Geological Controls on Geological Carbon Storage Capacity, Efficiency, and Security in the Middle Devonian Sylvania-Bois Blanc Saline Aquifer, Central Lower Michigan, USA

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The Middle Devonian Sylvania Sandstone is a proven brine reservoir in the Michigan basin, USA. Preliminary study of the Sylvania by the US DOE-NETL Regional Carbon Sequestration Partnership Program estimated as much as 1.5 to 3.8 billion metric tons (GT) of Geological Carbon Storage (GCS) capacity. The objectives of this study are to evaluate the geological controls on reservoir properties and more confidently assess regional storage capacity, efficiency, and security in this lithologically and stratigraphically complex saline aquifer target.

Quantitative petrophysical analysis of the Sylvania–Bois Blanc sequestration system from 355 modern wire-line log suites and conventional core analysis data from 53 wells indicate saline aquifer reservoir facies are present in a complex lithofacies assemblage including sandstone, dolomite to dolomitic limestone, chert and tripolotic chert to cherty carbonates in a southeast to northwest trending “fairway” in central Lower Michigan. Little conventional core sample material for unequivocal calibration of reservoir properties to wire-line log facies has been available for this study to date although an important set of samples was recently acquired.

Diverse lithofacies in the Sylvania-Bois Blanc may have been deposited in a SW to NE oriented mixed clastics and carbonate sabhka to off-shore marine ramp environment. Quartz sand was derived by long shore transport from a source to the southeast of the present distribution of the Sylvania and Bois Blanc formations in the Michigan basin. Chert and tripolotic chert are more common in the northwest, while sandstone dominated lithofacies are more common to the southeast. Dolomitic carbonate and cherty dolomitic carbonate dominate to the east and northeast in more open marine portions of the basin.

Three, distinctive, end member reservoir facies are identified in the Sylvania-Bois Blanc interval: 1) moderate porosity - moderate to high permeability sandstone, with good injectivity potential, 2) high porosity – moderate to high permeability sandy-grainy-sucrosic and dolomitic carbonate with very good injectivity potential, and 3) very high porosity – generally low to moderate permeability, calcareous to tripolotic chert with low to moderate injectivity potential but high potential storage efficiency and storage security. Complex stratigraphic and lateral facies transitions indicate short spatial scale variation in reservoir properties and the presence of internal confining layers. Depending on assumptions of injectivity and storage efficiency, regional GCS capacity estimates calculated in this study range from a conservative estimate of 1.85 GT to over 7 GT. Consideration of complex reservoir facies architecture and distinctive petrophysical properties of prospective reservoir facies could result in higher GCS capacity estimates and significant enhancement of storage efficiency and security due to enhanced capillary entrapment in the Sylvania-Bois Blanc zone.