Master Project proposal

Project Details

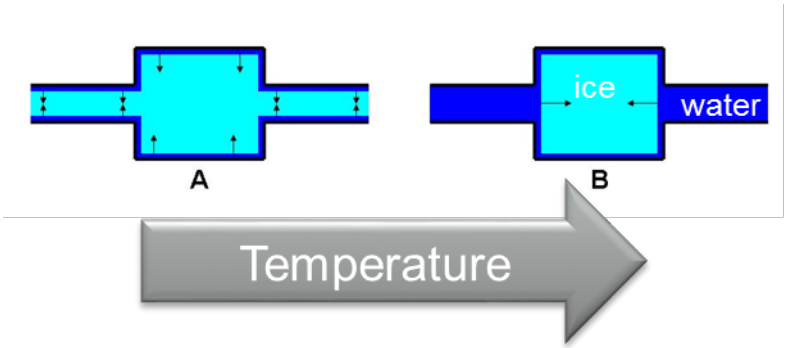
Title	**Cryo-NMR – Determining the fluid water content of frozen rocks**
Principle Supervisor	**Norbert Klitzsch**

Mountain permafrost is currently undergoing substantial changes due to climate change and consistent warming. Thawing has been observed at many permafrost sites worldwide. As permafrost and especially its ground ice content can neither be assessed visually from the surface nor by standard remote sensing approaches, geophysical methods are being increasingly used to investigate the spatio-temporal permafrost evolution.

In the project "SIP in ice" (www.sip-in-ice.eu), we use **induced polarization (IP)** measurements for the improved imaging and quantification of ice content at alpine permafrost sites. The involved petrophysical model is validated by means of **spectral induced polarization (SIP)** laboratory measurements collected during controlled freeze-thaw cycles on soil/rock samples. For the validation, the knowledge of the fluid and frozen water portions at each temperature would be beneficial. Therefore, NMR relaxometry shall be applied to monitor the fluid water content during freeze-thaw cycles on selected samples.
Nuclear Magnetic Resonance (NMR) relaxometry is a method for determining the water or fluid content of rocks. The NMR amplitude, which is proportional to the proton and, thus, to the water content, can be derived from NMR measurements. Due to the pore-size dependent freezing and melting point depressions, the ice content of a porous rock is not only temperature dependent but also inversely proportional to pore size, as given by the Gibbs–Thomson equation. This relation is used in Cryo-NMR to derive the pore size distribution (PSD) of nano- and microporous rocks. Beside the NMR amplitude, a relaxation time distribution (RTD) can also be derived from NMR measurements on water saturated, unfrozen rocks. From RTDs the PSD is usually obtained by a calibration procedure using, e.g., mercury intrusion porosimetry or gas adsorption.

This Master thesis project has three main **tasks**:

1. Carry out NMR measurements during controlled freeze-thaw cycles on selected samples (including calibration measurements) and interpret this data in terms of temperature dependent fluid water and ice content.
2. Derive the PSD from the Cryo-NMR measurements using the whole melting path;
   derive the PSD using just one Cryo-NMR measurement for calibrating the relaxation time distribution.
3. Quantify the uncertainty of the determined PSD/RTD using the Matlab Toolbox DREAM (Vrugt 2016).



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	Yes	NMR (and SIP)
Temporary relocation at a research partner	Yes	Maybe, one or two weeks at Bonn Univ.
Temporary relocation for fieldwork	No	
Coverage of costs relocation/accommodation/expenses	No	
Local assistance provided	Yes	Visa / housing / student assistant contract possible
Publication possible	Yes	

Supplementary Documents