The Röt Halite Member of the Southern North Sea – A critical top seal for carbon dioxide storage in the Bunter Sandstone Formation

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Abstract

The Bunter Sandstone Formation is under consideration as a storage reservoir for carbon dioxide in the UK Southern North Sea, where the Dowsing Formation provides the top seal. Over much of the basin, an evaporitic unit known as the Röt Halite Member is present at the base of the Dowsing Formation. The Röt Halite is separated from the Bunter Sandstone by a thin mudstone unit equivalent to the Solling Formation of the Netherlands. Previous studies have suggested that the Röt Halite will provide an effective top seal for carbon dioxide storage on the basis that it is dominated by bedded halite (Heinemann *et al*., 2012; Williams *et al*., 2014). Despite this, detailed knowledge of the lithological heterogeneities and structural variations within the unit are lacking, specifically with respect to its potential to act as an effective seal for carbon dioxide. High-resolution correlation of petrophysical logs was conducted to provide an improved understanding of the distribution of individual halite cycles across the UK Southern North Sea. Seismic reflection data were then used to elicit information on post-depositional deformation styles, in an attempt to relate Röt Halite thickness and the number of individual cycles to the presence or absence of throughgoing faults.

The Röt Halite is easily differentiated by the presence to halite, relative to the red-brown, playa-lake mudstones of the lowermost Dowsing Formation. Southworth (1987) recognised five evaporite cycles within the Röt Halite, each separated by a thin mudstone overlain by a thin bed of dolomite or anhydrite. Each halite cycle resulted from a rapid marine transgression followed by gradual marine regression, with halites generally precipitated in shallow evaporite basins. The Röt Halite is overlain by a sabkha facies comprising an interbedded sequence of anhydrites, dolomites and dolomitic mudstones, which overstep the Röt Halite towards the landward margins.

Isochore maps for each of the individual depositional cycles within the Röt Halite provide an indication of the palaeoenvironmental evolution. Top seal quality is expected to be optimal in regions where all five of the evaporite cycles are present. The margins of individual cycles are most likely to comprise of impure halites (Southworth, 1987), and may also be affected by dissolution features which could potentially have resulted in deformation and fracturing which can form seal bypass systems through salt (Cartwright *et al*., 2007). While the presence of halite does suggest that top seal quality will be maintained, identifying the location of such margins may be used as an indicator to help identify objectives for further appraisal and risk reduction measures.

Correlation of petrophysical logs and seismic reflection data suggest a conformable and generally uninterrupted distribution of Röt Halite across the basin. Zones of deformation and halokinesis are largely constrained to major structural discontinuities caused by post-depositional mobility of deeper evaporites of the Zechstein Group. The Röt Halite has been invaded by potassium-rick Zechstein salts in some areas, resulting in allochthonous salt overhangs adjacent to some salt walls. Pre-existing faults represent one of the key geological containment risks for carbon dioxide storage in the Bunter Sandstone (Williams *et al*., 2014). Small-offset extensional faulting near the resolution of seismic data occurs over the crests of many anticlinal structures of interest for carbon dioxide storage in the Bunter Sandstone. In some structures, the Röt Halite acts as a detachment layer preventing faults from extending downwards into the Bunter Sandstone. In contrast, other structures exhibit faults are throughgoing with clear offsets are observed both above and below the Röt Halite. Whilst no direct relationship is inferred, observations are presented to compare the thickness of Röt Halite and number of evaporite cycles with the degree of throughgoing faulting.

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