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Hydrogeological impact of fault zones on a fractured carbonate aquifer, Semmering (Austria)

Cyril Mayaud (1), Gerfried Winkler (1), and Peter Reichl (2)

(1) Institute for Earth Sciences, University of Graz, NAWI Graz, Austria, (2) Institute for Water, Energy and Sustainability, Joanneum Research, Austria

Fault zones are the result of tectonic processes and are geometrical features frequently encountered in carbonate aquifer systems. They can hamper the fluid migration (hydrogeological barriers), propagate the movement of fluid (draining conduits) or be a combination of both processes. Numerical modelling of fractured carbonate aquifer systems is strongly bound on the knowledge of a profound conceptual model including geological and tectonic settings such as fault zones. In further consequence, numerical models can be used to evaluate the conceptual model and its introduced approximations.

The study was conducted in a fractured carbonate aquifer built up by permomesozoic dolo/limestones of the Semmering–Wechsel complex in the Eastern Alps (Austria). The aquifer has an assumed thickness of about 200 m and dips to the north. It is covered by a thin quartzite layer and a very low permeable layer of quartz-phyllite having a thickness of up to several hundred meters. The carbonate layer crops out only in the southern part of the investigation area, where it receives autogenic recharge. The geological complexity affects some uncertainties related to the extent of the model area, which was determined to be about 15 km^2. Three vertical fault zones cross the area approximately in a N-S direction. The test site includes an infrastructural pilot tunnel gallery of 4.3 km length with two pumping stations, respectively active since August 1997 and June 1998. The total pumping rate is about 90 l/s and the drawdown data were analysed analytically, providing a hydraulic conductivity of about 5E-05 m/s for the carbonate layer. About 120 m drawdown between the initial situation and situation with pumping is reported by piezometers. This led to the drying up of one spring located at the southern border of the carbonates.

A continuum approach using MODFLOW-2005 was applied to reproduce numerically the observed aquifer behaviour and investigate the impact of the three fault zones. First simulations were done under laminar flow conditions, an attempt allowing nonlinear flow with a new released package was implemented later. Preliminary results show that the implementation of the three faults zones with a much lower hydraulic conductivity compared to the aquifer is essential to reproduce properly both situations with and without pumping. This approves the high impact of fault zones on groundwater flow in fractured aquifer systems. Finally, this example shows that numerical modelling can help to reduce the uncertainties of conceptual models.