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The influence of fault segmentation on drainage network re-organisation and basin stratigraphy

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Landscape evolution in an extensional basin reflects a history of fault activity, erosion, drainage network evolution, and sediment transport and deposition. There is a need to fully couple knowledge and research on rift-related drainage catchment evolution with analysis of depositional systems and stratigraphic architecture in hangingwall depocentres. An integrated approach is needed in order to deconvolve climate, tectonic and relative sea-level change from the preserved stratigraphic record. The spacing of outlets within a rift is dependent not only on slope length but also by the pre-existing drainage network and the evolving fault array.

A three-dimensional numerical model of erosion and clastic sedimentation is applied to investigate the effect of displacement on interacting normal faults on the development of drainage networks and the distribution of deposition in an extensional basin. Material is eroded through a stream-power incision law and deposited in the basin using a modified diffusion algorithm. The initial topography is developed to a steady state before experiments commence. This system is then perturbed by the introduction of a pair of propagating normal faults at varying displacement rates (1.0m/kyr - 2.0m/kyr), locations relative to one another (along strike, en echelon, or adjacent) and activity times, to demonstrate the influence of fault propagation and interaction on drainage capture, network re-organisation, sediment routing and deposition.

When the faults lie along strike and propagate towards one another, a large proportion of the drainage network is routed through the narrowing gap between the faults, and this large catchment may follow the same drainage pathway long after the faults have become connected. When the faults have an en echelon distribution, the relative separation of the two faults is a key control on the subsequent drainage network evolution. When the relative timing of the two faults is altered, further modifications to network re-organisation and depositional geometries occur. If the upslope fault is active first, drainage re-directed around the fault tip has sufficient stream power to continue to cut across the downslope fault when it becomes active. However, if the downslope fault becomes active first, the drainage is directed around fault tips in turn, dependent on their orientation. The degree of overlap of the faults is a key control on the development of any internal drainage; the greater the overlap the more likely internal drainage in the footwall of the downslope fault and hanging wall of the upslope fault. This situation is most exaggerated when the two faults are directly adjacent, without any offset. The various drainage network histories are in turn reflected in the architecture of the stratigraphy deposited in the hanging walls, which is often different from that anticipated by consideration of the downslope fault alone.