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The temperature-dependent destabilization of frozen rock walls and how to learn more about it

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The unusual properties of water at temperatures that are at or few degrees below its freezing point have long been recognized to be a dominant factor of many weathering processes. This includes the deeper destabilization of steep following permafrost degradation. Both, the understanding of climatic control on landscape evolution in cold mountains and the assessment of natural hazard potential from large rock fall require an understanding of these processes. Cryogenic weathering acting at depths of tens of centimeters and large rock fall acting at depths of tens of meters form end-members of a continuum of phenomena resulting from these processes and, at the same time, providing evidence for their investigation.

The intense rock fall activity from steep and likely perennially frozen rock walls during the hot summer of 2003 in the European Alps has raised public awareness and scientific interest in this topic. At the same time it provides evidence to test established hypotheses of destabilization mechanisms. Especially the timing of rock fall in 2003 strongly suggests mechanisms other than the reduction of shear strength of warming ice, the loss of cohesion or the build-up of water pressure upon melt of ice-filled crevices to be important.

The comparison of measured and modeled surface temperatures with rock temperature measurements at depth points toward possible thermal offset mechanisms that may exist below fractured bedrock surfaces and may cause or preserve permafrost below rock surface having positive mean annual temperatures.

This contribution summarizes and proposes different mechanisms for destabilization

that act on depth scales of tens of centimeters to tens or hundreds of meters and points to important open questions. Especially the recent availability of rock temperature data sets and models for complex topography opens new possibilities in the investigation of cryogenic weathering.