A Regional Wellbore Evaluation of the Basal Cambrian System

Kyle A. Glazewski,[1] John A. Hamling,[1] Wesley D. Peck,[1] Thomas E. Doll,[1] Jason D. Laumb,[1] Charles D. Gorecki,[1] Nicholas A. Azzolina,[2] David V. Nakles,[2] Edward N. Steadman,[1] and John A. Harju[1]

[1]Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, North Dakota 58202-9018

[2]The CETER Group, Inc.
4952 Oakhurst Avenue
Gibsonia, Pennsylvania 15044

Abstract

The basal Cambrian formation is one of several deep saline formations within the Plains CO_2 Reduction (PCOR) Partnership region that has been identified as a potential CO_2 storage site. The basal Cambrian system spans a region that includes parts of both the United States and Canada. On the U.S. side of the border, the basal Cambrian system covers an area of approximately 507,155 square kilometers (195,814 square miles) and occurs in the states of Montana, North Dakota, and South Dakota; on the Canadian side of the border, it encompasses nearly 811,345 square kilometers (313,285 square miles) in the provinces of Alberta, Saskatchewan, and Manitoba. The basal Cambrian formation has the potential to store between 257 to 834 billion tonnes of CO_2, making it one of the largest potential CO_2 storage resources in the region.

This work evaluates one component of CO_2 storage in the basal Cambrian system – the integrity of legacy oil and gas exploration and production wellbores that penetrate the system on the U.S. side of the border. These legacy wells provide a potential conduit through the cap rock formation, which would otherwise act as a seal to maintain CO_2 in the storage reservoir. The assessment process occurred in five primary steps: 1) identify all wells that penetrate the basal Cambrian system and obtain well files from each respective state regulatory office, 2) record data on leakage risk factors for each well, 3) score and rank each well based on a weighted ranking for each leakage risk factor, 4) evaluate the spatial relationships among well ranking using geostatistics, and 5) identify contiguous portions of the basal Cambrian system that would minimize exposure to high-ranking (i.e., higher-risk) wellbores and thereby represent potential areas for future CO_2 geologic storage.

Information was collected for 826 wells penetrating the basal Cambrian system. Data were available for the following leakage risk factors, which were broadly classified into “shallow” and “deep” factors. Shallow leakage refers to the well integrity in the upper portion of the well, where shallow gas, if present, may leak along the outside of the casing/wellbore annulus to shallow

freshwater aquifers or through a casing leak and along the inside of the production casing to the surface. Shallow leakage factors used in this study included 1) spud date, 2) well type – drilled and abandoned, cased well abandonments, or drilled and cased wells, 3) well total depth, 4) the presence or absence of an additional abandonment plug inside the well casing near the surface, and 5) height of production casing cement top. Deep leakage was defined as leakage (cross flow) from a target production zone or CO_2 injection zone back into the wellbore (or outside the casing) where it moves upward into an adjacent permeable zone (productive zone or aquifer). Deep leakage factors used in this study included 1) the number of fracture and acid treatments, 2) the type of wellbore abandonment – cement plugs or bridge plugs, and 3) the number of completions (perforations).

A ranking scheme was developed for each leakage risk factor using a modified version of methods developed by Watson and Bachu (2007) for the Canadian province of Alberta. The output of this process was a ranking of each wellbore based on the combined effects of the eight leakage risk factors (five shallow plus three deep leakage risk factors). The ranked wellbores were then analysed for spatial correlation using geostatics. A semi-variogram was fit to the data set from which kriging was used to interpolate wellbore rankings across the basal Cambrian system. The resulting areas of high-risk rank represent portions of the basal Cambrian system where there is a higher density of wellbores with higher leakage risk factors. In contrast, areas of low-risk rank represent portions of the basal Cambrian system with lower density of wellbores with leakage risk factors and, therefore, represent potential locations for future geologic characterization for long-term CO_2 storage. These "lower-risk areas" were compared against the locations of stationary CO_2 sources within the PCOR Partnership region to identify optimum targets for future geologic characterization. This presentation will review the data analysis process and results.

References

Watson, T.L., and Bachu, S., 2007, Evaluation of the potential for gas and CO_2 leakage along wellbores: Presented at the Society of Petroleum Engineers (SPE) E&P Environmental and Safety Conference, Galveston, Texas, March 5–7, SPE Paper 106817.

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