Natural methane seepage at Berta salt diapir located in the Northwestern part of the German North Sea

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Methane escaping from the seafloor, particularly in shallow shelf regions, represents a source of atmospheric methane; however, the exact contribution remains uncertain. This applies to both, natural gas seepage and methane potentially leaking from abandoned oil and gas wells. During the RV Heincke cruise HE537 in July 2019, we investigated the seafloor within the German Exclusive Economic Zone of the North Sea for signs of gas release. Although none of the examined abandoned wells showed clear gas emissions, we detected hundreds of previously unknown gas flares across the study area (Römer et al., 2021a). The area at the salt dome Berta was identified as a hotspot (Fig. 1), characterized by methane concentrations in the water column up to ten times higher than background levels. Parameters such as emission intensity, temporal variability, flux rates, local atmospheric methane concentrations, microbial processes, and the isotopic composition of the gas remained unresolved. However, an improved understanding of shallow seep systems along continental shelf margins is essential for assessing their role in gas exchange and fluid fluxes from the seabed into the water column and ultimately to the atmosphere.

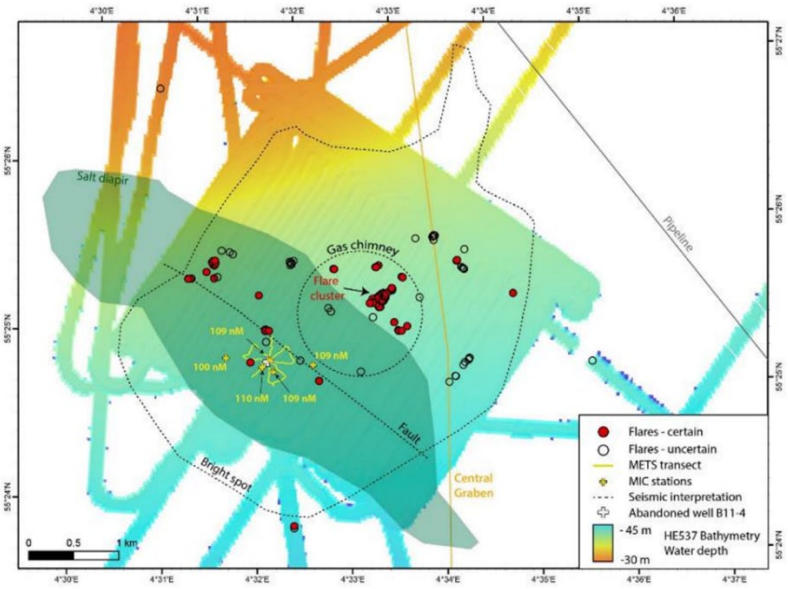

Fig. 1: Main work area at the Berta salt diapir characterized by a complex seep system focussed in a cluster above a seismically imaged gas chimney and along a seismically interpreted fault structure (seismic interpretations by Müller et al., 2018).

Building on these findings, we further examined the active gas system at the newly discovered seep sites in the German North Sea during the follow-up RV Maria S. Merian cruise MSM98 in 2021 (Römer et al., 2021b). In addition to ship-based hydroacoustic surveys, sediment sampling with a multicorer, and water sampling with the onboard CTD, we used an air analyzer to detect methane concentrations above the sea–air interface, a miniROV for gas bubble sampling, a towed electromagnetic system ("Golden Eye") for identifying shallow gas accumulations in sediments, and a sonar lander to monitor bubble release variability. Comprehensive hydroacoustic mapping revealed the spatial distribution and abundance of numerous gas emission sites, some of which were quantitatively assessed and sampled. The sonar lander — deployed at two sites for several days each — recorded significant fluctuations in bubble flux. The "Golden Eye" system was used in four deployments, and the miniROV successfully sampled gas bubbles at two different seep sites. This integrated approach has enhanced our

knowledge of biogenic methane fluxes originating from seabed sediments, its subsequent transport through the water column, and their possible atmospheric implications.

References:

Müller S, Reinhardt L, Franke D, Gaedicke C and Winsemann J, 2018. Shallow gas accumulations in the German North Sea. Mar. Petrol. Geol. 91, 139–151.

Römer, M, Blumenberg, M, Heeschen, K, Schloemer, S, Müller, H, Müller, S, Hilgenfeldt, C, Barckhausen, U and Schwalenberg, K, 2021a. Seafloor methane seepage related to salt diapirism in the northwestern part of the German North Sea. Frontiers in Earth Science, 9. doi:10.3389/feart.2021.556329.

Römer M, Schwalenberg K, Barckhausen U, Hagedorn D, Heeschen K, Blumenberg M, Schlömer S, Krüger M, Krupinski S, Gutierrez Flores P, Gaide S, Malnati J, Marcon Y, 2021b. Variability, amount and fate of methane seepage in the German North Sea, Cruise No. MSM98, 08.01.2021 - 23.01.2021, Emden (Germany) - Emden (Germany), MARIA S. MERIAN-Berichte. Gutachterpanel Forschungsschiffe, Bonn, https://www.tib.eu/de/suchen/id/awi%3Aa7826c2f232522304905002aaf53203ae2e825bd.

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