Geophysical Research Abstracts
Vol. 15, EGU2013-12537, 2013
EGU General Assembly 2013

Estimation of rheological parameters from the geometry of a single-layer fold train

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One of the focuses in the analysis of the geometry of buckle folds is their relation to the rheological parameters of the rocks and the amount of shortening. Even in the simple case of a single layer (where the effects of e.g., heterogeneity or anisotropy are neglected and the rock behaviour can be described as linear viscous material), such a relation is not determined in a satisfactory way. This is due to the dependence on the initial perturbation, whose influence on the fold shape is inaccurately quantified but known to be significant (e.g., Mancktelow, 2001). Thus, the aim of this work is to describe the fold shape as a function of the following parameters: viscosity ratio, shortening, and initial perturbation. We explore two approaches: 1) a range of possible fold geometries is constrained for a given set of parameters using forward simulations and 2) backward modelling.

In the first approach, establishing the relations between the fold shape and the parameters requires an understanding of the influence of the analysed parameters on the final amplitude spectrum and then the correlation between the final amplitude spectrum and the fold geometry. The role of viscosity ratio, shortening, and initial perturbation can be quantitatively established using theoretical models. For this reason, we employ the Large Amplitude Folding model (Adamuszek et al., 2012), a mathematical model that satisfactorily predicts the evolution of fold geometry parameters up to large amplitudes. Using LAF, we calculate the final amplitude spectrum for selected initial amplitude spectra, viscosity ratio, and shortening. The characteristic features of the final spectrum are described and the influence of the input parameters is tested. Then, for given spectrum, we generate a fold interface by adding the waveforms from the spectrum (with determined wavelength and amplitude) and the phase shift is randomly chosen. The obtained fold train is analysed using the automated Fold Geometry Toolbox (Adamuszek et al., 2011). Here, the fold geometry is described with a simple set of parameters such as arclength, wavelength, amplitude, and thickness. By varying the phase shift, we can easily generate a large number of fold shapes, whose diversity is analysed using statistical methods. Then, these statistical measures are correlated with the amplitude spectrum and further with the studied parameters.

In the second approach, we study reverse modelling. This is based on the trial and error method, where the range of viscosities and shortening values are tested. We investigate the sensitivity of the choice of the parameters on the unfolding process and the evolution of the geometrical parameters. Additionally, an influence of the choice of the boundary conditions is examined. The reverse modelling is performed using LAF and finite element method and these methods are compared. We explore limitations of these two approaches and their sensitivity on the choice of perturbation type and amplitude. Finally, we perform the analysis on natural fold examples.

References:

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