

Spatial Variability of Injectivity and Storage Capacity in a Geologically Complex Sequestration Target: The Devonian Sylvania Sandstone, Michigan Basin USA

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The Devonian Bois Blanc and Sylvania Sandstone formations are prospective, saline reservoir geological sequestration (GS) targets in the central Michigan Basin, USA. Reservoir quality in the Sylvania is well documented by extensive brine mining since the late 19th century. The Bois Blanc and Sylvania are overlain by confining layers of the Devonian Amherstburg and Lucas formations and this GS system is present throughout a region with high CO₂ emissions (>~20 Mmt/year), making it an important target for large scale GS feasibility investigations. Previous estimates of regional geological sequestration capacity (RGSC) have substantial uncertainty due to stratigraphic/lithologic complexity in these units. In order to reduce RGSC uncertainty, a detailed stratigraphic and petrophysical study of 5 cored wells, 50 conventional core analyses, and 115 modern well logs was undertaken. These studies indicate that reservoir heterogeneity is primarily due to lateral and vertical lithofacies variations amongst siliceous, shallow shelf carbonates of the Bois Blanc lithofacies and interfingering, reworked, aeolian quartzose littoral sandstone of the Sylvania lithofacies. Core to wire-line log calibration using gamma ray, density, neutron porosity, and photoelectric effect logs provides confident discrimination amongst tripolitic chert, sandstone, and carbonate lithofacies.

Isolith maps and cross sections indicate that Sylvania Sandstone lithofacies dominate in southeast Lower Michigan and are transitional to mixed sandstone, tripolitic chert, and carbonates towards the northwest and are replaced completely by tripolitic chert and carbonates lithofacies in northwestern Lower Michigan. Core analysis indicates that sandstone lithofacies have moderate to good porosity (\emptyset) and high permeability (K) and are excellent injection targets. Tripolitic chert lithofacies have high \emptyset and low to moderate K and questionable injection potential. All other lithofacies have low \emptyset and K. Substantial regional variation in the thickness of sandstone lithofacies may further limit sites suitable for CO₂ injection. Detailed reservoir characterization studies indicate approximately 730 million metric tons of RGSC in the Sylvania Sandstone in central Lower Michigan. Reservoir characterization studies are focused not only on RGSC but also on the identification of regional reservoir compartments and risks associated with over-pressuring during large-scale deployment of regional CO₂ injection wells.