S T U D I A G E O M O R P H O L O G I C A C A R P A T H O - B A L C A N I C A
VOL. XXXIX KRAKÓW 2005 PL ISSN 0081-6434
L A N D F O R M E V O L U T I O N I N M O U N T A I N A R E A S

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GEOMORPHIC RESPONSE TO LAND USE CHANGES IN THE MYJAVA HILL LAND, SLOVAKIA, WITHIN THE LAST FIFTY YEARS

Abstract. The contribution assesses the geomorphic response to the large-scale land use changes associated with the collectivization in agriculture in the area of the Myjava Hill Land, Slovakia. The attention is focused 1) on the geomorphic effect of runoff processes (i.e. erosion-accumulation operation of surface runoff) in current landscape during particular extreme rainfall and snowmelt events, 2) on their total geomorphic effect within the whole post-collectivization period and 3) on the differences in the spatial organization, behaviour, rate and geomorphic effectiveness of runoff processes in the pre- and post-collectivization periods. The acquired results suggest marked post-collectivization acceleration of runoff processes, confirmed by a significant increase of their effectiveness, resulting in profound changes in the landform geometry. The most marked landform changes were identified in depressed positions, namely in the form of vertical increase of colluvial bodies under slopes and the rise of bottoms of dry valleys and of gullies incised in them; these changes represent the effect of accumulation of correlative sediments of accelerated runoff erosion. The author consider the post-collectivization period in conditions of Slovakia as historically the 5th stage of acceleration of runoff processes but at the same time as the first one which was conditioned exclusively by land use changes (the older stages are considered as result of cumulative influence of land use and climatic changes).

Key words: geomorphic response, land use changes, the Myjava Hill Land, Slovakia

INTRODUCTION

The main factors determining the landscape we see today are the past and present agricultural activities, climatic variations, and susceptibility of soils and parent materials to erosion (Geeson and Thornes 1996). Land use changes associated with farming have significantly influenced, alongside climatic changes, the landscape evolution since the beginnings of agriculture. Geomorphic response to both land use and climatic changes is represented by the change in the spatial organization, behaviour, rate and effectiveness of geomorphic processes resulting consequently in the transformations of conditions of relief evolution in time and space.

A farmer modifies the relief both directly and indirectly. The most profound direct intervention into the relief in farmland is the lowering of terrain convexities and the rise of concavities by the long-year tillage. The key indirect human influence is represented by an acceleration of the originally natural geomorphic processes due to the transformation of woodland into farmland as well as due to later changes in character and intensity of farming. This contribution deals above all with runoff geomorphic processes (i.e. erosion-accumulation operation of surface runoff; cf. Stankoviansky 1997), as they represent the most spread and geomorphologically the most effective processes acting in intensely used hilly to upland farmland, i.e. in such a landscape in which also our research has been conducted. Beside the assessment of the geomorphic effect of accelerated runoff processes, the author reflects also on the causes of the acceleration in the historical context.

What was the history of operation of accelerated runoff processes in the territory of the former Czechoslovakia? Š. Bučko (1980) in the area of Slovakia and O. Stehlík (1981) in the area of Czech Republic distinguish four stages of marked acceleration of runoff processes. They agree in temporal limits of the first three of them. In their opinion the oldest stage is linked with the end of the Younger and especially with the Late Bronze Age, the 2nd stage coincides with the period of stabilization of the Slavic settlement and the Great Moravian Empire (the 8th–9th centuries) and the 3rd stage agrees with the period of the so-called great colonization in the 13th–14th centuries. According to Š. Bučko (1980), the 4th stage of acceleration of runoff processes is linked with the period of the Walachian colonization in the15th–17th centuries, while O. Stehlík (1981) links it with the years 1750–1850. The latter author finds this stage as the first when anthropogenical influences were stronger than climatic changes. M. Stankoviansky (2003a, b, c) confirmed influences of both "Bučko's" and "Stehlík's" stages in the Slovak-Czech contact zone in the form of two phases of permanent gully formation; he considers them parts of the 4th stage of acceleration of runoff processes. Though the conditions favouring disastrous gullying in this period were extensive forest clearance and expansion of farmland connected with the so-called "kopanitse" colonization, the triggering mechanism seems to have been an increased frequency of extreme rainfall and snowmelt events during the almost synchronous Little Ice Age (LIA), occurring by H. H. Lamb (1984) between 1550 and 1850. This statement suggests (in contradiction to the above quoted Stehlík's opinion) that the cause of the 4th stage of acceleration of runoff processes was also the coincidence of land use and climatic influences.

A significant acceleration of runoff processes is connected with large-scale land use changes due to the collectivization in agriculture realized after political and social changes in former Czechoslovakia in 1948. This period of increased erosion still goes on and its duration does not exceed in fact five decades. Numerous authors pointed at the role of collectivization in acceleration of runoff processes so far (e.g. Bulíček et al. 1977; Stehlík 1981; Juráň 1990; Jambor

1997; Juráni 2000; Fulajtár and Janský 2001, p. 94), but the assessment of its geomorphic response on the basis of detailed terrain investigation was realized only by the author of this contribution and his team from the Institute of Geography, Slovak Academy of Sciences, Bratislava, namely in the area of the Myjava Hill Land in the period 1993–1996. The author´s investigation in the area under study still continues. The contribution summarizes acquired results and brings main conclusions of this long-year investigation.

NATURAL CONDITIONS AND LANDUSE EVOLUTION OF THE STUDY AREA

The Myjava Hill Land (Fig. 1) is situated in western Slovakia near the frontier with Czech Republic. This area of 384 km^2 is the downfaulted zone between the flysch massif of the White Carpathians and the limestone-dolomite part of the horst of the Little Carpathians. Its character is mostly plateau-like with a relief of the order of 40–130 m. It comprises primarily the Senonian, Palaeogene and Neogene sedimentary rocks of medium to low resistance with a considerable thickness of fine-textured regolith, reaching locally to 10 m, exceptionally to 15 m. Cambisols and Luvisols are the most frequent soil types. The mean annual precipitation is 650–700 m. The natural vegetation was predominantly oak and oak-hornbeam forests with beech forests in the highest parts.

The present-day cultural landscape of the overwhelming majority of the study area is the result of a relatively short, little bit more than seven centuries lasting anthropogenical transformation of the original forested landscape. Though its marginal parts were settled much earlier, the major stages of anthropogenical intervention relate to the foundation of medieval villages in the 14th century and above all to the kopanitse colonization beginning in the second half of the 16th century and culminating at the end of the 18th century (Stankoviansky 1997). The characteristic feature of the kopanitse landscape until the 1st half of the 20th century was a dense network of small hamlets dispersed irregularly among the villages surrounded by a mosaic of small, narrow plots, tilled predominantly along the contour lines, less often down-gradient. This resulted in a dense network of artificial linear landscape elements such as field boundaries, banks, lynchets, headlands, access roads, paths and drainage furrows.

The situation changed totally in the course of the collectivization in agriculture between 1949 and 1975. The collectivization has brought the basic changes in the land use pattern in the substantial part of agriculturally utilized areas. The mosaic of original small private parcels vanished in favour of vast collectivized land units (Fig. 2). The most inconvenient terrain adjustment was represented by the levelling of the former terraced plots. Creation of large cooperative fields was accompanied by the destruction of a network of artificial linear landscape elements. Significant terrain adjustments were performed also in the framework of land reclamation in the second half of the 1970s and even in the 1980s. Especially

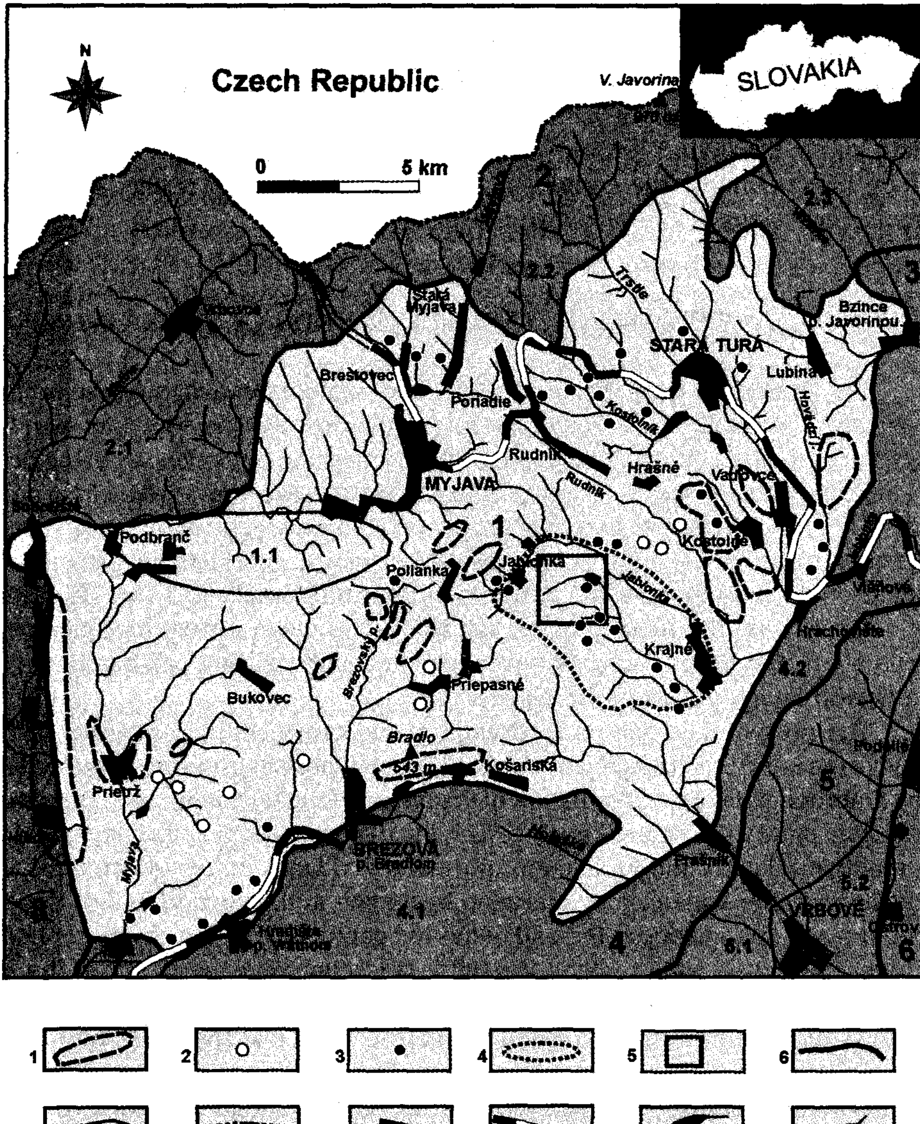

Fig. 1. Location map of the Myjava Hill Land (with the study sites). 1 — study areas of permanent gully systems, 2 — study sites of isolated permanent gullies, 3 — study sites of geomorphic effect of particular extreme rainfall events, 4 — boundary of study area of geomorphic effect of particular snowmelt events, 5 — selected part of this area (cf. Fig. 3 in Stankoviansky 1997), 6 — boundaries of geomorphic units, 7 — boundaries of geomorphic subunits, 8 — state boundary with Czech Republic, 9 — settlements, 10 — railway roads, 11 — reservoirs, 12 — watercourses.

Geomorphic units: 1 — Myjava Hill Land: 1.1 — Branč Klippes; 2 — White Carpathians: 2.1 — Žalostiná Upland, 2.2 — Javorina Highland, 2.3— Beštiny, 2.4 — Bošáca Klippes; 3 — Považie Basin; 4 — Little Carpathians: 4.1 — Brezová Carpathians, 4.2 — Čachtice Carpathians; 5 — Trnava Hill Land: 5.1 — Sublittlecarpathian Hill Land, 5.2 — Trnava Loessy Plain; 6 — Lower Váh Flood Plain; 7 — Bor Lowland; 8 — Chvojnica Hill Land

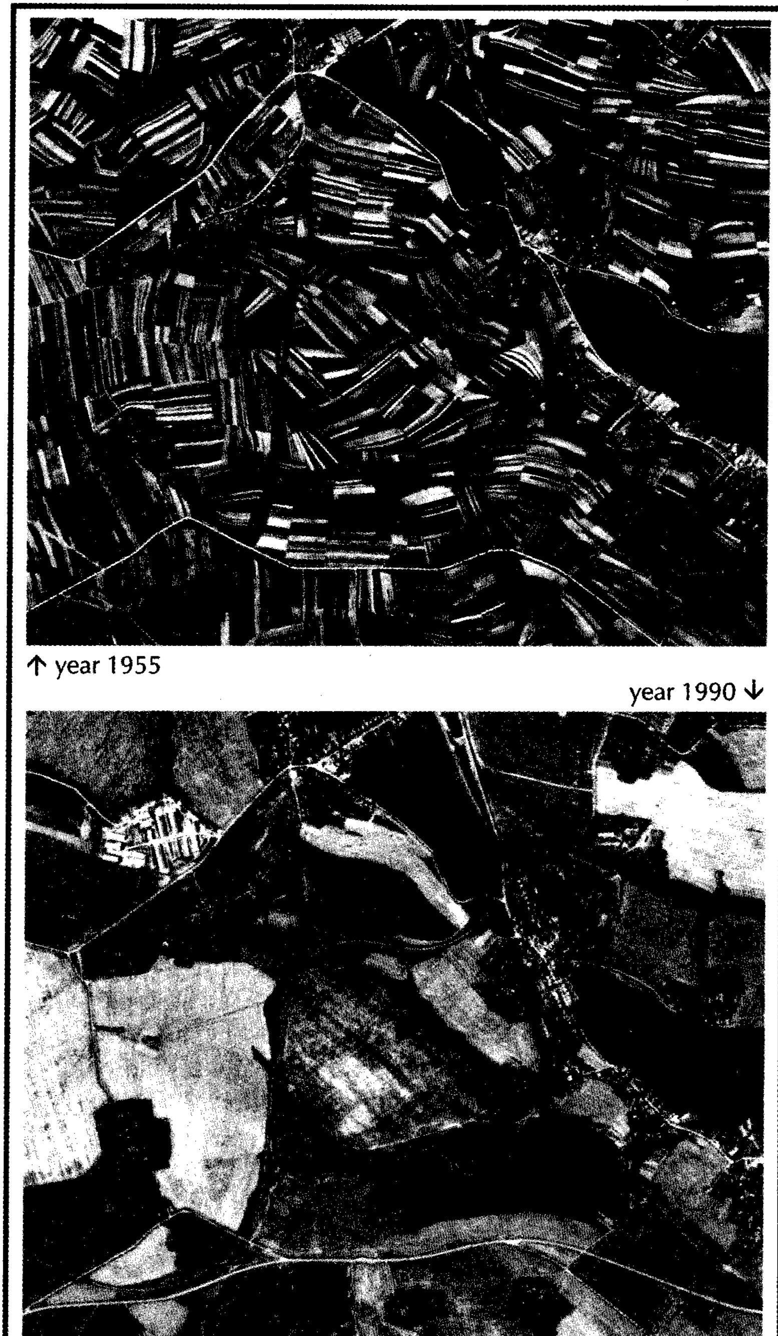

Fig. 2. Pair of aerial photographs showing an example of land use pattern before and after collectivization (indicating large-scale land use changes in surroundings of the villages of Poriadie and Rudník)

negative feature of collective farming include the introduction of crop rotation unsuited to hilly landscape.

As for the current land cover, 70% of the area of the Myjava Hill Land is the agricultural landscape (55% of arable land, 13.4% of land principally occupied by agriculture with significant areas of natural vegetation, 1.6% by fruit trees and berry plantations, pastures and complex cultivation patterns), 21.5% is woodland.

MATERIAL AND METHODS

In order to assess geomorphic response to large-scale land use changes connected with collectivization in the study area, it was necessary to know and understand the specific features (regularities) of spatial organization, behaviour, rate and effectiveness of runoff processes both in the present-day and pre-collectivization landscapes. As for the study of this phenomenon in the post-collectivization period, the attention was concentrated on two aspects. The first of them was the geomorphic effect of particular erosion-accumulation events (linked with extreme rainfall and snowmelt events), assessed on the basis of the detailed terrain investigation and documentation of their manifestations. The second studied aspect was the total geomorphic effect of runoff processes within the whole post-collectivization period. This effect was assessed by the measurements of thickness of post-collectivization sediments deposited in depressed positions using various buried artifacts or buried soils, partially buried telephone poles, fence posts or trees, and using the ^{137}Cs method. Information on operation of runoff processes in the pre-collectivization landscape, as well as qualified expert estimates concerning modifications of relief geometry was acquired on the basis of personal communication with relevant local people, mostly farmers, using their knowledge of landforms on study sites as they existed in the past. A comparison of the acquired knowledge on runoff processes and on their geomorphic effect in the present-day and past landscapes enabled to formulate conclusions on geomorphic response to profound land use changes which happened approximately a half a century ago. Knowledge on the land use pattern before collectivization was acquired by the analysis of aerial photographs from 1955.

RESULTS AND DISCUSSION

Out of L. Starkel's (2000) types of extreme events manifesting by apparent geomorphic effect, the most important role in the study area in the given period was played above all by local, short-lasting heavy downpours, with daily totals exceeding 20 mm and the rain intensity exceeding 1–3 mm per minute; the occurrence of geomorphologically effective snowmelt was rare (only in 1993). The meteorological station in Myjava, situated roughly in the centre of the study area, recorded in the period 1993–2000 4–8 days per year with total rainfalls exceeding 20 mm. However, the annual frequency of extreme rainfall events manifested by high geomorphic effectivity of runoff processes ranged from 1 to 3 in this period, while three downpours were registered in 1993 only (cf. Stankoviansky 1997). The discordance between the number of days with high totals and the number of extreme erosion-accumulation events is connected with the fact that some rainfalls did not reach the adequate intensity and if so, the event happened in the period when fields were sufficiently covered by vegetation and thus were protected against runoff erosion. In such cases it was possible to observe an increased effect of fluvial processes only. The most damaging erosion-accumulation events were triggered by the spring downpours in May and June. The highest daily maximum after 1993 reached 79.6 mm, particularly on June 22, 1999 (Faško and Šťastný 2002), the absolute daily maximum within the whole post-collectivization period reached 142.5 mm, namely on July 1, 1954 (*Klimatické*... 1968). Naturally, because of the limited areal extent of events of this type, the above data need not reflect fully either the real number of events or the real total in the centre of their occurrence.

GEOMORPHIC EFFECT OF RUNOFF PROCESSES IN PRESENT-DAY LANDSCAPE DURING THE PARTICULAR EXTREME RAINFALL AND SNOWMELT EVENTS

Generalization of results of the detailed field investigation and documentation of the geomorphic effect of numerous extreme rainfall and snowmelt events in the study area enabled to formulate the following conclusions concerning both partial processes of runoff erosion and runoff accumulation.

As far as the erosion processes is concerned, the geomorphic effect of both areal and linear (gully) erosion was studied. Areal erosion is understood as the sum of the operation of sheet wash, rill and inter-rill erosion (cf. Zachar 1970, p. 41). It affects all regularly cultivated hillslopes or their portions not dissected by hollows of any shape and size. The effect of sheet wash is the lowering of the surface of affected upper hillslope portions, in fact unnoticeable to the naked eye. However, under the definite circumstances it is possible to estimate the thickness of the removed soil layer, especially when the event occurs shortly after sowing and the layer of soil is washed out from the whole field including seeds. In such a case, the minimum thickness of the removed soil corresponds with the depth of sowing. The most striking case occurred on the hillslope situated easterly from the village of Osuské, affected by two consecutive downpours. The first heavy rainfall on May 15, 1993 resulted in the removal of soil including the seed. The field was sown again with the same seed (i.e. beet for feeding). The following downpour in June 6, 1993 washed out again the soil together with seed. As the depth of sowing of this plant is ca 1–2 cm (P. Jambor, agricultural engineer; personal communication), the hillslope surface has been probably lowered during the mentioned events by at least 3–4 cm.

Much more distinct is the geomorphic effect of rill erosion. Spatial organization, density, shape and size of rills depend on the inclination and length of the cultivated hillslope, state of the soil surface in time of the event and on the character of the event itself. The maximal depth of rills formed due to extreme rainfalls was recorded on fields close to the hamlet of Omastov vrch in the area of the Turá Lúka community (part of Myjava) after a sequence of downpours in May 2004, reaching locally to 20–30 cm (Photo 1). However, the absolutely maximal rills were generated due to the snowmelt on gently inclined slopes of the flat hill situated to the NE from the village of Jablonka in March 1993. They were formed on the large field, thinly sown with oil rape, and their depth reached to 30 cm and exceptionally even more (Stankoviansky 1995). In general, the depth of rills did not exceed in fact the thickness of cultivation layer. The effect of the inter-rill erosion is the lowering of surface between rills by the same way as it is in the case of sheet wash. Thus, the resulting effect of the areal erosion during every extreme event (of course, in combination with the conventional tillage operation that follows, obliterating the surface of fields affected by rilling) is the progressive lowering of hillslope surface.

The current linear erosion in the study area is controlled mostly topographically, it is linked with the bottoms of dells and of other linear depressions of various origin deepened into hillslopes. However, linear erosion can be also controlled by artificial linear landscape elements, namely by access roads running along the gradient or obliquely across the hillslope, field boundaries, various culti-

Photo 1. Geomorphic effect of runoff erosion due to a sequence of downpours in May 2004 in surroundings of the hamlet of Omastov vrch west of Myjava

vation furrows, vehicle wheel tracks etc. It is initiated by the temporally limited flows formed due to the concentration of runoff. Linear erosion did not result in the creation of permanent gullies within the whole research period; it was manifested only by the formation of the so-called ephemeral gullies (the term introduced by Foster and Lane 1983) of two types. The first type, represented by the broad and shallow ephemeral gullies, typical for the removal of a part or all cultivation layer, occurred much more frequently.

The width of such ephemeral gullies, corresponding in fact with the width of actual concentrated flow, reached in the shallow hillslope hollows to 5–6 m (e.g. in the surroundings of the village of Osuské due to the downpour on May 15, 1993) and along the bottoms of dry valleys to 10–12 m (e.g. in the Raková valley situated westerly from the hamlet of Dolný Štverník in the area of the Brezová p. B. community due to the downpour on July 2, 1995). The depth of these erosion features ranged from some centimetres to 25–30 cm in case of removal of the whole cultivation layer. The microforms similar to the pot-holes, deepened in the firm sub-cultivation layer (so-called plough pan) were appearing often on the bottoms of ephemeral gullies (cf. Stankoviansky 1997). This type of ephemeral gullies originates, according to J. Poesen and G. Govers (1990), during high-intensity low-frequency rainstorms. Joining of some shallow gullies can result exceptionally in the formation of relatively extensive area with removed cultivation layer (e.g. the washed patch ca 20 m broad was formed on the left side of the Raková valley during the above mentioned event).

The second type of narrower and deeper ephemeral gullies, incised in plough pan, occurred much more rarely. According to J. Poesen and J. Govers (1990) such gullies originate during the low-intensity high-frequency rainstorms. The maximal depth of these gullies in the investigated period reached 50 cm. As for the whole post-collectivization period, ephemeral gullies of this type did not exceed the depth of 1 m (M. Drška, former chair of the collective farm in the Kostolné community; personal communication concerning the area of his village). Gullies were always erased by the subsequent tillage operation but were formed again on the same places during the next extreme events.

Accumulation of the eroded material in the consequence of the particular extreme rainfall and snowmelt events was studied under horizontally straight hillslopes, in mouths of dells and dry valleys, as well as in their bottoms.

The geomorphic effect of accumulation under straight hillslopes, undissected by various hollows and thus modelled only by processes of areal erosion, represents the vertical rise of colluvial bodies in the form of continual footslope belts. Maximal effect of accumulation during the single event was recorded after the downpour on May 6, 1993 close to the hamlet of Paprad in the area of the Stará Turá community. The thickness of sediment at the foot of the left side of the Kostolník valley and on the anthropogenically controlled terrace in its lower part, deposited during this event, reached locally up to 50 cm (Stankoviansky 2003b, p. 117).

Accumulation in mouths of dells and dry valleys, in case of various obstacles also in their bottoms, is connected with the so-called muddy floods (the term introduced by Auzet 1987 in its French version "inondations boueuses"), representing floodings due to runoff with a high sediment concentration, generating muddy deposits. Occurrence of muddy floods is linked above all with the runoff concentration and the consequent ephemeral gullying in dells and dry valleys (Stankoviansky 2002). This phenomenon is different from mudflows belonging to mass movements.

The geomorphic effect of the individual muddy floods, i.e. the thickness of accumulated muddy layer, ranged between some centimetres and 50 cm within the investigated period. Differences are connected with specific features of both erosion and accumulation. The volume of material transported by flood depends on the extent of erosion within the dell or dry valley basins, especially on the extent of the concentrated flow erosion. That is why the most intense and thus at the same time also the most damaging muddy floods occur in May and June when fields are bare or only insufficiently protected by vegetation. The thickness of accumulation depends also on the topography of the site where the material is deposited, above all on its size and shape. However, accumulation is supported beside topography also by the influence of the so-called buffer zones (on the contact of the field with the meadow, orchard, forest, etc.) and especially by the artificial terrain barriers. Maximal thickness of sediment deposited due to muddy floods was recorded in the mouth of shallow, wide and only very slightly inclined slope hollow sown with corn into the valley of the Brezovský potok Brook between the hamlet of Rásnik and the village of Osuské. Almost 60 cm thick fresh colluvial cone was deposited during two consecutive downpours on May 15, and June 4, 1993. The thickness of sediment was influenced in this case by the barrier created by the railway dike (cf. Stankoviansky 2002). Naturally, only those muddy floods showed distinct geomorphic effect which occurred in an open country; the deposits generated by muddy floods which affected areas of villages or small towns were always removed by local residents.

TOTAL GEOMORPHIC EFFECT OF RUNOFF PROCESSES IN THE POST-COLLECTIVIZATION PERIOD

The total geomorphic effect of runoff processes during the whole post-collectivization period, expressed by the modifications of landform geometry, represents the cumulative manifestation of the sequence of repeated, consecutive, anonymous erosion-accumulation events within the last approximately five decades. The differences between geometric changes are discernible if they are the results of erosion or accumulation.

Repeated areal erosion leads to the hillslope lowering. Though the lowering of surface during the individual events is in most of cases practically unnoticeable to the naked eye, the cumulated effect of all erosion events in the framework of the whole post-collectivization period in the same place was probably considerable. However, a more precise assessment of hillslope lowering is rather complicated, because the lowering itself is not only the result of runoff erosion but also of tillage erosion (cf. Stankoviansky 2001). Moreover, it is very hard to estimate the surface lowering during the whole, long centuries lasting cultural period (in the most affected places perhaps as much as 100–150 cm, locally maybe even more), therefore it would be even harder to distinguish what part of this long-term effect corresponds with the post-collectivization period (Stankoviansky 2003b, p. 97–98). The precise assessment of the post-collectivization slope lowering would be possible only in case if co-operative fields originated by ploughing of the former meadows, unfortunately such an assessment was not done. The only qualified expert estimate is available for the right side of the Kostolník valley at the hamlet of Paprad in the area of the Stará Turá community. The surface of the large cooperative field, which originated by merging the former small contour plots in 1959–1960, was lowered so far roughly by 40–50 cm (M. Buno, former collective farmer; personal communication) (Stankoviansky 2003c, p. 98). Naturally, also in this case it was a result of combined operation of both runoff and tillage erosion. This estimate corresponds apparently with conclusions of P. Mederly (1992), who identified the post-collectivization surface lowering in the area of the village of Boršice (south-eastern Moravia, Czech Republic), ranging on the steepest hillslope portions between 20 and 60 cm.

The geomorphic effect of repeated linear (ephemeral gully) erosion in thalwegs of depressed landforms represents either a gradual formation of the so-called washed furrows (Stankoviansky 2000), known as "niecki zmywowe" by M. Klimaszewski (1981, p. 298), or deepening of older ones.

Visually more conspicuous and thus more suited for study are the geometric relief changes resulting from the repeated accumulation of eroded material in depressed positions. Within the post-collectivization period the older colluvia and fills of valley bottoms were covered by new sediment layer. To distinguish older sediments from younger and to assess the thickness of the latter, such sites were used where young sediments buried the original soil or various artifacts, or partially buried telephone poles, fence posts, tree trunks etc. For the assessment of the post-collectivization changes in the relief geometry in the particular sites the knowledge on their history was also very important. Generalization of results of the assessment of numerous sites enabled to distinguish two basic types of relief changes: a) an increase of the colluvial bodies under the slopes at margins of valley bottoms caused by deposition of the material coming from the side, and b) the increase of the bottoms of dry valleys and incisions in them by deposition of material coming mainly or exclusively from the upper valley reaches. Both mentioned types are demonstrated on the selected examples below, representing sites with maximal thickness of young accumulation. Their common feature is their similar geological situation, while the prevailing Palaeogene flysch rocks and the Neogene sandstones of moderate to low resistance are covered by a relatively thick regolith.

The maximal growth of colluvial bodies under slopes at margins of valley bottoms was identified in the Kostolník valley close to the hamlet of Paprad in the area of the Stará Turá community, already mentioned above in connection with an assessment of effect of accumulation during particular event. This site is at the contact zone of the horizontally straight left slope portion and the adjacent part of the floodplain. A marked, flat, gently inclined colluvial body follows the contact of the slope and the valley bottom, almost reaching the channel of the Kostolnik brook situated asymmetrically just below the opposite valley slope. A large co-operative field created by the merging the former small contour plots in 1959–1960, runs continuously from the slope to the footslope colluvial body and extends to a narrow strip of alluvial forest following the channel. A soil profile, excavated in the colluvium at a point situated 15 m from the left valley side and approximately 90 m from the brook, revealed an almost 70 cm thick layer of young colluvium, burying the topsoil at the surface of the former valley bottom (Stankoviansky et al. 1999, p. 20). It is supposed that the thickness of colluvium just at the foot of the slope reaches about 1 m. It was confirmed that the bed of the young colluvium, delivered from the slope by repeated areal erosion, was deposited after collectivization. This statement is based on the documentation of the geomorphic effect of the heavy rainfall in this locality on May 6, 1993 (see above), as well as on the qualified expert estimate (M. Buno).

Another example of the thickness of the post-collectivization footslope colluvial body reaching ca 1 m, in this case deposited by the concentrated runoff, is introduced by M. Stankoviansky (1994) from the Rybník valley in the area of the Bzince p. J. community. The above results correspond well with the results of similar investigation in the area of southeastern Moravia. P. Mederly (1992) identified the vertical post-collectivization increase of the footslope colluvia in selected localities in the area of the Boršice community, often reaching 50–100 cm, J. Obršlík (2004) identified such increase in the area of the Ždánice and Archlebov communities, often exceeding 80–100 cm.

As for the increase of dry valley bottoms, it is obvious (of course, on the assumption that the delivery of sediment is similar) that the narrower sedimentation area, the thicker bed of the sediment and at the same time the bigger increase of the valley bottom. This phenomenon is demonstrated on the example of three different dry valleys below, namely 1) with broader bottom, 2) with narrower bottom and finally 3) with a gully incised along the thalweg.

The first case is represented by the marked dry valley situated to the W from the village of Kostolné. It is wide, 700 m long, and asymmetrical both as for the height and inclination. The extensive cooperative field, comprising in fact the whole valley basin, originated by merging of the former small private plots in two stages, in 1952 and 1957. These interventions resulted in the profound acceleration of runoff processes, especially on the steeper right valley side. This valley side and also the valley head are covered by grassland since the early 1990s to prevent erosion. To evaluate the thickness of the post-collectivization accumulation at the valley bottom the ^{137}Cs method was used. It was found that accumulation since the 1950s resulted in the rise of the valley bottom by about 35 cm (Stankoviansky et al. 1999, p. 26).

The second example is represented by 1 km long dry valley situated close to the hamlet of Luskovica in the area of the village of Krajné. The wide, amphitheatre-like valley head is gradually narrowing downwards and in the bottom of its lower reach there is incised trough-like cut. Upper reaches of the valley are now used as one large cooperative field created by merging of previous small contour fields in 1959–1960. A buried telephone pole erected on the bottom of the trough-like cut in 1961 indicates 105 cm thick layer of sediment generated during heavy rainfall events in the post-collectivization period (Stankoviansky 1997). A profile excavated near the pole revealed nine sediment layers, distinguishing by thin sheets of decomposed organic matter, ranging in thickness from 3 to 19 cm (Stankoviansky et al. 1999, p. 29–31). These sediment layers correspond to nine muddy floods in the period after 1961. The sediment, delivered from the valley head, was deposited due to the barrier caused by the embankment of the access road, which leads obliquely through the valley bottom.

The last example with the maximal discovered thickness of young sediments within the whole study area is represented by the 900 m long dry valley situated

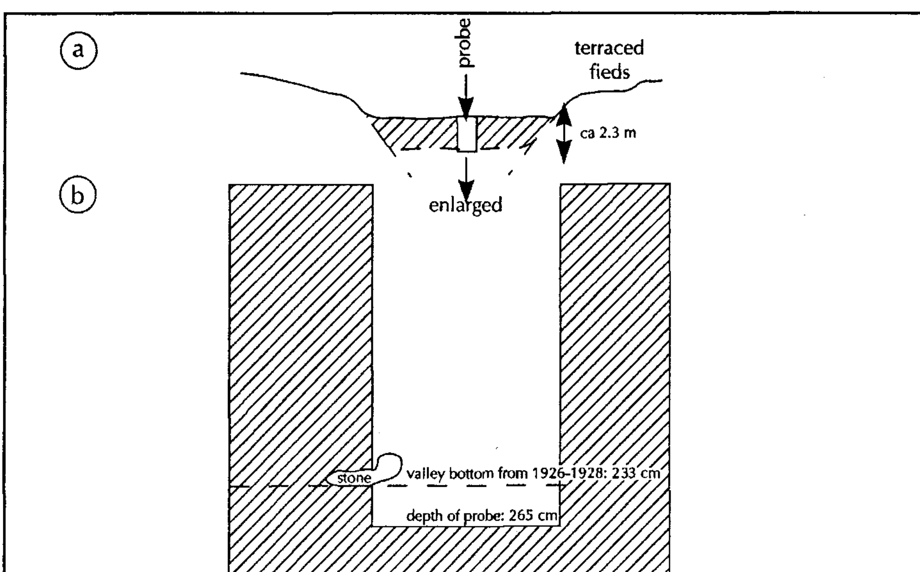

Fig. 3. Schematic cross-profile through the fill of gully incised along the bottom of dry valley at the hamlet of Hučkovci west of the village of Kostolné, showing the maximal thickness of the post-collectivization accumulation discovered in the study area (more than 2 m)

close to the hamlet of Hučkovci approximately 1.5 km to the W from the village of Kostolné. The distinct gully with steep sides and flat bottom was situated along the valley floor in the first half of the 20th century. The gully was almost completely filled by young sediments (Fig. 3). The original base of the gully, dated 1926–1928, was identified at the depth of 233 cm in the profile, on the basis of flat stones and broken pottery dated by the local resident Š. Hučko, as well as on the basis of his knowledge of the shape and depth of the gully in the past (Stankoviansky et al. 1999, p. 27). This layer of sediment might have been deposited after 1945, i.e. following bush clearing in the upper valley reaches and the founding of small private fields, but especially after 1959–1960 when these small fields were transformed into a large cooperative unit. M. Lehotský (2001) supposes on the basis of identified layers that this fill could be a result of about 11 events.

DIFFERENCES IN OPERATION OF RUNOFF PROCESSES IN THE PRE- AND POST-COLLECTIVIZATION PERIOD

Comparison of data on the course and geomorphic effectiveness of runoff processes in conditions of collectivized landscape, acquired by detailed field investigation, with information on acting of these processes in the pre-collectivization landscape, acquired on the basis of interviews with local experts, enabled to identify the differences in their operation in these two temporal horizons and thus to assess the geomorphic response to large scale land use changes connected with collectivization and to formulate following conclusions.

Runoff processes also operate today on such hillslope portions where they did not occur before (e.g. on former meadows transformed into fields) and, on the contrary, absent there, where they acted before (e.g. on former fields transformed into meadows or forests).

The formation of large blocks of cooperative fields and removal of a dense network of artificial linear landscape elements resulted (in spite of a diminishing of the total area of arable land) in the change of the predominance of linear erosion to the prevalence of areal erosion, manifested by the profound spatial increase of hillslopes affected regularly by areal erosion of increased intensity. However, the intensification of areal erosion does not concern all hillslopes; it varies from place to place in relation to the previous type of cultivation. The most marked increase of intensity of processes is on those hillslopes, which were cultivated along contours before collectivization, especially on steeper hillslopes with former terraces. It is evident that more sediment moves downslope after collectivization than before it. However, it is typical for the post-collectivization period that the majority of eroded and transported material is deposited under hillslopes and is not carried away from the catchments by local watercourses.

Large-scale land use changes influenced also the operation and geomorphic effectiveness of linear erosion expressed by the ephemeral gully formation. As the current network of pathways of regularly repeating concentrated flows is much less dense than in the past (as it is controlled almost exclusively topographically), it is obvious that the effectiveness of linear erosion along one pathway is (under the same intensity of extreme events) higher than before collectivization.

In the post-collectivization period the geomorphic effectiveness of meteorological-hydrological events, especially extreme rainfalls markedly increased, as was expressed by the increase of the occurrence of muddy floods, as well as by the growth of the rate of their harmfulness. Markedly increased occurrence of muddy floods (under the frequency of extreme events comparable with the pre-collectivization period), contributing significantly to the enormous total post-collectivization geomorphic effect of runoff processes, was confirmed both by identification of thick beds of correlative sediments (resulting in profound changes in landform geometry) and by the memories of residents.

Naturally, it is not possible to compare the absolute value of accumulation in the post- and pre-collectivization periods because of the relatively short duration of the former. On the other hand, the above results clearly indicate the marked acceleration of runoff geomorphic processes in comparison with the period roughly since the middle of the 19th till the middle of the 20th centuries, when the operation of these processes was evidently lowered (Stankoviansky 2003c, p. 127). The increased rise of colluvial bodies in depressed positions within the last five decades testifies to it.

CONCLUSIONS

Large-scale land use changes (including terrain adjustments) connected with collectivization in agriculture resulted in a significant modification of the relief in the territory of the Myjava Hill Land. Direct and very fast human interventions into the relief, expressed by the levelling of the old field terraces (formed by the long-term tillage) and filling of some smaller gullies, resulted in a reacquiring of smoothly shaped surface of hillslopes, though rather lowered in comparison with the period of the beginning of their agricultural utilization. Slower but not less marked relief changes were performed under the influence of significant change in the character of operation of runoff processes on the new, large, cooperative fields. Their spatial organization, behaviour, rate and geomorphic effectiveness changed. Acting of runoff processes in a totally changed agricultural landscape was markedly accelerated, what was confirmed by the significant increase of their geomorphic effectiveness. Knowledge acquired in the study area authorizes us to consider the post-collectivization period in conditions of Slovakia as the independent, historically the 5th stage of acceleration of runoff processes. On the other hand, this period is in fact the first of historical stages of acceleration of runoff processes, which is exclusively determined by land use changes. The above conclusions of M. Mederly (1992) and J. Obršlík (2004) from the Moravian part of Czech Republic suggest that the marked acceleration of runoff processes was not characteristic only for Slovakia but obviously also for other countries with similar nature of collectivization.

Though the post-collectivization (i.e. the 5th) stage of acceleration of runoff processes is really profound, it is far from reaching the geomorphic effect of the preceding 4th stage, which was the result of the cumulative influence of both land use and climatic changes (LIA) and is in the study area connected with the period roughly since the middle of the 16th until the middle of the 19th centuries. These conclusions encourage us to state that the most marked acceleration of runoff processes, and thus at the same time the most profound changes in geometry of landforms in the agricultural landscape within the temperate forest morphogenetic zone, happened in the periods when anthropogenical and climatic influences were synchronous.

ACKNOWLEDGEMENTS

This contribution is a part of the project No. 1/0038/03 supported by the Grant Agency of the Ministry of Education of Slovak Republic and the Slovak Academy of Sciences (VEGA). The author expresses his gratitude for meteorological data to RNDr. Pavel Šťastný, PhD., Slovak Hydrometeorological Institute, Bratislava, for data concerning the current land cover to RNDr. Marcel Šúri, PhD., Institute of Geography, SAS, Bratislava, and for valuable advice to Ing. P. Jambor (Soil Science and Conservation Research Institute, Bratislava), M. Drška, M. Buno (local farmers) and Š. Hučko (local resident; in memoriam).

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STRESZCZENIE

M. Stankoviansky

GEOMORFOLOGICZNE SKUTKI ZMIAN UŻYTKOWANIA ZIEMI NA OBSZARZE POGÓRZA MYJAWSKIEGO NA SŁOWACJI W OKRESIE OSTATNICH 50 LAT

Praca omawia geomorfologiczną reakcję na wielkoskalowe zmiany użytkowania ziemi związanych z kolektywizacją rolnictwa na obszarze Pogórza Myjawskiego w zachodniej Słowacji. Zwrócono uwagę na: 1) skutki geomorfologiczne procesu spłukiwania, tzn. działania erozji i akumulacji, na współczesnych formach rzeźby podczas ekstremalnych opadów i roztopów, 2) sumaryczny efekt geomorfologiczny za cały okres po kolektywizacji rolnictwa, oraz 3) przestrzenne zróżnicowanie przebiegu, rozmiarów i efektywności geomorfologicznej procesu spłukiwania w okresach przed i po kolektywizacji. Uzyskane wyniki pokazują, że nastąpiło znaczne przyspieszenie spłukiwania po kolektywizacji rolnictwa po roku 1948, potwierdzone przez wyraźny wzrost jej efektywności, powodujący istotne zmiany geometrii form rzeźby. Najwyraźniejsze zmiany zostały stwierdzone w formach wklęsłych, przede wszystkim w postaci pionowego przyrostu miąższości utworów koluwialnych u podnuży stoków i podniesienia den suchych dolin i rynien w nich wyciętych. Te zmiany stanowią efekt akumulacji osadów korelatywnych przyspieszonej erozji powierzchniowej. Autor stwierdza, że okres po kolektywizacji rolnictwa był w warunkach słowackich piątym stadium przyspieszonego spłukiwania, a równocześnie jest pierwszym, które było uwarunkowane wyłącznie przez zmiany użytkowania ziemi. Uważa, że starsze stadia były uwarunkowane nakładaniem się zmian użytkowania ziemi i zmian klimatycznych.