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3D hydrogeological modelling for groundwater catchment delineation in a karst environment

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The delineation of groundwater catchments in karst aquifers is a challenge. Because of the presence of large scale heterogeneities in the subsurface, e.g. karst conduit systems, groundwater catchments can differ substantially from surface water catchments. Furthermore, because of the thick vadose zones, the number of groundwater wells is often insufficient to establish a piezometric contour map. Water tracing techniques provide another method for catchment delineation in karst aquifers. However, appropriate tracer injection points are required. If neither a larger number of groundwater wells nor tracer test results are available, catchment delineation is not feasible.
The aim of the presented study is to compile the available geological information in order to decipher an approximate delineation of spring groundwater catchments in complex karst systems.
The study area is located on the western graben-shoulder of the Jordan Rift Valley northwest of the Dead Sea. The aquifer is composed of karstified Cretaceous carbonate rocks. Ground level ranges from 1000 m above sea level in the mountain range in the west to less than -400 m at the Dead Sea in the southeast. The mean annual precipitation is about 600 mm/y in the mountainous area in the western part of the study area and decreases towards the east to about 150 mm/y in the Jordan Valley. Therefore the main recharge of the aquifers take place in the mountain range. The aquifer discharges in the arid Jordan Valley via several springs, which are the basis for oases like Jericho. However, due to the complex hydrogeological conditions the catchments of the springs are unknown. This has severe implications regarding groundwater protection from a qualitative as well as quantitative perspective.
The approach requires the construction of a detailed three-dimensional geological model. This was done using the software GoCAD, accounting for the available structural information. Based on the geological model a steady state numerical groundwater flow model is set up using the software FEFLOW 6.0. Different scenarios of aquifer geometry and hydraulic parameter combinations are simulated, i.e. a variable refinement of the hydrostratigraphy and a differing hydraulic function of the main faults.
This technique has potential for karst aquifer systems where hydrogeological information is scarce, but geological information is available. Subsequently the catchment boundaries may be revised by conducting selective tracer tests.