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Direct rockfall measurements in the Northern Alps – spatio-temporal patterns and the significance for long-term studies

O. Sass

Institute of Geography, University of Innsbruck, Austria (oliver.sass@uibk.ac.at)

The number of field studies dealing with the distribution and quantity of rockfall at alpine rock faces is still comparatively low. In previous investigations, debris falls were quantified by means of more than 60 collectors in six study areas in the northern and central Alps. In all study areas, the weathering rate was strongly influenced by three factors: Firstly, a combination of joint density and porosity of the bedrock; secondly, rockwall orientation with north faces delivering thrice the amount of rockfall than south faces; thirdly, the presence or non-presence of permafrost in the rock. Conversely, no general increase of rockfall with elevation was found. According to the results, the water supply of the rockwalls during freeze-thaw conditions is supposed to be a prominent controlling factor of frost weathering rates. This is confirmed by the observed temporal distribution of rockfalls. Sediment delivery to the collectors was highest in summer periods with "wet" freeze-thaw cycles caused by passing cold fronts. Conversely, strong winter frost turned out to be virtually inefficient without liquid water supply.

Talus volumes were derived from geophysical, mainly ground-penetrating radar profiling on more than 30 scree slopes. According to the scree cubature, the weathering rates at north faces are two times higher than at south faces, the rockwalls in which permafrost is present showed the highest retreat rates, and no interrelation between rockwall retreat and elevation could be found. These patterns agree with the recent rockfall measurements. However, the absolute rates of rockwall retreat derived from scree volumes (200-850 mm/ka) are generally much higher than the measured recent removal rates (50-300 mm/ka). The possible reasons for this discrepancy include accelerated weathering during cold phases and the contribution of boulder and block falls to the sediment budget which are not registered by the small collectors.

In order to cover an intermediate time span of decades or centuries, extensive lichenometric measurements on talus debris have been carried out in the Kühtai area (Austrian Alps). The combined spatial and temporal patterns found, confirm that the presence of permafrost in the rockwalls is an important factor promoting rockfalls. Fresh clasts are much more frequent under rockwalls where frozen rock is likely to be present. The study provided evidence for enhanced boulder fall activity in the Little Ice Age, however not equally in every position. At talus sites which are only moderately active today, the geomorphic activity seems to have been roughly four times higher in the last cold phase of the LIA, probably due to harsher climatic conditions with enhanced frost weathering. In positions where permafrost is still present today, no distinct LIA peak can be observed. As these sites are highly active anyway, further climate cooling (like in the LIA) was obviously not able to increase weathering rates any further. Rockwall retreat rates derived from lichen coverage are between 400 and 1,500 mm/ka. However, these values are probably too high because the effects of clast relocation on lichen growth can not be eliminated.