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3D Geoelectrical study of the Séchilienne Landslide : new constraints on the large scale water flow

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The Séchilienne Landslide is an active and large volume (nearly 100 millions of m3) instability located in the French Alps, about 25 km South East of Grenoble (Isère). The slope is composed of highly fractured and foliated micaschites. The displacement rate varies from cm to dm a year according to the location. Hydrogeological and hydrochemical processes within the fractured hard rock (water infiltration, chemical alteration) are the major mechanisms controlling the deformation of the unstable slope.

Several geophysical campaigns have been realized in the last 10 years, complemented by permanent hydrogeological and geochemical monitoring at some specific location inside and outside the landslide. Electromagnetic soundings, electrical resistivity tomogaphy, induced polarization, spontaneous potential and seismic tomography profiles were acquired since 2000, aiming at estimating the depth of the sliding surface, at differentiating compartments characterized by different mechanical behavior, and at detecting the presence of water (storage and flows). These methods are however based on the assumption that the structures are bi-dimensional, which is not the case in this area (high slope gradient, complex topography, fractures with several orientations and fillings, heterogeneous media).

In 2017, a 3D electrical resistivity tomography has been carried out at the scale of the slope to map the high contrasts of resistivity (100 Ohm.m up to more than 10 kOhm.m) identified by previous surveys, with a sensitivity down to the first five hundreds of meters. The survey was realized using IRIS Instrument's VIP current transmitter TIPIX 3000 and a set of IRIS Instruments V-Fullwavers systems as receivers. The Vfullwavers are independent units synchronized with GPS PPS signal, that measure continuously the variations of electrical potential as time-series, between a set of three electrodes, grounded as two orthogonal dipoles. For this survey, 23 V-fullwavers with two 50m-dipoles each have been deployed over an area of circa 2km2, and 34 injections were distributed over the area.

Data with large uncertainties (occasional thunderstorms, low energy of the receivers) have been filtered. The software package BERT has been used to invert the apparent resitivity and model this complex data set, providing the first 3D resistivity model of the entire unstable area. A LiDAR DEM provided a detailed knowledge of the topography, so that topographic effects could be accurately modeled. An unstructured tetrahedral mesh refined at the surface has been used for the inversion. A structural model has been considered as constraint to the inversion, and the inverted model has been interpreted with additional Controlled-Source Audio-Magnetotelluric (CS-AMT) soundings and past ERT measurements.

The 3D resistivity model allows identifying a major fracture sets oriented NE-SW and separating a conductive zone to the Est and a resistive zone to the East. Water saturated zones at the close surface and shallow superficial morainic deposits are identified respectively in the upper part and the Eastern part of the slope. The fault system is believed to conduct the water from the upper-part of the slope down to the unstable area.