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3D seismic analysis of the Collyhurst Sandstone: implications for CO_2 sequestration in the East Irish Sea Basin

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Carbon Capture and Storage (CCS) is a vital technology towards low-carbon energy resources and the mitigation of global warming trends induced by rising CO_2 levels in the atmosphere. The East Irish Sea Basin (EISB) is a key area for CCS in the western UK, having high CO_2 storage potentials in explored hydrocarbon fields and in saline aquifers within the Permo-Triassic Sherwood Sandstone Formation. However, the theoretical storage potential of the EISB could be poorly estimated as the reservoir-prone Lower Permian formations are not considered in detail by current estimations. This work aims to fill this gap, focusing on the characterisation of the Lower Permian Collyhurst Sandstone Formation as a viable storage unit. The potential for CO_2 storage is estimated as the total volume/area of suitable closures that are isolated by structural traps, occurring at depths suitable for CO_2 injection and containment (>800m). Detailed structural and stratigraphic interpretations were made using 3D seismic data to assess the storage potential of the Collyhurst Sandstone Formation in the southern EISB. The basin strata is compartmentalised by numerous N-S trending faults. A higher degree of compartmentalisation occurs within regional anticlines where elongated tilted blocks are observed, bound by predominantly west-dipping faults that induce a variable offset of the Collyhurst Sandstone strata. Contrastingly, higher lateral continuity of this formation is observed within graben basins were faults are less frequent and with minor offset, thus potentially creating larger storage closures. Fault dip orientation in the grabens is variable, with west and east dipping faults occurring as a function of large east-dipping listric faults. This study was complemented by the stress modelling of the interpreted faults in order to assess the risk of CO_2 leakage. Analysis of borehole breakouts observed in four approximately vertical wells in the EISB suggest a maximum horizontal stress orientation of $155\pm10^{\circ}$. Under the regional stress conditions, east dipping faults show the highest slip tendencies and leakage risk, especially when present within shallower structures. The highest storage potential for the Collyhurst Sandstone Formation is observed within the basin grabens where its greater depth of occurrence favours the injection of supercritical CO_2 and mitigates the risk of geomechanically-induced fault leakage. The results of this work further expand the understanding of prospective areas for CO_2 sequestration in the East Irish Sea Basin in locations where the primary Sherwood Sandstone Formation is either too shallow, discontinuous or eroded.