GEOMORPHOLOGICAL ANALYSIS OF THE REGION OF THE MIDDLE PART OF THE ROKYTNÁ RIVER VALLEY AND ITS SURROUNDINGS

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SUMMARY

The main objective of the present paper is to differentiate and map the individual landforms in the region of the middle reaches of the Rokytná River Valley, to determine their development and age. Attention is further paid to the reconstruction of the individual stages of development of the georelief and the determination of the denudation chronology. From the point of view of genesis the paper concentrates on two main problems:

- the analysis of planation surfaces and particularly judging the possibility of their being affected by sea abrasion;
- the analysis of the shape of the river network, the age of the valleys of the water streams and the influence of tectonic movements on the formation of valleys.

1. INTRODUCTION

Under the influence of the studies by Hassinger (1914), an opinion prevailed that the present topographic positions of flats at the eastern margin of the Bohemian Highland had been formed as a system of abrasion terraces of the Miocene sea. Tectonically unchanged position of these erosional platforms was proposed by other Říkovský (1934) and Novák (1942). The possibility of tectonic effect was hinted at already by Andrusov (1932), but in general this view was accepted only in the postwar time by Vitásek (1949) and Krejčí (1952). An overview of the present opinions of the above problems is given by Karásek (1991). Possibility of regional occurrence of abrasion landforms was submitted by many authors (Dlabač, 1976; Ondráček, 1979; Czudek, 1969; Karásek, 1988).

2. THE LOCATION OF THE STUDIED TERRITORY

The studied region is situated on the southeastern margin of the Česká vysočina (the Bohemian Highland) near the town of Moravský Krumlov. The axis of the territory is the river Rokytná (Fig. 1). The territory reaches the highest elevation by the hilltop Tanárka (391 m above sea level), the lowest situated is the region where

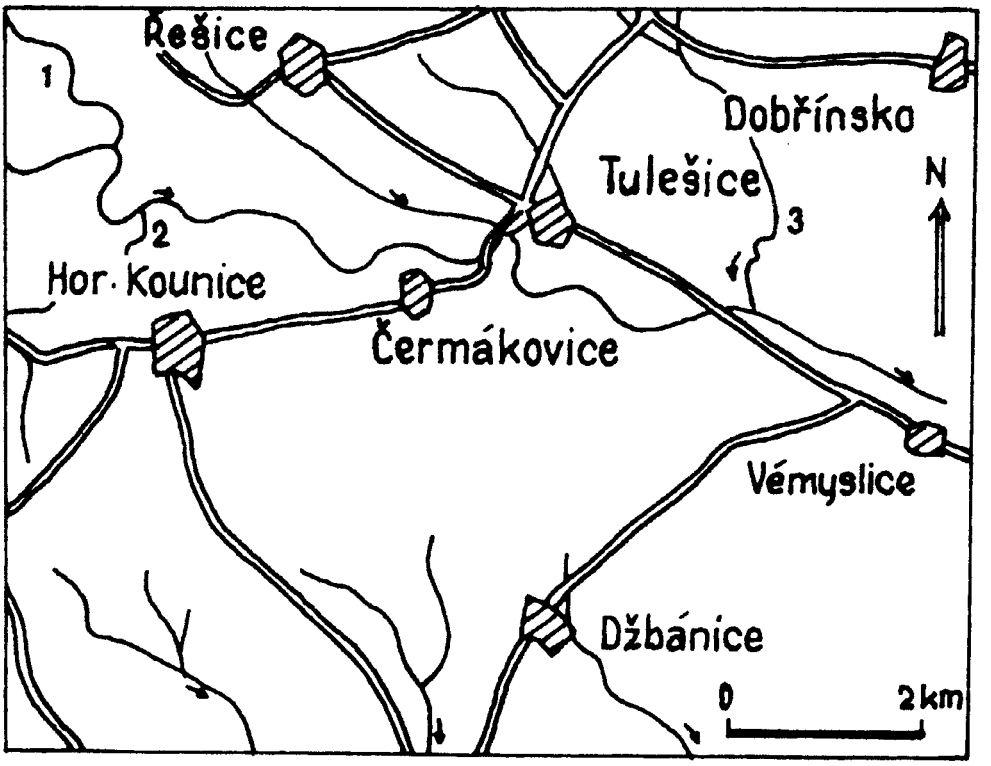

Fig. 1. Location of the investigated area.
1 - Rouchovanka river
2 - Kounický potok brook
3 - Dolnodubňanský potok brook

the river Rokytná leaves the studied territory with the surface at the height of 244 m above sea level. The relative height difference in the studied territory is thus 147 m. On the basis of mean heights of the centres of squares (1 by 1 km) a map of mean heights of the georelief was made with isolines of 10 m (Fig. 2). These isolines will model a sort of "height generalised georelief" (Čapek, Kudrnovská, 1982) in which there usually occur more negative (concave) shapes than in the reality. From a map made like that it follows that the height of the georelief increases generally from E to W. The valley of the Rokytná separates two regions different in height as well as in shape.

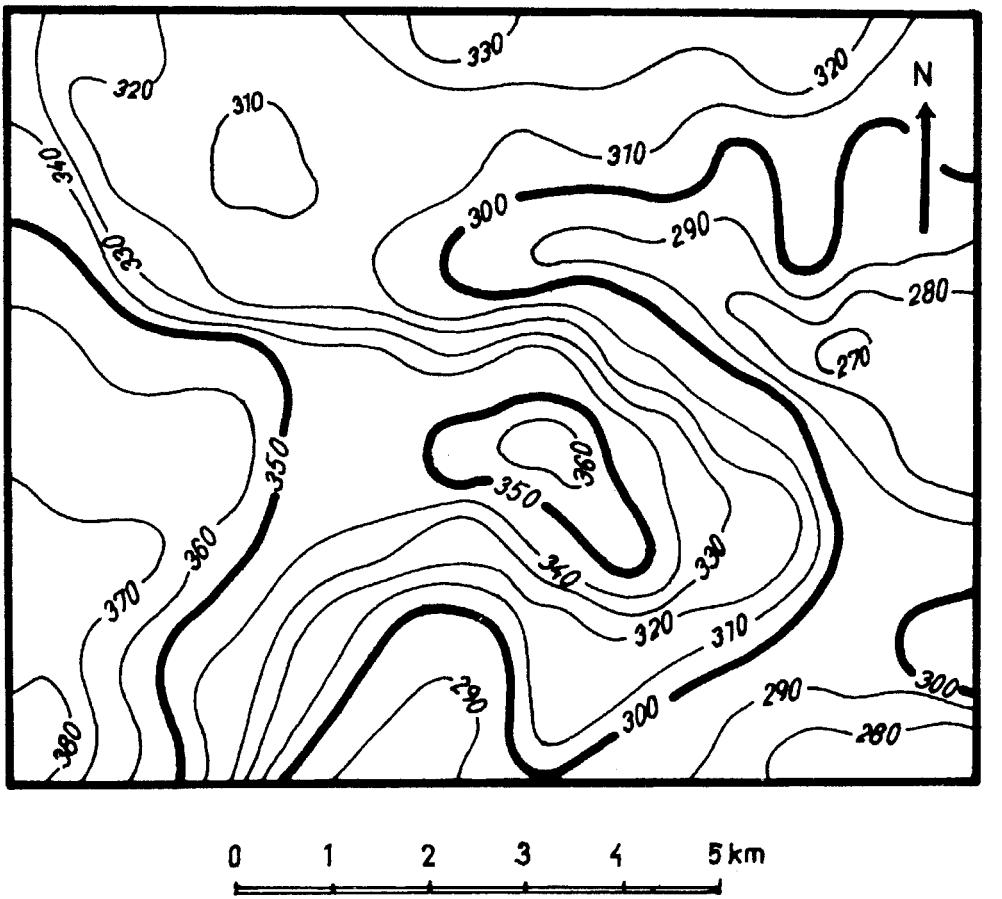

Fig. 2. Map of the georelief mean heights

3. MORPHOSTRUCTURAL ANALYSIS

The region of the middle reaches of the Rokytná is a part of the so-called Rokytná complex of gneisses (Svoboda et al., 1964) cropping out at the southeastern margin of the Moldanubic and is wedged among the Třebíč-Meziříčí pluton, the Svratka arch and the Dyje arch. The whole complex is formed by gneiss migmatites at different degrees of migmatisation. Characteristic is the presence of amphibolites, serpentinites, eclogites and granulites. At the northeastern margin the Náměšť granulite massif crops out with a well developed granulite formation.

After the Variscan folding the studied territory was a region of long-term denudation, so that from the platform cover only Tertiary and Quaternary formations are developed.

From the Tertiary only sediments of three phases of the Miocene have been preserved on the territory of the sheet. Lower Miocene is represented by the regional stage of the Ottnangian, micropalaeontologically sediments of the Carpathian were documented and from middle Miocene sediments of lower Badenian - Moravian were proved.

As follows from stratigraphical overviews of fossil weathered materials (Kužvart, 1965; Zeman, 1980), denudational relicts of fossil tropical weathered materials may have been preserved in the studied territory, particularly dating back to the time of the Palaeogene and the turn of the Miocene and the Pliocene. From the former period, due to repeated activity of the Miocene sea and Quaternary denudation only relics were preserved in the depressions of the basal weathering surface. Those depressions are linked with the regions of occurrence of cracks and/or faults and also with contacts of petrographically different types of rocks. In the studied territory kaolinic weathered materials of Palaeogene age were found in the borings below the fluvial material of the Rešický potok Brook plain, where they are bound to fissures.

The areal occurrence of clayey wastes was found along the road connecting Dolní Dubňany and Tulešice. With respect to the height of the studied section (318-322 m above sea level) and its situation in the georelief (in the crest part and on gentle slopes) its origin as late as in the second period of kaolinization (end of Miocene-Pliocene) cannot be excluded. Since in most of the sections the gradual transition to the weathered bedrock is well recognizable as well as the linkage with petrographical changes, the connection of this material with marine sediments is improbable.

Quaternary cover formations are represented by the following genetic types of Pleistocene sediments in the studied territory: proluvial sediments, fluvial sediments, eolithic sediments and slope deposits. Holocene sediments are represented by deluviofluvial sediments, fluvial sandy-loamy sediments and flood loams and anthropogenic sediments.

4. ANALYSIS OF PLANATION SURFACES

The oldest destruction form found during geomorphological mapping are planation surfaces situated at flat watersheds. An exact delimitation of margins of erosional platforms only very gradually pass into gently inclined slopes. The area of those surfaces is diminished by a thick network of inclined dells which, intersecting in their upper parts, form passes, thus conspicuously dissecting the georelief.

The planation surfaces are located at heights above sea level of 385 m to 285 m, i.e. in the height span of about 100 m. Comparing the mean heights of the plains we find that most of them fall into the class of 320-360 m above sea level. Most of them level different resistant rocks and their height position thus depends on the level of the denuded basal weathering surface. That surface was formed during the Palaeogene

tropical weathering and partly denuded before the Miocene, but in the main period of the Pliocene when in the crest parts of the georelief the levelled surface of the etchplain type was formed (Czudek, Demek, 1970). Different height positions of those erosional platforms is linked up with the petrographical diversity of the territory and with the jointing of the crystalline bedrock. Open remains so far the problem of the origin and development of small piedmont surfaces. For a more accurate description of their rise and development a sufficient number of borings and probes was not available.

5. ANALYSIS OF RIVER VALLEYS

The river Rokytná is characterised in a considerable part of the studied territory by rapid changes of the direction of its stream. River valley is relativly deep and

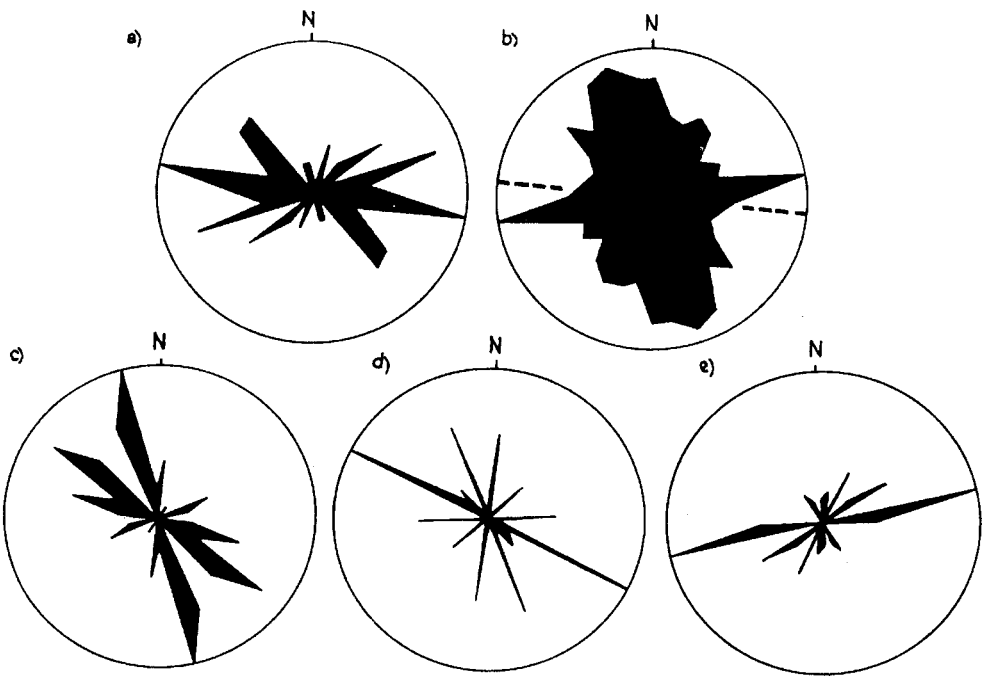

Fig. 3. Comparison of the stream directions and joint system " directions:
a) Rokytná river
b) main joint directions
c) Dolnodubňanský potok brook
d) Rouchovanka river
e) Kounický potok brook

narrow with steep valley slopes and without visible terracces. A question therefore arises whether those direction changes are linked up with the directions of the joint systems in the region that may have been used by the river for its stream as directions of a weakened cohesion of rocks. For verifying that assumption wind rose diagrams of the directions of the stream and those of the joint systems of the Rokytná and its tributaries were made and their comparison was carried out (Fig. 3). From the comparison of the dependence of the direction of water streams on the joints and foliations it follows that the Rokytná exhibits dependence on the main direction of foliations of the studied territory (WNW-ESE). Its tributaries have a trend of utilising also the main joint maximum in the direction of approximately N-S.

The valley of the river Rokytná in the studied territory is mostly very narrow and its floor is practically formed exclusively by massive rocks with a cover of fluvial deposits. The remnants of tropical kaolinic weathered materials were not registered in the valley. The decisive role for the limitation of the age of the valley is that of the occurrences of Miocene sediments at the level of the fluvial plain and/or on the valley slopes. A small occurrence was found W of the studied territory near the Újezd mill (Plamínková, 1983), continuous occurrences south of the village of Rešice, near the village of Čermákovice, Tulešice, near Oulehla's and Kuchyňka's mills and, finally, near Vémyslice. The thickness of the Neogene varies from 8 to more than 30 m, reaching its maximum height above the river near Tulešice (55 m). If the above sediments occur at the level of the valley floor fluvial plain in an unimpaired position, then one of the possible explanations is the existence of the valley as a concave shape of the georelief already before the Miocene. Later it was filled with sediments of marine transgressions and in the course of the Pliocene and the Quaternary it was gradually exhumated into the present form. The occurrence of periglacial forms on the rock slopes witnesses the fact that the exhumation of the valley took place in the Pliocene and above all in Early Pliocene. The origin of the valley of the Rokytná as a post-Miocene ramp valley and the transfer of marine sediments to the level of the valley floor is less probable due to the demonstrated connection to the joints than the former variant.

The accumulations of Pleistocene fluvial sediments were preserved in the studied territory in only isolated islets in the valley of the Rokytná. For their more accurate stratigraphical inclusion absolute dating has so far been missing. In the studied territory it is possible to distinguish only three levels of sandy gravel fluvial accumulations included by Zeman (in Dlabač et al., 1975) into the Mindel and/or Riss.

6. DENUDATION CHRONOLOGY OF THE STUDIED TERRITORY WITH PARTICULAR CONSIDERATION OF THE DEVELOPMENT OF THE PLANATION SURFACES

The oldest form of the georelief are erosional platforms in the watershed parts which I consider to be the remodelled remnant of the so-called Palaeogene planation surface. This planation surface had originally the form of a peneplain with deep kaolinic weathering products and its development took place in the warm savanna climate of the end of the Mesozoic and the Early Palaeogene.

Towards the end of the Palaeogene and at the turn between the Palaeogene and the Neogene intense tectonic movements appear in connection with the Sázava orogenic period in the Outer Western Carpathians linked up with the dissection of the planation surface. The pre-Miocene georelief has a dissected character with eminences constituted by the crystalline bedrock and depressions filled with clayey sediments.

From the beginning of the Miocene repeated regional uplifts are evident in the territory with subsequent falls corresponding to the marine ingression of the individual steps. Altogether three cycles are documented in the studied territory, which are the Ottnang, Carpathian and Badenian floods. Before each transgression there was a substantial removal of older Miocene beds.

For the influencing of the georelief by marine abrasion in the individual stages of development a number of factors were determining from which it is necessary to mention above all:

- the extent of floodings in the direction towards the centre of the Bohemian Highland;
- the cover with weathering products and the vertical differentiation of the georelief in the preceding stages of development and the character of marine sediments following from them;
- tectonic movements in the given period affecting to aconsiderable extent the degree of the georelief differentiation.

The sedimentation of the Ottnagian took place in a relatively dissected georelief of a strongly kaolinized crystalline complex with variable communication with the open sea. The occurrence of Ottnangian sands at the height above sea level of up to 360 m witnesses the fact that the territory was flooded to a considerable height in the Ottnangian. This fact is, by the way, also confirmed by hypsometric data. Čtyřoký (1980) describes the occurrence of sandstone rolled pebbles in the surroundings of Dukovany and in connection with that he assumes that the marginal facies of the sea reached also far to the north of Dukovany. At present the sediments of the Ottnangian occur continuously on the valley slope of the Rokytná in the surroundings of Vémyslice, and there are islet occurrences on the slopes of water streams in the catchment area of the Jevišovka. In regions north of the stream of the Rokytná

Ottnagian does not occur. Small relics of Ottnangian sediments in a sandy-gravel facies are also found on the water divide plains, but their character as well as the surrounding georelief witness rather the overlap of the already flat surface with sediments.

Most of the sediments between Brno and Znojmo included in the Ottnangian have a very characteristic association of heavy minerals with conspicuously high content of staurolite and further minerals resistant to tropical weathering (Krystek, 1983). They witness the fact that the material of the crystalline complex weathered in that way (depleted by pyrop) was for a long time entrained from the margins of the Bohemian Highland to a foredeep. This entrain persisted approximately in the period of Eggenburgian-Ottnangian. Typical of the above period is rather the denudation of the underlier than its active modelling.

Despite the above facts in the period of the deposition of the Rzehakian layers the abrasion activity of the sea took probably place. The evidence thereof are the block accumulations on the basis of Rzehakian layers near the village of Želetice (Dlabač, 1976). Due to the dissected georelief a number of small isles jutted above the level of the flood and on their margins the disturbing activity of waves could form abrasion cliffs without producing extensive abrasion plains. In this way it is also possible to explain the uneven character of the shoreline. Evidence of the above type of modelling was also found in the studied territory near the locality Na Vartě, south of the village of Vémyslice (Fig. 4).

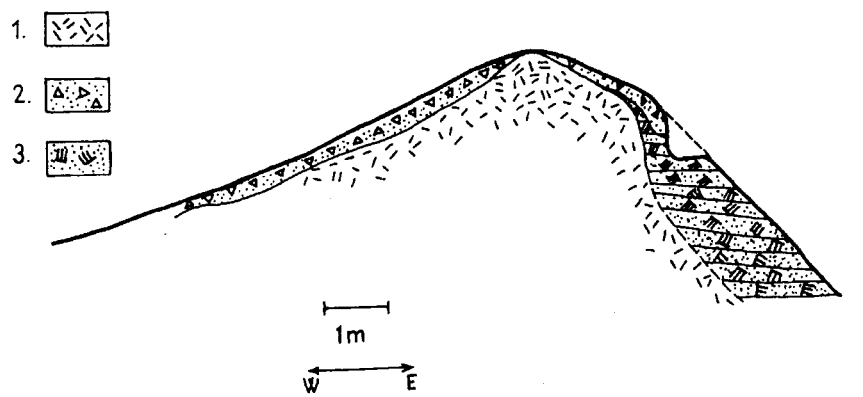

Fig. 4. Remnant of an old abrasion cliff created by the activity of the Lower Miocene sea:
1) slightly weathered migmatite (lit-par-lit gneiss)
2) shallow soil with angular stones
3) Miocene sea sands with weakly weathered angular blocks of migmatite

Strong tectonic activity connected with movements in the flysh units meant the onset of a new sedimentation cycle in the Carpathian and the shift of the foredeep axis towards the west. The denudation relic of the Carpathian found at the height of 312 m above sea level in a valley SE of Rešice admits the possibility that the Carpathian sea had flooded a considerable part of the SE margin of the Bohemian Highland. The Carpathian took up a large continuous area and according to hypsometry about as much as 200 m thick overlapped the present georelief. From the position of the present-day small relic it follows that the pre-Badenian relief originated after almost a complete removal of the sediments of the Carpathian during the regional uplift of the region. Sediments of the Moravian are deposited mostly on the rocks of the pre-Miocene bedrock.

In the Carpathian material rich in pyrop was entrained witnessing the fact that chemical heatherings with conspicuously high content of staurolite had already been denuded (Krystek, 1983). This fact does not confirm the assumption expressed by Dlabač (1976) who speculates about repeated phases of tropical weathering between the individual phases of Miocene transgressions.

A new transgression penetrates into the studied territory in the Badenian from the SE. The Badenian (the Lanzendorf series) - of Moravian forms an extensive sheet north of the Rokytná in the vicinity of the community of Dobřínsko. On the basis of heights above sea level of the occurrence of denudation relics of the Moravian in the immediate neighbourhood of the mapped territory (Velký kopec 392 m above sea level) it is possible that in some terminal phase the whole territory was overlapped with sediments of the Moravian Sea.

From the thickness of the distribution and the lithological character of denudation relics of the Moravian it is evident that there was a gradual covering of the terrain with marine sediments due to the sinking of the region. Originally only the deep valleys with preserved beach sands were flooded (Dolní Dubňany). During the sinking of the land the flood extended, leaving in the georelief traces of the abrasion activity, the same as in the transgression of the Ottnangian. Conditions for the development of the abrasion activity were, however, less favourable in that period - the georelief was no longer affected by intense tropical weathering between Carpathian and Moravian transgression. This fact is witnessed by the dominance of pyrop in the association of heavy minerals occurring in marine sediments. Higher situated convex parts of the georelief consisting of more resistant rocks only weakly weathered then were subject less intensely to abrasion. The outcrops of sand are often lined with granulite and quartz rolled pebbles (Dlabač, 1976). Although the Moravian occurs in numerous places also on amphibolites and serpentine, the rolled pebbles of those rocks are not found there. This fact is probably linked up with a lower resistivity of the two types of rocks towards chemical weathering which took place in the Palaeogene.

Regions constituted by those rocks appeared as depressions at the time of the Badenian flooding and they were filled with remnants of tropical degraded material which have been preserved at the above types of underlier until the present, or by sediments of younger Miocene phases. Morphological signs of the abrasion cliff are found north of the communication Dobřínsko - Dolní Dubňany in the form of a terrain step separating two flats. The rise of those two flats can also be explained by subaeric levelling processes during the denudation of the basal weathering surface.

In the surroundings of Tulešice and Rakšice there occur Miocene sediments of undifferentiated age which are located on the margins of plains and above the left valley slope of the Rokytná they even cover their surface. The transition of those sediments into the parts of plains formed by crystalline rocks is morphologically imperceptible and it is therefore clear that a younger phase of levelling must have taken place there. In some denudation relics of the Miocene W of Rakšice moldavites were found (Trnka, Houzar, 1991). With respect to the age of the fall of the moldavites - in the Middle Badenian - (Čtyřoký, 1980) it is necessary to take into consideration the possibility of the redeposition of Miocene sediments by means of palaeostreams in the Upper Miocene or at the beginning of the Pliocene.

In the subsequent period of the development of the georelief after the regression of the Badenian sea and in the Pleistocene an important period for the development of surface forms sets in. The water streams follow the retreating sea and cut into marine sediments on the emerged surface. Fluvial erosion leads to a gradual removal of Miocene marine sediments and a partial exhumation of the pre-Miocene georelief.

In the Upper Pliocene a phase sets in of a mildly warm and humid climate and the entrainment of tropical degraded material from most of the territory is finished. On most of the flats the basal weathering surface is uncovered and a new type of levelled surface comes into being - the etchplain. This planation surface cuts both the crystalline bedrock and Miocene sediments.

In the Pleistocene the georelief of the studied territory develops under the influence of climatic oscillations during which the region found itself in the periglacial climatomorphogenetic zone. The denudation of Miocene sediments goes on as well as the gradual clearing of pre-Miocene valleys dependent on joints. As follows from the height of the deposition of Pleistocene river sediments, the exhumation of the valleys takes place to a decisive extent only in that period. At the beginning of the Holocene the climate changes again and despite partial oscillations a mild humid climatomorphogenetic zone prevails. The decisive role in the development of the georelief is that of fluvial erosion and accumulation and - linked up with them - the modelling of the valley slopes. Man becomes a conspicuous modelling factor, starting from the Neolithic. He changes above all the pattern of the vegetation cover, thus conditioning the development of erosional processes on the slopes. The material

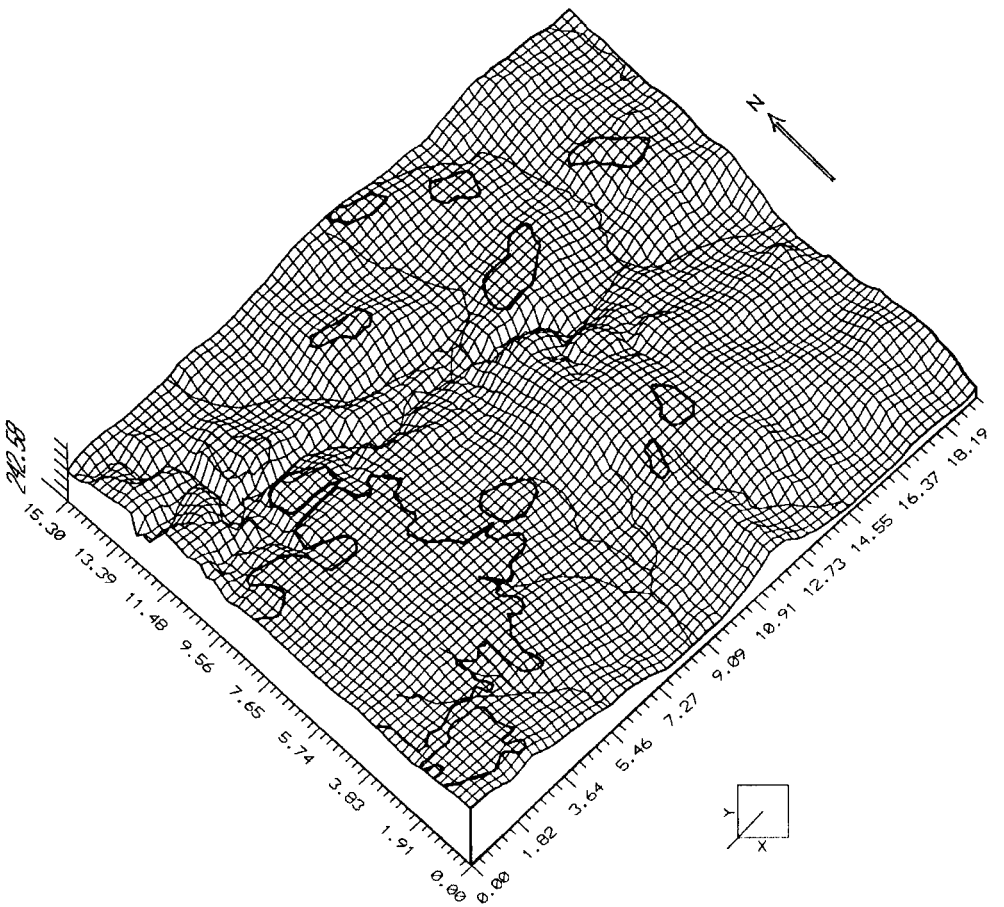

Fig. 5. DTM model of the studied area with planation surfaces larger than 10 ha

entrained from those regions is deposited in the form of flood loams in the valleys of water streams. Direct impact of human society into the development of the georelief are at present visible particularly in the regions of fluvial plains where a number of reservoirs and water mills have been built. These interventions into the water regime have moderated the dynamics of the development of the plain.

7. CONCLUSION

The paper deals with a comprehensive geomorphological analysis of the region of the middle reaches of the river Rokytná, delimiting the main stages of its development. The results of the analysis confirm that the main planation surface of the studied

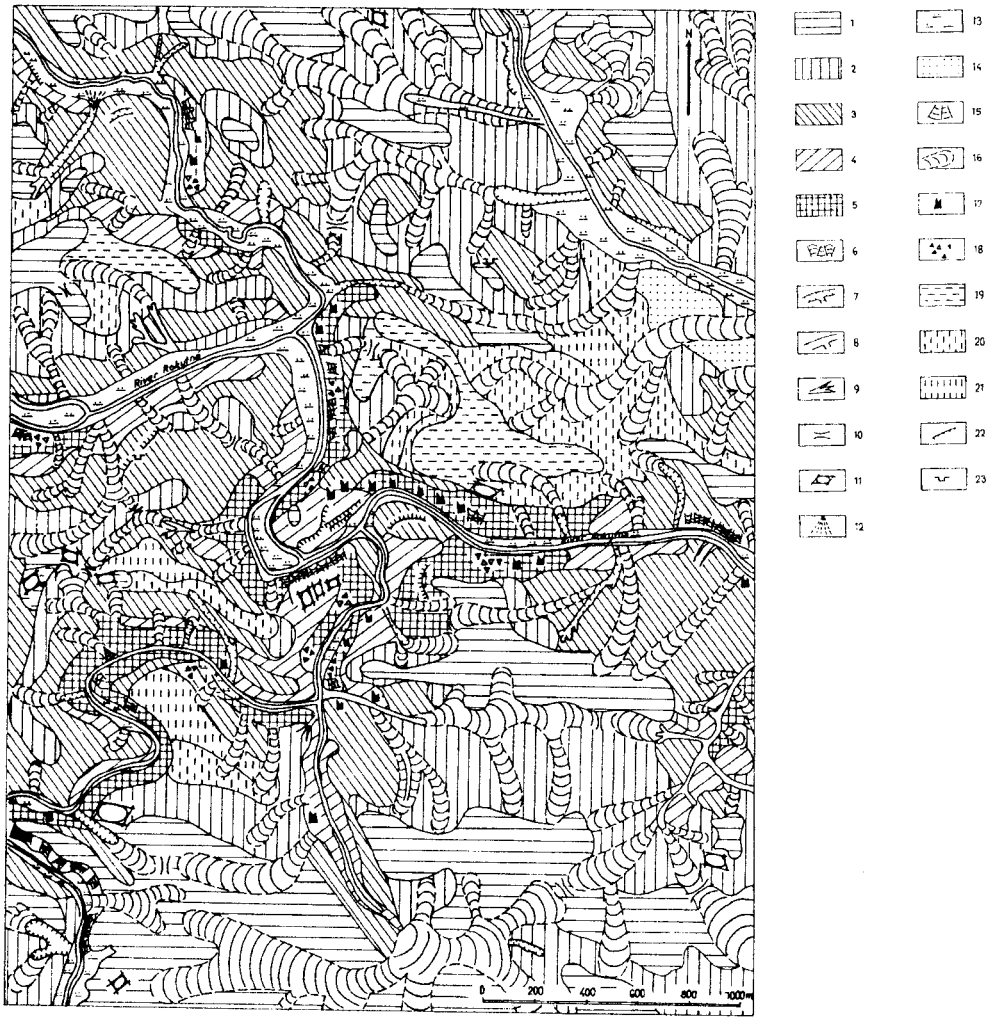

Fig. 6. Example of the detail geomorphological map based on the IGU legend. Legend: 1 - planation surfaces, 2 - fluvio-denudational slopes inclined at 2-5°, 3 - inclined at 5-15°, 4 - inclined at 15-35°, 5 - inclined at 35-55°, 6 - inclined over 50°, 7 - gullies, fresh, 8 - gullies, old, flat floored, 9 - rills, 10 - passes, cols, 11 - residual hills, 12 - debris cones, 13 - river-built plains consisting of loam, silt and clay, 14 - river-built plains consisting of sand and gravel, 15 - alluvial fan consisting of silt, loam and clay, 16 - dells, 17 - small residuals, tors, 18 - block stream, rock glacier, 19 - loess-cover mantling older relief inclined at 0-2°, 20 - inclined at 2-5°, 21 - inclined at 5-15°, 22 - agricultural benches on slopes, 23 - quarry

territory is not abrasion platform, but was created due to subaeric modelling, having the character of an etchplain (Czudek, Demek, 1970). Miocene sediments cover only part of the plains and their lithology and surrounding landforms do not correspond to the abrasion type of coast. The activity of Miocene transgressions is reflected - besides extensive sedimentation - by the rise of local abrasion forms which are often overlapped and remodelled by younger geomorphological processes.

On the basis of the occurrence of tropical kaolinic degraded materials two stages of their development can be assumed. The first took place in the period of Upper Cretaceous-Palaeogene and the remnants of the degraded crust of that period are preserved only in the depressions of the basal weathering surface. A more extensive in area occurrence of degraded material in the region of elevations is probably linked up with the younger stage of kaolinic weathering in the period of Upper Miocene-Pliocene.

So far open remains the problem of the neotectonic activity of the region which requires a solution within broader connections with the surrounding georelief.

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