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Strike-slip fault Kinematics and mechanics at the seismic cycle time-scale : Results from new analogue model experiments.

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The average seismic cycle duration extends from hundred to a few thousands years but geodetic measurements, including trilateration, GPS, Insar and seismological data extend over less than one century. This short time observation scale renders difficult, then, to constrain the role of key parameters such as fault friction and geometry, crust rheology, stress and strain rate that control the kinematics and mechanics of active faults.

To solve this time scale issue, we have developed a new experimental set-up that reproduces scaled micro-earthquakes and several hundreds of seismic cycles along a strike-slip fault. The model is constituted by two polyurethane foam plates laterally in contact, lying on a basal silicone layer, which simulate the mechanical behaviour of an elastoplastic upper crust over a ductile lower crust, respectively. To simulate the boundary conditions of a strike-slip fault, a computerized motoreductor system moves the two compartments on an opposite sens and at a constant very low velocity (a few μm/s). The model spatial and temporal scaling, deduces from analog material physical and mechanical parameters, implies that 1 cm in the model represents 2-3 km in the nature and 1 s is equivalent to 5-15 years.

Surface-horizontal strain field is quantified by sub-pixel correlation of digital camera pictures recorded every 16 μm of displacement. For each experience about 2000 horizontal-velocity field measurements are recorded. The analysis of model-interseismic and coseismic surface displacements and their comparison to seismogenic natural faults demonstrate that our analog model reproduces correctly both near and far-field surface strains. To compare the experiences, we have developed several algorithms that allow studying the main spatial and temporal evolution of the physical parameters and surface deformation processes that characterise the seismic cycle (magnitudes, stress, strain, friction coefficients, interseismic locking depth, recurrence time, ...). We also performed surface-velocity field inversions to assess the spatial distribution of slip and stress at depth along the fault plane.

Our first results suggest that far-field boundary-velocity conditions play a key role on the seismic cycle by influencing earthquake magnitudes and recurrence time, as well as the capability of the fault to generate characteristic earthquakes. We observed that low strain rate generates rare large size characteristic earthquakes and high strain rate numerous low to moderate magnitude more distributed earthquakes. Our first hypothesis is that this behaviour may be controlled by the brittle/ductile coupling at the base of foam plates. For a high strain rate, viscous forces in the silicone layer increase as well as coupling at the base of the foam plates. These features force the fault to slip at a velocity close to the far field velocity and induce a more heterogeneous stress field along the fault incompatible with characteristic earthquake behaviour. For a low strain rate, silicone almost behaves as a newtonian fluid and viscous forces strongly decrease, allowing the fault to locked and to accumulate more elastic strain. Stresses are then relaxed by larger seismic events. Another hypothesis is that this behaviour may be controlled by a time-dependent static frictional strength.