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Lithosphere erosion and breakup due to the interaction between extension and plume upwelling

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We have built up 2D numerical models of coupled crust - lithospheric mantle - upper mantle systems. The reconstructed sections are subjected to external velocity fields and mantle plume impingement beneath the lithosphere, both acting simultaneously. The models are designed to simulate the interaction between plumes and lithosphere in an extensional setting with the main purpose to contribute to address the following questions: 1) Are plumes capable of weakening certain lithospheric regions? Where and when are the main effects observed? 2a) Can a plume really cause a plate break-off and drifting with no external contribution; 2b) if yes, are there any particularly favorable conditions required? In our models a novel aspect is melt generation due to plume, upper mantle and lithospheric mantle partial melting. Produced melts are capable to ascend across the reconstructed sections due to buoyancy. Furthermore, heat transport related to melt movement is taken into account and leads to a significant heating of host rocks at the melt neutral buoyancy depth.
In absence of external stress or velocity fields, the effects of plume impingement beneath the lithosphere are negligible at surface. Here the main observed feature is the production of doming at various length scales, depending on the adopted rheology for the crust. At depth, the main effect is a thermo-mechanical erosion of the lithospheric mantle with production of melts and subsequent underplating of the crust. The heat flux due to plume impingement and crust underplating determines a weakening of crust and lithosphere. However, the strength drop is not followed by an appreciable deformation. When external stress or velocity fields are applied, the coupled effects with plume presence and melt production lead to great modifications of the lithospheric structure. Topography profiles are characterized by the presence of a horst and graben structure, and extensive erosion of the lithosphere always occurs. The presence of melts contributes in weakening the crust and the uppermost lithospheric mantle, thus favoring the plate rupture and blocks drifting. Our results seem to exclude the possibility that forces related to plumes uprising are capable of breaking off the plates and cause blocks drifting. On the other hand, we support the possibility that plume uprising may strongly favor plate breakup, when combined with external far field forces.