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Evaluation of CO_2 Storage Capacity, Leakage Mechanisms and Injector Well Placement in a Giant Oilfield at Late Stage of Production

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A demonstration study was undertaken to evaluate both the data requirements and the modeling techniques needed to quantify the risked volumes of CO_2 which could be stored within a giant field in the North Sea, UKCS. The study examined the geologic model uncertainty, the complex fluid description and the risk of possible leakage mechanisms. A high-resolution reservoir filling simulator, based on an invasion-percolation algorithm, was used to produce a nested uncertainty analysis, where multiple realizations of multiple scenarios were combined to evaluate the range of volumetric outcomes.

The geologic model consisted of an inverted seismic volume calibrated to lithology (LI volume) with a deterministic top seal. The resolution of this model (25x25x5m) was sufficient to allow the full capture of the geologic structure directly from the geophysical volume without any upscaling, even though the total number of cells in the model (>80 million) would challenge conventional reservoir simulators.

The reservoir model was initially calibrated by performing a reservoir filling study to the known undersaturated black-oil composition and volumetrics. This was achieved through iterative assignment of petrophysical attributes (porosity, capillary threshold pressure, saturation end-points) to the LI attribute, with point calibration to the 100+ wells drilled on the field. In the course of this calibration, the top seal capillary threshold pressure was determined to be the fundamental control on overall column height, and constraints on the effective property were derived. Additionally, the field spill point was accurately determined (subtly different to a geometrically-mapped spill-point) and the failure mode for a NW extension to the field identified.

Once the geologic model was calibrated petrophysically, the petroleum fluid was then substituted by CO_2 phase at the appropriate reservoir PVT conditions. A range of scenarios was again run, this time to evaluate the volumetric response to varying seal capacities within the range identified previously. This modeling showed the effects both of increasing overall column height, but also interestingly the effect of accessing zones within the field footprint which had not be accessed by the lower buoyancy oil. Failure modes were identified, ranging from crestal fracture development to tilting due to subsequent geologic deposition/ erosion. Additionally, a high-level screening of injector well locations from the five current platform locations was conducted.

Overall, the reservoir filling model provided an extremely effective tool to both technically assess the uncertainty around the potential storage volumes of CO_2, and to communicate this visually both internally within the company and externally to stakeholders. Keeping the physics of the model simple allows the key controlling factors to be assessed whilst fully capturing the geologic uncertainty, and hence appropriate ranges of volumes to be determined. Establishing the data requirements for this workflow has enabled it to be subsequently deployed on candidate sites for CO_2 injection with optimal impact.