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Induced Seismicity Monitoring, Management and Mitigation (ISM3) for Gigaton CO_2 Storage

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Preamble

Like any type of large-scale industrial activity, geological storage of CO_2 produces environmental and safety hazards that require careful assessment, monitoring and mitigation. Among these hazards, induced seismicity — earthquakes attributed to human activity — has arguably provoked the most visceral public reaction and vigorous scientific debate. As CO_2 capture and storage (CCS) projects scale up from current megaton levels (e.g. Shell's QUEST project) to the gigaton (Gt) level required to achieve Canada's net-zero commitments, the subsurface volume affected by changes in pressure and stress will correspondingly increase — thus elevating the relative risks of induced seismicity compared with currently active projects.

For example, in the past decade there has been a net ~1 Gt of saltwater disposal (SWD) into deep formations in Oklahoma and southern Kansas, suggesting that the spatial footprint and logistical complexity in that context may apply for scaling-up CCS. While the subsurface conditions in western Canada are likely well suited for CCS at such a scale, there are known areas of induced seismicity from oil and gas development that must be avoided.

Progress in theoretical and numerical studies is necessary to understand complex, nonlinear systems that drive induced-seismicity processes and western Canada arguably represents the best area in the world to develop and refine these technologies, including development of "next-generation" methods for seismic risk forecasting.

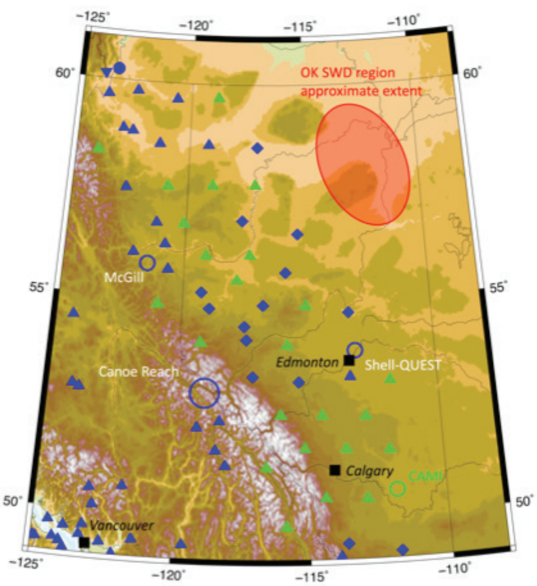
Objectives

The objectives of this proposed project are: 1) to densify existing real-time induced seismicity monitoring networks, in order to undertake baseline seismicity monitoring with uniform coverage over a region of sufficient size that it could encompass a Gt scale CCS project; 2) combine conventional seismograph monitoring with geodetic systems at 30 stations, to enable observations of slow-slip events that can elude existing monitoring; 3) to develop and validate a robust stochastic framework to enable probabilistic seismic hazard assessments derived from physics-based models. This approach will underpin the development of risk-management schemes for support of rapid, science-informed decision making that could enable injection sites to avoid triggering events that, left unmitigated, might shut down a project. The technology developed within this initiative will be readily exportable beyond Canada's borders.

Methods

1) Install a new network of up to 30 real-time telemetered seismograph stations (shown by green triangles) in Alberta (18) and British Columbia (6). This new network will complement existing stations (shown by blue symbols) as well as existing (blue) and proposed (green) seismograph arrays. Data from these stations will be streamed to existing archival facilities, where they will be available in near real-time to researchers around the world.

2) Highly qualified personnel (HQP) at the UCalgary, and other institutions, in collaboration with federal agencies and international partners, will develop advanced computational methods for physics-based simulation to create a stochastic framework for IS risk-management. The outcomes from this work will be validated using network observations from areas of known IS.



Proposed distribution of new stations (green triangles) existing stations (blue symbols) and arrays (circles). The approximate extent of saltwater disposal (SWD) in Oklahoma (OK) is shown for reference.

CAMI = Containment and Monitoring Institute, where a seismic array is already deployed.

Budget

The total budget for this proposal is $2.0M. Broadly speaking this includes $1.2M ($50K per station) to purchase and install equipment, operational cost of $100K per year for 3 years and $300K to recruit new HQP.

Timeline

This project is expected to commence starting in summer 2023.