

Controversies in Carbon Capture and Geological Storage

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Summary

Divergence of opinions, contentious debates, and the discomfort of cognitive dissonance are not merely disruptive forces; we argue that they can serve as guideposts to unexplored opportunities for those seeking a profound comprehension of the intricate world around us. One arena where such challenges are prominent is the field of carbon capture and permanent geological storage (CCS), a field with a relatively brief history.

The narrative of CCS unfolds through limited pilot studies conducted at locations like Quest in Alberta, Aquistore in Saskatchewan, Otway in Australia, and Sleipner in the North Sea, each offering invaluable insights (Furre et al., 2017; Dance et al., 2019; White et al., 2019; Harvey et al., 2021). Building on these foundations, Ringrose et al. (2022) spoke of the differences between CCS and gas and Hunt et al. (2023) employed analogical reasoning, drawing parallels from established geoscience domains to enrich our understanding. However, a note of caution is essential: the wisdom gleaned from pilot studies and analogies should not be accepted blindly. Scepticism and critical examination must accompany our reliance on these sources of knowledge, for lessons can be misleading and analogies can falter. Pilot studies, by their nature, deviate from the norm, and CCS, as a burgeoning field, harbours peculiar and unforeseen elements demanding meticulous scrutiny.

During this talk we will abandon comfort and confirmation bias with the attempt to get messy—it is time to look at the controversies in CCS. With that in mind, the intent of this talk is to be provocative, shining a light on some of the things that we believe are interesting and unique to CCS as well as some current thinking we believe should be examined and challenged. Be warned, a sense of humour is required for this talk, as we heavily employ satire.

Method

We intend to stimulate the audience by presenting thought-provoking ideas that are categorized into three distinct classes:

- 1) Puzzling aspects of CCS warranting in-depth consideration.
- 2) Imperative shifts required in an evolving field.
- 3) Exercise caution—certain elements in CCS should not be assumed.

We will present these ideas largely with the Socratic Method, by asking and answering questions, in a kind of a dialogue with the audience. No one will be singled out, but we will ask for some participation.

Observations—or, controversies...?

Let's brainstorm:

1. Seismic is not the only method for MMV (monitoring, measurement, and verification), but it is the most expensive. The cartoon shown in Figure 1 might seem offensive, but it is intended as humor meant to provoke discussion. In circumstances where seismic provides sufficient value, it can indeed justify its costs. Let us talk about those circumstances, the value that seismic brings and ways in which its costs may sometimes be reduced.

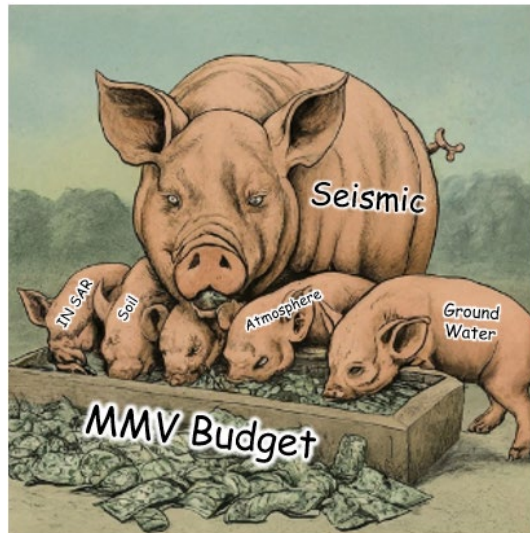


Figure 1 – Satirical drawing of the relative costs associated with MMV programs.

2. Figure 2 illustrates a 3D seismic tug-of-war— While some would like 3D everywhere, others prefer none whatsoever. Why does this divergence of opinion exist?

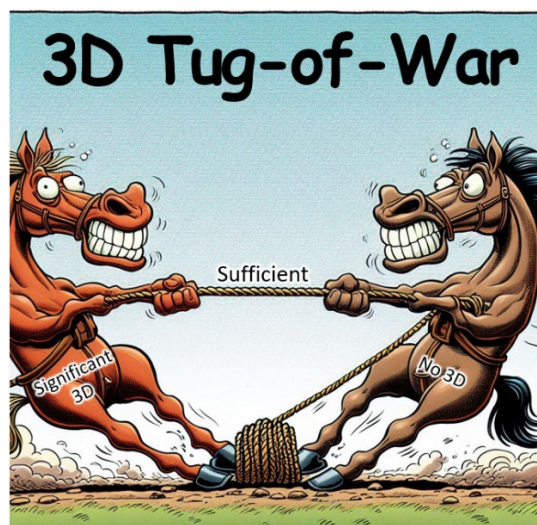


Figure 2 - Satirical figure depicting the disagreement over the role of 3D seismic in MMV. At stake is sufficiency.

3. Large-scale, commercial CCS projects are significantly different than a pilot.
4. Onshore and offshore CCS projects are different.
5. Most carbonate storage intervals will not be like Weyburn. Weyburn is easily monitored seismically as it's very porous. Significant work will be required for deeper, tighter carbonates sitting below thick Mannville coal sections in regions like central Alberta.
6. Permanent storage of CO₂ in deep saline aquifers does not require structural or stratigraphic trapping mechanisms.
7. "Wet discoveries," or, what our oil and gas colleagues would describe as a dry hole. What is good about them, and what are we missing because we have a legacy of thinking about petroleum systems and looking at areas from a hydrocarbon lens?
8. Some have referred to Alberta as the "Saudi Arabia of storage" when describing the regional storage potential of the Basal Cambrian Sandstone (BCS). How can such claims be made given the miniscule wellbore dataset associated with this interval? What if some hub proponents drill appraisal (i.e., exploration...) wells and encounter subsurface characteristics that are far poorer than expected? Figure 3 depicts typical exploration well outcomes in the pursuit of oil and gas discoveries. Will CCS appraisal wells demonstrate that there are larger wedges of economic storage and injectivity on the exploration wheel? Only time will tell.

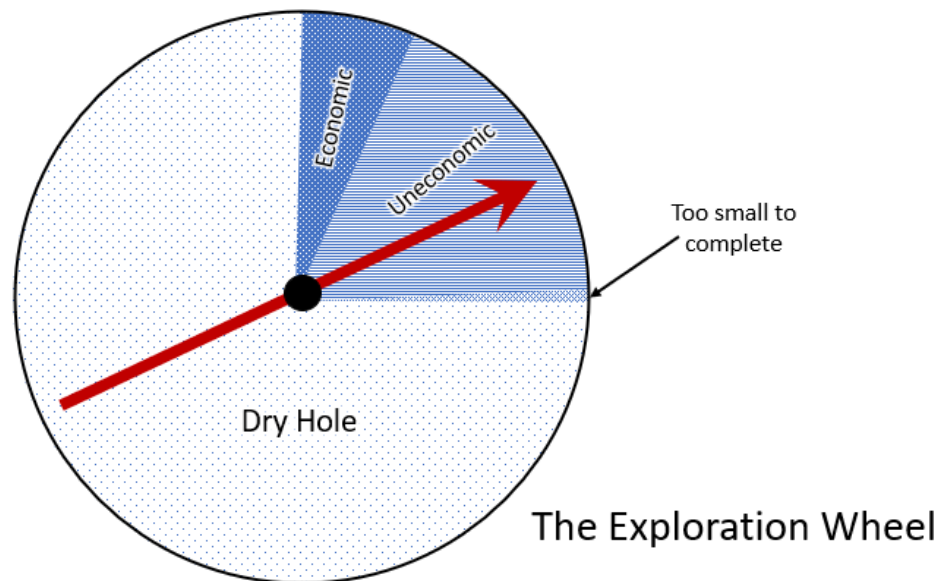


Figure 3 - The Exploration Wheel. Fictitious well outcomes are highlighted by the various categories shown on the wheel. Testing of the range of potential outcomes is obtained by spinning the red arrow around the wheel (modified from Capen, 1992).

9. CCS and cement production facilities share similarities in that they are most likely to be located proximal to their customer(s). For every additional kilometre of pipe needed for CO₂ transportation, the costs of a CCS project increase rapidly. This is unlike oil and gas fields, where economic developments have occurred in extremely remote areas.

Novel Information

This presentation aims to stimulate contemplation by delving into the intriguing nuances and distinctive aspects of CCS. Shedding light on these intricacies is intended to underscore their inherent value. One notable aspect worth exploring is the absence of a traditional trapping mechanism for geological storage of carbon in deep saline aquifers in Canada. This deviation raises a compelling point for discussion, especially in the context of ensuring the perpetual containment of injected CO₂—a concept that may initially seem paradoxical but deserves thoughtful examination.

However, the discourse doesn't end with these peculiarities. It extends to a critical evaluation of how we approach CCS itself. The methodology, specifically the application of MMV, demands a renewed critical evaluation. Acknowledging the relatively nascent nature of the field, we advocate for a nuanced consideration of pilot studies. Drawing a clear distinction between the methodologies employed in pilot projects and those suitable for large, commercial endeavours is paramount. While pilot studies offer valuable insight, a discerning evaluation is necessary to determine which practices should be retained and which should be discarded. This concern is well understood by most who work on pilot studies but may sometimes be missed by those not closely involved in such work.

One such example demanding scrutiny is the substantial cost associated with seismic activities in MMV. Extrapolating the current approach used in various pilots to a commercial storage project could result in costs comprising nearly 50% of the entire MMV budget—an arguably excessive expenditure. This calls for a reevaluation of the cost-effectiveness and appropriateness of employing seismic techniques in MMV for large-scale, commercial projects. It is imperative that we navigate these intricacies with a critical eye, recognizing the evolving landscape of CCS and adapting our methodologies accordingly.

In delving into the intricacies and controversies surrounding CCS, it becomes apparent that a certain level of self-contradiction is inevitable. While addressing the potential peril of overconfidence in our surface and subsurface characterization practices, it is crucial to recognize the limitations, for example, of the lessons on the Basal Cambrian Sand from the Quest project. It is essential to avoid the misconception that de-risking of one area entirely extends to all regions of BCS deposition; hence, humility in characterization and appraisal activities remains important. Striking a delicate balance, geoscientists and engineers must navigate the fine line of prioritizing their efforts. Deciding when to relinquish exhaustive efforts on a relatively familiar subject in favour of dedicating more attention to an unknown domain demands a nuanced approach. In essence, this talk invites us to grapple with the contradictions inherent in our methodologies, emphasizing the need for a discerning and balanced perspective.

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