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The role of heterogeneous fault parallel normal stress in strike-slip dominated fault systems

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Many scaled analogue model studies have investigated the evolution of strike-slip dominated structures that deform large parts of the Earth's upper crust. In these models, the tectonic regime (pure strike-slip, transpression or transtension), the presence or absence of inherited structures, and the use of different materials have an important impact on the final structural style.

Here we compare analogue models developed with homogeneous fault-parallel normal stress on both sides of the main strike-slip fault (modelled introducing a velocity discontinuity, VD, the classical Riedel shear experiment) with models with heterogeneous normal stress. "Equal-stress" models produce symmetric en-echelon, synthetic Riedel shears. When displacement increases, Riedel shears are offset as deformation is taken up by a central through-going (primary) fault developing above VD. Conversely, pure strike-slip models with an inherited structure positioned above VD produces heterogeneous stress conditions along VD. As a result, Riedel shears do not form above VD, but mainly occur on the less compressive side of VD. When displacement increases, the primary fault forms above VD, however the pre-existing Riedel shears are only linked by the shear tips which are closer to VD. The resulting structure is dominated by a system with a primary fault with secondary splay faults, which is much more common for regional strike-slip faults than Riedel shears offset by a central through-going fault.

In our new models, the stress heterogeneity is induced by compression along a secondary VD perpendicular to the main VD. This produces differing strike-slip fault parallel normal stress on either side of the main VD. Along the main VD, we simulate alternatively pure strike-slip, transpression, and transtension by varying the direction of the moving plate. All transpressional models produce pop-up structures along main VD, whose boundary fault dip decreases as the compressional component increases. The pure strike-slip model forms two conjugate oblique-slip reverse faults, which are steeper than their equivalents in the transpressional models, plus a sub-vertical fault is situated above VD. Transtensional models show spatially heterogeneous fault styles. In part, we see the formation of a primary fault and secondary splay faults, typical of near-strike-slip setups. In another part, we see a structure with two steeply-dipping conjugate oblique-normal faults bounding several minor sub-vertical faults forming as the extensional component increases.

Several natural cases of strike-slip faults show asymmetric fault splays located only on one side of the primary fault (e.g. the San Andreas Fault in California and the western section of the North Anatolian Fault (the Aegean-Marmara section). A similar fault pattern was also obtained in our strike-slip-dominated transtensional model, but in our pure strike-slip model with inherited structure as well. These results show the importance of heterogeneous stress conditions, which can be produced by different tectonic regimes, for instance an inherited structure or an additional VD. Preliminary results of this study have wide implications and can be used to better understand natural cases where "non-conventional" strike-slip structures are observed.