Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 63 (2014) 4145 – 4149

Energy Procedia

GHGT-12

Monitoring and verification of injected CO_2 at the Aquistore site, Saskatchewan, Canada: Sampling of Tertiary, Cretaceous, and Devonian aquifers to establish a baseline and continued monitoring during CO_2 injection.

Gavin K.S. Jensen[a], Ben J. Rostron[b]

Saskatchewan Ministry of the Economy, Saskatchewan Geological Survey, 201 Dewdeny Ave., Regina, S4N 4G3, Canada
Dept. of Earth & Atmospheric Sciences, University of Alberta, Edmonton, Canada

Abstract

Aquistore is a research and monitoring project that is independently managed by the Petroleum Technology Research Centre (PTRC). This project intends to demonstrate the feasibility of storing anthropocentrically produced CO_2 in a deep saline formation, as an alternative to releasing greenhouse gas into the atmosphere. Aquistore is located in south-eastern Saskatchewan, Canada, south of the town of Estevan, just north of the Canada-USA border. The CO_2 is sourced from the Sask Power Boundary Dam coal-fired generation station. This source is located approximately 4 kilometers from the injection site. The Deadwood and Winnipeg Formations of Cambrian and Ordovician ages respectively, are the target injection layers. Theses formations are at a depth of approximately 3300m metres below the surface.

Peer-review under responsibility of the Organizing Committee of GHGT-12

Keywords: Aquistore; CO2 storage; monitoring; stable isotopes; Saskatchewan

Peer-review under responsibility of the Organizing Committee of GHGT-12
doi:10.1016/j.egypro.2014.11.445

1. Introduction

Aquistore is the first fully-integrated CO_2 capture and storage project in Canada. CO_2 is provided by the Boundary Dam coal-fired power generation station and Aquistore will inject "slipstream" CO_2 that is not utilized by an active EOR operation which will use the majority of the CO_2.

As the need grows to quantify and authentic the long term storage of CO_2 at such injection sites as Aqusitore, with the possibility of achieving carbon tax credits, with a given volume of stored CO_2. The various monitoring and verification techniques employed will have a better understanding of the distribution and concentration of CO_2 and determining if out-of-zone migration occurs. This project is focusing on investigating if out-of-zone migration has occurred.

The Saskatchewan Geological Survey initiated a sampling project with the PTRC near the Aquistore Project site due to growing concerns of monitoring and verification of injected CO_2 at carbon storage sites,. The Saskatchewan Geological Survey sampled currently producing oil and water source wells over the past 3 years within close proximity to the Aquistore site, to establish a hydrogeochemical baseline of overlying regional aquifers prior to CO_2 injection. Sampled wells are located approximately 3.5 kilometres to the north of the Aquistore site, in line with the predicted migration direction of injected CO_2 (Figure 1). These wells are the closest currently producing wells to Aquistore, with the next such wells 15 kilometres further to the north. There is an Aquistore monitoring well that is located 150 metres to the north of the injection well. Samples from the Deadwood and Winnipeg formations have been taken prior to CO_2 injection and will be taken during injection to establish the migration time and path way of the injected CO_2. This monitoring well along with the aforementioned currently producing wells will provide a monitoring and verification technique to ensure that the injected CO_2 does not migrate out-of- zone. These wells span a large portion of the overlying strata, from the Devonian to the Tertiary. The producing oil formation is lower Devonian Winnipegosis Formation at a depth of 2565 metres. The Winnipegosis Formation is stratigraphically below the Prairie Evaporite Formation the regional seal for Aquistore project. The water source wells are from the lower Cretaceous Manville Formation at a depth of 1090 metres and from the Tertiary Ravenscrag Formation at a depth of 150 metres.

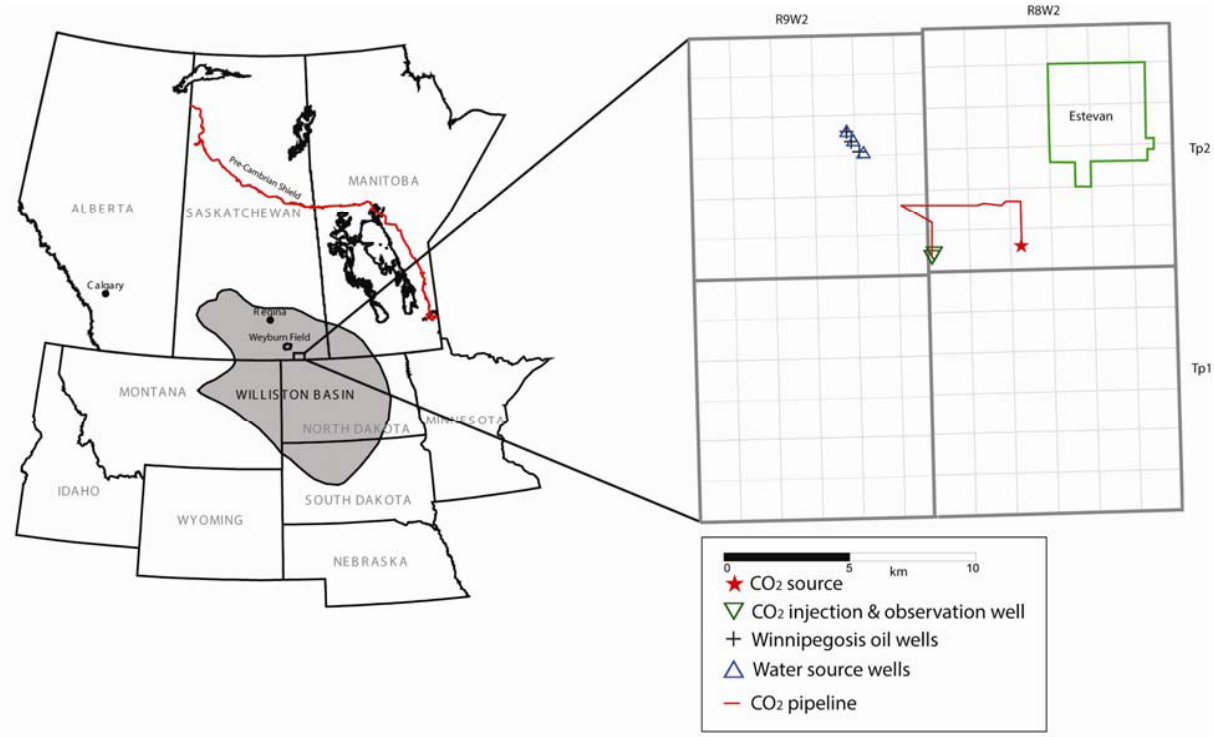

Figure 1: Location Map showing the Williston Basin and the enlarged area with the CO2 source (Boundary Dam) and CO2 pipeline. Aquistore's injection and observation wells. As well as the wells sampled for this project.

This research will provide early detection of out-of- zone migration or it will provide evidence that there is no out-of- zone migration since these wellbores represent one of the easiest pathways for out-of- zone migration. Samples analysis includes a full range of major and minor ions as well as deuterium and oxygen-18 isotopes. A vertical hydrostratigraphic isotopic profile will be produced with samples from the Deadwood,Winnipeg, Winnipegosis, Manville and Ravenscrag Formations. Sampling of the Winnipegosis, Ravenscrag and Manville wells post injection once a year will occur to determine if there is any out-of- zone migration from the Aquistore site. Additionally, pressure in the producing wells will be monitored to examine if there is any affect from the Aquistore site. This monitoring will aid in ensuring the secure long term storage of CO_2 at the Aquistore site.

2. Sampling Technique

A representative from the company operating the wells was met at each well to obtain a sample. The samples obtained from the producing wells were taken directly from wellheads. In the field, each well was sampled based on the protocol from Lico et al. [1] except for the following modifications. All samples were delivered to Isobrine Solutions for chemical analysis.

1. Any production chemicals (e.g. demulsifer or corrosion inhibitor, etc.) that were being used on the well were turned off prior to sampling.

2. Samples (oil and water) were taken directly from the well-head into 1 litre high-density, polyethylene containers. Control samples were taken to determine if production chemicals affected the hydrochemical signature of the produced formation waters, and none were noted. Samples were then allowed to gravity separate inside the container.

3. Water samples were filtered through a 0.45 µm polyethylsulfane filter. This pore size was used to remove any colloids/organics that were present.

4. Samples were then split into:
   - A) Samples for anion determination, which were untreated and tightly sealed for analysis.
   - B) Samples for cation determination, which were acidified to a pH<1 with triple-distilled 2.8N HNO_3 acid, which was added in the amount of 1% of the cation split volume (e.g. 1 mL of acid per 100 mL of sample) and then tightly sealed for analysis.
   - C) Splits for isotopic analysis were taken in non-coated, non-additive Becton-Dickinson brand 10mL vacutainers from the first 500mL filtered.

Samples obtained from the Aquistore wells were done so while drilling the wells. Samples were taken with Schlumberger's modular formation dynamics tester (MDT)© tool.

3. Results

At the time of publication CO_2 injection has not commenced at the Aquistore site. Isotopic and total dissolved solids (TDS) are displayed in this paper (Figure 2). A complete data set will be published at a later date after injection of CO_2 has commenced and subsequent sampling has occurred. There are unique isotopic signatures that are present in the injection strata (Cambro-Ordovician aquifer) which differ from the overlying oil and water producing aquifers. Generally, isotopic compositions increase with depth (Figure 2). This trend has been observed in other oil producing regions in the Williston Basin [2,3]. The TDS also increases with depth, which also has been previously observed [2,3]. Additionally, there are unique isotopic compositions within the Cambro-Ordovician aquifer, between the Winnipeg and Deadwood formations, while in contrast the chemistry (TDS) is relatively homogeneous. Isotopic values can be used to fingerprint formation fluids and determine possible mixing trends between formations [3,4].

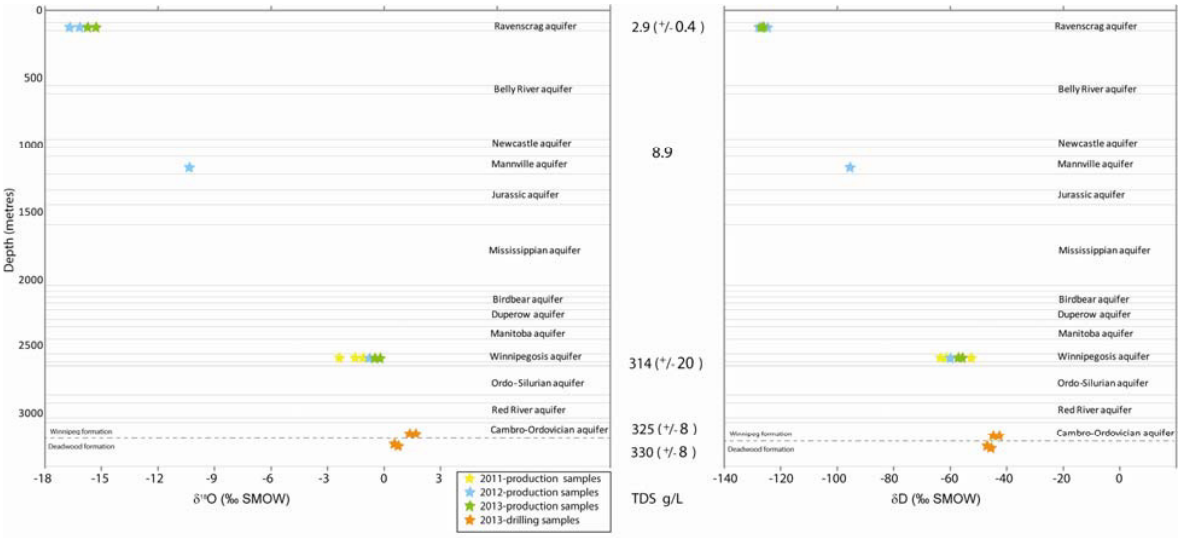

Figure 2: Hydrostratigraphy present at the Aquistore injection well. Isotopic compositions and TDS plotted versus depth. Samples taken from the producing oil and water source wells and the Aquistore well, locations on Figure 1.

4. Future Research

The sampling completed prior to injection will form the basis for establishing background levels in the nearby producing oil and water wells. Sampling once a year until the project is completed will monitor if any changes occur from the background levels. This project will aid in verifying that the long term storage of greenhouse gases (GHG) in the subsurface is a viable option for reducing GHG emissions to the atmosphere, as well as establishing, through Aquistore and Boundary Dam, that clean coal is a viable option for the future.

References

[1] Lico, M. S., Kharaka Y. K., Carothers, W. W. and Wright, V. A., (1982): Methods for collection and analysis of geopressured geothermal and oilfield water. United States Geological Survey Water Supply Paper 2194.

[2] Rostron, B.J., Kelley, L.I., Kreis, L.K., and Holmden, C. (2002): Economic potential of formation brines: interim results from the Saskatchewan brine sampling program; *in* Summary of Investigations 2002, Volume 2, Saskatchewan Geological Survey, Sask. Industry Resources, Misc. Rep. 2002-4.2, CD-ROM, Paper C-1, p29.

[3] Rostron B.J., Arkadakskiy S. (2014): Fingerprinting "stray" formation fluids associated with hydrocarbon exploration and production. Elements, August 2014, v. 10 p. (4) 291-296.

[4] Jensen, G.K.S., (2007): Fluid flow and geochemistry of the Mississippian aquifers in the Williston Basin, Canada-U.S.A. Unpublished M.Sc. thesis, Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada, 123p.