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Geochemical alteration vs mechanical weathering on stability of unstable slope : Case of the deep seated landslide of Séchilienne (Isère, France)

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The Séchilienne landslide is located on the right bank of the Romanche River, South East of Grenoble (Isère, France). The active zone of the gravitational instability involves several millions of cubic meters. The geology consists of fractured hard rocks (micaschists) with double permeability and strong spatial heterogeneities. The permeability of the basement areas is rather obtained by long term weathering, which can be associated with a mechanical action in high relief mountainous regions.
Water plays two major roles, the first one being a hydrogeological process, which is a factor that worsens instability, and the second one being a geochemical factor that alters the massif, making it less cohesive. These two factors interact through time and modify permeability and therefore the flow of water within the rock.

Hydrochemistry simultaneously provides information about water flows (location and amount of refill, types and flow patterns, storage, residence time), and also about the acquisition of the chemistry during its transit through the aquifer (water-rock interaction during the transit, quantification of the alteration). The issue is to improve the knowledge of the genesis of the chemical signal, and to define the contributions of the knowledge of this signal in terms of functioning, on the pressure transferring as well as on the mass transferring and its effects. Hydrogeochemistry, which is integrative of the entire “history” of the water in the different compartments, paired with geochemical modelling, which allow the discrimination of the chemical signal according to its path in the aquifer, turns out to be an appropriate method for the objective. These tools (hydrogeochemistry & geochemical modelling) are designed to understand the complex relationship between chemical weathering, hydromechanical changes and weakening / deformation of the unstable rock slope

The deformation of the unstable slope is monitored by on-site extensometric gauges, inclinometers, GNSS and at distance by a terrestrial radar and a total station.
A hydrogeochemical monitoring of the non-saturated zone in a fractured hard rock is established since 2010 on the site. This monitoring leaded by the French Landslide Observatory (OMIV) consists of continuous measurements of physical parameters (Temp. EC. Flow rate) on two groundwater outlets and weekly samplings of the waters for quality monitoring

Hydrochemical studies allows a sufficient resolution to detect exchange between compartments of contrasted permeability within fractured aquifers. They enabled to determine the influence of the hydrodynamic conditions variations at the aquifer scale, on exchange modalities between the pervious zone and the less pervious zone, and to highlight that permeability variations on mechanical stress effect may induce variations of the chemical signal of a fractured aquifer.

Geochemical alteration represents a significant contribution compared to mechanical weathering on the long term (multiannual evolution by mechanical and geochemical damage of the fractures and the rock matrix), to the medium and short-term (seasonal and instantaneous effect of hydro-mechanical fluctuations located in the fractures of the slope) evolution of the rock slope failures.
The reconstitution of the chemical evolutions of water and minerals during the transit of water through the rock, might allow establishing local erosion balance In addition it might also allow to locate and to quantify at the scale of a rock slope, the chemical erosion able to induce “chemical tiredness” of the rock.