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Quantifying structural controls of rockfall activity on alpine limestone cliffs: a LiDAR-based geological approach in the Wetterstein Mountains, Bavarian Alps.

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In mountainous regions, rockfall represents one of the most hazardous processes potentially threatening human life and infrastructure. For risk assessment and dimensioning rockfall mitigation, a thorough understanding of rockfall processes is crucial. Here, the rate of backweathering and rockfall supply are key factors for sediment budget assessment in rock slope environments. However, recent LiDAR approaches do not cover the entire spectrum of rockfall magnitudes (e.g. small fragmental rockfall, rare large events) and many former rockfall studies do not address geological and geotechnical factors controlling rockfall.

The test setup was deliberately chosen to reduce the degrees of freedom for rockfall-controlling factors. Lithology, aspect, slope gradient and porosity were kept uniform but scan sites were chosen vary bedding orientation and joint density systematically along a 600 m high limestone rock face. Terrestrial laser scanning (TLS) was used to detect and quantify rockfall activity (mm/a) at five selected rock walls of the north-facing rock slopes of the Reintal Valley over the course of one year. Additionally, structural data were obtained by traditional scanline measurements and TLS-based analysis. The compatibility of TLS methods was tested by validating the data with existing rockfall inventories obtained by direct measurements by Krautblatter et al. (2012).

The results show a high discrepancy of seasonal rockfall activity between summer months (0.001 to 0.022 mm/a) and autumn to spring (0.021 to 0.364 mm/a) as well as between favorable bedding orientation (0.015 mm/a) and daylighted bedding (max. 0.264 mm/a). A significant effect of joint spacing on rockfall activity is not evident in the data or overlain by the bedding orientation effect. Nevertheless, the differences in estimated block sizes between the observed rock walls is clearly visible in the TLS derived particle size distribution. The latter was adduced to extrapolate rockfall magnitudes smaller than TLS effective resolution (0.01 to 0.1 m^3 at 400 to 800 m range) using an inverse power law function. However, the effect of secondary and primary rockfall on the results is still subject of discussion. Also, locally unique stress fields and the history of local rock slope evolution is an issue.

Here we have chosen a well-established test site to (i) systematically analyse the structural geological imprint on rockfall activity in limestone cliffs and (ii) to validate the explanatory power of the incomplete rockfall size coverage of TLS at sites with frequent small fragmental rockfall.

Krautblatter, M., Moser, M., Schrott L., Wolf, J. & Morche, D., 2012. Significance of rockfall magnitude and carbonate dissolution for rock slope erosion and geomorphic work on Alpine limestone cliffs (Reintal, German Alps). In: Geomorphology, 167-168: 1-14. DOI:10.1016/j.geomorph.2012.04.007