Master Project proposal

Project Details

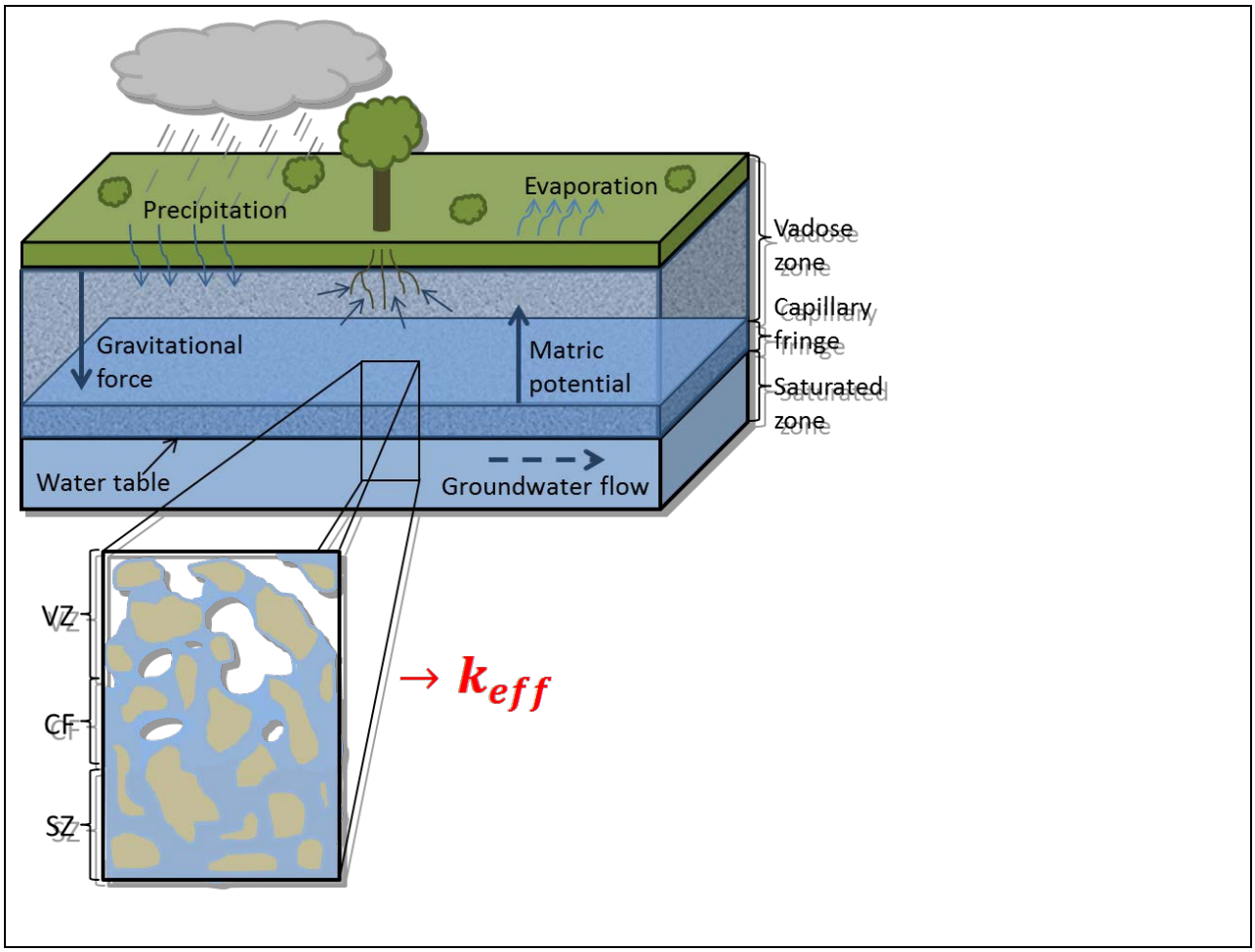
Title	**Improved estimation of effective permeability from NMR**
Principle Supervisor	**Norbert Klitzsch**
Local Supervisor	**Johanna Ochs**

The effective permeability, i.e., the permeability of a fluid (e.g. gas) in the presence of another fluid (e.g. water), is very crucial for processes that involve more than one fluid in the pore space. In the context of global warming, for example, the knowledge of the effective permeability of soils is of utter importance for long-term simulations of the water content in the vadose zone and, thus, for the agricultural use of these soils/areas. Other examples, which require a good grasp of effective permeability, are deep geothermal, underground fluid storage, and, last but not least, natural oil and gas reservoirs.
However, measuring effective permeability on rock/soil samples in the lab is a very tedious task, i.e., it can take several weeks to measure the drainage path of a low permeability sample. Therefore, an in-situ prediction of effective permeability based on geophysical measurements would be a considerable advancement. The method to be applied in this Master thesis project is **Nuclear Magnetic Resonance (NMR) relaxometry.**

NMR is as geophysical method for determining the water or fluid content of rocks and soils. Beside the NMR amplitude, which is proportional to the proton and, thus, to the water content, a relaxation time distribution (RTD) can be derived from NMR measurements. From RTDs, the pore size distribution (PSD) is usually obtained by a calibration procedure by, e.g., mercury intrusion porosimetry or gas adsorption. Recently, Hiller and Klitzsch (2018) suggested a joint inversion approach to derive pore size distribution directly from NMR measurements at different water saturations. However, Ivanov (2019) showed on carbonate samples that this approach underestimates the pore sizes. We address this to the underlying capillary bundle model, which oversimplifies the water distribution in the pore space at partial saturation.

The **tasks** of this Master thesis project are:

1. Review the literature about two-phase flow and fluid distribution in pore networks at partial saturation.
2. Suggest an alternative to the capillary bundle model and implement it in the joint inversion approach. Validate your approach using existing lab data, NMR by Ivanov (2019) and image derived PSDs by Malai (2018).
3. Implement at least one approach to estimate effective permeability from PSDs. You could also incorporate resistivity as constraint on permeability. Validate your approach using existing data (Malai 2018; Li 2016).
4. Apply the improved approach to NMR logging data measured in the vadose zone and predict PSD and effective permeability. Estimate their uncertainties by propagating the RTD error to them.


Precipitation
Evaporation
Vadose zone
Capillary fringe
Saturated zone
Gravitational force
Matric potential
Water table
Groundwater flow
VZ
CF
SZ
$\rightarrow k_{eff}$

Skill Profile	0 1 2 3 4 5	comments
Programming		
Fieldwork		
Laboratory work		
Theory		
Processing		
Interpretation		
Geology		

Opportunities provided

		comments
Approved Further Education / Training	No	
Training with particular software	Yes	MATLAB NMR Toolbox “NUCLEUS”
Training with particular hardware	No	
Temporary relocation at a research partner	No	
Temporary relocation for fieldwork	No	
Coverage of costs relocation/accommodation/expenses	No	
Local assistance provided	Yes	Visa / housing
Publication possible	Yes	

Supplementary Documents

Hiller and Klitzsch (2018): https://doi.org/10.1190/geo2017-0697.1