



Investigations of Clay Smear in mechanically layered Sequences: Insights from Analogue and Numerical Particle Flow Models

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The aim of this study is to improve the knowledge of the mechanical and kinematic evolution of clay smear in order to enhance the potential of quantitative fault seal predictions. We compare clay smear in model experiments and PFC2D particle flow simulations above rigid basement containing a normal fault with 70° dip. The experimental models consist of layered sand-clay sequences with carefully characterized material properties, which are water- saturated and deformed in a novel underwater sandbox. During the experiments sand is drained (pore pressure is everywhere hydrostatic) and clay is undrained with development of overpressure in some experiments. Quantitative analysis of displacements is done by means of Particle Image Velocimetry (PIV), which allows high resolution analysis of the velocity field on particle scale.

Results show a strong dependance on the geometry (number of layers and layer thickness) of the layers and on mechanical properties of the clay. The evolution of clay smear is correspondingly complex. Multilayers of soft clay develop relays between basement fault-related deformation bands which initially propagate in directions related to the elastic stress field and later evolve into kinematically more favourable

positions. The sheared sand and clay layers become stabilized and thicken by grain-scale mixing.

In contrast, models in which the clay is strong enough to develop tensile fractures, the clay layers fracture and rotate in the fault zone as angular boudins. In models with intermediate clay strength the boudins are progressively eroded and softened to become a soft clay gouge.

PFC2D simulations produce essentially the same structural elements, although material properties are different from those in our experiments, and pore pressure is not taken into account. We interpret this as evidence for the robust nature of the evolving structures, which are proposed to evolve in normal fault zones under a wide range of effective stress and different rock types.