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A Novel Approach for Carbon Capture and Sequestration Pilot Study in the Western Desert of Egypt

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Abstract

As Egypt moves toward its decarbonization goals, carbon capture and storage (CCS) has emerged as a key strategy to reduce industrial CO_2 emissions. A novel Decision-Based Modeling (DBM) workflow was implemented to evaluate potential CO_2 sequestration sites near the Obaiyed and Badr El Din facilities in Egypt's Western Desert. The pilot aimed to identify and de-risk geologic formations capable of safely storing over 350,000 metric tons of CO_2 per year.

The modeling approach was structured in three integrated phases. The first was centered on static modeling, where 20 candidate formations were screened using geologic, petrophysical, and structural criteria. Key selection metrics – such as seal quality, fault proximity, reservoir architecture, and lateral/vertical containment potential – were encoded into a scoring framework. This enabled the ranking of formations for high-resolution evaluation.

Selected formations, notably within the Kharita and Bahariya intervals, were then advanced to Phase Two, where dynamic simulation forecasted CO_2 plume migration, trapping behavior, and storage capacity. A range of static-to-dynamic sensitivity scenarios assessed the impact of porosity, permeability, water salinity, and completion design on plume containment.

In Phase Three, the reservoir models were coupled to 3D Geomechanical simulations to assess stress-field evolution, caprock integrity, and fault reactivation potential under injection conditions. The simulations demonstrated that several sites could maintain structural integrity with minimal uplift and low leakage risk under conservative stress scenarios.

Ultimately, four high-confidence sites were confirmed capable of long-term CO_2 storage. This case study highlights the value of a structured DBM workflow – grounded in robust static modeling and validated through dynamic and Geomechanical simulation – in enabling efficient and responsible CCUS deployment in geologically complex settings.