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Hydraulic characterisation of carbonate aquifers with pumping tests – comparison of analytical and numerical data evaluation methods

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This work deals with the analysis of pumping tests in strongly heterogeneous media. Pumping tests were performed in the catchment area of the Lez spring (South of France), which is composed of carbonate rocks. Pumping rates for the different tests varied between 0.04 l/s – 0.7 l/s, i.e. the radius of influence of the cone of depression is small. The investigated boreholes are characterised by tight rocks, moderate fractures and karstified zones. The observed drawdown curves are clearly influenced by the rock characteristics. Single drawdown curves show S-shape character. Data evaluation was performed with the solution approaches of Theis (1935) and Gringarten-Ramey (1974), which are implemented in the employed software AQTESOLV (Pro 4.0). Parameters were varied in reliable data ranges with consideration of reported values in the literature. The Theis method analyses unsteady flow in homogeneous confined aquifers. The Gringarten-Ramey solution describes the drawdown in a well connected to a single horizontal fracture. The Theis curve fails to represent the characteristics for nearly all of the measured drawdown curves, while the Gringarten-Ramey method shows moderate graphical fits with a small residual sum of squares between fitted and observed drawdown curves. This highlights the importance of heterogeneities in the hydraulic parameter field at local scale. The determined hydraulic conductivities of the rock are in reasonable ranges varying between 1E-04 m/s and 1E-08 m/s. Wellbore skin effects need to be discussed further in detail. While the analytical solutions are only valid for specific geometrical and hydraulic configurations, numerical models can be applied to simulate pumping tests in complex heterogeneous media with different boundary conditions. For that reason, a two dimensional, axisymmetric numerical model, using COMSOL (Multiphysics 4.1), is set up. In a first step, the model is validated with the simulated curves from the analytical solutions under appropriate boundary conditions. In a second step, a complex geometry with a horizontal fracture is introduced into the numerical model and the influence towards the drawdown in the well is investigated.