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Past debris-flow activity from tree-ring analysis at the Bruchji torrent, Valais, Switzerland

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Introduction

The aim of the presented work is to reconstruct the frequency of debris-flow events at the cone of the debris-flow torrent Bruchji, Valais, Switzerland. A detailed geomorphic map (1:1'000) of the whole cone was realized in 2001 to get an idea of former flow paths and debris-flow deposits present on the cone. Based on this map all trees which have obviously been influenced by debris-flow activity on the cone were cored. The samples were analysed to determine disturbances in growth that could be related to debris flow activity. To represent common growth variations of each tree species in the area, a reference chronology for each species (*Picea abies* (L.) Karst. and *Larix decidua* Mill.) was established. The samples allowed determination of 39 event years in the past 140 years. By combining the results of tree-ring analyses and geomorphic mapping, the distribution of simultaneously disturbed trees in the same year allowed reconstruction of twelve formerly active flow paths. The results show that the combination of tree-ring analyses and geomorphic mapping is a valuable tool for reconstructing the activity of a debris-flow torrent.

Research area

The village of Blatten/Naters (Valais, Switzerland; Fig. 1) is close to the torrent Bruchji and is threatened by debris flows (e.g., Johnson 1970; Costa 1984; Johnson & Rodine 1984; Pierson & Costa 1987). In the past few years, different debris-flow events led to damage to elements of the infrastructure, such as roads or bridges.

To protect the village, between 1976 and 2002 different counter measures (debris-retention basin, deflection dam and enforcements of the channel) were taken (Municipality of Naters, 2001) without knowledge of the process characteristics at the location.

The chronological data regarding past events at the Bruchji torrent are absolutely insufficient. Debris-flow events are only known to have occurred between 1905 and 1907 and after 1987 (Jossen 2000).

The aim of this study is to reconstruct the activity of the Bruchji torrent as far back in time as possible. A further goal consisted of closing the data gap between 1907 and 1987.

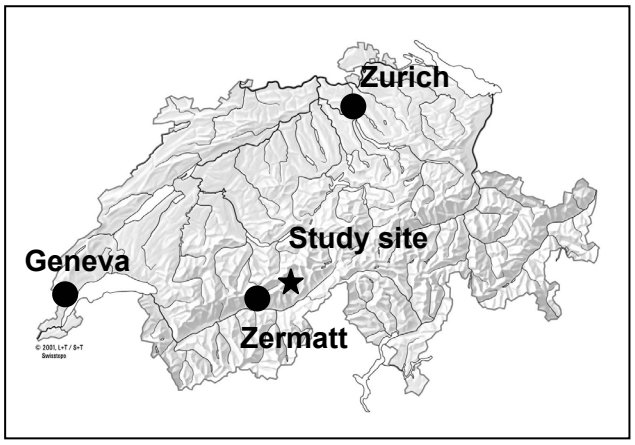

Figure 1: The study site Bruchji (Blatten/Naters) in the Valais, Switzerland.

Material and methods

The first step for this study was the realisation of a detailed geomorphic map of the whole debris-flow cone at a scale of 1:1'000 (Leser & Stäblein 1975). All forms related to debris flows were mapped. This map was used as the basis of the sampling strategy and the analysis of the samples, since the position of a tree within the debris-flow forms shows what kind of reaction can be expected in the wood.

To represent the debris-flow independent growth variations of each species at the location, a reference curve was established (methodology: see Cook & Kairiukstis 1990).

All trees on the cone, which were obviously disturbed by debris flows, were cored. Normally two samples per tree were taken with an increment borer. In total about 800 cores from 398 trees were sampled, of which the majority was *Picea abies* (L.) Karst. and the smaller part *Larix decidua* Mill.. The average age of the trees was about 102 years.

The comparison of the growth curve of the disturbed trees with the reference curve showed growth anomalies that could be related to the influence of a debris flow (e.g., Alestalo 1971; Shroder 1980; Braam *et. al.* 1987).

Results

We established a geomorphic map with all forms related to debris flows. Figure 2 shows a small part of the map with a channel and the lateral levees and some lobes. Most of the forms can be determined on the orographically right side of the cone.

The analysis of the cores allowed us to determine 39 event years in the past 140 years. Figure 3 gives an example for the determination of event years.

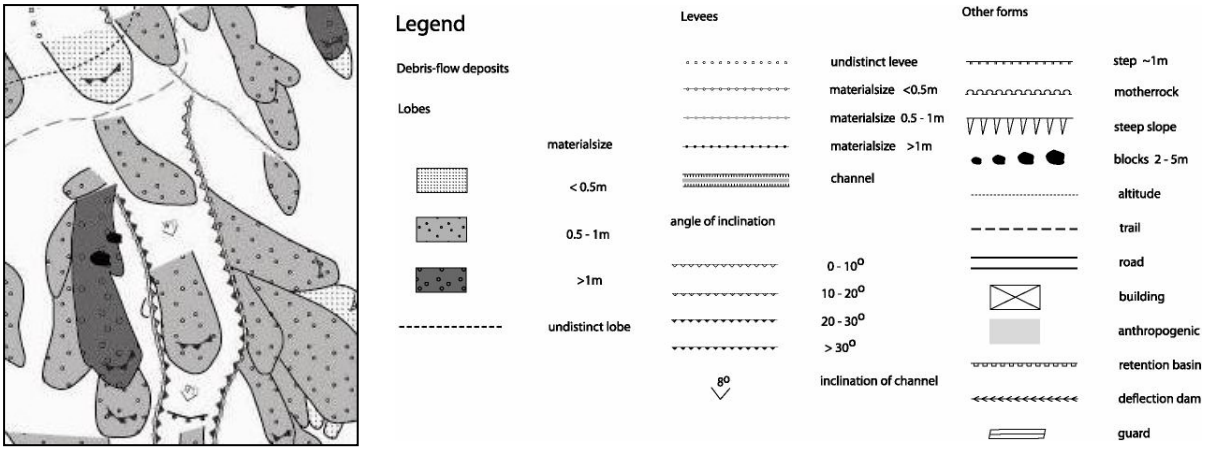

Figure 2: This is a part of the geomorphic map of the debris-flow cone. The symbols for the legend are based on the "Symbolbaukasten zur Kartierung der Phänomene" (Kienholz & Krummenacher 1995) and have been modified by Gärtner (1996, compare also Dikau et al. 1996).

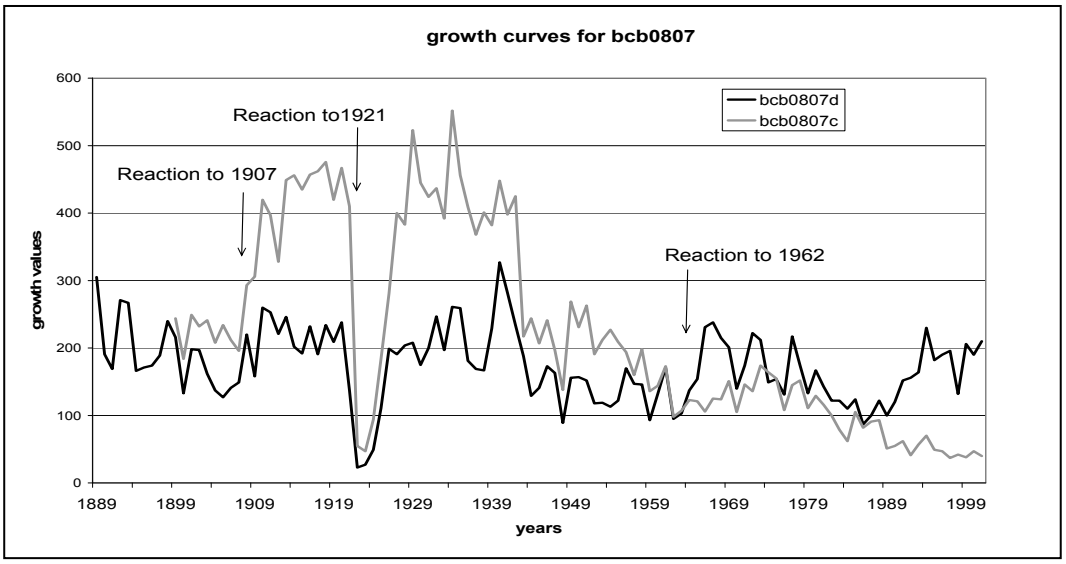

Figure 3: These are the two growth curves for tree No. 0807, where three event years could be identified (1907, 1921 and 1962). The tree shows eccentricity after 1907, a severe growth depression starting in 1921 and eccentricity on the other side after 1962.

Three event years could be identified in this tree. The first one must have taken place in 1907 because the tree starts to show eccentricity and compression wood in 1908. In 1921, rows of traumatic resin ducts are present and the growth curves show a severe growth depression. The eccentricity after 1927 is still caused by the event of 1907. Then suddenly, in 1962, the other side of the tree formed wider year rings. Again, traumatic resin ducts are visible in 1962, so the event must have taken place in this year.

Most of the defined event years have taken place in the twentieth century. This is due to the fact that the majority of the trees is not much older than 100 years. An intensive period with a

lot of debris-flow events can be seen between 1940 and ca. 1960. After 1976, only small-scale events involving a small number of trees could be determined, which can be explained by the protective constructions that have been built between 1976 and 1978.
The combination of dendrogeomorphological analysis and the geomorphic map allowed the elaboration of 12 formerly active flow tracks.

Discussion

The study closed the data gap between 1907 and 1987 by 28 event years. Our data proof that the Bruchji torrent has been active all the time but the debris-flow events have not been recorded.
Furthermore, the study shows that the combination of tree-ring analysis and geomorphic mapping is a valuable tool for reconstructing the activity of a debris-flow torrent. The mapping helped to identify formerly active flow tracks.
It must be taken into account that this study shows only a minimum-frequency for debris-flow events in the Bruchji torrent. Events not leaving the channel or not influencing trees strongly enough, cannot be identified and therefore do not appear in the frequency.
Nevertheless, 39 event years could be established, which makes the combination of dendrogeomorphology and geomorphic mapping a valuable tool for the reconstruction of past debris-flow activity.

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