Seal Rock Characterization for CCUS Feasibility: A Case Study from Dutch Offshore North Sea

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Abstract

Depleted hydrocarbon fields are generally considered as good candidates for CO2 storage (CCUS). This is largely due to its proven reservoir quality. However, during the production the focus was to increase the recovery from the reservoir. Very little attention has been given to understand the seal formation. This is particularly valid in the hydrocarbon producing fields as the main focus was to increase recovery from the reservoir. As the results, cores and complete log sets covering the seal and all overburden formation is largely absent. This paper highlights a novel approach in assessing the seal formation. In the absence of complete datasets, an approach utilizing drill cuttings have been implemented to base the characterization of seal formation. The presented case study is from depleted fields in the Dutch offshore.

The drill cuttings were first analysed with QEMSCAN. The outcome includes lithological variations, mineral types and composition. With continuous sampling, QEMSCAN data provides insights into vertical heterogeneity in the seal formation. The mineral assemblage from QEMSCAN can be also used to generate synthetic logs to aid the rock physics analysis in the seal formation. Additionally, with nano-indentation tool, the mechanical properties of each rock type can be estimated. The approach also includes digital rock modelling and numerical simulation in finite element, to upscale the mineral scale properties into reservoir scale, used to calibrate the rock physics.

The targeted formation for the study is known as the Lower North Sea Group (LNSG), a thick sedimentary sequence deposited in marine environment during the Tertiary. From the drill cuttings analysis, it is found that the LNSG is predominantly of shale, but heterogenous with porous siltstone is also observed. Delineating the distribution of siltstone is crucial as it poses risk to the seal formation. The petrophysical evaluation indicates 16% effective porosity for the siltstone, which poses a significant risk for the sealing capacity of the LNSG. It is generally observed in the upper part of the LNSG, related to the depositional settings. Through well correlation and mapping, the distribution of high-siltstone unit in LNSG has be delineated. It is mainly constrained in the norther segment of the studied area. The presence of quartz siltstone however does not affect the overall mechanical properties of the LNSG. It is generally soft due to abundant clay minerals. Based on this result, the risk for storage leakage due to lithological factor in the seal formation is very minimal. From the mechanical properties, the Lower North Sea Group is generally softer which is sufficient for as the seal formation. Therefore, further assessment on the existing well condition in the high-risk area should be the priority, to identify any possible leakage pathway due to poor well design.