Introduction

Mesozoic and Paleozoic effective petroleum systems of Saudi Arabia have stood the test of time, making them a prime contender for upcoming CCS initiatives. The presented research uncovers comprehensive regional evaluation of Mesozoic carbon storage systems, alongside targeting maturation of CCS prospects in the Central Arabian graben. Notably, the Upper Jurassic to the Cretaceous sequences boast enormous volumetric potential and expansive geographical reach across the Kingdom. The project is exercising pioneering approach in targeting several stacked intervals of different age and lithologies.

Method and/or Theory

An extensive repository of data has been compiled from decades of hydrocarbon exploration activities targeting the Mesozoic sequences, ranging from surface outcrops in the western regions to numerous drilled and thoroughly sampled wells in the eastern areas, supplemented by 3D seismic surveys. To elucidate the complexities of the Mesozoic sequence development, a collaborative, multidisciplinary effort was undertaken, integrating diverse datasets from both regional and prospect scales. By converging these multiple data streams, the team successfully identified and quantified the fundamental elements of the carbon dioxide storage systems, including pivotal reservoir-seal pairings. Ultimately, 3D static and dynamic models of individual plays were harmonized into a comprehensive, unified model of the Central Arabian graben, providing a robust framework for assessing carbon storage potential.

Large, distinct mega-sequences were discerned in the Mesozoic sequences, comprising carbonate-dominated Upper Jurassic and more clastic-rich Upper Cretaceous formations. During the Upper Jurassic, the Arabian Plate underwent a gradual sea-level rise, marked by the deposition of carbonates in shallow marine environments. Shallowing-upward cycles led to the formation of complex systems featuring infra-tidal carbonates and arid supratidal evaporites. Interbedded Tithonian anhydrites with carbonate stringers created a robust regional seal and a recognizable marker indicating the culmination of intra-cratonic rifting. Concurrently, many Upper Oxfordian and Kimmeridgian limestones retained excellent reservoir quality. A eustatic sea-level drop in the Lower Cretaceous was succeeded by the deposition of thick, high net-to-gross clastic sections in shallow marine settings. Regional and localized uplifts served as prominent sediment sources throughout the Cretaceous period. The transgressive Albian shale formed an extensive seal for the Cretaceous systems.

The structural setting is also conducive to carbon storage systems. Gentle monoclinal sinks are situated near confined structural and tectonostratigraphic traps. The observed overpressure in sealing units is anticipated to further enhance containment capacity. Multiple suitable carbon storage systems have been identified in the Central Arabian graben, spanning from the Late Jurassic to the Cretaceous. Those favorable settings consent for exploring numerous trapping geometries and trapping mechanisms.

Volumetric analysis was supported through a probabilistic assessment and 3D static modelling. The project is concluded with a numerical reservoir modelling study to upscale carbon dioxide injections and carbon dioxide plume development. All intervals demonstrated high porosity and permeability properties. Relatively lower net thickness was observed in Cretaceous clastic stratigraphic traps, but even those selected intervals well exceeded CCS industry recommendations. Development scenarios were explored using 3D dynamic models, which included various well locations and different injection rates. The injection was modeled over a period of two decades to reach a targeted cumulative volume.

The reservoir simulations provide valuable insights into the movement and changes in reservoir properties due to the upscaling of CO_2 injection and can, therefore, contribute to the safe adoption and implementation of CCS.

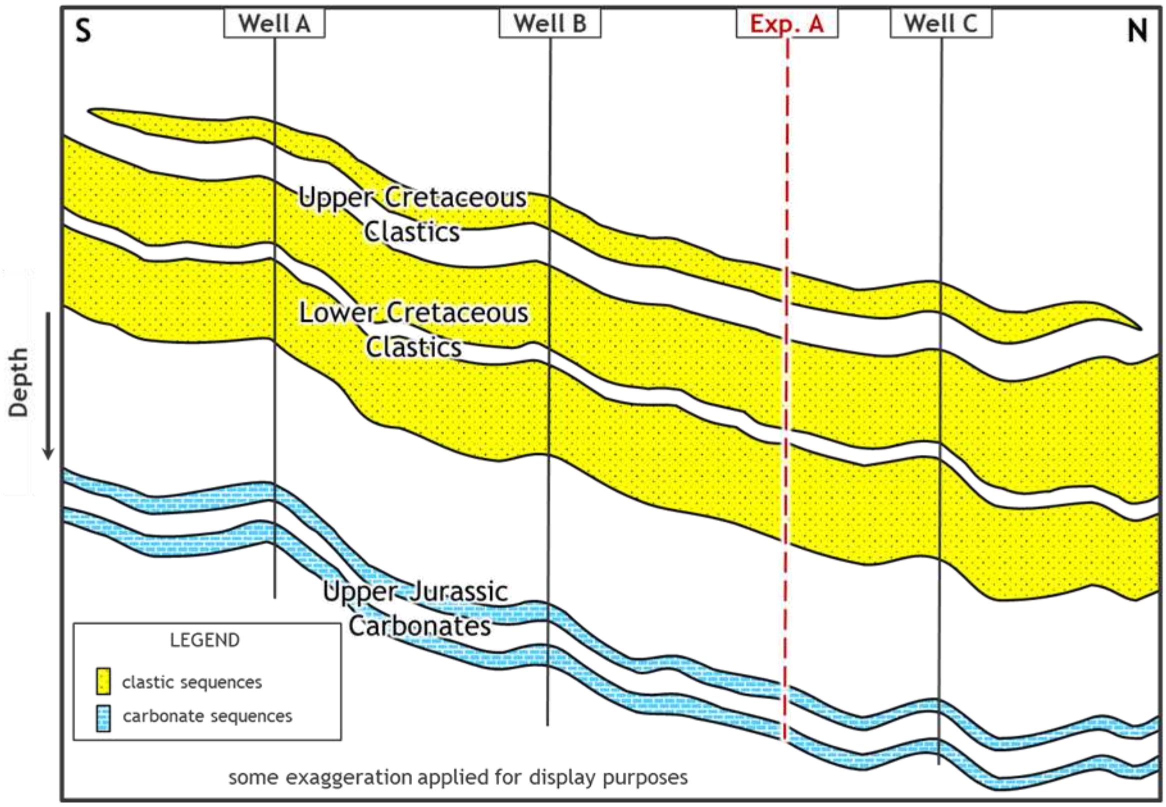

Figure 1 *Diagram for selected Mesozoic sequences with several stack targets in the Upper Jurassic carbonate and the Cretaceous clastic reservoir sections. Trapping configuration ranges from subtle structural traps at all levels to more volumetrically extensive stratigraphic traps in the Upper Cretaceous. Sizeable storage opportunities are identified in semi-confined and un-confined saline aquifers.*

Conclusions

The study of the Mesozoic carbon dioxide storage systems in the Kingdom of Saudi Arabia have demonstrated exceptional potential, impressive capacity, injectivity, and containment characteristics. Moreover, the project has exhibited its viability, underscoring its potential for long-term sustainability and commercial success. The availability of an extensive existing dataset eliminated the need for an expensive exploration data program. This yielded substantial savings in terms of time and resources. Furthermore, the project is aligned with the Kingdom of Saudi Arabia's Vision 2030, which actively promotes and supports the development of CCS initiatives.

References

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