Geophysical Research Abstracts
Vol. 20, EGU2018-9900, 2018
EGU General Assembly 2018

What controls the length of strike-slip fault segments? Insight from sandbox experiments.

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Co-seismic ruptures of continental strike-slip faults are usually segmented, with segments bounded by fault bends and step overs. Based on field observations, it has been shown that the length of these segments varies from 18km to 25km, independently of the regional tectonic setting. Moreover, the geometrical complexities delimiting fault segments have been described as areas of highly variable co-seismic deformation. Based on these observations, it has been suggested that the thickness of the seismogenic crust could control the structural scaling, and that inherited structures might govern the distribution of the deformation along the fault.

The formation of strike-slip faults has been thoroughly described by sandbox analogue experiments. The first structures to appear are en échelon Riedel shears. These shears are then abandoned in favour of horizontal shears, formed between the Riedel shears, that coalesce to form the final strike-slip fault. In this study, we consider that these horizontal shears are analogues of the fault segments and we characterize the parameters controlling their length, and thus the final fault geometry. More precisely, we test and quantify the effect of the sand pack thickness as well as the effects of internal and basal frictions on the segment length.

In our experiments, the average spacing between the Riedel shears and the sand-pack thickness appear to be linearly correlated. The internal friction strongly impacts this correlation: a variation of the internal friction generates a modification of the slope coefficient. On the contrary the basal friction has almost no impact and only slightly affects the intercept. Comparison of our results to natural cases, considering a standard internal friction for the upper crust, shows a good agreement between the two datasets, which supports the hypothesis of a crustal control on the fault geometry. As a consequence, we argue that Riedel shears act as inherited structures inducing distributed deformation between the segments.

We thus finally focus our study on the accommodation of the deformation along the initial structures, to investigate the deformation transfer during the fault formation. We observe a significant amount of off-fault deformation along the Riedels, which seems to be independent of the material thickness. These results imply that the seismogenic crust thickness has a strong impact on the fault geometry but not on the way deformation is accommodated.