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Induced polarization (IP) imaging for the improved characterization of clay-rich landslides

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Landslides pose a significant socio-economical natural hazard, in particular those developed in clay-rich environments due to their suddenness, volumes and propagations. Typically induced by meteorological phenomena (i.e. strong precipitations) the understanding of water circulation in clayey landslides is critical for an adequate hydromechanical modeling and the development of accurate early warning systems. In recent years, electrical resistivity tomography (ERT) has been widely applied to characterize the structure of landslides and monitoring of hydrogeological changes, aiming at an improved understanding of the water flow patterns. However, clay-rich sediments limit the applicability of ERT due the low contrast in the electrical signatures of clay minerals and saturated soil. Taking into account the strong induced polarization (IP) response in the presence of clay minerals, we propose the application of the IP imaging method to improve the delineation of structures and heterogeneities controlling water flow circulation in clayey landslides.

To better evaluate the IP method at different geological conditions, here we discuss IP imaging results for data collected at two different landslides located in France (La Valette in the South East Alps, and Lodève located in the southern border of the Massif Central Massif) as well as two sites in Austria. These sites were selected due to the extensive non-geophysical information available and the ERT monitoring data measured over several years. IP measurements have been collected in both time- and frequency-domain to further assess the advantages of the different techniques in particular towards the quantification of hydrogeological parameters, such as dominating grain size and hydraulic conductivity. Imaging results demonstrate an improved lithological characterization, permitting the delineation of the sliding plane as well as a better discrimination of clay lenses with enhanced resolution. Nevertheless the clay-rich minerals have demonstrated a lower IP response than the lithological contact at the sliding plane between sediments and consolidated rocks. Furthermore, our results revealed the possibility to solve for clay-filled fractures in the rock underlying the sliding materials. The frequency-dependence in the electrical properties appear to be negligible in the frequency range studied (0.5 – 225 Hz), and the estimation of hydrogeological parameters is ongoing work, considering the up-scaling of petrophysical models derivated from laboratory observations. Furthermore, we present results from a monitoring experiment conducted on a small landslide in Austria, where IP datasets were collected in a broad frequency bandwidth over a time span of five weeks on a daily basis. IP imaging results suggest an improved sensitivity in the polarization effect to asses temperature and saturation changes in the near surface of the landslides. Compared to ERT monitoring data collected on the site before, IP monitoring results show a general improvement regarding the interpretation towards possible preferential flow paths.

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