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LANDFORM EVOLUTION IN MOUNTAIN AREAS

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GENERAL ASPECTS OF DENUDATION CHRONOLOGY OF THE WEST CARPATHIANS

Abstract. We outline relevant methodical approaches for the revision of the West Carpathian denudation chronology. They are based on the exploitation of a new geotectonical reconstruction of Neogene evolution of the Carpathians, absolute dating methods, complex geomorphological research, quantification and modelling, which resulted in the creation of geomorphological information system. It is methodologically important to distinguish between local and regional denudation chronology too.

The general character of the West Carpathian denudation chronology is determined by tectonic and climatic conditions, which are homogenous in the majority of the West Carpathians for a relevant time period. This homogeneity has, as a rule, a characteristic trend in space and time. The period of extensional tectonics in Badenian–Pannonian (Kováč 2000) is the example, with which we connect the creation of the polygenetic initial flat surface of the majority of the current relief — the Midmountain level. Tectonic subsidence is generally a key factor for the explanation of planation in tectonically active regions. We consider the W–E and S–N shifting of the denudation phases in the West Carpathians to be in harmony with this geotectonic influence.

The existence of three generations of Neogene planation surfaces is documented at two locations in the west and central Slovakia. The contribution to the identification and dating of recent tectonic movements (site Devínska Kobyla — Bratislava) and to the dating of the youngest West Carpathian volcanism (site Putikov Vŕšok near town Nová Baňa) are shown in these examples too.

Key words: denudation chronology, geomorphological mapping, planation surface, geomorphological evolution, West Carpathians

INTRODUCTION

Decreasing interest is devoted to denudation chronology in geomorphology. Development of methods of absolute dating rightfully focuses the attention of geomorphologists, however methods of relative dating of land surfaces (stratigraphy, denudation chronology) are still relevant (Watchman and Twidale 2002). Denudation chronology is an inherently geomorphological manner of dating. Spatial relationships among landforms have essentially similar informational power, as do relationships among rock layers. Nobody doubts the value of stratigraphy in geosciences, however denudation chronology does not have such high status. J. Whittow (1984) wrote: “Unless methods of absolute dating or pollen analysis are adopted, denudation chronology must remain a rather subjective and speculative exercise rather than a scientific study”. Certainly, scientific denudation chronology must be linked with methods of rock dating. Knowledge of the ages of base rocks, regoliths or correlated deposits are necessary conditions for the scientific conceptualisation of denudation chronology. However, spatial relationships of landforms (the basis of denudation chronology) give unique chronological information in connection with stratigraphy and absolute dating.

The West Carpathians are an autonomic part of the Carpathian chain with specific geotectonic and morphological evolution. The solution of problems connected with the surfaces of planation and denudation chronology has a long and rich tradition in the region (in detail see Bizubová 1993). In the first half of the 20th century the concept of abrasion represented the first mainstream of ideas related to the genesis of the West Carpathian's planation surfaces. This concept represented the opinion that levels in mountains and in the intramountain basins of the West Carpathians are the remains of abrasion terraces of the oscillating Neogene sea. The main proponent was H. Hassinger (1914). His ideas were developed primarily by J. Daneš (1920), F. Vitásek (1932), V. Dědina (1922), and J. Hromádka (1929). M. Lukniš (1964) admitted the existence of abrasion levels on the western slope of the Malé Karpaty Mountains too.

Advocates of the second mainstream of ideas — denudation conception — assumed planation in the subaerial conditions as well as a big influence from neotectonics and changes of the base level. The first of them, L. Sawicki (1909) expressed the opinion of denudation genesis of levels of the West Carpathians. These ideas were developed by many authors; J. Smoleński (1911), F. Machatschek and M. Danzer (1924), J. Moschelesová (1923), L. Dinev (1943), M. Klimaszewski (1934, 1965), M. Lukniš (1962, 1964), E. Mazur (1963, 1965), T. Czudek et al. (1965), and L. Starkel (1965, 1969).

The scheme of denudation chronology of the West Carpathians, which was for many years been the basis of studies of Slovak georelief, was presented in the 1960's by M. Lukniš and E. Mazúr. Though the authors published their result individually, a mutual influence was evident. They assumed simultaneous evolution in the entire territory of the West Carpathians, but they had a different opinion on the age of the planation surfaces. M. Lukniš (1962, 1964) considered two generation of planation surfaces — the older from the Sarmatian–Pannonian age and the younger from the Late Pliocene, as a pediment 70–150 m above present river valley bottom. M. Lukniš later shifts the age of the younger level to the Mindel–Riss integlacial and considers the existence of older surfaces, exhumed from Paleogene sediments or volcanic rocks. E. Mazúr (1963, 1965) considered the existence of a third generation of planation surfaces. The Top level, which was formed by processes of subaeric destruction after Styerian phases, is the oldest

(Tortonian and Early Sarmatian). The Midmountain level was placed in the Pannonian. It is a supposed pediplane with large regional extent. The River level originated in the Late Pliocene and was formed by lateral river erosion as well as by parallel retreat of slopes. E. Mazúr's concept employed the correlation between levels, filling of the intramountain basins and phases of tectonic processes and was the basis for regional geomorphological research in Slovakia until of 1990's.

Eleven years ago, we introduced a new point of view on the planation surfaces question, on the basis of new geological and geomorphologic facts (Bizubová and Minár 1992). In comparison with E. Mazúr (1963), we assumed longer formation of the Midmountain level and stressed the time-space dynamics of planation surfaces formation (W–E and S–N shift of principal stages in time) as well as an existence of more unfinished geomorphologic cycles, one from which results in the Undermidmountain level (Zaťko et al. 1990) — likewise as M. Klimaszewski (1965) and L. Starkel (1965) recognised for the Polish Carpathians a long time ago. The mechanism of the formation and age of planation surfaces, their relationship to the geodynamic evolution of the West Carpathians and the question of simultaneity of the West Carpathian evolution has become a subject of discussion recently. W. Zuchiewicz (1987) emphasized the problems of defining the time and spatial characters of the surface planation in the Polish Carpathians. He mentioned asynchronous evolution of the West and East Carpathians. We have pointed out asynchronous evolution of georelief in the Outer and Inner West Carpathians (Bizubová 1998). J. Činčura (1998) prefers the origin of planation surfaces before Neogene. J. Urbánek (2002) challenges the existence of a uniform initial surface of the West Carpathians (the Midmountain level).

Criticism of the schematic approach to West Carpathians denudation chronology is well founded. Regional denudation chronology expresses the trend, which can be changed in space and time and deformed or fully masked by local factors. Smaller landforms are influenced predominantly by local factors, but within the framework of regional influences. Knowledge of the regional framework contributes to the solution of local denudation chronology problems, which are very important for detailed geoecological research, natural hazards and risk evaluation and estimation of ecological stability or carrying capacity. On the other hand the regional conceptions have to be conceived and confirmed on the basis of detailed local studies.

MATERIAL AND METHODS

The speculative character of denudation chronology is generally regarded as its biggest weakness. It is a consequence of limited accessible information and subsequently its main characteristic method — abduction. Abduction (reverse deduction) combines the resulting state of affairs (B) with a law (L) to infer the controlling state of affairs (A) (Rhoads and Thorn 1993). Uncertainty of various inferences increases with the age and area of the study object, and together decreases the possibility of quantification. Corroboration of the inferences is consequently very often problematic. However, if the inferences create a logical system then their credibility rises with the number of system elements and their mutual connections. This is the way to create more credible denudation chronology.

Ergo, the regional scheme of denudation chronology should reflect the maximum of the available facts and information and their mutual relations. The traditional scheme of the West Carpathians denudation chronology was created on the basis of a whole spectrum of contemporary methods and information (study of territorial differentiation of planation surfaces, analysis of regolith, truncated rocks, correlated sediments or paleoclimatic and neotectonic reconstructions). Possibilities of morphological interpretations are at present extended by modern plate tectonic reconstructions (Kováč 2000), which are based on modern dating methods (radiocarbon, uranium series and argon dating, fission track dating, paleomagnetism and oxygen isotope ratios, electron spin resonance) and another geophysical, geochronologic, volcanologic, paleomagnetic, structural and sedimentological data. Reconstructions involve description and explanation of reasons of movement and rotation of the West Carpathians block as well as characteristics of tectonics in time and space.

An inherent potential of geomorphology for the solution of denudation chronology problems lies in the quantification of used methods, in respect of the hierarchical nature of georelief, in system approach and in effective use of models and modelling. All these aspects led to the creation and use of the geomorphological information system, which is the most powerful instrument for the formation of denudation chronology. Complex geomorphological mapping on the basis of the elementary landforms concept (Minár 1995) is a suitable basis for creation of such system. The elementary landforms are exactly geometrically defined elementary parts of georelief, which are characterised by roughly constant values of altitude, or some from altitude derived morphometric parameters (slope, aspect, curvatures etc.). The geometrical homogeneity is a consequence of their genetic homogeneity and age homogeneity, as well as a condition for the homogeneity of recent geomorphic processes in the elementary landforms. Mapping of the elementary landforms requires the harmonization of various genetic, geometric, dynamic and chronologic information not only for individual elementary landforms, but also for their spatial and hierarchical structures. A strong basis for the creation and verification of local and regional denudation chronology conceptions is created in this way.

We treat as fundamental the separation of regional and local denudation chronologies from the point of view of methodology and interpretation. Local chronologies make elemental constructional components for regional chronology, which is made by their generalisation, whereas regional denudation chronology has to be only a working hypothesis in the process of the creation of local denudation chronologies. Some of the methods and information sources have similar importance for both, others are more significant for one, or the other (Fig. 1).

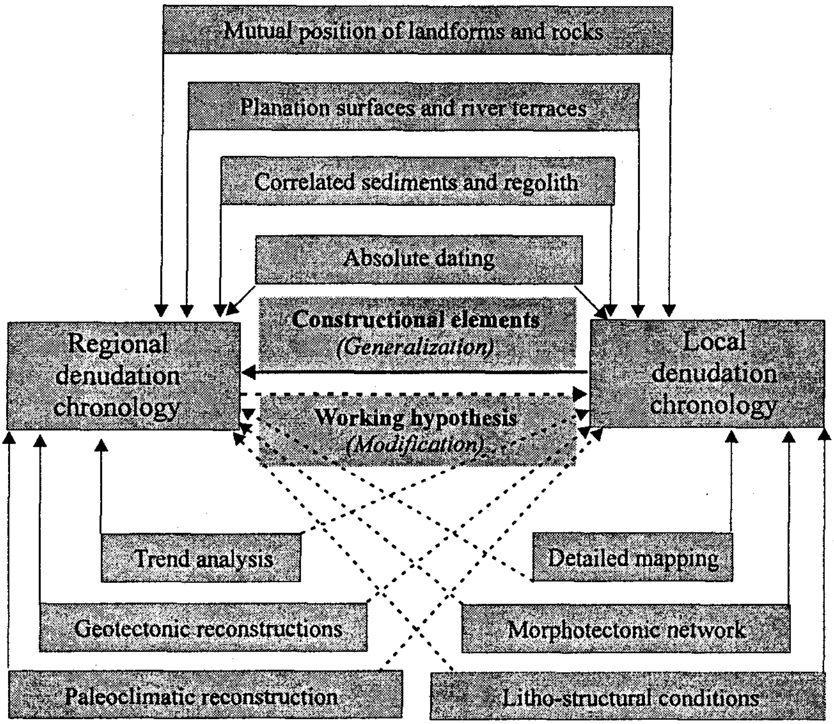


Fig. 1. Methods and information sources of regional and local denudation chronology and their relationships

GENERAL OUTLINE OF THE WEST CARPATHIANS DENUDATION CHRONOLOGY

The absence of full area, systematic geomorphic mapping and functional geomorphological information system are the main barriers to the creation of modern regional denudation chronology of the West Carpathians. However, accumulated new geomorphological and geotectonical knowledge has enabled the modification and appendage of traditional conceptions of the West Carpathians denudation chronology so that the modified conception can be used as a working hypothesis for the creation of local denudation chronologies and a generally acceptable regional chronology of the West Carpathians.

Our initial revision of the West Carpathians denudation chronology (Bizubová and Minár 1992) was based on strictly defined tectonic phases. But

Table 1

Correlation of geotectonic events (after Kováč 2000; Davidson 1997), paleogeographical reconstructions (after Planderová et al. 1992; Vass 1989) and the West Carpathians (W. C.) relief development. A hypothetical generalization of planation trends is expressed in the last two columns: the number of letters 'I' indicates assessed available relief, decreasing number of 'I' signals possible stages of planation, with their time shifting in W–E direction (penultimate column) and N–S direction (last column)

Age (Ma)	Stage (regional)	Global geotectonic	Regional geotectonic	Paleogeographical reconstruction	Morphological consequence	Available relief W ↔ E		Available relief S ↔ N	
19		Early Miocene compressional pulse	Collision with European platform → compression and eastward extrusion of W. C.	Climate cooling, culmination of basins sedimentation rate (shifted from W → E)	Folding, nappe removal of Outer W. C., tectonic uplift of Inner W.C.	IIIIII	III	IIIII	I
						IIIII	IIII	IIIII	II
	Ottnangian					IIII	IIIII	IIIIII	III
						IIII	IIIIIII	IIIIIII	IIII
17.5			Retreat of subduction and its roll back effect → stretching and NE–SW extension, final nappe pushing (west) → compression	Different climate, varied sediments (from conglomerates, sands to clays)	Uplift on the north and west, subsidence of south periphery of W. C. Rise of marine and lake basins	IIIII	IIIII	IIIIII	IIIII
						IIIIII	IIIII	IIIIIII	IIIII
	Karpatian					IIIII	IIII	IIIIII	IIIIII
						IIIIII	IIII	IIIIIII	IIIIII
16.5						IIIII	III	IIIIII	IIIIIII
						IIIIII	IIII	IIIIII	IIIIIII
	Badenian	Mid Miocene compressional pulse?	Accelerated subduction → NW–SE (west) and E–W (east) extension, final nappe pushing (east) → compression	Sudden deepening of basins, its continuous shallowing, high dynamic of depth and sediments character	Rise and forming recent pattern of basins. Volcanism and planation shift from west to east	IIIII	IIIII	IIIII	IIIII
						IIIII	IIIIII	IIIII	IIIII
13.6						III	IIII	IIII	IIII
	Sarmatian					IIII	IIIII	IIII	IIIII
						III	IIIII	IIII	IIIII
			Finish of subduction → fade out of extensional phase → fade out of basins subsidention, S–N extension (east), compressional events	Shallowing of basins, soft grained sedimentation, kaolin weathering crusts	Fade out of volcanism and vertical tectonic differentiation → Midmountain level (from SW to NE)	II	IIII	II	IIIII
11.5						I	III	I	IIII
						II	III	II	III
	Pannonian					I	II	I	III
						I	I	I	III
7.1						II	I	I	III

Age (Ma)	Stage (regional)	Global geotectonic	Regional geotectonic	Paleogeographical reconstruction	Morphological consequence	Available relief W ↔ E		Available relief S ↔ N	
	Pontian		Rising thrust of Adriatic plate on W. C. (without compensation by subduction) → N–S compression and tectonic inversion in basins → compressional regime with shortening terms of relative tectonic calm	Hiatus in the west (shifting eastward)	Cutting of planation surface (from W to E)	III	I	II	IIII
						III	II	III	IIIII
				Warming, local kaolin weathering	Undermidmountain level? (from S to N)	II	II	II	IIII
5.3		Pliocene– –recent compressional pulse (less active period)				II	II	II	III
	Dacian			Coarse grained sediments, distinct cooling	Tectonic uplift → forming of W. C. dome (mainly central part), cutting of planation surfaces	III	III	III	IIII
						IIII	IIII	III	IIIII
						IIIII	IIIII	IIII	IIIIII
3.3						IIIIII	IIIIII	IIII	IIIIIII
	Romanian	Pliocene– –recent compressional pulse (more active period)				IIIIIII	IIIIIII	IIIII	IIIIIII
				Cooling, presence of kaolin weathering	River level (from S to N)	IIIIII	IIIIII	IIII	IIIIIII
						IIIIII	IIIIII	IIII	IIIIII
1.8				Rapid cooling, disappear of overflowed lakes	Cryoplanation, river terraces. Tectonic uplift → Forming of W. C. dome, cutting of planation surfaces	IIIIII	IIIIIII	IIIII	IIIIII
	Quaternary					IIIIIII	IIIIIIII	IIIII	IIIIIII
						IIIIIII	IIIIIIII	IIIIII	IIIIIIII
						IIIIIIII	IIIIIIIII	IIIIIII	IIIIIIIII
0						IIIIIIIII	IIIIIIIIII	IIIIIIII	IIIIIIIIII

the latest geotectonic reconstructions (Kováč 2000) break away from it and stress a continuity of tectonic development. So space for the formation of planation surfaces is seemingly reduced. However, the improved localisation and explanation of the phases of tectonic compression and extension in space and time enables us to look for a dynamic explanation of planation process and explain other significant characteristics of the West Carpathians landforms too.

Table 1 correlates the main geotectonic events (Kováč 2000; Davidson 1997), paleogeographical conditions (Planderová et al. 1992; Vass 1989) and their probable morphological impact in the West Carpathians. The neotectonic uprising of the West Carpathians is possibly connected with the Early Miocene global compressional pulse (Davidson 1997). Regionally this resulted in the collision of the Alpaca lithospheric block with the North European platform, which caused the compression of the West Carpathians and their eastward extrusion. Consequently the retreat of subduction in the front of the North European platform caused the roll back effect and the tectonic stretching and extension of the territory (Kováč 2000). The rise of marine and lake basins not only on the periphery but also within the West Carpathians is evidence of subsidence tendencies connected with the extensional regime. The coincidence of the main directions of reconstructed extension (Kováč 2000) with the planview of the spurs of the Pannonian basin and intramountain basins confirm this implication. Therefore the depth of the Neogene bases in the basins can generally signalise the intensity of the subsidence tendencies (Fig. 2).

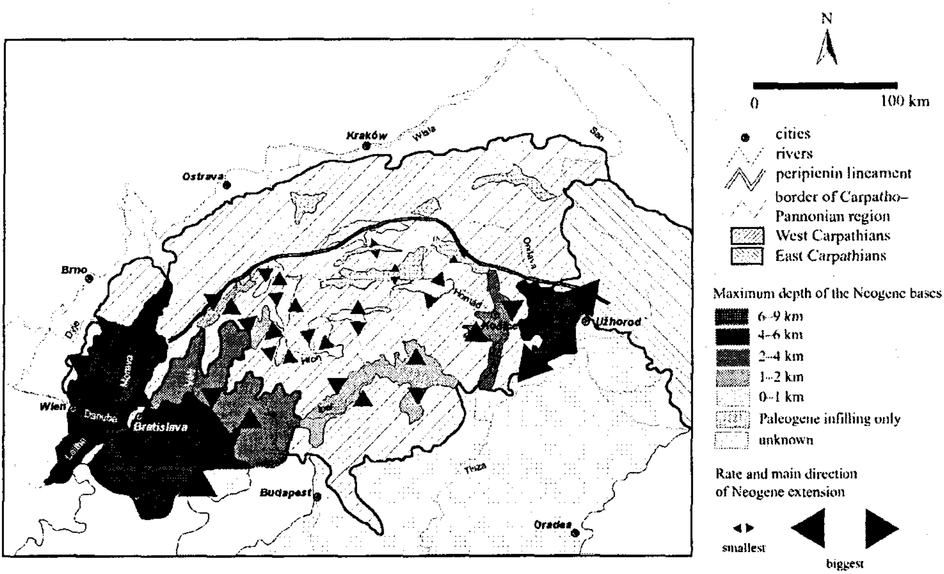


Fig. 2. Depth of the Neogene bases in the basins of the West Carpatho–Pannonian region and the rate of the Neogene extension (with utilization of information from Kováč 2000)

Tectonic subsidence plays a crucial role in our explanation of the origin of the Pannonian Midmountain level (Mazúr 1963, 1965), or the initial Sarmato–Pannonian surface (Lukniš 1962, 1964), which has a key position in the West Carpathians denudation chronology. It is problematic to explain the origin of this surface by a simple pediplanation process in the framework of mobilistic geotectonic conceptions. We created a hypothesis of planation in tectonically active regions and the final flat surface we named tectoplain (Minár 2003). The tectoplain is a polygenetic (denudation–accumulation), stepped flat surface rapidly formed under conditions of prevailing extension and subsidence tectonics. Its rapid rise is due to the tectonic subsidence of a part of a block below the base level, rapid retreat of fault slopes, expansive abrasion during a transgressive regime, local sediment deposition that together with tectonic erosion eliminates isostatic compensational uplift (Fig. 3). The majority of the surface probably has the character of a pediplain and accumulation planes but it also includes abrasion terraces, older subsided planation surfaces, exhumed surfaces or stripped plains. Dominance of erosion and accumulation over the local tectonic differentiation is the basic condition of tectoplain formation (Fig. 4).

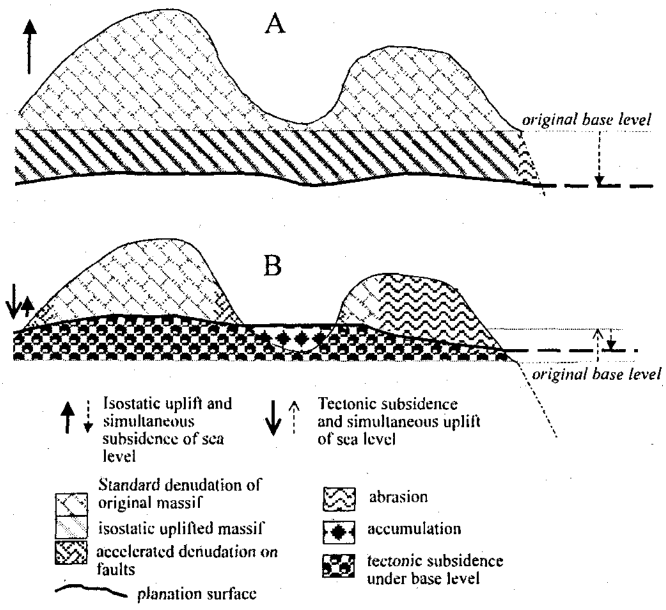


Fig. 3. Tectonically induced planation effect (B) in comparison with standard planation (A). A — Denudation processes have to remove not only the mass of the initial mountains, but also the mass of rocks uplifted above the see level by compensating isostatic rise. The planation effect of abrasion in a regressive regime of the sea is low, B — Tectonic subsidence caused by an extensional tectonic regime can exceed the effect of compensative isostatic rise, which is reduced also by retention of sediments in the local depressions. Sea transgression markedly enhances the effect of abrasion, and denudation on active fault lines is accelerated. Accumulation in depressions subsided under base level and subsidence of part of the initial mountains under the base leads to more rapid planation too

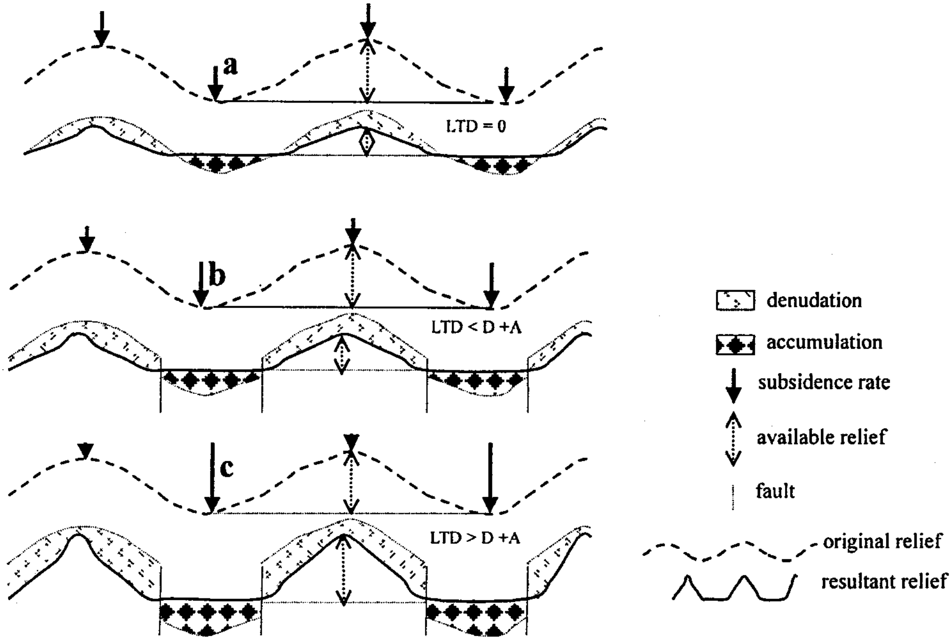


Fig. 4. Influence of relationship between local tectonic difference (LTD), denudation (D) and accumulation (A) to planation of tectonic subsiding surface. a — The area subsides as a block without local tectonic differentiation › the high planation effect (available relief is decreasing rapidly), b — The area is differenced on the tectonic blocks with various rate of subsidence, but growth of available relief caused by tectonics is exceeded by planation effect of denudation and accumulation › reduced planation effect (available relief is decreasing slowly), c — As b), but growth of available relief caused by tectonics exceeds planation effect of denudation and accumulation › no planation effect (available relief is increasing)

The Midmountain level could have been formed in the extensional tectonic phase after the final nappe pushing in the Outer West Carpathians. The process was in accordance with the character of tectonics; most intensive on the south and fading out northwards (in the Outer Carpathians) and simultaneously the planation shifted from the west to the east. The plane surface achieved maximum extent in the Late Miocene (Pannonian in the west and Pannonian–Early Pontian in the east) at the time of tectonic inversion and formation of the new compression regime.

The Pliocene — recent global compressional pulse has, according to J. K. Davidson (1997), increasing intensity in the Late Pliocene and Quaternary. It seems that the rising thrust of the Adriatic plate on the West Carpathians, without compensation by subduction (Kováč 2000) is in line with this tendency. Therefore we suppose an existence of times of relative tectonic calm in the Pontian and Late Pliocene (up to Early Quaternary) during which were formed pediments of the Undermidmountain and River levels. Naturally, the question of temporal and spatial differentiation of the origin of the pediments is opened. A system of Quaternary cryoplanation surfaces and river terraces creates the last element of the general scheme of the West Carpathians denudation chronology.

EXAMPLES OF LOCAL DENUDATION CHRONOLOGY

The general outline of the West Carpathians denudation chronology has to be (according to our propositions) synchronized with the results of local morphochronological studies. The local denudation chronology moreover brings new specific information. Therefore we notice two small examples of such results, which were obtained on the basis of detailed, complex geomorphological research.

The Devínska Kobyla is a part of the Malé Karpaty Mountains above of the confluence of the Danube and Morava rivers. The result of detailed complex geomorphological research of the territory is published in a map of scale 1 : 10,000 (Minár and Mičian 2002). On the boundary between the Carpathians and the Vienna basin a system of three Neogene planation surfaces (the Midmountain, Undermidmountain and River level) and a system of Quaternary river terraces with the cryoplanation glacis at the same altitude as the oldest Early Pleistocene terraces, has evolved (Fig. 5). The site is in very good condition for dating planation surfaces as they truncate (or are covered by) rocks of various age (Scheme 1). The Midmountain level truncates Mesozoic, but also Badenian and Sarmatian sediments, in addition the Undermidmountain level is situated on the Pannonian sediments and the River level site directly above the oldest Quaternary terraces. The situation is thus fully in harmony with our general outline of the West Carpathians denudation chronology. A local peculiarity is the occurrence of the exhumed abrasion surfaces (terraces), which can be integrated to any of the planation surfaces. Moreover, a local morphochronological study in this case also brings very interesting neotectonic conclusions. Two systems of morphotectonic framework were identified. On the basis of the age of the youngest faulted surfaces, the time of the last tectonic movements was specified. Significant horizontal movement (some hundreds of meters) during the Late Pleistocene or Holocene was identified in this way, which is extremely important from the point of view of the seismic hazard estimation of the very rapidly developing periphery of Bratislava.

The results of detailed geomorphological research in the middle Hron river region (Zaťko et al. 1990; Minár 1995) are our second example (Fig. 6). Three easily datable Neogene surfaces of planation have been identified here too. The age of the Midmountain level generally determines the age of truncated volcanic rocks — the Sarmatian andesites (Lukniš 1962, 1964). The position of the youngest Sarmatian lava flows in the central part of the Pohronský Inovec Mountains only some dozens of meters above the Midmountain level and a harmony of the

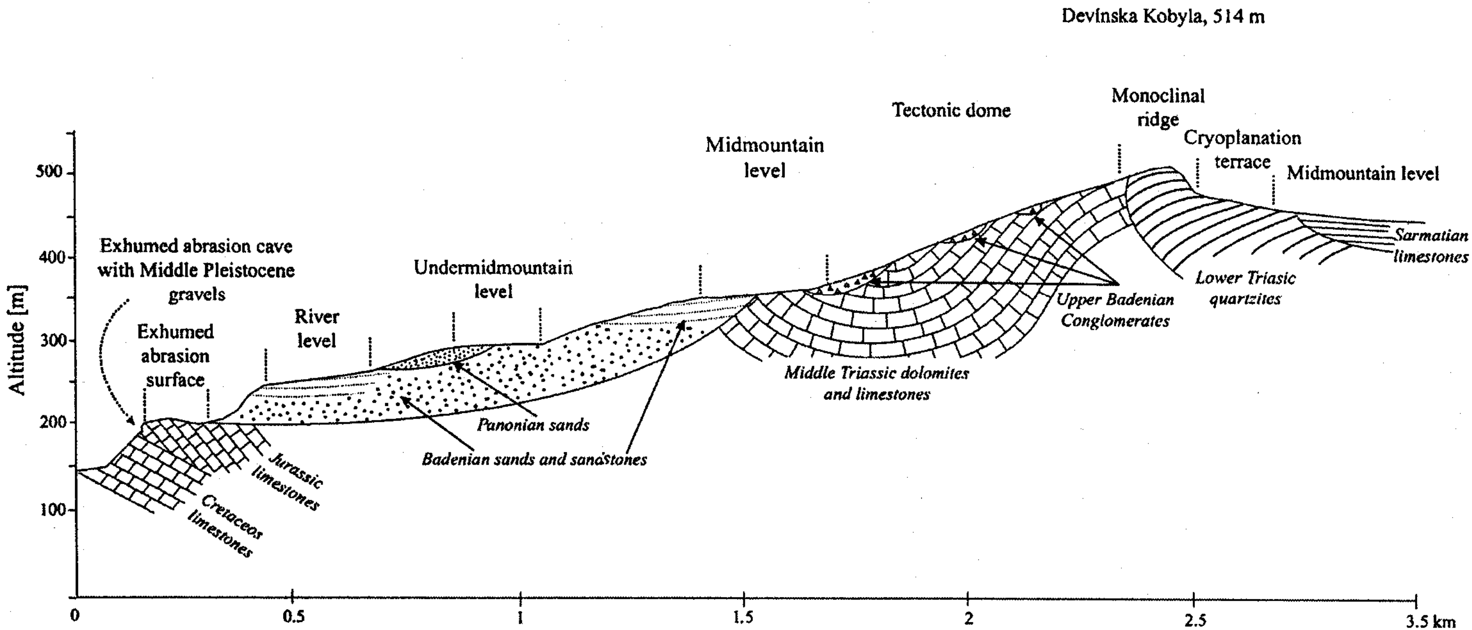
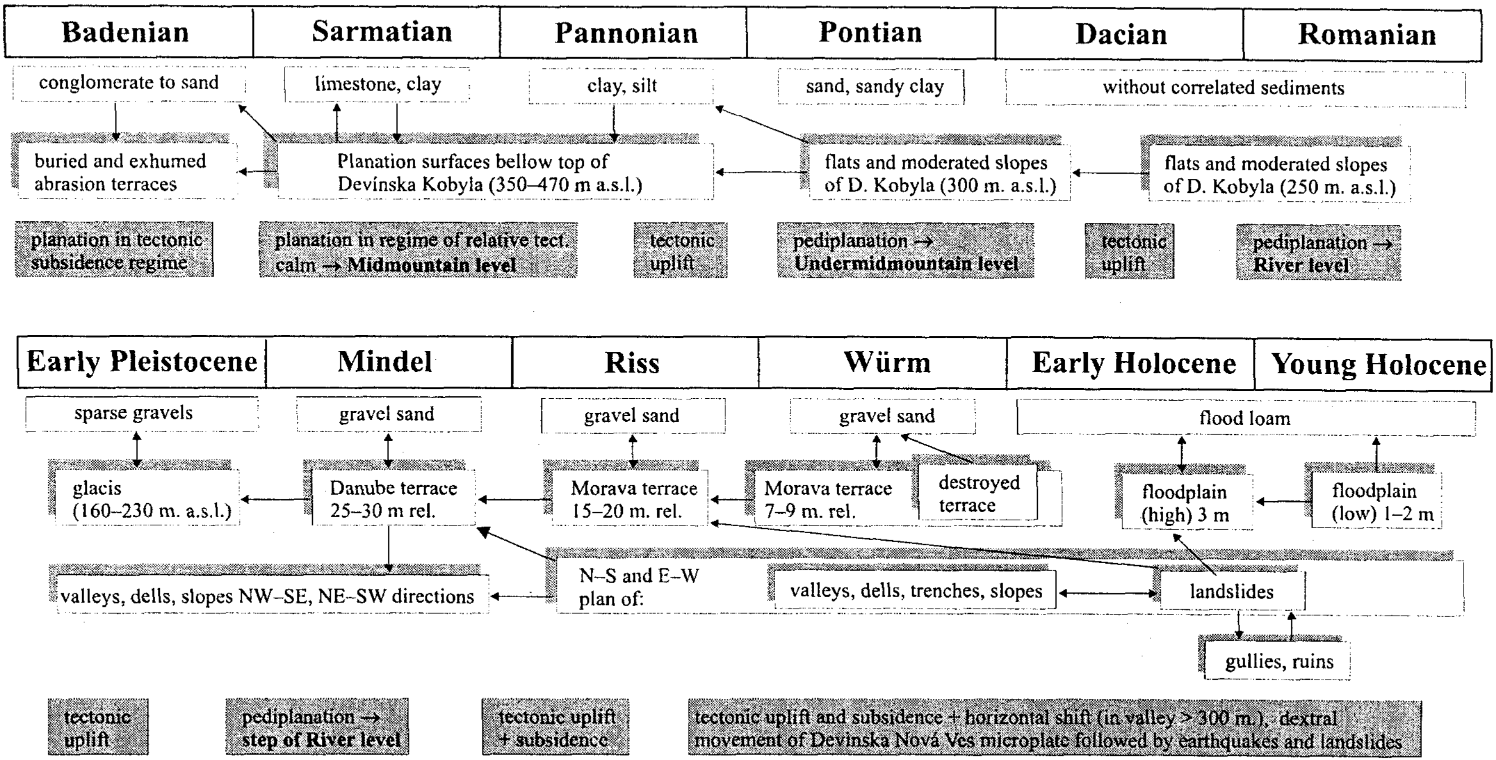


Fig. 5. Cross section across Devínska Kobyla. Sources: Vaškovský et al. 1988; Kováč et al. 1991; Minár and Mičian 2002



Scheme 1. Chronological morphosystem scheme of part of Bratislava — Devínska Nová Ves (the arrows point away from younger forms or rocks to older forms or rocks, which determined them chronologically, bidirectional arrows express contemporaneous origin)

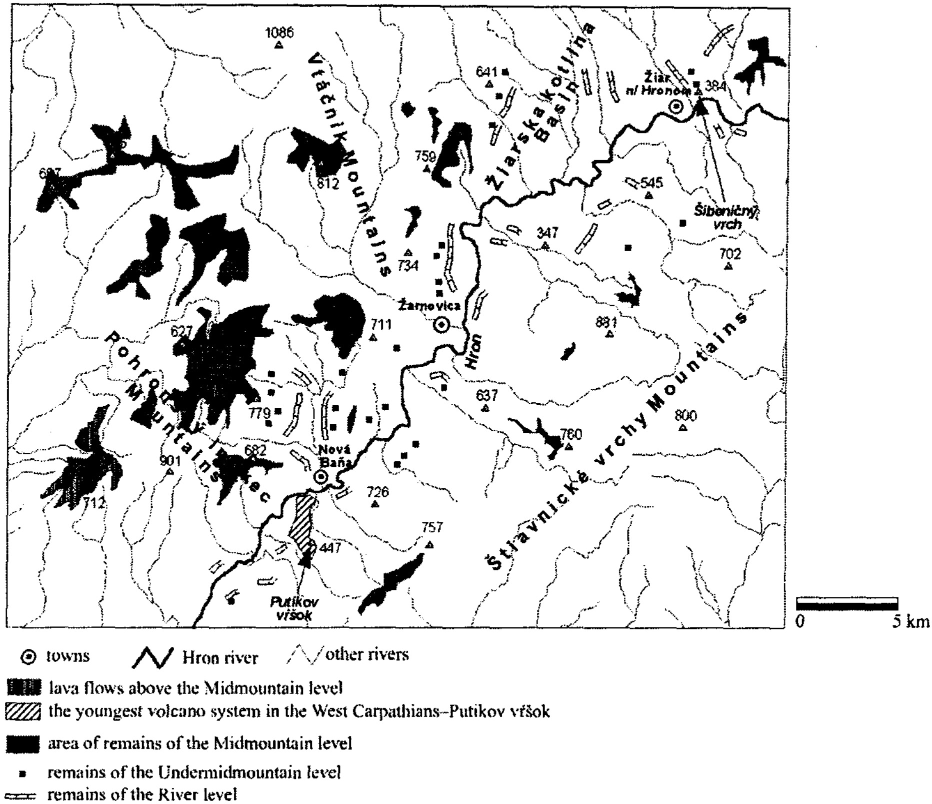


Fig. 6. Situational map of the middle Hron river region

lava flows' lamination with surface slope suggest, that lava flows were flowing to the valley bottoms, which were the base level for the formation of the Midmountain level. It is in agreement with the idea of the Sarmato–Pannonian age of the Midmountain level (L u k n i š 1962, 1964).

An existence of two steps (pediments) above the river terraces is visible in the Hron valley, mainly at the edge of the Žiarska kotlina Basin. While the lower step is a direct continuation of the highest river terraces (consequently it is the Late Pliocene–Early Pleistocene age), the higher step is partly covered by the "Hron gravels formation", which is dated from the Pliocene to Early Pleistocene. Considering the Late Pannonian age of some base basaltic rocks (e.g. the flat top of the Šibeničný vrch near the town Žiar nad Hronom), the higher step can have been created in the Pontian–Pliocene period and therefore can be a fragment of the Undermidmountain level.

The dating of the youngest West Carpathians volcanism (volcano "Putikov vŕšok" near the town Nová Baňa) is an excellent example of effective utilization of the local denudation chronology in this territory. Repeated dating by direct methods did not bring adequate results. The standard Ar–K dating method showed a value below the detectability limit of the method (0.4 Ma), or a value near it (0.53 Ma) (Šimon and Halouzka 1996). The latest dating attempts by Ar–Ar method give ambiguous results too (L. Šimon — personal communication). The set of following geomorphic indicators enabled us (Zaťko et al. 1990) to specify the age of volcanism to the Riss–Würm interglacial, at most to the Early Würm (1.3–0.6 Ma). The main evidence is the position of the lava flow base at the level of the recent floodplain, which is at the same level as the base of the lowest (Würm) terrace. Other evidence represents the character of the cross section and longitudinal profiles of the valleys influenced by volcanism, shallow undeveloped periglacial dells on the lava flows, or the freshness of the cinder cone form.

CONCLUSIONS

We suppose, that despite doubts about the regional West Carpathians denudation chronology, this is the chance to find its modern face today. On the one hand it requires respect of the new geotectonic reconstruction and results of modern methods of geological dating, the creation of the complex geomorphic information systems based on the detailed research and mapping, quantification and modelling. On the other hand, the regional denudation chronology has to be more flexible, not static; it must respect an existence of the temporal and spatial trends and results of the local denudation chronology studies. Local studies would take priority as a result of a more reliable information base, and their greater interpretative possibilities. Local denudation chronology can be a powerful tool for dating in the cases where absolute dating methods fail, or are problematic. It can contribute to the evaluation of natural hazards and risks, as well as to the understanding of the behaviour of complex geosystems.

The outlined conception of the general denudation chronology of the West Carpathians arises from older and for a long time generally accepted conceptions (Klimaszewski 1934, 1965; Lukniš 1962, 1964; Mazúr 1963, 1965; Starkel 1965, 1969; Czudek et al. 1965). However, these conceptions vary by more details (number, age and genesis of surfaces of planation) and mobilistic geotectonic theory now puts into question some starting points of these conceptions (e.g. time of relative tectonic calm needed for creation of the Midmountain level as a pediplain). The stratigraphic position of planation surfaces have to be revised continuously with the development of geological dating. We have attempted to show that the harmonization of older conceptions with the latest regional geotectonic theory (Kováč 2000) is possible. New data confirms and gives more precision to some of the older conceptions and can be an arbiter between them. We can summarize the more important conclusions follow:

The regional mobilistic conception (Kováč 2000) explains regional morphotectonic differentiation, which was considered earlier in papers of E. Mazúr (1965), L. Starkel (1965) or W. Zuchiewicz (1987). We suppose generally W–E and S–N shiftings of the morphotectonic stages in the West Carpathians as a consequence of geotectonic trends.

The origin of the Midmountain level as a tectoplain is an alternative hypothesis, which explains the formation of the regional surface of planation in active orogene. It is in line with the conception of "initial surface" of E. Lukniš (1962, 1964) to which it gives a deeper geotectonic explanation.

It is suitable to consider more then one stage of partial planation in the Pliocene and Early Pleistocene in the line with M. Klimaszewski (1965) or L. Starkel (1965, 1969) but contrary to E. Mazur (1963, 1965) and M. Lukniš (1962, 1964).

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STRESZCZENIE

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OGÓLNE ASPEKTY CHRONOLOGII DENUDACJI KARPAT ZACHODNICH

Autorzy prezentują metodyczne podejście zmierzające do rewizji chronologii denudacji Karpat Zachodnich. Opiera się ona na wykorzystaniu geotektonicznej rekonstrukcji Karpat w neogenie, datowaniu bezwzględnym, kompleksowych badaniach geomorfologicznych, ujęciu ilościowym i modelowaniu poprzez zastosowanie geomorfologicznego systemu informacji. Należy też rozróżnić metodologię badań chronologii denudacji w skali lokalnej i regionalnej.

Ogólny charakter chronologii denudacji Karpat Zachodnich jest określony przez warunki tektoniczne i klimatyczne, które były homogeniczne na większości terytorium w określonych okresach. Ta jednorodność miała charakterystyczne trendy w przestrzeni i czasie. Okres ekstensywnej tektoniki w badenie–pannonie pokazuje jak powiązać poligeniczną inicjalną powierzchnię (dla współczesnej rzeźby) poziomu śródgórskiego. Wginanie tektoniczne było istotnym czynnikiem dla tworzenia zrównań w obszarach aktywnych tektonicznie. Stwierdzono, że przesunięcia faz denudacji w przekroju W–E i S–N było powiązane z tendencjami geotektonicznymi.

Obecność trzech generacji zrównań neogeńskich jest ilustrowane dwoma przykładami: współczesnych ruchów tektonicznych koło Bratysławy (Devinska Kobyła) i datowaniem czwartorzędowego wulkanizmu koło Nowej Bany.