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Dynamic reverse modeling of flanking structures

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Flanking structures are deflections of marker lines around a planar discontinuity, such as a dike or a fracture (e.g. Grasemann et al. 2003). The presence of this discontinuity induces a non-homogeneous flow field in the vicinity of the fracture during deformation, which causes a deflection of the marker lines from their initially straight orientation. Various types of flanking structures develop depending on the flow field (described by the vorticity number W_k), the initial fracture orientation α, and the time τ at which the structure is observed (also reflecting the total strain associated with the bulk flow).

We investigated the possibility of retrieving information about the kinematic vorticity number W_k of the flow field in which a specific flanking structure formed for the case of a known bulk shear sense but unknown initial fracture orientation α and bulk strain (or time τ). An analytical solution for the velocity field around a very thin, weak inclusion in linear viscous material is used to model the deformation around the fracture (Schmid & Podladchikov 2003). The structure is retro-deformed and an attempt is made to find the flow field that transforms the marker lines back into their initially straight shape. If a finite structure is reverse modelled applying the correct flow field, the marker lines will eventually become parallel, straight lines. If the flow field is not correct, the marker lines will never become straight at any time and a residual remains. A plot of this residual value against time τ and W_k allows a minimum to be located corresponding to the most likely correct values for these parameters.

An investigation of the six different types of flanking structures that occur in transpressional general shear flow fields (Grasemann et al. 2003) showed that the bulk strain that led to the formation of a flanking structure, as well as the kinematic vorticity number of the flow field Wk, can be reconstructed to high accuracy. Best results are obtained for s-type flanking structures, where well-constrained minima occur for the vorticity number W_k. The use of different types of flanking structures from the same

outcrop increases the accuracy of the reconstruction.

Application to natural examples is possible in cases where the assumptions underlying the analytical solution are met. Plane strain can be assumed where the orientation of the stretching lineation is constant on the scale of the flanking structure. The initial orientation of the marker lines is assumed to be parallel to the fabric attractor in highly deformed rocks, such as mylonites. Since most flanking structures are low strain structures, the flow field is assumed to be constant for the time of structure formation. As expected, natural examples show minima that are less well-defined than for synthetic examples. In nature, marker lines are not equally distributed along the fracture, which hinders an accurate reconstruction and the marker lines themselves may not have been perfectly straight initially. However, applying the method to several flanking structures from the same outcrop increases the accuracy and provides quantitative constraints on the vorticity number W_k.

References

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