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Extraordinary PVT fluctuations resulting from Ice Age exhumation in the southwestern Barents Sea

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Petroleum exploration in the southwestern Barents Sea has concentrated on the Mesozoic sandstone plays of the Hammerfest Basin. These have yielded abundant gas and very little oil. Such findings are typical of peripheral North Atlantic Margin basins that have undergone Cenozoic exhumation. This is generally thought to have occurred either during the Palaeocene, Oligocene-Miocene, or Pleistocene. Hammerfest Basin erosion is widely estimated to be in the range, 500-1500 metres. The relative severity of individual episodes and impact on fluid dynamics within the basin are poorly constrained. We apply basin modelling tools to establish the sensitivity of the petroleum system to three cited scenarios for Cenozoic exhumation. Vitrinite reflectance and temperature data constrain burial and thermal histories. Calibration is not possible using heat flow variations alone; erosion timing and magnitude are required to match available data. The calibrated model indicates a significant thermal disequilibrium in the Hammerfest Basin at the present day resulting from Late Cenozoic exhumation. Forward modelling of Pleistocene ice sheet loading allows for an estimation of pressure and temperature fluctuations in response to glacial-interglacial cycles. Routine PVT analysis and volumetric calculations of hydrocarbon phase behaviour suggest that fractionation alone is unlikely to account for giant gas-dominated accumulations in the Hammerfest Basin as the maximum potential gas fractionation resulting from an uplifted saturated oil accumulation is less than half the observed hydrocarbon pore volume in Snoehvit at the present day. However, consideration of unusual PVT conditions resulting from rapid cycles of ice sheet loading and erosion during the Pleistocene may furnish a mechanism for fractionating large amounts of gas over a short period of time. We hypothesise an estimated twenty episodes of extraordinary hydrostatic pressure fluctuations in excess of 5 MPa, and a related temperature drop of 20 Celsius over the period, 1.0-0.12 Ma, for the Snoehvit field.