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The role of water in the formation of clay-rich layers at the slip surface of slope instabilities (Diezma landslide, SE Spain)

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Slope instabilities with a low basal slope (<15º) are lately researched in order to evaluate triggering and conditioning factors. In these landslides, mechanical properties of the rupture surface are exceptionally low. The increase of the pore pressure has been commonly postulated to explain the drastic reduction of strength properties. Low-permeability layers could be preferred candidates to concentrate the largest increase of pore pressure. These clay layers are usually found in sedimentary sequences and colluvial formations. However, in some landslides around the world, a clay-bearing layer of extraordinary purity, have been detected in the rupture surface. Mechanical properties of this layer are lower than the rest of the sliced mass conditioning the slope stability.

In the Diezma landslide (SE Spain), a complex movement affecting an area of 6.2 ha, a centimetre layer of smectite clay (montmorillonite-beidellite) controls the strength properties of the whole sliced mass. The triggering factor of this landslide is linked to the infiltration of water from a karstic aquifer located in the head area. Based on the geophysical surveys performed, we have been able to determine the 3D geometry of the main sliding surface, which was in part known from previous borehole data. Electrical resistivity profiles have also revealed to be an excellent tool to detect the degree of moisture in the marly clay materials of the landslide body. Subterranean water stream produces an active hydrolysis of marls fragment and the follow-up of their argillation, typical of chemical and physical interactions between the slip-zone materials and the slip-zone groundwater, when it was chronically saturated.

In this study, thermodynamic stability of clay minerals (smectite and kaolinite) and water chemistry (Ca+2 ions) along the slip surface of the Diezma landslide were evaluated. Calcium hydro-carbonate groundwater, as subterranean water percolating the Diezma landslide, induces the formation of smectite clay minerals while low-mineralized water favors the alteration to kaolinite. Chemical composition of the water has been analyzed in three different points of Diezma landslide: in the spring water, located in the edge carbonate-marly clay materials (0 m above surface), above the head of the landslide (-11 m.a.s) and at the lower part of the landslide (-27 m.a.s). From point 1 to point 2, as a result of the leaching of gypsum-bearing marly rocks, calcium carbonate is formed, reducing the Ca+2 and HCO_3- concentrations in the water. Between these two points, only short displacements have been detected on the slip surface. However, from point 2 to point 3, groundwater obtained at depth, such as that found in the vicinity of a landslide slip surface, tends to come from a chemically reduced condition because of the lack of oxygen. The concentration of HCO_3- ion content increased indicating calcite dissolution, which facilitates the formation of smectite. Borehole data confirms that smectite content along the slip surface increases to the lower parts of the Diezma landslide.

Meanwhile, this study shows that there is a strong relationship between groundwater and the formation of smectite in slip-surface clay. It further indicates that there is active ion exchange as groundwater comes in contact with slip surfaces (above the impervious zone). As a result, Ca+2 ions are separated within the groundwater, and at the same time, by increased HCO_3- ion content, smectite begins to form.