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Numerical simulation of layer folding in simple shear

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Folds and associated cleavages provide information on the deformation conditions during their formation. They are widely used to estimate the orientation and magnitude of shortening. However, folds potentially contain much more information, especially on rheology and kinematics of deformation. In order to be able to improve the use of folds for strain analysis, we first need to quantify the relationship between all parameters that determine fold geometry and scale.

Most current numerical models of folding focus on the deformation of single layers oriented parallel to the shortening direction and pure shear conditions. These are very restrictive conditions that are difficult to apply to natural folds developed under non coaxial deformation (i.e. in shear zones). In this contribution we present series of two dimensional numerical simulations of single- and multilayer folding in simple and pure shear. This allows us to compare the development of folds in both deformation cases. For this purpose, we use the software packages Elle and Basil to simulate linear and non-linear viscous deformation (Bons et al., 2008).

Our models are defined by a system of layers in which we systematically vary: (a) the spacing between competent layers, (b) the viscosity ratio between hard and soft layers, (c) the stress exponent and (d) the initial orientation of layers with respect to the shear plane. With this approach we can compare the refraction of the foliation, the shape of folds and the orientation distributions of axial planes.

The results show that the geometry of single layer folds in pure and simple shear is very similar. Only by using foliation refractions can one distinguish between coaxial and non-coaxial cases. The differences become more visible when multilayers are deformed, as flexural flow between fold trains leads to the development of disharmonic fold shapes, where antiforms and synforms are coincident between consecutive layers. A slight difference in the shape of folds can also be used: while m-shape folds predominate in pure shear conditions, omega-shape folds develop in simple shear.

Using a power-law non linear viscous rheology instead of linear viscosity leads to an increase of the viscosity contrast between hard and soft layers. Fold envelopes start to appear curved when this contrast increases above a value of approx. 50. The viscosity contrast also controls the relationship between layer shortening and thickening, the spread of axial plane orientations, amplitudes and wavelengths.

References:

Bons, P.D., Koehn, D. and Jessell, M.W. (Eds.). 2008. Microdynamics Simulation. Lecture Notes in Earth Sciences, 106. Springer-Verlag.