Preferential flow paths in a karstified spring catchment: A study of fault zones as conduits to rapid groundwater flow

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Introduction
The Weendespring is a local source of drinking water in the city of Goettingen, located in central Germany. As part of the cuesta geomorphological structure, the Weendespring catchment is intersected by several fault zones along the main flow path of the catchment. It is particularly important to understand the vulnerability of the catchment and effect of fault zones as rapid transport of contaminants. Model results have been obtained at the spring only a few days after the application of fenitrothion within the catchment in a range of approximately 0.8 km. The layout underlay the majority of these fields as an assumed, fault zones within the area are likely to create rapid flow paths to the main aquifer layer and the spring. The model corroborates the catchment as containing three hydrological time-line units with varying degrees of karstification intersected by the major highly conductive aquifer layer the middle Muschelkalk as an aquitard and the upper Muschelkalk as another conductive layer. Many studies have sought to identify a connection between fault displacement and fault zone widths. These flow paths may enhance the dissolution of the Muschelkalk within these zones and produce a positive feedback loop leading to even higher preferential flow paths. Here we use the Doering flow model with three distinct hydrological units and separate fault zone parameters.

Objectives
- Implement unsaturated flow modeling with Richard’s equation and Van Genuchten parameterization
- Conduct a sensitivity study on the fault parameters as well as the aquifer and aquitard parameters
- Create a dual continuum model for fractures and faults
- Create a concept model of hydraulic networks in carbonate rocks, illustrated by examples from Poland (Triassic limestone
- Constitute the conceptual model containing three hydrological time-line units with varying degrees of karstification intersected by the major highly conductive aquifer layer the middle Muschelkalk as an aquitard and the upper Muschelkalk as another conductive layer. Many studies have sought to identify a connection between fault displacement and fault zone widths. These flow paths may enhance the dissolution of the Muschelkalk within these zones and produce a positive feedback loop leading to even higher preferential flow paths. Here we use the Doering flow model with three distinct hydrological units and separate fault zone parameters.

Study Area
The Weendespring catchment is located in Goettingen, Lower Saxony, Germany within the cuesta geomorphological structure of the Northwest German Basin. The cuesta geomorphological structure contains a landscape of faults, and the Muschelkalk limestone makes it karstified. The conceptual model of the cross-section of the catchment was defined by the blackbook Goettinger for their protection areas.

Geology
Hydrogeological Unit

3-D Interpolated hydrological unit bases

Study Area

Leinetal Graben

Study Area

Land Use

Hydrogeological Unit

Extensive karstification and conduits

Geology

Climate

Data

Recharge zones, provided by the Lower Saxony Water Authority (LWG), were used to sparsely distribute recharge along the 3D profile. The recharge zone values range and areas were used to calculate a zone factor based on average yearly recharge intensities, which were then multiplied by the average daily interception (calculated above) to produce unique zones of higher or lower yearly recharge.

Recharge Zones

References

Conclusions
Both fault zone scenarios appear to have potential to fulfill the spring’s discharge curve. They must be further examined to determine which of the scenarios better fits the spring’s discharge. The parameters with the greatest influence on the flow are hydraulic conductivity and storage.

Outlook
- Conduct a sensitivity study on the fault parameters as well as the aquifer and aquitard parameters
- Collect hydraulic head, precipitation, and other weather data within the catchment for better model calibration
- Implement unsaturated flow modeling with Richard’s equation and Van Genuchten parameterization
- Create a dual continuum model for fractures and faults
- Carry out 3D simulations to better understand flow paths