CHARACTERIZATION AND MODELING OF THE BROOM CREEK FORMATION FOR POTENTIAL STORAGE OF CO_2 FROM COAL-FIRED POWER PLANTS IN NORTH DAKOTA

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ABSTRACT

Future fossil fuel-based energy production facilities may include carbon management strategies as part of their overall operational plans. Brine-saturated formations appear to have significant capacity to store carbon dioxide (CO_2), provided that they have adequate porosity, permeability, temperature and pressure conditions, and competent seals. The brine-saturated Broom Creek Formation in the North Dakota section of the Williston Basin has been identified as a potential sink for large-scale CO_2 sequestration. The Pennsylvanian/Permian Broom Creek Formation is a laterally extensive sandstone at the top of the Minnelusa Aquifer System, which is capped by the Opeche shale. A wide variety of previously generated data, including well logs, core analyses, water analyses, and other published data, have been used to construct a detailed geological model of an area of the Broom Creek Formation in the vicinity of six coal-fired power plants located in central North Dakota. The geological model, in conjunction with injection simulation modeling efforts, is being used to develop estimates of injection rates and predictions of plume size and migration tendencies. This case study describes an approach that can be applied to conducting subregional-scale characterization of geologic formations for the purpose of large-scale CO_2 sequestration operations.

The Plains CO_2 Reduction (PCOR) partnership is a collaborative program to assess regional sequestration opportunities.

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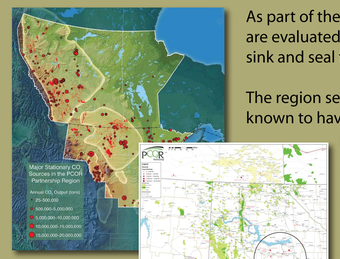
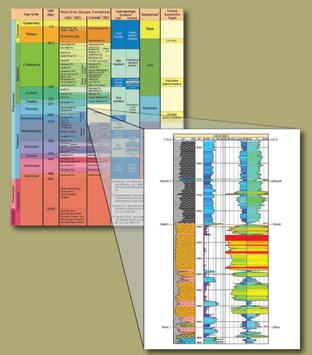
SITE SELECTION AND CHARACTERIZATION



As part of the site selection process, CO_2 sources and geological sinks are evaluated and matched according to CO_2 output and the presence of sink and seal formations.

The region selected for this study is part of the Williston Basin, which is known to have sedimentary sequences up to14,000 ft thick and has produced oil and gas for over 50 years.

The study area, referred to as the Washburn Study Area, encompasses 7500 square miles and is home to six coal-fired power plants and one coal gasification plant which combine for annual emissions of over 36 million tons of CO_2. The Washburn Study Area is underlain by multiple stratigraphic horizons that may be amenable to CO_2 storage.

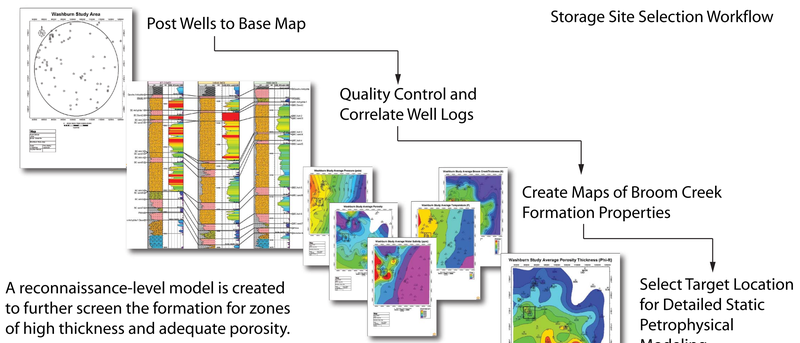


Regional geological evaluations based on readily available data sources are conducted to identify potential stratigraphic horizons that may be suitable for sequestration of CO_2.

The Pennsylvanian/Permian-aged Broom Creek was identified as a suitable candidate for evaluation based on:

- Existing oil, gas, and water well data.
- Thick sand packages.
- Significant sealing formations.
- Lateral extent.

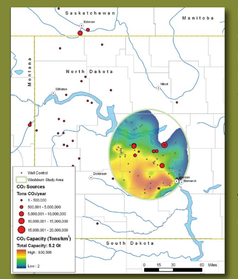
Storage Site Selection Workflow



A reconnaissance-level model is created to further screen the formation for zones of high thickness and adequate porosity.

Results of this model are then used to create a detailed static petrophysical model of an injection target, which is then used for dynamic modeling of CO_2 sequestration scenarios.

ESTIMATION OF STORAGE CAPACITY BASED ON STATIC MODELING



Pressure P (psia) and temperature T (°F) distributions within the model were assigned by populating the model with depth (D, ft) in each cell and applying regional gradients. The formulae for pressure and temperature are:

$$P = 14.7 + 0.4616 \times D$$
$$T = 43.5 + 0.0123 \times D$$

The mass of CO_2 that might be stored in the area was estimated with the formula:

$$GCO_2 = V \times \Phi \times \rho \times E$$

Parameter	Units*	Description
GCO_2	M	Mass estimation of saline-formation CO_2 storage capacity
V	L3	Volume of the saline formation
Φ	L3/L3	Average porosity of the entire saline formation
ρ	M/L3	Density of CO_2 evaluated at pressure and temperature that represents the storage conditions in the formation
E	L3/L3	CO_2 storage efficiency factor that reflects a fraction of the total pore volume filled by the CO_2

* L is length; M is mass.

Formation	Pore Volume (ft^3)	Average Temperature (°F)	Average Pressure (psia)	CO_2 Density (lb/ft^3)	CO_2 Stored at E = 4 (tons)	At E = 1 (tons)
Broom Creek	5,490,000,000,000	110	2500	47.7	5,237,460,000	1,309,365,000

DYNAMIC MODELING

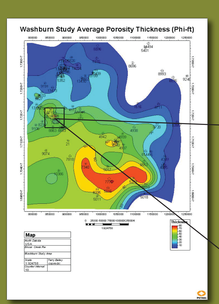
Based on the results of the reconnaissance evaluation, a site was selected to develop a detailed petrophysical model to be used for dynamic modeling.

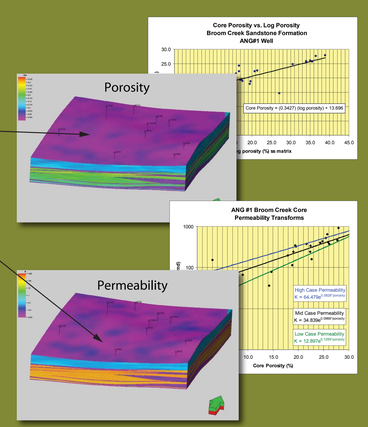
The site encompasses approximately182 square miles in the northwestern portion of the study area.

Log data from ten wells were used to populate the model with formation thickness, porosity, permeability, water saturation, and salinity.

The following types of log data were used:

- Gamma ray
- Resistivity
- Porosity

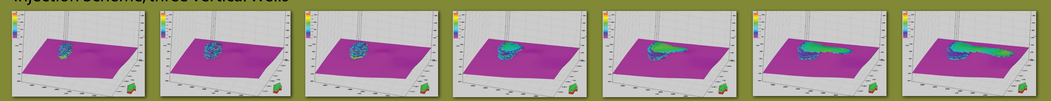




CO_2 Injection Simulation

- 50-million-ton cumulative injection over 50 years

Injection Scheme, three Vertical Wells



Injection Scheme, 6400-ft Single Leg, Horizontal Well