Finite Element Modeling of Bedding Surface Slip and Fracture Evolution during Asymmetric Folding

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We investigate the reactivation of fractures and the development of bedding surface slip during the deformation of the asymmetric anticline at Sheep Mountain, WY using finite elements. A series of numerical simulations were run to show the effect of mechanical stratigraphy, layer thickness, slip on bedding surfaces, and tectonic shortening of the fold on the response of a three-layer (ductile, brittle, ductile) composite. The two-dimensional model uses large deformation frictional contact mechanics to capture the response of existing fractures and slip along bedding surfaces, and considers both elastic and elastoplastic rheologies. The computational results demonstrate the relationships among overall configuration of the multilayer, slip on bedding surfaces, and the sequence and mode of deformation (opening versus shearing) of bed-perpendicular fractures. We show that fractures located in the hinge are mainly reactivated as joints and that those in the forelimb are predominantly reactivated as thrust faults. A flexural slip mechanism develops during folding when the layers bounded by frictional bedding surfaces have similar stiffnesses. In contrast, when the difference in the layer stiffnesses is significant (softer outer layers) the deformation is accommodated within the softer units without exceeding the frictional strength of the bedding surfaces. We compare the numerical results with fracture data collected at Sheep Mountain Anticline and discuss the similarities and differences between the field observations and the model results.