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Permafrost aggradation in the rock crest „Steintälli“ (Valais, Switzerland) as a multiannual response to cool summers recorded by a three-year monitoring of rock permafrost by 2D/3D ERT and refraction seismics

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Degradation and aggradation of permafrost in rock walls have significant influence on rock instability and associated hazards such as rockfalls, rock creep and rock subsidence. As heat propagates slowly in rock masses, apart from cleft water flow, thermal and spatial response of rock permafrost to climatic fluctuations remains a poorly observed phenomenon.

First 2D ERT (four transects) and refraction seismic measurements at the Steintälli, a north-south facing gneissic rock crestline between Matter and Turtmann Valleys at 3150 m a.s.l., were conducted in summer and autumn 2005. In 2006 an additional combined 3D ERT and refraction seismic array including 200 electrode positions and 120 geophone positions was installed and measured repeatedly. The simultaneous measurements of 2D/3D ERT and refraction seismics were continued in 2007. 4 rock wall temperature loggers were installed in 2005 and supplemented by another 4 in 2006 to monitor thermal conditions in the 2D/3D arrays. Data from an adjacent meteorological station is available since 2002. Rock samples were taken to the laboratory to conduct resistivity measurements at subzero conditions.

In comparison to previous summers, late summer conditions and especially August temperatures were extraordinarily cool in 2005, 2006 and 2007. This results in a decreasing thawing depth above bedrock permafrost mostly below 3-5 m in 2006 and

2007 and much lower than in warm September 2005. Moreover, a remarkable aggradation of rock permafrost in terms of spatial extent and resistivity values is observed, that may correspond to lower temperatures or higher ice content. Especially in the north-facing 2D-transects the spatial extent of rock permafrost appears to have increased by as much as 50-100%; resistivity values in the core of the permafrost bodies have increased up to more than 50% but exhibit inhomogeneous responses. In the south-facing transect, which did not display a stable high-resistivity body in summer 2005, a possible permafrost body evolved in depth of 6-9 m that is now clearly visibly in the 2007 tomography. These changes are also observed in the 3D tomographies covering 2006 and 2007.

These datasets with up to 8 time sections provide detailed insight into spatial and thermal response of rock permafrost to climatic fluctuations. These do not only include linear changes in terms of permafrost aggradation, but the observed blockage of former cleft water flows could also initiate a disproportional response due to a change in the system setting. Possibly, this analysis could help to improve the understanding of what happens in response to longer-term climatic changes such as global warming.