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2D-frost weathering indices for rock walls

Justyna Czekirda[1], Bernd Etzelmüller[1], Alan W. Rempel[2], and Sebastian Westermann[1]
[1]Department of Geosciences, University of Oslo, 0316 Oslo, Norway
[2]Department of Earth Sciences, University of Oregon, Eugene OR, USA

The importance of frost weathering processes has long been discussed in the context of cold-climate landscape evolution. The 9 % volumetric expansion of in situ water when it freezes to ice was initially held responsible for generating the stresses that create and widen cracks in rocks. This theory has since been challenged by the theory of ice segregation in rocks, in which the growth of ice lenses is supplied by additional water that is drawn to the freezing front. Numerical modelling and laboratory experiments suggest that segregated ice growth can generate enough stress to cause rock damage and is most intense between approximately -8 and -3 ☐ (the precise range depends on rock properties), in the so-called frost cracking window (FCW). The two theories of weathering have different implications for landscape evolution: (1) if in situ volumetric expansion is more important, most frost weathering should occur close to the freezing point, (2) if ice lensing is more important, most frost weathering should occur in the FCW. For the latter theory, several frost weathering indices have been developed based on such factors as the time spent vulnerable to cracking within the FCW, the magnitudes of ground temperature gradients that induce water transport, and other factors that affect water availability.

In this study, we model ground temperature using the ground heat flux model CryoGrid 2D (Myhra et al., 2017) and apply the one-dimensional frost weathering index proposed by Rempel et al. (2016), where frost weathering potential is assumed to be correlated with porosity changes that accompany gradients in water flux. Here, we adjust the frost weathering index so that frost weathering potential is modeled in two dimensions. Our results predict spatial and temporal patterns of frost weathering in rock walls that can be tested in the field.

References

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