Conceptualization of flow and transport in a limestone aquifer by multiple dedicated hydraulic and tracer tests - DTU Orbit (23/12/2018)

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Limestone aquifers are of great interest as a drinking water resource in many countries. They often have a complex crushed and fractured geology, which makes the analysis and description of flow and transport processes in such aquifers a challenging task. In this study, the solute transport behavior including fracture-matrix interaction in hydrogeological units of a limestone aquifer in eastern Denmark was characterized by designing, conducting and interpreting six depth-specific tracer tests involving natural- and forced-gradient conditions with multiple tracers representing different diffusion properties. To determine flow parameters, the tracer tests were complemented by a comprehensive set of depth-specific borehole and hydraulic tests.

Based on the tests, a new and stronger conceptual understanding was developed for the different aquifer units. The investigated limestone aquifer is composed of a glacially crushed unit and two fractured units, with calcarenitic and bryozoan limestone of similar hydraulic properties. Hydraulic tests revealed, that the crushed unit has a lower hydraulic conductivity than the fractured limestone units, likely due to the crushed conditions with small limestone clusters and small-aperture fractures potentially filled with fine material.

In the fractured limestone units, a distinct preferential flow and primary transport along major horizontal fractures was inferred from the tracer tests under forced-gradient conditions. The dominant horizontal fractures were identified on impeller flow logs and appear connected between wells, having an extent of up to several hundred meters. Connectivity between the aquifer units was investigated with a long-term pumping test and tracer tests, revealing restricted vertical flow and transport. A very pronounced hydraulic conductivity contrast between major fractures and matrix could also be inferred from the borehole and hydraulic tests, which is consistent with the findings from the tracer tests. However, the difference in the matrix diffusion behavior of the simultaneously injected tracers and a long tailing in the breakthrough curves revealed that matrix diffusion has a strong influence on the solute transport in the fractured limestone.

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