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The use of morphometric parameters in tectonic geomorphology (on the example of the Western Beskydy Mts)

TOMÁŠ PÁNEK

University of Ostrava, Faculty of Science,
Department of Physical Geography and Geoecology, Czech Rep.

Abstract

The aim of the study is the application of some morphometric parameters for morphotectonic research of the culmination area of the Outer Western Carpathians within the Czech Republic. With the use of morphometric characteristics of basins known zones are verified and potential zones of neotectonic activity are delimited. With the use of statistic methods differences between main nappe units of the area are defined and dependence between chosen structural characteristics and georelief is determined.

Key words: tectonic geomorphology, morphometry, statistical tests, ANOVA, cluster analysis, Western Beskydy Mts, flysch Carpathians

1. Introduction

Tectonic geomorphology deals with relations between tectonics and geomorphological processes shaping areas of active Cenozoic deformations (Burbank, Anderson, 2001). At present, tectonic geomorphology is heading up to the stage of very sophisticated discipline of science with proper methodical procedures, theoretic problems and strong interdisciplinary approach. Inseparable part of this approach is quantification with the use of geomorphometric methods and statistic analysis. Not exaggerating we can say that implementation of morphometric and statistic methods into tectonic geomorphology over the last few years is experiencing the same boom as during the first wave in the 1950's and 1960's. Nowadays development of geomorphometric and geostatistic methods is connected especially with possibilities of fast derivation of parameters from a digital elevation model (DEM thereinafter) which in GIS environment provides even exacting calculations practically unrealizable in analogue representation. (Sung, Chen, 2004).

This study shows possibilities of morphometric statistic analysis of DEM by interpretation of morphotectonic features of the culmination area of the Outer Western Carpathians within the area of the Czech Republic (Fig. 1). The aim is to compare differences in morphology of the main nappe units building the mountain range and to contribute to the definition of neotectonically active zones. The studied area is built by flysch rocks of the Magura and Silesian nappes which were folded during Saavian and Steyerian orogenetic phases from the Oligocene to the Middle Badenian stage. Contemporary morphological individualization of the area is the result of selective denudation of lithologically manifold flysch rocks and neotectonic movements in the Pliocene and the Quaternary.

2. Morphometric parameters in tectonic geomorphology

Morphometry has been a significant instrument of structural geomorphology (Strahler, 1952) since the 1950's. Quantitative data of the georelief provide mutually comparable data of the stage of the development and tectonic activity of geomorphologic units. Morphometry is becoming an irreplaceable part of structurally geomorphological studies, especially after the works of W. B. Bull and L. D. Mc Fadden (1977) were published, and its development is currently connected with the introduction of DEM and GIS technologies.

The advantage of morphometric parameters is in their fast derivation, mutual comparison and possibility of statistic evaluation for arbitrarily vast areas. Generally, they themselves do not make up the only databasis for geomorphological purposes but are of valuable support for terrain morphotectonic mapping, structural surveying, and geochronological and geophysical methods. As unique we can consider morphometric characteristics in large-scale geomorphology, which thanks to the global coverage of the Earth by a digital elevation model (e.g. GTOPO30) profiles to be a special tendency of tectonic geomorphology (Fielding, 2000; Kühni, Pfiffner, 2001; Miliaresis, 2001; Miliaresis, Iliopoulou, 2004).

Morphometric parameters used in tectonic geomorphology (Tab. 1) can be divided into hypsometric variables, characteristics of gradient and georelief energy, characteristics of valley networks and valley profiles, characteristics of the shape of basins, characteristics of the morphology of slopes and newly introduced characteristics using DEM for calculations (e.g. directional derivatives of elevations, autocorrelation etc.). The interpretation of these characteristics is based on the fact that in the course of vertical and generally also horizontal tectonic movements the scope of elevations changes thereby changing hypsometric conditions and relief energy and subsequent changes of the altitude of erosion basis fundamentally influence the morphology of valley profiles and the groundplan of basins. A special category of morphometric characteristics expresses directly the stage of activity of chosen tectonic forms of the relief (Silva et al., 2003) or morphological features of correlate forms such as e.g. alluvial cones (Sorisso-Valvo, M. et al., 1998). Tectonic processes influence also anisotropy of rocks and georelief (Jordan, 2003; Jordan et al., 2003), periodicity, fractal parameters of the georelief (Sung, Chen, 2004) and other geometric quantities.

Tab. 1 Morphometric characteristics used in tectonic geomorphology

Morphometric parameter	Mathematical derivation*	Significance	Selected sources
Hypsometric parameters • H_i – Hypsometric integral	$H_i = \frac{H_{mean} - H_{min}}{H_{max} - H_{min}}$	Most tectonically active areas show high values of Hi (usually Hi > 0.6)	Huertrez et al. (1999), Chen et al. (2003)
Parameters of landform gradient • R – Local relief • IR – index of relief • ZR – landscape roughness	$R = H_{max} - H_{min}$ $IR = R/L$ $ZR = H_{mean}/R$	Areas with high uplift show high values of R, IR and ZR	Engstrom (1989), Formento-Trigilio, Pazzaglia (1998)
Parameters of drainage patterns • D_d – Drainage density • F_v – valley frekvency • R_b – bifurcation ratio • $N1/N$ ratio	$D_d = \sum L/A$ $F_v = Nu/P$ $R_b = \sum \frac{N_u}{N_{u+1}}$	The highest values of drainage pattern parameters are confined to areas showing the most intensive Quaternary uplift and diversified lithology	Musumeci et. al. (2003), Zuchiewicz (1995a)
Stream long-profiles parameters • S – Stream-bed gradient • SL index • K-index – concavity index	$S = (H_{max} - H_{min})/L$ $SL = (\Delta H/\Delta L)*L$	Disequilibrium conditions suggest tectonic disruption of the bed	Chen et al. (2003), Radoane et al. (2003), Zuchiewicz (1995b)
Valley cross section parameters • V_{fw} – Valley floor width • V_f – Valley floor width/ /valley hight ratio	$V_f = \frac{2V_{fw}}{\frac{(E_{ld} - E_{sc}) + (E_{rd} - E_{sc})}{2}}$	Low values of V_{fw} and V_f show possible uplift tendency or zones of more resistant bedrock	Bull, McFaden (1977), Zuchiewicz (1995c)
Drainage basin shape parameters • R_e – Drainage basin elongation ratio • B_c – Drainage basin compactness • B_s – Drainage basin shape ratio	$R_e = \frac{2\sqrt{A} : \sqrt{\pi}}{L}$ $B_c = P/A$ $B_s = B_l/B_w$	$R_e < 0.5$ – low tectonic activity $R_e = 0.5$–0.75 – moderate tectonic activity $R_e > 0.75$ – strong tectonic aktivity	Engstrom (1989), Kryzsowski et al. (1995), Ramírez-Herrera (1998)
Mountain front parameters • Smf – Mountain front sinuosity	$Smf = Lmf/Ls$	$Smf = 1.0$ – most tectonic activity Smf > 1.0 – less tectonic activity	Bull, McFaden (1977), Silva et al. (2003)
DEM-derived parameters • Autocorrelation • First and second directional derivative etc.	Derivation of elevation in given azimuth	Enhancement of selected morphostructural features – lineaments, structural ridges etc.	Jordan et. al (2003), Jordan (2003)

* **symbols:** H_{mean} – mean elevation of the basin, H_{max} – elevation of the highest point within the basin, H_{min} – basin mouth, L – basin lenght, A – basin area, N_u – number of valley segments of given hierarchical order, P – basin perimeter, B_l – lenght of the basin measured from its mouth to the most distant drainage divide, B_w – width of the basin measured across the short axis, Lmf – lenght of mountain front along the mountain-piedmont junction, Ls – straight-line lenght of the front

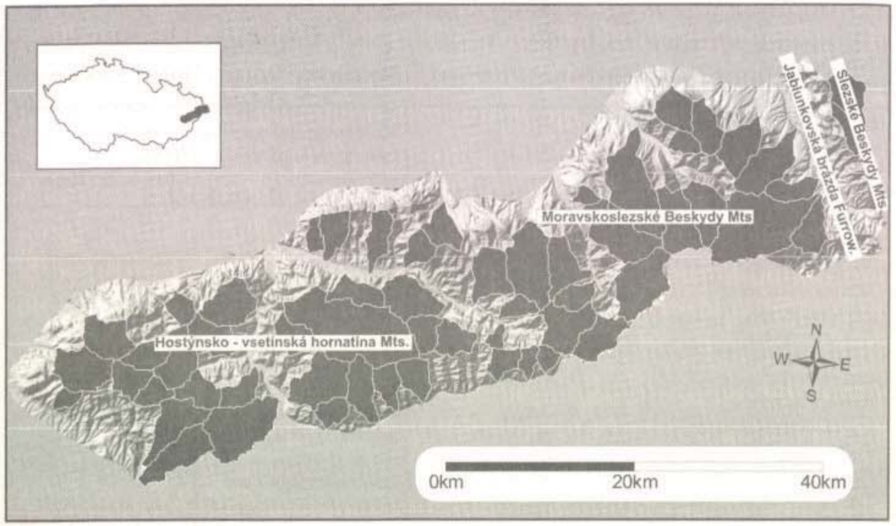


Fig. 1 Location of the studied area within the Czech Republic and studied basins of the fourth order within the area of the Western Beskydy Mts.

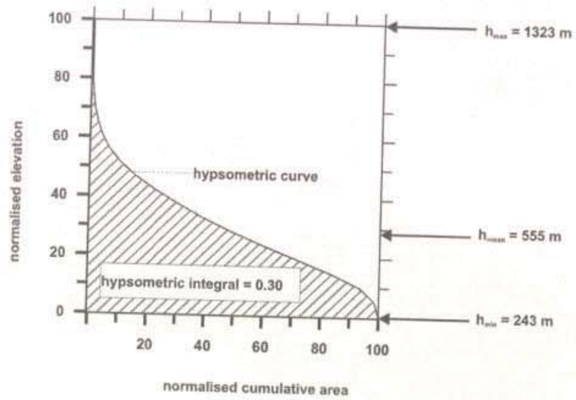
3. Drainage basins morphometry of the western Beskydy Mts

3.1. Hypsometric analysis

Hypsometric parameters stand for quantitative expression of the relation between the area and the elevation of the given territory (Strahler, 1952; Summerfield, 1991; Hurtrez et al., 1999). A frequently used characteristic is hypsometric integral (Hi), which numerically expresses the shape of hypsometric curve (Fig. 2). High Hi values are typical for convex hypsometric curves expressing a relatively large area of the territory situated in higher relative elevations. High Hi values (especially above 0.6) are characteristic for tectonically mobile units with tendency to uplifts (Hurtrez et al., 1999; Delcaillau et al., 1998; Chen et al., 2003; Riquelme et al., 2003). Hypsometric integral is also an indicator of potential rock denudation from the basin (Bishop et al., 2002). Low value of the integral shows a big volume of rocks denudated from the basin while high values indicate even big erosion potential.

Hypsometric integral in the studied area was calculated both for individual basins of the 4th order and continually with the use of a mobile window of the area of 2.05 km^2. The distribution of the values of hypsometric integral corresponds with tectonic structure of the territory. High values above 0.5 can be found particularly on the forefront of the Magura nappe in the area of a block-uplifted culmination part of the Moravskoslezské Beskydy Mts, on the south-west margin of the studied area roughly along the line of the Holešovský fault and similarly also along the Jablunkovské fault range in the eastern part of the territory. The largest territory as for the area with highly

A



$$\text{hypsometric integral(Hint)} = \frac{h_{mean} - h_{min}}{h_{max} - h_{min}}$$

B

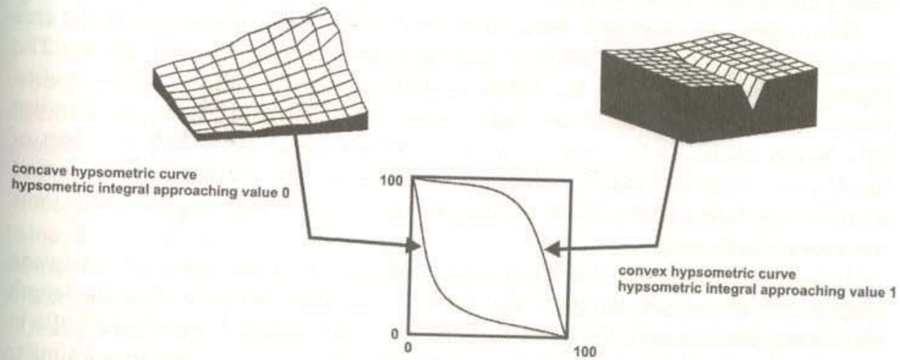


Fig. 2 Derivation of hypsometric integral from hypsometric curve (**A**) and the scheme of the area with high and low values of hypsometric integral (**B**) (modified according to Hurtrez et al. 1999)

above-standard value of the integral above 0.6 is situated in the eastern part of the Moravskoslezské Beskydy Mts where it copies the eastern wing of the vault uplift which formed present elevation structure between the highest point of the territory – Lysá hora Mt. – and the Jablunkovské fault range (Fig. 3).

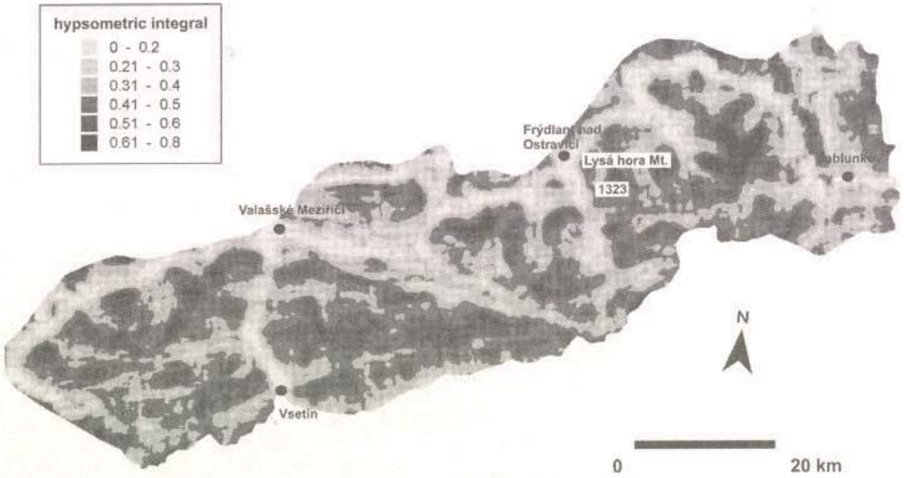


Fig. 3 Distribution of values of hypsometric integral in the area of the Western Beskydy Mts. The values were calculated over DEM for windows of the mobile filter of the side of 2.05 km

3.2. Analysis of energy and the georelief gradient

Characteristics of the relief gradient and energy include a great amount of parameters derived from vertical articulation and inclination of the territory. The relief energy is mostly connected with an increase of erosion basis and neotectonic movements.

Relief energy (R) represents basic characteristics of vertical articulation of the area and at the same time it is a quantity entering other morphometric calculations. The parameter was calculated as the difference of H_{max} and H_{min} in each of the studied basins. The values oscillate in the range of 242–909 m; the highest ones are observed with basins located in the area of partial Godulla nappe in the culmination part of the Moravskoslezské Beskydy Mts (basins of Mohelnice, Čeladenka, Řečice and other rivers). Relief energy is the first rough look in the arrangement of neotectonic movements in the area.

Relief ratio (R_r) is non-dimensional characteristics calculated as a ratio between relief energy (*R*) and the length of the basin (*L*). Its value increases while the length of the basin decreases and the relief energy grows. The average value of relief ratio in the studied area is 0.09 with the range of 0.03–0.25. The highest values have a similar arrangement as the relief energy in the culmination part of the Moravskoslezské Beskydy Mts, however, unlike absolute relief energy high values can be observed also on anaclinal basins on the forefront of the Magura nappe in Hostýnsko-vsetínská hornatina Mts. Long basins with the highest relief energy value in the culmination part of the Moravskoslezské Beskydy Mts. have their relief ratio value reduced (Fig. 4).

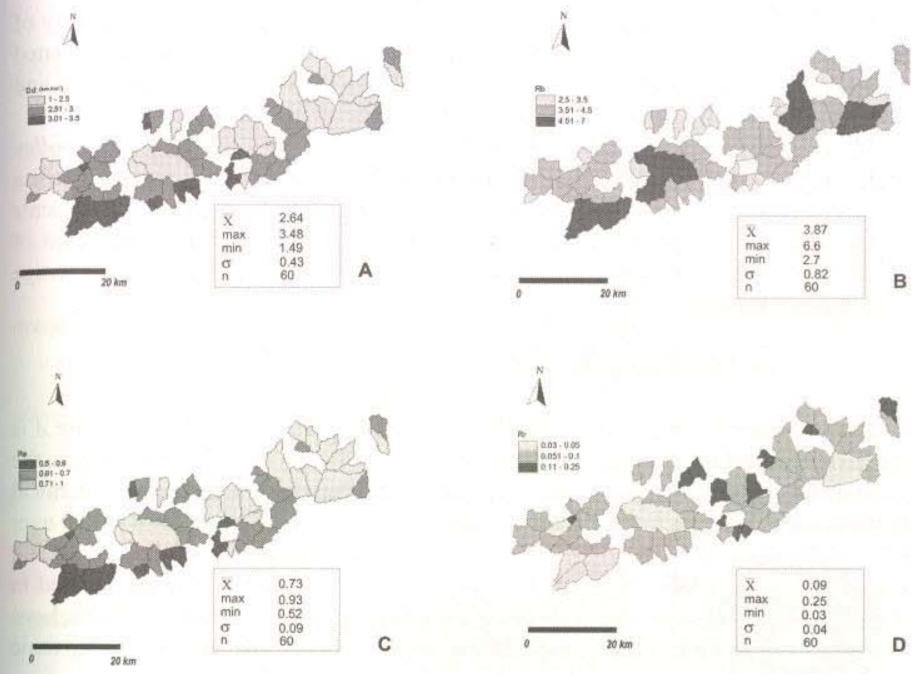


Fig. 4 Selected morphometric parameters of basins of the fourth order of the Western Beskydy Mts.

3.3. Analysis of valley networks

Valley network is a very sensitive indicator of tectonic and erosion denudation processes. Characteristics of the development of the valley network indicate the stage of erosion transformation of the territory and the groundplan of valley networks is a good indicator of tectonic composition.

Drainage density (D_d) calculated as a ratio of sums of lengths of all valley lines in the given basin to its area has to a great extent inversion arrangement of maximum values in comparison with the values of *R* and R_r (Fig. 4). The highest values are distributed in the area with a small value of vertical articulation in the south-west and southern parts of the Hostýnsko-vsetínská hornatina Mts. on complexes of Zlín strata of the Magura nappe (e.g. basins of Všemínka, Rokytenka and Trnávka Rivers). Values of 60 studied basins oscillate in the range of 1.49–3.48 km · km^{-2} with the average value of 2.63.

Bifurcation ratio (R_b) is an indicator of branching of valley systems in the basin. It is calculated as an average value of partial bifurcation ratios (i.e. the ratio between the number of valleys of the first and second orders, the ratio between the number of valleys of the second and the third orders and the ratio between the number of valleys of the third and the fourth orders). According to Zuchiewicz (1989), high values of bifurcation ratio can be found in the territory with the presence of young tectonic movements. In the studied area the average value of bifurcation ratio is 3.87 in the range of measured values of 2.7–6.61. The highest values can be observed in basins with a big density of the valley network (e.g. Všemínka, Trnávka and Rokytenka Rivers), basins situated in the culmination part of the Moravskoslezské Beskydy Mts (Mohelnice River) and basins mouthing into the Jablunkovská brázda Furrow (Lomná River) (Fig. 4).

The ratio of the number of valleys of the first order to the whole number of valley segments (N1/N) shows the stage of rejuvenation of the given basin. Similarly to the case of R_b the ratio of $N1/N$ indicates a possible presence of young tectonic movements and especially lithological diversity (Zuchiewicz, 1989). The spatial arrangement of values is similar to that of bifurcation ratio with the range of 56.8–82.6%; the average value being 74.9%.

3.4. Analysis of the basin shape

Basin elongation (R_e) is calculated from the relation of $R_e = (2\sqrt{A}: \sqrt{\pi})/L$ where A is the basin area and L is the length of the basin. While the value of the index increases, the groundplan shape of the given basin approaches an ideal circle with the area identical to the basin. According to Zuchiewicz (2001) the values of R_e varying from < 0.50 over 0.50.–0.75 up to > 0.75 oscillate in the basins in tectonically active, slightly active and inactive areas. According to this ratio most basins in the studied area are situated in the zone with weak tectonic movements; only few basins (e.g. Mohelnice, Hluchová Rivers, etc.) with their values approach the category manifesting intensive neotectonic uplifts (Fig. 4).

Basin compactness (B_c) stands for a quantitative indicator of the segmentation of the basin groundplan. It is calculated as the ratio between the perimeter length of the basin and its area. The higher the B_c value is, the higher the length of the main watershed divide is at the expense of the basin area, therefore the groundplan segmentation of the basin grows. High B_c values are observed particularly in basins in less resistant rocks with long-term erosion activity.

3.5. Autocorrelation analysis

Autocorrelation analysis of the elevations field shows the degree of anisotropy (isotropy if you like) of the georelief. Generally, anisotropy represents a feature indicating that a physical quantity is dependent on the direction in which it is measured. Anisotropic georelief is noted for strong polarization pointing out to lithological, structural or tectonic predisposition. Isotropic georelief is, with the exception of isometric deformation structures, mostly autonomous on structurally lithological building. The use of autocorrelation analysis in tectonic geomorphology is generally connected with the structure of correlograms and variograms above DEM (Jordan, 2003b). Except autocorrelation analysis of elevations, it is possible to study also anisotropy of the distribution of tectonic elements, expansion of geochemical activity of chosen gases indicating tectonic or volcanic activity etc. (Ciotoli et al., 2003).

For the area of the Western Beskydy Mts a special correlogram for the Silesian and Magura nappes (Fig. 5) was created. The Magura nappe appears here as an anisotropic body with overall polarization of WSW–ENE, which reflects inner lithological structure

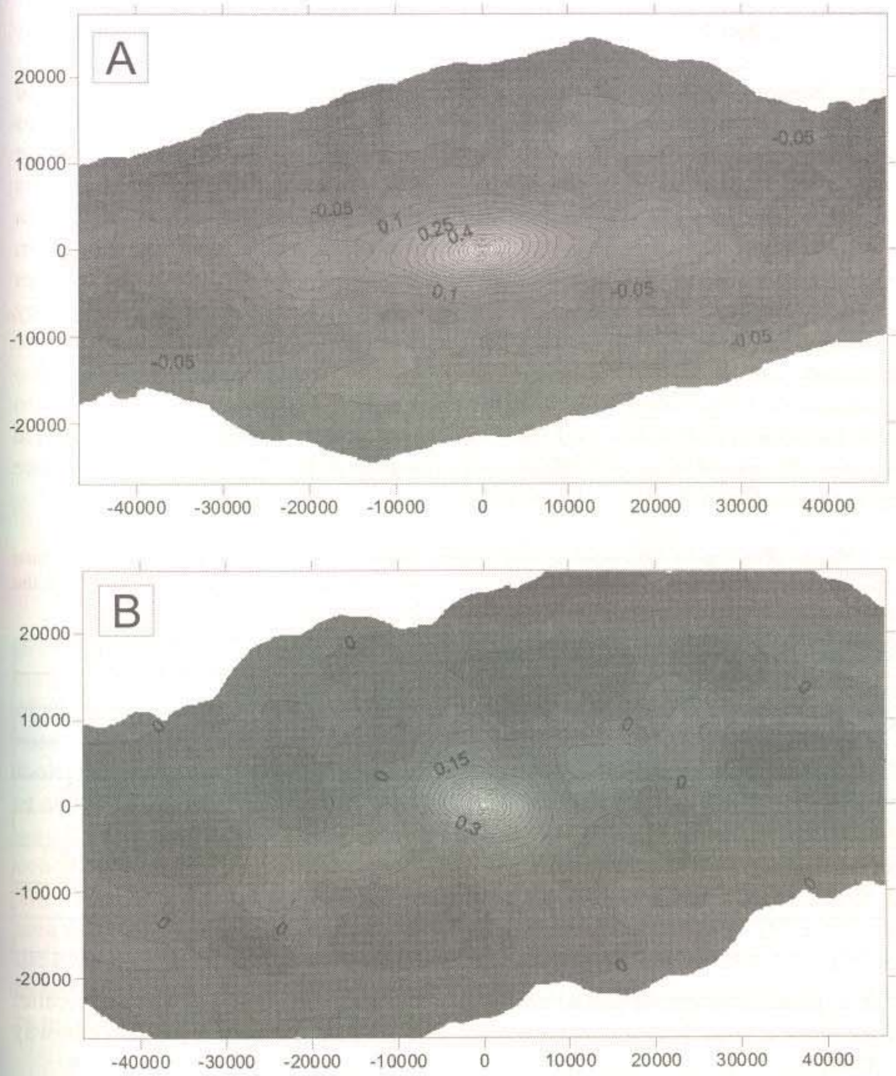


Fig. 5 Autocorrelation analysis of the relief of the Magura and Silesian nappes within the area of the Western Beskydy Mts. **A** – correlogram of the Magura nappe, **B** – correlogram of the Silesian nappe

of the nappe and the direction of fold axes. The Silesian nappe appears to be rather an isotropic body with a slight supposition of anisotropy in the direction of NNW–SSE. The georelief on the body of the Magura nappe has, on the base the autocorrelation analysis, a much closer linkage to lithology and paleotectonics than the Silesian nappe. The direction of strata of sediments of the Silesian nappe is generally consistent with the direction of rocks of the Magura nappe; however, the linkage of the georelief of the Silesian nappe to the inner construction of the nappe is much smaller.

4. Results

The Western Beskydy Mts form two nappe units of the first order that are characterized by different morpholithology, paleotectonics and in some aspects also style of neotectonic forming. The differences can be distinguished both at visual study of DEM and its derivations (e.g. from the construction of correlogram) and in values of morphometric parameters calculated separately for both the Silesian and the Magura nappes. The Silesian nappe is noted for more intensive neotectonic transformation which displays generally in higher values of relief energy; the Magura nappe features a stronger erosion modification reflecting in higher values of parameters of valley networks (R_b, $N1/N$, D_d, etc.). The significance of the differences of morphometric parameters was verified by means of statistic tests. Except parametric t-test also nonparametric U test (Mann – Whitney test) was applied because it was not possible to verify the normal distribution with all observed parameters. Testing on the confidence level $p = 0.05$ proved significant differences in cases of R, R_r, H_{int} and D_d; the difference was not proved with R_b, $N1/N$, R_e and B_c (Tab. 2).

Tab. 2 Results of testing the differences of morphometric parameters between the Magura and the Silesian nappes by means of parametric t-test and nonparametric U-test. Characteristics varying significantly on the confidence level of $p = 0.05$ are marked in grey

Variables	Magura nappe	Silesian nappe	T-test	U-test
R (m)	381.75	617.25	0.0000000002	0.000000
Rr	0.06	0.1	0.0005537329	0.000038
H_{int}	0.44	0.39	0.0005857922	0.000952
Rb	4.02	3.7	0.1359770451	0.130642
$N1/N$ (%)	75.91	73.83	0.0673255792	0.114534
Dd (km·km^{-2})	2.82	2.42	0.0002531731	0.000396
R_e	0.71	0.68	0.6483000489	0.259511
B_c	1.26	1.2	0.5777909753	0.528771

It is possible to derive partial results of structural conditionality of the georelief of the Silesian and Magura nappes even from applied variance analysis (one-way ANOVA).

The aim was to answer two principal questions:

1) Is there any statistically significant difference in measurable parameters of the georelief of basins situated in different structural conditions?
2) Is there any statistically significant difference in measurable parameters of the georelief of basins situated in different lithological conditions?

The basic step to answer the first question was to classify basins according to their dominant deposition conditions. The basins were classified into *anaclinal* (situated mainly on bedding forefronts, $a = 14$), *cataclinal* (situated mainly on bedding planes, $a = 6$), *diaclinal* (cutting anticlines and synclines, $a = 16$) and *subsequent* (copying fold axes and stripes of less resistant rocks, $a = 24$). Variance with individual morphometric characteristics was calculated for each of the stated categories (Tab. 3). From the

results of one-way ANOVA we can derive that bedding conditions definitely affect only the distribution of values of hypsometric integral (H_{int}) and the density of the valley network (D_d). In cases of the other morphometric parameters there is no linkage to bedding conditions in the studied area, which can be explained by stronger activity of lithology and neotectonics.

Tab. 3 Results of one-way ANOVA for basins situated in different lithological conditions

	F	P	F_{krit}
R	2.403513	0.077102	2.769433
R_r	0.425725	0.735316	2.769433
H_{int}	3.539488	0.020269	2.769433
R_b	1.699635	0.177531	2.769433
$N1/N$	0.505623	0.679981	2.769433
D_d	3.556634	0.019869	2.769433
R_e	1.478401	0.23027	2.769433
B_c	1.150891	0.336668	2.769433

To answer the second question the studied basins were classified according to their prevailing lithology into *basins with the prevalence of resistant rocks* (sandstones and conglomerates, $A = 23$), *basins lithologically manifold* (with proportional representation of sandstones and claystones, $N = 25$) and *basins with the prevalence of little resistant rocks* (with the prevalence of claystones and clay shales, $N = 12$). The classification took place according to published geological maps of 1 : 50 000 and 1 : 25 000 (Menčík et al., 1983; Menčík and Tyráček, 1985; Pesl et al., 1991; etc.). Further, the analysis was carried out similarly to the case of bedding conditions (Tab. 4). Unlike bedding conditions, lithology affects a greater number of studied morphometric parameters. The linkage to lithological conditions is connected also with both parameters of the area gradient (R and R_r) and parameters of valley networks (R_b, $N1/N$, D_d and F_v). On the contrary, the value of hypsometric integral is not dependant on lithology. Similarly to bedding conditions, lithological conditions do not influence the characteristics of the basin shape (R_e and B_c).

Tab. 4 Results of one-way ANOVA for basins situated in different structural conditions

	F	P	F_{krit}
R	3.285736	0.044613	3.158846
R_r	4.369884	0.017153	3.158846
H_{int}	1.72928	0.186589	3.158846
R_b	3.637866	0.032591	3.158846
$N1/N$	4.026378	0.02314	3.158846
D_d	3.710963	0.030547	3.158846
R_e	0.057826	0.943869	3.158846
B_c	0.584859	0.560493	3.158846

To confirm the differences between the morphology of both the nappe units and general structural predisposition of the georelief of the Western Beskydy Mts, the studied basin were standardized by means of *k*-means clustering. The method is based on searching for and clustering of studied entities on the base of their similarity (Davis, 2002). Three clusters with specific display of morphometric parameters were determined in the studied area (Tab. 5, Fig. 6). Except for the cluster 1 their distribution is spatially influenced and basins within clusters occur in identical morphostructural conditions.

Tab. 5 Average values of morphometric characteristics for clusters created by *k*-means procedure (**A**) and their variance analysis (**B**). Significantly different characteristics for individual clusters are marked in grey

A

Variables	Cluster I	Cluster II	Cluster III
R	*544.25*	*390.56*	*654.38*
R_r	0.13	0.06	0.08
H_{int}	0.37	0.43	0.43
R_b	2.95	4.07	4.17
$N1/N$	68.68	76.62	76.27
D_d	2.73	2.85	2.13
R_e	0.68	0.72	0.66
B_c	1.71	1.19	0.96
Σ	*12*	*32*	*16*

B

	F	P	F_{krit}
R	26.22765	0.00000	3.158846
R_r	19.25705	0.00000	3.158846
H_{int}	4.690938	0.01300	3.158846
R_b	13.19484	0.00002	3.158846
$N1/N$	33.7192	0.00000	3.158846
D_d	28.66896	0.00000	3.158846
R_e	0.454533	0.63702	3.158846
B_c	24.95786	0.00000	3.158846

Cluster 3 (16 basins) contains basins that, except for three of them, lie in the area of the Silesian nappe. It concerns basins with a high value of R, R_r, H_{int}, R_b, $N1/N$ and again with low values of R_e and B_c. Values of morphometric parameters are here characteristic for areas with intensive neotectonic movements, which correspond with the position in the culmination area of the Western Beskydy Mts above the ramp of the sub-Beskydy step and in the vicinity of the tectonically active Jablunkovské fault range.

Cluster 2 (32 basins) is located, except for five basins, in the area of the Magura nappe and is characterized by low values of R, R_r and again by a high value of $N1/N$,

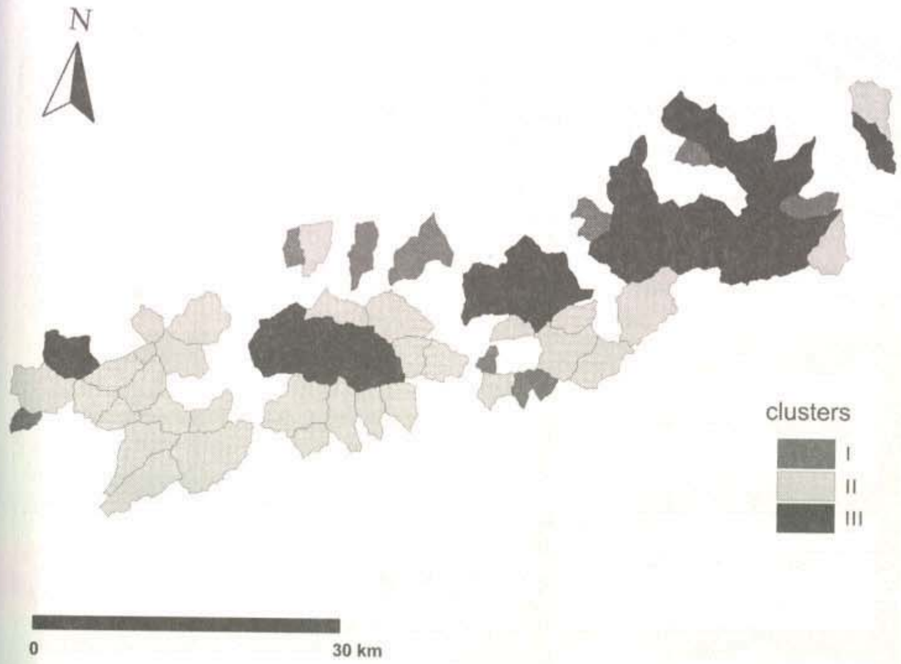


Fig. 6 Result of *k*-means clustering of basins of the Western Beskydy Mts

D_d, R_e and B_c. Values of morphometric parameters of the cluster 2 point to a weaker influencing neotectonics and to a more intensive (and evidently also effecting longer time) erosion.

Cluster 1 (twelve basins) is the most heterogeneous one as for the space. Eight out of the twelve basins can be found in the area of the Silesian nappe and They are noted for their relatively high values of R, R_r, R_e and B_c and low values of H_{int}, R_b and $N1/N$.

5. Conclusion

Morphometric characteristics can stand for a very useful supplementary source of information at morphostructural analysis of the georelief. However, their application depends on the selected criterion of elementary zones to which the characteristics are related. Mutual hierarchic comparability of quantitative zones is especially necessary. In the studied area basic differences between the main structural units building the area of the Western Beskydy Mts could be defined by means of simple morphometric characteristics. Some morphometric indicators further verified or revealed a possible dynamic morphotectonic boundary. The application of multivariate statistics proved, in general features, morphological differences of the main structurally tectonic units acquired by geomorphological mapping and made it possible to differentiate these units in detail (Fig. 7).

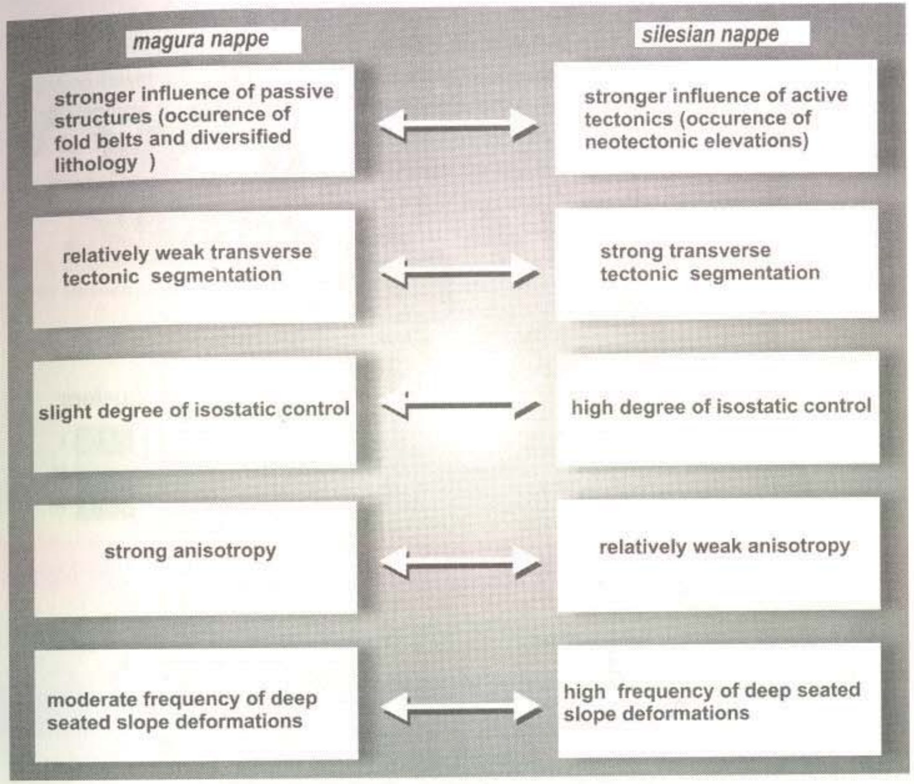


Fig. 7 Main morphostructural differences between the Magura and Silesian nappes in the area of the Western Beskydy Mts

Hypsometric–morphometric parameters and DEM analysis made it possible to define zones that within the studied area embody probable displays of young tectonic deformations. It concerns the area of the south-west marginal slope of the Hostýnské vrchy Highlands along the line of the Holešovský fault, the north marginal slop of the Vsetínské vrchy Highlands on the forefront of the Magura nappe, the watershed ridge of the Vsetínské vrchy Highlands between Vsetínská and Rožnovská Bečva, culmination northern range of the Moravskoslezské Beskydy Mts, Jablunkovské fault range with morphological displays of marginal slopes of the Moravskoslezské and Silesian Beskydy Mts and the block of the Silesian Beskydy Mts.

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THE USE OF MORPHOMETRIC PARAMETERS IN TECTONIC GEOMORPHOLOGY (ON THE EXAMPLE OF THE WESTERN BESKYDY MTS)

Résumé

Morphometric analysis belongs to strong instruments of tectonic geomorphology. The application of morphometric and statistic methods has recently been significantly simplified by the availability of DEM and GIS technologies. Morphometric parameters can be together with the analysis of morphostratigraphic levels, measurement of structural elements and terrain mapping understood as an important data source for morphotectonic analysis.

In the studied area of the Western Beskydy Mts all basins of the fourth order were analysed from the morphometric point of view. Hypsometric characteristics, characteristics of the relief energy, valley networks and basin shape were identified. Correlograms separately for the Magura nappe and the Silesian nappe were constructed additionally. By means of testing we verified a significant difference between the Magura and the Silesian nappes as for the characteristics of the relief energy, hypsometry and the density of the valley network. Concerning other characteristics (particularly the basin shape) no important differences were found between both main structures. The variance analysis proved a bigger influencing of the georelief of the Western Beskydy Mts by lithology than by older tectonics represented by bedding conditions of rocks. A different structural situation and morphostructural building of the area mapped earlier were to a great extent proved also by applied k-means clustering.