Water inflows into a deep tunnel through the Reunion volcano: observation and modeling

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ABSTRACT

As part of a general project for water allocation, a 7 km-length gallery has been drilled through the shield volcano of the La Réunion Island. During the tunnel drilling, many water inflows have occurred with a maximum total discharge rate close to 2000 l/s. Three aquifer portions have been encountered during the drilling: a first fractured zone between 1200 and 1400 m from the tunnel entrance, a second aquifer between 3000 and 3600 m and finally a third one between 4700 and 5200 m. These water inflows induced delays in tunnel drilling and the total completion of the drilling took almost 10 years. These underground works gave the first opportunity to observe and monitor the geology and hydrogeology deeply into a shield volcano. The available data are the total discharge rate at the tunnel outlet and the drilling progression.

Several modeling approaches have been applied in order to simulate the discharge rate evolution as a function of drilling speed. First, the confined aquifer solution of Jacob and Lohman convoluted for a progressive drilling failed to properly simulate the flow rate in the La Reunion tunnel due to the hypothesis of a radially infinite aquifer which is not met when the drawdown reaches the water table. The classical analytical solution of Goodman for an unconfined aquifer provides a satisfying matching. Nevertheless, this solution corresponds to a very specific case neglecting the recharge rate at the top of the aquifer. The generalized solution of Perrochet and Musy (1992) for an unconfined aquifer with a constant recharge rate is more suited in order to take into account the rainy seasons during the duration of the drilling. Its application is illustrated. It allows computing the length of the depression zone drained by the tunnel. The solution can be applied in order to compute steady-state discharge rate.

The assumptions made in modeling help to increase knowledge of young volcanic aquifers, including the presence of productive aquifer within the lands under 1000 meters of rock cover.