



## **Recent glacial events in the Norwegian North Sea – implications towards a better understanding of charging/leakage of oil fields and its impact oil exploration**

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Recent drilling and appraisal on the Southern Utsira High, Norwegian North Sea, has proved several large oil/gas discoveries, including the giant Johan Sverdrup, Edvard Grieg, Draupne, Ragnarrock and Apollo oil fields, making this a prolific petroleum area.

The Southern Utsira High contains a variety of hydrocarbon density fluids found at several stratigraphic levels illustrating the compartmentalized nature of accumulations and charge history.

The Southern Utsira High has been in a position to receive an oil/gas charge for a considerable period of time, with the basin towards the west most likely generating petroleum from early Eocene (50M Mabp) to its maximum present day burial depth. However, reservoir temperatures on the Southern Utsira High are just above the threshold for biodegradation (80°C). The Southern Utsira High oils are non-biodegraded suggesting that the majority of the oil charged relatively late – ca.3 million years ago to present day.

The effects of the glaciation on the filling history of the Southern Utsira High are currently being assessed. It is clear that several erosional surfaces in the Pliocene can be identified, as well as glacial channels and moraine deposits, indicating that significant deposition and erosion occurred in the last five million years. Importantly, the effects of glacial rebound mean that the Southern Utsira High more than likely underwent tilting and possible leakage, not just once, but several times in the last 1 million years.

The effects of tilting/leakage of geological areas on oil migration have been recognized by several authors. However, the detailed integration of geological mapping and geochemical evidence has not previously been published. The implications of a detailed assessment of tilting of a 'high' through time are; 1) opening up areas where oil migration is thought to be high risk or impossible; 2) identify possible paleo-oil columns aiding the de-risking of discovery appraisal strategies.

The evidence of tilting/leakage of oil accumulations through time can be recognized in several oil fields on the Utsira High. The giant Johan Sverdrup discovery oil columns contain paleo-OWC, residual oil zones/paleo-oil columns, and oil shows considerably deeper than the current OWC or residual oil columns.

Lundin has performed detailed mapping of the seabed and water column in the Alvheim/Utsira High areas in order to identify areas of gas leakage and its geological manifestations on the seabed and ultimately resulting in the collection of high quality samples. Results shows that gas leakage is prominent over the Alvheim and Utsira High areas and the implications of this to oil exploration will be discussed.

In summary, Lundin's approach to oil migration is to better understand the fluid/gas movement throughout the whole basin through time.

The talk will focus on the role of glaciations on the timing of charge from the South Viking Graben, fill-spill directions on the Southern Utsira High, the effects of late tilting/leakage on the charge/re-distribution of oil, and seabed / water column characterization and sampling. All placed in the context of oil exploration.