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The Gog Quartzite: CCS Analogue Extraordinaire and Potential Target

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Summary

Injecting carbon dioxide into reservoirs has been undertaken since the 1940s, mostly as a method to enhance oil recovery (EOR). With the recognition of the impact of climate change, interest in carbon sequestration has increased exponentially, with no less than 25 CCS projects ongoing in Alberta alone. Most of the injection projects focus on Cambrian quartzites, which meet the requirements for carbon dioxide injection.

The Gog Quartzite has been used as an analogue for other Cambrian formations which have been used to sequester carbon dioxide, for example in the QUEST Project. Outcrops of the Gog Quartzite provide the chance to view an excellent CCS analogue at surface. The Gog Quartzite also has potential to act as a CCS reservoir in its own right.

Method

The main requirements for CO2 injection are:

- a reservoir with sufficient porosity and permeability to allow ingress of supercritical fluids\
- a laterally extensive reservoir with relatively homogeneous properties
- depth of burial of 1 to 4 kilometres
- a highly efficient seal, ideally with an associated “back up” secondary seal at a different stratigraphic horizon.

Cambrian formations such as the Basal Cambrian Quartzite and the Deadwood Formation meet these criteria and have proven successful in projects such as Quest (Alberta) and Aquistore (Saskatchewan) respectively. In both cases, the Gog Quartzite provided a suitable analogue and potential CCS target.

A series of outcrops of the Gog Quartzite were identified and fieldwork was undertaken to characterize the facies making up these potential reservoir rocks. Outcrops included those in Kicking Horse Pass (Sink Lake and Spiral Tunnels, both outcropping along Highway 1); Lake Louise; Taylor Lake; Moraine Lake and several smaller outcrops. Study of these outcrops allowed the development of a facies scheme that could then be tied directly to reservoir development.

Results, Observations, Conclusions

The outcrops studied allowed the identification of a series of reservoir facies, supported by the associated trace fossils:

Facies	***Interpretation***	***Characteristics***
Trough cross-bedded sandstone with *Arenicolites*, *Skolithos*	Deposition in shallow marine setting as a result of longshore drift	Main reservoir facies for hosting liquid CO2
Rippled sandstone	Wave rippled sandstone, typically overlying trough cross-bedded sandstone. Part of an overall shallowing upward cycle	Possibly less porous sandstone that may act as a baffle
Contorted sandstone	Response to dewatering of thick sandstone beds	Likely to act as a poor quality seal due to cementation associated with the agitation of the sandbody
Black shale with trilobite burrows, *Rusophycos*	Thin shales indicating marine flooding surfaces	Potential baffle

The extensive outcrops at Spiral Tunnels expose more than 600 m of vertical section through the Gog Quartzite. This enabled an analysis of the stacking patterns and changes in thickness, which in turn could be related to sequence stratigraphy. Putting this data together with the facies models allows simple depositional models to be erected that can then be transmuted into reservoir models suitable for modelling CO2 injection.

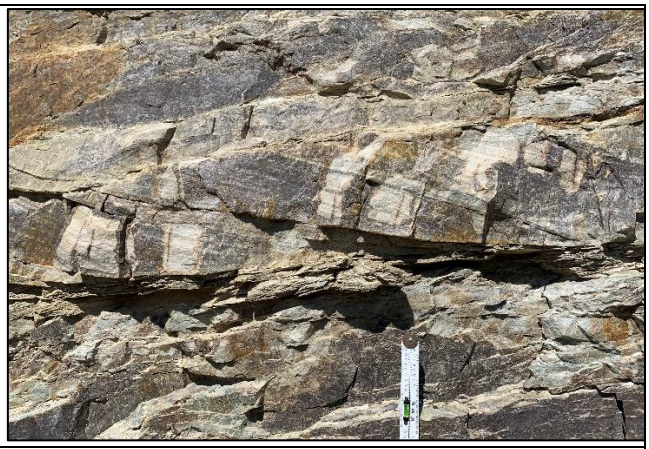
In addition, the faults, fractures and folds were recorded to allow an overview of the potential for leakage of injected CO2 from these reservoirs. Fracture models were created using this data that can be directly applied to assist with estimating the risk of leakage from these rocks in the subsurface. These models can also be superimposed on the simple reservoir models created form the facies analysis.

Novel Information

The work undertaken on the Gog Quartzite allows a three dimensional view of a direct analogue to potential carbon sequestration targets such as the Basal Cambrian Quartzite and Deadwood Formations. This allows geoscientists working on carbon sequestration to get a feel for the reservoirs that they are studying, at a level of detail greater than available through seismic analysis or core studies. Simple reservoir models have been created on which fracture patterns can be superimposed, suitable for reservoir simulation of gas injection.

Acknowledgements

Thank to Stantec for allowing me the chance to study these rocks.

	
View of outcrop at Sink Lake	Trough cross-bedded sandstone deposited in shallow marine conditions. Note the fracture running down the face.
	
Thin interbedded black mudstone beds	The excellent outcrops at Spiral Tunnels provide the opportunity to examine stacking patterns in sandstone beds.