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Influence of inherited faults on deep-seated progressive failure in slopes: a 2-D physical modeling approach based on the Southern French Alps massif area.

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Deep-seated progressive failure that takes place in heterogeneous rock masses is mainly linked to long term environnemental evolution. Among structural heterogeneities, large-scale highly penetrative inherited faults commonly cut most of the massifs. This was observed in the Southern French Alps (Argentera-Mercantour massif) where several families of faults were accurately mapped [Follaci, 1987, 1999; Guglielmi & al., 2001, 2002; Jomard, 2006]. Among these, a family of normal listric faults parallel to the valley (orientation WNW – ESE) and dipping 80° SW close to the topographic surface seemed to play a dominant role in the massif slopes deformations. Indeed, large volume landslides like the "La Clapière" landslide clearly initiate and evolute on such major structures.

This work is an attempt to analyze the role of large inherited faults on progressive failure in rock slopes. Is those faults geometry a key parameter that influence both the gravitational deformation of the hillside and the nature of the movements? What is inherited and what is induced from gravitational processes in the fault zone that bounds the currently active large landslides? In order to answer these questions, we performed 2-D physical scaled models using an original technique [Chemenda & al., 2005]. Our models are based on the geometry of the "La Clapière" hillside. Four sets of experiments were carried out with six normal listric faults and with or without thrust fault at the foot of the slope.

In the two sets of experiments where we considered the normal listric faults and the thrust fault, the inflexion of the listric fault geometry was imposed at depth, below the thrust fault in the first set of experiments and above the thrust fault in the second one. Results show that, in both cases, the moving mass is bounded by the thrust fault at depth and by the sub vertical fault that is the closest to the massif crest. The main difference between the two models concerned the internal deformation of the moving mass. In the first case, units delimitated by the normal faults toppled. In the second configuration the toppling was avoided by the shape of the faults at depth and very few internal deformations was observed. In the two last sets of experiments where the thrust fault was not figured, the involved volume of moving mass appeared similar to the volume observed in the two first experiments. The mobilised volume is delimitated by the same sub vertical fault near to the crest and a gravitational fault linking this normal fault and the toe of the valley. Internal deformation of that volume appeared similar to what was observed previously but it was much more dependant on the normal faults geomatry at depth. Indeed, for a shallow inflexion of faults, a sub horizontal fault linking the inflexion points was generated and the internal deformation of the moving mass was much more complex with sliding of the upper units and rotation of the lower ones conducting to the formation of normal trenches on the topographic surface. These superficial deformation appeared very close to the one observed on the La Clapière landslide.

Our results showed that the geometry at depth of a few major inherited faults have a great influence on the gravitational deformation of a massif slope. Thus, it is of major importance to characterize not only the fault networks affecting the slopes close to the instabilities but also their geometries at much larger kilometric scales. Moreover our results also demonstrated that the presumed tectonic thrust fault at the foot of the slope seems more likely to be due to gravitational processes. Our modelling technique appears to be a powerful tool to determine the part of the deformation inherited from tectonic and the part due to gravitational loading and to follow progressive failure in such heterogenous medias set in complex boundary effetcs problems.