Occurrence and susceptibility assessment of rock-block slides on clay-shale tectonized slopes

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Recent research and reviews into landslide/erosion processes on tectonized clay-shales outcrops of South East France suggest that the main landslide type triggered in this geological formation are rock-block slides. These landslides occurred along gullies, sometimes at the shallow regolith-bedrock interface, sometimes more in depth along bedding planes and structural discontinuities faulting the hillslopes. Due to the high frequency and low impact of shallow landslides, their occurrence and characteristics are difficult to study, and they are very often not recorded in landslide inventories.
This work attempts to provide an assessment of contributing factors and their incidence in the occurrence of rock-block slides in the "Terres Noires" through the study of three gully complexes: (1) a small gully located in the Roubines area in the Barcelonnette Basin which failure has occurred in 1997, (2) a gully complex in rupture since 1999 in the Laval catchment at Draix, and in the small Moulin erosion prone catchment at Draix.
First, the hydrological and mechanical controls on gully head collapses are identified by modelling the hydrology, stability and deformation of slides. All landslides experience the same failure mechanisms and are controlled by the local geological structure. The hydrological and slope stability simulations show that for slope gradients higher than 35°, the hillslopes are near the equilibrium limit, unless saturation is achieved. On the contrary, for slope gradients lower than 35°, the simulations show that failure in saturated conditions can occur only if excess pore pressures along the discontinuities are built up. These positive pore pressures can only be reached where preferential (vertical) fissure flows conduct water from surficial tension cracks into the base of the sliding surfaces. In addition, it is shown that failure in unsaturated conditions is only possible where the toe of the hillslope is undercut. Moreover, a stress analysis of the gully hillslope in the Roubines area reveals the build up of shear stress both at the summit of the crest (influence of the cracks) and at the hillslope base.
Second, the geomorphological and geological predisposing conditions of failures are extrapolated from the simulations, and a tentative hazard assessment of the Moulin catchment is proposed. Two different approaches were investigated by applying a statistic approach to estimate the relative contributions of the factors responsible for instability and assess the landslide susceptibility, and a a deterministic/dynamic approach to incorporate the temporal dimension in the analysis. The study was divided in seven main stages: landslide inventory update, geological characterization, relief characterization, soil depth modelling, statistical and deterministic susceptibility modelling and finally, the models are validated by comparing the results with the landslide inventory.