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Monitoring Frost Weathering using Resistivity Measurements

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The actual process of frost weathering and its dependency upon certain temperature and pore water parameters is still a matter of debate. The role and effect of rock moisture is still uncertain because there is still a serious lack of monitoring data on pore water content under natural conditions. We derived information on moisture contents and fluctuations from resistivity measurements. In the 1D-approach, more than 1000 freeze-thaw events were registered and analyzed in high temporal resolution. Additionally, 2D-rock sections of 2 m length were monitored using a GeoTom ERT device. Rockfall measurements provide supplementary data on weathering rates in different topographical positions. The investigations were carried out in the Karwendel Mountains (German Alps) and in Cwm Idwal (Wales).

When the temperature records sink below zero, distinct drops in the rock conductivity curve occur. These events were analysed for the freezing point of the pore water, the speed of freezing, the amount of freezing water as well as the amount of pore water remaining unfrozen. The curves provide evidence of unfrozen pore water that is pressed into the rock by expanding ice near the surface. Conversely, there is no support from the data for the theory of moisture movement towards ice formations (cryogenic suction), as the amount of unfrozen water remains the same even during long periods of constant freezing.

The 2D-resistivity sections graphically display the formation of ice bodies. Frozen patches are recognizable by means of a very high resistivity ($>$ 15000 m). Falling resistivity (increasing moisture) was monitored immediately behind the surficial ice formations. This occurrence is assigned to pore water being pushed away

from the freezing front into the rock, as predicted by McGreevy and Whalley in 1985. According to the results, hydraulic pressure seems to be an important mechanism for frost weathering and for frost-related hydration shattering. This type of weathering is most likely to occur at a depth range of 5 - 20 cm during diurnal freeze-thaw cycles.

The measurements suggest that the highest pressure is generated when the rock surface is wetted by preceding rainfall. Furthermore, favourable conditions for frost shattering are likely to occur in north-facing rock faces and when the displaced water is trapped inside the rock, for example, between superficial ice and permafrost. According to our rockfall measurements, these are indeed the positions and times in which the weathering rates are highest.