Characterizing CCUS Sites in Sandy Reservoirs: From Regional Screening to Prospect Identification and Assessment

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Abstract

The last United Nations Climate Change conference (COP28) has concluded with the need for deep and rapid reductions in greenhouse gas emissions to keep 1.5 C global temperature increase withing reach. To meet this goal, this year's agreement recognizes that implementation of removal technologies such as carbon capture and storage will be imperative to reduce emissions and mitigate the effects of climate change. It is in this scenario where the holistic expertise of the O&G exploration geologist can be now repurposed to assess the feasibility of potential CO2 storage sites in sedimentary basins near to anthropogenic emitting hubs.

Here, we showcase an example in the Broad Fourteens Basin (Dutch North Sea) where we performed several basin analysis techniques to identify, de-risk and estimate the capacity of a potential CO2 storage site. We take advantage of a wealth of publicly available seismic and well data together with the fact that the area is known for its world class Late Permian Rotliegend sandstone reservoir. Because of its remarkable porosity and permeability properties and the existence of an overlying evaporitic seal (the Late Permian Zechstein Group), this traditional gas reservoir is now reimagined as a potential target for CO2 storage in depleted fields. The used methodology comprises: a) structural mapping of several key horizons and associated bounding faults, b) well log analysis for estimating potential storage volumes, c) fracture response/stability modelling, and c) fault seal analysis. The Rotliegend formation is characterized by very extensive reservoir intervals across the basin, yet pervasively faulted as a result of multiple tectonic phases. The traps are usually horst blocks bounded by extensional faults and relay zones, often with Zechstein evaporites as lateral seal across the bounding faults.

To estimate the potential volume of the storage site, we use a fluid in place equation taking into account gross- rock volume, net-to-gross ratio, reservoir porosity, fluid saturation and density of the CO2 at reservoir conditions. The structural modelling workflow aims to test several scenarios where the reservoir compartments face different stress regimes to determine how bounding faults and relay zones may respond to the injection of CO2. We compute magnitude and direction of slip accommodated by the interacting bounding faults based on the present-day stress field, and simulate strain and stress magnitudes around the fault zones to obtain the most likely orientation of associated fracturing. Then, we evaluate fault stability and brittle failure by calculating the magnitude of pore pressure change required to bring a fracture into failure, and the change in the stress field associated with fault slip. Finally, we investigate the potential risk of fault seal being breached by fault reactivation under different stress regimes and its impact on subsurface fluid flow.

The quantitative analysis of faults and associated fracture systems under different 3D stress regimes provides valuable information on the behavior of existing structures and will ultimately de-risk the feasibility of the CO2 storage site and its long-term stability to keep the gas in

place. The workflow presented here is applicable wherever sandy reservoirs are targeted, and represents a road map for regional screeners and/or prospect identifiers helping to perform robust structural and geomechanical studies to assess and test future CO_2 storage sites.