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Hydrological and chemical characterization of an earth slide-flow

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To understand the origin of instability and the evolution of large and deep earth slide-flows, it is important to define the origin and path of groundwater and the role of the groundwater on the landslide deposit rheology. To achieve these goals it is important characterize, physically and chemically, the bedrock and slope deposits and the groundwater system.
This study deals with the hydrological and geochemical characterization of a reactivated earth slide-flow affecting Cretaceous flysch, located in the northern Apennines of Italy. In situ permeability and pumping test, continuous monitoring of groundwater levels, electrical conductivity, temperature, furthermore, hydrochemical and isotope analysis were the adopted prospecting methods. In detail, oxygen, deuterium and tritium isotopes, the major cations and anions and the Boron content have been analyzed. To investigate the relation between the groundwater chemical elements, the total dissolved solids and the changing in the landslide behavior some geotechnical tests have been conducted.
Groundwater levels were monitored for more than 5 years by means of transducers in 5 standpipe piezometers, fissured above or below the sliding surface. Results showed that two overlaying aquifers exist at the slope scale: an unconfined one, in the fractured flysch of the rock slide; a semi-confined one, in the undisturbed flysch below sliding surface.
Pore pressure in the unconfined aquifer is controlled by rainfall, with fluctuation of several meters occurring hours or days from onset of precipitation. On the contrary, pore pressure in the semi-confined aquifer shows little response to precipitation events, has fluctuations of few meters related to seasonal trends, and maintains pressure head higher than that in the unconfined one. This makes it a relevant factor for the stability of the slide. Storage coefficient of 10-3 and hydraulic transmissivity of 1E-5 m2/s were estimated for the unconfined aquifer with a pumping test carried out with several control piezometers.
The geochemical characterization obtained by sampling and lab analysis highlighted two groundwater types in the landslide area. One shallow, directly connected with rainfall, that can be classified as cold (13° C) and Ca-carbonate rich with electric conductivity around 800 μS/cm and which is characterized by 6.5 Unit Tritium. The second consists of deep-fluids, rich in Na-sulfate and Boron. This deep-fluids are characterized by cold temperature (13° C) and high salinity, over 4000 μS/cm and which is characterized by 3.5 Unit Tritium. Both groundwater have an oxygen and deuterium composition similar to the local rainfall.
The results obtained in Ca' Lita show a high complexity of the groundwater flow due to high heterogeneity and anisotropy of the hydraulic characteristics inside the landslide deposit and in the underlying fractured bedrock. Moreover, the hydrogeological study has individuated a rising of deep fluids in the landslide area, which can have a negative effect on the stability of the whole slope. The research results will be used to design and implement deep drainage systems for risk mitigation purposes.