

Name of research institute or organization:

**Institute of Geological Sciences and Laboratory for High Energy Physics
University of Bern**

Title of project:

Development and scientific application of nuclear emulsion particle detectors to geological problems

Project leader and team:

Proffs. Fritz Schlunegger and Antonio Ereditato, project leaders
Prof. Paola Scampoli, UniBe
Dr. Nishiyama Ryuichi, PostDoc, UniBe
Dr. Akitaka Ariga, UniBe
David Mair, PhD student
Alessandro Lechmann, PhD student, UniBe
Thomas Siegenthaler, technical staff, UniBe
Roger Hänni, technical staff, UniBe
Jan Christen, technical staff, UniBe
Simon Klingele, geometer, Flotron AG, Meiringen

Project description:

This is an interdisciplinary project between the fields of *Earth Sciences (geology and geomorphology)* and *Physics (particle physics methodologies)* where we aim at imaging the base of an Alpine glacier in 3D with nuclear emulsion particle detectors exposed to the cosmic muon flux. As a first task with completed scientific results, we have installed emulsion films at three sites along the tunnel of the Jungfraubahn and mapped the shape of the bedrock under the Alteschglacier on the southern side. We then used the patterns of detected muons to map the orientation of the bedrock underneath this glacier, thereby documenting the first successful application of muon radiography in a steep and glaciated environment. We were able to show that the dip and strike angles of the reconstructed bedrock surface agree with those of the hillslope exposed above the glacier. In addition, the orientation of the bedrock is parallel to the glacier's flow direction estimated from the topography of the glacier surface. These morphometric data indicate that the ice, at least within 50 m depth below the surface, has passively slid on the preexisting hillslope. However, because of the steep dip of the bedrock-ice interface, a further lowering of the ice surface in response to ongoing warming will strongly increase the risk for bedrock failure in the area surrounding the research station. We have published these results in the Journal Geophysical Research Letters (Nishiyama et al., 2017), from where the statements above are taken.

Key words:

Nuclear emulsion particle detectors, bedrock topography, image analysis, glacial erosion

Collaborating partners/networks:

Colleagues from Nagoya University

Scientific publications and public outreach 2017:

Refereed journal articles and their internet access

Nishiyama, R., A. Ariga, T. Ariga, S. Käser, A. Lechmann, D. Mair, P. Scampoli, M. Vladymyrov, A. Ereditato, F. Schlunegger, First measurement of ice-bedrock interface of alpine glaciers by cosmic muon radiography, *Geophysical Research Letters*, **44**, 6244-6251, doi: 10.1002/2017GL073599, 2017.
<http://onlinelibrary.wiley.com/doi/10.1002/2017GL073599/abstract>

Conference papers

Lechmann, A., D. Mair, A. Ariga, T. Ariga, A. Ereditato, S. Käser, R. Nishiyama, P. Scampoli, M. Vladymyrov, F. Schlunegger, Geological constraints for muon tomography: The world beyond standard rock, European Geosciences Union, General Assembly, Vienna, Austria, April 23-28, 2017, Geophysical Research Abstracts, 19, EGU2017-5100, 2017.

Mair, D., A. Lechmann, N. Akcar, F. Schlunegger, Quantifying the erosional mechanisms of steep headwalls: the case of the Eiger (Central Swiss Alps), European Geosciences Union, General Assembly, Vienna, Austria, April 23-28, 2017, Geophysical Research Abstracts, 19, EGU2017-12165, 2017.

Mair, D., A. Lechmann, F. Schlunegger, How to build the Eiger: Surface expression of litho-tectonic preconditioning, European Geosciences Union, General Assembly, Vienna, Austria, April 23-28, 2017, Geophysical Research Abstracts, 19, EGU2017-8932, 2017.

Nishiyama, R., A. Ariga, T. Ariga, S. Käser, A. Lechmann, D. Mair, P. Scampoli, M. Vladymyrov, A. Ereditato, F. Schlunegger, Bedrock topography beneath uppermost part of Aletsch glacier, Central Swiss Alps, revealed from cosmic-ray muon radiography, European Geosciences Union, General Assembly, Vienna, Austria, April 23-28, 2017, Geophysical Research Abstracts, 19, EGU2017-7723, 2017.

Magazine and Newspapers articles

“Forscher ‘röntgen’ den Eigergletscher”, Luzerner Zeitung, June 12, 2017.

“Berner Forscher durchleuchten den Eigergletscher mit neuer Technik”, Blick, June 12, 2017.

“Vom Tunnel her wurde der Gletscher geröntgt”, Berner Zeitung, June 13, 2017.

“‘Röntgenblick’ in den Eigergletscher”, Jungfrau Zeitung, June 14, 2017.

“Mit kosmischen Teilchen den Eigergletscher durchleuchten”, Ingenieur.de, June 16, 2017.

“Forscher röntgen Gletscher”, Berner Zeitung, August 5, 2017.

Radio and television

“Der Blick unter den Gletscher”, Deutschlandfunk, June 14, 2017.

“Röntgenbild vom Gletscher gelungen”, SRF 2, June 17, 2017.

Address:

Institut für Geologie
Universität Bern
Baltzerstrasse 1+3
CH-3012 Bern

Physikalisches Institut
Labor für Hochenergiephysik
Universität Bern
Sidlerstrasse 5
CH-3012 Bern

Contacts:

Prof. Fritz Schlunegger
Tel.: +41 31 631 8767
Fax: +41 31 631 4843
e-mail: fritz.schlunegger@geo.unibe.ch

Prof. Antonio Ereditato
Tel.: +41 31 631 8566
Fax: +41 31 631 4487
e-mail: antonio.ereditato@cern.ch