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Analysis of water infiltration in soft clay-shale unstable hillslopes (South French Alps): proposition of a three reservoirs conceptual model.

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In the black marls area of the French South Alps, landsliding is mainly initiated by the subsurface flows. In this environment one of the research challenges is to understand the preferential flows initiation conditions as well as the interacting processes between event water and old water.
The study of these complex and heterogeneous hillslopes is often difficult in natural climatic conditions. In this case, a multi-methods approach under simulated rainfall could be an alternative for a small scale hydrologic study of landslides.
In the Draix Research Experimental basins (near Digne les Bains, French South Alps), a simulated rainfall experiment was carried out on a 103 m^2 plot during 67 hours. The plot was instrumented with 28 piezometers (1 to 4 m depth) and a profile of water content sensors on the first meter. In total, 670 mm of rainfall were injected of which 60 % infiltrated. Two tracers were used to compare the landslide behaviour under unsaturated and saturated conditions. During the first 35 hours, the artificial rainfall was marked with bromide (EW1), in the second phase; the rainfall was marked with bromide and chloride (EW2). This double tracing allowed us to differentiate the rainfall EW1, from the rainfall EW2 and from the pre-event water PEW. The tracing results showed that in spite of the heterogeneity of the landslide, the dynamic of the components was similar from a piezometer to another. The PEW contribution ranged between 30 to 70 %. Most of the time, the deeper was the piezometer, the higher was PEW proportion. After the rainfall stop, PEW contributed 95 % of total flow. In order to explain the complexity of the responses, we propose a 3 reservoirs conceptual model. The structure of the model was defined by crossing "soft" data from the description of the soil structure and hydrodynamic data. The 3 reservoirs are 1) transmissive (preferential pathways), 2) capacitive (clay matrix), and 3) intermediate (matrix macropores). These reservoirs have got flow thresholds, which could be compared to succion forces. The more capacitive is the reservoir, the larger is the water volume needed to reach the threshold. When the threshold is overtaken, the reservoir is able to generate lateral and vertical flows. During rainfall, the soil is mostly transmissive and the semi-transmissive and preferential flow reservoirs contribute to the flow. After rainfall, most of the flow comes from the capacitive reservoir which is mainly composed of pre-event water.
This conceptual model with 3 reservoirs made it possible to explain the mobilization of the pre event water and contributes to the discussion about the old water paradox.