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Geotectonic modeling of lithosphere dynamics and deformation: advances and challenges (inspired by geological observations)

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Thermo-mechanical numerical modeling becomes a universal tool for studying short- and long-term lithosphere processes, validating and verifying geodynamic and geological concepts and putting stronger constraints on the observational data. State-of-the-art models are focused on most complete integration of geoscientific methods and geological observations and account for complex thermo-rheological and mineralogical structure of the lithosphere, implement high resolution calculations allowing for direct match of their outputs with the geological and geophysical observations. Challenges of these models are vast including understanding of the behavior of complex geological systems and processes, parameterization of rheological parameters and other rock properties for geological conditions, not forgetting a large number of future methodological breakthroughs such as the development of ultra-high resolution 3D models coupled with thermodynamic processes, fluid circulation and surface processes. We here discuss both geological and geodynamic applications of the models, their principals, and major results of regional modeling studies focused on rifting, convergent and transform plate boundaries and mantle-lithosphere interactions.