THE SPATIO-TEMPORAL RECONSTRUCTION OF ROCKFALL ACTIVITY IN OUTER WESTERN CARPATHIANS USING DENDROGEOMORPHOLOGY

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Introduction

Rockfall is one of the most dangerous natural hazards (Badger and Lowell, 1992, Hantz *et al.*, 2021). Its interaction with trees usually leads to their damage or even to their death. Trees ca be used as a rockfall research tool. Tree rings are an effective natural archive and by using dendrogeomorphic methods, individual events can be succesfully dated (Stoffel, 2006).

Objectives

The main aim of this study is a detailed comprehensive analysis of rockfall at a site in Outer Western Carpathians by adressig the following objectives:

- O1 Constructing rockfall chronology;
- O2 Recontructing its spatio-temporal variability;
- O3 Analyzing potential triggers;
- O4 Definig key rock wall parameters in the escarpment environment that predispose rockfall activity.

Study area

The study site is located on the western slope of the Příslop peak (782 m a.s.l.) in the Moravskolezské Beskydy Mountains. Rockfall at the study site is situated on a slope that is formed by a structural escarpment of flysch layers with the occurrence of thick layers of conglomerates. The escarpment has a frontal character, with a total length exceeding 0.5 km.

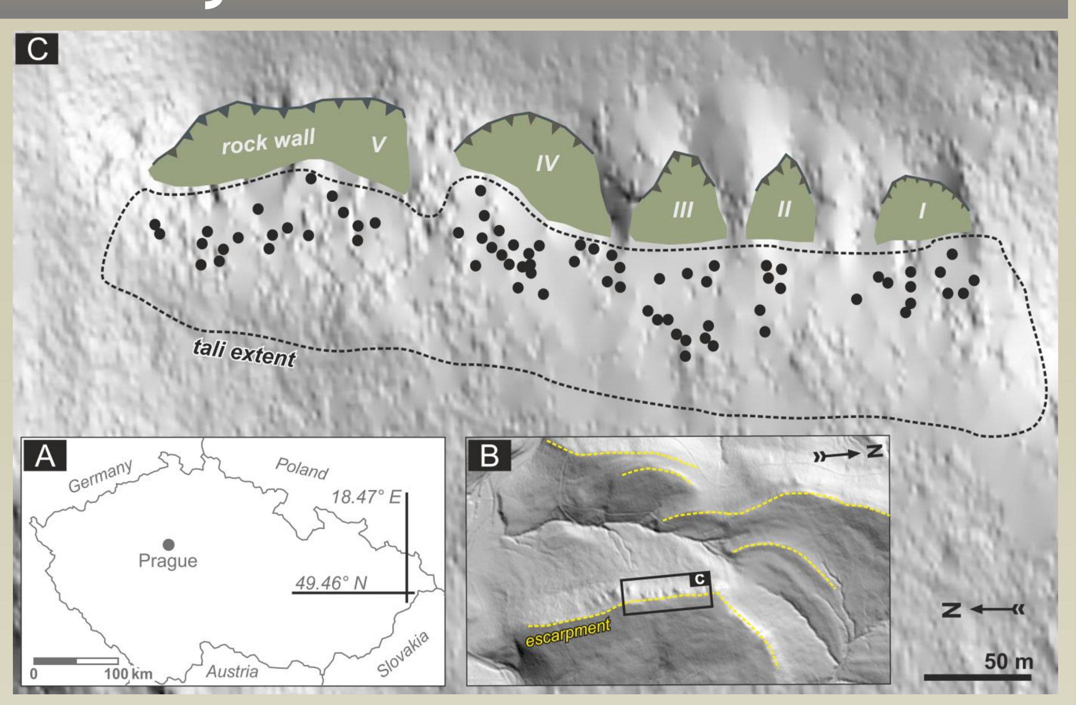

Figure 1. Location and morphology of the studied area. **A-** Study site within the Czech Republic. **B-** The rockwall position at the study site. **C-** the five analyzed rock walls divided from the escarpment

Methodology

Four increment cores were taken from each recorded tree (*Picea abies*, n=74) using a Pressler increment borer. Visible scars and growth disturbances were identified and analyzed in 296 cores. The structural measurements of the bedding planes and joints was performed using a geological compass. The positions of the mapped forms were recorded using a GPS device and LiDAR based DEM. Based on the age of the trees and the increment rate, we calculated the total number of exposed diameter (ED) for each tree in a given year (Stoffel *et al.*, 2005a).

Bibliography

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Stoffel, M., Schneuwly, D., Bollschweiler, M., Lièvre , I., Delaloye, R., Myint, M., Monbaron, M., 2005, *Analyzing rockfall activity (1600-2002) in a protection forest- A case study using dendrogeomorphology.* Geomorhpology 68(3):224-241;

Stoffel M., 2006, *A review of studies with tree rings an rockfall activity: The role of Dendrogeomorphology in Natural Hazards Research.* Natural Hazards 39(1):51-70.

Results

The reconstructed chronology covers a period of 100 years. A total number of 93 rockfall hits affected 38 trees (out of 74 sampled trees). More than half reactions resulted in abrupt narrowing of tree rings (n= 79, 62%). We identified 30 visible scars in 46 trees.

The highest values of the mean recurrence of rockfall hits (R_i) are located in the upper part, near the rockwall. Highest values of rockfall rate (RR_t) are situated in the southern side.

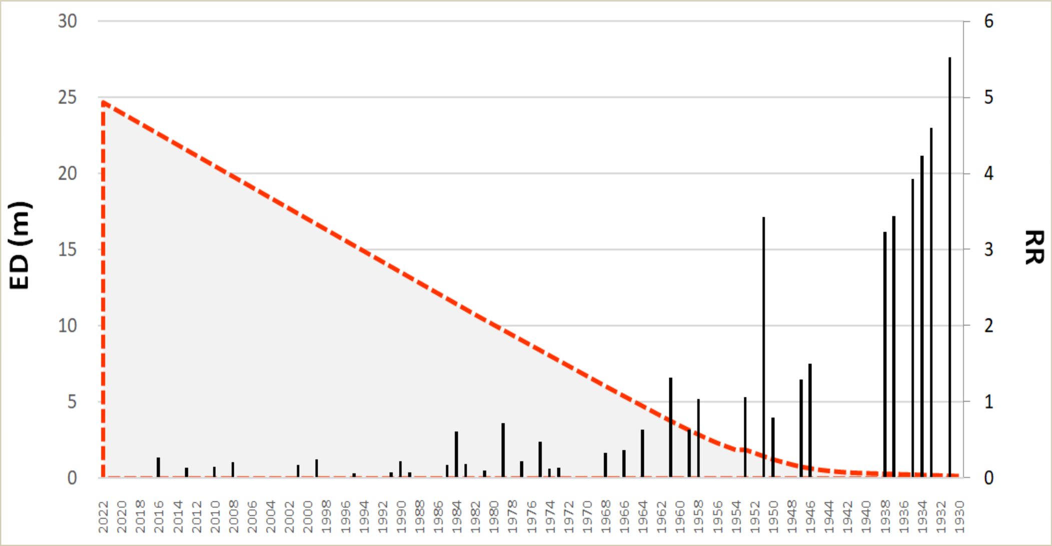

Figure 2. Rockfall activity. Rockfall rate (black bars) and the development of exposed diameter (ED) in time, depending on the sample size. A minimal ED (20%) starts in 1965.

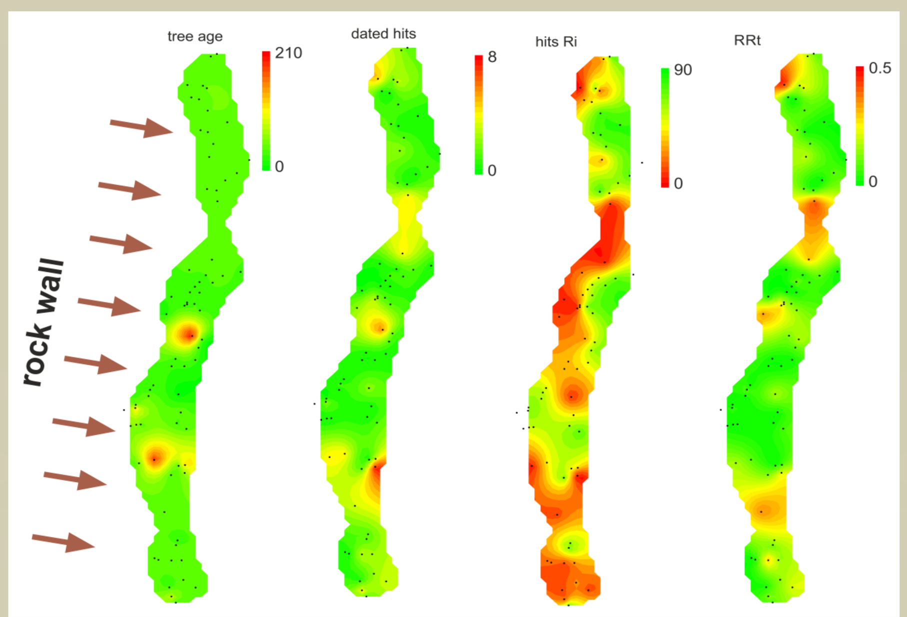

Figure 3. Interpolated values resulted from tree ring series

Discussion

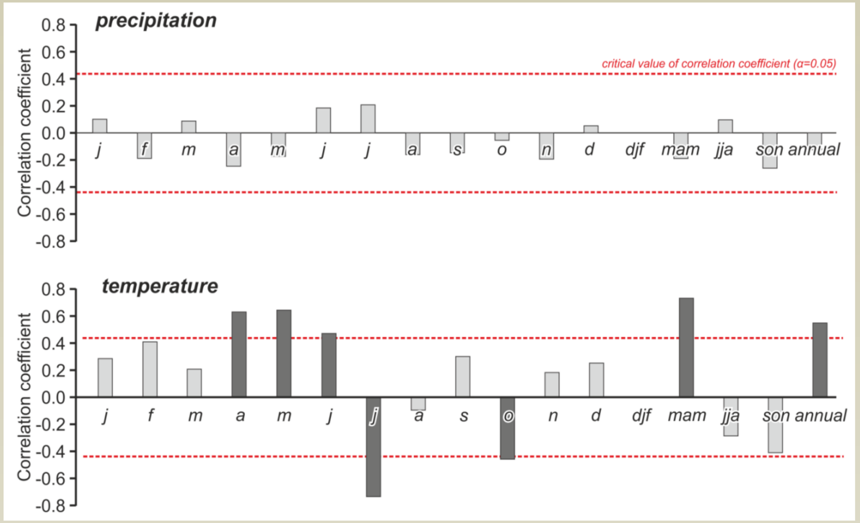

Figure 4. Precipitation and temperature data from Bílá meteorological station

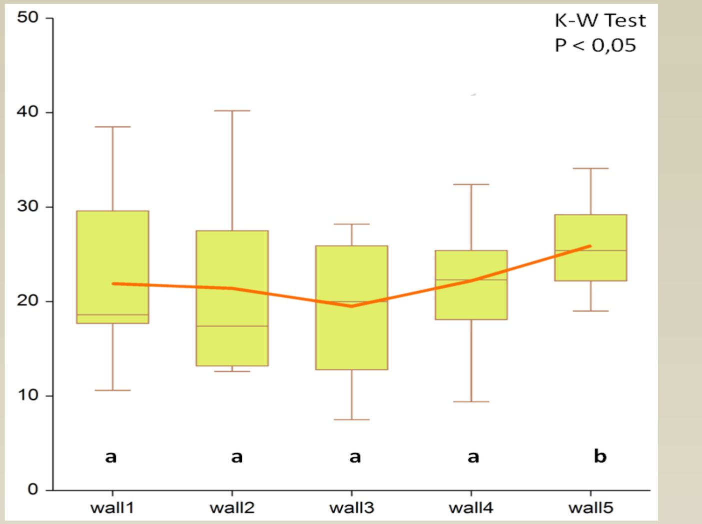

Figure 5. K-W test for RR_t between the five rockwalls

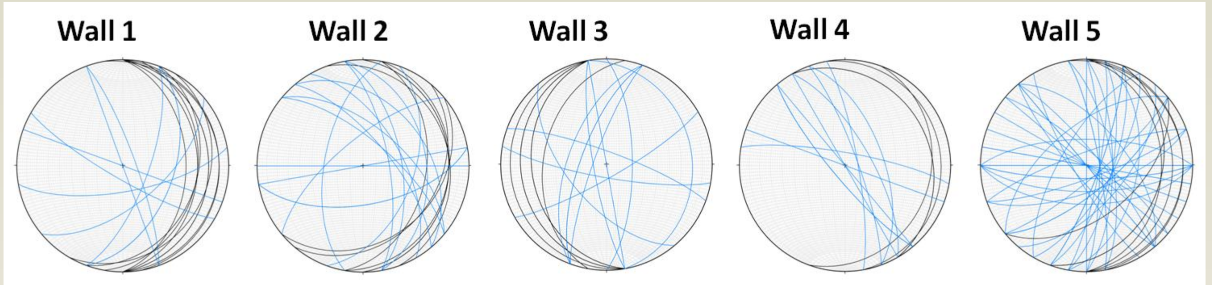

Figure 6. Stereonets for each rockwall showing the orientation and steepness of the cracks

Conclusion

✓ Rockfall intensity was higher between 1973-1991 and decreasing after 1991; trees further away from the wall were more damaged.

✓ There are no significant differences between different rockfall parameters recorded by trees under different rockwalls (K-W test, P= 0,05);

✓ The orientation and the steepness of the craks are not visually diferrent between the walls, except wall 3, which has an western orientation

✓ Precipitation data does not seem to have any effect on rockfall activity. Temperatures have a stronger influence; The significant effect seems to be caused by the high temperatures in spring, which could be related to the melting of the snow cover.