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Interaction between slip events, erosion and sedimentation along an active strike-slip fault: Insights from analog models

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Recovering information on past (i.e. last 102-104 yrs) large earthquakes on faults is a challenge. The classical approach –especially used on strike-slip faults– consists in searching morphological markers such as river channels, streams, alluvial fans, ridges or terrace risers, etc, that would be offset by the fault, and measure these offsets by reconstructing the original position and shape of the markers. Combined with the dating of the offset markers, this morphotectonic paleoseismological approach may provide information on the slips and ages of the most recent earthquakes on the fault under study. Yet, the approach is complex as it depends on the recognition of unambiguous paired markers on either side of the fault. And our capability to recognize similar markers on either side of a fault in turn greatly depends on the 'evolution' that these markers may have sustained subsequently to their very first slip disruption. Did the repeating earthquake slip events modify their surface appearance? Did their morphology and position (ex: burying, destruction, modification, etc) evolve with the sedimentation and erosion that might have occurred during the fault history? Etc. These questions have rarely been approached for they are difficult to address in natural settings. And as we are unable to answer them in the natural cases that we study, the slip reconstructions that we provide are generally uncertain as they are likely based on an incomplete or biased record of the past fault slips. Therefore, the objective of our work is to contribute to better understand and document the nature and 'evolution' of the morphological markers that are commonly used in morphotectonic and paleoseismological analyses, especially along strike-slip faults. We approach these questions experimentally. We have developed an original experimental set-up made to simulate repeated slip events on a strike-slip fault placed in a wet environment sustaining sedimentation and erosion. The fault device is indeed coupled with a rainfall system, while an optical measurement apparatus that includes digital cameras and a laser interferometer, allows observing and measuring continuously at very high resolution the evolution of the model surface morphology. The analog material is a mix of granular materials –glass microbeads, silica powder and plastic powder saturated in water, whose mass composition and, consequently, mechanical properties lead to a geometric scaling of about 1:10 000 and to a temporal scaling on the order of one second equivalent to a few dozens of years. The protocol allows monitoring together the evolution of the fault and that of the morphological markers that the fault progressively offsets as slip events are imposed. We have conducted several experiences in different settings and we will present the preliminary results that we have obtained. We basically could survey the formation and evolution of a strike-slip fault from its immature stages up to one hundred repeated slip events. Under the combined effects of accumulating slip, erosion and sedimentation, the model surface exhibits tectonic and morphological structures similar to natural features (Riedel's shears, pressure and shutter ridges, pull-apart basins, alluvial fans, terrace risers, braided rivers, etc), whose space and time evolution can be precisely analyzed. Deformation partitioning, sequential formation of alluvial terraces, stream captures, development of 'traps' filling with sediments, etc, are especially observed. The control on the imposed amplitude and frequency of the rainfall cycles allows us to examine the impact of these rainfalls on the fault morphology and the evolution of the associated morphological markers. Finally, we can compare the imposed slip events (number, amplitudes, repeat times) with the cumulative offsets eventually visible and measurable at the model surface. Marked discrepancies are found between imposed and final apparent offsets that shed light on the uncertainties that may affect the morphological and paleoseismological analyses performed on natural cases. We apply our results to further analyze one natural fault site in New Zealand (Terako, Hope fault), described in another session (Beauprêtre et al.).