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Basin formation and inversion: The role of shear heating, tectonic pressure and hydration/melting in the lithosphere

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Nature displays numerous examples of basin formation and inversion that cannot be explained by simple rift and post-rift subsidence models. One example is the super-regional Base Cretaceous Unconformity, mapped on-land East Greenland and most of the Norwegian continental shelf. This uplift and erosion unconformity matches a major phase of continental extension, a time for which standard models predict major subsidence. These models attribute surface displacement to tectonic events and thermal contraction. Mineral phase transitions and metamorphic reactions within the lithosphere may in some cases subdue syn-rift subsidence and increase post-rift subsidence. Here we present numerical simulations that demonstrate that shear heating and tectonic pressure may dramatically shift predictions of basin models and lead to syn-extensional uplift and more pronounced post-extensional subsidence. We show that basins can be augmented by hydration of the lower crust (e.g. eclogitization = contraction and heating) and inverted by hydration of the upper mantle (e.g. serpentinization = expansion and heating). Uplift and subsidence driven by metamorphic reactions may be at least as significant as the effect of pure tectonothermal mechanisms. Evidently our understanding, and even apparent observation of structural events (e.g. rifting), and particularly their timing, is intimately linked to our concepts of the involved processes. Here we compare major Late Jurassic-Cretaceous structures in the Northeast Atlantic to different types of basin models, and arrive at new and in part counterintuitive results in regard to timing, structural style and thermal influence on basin formation.