EAGE

REVAMPED BROWNFIELD MODEL FOR CO2 STORAGE ASSESSMENT, ENHANCING DEPO-ENVIRONMENT CHARACTERIZATION AND CONTAINMENT

Introduction

Fluvial deposits are considered as one of candidates for CO2 storage. However, their complex and often highly heterogeneous fluvial architectures pose considerable challenges, leading to variability in storage efficiency. The injectivity of CO2 is inherently dependent on the scale of this heterogeneity, with flow barriers playing a critical role in influencing the migration of the CO2 plume. This paper examines a highly depleted gas field, characterized by multiple channels stacked, as a potential CO2 storage site. One of the key challenges in characterizing and modelling this reservoir is the degradation of seismic data quality, primarily due to the presence of a large shallow gas cloud, which continues to complicate reservoir modelling even as the field nears the end of its productive life. The most significant uncertainty in this field revolves around the distribution of fluvial facies, a critical factor that directly impacts both CO2 containment and the efficiency of storage.

The focus of this study is to present a comprehensive and fully reconstructed reservoir model that extends from the seabed through the shallow overburden, under burden, and depleted reservoirs. Importantly, this completely new model built to replace preexisting reservoir model in the year 2005, enhancing its sedimentological representation while integrating state-of-the-art geoscience and dynamic data. Following the model's re-building, a rigorous history matching process is undertaken to ensure its accuracy. This model is subsequently used for CO2 injection forecasting, thermal simulations, and coupled with a 3D geomechanical model to assess the long-term integrity of CO2 containment.

Method

The methodology focuses on constructing detailed depositional environment models, spanning from the seabed to depleted reservoir zones (Figure 1), by extracting geobodies from seismic attributes. It enables the identification of previously indiscernible geological features obscured by gas clouds. Channel geobodies, observed through 3D seismic cubes, are integrated with regional geology, well logs, outcrops, and production data to develop comprehensive sedimentology models across the field. This crucial step highlights heterogeneity and connectivity risks in fluvial systems, such as meanders and branching structures, significantly influencing CO2 injection pathways and long-term storage efficiency (Figure 2).

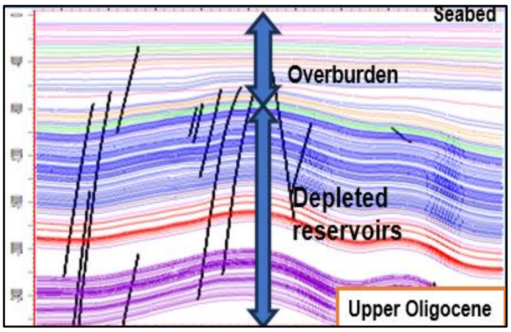

***Figure 1**: Model boundary for full static model rebuilding covers from seabed to base of Oligocene reservoir.*

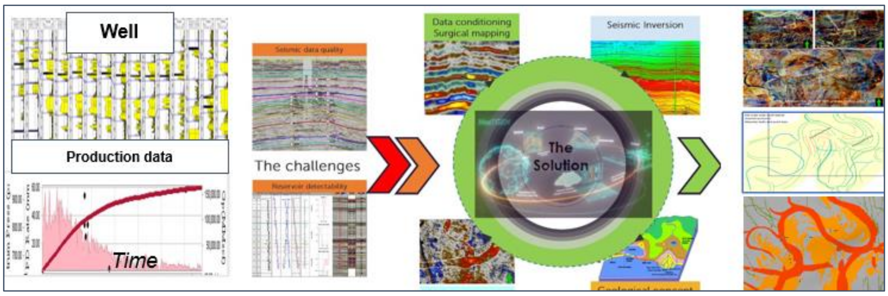

***Figure 2**: Integrated workflow from well, production data, new seismic attributes, sedimentology analysis, results in new facies model which enhances indiscernible geobodies in reservoir model 2005*

The newly developed facies model represents an advancement over the legacy reservoir model, which was originally based on facies distribution assumptions in 2005 (Figure 3). This complete overhaul introduces a far more accurate and refined representation, driven by new technology and comprehensive sedimentology analysis that elevates the understanding of geological features. The model's transformation is directly supported by the meticulously reviewed sedimentological interpretation, offering a more robust and data-driven foundation that significantly outperforms the previous assumptions.

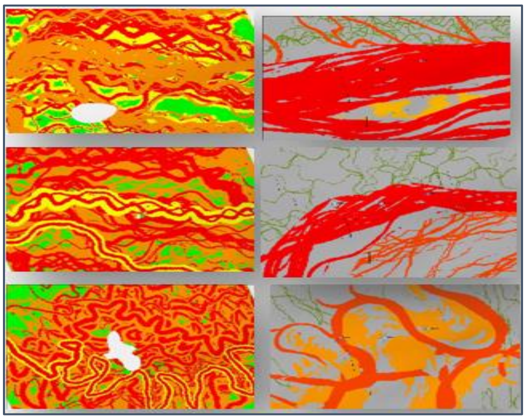

***Figure 3**: Facies model comparison between old model (left) vs new model (right) in some zones.*

A comprehensive facies distribution was meticulously generated for the entire field, extending from the seabed to the deepest injection targets. The development of full static and dynamic models, encompassing the shallow overburden, under burden, and all depleted zones, is absolutely critical for CCS modelling. This model will serve not only for history matching and injection forecasting, but also for thermal simulations and 3D geomechanical modelling. Therefore, a high-resolution model, capturing every individual mudstone and sandstone package (both water and gas-bearing), is essential in providing unparalleled insights into reservoir heterogeneity, CO_2 plume prediction, fault seal analysis, and caprock properties. Such a large-scale, intricate model is paramount for reservoir engineering and geomechanics in ensuring the integrity of CO_2 containment. Figure 4 shows significant difference in term of model boundary and level of detailed between the old and new model which will be used for full containment risk and CO_2 storage assessment.

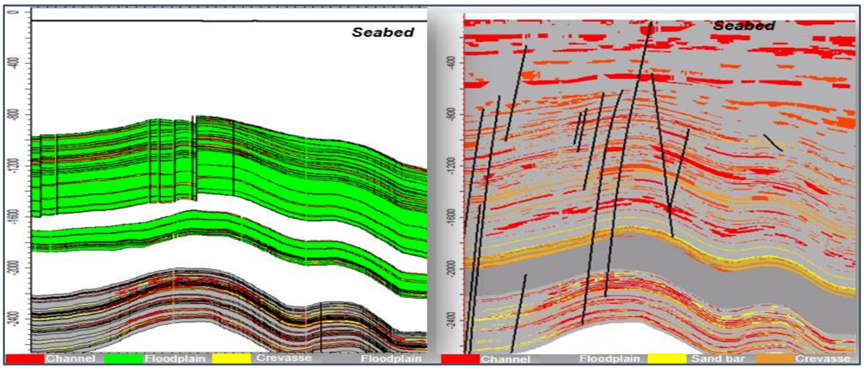

Figure 4*: Full comparison between old model (left) vs new model (right)*

This new reservoir model, with better reservoir heterogeneity, allows for more realistic simulations of the reservoir's behavior. This includes capturing the varying properties across different reservoir zones, which can have significant effects on CO2 movement, pressure build-up, and production rates. The dynamic modelling obtained more accurate match with actual gas rates and cumulative gas production. Also, CO2 injection planning involves not just injecting CO2 but also assessing where and how to inject it for maximum storage efficiency and containment integrity. Older model fail to capture the complexities of reservoir heterogeneity, leading to inaccurate predictions and suboptimal injection strategies. The new model addresses these limitations by incorporating better representation of reservoir heterogeneity, allowing for more accurate predictions of CO2 injection behavior. This improved accuracy leads to better long-term planning, reduced risks, and greater efficiency in CO2 storage. Figure 5 below shows 3 selected sand packages in supercritical condition and with good reservoir property and connectivity for CO2 storage and also CO2 plume migration over 20 years injection.

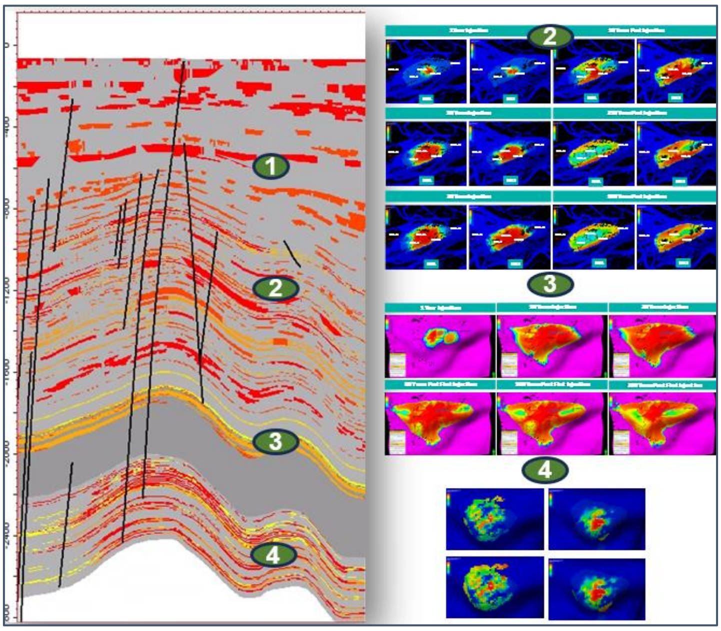

Figure 5: *Channel stacked sands 800-2000m tvdss with good connectivity are selected and simulated results of CO2 plume size in each zone over 20 years of injection.*

Conclusions

CO2 storage requires sophisticated modeling that seamlessly integrates static, dynamic, and geomechanical elements. The selected CO2 storage site underwent a rigorous full-field model rebuild, spanning from seabed to reservoir, meticulously tailored to meet all necessary criteria, including overburden, under burden, and depleted zones. A cutting-edge sedimentological interpretation, leveraging an integrated geoscience and production data approach, enabled a comprehensive characterization of complex channel systems, revealing their geometry and intrinsic properties with high precision. The resulting analysis identified large channel belts, capped by thick, laterally extensive mudstones—maximum flooding surfaces—as the prime candidates for CO2 storage due to their unparalleled storage efficiency, vast capacity, and robust containment potential. In stark contrast, narrow tributary channels and tidal creeks, exhibiting limited thickness and poor permeability, were deemed high-risk zones, marked by suboptimal storage efficiency and injectivity. This reconstructed model not only advances the understanding of the depositional environment, reservoir heterogeneity, and connectivity, but also serves as a critical tool for identifying and selecting the most viable CO2 injection targets. Crucially, the model aligns with both reservoir engineering and geomechanical requirements, enabling detailed studies on injectivity, leakage risk, and containment integrity essential elements for ensuring the safety, efficiency, and long-term viability of CO2 storage sites.

Acknowledgements
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