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Crust-mantle and intra-crustal decoupling: consequences for continental rift basin dynamics

Evgueni Burov and Benjamin Huet
ISTEP, UMR 7193 UPMC-CNRS, Université Pierre et Marie Curie - Paris 6, Paris, France (evgenii.burov@upmc.fr)

It is generally assumed that styles of continental rifting are mainly conditioned by the initial integrated strength of the lithosphere. For example, strong plates would extend in narrow rifting mode, while weak lithospheres would undergo stretching in wide rifting mode. However, this classification might be insufficient because the notion of the integrated strength ignores the internal rheological structure of the lithosphere that may include several zones of crust-mantle or upper-crust-intermediate (etc) crust decoupling. As it has been already discussed in previous studies, the presence of decoupling zones is very important because it may result in substantially different evolution of the rift zone. Indeed, mechanical decoupling between the competent layers results in overall drop of the flexural strength of the system and may also lead to important horizontal flow of the ductile material. In particular, the commonly inferred concept of level of necking (that assumes the existence of a stationary horizontal stretching level during rifting) looses its sense if necking occurs at several distinct levels. In this case, due to different mechanical strength of the rheological layers, several necking levels develop and switch from one depth to another resulting in step-like variations of rifting style and in accelerations/decelerations of subsidence during the active phase of rifting. During the post-rifting phase, initially decoupled rheological layers may tend to stick together resulting in step-like strengthening of the lithosphere and deceleration of subsidence. Hence, the entire rift system may exhibit polyphase subsidence behavior, which may be entirely conditioned by its internal structure and not by external factors. Similar phenomena can be observed in case of reversal of tectonic stresses. To demonstrate these ideas, we implemented series of systematic thermo-mechanical numerical models. The experiments confirm the importance of the rheological decoupling in the lithosphere for the style of rifting and subsidence history. We also test the importance of tectonic heritage that may result , for example, in inversion of "normal" rheological sequences in post-orogenic lithospheres and thus in formation of additional levels of mechanical decoupling.