Permafrost long-term monitoring network

WP6 Permafrost and Natural Hazards
Action 6.1 – Method sheet

Electrical Resistivity/Impedance Tomography (ERT/EIT)

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General information	
Category	Geophysical measurement
Background	Electrical Methods
Basic principles	
Technology	Surface-based geophysical methods represent a cost-effective approach to permafrost characterization. In ERT, the spatial distribution of electrical resistivity is determined from a set of electrical resistance measurements collected by an array of electrodes. Each measurement involves four electrodes: two electrodes where an electric current is injected and two electrodes where the resultant voltage response is measured; the voltage-to-current ratio defines the resistance. By systematically changing the location of the four electrodes, a resistance data set is assembled from which the underlying resistivity distribution can be computed by means of inverse modeling. ERT is considered well-suited for permafrost studies as freezing and thawing of most materials are associated with a significant, detectable resistivity change. The installation of permanent electrodes allows direct assessment of spatial and temporal permafrost variability. Laboratory-calibrated quantitative ERT does not only identify frozen and unfrozen rock but provides certain quantitative information on frozen rock temperature (details see Krautblatter *et al.*, 2010).
Data processing	Quantitative interpretation of ERT represents a non-trivial task as numerous factors have an influence on the inverted resistivity values, such as electrode arrangement, measurement scheme, and regularization approach. The appropriate description of the data errors in the inversion is of particular importance. Underestimation of data errors results directly in the fitting of data noise (i.e. details in the data are sought to be explained by the resistivity model although they represent noise) and thus the creation of artifacts in the ERT image. Overestimation does not fully exploit the information given in the data (i.e. details in the data are not sought to be explained by the resistivity model although they represent “signal”) at the cost of contrast in the final image. A sophisticated data error description in the inversion (e.g. in CRTomo) must be considered a prerequisite for the quantitative interpretation of ERT images.
Possible applications	
Why?	Detection and monitoring of the state of permafrost inside rock walls
What?	Here rock walls, but also suitable for rock glaciers, moraines, landslides, glacial debris-cover
Where?	High mountains for physically accessible study objects

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Main results

- ERT monitoring of permafrost degradation and aggradation in rock walls
- Detection of fluid flow
- EIT with induced polarization allows the detection of fine-grained fracture fillings

Main advantages

- Cheap installation of electrodes
- Highly redundant measurement conditions for monitoring applications
- Good evaluation possibilities of inherent error e.g. by reverse current and normal reciprocal error measurements
- Highly develop computing routines for different applications

Main disadvantages/problems

- Repeated effort of data quality and error models esp. in difficult measurement conditions
- Problem of fixing electrodes and cables along steep rock faces
- Expensive measurement devices (ca. 50.000 €)
- High level of expertise for the interpretation of measurements

References

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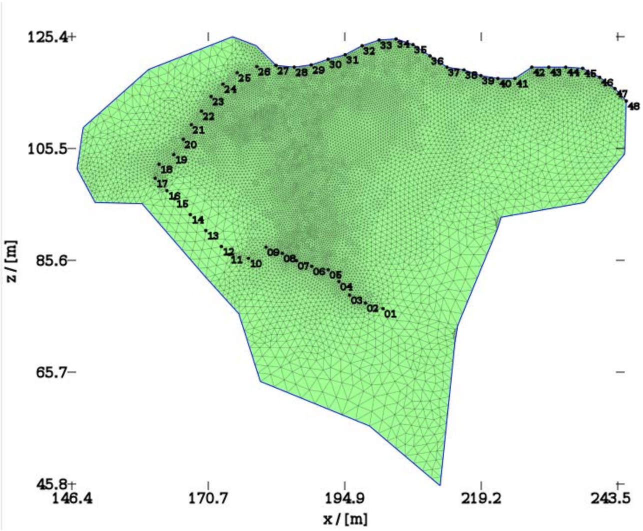
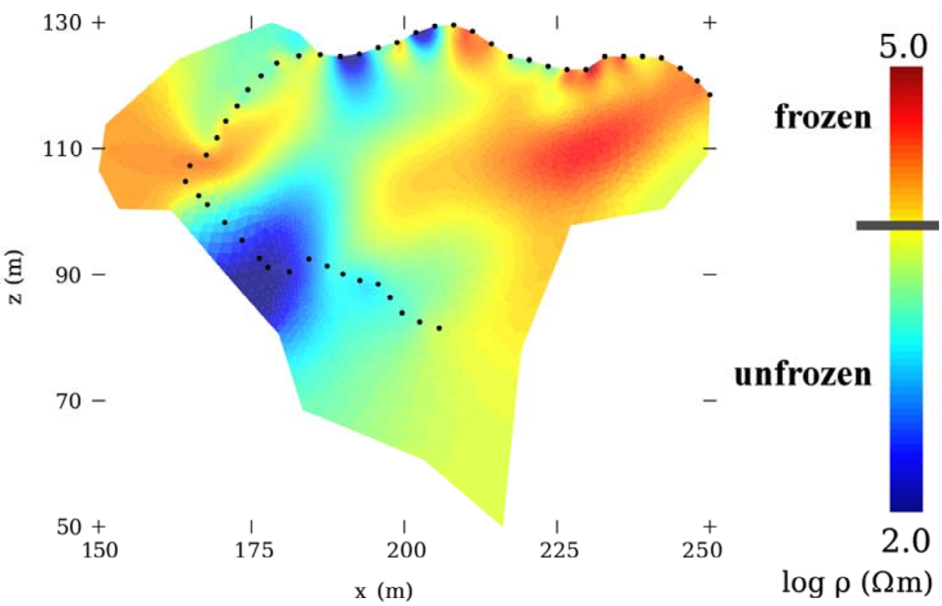
Electrode *array along the Piton Nord (Aiguille du Midi); b and c) Installation of electrode array at the Piton Central (Aiguille du Midi, summit 3842 m a.s.l.) in December 2008 (climber: L. Ravanel). Photos M. Krautblatter*



High-resolution ERT Grid of the Piton Central of the Aiguille du Midi (Mont Blanc massif) showing 48 electrode positions along the galleries.



Electrical resistivity tomography of the Piton Central. According to laboratory resistivity measurements, yellow (10^4 ohm) marks the transition from unfrozen granite (blue/green) to much higher values frozen granite (red). The well-defined section of the tomography is enclosed by the U-shaped electrode array.