Name of research institute or organization:

Department of Geography, University of Zurich

Title of project:

Permasense

Project leader and team:

Dr. Stephan Gruber, project leader
Dr. Jan Beutel, group leader ETH
Dr. Lucas Girard, postdoc
Andreas Hasler, Stefanie Gubler, Matthias Keller, PhD students
Samuel Weber, Josua Hunziker, MSc students
Roman Lim, Mustafa Yuecel, technician

Project description:

Topic: Understanding rock temperatures in heterogeneous rock walls

The thermal condition of high-alpine mountain flanks can be an important determinant of climate change impact on slope stability and correspondingly down-slope hazard regimes. We analyze time-series from 17 shallow temperature-depth profiles at two field sites in steep bedrock and ice, one of them being on Jungfraujoch. Extending earlier studies that revealed the topographic variations in temperatures, we demonstrate considerable differences of annual mean temperatures for variable surface characteristics and depths within the measured profiles. This implies that measurements and model related to compact and near-vertical bedrock temperatures may deviate considerably from conditions in the majority of bedrock slopes in mountain ranges that are usually non-vertical and fractured. For radiation-exposed faces mean annual temperatures at depth are up to 3 °C lower and permafrost is likely to exist at lower elevations than reflected by estimates based on near-vertical homogeneous cases. Retention of a thin snow cover and ventilation effects in open clefts are most likely responsible for this cooling. The measurements presented or similar data could be used in the future to support the development and testing of models related to the thermal effect of snow-cover and fractures in steep bedrock.

Topic: Understanding rock damage induced by freezing in high alpine rock walls
see: www.permasense.ch/research/geoscience/rock-damage.html

The formation of ice within rock is an important driver of rock damage near the surface and up to several meters depth. In steep terrain, this process may be crucial for the slow preconditioning of rock fall from warming permafrost areas. Laboratory experiments as well as theoretical studies have contributed to clarify the basic mechanisms through which ice formation can damage rock. However, the transfer of corresponding theoretical insight and laboratory evidence to natural conditions characterized by strong spatial and temporal heterogeneity is nontrivial. In order to prepare the corresponding characterization of rock damage in natural conditions, our approach is mainly based on in-situ measurements of acoustic emissions (AE), a technique commonly used to track damage evolution in solid materials. The application of this technique to field investigations of rock damage due to freezing is nevertheless completely new.

During year 2011, the main achievement of the project was the instrumentation of two continuous monitoring sites close to the Jungfraujoch research station. Each site is composed of two acoustic sensors, inserted at 10 and 50cm depth in the rock, a 1m-long temperature probe, as well as a capacitance probe intended to estimate variation in rock liquid water content. The deployment of these different sensors in the field was preceded by the development of a specific protocol for their installation in boreholes drilled in the rock-wall. For the acoustic sensors, a custom-made casing was specifically developed for this deployment. The two monitoring sites are operational since September 2011.

Analysis of preliminary data collected during the periods where the rock-wall froze is insightful: (a) Acoustic signals can be generated during periods where the rock freezes. When this is the case the statistical properties of the signal correspond to that of micro-fracturing. (b) However, rock freezing can also occur without the generation of acoustic activity. The explanation to this contrasting behaviour probably lies in the level of water-saturation of the rock.

These analyses should be taken further using long time series, which we expect to acquire in the coming year.

Key words:

Permafrost, acoustic emission, weathering, rock temperature, wireless sensor networks

Internet data bases:

data.permasense.ch and www.permasense.ch

Collaborating partners/networks:

Dr. David Amitrano, ISTerre, CNRS / Université J. Fourier, Grenoble, France

Scientific publications and public outreach 2011:

Peer reviewed journal articles

Hasler, A., Gruber, S. & Haeberli, W., Temperature variability and thermal offset in steep alpine rock and ice faces, The Cryosphere, **5**, 977–988, 2011.

Conference papers

M. Keller, M. Woehrle, R. Lim, J. Beutel, L. Thiele, Comparative performance analysis of the PermaDozer protocol in diverse deployments, 6th IEEE International Workshop on Practical Issues in Building Sensor Network Applications, Bonn, Germany, 2011.

Scientific communications (Poster)

Girard, L., S. Gruber, S. Weber and D. Amitrano. Understanding the role of freezing in rock damage under natural conditions, SGmG yearly meeting, St. Nicklaus, Switzerland, July 2011.

Girard, L., S. Gruber, S. Weber and D. Amitrano. Understanding the role of freezing in rock damage under natural conditions, NCCR MICS workshop, Zurich, Switzerland, September 2011.

Girard, L., S. Gruber and D. Amitrano. Damage dynamics inferred from acoustic emissions in a partially frozen rock-wall, AGU Fall meeting, San Francisco, USA, December 2011.

Scientific communications (Talk)

Girard, L., S. Gruber, S. Weber, J. Beutel and D. Amitrano, Freezing-induced rock damage inferred from acoustic emissions, Swiss Geoscience Meeting, Zurich, Switzerland, November 2011.

Beutel, J., S. Gruber: PermaSense. Workshop on methods for monitoring in permafrost environment. PermaNet Final Conference, Chamonix, France, June 2011.

Gruber, S., Landsides in cold regions: making a science that can be put into practice, Keynote at the World Landslide Forum, Rome, October 2011

Theses

Weber, S., Acoustic sensing in mountain permafrost: designing and testing a measurement assembly, MSc Thesis, University of Zürich, 2011.

Hunziker, J., Acoustic emission sensing in wireless sensor networks. MSc Thesis, ETH Zurich, May 2011.

Talzi, I., Dynamic code morphing in networked embedded systems. PhD Thesis, University of Basel, July 2011.

Hasler, A., Thermal conditions and kinematics of steep bedrock permafrost. PhD Thesis, University of Zürich, July 2011

Address:

Glaciology, Geomorphodynamics & Geochronology
Dept. of Geography
University of Zurich
Winterthurerstr. 190
CH-8057 Zurich, Switzerland

Contacts:

Lucas Girard
Tel.: +41-44-63 55 219
e-mail: lucas.girard@gmail.com