Containment and Monitoring Institute (CaMI)
Carbon Management Canada
&
University of Calgary

Introduce a new Field Research Station (FRS)

November, 2013

Executive summary

Carbon Management Canada (CMC) and the University of Calgary announce their new joint project to develop a field station for containment and monitoring technologies. The field research station is a platform for development and performance validation of technologies intended for measurement, monitoring and containment of subsurface fluids including carbon dioxide. CMC is investing an initial $4.4M in development of this field-based facility in Alberta and have applied for a further $5M capital contribution from Western Diversification. We are seeking expressions of support and inviting industry to join in this collaborative development exercise with participation offered via sponsorship, contract R&D projects, facility rental and through technology company creation and support. The facility can also be used for public outreach and engagement activities

Introduction

Carbon Management Canada (CMC) has established CMC Research Institutes, Inc. with a mission to accelerate the commercial uptake and widespread implementation of industrial ghg mitigation technologies through establishment of a series of research institutes. The first of these, the Containment and Monitoring Institute (CaMI), is developing a comprehensive Field Research Station (FRS) to facilitate and accelerate research and development leading to improved understandings and technologies for geological containment and storage of CO_2 and monitoring of fossil fuel production and environmental mitigation. Unconventional fossil fuel extraction (e.g. shale gas and in-situ oil sands) and carbon capture and storage (CCS) require radical 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 and operational and environmental conformance. Subsurface research has 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, CaMI is establishing the FRS 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) as well as new approaches to the integration of low-resolution volume-based datasets (3D seismic volumes) with high resolution point measurements (wells).

Containment monitoring technology drivers

There is an urgent need to better characterize containment risks in both natural and engineered systems. Loss of containment impacts the environment whether this is on the surface or in the subsurface, and it may lead to delays in resource production or loss of efficacy of fluid disposal. Effective monitoring technologies and integrated monitoring systems are thus becoming critically important to many sectors in the petroleum industry and the FRS will be a unique opportunity to develop, refine and calibrate these systems. Applications include:

- Secure carbon storage (CCS)
- Steam chamber containment and effectiveness
- Tertiary/Enhanced petroleum recovery
- Characterization of hydraulic or natural fractures
- Groundwater protection
- New or legacy well construction /abandonment issues and fugitive emissions
- Acid gas or other fluid disposal
- Induced seismicity risk analysis and mitigation

CCS is a CO_2 emissions reduction strategy that is an integral part of climate change action plans at both the federal and Alberta government levels. A specific goal 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 CO_2 leakage from a deeper, large-scale CO_2 storage site. Of paramount importance to CCS is the ability to track and quantify the injected CO_2 plume in the storage formation and to detect any migration through the overlying cap rock into shallower aquifers, or release into the atmosphere. Cap rock assessment procedures need development as cap rock facies may vary laterally and fluid migration pathways (e.g. fault injectites) may intersect cap rock sequences. Alternate strategies for assessment of cap rocks are required and these will be developed at FRS. Advanced monitoring technologies for monitoring subsurface fluids are equally important for shale gas and oil sands production through early detection of loss of fluid containment or stray leakage during operations, due either to loss of well integrity or failure of cap rock seals. Of particular concern is the potential leakage of petroleum or other subsurface fluids into overlying formations, shallow aquifers containing potable water, or into the atmosphere.

Monitoring and verification of containment and injected CO_2 conformance are vital not only for public acceptance of CCS but also for the ultimate transfer of environmental liability from the operator to the government. For unconventional fossil fuel exploitation, surveillance of the overburden from the ground surface to the reservoir is needed to verify containment of process fluids (e.g. hydraulic fracturing fluids or produced fluids), and to monitor well integrity. Comprehensive monitoring technologies and protocols thus need to be established, using a wide range of existing and next-generation technologies.

A further key aspect of research into monitoring and reservoir surveillance leading to technology deployment and commercialization is having appropriately trained and qualified personnel. CaMI will partner with the University of Calgary and others to develop training programs at the FRS for undergraduate and graduate students as well as commercial training for industry scientists, engineers and technologists.

Technology programs

The FRS program will be designed around 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 700 m. The injection targets are water filled sandstones within Upper Cretaceous clastic reservoir formations, with overlying shales or mixed sand/shale sequences forming the cap rocks.

A physical site location has been selected and agreements for surface and subsurface access have been negotiated. At present a public outreach program is in progress and the site is expected to be announced in a press release early in 2014 once public confidence is assured. This outreach development phase will be completed by the end of 2013.

Initially CO_2 for the injection project will be obtained from industrial sources, but once established, a stream of CO_2 for the project will be produced by a novel solid-oxide fuel cell (SOFC) located on site that will also produce clean heat and power for site operations. The FRS will build towards a green-field energy research station and hub. CO_2 streams from SOFCs can be designed to contain some unused fuel (methane) and the monitoring program will also address detection and fate of methane in the injection zone and overlying formations.

The technologies that will be implemented and further developed at the site include:

- Innovative, data linked geophysical and geochemical surface, aerial and subsurface surveillance systems.
- Novel cap rock assessment procedures
- Analytical and Measurement methods will include:
    - 3D surface seismic surveys
    - time-lapse seismic data analysis
    - borehole seismic measurements, including 3D vertical seismic profiles (VSP)
    - cross-well seismic measurements and analysis
    - high-resolution Global Positioning System (GPS) and Interferometric synthetic aperture radar (InSAR) geodetic surveys

    - comprehensive well logging and analysis
    - microseismic monitoring programs
    - electrical and electromagnetic borehole surveys
    - surface electrical resistivity tomography
    - microgravity surveys
    - rock mechanics
    - time-lapse downhole pressure and temperature monitoring and analysis
    - on-site surface and subsurface geochemical sampling and analysis capabilities
    - time-lapse geochemical data analysis
    - reservoir fluid residence time analysis for cap-rock assessment
    - nanosensor technology development for cap rock surveillance
    - hydrologic techniques and near-surface geophysical methods
    - hydrostratigraphic characterization
    - advanced aquifer testing and analysis, including tracers
- solid oxide fuel cell technology
- other technologies as they become available for validation or development

FRS Site Development

Figure 1 illustrates the schematic layout of infrastructure at the site, which will be established on slightly less than one section of land (approximately 1 km x 1 km in accessible area).

Schlumberger Carbon Services has been contracted to develop and construct the FRS infrastructure. The final well design and layout will be determined after initial reservoir modelling has been undertaken. Separate injector wells will be drilled for the two target depths (300 m and 700 m) and cap rock and reservoir horizons for both levels will be cored for geomechanical analysis, mineralogy and cap rock studies. Full log suites will also be run in both wells. Observation wells will be fully instrumented with both permanent and retrieval sensors. The periodic injection of small volumes of CO_2 will be tracked by these down-hole monitoring technologies as well as by various surface surveys.

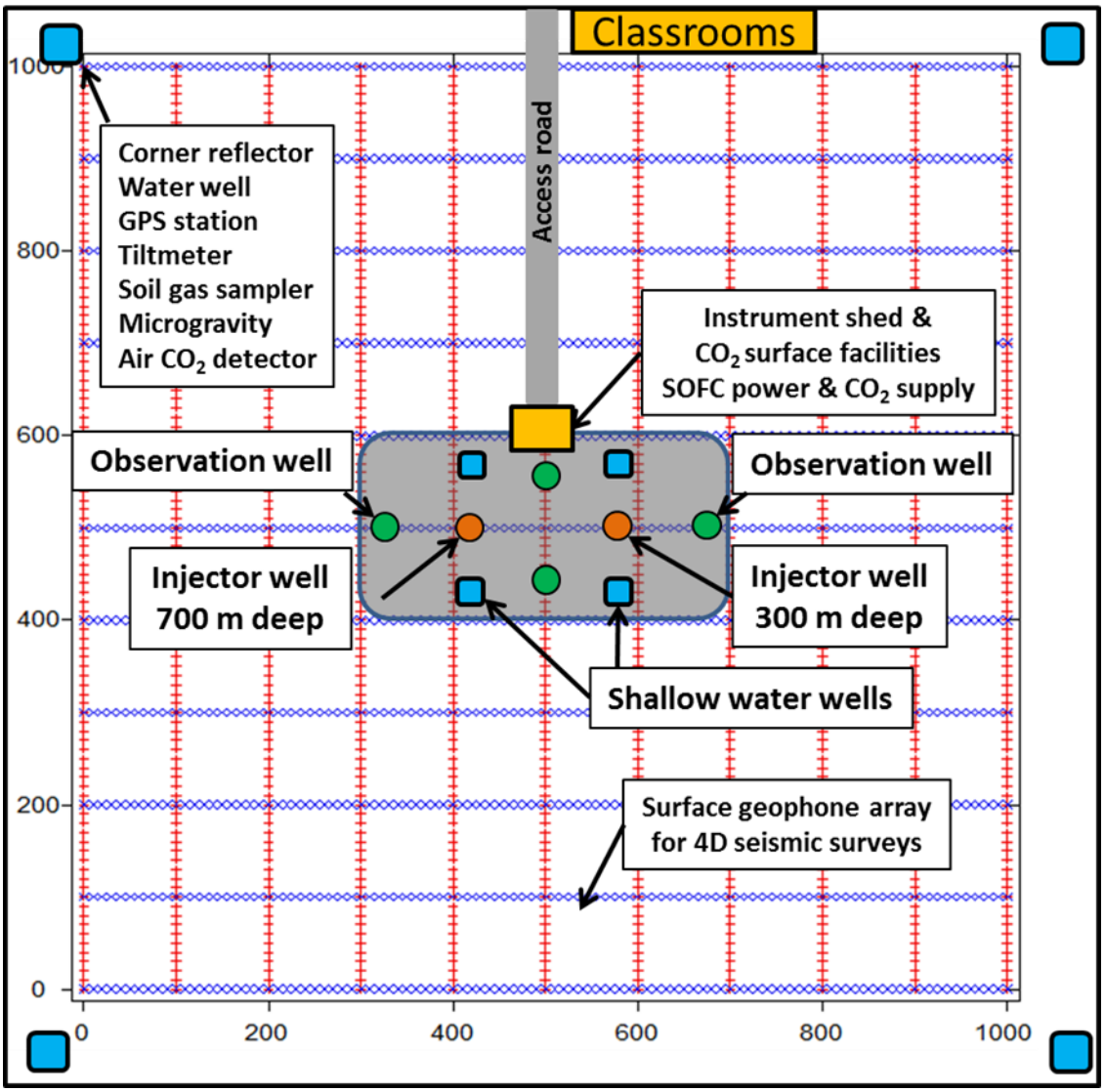

Figure 1. Schematic FRS site layout map

Site activities will focus on research and technology development as well as training inmonitoring technologies. Geophysical, geochemical, geomechanical and geodetic monitoring of the subsurface gas plume (both CO_2 and methane) will be complemented by near-surface hydrogeological studies to better understand shallow groundwater systems, near-surface subsurface fluid flow, and to establish the fate of both CO_2 and CH_4 in an aquifer below ~225 m depth, which is the local base of groundwater protection. Researchers from industry, the University of Calgary and from the CMC Network of researchers across Canada and internationally will be able to take part in

research at the site with various access protocols. We are inviting partners to join in this collaborative development exercise with partnership offered via sponsorship; contract R&D arrangements and by other collaboration mechanisms. The facility can also be used for public outreach and engagement activities.

Infrastructure

The FRS infrastructure will initially consist of:

- A 3D seismic array (either permanent or deployable) for research and training in time-lapse surface seismic methods for CO_2 monitoring, particularly 3D data acquisition schools.
- Two 300 m deep and two 700 m deep vertical observation wells, fully instrumented with geophones, for research and training in 3D VSP survey design and data analysis. Geophones will be placed behind casing to enable retrievable tools to be used in the cased wellbore. The observation wells will also include fluid sampling tubes for geochemical analyses of subsurface fluids and training in sampling protocols as well as fibre-based pressure and temperature sensors.
- A mobile, truck-mounted geochemistry laboratory for in-field real time analyses.
- Two injection wells (300 m and 700 m deep) with appropriate well-head apparatus for injecting small volumes of CO_2 into the target formation.
- Broad-band seismometer and a passive seismic array for research and training in microseismic monitoring.
- Downhole electrical resistivity tomography systems.
- Permanent GPS monuments and a near-surface tiltmeter array for monitoring ground surface deformation associated with fluid injection or retrieval.
- InSAR reflectors for monitoring ground surface dilation and integrated training between surface and downhole monitoring technologies.
- Shallow multi-level groundwater monitoring and sampling wells (between 4 and 8 to penetrate shallow aquifers).

- Permanent monuments for time-lapse microgravity surveys to monitor subsurface density changes due to fluid substitution.
- A solid oxide fuel cell and associated CO_2 capture unit.

This infrastructure will enable a full spectrum of research and training programs to be undertaken, from individual technologies to integrated monitoring system design and implementation.

Site Characterization

The full characterization of a selected site will be undertaken in late 2013 – early 2014. This would include building regional and local geological models from available well data, undertaking a high-resolution 3D seismic survey of the site, and sampling shallow potable aquifers from existing water wells within 3 km of the site.

Outcomes

The FRS will provide tremendous opportunities for industry and university personnel to participate in leading edge research about surface and subsurface characterization and monitoring that are of critical importance to Alberta and Canada. It will provide a platform to validate current and novel monitoring, detection and measurement technologies, as well as support for equipment and services companies developing new products and methods for the industry. The site will also serve an important role to educate the public about subsurface containment issues and how to de-risk injection schemes. In particular, it will excite students of all ages about career opportunities in these fields and inform the public about both carbon capture and storage (CCS) as well as measurement, monitoring and verification (MMV) practices which can be applied to other resource developments, such as shale gas and oil sands production.

Funding

CMC currently has $4.4M allocated to this project, and has an application into Western Diversification (WD) for an additional $5M capital contribution.