

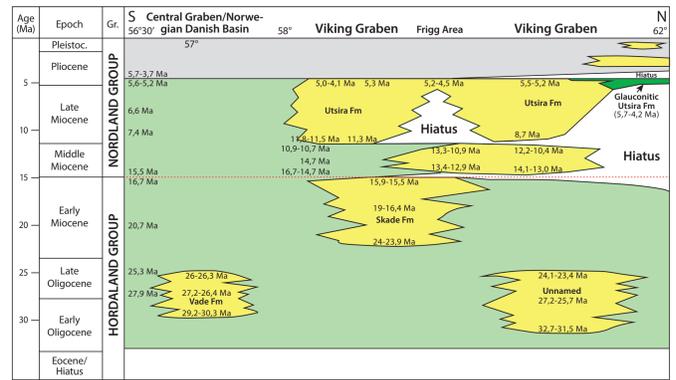
CO₂ storage in the Utsira-Skade aquifer



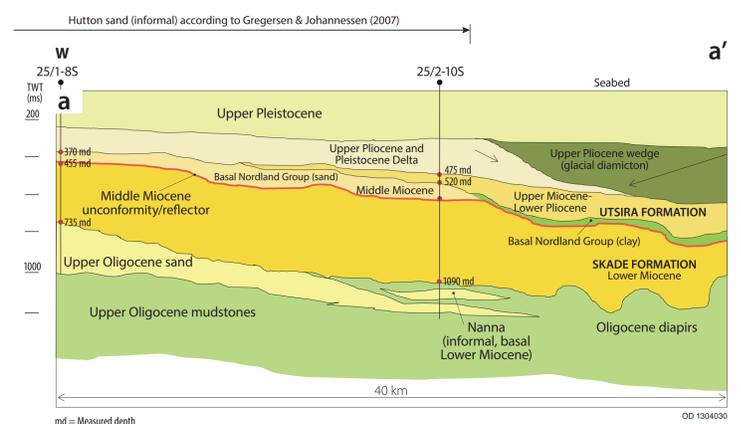
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 Drawings:
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Storing of CO₂ in the Utsira Formation is well documented, and since 1996, one megaton of CO₂ has been injected at the Sleipner Field in the Norwegian sector block 15/9. The Utsira Formation (Upper Miocene to Lower Pliocene) is a shallow marine, sandy deposit which underlies Upper Pliocene-Pleistocene sandy deposits of the Nordland Group and overlies Middle Miocene sandy deposits (suggested called Eir Formation by Eidvin et al., 2013) and the Skade Formation (Lower Miocene). The proximal part of this sandy system lies in the UK sector. In that areas the deposits are deltaic and are called Hutton sand (informal).

The Utsira Formation and the Skade Formation constitute the main part of this sandy system and are considered as a single aquifer. The Utsira Formation covers an area which is 450 km in North-South direction and 90 km in East-West direction. The Norwegian Petroleum Directorate (NPD) has remapped and calculated the total storage potential in a southern depo-center of this aquifer system. A reservoir simulation model covers an area of 1600 km² of the southern Skade-Utsira depo-center, and the model estimates a capacity of one gigaton.

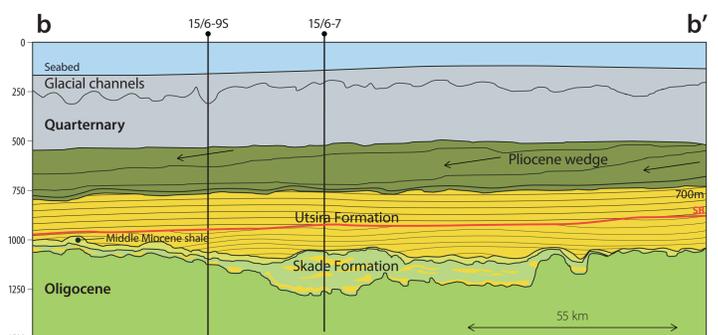


Post Eocene lithostratigraphy of the Norwegian North Sea (after Eidvin et al. 2013)

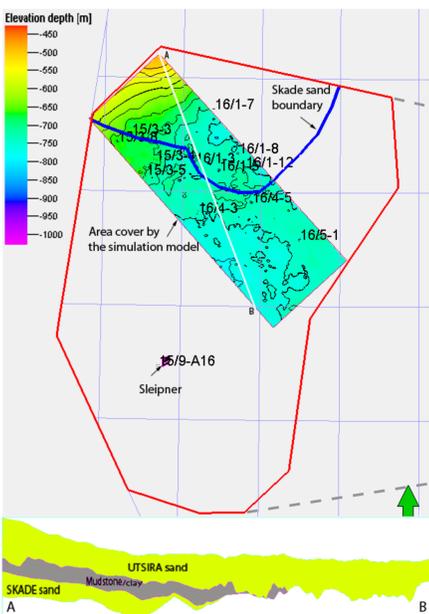


This geosection illustrates how four different delta sands, which constitute the outer delta front of the Hutton sand system (informal name used in UK waters only) are deposited. In Norwegian waters the lower Miocene Skade Formation is turbiditic in origin and overlies Oligocene mudstones. The Utsira Formation overlies a mud prone distal Middle Miocene unit and thins out west from the delta front towards the 25/1-8S area (overlying sandy Middle Miocene deposits). An Upper Pliocene delta builds on top of the Utsira Formation in the 25/2-10S area.

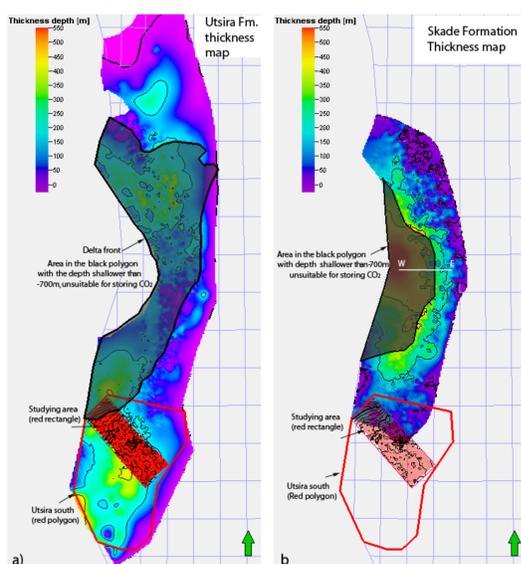
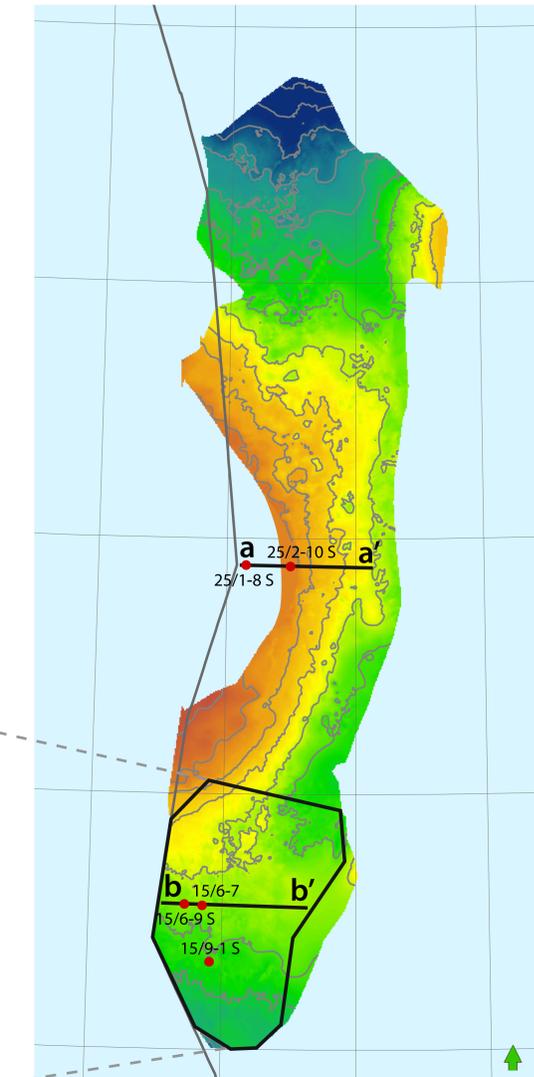
(Eidvin, T., Riis, F. & Gjeldvik I.T.; NGF Winter Conference 2013
 "The Upper Miocene-Lower Pliocene Utsira Formation in the northern North Sea")



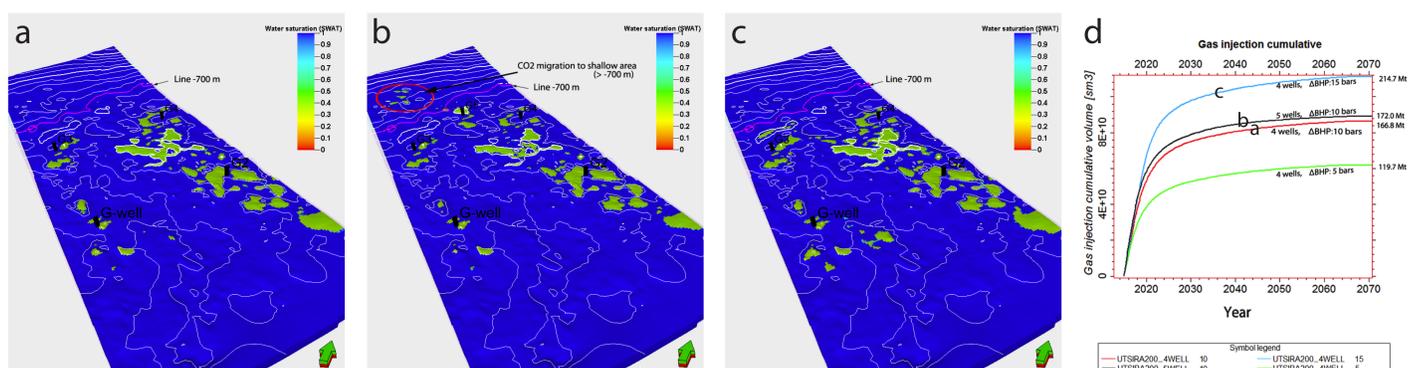
The Skade Fm, Lower Miocene, consists of marine sandstones (mainly turbidites) deposited over a large area of the Viking Graben (From 30/5-2 in the north, to 15/6-7 in the south). The maximum thickness exceeds 300 m and decreases rapidly towards the south and east, where the sands terminate towards large shale diapirs.



The Utsira Formation extends from quadrant 34 in the north, to quadrant 15 in the south. It is deposited in a shallow marine environment and is reworked by tidal currents. The red polygon to the south defines the southern depocenter. Underlying the Utsira Formation, the Skade Formation extends from quadrant 30 to quadrant 16 and is deposited mainly as turbidites. The red rectangle shows the 1600 km² area covered by the reservoir simulation model.



A general observation is that the CO₂ plume will migrate upwards and follow the topography. Local highs are created as a response to differential compaction where sand is deposited on shale. These highs will trap the CO₂ as it moves up towards the NW. Red line indicates area shallower than 700 m depth. Here the CO₂ behaves as a gas, hence not suitable for storing. Note that in case a and b (4 versus 5 wells) it's relative little difference, as seen in the curve to the right. Approximately 170 Mt can be injected in the Utsira-Skade aquifer within the segment model.



Eidvin, T., Riis, F., Rasmussen, E. S. and Rundberg, Y., 2013. Investigation of Oligocene to Lower Pliocene deposits in the Nordic area. NPD Bulletin No 10. Available from the internet: http://www.npd.no/engelsk/cwi/pbl/NPD_papers/Hyperlink-NPD-Bulletin-10.pdf. Accessed April 28, 2014.

Eidvin, T., Riis, F. & Gjeldvik I.T.; NGF Winter Conference 2013
 The Lower Oligocene-Lower Pliocene Molo Formation on the inner Norwegian Sea continental shelf

Suggested further reading:
 Eidvin, T. & Rundberg, Y., 2007. Post-Eocene strata of the southern Viking Graben, northern North Sea; integrated biostratigraphic, strontium isotopic and lithostratigraphic study. Norwegian Journal of Geology 87. 391-430.

Eidvin, T., Dybkjær, K., Piasecki, S. & Rasmussen, E.S. in prep:
 Strontium isotope stratigraphy based on analyses of mollusk tests from the upper Oligocene-Miocene succession in Denmark with correlation to the Norwegian continental shelf.

Gregersen, U. & Johannessen, P.N., 2007. Distribution of the Neogene Utsira Sand and Hutton Sand, and the succeeding deposits in the Viking Graben area, North Sea. Marine and Petroleum Geology 24 p 591-606.

Holland et al., 2014: NPD publication, CO₂ Storage Atlas Norwegian Continental Shelf.

Pham, V.T.H., Riis, F., Gjeldvik, I.T., Halland, E.K., Tappel, I.M., Aagaard, P., 2013:
 Assessment of CO₂ injection into the south Utsira-Skade aquifer, the North Sea, Norway, Energy, Volume 55, p 529-540.