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Spatial distribution of potential planation surfaces in the Bohemian Forest (the Šumava Mts.)

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Abstract
This paper focuses on delimiting the spatial distribution of potential planation surfaces in the Bohemian Forest (=the Šumava Mts.). Use of the morphometric method involves one attribute of the phenomenon: characteristic slope value (0–2°, 0–5°). This is the first step to inferring where real planation surfaces may occur. In the area of interest, we have described the elevation levels on which planation surfaces are likely to be found. These levels are set in the Železnorudská Hornatina highlands at an elevation of 650–750 m a.s.l., 1100–1150 m a.s.l., and 1325 up to 1340 m a.s.l.; in the Boubínská Hornatina highlands at 880–1025 m a.s.l. and 1125–1150 m a.s.l.; in the Šumavské Pláně plateau at 780–900 m a.s.l., especially at 1075–1175 m a.s.l., where there is a massive extent, and at 1225–1300 m a.s.l.; in the Trojmezenská Hornatina highlands at 750–800 m a.s.l., 900–940 m a.s.l., 1075–1250 m a.s.l.; in the Želnavská Hornatina highlands there is no clear evidence of any predominating altitudinal level. ArcGIS executed the spatial data processing.

Key words: the Bohemian Forest, potential planation surfaces, GIS, altitudinal levels

Introduction

This paper investigates the spatial distribution of planation surfaces in the Czech part of the Bohemian Forest. The planation surface is a geographically plain surface, which is the end product of all processes of planation by erosion (Fairbridge 1968, Goudie 2004). The aim is to indicate areas of potential incidence by the morphometric attributes of this phenomenon, using analysis in GIS (ESRI 2003). Spatial distribution is a partial method that describes their difference, in this case in altitude; the results are intended to be used in broader research. As the indication involves only one attribute – the slope value – this method does not account for all specificities of planation surfaces (for example, this method cannot indicate pediments, or tectonic inclination of part of the earth's crust). The area of interest is identical to the Šumava geomorphological unit, according to Demek's geomorphological regionalization of relief (Demek 1987) (see Fig. 1).

Sources of data

The main data source for all operations was Digital terrain model 25 (DMÚ 25), produced by the Geographical Service of the Czech Army (Geografická služba Armády České republiky 2003), the first edition. They are vector data, contour line interval 5 m, and coordinate system S-JTSK. The data were used when creating TIN. Data for geomorphological regionalization (exact boundaries of geomorphological units) were obtained from map applicati-

Fig. 1. Study area with names of the geomorphological units, according to Demek's geomorphological regionalization of relief (Demek 1987).

ons available at http://geoportal.cenia.cz. Topology data, such as settlements, rivers and lakes, were obtained from ArcData Praha – ARC ČR 500. All operations were processed in ESRI – ArcGIS 9.0 (ArcMap™, 1999–2004).

Methodology

The planar model, TIN (Triangulated Irregular Networks), was created from the contour line base, considered as hardlines. Hydrological data were not taken in, because of very coarse level of accuracy. From TIN we derived a slope map, which was then converted to polygons. We selected areas with slope value 0–2° from the thematic slope map. This value seems to be more reasonable than 0–4°, even though it is used by other authors. These areas were cleared from the areas in concave-shaped relief, as floodplains, lake surfaces and other areas with no planation surfaces (they are not of erosion-denudation origin). This was done using common sense. Statistical evaluation was the next step: each polygon was allocated according to its calculated area and altitude. When a polygon overlapped the contour lines, the

"Intersect" tool was used to divide the particular polygon into "inter-contourline polygons". A chart (Fig. 2) shows the altitude of the lower contour line, which smoothes out big variations with a sliding average. The charts were created not for the geomorphological unit, but for the subunits: the Železnorudská Hornatina highlands, the Boubínská Hornatina highlands, the Šumavské Pláně plateau, the Trojmezenská Hornatina highlands, the Želnavská Hornatina highlands, and the Vltavická Brázda furrow. The same procedure was done for areas with slope 0–5°. Spearman's correlation coefficient was calculated to verify the interrelation between areas of slope 0–2° and 0–5°. This coefficient shows the strength of a link between two data sets. The value may vary from –1 to 1, where 1 means perfect positive correlation, 0 no correlation, and –1 perfect negative correlation. The notation comes from Zvára (2004).

Results

Distribution of areas within the Šumava geomorphological unit in respect to altitude does not show much close relation between areas of slope 0–2° and 0–5°. The most extensive areas of the 0–2° slope occur at 1230–1260 m a.s.l. and 1290–1335 m a.s.l. (Fig. 2). The curve of distribution areas up to 5° varies significantly (Fig. 3). The largest extent is in the levels of 725–800 m a.s.l. and 1030–1080 m a.s.l. Even the Spearman's correlation coefficient shows the minimum relation between these two data sets (0–2° and 0–5°): its value is only 0.365. Given the large area of interest and the slightness of potential planation surfaces, the entire output maps are not shown, but the author will supply them in *.shp format on request. For illustration, Fig. 4 shows a comparison of partial scaled-down maps for angles 0–2° and 0–5°.

In the Boubínská Hornatina highlands, the abundant areas of small inclination are at the levels of 880–1025 m a.s.l. and 1125–1150 m a.s.l. In the Trojmezenská Hornatina highlands,

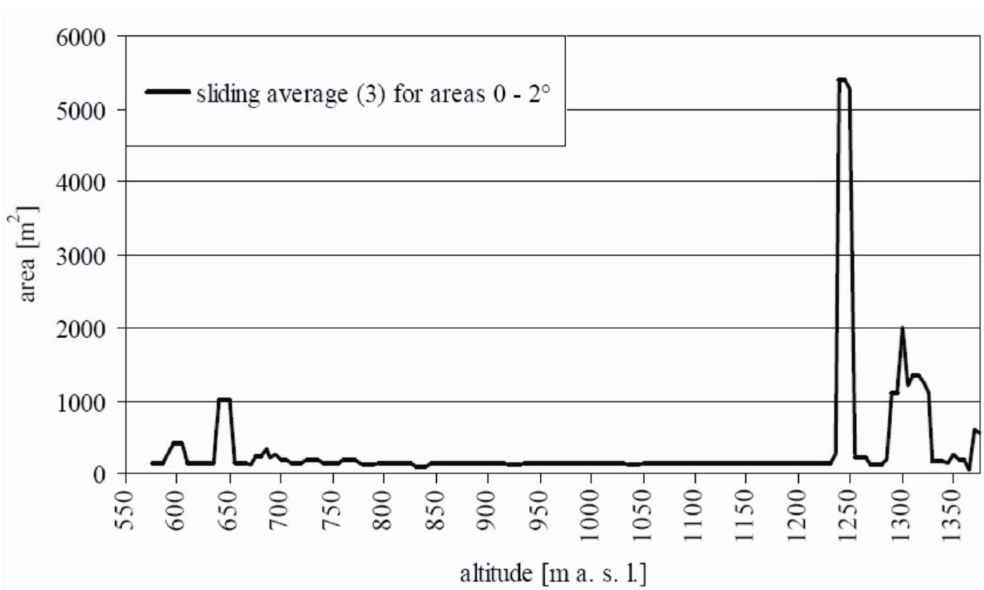

Fig. 2. Distribution of the areas of angle 0–2° in respect to altitude for geomorphological unit (sliding average – 3).

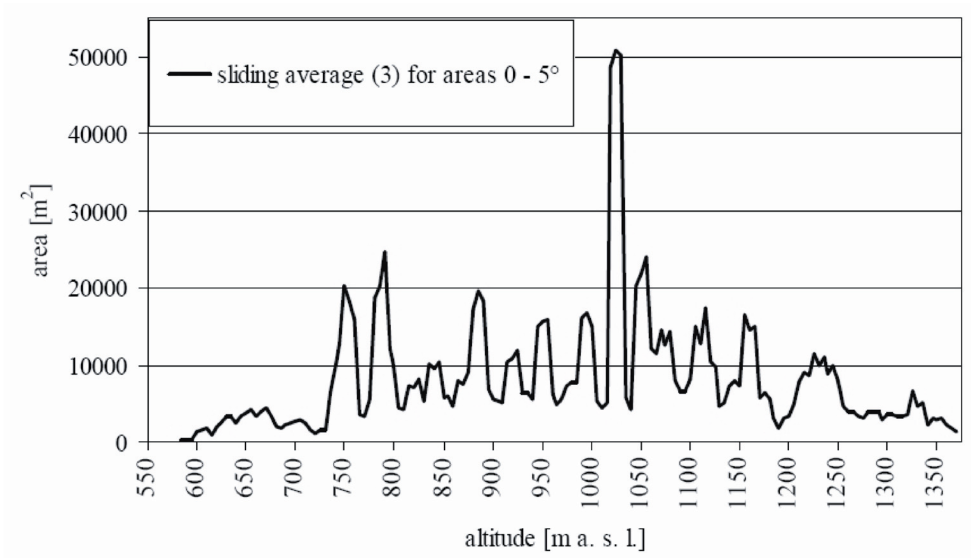

Fig. 3. Distribution of the areas of angle 0–5° in respect to altitude for geomorphological unit (sliding average – 3).

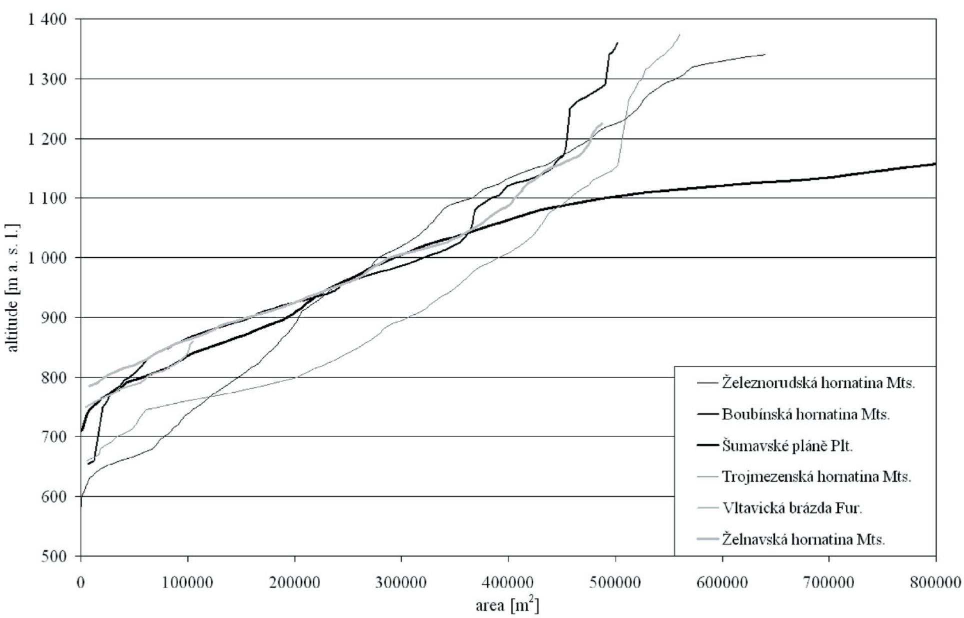

Fig. 4. Distribution of the areas of angle 0–2° in respect to altitude for geomorphological subunits, cumulative explication.

they occur about 750–800 m a.s.l., 900–940 m a.s.l., and 1075–1250 m a.s.l. The Šumavské Pláně plateau contains many potential planation surfaces (this subunit was defined as a plateau because of its morphological attributes). A trace of small slopes can be found at 780–900 m a.s.l., while a massive increase of such areas occurs at 1075–1175 m a.s.l. The next level of abundant incidence is at 1225–1300 m a.s.l. In the Vltavická Brázda furrow, there is no evidence of any relevant potential planation surfaces (pediments are not considered). The Železnorudská Hornatina highlands appears to have relatively uniform distribution, although several levels may be defined: the first is at 650–750 m a.s.l.; the second is at 1100–1150 m a.s.l.; and the third is from 1325 up to 1340 m a.s.l. By contrast, the curve of distribution of areas with inclination 0–2° of the Želnavská Hornatina highlands is much more uneven. Clear-cut levels of potential planation surfaces are not easily identifiable. At an altitude of 900 m a.s.l., a short increase may be found, then from 1000–1045 m a.s.l. and 1150–1170 m a.s.l. The same distinction of potential planation surfaces was made for the data set of the areas with inclination 0–5°. The results gained from this analysis were not given much weight because of the small correlation between data sets of 0–2° and 0–5°.

Discussion

As the low angle of slopes is the primary attribute of planation surfaces, the identification of potential planation surfaces according to this attribute is relevant. Determining the boundary value of the slope is the central issue. The inclination interval 0–5° is too wide and probably includes many relief segments with different genesis, so it does not correlate with the characteristic of plain's data set up to 2° (low value of Spearman's correlation coefficient – 0.365).

The curves of spatial distribution of potential planation surfaces (Figs. 2, 3, 5) show the maximum extent of areas on which planation surfaces may occur. It is assumed that the extent of proved planation surfaces would not exceed these limits. Although the probability is enhanced by correction of evidently denudational – accumulative segments, the run of the curves gained in this method do not have to relate closely to the planar distribution of real planation surfaces.

Fig. 5. An example of a scaled down map – on the left areas of the angle 0–5°, on the right areas of the angle 0–2°.

There are several discrepancies between the data in Král (1985) and Hartvich (2004) for the planation surfaces of the Železnorudská Hornatina highlands (Table 1). Their altitudinal indication does not show all of the potential surface levels because they focused on a much smaller study area, whereas we considered the whole subunits. They gave elevation data for the previously proved planation surfaces, whereas we present potential planation surfaces on a larger scale. Král (1985) used a very inaccurate method in comparison with current GIS tools. Mentlík (2001) defined several planation surfaces in the Železnorudská Hornatina highlands, but only for one ridge.

A consensus has almost been reached for the Šumavské Pláně plateau: the difference within one interval is up to 100 m. Within this subunit, Baláková (2004) described planation surfaces, but without setting any levels. She focused on relief segmentation to even smaller units, which we do not consider as being representative on a large scale.

There is a total overlap in interval 900–940 m a.s.l. in the Trojmezenská Hornatina highlands (Král 1985). Within this subunit, Votýpka (1975) described some planation surfaces, but his criterion of slope angle was much wider (2–8°) because he described surfaces that probably were tectonically inclined. Therefore, it is difficult to give their exact altitude. Votýpka (1975) distinguishes three types of planation surfaces: summit flats, saddle flats and slope flats. However, he considered only a geomorphological district (i.e. a unit smaller than a subunit).

To date, no literature describes a level of two subunits. There are four possibilities for distinguishing altitudinal indication: using a distinct methodology (potential × verified planation surfaces), finding a different quality of data, defining the extent of a study area, or adjusting the scale of research.

A distinct methodology of defining planation surfaces has three aspects, the first of which is technical. Earlier geomorphologists (Král 1985) used inaccurate manual methods akin to using a ruler for inferring the slope from contour lines. Today, sophisticated software generates much faster and more precise counts. The second aspect involves geomorphologists' investigative methodology, which varies depending on type of relief, available data, and the scale of focus. For example, flat summits in Utah (Munroe 2006) with an altitude higher than 3400 m a.s.l. have no vegetation, whereas in the Bohemian Forest they are completely different. The third aspect, which warrants serious consideration, involves precisely defining

Table 1. Comparison of altitudinal classification of planation surfaces according to different authors.

	Král (1985)	Hartvich (2004)	Potential planation surfaces
Železnorudská Hornatina highlands	1000–1020 m a.s.l.	1065, 1085 m a.s.l. 940–970 m a.s.l. 820–850 m a.s.l.	1326–1340 m a.s.l. 1100–1150 m a.s.l. 650–750 m a.s.l.
Želnavská Hornatina highlands			1150–1170 m a.s.l. 1000–1045 m a.s.l. 900 m a.s.l.
Šumavské Pláně plateau	1220–1240 m a.s.l. 1000–1020 m a.s.l.		1225–1300 m a.s.l. 1075–1175 m a.s.l. 780–800 m a.s.l.
Trojmezenská Hornatina highlands	1330–1350 m a.s.l. 900–940 m a.s.l.		1075–1250 m a.s.l. 900–940 m a.s.l. 750–800 m a.s.l.
Boubínská Hornatina highlands			1125–1150 m a.s.l. 880–1025 m a.s.l.

the results of research to avoid comparing dissimilar things. As mentioned above, there is a significant difference between a planation surface and a potential planation surface.

Geomorphologists (Hartvich 2004, Mentlík 2001) do not use geomorphological regionalization (Demek 1987, Balatka & Kalvoda 2006) when choosing their study area, but we prefer to use defined geomorphological regionalization because it allows for more systematic research. It is possible that relief of given units in general (and planation surfaces) would have been formed under relatively homogenous tectonic conditions. As far as the process of defining levels of planation surfaces is concerned, a comparison of units smaller than geomorphological subunits is not ideal. Smaller (therefore, less representative) units could cause to misinterpretting the levels of planation surfaces in a wider context.

Conclusion

One attribute was applied: for indication of potential planation surfaces minimum inclination. The digital terrain model was created and analysed to create maps of potential planation surfaces. Levels of potential planation surfaces were described as follows: in the Boubínská Hornatina highlands at 880–1025 m a.s.l. and 1125–1150 m a.s.l.; in the Trojmezenská Hornatina highlands, they occur about 750–800 m a.s.l., 900–940 m a.s.l., and 1075–1250 m a.s.l. The Šumavské Pláně plateau was indicated at 780–900 m a.s.l., especially at 1075–1175 m a.s.l., then at 1225–1300 m a.s.l. In the Vltavická Brázda furrow, there is no evidence of any relevant potential planation surfaces (pediments are not considered). In the Železnorudská Hornatina highlands at 650–750 m a.s.l., 1100–1150 m a.s.l., and 1325 up to 1340 m a.s.l. In the Želnavská Hornatina highlands there is no clear evidence of any predominating altitudinal level. However, clear-cut levels of potential planation surfaces are not easily identifiable.

The elevation levels of abundant areas for geomorphological units and subunits were described and discussed with data given in extant literature (Votýpka 1975, Král 1985, Mentlík 2001, Hartvich 2004). The differences are attributable to the facts that geomorphologists usually focus on small areas, which are not identical to geomorphological segments given by Demek (1987) or even modern geomorphological segmentations (Balatka & Kalvoda 2006), so comparisons with other authors' contributions will always be inaccurate.

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