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Gouge compaction as softening process? Clues from analytical solution and 2D mechanical modelling.

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A number of field observations suggest that sliding on fault planes may occur at very shallow dip in the brittle field. The existence of active low angle normal faults is much debated because (1) the classical theory of fault mechanics implies that faults are locked when the dip is less than 30° and (2) shallow dipping fault planes do not produce large earthquakes (M > 5.5). To reconcile observations and theory,we propose a new model for fault reactivation by introducing an elasto-plastic frictional fault gouge as an alternative to the classical dislocation models with frictional properties. Contrary to the classical model which implies that the dilation angle ψ equals the friction angle φ, our model accounts for $\psi < \varphi$ and permits $\psi < 0$ in the fault gouge as deduced from laboratory and field observations. Whilst the predicted locking angles differ in most cases by less than 10° from the classical model, a significant amount of plastic strain (strain occurring in elasto-plastic regime) is predicted to occur on badly oriented faults prior to locking when the fault gouge is allowed to compact.

To complement the analytical solution, we have run 2D mechanical models of fault zones obeying to this rheological model at upper crustal scales. We find that the results obtained for small strain analytically are applicable for larger displacement and can be used to discriminate between the numerical models. When the numerical resolution of the mechanical models is sufficient to allow the formation of shear bands within the compacting zone, we produce the neoformation of Riedel shear within the gouge which orientations can be predicted from the analytic solution. On the contrary of the compacting fault zone which behaves at large scale in a hardening regime, these Riedel shears form in a softening regime which is dynamically unstable. We propose that such a model could be applied to the behaviour of the Western Gulf of Corinth, where most of the extension is accommodated on a creeping shallow dipping detachment within which the repeated microseismic activity produces multiplets that we interpret has the Riedel shear produced in our high resolution 2D models.