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A new perspective on the physics of anastomosing ductile and brittle shear-zones

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Crustal scale shear zone systems are related in many cases with plate tectonics such as continental collision zones. Many of these mega-shear zones form a network of branches with complex structures. Field data on exposed shear zones give insights in the final stage, but it is unclear how shear zone branches interact, what the kinematic processes are at the jog between two branches and how the shear zones grew in a complex high strain system at different crustal depths.

Here, we show the results of 2-D numerical models with a visco-elastic-plastic code to study strike-slip shear zones formed under both brittle and ductile conditions. The large-scale models run under constant strain rate boundary conditions with Mohr-Coulomb plasticity and power-law viscous rheology. Initial heterogeneities inserted in the model result to localization of strike-slip shear zones at different crustal levels. Under brittle conditions, localization occurs because the plastic yield strength is reached in combination with a reduction of the friction angle with on going strain, whereas under ductile conditions viscosity weakening in combination with a power-law viscous rheology is required for localization to occur.

Strain weakening under both brittle and ductile conditions is demonstrated to play a crucial role in producing new high-strain zones at low angles to the main shear zones that connect the shear localizations. New anastomosed localizations lead to an inactivity of older shear zones and to a change in the slip motion of the jog part between the shear branches. Strain indicators observed in the field do thus not necessarily indicate the overall sense of shear of the large-scale shear zone.

The modelling shows that most localized zones remain active and develop zones of strong pressure gradients for long periods of time. We implemented strain markers and incremental deformation patterns to form an overview of the evolution of the shear zone from its initial to the evolved, finite strain, stages. Systematic modelling results are presented to show the types of shear zones that develop as a function of ambient rheology, temperature and weakening parameters.