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HISTORICAL AND PRESENT SLOPE EVOLUTION IN HILLY FARMLAND (ON THE EXAMPLE OF THE MYJAVA HILL LAND, SLOVAKIA)

ABSTRACT: STANKOVIANSKY M., *Historical and present slope evolution in hilly farmland (on the example of the Myjava Hill Land, Slovakia).* (IT ISSN 1724-4757, 2003).

The overwhelming majority of the Myjava Hill Land, namely its eastern and central part, is specific with the relatively short-term human interference into the original natural landscape. The mentioned territory was settled in two stages between the early 14th and late 18th centuries. It is possible to distinguish two different types of slope evolution in this area in the past after the transformation of former woodland into farmland. The first type was characteristic by the leading role of linear water erosion, occuring in time of colder and wetter fluctuations in the course of the Little Ice Age, when disatrous gully erosion resulted in the formation of dense network of gullies. The second type was typical for the combined acting of areal water erosion and tillage erosion. It was linked temporally with the periods between and after climatic fluctuations and spatially with the slope portions not suffered by gullying. The operation of these processes, lasting centuries, resulted in the lowering of the surface of slopes and ridges with different nature in case of slope portions cultivated along contours and gradients. The slope evolution was totally changed due to the collectivization in agriculture. Its results are the total smoothing of slopes and marked acceleration of their lowering. Conclusions of this study are still more valid for the hilly environments in Slovakia with much longer duration of agricultural interference.

KEY WORDS: Hilly agricultural landscape, Linear water erosion, Gullies, Areal water erosion, Tillage erosion, Slope lowering, the Myjava Hill Land, Slovakia.

INTRODUCTION

The objective of the article is to elucidate the historical evolution and transformation of slopes in the hilly agricultural landscape of Slovakia on the example of the Myjava Hill Land. Hill lands represent the transitional step between plains and mountains. Their typical feature is high vulnerability against geomorphic processes, resulting both from their natural conditions and the character of their land use. The high morphodynamics of the hilly environment results in significant transformation of its landforms. The main natural prerequisities of the high hill landforms dynamics are represented by their morphometric parameters and especially by the low geomorphic value of sedimentary (exceptionally older than Neogene) complexes building them, resulting in significant thickness of regolith. The most important anthropic prerequisities of accelerated morphodynamics of hill lands are their forest clearing and intense agricultural utilization. According to Bučko & Mazúrová (1958), they belong to the most affected areas of Slovakia in the past and also to the most attacked areas at present from the viewpoint of water erosion, both linear and areal. However, besides water erosion, an important role in the landform transformation was also played by tillage erosion, which did not attract the attention of Slovak natural sciencists so far (cf. Lobotka, 1958).

STUDY AREA

The Myjava Hill Land (384 km^2) is situated in Western Slovakia near the frontier with the Czech Republic. This geomorphic unit represents a lowering between the more uplifted massifs of the White and Little Carpathians (fig. 1). The character of the Myjava Hill Land is mostly plateau-like with relief of the order of 40-130 m. It comprises primarily the Neogene, Paleogene and Sennonian sedimentary rocks of medium to low resistance which result in considerable thickness of fine-textured regolith. The islands of loess and loess loams of different areal

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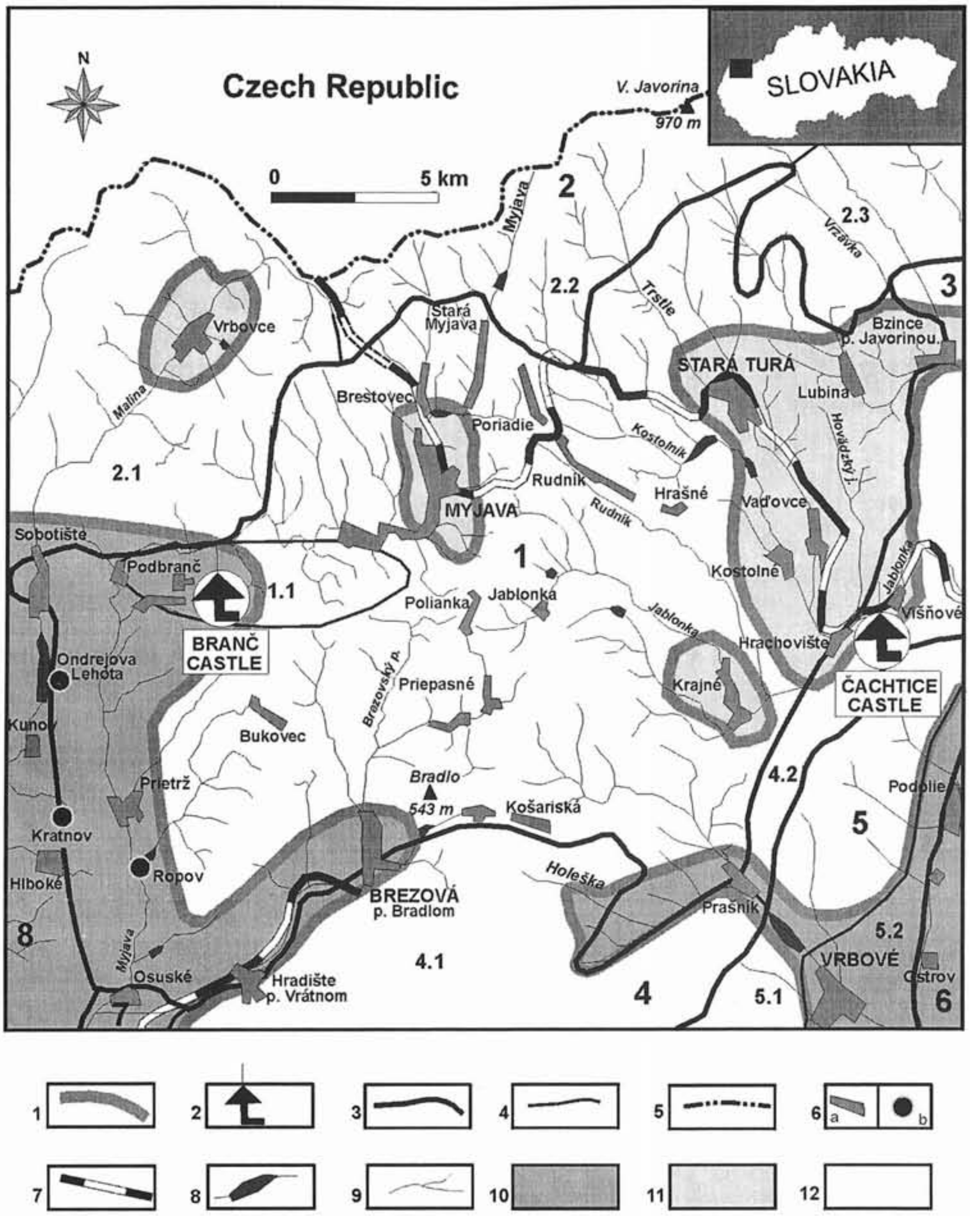


FIG. 1 - Situation map of the Myjava Hill Land with its settlement history - *Legend*: 1. boundaries of areas settled in different periods, 2. medieval castles, 3. boundaries of geomorphic units, 4. boundaries of geomorphic subunits, 5. state boundary with the Czech Republic, 6. settlements, 7. railway roads, 8. water reservoirs, 9. streams, 10. territory settled in the 13^{th} century and earlier, 11. territory settled in the 14^{th} century, 12. territory settled in the period from the late 16^{th} century to the late 18^{th} century (the kopanitse colonization) - *Geomorphic units*: 1. Myjava Hill Land: 1.1. Branč Klippes; 2. White Carpathians: 2.1. Žalostiná Upland, 2.2. Javorina Highland, 2.3. Bošáca Klippes; 3. Považie Basin; 4. Little Carpathians: 4.1. Brezová Carpathians, 4.2. Čachtice Carpathians; 5. Trnava Hill Land: 5.1. Sub-Little-Carpathian Hill Land, 5.2. Trnava Loessy Plain; 6. Lower Váh Flood Plain; 7. Bor Lowland; 8. Chvojnica Hill Land.

extent and thickness occur locally, usually on lower slope portions. This is why the total thickness of the Quaternary clayey-loamy to loamy slope sediments often reaches up to 10-15 m (Stankoviansky, 1997). Cambisols and Luvisols are the most frequent soil types. The mean annual precipitation is 650-700 mm. The territory was originally covered predominantly by Carpathian oak-hornbeam forests, locally with oak and beech forests (Maglocký, 2002).

MATERIAL AND METHODS

The following methods were used in this study: field geomorphic investigation, analysis of historical sources, interpretation of topographical maps and aerial photographs and interviews with local farmers. The detailed field reconnaisance enabled to elucidate the historical slope evolution through mapping of permanent, relic gullies, the actual slope evolution by means of documentation of ephemeral manifestations of rill and concentrated flow erosion due to particular heavy rainfall and snowmelt events, as well as the total geomorphic effect of long-term tillage. The analysis of historical sources, consisting of publications of historians, old maps, as well as local municipal and church chronicles contributed to the assessment of the settlement, land use and gully network evolution and also to the dating of stages of disastrous gully erosion since the beginnings of the settlement history. The interpretation of topographical maps and aerial photographs helped to understand the land use changes in the 2^{nd} half of the 20^{th} century, i.e. in the post-collectivization period. The interviews with old farmers enabled to imagine the geomorphic effect of terrain adjustments associated with the collectivization.

RESULTS

The forest clearing of the territory of the Myjava Hill Land and its agricultural utilization, connected with individual stages of its setlement, created conditions for intense operation of geomorphic processes. The landform evolution due to these processes during the settling of the study area is on the one side closely intertwined with a nature and extent of human interference in the natural landscape, manifested by specific evolution of land use pattern, or by climate changes concerning with colder and wetter fluctuations in the framework of the Little Ice Age (LIA) on the other. The present-day appearance of landscape in the predominant part of the Myjava Hill Land is the result of approximately seven centuries of human activity in the formerly natural landscape. Natural landscape development lasted almost to the end of the 13th century (Varsik, 1972). Although the beginnings of the settling are dated to the early 14th century (with exception of the marginal part in W and SW which was settled much earlier) (fig. 1), the main wave of settlement is associated with the so-called «kopanitse» colonization, which started in the second half of the 16th century and culminated at the turn of the 18th and the 19th centuries (Horváth, 1979). Colonization of the territory by the «kopanitse» settlers and their farming on acquired areas led in the course of almost four centuries to the creation of a typical land use pattern, as we know it from the first half of the 20th century. During this period, there was gradual extension of fields to the detriment of originally more widespread pastures. The growing population resulted in hereditary division of existing fields into ever smaller plots, which became increasingly narrow because they were divided longitudinally. Thus, the characteristic feature of the kopanitse settlement was a dense network of tiny hamlets dispersed irregularly among the villages in the agricultural landscape, represented by a mosaic of small, narrow plots. These plots were tilled predominantly along the contour lines, less often down-gradient.

Geomorphic response to the environmental (i.e. land use, climatic) changes affected with an exception of tiny, permanently forested islands practically the whole territory of the Myjava Hill Land. It manifested by high landform dynamics under the influence of water and tillage erosion and resulting significant relief transformations, both linear and areal. It is possible to distinguish two basic types of slope evolution in the past.

Historical slope evolution under predominance of linear (gully) erosion

The linear (gully) erosion, repeatedly operating along former artificial linear landscape elements, on destructed surfaces of pastures or along thalwegs of topographic depressions resulted in development of dense network of gullies, showing the density here and there up to 11 km/km^2. The cadastral maps from the turn of the 19th and 20th centuries reveal that the gullies on horizontally straight slopes are fully controlled by the old land use pattern (fig. 2). The overwhelming majority of gullies is very well preserved, they have sharp features and shows a «V» shaped cross profile. The gullies often reach depths up to 10-15 m, rarely up to 20 m and exceptionally even more. The length of gullies reaches up to 800 m on slopes, up to 700 m on ridge tops and up to 1,700 m in dry valley floors. Thus, the inevitable condition for the gully formation was human interference, but the triggering mechanism of disastrous gullying was represented by the extreme rainfalls in the course of the LIA. According to Lamb (1984), the LIA falls approximately within the period 1550-1850, which is in fact the same as the period of the kopanitse colonization. On the basis of the analysis of old maps from the 1st (1782), the 2nd (1837-1838) and the 3rd (1882) military mappings of the Old Hungarian territory within the Habsburg Monarchy, as well as of the analysis of the local historical sources, two stages of possible gully formation were identified. The first stage occured sometime in the period between the second half of the 16th century and the 1730s, the second between the 1780s and the 1840s (Stankoviansky, 2003).

Historical slope evolution under combined influence of areal water erosion and tillage erosion

Diametrically different geomorphic evolution was going on arable slopes unaffected by the gully formation, or on tilled slope portions between the gullies. Geomorphic response of the mentioned slopes to environmental changes (including the direct human interferences in the relief) had an areawide character. The areal water erosion and tillage erosion operated on the whole area of sloping terrain utilized as fields, only their share was changing from place to place according to topographical position and tillage direction, either along contours or gradients (Stankoviansky, 2001). The long-term repeated operation of mentioned processes resulted in the formation of colluvial bodies, while colluvium is meant in the sense of Bork & *alii* (1998, p. 317) as the correlate sediment of soil erosion.

In case of slopes with contour cultivation, the tillage erosion clearly predominated over water erosion. The result of long-term operation of contour tillage erosion was formation of numerous terraced fields (fig. 3a-b). The most marked terraces with the highest steps (up to 3 m) have originated in the deepest valleys with the steepest slopes.

In case of slopes with gradient cultivation (fig. 4), the tillage and water erosion operated mutually, but in uppermost slope portions and especially on ridge tops the tillage erosion clearly predominated. The resulting effect of combined operation of these processes on the system of narrow strips of gradient fields was a matter of the spatial organization of parcels with different land use and of appli-

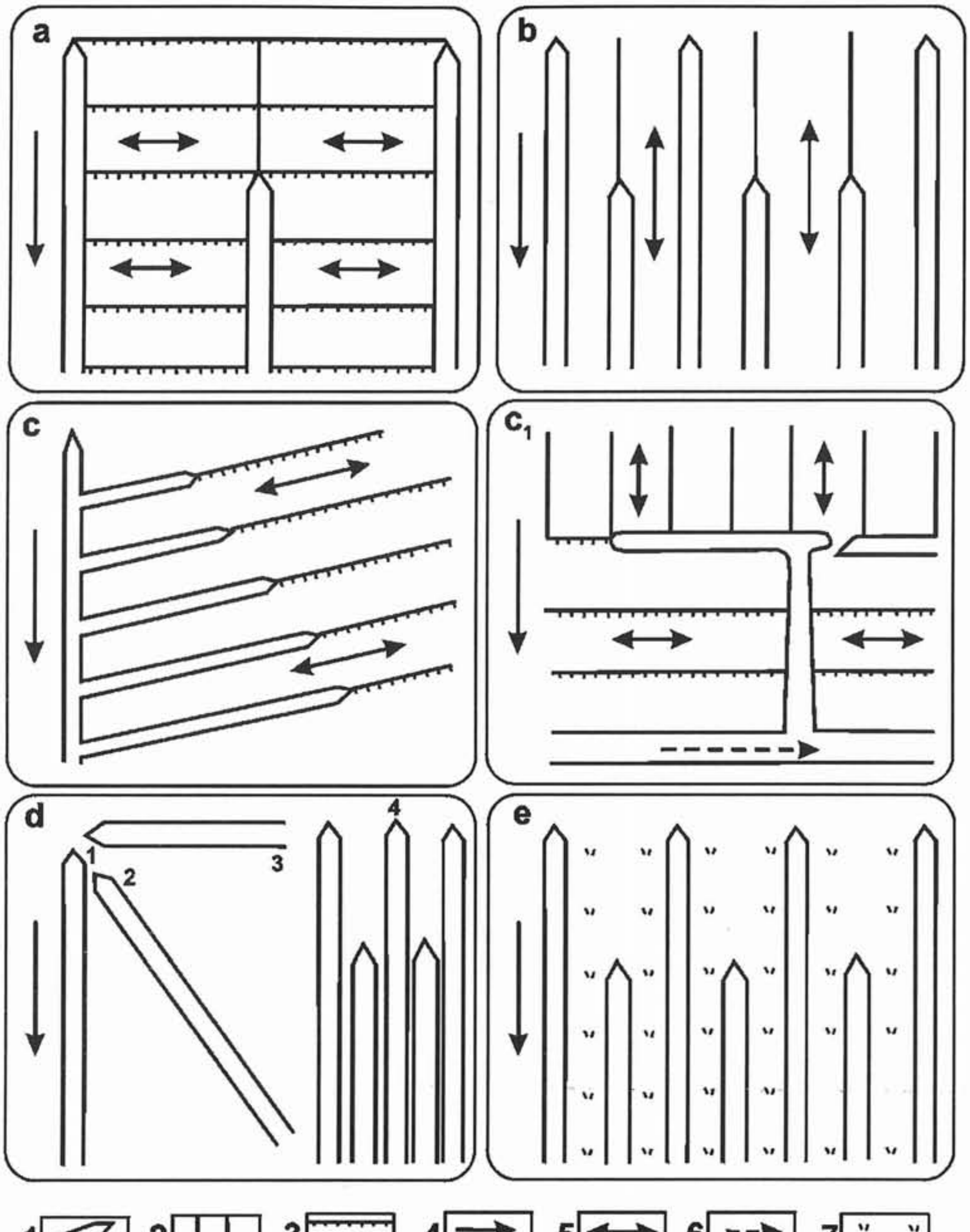
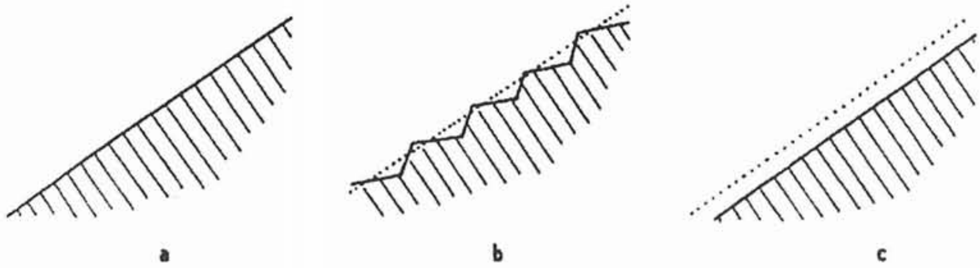


FIG. 2 - Types of the linkage of gullies to the former land use pattern on straight slopes - Legend: a. gullies on the slopes with horizontal, contour cultivation, b. gullies on the slopes with up-and-down cultivation, c. lateral gullies on the slopes with subhorizontal cultivation, entering to the main, gradient gully, c_1. example of gullies linked to the boundary between two blocks of fields with different tillage direction, entering to the main, gradient gully, d. gullies linked to the access roads and paths: d_1. following gradient lines, d_2. running aslant the contour lines, d_3. following divide lines, d_4. gully sets, e. gullies on pastures. 1. gullies, 2. parcel borders, 3. lynchets (steps of terraced fields), 4. direction of hillslope gradient, 5. direction of cultivation, 6. direction of thalweg gradient in cut along dry valley bottom, 7. pastures.

cated manner of ploughing. For instance, the field situated between two orchards was gradually lowered in form of shallow, rounded linear depression (fig. 5a). Similar phenomena can be seen even in the case of the fields situated between relic, today forested and therefore in fact stabilised gullies (fig. 5b). On the contrary, the regular ploughing from margins of long and narrow parcel towards its centre gradually resulted in creation of low rounded ridge situated along the longitudinal axis of the field. It was the result of farmer's effort to deflect runoff towards parcel borders. The consequence of long-term reiteration of this process was lowering of terrain surface on blocks of neighbouring fields cultivated in this way, namely by tillage erosion on vaulted parts and by water erosion along the parcel borders (fig. 5c).

The above statements allow to suggest, that the decisive areawide operating geomorphic process in long-term landform evolution in arable hilly environment is that of tillage erosion. The longer period of intense farming activity in the given area, the greater effect of this process. Our results are in coincidence with Bork (1989), who states that the tillage erosion predominated over water erosion in morphogenesis of agriculturally utilized areas in periods without extreme rainfall events.

FIG. 3 - Schematic sketch of the lowering of the slope surface under contour tillage (cross-section of slope in gradient direction) - *Legend*: a. original slope inherited from the times of periglacial morphogenesis, b. system of terraced fields, c. present-day slope surface created by planation of terraced steps in terms of collectivization - *Note*: Dotted line indicates the original surface.



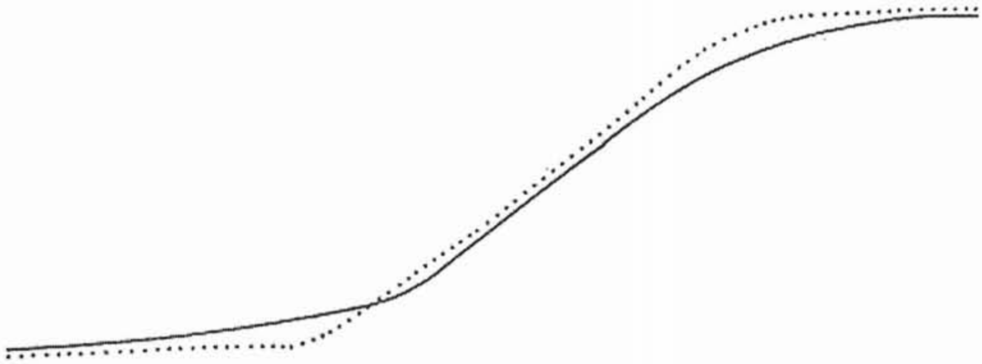


FIG. 4 - Schematic sketch of the lowering of the slope surface under gradient tillage (cross-section of slope in gradient direction) - *Note*: Dotted line indicates the original surface.

Slope evolution in the post-collectivization period

The above scheme of long-term slope evolution in agricultural landscape was totally changed in association with the collectivization in agriculture which took place after 1948 under the new, communist regime. The collectivization has brought the basic changes in the land use pattern on the substantial part of agriculturally utilized areas. The mosaic of original small parcels has vanished in favour of vast collectivized land units. The most inconvenient terrain adjustment was levelling of the former terraced plots (fig. 3b-c). The merging of the gradient fields and their cultivation under new conditions caused either the levelling of original terrain denivelations or their copying into the present-day cooperative fields. Planation of numerous smaller gullies was also part of terrain adjustments performed in that times. The resulting effect of the direct human interference into the landforms of agriculturally utilized hilly landscape during collectivization was going back to smoothly shaped relief (of course, with an excep-

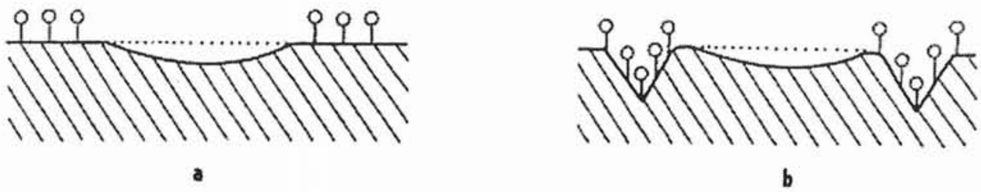
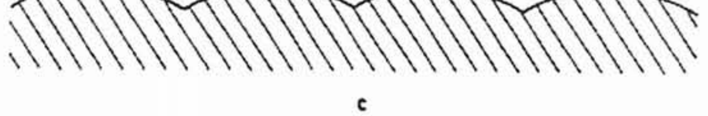


FIG. 5 - Schematic sketch of the differentiated lowering of the slope surface under gradient tillage (cross-section of slope in contour direction) - *Legend*: a. field between orchards, b. field between forested gullies, c. block of fields ploughed towards the longitudinal axes of individual parcels - *Note*: Dotted line indicates the original surface.



tion of gullies), similar to that, which was inherited from the times of periglacial morphogenesis. However, the present-day surface is markedly lowered, not only in comparison with the surface from the end of the last glacial, but also with respect to the surface from the beginnings of collectivization!

The «new» relief under the «new» land use pattern shows also «new» spatial organization of water erosion processes. The artificial linear landscape elements, markedly influencing the course of erosion processes in the past, were removed. This is why the behaviour of water erosion today is controlled unequivocally topographically. The straight slopes are typical for the operation of areal erosion (the sum of sheet wash, rill and interrill erosion), the slope hollows of different origin and depth for the acting of concentrated flow erosion, leading to the formation of ephemeral gullies. However, the erosion microforms are regularly erased by the subsequent tillage operation (Stankoviansky, 2000).

The lowering of slope surface as consequence of combined acting of water and tillage erosion in the post-collectivization period is in fact unobservable by naked eye, though it takes place. The best conditions for identification of the relief transformations in this period are in depression landforms, namely in bottoms of dry valleys, valley cuts and at the footslopes, while the maximum thickness of post-collectivization accumulation reaches locally up to 1 m and exceptionally even more (cf. Stankoviansky & *alii*, 2000).

CONCLUSIONS

High slope dynamics and resultant land form transformation in agricultural landscape of the Myjava Hill Land, associated with several centuries lasting operation of tillage erosion and with episodic occurence of water erosion especially in periods with higher frequency of extreme events (i.e. during the LIA), testify to significant affection of the given territory by the system of geomorphic processes. It is possible to distinguish two different types of slope evolution in the past. The first type is characterized by the predominance of linear (gully erosion), the second type by combined influence of areal water erosion and tillage erosion. The latter type exhibited different features in association with two different ways of the tillage, namely along contours or gradients. The long-term, historical slope evolution was significantly changed due to the collectivization of agriculture, resulting in the smoothing of slopes and marked acceleration of their lowering. The above conclusions on the nature of slope evolution (especially historical) in the Myjava Hill Land are still more valid for the hilly environments in Slovakia with much longer duration of agricultural interference.

The results from the Myjava Hill Land, showing high effectivity of geomorphic processes (namely water and tillage erosion) in the agricultural landscape both from the long-term and short-term viewpoints are in accordance with the results of study of their past and current geomorphic effect in other parts of Slovakia (cf. for example Bučko & Mazúrová, 1958, Lobotka, 1958, Košťálik, 1965, Zachar, 1982), as well as in adjacent countries, namely in Czech Republic (cf. for example Láznička, 1957, 1959, Stehlík, 1954, 1981, Demek & Seichterová, 1962, Hrádek, 1989) and Poland (cf. for example Lach, 1984, Maruszczak, 1986, Buraczyński, 1989/1990, Janicki & *alii*, 2002, Kukulak, 2002).

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