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Permafrost long-term monitoring network

WP6 Permafrost and Natural Hazards
Action 6.1 – Method sheet

Ground Penetrating Radar (GPR)

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General information	
Category	Geophysical Surveying
Background	Georadar
Basic principles	
Technology	Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to study the ground down to a depth of several tens of meters. This non-destructive method uses electromagnetic radiation in the microwave band (commonly 15 – 80 MHz) and detects the reflected signals from subsurface structures. GPR can be used in a variety of media, including rock, soil and ice. The depth range of GPR is limited by the electrical conductivity of the ground, the transmitted center frequency and the radiated power. As conductivity increases, the penetration depth decreases. This is because the electromagnetic energy is more quickly dissipated into heat, causing a loss in signal strength at depth. Higher frequencies do not penetrate as far as lower frequencies, but give better resolution. Optimal depth penetration is achieved in ice where the depth of penetration can achieve several hundred meters. Good penetration is also achieved in dry sandy soils.
Data processing	We use the Ground Penetrating Radar GSSI SIR System 2000 equipped with a multiple low frequency antenna with a centre frequency of 15 -80 MHz and constant antenna spacing in point mode (constant-offset profiling). Data are collected by fixed-offset reflection profiling. Distance between transmitter and receiver is 4 m, step size (distance between the data collection points) is 0.5 - 1 m. The antennas are oriented perpendicular to the profile direction. The main record parameters are 1000 ns time range, 1024 samples/scan, 16 bits/sample, and 32-fold vertical stacking. The data are processed with automatic gain control (AGC) function, bandpass-filter, migration velocity analyses, migration, time to depth conversion and elevation correction. In the case of identified air wave events (e.g. reflections from steep rock walls) we additionally apply an F-K filter to suppress these signals.
Possible applications	
Why?	Determination of the thickness of glaciers, rock glaciers, landslides, and internal structures (e.g. thickness of the frozen core, active layer of rock glaciers).
What?	Glaciers, rock glaciers, moraines, landslides, glacial debris-cover
Where?	Rock glaciers, glaciers, landslides, grassland, bare ground, ice, not possible in forested areas.

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Main results

- Profiles (radargrams) showing thickness and internal structures
- Identification and quantification of ice content, thickness
- Determination of geometric features for structural and geomechanical analysis

Main advantages

- Precision: dm - m
- Easy acquisition
- Measuring range: dm to tens of meters
- Accuracy: depends on the material of the ground, ground roughness, measuring parameters
- Data availability: real time, but data processing is necessary

Main disadvantages/problems

- Data processing is fairly long and complex
- Weight and induced logistical problems
- No rain during surveying
- Very low temperatures (below -10°C) can cause problems (energy support)
- Highly specific software
- For measurements in the field a team of 3 – 4 persons is needed, on rock glaciers or glaciers transects to a length of 1 – 1.5 km can be measured on one day depending on the measuring conditions.

References

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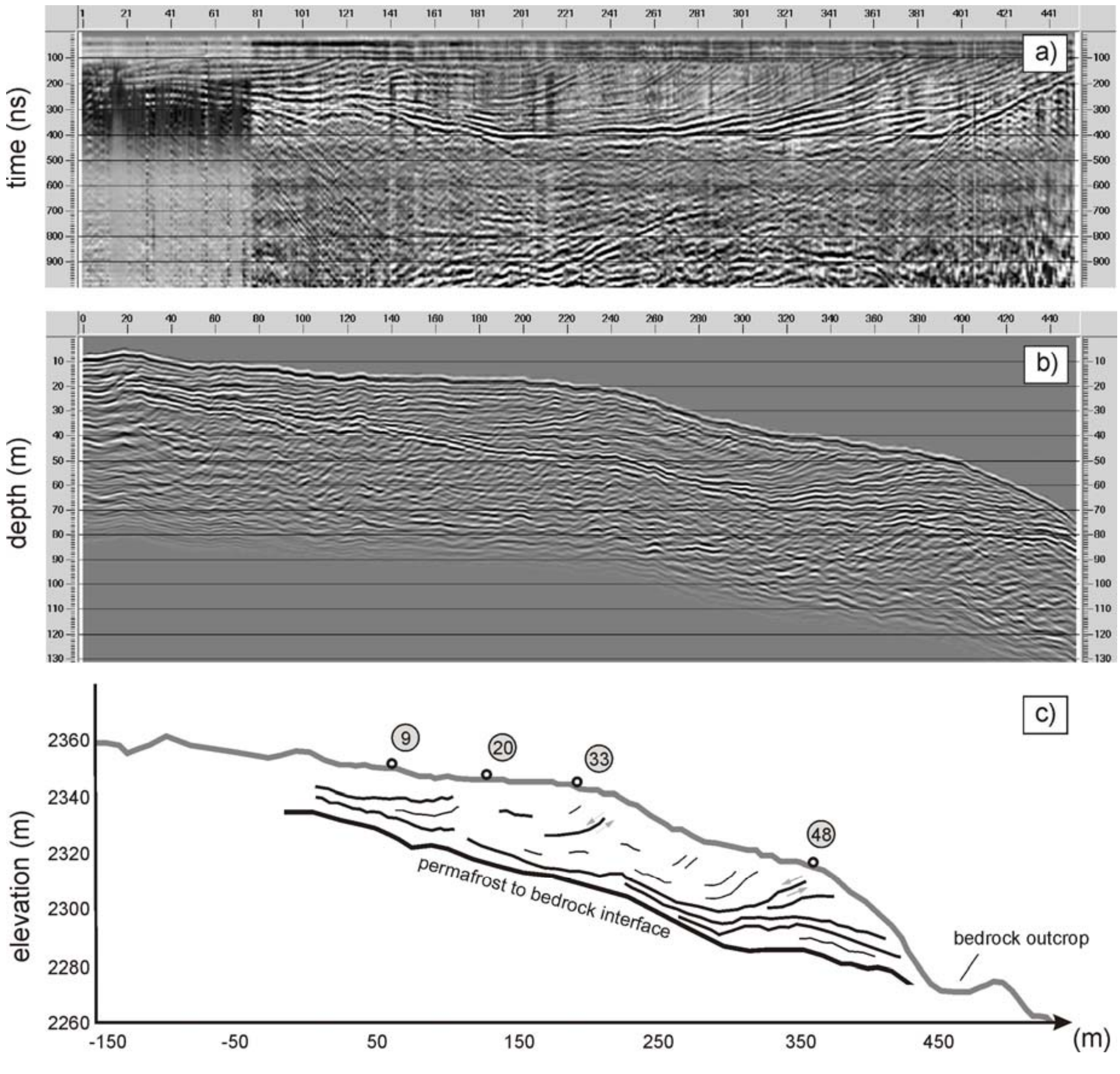
Ground Penetrating Surveying on a rock glacier using a GSSI SIR 2000 equipped with a multiple low frequency antenna with a centre frequency Of 35 MHz. Best results on rock glaciers are achieved when measurements are carried out during winter when the rock glacier is covered with a thick snow cover.



Longitudinal georadar profile, Cadin del Ghiacciaio rock glacier at Hohe Gaisl/Croda Rossa (Dolomites) with 35 MHz antennae. a) raw data with constant gain; b) signal processed data (AGC, band pass filter, F-K filter) after migration, time to depth conversion and elevation correction; c) interpretation of the major reflectors and shear zones (from Krainer et al.*, 2010)*