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Release of thermogenic-methane in the Hammerfest Basin after the Last Glacial Maximum. Indications from numerical modelling and 3D seismic reflection data

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The Hammerfest Basin, located in the SW Barents Sea, is characterized by present-day under-filled hydrocarbon accumulations, which are known to have leaked in the past (Dimakis, 1998; Ohm et al. 2008). Late Cenozoic erosion and high latitude glaciations are thought to have driven the redistribution and leakage of these thermogenic fluids providing a source of thermogenic methane to the hydrosphere. The timing, extent and driving factors for the leakage events are still largely unconstrained. Therefore, we investigated present and past leakage of liquid and gaseous hydrocarbons over the Snøhvit and Albatross gas fields of the Hammerfest Basin and analyse its dynamics in response to multiple phases of tectonic uplift and glaciations by means of a combined approach of numerical modelling and interpretation of a high resolution 3D seismic reflection cube.

Our data-constrained 3D basin model of the basin allowed us to quantify the masses of hydrocarbons generated, accumulated and eventually leaked from the reservoirs during the evolution of the basin. Particular emphasis was placed on analysing the fate of leaked volumes of methane within the dynamics of Plio-Quaternary glacial cycles and possible formation or destabilization of gas hydrate deposits. Besides reproducing quite accurately the composition and volume of the hydrocarbons -particularly the gaseous phase- present in the main reservoirs, the model predicts the development of overpressures in the reservoirs due to the ice loading of the basin during the glacial periods. Predicted reservoir pressure fluctuations derived from cyclic loading-unloading during the glacial-interglacial periods are up to 5 MPa. The under-filled nature of the present-day accumulations would result from leakage events during the episodes of glacial retreat, in the transition from glacial to interglacial periods.

Considerations of the gas hydrate stability conditions in the basin during the time span between 1.00Ma and $\approx$11,500 years suggest that the leaked thermogenic methane was probably trapped as gas hydrate deposits during the glacial events and then released at once upon hydrate destabilisation during the Last Glacial Maximun (LGM). These results are supported by the identification on the 3D seismic data of both buried and seafloor mega-pockmarks (1-2 km wide), giant pockmarks (100-300 m wide) and pockmarks (up to100 m wide), which are linked to deep, shallow and Intra Paleocene regional faults.

The described mechanism allows the temporal focussing of significant amounts of deep thermogenic fluids, including methane, in shallower levels of the basin and further sudden release to the hydrosphere. Predicted leaked volumes of thermogenic methane are at least 200 Tg only from this area of the Hammerfest Basin.

References

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