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Localisation of Normal Faults in Multilayer Sequences

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Existing conceptual growth models for faults in layered sequences suggest that faults first localise in strong, and brittle, layers and are later linked in weak, and ductile, layers. We use the Discrete Element Method (DEM as implemented in *PFC-2D*) for modelling the growth of a normal fault in a brittle/ductile multilayer sequence. The calibrated model lithologies have rheologies equivalent to those of limestone and shale, hereafter referred to as 'strong' and 'weak' layers, respectively. The multilayer sequence consists of four, 1m thick strong layers and four, 1.5m thick weak layers. Propagation of a single normal fault through the brittle/ductile multilayer is achieved by a predefined normal fault at the base of the model, while maintaining a constant overburden pressure at the top of the model. The model is analysed in 1cm throw increments and the final throw is 10cm. We employ tensor mechanics to compute a homogeneous strain from the particle position vectors within certain regions of interest along the modelled fault. Additionally the average stress tensor within these selected regions is obtained. The stress/strain paths and the strain energy history of the DEM model are consistent with conceptual models of fault growth in layered sequences. The modelling reveals that faults in brittle/ductile sequences at low confining pressure and high strength contrast localise first as Mode I fractures in the brittle layers. Low amplitude monoclinal folding prior to failure is accommodated by ductile squeeze flow in the weak layers. The initially vertically segmented fault arrays are later linked via shallow dipping faults in the weak layers. Faults localise, therefore, as geometrically and kinematically coherent arrays of fault segments in which abandoned fault tips or splays are a product of the strain localisation process and do not necessarily indicate linkage of initially isolated faults. Fault tip lines in layered sequences are expected to be more advanced in the strong layers compared to weak layers, where the difference in propagation distances is most likely related to strength and/or ductility contrast.