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SIMULATION

ANNUAL REPORT

2025 - 2026

TABLE OF CONTENTS

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WE BELIEVE THAT . . .

“Diversified sources of affordable energy, including petroleum and natural gas, are required to meet growing global demand. The research that we sponsor develops technologies and skills to improve global energy security, while reducing environmental impacts.”

VISION

“ Creating a more sustainable energy future through simulation research. ”

MISSION

“ Promote and fund university research in energy resource modelling with industry collaboration and technology transfer.”

MESSAGE FROM MANAGEMENT

Welcome to our 2025-2026 annual stakeholder report. The year was defined by a continued focus on technically rigorous, industry-relevant research, a strengthened global engagement at our events, and a shared commitment to advancing practical solutions for global energy challenges.

Guided by our members and partners, Energi Simulation remained focused on its core mandate: promote and fund university research in energy resource modelling with industry collaboration and technology transfer. Throughout the year, we consistently emphasized that the global energy transition is a challenge of addition rather than substitution. Our research chair and engagement activities highlighted scalable technologies, system integration, and the realities of global energy security and energy poverty concerns, reinforcing Energi Simulation's role as a dependable and technically grounded voice in global energy discussions.

A major driver of impact continues to be the work of our 12 research chairs across 10 universities in 6 countries. Together, these chair teams represent a global network of approximately 300 researchers conducting impactful work in areas such as reservoir simulation, geomechanics, geothermal energy, carbon capture and storage, underground hydrogen storage, and energy data science. Collectively, Energi Simulation–supported research has contributed to more than 5,700 publications and has graduated over 1,100 students since 2008. This body of work directly supports energy resource modelling and underpins practical, deployable solutions for future energy systems.

A key milestone during the year was the well-attended Energi Simulation Summit and School in Rio de Janeiro, Brazil. Held during September 23–26, 2025, the event brought together industry members, research chairs, students, and an online audience under the theme 'Unlocking Global Energy Resources'. The Summit and School strengthened knowledge transfer, showcased research outcomes, and deepened collaboration across industry and academia on a global scale.

Photo: ES Board of Directors, Research Chairs and Management group photo at the Energi Gala 2025 in Rio de Janeiro, Brazil

As an organization committed to advancing technical research for the benefit of industry and society, Energi Simulation recognizes the importance of fostering informed conversations about the evolving global energy landscape through its role as a principal sponsor of the documentary '*War on Carbon*: *The Battle for the Future of our Planet*'. The film draws on Energi Simulation–supported research and global case studies to explore practical, technology-driven pathways to meet growing global demand for energy and emissions reduction, including geothermal energy, CCUS, and hydrogen. A rough cut was presented at the Summit in Rio de Janeiro and at COP 30 in Belém, Brazil, extending the reach and influence of Energi Simulation's research beyond traditional technical audiences.

Photo: Research Chairs Giovanni Grasselli, Rick Chalaturnyk, Hadi Hajibeygi and Sebastian Geiger (4 out of the 6 Chairs featured in the film) are with movie producer Sylvester Ndumbi for the 'War on Carbon' Rough-Cut Premiere at the Energi Simulation Summit 2025 in Rio de Janeiro, Brazil

With a cumulative research funding of 53 million Canadian dollars since 2008, Energi Simulation continues to serve as a global facilitator and catalyst in connecting industry and academia, providing funding and guidance, and enabling impactful research that advances both energy security and emissions reduction. We remain committed to delivering value to our members and to strengthening our global influence through credible research, technology transfer, collaboration, and leadership.

~ Energi Simulation Management

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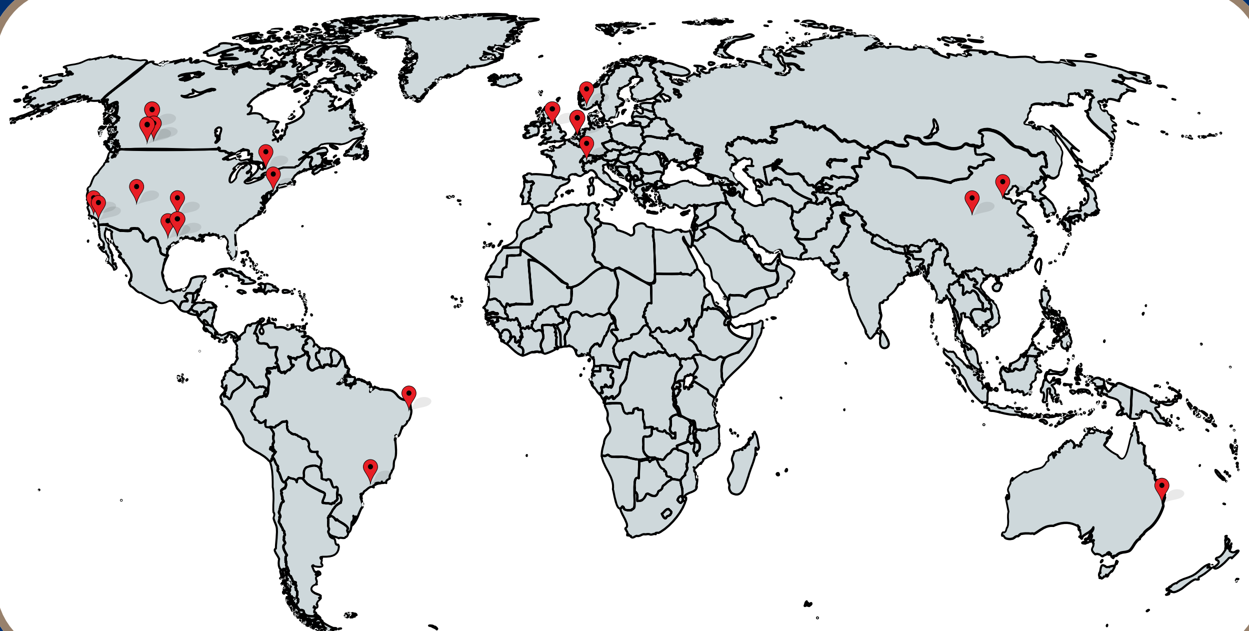
RESEARCH CHAIRS IN 2025



Former and Current Research Chair and Project Locations

University of Calgary
Dr. Apostolos Kantzas
Energy Transition

USC University of Southern California
Dr. Behnam Jafarpour
Subsurface Energy Data Science

TU Delft
Dr. Sebastian Geiger
Sustainable GeoEnergy

University of Toronto
Dr. Giovanni Grasselli
Geomechanics for Energy Transition

TEXAS The University of Texas at Austin
Dr. Ryosuke Okuno
Carbon Utilization & Storage

TU Delft
Dr. Hadi Hajibeygi
Subsurface Storage & Multiscale Modelling

University of Alberta
Dr. Rick Chalaturnyk
Subsurface Energy Geomechanics

ETH zürich
Dr. Maren Brehme
Geothermal Exploration and Operation

Heriot Watt University
Dr. Arne Skauge
Low Net Carbon EOR and Energy Transition

Universidade Federal de Pernambuco
Dr. Leonardo Guimarães
Underground Storage and Reservoir Management Optimization

UNICAMP
Dr. Denis Schiozer
Short-term Reservoir Management and Digital Fields Concepts

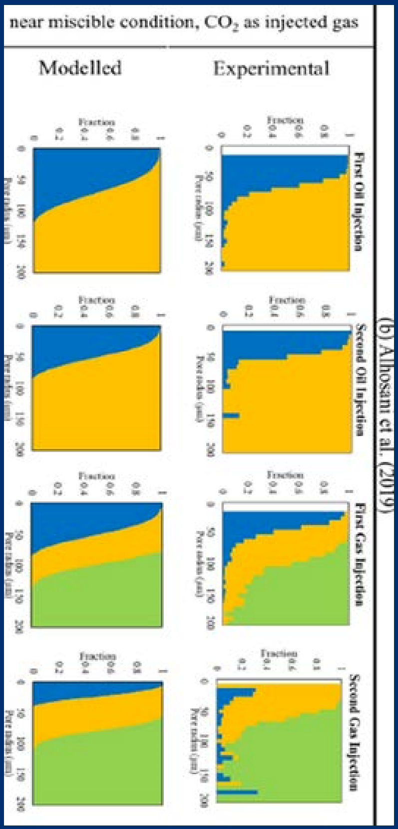
Heriot Watt University
Dr. Eric Mackay
CCUS and Reactive Flow Simulation

BACKGROUND

In the evaluation of gas injection, water-alternating-gas (WAG) injection, or gas storage in mature oil reservoir projects, understanding of three-phase fluid flow as functions of saturation history, phase trapping, hysteresis in flow functions, and transition towards miscibility is important. Dr. Arne Skauge's research team have studied and addressed some of these complicated fluid flow characteristics.

RESEARCH FOCUS

Going back to the basics, the research team's recent focus was to understand three-phase pore filling as consequences of transition to miscibility at different wetting conditions. By including an empirical model to 3D relative permeability and a model anchored to pore scale 3-phase physics into one complete WAG model that covers all WAG cases from immiscible to miscible conditions, evaluation of gas/WAG injection and storage projects would be more robust and provide more realistic and reliable results.



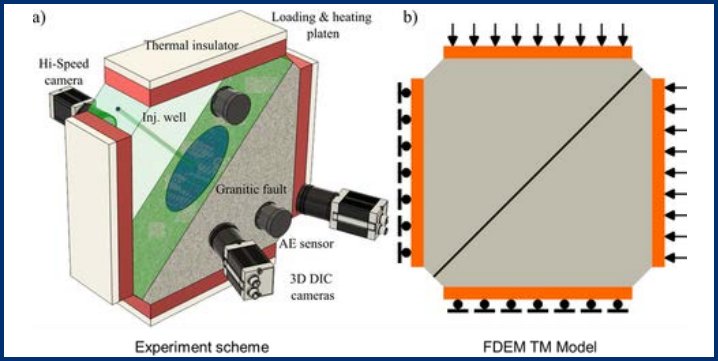
OUTCOME

It was found that immiscible to miscible transition affects both the 3-phase occupancies and the 3-phase displacement paths for some wettability distributions quite radically. Investigating various wettability structures (water-wet, oil-wet, mixed-wet and fractional-wet), smaller pores are the key physical rock parameter that controls and determines phase invasion saturation paths. In all wettability structures with different gas injection (N_2 and supercritical CO_2) and miscibility conditions (immiscible and near miscible), the applied theory captures the physics of 3-phase displacements using the simplest capillary bundle (CB) model despite limitations of the CB model. The applied model is verified by experimental data, both the theory and the results (minimum parameter adjustment), which means the underlying 3-phase displacement physics is broadly valid. However, there are other phenomena that the CB model cannot model. Future work would include phase trapping and hysteresis using pore network model. Better understanding of 3-phase fluid systems should help with the technical and economic evaluation of fluid injection or subsurface energy storage projects.

University of Toronto – Dr. Giovanni Grasselli
Theme: Geomechanics for Energy Transition

BACKGROUND

With expertise in experimental testing, rock mechanics, fracture modeling, geophysics, micro-seismic, microscopy, AI/ML, geoscience, and a state-of-the-art geomechanics testing laboratory set-up and numerical modelling capabilities, Dr. Grasselli's research team has been providing technical support to oil and gas, mining, tunneling, concrete material, geophysics, and nuclear waste storage projects. Notable recent research impacts are the finding that fracture propagation during hydraulic fracturing in a formation could be influenced by bedding planes, and the development of numerical models that could predict induced seismic activities due to fluid injection into subsurface reservoirs.



RESEARCH FOCUS

A physical model, with a granitic fault, was set up to study injection induced seismicity in geothermal reservoirs. Injectivity, pressure and temperature, fault cracking and slip were monitored. A conceptual thermomechanical (TM) finite discrete element model (FDEM) was also set up to match observations from the experiment.

OUTCOME

Experimental results indicated that pressure peaked at 8 MPa during the first cycle; however, despite a 66% increase in injection rate in the subsequent cycles, the peak pressure decreased. This decrease is attributed to permeability enhancement caused by cooling-induced off-fault cracking and fault slip. Two off-fault macrocracks partitioned the fault into three segments, which slipped interactively, with slip illustrated at two points within each segment.

Cracks initiated and propagated perpendicular to the fault, driven by cooling-induced tensile stresses; subsequently, macroscopic normal faulting deflected the propagating macrocracks into a subvertical orientation. Relative position on cracks on the foot and hanging walls are similar in both the experiment and FDEM-TM model.

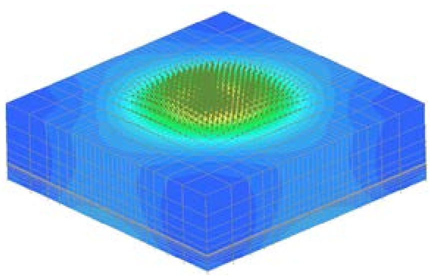
The research team has been successful in using 3D kinematic DIC (digital image correlation), High Speed DIC, and AE (acoustic energy) to infer invaluable and novel insights on kinematic and dynamic interactions between faults and fractures. Their FDEM TM model is also robust and realistic in matching the experimental observations. With better understanding of fault and fracture interaction due to pressure and temperature changes, and using the appropriate numerical modelling tools, geothermal energy extraction projects may be properly designed.

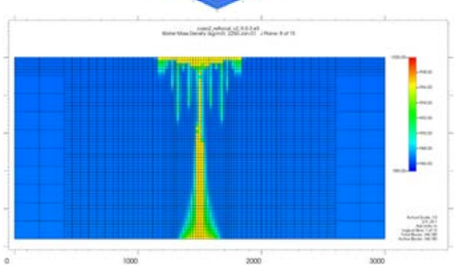
Universidade Federal de Pernambuco – Dr. Leonardo Guimarães

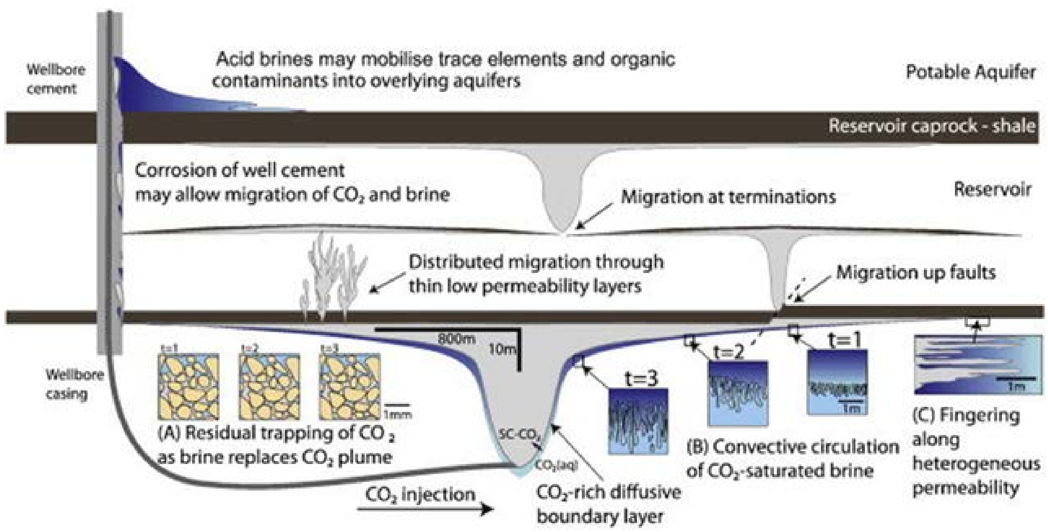
Theme: Underground Storage and Reservoir Management Optimization

BACKGROUND

Geomechanics plays an important role in carbon capture and storage (CCS) projects, encompassing well location, hazard assessment, and monitoring. Potential geomechanical risks, such as fault reactivation and cap rock fracturing, should be considered for CO_2 injection into geological formations. With state-of-the-art laboratory testing equipment and numerical modelling capabilities, Dr. Leonardo Guimarães and his research team have been performing studies, from micro- to macro-scale, helping to address the technical challenges relating to underground storage and reservoir management optimization in support of the industry.







RESEARCH FOCUS

The CO2GEOMEC project aims to develop numerical models for studying the geomechanical effects of CO_2 injection and plume migration in deformable geological formations in CCS projects. The modeling parameters are validated through laboratory experiments, including rock mechanics, conventional petrophysics, digital petrophysics, and tomography.

OUTCOME

Recent research work revealed that solving multi-physics problems in large domains requires a framework to separate spatial and temporal scales. How frequently information is exchanged between the different physics should be defined. Modelling should go beyond the governing differential equations, by integrating material properties and operational (boundary) conditions, which must be addressed on a case-by-case basis. For instance, even though both involve underground storage in porous media, CO_2 storage in saline aquifers and in depleted gas reservoirs differs in terms of available information, pressure history and stress path, trapping mechanisms, geochemical and geomechanical risks, and monitoring opportunities. In basalts, these differences are even more significant.

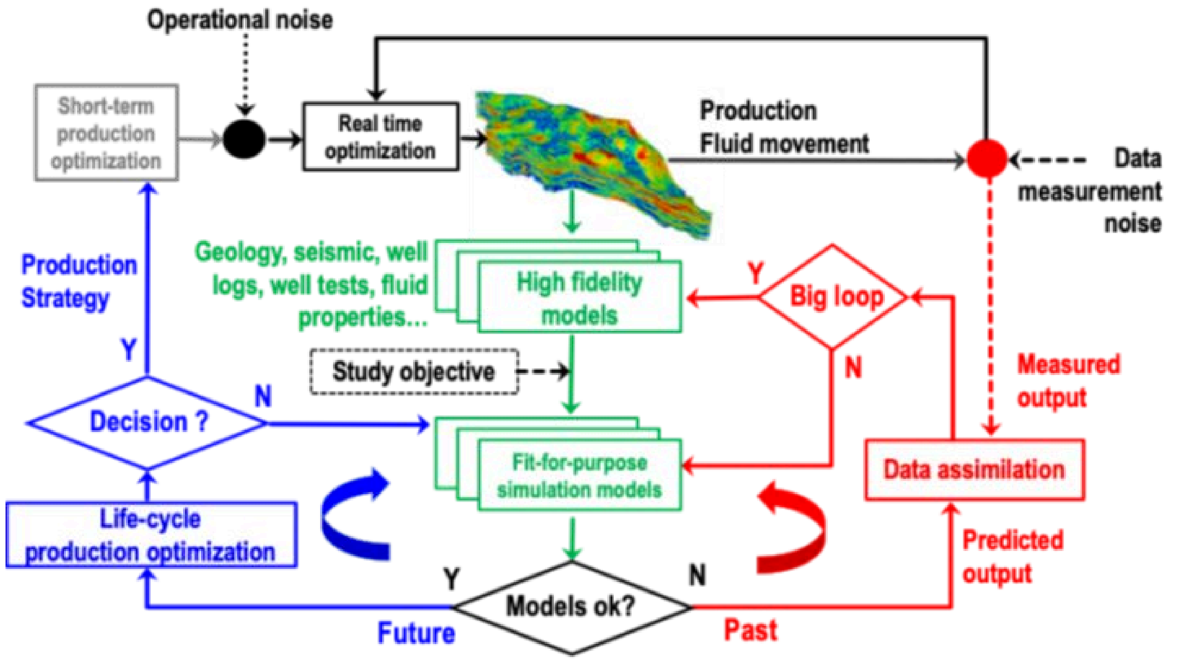
Universidade Estadual de Campinas – Dr. Denis Schiozer
Theme: Short-term Reservoir Management and Digital Fields Concept

BACKGROUND

Simulation models are often used for life-cycle objectives, but not for short-term, real-time applications. Life-cycle decisions based on reservoir models are very complex and time-consuming. There is a need to speed up decision process for real-time reservoir management of the prolific offshore pre-salt oil fields in Brazil, which requires much shorter time for decision making.

RESEARCH FOCUS

Dr. Schiozer's research team has been working to develop methodologies to improve the quality of short-term production forecast and decisions, by integrating machine learning with their data- and model-driven production strategy optimization workflow, for the field in digital form. They aim to contribute to the efficient and effective production of energy for the nation.



OUTCOME

The 12-step closed-loop reservoir management workflow developed by Dr. Schiozer has been effectively deployed to support life-cycle and short-term production optimization decisions for the pre-salt oil reservoirs. Using reservoir model- and production data-driven machine learning, applying to a digital-twin of the reservoir, realistic real-time operational decisions can be made. The conceptual digital twin is being developed and workflow enhanced to further improve its accuracy and reliability in supporting better field management including fast reaction to operational problems.

University of Calgary – Dr. Apostolos Kantzas

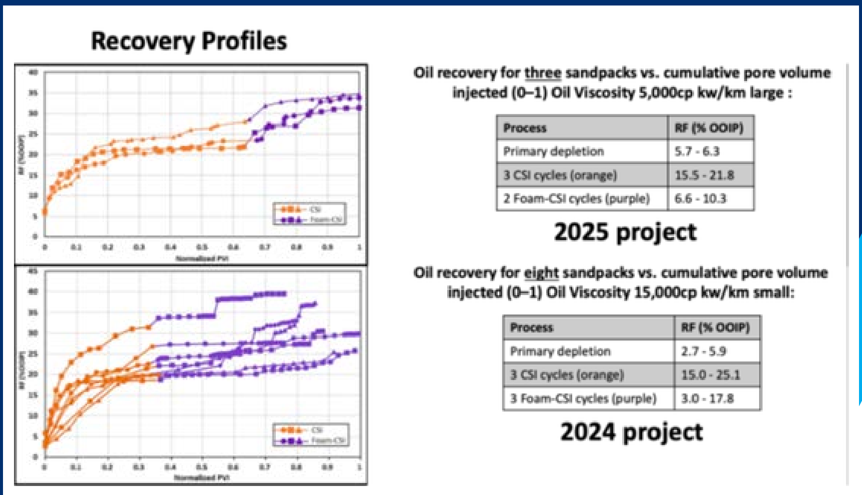
Theme: Energy Transition

BACKGROUND

In the pursuit of subsurface energy resource recovery technologies, nanofluids are being explored to enhance the effectiveness and efficiency of current processes. For instance, some nanofluids with better thermal and transport properties than water or other fluids could help optimize heat transfer while minimizing pressure loss and ensuring long-term stability of a geothermal energy extraction scheme. Nanofluids have also been used in enhance oil recovery projects.

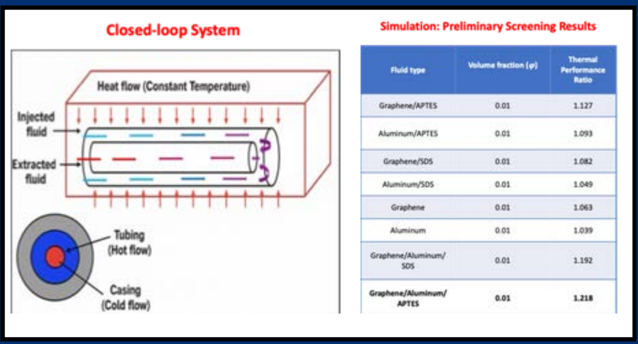
RESEARCH FOCUS

Dr. Kantzas' research program involves two major themes, with one on the fundamentals of unconventional resources, and the other on energy harvesting processes. For geothermal energy extraction projects, instead of using water, CO_2 or brine as heat carriers, the research team is working to develop and validate stable, efficient nanofluids. They also evaluate the use of nanoparticles to further enhance oil recovery from foam assisted cyclic solvent injection schemes.



Process	RF (% OOIP)
Primary depletion	5.7 - 6.3
3 CSI cycles (orange)	15.5 - 21.8
2 Foam-CSI cycles (purple)	6.6 - 10.3

Process	RF (% OOIP)
Primary depletion	2.7 - 5.9
3 CSI cycles (orange)	15.0 - 25.1
3 Foam-CSI cycles (purple)	3.0 - 17.8



Fluid type	Volume fraction (φ)	Thermal Performance Ratio
Graphene/APTES	0.01	1.127
Aluminum/APTES	0.01	1.093
Graphene/SDS	0.01	1.082
Aluminum/SDS	0.01	1.049
Graphene	0.01	1.063
Aluminum	0.01	1.039
Graphene/Aluminum/SDS	0.01	1.192
Graphene/Aluminum/APTES	**0.01**	**1.218**

OUTCOME

In a geothermal system, the advantages of surface modified (Coated) nanofluids are high surface area for greater heat transfer, high stability with dominant Brownian motion, lower pumping power for the same heat transfer, less clogging thus enabling miniaturization, and tunable properties via particle concentration. For the closed-loop system studied, it was found that a hybrid fluid of graphene/aluminum/APTES [(3-Aminopropyl)triethoxysilane] could deliver the highest thermal performance at both low and high concentrations, outperforming all other fluids.

For enhanced oil recovery process, foam assisted cyclic solvent injection has been shown to increase oil recovery by improving sweep efficiency, solvent performance and storage. The introduction of nanoparticles helps to prevent film thinning and bubble coalescence, further increasing sweep efficiency and foam stability.

Delft University of Technology – Dr. Sebastian Geiger

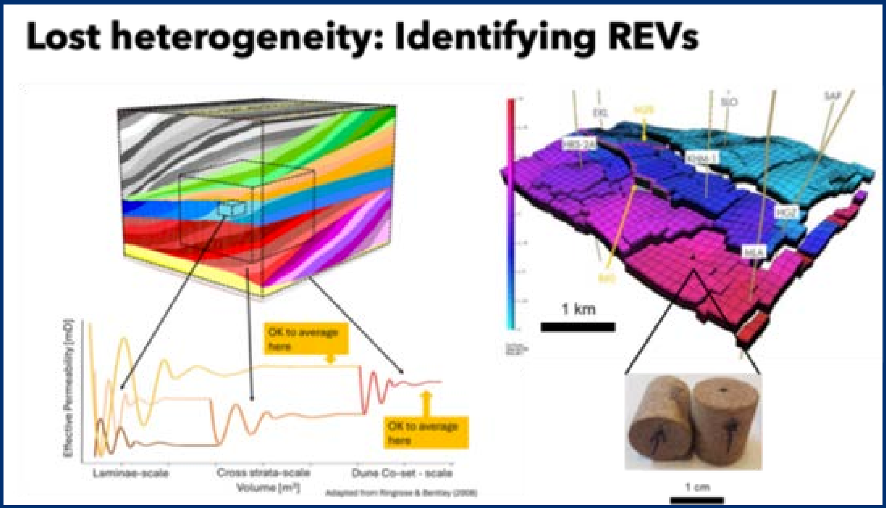
Theme: Sustainable GeoEnergy

BACKGROUND

Having reasonably realistic geological models for subsurface energy resources is essential for proper their exploration and development planning. However, because of limited data availability, from core samples, well logs, and if affordable, seismic surveys, it would be useful to have agile workflows to build meaningful models faster and capture heterogeneity across scales, helping to identify the most valuable information and screen the most promising project locations.

RESEARCH FOCUS

Dr. Sebastian Geiger and his research team have developed an open-source rapid reservoir modelling (RMM) tool that could generate geological models quickly based on preliminary understanding and sketches of geologic stratigraphy. Streamline flow simulations are then run using multiple realizations of the geologic model to arrive at a reasonable interpretation. To further capture the heterogeneity across scales, they adopted an approach to identify representative elementary volumes (REVs). This is a concept from materials and geoscience used to define a volume over which a measurement is representative of the whole. This allows the use of fewer but representative grid blocks in reservoir simulation, providing faster and reasonable delivery of results.



OUTCOME

Methods to identify REVs for porosity and permeability in geological models were tested successfully. Simple guidelines for REVs were developed, REVs were validated. While we cannot get way with traditional history matching workflows in low-carbon energy applications, we need to do better in transferring geological heterogeneity across scales, especially for complex physics. The combination of RRM and REV workflows provides a quick and reasonable reservoir model for subsurface energy resource evaluation.

Theme: Geothermal Exploration and Operation

BACKGROUND

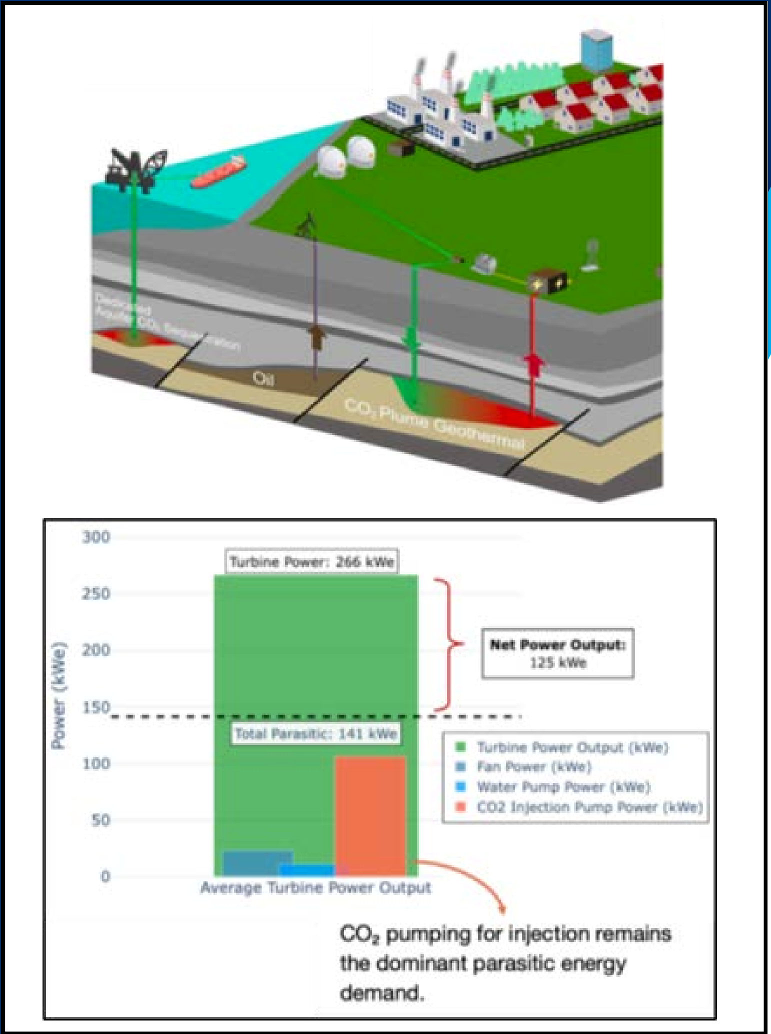
CO_2 plume geothermal (CPG) has been proposed as a novel technology that couples geological carbon storage (GCS) and sustainable, clean power generation, for achieving the global negative emission targets. Mature oil fields offer significant potential for the implementation of CPG energy production. Combining CO_2 EOR and CPG could potentially make CCUS operations more sustainable and economically viable.

RESEARCH FOCUS

A research project with 3D reservoir models were set up to simulate sequentially the three stages of field operation, from waterflooding to CO_2-EOR, followed by CPG. Coupled reservoir-wellbore simulations with surface facilities were also performed. Surface processes and parasitic loads were modeled with an in-house software for techno-economic analysis of geothermal systems to evaluate net power output and system performance.

OUTCOME

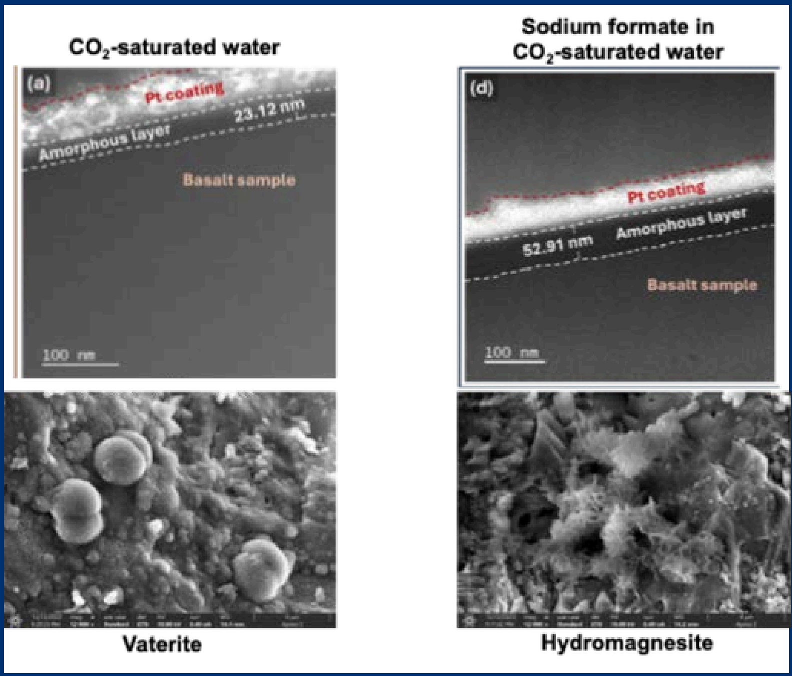
For the base case, which was a relatively homogeneous 1 km² reservoir with 0.1 PV/year CO_2 injection, the transition from CO_2-EOR to CPG yields a thermodynamically feasible phase of power generation, with net-positive output maintained over multiple years. It was concluded that post-EOR reservoirs can sustain net-positive power via CPG. Net output is strongly affected by parasitic loads, especially CO_2 pumping. Injection rate, reservoir heterogeneity, and power plant design affect overall performance.



University of Texas at Austin – Dr. Ryosuke Okuno
Theme: Carbon Utilization and Storage

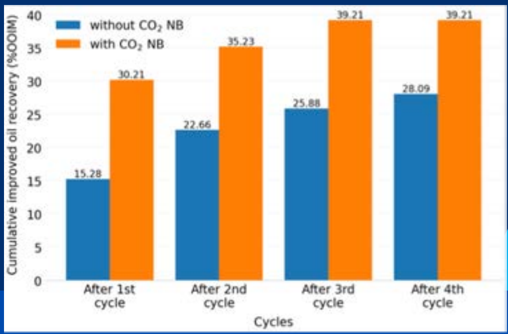
BACKGROUND

Because of the density and viscosity differences of CO_2 and formation fluids (i.e. water, oil), development of CO_2 injection / storage projects needs to consider conformance, containment and capacity issues. The potential of having an engineered fluid that could enhance the capturing and storage of CO_2 should be investigated. To reduce the environmental footprint of existing CO_2 EOR projects, it would be an added benefit if the engineered fluid could further increase the economic recovery and subsequently expand the CO_2 storage capacities of the fields.



RESEARCH FOCUS

Dr. Okuno's research program focuses on the fundamentals of thermodynamics and (geo)chemistry, engineered fluids, experimentation, and software development, in support of CCUS and EOR. Three main functional fluids being studied are ketone, nanobubble and formate, with the latter two being related to CCUS research.



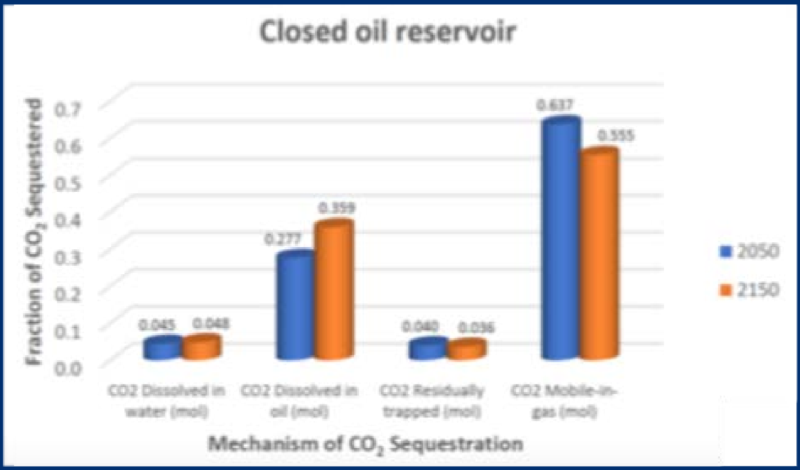
OUTCOME

Nanobubble fluid was found to have 1.7 to 1.8 times the inherent solubility for CO_2. It could serve not only to further enhance oil recovery, but also act as a higher capacity carrier of CO_2 than traditional fluids for CO_2 storage. Another promising carbon carrier is formate species (sodium or potassium formate). Formate is highly soluble in brines. It is widely used to densify well-completion/workover fluids, because of its good HSE profiles and low cost. With its mobility control and wettability alternation abilities, formate was found to be a good EOR agent in earlier studies by Dr. Okuno. Formate can also be used as an alternative carbon carrier, generated from captured CO_2 or gas-fed electrochemical process. Aqueous formate solution also remains as an effective carbon carrier in shallow formations. Formate can also be applied to in situ mineralization of CO_2 in basalt. Dr. Okuno's experiments showed that sodium formate in CO_2-saturated water could enhance the dissolution of metal silicates, resulting in the precipitation of carbonate minerals.

Heriot-Watt University – Dr. Eric Mackay
Theme: CCUS & Reactive Flow Simulation

BACKGROUND

While there is a mandate to reduce CO_2 emissions in many nations, worldwide demand for hydrocarbons continues to grow at a pace of more than 100 million barrels of oil equivalent per day. Technologies that can deliver negative emissions are expensive. Addressing the challenges from a geoenergy perspective, technologies may be developed to make remaining oil and gas production more energy efficient, advance the use of lower carbon energy sources, and use hydrocarbon extraction to facilitate CO_2 storage efficiency and cost effectiveness.



RESEARCH FOCUS

Dr. Mackay's research has been on flow assurance and scale technology. To make remaining oil and gas production more efficient, research is being conducted on the management of oilfield scale in carbonate reservoirs, by evaluating solubility and retention of phosphate scale inhibitors and studying the impact of initial and injected CO_2 on in situ reactions and scale in wells. For the advance use of lower carbon energy sources and sectors, researchers are investigating the performance of polymeric scale inhibitors to prevent silicate scale, helping to manage oilfield scale in geothermal wells. Also, a numerical study of biological and geochemical reactions in porous media is being performed for the reactive flow during hydrogen storage. The research team also studied the synergies in CO_2 EOR with twin objectives of maximizing NPV and maximizing CO_2 left behind. Similarly, CO_2 injection into depleted gas reservoirs could also extend gas recovery and ultimately provide storage of CO_2. Temporary CO_2 storage to enable later CO_2 EOR, then subsequently permanent storage is also a CO_2 injection process design that is being evaluated.

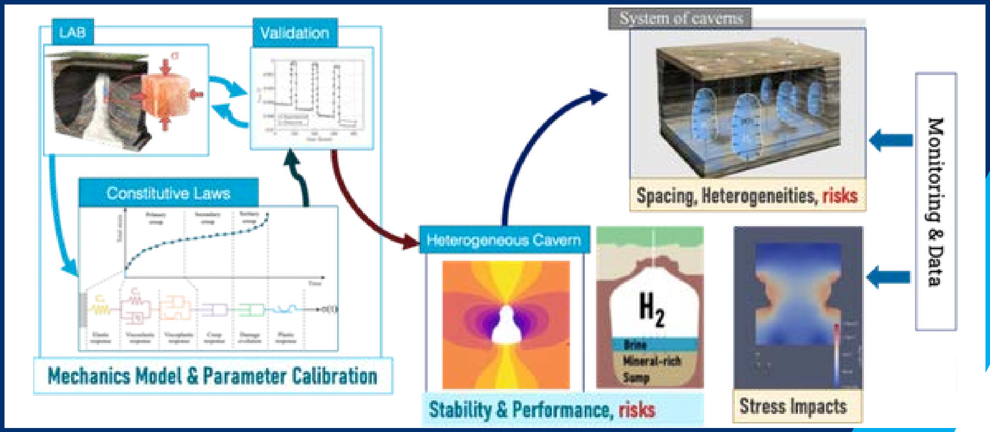
OUTCOME

While improvement to conventional oil recovery processes has been advanced over the years, onging research in the area still needs to be conducted. Learnings from the research could be applied to other fields in geoenergy more generally. New approaches to CO_2 flooding of oilfields to increase recovery with added objective of leaving CO_2 in subsurface – during or after oil recovery – as means to finance CO_2 storage are being developed. We should also look for synergies: e.g. utilizing pressure reduction from hydrocarbon recovery to increase CO_2 storage capacity, and pressure increase from CO_2 injection to improve oil recovery. Capturing and storing present day CO_2 emissions for recovery and future reuse in CO_2 EOR, with potential for ongoing storage, are also practical ways to support decarbonization efforts.

Delft University of Technology – Dr. Hadi Hajibeygi
Theme: Subsurface Storage and Multiscale Modelling

BACKGROUND

As the earth is home to 8.2 billion people,180,000 TWh energy is required annually, resulting in ~40 Gt CO_2 emissions each year. While scaling clean energy system is important, developing mass storage technologies for clean energy (e.g. hydrogen) is also crucial. To store giga-tonnes of hydrogen, deep salt caverns could provide the needed capacity. While there is over half a century of experience in solution mining from salt caverns, there are new technical challenges that need to be addressed for hydrogen storage.



RESEARCH FOCUS

To evaluate salt caverns for cyclic energy storage, one needs to evaluate dome-scale heterogeneities & uncertainties, faults & weak zones, system design & operation, and abandonment. For a single salt cavern, one should consider geomechanics, geology, geometry, stability (rapid cycles, wellbore), subsidence, bio-geochemistry & hydrogen exposure, and abandonment & monitoring, etc. Rock mechanics study is also essential. All these would involve laboratory studies, numerical simulations, and field applications. Professor Hajibeygi's research team has developed the 'SafeInCave' open-source simulator to help with forward & inverse modeling of underground hydrogen storage in salt caverns, from calibrating, simulation, optimization, to abandonment

OUTCOME

Laboratory testing provided data to construct constitutive laws and parameters for the rock, including transient creep characteristics. The impact of viscoplastic & viscoelastic deformations is important. Lab-scale can have higher sensitivities to viscoplasticity than field-scale. It was also found that model calibration is very important, as lab-scale had lower sensitivity to model parameters than field scale simulation. Higher discharge rates could result in formation stress changes that encroach upon the rock failure boundary. Fast cycling, heterogeneity & weak zones can be real challenges. Pressure-solution creep is critical when deviatoric stress <5MPa. This is important for underground hydrogen storage. The 'SafeInCave' is an easy to use, C++/Python-based tool, with good interface, for enhanced stability studies of underground hydrogen storage in salt caverns.

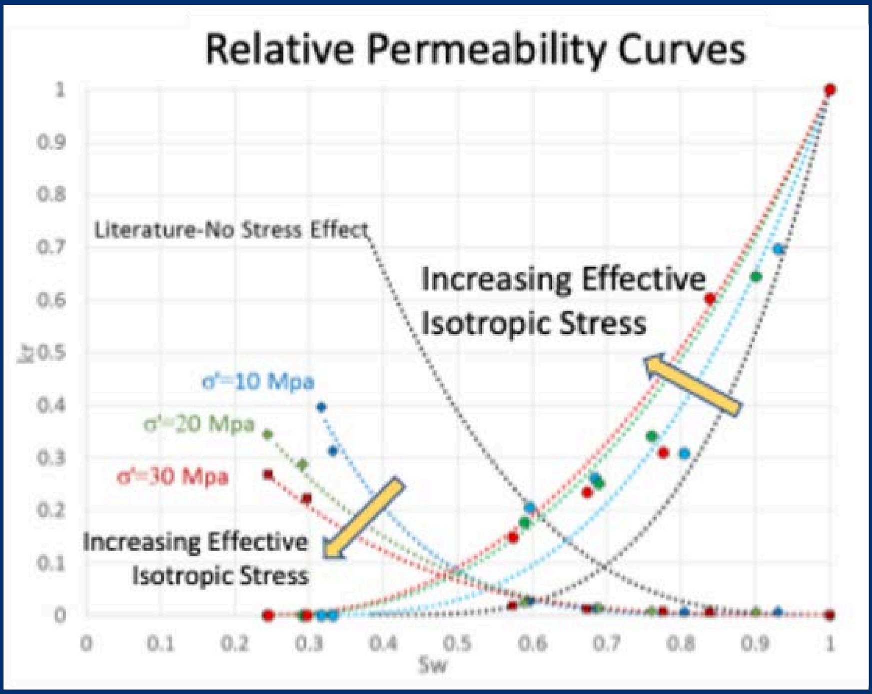
University of Alberta – Dr. Rick Chalaturnyk
Theme: Subsurface Energy Geomechanics

BACKGROUND

In the modelling of conventional and unconventional reservoirs for hydrocarbon recovery, and other subsurface energy projects such as carbon capture, utilization and storage (CCUS), underground hydrogen storage, and geothermal energy extraction, coupled or uncoupled reservoir-geomechanical simulators are often employed. The need for geomechanical modelling is not only for assessing caprock integrity, formation failure/leakage, surface subsidence/heave, fault reactivation, and induced seismicity, but also for predicting changes in porosity and permeability of the formation that could affect storage capacity and fluid flow.

RESEARCH FOCUS

Equipped with a state-of-the-art geomechanical laboratory testing facility at the University of Alberta, Dr. Rick Chalaturnyk and his research team members have been running physical experiments and numerical modelling to assess rock behaviour during the loading and/or unloading cycles of subsurface energy storage or extraction process, under various reservoir pressure, temperature, and anisotropic stress conditions. As impending (existing) regulations/standards will demand reservoir-geomechanical simulations of failure to identify leakage pathways, part of the team's recent research focus is on the understanding of rock behaviour under various stress paths.



OUTCOME

Failure modeling will require the full understanding of constitutive behaviour, which includes modeling pore pressure response up to and including during failure. Failure processes are complex and require experimental data to support modeling and understanding the predictions. Evolution of pore pressure is key for caprock integrity, induced seismicity, pressure communication, etc. It is important to know the stress paths and establish permeability relationships for the right stress paths.

BACKGROUND

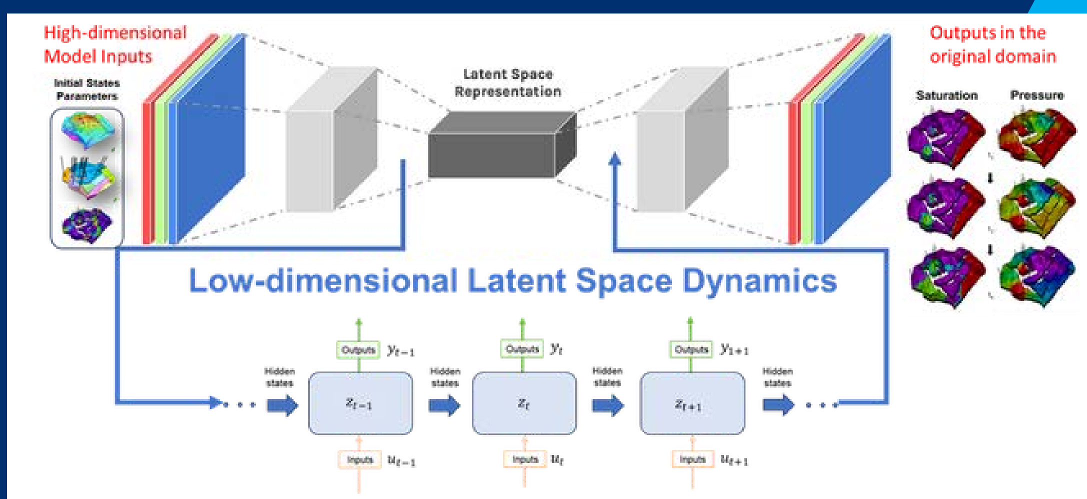
Integrating Physics and AI for Prediction in Subsurface Energy Systems

Subsurface energy systems, including geologic carbon storage, geothermal energy, and oil and gas reservoirs, rely on computational models to predict how fluids move deep underground. These models guide major operational and investment decisions. However, subsurface environments are highly complex, measurements are sparse and noisy, and traditional simulations are computationally intensive. Updating models with new field data can therefore be slow and uncertain, limiting real-time decision-making. The Chair program integrates physical laws with modern artificial intelligence to make subsurface modeling faster, more adaptive, and better suited for uncertainty-aware decision support.

RESEARCH HIGHLIGHT

AI-Enabled Data Assimilation for Subsurface Energy Systems

In 2025, the Chair developed a new deep learning framework for efficiently updating subsurface flow models using monitoring data from geologic CO_2 storage sites. Instead of repeatedly running large-scale simulations, the method learns compact and physically consistent deep learning-based representations of the subsurface flow system. These representations allow new data—such as pressure measurements or plume observations—to be incorporated quickly and reliably. The approach improves the consistency of model predictions while significantly reducing computational cost. This work was demonstrated on large-scale CO_2 storage problems, showing how AI can enhance both the speed and reliability of underground flow forecasting.



OUTCOME

The 2025 research advances a new paradigm for subsurface modeling: moving from slow, simulation-driven updates to efficient, data-informed prediction systems. By combining physics with AI, the Chair program enables faster forecasting, improved uncertainty management, and more confident decision-making. These advances strengthen the technical foundations for next-generation predictive tools for subsurface energy systems.