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Modeling of ductile deformation in anisotropic rocks with slip surfaces

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Flanking structures and sheath folds can develop in layered rocks due to flow perturbation around slip surfaces in shear zones (Exner and Dabrowski, 2010; Reber et al., submitted). Mechanical anisotropy of the host rock has been shown to play a major role in determining the slip rate and the flow pattern around it (Kocher and Mancktelow, 2006; Fletcher, 2011). In addition, anisotropic fluids such as ductile foliated rocks have a 'memory' of deformation due to evolving microstructure. For example, the rotation of a rigid circular inclusion embedded in a layered host in layer-parallel shear results in the structural reorganization around it, which leads to the modification of the flow pattern in the host and in consequence to a massive reduction of the inclusion rotation rate (Dabrowski and Schmid, 2011).
Willis (1964) derived an analytical elastic solution for an elliptical inclusion in a homogeneous anisotropic matrix subject to a uniform load in the far field. The solution can be reduced to the case of an incompressible viscous medium. The case of an arbitrarily oriented inviscid slit under shear parallel to the principal axis of anisotropy can be obtained by reducing it even further. Although derived for the initial state of homogeneous planar anisotropy, the solution provides useful insights into the large deformation behavior of the system.
In this study, I will use different models and numerical modeling techniques to assess the impact of mechanical anisotropy and structural development on the perturbing flow around an inviscid slit (slip surface) embedded in a host comprising discrete isotropic layers in layer-parallel simple shear. In the limit of thin layers (the number of layers intercepting the slit tends to infinity), the host is modeled as an anisotropic fluid. The anisotropic viscosity is determined by the bulk anisotropic viscosity of the layered system. The layering is initially planar or equivalently the anisotropy is initially homogeneous. Both non-planar layering and variable orientations of the principal axis of the anisotropy develop around the slit with large deformation.

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