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Measuring rock moisture using different techniques in the sandstone area of Saxony

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Rock moisture is an understudied factor governing weathering and rockfall. Many weathering processes like hydration, thermal and frost cracking are governed by moisture availability. However, weathering studies have primarily focussed on temperatures. The role of moisture supply has not been given the same attention, also because there is no humidity sensor that meets all requirements for application in rock.

In the sandstone area of Saxony in eastern Germany ("Saxonian Switzerland"), climbing on wet rock poses a safety problem as the sandstone loses stability when saturated. Visitor guidance measures ('rock traffic lights') were implemented to temporarily stop climbing at rocks that are too wet. To accompany this measure, we carried out a pilot study at the Gohrisch sandstone massif, involving moisture measurements in the four cardinal directions at the rockwall base and near the summit of the massif. We used a combination of (a) electrical resistivity electrodes, combined with wind-driven rain collectors; (b) 2D-electrical resistivity (ERT); (c) microwave sensors (MW) with four sensor heads for different penetration depth and (d) Schmidt Hammer (SH) measurements to assess rock stability. All techniques were accompanied by laboratory measurements at rock samples.

Electrical resistivity, MW readings and SH rebound all showed very good correlations with rock moisture in laboratory samples. However, the range of values measured in the field strongly differed from laboratory values so that the calibration curves could not be applied to field data. Presumeably this is due to lithological differences between the fresh quarry samples and the pre-weathered rock faces.

ERT profiles using adhesive electrodes showed good reliability (RMS error 5-14%). Most sites were slightly wet at the surface, drier at 5-15 cm depth and moderately wet at 20-30 cm depth (1000 – 8000 Ohmm). The site Bottom North was much wetter than all others, and the two top positions were dried out at the surface probably due to wind. This distribution was roughly confirmed by microwave sensor data. Direct correlation between MW and ERT measurements was poor as measurement principle and geometry are very different.

Schmidt Hammer data was very consistent with microwave moisture in the lab (lower rebound at wetter surfaces); however not in the field, where the wetter Bottom North site showed highest

rebound values. The summit positions showed significantly lower rebound which we attribute to stronger weathering (more dry-wet cycles). Lab results show that the sandstone loses stability (SH rebound) mainly between 60% and 100% pore saturation. Currently we cannot reliably determine if this saturation was actually reached in the field.

The combined interpretation of all measurements, even if imperfectly calibrated, points to surface-parallel weakness zones that have developed at all sites except of Bottom North which is almost never hit by sunlight. Water supply by rainfall is weak at the almost vertical sites; water rather seems to infiltrate in flat areas and to seep out at the base of the massif. The results help to understand the distribution of dampness in the rock and will be supplemented by continuous monitoring and numerical simulations.