ROCK PEDIMENTS AND BAHADA IN THE FRENŠTÁTSKÁ BRÁZDA FURROW (THE MORAVIAN-SILESIAN CARPATHIANS, CZECH REPUBLIC)

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The Frenštátská brázda Furrow is an intermontane depression in the central part of the hilly land of the Podbeskydská pahorkatina in the Moravian-Silesian Carpathians on the territory of the Czech Republic. The bottom of the Trojanovická brázda Furrow is composed of rock pediments inclined from the frontscarp of the Moravian-Silesian Beskids to the centre of the depression. Pediments level flysch rocks of the Godula development of the Silesian unit of the Outer group of nappes of the Moravian-Silesian Carpathians from Jurassic up to Oligocene age. The authors distinguished 3 levels of rock pediments. Parts of higher pediments are covered by sands and gravels of alluvial fans of preglacial age (Lower Pleistocene). The middle and the lowest pediments are mostly covered by Pleistocene sands and gravels of alluvial fans coalescing into a bahada. Pediments were formed by lateral erosion of the Lubina River and its tributaries springing from the mountains of the Moravian-Silesian Beskids, as suggested by A. Ivan (1987).

Key words: rock pediments, bahada, the Moravian-Silesian Carpathians

INTRODUCTION

The Frenštátská brázda Furrow is an intermontane depression in the central part of the hilly land of the Podbeskydská pahorkatina in the Moravian-Silesian Carpathians on the territory of the Czech Republic. The Silesian and Subsilesian units of the Outer Carpathian nappes predominate in the surface structure of the mountains and piedmont area (MENČÍK et al. 1983). Geomorphologists have studied the rock pediments on the territory of the hilly land of the Podbeskydská pahorkatina for a long time (DEMEK, ed. 1965 and 1976, BUZEK 1969, 1972 and 1973, IVAN 1987 or KŘÍŽEK 2005). Data also exist on alluvial cones coalescing into a bahada at the foot of the Moravian-Silesian Beskids (ŽEBERA 1955, PESL 1999, MENČÍK and TYRÁČEK 1985 or ROTH and RŮŽIČKA 2001). However, the genesis and age of rock pediments and related terminology of these landforms still remain open for discussion.

The authors present results of rock pediment and bahada investigations in the depression of the Trojanovická brázda Furrow (**Fig**. **1**) as a subward of the Frenštátská brázda Furrow, in the frame of the geomorphological unit Podbeskydská pahorkatina and the Západobeskydské podhůří geomorphological subsystem (**Fig. 2** and **Tab. 1**).

THE AREA OF STUDY

The Frenštátská brázda Furrow is an intermontane depression situated between the Moravian-Silesian Beskids in south and west and the highland of Štramberská vrchovina in north (**Fig**. **2**). The depression developed in the flysch rocks of the Godula Nappe of the Silesian unit of the Moravian-Silesian Carpathians (MENČÍK et al. 1983, STRÁNÍK et al. 1993 or DUBEC et al. 2001). after the stabilisation of Carpathians nappes in the middle Miocene (in Badenian – CHLUPÁČ et al. 2002, p. 27). The depression is elongated from west to east at the foothills of the Moravian-Silesian Beskids in the length of 4.6 km. The depression is limited by a higher ridge Žaryský hřbet (Maralův kopec 577.9 m a. s. l.) in east (**Fig. 2**). The bottom of the Trojanovická brázda Furrow is mostly flat and inclines from south to north (inclination from 0.5 to 4 degrees). The bottom exhibits elevation from 500 m to 580 m a. s. l. at the foothills of the Moravian-Silesian Beskids in south and 410 m a. s. l. by the town of Frenštát pod Radhoštěm in north. The monad-

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Fig. 1 General view of the Trojanovická brázda Furrow from foreland of the mountains of the Hodslavický Javorník

nock of Helštýn (482 m a. s. l.) rises over the flat bottom of the furrow. The Lubina River and its tributaries (especially the Radhoštnice, the Bystrá and the Lomná Rivers), that springs in the mountains of the Moravian-Silesian Beskids, follow the general declination of the terrain and flow across the depression from south to north.

METHODS

Authors used the method of detailed geomorphological mapping in the field, evaluation of remote sensing data and thematic maps and compiled digital colour detailed geomorphological map in the scale 1:10 000 of the area and its surroundings. ArcGIS 9.2 software was used for map compilation. Data were stored in 3 layers of the database in the format ESRI shape file (SHP). Data from number of bore holes were also evaluated. Location of bore holes cited in the text is presented on the **Fig. 2.**

PEDIMENTS

The bottom of the Trojanovická brázda Furrow is composed of rock pediments gently inclined from the frontscarp of the Moravian-Silesian Beskids to the centre of the depression (IVAN 1987). Pediments are essentially rock-cut surfaces that level flysch rocks of various resistances to erosion (BUZEK 1969) of the of the Godula development of the Silesian unit of the Outer group of nappes of the Moravian-Silesian Carpathians from Jurassic up to Oligocene age. In the direction from the frontscarp of the Moravian-Silesian Beskids onwards there are layers of the middle and lower Godula formation, coloured Godula formation, Lhoty formation, Veřovice member and the Hradiště formation (DUBEC et al. 2001). Very resistant to erosion are coarse grained quartzy sandstones of the middle and lower Godula formation, medium resistance exhibit silicified quartzy sandstones containing glauconite of the Lhoty formation and deposits of the coloured Godula formation (especially up to several metres thick layers of coarse grained to medium grained quartzy Ostravice sandstones – DUBEC et al. 2001). Claystones of the Lhota formation and the Veřovice member exhibit low resistance to erosion. Bedrock occur in riverbeds, especially of the Lubina and the Radhoštnice Rivers, occasionally also in beds of the Lomná and the Bystrá Rivers. Further bedrock can be found on steep valley sides of rivers in the Trojanovice depression, e.g. in the valley of

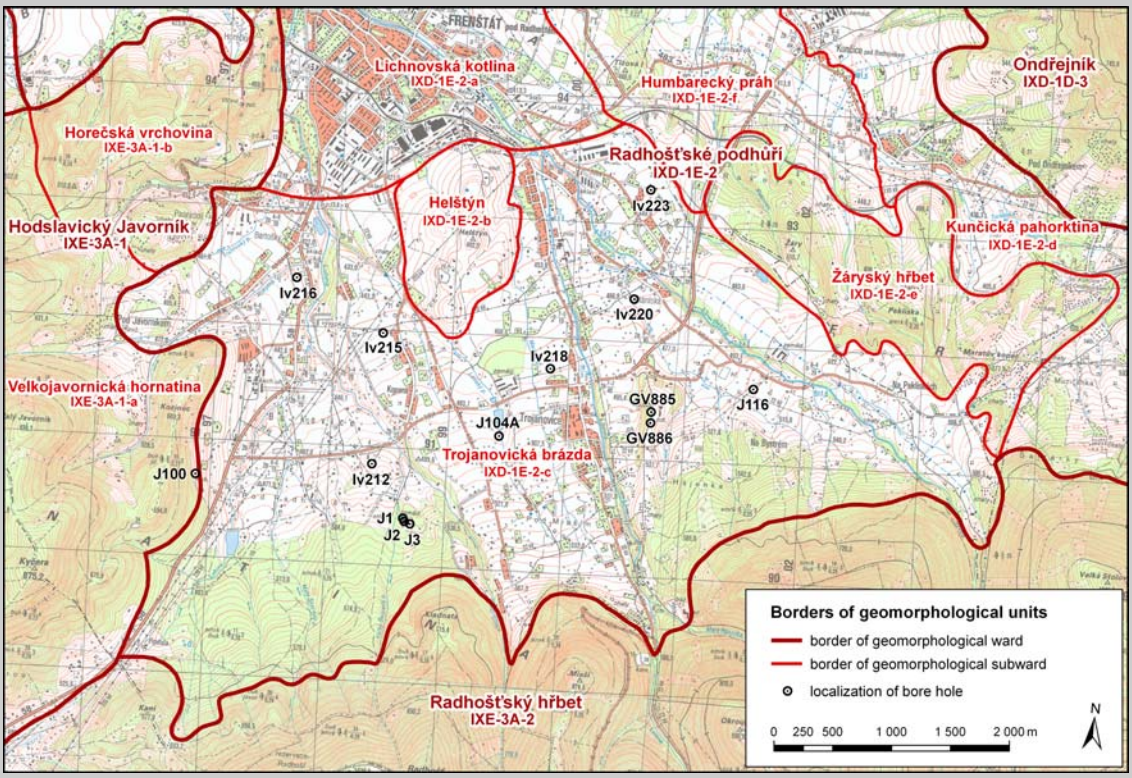

Fig. 2 The Trojanovická brázda Furrow and neighbouring geomorphological units

the Lomná R. in the village Trojanovice or in valley of the Bystrá R. on the locality Na pekliskách.

According to the present knowledge, pediments in the Trojanovická brázda Furrow occur at least in two and presumably in three levels. The higher level of pediments (higher pediment) has been found on the narrow ridge with weekend houses running from south to northeast from the village Trojanovice above the Lomná river (**Fig. 3)**. This higher pediment has in south at the foot of the frontscarp of the Moravians-Silesian Beskids altitude 565 m (25 m above the Lomná River) and 515 m in north. Erosion remnant of the higher pediment is limited by steep erosion slopes on both sides, on which is protruding bedrock (sandstones of the Hradiště formation and claystones of the Veřovice member). Especially the western slope is rocky, expressive and steep. The higher rocky pediment is partly covered by gravels of the alluvial cone, that are on the geological map (PESL 1999) classified as proluvial gravels of preglacial age (Lower Pleistocene).

Smaller remnant of the higher pediment is preserved on the forested ridge on rocks of the Lhota formation around the spot height of 549.1 m a. s. l. situated to the south from the locality Na Bystrém. This remnant of the dissected higher pediment is also limited to the lower pediment level (middle pediment) by erosion slopes. The remnant of the dissected higher pediment is also preserved on a rounded hill composed of claystones of the Veřovice member with spot height of 491.8 m a. s. l., on the divide between the Malý Škaredý potok Brook and the Radhoštnice River to the east from the settlement Buzkovice (part of the village Trojanovice).

The authors also found the higher pediment around the spot height Tížová (448.9 m a. s. l.) on the southeastern slope of the Humbarecký

IXD Západobeskydské podhůří Piedmont – geomorphological subsystem IXD – 1E Podbeskydská pahorkatina Hillyland – geomorphological unit IXD – 1E Frenštátská brázda Furrow – geomorphological subunit IXD – 1E – 2 Radhošťské podhůří Piedmont – geomorphological ward IXD – 1E – 2-c Trojanovická brázda Furrow – geomorphological subward

Tab. 1 Place of the Trojanovická brázda Furrow in the hierarchy of geomorphological regions in the studied area (see **Fig.2**)

Fig. 3 Remnant of the higher pediment situated eastward from the village Trojanovice above the Lomná River and partly covered by pre-glacial gravels

práh (**Fig. 2**) on the contact with the Trojanovická brázda Furrow. In contrast to the above mentioned remnants of the higher pediment, the cover of this rock pediment is composed of proluvial gravels of Middle Pleistocene age – older group (ROTH and RŮŽIČKA 2001). Bedrock of this rock pediment is formed by black-grey claystones of the Veřovice member.

The middle level of pediments (middle pediment) takes large areas at the bottom of the Trojanovická brázda Furrow. Middle pediment reaches the altitude of around 550 m a. s. l. in south at the foot of the frontscarp of mountains Moravian-Silesian Beskids and 420 m a. s. l. (15 m above the Lubina R.) in north around the town of Frenštát pod Radhoštěm. In the western part of the Trojanovická brázda Furrow on the locality Na pasekách appears the bedrock surface of the middle pediment on the divide between the Lubina R. and the Malý Škaredý potok Brook on surface and forms the foot of the steep foreland of the Moravian-Silesian Beskids up to the settlement of Buzkovice (part of the village Trojanovice). The bedrock of the middle pediment composed of black-grey claystones of the Veřovice member also appears on surface on the divide between the Malý Škaredý potok Brook and the Radhoštnice R. up to the settlement of Kopaná (part of the town of Frenštát pod Radhoštěm). The bedrock base of the middle pediment is also exposed from the right slope of the incised valley of the Radhoštnice R. The bedrock surface of the middle pediment appears on the divide between the Radhoštnice R. and the Lomná R. at the foot of the foreland of the Moravian-Silesian Beskids as a narrow strip on the locality Pod Miaším. On the other side, the bedrock of the middle pediment protrudes on the surface in larger are-as on the divide between the Lomná R. and the Bystrá R. The gentle inclined bedrock surface of the middle pediment cuts mostly in flysch rocks of the Lhota and Hradiště formation protrudes on the locality of Háje and extends to north up to the locality Na Bystrém. The pediment surface is covered by slope deposits close to the foot of the steep frontscarp of the Moravian-Silesian Beskids. The thickness of the slope deposits reaches in gullies up to 12 m in this area. The inclination of the pediment surface close to the foot of the steep frontscarp lies between 5 and 15 degrees. The degree of sloping of the rock pediment surface decreases northwards down to 2 degrees.

Also the low pediment presumably developed in the Trojanovická brázda Furrow bounded on the rock bottom of the Lubina R. valley and the valleys of its tributaries. The evidence of that are bore holes on a construction site of the shaft Doubrava in the village Trojanovice

at the foot of the steep foreland of the Hodslavický Javorník Mountains (**Fig. 2**). Low pediment levels deposits of the Lhota formation. The bedrock of the rock pediment is covered by fluvial gravels up to 4 m thick covered over by younger slope deposits up to 16 m thick (POLÁŠKOVÁ and POLÁŠEK 1981). There are not enough bore holes available to the authors to delimitate the areal extent of this low pediment.

QUATERNARY ALLUVIAL CONES AND BAHADA

Rock pediments in the Trojanovická brázda Furrow are partly covered by Quaternary sediments. Together with the above mentioned slope deposits there are mainly sands and gravels of alluvial cones deposited by water courses and gravity flows coming from the mountain area of the Moravian-Silesian Beskids (RŮŽIČKOVÁ et al. 2001, p. 13). In Czech terminology, the Pleistocene deposits of the alluvial cones are often referred to as proluvial sediments (PESL 1999, MENČÍK and TYRÁČEK 1985 or ROTH and RŮŽIČKA 2001). The sediments of alluvial cones mostly comprise of gravels of various grading, the degree of sorting is low and the clasts are subangular to subrounded. Alluvial cones are coalescing into a bahada in the northern part of the Trojanovická brázda Furrow. Alluvial cones are of Quaternary age, but their precise dating is still object of discussion. The authors are using the dating method of alluvial cones applied in geological maps of the Czech Republic in the scale of 1: 50 000 (PESL 1999 or ROTH and RŮŽIČKA 2001).

Alluvial cones are developed in several levels and partly cover rock pediments. Erosion remnants of the oldest alluvial cones cover the higher pediments. The higher rock pediment situated eastwards from the village Trojanovice is partly covered by gravels dated as preglacial and of Lower Pleistocene age. Bore holes GV885 and GV886 have shown that gravels are 1.7 – 2.3 m deep. The sandstone clasts are subangular to subrounded. The area of gravels is smaller than depicted on the geological map (PESL 1999). The same type of preglacial gravels should - according the geological map, cover the slope of the spot height on the divide between the Malý Škaredý potok Brook and the Radhoštnice R. eastwards from the settlement Buzkovice. But the bore hole Iv 212 situated on this slope exposed only the bedrock (claystones of the Veřovice member).

The higher alluvial cone of the Lubina R. developed on the middle pediment on the left river bank under the confluence with the Malý Škaredý potok Brook (from the right) and the Rokytná R. (from the left). The bore hole Iv 216 has shown the thickness of gravels 5.6 m and the bore hole J100 situated downstream (locality Siberie) the thickness of 3.4 m. The alluvial cone has been dated into the Upper Pleistocene. In a bore hole situated on the construction site of the shaft Doubrava there are up to 4 m thick fluvial gravels, covering the lowest pediment, buried by Pleistocene slope deposits.

Alluvial cones of the Radhoštnice R. and its left tributary the Velký Škaredý potok Brook begins just at the frontscarp of the Moravian-Silesian Beskids. As evidence for that serve the bore holes J1, J2 and J3 that have shown subrounded gravels of 0.6 – 2.7 m thickness mantling the middle pediment and buried under 1.3 – 1.9 m thick Pleistocene slope deposits. Gravels were most likely deposited in Middle Pleistocene. The pediment cuts black-grey claystones of the Veřovice member. Down stream alluvial cone coalesce with adjacent cones into a bahada. The bore hole Iv 215 situated in the settlement of Kopaná has shown the thickness of bahada gravels of 4.6 m but this bore hole does not reach the bedrock.

The Lánský potok Brook flows on the surface of a bahada. There were several wells bored around the water reservoir in the village Trojanovice. In the bore hole J104A situated in the front of the dam were gravels 2.5 m thick. The bedrock is formed by claystones of the Veřovice member.

The alluvial fans of the Lomná R. also begin just at the frontscarp of the Moravian-Silesian Beskids where the river debouches on to a middle pediment. A narrow lower shelf is incised into the surface of probably Upper Pleistocene alluvial cone along the road Ráztoka-Trojanovice. The thickness of gravels of the Lomná R. alluvial fan reached in the bore hole Iv 218 situated in the village Trojanovice the thickness of 5.2 m. Middle pediment cuts claystones of the Veřovice member on this locality. The bore hole located on the left river bank of the Radhoštnice R. on the southern edge of the town of Frenštát pod Radhoštěm has shown that gravels of the alluvial cone coalescing into a bahada have the thickness of 5.4 m. Clasts are medium rounded, average diameter of sandstone gravels is 3 – 7 cm. Deposits of alluvial fan mantle the middle pediment that levels claystones of the Veřovice member.

Also the apex of alluvial cone of the Bystrá R. begins at the foot of the frontscarp of the Moravian-Silesian Beskids where the river emerges from the constriction of deep incised mountain valley with rapids. The higher allu-

vial fan of the Bystrá R. on the right river bank has a shape of classical cone on the topographic map. Cone sediments there are dated as Middle Pleistocene ones. The Bystrý potok Brook flows on the surface of the higher fan at the foot of the Žaryský hřbet Ridge. The bore hole J116 situated on the left bank of the Bystrá R. in the village of Trojanovice – Na Bystrém has shown that the thickness of the higher fan gravel reaches 10 m. The middle pediment is cut into claystones of the Veřovice member on this locality. Downstream in the settlement of Plániska (part of the town of Frenštát pod Radhoštěm) the thickness of gravel mantle on middle pediment reaches 7.20 m (bore hole Iv 220). The pediment is also cut into claystones of the Veřovice member. Bore hole Iv 223 situated on the right bank of the Bystrá R. in the town of Frenštát pod Radhoštěm has shown the thickness of cone gravels of 4.8 m. Sandstone gravels had dimensions up to 15 cm and were only subrounded. The bedrock of the middle pediment was formed by claystones of the Veřovice member.

DISCUSSION

L. BUZEK (1969) and A. IVAN (1987) share the same opinion that homogenous planation surface of the pediment type (pediplain) was developed in the Trojanovická brázda Furrow in the Upper Pliocene. The pediplain have been dissected due to tectonic movements and climatic changes by fluvial valleys at the end of Pliocene and during the Quaternary and after developed new younger pediments. A. IVAN (1987) believes that the dissection of the pediplain and the formation of river valleys materialized in a very short period of time.

This model of the relief development of the Trojanovická brázda Furrow during the Pliocene and Quaternary looks very realistic, nevertheless, it brings some terminological problems. According to the American terminology it is possible to denote studied gentle inclined erosion foothill surfaces as rock pediments. Sediments of mixed fluvial and gravitational origin (gravels, sands) and slope deposits that occasionally mantle subjacent rock pediments can be collectively named as a bahada (WHITTOW 1984). Deposits of alluvial cones at the foot of forelands carry features of fluvial sediments. As streams debouching from the mountains enter the flatter area of the depression of the Trojanovická brázda Furrow they divaricate, lose velocity and transporting power, and deposit bed load (gravels, sands) in large quantities. The barrage on the Lomná R. in Trojanovice (river km 6.492) at the foot of the frontscarp that is completely filled by sands and large gravels following a flood or a snow melt can serve as evidence. The processes of weak strata planation and rock pediments formation, initially by rills and gullies and subsequently by distributary streams, were described by C. R. TWIDALE (1978).

E. RŮŽIČKOVÁ et al. (2001) suggested that the vast alluvial fans from the foothills of the Moravian-Silesian Beskids were formed primarily during the glacial periods of the Quaternary period when climatic conditions (sparse vegetation, occurrence of permafrost) favoured surface runoff, congelifluction and creep.

Geomorphologists in Europe distinguish on one hand rock pediments that level rocks of the same resistance to erosion as are rocks on back slope above the pediment, on the other hand glacis d´érosion where the steeper back slope form more resistant rocks than gentle foot slope. Glacis develop by lateral erosion of rivers without backwearing of the back slope (MENSCHING 1968). The analysis of M. GUTIÉRREZ (2005) has shown that terminology of glacises is confusing. Therefore the authors in this paper accepted the American terminology and all gently sloping foot surfaces in the Trojanovická brázda Furrow call the pediments. However, rock pediments are controversial landforms and the world geomorphological literature presents two main theories of their origin:

i) pediments are regarded as an active basal slope or slope of transport, left by recession of the mountain front,

ii) pediments may also form from lateral planation thanks to running water (WITHERICK et al. 2001).

It has also been noted that pediments are usually associated with relief development in dry and subtropical climate. Pediments also develop in humid tropics (WHITTOW 1984) and in periglacial climate (WAKO 1963, DEMEK 1972).

The authors did not found evidence of recession of steep foreland of the Moravian-Silesian Beskids composed of resistant flysch sandstones of the middle Godula formation. For that reason it is possible to agree with the opinion of A. IVAN (1987) that pediment in the studied area developed due to lateral planation of the Lubina R. and its tributaries in medium and less resistant rocks of the Silesian nappe. The dating of pediment formation remains an open question. Cryogenic slope deposit and gravels and sands of Quaternary alluvial cones mantle only a part of rock pediment surfaces. Higher rock pediments have to develop in dryer climate of uppermost Pliocene or Lower Pleistocene. A remnant of preglacial (Lower Pleistocene) gravels and sands (PESL

1999) mantling a part of higher pediments can serve as an evidence for this opinion. Middle pediments are partly covered by gravels and sands dated on the geological map as Middle and Upper Pleistocene. Coalescing alluvial fans form a bahada in the northern part of the studied area. It is possible to suppose that middle pediments developed during cold periods of Pleistocene as cryopediments. The authors have not got sufficient information on the areal extent of the lowest pediment.

CONCLUSIONS

Authors studied rock pediments and bahada in an intermontane depression Frenštátská brázda Furrow in the central part of the hilly land of the Podbeskydská pahorkatina in the Moravian-Silesian Carpathians. The main features of the relief were formed in the post-Pannonian period (DANIŠÍK et al. 2008), mainly during the Pliocene erosion megaphase. Authors distinguished three levels of pediments of Upper Pliocene and Pleistocene age. Authors did not found traces of backwearing of back slopes of pediments and agree with opinions of A. IVAN (1987) that pediments were formed by lateral corrasion by divaricating streams springing from mountains of the Moravian-Silesian Beskids. It is possible to suppose that middle pediments developed during cold periods of Pleistocene as cryopediments. Quaternary proluvial gravel deposits covering partly rock pediments coalesced into a bahada.

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REFERENCES

BUZEK, L. (1969). *Geomorfologie Štramberské vrchoviny*. Spisy Pedagogické fakulty v Ostravě, 11, 91 p.

BUZEK, L. (1972). Zarovnané povrchy Radhošťských Beskyd (Planation surfaces of the Radhošťské Beskydy Mts.). *Acta Facultatis Paedagogicae Ostraviensis*, Serie B-2, 28, Ostrava, 23 – 43.

BUZEK, L. (1973). Svahy Radhošťských Beskyd a Štramberské vrchoviny. *Spisy Pedagogické fakulty v Ostravě*, řada E-3, 33, 47 – 59.

DANIŠÍK, M., PÁNEK, T., MATÝSEK, D., DUNKL, I., FRISCH, W. (2008). Apatite fission track and (U-Th)/He dating of teschenite intrusions gives time constraints on accretionary processes and development of planation surfaces in the Outer Western Carpathians. *Zeitschrift für Geomorphologie, NF*, 52, 3, 273 – 289.

DEMEK, J. ed. (1965). *Geomorfologie Českých zemí*. Nakladatelství ČSAV, Praha, 335 p.

DEMEK, J. (1972*).* Die Pedimentation im subnivalen Bereich. *Göttinger geographische Abhandlungen*, 60 (Hövermann, J., Oberbeck, G., eds. Hans-Poser-Festschrift), Goltze Verlag, Göttingen, 145 – 154.

DEMEK, J. (1976). Planation surfaces of the Moravian Carpathians (Czechoslovakia). *Sborník Československé společnosti zeměpisné*, 61, 1, 9 – 15.

DUBEC, O., ELIÁŠ, M., MACHEK, P., MANOVÁ, M., MATÝSEK, D., NOVÁKOVÁ, D., RACLAVSKÁ, H., SKÁCELOVÁ, D., SKALICKÝ, J., ŠALANSKÝ, K. (2001). *Vysvětlivky k souboru geologických a ekologických map přírodních zdrojů. List 25-21 Nový Jičín*. Český geologický ústav, Praha, 68 p.

GUTIÉRREZ, M. (2005). *Climatic Geomorphology*. Elsevier (Developments in Earth Surface Processes Series, 8), Amsterdam, 760 p.

CHLUPÁČ, I., BRZOBOHATÝ, R., KOVANDA, J. STRÁNÍK, Z. (2002). *Geologická minulost České republiky*. Academia, Praha, 436 p.

IVAN, A. (1987). Reliéf. In Mikulík, O., ed. *Geografické hodnocení stavu životního prostředí Frenštátska a prognóza jeho změn pod vlivem budování a provozu nových dolů. Geografie – Teorie-výzkum-praxe*, 6, ČSAV Geografický ústav, Brno, 14 – 19.

KŘÍŽEK, M. (2005). *Morfostruktury a morfoskulptury Rusavské hornatiny*. PhD thesis, Přírodovědecká fakulta, Univerzita Karlova, Praha, 211 p.

MENČÍK, E., ADAMOVÁ, M., DVOŘÁK, J., DUDEK, A., JETEL, J., JURKOVÁ, A., HANZLÍKOVÁ, E., HOUŠA, V., PESLOVÁ, H., RYBÁŘOVÁ, L., ŠMÍD, B., ŠEBESTA, J., TYRÁČEK, J., VAŠÍČEK, Z. (1983). *Geologie Moravskoslezských Beskyd a Podbeskydské pahorkatiny*. Ústřední ústav geologický, Academia, Praha, 307 p.

MENČÍK, E., TYRÁČEK, J. (1985). *Beskydy a Podbeskydská pahorkatina (Přehledná geologická mapa 1:100 000)*. Ústřední ústav geo-

logický, Praha.

MENSCHING, H. (1968). Glacis-Fussfläche-Pediment. *Zeitschrift für Geomorphologie*, 2, 165 – 186.

PESL, V. (1999). *Geologická mapa ČR 25 – 23 Rožnov pod Radhoštěm (1:50 000)*. Český geologický ústav, Praha.

POLÁŠKOVÁ, M., POLÁŠEK, S. (1981). Vývoj kvartéru na lokalitě průzkumné jámy Frenštát-západ. *Sborník Geologického průzkumu Ostrava*, 117 – 120.

ROTH, Z., RŮŽIČKA, M. (2001). *Geologická mapa ČR 25 – 21 Nový Jičín (1:50 000)*. Český geologický ústav, Praha.

RŮŽIČKOVÁ, E., RŮŽIČKA, M., ZEMAN, A., KADLEC, J. (2001). *Quaternary clastic sediments of the Czech Republic*. Český geologický ústav, Praha, 67 p.

STRÁNÍK, Z., MENČÍK, E., ELIÁŠ, M., ADÁMEK, J. (1993). Flyšové pásmo Západních Karpat, autochtonní mesozoikum a paleogén na Moravě a ve Slezsku. In Přichystal, A., Obstová, V., Suk, M., eds. *Geologie Moravy a Slezska*. Moravské zemské muzeum a Sekce geol. věd PřF MU, Brno, 107 – 122.

TWIDALE, C. R. (1978). On the origin of pediments in different structural settings. *American Journal of Science*, 278, 8, 1138 – 1176.

WAKO, T. (1963). Valley features along the Sarugaischi river – A note on block field, cryopediment, and relict soil in the Kitakami Mountainland. *The Science Reports of the Tohoku University, 7th Series (Geography)*, 12, 1, 53 – 69.

WHITTOW, J. (1984). *The Penguin Dictionary of physical geography*. Penguin Books, London, 591 p.

WITHERICK, M., ROSS, S., SMALL, J. (2001). *A Modern Dictionary of Geography (Fourth Edition)*. Arnold, London, 293 p.

ŽEBERA, K. (1955). Ostravské proluviální suché delty. *Věstník ÚÚG*, 30, 4, Praha, 181 – 184.