Towards operational application of Spectral Induced Polarization for alpine permafrost environments – improvement of data quality

Theresa Maierhofer[1,2], Christin Hilbich[2], Christian Hauck[2], Adrián Flores-Orozco[1]

(1) Geophysics Research Division, Department of Geodesy and Geoinformation, TU-Wien, Austria –
(2) Department of Geosciences, University of Fribourg, Switzerland

Electrical resistivity tomography (ERT) is a widely applied technique to investigate the spatial distribution and temporal evolution of permafrost. Especially ice-rich permafrost is easily detectable with ERT. However, in many cases the interpretation of the subsurface electrical resistivity is ambiguous, and additional information is needed to improve the quantification of the ice/water content within the subsurface. We therefore extend the investigation of electrical conduction mechanisms by taking into account the capacitive properties of the subsurface by means of Induced Polarization (IP) methods. This includes the measurement of the amplitude ratio and the phase shift between the periodic voltage and current signals associated to polarization effects at the water-ice interface. Moreover, IP measurements were conducted over a broad range of frequencies (in the so-called spectral IP (SIP)), to quantify the frequency dependence of the IP in the subsurface materials. The SIP method was tested in an imaging framework at different mountain permafrost sites in the Swiss Alps. The selected study areas are well-established permafrost monitoring sites and provide a comprehensive geophysical characterization as well as borehole temperatures for validation. The sites cover different geomorphological landforms, substrates and ice contents. We present here SIP imaging results from the Lapires site in the Valais Alps, a large north-facing talus slope at ~2600 m altitude. SIP data were collected along several profiles as normal and reciprocal pairs for quantification of data error. We tested different measurement protocols and cable layouts, carefully designed to minimize unwanted electromagnetic effects in the data. Our results show that shielded and separated cables help to improve data quality and thus, the quantification of the SIP response of frozen rocks. Additionally, SIP anomalies agree with ice-rich permafrost as delineated from previous studies, yet spatial variations permit us to distinguish between ice- and air-filled pores, improving the interpretation of ERT.