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Granular mechanics and rifting

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Numerical models have proved useful in the interpretation of seismic-scale images of rifted margins. In an effort to both test and further illuminate predictions of numerical models, workers have made some strides using map-scale field relations, microstructures, and strain analyses. Yet, fundamental predictions of modeling and tectonic restorations are not able to capture critical observations. For example, many models and interpretations call on continuous faults with restorable kinematic histories. In contrast, s-reflectors and other interpreted shear fabrics in the middle crust tend to be discontinuous and non-planar across a margin. Additionally, most rift-evolution models and interpretations call on end-member ductile flow laws over a range of mechanical and thermal conditions. In contrast, field observations have found that a range of “brittle” fault rocks (e.g., cataclasites and breccias) form in the deeper crust. Similarly, upper crustal materials in deep basins and fault zones can deform through both distributed and localized deformation. Altogether, there appears to be reason to bring a new perspective to aspects of the structural evolution of rifted margins.

A granular mechanics approach to crustal deformation studies has several important strengths. Granular materials efficiently localize shear and exhibit a range of stick-slip behaviors, including quasi-viscous rheological responses. These behaviors emerge in discrete element models, analog-materials experiments, and natural and engineered systems regardless of the specific micromechanical flow law. Yet, strictly speaking, granular deformation occurs via failure of frictional contacts between elastic grains. Here, we explore how to relate granular-mechanics models to mesoscale (outcrop) structural evolution, in turn providing insight into basin- and margin- scale evolution.

At this stage we are focusing on analog-materials experiments and micro-to-mesoscale observations linking theoretical predictions to structural geological observations. With this combined approach we seek to establish characteristic length scales such as grain sizes and shear zone thicknesses, and time-scales such as stick-slip event dynamics. This would allow us to define a flow law at the mesoscale from comparing the experimental results and the field observations. This rheology could eventually be used to model the strain localization history of rifted margins