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Structure and Temperature Configuration of the Barents Sea and Kara Sea region and implications for its lithospheric strength

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The Arctic Barents Sea and Kara Sea are located between the Proterozoic East-European Craton in the south and Cenozoic passive margins in the north and the west. To investigate the present-day density and temperature structure of the underlying lithosphere, we assess how compositional heterogeneities in the subsedimentary crust control the distribution of thermal properties and consequently temperature anomalies. Considering the derived thermal configuration, we model the lithospheric strength and the effective elastic thickness and implications on the crustal deformation.

We make use of a lithosphere-scale 3D structural model that resolves the thicknesses of five sedimentary units, two layers of the subsedimentary crust as well as the lithospheric mantle. The geometries of this 3D structural model are consistent with interpreted seismic refraction and reflection data, geological maps and previously published 3D-models. For the sedimentary units the density distribution is dependent on lithology, porosity and effects of post-depositional erosion. Density anomalies within the continental lithospheric mantle are derived from a recently published velocity-density model. Starting with this initial 3D gravity model, the density distribution is stepwise modified to reproduce the observed gravity field to further investigate the composition of the crystalline crust.

The obtained density distribution within the lithosphere provides further constraints on regional variations in thermal properties to calculate the conductive 3D thermal field. The modelled 3D thermal field is validated with measured borehole temperatures to assess the major controlling factors of the latter.

Based on the 3D structural and thermal model, we develop a rheological model assuming a brittle and temperature-dependent ductile rheology for the sediments, the crystalline crust and the lithospheric mantle. Our results indicate that the integrated lithospheric strength and the effective elastic thickness correlate regionally with the thickness of the lithosphere. The crust and the mantle lithosphere are mostly decoupled apart from areas characterised by a thick mafic lower crust. Notably, regions which experienced Cenozoic deformation and volcanism are underlain by the weakest and thinnest lithosphere. Modelling of the gravitational potential energy indicates that ridge push may account for contractional structures observed in the western and central Barents Sea.