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The impact of local rock properties on the karstification of aquifers close to dam sites: the case of a gypsum karst aquifer on the Birs river in Switzerland

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A small dam site, built a bit more than 100 years ago on the Birs river near Bazel (Switzerland), caused a significant impact on the evolution of the gypsum karst aquifer in the vicinity of the hydraulic structure. Several sinkholes provoked subsidence of the dam and the highway nearby. Extensive technical measures had to be conducted in order to prevent further karstification. The numerous geophysical and geological field studies executed in the area, together with a 3D hydrogeological model of the aquifer, provide very detailed information for the boundary conditions and the local properties determining the karstification.

In this work, we present a 2D karst evolution model of the aquifer in the vicinity of the dam structure. In contrast to older studies, this time the focus of the research are not basic processes governing the karst evolution, but modeling the temporal development of the real aquifer. We demonstrate that a detailed knowledge of the local properties (hydraulic conductivity, solubility) of the rock is of crucial importance when modeling real aquifers. Areas containing insoluble material can impair the karstification considerably and even stop it. On the other hand, even thin lenses of gypsum or other soluble rock can provide preferential pathways and decrease the karstification times considerably. Aquifers located in thick layers of soluble material exhibit a channel-like karstification pattern along areas with high hydraulic gradients or high hydraulic conductivities. In contrast to this, if the amount of soluble material is limited, then the pattern is diffuse, and is determined mainly by the chemical properties of the rock. This wide range of possible scenarios is a warning that solutional features, such as sinkholes, can develop far away from the hydraulic structure and endanger facilities at the surface. Using the large amount of information about the aquifer on the Birs river, we demonstrate that it is not possible to model a real aquifer without taking into account the local solubility properties of the host rock. Our model is able to reproduce and explain the main geological features revealed by field studies. This gives us confidence to provide a forecast about the future development of the aquifer for the time after the engineering measures preventing the further karstification have been conducted.