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Evolution of fault geometry and ductile fabrics under brittle-ductile conditions: an example from the Mount Abbot Quadrangle, Sierra Nevada, CA

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We use thin-section analysis and a finite element model to investigate an outcrop from the Mount Abbot Quadrangle of the Sierra Nevada, CA, which provides a unique opportunity to study faults and ductile fabrics in granodiorite that formed under brittle-ductile conditions. The outcrop features an 11cm thick aplite dike that is offset a total of 45cm through a right-step between two sub-parallel left-lateral faults. The contractional step is 13cm wide and is characterized by ductile deformation, which is evidenced by extreme thinning of the dike to 1.5cm thick and intense fabric development in the granodiorite. The deformation of the dike within the step provides a graphical measure of the strain and a significant feature to capture in the mechanical model.

We obtained 12 core samples from the outcrop for thin-section analysis. The thin-sections allow us to quantify changes in mineral assemblages and fabrics from the center of the step to the undeformed regions of granodiorite. The ductile deformation within the step is characterized by quartz recrystallization, undulatory extinction and S-C mylonitic fabrics. We use the commercial finite element software ABAQUS to test a variety of constitutive laws that may govern this style of deformation. The preliminary model employs a Mohr-Coulomb elasto-plasticity constitutive law for continuum deformation and a Coulomb friction law for fault slip. The model assumes homogeneity and isotropy of material properties throughout the model domain and thus does not distinguish what may be significant differences in mechanical properties between the aplite and the granodiorite.

Although the preliminary model is highly simplified, the results do correlate in some respects with the field observations. For example, regions of strain concentration and plastic yielding in the model correspond to regions of foliated granodiorite and thinning of the dike in the outcrop. On the other hand, the present model fails to capture the geometry of the stretched portion of the dike and the displacement between the fault tips. We explore a range of boundary conditions, mechanical properties, and constitutive laws to establish more correlative results. A better understanding of the deformational behavior of granitic rocks at the brittle-ductile transition, which is interpreted to be the base of the seismogenic zone, has important implications for earthquake science.