CO_2 Storage Potential of the Cambro–Ordovician Saline System in the Northern Great Plains–Prairie Region of North America

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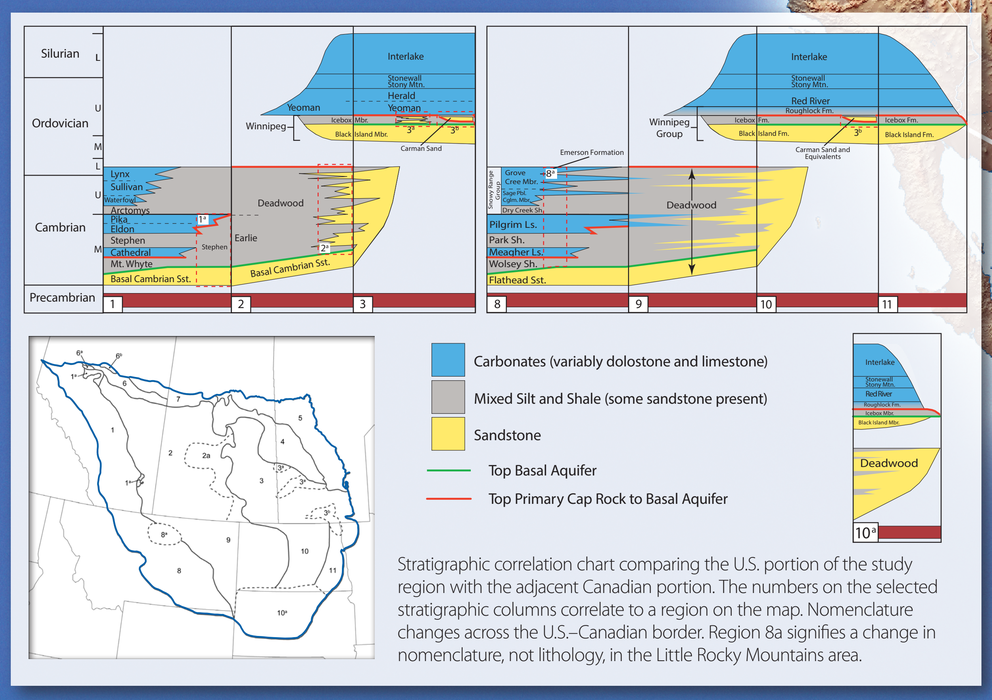
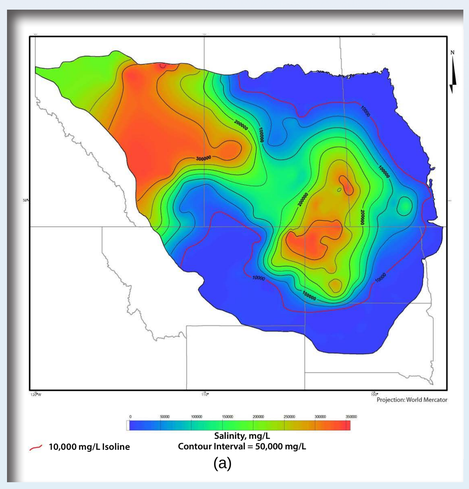
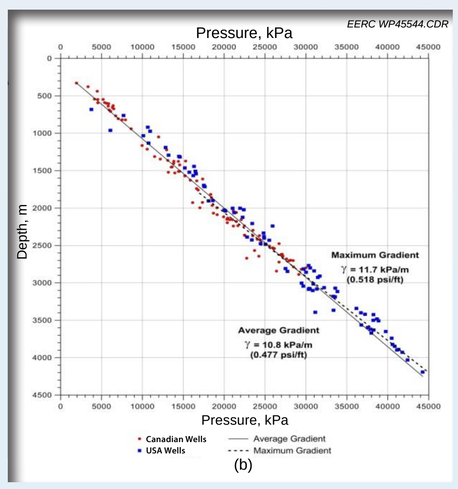
Abstract

A 3-year binational effort between the United States and Canada was initiated to characterize the 1.34-million-km^2 Cambro–Ordovician saline system (COSS) in the northern Great Plains–Prairie region of North America and determine its CO_2 storage resource. To date, no other studies have attempted to characterize the storage resource potential of large, deep saline systems that span the U.S.–Canada international border. Significant effort is being devoted to understanding the geologic and hydrogeologic architecture of the COSS and its CO_2 storage resource. Stratigraphically, the COSS is the lowermost saline system in the region and is dominated by thick, clean sandstone in Alberta and grades into alternating sandstone, shale, and carbonate lithologies in west-central North Dakota. Porosity of the system varies from less than 1% in the very deep areas to more than 25% in shallower regions. The saline system reaches a thickness of 400 meters in west-central North Dakota and central Saskatchewan and is capped by an extensive series of shale and low-permeability carbonates. The area of the basal saline system suitable for CO_2 storage was determined using the following criteria: a) CO_2 should be stored at a distance greater than 20 km from the 10,000-mg/L water salinity isoline to protect groundwater resources, b) porosity should be greater than 4% to ensure storage resource and injectivity, and c) CO_2 should always be in dense phase. The storage resource was estimated using thickness, porosity, and CO_2 density calculated at in situ conditions and using a storage efficiency coefficient of 2.4%, resulting in a P50 storage resource of 113 Gt CO_2.



Stratigraphic correlation chart comparing the U.S. portion of the study region with the adjacent Canadian portion. The numbers on the selected stratigraphic columns correlate to a region on the map. Nomenclature changes across the U.S.–Canadian border. Region 8a signifies a change in nomenclature, not lithology, in the Little Rocky Mountains area.





Water salinity in this system increases with depth, ranging from values <10,000 mg/L in recharge and discharge areas to values >300,000 mg/L in the basin centers. Mapped areas outside the 10,000 mg/L isoline were clipped out of the preliminary modeling results, removing from consideration a significant portion of the COSS. Pressures with an initial gradient of 10.8 kPa/m were assumed to increase to 11.5 kPa/m as a result of CO_2 storage, and temperatures at the top of the COSS were determined from drillstem tests and bottomhole temperature measurements. The distribution of CO_2 density at the top of the COSS was based on these pressures and temperatures. When combined with the salinity restriction, the area of the COSS suitable for supercritical CO_2 storage is reduced to 700,000 km^2.

This final map illustrates the seamless spatial distribution and variability of the geologic CO_2 storage resource of the COSS across the northern Great Plains–Prairie region of North America. Assuming no increase in CO_2 emissions from the large stationary sources in the region and a capture efficiency of 90%, the P50 storage resource identified in this study will suffice to store CO_2 from these sources for 784 years.

The groundwork and success of this effort serve as the foundation of the next step in this project. Work now continues toward a comprehensive, seamless 3-D model of the COSS that will take into account the internal heterogeneity of complex facies relationships that exist vertically and laterally through the COSS. It is expected that much of the porosity for many of the individual sand bodies that was lost or diminished through the process of creating well-averaged values for the 2-D model will contribute significantly to the CO_2 storage resource in the 3-D model.

Range of CO_2 storage resource estimates for the portion of the COSS suitable for CO_2 storage at the P10, P50, and P90 probability levels

Probability		P10	P50	P90
Saline formation efficiency factor[1]		1.2%	2.4%	4.1%
CO_2 storage resource	United States	14 Gt	28 Gt	48 Gt
	Canada	43 Gt	85 Gt	145 Gt
	Total	57 Gt	113 Gt	193 Gt

Reference

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