Assessment of caprock sealing capacity and monitoring its integrity during injection operations is vital for sustainable growth in the oil and gas industry. In Alberta, thermal in-situ projects rely on caprock to contain the injected fluids and pressure, as well as mitigate the associated environmental and safety risks. Subsurface containment loss incidents in the last decade have further highlighted the significance of caprock integrity in the appraisal, development and abandonment stages of many thermal projects for operators, regulatory bodies, service companies and stakeholders.

From a technical perspective, it is essential to incorporate an integrated, multidisciplinary approach toward caprock integrity. Complexities such as heterogeneity and constitutive behavior in response to high pressure, high temperature, formation expansion and dilation, depletion, measurements, modeling, and monitoring challenges must be addressed. Additionally, the use of numerical modeling as a predictive tool and also the implementation of monitoring techniques require consideration. From an asset management standpoint, certain processes, reviews, and possibly teams required to proactively analyze containment of fluids below caprock are needed to provide recommendations to mitigate the risk of breaching the caprock seal.

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Workshop Format
Workshops maximize the exchange of ideas among attendees and presenters through brief technical presentations followed by extended Q&A periods. Focused topics attract an informed audience eager to discuss issues critical to advancing both technology and best practices.

Many of the presentations are in the form of case studies, highlighting engineering achievements and lessons learned. In order to stimulate frank discussion, no proceedings are published and members of the press are not invited to attend.
TECHNICAL AGENDA

TUESDAY, 20 SEPTEMBER

0700-0800 | Workshop Registration/Breakfast

0800-0930 | Session 1: Geological and Geomechanical Characterization of Caprock

Session Chairs: Rachelle Pinnow, Cenovus Energy
Sahar Ghannadi, University of Alberta
Vahid Mostafavi, ConocoPhillips Canada

Detailed characterization of geological and geomechanical properties of the caprock before thermal operations is required to recognize the containment risks at static conditions. A simplified static geological and geomechanical model generated with unrealistic assumptions does not allow for reliable pre- and post-steaming caprock and well integrity analyses. The geological analysis involves sedimentological, structural and petrophysical analyses, interpretation of depositional environment (i.e. geometry of the caprock, and facies), as well as mapping discontinuities such as fractures, Quaternary incisions, and karsting. The geomechanical characterization consists of estimation of in-situ stresses, mechanical properties and pore pressure. This session includes presentations focusing on this topic of caprock characterization.

- Presentation 1: Static Geomechanical Modeling: Significance and Workflow
  Vahid Mostafavi, ConocoPhillips Canada Ltd.
- Presentation 2: Characterization of Natural Fractures in Caprock Using Borehole Resistivity Images
  Dragan Andjelkovic, Schlumberger
- Presentation 3: Firebag Pad 110 Bullheading Startup Geomechanical Assessment
  Ken Powless, Suncor Energy

0930-1000 | Poster Showcase & Coffee Break

1000-1130 | Session 2: Challenges and Uncertainties for Caprock Modeling

Session Chairs: Mohammad Islam, Strategic Reservoir Solutions Inc.
Mazda Irani, Suncor Energy
Dale Walters, CGG Services (Canada) Inc.

This session will discuss inherent challenges and recent advances in geomechanical modeling studies involving thermal applications. Such modeling studies will cover estimating the stress changes within the caprock, examining the integrity of the cement sheath of thermal injection wells, evaluating the effects of intrinsic stress anisotropy and natural fractures within the shale layers in caprock assessment as well as understanding the challenges involved in modeling geomechanical impact of CSS operations.

- Presentation 1: Risk Analysis and Scales of Investigation in the Modeling of Thermal Well and Caprock Integrity
  Ken Glover, Trican Well Service
- Presentation 2: Numerical Assessment of the MOP in SAGD Considering the Mechanical Anisotropy of the Cap Shale
  Alireza Nouri, University of Alberta
- Presentation 3: Modeling Approaches at CNRL's Primrose CSS Operation
  Peter Thomsen, CNRL

1130-1300 | Networking Luncheon

1300-1430 | Session 3: Challenges of Laboratory Analysis of Caprock

Session Chairs: Mike Carlson, Applied Reservoir Enterprises
Richard J. Chalaturnyk, Foundation CMG
Michelle Uwiera-Gartner, Gartner Works Ltd.

Laboratory testing of caprock is critical to properly characterize the rock properties for input into geomechanical models and the investigation of caprock modes of failure. The test results are also requested by the AER as part of project licensing applications. Understanding how these tests work, what results can be expected and options available are important to those involved in caprock studies.

- Presentation 1: Physical Modeling for SAGD Caprock Integrity with the Centrifuge Facility
  Richard J. Chalaturnyk, University of Alberta
- Presentation 2: Laboratory Measurement of Caprock Water Permeability
  Ming Liu, Big Guns Energy Services Inc.
- Presentation 3: Atterberg Limit Tests Indicate Physical Properties in Caprock: A Low Cost Screening Tool for Caprock Integrity Evaluation
  Michelle Uwiera-Gartner, Gartner Works Ltd.
Trust BitCan to Achieve Superior Caprock Integrity Results

At BitCan, we offer a complete solution package to achieve unparalleled caprock integrity results. With more than 100 years of combined experience, our industry leading professionals are equipped to address your toughest caprock integrity challenges.

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Trusted BitCan complete solution services include:
• open-hole mini-frac and formation tests;
• analytical calculation of mechanical properties from well logs;
• regional 3-D simulations and probability risk assessment; and
• continuous diagnosis and prognosis on the caprock integrity.

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• promote convective transport;
• place the stimulants at target time and space; and
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FUSE™: Fast and Uniform SAGD Start-up Enhancement (Canadian patent 2,817,612). Developed with a major SAGD operator, FUSE™ is a proven and trusted BitCan technology. Applied in marine and continental deposits on nearly 100 SAGD wells, FUSE™ has delivered an earlier production start, improved production rates and a rapid drop in CSOR. Inherently safe for the well and caprock integrity, FUSE™ can break through shale stringers near the wells, and does not require special well drilling and completion.
This session will look to discuss a current/modernized view on caprock monitoring design and strategy (short-term and long-term). With many of the producing companies following their incumbent observation well design, what is the next shift in managing and utilizing this data? Why and how we are monitoring the thermal project is a constant evolution. Please join us to address the advances and shortcomings of caprock monitoring. Take a peek into how dynamic modeling is changing the real-time picture of caprock monitoring, surveillance data collection, wells, 4D seismic, heave monitoring, and others.

- **Presentation 1:** Real Time Automated Alarm System for Long Term Reservoir Monitoring  
  Marc Prince, ESG Solutions

- **Presentation 2:** Mathematical Inversion of Monitoring Data as the Ultimate Means to Safeguard the Caprock Integrity  
  Yanguang Yuan, BitCan Geosciences & Engineering Inc.

- **Presentation 3:** Investigation of Post-Abandonment Surface Deformation in SAGD Operations  
  Amir H. Hosseini, ConocoPhilips Canada Ltd.

1630-1800 | Ice Breaker Networking Reception

**WEDNESDAY, 21 SEPTEMBER**

0700-0800 | Workshop Registration/Breakfast

0800-0930 | **Session 5: In-situ Stress Testing in Caprocks: DFITs, Minifracs, and Microfracs**

Session Chairs: Pat McLellan, McLellan Energy Advisors  
Robert Hawkes, Trican Well Service Ltd.  
Ken Powlow, Suncor Energy

In this session we will hear presentations on comprehensive field stress testing programs conducted in caprock shales of the Clearwater Formation and Colorado Group. Operational, test design, and interpretation aspects will be described including differences in techniques that reflect varying injection volumes, equipment, formation permeability, fracture closure pressure selection, and project goals. A comparison of measured stress data to calculated stresses using different predictive equations highlights the importance of local calibration and the caution required when extrapolating stresses to locations where geological history, pore pressures and overburden stresses differ. Complications that arose in performing stress tests in a deep Leduc water disposal reservoir and its caprock will complete this session.

- **Presentation 1:** Insights on Thermal Reservoir Recovery Containment; Integrating Geology with DFIT Interpretation  
  Radu Buzea, Cenovus

- **Presentation 2:** Predicting Minimum Horizontal In-situ Stresses in Shallow Alberta Caprocks Compared to Measured Microfrac-Derived Stresses: Which Models Work Best and Why?  
  Pat McLellan, McLellan Energy Advisors Inc.

- **Presentation 3:** Didn’t Crack Under the Stress, Challenges in Openhole Stress Testing  
  Barbara Wingate, Shell Canada

0930-1000 | Poster Showcase & Coffee Break

1000-1130 | **Session 6: Regulatory Aspect of Caprock Integrity**

Session Chairs: Michael Webb, Suncor Energy  
Corey Froese, Alberta Energy Regulator

For many provincial regulators and SAGD operators in the Athabasca region, 2014 and 2015 were important years to assist in building the draft directive for Reservoir Containment for Shallow Thermal Bitumen Recovery. This panel discussion focuses on the key discussions and technical work that went into the AER’s Reservoir Containment for Shallow Thermal Bitumen Recovery draft directive. Starting with two technical speakers from the AER and CAPP, this panel discussion allows the audience to participate in a broader discussion about the role of the regulator in directing best practices for caprock definition, assessment and monitoring.

- **Presentation 1:** Evolution of Regulation for Ensuring Caprock Integrity in Shallow SAGD Operations  
  Felix Chiang, Alberta Energy Regulator

- **Presentation 2:** An Industry Assessment of Reservoir Containment in the Shallow Thermal Area—A Risk Management Approach  
  Patrick McDonald, Canadian Association of Petroleum Producers

- **Panel Discussion:** Regulatory Framework for Reservoir Containment for Shallow Thermal Bitumen Recovery  
  Panel participants:
  - Felix Chiang, Reservoir Engineer, Alberta Energy Regulator
  - Patrick McDonald, Oil Sands Manager, Canadian Association of Petroleum Producers
  - Andrew MacPherson, Director In Situ Authorizations, Alberta Energy Regulator
SPE Thermal Well Integrity and Design Symposium

29 November-1 December 2016
The Banff Springs Hotel | Banff, Alberta, Canada
www.spe.org/go/thermal

Join the experts in the thermal in-situ community to gain insights on how to maximize recovery, reduce costs and prevent harmful environmental impact through effective thermal well design and integrity management.

### Upcoming SPE Canada Events

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<td>Thermal Well Integrity and Design Symposium</td>
<td>29 Nov–1 Dec 2016</td>
<td>Banff, Alberta</td>
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<td>Unconventional Resources Conference</td>
<td>15–16 Feb 2017</td>
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<td>Heavy Oil Technical Conference</td>
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### Upcoming SPE Canada Training Courses

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<td>Addressing New Opportunities in Mature Oil and Gas Fields</td>
<td>27 Oct 2016</td>
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<td>Geology for Engineers</td>
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<td>Introduction to Petroleum Engineering and Geosciences for the Energy Industry</td>
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<td>Strain-Based Casing Design for Thermal Applications</td>
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<td>Geomechanics for Caprock and Casing Integrity in Thermal Recovery</td>
<td>28 Nov 2016</td>
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<td>Casing and Tubing Design</td>
<td>6–7 Dec 2016</td>
<td>Calgary, Alberta</td>
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For more information about SPE Canada events visit [www.spe.org/canada](http://www.spe.org/canada)
1130-1300 | Keynote Luncheon: “Public Perception and Thermal Applications: Bolstering the Social Licence to Operate” Talk From Borden Gervais Ladner LLC

Speaker: Alan Ross

All regulatory bodies operate in a broader social and political context. Recently, the concept of social licence has received increased attention in debates over natural resource extraction and regulation. This presentation will review both the concept of social licence and its impact on regulatory decision making. The latter will focus specifically on the relevance of social licence with regard to thermal applications.

1300–1430 | Session 7: Analysis of Caprock Failure Incidents

Session Chairs: Mike Carlson, Applied Reservoir Enterprises
Peter Thomsen, CNRL
Michelle Uwiera-Gartner, Gartner Works Ltd.

Past experiences are important for understanding and defining caprock integrity. This session reviews some of industry’s experiences and learnings to date. A significant part of the AER’s requirements for project approvals are based on field operational experiences.

- Presentation 1: Primrose Flow To Surface Study Findings
  Peter Thomsen, CNRL

- Presentation 2: Forensic Reservoir Geomechanical Analysis of the Joslyn SAGD Steam Release Incident
  Rick Chalaturnyk, University of Alberta

- Presentation 3: Mechanical Behaviour of Faults in Caprock During SAGD Operation
  Baohong Yang, BitCan Geosciences & Engineering Inc.

1500–1630 | Session 8: Risk Management Tools and Processes for Subsurface Containment Assurance

Session Chairs: Anthony Nguyen, Devon
Mehdi Khajeh, Cenovus Energy
Corey Froese, Alberta Energy Regulator

This session will review current practice of Risk management tools, techniques and processes for subsurface containment assurance. The session will begin with an overview of risk management from the Alberta Energy Regulator (AER) perspective and its application to caprock related activities. This will be followed by presentations from industry operators outlining the current and future state of practice for managing subsurface containment through preventative and reactive systems.

- Presentation 1: Regulatory Application of Risk Management for Caprock Integrity
  Corey Froese, Alberta Energy Regulator

- Presentation 2: Considerations for Subsurface Integrity Management (SSIM) in Thermal Operations
  Benjamin Pulgar, Chevron

- Presentation 3: Containment Assurance Risk Management System
  Kate Easton, ConocoPhillips Canada Ltd.

1630–1700 | Workshop Wrap Up

On behalf of all the speakers and committee members of the SPE Workshop: Caprock Integrity for Thermal Applications and in lieu of speaker/committee gifts, SPE Canada has made a donation to Edmonton's Food Bank.

We have chosen this charity because of its support to those affected by the Fort McMurray Fire.

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