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A 3D structural model of fault drag from differential GPS mapping: evidence for rotation of high-angle normal faults

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Deflection of markers approaching a discontinuity is known as fault drag. Although 2D sections and kinematic restorations provide a useful first order approximation of an implicit plane strain geometry of fault drag, especially deformation at fault tips or in fault relay zones require for 3D mechanical models. Synthetic datasets of ideal fault zones may facilitate understanding of general effects and trends, but detailed geometries of fault drag, which are a function of the heterogeneous displacement field, are strongly dependent on small spatial variations of orientation of a fault surface. Thus, datasets of natural fault surfaces and fault drag are required to generate mechanical models of realistic 3D structures for the reconstruction of fault histories.

We present a 3D structural model of a brittle-ductile fault zone with associated fault drag, kinematically mapped with a differential GPS system. The dataset visualizes a markedly non-cylindrical, non-symmetric geometry of drag across the fault. The field observations displays a broad frictional-viscous fault system crosscutting foliated greenschist facies metasediments and meta-volcanoclastic rocks. The foliation, which is parallel to the metamorphic layering, is significantly deflected near the fault planes accommodating deformation by ductile second order folding, formation of crenulation cleavage in the fold hinges and small scale brittle faults and fractures. There is a pronounced interrelation between brittle and ductile deformation both within the distinct fault planes and the deflected host rocks constraining the formation of the structure within the brittle-ductile transition zone.

Additional to accurate 3D geometrical modelling, the dataset serves as input for mechanical models of fault drag along non-planar fault surfaces. Thereby, progressive evolution of the structure can be reconstructed, with special focus on the effects of non-planar fault geometries on non-cylindrical non-plane strain structures. The model results suggest that the geometry of fault drag provides a powerful tool to unravel mechanical interaction between fault planes.