# Towards a rock physical model for fine grained permafrost: Insights from velocity and NMR measurements

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**Abstract:**

Mechanical behavior of permafrost is affected by small temperature disturbances: a slight increase in temperature may lead to significant ground subsidence and loss of shear strength. Especially for fine-grained permafrost, current rock physical models fail to capture the relationship between the unfrozen water content (UWC) and stiffness and failure strength of permafrost samples.
In this study, we applied cyclical axial loading to a permafrost sample undergoing sub-zero temperature changes. We assessed the impact of these temperature changes (and thus UWC changes) on the strength and stiffness of the specimen, measured by mechanical deformation upon application of stress and changes on the bulk modulus calculated from compressional and shear ultrasonic velocities (Figure 1a).
We performed NMR T2 relaxation measurements to measure the liquid water content within the sample at each temperature step (Figure 1b). Furthermore, analysis of the relaxation distribution allows us to infer where in the pore space this water was located. Even at -10° C, the sample had a significant UWC, probably due to impact of surface effects and capillary tension on the freezing temperature of the water, since the salinity of the saturating fluid was low. The combined interpretation of the elastic data using Hashin-Shtrikmann bounds and the NMR $T_2$ relaxation distributions suggests that for our fine-grained sample, ice was the frame-forming material, and the soil grains do not contribute to the shear stiffness of the sample on the temperature range tested.

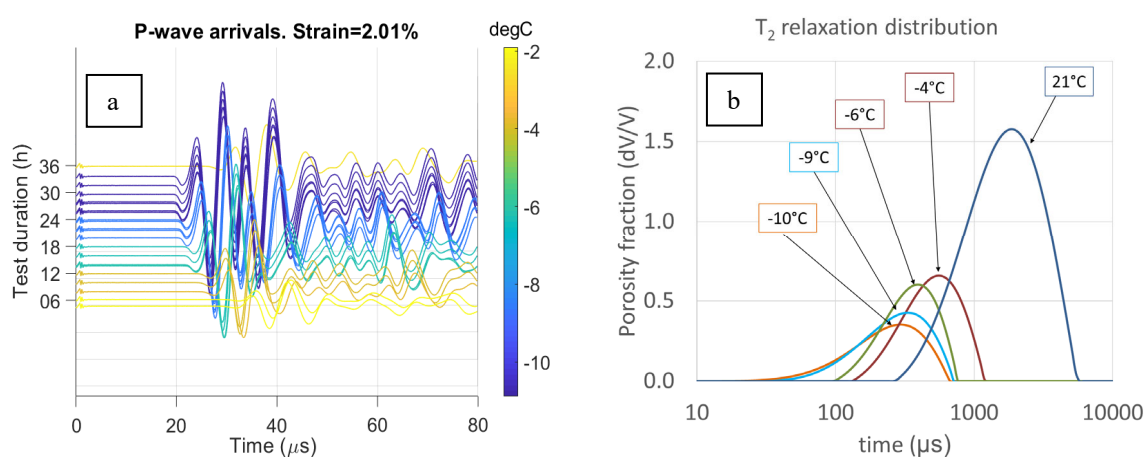


Figure 1- a) Impact of temperature and UWC on compressional velocity and b) $T_2$ relaxation distribution of a permafrost sample.