Hydrodynamics and the Evaluation of CO_2 Storage in Saline Aquifers

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Background: Carbon Storage in Saline Aquifers

The Government of Alberta Carbon Sequestration Tenure Management plan currently focuses on the permanent disposal of carbon dioxide into zones deeper than 1,000 meters with no associated hydrocarbon recovery. As a result, the deeper saline aquifers that were tested in the 1950s in search of hydrocarbons are now coming back full circle as a destination for sequestration. These deep formations avoid some of the risks associated with CO_2 EOR and depleted oil and gas pools, including the presence of legacy wellbores or potential future hydrocarbon development.

However, the process is not without risk—the risk simply lies elsewhere—by the lack of well control in the aquifer, and in the interpretation of a vintage data set. The risk is also not without reward. Shell Quest, for example, is one of four commercial projects in operation in Canada (and one of 26 in the world) and to date has captured over 6 MT of CO_2. The original November 2010 application for Shell Quest consisted of a map area of approximately 90 townships with only eight control wells, with several ranging in vintage from 1948 to 1955.

Quest is currently injecting into the Basal Cambrian Sand (BCS) saline aquifer. The BCS is a well-sorted, highly mature quartz arenite deposited during a prolonged period of marine transgression directly on the eroded Precambrian surface (Pugh, 1971, 1973). In fact, only two commercial projects in Canada involve saline aquifers, and both inject into the BCS—Quest and the Boundary Dam Aquistore Project. Figure 1 is a map of the storage potential of this system from the Plains CO_2 Reduction (PCOR) partnership over the Western Canada Sedimentary and Williston Basins.

Where can one go to find sufficient pore space to sequester CO_2 in western Alberta, especially with so few deep Cambrian penetrations? And what is the process for determining CO_2 storage capacity? The workflow requires an Explorationist's mindset combined with a deep dive into the world of fluid dynamics.

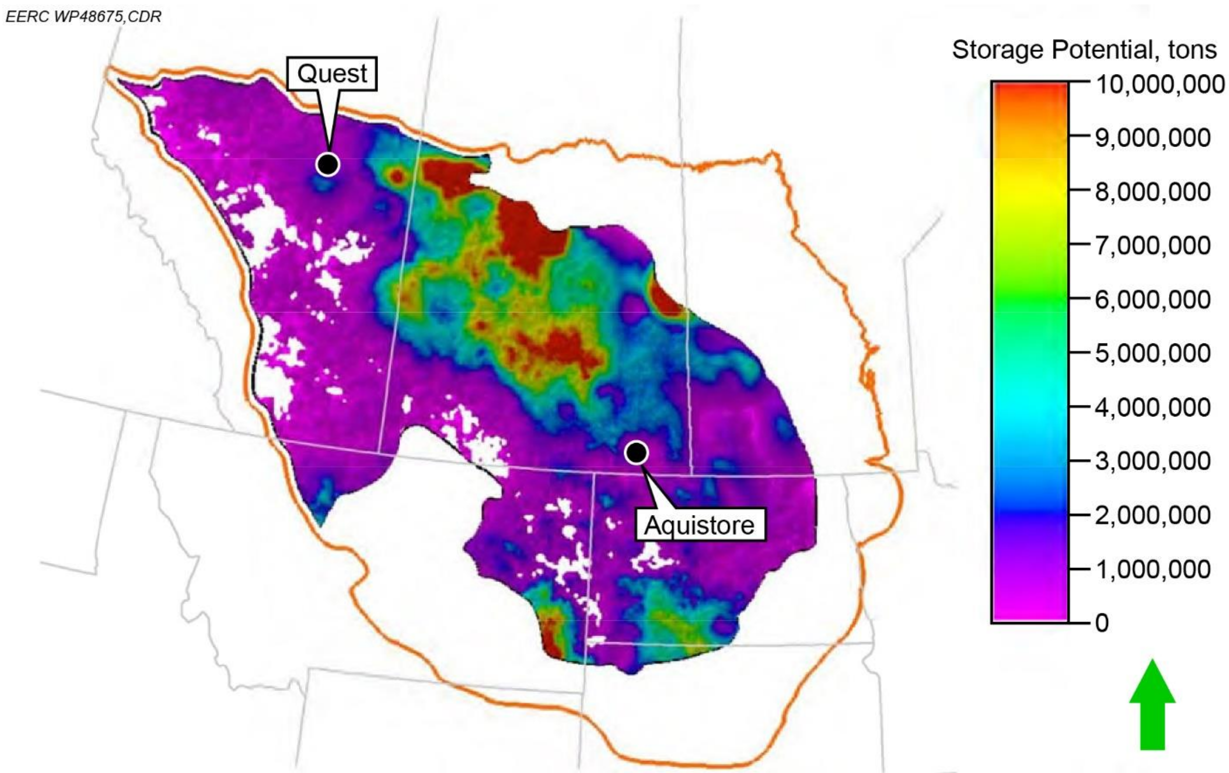

Figure 1: Storage potential (in tons) if the Basal Cambrian Saline system using a storage efficiency factor of 9.1%. Modified from Peck et al. (2014).

Hydrodynamics Workflow in Carbon Storage

This presentation will start with a high level overview of Quest and head west to discuss a workflow to explore other zones within the Cambrian. While our route may touch upon the challenges of using older logs and core data to estimate structure, thickness and reservoir quality within the aquifer—harkening back to the days of petroleum exploration—most of the focus will be on hydrodynamics and its important role in determining the suitability of these zones as potential storage targets.

The role of hydrodynamics in evaluating aquifers for CCS includes the collection and interpretation of pressure measurements, such as drillstem tests (DSTs). This pressure data is a key component in the estimation of flow magnitude and direction, as well as identifying potential areas where cross-formational flow may result in a risk to containment. Reservoir pressure and temperature are also needed to estimate the density of carbon dioxide in the reservoir, which impacts the amount of CO_2 that can ultimately be stored. Static storage capacity estimates will be addressed, including the difference between theoretical and effective storage capacity, and the scale dependency of these estimates, which is reflected in the storage efficiency factor (or E_{saline}) value used. Effective permeability, which is another important element in evaluating the dynamic aspects of storage, can be extracted from DSTs and used in conjunction with core data.

Hydrodynamics, and its integration with geological evaluation, plays a key role throughout the entire screening and planning process from understanding the current conditions of the aquifer, to modelling how an aquifer will respond to injection, to estimating where a plume will migrate over time.

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