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Impact of fluid-rock and metamorphic reactions on style of rifting during formation of hyper-extended continental margins.

Leila Mezri, Leatitia Le Lepourhiet, Evgene Burov, and Christian Gorini
UPMC Univ-Paris 06, UMR 7193, ISTeP, F-75005 PARIS,France (leila.mezri@gmail.com)

It is now well established that the geometries of different rifted margins , specifically hyper-extended, cannot be explained by a simple scenario of extension of a horizontally uniform lithosphere. Indeed, over the last decade, the scientific community pushed forward models with heterogeneous initial conditions to simulate the impact of structural inheritance on the geometry and on the amount of pre-break up extension accommodated by passive margins. In this study, we develop a principally new model of structural inheritance where the latter is introduced in a physically-consistent way, as a consequence of metamorphic reactions and of the associated fluid pathways impacting crustal rheology during extension. The metamorphic reactions imply important mass transfers and occurrence of non-hydrostatic fluid pressure gradients during deformation. These two phenomena are known to have a considerable influence on the effective mechanical properties of the rocks within the shear zones. The observed P-T-t paths indicate that during extension, the rocks experience initial decompression, followed by a phase of reheating and ended , almost systematically, by a retrograde phase, in which temperature and pressure diminish with increasing deformation. The occurrence of retrograde reactions implies that at some stages the water re-enters the dehydrated parts of the system, resulting in rheological (re)-softening. Otherwise, without water, metamorphic reactions would not occur and the rocks would have preserve their dry (i.e. strong) rheologies. These last factors, i.e. meta-stable states and retrograde reactions in presence of water, are not accounted in current thermo-dynamically coupled thermo-mechanical models. However, they are crucial for localization of deformation and exhumation of rocks. Fluid circulation is also affected by rock porosity and permeability that in-turn are the functions of strain and of the degree of metamorphism. Using a new numerical approach that couples fluid flow and out-of-equilibrium thermodynamics, we undertake a parametric study of porosity and permeability using well calibrated metamorphic data from the Alps allowing for account for impact of metamorphic inheritance on rifting. We demonstrate that these factors influence the rheology of the lithosphere and deformation styles at large scale , in particular enabling migration of the level of necking during rifting.