Laboratory Methods to Determine Residual Saturations for Geological CO_2 Storage in the Basal Cambrian Sandstone

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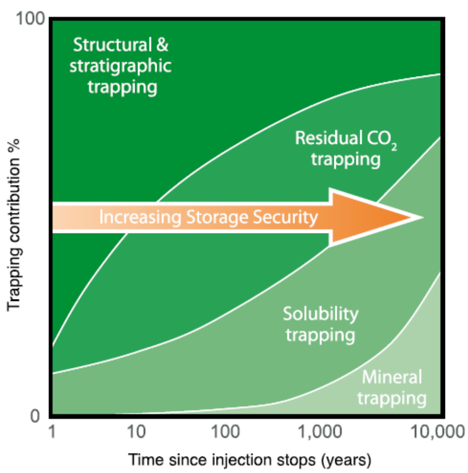
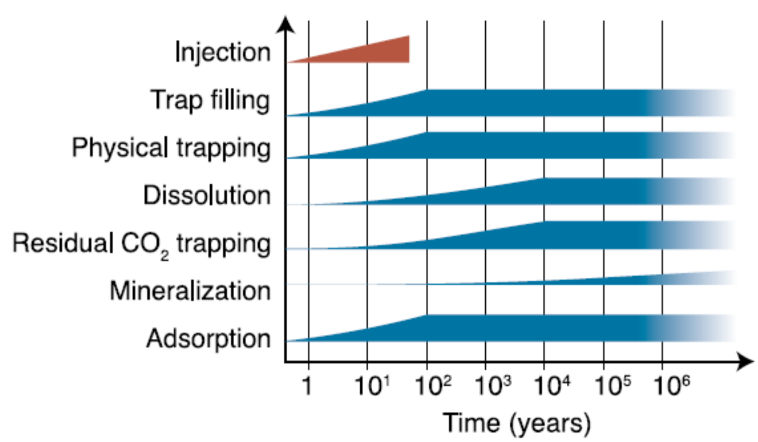
Summary

The Basal Cambrian Sandstone is one of the premier formations in Alberta, Canada and possibly the world for CO_2 storage. The geology (thickness, depth, and regional extent) and petrophysical properties (porosity and permeability) are ideal for injectivity. Containment of the CO_2 is supported with several caprocks sections in the Deadwood and evaporitic intervals farther up section, providing the Basal Cambrian with the ultimate seal. These static properties are generally well understood as the section is explored and analyzed.

Understanding the fluid dynamics and ultimate storage capacity is required to predict plume movement and saturation distributions within it. This presentation focuses on this topic and how various laboratory methodologies can aid in dynamic modelling.

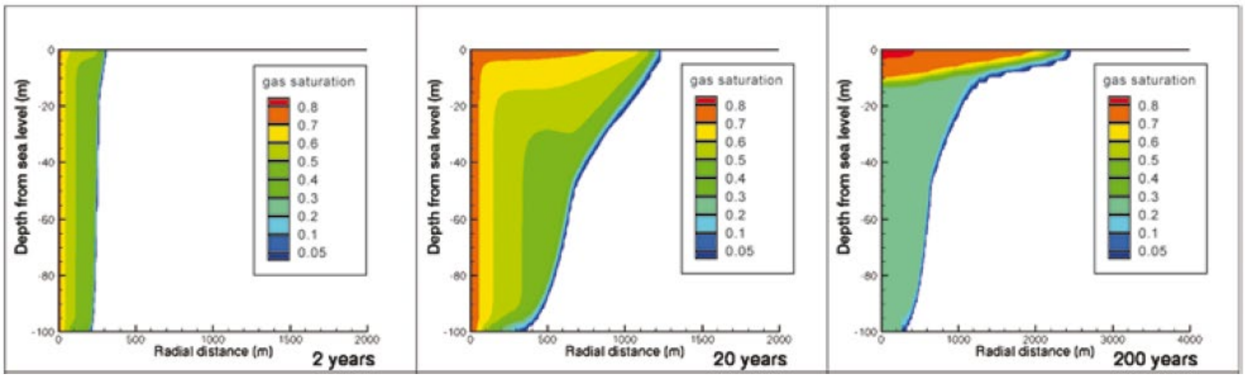
Using core analysis to determine storage capacity starts with determining the total pore volume, which can be accomplished using routine core analysis. The total pore volume alone does not determine the true storage capacity for CO_2. To understand true storage capacity of CO_2, one must understand the Structural, Residual, Soluble, and Mineral trapping. Commonly used special core analysis methods, designed for oil and gas reservoirs, are suitable to determine structural and residual CO_2 saturations for geological storage.





Structural trapping begins with the injection of CO_2 in a brine saturated aquifer. Initially a viscous flow regime is dominant. The relatively low viscosity of CO_2, compared to that of brine, creates an unfavourable mobility ratio. This causes CO_2 to move faster than brine which results in a low sweep efficiency. Buoyancy, caused by the density difference between CO_2 and brine, causes CO_2 to migrate vertically. As the viscous flow regime diminishes the further away from the injection site, or from stopping injection, a buoyancy flow regime becomes dominant. As the CO_2

plume moves upwards and injection is stopped, formation brine imbibes back into the former boundary of CO_2 plume. The imbibition of brine back into the CO_2 plume results in a trapped CO_2 saturation, which can be a significant contribution to the ultimate storage capacity.



To determine stratigraphic storage there are a few Special Core Analysis tests that can help. Core flood tests, namely CO_2-Brine Relative Permeability, is primarily used to quantify two-phase flow but can also help to understand the residual saturations from a viscous flow regime. Capillary Pressure and Centrifuge Relative Permeability tests can help to understand the residual saturations from a buoyancy flow regime. To determine the trapped CO_2 storage, there are a couple of types of imbibition tests. Co-Current Imbibition testing can be measured immediately after a Relative Permeability core flood, at reservoir conditions, starting at an initial gas saturation equivalent to the residual saturation from a viscous flow regime. Counter-Current imbibition testing is a simpler test done at ambient conditions but with the advantage of repeating the test multiple times with different initial gas saturations. This can create a relationship between initial gas saturation and trapped gas saturation and can be useful to tie into Capillary Pressure or Centrifuge Relative Permeability testing.

With a combination of these tests, a better understanding of residual saturations and trapped CO_2 saturations can be accomplished and give confidence to the long-term capture and storage of CO_2 within the Basal Cambrian Sandstone.

References

IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change [Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 442 pp.