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Geophysical Characterization of a Rock Glacier in the Turtmann Valley, Switzerland

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Degradation of alpine permafrost, caused by global warming, can lead to landslides and ground instabilities. To design appropriate countermeasures, advanced knowledge on its mechanical, thermal and hydrological behaviour is required. For that purpose, an interdisciplinary project has been launched by three research groups with specialisations in Geotechnics, Geophysics and Hydromechanics.

A rock glacier located in the Turtmann Valley (Canton of Valais, Switzerland) was selected as a study site for this project. This rock glacier exhibits a number of peculiar features, including extension features accompanied by surface depressions near the rooting zone of the glacier and increased surface movements of up to $1.5ma^{-1}$ near the frontal part. Both of these phenomena are still poorly understood.

Several geophysical surveys were conducted during spring and summer 2010 to delineate the volume of the Turtmann Valley rock glacier, as well as the occurrence of ice and possible internal shear planes. So far, two seismic lines, three georadar profiles and one geoelectrical profile have been acquired. The seismic data were analysed with refraction tomography, and the resulting tomograms allowed the bedrock topography to be mapped and gross internal structures to be identified. Average bedrock depths were estimated to be 20 to 25 m. The seismic tomograms also indicate that a bedrock barrier subdivides the rock glacier in two flow branches in its lower part. 25 and 50 MHz Georadar data provided more detailed information about the internal structures. Several internal reflectors may indicate the existence of internal shear planes, but none of them seem to extend over larger distances. Additionally, the georadar data yielded estimates of bedrock depths, which were in good agreement with the seismic results. Tomographic inversions of the geoelectric data showed a very heterogeneous mixture of frozen ground and ice-free regions. Degradation of permafrost seems to have occurred towards the flanks of the rock glacier.

The locations of five boreholes were selected based on the results of the surface-based geophysical measurements. Four approximately 25 m deep boreholes were drilled in a collinear configuration, with a spacing of about 10 m. The borehole array extends over an area, with two transverse surface depressions. We measured crosshole radar with 100MHz antennas in three tomographic planes. The boreholes were equipped with thermistor chains after completion of the radar crosshole measurements. Additional temperature sensors were installed at the surface near the boreholes. The fifth borehole, which is 1m away from the most downslope borehole in the collinear array, was equipped with an inclinometer chain right after drilling.

Based on the information offered by the initial 2D geophysical measurements and the deformation and temperature data, it is planned to conduct high-resolution 3D georadar and possibly 3D geoelectrical surveys over zones of particular interest. Furthermore, an attempt will be made to collect a comprehensive 3D nuclear magnetic resonance data set across the entire rock glacier. Results of these geophysical campaigns will serve as important constraints for thermomechanical modelling and delineating advanced groundwater flow path patterns.