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Groundwater flows in weathered crystalline rocks: Impact of piezometric variations and depth-dependent fracture connectivity

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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. Understanding groundwater flows in such a context is of prime importance for sustainable aquifer management. Here, we describe a detailed study of fracture properties and relate the hydraulic connectivity of fractures to groundwater flows at local and watershed scales. Investigations were carried out at a dedicated Experimental Hydrogeological Park in Telangana (Southern India) where a large network of observation boreholes has been set up. Twenty-eight boreholes have been drilled in a small area of about 18,000 m^2 in which borehole loggings and hydraulic tests were carried out to locate the main flowing fractured zones and investigate fractures connectivity. Several hydraulic tests (nineteen slug tests and three pumping 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 permeable 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. Thus, our results suggest that the shape of the interface at the bottom of the saprolite and the upper part of the granite controls groundwater recharge and contaminants transport and should be taken into account for aquifer management and groundwater prospection.