Modelling the effects of crustal metamorphism and lithosphere buckling on subsidence: a case-study from the ultra-deep East Barents Sea basin.

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Lithospheric extension is one of the most common mechanism to explain the formation of intra-continental sedimentary basins. However, extension is an unlikely mechanism for the formation and preservation of certain intra-continental basins as for example the East Barents Sea basin (EBB), whose origin remains unexplained. The EBB is one of the deepest sedimentary basins in the world. It has a very large subsidence, accommodating an up to 20 km thick sediment succession. Subsidence in this area started in the Early Palaeozoic, with a significant acceleration of subsidence during Late Permian-Early Triassic times. The observed gravity signal suggests that the East Barents Sea is at present in isostatic balance and 2 dimensional crustal-scale balancing indicates that a mass excess is required in the lithosphere to compensate for the observed large subsidence.

Permian-Triassic extension has been proposed to explain the present-day large subsidence and the subsidence history. However, seismic data and isostatic considerations indicate that lithospheric extension is an unlikely mechanism. An alternative mechanism is therefore required to explain the formation and preservation of the EBB. It is proposed that lithospheric shortening/buckling initiated the basin formation and triggered metamorphism and densification of crustal mafic rocks giving the required mass excess for its preservation. This mechanism is here evaluated using two modelling approaches.

At first, using 2D isostatic density models of continental lithosphere we evaluate the conditions for crustal phase changes to give enough mass excess to compensate for the observed subsidence beneath the EBB. The 2D models are computed along seismic transects crossing the East Barents Sea. Crustal density is given by pressure, temperature, and composition dependent phase change models. Second, we use a 2D finite element forward thermo-mechanical modelling approach to evaluate the conditions for lithospheric shortening/buckling combined with crustal rock metamorphism to initiate and preserve compensated ultra-deep sedimentary basins. The lower crust is modelled with petrologic consistent densities that depend on pressure and temperature taking into account de-hydration at high P-T conditions. Various models are tested, characterized by different compositions for the lower crust. Results show that lithospheric shortening/buckling may result in compensated ultra-deep basins like the EBB provided the presence of crustal heterogeneities such as a mafic underplate.