Imaging rock deformation on multiple scales: advances in better understanding heterogeneous deformation

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Heterogeneous deformation is intrinsic to natural deformation. Using the orientation of principal strain axes inferred from fault-kinematic analysis, the heterogeneity of upper-crustal deformation is illustrated for the southern Central Andes, Argentina, and the Eastern Penokean Orogen, Canada. In both regions, the data sets amount to several thousand brittle faults. To better comprehend such large data sets with regard to the heterogeneity of deformation from the outcrop to the crustal scales, several methods imaging strain perturbations were applied. Scaled analogue experiments allowed an assessment of the influence of mechanical anomalies on the patterns of principal strain axes. For the central Andes, analysis of remote sensing data complemented the experiments and involved the development of an ArcGIS workflow quantifying geomorphic indices. For the Eastern Penokean Orogen, the principal strain axis pattern was visualized by a workflow that involved Python scripting and ArcGIS-based interpolation based on Ordinary Kriging. The application of various imaging techniques provided a number of fundamental results regarding the heterogeneity of deformation: (1) Strain perturbations caused by mechanical anomalies lead to kinematic partitioning of deforming upper crust that significantly influences patterns of principal strains. (2) The inversion of brittle shear faults adheres to local strain, not paleo-stress, and portrays the kinematics of prominent discontinuities. (3) Differently oriented strain axes may not unequivocally point to regional deformation caused by successive and distinct deformation regimes. (4) Brittle fault data should not be used as proxy for estimating directions of plate-scale motions.