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Fault system polarity: A matter of chance?

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Many normal fault systems and, on a smaller scale, fracture boudinage exhibit asymmetry so that one fault dip direction dominates. The fraction of throw (or heave) accommodated by faults with the same dip direction in relation to the total fault system throw (or heave) is a quantitative measure of fault system asymmetry and termed ‘polarity’.
It is a common belief that the formation of domino and shear band boudinage with a monoclinic symmetry requires a component of layer parallel shearing, whereas torn boudins reflect coaxial flow. Moreover, domains of parallel faults are frequently used to infer the presence of a common décollement.
Here we show, using Distinct Element Method (DEM) models in which rock is represented by an assemblage of bonded circular particles, that asymmetric fault systems can emerge under symmetric boundary conditions. The pre-requisite for the development of domains of parallel faults is however that the medium surrounding the brittle layer has a very low strength. We demonstrate that, if the ‘competence’ contrast between the brittle layer and the surrounding material (‘jacket’, or ‘matrix’) is high, the fault dip directions and hence fault system polarity can be explained using a random process. The results imply that domains of parallel faults are, for the conditions and properties used in our models, in fact a matter of chance.
Our models suggest that domino and shear band boudinage can be an unreliable shear-sense indicator. Moreover, the presence of a décollement should not be inferred on the basis of a domain of parallel faults only.