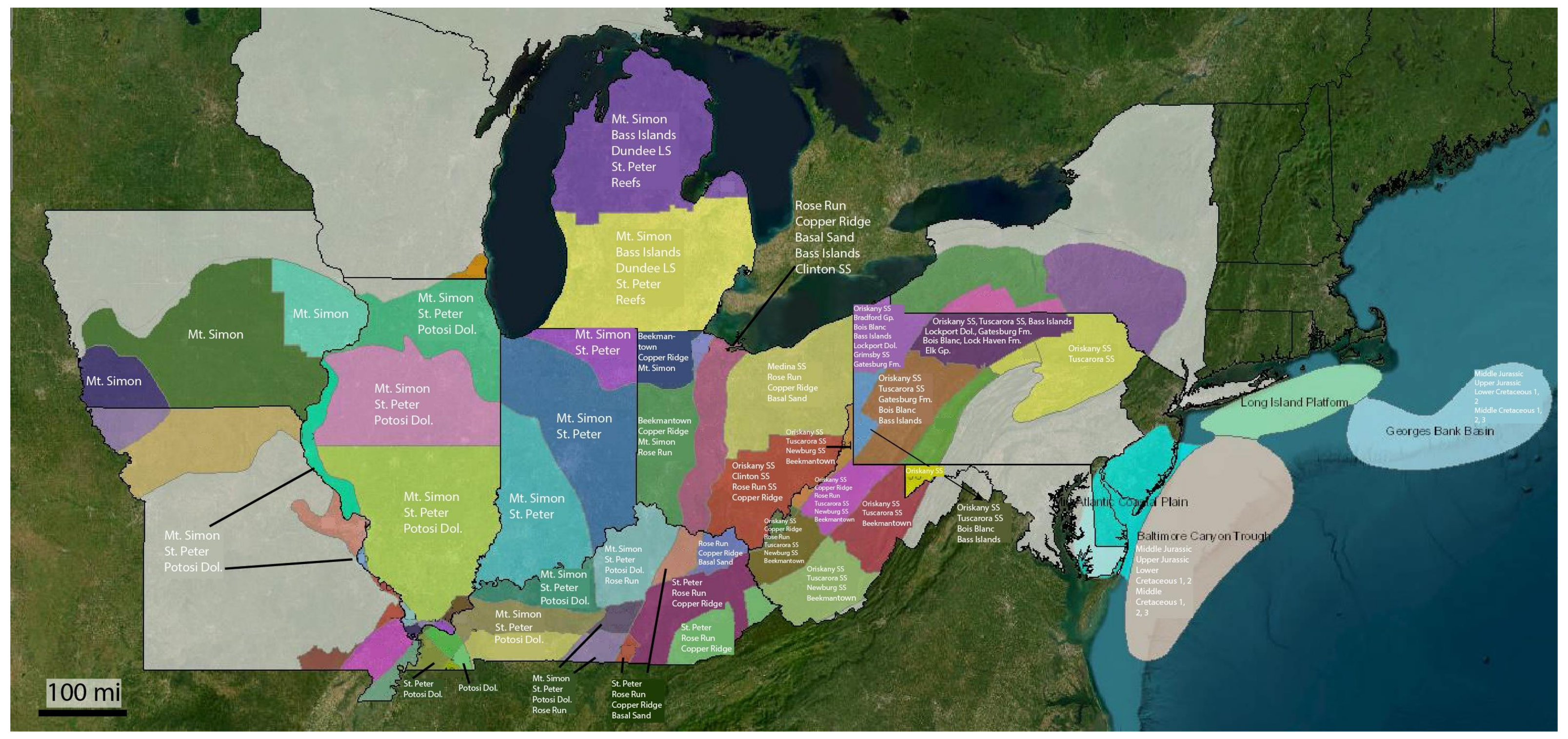


Each of the 48 interior and 4 off-shore subregions is represented by a unique stratigraphic column. The stratigraphic columns identify the formations within each subregion and their suitability as a CO_2 storage reservoir or a seal.

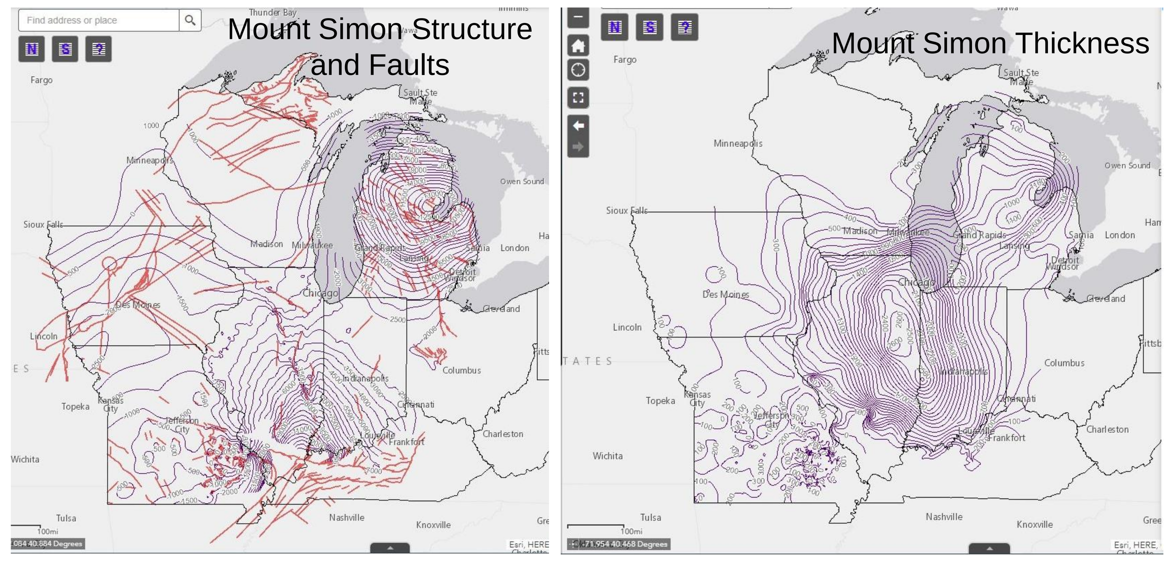
(left) Example stratigraphic columns for subregions in the Northern Appalachian Basin showing all formations shallower and deeper than 2,600 ft (red-dashed line) corresponding to supercritical CO_2, and color coded relative to their function for carbon storage (storage target, confining unit, etc.).

The geology of the MRCI region consists of distinct packages of sedimentary rocks that can be grouped by age and characterized by function.

Maps Database and Data Inventory



Across the 20-state MRCI region, there are 28 key formations that are potential storage targets. Many of these formations occur in more than one subregion. The map above identifies the key storage formations within each of the 48 subregions and the off-shore area.

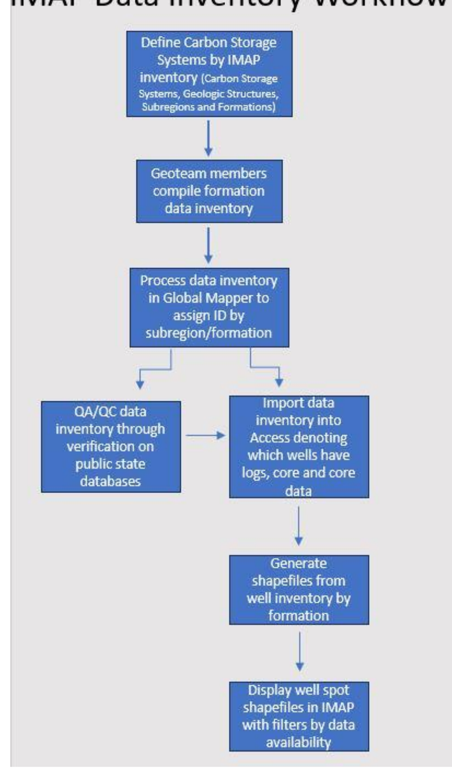


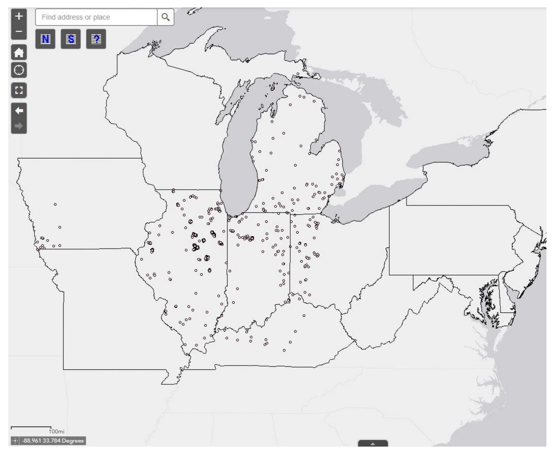
Example maps in ArcGIS

Available geologic maps from previous projects and studies were compiled into an ARC GIS. Map types include formation depth, structure, and thickness.

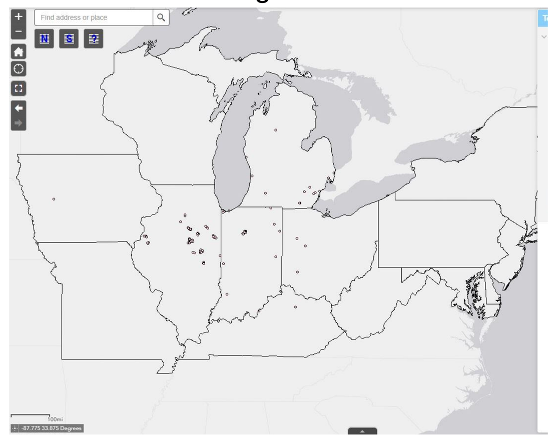
MRCI Carbon System Interactive Map Applications (wvnet.edu)

IMAP Data Inventory Workflow





Mount Simon Wells with geophysical logs



Mount Simon Wells with Core Data

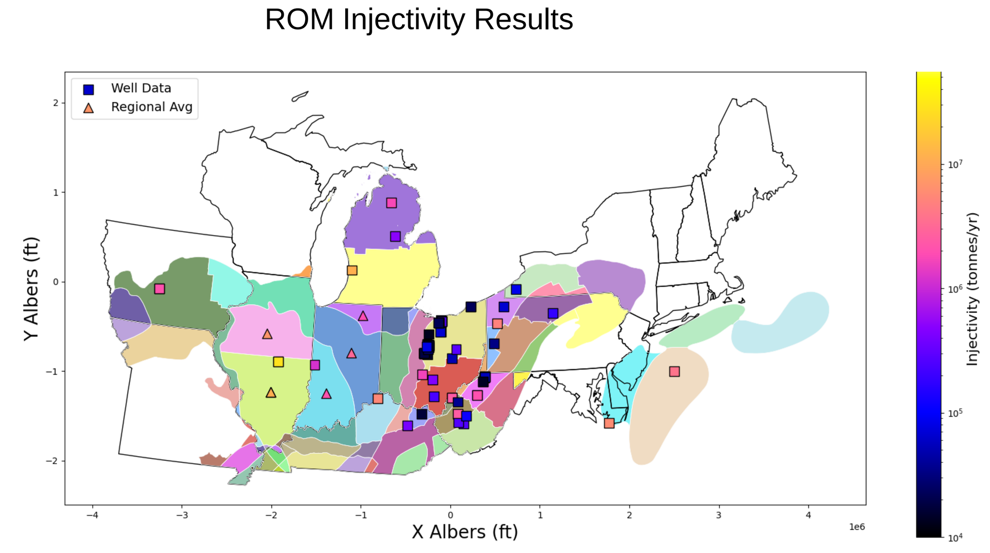
Key storage formations with well data

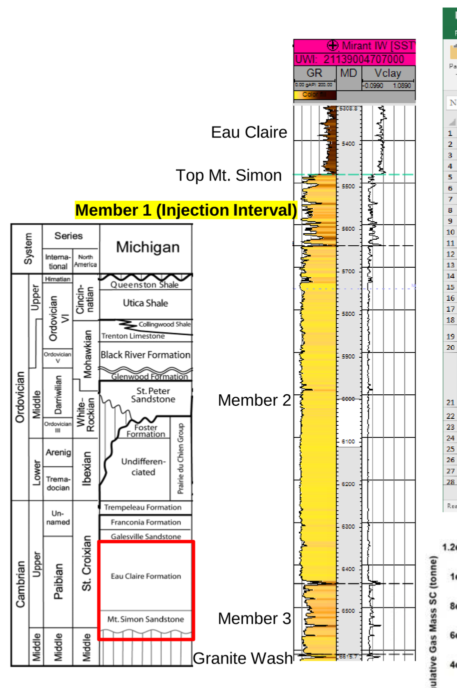
Formation	Count of Wells	Wells with Logs	Wells with Core Analysis
Basal Sand	186	184	3
Bass Islands	1,891	1,889	1
Beekmantown Dol.	36	32	1
Bois Blanc	1,481	1,481	
Bradford Gp.	4	4	
Clinton SS	1,983	1,982	1
Copper Ridge Dol.	2,306	2,233	18
Dundee LS	284	284	11
Elk Gp.	6	6	
Gatesburg Fm.	100	100	
Grimsby SS	5,179	5,179	
Lock Haven Fm.	22	22	
Lockport Dol.	4,389	4,389	
Lower Cretaceous 1	44	40	5
Lower Cretaceous 2	44	39	7
Medina SS	3,633	3,633	1
Middle Cretaceous 1	44	40	
Middle Cretaceous 2	44	40	3
Middle Cretaceous 3	44	40	1
Middle Jurassic	44	31	
Mt. Simon SS	1,360	1,116	143
Oriskany SS	8,105	6,868	6
Potosi Dol.	1,004	851	3
Rose Run SS	2,431	2,347	18
Salina Gp.	271	271	3
St. Peter SS	8,282	3,500	222
Tuscarora SS	249	201	2
Upper Jurassic	44	40	12
Total	43,510	36,842	461

CO_2 Injectivity Evaluation

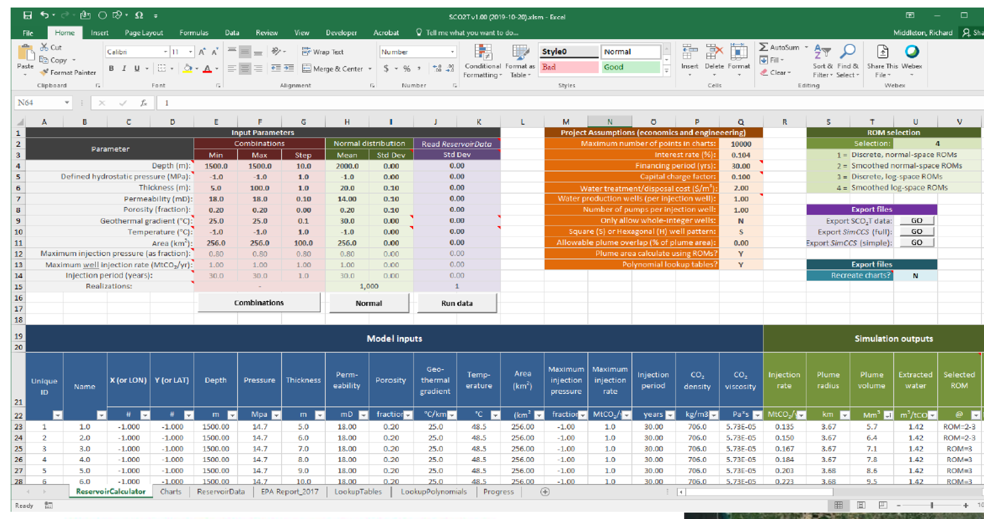
- The feasibility of injecting commercial-scale quantities of CO_2 ($\geq$1 MMT for 30 years) was investigated for different geologic formations across the MRCI region.
- Two approaches were used: 1) a reduced order model (ROM) that was trained to synthetic data from a 3D numerical flow model and 2) site-scale 3D numerical flow models for individual sites.
- Injectivity of different formations can be compared on the basis of number of injection wells and Area of Review (CO_2 plume area and pressure-impacted area) required to accommodate the target injection rate/quantity of CO_2.

ROM Injectivity Results

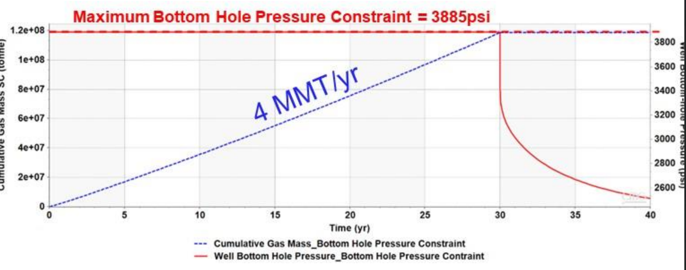


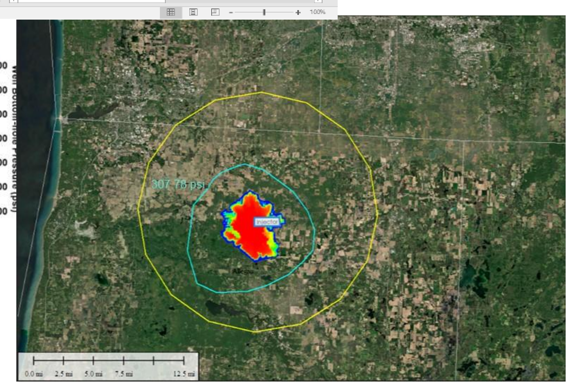


CO2 injection potential in the Mount Simon Formation in SW Michigan

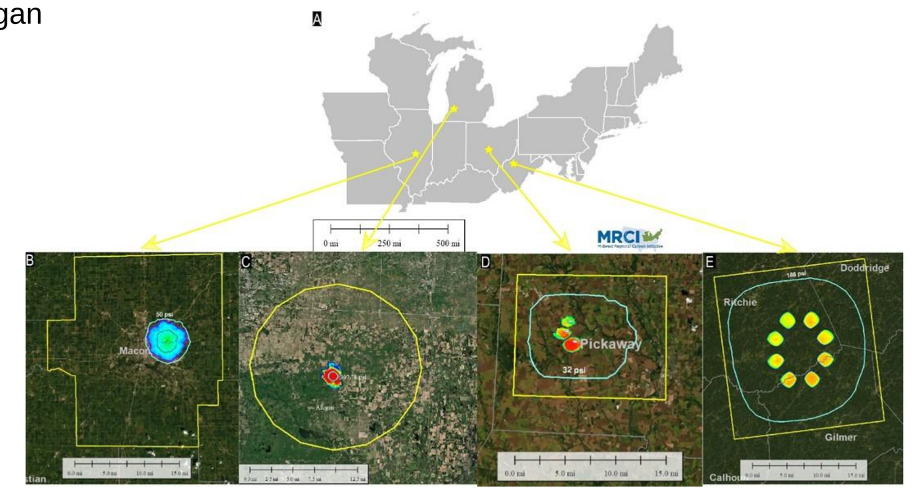


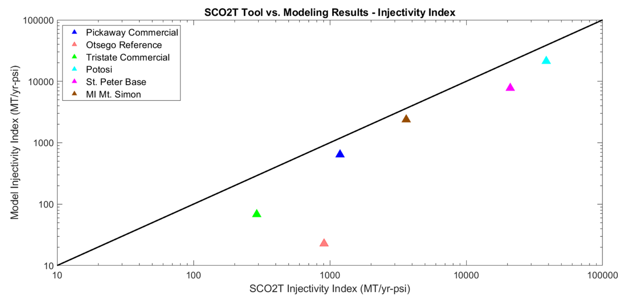
ROM inputs/outputs





Results of site-specific numerical model to predict CO_2 plume size and pressure affected area in Mount Simon Formation in SW Michigan.





(left) Comparison of modeled CO_2 Plumes and Pressure-Based Area of Review (AOR) for Commercial-Scale Injection Target (1 million tonnes/yr); (right) comparison of ROM injectivity and numerical model injectivity.

Summary

Numerous geologic formations that are candidates for CO_2 storage are present throughout the 20-state MRCI region. To assist developers of CO_2 future geologic storage sites, basic information about the formations such as depth, structure and thickness is needed. Moreover, geologic properties that control injectivity (e.g., porosity and permeability) are needed so that operators can determine the number and spacing of CO_2 injection and monitoring wells. In this study, geologic maps were compiled for these potential storage reservoirs and available geophysical logs and core data were inventoried. These maps and the inventory of available logs and core data were integrated into an ARC GIS tool that will be available to the public at the conclusion of this project.

The injectivity of the geologic storage formations was evaluated with two methods: a Reduced Order Model (ROM) and site-scale 3D numerical models. Injectivity was found to vary over a large range across the MRCI region. The Mount Simon and Potosi Formations have highest injectivity (tonnes/yr), each requiring only one well to meet the injection target of 1 million metric tonnes/yr for 30 yrs; whereas the Oriskany Formation has the required 8 injection wells to meet the injection target. The Mount Simon site in SW Michigan is capable of receiving 4 MMT/yr for 30 yrs, which may be sufficient for a hub-scale CO_2 storage site.

Acknowledgements - The primary funding for the MRCI program is from the US Department of Energy's National Energy Technology Laboratory (NETL) under DOE project number DE-FE 0031836 with Mrs. Dawn Deel as the DOE project manager. A number of industry sponsors and technical team members from state geological surveys and universities support MRCI through technical collaboration as well as cash and in-kind contributions. Please www.midwestccus.org for details.