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Study of groundwater-quarry interactions in the context of energy storage systems

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Pump storage hydroelectricity is an efficient way to temporarily store energy. This technique requires to store temporarily a large volume of water in an upper reservoir, and to release it through turbines to the lower reservoir, to produce electricity. Recently, the idea of using old flooded quarries as a lower reservoir has been discussed. However, these flooded quarries are generally in relation with an unconfined aquifer. Consequently, pumping or injecting large volumes of water, within short time intervals, will have an impact on the adjacent water table. The objectives of this study is to understand the consequences of pumping/injection of large water volumes in a quarry on the adjacent unconfined aquifer. Numerical tools are used to understand the impact of oscillatory pumping in a quarry on the aquifer. Sinusoidal pumping are imposed on a generic quarry modelled with a 3D finite difference simulator. The period of the sinusoidal pumping is maximum 12 hours. We observe and study the propagation of this stress in the adjacent porous media and the amplitude of water level variations in the quarry, as a function of the hydraulic parameters. Two different configurations have been considered: homogeneous hydraulic parameters in the porous media and the presence of a fractured zone in the vicinity of the quarry. Results show that the influence of the quarry – aquifer interactions on the amplitude of water level fluctuations in the quarry remains low whatever the hydraulic parameters. The attenuation of the groundwater head fluctuations in the porous media logically increases with the distance of the quarry. In the homogeneous case, we have an equal propagation of the stress in all point of the environment. The maximal distance of propagation increases with the hydraulic conductivity and the porosity values. The presence of a fractured zone induces preferential flow paths, which distort significantly the zone impacted by the sinusoidal pumping. In the fracture, the distance of influence may increase by more than one order of magnitude, depending on the fracture and matrix hydraulic properties. In this study, we have focused on the impact assessment of pump/storage operations on aquifers. However, the actual field monitoring of groundwater levels fluctuations around a pump/storage system would also allow constitute an efficient characterization tool, by inversion of collected data.