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Detachment folds versus thrust-folds: numerical modelling and applications to the Swiss Jura Mountains and the Canadian Foothills

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The Jura Mountains and the Foothills of the Canadian Rockies fold-and-thrust belts are classical examples of thin-skinned belts where folds develop over weak detachment horizons. They offer the possibility to observe and measure strain in folds. In these two belts, a large spectrum of fold geometries is expressed, from symmetric box-fold or pop-up structures to asymmetric thrust-related folds.

In this study, we focus on the quantification and prediction of the brittle strain distribution in folds as a function of the fold geometry. Fold geometry is considered as a continuum between two end-member structural styles: symmetric detachment folds and asymmetric foreland-vergent thrust-folds.

We performed two-dimensional numerical simulations of visco-plastic detachment folding. The models are used (1) to systematically examine the influence of different initial parameters on the resulting geometry and style of folding and (2) to quantify the local strain pattern through time. The different parameters tested are the following: presence and size of initial geometrical perturbation at the detachment-sediment interface, rheology of the detachment (frictional vs. viscous), additional detachment layer within the series and overbunden thickness.

Results of single detachment layer models show that the asymmetry of folds is primarily controlled by the height of the initial geometrical perturbation, regardless to the rheology of the detachment (frictional vs. viscous). Additional detachment interlayer within the series decreases the brittle strain within the stiff layers and favours more rounded anticlines geometry.

The models were then adapted to the Swiss Jura and the Canadian Foothills settings. Compared to field observations and cross-sections of existing fault-related anticlines, the proposed simulations agree with the first order geometry and the development of associated localized zones of brittle deformation.