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MORPHOSTRUCTURES OF THE WEST CARPATHIANS OF SLOVAKIA

INTRODUCTION — INITIAL HYPOTHESIS

In the mid-sixties Mazúr (1964, 1965) interpreted the relief of Slovakia in a new way. The key concept of new interpretation was morphostructure. Big surface landforms were interpreted as active morphostructures formed due to Neogene faulting. In rather simplified way one could say that the mountain ranges were characterized as horsts and basins as grabens. The mosaics of these two contradictory morphostructures results in a "basin-like landscape" character of Slovakia. Passive morphostructures were acquired in the sense of the new interpretation secondary function. Smaller forms, tiny fillings of big forms were interpreted as passive morphostructures.

The function of Mazúr's concept in the Slovak geomorphology was changing in an interesting manner. E. Mazúr opened the problem. He conceived a new, well-grounded and meaningful hypothesis or system of hypotheses on the relief genesis of Slovakia. These hypotheses were to be verified, reformulated. Gradually they should change into statements equaling the laws. After all, it is the sense of each system of hypotheses. But something different occurred. The studies of E. Mazúr changed their function relatively soon. They lost their character of studies opening an problem and stimulating futher research. Instead, they were attributed the character of conclusive statements that had solved the problem. Instead of a system of well-grounded and stimulating hypotheses there suddenly was a petrified paradigm. Later obtained relevant knowledge has not entered the Mazúr's scheme, it neither confirmed, transformed nor denied it. The paradigm remained intact, research of morphostructures got stuck in a blind valley. We shall try to outline the process. Since the times when E. Mazúr wrote his studies many geological studies and maps have been published. It is not possible to quote and evaluate all never relevant works from the point of view of morphostructures in a short study like this. Let us mention only some of them, with evident relation to morphostructures (Fusán and Plančár 1980; Halouzka 1994;

Kvitkovič and Plančár 1975; 1977; Kvitkovič and Vanko 1990). Numerous geological structures have been considered morphostructures, without giving any convincing evidence. They are geological structures that should be put in relation to the surface forms (topographic situation), i.e. they must be interpreted as morphostructures. This interpretation was not realised in an explicit form. Such works remain outside the Mazúr's scheme, and do not influence it.

Similar position is that of the works treating the interpretation of remote sensing products (Feranec and Pospíšil 1981; Kvitkovič and Feranec 1986; Klinec et al. 1985; Feranec and Lacika 1991; Jakál et al. 1992). These interpretation schemes bring projection of dense networks of linear and non-linear dividing marks. There is no doubt of their importance for the search of morphostructures. But these dividing marks are not full value morphostructures, either. Their relation to topographic situation is not precisely assessed, the surface form manifesting in the dividing mark is not identified. There is one step missing to incorporate them into the Mazúr's scheme, which would mean its enhancement and transformation.

There are numerous older geomorphological studies treating morphostructures of a certain region actually in line with the concept of E. Mazúr (Urbánek 1966; Činčura 1969; Stankoviansky 1979). New facts supporting certain correction of the image appeared in recent Slovak geomorphological literature. Here belong the works Jakál (1975), Lacika (1989, 1993 1997), Lacika and Gajdos (1997), Lacika and Urbánek (1997), Dzurovčin (1990, 1997), Bizubová (1993), Bizubová and Minár (1992), Urbánek (1992 1993), and Harčár (1997). Nevertheless, systemic correction of Mazúr's paradigm was not accomplished.

The aim of this study is to return to original meaning Mazúr's works. It should be understood as a system of hypotheses which open and stimulate the research of morphostructures and not as a petrified paradigm. We shall try to re-evaluate the system of hypotheses and transform them in more adequate form, making use of the recent knowledge. The case is not to deny Mazúr's idea, but to deepen and revive it.

NEW HYPOTHESIS

The morphostructural plan of the West Carpathians is complicated. The character of the West Carpathians is that of a dome (described in detail by E. Mazúr) forming the opposite to the Pannonian Basin. But in the dome there is a dense network of tectonic lines. The network is distinctly differentiated. It consists of several systems different from each other by orientation of the dominating lines and the nature of differentiation among single blocks. Precisely, these systems of lines are missing in Mazúr's conception and they are anticipated

by numerous geological maps. The dome has two basic parts — the core and the periphery. The core consists of the highest mountain ranges, big highlands (the Tatry Mts, Nízke Tatry Mts, Velká and Malá Fatra Mts). The periphery consists of highlands and hilly landscapes that gradually decline southward to the lowlands. The dome is cut by a dense network of lines that differentiates the dome without disturbing it (Fig. 1).

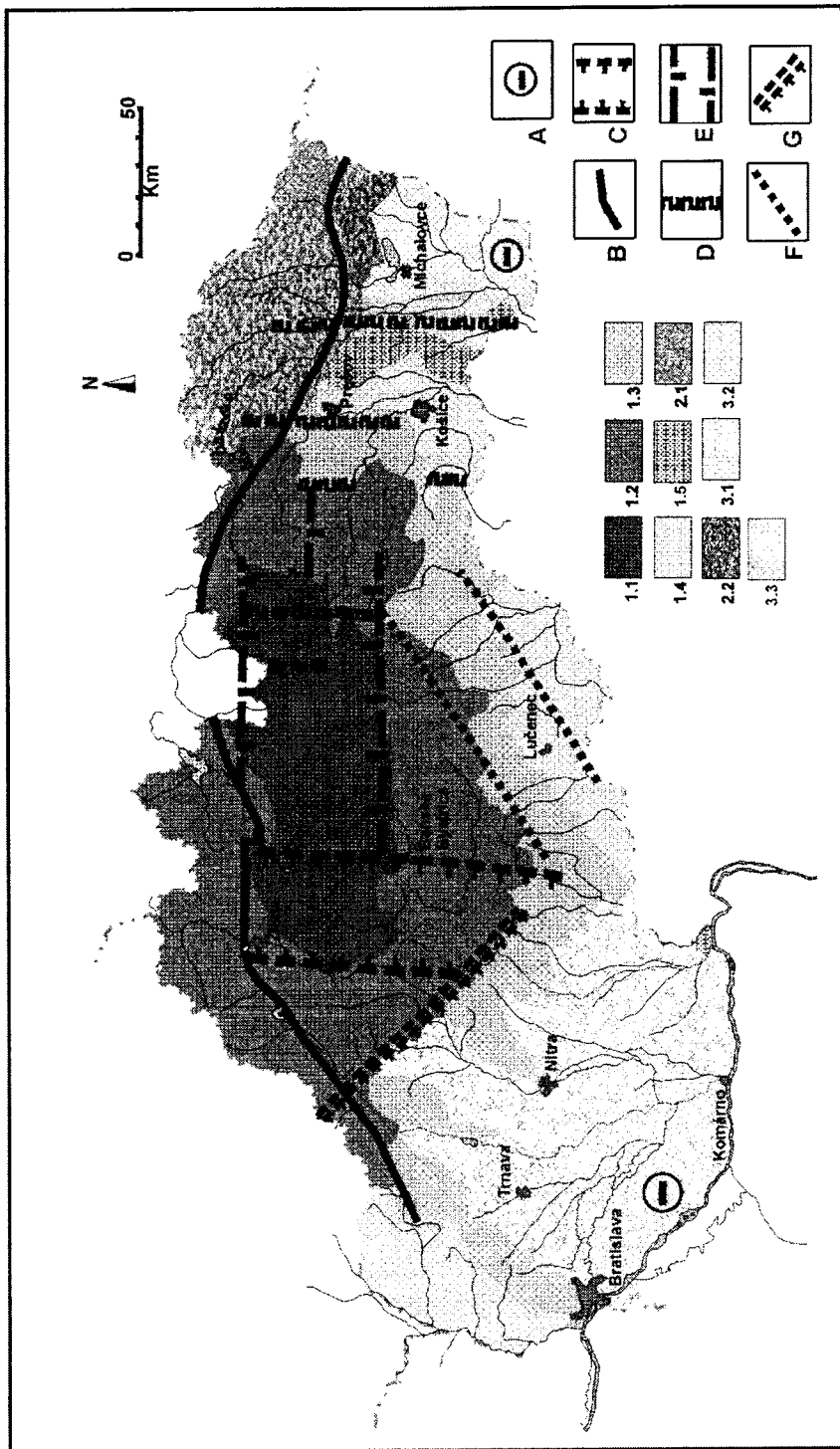
The Klippen belt should be mentioned as the first morphostructure. It is situated on deep seismoactive faults. The Klippen belt manifests itself as a long depression, in the axis of which follow strong rivers (Váh, Orava, Dunajec, Poprad, Torysa). The Klippen belt separates the outer Carpathians, with prevalence of tangencial movements, from the Inner Carpathians where the radial movements prevail. This morphostructure was described in detail by E. Mazúr.

The Central Slovakian north-south system between Žilina and Banská Bystrica runs almost across all of Slovakia. Many geological maps of the belt contain the drawings of numerous faults of N-S strike. These faults are crossing volcanic, crystalline, Mesozoic, volcanic rocks and Neogene sediments. They manifest markedly in big surface forms — in the ridges of mountain ranges, system of fazeted slopes, foothills, basins, valleys and furrows. From the morphostructural point of view these big forms are mosaic of horsts and grabens.

The shape of the Eastern Slovakian north-south system is that of a belt, whose axis passes Prešov and partially Košice. There is an agreement in geological and geomorphological compositions: geological maps show the faults in N-S strike. This strike distinctly manifests itself also in the composition of big surface forms. Similar to the central Slovakian system, there is a mosaic of basins and mountain ranges, or grabens and horsts. The system includes the volcanic crystalline-Mesozoic and flysch mountain ranges. Also the border between the Western and Eastern Carpathians or that between the Western Carpathians and the Pannonian basin lies on the lines belonging to it.

The highest mountain ranges, the Tatry Mts, Nízke Tatry Mts together with the Liptovská kotlina basin, and Horehronské podolie valley the south of the Nízke Tatry Mts, form the Northern Slovakian east-west system. As seen from the morphostructural point of view, it is a classical system of horsts and grabens. It creates the highest part of the centre of the West Carpathian dome. Moreover the elevational difference between the horsts and grabens reaches the maximum here. The western border is less distinct. The east-west morphostructure type has been formed in the Hornádska kotlina basin, foothills of the Levočské vrchy Mts and the karst region of Slovenský raj too. They end in the Branisko Mts which is a part of the eastern Slovakian north-south system.

The central, east and north Slovakian systems share a common feature. They are all the systems of grabens and horsts. This common feature differentiates them from the rest of the Slovakian territory. The notion "basin landscape",



denoting precisely the mosaic of horsts and grabens related by E. Mazúr to the whole of the Slovakian Carpathians must be then restricted to the mentioned three systems, in order to reach its full validity.

The southern Slovakian NE-SW system is approximately delimited by the Muráň fault line (Pospíšil et al. 1989) in the north and the axis of the Juhoslovenská kotlina basin in the south. Relief declines from the Muráň fault line to Juhoslovenská kotlina basin. The relief energy is considerable. But the mosaic of the clearly individualized horsts and grabens or pronounced faceted slopes is missing here. Morphostructures are different here from those in "basin landscape" of the previous three systems. The difference can not be specified as yet. But it is a problem that has influenced the Slovak geomorphology. With a certain degree of simplification one can state that the difference is expressed by the difference between the Lukniš' and Mazúr's conceptions. Mazúr's hypothesis (1963) is based on situation in Žilinská kotlina basin and its environs. Lukniš's conception (1962, 1964, 1972) is based in situation in Juhoslovenská kotlina basin and the contiguous mountain ranges. Both geomorphologists generalized results of their regional research for all of Slovakia.

The differences between the two geomorphologists should be understood as regional differences between morphostructures. Besides the duality between the outer and inner Carpathians as manifested in Klippen belt and emphasized by E. Mazúr, there also exists another duality. The Muráň line or more precisely the valley of the river Hron separates the "basin landscape" in the north from the different morphostructures in the south.

Mazúr's works present an implicitly formulated question. How and in what manner did the vertical differentiation of the basins and lowlands proceed? Was

Fig. 1. Morphostructural scheme of Slovakia: 1. West Carpathians: 1.1. Central morphostructures of West Carpathian dome, 1.2. Transitive morphostructures of West Carpathian dome, 1.3. Marginal morphostructures of West Carpathian dome, 1.4. South morphostructural depression, 1.5. South morphostructural elevation, 2. East Carpathians: 2.1. Outer zone morphostructures of East Carpathians, 2.2. Inner zone morphostructures of East Carpathians, 3. Pannonian Basin: 3.1. Záhorie morphostructures of Pannonian Basin, 3.2. Danube morphostructures of Pannonian Basin, 3.3. East Slovakian — Slovakian morphostructures of Pannonian Basin, A — Morphostructures showing maximum subsidence, B — Klippen belt, C — Central Slovakian north-south system, D — Eastern Slovakian north-south system, E — Northern Slovakian east-west system, F — Southern Slovakian NE-SW system, G — Western Slovakian NW-SE system

Ryc. 1. Schemat morfostrukturalny Słowacji: 1. Karpaty Zachodnie: 1.1. centralne morfostruktury wyniesienia Karpat Zachodnich, 1.2. struktury przejściowe wyniesienia Karpat Zachodnich, 1.3. struktury brzeżne wyniesienia Karpat Zachodnich, 1.4. południowe zapadliska morfostrukturalne, 1.5. południowe wyniesienia morfostrukturalne, 2. Karpaty Wschodnie: 2.1. zewnętrzna strefa morfostruktur Karpat Wschodnich, 2.2. wewnętrzna strefa morfostruktur Karpat Wschodnich, 3. Basen Panoński: 3.1. morfostruktura Záhorie w Basenie Panońskim, 3.2. morfostruktura Dunaju w Basenie Panońskim, 3.3. wschodniosłowackie morfostruktury Basenu Panońskiego, A — morfostruktury wykazujące maksymalną subsydencję, B — Pas Skalicy, C — system południkowy Karpat słowackich, D — system południkowy Karpat Wschodnich, E — system równoleżnikowy północnej Słowacji, F — NE-SW system południowej Słowacji, G — NW-SE system zachodniej Słowacji

it compression or tension, did uplift or subsidence dominate? A justified and adequate answer is not available yet. But it can be anticipated. The counterpoint of the West Carpathian dome are the lowlands, the Podunajská nížina lowland and Východoslovenská nížina lowland. Both areas are subject to intense tectonic sinking. Both lowlands have certain central areas with pronounced and most intense subsidence. In the Podunajská nížina lowland it is the area around Gabčíkovo (Halouzka 1994), in the Východoslovenská nížina lowland it is the area between the rivers Latorica and Tisa. The subsidence is progressively less intense proceeding towards the circumference of the lowland and the West Carpathian dome. The subsidence tendency radiating from Podunajská nížina lowland probably ends as far as in the deep seismo-active fault of NW–SE strike. It means that there are several mountain ranges in the sphere of its dominance. Subsiding tendencies spreading from the Východoslovenská nížina lowland are even less distinctly limited. They can end, as mediated by the north–south faults of the mentioned eastern Slovakian system as far as in the Branisko Mts or even in the eastern limits of the Tatry Mts and Nízke Tatry Mts. Subsidence spreading of Východoslovenská nížina lowland is probably shown also in the transversal depression of the Nízke Beskydy Mts (Harčár 1997).

During the Neogene an intense volcanic activity took place in the north–south systems. It is possible to assume that not only at the centres of volcanic activity, but in all central Slovakian and eastern Slovakian north–south systems subsidence prevailed. This assumption can be also extended over to the north Slovakian east-west system.

There is another phenomenon supporting the theory. Composition of many mountain ranges is step-like. Normally there are rests of two generations of planation surfaces preserved. The older generation is located in central, higher parts of the mountain range, younger is in peripheral, lower parts. The mountain ranges were getting higher and wider. This situation rather corresponds to the gradual subsidence of grabens.

Finally there is the question of the east–west differentiation of the West Carpathians. As a matter of fact, the differences between the western and eastern parts of the West Carpathians are not negligible despite of some common features. The folding of flysch strata took place sooner in the west than in the east. The volcanic rocks and the valley network in the east are also younger.

The fight for the water divide is not a uniformly distributed phenomenon. It is rare in the western part of the territory, compared to the eastern part where it is more frequent. The fight for the water divide, realised or potential capturing is frequent with the rivers flowing from the Nízke Beskydy Mts to the Východoslovenská nížina lowland. Rather intense fight for the water divide is going on between the Poprad and Hornád rivers and the Poprad and Torysa rivers, in both cases at the cost of the Poprad river. The fight for the water divide going on between Hron or Hnilec and the rivers flowing southward to the Juhoslovenská kotlina basin, is at the cost of the Hron or Hnilec rivers. This

west-east differentiation suggests that the development of the valleys was not simultaneous in Slovakia.

Also the new views of the classic problem of the planation surfaces closely connected with the problem of morphostructures prove the lack of synchronicity of the development.

According to the classical scheme there are three generations of planation surfaces in the Slovak Carpathians — the high level, middle level, and river level of planation surfaces (Mazúr 1963, 1964, 1965). The contemporary state of the art does not allow for a conception of other and justified comprehensive theory. But the classic theory raises some questions. The high level was never reliably identifiable in the field or distinguished from the middle level. Mazúr himself did not mention the high level in his study of 1976. The term middle level means the Pannonian planation surface, seen in the major part of the Slovak territory, and broken to the horst and graben systems after the Pannonian time. In the field the term refers to extensive, well-preserved or clearly identifiable plain areas. A question arises whether the origin and age of this extensive surface is the same. Some studies (Bizubová and Minár 1992; Dzuřovčín 1990; Jakál 1975; Lacika 1997) arrived at a conclusion that there exist fragments of a planation surface that is younger as middle level and older than river one. Other studies (Urbánek 1992) assert that polygenetic surfaces exist in some places. The river level developed on the middle level planation surface. The development of the planation surface was not interrupted there by tectonic movements or climatic changes. It is not possible to state that the quoted knowledge radically refutes the existence of the middle level. The original, relatively simple idea of the extensive and uniform Pannonian surface is differentiated in a finer manner. It tries to suggest that the development was synchronous. The river level is in many places free of problems. The rests of the pre-Pleistocene planation surface are left in the valleys (at the foothills of the mountain ranges) above Pleistocene terraces. The traces of older valley bottoms, situated high above the existing one, can be seen in any bigger valley. But such form does not necessarily mean the same origin. Interpretation of all these forms as the rests of river level can be erroneous. The development of the valleys was not necessarily synchronous over the whole of the Slovak Carpathians. It is also suggested by the above mentioned east–west differentiation.

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REFERENCES

- Bizubová M., 1993. *The dating of gradated surfaces of the Western Carpathians*. Acta Facultatis Rerum Naturalium Universitatis Comenianae, Geographica 32, 56–63.
- Bizubová M., Minár J., 1992. *Some new aspect of denudation chronology of the West Carpathians*, [in:] Stankoviánsky M., *Abstract of papers International symposium "Time, Frequency and Dating in Geomorphology"*, Tatranská Lomnica–Stará Lesná, June 16–21, Bratislava, p. 10.
- Činčura J., 1969. *Morfoģenéza južnej časti Turciánskej kotliny a severnej časti Kremnických vrchov*. Náuka o Zemi, Geographica 2, SAV, Bratislava.
- Dzurovčin L., 1990. *Geomorfologická analýza strednej časti Slánskych vrchov*. Kandidátska dizertačná práca, archív Geografického ústavu SAV, Bratislava.
- Dzurovčin L., 1997. *Morfoštruktúry slovenskej časti Karpát a ich formovanie v rámci Neoeurópy*, [in:] Harčár J., Nižňanský B., *Zborník z konferencie "Krajina východného Slovenska v odborných a vedeckých prácach"*, Prešov, 137–144.
- Feranec J., Lacika J., 1991. *Identification and Analysis of a "Gravity Nappe" in the South-Eastern of the Malé Karpaty Mts by Using Radar Image*. Proceeding of the Eight Thematic Conference on Geologic Remote Sensing. Exploration, Engineering and Environment, Vol. 1, April 29–May 2, Denver, Colorado, USA, 663–676.
- Fusán O., Plančár J., 1980. *Hlbinná stavba 1:1 500 000* [in.] *Atlas SSR*, eds, Mazúr E., Jakál J., Veda, Bratislava.
- Halouzka R., 1994. *DANREG — Neotektonická mapa Podunajska na Slovensku (1:100 000)*. Manuscript, archív GÚDŠ, Bratislava.
- Harčár J., 1997. *Problémy morfoštruktúrnej analýzy Nízkyh Beskýd*, [in:] Zborník z konferencie "Krajina východného Slovenska v odborných a vedeckých prácach", eds Harčár J., Nižňanský B., Prešov, 105–110.
- Jakál J., 1975. *Kras Sílickej planiny*. Osveta, Bratislava, 149 pp.
- Jakál J., Feranec J., Harčár J., Lacika J., Urbánek J., 1992. *Využitie radarových záznamov v geomorfológii*. Mineralia Slovaca, 24, 3–4, 257–270.
- Klinec A., Pospíšil L., Feranec J., Stankoviánsky M., 1985. *Identifikácia gravitčného príkrovu v Nízkyh Tatrách pomocou kozmických snímok*. Mineralia Slovaca 17, 6, 485–499.
- Kvitkovič J., Plančár J., 1975. *Analýza morfoštruktúr z hľadiska súčasných pohybových tendencií vo vzťahu k hlbinnnej geologickej stavbe Západných Karpát*. Geografický časopis 27, 309–325.
- Kvitkovič J., Plančár J., 1977. *Recentné vertikálne pohyby zemskej kóry vo vzťahu k zemetraseniam a seizmoaktívnym zlomom v Západných Karpatoch*. Geografický časopis 29, 239–253.
- Kvitkovič J., Feranec J., 1986. *Lineárne a nelineárne rozhrania Západných Karpát identifikované pomocou kozmických snímok*. Geografický časopis 38, 2-3, 152–163.
- Kvitkovič J., Vanko J., 1990. *Recentné vertikálne pohyby Západných Karpát pre epochu 1951–1976*. Geografický časopis 42, 345–356.
- Lacika J., 1989. *Morfoštruktúra Cerovej vrchoviny*, [in:] *Zborník referátov z geografického seminára*, UPJŠ Prešov, 37–42.
- Lacika J., 1993. *Morfoštruktúrna analýza Poľany*. Geografický časopis 45, 2–3, 233–250.
- Lacika J., 1997. *Morfoštruktúry Kremnických vrchov*. Geografický časopis 49, 1, 19–33.
- Lacika J., 1997. *Geomorfologické pomery zázemia stavby jadrovej elektrárne Mochovce*. Geographia Slovaca 12, 79–92.
- Lacika J., Gajdoš A., 1997. *Morfoštruktúry Starohorských vrchov*, [in:] Michal P., ed. *Prírodné prostredie stredného Slovenska — jeho ochrana a tvorba*, Geografické štúdie. Univerzita Mateja Bela, Banská Bystrica, 28–34.
- Lacika J., Urbánek J., 1997. *Morphostructures of the Slovak Carpathians*, [in:] Plašienka D., eds., *Alpine evolution of the Western Carpathians and related areas* Hók J., Vozár J., Elečko M., International conference held on occasion of the Centennial of Dimitrij Andrusov in Bratislava, Bratislava, 29–30.

- Luknič M., 1962. *Die Reliefentwicklung des Westkarpaten*. Wissenschaftliche Zeitschrift der Martin Luther Universität Halle-Wittenberg. Math. Nat. XI, 10, Hale, 1236–1244.
- Luknič M., 1964. *Pozostatky po starších povrchoch zarovnania reliéfu v československých Karpatoch*. Geografický časopis 3, 289–298.
- Lukniš M., 1972. *Reliéf*, [in:] *Slovensko II — Príroda*, ed., Lukniš M. Obzor Bratislava, 124–202.
- Mazúr E., 1963. *Žilinská kotlina a pril'ahlé pohoria*. Vydavateľstvo SAV, Bratislava, 185 pp.
- Mazúr E., 1964. *Intermountain basins a characteristic element in the relief of Slovakia*. Geografický časopis 2, 105–126.
- Mazúr E., 1965. *Major features of the West Carpathians in Slovakia as a result of young tectonic movements*, [in:] *Geomorphological problems of Carpathians*, ed., Mazúr, E., Stehlík, O., SAV, Bratislava, 9–54.
- Pospíšil L., Bezák V., Nemčok J., Feranec J., Vass D., Oberhauer D., 1989. *Muránsky tektonický systém — významný príklad horizontálnych posunov v Západných Karpatoch*. Mineralia slovaca, 21, 305–322.
- Stankoviánsky M., 1979. *Geomorfologická pomery Čachtických Karpýt s osobitným zreteľom na Čachtický kras*. Slovenský kras, 17, 59–76.
- Urbánek J., 1966. *Malé Karpaty a pril'ahlá časť Podunajskej nížiny v oblasti Jur-Pezinok*. Náuka o Zemi II, Geographica 1, SAV, Bratislava.
- Urbánek J., 1992. *Vývoj dolín v južnej časti Malých Karpát*. Geografický časopis 44, 162–173.
- Urbánek J., 1993. *Geomorfologické formy tektonického pôvodu (identifikcia a mapovanie)*. Mineralia slovaca 25, 131–137.

STRESZCZENIE

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MORFOSTRUKTURY KARPAT ZACHODNICH NA TERENIE SŁOWACJI

W połowie lat sześćdziesiątych duże jednostki geomorfologiczne słowackich Karpat Zachodnich były interpretowane jako aktywne morfostruktury uformowane w neogenie. Ostatnie wyniki badań autorów potwierdzają tę hipotezę i podbudowują ją nowymi argumentami. Wypiętrzenie Karpat Zachodnich przecinają nieliczne systemy linii tektonicznych, które różnią się orientacją, charakterem i wiekiem ruchów. Dominujące linie morfostrukturalne przedstawiono na rycinie 1.