Assessing the Potential Reservoirs and Seals of the Cambro-Ordovician Knox Group in the Illinois Basin for CO_2 Sequestration

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Introduction

Carbon sequestration is becoming an important strategy worldwide for continued utilization of fossil fuel to meet the world's energy demand. Among various methods for carbon sequestration, injection in deep saline formations appears to provide the safest method for storing a large volume of CO_2. Porosity, permeability, thickness, the lateral extent, the depth of reservoir rocks, and the presence of multiple impermeable seals are among the factors that control the feasibility of CO_2 sequestration in deep saline formations. To determine lateral and vertical lithologic variations of the rocks within the Knox Group that could serve as reservoirs or seals for CO_2 storage, 11 deep wells from the Illinois Basin were examined in detail.

Well cuttings and available cores, geophysical logs, and samples from exposures in west-central Missouri were studied in detail. The Missouri outcrop samples were examined and compared with rocks encountered in the Illinois subsurface. A north-south cross section was prepared extending from Stephenson County in northwestern Illinois to Gallatin County in southern Illinois. The results showed that the Knox Group in the Illinois Basin and adjacent Midwestern regions may be an attractive target for CO_2 sequestration because these rocks are 1) laterally extensive, 2) consist of some porous and permeable dolomite and sandstone intervals, and 3) contain abundant impermeable shale and carbonate seals. The rocks of the Knox Group, because of their thickness (up to 6,000 feet), widespread occurrence, and depth (more than 10,000 feet) in the deeper part of the basin, can provide a significant reservoir for CO_2 storage. Furthermore, the porous rocks of the Knox Group can capture CO_2 that may leak from the underlying Mt. Simon Sandstone, currently a major target reservoir for CO_2 sequestration in the U.S. Midcontinent.

Conclusions

The siliciclastic intervals in the southward-thickening Knox Group become thinner or change to mainly carbonate-dominated intervals southward. The Everton Dolomite pinches out in Weaber-Horn No. 1, Fayette County. Although it is a dolomite unit in its type locality in Missouri, the Everton is a dense fossiliferous lime mudstone to wackestone with echinoderm and brachiopod fragments in the wells studied in this investigation. The Shakopee and Oneota Dolomites generally consist of dense fine to medium crystalline dolomite containing oolitic chert nodules. The Jordan (facies equivalent of the Eminence Formation in northern Illinois), New Richmond, Gunter, and Galesville Sandstones are generally porous and attain a porosity of up to 20%. Both the Gunter and New Richmond Sandstones are absent in the southern half of Illinois. The Eminence Formation, Potosi Dolomite, and Franconia Formation are present in all wells; the Eminence and Franconia Formations are generally dense and change to sandy dolomite northward.

Except for the Potosi Dolomite, which in places consists of drusy quartz-bearing vugular dolomite, the carbonates of the Knox Group studied so far are generally tight and do not show visible intercrystalline porosity; thus, they may provide potential seals for CO_2 reservoirs. The shallow depth and lack of effective seals may exclude the Gunter and New Richmond Sandstones from CO_2 storage. Therefore, the Galesville Sandstone and the Potosi Dolomite within the Knox Group and the overlying St. Peter Sandstone have the greatest potential for CO_2 sequestration. However, the dense carbonate intervals of the Knox may be locally fractured, thus enhancing their potential for CO_2 storage. More work is needed to delineate the presence of any fractured permeable interval within the dense carbonates of the Knox Group.

Acknowledgments

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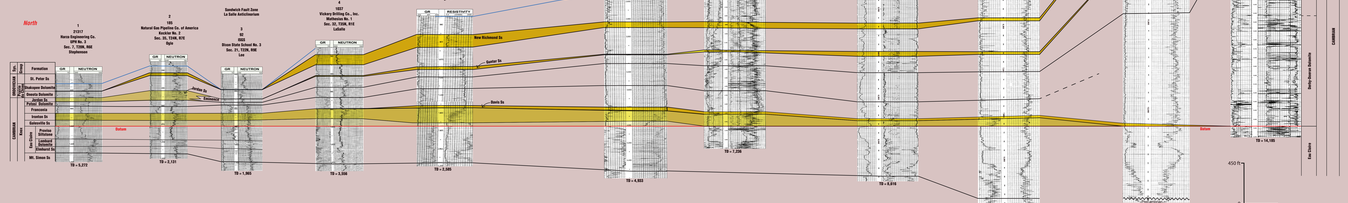
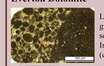


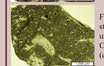
KNOX GROUP

ORDOVICIAN SYSTEM

Everton Dolomite

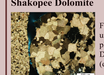


Lime mudstone capped by intraclastic grainstone facies under plain light; thin section photomicrograph from Texaco Inc., Johnson No. 1, Marion Co., IL (depth 5,570–5,580 ft).

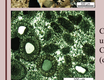


Fossiliferous lime mudstone to wackestone with echinoderm fragments under plain light from Texaco Inc., Cuppy No. 1, Hamilton Co., IL (depth 7,760–7,765 ft).

Shakopee Dolomite



Fine to coarsely crystalline dolomite under polarized light; thin section photomicrograph from Conoco Inc., Dyhrkopp No. 4-1, Gallatin Co., IL (depth 7,140–7,150 ft).



Chertified ooid intraclast grainstone under polarized light from Texaco Inc., Cuppy No. 1, Hamilton Co., IL (depth 8,500–8,505 ft).

New Richmond Sandstone

Fine- to medium-grained rounded quartz sandstone with fine to coarsely crystalline dolomite under polarized light; thin section photomicrograph from Northern Illinois Gas Co., Fordyce No. 1, Livingston Co., IL (depth 710–715 ft).

Fine- to medium-grained rounded quartz sandstone under polarized light; thin section photomicrograph from Vickery Drilling Co., Inc., Mathesius No. 1, LaSalle Co., IL (depth 285–290 ft).

Oneota Dolomite

Coarsely crystalline dolomite with relicts of oolites and crinoids under plain light; thin section photomicrograph from Humble Oil & Refining Co., Weaber-Horn Unit No. 1, Fayette Co., IL (depth 5,345–5,350 ft).

Thin section photomicrograph of zoned dolomite crystals in the medium to coarsely crystalline Oneota Dolomite under polarized light; road cut along Highway 5, MO.

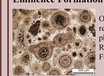
Gunter Sandstone

Thin section photomicrograph of fine- to medium-grained, well-rounded quartz arenite under polarized light; road cut along Highway 5, MO.

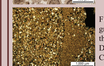
Fine- to medium-grained rounded sandstone under plain light; thin section photomicrograph from Northern Illinois Gas Co., Fordyce No. 1, Livingston Co., IL (depth 1,100–1,105 ft).

CAMBRIAN SYSTEM

Eminence Formation



Oolitic chert showing partial hematite replacement under plain light; thin section photomicrograph from Humble Oil & Refining Co., Weaber-Horn Unit No. 1, Fayette Co., IL (depth 5,690–5,695 ft).



Finely crystalline sandy dolomite and fine-grained sandstone under polarized light; thin section photomicrograph from Vickery Drilling Co., Inc., Mathesius No. 1, LaSalle Co., IL (depth 540–545 ft).

Potosi Dolomite

Hand sample of drusy quartz in the Potosi Dolomite. Junction of Highways 21 and 47, south of Potosi, MO.

Thin section photomicrograph of drusy quartz in a fine to coarsely crystalline dolomite under polarized light; Vickery Drilling Co., Inc., Mathesius No. 1, LaSalle Co., IL (depth 550–555 ft).

Franconia Formation

Sandy glauconitic, fine to medium crystalline dolomite under polarized light; thin section photomicrograph from Texaco Inc., Johnson No. 1, Marion Co., IL (depth 7,470–7,475 ft).

Sandy, fine to medium crystalline dolomite with relics of fossils and pellets under plain light; thin section photomicrograph from Peoples Gas Light & Coke Co., Lamb No. 1, DeWitt Co., IL (depth 3,744 ft).

Davis Sandstone

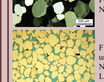
Glauconitic dolomitic sandstone under polarized light; thin section photomicrograph from Peoples Gas Light & Coke Co., Lamb No. 1, DeWitt Co., IL (depth 3,821 ft).

Ironton Sandstone

Fine- to medium-grained quartz sandstone with dolomitic cement under polarized light; thin section photomicrograph from Vickery Drilling Co., Inc., Mathesius No. 1, LaSalle Co., IL (depth 810–815 ft).

Galesville Sandstone

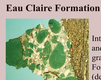
Medium- to fine-grained quartz sandstone with dolomitic cement under polarized light; thin section photomicrograph from Peoples Gas Light & Coke Co., Lamb No. 1, DeWitt Co., IL (depth 3,971 ft).



Fine-grained porous quartz sandstone under plain light; photomicrograph from Northern Illinois Gas Co., Fordyce No. 1, Livingston Co., IL (depth 1,710–1,715 ft).

Knox Lithostratigraphy in Northern Illinois
Natural Gas Pipeline Co. of America, R. Keckler No. 2, Ogle Co.

Eau Claire Formation

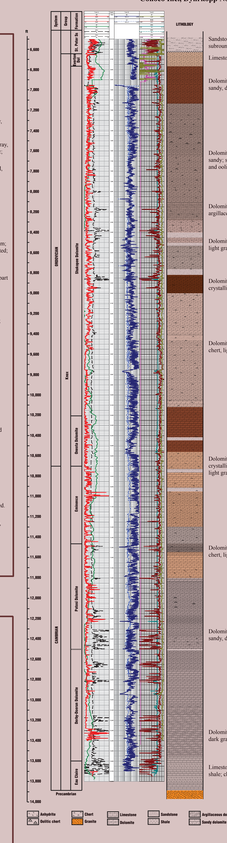


Interlayered glauconitic quartz sandstone and siltstone under plain light; photomicrograph from Northern Illinois Gas Co., Fordyce No. 1, Livingston Co., IL (depth 1,800–1,805 ft).

Siltstone to very fine sandstone, fossiliferous (*Lingula*) under plain light; thin section photomicrograph from Peoples Gas Light & Coke Co., Lamb No. 1, DeWitt Co., IL (depth 4,500 ft).

Fossiliferous lime mudstone to wackestone with trilobites, crinoids, and pellets under plain light; thin section photomicrograph from Conoco Inc., Dyhrkopp No. 4-1, Gallatin Co., IL (depth 13,650–13,660 ft).

Knox Lithostratigraphy in Soutern Illinois
Conoco Inc., Dyhrkopp No. 4-1, Gallatin Co.



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