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Groundwater flows in weathered crystalline rocks: impact of piezometric variations and depth-dependent fracture connectivity on groundwater resources

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Groundwater in shallow weathered and fractured crystalline rock aquifers is often the only perennial water resource, especially in semi-arid region such as Southern India. Here, we show through a detailed study how understanding groundwater flows in such a context is of prime importance for sustainable aquifer management. In particular, we describe how groundwater resources are depending on the hydraulic connectivity of fractures which controls groundwater flows at local and watershed scales.
Investigations were carried out at a dedicated Experimental Hydrogeological Park in Andhra Pradesh (Southern India) where a large network of observation boreholes has been set up. Several hydraulic tests performed under two water level conditions revealed contrasting behavior. Under high water level conditions, the interface including the bottom of the saprolite and the first flowing fractured zone in the upper part of the granite controls groundwater flows at the watershed-scale. Under low water level conditions, the aquifer is characterized by lateral compartmentalization due to a decrease in the number of flowing fractures with depth. Depending on the water level conditions, the aquifer shifts from a watershed flow system to independent local flow systems. A conceptual groundwater flow model, which includes depth-dependent fracture connectivity, is proposed to illustrate this contrasting hydrological behavior. Implications for watershed hydrology and groundwater chemistry are also discussed. This case study shows the vulnerability of such groundwater systems to human impacts and climate variability.