Report on the outcomes of a Short-Term Scientific Mission[1]

Action number: CA24157

Grantee name: Paula Johns

Details of the STSM

Title: **Practical TEM training and assessment for future permafrost monitoring**

Description of the work carried out during the STSM

During the first week of my STSM at TU Wien, I joined Lukas Aigner and Sophie Francis for two days of geophysical field measurements. I became familiar with different acquisition systems, including fast transient electromagnetics (TEM), late-time TEM and frequency-domain induced polarization (IP). The fieldwork provided practical insights into instrument setup and operation, acquisition procedures, data quality and the relative logistical requirements of different systems. The exposure to frequency-domain IP was an additional element alongside the originally planned focus on TEM.

Following the fieldwork, Lukas Aigner introduced me to Python-based TEM processing and inversion workflows and shared scripts that I could use to gain initial practical experience with TEM inversion. Discussions with Adrián Flores-Orozco addressed TEM instrumentation and its potential application to alpine permafrost, including the challenges posed by highly resistive and heterogeneous terrain. We considered the effects that induced polarization can have on TEM transients, their implications for processing and inversion, and possible ways to identify and account for them. We also discussed opportunities for future collaborative TEM measurements at alpine permafrost sites, particularly the potential for repeated surveys under contrasting seasonal conditions.

During the second week, I participated in the geophysical field course at the Austrian soda lakes. I gained further hands-on experience with fast TEM acquisition and instrument operation, practiced explaining measurement procedures to students, and worked on processing and inverting TEM data acquired during the course. The conductive soda-lake environment differed substantially from alpine permafrost and primarily served as methodological training rather than a direct analogue.

During the week, we also discussed the potential application of time-domain induced polarization (TDIP) in permafrost environments. In addition, I had the opportunity to refresh my knowledge of seismic methods and attend Adrián Flores-Orozco's theoretical lectures, which provided valuable background and helped consolidate my understanding of the geophysical methods discussed and applied during the STSM.

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the Grant Holder Manager to verify the grant documents compliance and proceed with the payment.

Description of the STSM main achievements and planned follow-up activities

The STSM provided valuable methodological training and scientific exchange, meeting the main objectives outlined in the original application while also opening additional research perspectives. I gained practical experience with TEM acquisition and instrument handling, an introduction to Python-based processing and inversion, and a more informed understanding of the practical factors that must be considered before transferring TEM to alpine permafrost research. The exchanges clarified the importance of instrument capabilities, acquisition geometry, data quality, possible IP contributions to TEM responses, and reproducibility for time-lapse measurements. These insights will help assess where TEM might complement the electrical resistivity tomography (ERT) and refraction seismic tomography (RST) methods already used in my doctoral research at the University of Fribourg.

A principal prospective follow-up is a feasibility study of repeated TEM measurements at an established alpine permafrost site, potentially near Cervinia, where earlier TEM data are available. The concept includes comparing different TEM instruments and investigating the repeatability of surveys under contrasting seasonal conditions, including snow-covered and snow-free periods. Such work would need to distinguish genuine subsurface changes from variations linked to instrumentation, acquisition geometry, environmental conditions and inversion. Combining repeated TEM measurements with three-dimensional ERT could provide additional constraints on subsurface heterogeneity and help assess the influence of three-dimensional structures on TEM responses in complex rock glacier environments.

A second research opportunity emerged from discussions with Adrián Flores-Orozco about the TU Wien group's expertise in induced polarization. Building on previous spectral IP research in permafrost by Theresa Maierhofer and colleagues, we discussed exploring TDIP measurements in frozen ground. Since Syscal Pro instruments are already used for ERT surveys in many permafrost study sites, their potential use for TDIP measurements could provide an opportunity to investigate polarization properties without requiring an entirely new acquisition system. However, the feasibility and interpretability of TDIP measurements in highly resistive, ice-rich environments would need to be tested. This idea arose through scientific exchange and was not a principal objective of the original TEM-focused application.

The visit contributes to PermaCOST WG1/WP1, particularly Task T1.2, through methodological capacity building and an initial assessment of a complementary permafrost monitoring technique. I plan to share the acquired knowledge with the Alpine Geophysics Research Group in Fribourg and use it to inform future survey planning. For now, no publication resulted directly from the STSM, although future joint studies could generate scientific outputs.