## PSSeal Capacity of Upper Ordovician Units in the Midwest Region: A Quantitative Approach Using Mercury Injection Capillary Pressure\*

Cristian R. Medina<sup>1,2</sup>, Maria Mastalerz<sup>1</sup>, Richard W. Lahann<sup>1</sup>, and John A Rupp<sup>3</sup>

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#### **Abstract**

The Midwest's subsurface exhibits a series of potential reservoirs for geologic carbon sequestration opportunities, including depleted oil and gas fields and deep saline aquifer systems. The Upper Ordovician contains many low-permeability units that could serve as regional caprocks to prevent the upward, density-driven migration of supercritical carbon dioxide injected into the units underlying them. These include the Maquoketa Group and equivalent units, which consist of thick and heterogeneous sequences of carbonates, silts, and clay-rich rock units. This heterogeneity results in distinctive sealing potential that, in addition to geomechanical factors, are controlled by the capillary entry pressure and permeability associated to the identified lithologic character.

This work uses mercury porosimetry analyses applied to samples from a four-state region (Indiana, Kentucky, Ohio, and Pennsylvania). Mercury injection capillary pressure analysis reveals insightful information about porosity, permeability, pore size distribution, and capillary entry pressure of these samples. This information, combined, allows the quantification of the seal potential of the sequence under study. In addition to Upper Ordovician samples, we analyzed samples from other stratigraphic intervals composed of carbonates and mudstones that will shed light on the effects of lithology on the sealing potential of these units.

Results of these evaluations indicate that, assuming 20% pore brine displacement by supercritical CO<sub>2</sub>, the Upper Ordovician sequences can prevent upward flow from a maximum CO<sub>2</sub>-column up to 1,500 m. Other units with similar sealing potential that were also evaluated include the Nolichucky Shale and Eau Claire Formation (Upper Cambrian), and the Cincinnati Group, Juniata Formation, Reedsville Shale, and Utica Shale (Upper Ordovician).

In conclusion, quantification of the seal capacity of widely distributed units revealed that there is a high potential for safe geologic CO<sub>2</sub> storage, but local-scale evaluations at targeted injection sites should be performed to verify our regional-scale results.

<sup>\*</sup>Adapted from poster presentation given at 2019 AAPG 48th Annual AAPG Eastern Section Meeting, Columbus, Ohio, October 12-16, 2019

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### **INTRODUCTION**

The Midwest's subsurface exhibits a series of potential reservoirs for geologic carbon sequestration opportunities. The Upper Ordovician contains many low-permeability units that could serve as regional caprocks to prevent the upward, density-driven migration of supercritical carbon dioxide injected into the units underlying them. These include the Maquoketa Group and equivalent units, which consist of thick and heterogeneous sequences of carbonates, silts, and clay-rich rock units.

### **METHOD**

Mercury Injection Capillary Pressure (MICP). The samples are from a four-state region (Indiana, Kentucky, Ohio, and Pennsylvania).

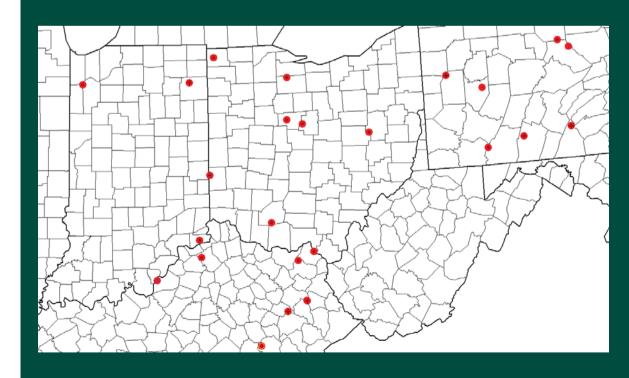
# The Seal Capacity Evaluation of the

Upper Ordovician Units results in

High Potential for Safe Geologic CO<sub>2</sub>

Storage in the Midwest Region.

Other units with similar sealing potential that were also evaluated include the Nolichucky Shale and Eau Claire Formation (Upper Cambrian), and the Cincinnati Group, Juniata Formation, Reedsville Shale, and Utica Shale (Upper Ordovician).



SYSTEM	SERIES	Michigan	Indiana	Ohio	Kentucky	Pennsylvania	SERIES	SYSTEM
SILU- RIAN	LO- WER	Cataract Gp	Brassfield Sexton Ls Creek Ls	Cabot Head Fm Brassfield Fm	Brassfield Fm Crab Orchard Fm	Rose Hill Sh Medina Gp Tuscarora Ss	Low Silur	1000000
ORDOVICIAN	UPPER	Queenston Sh  Utica Sh  Collingwood Sh.  Trenton Fm	Maquoketa Gp  Trenton Lexington	Queenston Sh  Cincinnati Gp  Utica Sh  Point Pleasant Fm  Trenton Ls  Lexington Ls	U. Cincinnatian Series  Clays Ferry Kope Fm Fm	Queenston Sh Juniata Fm  Reedsville Sh  Utica Sh Antes Fm  Trenton Gp	UPPER	
		Black River Fm	Black River Gp	Black River Gp	Lexington Ls High Bridge Gp	Black River Gp		
	JE	Glenwood Fm	St. Peter Ss Ancell Gp	Wells Creek Fm St. Peter ss	St. Peter Ss Wells Creek Fm	Loysburg Fm		IAN
	LOWER	St. Peter Ss	A transfer for transfer a law at the street and a district			Wells Creek Fm up up bellefonte Fm Axeman d D uwo G D	MIDDLE	ORDOVICIAN
		Foster Fm (Undifferentiated)	Prairie Du Chien Gp Knox Super- group	Beekmantown dol	Beekmantown Dol Q XO	Fm Nittany Fm Nittany Fm Stone-Engle Fm Parke henge	LOWER	
CAMBRIAN	UPPER	Franconia Fm Galesville Ss Eau Claire Fm	Potosi Dol  Franconia Fm Ironton 5s Galesville Ss  Eau Claire Fm  Potosi Dol  Galesville Ss  Galesville Ss  Galesville Ss  Galesville Ss		Rose Run ss  Copper Ridge dol  Eau Claire Fm  Conasauga Gp	Mines Mbr Upper Sandy Mbr Middle Dol Ore Hill Mbr Lower Sandy Mbr Stacy Mbr	UPPER	CAMBRIAN
	MIDDLE	Mt. Simon Ss	Mt. Simon Ss	basalss  Mt. Simon Ss	MC SIMON SS	Pots-dam Ss Pleasant Hill Fm	MIDDE LOWER	CA

Mercury injection capillary pressure analysis reveals insightful information about porosity, permeability, pore size distribution, and capillary

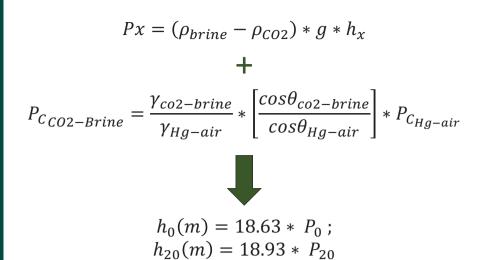
entry pressure of these samples. This information allows the quantification of the seal potential of the sequence under study.

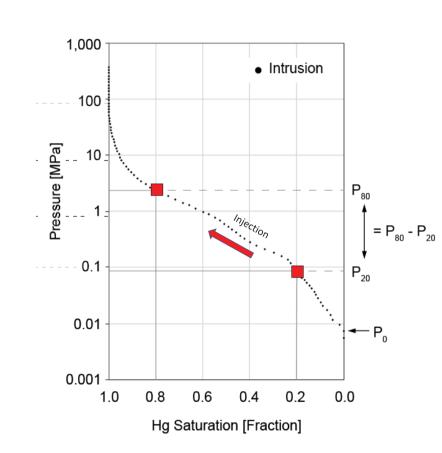




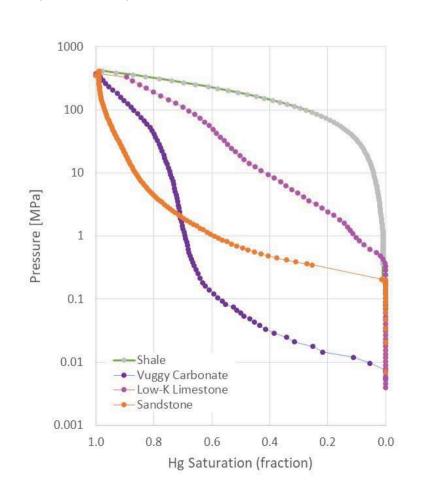
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## Theory





Capillary pressure curve indicating entry pressure ( $P_0$ ) and pressure at 20% and 80% of mercury saturation ( $P_{20}$  and  $P_{80}$ , respectively).



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### RESULTS: CO<sub>2</sub>-Gas Column

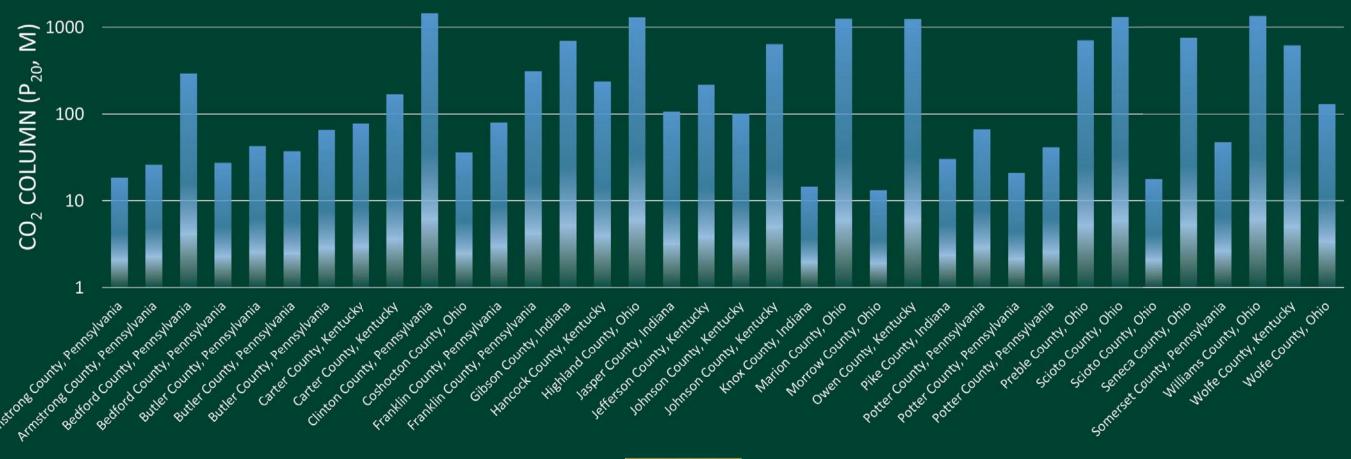
- Assuming 20% pore brine displacement by supercritical CO<sub>2</sub>, the Upper Ordovician sequences can prevent upward flow from a maximum CO<sub>2</sub>column up to 1,500 m.
- Other units with similar sealing potential that were also evaluated include the Nolichucky Shale and Eau Claire Formation (Upper Cambrian), and the Cincinnati Group, Juniata Formation, Reedsville Shale, and Utica Shale (Upper Ordovician).

### **DISCUSSION**

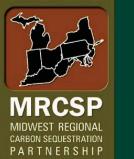
- Local-scale evaluations at targeted injection sites should be performed to verify our results.
- Shale content from GR can be used to establish a relationship or correlation with MICO results (work in progress).

Assuming 20% of pore brine displacement by supercritical CO<sub>2</sub>, the Upper Ordovician sequences can prevent upward flow from a maximum CO<sub>2</sub> column up to 1,500 m.

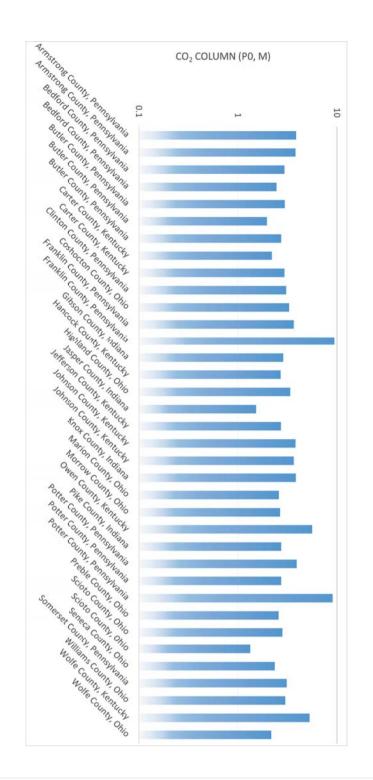


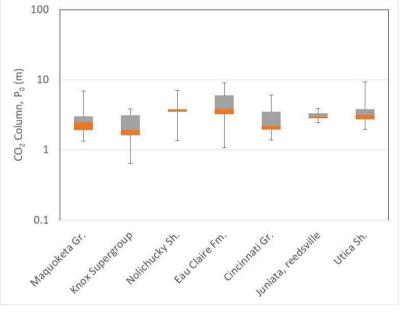


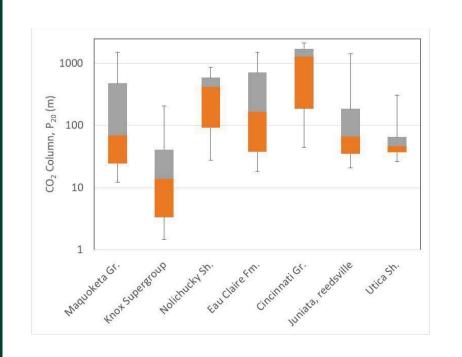












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