

Box Fold Shape and Fractures: Differences Observed from Buckling vs. Detachment Folding

Caroline Burberry¹, Andreas Eckert², Yuxing Wu³

¹University of Nebraska-Lincoln; ²Missouri University of Science & Technology; ³University of Oklahoma

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Abstract

Fracture patterns, i.e., their type, location and orientation, are a result of the dynamics of fold development, and are dependent on parameters such as strain rate, viscosity, competence contrasts, pore pressure, and folding processes such as flexural slip and flexural flow. Curvature based fracture prediction can give misleading results, because curvature is purely a geometric property and does not consider the evolution of the structure, and therefore is not linked to the dynamics. In this study, we show two different box folds (that is, double-hinged folds) forming via different folding mechanisms. Fold A forms via viscoelastic buckling and is simulated in a numerical model as a stack of competent layers which can slip past each other, embedded in a less competent matrix. Fold B forms via detachment folding above a ductile (salt) decollement, and is built in an analog model using layers of sand over silicon. For the purposes of comparison, both folds are considered as effective single layers. The fold shapes during deformation, from initiation to limb lock up, are quantified by the use of Bezier curves, describing shapes such as chevron, sinusoidal, parabolic, and double-hinged structures. Results indicate that Fold A developed through a sinusoidal and parabolic geometry before evolving to a box fold, with flexural slip on the limbs between the plates of the effective single layer. Flexural slip occurs at discrete points within the fold evolution rather than continuously throughout the deformation sequence. Fold B, in contrast, evolves only through a parabolic stage to a box fold stage, and no flexural slip occurs in this structure. Similarly, fracture patterns are distinct between the two structures, with Fold A developing a more complex fracture pattern than Fold B, which is dominated by outer-arc stretching and hinge-parallel fractures. These results are applicable particularly to petroleum

provinces where box folds are plentiful, such as the Zagros of Iraq and Iran.

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