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Monitoring technology innovation at the CaMI Field Research Station, Brooks, Alberta

Don C. Lawton[1,2], Kirk G. Osadetz[2] and Amin Saeedfar[2]

[1]University of Calgary; [2]Containment and Monitoring Institute, CMC Research Institutes, Inc.

Summary

The Containment and Monitoring Institute (CaMI) of CMC Research Institutes, Inc. and the University of Calgary have constructed a Field Research Station for research into monitoring technologies for containment and conformance of subsurface fluids, particularly CO_2. The field research station is a platform for development and performance validation of technologies intended for measurement, monitoring and verification of CO_2 storage. Outcomes of the research will also have adjacent applications such as assessing and monitoring cap rock integrity in oil sands during production, assessing fugitive emissions in shale gas production and monitoring CO_2-enhanced oil recovery programs. The project will undertake applied research into monitoring technologies, graduate student and industry professional training, as well as public outreach and engagement activities.

Introduction

CMC Research Institutes Inc., in conjunction with the University of Calgary, has established the Containment and Monitoring Institute (CaMI), to develop a comprehensive Field Research Station (FRS) to facilitate and accelerate research and development leading to improved understandings and technologies for geological containment and secure storage of CO_2, and for monitoring fossil fuel production and environmental mitigation. Carbon capture and storage (CCS) is a CO_2 emissions reduction strategy that is an integral part of Canada's climate change action plans, as demonstrated by the Quest CCS project by Shell and partners which has now been operating in Alberta for over a year.

Specific goals for the FRS related to CCS is to develop and refine monitoring technologies to determine the detection threshold of gas-phase CO_2 in the subsurface, as an analogue for early-detection of CO2 leakage from a deeper, large-scale CO2 storage site, to develop monitoring technologies for optimizing CO_2 enhanced oil recovery (CO2-EOR) and de-risk CCS in general. In addition to CCS monitoring, the CaMI FRS is pursuing research into the important question of gas (CO_2 and CH_4) migration in the shallow subsurface. Unconventional fossil fuel extraction (e.g. shale gas and in-situ oil sands) requires new approaches and innovative technologies to be developed for sampling, measurement and monitoring methodologies in order to provide comprehensive models of the subsurface and to ensure containment as well as operational and environmental conformance. Research into subsurface processes have never been more important than it is today, and new sensing and sampling technologies are required. New businesses and technologies will be needed not only for regulatory compliance (verification) but also for leak detection mitigation, source identification and crucial performance validation to drive the improvement of processes and to alleviate public concerns about technical safety.

To address these challenges, the FRS has been established to undertake research into the efficacy and evaluation of monitoring technologies in a realistic field setting. The facility will be used to test new measurement, monitoring and verification (MMV) technologies as they are developed and commercialized (e.g. fibre optic devices, slim wells, new analytical instruments for air and water analyses, integrated geophysical surveys) as well as new approaches to the integration of volume-based datasets (3D seismic volumes) with high resolution point measurements (wells). Outcomes of the project will be an assessment of MMV technologies for CCS and shallow gas migration in general.

The Field Station

Figure 1 shows the location of the FRS. It is approximately 25 km southwest of Brooks, Alberta, on ¾ section of land owned by Cenovus Energy.

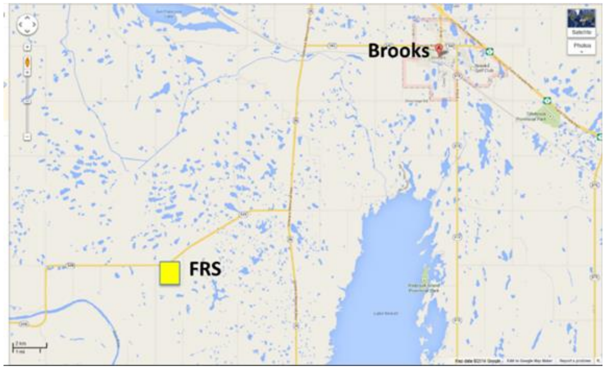

Figure 1. Location of the FRS near Brooks, Alberta

The FRS program is designed around injecting small tonnages (up to 1000 tonnes per year) of CO_2 (possibly with small amounts of impurities such as CH_4 or other tracers) to be injected into the subsurface at depths of approximately 300 m and 500 m. The injection targets are water-saturated sandstones within Upper Cretaceous formations, with overlying shales and mixed sand/shale sequences forming the cap rocks. The target formations are the Basal Belly River Sandstone (300 m deep) and the Medicine Hat Formation (500 m deep), as shown schematically in Figure 2. The project will be staged in 3 phases, namely Phase 0 (baseline), Phase 1 (300 m deep CO_2 injection and monitoring) and Phase 2 (500 m deep CO_2 injection and monitoring).

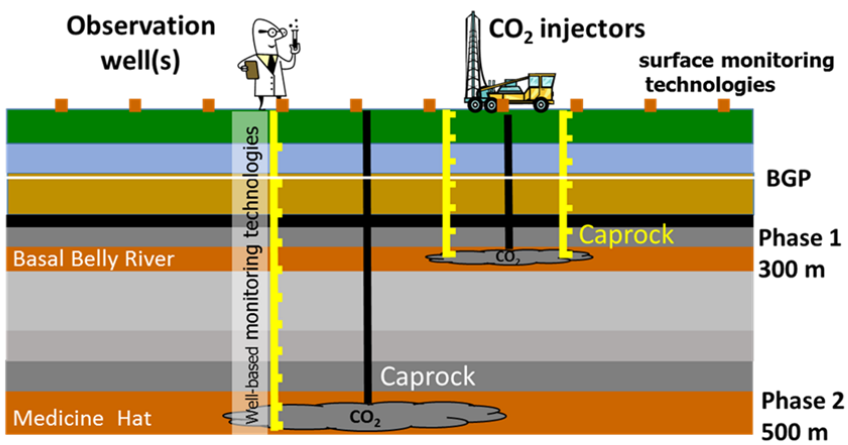

Figure 2. Schematic depth section of the FRS. Phase I (300 m) and Phase II (500 m)

Goals

The overall goals of the project are to:

- Provide a world-leading site for the improvement of existing and the development of new continuous and discrete subsurface and surface measurement, monitoring and verification MMV technologies related to CCS and other containment and conformance requirements.
- Determine the CO_2 detection thresholds and sensitivities for a wide range of continuous and discrete subsurface and surface (MMV) technologies.
- Prioritize MMV technologies for verification of conformance and containment of CO2 and other fluids in the subsurface.

- Provide quantitative measurement, monitoring and verification data that further enables industrial scale geological carbon (CO_2) storage (CCS) in Alberta and elsewhere.
- Better understand gas migration at shallow to intermediate depths in the subsurface and to identify gas migration pathways and interactions between mixed gases.
- Educate and train students, professionals and technicians in the science, engineering and policy for the accelerated implementation of industrial-scale CCS.
- Identify and undertake research for better methods for understanding spatial variations in cap rock integrity.
- Evaluate efficacy of in-field analytical geochemical and hydrogeochemical analyses in monitoring programs using a new mobile field laboratory.

Geology

At the site, the Countess well (100/10-22-017-16W4/00) was drilled vertically to 550 m TD and penetrated a typical succession of Upper Cretaceous strata in southeastern Alberta including:

- Upper Colorado Group, predominantly shale with lesser sandstone in the Medicine Hat Fm.,
- Conformably overlying Lea Park Fm., predominantly siltstone and shale with minor fine sandstones near the its top and the gradationally and,
- Conformably overlying Belly River Group, predominantly sandstones, siltstones mudstones and coals.

The bedrock succession is unconformably overlain by 24 m of Holocene glacial deposits and soils. The bedrock surface occurs high in the Dinosaur Park Fm., but the Lethbridge coal zone is eroded locally. The injection target is the Brosseau Member of the Foremost Formation. Glombick (2014) re-introduced Brosseau Member (Allen, 1919) to describe the distinct, commonly massive to plane or low angle cross-bedded sandstone at the base of Foremost Formation Belly River Group, although this term was previously employed for regions west of the 5th Meridian, where the Brosseau Member is composed of up to three vertically stacked allostratigraphic shoreface parasequence sets. In the 10-22 well, the Brosseau Member, or basal Foremost, predominantly medium-grained sandstone, occurs a single allostratigraphic unit (shoreface parasequence set) between depths of 301.65 and 295.65 m. Figure 3 shows the log interpretation from the injector well (10-22) and observations wells (102 and 103).

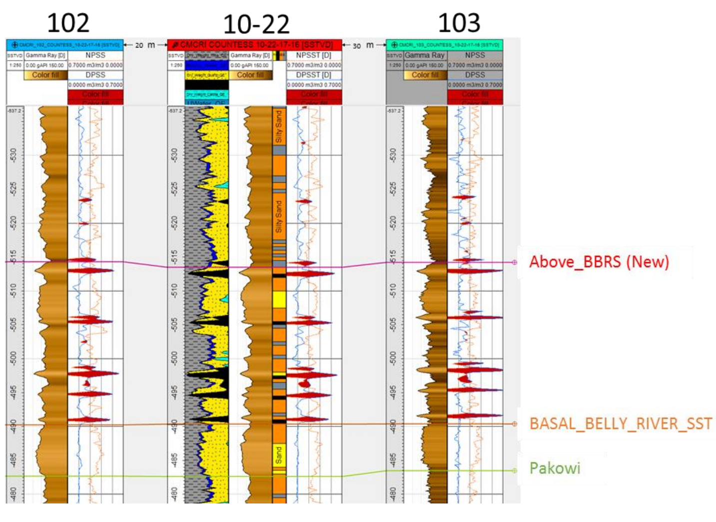

Figure 3. Interpreted logs from CaMI Field Research Station wells

Infrastructure

Infrastructure and monitoring technologies installed at the FRS include one injection well, two observation wells and surface CO_2 handling facilities (storage tank, refrigeration unit, pump, gas heater), power shack, instrument trailer). The site layout is show in Figure 3.

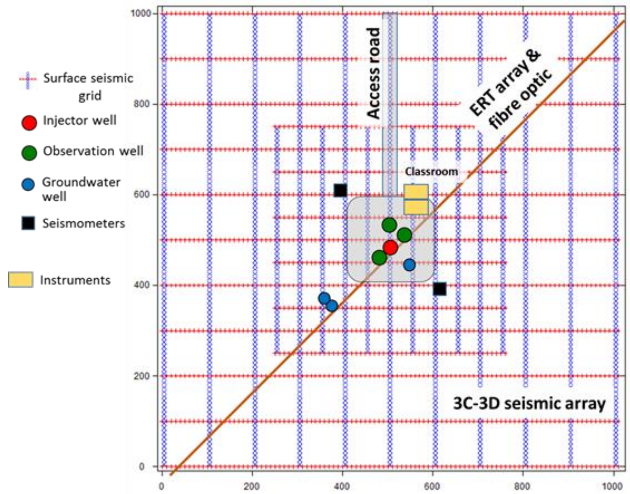

Figure 3. Layout map of the CaMI Field Research Station

Permanent monitoring instruments in the observation wells include a U-tube sampling system, fibre optic packs for DTS and DAS applications, geophones, electrical resistivity electrodes and pressure/temperature gauges. Permanent surface monitoring technologies include fibre optic cables (linear and helical wound) for seismic DAS recording, and 112 electrodes for permanent electrical resistivity imaging. Figure 4 shows PP and PS seismic data volumes recorded from the acquisition grid shown in Figure 3.

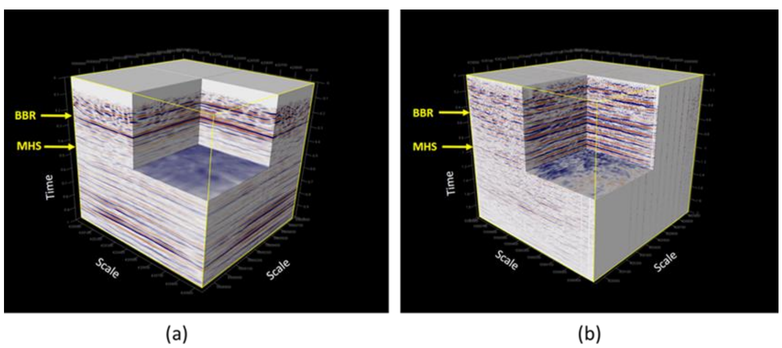

Figure 4 Baseline PP and PS seismic volumes from the CaMI Field Research Station

Conclusions

The CaMI Field Research Station is complete and baseline data are now being collected. CO_2 injection is planned to start in April of this year.

Acknowledgements

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References

Glombick, P.M., 2014. Subsurface Stratigraphic Picks for the Belly River Gp./Lea Park Fm. Transition in East-Central Alberta, Alberta Energy Regulator Alberta Geological Survey Digital InFm. Series DIG 2013-0031 (tabular data, tab delimited format) (0.28 MB)