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Force, energy and mass balanced basin models: New concepts and Arctic examples.

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Classic basin models envision syn-extensional rift basins that further develop into post-rift basins by thermal contraction of the uplifted asthenosphere below the thinned lithosphere (thermal subsidence).

Such models have been widely and often successfully applied, in part because the researcher can choose between symmetric (McKenzie - model) or asymmetric (Wernicke- model) lithospheric thinning, thereby displacing the focus of uplift and subsidence in space and time, fitting a given geological scenario. However, despite their success, these models do not consider first-order petrological observations and some physical principles. For example, the density of rocks in these models varies only as a function of temperature. In contrast, classical petrology demonstrates that rock densities depend on both, pressure and temperature. Furthermore, mineral phase transitions cause abrupt density changes and are predominantly pressure sensitive.

More recent basin models account for mineral phase transitions and demonstrate that modeled subsidence differs by several km when compared to results of earlier models. Our study takes a step further in exploring the effect of metamorphic reactions deep below basins. In what optimistically might be called a next generation of basin models, we add mass balanced metamorphic reactions, energy balanced hydration and dehydration reactions and melting, and force and energy balanced pressure and temperature calculations. To isolate the effects, we start with 1D models.

As a case study of the Permian to Jurassic Barents Sea scenario, we study how compressed lithosphere may develop deep marine basins. In our modeled scenario, eclog-

itization (c. 10 % volume reduction) of the gabbroic lower crust leads to densification of the lithosphere and formation of a deep basin. Using geophysical methods, it is not trivial to distinguish eclogite (crust) from peridotite (mantle). Thus, compressional basins may appear like classical rift basins that form above an updomed Moho, but this apparent Moho could be a metamorphic front within the crust below a supra-eclogite basin. Similar style basins may form by hydration and subsequent eclogitization of previously subducted, metastable (un-reacted) granulitic lower crust under eclogite-facies PT conditions.

As a case study of the Permian-Triassic and Jurassic-Cretaceous basins in East Greenland scenario, we study how garnet-spinel-plagioclase mineral phase transitions in mantle peridotite cause regional syn-rift uplift, followed by accelerated post-rift subsidence. This becomes particularly evident in the force and energy balanced models, where shear heating and tectonic underpressure drive large domains of the mantle into the plagioclase field and might even cause partial melting.

Application to these two natural examples illustrate how our force, energy and mass balanced basin models contrast with classic pure thermal models and in some cases predict completely opposite subsidence and thermal histories.