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Małgorzata Wistuba

Slope-Channel Coupling as a Factor in the Evolution of Mountains

The Western Carpathians and Sudetes

Doctoral Thesis accepted by
University of Silesia in Katowice, Sosnowiec, Poland

Springer

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Supervisor's Foreword

Numerous works have been published on the mechanisms of relief evolution in mountain areas but new questions and research problems still arise during field observations. One of these is the issue of determining the importance of coupling between geomorphic processes on slopes and fluvial erosion and deposition in valley bottoms for the evolution of montane relief at a general scale.

This thesis undertakes a comprehensive analysis of the links between slope and channel subsystems in small mid-mountain catchments so as to propose on that basis some generalisations and conclusions of broader importance, which would lead to the development of a schema for relief evolution in mid-altitude mountains. This objective was accomplished through studies in ten stream catchments located in the Western Carpathians and Sudetes in the Czech Republic.

The studies conducted have shown that mass movements on slopes, in particular landsliding, and fluvial erosion on valley floors of small, forested, mid-mountain catchments are coupled. When slope material is transported into valley floors, it enters river channels and causes feedback bringing on erosion at the foots of slopes. On the other hand, fluvial erosion occurring at the boundary between slopes and valley floors causes disturbance of the slope equilibrium and another generation of mass movements. Repeating cycles of landsliding and erosion cause the gradual transformation of V-shaped cross profiles of valleys into flat-bottomed ones and a gradual retreat and lowering of slopes.

The thesis contains an extensive and a diverse range of documentation on field and laboratory studies which were the basis for the generalisations later presented which frequently go beyond the previously recognised facts concerning the evolution of relief in forested mid-mountain areas of the temperate climatic zone. The thesis represents a new perspective in understanding relief, particularly within the study areas of the Western Carpathians and Sudetes.

The thesis is also of potential interest to all researchers dealing with the problem of geomorphic coupling because the results were obtained through the use of an original approach, never before applied in analyses on slope-channel feedback.

The occurrence, length and frequency of the cycles of slope-channel coupling were determined by means of dendrochronological dating. This results from the rapid recent development of dendrogeomorphological methods. In the thesis, the precise dating of erosion was applied through the analysis of wood anatomy in

roots. An original method, developed for the needs of the thesis, was also applied and described. The method allows the dating of mass movement activity on slopes using the eccentric growth of trees tilted by ground instability. Comparison of temporal patterns of mass movement on slopes and fluvial erosion on valley floors was key to proving the great importance of positive feedback between slopes and channels in the evolution of mid-altitude mountain landscapes. At the same time, the method of eccentricity analysis developed proved its value in landslide studies and shows great promise in scientific analyses of, e.g. triggering factors and the spatial pattern of landsliding, but also in practical applications, e.g. estimating landslide hazard and risk. Hence, the thesis presented is also a good example of scientific work in which a purely research problem was to be solved, but the tools developed for that purpose can also have practical application.

Sosnowiec, Poland, June 2014 Prof. Ireneusz Malik

Abstract

Coupling between hillslopes and river channels is often considered to be a fundamental aspect of the functioning of geomorphic systems. In this thesis, coupling between the delivery of slope material into valley floors and river erosion was considered to be a factor in the evolution of mid-altitude forested mountains, where the connectivity between slope and fluvial subsystems is, so far, poorly recognised.

The thesis describes geomorphological and dendrochronological investigations carried out in mid-altitude areas of the Sudeten Mts and Carpathian Mts to analyse temporal and spatial relations between slope and fluvial processes (landsliding and erosion in particular). Landsliding and erosion occurrence were dated using the annual rings of Norway spruce. Using an original dendrogeomorphic approach it was possible to determine the cyclic occurrence of landsliding and erosion in the catchments studied during recent decades. The results show that the processes studied are strongly interdependent. Fluvial erosion can trigger landsliding by undermining slope bases. Landsliding can intensify erosion by delivering slope material into valley floors.

The results of dendrochronological studies have permitted a better understanding of the relief observed in areas where landslides and erosion are coupled. A schema was established which describes the evolution of mid-mountain landscape. This was discussed taking into account the influence of geological setting, human impact, climate change and tectonic activity. Using the results obtained from the ten catchments analysed and data obtained from the literature review, a proposition was made that the established model may describe a general rule for the evolution of mid-mountain landscape.

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