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Distinct Element Method modelling of fold-related fractures in a multilayer sequence

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Natural fractures have a significant impact on the performance of hydrocarbon systems/reservoirs. In a multilayer sequence, both the fracture density within the individual layers and the type of fracture intersection with bedding contacts are key parameters controlling fluid pathways. In the present study the influence of layer stacking and interlayer friction on fracture density and connectivity within a folded sequence is systematically investigated using 2D Distinct Element Method modelling. Our numerical approach permits forward modelling of both fracture nucleation/propagation/arrest and (contemporaneous) frictional slip along bedding planes in a robust and mechanically sound manner. Folding of the multilayer sequence is achieved by enforcing constant curvature folding by means of a velocity boundary condition at the model base, while a constant overburden pressure is maintained at the model top.

The modelling reveals that with high bedding plane friction the multilayer stack behaves mechanically as a single layer so that the neutral surface develops in centre of the sequence and fracture spacing is controlled by the total thickness of the folded sequence. In contrast, low bedding plane friction leads to decoupling of the individual layers (flexural slip folding) so that a neutral surface develops in the centre of each layer and fracture spacing is controlled by the thickness of the individual layers. The low interfacial friction models illustrate that stepping of fractures across bedding planes is a common process, which can however have two contrasting origins:

1. The mechanical properties of the interface cause fracture stepping during fracture propagation.
2. Originally through-going fractures are later offset by interfacial slip during folding.

A combination of these two different origins may lead to (apparently) inconsistent fracture offsets across bedding planes within a flexural slip fold.