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Insights into the activity, formation and origin of seep systems on the seafloor in the SW Barents Sea

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The southwestern Loppa High region, being part of the Barents Sea located in the north of Norway, is a promising area for oil and gas exploration since hydrocarbon discoveries have been made in this area in recent time. Additionally, surface features for hydrocarbon seepage, so called “cold seeps” have been detected on the seafloor, comprising extensive pockmark fields, carbonate crusts bearing areas and fault related gas flares. Leaking hydrocarbons are of specific interest since they are potential indicators for hydrocarbon reservoirs in the subsurface and the emitting hydrocarbons such as the greenhouse gas methane can have significant impact on the evolution of global warming when reaching the atmosphere.
In this study cold seep systems like huge pockmark areas and carbonate crust sites from the SW Loppa High region were examined in detail, in order to determine the activity, formation and spatial distribution of the different seepage structures as well as the origin and timing of the seeping hydrocarbon fluids. The sample material comprising sediment cores from pockmarks, reference sites and carbonate crust areas as well as carbonate crust samples have been analyzed applying a combined biogeochemical and microbiological approach.
In the carbonate crust area diagnostic biomarkers for the anaerobic oxidation of methane (AOM) were detected in the sediments as well as in the corresponding carbonate crusts. Their depth profiles show a distinct interval of higher concentrations, which points towards a shallow AOM zone in the investigated core. The biomarkers were also characterized by very negative carbon isotope signatures, indicating the involvement of the source microorganisms in the process of AOM. These data and active gas bubbling during sampling indicate the presence of methane at the carbonate crust site. In contrast in the pockmark areas active release of gas from the sediment could not be observed, neither in the gas measurement nor in the biogeochemical data. Diagnostic AOM biomarkers were essentially absent. This suggests that the pockmarks have been formed in the past. Chand et al. (2012) showed using high resolution sub-bottom profiler images of pockmarks that the pockmarks cut through the glaciomarine deposits, indicating their formation during the last deglaciation.
The different extent and activity of the seep structures suggests different formation scenarios. The seeps in the carbonate crust area seem to be the surface phenomenon of thermogenic gas migrating upwards from deeper hydrocarbon sources such as the Skrugard oil discovery along faults to the surface, which is supported by seismic data. In contrast, the huge pockmark areas are speculated to be attributed to large volumes of gas accumulated over a wide area as gas hydrates under the ice shield covering the Barents Sea during the last glacial period. During the last deglaciation and the retreat of the ice shield the gas hydrates rapidly decomposed upon the pressure release, leading to the formation of the spatially extended pockmark fields. A massive maybe explosive release of methane from decaying gas hydrates in a short time might have had a significant impact on the climate evolution during the last deglaciation. Although both seep systems seem to be morphologically totally different from each other, it is conceivable that these features were related in the past. The gas hydrates in the past may have been fed by the same fault system, which today act as conduits for the active cold seeps.

Chand et al. 2012. Earth and Planetary Science Letters, 331-332(0), 305-314.