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Smeaheia, A Potential Northern North Sea CO2 Storage Site: Structural Description And De-Risking Strategies

M.J. Mulrooney[1]*, J. Osmond[1], E. Skurtveit[1,2], L. Wu[3], A. Braathen[1]
[1]Department of Geosciences, University of Oslo, [2]Norwegian Geotechnical Institute, [3]Equinor ASA

Summary

Smeaheia is a potential subsurface CO2 storage site located on the Horda platform in the Norwegian sector of the North Sea. The site is currently being investigated as part of the Norwegian CCS Research Centre, which envisages injection, and storage of CO2 into shallow-marine deposits comprising the Jurassic Viking Group. Two prospects, defined as fault-bound structural closures, have been identified, i) Alpha in the footwall of the Vette fault, and Beta in the Hanging wall of the Øygarden fault. In this contribution we present the fundamental structural framework of the Smeaheia site as derived from seismic interpretation of a high resolution 3D dataset. Qualitative and quantitative fault seal properties of the Vette fault are presented. Juxtaposition and shale gouge ratio analysis suggest the Vette fault has a high sealing probability for the Alpha closure. A relay zone to the south of the structure is more likely to be non-sealing and may facilitate pressure communication with a neighbouring fault block where hydrocarbon production has been ongoing. This communication may have resulted in Smeaheia being depleted. Risk of fault reactivation is assessed based on likely in-situ stress states, hydrostatic pressure regimes and the aforementioned depleted pressure regimes.

Results of fault slip tendency and dilation tendency are graphically presented in figure 2 for a normal, anisotropic, in-situ stress given a hydrostatic pressure regime. Slip tendency for both the reservoir and caprock intersecting faults is shown to be low risk (all values 0.4 or lower), while dilation tendency for both intervals exceeds 0.6 in a small number of locations (max value of 0.86). Sub-hydrostatic pressure regimes (related to troll field depletion) reduce the risk of both fault dilation and slip. Calculations considering a strike slip in-situ stress (less likely) increase dilation and slip risk on intra-block subsidiary faults that trend NW–SE.

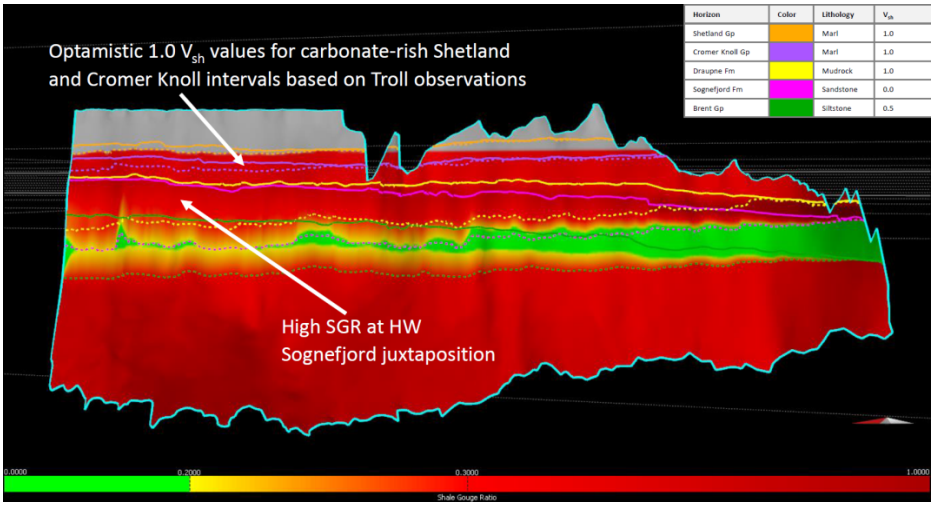

Figure 1 *Uncalibrated Shale Gouge Ratio (SGR) calculations for the Vette fault using Vshale approximates for Jurassic–Cretaceous successions.*

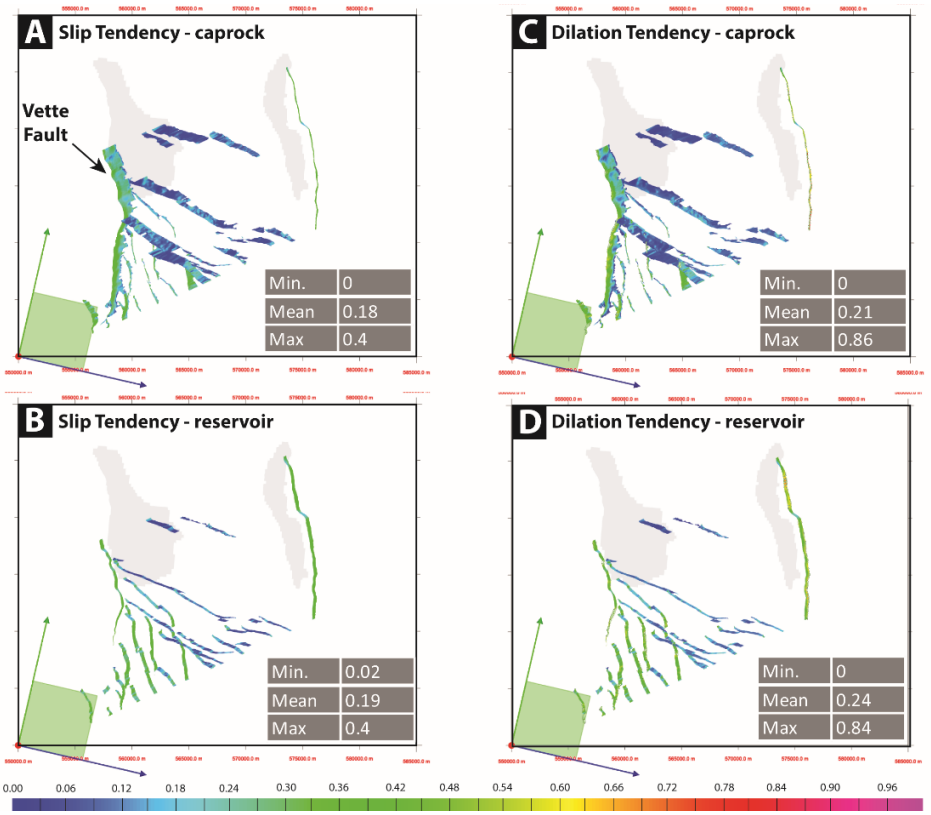

Figure 2 *A) Plan view projections of fault planes that intersect the caprock (A, C) and the reservoir (B, D) colour mapped with Slip Tendency (τ/σn) in A and B, and Dilation Tendency [(σ1 – σn) / (σ1 – σ3)] in C and D. Dilation Tendency values equal or greater than 0.6 are highlighted in C and D, i.e. the value equal to the static friction in a rock above which faults may rupture. Slip Tendency values do not exceed 0.4. Shaded grey areas represent the Alpha (left) and Beta (right) closures, respectively.*

Minimum, mean and maximum values are displayed in tables. Directional arrows in bottom left of each panel represent principal stress axes, σ1 (red), σ2 (green) and σ3 (blue).

Conclusions

Provisional results of fault seal and caprock integrity studies for the potential Smeaheia CO_2 storage site are as follows:

- The north part of the primary Vette fault segment that abuts the Alpha prospect shows low potential for cross-fault leakage at the level of the reservoir interval.
- Considerable cross-fault juxtapositional area between the Cromer Knoll Group (hanging wall) and the reservoir interval (footwall) is identified and requires more detailed modelling.
- The Vette fault relay zone and intra-block subsidiary faults show considerable cross-fault self-juxtaposition of the reservoir interval. These faults may baffle fluid flow, but not act as substantially sealing faults.
- An extensive population of polygonal faults affecting the Smeaheia overburden is identified, a small percentage of which extend down-section into the reservoir interval.
- Several deeper routed tectonic faults extend up through the overburden.
- No evidence of faulting is observed above the base Quaternary unconformity.
- Populations of quaternary paleo-pockmarks and seafloor pockmarks are identified, spatial affinity with underlying structures has not been observed.
- Preliminary fault stress analysis of a hydrostatic pressure model shows low potential for fault reactivation in the Smeaheia area. Strike-slip scenarios represent higher risk, while depletion scenarios represent lower risk.

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