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Mechanics of single-layer folding and its applications

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Single-layer folding originates from a mechanical instability which has been studied intensively by Structural Geologists, because folding occurs frequently and on all scales during rock deformation. Existing mathematical results for single-layer folding are reviewed, and applications to strain estimation and folding-mode classification using observable fold geometries are shown. The presented examples show how to relate geometrical fold parameters, such as thickness and hinge distance, to mechanical properties. A new scaled amplification equation is presented for finite amplitude folding of viscous single layers. The scaled equation provides a single curve which describes the evolution of the fold amplitude with progressive shortening and is valid for all folds having different viscosity contrasts and different initial amplitudes. Shortening is quantified by the ratio of initial fold wavelength to current fold wavelength, which is scaled by the crossover strain. The crossover strain is the amount of layer-parallel shortening, for which the linear theories of folding are valid, and can be calculated using bifurcation analysis. The scaled equation further allows calculating the evolution of the effective fold growth rate and the amplification velocity with progressive shortening. This enables quantifying the boundaries between the three folding stages nucleation, amplification and kinematic growth. During kinematic growth (i.e. the effective fold growth rate is zero) all viscous single-layer folds amplify identical, independent on the viscosity contrast, and the amount of shortening can be directly estimated from the ratio of vertical to horizontal hinge distance. The analytical results are verified by numerical, finite element, simulations. Furthermore, applications to parasitic fold development in multilayers and 3D single-layer folding are presented.