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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, shrinking/swelling and thermal cracking are governed by moisture availability, and a high degree of saturation is a precondition for frost cracking. 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. Voluntary visitor guidance measures ('rock traffic lights') were implemented to temporarily stop climbing at rocks that are too wet. To accompany this measure scientifically, we carried out a pilot study at the approx. 70 m high Gohrisch sandstone massif, involving moisture measurements in the four cardinal directions (N, E, S, W) at the rockwall base, and at N and S near the summit of the massif. We used a combination of (a) electrical resistivity electrode pairs, combined with wind-driven rain (WDR) collectors; (b) 2D-electrical resistivity (ERT); (c) handheld microwave sensors with four sensor heads for different penetration depth; (d) numerical simulations and (e) Schmidt Hammer measurements to assess rock stability. All techniques were accompanied by laboratory measurements at rock samples.

WDR was registered at two of six sites, the distribution being due to micro-topography rather than wind direction. At these sites a clear response of (decreasing) resistivity on driving rain was registered. 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 (which might be due to surface-parallel zones of weakness) 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 confirmed by microwave sensor data: Moisture contents show little differences between the sites except of the North site which was wetter at all depths. 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. According to ERT calibration, saturation >60% was only reached near the surface at North Bottom, while at some decimetres depth, saturation rarely exceeded 50%. Calibration from electrical resistivity to moisture and microwave reflectance to moisture was successful in the lab; however, the measured resistivity and microwave range did not match the values measured in the field. Calibration needs to be achieved directly at the field site which remains an open task.

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