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# Geophysical and physical measurements applied to characterize an area prone to quick clay landslides in SW Sweden

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The study of quick clay landslides in Nordic countries, such as Sweden and Norway, is wide and varied. However, the occurrence of catastrophes like those in Munkedal, Sweden, in 2006, demands a more complete characterization of these materials and their extensiveness. The objectives of this research are mainly focused on obtaining information about the properties and behavior of quick clays in an area prone to landslides in southwestern Sweden.
Two fieldwork campaigns were carried out in 2011 and 2013, using methods such as 2D and 3D P-wave and S-wave seismic, geoelectrics, controlled-source and radio-magnetotellurics, ground gravity, as well as downhole geophysics (measuring fluid temperature and conductivity, gamma radiation, sonic velocity and resistivity) performed in three boreholes located in the study area. Drill cores recovered using the SONIC technique provided samples for paleontological information, as well as laboratory measurements of physical properties of the subsurface materials to a maximum subsurface depth of about 60 m. The laboratory measurements included grain size analysis, mineral magnetic properties, electric conductivity, pH, salinity, total dissolved solids, x-ray fluorescence (XRF), and a reconnaissance study of the fossil content.
A correlation study of the downhole geophysical measurements, 2D seismic sections located at the intersection with the boreholes and the sample observations indicated that the presence of quick clays is associated with contacts with coarse-grained materials. Although the PVC casing of the boreholes interferes with the sonic and resistivity measurements, the perforated parts of the PVC casing show significant changes. The most important variations in magnetic susceptibility and conductivity mostly coincide with these coarse-grained layers, supporting the seismic data. Coarse-grained layers are characterized by enhanced magnetic susceptibility and conductivity. Grain size analysis results on subsamples from the deepest borehole (the one closer to the river) correlate with changes in the natural gamma measurements. Overall, the fine sediments dominate over the coarser ones, and clay and fine silt are found to be the most abundant. The preliminary paleontological observations indicate that the most of the sediments were formed in a glaciomarine environment. Additionally, XRF measurements were performed on subsamples from the deepest borehole, indicating high Cl/V values (a good salinity indicator) in the thickest coarse-grained layer.
In conclusion, all the collected data show a comprehensive description of the subsurface in the area. The characteristics of the observed quick clays will offer more information about these materials in Sweden, expanding our knowledge about them and assisting in risk assessments in similar areas where similar geohazards are present.

Future work will be geared towards processing of the data collected in 2013, including a seismic line across the river, which will complement and extend the study area. New fieldwork campaigns and inversion of surface wave data will improve the interpretation of the shallow subsurface. Furthermore, geotechnical data from the site, obtained by the Swedish Geotechnical Institute, will be used to define and support the presence of quick clays in the area.

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