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Flow processes investigation in soft clay shales from tracing experiments at laboratory scale

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An expriment of simulated rainfall at lab scale has been carried out to investigate the role of soil heterogeneity upon infiltration in black marl material. Black marls spread over large areas in the SE France. As a result of the high water pressure variations they create, the flow conditions at the hillslope scale have implications on erosion and soil stability. In situ experiments in the ORE Draix showed that black marls may have large storage and drainage capacities. They gave also the opportunity to describe in detail the nature of heterogeneity (Garel, 2010). For example, structure was shown to be made of a complex mixing between fully weathered regolith and partly fresh marl blocks. These blocks are expected to generate here and there hydraulic discontinuities which may result in local perched aquifers or lateral redistribution of flow. In order to have a more detailed knowledge of the flow processes and the interaction of the contributive reservoirs (active porosities), tracing experiments under simulated rainfalls have been carried out in the laboratory. We have used a small-scale model of 66 x 22 x 57 (L xl xH) with a slope of around 4°. This model represented a juxtaposition of 3 columns 22 x22 (L x l). 2 marl blocks approximately 10 cm x 20 cm x 22 cm were inserted in the regolith matrix at different depth in the 2 upslope columns respectively. The rainfall simulator was customized so that rainfall was uniformly spread over the most upslope column area. Gravitational water was collected downslope using a collection gutter and discharge was recorded with a precision balance connected to a datalogger. 20 TDR probes and 11 microtensiometers were evenly inserted on the model's sides. The experimental procedure comprised 2 rainfall simulations of 17,4 h and 10,2 h duration (intensities 15,6 mm/h and 16,7 mm/h, respectively) with a break of 26 days in between. The former was carried out using deuterium as a tracer while KBr was used in the latter. The first simulation aimed at computing the contribution of rainfall 1 and pre event waters to the flow. The combined sampling for deuterium and Br over the second experiment made it possible to split the contributions of rainfall 1, rainfall 2 and pre event water.

Results show that marl blocks play only partly the role of hydraulic barriers. At the block contact, part of water diverged and was laterally redistributed while another part infiltrated to the blocks and even passed through them. This result shows the active role of the marl foliated structure. In term of hydrological budget, the first simulation resulted in a flow coefficient (ratio between total flow and total rainfall) of 89 %. The second experiment was shorter and the flow coefficient dropped to 75 %. Tracing data indicate that event water contribution was only 10 % during the first simulation. For the second experiment, event water contributed even lower (4 %) whereas the participations of previous rainfall (experiment 1) and pre event water were 47 % and 49 % respectively. The mapping of water content and pressure head enabled us to complete the conceptual hydrological model of the system.

Garel, E. (2010) : Etude des processus de recharge des nappes superficielles et profondes dans les versants marneux fortement hétérogènes. Cas des terres noires des Alpes du Sud de la France-ORE Draix. Avignon : Université d'Avignon et des pays de vaucluse, 180 p. (thèse de doctorat)