CHANGES IN SPATIO-TEMPORAL PATTERNS OF ROCKFALL ACTIVITY ON A FORESTED SLOPE OVER THE LAST 50 YEARS – A CASE STUDY USING DENDROGEOMORPHOLOGY

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INTRODUCTION

Over the last few years, rockfall research has increasingly focused on hazard assessment and risk analysis. Input data on past rockfall activity were gathered from historical archives and lichenometric studies or were obtained through frequency–volume statistics. However, historical records are generally scarce, and lichenometry may only yield data with relatively low resolutions. On forested slopes, in contrast, tree-ring analyses may help, generally providing annual data on past rockfall activity.

Results presented primarily focus on frequencies (*how often*), spatial distributions (*where*) and seasonality *(when)* of rockfall activity on an active slope in order to (i) obtain detailed information on inter-annual differences in rockfall activity, to (ii) investigate spatial differences in rockfall activity as well as to (iii) analyse the occurrence of rockfall events within the season with tree-ring analysis.

The area investigated within this study is located close to the village of Saas-Balen in the Valley of Saas (Valais Alps, Switzerland) at an elevation ranging from 1,490 to 1,710 m a.s.l. The study site covers a surface of nearly 30 ha with an average slope angle of about 36 degrees.

RESULTS

More than 800 increment cores from 205 severely injured European larch (*Larix decidua* Mill.), Norway spruce (*Picea abies* (L.) Karst.) and Swiss stone pine (*Pinus cembra* ssp. sibirica) trees have been sampled on the slope so as to determine spatial, temporal and seasonal variations of rockfall activity. Additionally, 32 smaller trees were cut and cross-sections prepared for every injury observed on the stem.

Results cover eight decades of rockfall activity and allow reconstruction of 2075 growth disturbances in the form of scars, tangential rows of traumatic resin ducts, reaction wood and abrupt growth changes. Overall, our data allowed dating of 775 single events between AD 1925 and 2006. Older trees are, however, scarce and events dated prior to the 1950s originate from a limited number of trees only. As a result of the comparably young forest stand, detailed analysis of changes in the frequency or spatial patterns basically covers the last 50

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years. While the period covered by our data is shorter than that reconstructed in similar studies, the amount of information on past rockfall activity is much denser and allows a more detailed and very profound analysis of what happened on the scale of a slope for at least half a century.

Spatial analysis of all the rockfall events were realised so as to identify differences in rockfall frequencies in the different parts of the slope. In addition, we investigated whether rockfall rather occurs in the form of low magnitude–high frequency events or if single events of high magnitude, but low frequency can be observed as well.

The rockfall rate varies from zero to more than six events m^{-1} yr^{-1}, with an average of 1.02 events m^{-1} yr^{-1}. Figure 1 illustrates the spatial distribution of rockfall activity at the study site. It can clearly be seen, that lowest recurrence intervals (highest activity) occur at the lateral boundaries of the forest stand whereas the lowest activity can be found in the centre of the stand where the individuals are protected by its neighbours further above.

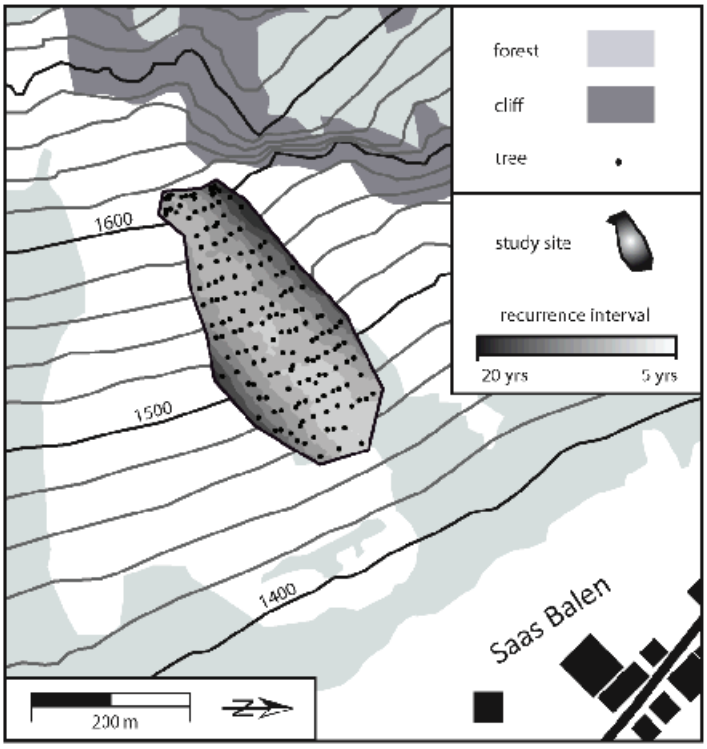

Fig. 1 Recurrence interval of rockfall events at the study site

CONCLUSION

Based on the considerable amount of data reconstructed and the results presented above, it may be concluded that on forested slopes, dendrogeomorphology has a large potential to provide new and very detailed insights on past rockfall activity, namely in the determination of the frequency of past rockfall activity.

Keywords: dendrogeomorphology, tree ring, rockfall, frequency, magnitude, seasonal timing, Swiss Alps