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The fate of gas hydrates in the Barents Sea and Kara Sea region

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The Barents Sea and Kara Sea are located in the European Arctic. Recent seismic lines indicate the presence of gas hydrates in the Barents Sea and Kara Sea region. Natural gas hydrates contain huge amounts of methane. Their stability is mainly sensitive to pressure and temperature conditions which make them susceptible for climate change. When not stable, large volumes of methane will be released in the water column and - depending on the water depth – may also be released into the atmosphere. Therefore, studying the evolution in time and space of the gas hydrates stability zone in the Barents Sea region is of interest for both environmental impact and energy production.

In this study, we assess the gas hydrate inventory of the Barents Sea and Kara Sea under the light of increasing ocean bottom temperatures in the next 200 years. Thereby, we make use of an existing 3D structural and thermal model which resolves five sedimentary units, the crystalline crust and the lithospheric mantle. The sedimentary units are characterised by the prevailing lithology and porosity including effects of post-depositional erosion which strongly affect the local geothermal gradient.

Governing equations for the conductive 3D thermal field and momentum balance have been integrated in a massively parallel finite-element-method based framework (MOOSE). The MOOSE framework provides a powerful and flexible platform to solve multiphysics problems implicitly on unstructured meshes.

First we calculate the present-day steady-state 3D thermal field. Subsequently, we use the latter as initial condition to calculate the transient 3D thermal field for the next 200 years considering an ocean temperature model as upper boundary. Temperature and load distributions are then used to calculate the thickness of the gas hydrate stability zone for each time step.

The results show that the gas hydrate stability zone strongly varies in the region due to the local geothermal gradient changes. The latter averages $\sim$28°C/km and may exceed 50°C/km close to the continental margin where the lithosphere is thinned.

This study shows that the 3D structural configuration as well as the temperature and pressure distributions is an ideal base to properly estimate the amount of gas hydrate which may have formed in this region.