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Competition between compaction bands, reverse faults and kink folds, as failure modes in carbonates

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A comparison is made between the conditions for the initiation of three modes of failure, compactions bands, reverse faults and kink-folds in carbonates, in terms of depth and dip of the competent layers seen as an imperfection. The predictions are analytical and based on the upper bound approach of the classical limit analysis. The competent rock is layered with weak interfaces strength described by the Mohr-Coulomb criterion. The competent material is also cohesive and frictional but with an additional closure in the compressive stress domain to depict the action of compacting deformation mechanisms.
The respective domain of dominance of each mode is presented in failure-mechanism maps, in the space spanned by the dip angle and the burial depth. The domain of the compaction band is at greater depths than the reverse faults with a boundary varying almost linearly with the imperfection angle. The kink-fold domain is for the larger imperfection angles regardless of the depth. The boundary with the two other domains of dominance is rather sensitive to the number of layers in the competent rock as well as to the friction of these weak interfaces.
The kink-band mode is also studied during its development. It is shown that,at its onset, with compaction band dominant conditions, it resembles a slip-enhanced compaction band due to the weak interfaces activation and the compaction along the parallel hinges. This hybrid mode migrates suddenly through the competent beam from the deepest towards the shallowest region and develops as a kink fold, after a negligible amount of shortening. The development occurs then in two phases: rapid rotation of the hinges followed by a widening of the kink band. It is found that the force for this development is decreasing first, sustains a minimum and then increases again. The orientation of the weak interfaces at this minimum force is function of the burial depth and of the increase in potential energy of the competent layer.