[PS]Seal Capacity of Upper Ordovician Units in the Midwest Region: A Quantitative Approach Using Mercury Injection Capillary Pressure*

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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_2, the Upper Ordovician sequences can prevent upward flow from a maximum CO_2-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_2 storage, but local-scale evaluations at targeted injection sites should be performed to verify our regional-scale results.

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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).

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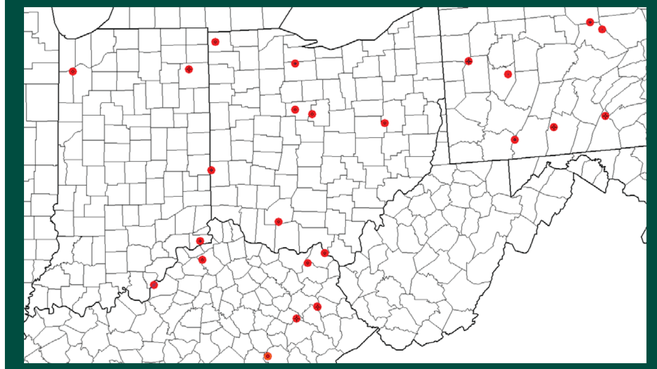
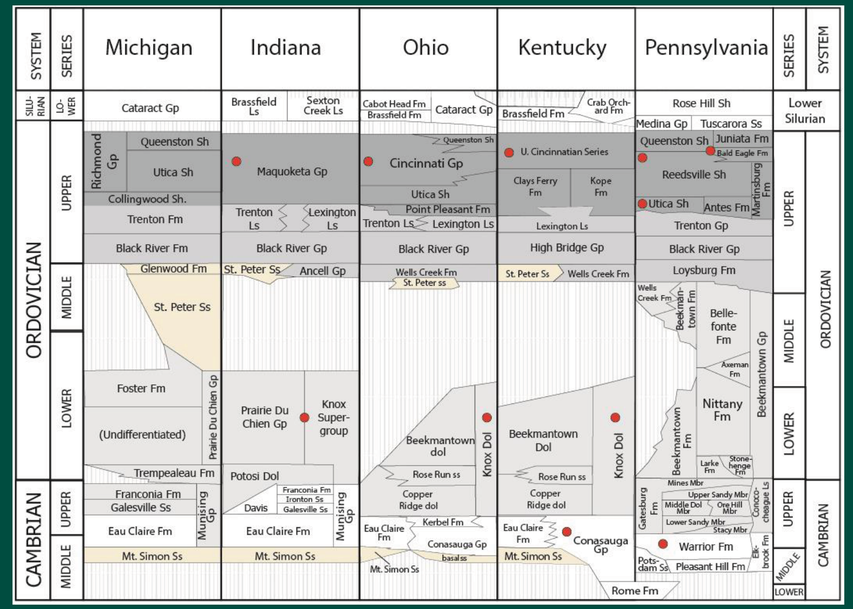
The Seal Capacity Evaluation of the Upper Ordovician Units results in High Potential for Safe Geologic CO_2 Storage in the Midwest Region.

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).





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.

Take a picture to download the poster (pdf)

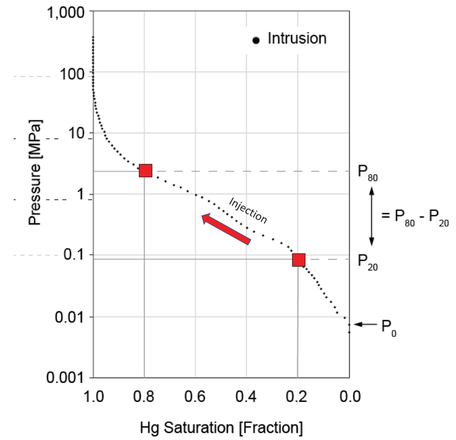
Theory

$$Px = (\rho_{brine} - \rho_{CO2}) * g * h_x$$

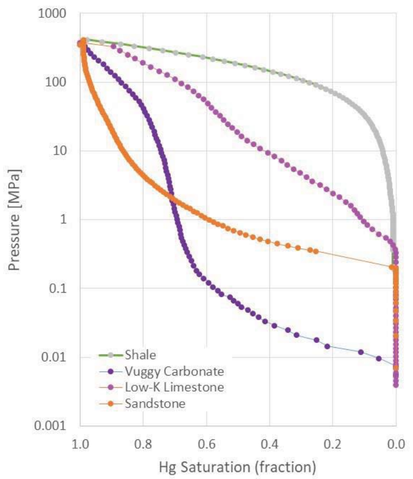
$$+$$

$$P_{C_{CO2-Brine}} = \frac{\gamma_{co2-brine}}{\gamma_{Hg-air}} * \left[\frac{cos\theta_{co2-brine}}{cos\theta_{Hg-air}}\right] * P_{C_{Hg-air}}$$

$$h_0(m) = 18.63 * P_0 ;$$
$$h_{20}(m) = 18.93 * P_{20}$$



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_2-Gas Column

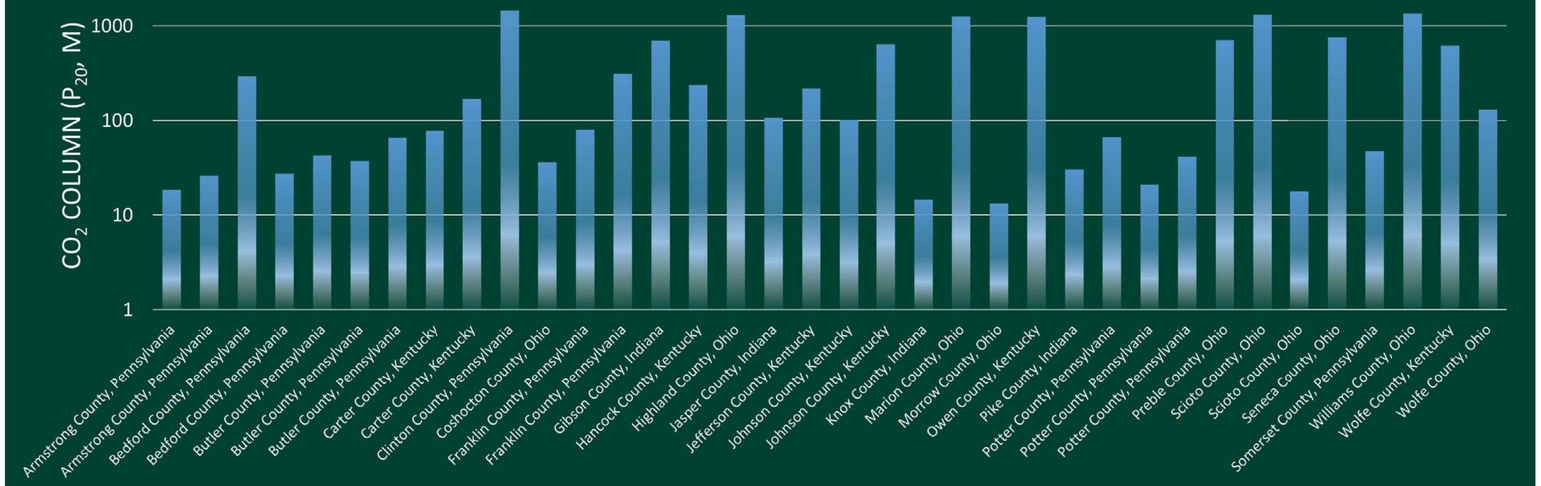
- Assuming 20% pore brine displacement by supercritical CO_2, the Upper Ordovician sequences can prevent upward flow from a maximum CO_2-column up to 1,500 m.
- Other units with similar sealing potential that were also evaluated include the Nolichucky Shale and Eau Claire Formation (Upper Cambrian), and the Cincinnati Group, Juniata Formation, Reedsville Shale, and Utica Shale (Upper Ordovician).

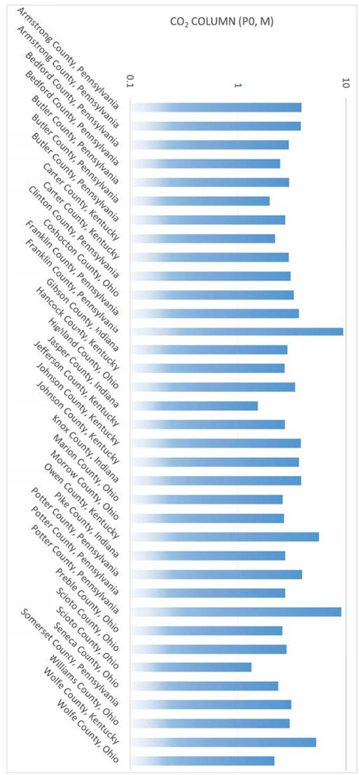
DISCUSSION

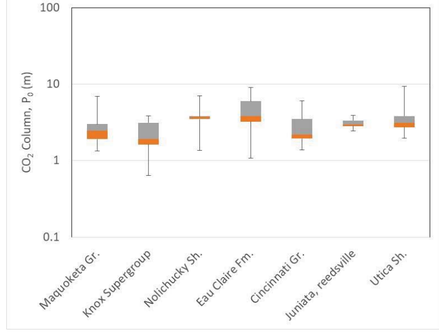
- Local-scale evaluations at targeted injection sites should be performed to verify our results.
- Shale content from GR can be used to establish a relationship or correlation with MICO results (work in progress).

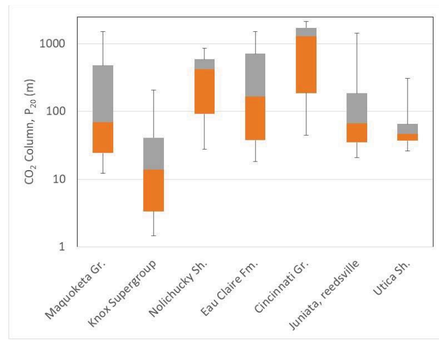
Assuming 20% of pore brine displacement by supercritical CO_2, the Upper Ordovician sequences can prevent upward flow from a maximum CO_2 column up to 1,500 m.

Calculated CO_2-gas column (in meters) using P_{20} as value of capillary pressure.









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