Preserved soil profile under forest and its evidence of relief change (Hlboká cesta example)

Anna Smetanová

Comenius University in Bratislava, Faculty of Natural Sciences, Department of Physical Geography and Geoecology, Mlynská dolina, 84215 Bratislava, Slovak Republic

Introduction

The soils in agricultural areas have been affected by accelerated erosion processes since the onset of agriculture. Although throughout the history the impact of water, wind and tillage erosion has been variable in space and time, it has brought significant changes of soil profiles. Soil truncation, contamination, decreasing of humus content and soil biodiverzity, salinization, landslides, flooding, soil sealing and compaction have been recognised to be the most dangerous [1]. Changes in soil characteristics influence soil erodibility and therefore geomorphological processes, while soil truncation represents directly a change of relief. Comparison of the depth of soil and its layers with original, undisturbed profile (reference profile) enables the evaluation of geometric changes of relief [2, 3]. Similar could be done with soil profiles tilled for certain period or soils previously tilled but now preserved under grassland or forest [4]. The aim of the study is to describe the relief changes using described approaches.

Methods

The study area is situated near the village Voderady in Trnavská tabuľa Table, which is part of Trnavská pahorkatina Hill Land. Due to neotectonic activity the plateu of Trnavská tabuľa has been devided to relatively elevated and declined blocks [5]. The soils on elevated local ridge and walls on road gully (Hlboká cesta) incised in the ridge were studied in 2009. Cultivated Chernozems on loess are predominant in this area. The cumulative rates of recent erosion were estimated on 16 $t.ha^{-1}.a^{-1}$ (^{137}Cs measurement, [6]) and 6.7 $t.ha^{-1}.a^{-1}$ (erosion modelling, [7] in surrounding area.

Total amount of seven soil profiles situated on the same type of morphometric elementary form have been studied. Six of them, drilled by percussion drilling, lie on the ridge which is under cultivation. The last profile is situated on semi-natural exposure in the wall of road gully. Gully is secondary afforested by *Robinia pseudoacacia* and succession species. Depth and truncation of soil profiles were studied; samples were taken for humus and

carbonate content analysis. The carbonate content analyses have not been processed yet, therefore are not considered in this study. The reconstruction of the gully development based on the study of historical maps (1st, 2nd, 3rd military mapping of Austrian-Hungarian Monarchy) and aerial photographs (1949, 1961, 2007) was used for relative dating.

Results and discussion

All studied profiles are situated on convex – convex parts of the ridge (Fig 1).

Fig. 1: Soil profiles location

The vertical difference derived on the base of detailed DEM [7] is maximum 4.4 m, slope varies from 0.4° on the local elevation (V-03) to 4.11° on the gully edge (V-07). The depths of soil profile show common features (Fig 2). Presuming that original A horizon of Chernozems was 50- 60 cm (or 55 cm in average) deep, they all are eroded. Soil profile truncation varies from 12 to 35 cm and is growing with increasing slope. Loss of more than 30 cm of soil occurs by profiles situated on slope 3.8°and higher. The most eroded is the profile under tree vegetation on the gully edge. Height difference of about 30 cm between its surface and the surface of the field was observed. Similar lowering of relief was described by [4] and is considered to be the result of tillage erosion [8]. Even there is no drilling situated near the

field border, according to the height difference, we can presume that the original humus horizon is completely or almost completely eroded there and the subsurface loess is being tilled. The humus content of the first horizon might be similar or slightly higher than the corresponding, 30 cm under surface situated horizon in the gully exposure.

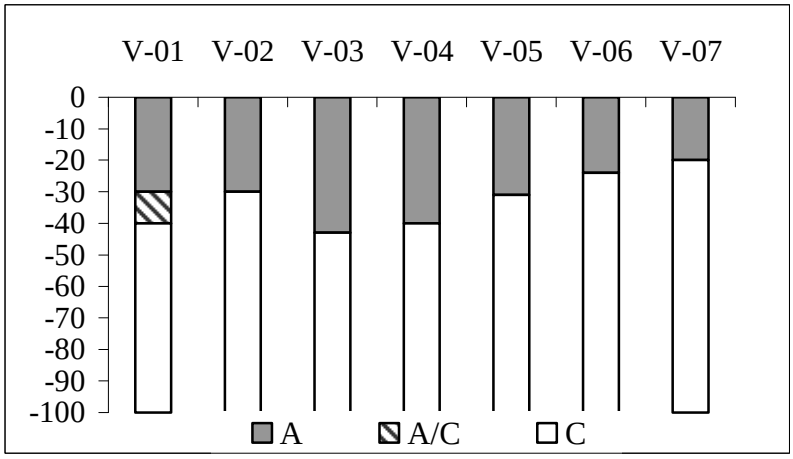

Fig. 2: Soil profiles depth

Humus content varies between remaining samples. The profile V-03 with deepest humus horizon (43cm) has the lowest content of humus, closed to 1% which is the distinguishing value between mollic and ochric horizon [9]. For relief reconstruction studies is essential to precisely evaluate the profile truncation, thus correctly interpret the origin of present day humus horizons. In the case of the profile V-03 the relatively deep tilled humus horizon could be created from loessic C horizon by deeper tillage, while fragments of original humus horizon could be mixed in during tillage. This represents profile truncation of more than 55 cm. If the present day tilled horizon originates in A horizon than smaller relief lowering occur. Considering the possible presence of A/C horizon in original soil profile complicates the interpretation.

The study of historical sources enables us to identificate the period of significant incision of the road gully. It occurred between 1784 and 1839, in the period between the 1st and 2nd military mapping (Fig 3). However the preservation of the gully is not clear from the following source (1882). The vegetation cover and its slow spatial spreading are evident since 1949. We can presume that from technical reasons (accessibility, needed space for turning of animal during tillage) the cultivation couldn't reach the gully wall. Therefore gully was protected by grass, bushes or (small) trees in 1882 - 1949.

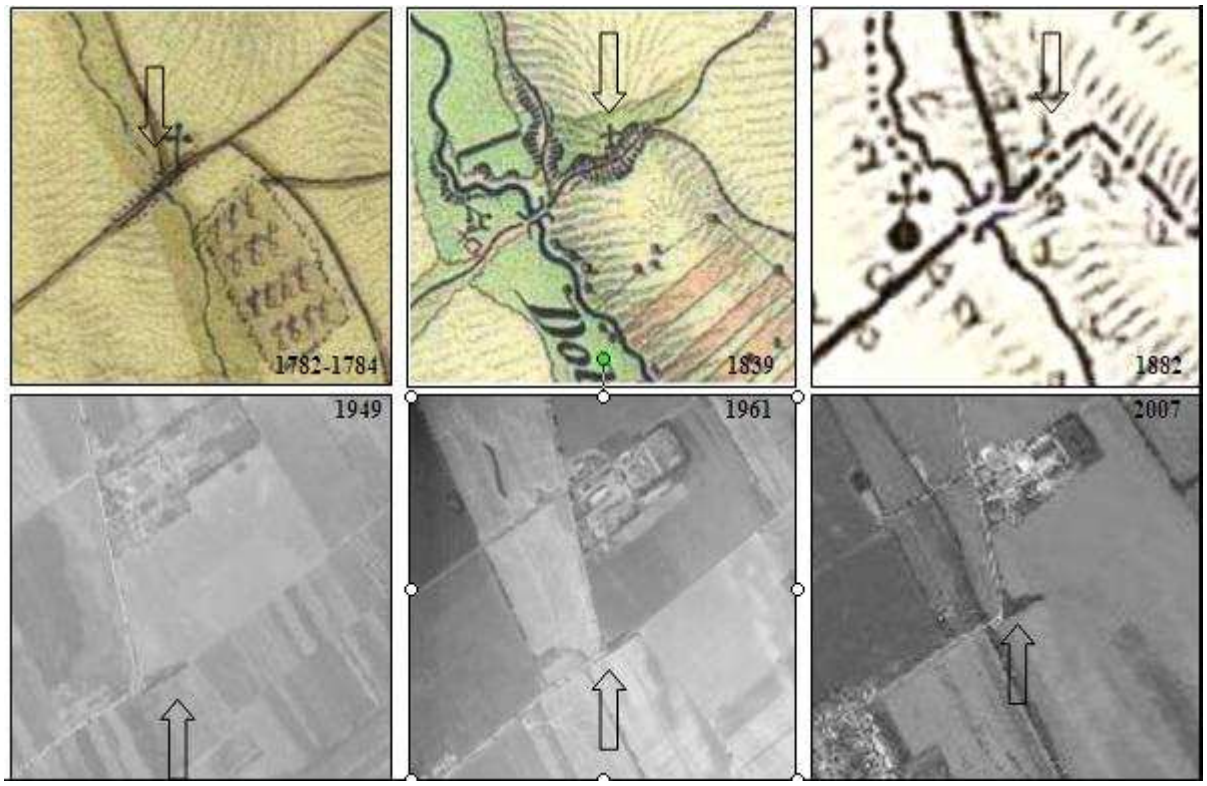

Fig. 3: Hlboká cesta road gully

Using this precondition the profile truncation of 35 cm observed on the wall of the road gully is result of erosion before 1882, but certainly is older than 1949. Dating of lowered (30cm) surface of the field closed to gully edge is 127 or 60 years respectively, what represent average erosion intensities 2.36 $mm.a^{-1}$ and 5 $mm.a^{-1}$. These values are higher that were measured by ^{137}Cs measurements (1.2 $mm.a^{-1}$, [6]) in surrounding area.

Conclusion

Significant erosion on convex – convex agricultural slopes on Chernozems was proved. The most eroded soils were found in the wall of Hlboká cesta road gully, created between 1784 – 1839. Since that time its preservation and lowering of nearby field surface are presumed. Although the profile truncation is higher on steeper slopes, the profiles could be deep truncated also on lower slopes near elevation. The analysis of humus content of tilled horizons must be therefore incorporated in relief reconstruction studies. Consensus on the border values of humus content concerning the origin of humus horizon is needed.

Acknowledgement

The work was supported by Comenius University under the contrat No. UK/224/2009, Slovak Scientific Grant Agency of the Ministry of Education of the Slovak Republic and Slovak Academy of Science under contract No. VEGA 1/0434/09. The author is thankful to Ms. Šárka Horáčková, Mgr. Katarína Džubáková, Mgr. Juraj Ondrčka and Mgr. Miroslav Žiak for their help during the field work.

References

[1] Imeson A., Arnoldussen A., de la Rosa D., et al. (2006) The way ahead. Soil Conservation and Protection in Europe. Heiloo, p. 39

[2] Bork H.-R., Bork H., Dalchow C. et al. (1998) Landschafts-entwicklung in Mitteleuropa.Wirkung des Menschen auf Landschaften. Gotha, Nemecko

[3] Dotterweich M. (2008) Geomorphology 101, p. 192

[4] Stankoviansky M. (2003) Geomorfologická odozva enviromentálnych zmien na území Myjavskej pahorkatiny. Univerzita Komenského v Bratislave, Bratislava, p. 66

[5] Stankoviansky M. (1993) Vývoj reliéfu južnej časti Trnavskej tabule. Geografický časopis 45 (1), p. 93

[6] Linkeš V., Lehotský M., Stankoviansky M. (1992) Proceedings VUPOP, p. 113

[7] Smetanová A., Kožuch M., Čerňanský J. (2009) Geomorph. Slov. et Boh. 2, p. 57

[8] Van Oost K., Van Muysen W., Govers G., et al. (2003) Eur. J. Soil Sci. 54, p. 63

[9] Sobocká J. (2000) Morfogenetický klasifikačný systém pôd Slovenska. VÚPOP, Bratislava, p.76.