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A numerical modelling approach to investigate the surface processes response to normal fault growth in multi-rift settings

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This study uses a numerical modelling approach to explore structural controls on erosional/depositional systems within rifts that are characterized by complex multiphase extensional histories. Multiphase-rift related topography is generated by a 3D discrete element model (Finch et al., Basin Res., 2004) of normal fault growth and is used to drive the landscape evolution model CHILD (Tucker et al., Comput. Geosci., 2001). Fault populations develop spontaneously in the discrete element model and grow by both tip propagation and segment linkage. We conduct a series of experiments to simulate the evolution of the landscape (55x40 km) produced by two extensional phases that differ in the direction and in the amount of extension. In order to isolate the effects of fault propagation on the drainage network development, we conduct experiments where uplift/subsidence rates vary both in space and time as the fault array evolves and compare these results with experiments using a fixed fault array geometry with uplift rate/subsidence rates that vary only spatially. In many cases, areas of sediment deposition become uplifted and vise-versa due to complex elevation changes with respect to sea level as the fault array develops. These changes from subaerial (erosional) to submarine (depositional) processes have implications for sediment volumes and sediment caliber as well as for the sediment routing systems across the rift. We also explore the consequences of changing the angle between the two phases of extension on the depositional systems and we make a comparison with single-phase rift systems. Finally, we discuss the controls of different erodibilities on sediment supply and detachment-limited versus transport-limited end-member models for river erosion. Our results provide insights into the nature and distribution of sediment source areas and the sediment routing in rift systems where pre-existing rift topography and normal fault growth exert a fundamental control on landscape development.