New ways to characterize Alpine earthflows: Combined geophysics and geodetic surveys

Oral presentation in Naples by: M. Jaboyedoff
Authors (not in order):
D. Jongmans. E. Larose, G. Biévre G. Maisant - University of Grenoble
M. Jaboyedoff, C. Michoud, P. Nicolet - University of Lausanne
J.P. Malet - CNRS, Strassbourg

Earthflows (ore related clay-rich flow-like landslides) can be triggered in various lithologies (flysch, clay-shales, varved clays, glacial deposits). Recent advances in remote sensing and geophysics permit to monitor new properties to understand the mechanics of these processes, and especially their possibility to transform in rapid mudflows. The objective of this work is to present some case studies from well documented slopes (Pont-Bourquin in Switzerland, Avignonet/Harmalières and La Valette/Super-Sauze in France) to illustrate the potentialities of these new techniques.

From a rheological viewpoint, earthflow material can exhibit various rheological behaviors; they can be considered as landslides that flow following a Herschel-Buckley law, but they can also slide on narrow failure surfaces which behavior are represented by frictional or visco-plastic laws including bifurcation. The latter indicate that, depending on the stress and water content, the mechanical properties drop down, which potentially promotes a catastrophic failure by liquefying the soil mass.

Such behavior can be monitored using S-wave velocity (Vs) based on ambient seismic noise. This revealed that a few days before catastrophic failure Vs decreases, indicating a progressive weakening of the material as it has been shown in Pont Bourquin Landslide (Switzerland). These behaviors have been confirmed by laboratory experiments on clays coming from Avignonet and Harmalières case studies.

Standard geophysics surveys, such as electrical resistivity tomography and seismic refection, permit also to characterize the unstable masses. LiDAR and geodetic surveys allow to characterize the surface movements. Combined to high-resolution 3D seismic refraction tomography, these datasets allow identifying and characterizing structures within the moving mass and allow to estimate their geotechnical properties. Such information is necessary to create a conceptual model of the slope movements. Such combined geodetical-geophysical approaches have been used at the La Valette and Super-Sauze case studies.

Changes in material behavior are promoted by variations in groundwater circulations and in 3D geometry of the deforming mass, by increasing the water content and/or creating overload by accumulating material in some zones of an earthflow. These changes can lead to catastrophic failures.

These new results demonstrated that monitoring the 2D/3D deformation and following the material property changes by geophysics appear to be a promising way to predict catastrophic failure.