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Modeling non-Andersonian fault growth following the energetic criterion: the creation of detachments and listric faults

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We simulate a fault growth implementing a 2D Boundary Element Method that imposes the balance of shear and residual frictional tractions acting on a non planar crack surface. The direction of the crack growth is the one that maximizes the strain energy release while the growth is inhibited if the strain energy release is lower than the work done against friction. Following this criterion, in a homogeneous elastic medium the dip angle of the fault during its growth is different with respect to the Anderson's prediction, which refers to the minimum tectonic stress capable of generating slip against friction. We also consider the crack growth in a heterogeneous elastic medium constituted by two welded half-spaces with different elastic properties, finding that for both normal and reverse faults, non-Andersonian dip angles are justified by the energetic criterion. The presence of a sharp rigidity contrast strongly influences the direction of crack growth. In particular, faults approaching softer materials tend to bend toward greater dip angles. Accordingly, our model is able to simulate non-planar, complex, fault geometries, as in the case of detachment and listric faults. Our results suggest that the rigidity contrast can foster the birth of curved fault geometries and it is a key parameter for the study of fault geometry formation.