Regional seal characterisation for CO2 storage, Northern North Sea

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Estimations of CO₂ storage capacities for saline aquifers, particularly the Utsira Formation (northern North Sea) have previously been calculated using a variety of numerical approaches. These are mainly based off reservoir depth maps and averaged petrophysical properties. In these first-pass estimations, a thick shale succession in the overburden is assumed to form the top seal. This is unlikely to be representative of the true, regional lithological heterogeneity and 3D variability of stratigraphic architecture, which may promote CO₂ migration out of the reservoir during injection.

This study utilises a recently acquired regional high-resolution 3D broadband seismic dataset (37,500 km²) and >200 wells in the North Viking Graben, with the aim to fully characterise the overburden of the potential CO₂ reservoir (Northern Utsira Formation). The objectives are to analyse: i) the presence and spatial extent of sandstone bodies in the overburden and their connectivity with the reservoir; ii) the presence of sand-filled slope channels on the clinoform foresets that may act as migration pathways; iii) evidence of previous fluid migration through the overburden. Manual seismic interpretation and well correlation is augmented by automated horizon propagation (Palaeoscan) to map individual clinoforms across the region. This is integrated with seismic attribute analysis, frequency decomposition and automated well lithology extraction to understand regional sand distribution and feature analysis (e.g. identification of channels and their fill, and possible shallow gas).

Large fan-shaped sandstone bodies (10s km-scale) are identified in the lower foresets and bottomsets of the clinothems. In the west, these are in connection with the Utsira Fm., or separated from it by a thin (<10 m) shale layer. These sands can be both beneficial to the storage capacity by producing additional gross reservoir volume (if sealed and below the critical depth for CO₂), or detrimental to it if they provide a path to bypass the Utsira Fm. top seal. In the south east, sand-filled slope channels and lobes (km-scale) are recorded in the prograding clinothems but are not observed to be in connection with the Utsira Fm. (located >100 m above top Utsira Fm.). No sand-filled channels were identified in the north east from seismic attribute analysis, however the well lithology extraction for this region contained ~3% sand, thus there is a possibility of sub-seismic resolution features. In the south, foresets directly downlap the Utsira Fm. This geometry juxtaposes several individual clinothems against the reservoir, increasing the likelihood of migration if there is sand presence. This contrasts with the scenario in the north, where the bottomset of a single clinothem disconnects the reservoir from younger clinothems and restricts
potential migration.

The outcome of this study is an integration of each of the regional feature maps to generate: i) a seal thickness map between the Utsira Fm. and the first overlying sand body; ii) the first leakage risk map of the Utsira Fm. that captures geological geometry and lithology distribution. These can be incorporated into any future storage estimations and identification of potential injection sites.