Institute of Fluid Mechanics
and Environmental Physics
in Civil Engineering

Masterthesis - Geological Faults as an Uncertainty Factor in the Simulation of Hydrothermal Doublet Systems in Multi-Layer Aquifers

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Background

Deep geothermal energy is considered a promising, baseload-capable, and climate-neutral energy source for sustainable heat supply. In line with the targets of the German Climate Protection Act (net greenhouse gas neutrality by 2045), it is gaining increasing importance. Despite its technical viability, geothermal energy usage in Germany remains limited, primarily due to high initial investment costs and the so-called exploration risk.
To reduce these risks, precise geological and numerical models are needed that realistically represent hydrogeological conditions and potential fault zones. Structural heterogeneities such as geological faults can significantly affect flow paths and thus the performance of geothermal systems.
This thesis focuses on the hydrothermal utilization of the Wealden Formation (also known as the Bückeberg Formation) in Burgwedel, where a municipal heating project is planned based on the development of multiple sandstone horizons. The emphasis lies on incorporating a known fault in the area and analyzing its impact on flow and heat transport behavior in the geothermal multi-layer system.

Objective

This Master's thesis aims to expand an existing numerical model of the Wealden Formation in Burgwedel by incorporating a geological fault, in order to investigate its influence on flow and heat transport in a multi-layer aquifer. The focus is on the following aspects:

Model Extension to Include a Geological Fault

The presence of a geological fault in the target area is known, but no detailed information is available regarding its geometry, extent, or hydraulic properties. The goal is to integrate the fault into the existing multi-layer model and to simulate various hypothetical configurations (e.g., thickness, permeability) and orientations.

Sensitivity Analysis

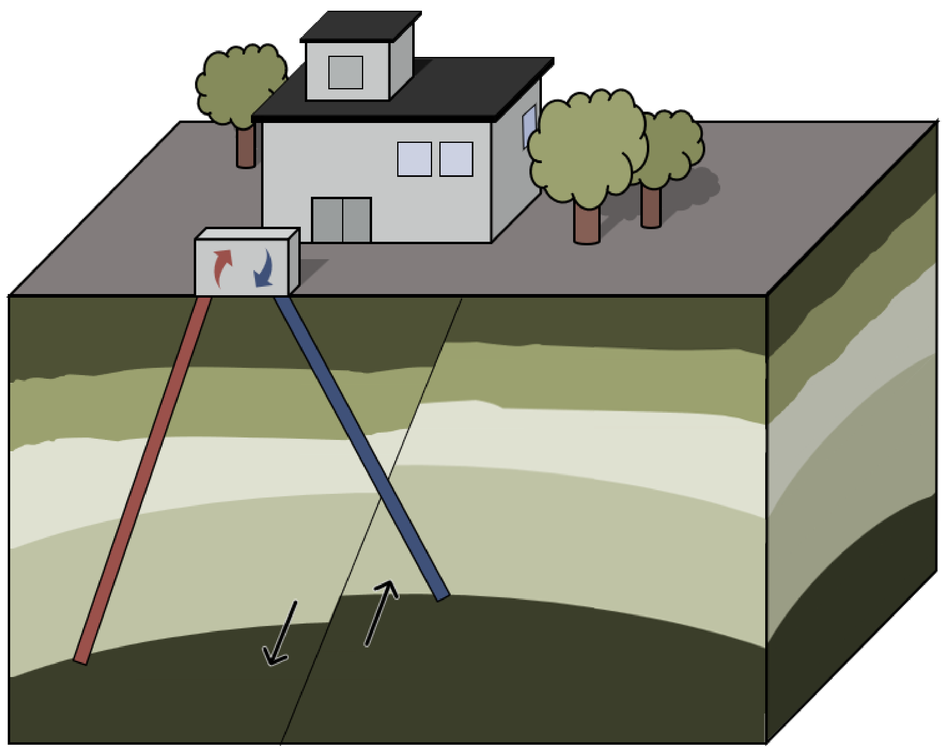
By systematically varying fault parameters, the study aims to assess how strongly this structural uncertainty affects flow and temperature fields. The results are intended to support a better understanding of the relevance of fault zones for the modeling and planning of hydrothermal doublet systems.

Work Plan:

1. Literature review on the geological structure of the Wealden Formation and the modeling of fault zones
2. Analysis of and familiarization with the existing OpenGeoSys multi-layer model
3. Parameterization and geometric implementation of the fault
4. Development of various scenarios with differing fault orientations and hydraulic properties
5. Simulation of the impact on flow and heat transport
6. Sensitivity analysis to assess structural uncertainty
7. Interpretation and discussion of the results in the context of geothermal system planning and risk assessment

Requirements

- Interest in geotechnical and geothermal engineering topics
- Basic knowledge of flow and heat transport processes is helpful
- Experience with numerical modeling tools is desirable but not required



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