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Estimating the importance of different pathways of methane discharge from deep-sea submarine sources

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During several field campaigns methane discharge was investigated by a multi technique approach at the deep-sea submarine mud volcano Haakon Mosby (HMMV, 1250 m water depth, Western Barents Sea).

Three pathways of methane release from the sea floor have been identified and are assessed here in respect to their relative importance:

1) Diffusive outflow of methane rich pore fluids carried along with recent upward mud flow from the HMMV's interior. Methane is released at the center region where methanotrophs are absent whereas it is efficiently bio-filtered at bacterial habitats around the center. Discharge rates were estimated from high resolution bottom water gradients obtained by a special water sampler.

2) Focused flow of methane-rich fluids releases dissolved methane into the bottom water column. Vertical flow measurements were carried out by means of the deep-sea ROV "Victor6000" and an acoustic travel time flow meter to calculate outflow rates.

3) Dominating the other pathways, large amounts of methane were found to be released by gas bubbles and gas hydrate flakes. Integrating hydrographic, acoustic, visual and geochemical observations it became evident that gas bubbles withstand dissolution due to the formation of a gas hydrate skin. Due to this phenomenon, bubbles are transported several hundred meters through the water column until leaving the temperature-pressure field of gas hydrate stability.

Microbial water column methane oxidation was found to be extremely slow which coincides with a low delta 13-C signature of methane dissolved in the higher water column. Although a portion of the methane is already microbially oxidized within the surface sediments of the HMMV and the bottom water, considerable amounts are transferred into the higher water column and, potentially, escape to the atmosphere, especially during deep winter mixing.