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Dendrochronological record of scree slopes activity on Ostrzyca basalt plug (South-Western Poland)

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Introduction

Geomorphological processes such as mass movements influence the environment in various ways regarding their intensity and pace as well as other factors, *e.g.*, like bedrock type or climate zone. Effects of such movements are recorded also in trees growing on unstable ground. Translocating material results in constant pressure on the stem from the upslope side, which consequently tilts the tree according to the movement direction. Changes caused by reactions of the plants to the activity of the ground can be observed in the annual increments. Trees form so-called reaction wood and exhibit eccentric growth, *i.e.* various portions of xylem are produced on the upslope and downslope parts of the stem. These differences in increment result in varying ring widths during the ground activity. Such phenomenon enables the application of dendrochronological methods for the analysis of geomorphological processes (Heinrich et al. 2007, Heinrich & Gärtner 2008, Stoffel & Perret 2006, Stoffel et al. 2005, Perret et al. 2006, Malik & Owczarek 2006, Kaczka & Morin 2006).

Scree slopes are surfaces consisting of sharp-edged rock debris formed by mechanical weathering of rock walls. Formation of scree slopes is strictly related to the rock wall as they are accomplished at its cost. Over the time the rock wall retreats and stops delivering fresh rock material, so the debris cover becomes stabilized. Scree slope activity expresses itself in two forms: delivery of new material and talus creep, i.e. gravitational transportation of the material within the slope. Talus creep, especially when debris cover is concerned, is one of the slowest mass movements. The mechanism of the process lies in the pressure put on the ground, which results in slope material being pushed and squeezed out alternatingly. As a result it is transported down the slope (Migoń 2006).

Scree slopes still remain one of the least examined land forms in the Sudety Mountains. So-far, studies (Baraniecki 1952, Synowiec & Jasińska 2002, Remisz et al. 2009) were fragmentary and did not cover the issue of their present activity. The application of dendrochronology for that purpose is rare (Malik et al. 2009).

The objective of the present study was to assess the activity of Ostrzyca scree slopes with the use of dendrochronological methods and to determine factors that control it.

Study site

Research was located on Ostrzyca (51 03' N, 15 46' E; 501 m a.s.l) in south-western Poland. The hill is the highest point of the Pogórze Kaczawskie, the foreland area of central part of the Sudety Mountains (Fig. 1). Ostrzyca is a plug whose origin is related to local volcanic activity that took place during late Tertiary block movements (Migoń et al. 2002). The hill constitutes a deeper part of volcanic neck that was exposed as a result of selective denudation (Birkenmajer 1967). It has a regular conical shape characterised by distinct concave-convex slope profiles (Fig. 1). Upper part of the hill (above 430-440 m a.s.l) is built of basalt rocks and debris, while the lower one consists of less resistant sedimentary formations, which the neck broke through.

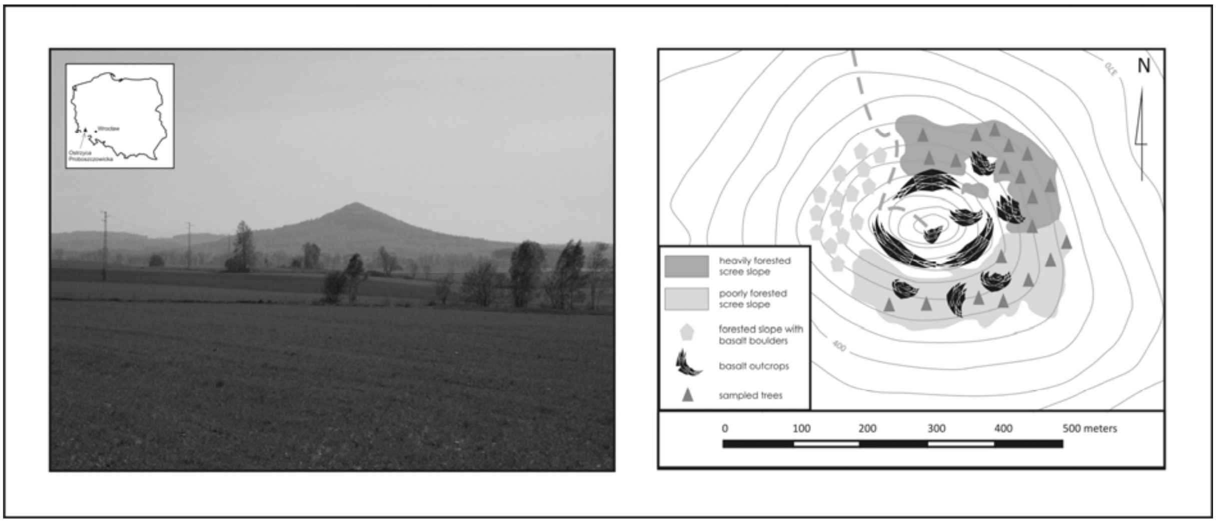

Figure 1: View on Ostrzyca and the scheme of the study site with location of sampled trees.

In 1926, Ostrzyca was recognized as a nature protection area. However, in 1944 it was converted for military purposes (construction of trenches), but in 1962 the protection status was restored. At present, “Ostrzyca Proboszczowicka” nature reserve covers 3,81 ha (Staffa 2002). As a result of the protection status the research area has remained relatively natural and has not been transformed by human activities, e.g. by establishing quarries. Thus, the original character of the area is preserved and geomorphologic forms are well-defined and distinguishable in nature.

Material and Methods

Research focused on the upper part of Ostrzyca, where disintegration of basalt outcrops lead to scree slope formation. We assessed both forms of scree slopes activity. Trees growing on the Ostrzyca slopes were examined for the presence of scars. We sampled 15 elms (*Ulmus glabra*), 3 maples (*Acer platanoides*), 1 sycamore (*Acer pseudoplatanus*) and 1 lime (*Tilia cordata*) chosen at random to detect the ground movements. We took two increment cores per tree. They represented upslope and downslope sides of the stems. For further analyses material was prepared according to the conventional procedures (Bräker 2002). We used CooRecorder and CDendro software (www.cybis.se) for tree-ring width measurements, cross-dating and chronology building.

To detect the episodes of scree slopes activity, we compared upslope and downslope chronologies of individual trees. Divergence in the course of increment’s width resulting from uneven xylem production caused by tree tilting (eccentric growth patterns) served as a diagnostic tool (Krąpiec & Margielewski 2000). We determined the beginning year and duration of the mass movements. In order to find out, if the intensive rainfall influences activity of Ostrzyca slopes, we compared the constructed tree ring chronologies with annual sum of precipitation. The climate data originated form Świerzawa meteo-station (10 km in SE direction) and covered the period 1977-2007.

Results

Out of the two forms of scree slope activity, only talus creep was observed on Ostrzyca. We did not find evidence of current delivery of new material as there were no injured trees with scars. The rock debris had round-shaped edges and usually was covered with vegetation (Fig 1, 2). Eccentric growth occurred in sampled trees.

Forest cover on Ostrzyca is relatively young, since the average age of the investigated trees was approximately 60 years. Only five sampled specimens were older than 100 years. The oldest sampled tree (elm) was 136 years old and the youngest (also elm) – only 54 years old.

Figure 2: Differences in vegetation cover between northern (left) and southern (right) slopes of Ostrzyca.

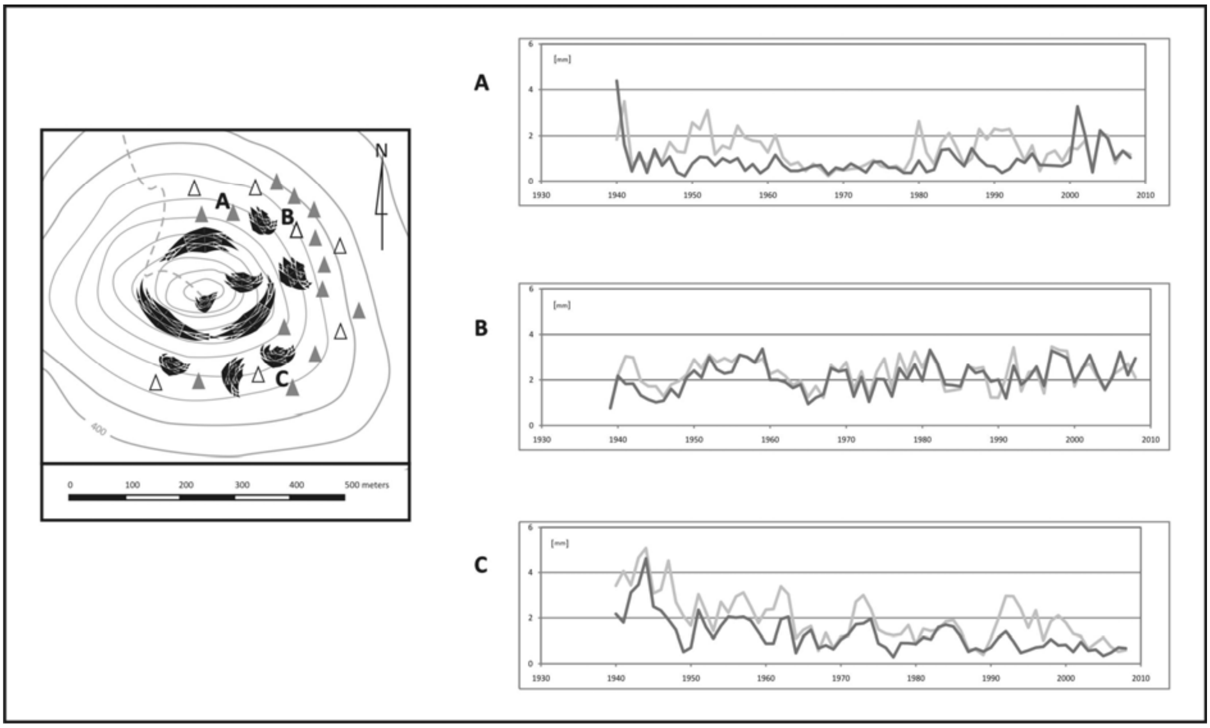

Figure 3: Spatial distribution of trees with (full triangles) or without (empty triangles) evidence of scree slopes activity and examples of chronologies representing 'active' (A, C) and 'non-active' (B) specimen (grey – upslope, black – downslope side chronologies).

Evidences of talus creep (eccentric growth) were found in thirteen trees, while in seven specimens no characteristic divergence in course of increment was observed (‘active’ and ‘non-active’ on Fig. 3 respectively). In the 20th century the slopes of Ostrzyca were very active during the years 1945-1962 and 1980/1990s (Fig. 4). The highest activity was observed in the period 1954-1960, when six to nine trees exhibited eccentric growth. Length of the individual episodes of talus creep varied from 3 to 13 years. The average duration of mass movements recorded in the constructed chronologies equalled 7,1 and 7,5 years on southern and northern slopes, respectively. No specific pattern of spatial distribution of trees indicating possible concentrated areas of talus creep was observed. Neither was it found that high rainfall coincided with periods of slope activity.

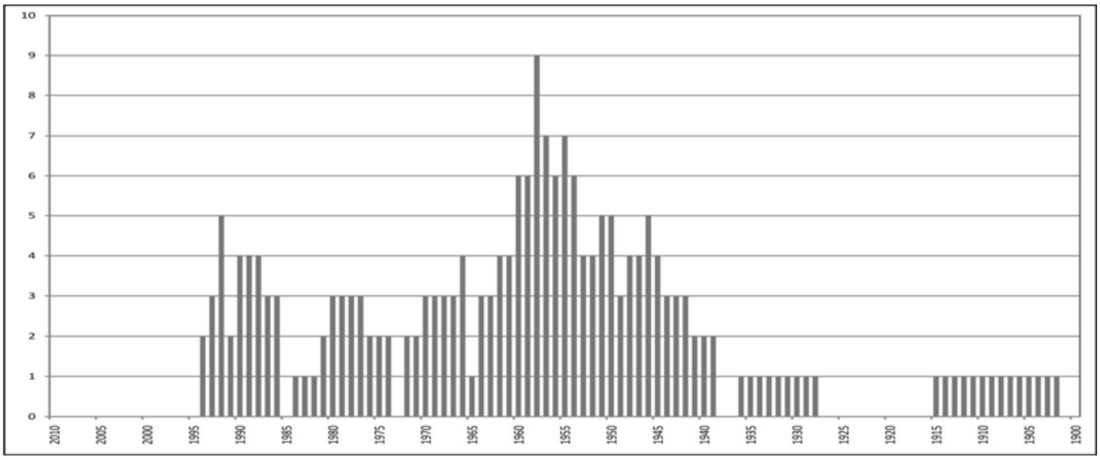

Figure 4: Temporal distribution of trees with growth eccentricity.

Discussion

The examination of living trees gave no evidences of delivery of new material to the debris cover but applied dendrochronological methods helped to detect the presence of temporary talus creep. These observations prove that scree slopes of Ostrzyca are still active geomorphological forms even nowadays. In the Kamienne Mts., Malik *et al.* (2009) found evidences of both forms of scree slopes activity. Not only fresh material deposition, but also mass movements in that area were distinct and well-defined. However, this activity seems to be the result of ongoing transformation of relatively young landslide scarps (Malik et al. 2009). In contrary, scree slopes of Ostrzyca were formed by the destructive impact of intensive physical weathering that occurred under periglacial conditions during previous glacial periods (Migoń et al. 2002). Hence, at present they are almost in a state of equilibrium as far as new material delivery is concerned (Kotarba 1976).

Intensity and occurrence of talus creep on Ostrzyca scree slopes are not related to the abundance of vegetation cover. Presence or lack of eccentric growth was found on densely forested western, northern and partly eastern slopes where rocks and debris originate from basalt outcrops and where they are intensively covered with lichens, mosses and herbal plants. Similar observations were made for the southern and eastern parts of the hill where the vegetation is rather sparse and occurs only on flat areas over rocks, in places where the slope changes its profile and at the end of debris cover.

Spatial distribution of tilted trees that exhibited eccentric growth suggests that talus creep on analysed slopes has rather local character. Narrow activity zones may be related to ridges of debris and locations where slopes become slightly steeper. However, confirmation of such a hypothesis requires further and more-detailed studies.

In contrary to observations from the Kamienne Mts. (Malik et. al 2009), no relationship was found between activity of scree slopes and annual precipitation on Ostrzyca. This disagreement may be caused by too short climate data series available to us. However, the debris covers at these sites vary regarding the shape of the material (tile-like stones in the Kamienne Mts. vs. more round/cubic on Ostrzyca). Furthermore, the role of animal trampling as a factor triggering debris cover transportation cannot be excluded. According to Govers and Poesen (1998) this phenomenon may contribute significantly to the evolution of scree slopes and should certainly not be neglected in study areas combining steep slopes and high density of wild animals. This may be partly reflected in the study area since Ostrzyca was declared as a nature reserve and hence, wild game may find refuge and good living conditions there.

Conclusions

The application of dendrochronology allowed to assess the activity of scree slopes of Ostrzyca basalt plug. Diversified spatial pattern of talus creep evidences suggest a wide-spread presence of abundant but rather narrow zones where this indiscernible type of mass movement takes place currently. We found that neither the vegetation cover nor the precipitation had any influences on the activity of examined scree slopes.

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References

Baraniecki, L. (1952): Gołoborza Ostrzycy i Sobótki. *Czasopismo Geograficzne* 21/22: 439-440.

Birkenmajer, K. (1967): Bazalty dolnośląskie jako zabytki przyrody nieożywionej. *Ochrona Przyrody* 32: 225-276.

Bräker, O.U. (2002): Measuring and data processing in tree-ring research – a methodological introduction. *Dendrochronologia* 20: 203-216.

Govers, G., Poesen, J. (1998): Field experiments on the transport of rock fragments by animal trampling on scree slopes. *Geomorphology* 23: 193-203.Heinrich I, Gärtner H, Monbaron M (2007) Tension wood formed in Fagus sylvatica and Alnus glutinosa after simulated mass movement events. IAWA 28/1: 39-48

Heinrich I, Gärtner H (2008) Variations in tension wood of two broadleaved tree species in response to different mechanical treatments: Implications for dendrochronology and mass movement studies. International Journal of Plant Sciences 169/7: 928-936. (doi: 10.1086/589695)

Kaczka, R.J., Morin, H. (2006): The dendrochronological records of debris flow activity in SE Quebec. In: Haneca, K. et al. (eds.). TRACE - Tree Rings in Archaeology, Climatology and Ecology 5: 233-239.

Kotarba, A. (1976): Współczesne modelowanie węglanowych stoków wysokogórskich na przykładzie Czerwonych Wierchów w Tatrach Zachodnich. *Prace Geogr. IGiPZ PAN* 120: 1-128.

Krąpiec, M., Margielewski, W. (2000): Analiza dendrogeomorfologiczna ruchów masowych na obszarze polskich Karpat fliszowych. *Kwartalnik AGH Kraków-Geologia* 26 (2): 141-171.

Malik, I., Owczarek, P. (2006): Dendrochronological records of erosion and sedimentation in a mid-mountain stream (Jeseniki Mountains – Czech Republic). In: Haneca K. et al. (eds.). TRACE - Tree Rings in Archaeology, Climatology and Ecology 5: 240-247.

Malik, I., Owczarek, P., Migoń, P. (2009): Rock fall as a source of sediment in the forested mid-mountains zone in the Kamienne mountains. In: Kaczka, R.J. et al. (eds.). TRACE - Tree Rings in Archaeology, Climatology and Ecology 7: 176-180.

Migoń, P. (2006): Geomorfologia. Wydawnictwo Naukowe PWN, Warszawa.

Migoń, P., Maciejak, K., Zygmunt, M. (2002): Peryglacjalna rzeźba wzgórz bazaltowych Pogórza Kaczawskiego (Sudety Zachodnie). *Przegląd Geograficzny* 74 (4): 491-508.

Perret, S., Stoffel, M., Kienholz, H. (2006): Spatial and temporal rockfall activity in a forest stand in the Swiss Prealps— a dendrogeomorphological casestudy. *Geomorphology* 74 (1–4): 219–231.

Remisz, J., Migoń, P., Malik, I., Owczarek, P., (2009): Stoki usypiskowe w polskiej części Sudetów – rozmieszczenie i wiek. In: Kostrzewski, A., Paluszkiewicz, R. (eds). Geneza, litologia i stratygrafia utworów czwartorzędowych. vol. 5, seria Geografia 88: 445-462.

Staffa, M. (2002): Słownik geografii turystycznej Sudetów. Vol. 7: Pogórze Kaczawskie. Wydawnictwo I-BiS. Wrocław.

Stoffel, M., Perret, S., (2006): Reconstructing past rockfall activity with tree rings: some methodological considerations. *Dendrochronologia* 24 (1): 1–15.

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. *Geomorphology* 68 (3–4): 224–241.

Synowiec, G., Jasińska, M., (2002): Rumowiska skalne w dolinach jarowych na Pogórzu Kaczawskim. *Przyroda Sudetów* 5: 175-184.