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Simple numerical models of the dynamic effects of surface processes on the evolution of rifted passive margins

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Many passive margins show evidence of large-scale surface transport of sediments from the onshore to the offshore during their evolution from continental rifting to post-rift margins. Examples can be found in the thick syn- and/or post-rift sedimentary packages of the Norwegian, Greenland, and West African margins. Surface processes not only directly impact the development of offshore sedimentary basins, but the resulting isostatic response to the redistribution of surface loads may influence onshore topography. For example, the flexural response to rift flank erosion and offshore sedimentation may assist in the preservation of rift escarpments. In addition, the redistribution of material by erosion and sedimentation also influences flow of viscous layers and impacts brittle strength of the crust.

I use simple numerical experiments to explore the response of passive margin evolution to surface processes. The models are built of crustal layers, a lithospheric mantle, and the underlying upper mantle. The lithologies have pressure-dependent brittle strength and a temperature-dependent viscous rheology. The numerical experiments examine the dynamic feedback relationships between surface processes (including fluvial or hillslope erosion), lithospheric thinning and strength. Results highlight the importance of crustal strength evolution in relation to surface processes. For a wide range of surface processes, a strong lower crust leads to relatively fast lithospheric break-up accompanied by rift flank uplift and focussed mantle upwelling. A weak lower crust generally delays break-up. But increasing surface processes can switch break-up style for intermediate strength lower crust. In that case, sedimentation has a delocalising effect, which delays break-up. Further experiments are aimed at investigating the longer-term response of mature passive margins to the continued action of surface processes.