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# Sources, extent and history of methane seepage on the continental shelf off northern Norway

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Active natural hydrocarbon gas seepage was recently discovered in the Hola area on the continental shelf off Vesterålen, northern Norway. We conducted acoustic and geochemical investigations to assess the modern and past extent, source and pathways of the gas seepage .

Water column echosounder surveys showed bubble plumes up to several tens of metres above the seafloor. Analyses of dissolved methane in the water column indicated slightly elevated concentrations (50 nM) close to the seafloor. To identify fluxes and origin of methane in the sediments we analysed sediment pore water chemistry, the isotopic composition of methane and of dissolved inorganic carbon ($d^{13}C_{CH4}$, $d^{2}H_{CH4}$, $d^{13}C_{DIC}$) in three closely spaced (<60 m) gravity cores. We identified a sulphate methane transition zone (SMTZ) in 1.0, 1.5 and 2.5 mbsf, respectively. Estimates of sulphate diffusion rates into the sediment are 56, 234 and 325 mmol/m$^2$year, probably governed by different methane fluxes from below. The high spatial variability in methane flux in the Hola area indicates channelled methane ascent to the seafloor. Investigation of high resolution subbottom profiler data will reveal if faults could be the conduits for the gas escape in the study area.

$d^{13}C_{CH4}$ (-50 to -60 ‰) and $d^{2}H_{CH4}$ (-190 to -225 ‰) values suggest a mixed source of thermogenic and biogenic methane, with indications for a higher proportion of thermogenic methane. Additionally, low nutrient concentrations (ammonium and phosphate) in the pore water suggest a minor activity of microbes decomposing organic matter. Thus, we assume that organic material that could serve as source for microbial methanogenesis is limited. Depth profiles of $d^{13}C_{CH4}$ and $d^{13}C_{DIC}$exhibit different gradients below the SMTZ excluding microbial methanogenesis as a sole methane source. Ongoing analysis of sedimentary total organic carbon will further contribute to identify the methane source.

Moreover, ubiquitous occurrence of methane-derived authigenic carbonates in the study area suggests considerable methane seepage in the past. U-Th dating of these carbonate crusts will provide insights into timing of past methane release and will allow to assess possible links with climate variations and atmospheric methane fluctuations.