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Reservoir Architecture Control on the Geometry of a CO_2 Plume Using 4D Seismic, Sleipner Field.

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Time lapse seismic from the Sleipner field, Norwegian North Sea represents a unique database to understand the geometry of a saline aquifer, the Utsira Sand Formation, and its role in containing sequestered CO_2. The heterogeneous high permeability Utsira Sand formation bounded by an overlying seal is surrounded by impermeable to semi-permeable intra-reservoir thin shale units that influence the migration of injected CO_2. It is important to understand and verify the dynamics of injected CO_2 plume migration as this ensures close to accurate predictions of the evolving and stable state of CO_2 in storage projects. Previous detailed interpretation results of the thin shale units and permeability flow path chimneys within the Utsira Formation have been used in this research. The Utsira Cap rock, IUTS1 and IUTS1 (Intra-Utsira Shale Units) are the top three units that affect the containment and upward migration path of injected CO_2. They are combined with seismic geobodies of the CO_2 plume across time lapse data. Here, these seismic geobodies are created using 2 methods to delineate the 3D shape and the cubic volume occupancy of the CO_2 plume within the reservoir. Method 1 employs the use of an envelope attribute volume, where samples are extracted from voxels that contain seismic trace amplitude values of injected CO_2 across the 3D data. These extracted samples are then tracked throughout the target area and then classed and quantified as a CO_2 geobodies. Method 2 applies the same concept; the only difference is the samples extracted from voxels are classed based on the proximity and connectivity of pre-defined amplitude values. Both methods employ the use of a Bayesian classifier which defines the probability density function used to categorise the extracted threshold values. Our result of the 3D geobody shapes are compared against the internal geometry of the reservoir which shows the influence of the cap rock and intra-reservoir thin shales on the CO_2 plume acting as baffles and flow paths. The amount of injected CO_2 is compared against the occupied volume of CO_2 within the reservoir rock. Result values are plotted in graphs and they give an indication of the upper and lower end of reservoir volume occupied by injected supercritical CO_2. These values are based on the porosity, permeability, density and temperature values of the rock volume, formation fluid and supercritical CO_2. The results also show a decrease in effective rock volume occupied by CO_2 reaching the Utsira top cap rock with increase in injected amounts of CO_2. Our results indicate that the methods proposed can be applied to storage reservoirs in their early to mid-stages to help predict and understand the internal geometries of the reservoir unit and how they can affect the containment or upward migration flow of CO_2. The CO_2 volumetric measurement can also be used as a well-grounded assessment for future saline aquifer storage projects.