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How efficient are frost weathering processes in Alpine rockwalls?

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Weathering processes prepare and can trigger rockfall, which are key agents of alpine landscape evolution and hazardous processes. The results of different weathering processes are hard to decipher, however, current knowledge emphasizes the dominant role of frost cracking in eroding alpine rockwalls. The processes responsible for frost cracking are volumetric expansion occurring due to top-down-freezing in autumn and bottom-up-freezing in early summer as well as ice segregation in winter (Draebing et al., 2017). In theory, frost cracking processes can produce ice pressure up to 207 MPa for volumetric expansion and up to 30 MPa for ice segregation (Matsuoka and Murton, 2008), which exceed by far the tensile strength of rocks and would inhibit the development of steep rockwalls.

In this study, we use a laboratory approach to simulate volumetric expansion and ice segregation under controlled conditions. We cut an artificial Mode I crack into rock samples from four alpine rockwalls with different lithology. We simulate short-term (i) top-down-freezing and (ii) bottom-up-freezing as well as long-term (iii) ice segregation by transferring observed rock temperature conditions from the field to the lab. We monitor crack deformation with crackmeters and model thermal- and ice-induced crack deformation. Based on the approach by Jia et al. (2017), we calculate ice pressure und ice stress intensity and compare our results to measured tensile strength and estimated fracture toughness of our rock samples.

Our results show that short-term volumetric expansion and long-term ice segregation produce stresses that widen cracks. Modelled ice pressures in our tests range between 1.96 and 9.1 MPa in (i) Top-down-tests and between 0.24 and 1.3 MPa in (ii) Bottom-up-tests. Modelled ice stress intensity factors range from 0.95 to 2.35 MPa $m^{1/2}$ for (i) Top-down-tests and from 0.13 to 0.96 MPa $m^{1/2}$ for (ii) Bottom-up-tests. Fractures have been fully saturated, which exist in the field probably only under rare situations, therefore, our values represent maximum potential values. The (iii) ice segregation induced pressure is between 0.44 and 0.7 MPa and ice stress intensity range from 0.21 to 0.35 MPa $m^{1/2}$. These values are much lower than in theory, however, conditions favouring ice segregation in the field exist for several months every winter.

Our data demonstrate that observed ice pressures and ice stress intensities can be developed that result under rare conditions in critical cracking, however, most stresses are below rock strength. Therefore, we conclude that subcritical cracking is the dominant process of frost weathering.

Draebing, D., Krautblatter, M., and Hoffmann, T.: Thermo-cryogenic controls of fracture kinematics in permafrost rockwalls, Geophysical Research Letters, 44, 3535-3544, 2017.

Jia, H., Leith, K., and Krautblatter, M.: Path-Dependent Frost-Wedging Experiments in Fractured, Low-Permeability Granite, Permafrost and Periglacial Processes, 28, 698-709, 2017.

Matsuoka, N. and Murton, J.: Frost weathering: Recent advances and future directions, Permafrost and Periglacial Processes, 19, 195-210, 2008.