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Subglacial bedrock topography of an active mountain glacier in a high Alpine setting – insights from high resolution 3D cosmic-muon radiography of the Eiger glacier (Bern, Central Alps, Switzerland)

David Mair (1), Alessandro Lechmann (1), Ryuichi Nishiyama (2), Fritz Schlunegger (1), Akitaka Ariga (2), Tomoko Ariga (2), Paola Scampoli (2,3), Mykhailo Vladymyrov (2), and Antonio Ereditato (2)

(1) Institute of Geological Sciences, University of Bern, Baltzerstrasse 1+3, CH-3012 Bern, Switzerland (david.mair@geo.unibe.ch), (2) Albert Einstein Center for Fundamental Physics, Laboratory for High-Energy Physics, University of Bern, Sidlerstrasse 5, CH-3012, Bern, Switzerland, (3) Dipartimento di Fisica "E. Pancini", Università di Napoli Federico II, Via Cintia, I-80126, Napoli, Italy

Bedrock topography and therefore the spatial-altitudinal distribution of ice thickness constrain the ice flow as well as the erosional mechanisms of glaciers. Although the processes by which glaciers have shaped modern and past landscapes have been well investigated, little information is still available about the shape of the bedrock beneath active glaciers in steep Alpine cirques. Here, we we apply the cosmic-muon radiography technology, which uses nuclear emulsion detectors for imaging the bedrock surface. This method should provide information on the bedrock topography beneath a glacier and related ice thicknesses and subglacial meltwater pathways. We apply this technology to the cirque of the Eiger glacier, situated on the western flank of Eiger mountain, Central Swiss Alps.

The Eiger glacier originates on the western flank of the Eiger at 3700 m a.s.l., from where it stretches along 2.6 km to the current elevation at 2300 m a.s.l.. The glacier consists of a concave cirque bordered by >40° steep flanks, thereby utilizing weaknesses within the fabric of the bedrock such as folds, joints and foliations. The middle reach hosts a bedrock ridge where glacier diffluence occurs. The lower reaches of the glacier are characterized by several transverse crevasses, while the terminal lobe hosts multiple longitudinal crevasses. A basal till and lateral margins border the ice flow along the lowermost reach.

While subglacial erosion in the cirque has probably been accomplished by plucking and abrasion where the glacier might be cold-based, sub glacial melt water might have contributed to bedrock sculpting farther downslope where the ice flow is constrained by bedrock. Overdeepening of some tens of meters is expected in the upper reach of the glacier, which is quite common in cirques (Cook & Swift, 2012). Contrariwise, we expect several tens of meters-deep bedrock excavations (characterized by concave curvatures of bedrock surface) at the site of ice diffluence.

The next step of our research will be identifying the morphometry of the bedrock beneath the glacier (e.g., slope angles, curvatures and changes thereof, width to depth ratios and roughness) based on the muon radiography. We will combine these data with information about the fabric of the bedrock to determine how the bedrock properties have conditioned the erosional processes in this steep glacial cirque.

References:

Cook, S.J., & Swift, D.A., 2012. Subglacial basins: Their origin and importance in glacial systems and landscapes. Earth-Science Reviews 115, 332-372.