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Time-lapse electrical resistivity tomography as an aid in active slope stability assessment

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Landslides pose risks to both infrastructure and communities globally; mitigating these risks requires an understanding of susceptible geological materials and trigger mechanisms within landslides, and how these can change with time.

Typically, site investigation of hazardous hillslopes involves discrete measurements to identify key mechanical parameters for the types of material present, but at low spatial resolutions. As a consequence slope stability modelling, which relies on these discrete measurements, does not always capture the full spatial or temporal complexity of the problem. Numerous studies have shown the benefit that geophysical techniques (e.g. geoelectrics, seismics) can bring to landslide site investigation, illuminating geometrical, mechanical and hydrological conditions of unstable hillslopes. Time-lapse electrical resistivity tomography (ERT) has been shown to be sensitive to changes subsurface in moisture content. Resistivity is readily related to water saturation using well established petrophysical relationships, which are of upmost interest given the majority of landslides are moisture induced.

In this study we present the use of a geoelectrical monitoring system on an active landslide in Lias mudrocks, North Yorkshire, UK. Building on previous studies of the field site, subsurface resistivity distributions determined from time-lapse ERT are converted into shear strength estimates through appropriate calibration between moisture content, electrical resistivity and matrix suction in order to compute pore pressures. The ERT workflow is constrained by other data streams, such as a series of GPS surveys to track electrode movements on the hillslope, seasonal temperature corrections, digital elevation models (observed by laser ranging) and seismic refraction surveys. Shallow borehole and field samples are used to determine mechanical parameters (such as density, internal frictional angle) and petrophysical relationships. Preliminary results show agreement between decreases in ERT-derived shear strength estimates and real slope movements observed by tilt meters and LIDAR images. Given the development of dedicated time-lapse ERT systems, and the use of electrical resistivity as a proxy for moisture content, and by extension pore pressure, we suggest the basis for coupling time-lapse ERT with hydromechanical modelling for real time slope stability assessment.