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Analysis of fluid migration and leakage in the Hammerfest Basin, South Western Barents Sea, from 3D seismic reflection data.

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The Hammerfest Basin, located in the SW Barents Sea is an active frontier for hydrocarbon exploration and an excellent setting for scientific research due to its complex geological setting, history and data availability. In particular, the role of glacial loading and unloading has likely played a significant role on the petroleum systems in the region, possibly leading to reactivation of older structures and neotectonics.

Natural gas seeps are common in sedimentary basins and can be found worldwide. The process of liquid and gaseous hydrocarbon leakage is highly important as it (1) is responsible for input of greenhouse gases (such as Methane) into the hydrosphere/ atmosphere, (2) indicates reservoir leakage, (3) impacts benthic ecosystems and (4) can lead to submarine slides due to slope instability. Understanding present and paleo gas seepage controls can provide essential information regarding petroleum system dynamics in the reconstruction of basin evolution.

We investigate a three dimensional (3D) seismic dataset, covering 950 km2 situated over the Snøhvit gas field to characterise the fluid migration pathways, their sequestration in the shallow subsurface and their expression on the present day or paleo seabed.

A polygonal fault interval was identified in Campanian age sediments in our study area, which could imply a permeable complex network of fault-controlled pathways that facilitate the migration of hydrocarbons. Polygonal faults in this sequence seem to develop orthogonally to both lithological boundaries and regional tectonic faults, where the straight fault segments extend away from the boundary/fault and link into more common polygonal fault patterns. The lithological control on the occurrence of polygonal fault patterns could indicate a change in rock properties, and can be used to differentiate between different sediment types. There are three main orientations of polygonal fault networks sampled in three different areas of the study area: dominant ENE/WSW, secondary NEN/SWS and a minor NE/ SW. The dominant orientation is similar to the main regional tectonic fault trend (EW), suggesting a tectonic influence upon the development of polygonal faults.

A large gas cloud (∼60 km2) is present in the western part of the study area. It is characterised by irregular amplitude anomalies at the top of the gas front and an acoustic wipe out zone below the amplitude anomalies. The diffuse gas zone is thought to be related to inhomogeneous distribution of gas within silty Paleocene sediments. Above the gas cloud a number of curvilinear faults linked to a series of buried paleo-pockmarks exist which extend to the present day seabed.

We propose that reactivated regional faults acted as preferential pathways for thermogenic fluids from the hydrocarbon reservoir through the Campanian sequence, eventually forming pockmarks on the paleo-seabed. Polygonal faults do not seem to act as vertical fluid conduits, yet do not impede flow along the reactivated faults. The results suggest that fluid escape commenced prior to the deposition of the present day sea bed.