Abstract

Porosity and permeability values collected from core analysis in the Upper Cambrian Mount Simon sandstone indicate a predictable relationship with depth owing to analogous changes in the pore structure. This porosity relationship is useful for evaluating the geologic carbon sequestration capacity in the midwest region. Regional porosity log data for the study area and subsurface geophysical logs indicate that the porosity of the reservoir is described by the function $\phi = 1.96 \times 10^{-10} e^{-0.00012d}$, where $d$ is the depth in feet. The correlation between local depth and porosity can help predict the petrophysical characteristics of the Mount Simon sandstone, and thereby inform the design of an onshore CO2 storage project. The data also suggests that porosity and permeability decrease exponentially with increasing depth in the Mount Simon sandstone. The decrease in porosity with depth is more pronounced than the decrease in permeability (figure 8). Log-derived porosity will be used to estimate permeability and reduce this uncertainty at the deepest part of the basin. Future studies will incorporate facies characterization to investigate the role that lithology plays in reservoir quality.

Previous Studies

Studies on the relationship of porosity and facies suggest that porosity generally decreases with depth. Most of the porosity observed in the Mount Simon sandstone in the Illinois Basin is bioturbated. The standard deviation of porosity measurements is often several percentage points. However, studies indicate that the decline in porosity with depth is not directly dependent on the porosity of the underlying units. Bowersox (2008) reported a maximum porosity of 26% at 7,000 ft depth. The study area was limited to sediments that include subsurface reservoir data, and therefore, the porosity measurements were not made in the Mount Simon sandstone. To address this limitation, we used a regression analysis to determine the porosity relationship with depth.

Thickncess and Net Porosity Foot Distribution

The integrated porosity and permeability data were used to estimate the amount of CO2 that could be sequestered in the Mount Simon sandstone (figure 4). A new function was determined to estimate the volume of CO2 that could be sequestered in the reservoir (figure 8). The function of the reservoir porosity (calculated geophysical logs, figure 4) was interpolated into the model (the horizontal displacement of injected fluids from buoyancy forces and the horizontal displacement of CO2 within the reservoir. Vertical continuity of high-porosity zones will also impact the performance of the geologic disposal of CO2. The results suggest that at depths greater than 7,000 ft, porosity decreases exponentially to values below 5%. Similarly, core analyses from 828 samples taken in the study area provide additional sources of petrophysical data. The regional trend of porosity with depth is described by the function $\phi = 1.96 \times 10^{-10} e^{-0.00012d}$, where $d$ is the depth in feet. In the Illinois Basin, porosity generally decreases exponentially with increasing depth in the Mount Simon sandstone. For example, in the study area, we observed a reversal in the porosity/depth relationship. Coarse-grained interbeds that were less porous are located in the upper part of the basin where the porosity/depth relationship is more pronounced than in the lower part of the basin. Therefore, a high degree of uncertainty remains. Log-derived porosity will be used to estimate permeability and reduce this uncertainty at the deepest part of the basin. Future studies will incorporate facies characterization to investigate the role that lithology plays in reservoir quality.

Conclusions

1. Previous studies agree that at depths lower than 7,500 ft, porosity decreases exponentially to less than 7%. Therefore, areas below this depth may not be suitable as CO2 storage sites.

2. We have not established the reservoir pressure-depth relationship for the Mount Simon sandstone. In the study area, we observed a reversal in the porosity/depth relationship. Coarse-grained interbeds that were less porous are located in the upper part of the basin where the porosity/depth relationship is more pronounced than in the lower part of the basin. Therefore, a high degree of uncertainty remains. Log-derived porosity will be used to estimate permeability and reduce this uncertainty at the deepest part of the basin. Future studies will incorporate facies characterization to investigate the role that lithology plays in reservoir quality.

References


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